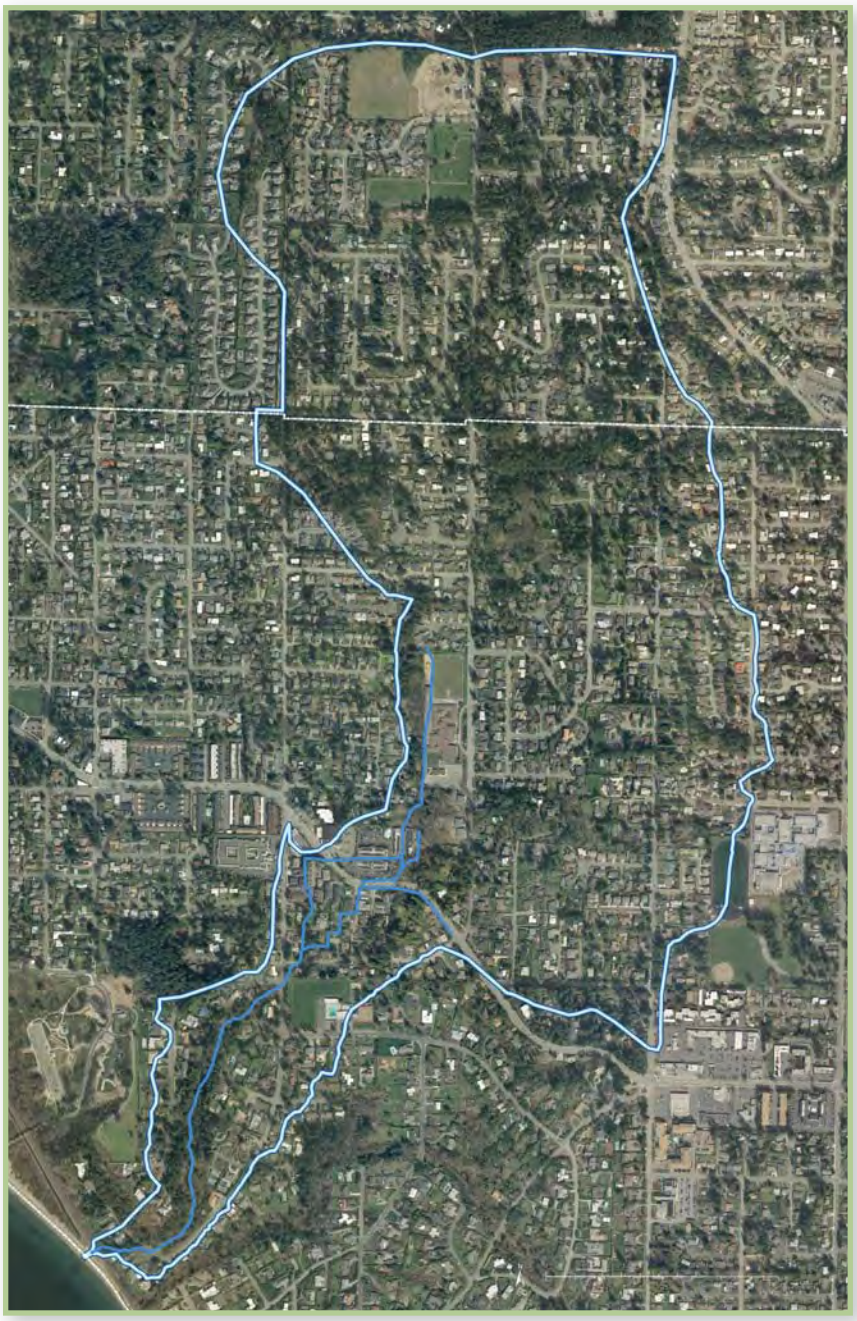


CITY OF SHORELINE

Storm Creek *Basin Plan*

March 2013

Wind Ward environmental LLC

OSBORN CONSULTING INCORPORATED

THE WATERSHED COMPANY

Cambria Science and Communication

Table of Contents

Tables

Figures

Photos

Acronyms

ADS®	Advanced Drainage System
B-IBI	Benthic Indices of Biotic Integrity
Bravo	Bravo Environmental
CCTV	closed circuit television
cfs	cubic feet per second
CIP	capital improvement project
CIPP	cured in place pipe
City	City of Shoreline
CMP	corrugated metal pipe
CPP	corrugated plastic pipe
CWA	Clean Water Act
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	US Environmental Protection Agency
ESA	Endangered Species Act
FC	fecal coliform
GIS	geographic information system
GMA	Growth Management Act
gpm	gallons per minute
ID	identification
IDDE	Illicit Discharge Detection and Elimination
LID	low-impact development
MPRI	Maintenance Pipe Ratings Index
NASSCO	National Association of Sewer Service Companies
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant discharge Elimination System
OPRI	Overall Pipe Ratings Index
ROW	right-of-way

SEPA	State Environmental Policy Act
SPRI	Structural Pipe Ratings Index
SWMM	stormwater management model
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service
WAC	Washington Administrative Code
WDFD	Washington Department of Fish and Wildlife
Windward	Windward Environmental LLC
WQ	water quality
WQC	water quality criteria
WQI	water quality index

Executive Summary

The Storm Creek basin (Figure ES-1) has experienced ongoing surface water problems, including localized flooding and erosion, since around 1990. The purpose of this basin plan is to present a comprehensive representation of the natural and built infrastructure in the basin so that the City of Shoreline (City) can direct its stormwater management resources to manage existing issues and minimize future problems. The City's specific goals and objectives include:

1. A condition assessment video of all stormwater pipes more than 12 in. in diameter to evaluate maintenance, repair, and replacement needs in the basin.
2. A prioritized list of structural and programmatic strategies, including a repair and replacement schedule, to solve surface water and infrastructure problems in the basin (e.g., water quality, flooding, and habitat).
3. Development of a template for future basin plans.

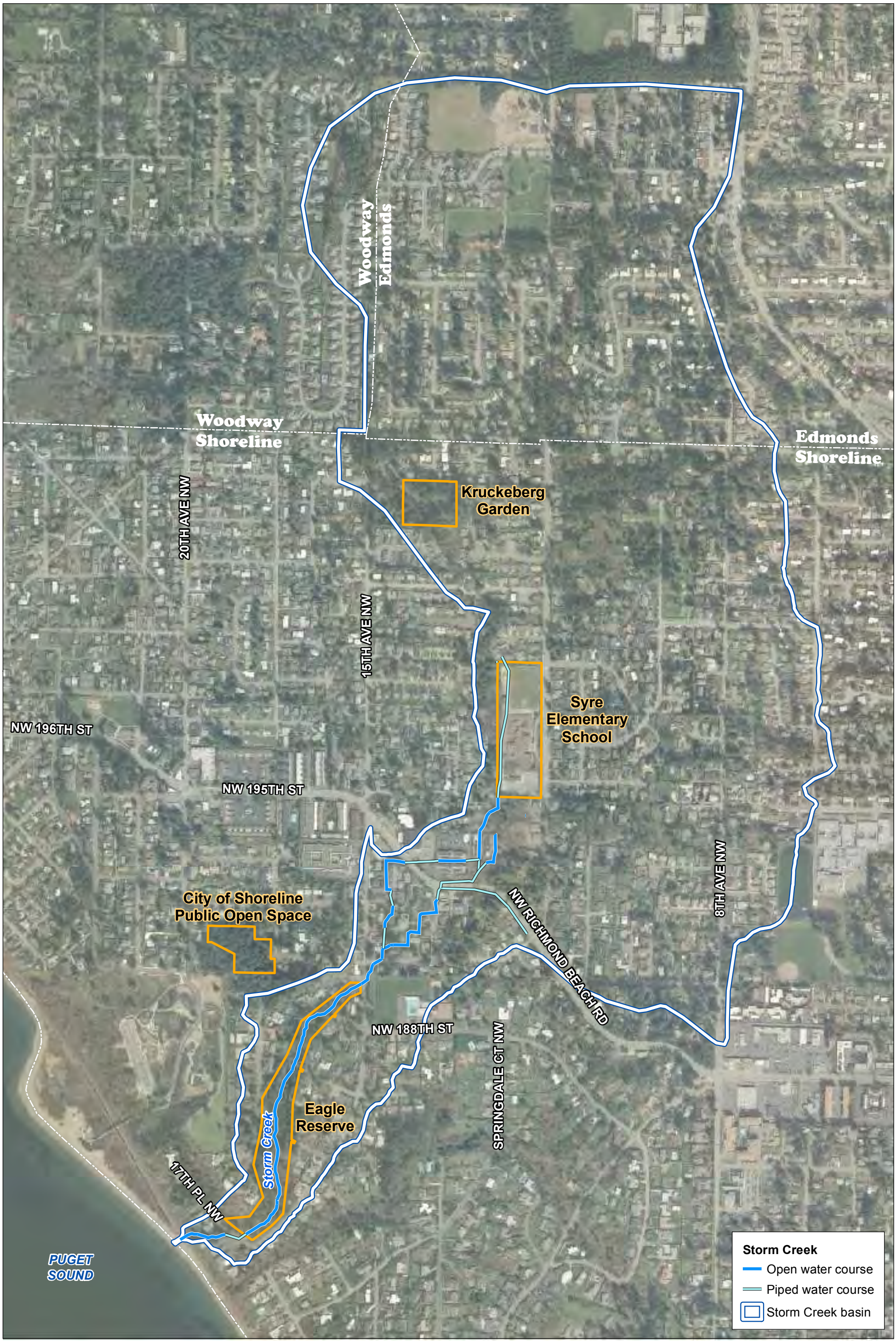


Figure ES-1. Storm Creek basin

Prepared by craigh, 3/8/2013; W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig ES-1 5140 Storm Creek basin.mxd

To develop this basin plan, the Windward Environmental LLC (Windward) team (including Osborn Consulting Inc., The Watershed Company, and Cambria Science and Communication):

- Used existing information and documents for historical context and reference
- Field-verified conditions in both the natural landscape and piped infrastructure
- Worked with the City and public to develop workable management strategies and feasible projects for managing stormwater in the Storm Creek basin

The specific natural and built characteristics of the Storm Creek basin, along with associated issues and potential solutions, are shown in Figure ES-2.

The primary stormwater-related issues in the Storm Creek basin include:

- Erosion at the mouth of Storm Creek
- Erosion and downcutting in the Eagle Reserve
- Piped infrastructure in need of maintenance, repair or replacement
- Localized flooding (dependent on storms and condition of ditches and infrastructure)
- Poor water quality due to the presence of fecal coliform (FC) bacteria and nutrients

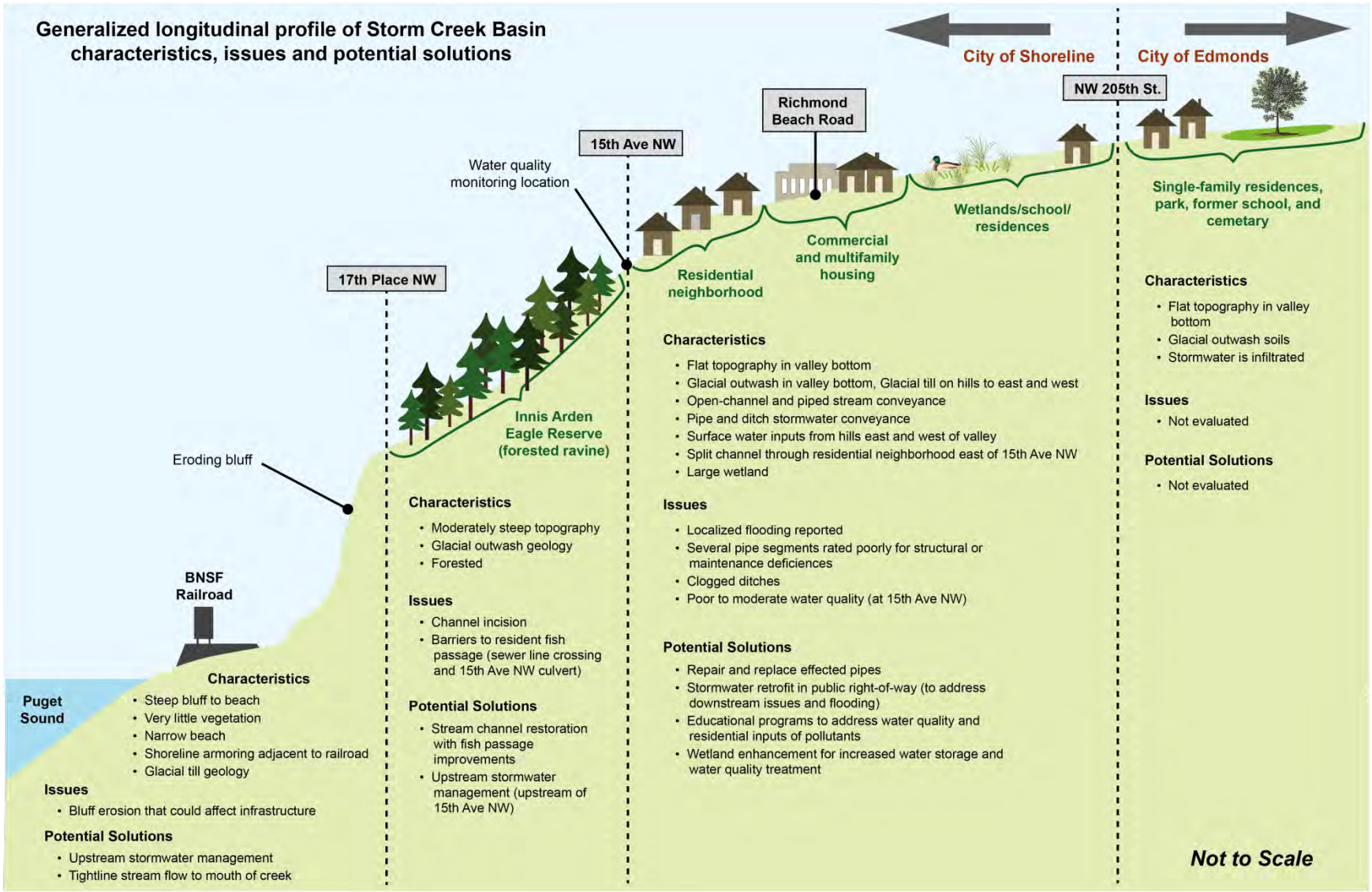


Figure ES-2. Schematic of Storm Creek basin characteristics, issues, and potential solutions

The existing stormwater-related issues are mostly related to urbanization that occurred largely prior to the City's incorporation in 1995. The Storm Creek basin was constructed mostly prior to 1990, when modern stormwater management techniques started to be employed in order to reduce water quality problems and erosion in small stream channels. These issues are exacerbated by the more frequent and higher peak flows that result from urbanization and a lack of stormwater management facilities.

The basin is mostly developed; the larger undeveloped properties (i.e., Eagle Reserve and private parcels between Syre Elementary School and Richmond Beach Road) are unlikely to be developed in the future, because they are considered either private park land (e.g., Innis Arden reserve property) or wetlands. Therefore, it is the properties not currently developed to their full zoning potential that pose the potential for significant land use changes in this basin. Under current stormwater regulations, as redevelopment occurs, stormwater management practices will be implemented where none currently exist. In order to accelerate the process, Windward has recommended potential options for stormwater retrofit, as well as projects that should be completed to improve water quality, minimize flooding, and improve existing infrastructure functionality. The full list of recommended strategies is provided in Section 6; Table ES-1 lists the criteria and scoring used prioritize these strategies.

Table ES-1. Criteria and scoring for project prioritization

Criteria	Rank Scores		
	High (5 Points)	Medium (3 Points)	Low (1 Point)
Likelihood of success	proven in other cases	mixed results	unproven
Number of issues addressed (water quality, habitat, erosion, flooding)	three	two	one
Protects infrastructure and public safety	both	one or the other	none
On public property	in ROW or existing easement	requires easement on other public property	private property
Cost	low (< $20,000)	medium ($20,000 to $50,000)	high (> $50,000)

ROW – right-of-way

The combined scores of individual criteria, ranked according to total points, are as follows:

- Low priority (13 points or fewer)
- Medium priority (13 to 18 points)
- High priority (19 points or more)

Out of 25 projects, 11 rank as high priority based on the above criteria, and an additional 4 projects rank on the high end of medium priority. These 15 projects are listed in Tables ES-2 and ES-3. The total estimated cost of implementation for the high-priority projects is approximately $800,000. The estimated cost to also implement

the medium-priority projects is an additional $631,000 (Table ES-3). The locations of all of the recommended projects are shown in Figure ES-3.

Table ES-2. Summary list of high-priority project recommendations

Issue Addressed	Project Name	Project Type	Total Score and Priority	Estimated Cost
Erosion at the mouth of Storm Creek	(ST-Study-2) evaluate deep infiltration of stormwater		HIGH (19)	$50,000
	(ST-Study-3) evaluate out-of-basin routing and infiltration		HIGH (19)	$30,000
Conveyance pipe maintenance and structural deficiencies	(ST-CIP-3) stormwater upgrades at 11th Avenue Northwest		HIGH (21)	$103,000
	(ST-Mon-4) monitor pipes not recommended for immediate replacement		HIGH (19)	$1,500/year
	(ST-Main-1) pipe maintenance modifications		HIGH (19)	$10,000
	(ST-CIP-5) open cut pipe replacement and modification of drainage structures		HIGH (19)	$293,000
	(ST-CIP-6) trenchless pipe repair		HIGH (19)	$180,000
	(ST-CIP-7) remove utility crossings		HIGH (21)	$2,000 – $5,000 (City staff time to coordinate utility crossing removals and follow up)
Habitat and fish passage	(St-Hab-2) daylight Storm Creek upstream of Richmond Beach Road		HIGH (19)	>$100,000

Issue Addressed	Project Name	Project Type	Total Score and Priority	Estimated Cost
Flooding	(ST-Ed-6) ditch education program		HIGH (23)	$8,000
	(ST-Ed-7) flood education program		HIGH (19)	$8,000

City – City of Shoreline

Table ES-3. Summary of highest ranked medium-priority project recommendations

Issue	Project Name	Project Type	Total Score and Priority	Estimated Cost
Water quality	(ST-Study-1) evaluate City landscaping policies		MEDIUM (17)	$4,000
Erosion at mouth of Storm Creek	(ST-Mon-3) monitor erosion		MEDIUM (17)	$6,000 first year, $1,000/annually in subsequent years
	(ST-CIP-2) convert roadside ditches to bio-infiltration swales		MEDIUM (17)	$617,000
Habitat and fish passage	(ST-Mon-5) cross section monitoring		MEDIUM (17)	$4,000/year

City – City of Shoreline

Basin-wide Projects

- ST-Ed-2
- ST-Ed-3
- ST-Study-1
- ST-Mon-4 (see Appendix F)
- ST-CIP-5 (see Appendix F)
- ST-CIP-6 (see Appendix F)
- ST-CIP-7 (see Appendix F)
- ST-Main-1 (see Appendix F)
- ST-Ed-6

High priority projects are shown in red.

Woodway Shoreline
Edmonds Shoreline
20TH AVE NW
15TH AVE NW
8TH AVE NW
NW 196TH ST
NW 195TH ST
NW 188TH ST
NW RICHMOND BEACH RD
SPRINGDALE CT NW
17TH PL NW
Storm Creek
PUGET SOUND
Kruckeberg Garden
Syre Elementary School
City of Shoreline Public Open Space
Eagle Reserve
ST-Ed-5
ST-CIP-2
ST-CIP-4
ST-Study-2
ST-CIP-8(a)
ST-Hab-3
ST-Hab-4
ST-Study-4
ST-Ed-7
ST-CIP-9
ST-Hab-2
ST-Ed-5
ST-CIP-3
ST-Ed-1
ST-Study-3
ST-Mon-1
ST-Main-2
ST-Hab-1
ST-Mon-2
ST-CIP-8(b)
ST-Mon-5
ST-CIP-1
ST-Mon-3
ST-Ed-4

Storm Creek
- Open water course
- Piped water course
- Storm Creek basin

Wind Ward environmental LLC

N

0 150 300 Yards

0 100 200 Meters

Figure ES-3. Locations of recommended projects

Prepared by craigh, 3/8/2013: W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig_ES-3 5187 Recommended projects.mxd

Most of the highest-priority projects are intended to correct existing pipe problems that resulted in poor structural or maintenance ratings scores during the condition assessment. Similar projects have been grouped together so that multiple small repairs and replacements can occur under one contract with the same equipment. Infiltration and routing studies that could help address high peak flows that have contributed to erosion in Storm Creek are also high priority. More information related to infiltration feasibility, particularly into deeper aquifers, would be helpful in identifying regional infiltration approaches in the Storm Creek basin.

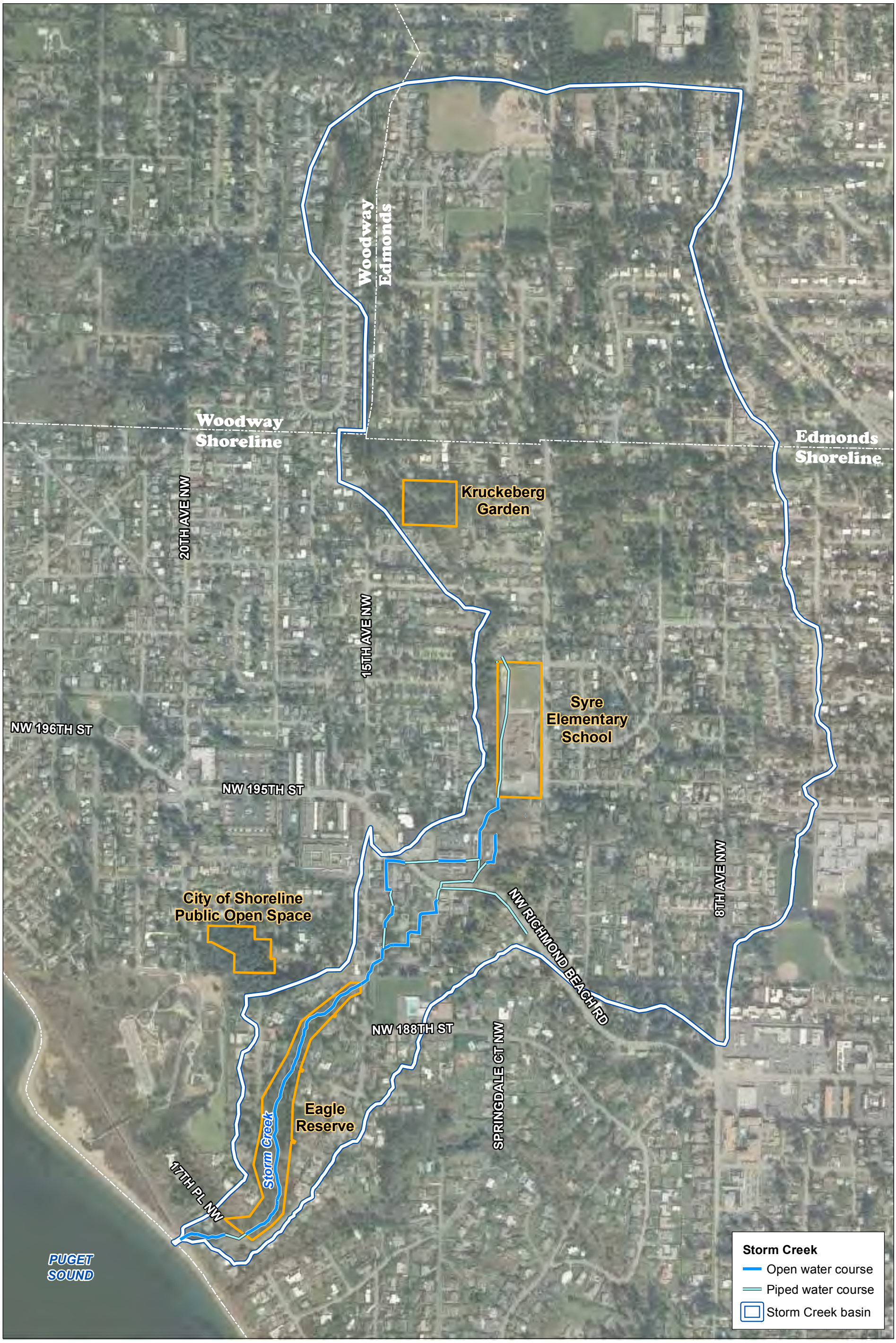
As a first step to addressing localized flooding and water quality issues, educational programs have been recommended to address the problems at the source, rather than at the point of manifestation. For instance, clogged ditches and infrastructure that cause flooding could be minimized through better care of roadside ditches bordering private properties. Finally, the recommended project to daylight Storm Creek upstream of Richmond Beach Road could address multiple issues, including flooding and resident fish passage, in addition to enhancing ecological function of the large wetland upstream of the Meadowbrook Apartments.

1 Introduction

The Storm Creek basin (Figure 1) has been experiencing ongoing surface water problems, including localized flooding and erosion, since around 1990. The purpose of this basin plan is to present a comprehensive representation of the natural and built infrastructure in the basin so that the City of Shoreline (City) can direct its stormwater management resources to manage existing issues and minimize future problems. The City's specific goals and objectives include completion of the following:

1. A condition assessment video of all stormwater pipes more than 12 in. in diameter to evaluate maintenance, repair, and replacement needs in the basin.
2. A prioritized list of structural and programmatic strategies, including a repair and replacement schedule to solve surface water and infrastructure problems in the basin (e.g., water quality, flooding, and habitat).
3. Development of a template for future basin plans.

To develop this basin plan, the Windward Environmental LLC (Windward) team (including Osborn Consulting Inc., The Watershed Company, and Cambria Science and Communication) used existing information and documents for historical context and reference, field verified conditions in both the natural landscape and piped infrastructure, and worked with the City and public to develop workable management strategies and feasible projects for managing stormwater in the Storm Creek basin.



Wind Ward LLC environmental

N

0 150 300 Yards

0 100 200 Meters

Figure 1. Storm Creek basin

Prepared by craigh, 3/8/2013; W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig 01 5140 Storm Creek basin.mxd

2 Previous Studies

A number of studies, both City-wide and Storm Creek basin-specific, were reviewed prior to evaluation and analysis of issues and potential solutions in the Storm Creek basin. These studies, including source, date, and relevance to Storm Creek basin, are listed in Table 1. Specific findings are discussed in the sections that follow.

Table 1. Reference material used in this basin plan

Reference	Author(s)	Date	Relevance
GIS coverages	City	unknown	GIS coverages were used in many of the analyses described in Section 3.
Service requests	City	2000 – 2011	Stormwater-related calls; information is summarized in Section 3.6.2 and Appendix C.
Geomap Northwest Documents	various authors	various dates	Site-specific geologic information is summarized in Section 3.3 and Figures 4 and 5.
Ecology-recorded water rights website	Ecology (2012)	various dates	Site-specific water rights information is summarized in Section 3.5.2 and Table 6.
City of Shoreline stream and wetland inventory and assessment: Appendices	Tetra Tech/KCM Inc. (2004)	2004	Relevant information is presented in Section 3.
City of Shoreline comprehensive plan	City (2011c)	2004	Relevant information is presented in Section 4.
Surface water master plan update, City of Shoreline	SAIC and SvR Design (2011)	2011	Relevant recommended projects are discussed in Section 5.
2007 Bioassessment report: biological and habitat assessment of Shoreline streams	The Watershed Company (2009)	2009	Information from this report, including data from macroinvertebrate sampling, was used in the water quality analysis in Section 3.8.
2009 freshwater assessment report: state of the water quality in Shoreline streams, lakes and wetlands	City – Jessica Williams (2010)	2010	Information from this report, including water quality monitoring data, was used in the water quality analysis in Section 3.8.
2011–2017 parks, recreation and open space plan	City (2011a)	2011	The only community parks located in Storm Creek basin are Kruckeberg Botanic Garden (3.8 acres) and the fields, playground equipment, and associated facilities at Syre Elementary School.

Reference	Author(s)	Date	Relevance
Shoreline inventory and characterization	ESA Adolfson (2010)	2010	Information on shoreline functions, characteristics, and opportunities are discussed in Section 3.
2011 transportation master plan	City (2011b)	2011	Recommended improvements include the roundabout at the intersection of 15th Avenue Northwest and Richmond Beach Road, sidewalk construction on 15th Avenue Northwest near 205th, and a Richmond Beach Rd corridor study.

City – City of Shoreline
Ecology – Washington State Department of Ecology
GIS – geographic information system

3 Basin Characteristics

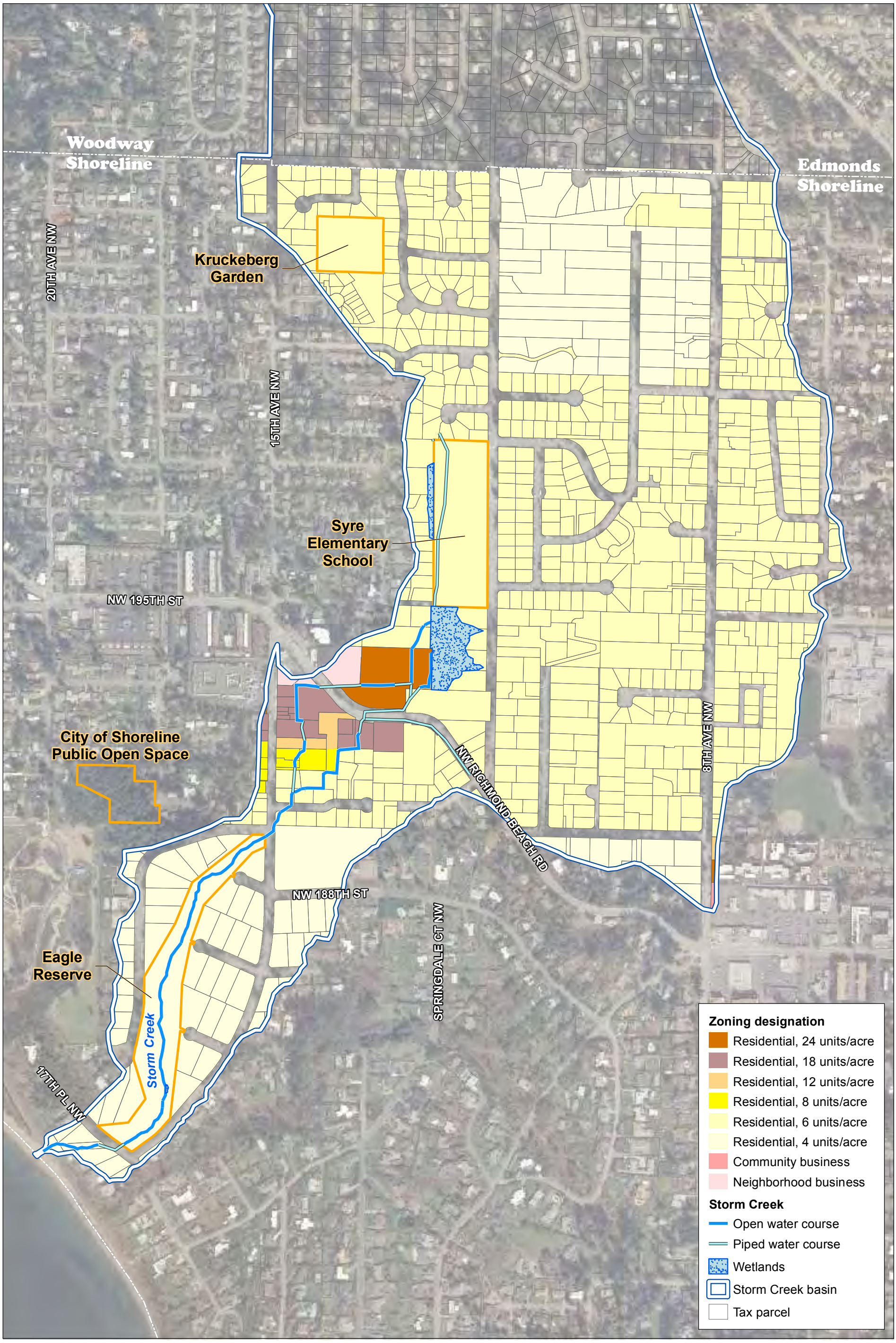
There are certain characteristics of individual drainage basins that influence the flow, pathways, and pollutants of surface water and stormwater which, in turn, can affect the natural and built environments in positive and negative ways. The characteristics of the Storm Creek basin in the context of surface water and stormwater flow are discussed in this section.

3.1 BUILT LANDSCAPE

The Storm Creek basin is approximately 474 acres in size, with 298 acres within the City limits and the remaining 176 acres in the City of Edmonds. Land use is predominantly residential, with only a few pockets of community and neighborhood business zoning along Richmond Beach Road (Figure 2). Table 2 lists the percentage of the basin that falls within each type of zoning. The currently "underdeveloped" areas with the potential for additional residential development through short-platting or subdivision are also listed in Table 2. The underdeveloped parcels were determined by comparing the numbers of existing to potential dwelling units per acre for each zoning class. For instance if an individual parcel is currently zoned R-4 (4 units per acre), but is effectively R-1 (1 unit per acre), that parcel would be considered underdeveloped. It would be possible, through subdividing the lot, to build three additional homes on that property.

How does the built landscape affect stormwater runoff?

The type and density of development affect the quantity of hard surfaces present to create runoff, as well as the types of pollutants that could be transported from different surface types.



Wind Ward environmental LLC

Figure 2. Zoning in the Storm Creek basin

Prepared by craigh, 3/8/2013; W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig 02 5142 Current zoning.mxd

Table 2. Zoning statistics within Storm Creek basin

Zoning Classification	Area of Basin Within Zoning Class (acres)	% of Basin Within Zoning Class	% of Parcels Within Zoning Class Currently Underdeveloped	Acres of Underdeveloped Parcels
Community business	0.12	<0.1	none	0
Neighborhood business	1.3	0.4	none	0
R-24	3.4	1	none	0
R-18	3.8	1.3	none	0
R-12	1.1	0.3	none	0
R-8	1.5	0.4	50%	0.75
R-6	167	56	15%	25
R-4	71.6	24	45%	32
City ROW*	49.6	16.6	15%	7.4
Total	**299.39**	**100**	**na**	**65.15**

*Underdeveloped ROW is the ROW that is not currently paved.
ROW – right-of-way

3.1.1 Age of development

The Storm Creek basin was largely built out by 1980, 90% of the homes having been constructed by then (Figure 3). As a result, most of the basin does not have stormwater management facilities to control flow or provide water quality treatment, since these types of facilities were not required until the late 1980s and early 1990s. Currently, the basin within the City consists of approximately 47% impervious surfaces (City and private roads, houses, and parking lots). Approximately 12 acres of undeveloped or lightly developed open space is present in the basin, including:

Why does the age of development matter?

Current stormwater practices were not in place when a large part of the Storm Creek basin was constructed (prior to 1980), resulting in little to no stormwater treatment facilities in the basin.

- Kruckeberg Garden (owned by the City) ~ 3 acres
- Eagle Reserve (owned by Innis Arden) ~ 8.5 acres

Small pockets of undeveloped property are present in areas that are unlikely to be developed due to the presence of steep slopes or wetlands.

3.2 TOPOGRAPHY

Storm Creek basin ranges in elevation from about 475 ft above mean sea level (near 8th Avenue Northwest on the northeastern edge of the basin) to sea level (at the mouth of Storm Creek in Puget Sound). A trough, approximately 100–200 ft lower than the ridges to the east and west, is present in the middle of the basin near Syre Elementary School. This flat area extends southwest to 15th Avenue Northwest, where Storm Creek begins to lose grade, dropping about 100 ft in elevation within the Eagle Reserve. At 17th Place

Northwest, Storm Creek experiences a rapid drop in elevation (approximately 100 ft within 400 ft of horizontal distance). The topography and geology (discussed in Section 3.3) of Storm Creek basin influence how surface water moves through the basin. In the upper, flatter parts of the basin, Storm Creek has a very narrow, shallow channel form and the water is generally quiescent. Wetlands are present where soils are poorly drained or groundwater tables are shallow. As the topography steepens, Storm Creek enters a narrow ravine and has a wider, deeper channel form due to greater flows, faster stream velocities, and erosive soil conditions.

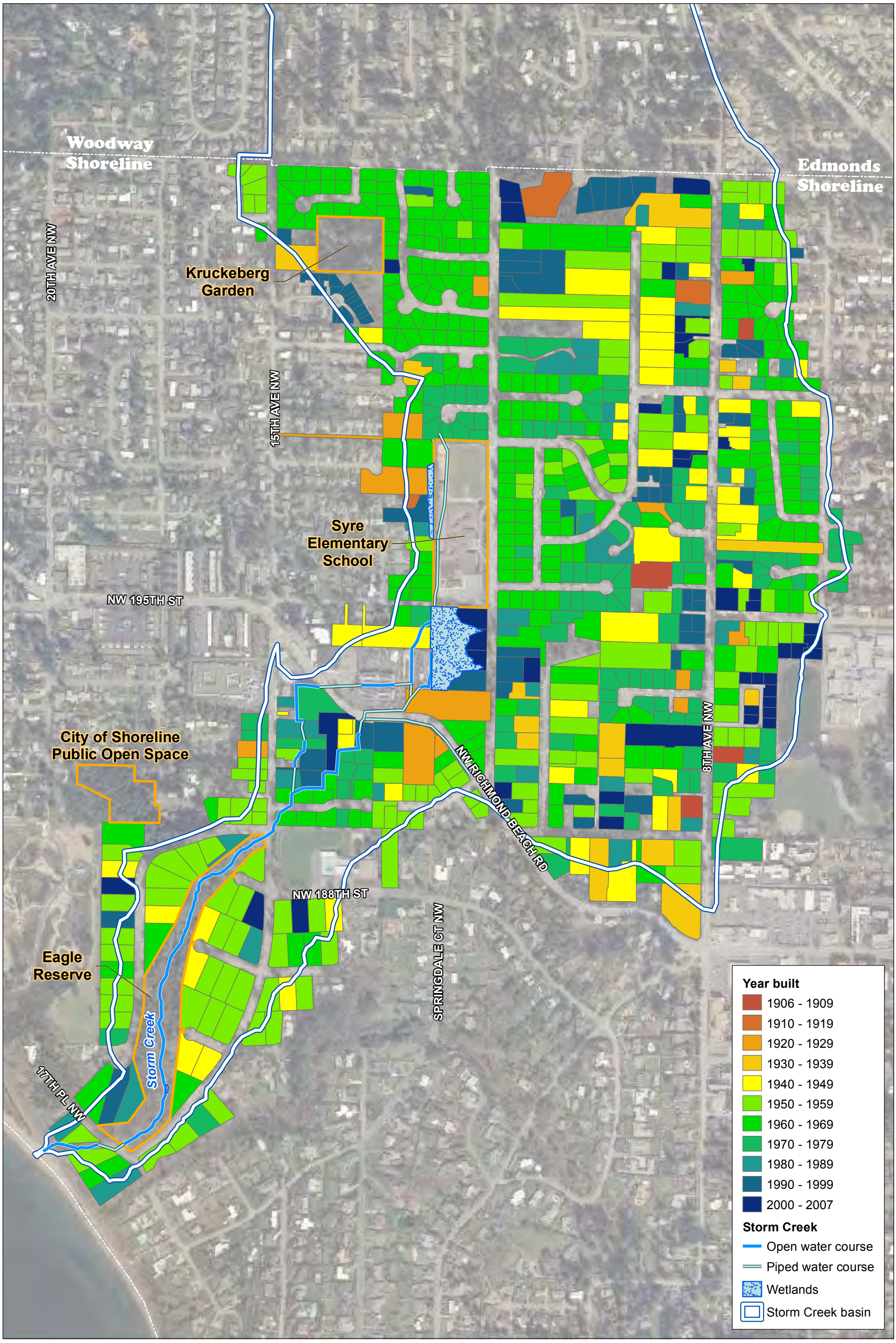
3.3 GEOLOGY AND GEOMORPHOLOGY

Geologic conditions in the Storm Creek basin are typical of the Puget Sound lowlands, consisting of glacially deposited sediments. The surface geology in more than 50% of the basin is mapped as Quaternary Advance Glacial Outwash (Figure 4). This outwash is present in the topographic trough located in the central part of the basin, and is characterized by well-drained sands and gravels, with interspersed layers of silt. The other predominant surface geology present in this basin is Vashon-age glacial till (~40%). The till, which is usually not very well drained, forms the ridges east and west of the trough and is generally very consolidated, having been overridden by great thicknesses of ice during glacial times. The area where Storm Creek drops into Puget Sound consists of pre-Vashon-age deposits, including transitional beds (clay) overlaying glacial till from the Possession age. Both advanced and recessional outwash is present in the Eagle Reserve, overlying the clay deposits and till. Seeps are often present at the points of contact between overlying sandy deposits (outwash materials) and underlying clay deposits (transitional beds); such seeps were observed in the Eagle Reserve. Figure 4 shows the general geology and locations of geologic cross sections.

What is the impact of geology on surface water runoff?

Geologic conditions affect how much water runs off the landscape naturally, how much is infiltrated, and how easily stream channels and hillslopes are eroded. The geologic conditions in the Storm Creek basin have naturally high potential for infiltration of surface water runoff.

Windward reviewed geologic boring logs and test pit data available through Geomap Northwest (Booth et al. 2004) to correlate surface geologic conditions to subsurface conditions, and to get an understanding of the thicknesses of the materials mapped. The cross sections in Figure 5 show the potential thicknesses of geologic materials in the basin. This information is important in order to identify potential stormwater management options, including infiltrative low-impact development (LID) techniques.



Wind Ward LLC environmental

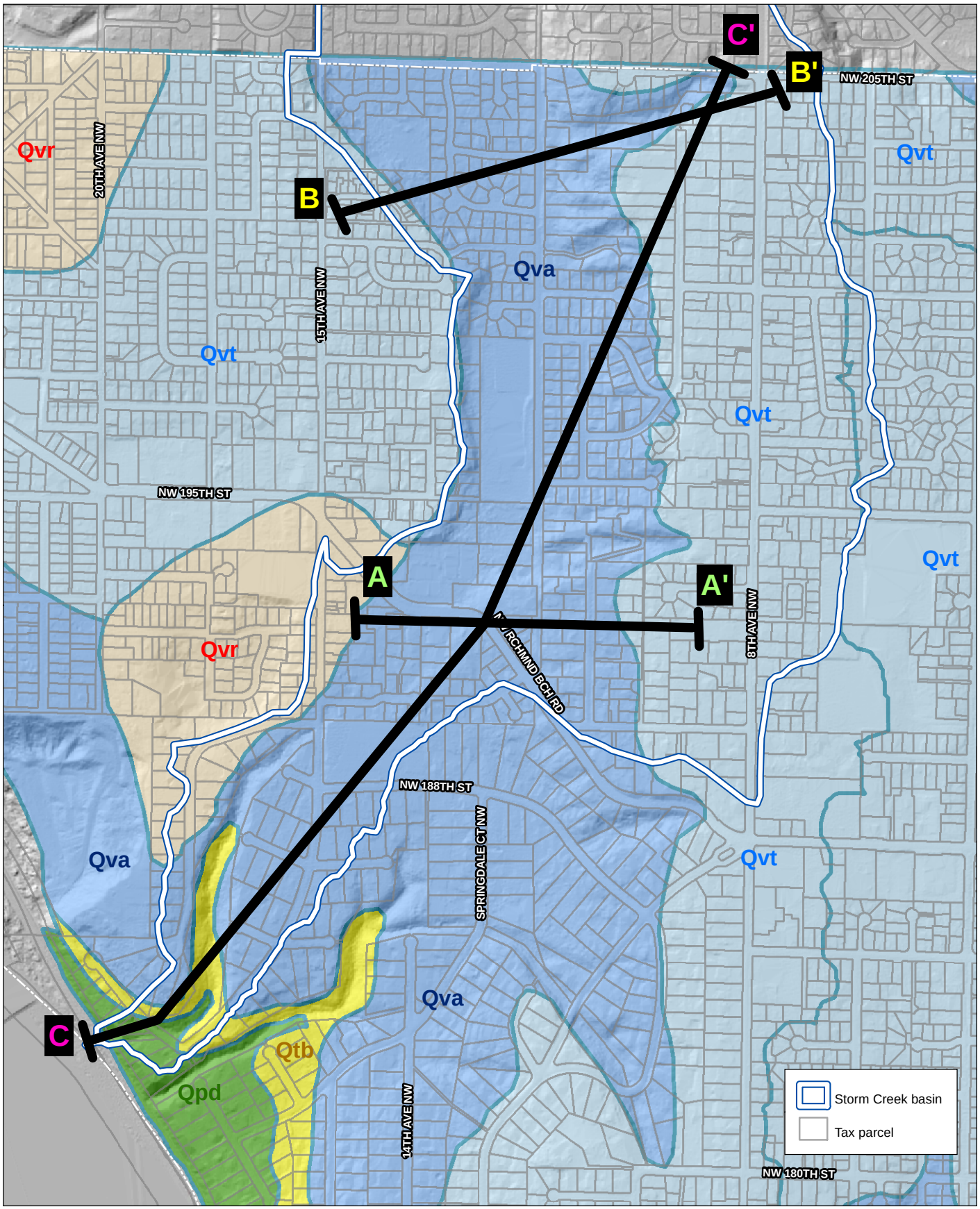
N

0 125 250 Yards

0 100 200 Meters

Figure 3. Age of housing stock in the Storm Creek basin

Prepared by craigh, 3/8/2013: W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig 03 5145 Age of housing stock.mxd



Prepared by craigh, 3/8/2013; W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps and Analysis\Storm Crk Basin Plan\Fig 04 5261 Geology and cross sections.mxd

Wind Ward LLC environmental

N

0 150 300 Yards

0 100 200 Meters

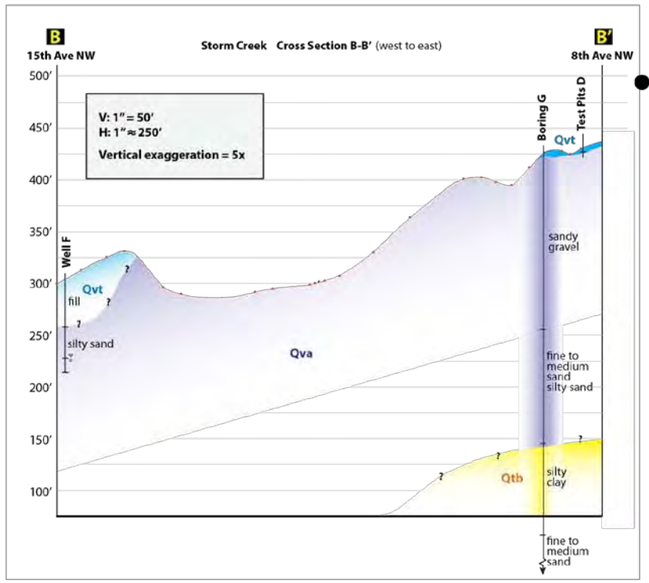
Figure 4. Storm Creek basin geology and locations of cross sections

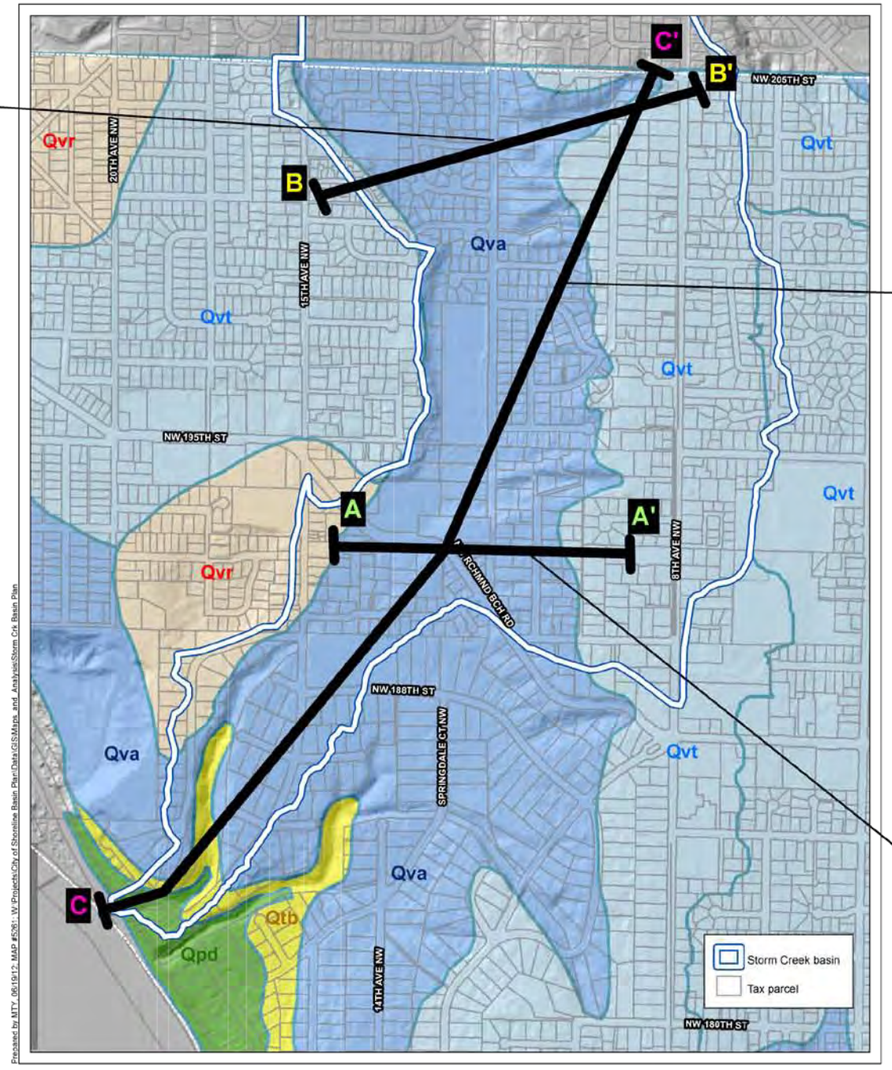
During field reconnaissance in September and October 2011, the Windward team walked the open channel portions of Storm Creek and observed the geomorphic conditions of the channel and hillslopes. A memorandum was prepared to describe the erosion occurring near the mouth of Storm Creek (Appendix A). The erosion in this location is severe and has the potential to affect public infrastructure, including Ronald Wastewater District's sanitary sewer line and the City's culvert on 17th Place Northwest.

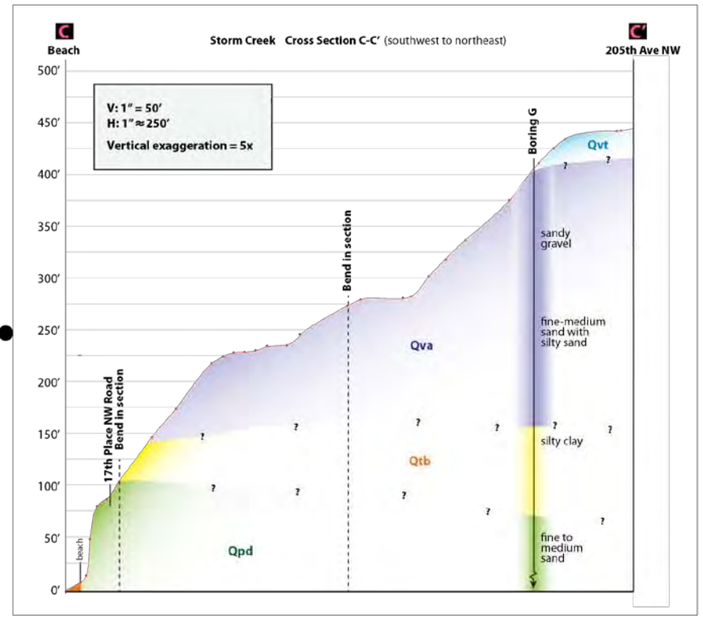
The stream channel within Eagle Reserve has also experienced incision up to several feet in some locations, and active erosion is also occurring along the stream channel banks (Photo 1), undermining trees along the stream bank. Most of the channel within Eagle Reserve is formed within glacial advance outwash, which is very sandy and easily eroded. Surface water flow resulting from impervious surfaces created as part of development in the basin likely caused the stream channel to enlarge in order to accommodate greater, more frequent flow events. Without monitoring data showing how the channel has changed over time, it is difficult to know whether the channel has largely adjusted to its current flow regime or whether it is continuing to incise. There are two structures in Eagle Reserve that act as grade control, limiting the amount of incision that occurs: the 17th Place culvert and stormwater structure on the downstream end of Eagle Reserve, and the sewer line crossing in the middle of Eagle Reserve. Both of these are discussed in Section 3.7.2. Downstream of the 17th Place culvert, several rock gabion structures have been installed over the years by both the Ronald Wastewater District (to protect its sanitary sewer pipe) and King County (to protect the road). These structures provide some channel stability in the immediate vicinity of the road. However, a knick point has developed downstream of the structures, at which point the channel drops rapidly and active erosion is occurring. The channel conditions through all reaches of Storm Creek are similar to those described by Tetra Tech in 2004 (Tetra Tech/KCM 2004), indicating minimal channel changes in the intervening 8 years.

What is incision?

Incision is a term used to describe the manner in which river and stream channels cut into underlying geologic material. This process is sometimes referred to as downcutting.







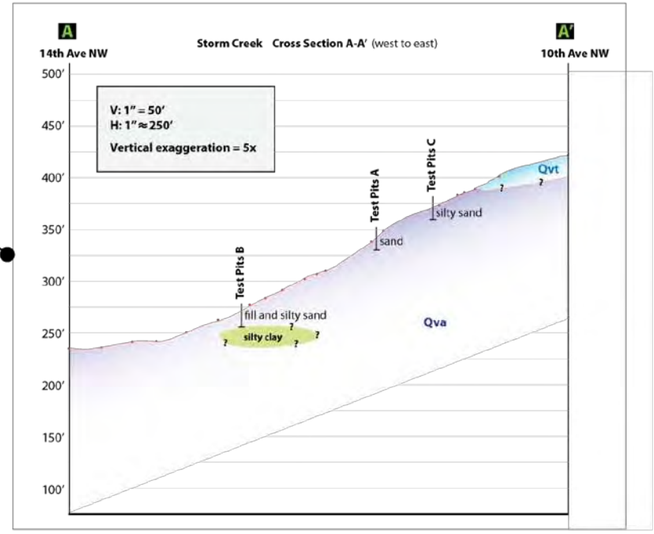


Figure 5. Geologic cross sections

Photo 1. Example of channel incision in Storm Creek within Eagle Reserve

3.4 SURFACE WATER

Storm Creek is the primary surface water feature in the basin. It consists of about 1 mile of open channel south of Richmond Beach Road that meanders through residential backyards between Richmond Beach Road and 15th Avenue Northwest and a steeper forested reach through the Eagle Reserve. Approximately 0.6 miles of piped stream is present north of Richmond Beach Road. Windward measured flow at three locations in the open channel within Eagle Reserve on September 27, 2011, and January 25, 2012. The flow measured an average of less than 1 cubic feet per second (cfs) in September and about 3 cfs in January.

A hydrologic model was developed using the US Environmental Protection Agency (EPA) stormwater management model (SWMM) to estimate current and historic (forested condition) flows to understand how flows have changed over time, and what level of effort it might take to return the basin to a more natural hydrologic regime. Hydrologic modeling using existing conditions indicates a flow increase of up to 400% more than forested conditions for the 25-year return flow, as measured at 17th Place Northwest (Table 3). The hydrologic modeling memorandum is included in Appendix B.

Table 3. Summary of modeled flows (cfs) for forested and existing conditions

Location	2-year Return Frequency (cfs)		25-year Return Frequency (cfs)		100-year Return Frequency (cfs)	
	Forested	Existing	Forested	Existing	Forested	Existing
Open channel flow near Syre Wetland 2	0.3	17.4	6.1	33.1	14.5	41.5
Open channel upstream of 15th Avenue Northwest	0.3	21.2	9.7	33.5	24.1	38.6
Open channel downstream of 17th Place Northwest	0.4	22.0	9.8	35.8	24.2	41.8

cfs – cubic feet per second

3.5 FLOODING

The scope of this project did not call for hydraulic modeling of the entire Storm Creek conveyance system. The hydraulic analysis was limited to the open channel reaches of Storm Creek (from the waterway's mouth up through the Syre Wetland), plus a handful of piped locations such as:

- Culvert crossings at arterials
- Piped systems contributing to Syre Wetland
- The lower couple hundred feet of conveyance for subbasins that are piped to Storm Creek

Potential flooding locations identified by the EPA SWMM analysis are presented in Table 4 and Figure 6. Figure 7 presents a map estimating the extent of potential flooding during a 100-year event based on the modeling information. This map is for planning purposes only and is to provide the City a general idea of what area(s) surrounding Storm Creek might flood during a 100-year event. Service requests were also reviewed to determine which areas within the Storm Creek basin had flooded in the past 10 years. Of the service requests reviewed, none indicated flooding relating to a lack of hydraulic pipe capacity in additional areas not identified as potential problems in the SWMM model. Service requests are discussed in Section 3.6.2.

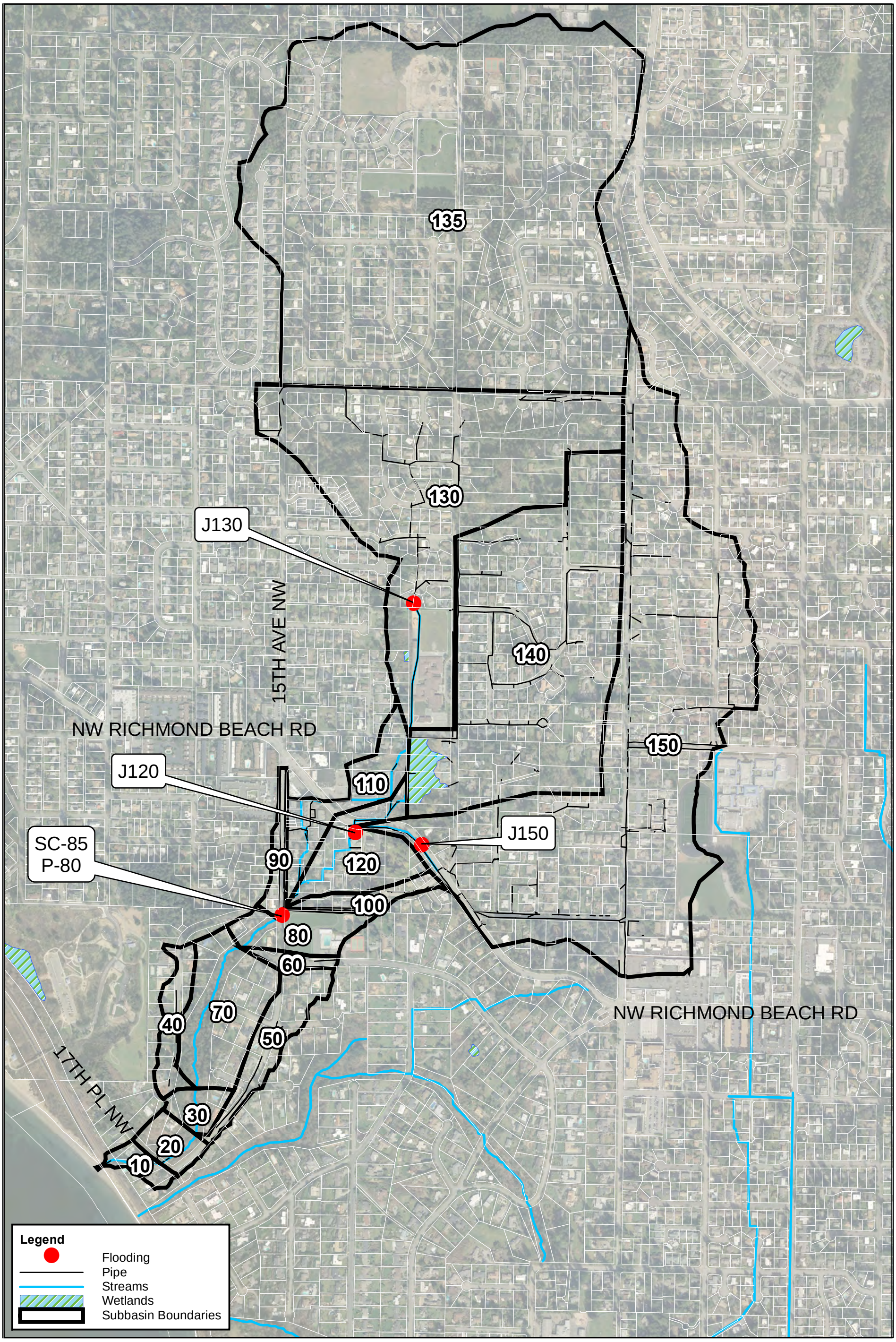
Table 4. EPA SWMM-predicted flooding (25-year return period)

Junction	Description of Location	Significance
J120	Flows from the north and east converge at this node located on the south side of Richmond Beach Rd., near 14th Place Northwest.	Flows from the north and east are routed through existing conveyance pipes prior to converging at J120, so their peak flows are realistic. However, the model also shows the runoff from basin 120 (11 acres) coming in at this location; realistically, basin runoff would be distributed across a larger area. Hence, peak flows may be artificially inflated at this location.
J130	This is the upstream node of the 1150-linear ft 24-in.-diameter concrete pipe behind Syre Elementary School; it receives runoff from basins 130 and 135 (239 acres total).	This area is not believed to be a real flooding problem. The model shows these nodes receiving runoff from more than 100 acres at one location, when in reality this runoff is routed through 12-in.-diameter storm sewers, which dampen peak runoff. This was addressed in the SWMM by allowing ponding to occur at these junctions, so the total volume of water stays in the model (as opposed to leaving the system via flooding) and flows through Storm Creek.
J150	This is the upstream node of the 520-linear ft 18-in.-diameter concrete pipe along Richmond Beach Rd.; it receives runoff from basin 150 (110 ac).	
SC_85 and P_80	This node received runoff from the 30-in.-diameter concrete culvert at 15th Avenue Northwest and upstream open channel.	Draft versions of the SWMM reported flooding at this location; however, none is indicated in the final version of the model. Regardless, this location it is a known bottleneck in the basin.

EPA – US Environmental Protection Agency
SWMM – stormwater management model

Several key locations in the SWMM were monitored for performance. These key locations were selected for one of the following reasons:

- SWMM results indicate flooding
- Complaints of increased erosion
- Flow analysis needed to support capital improvement project (CIP) development

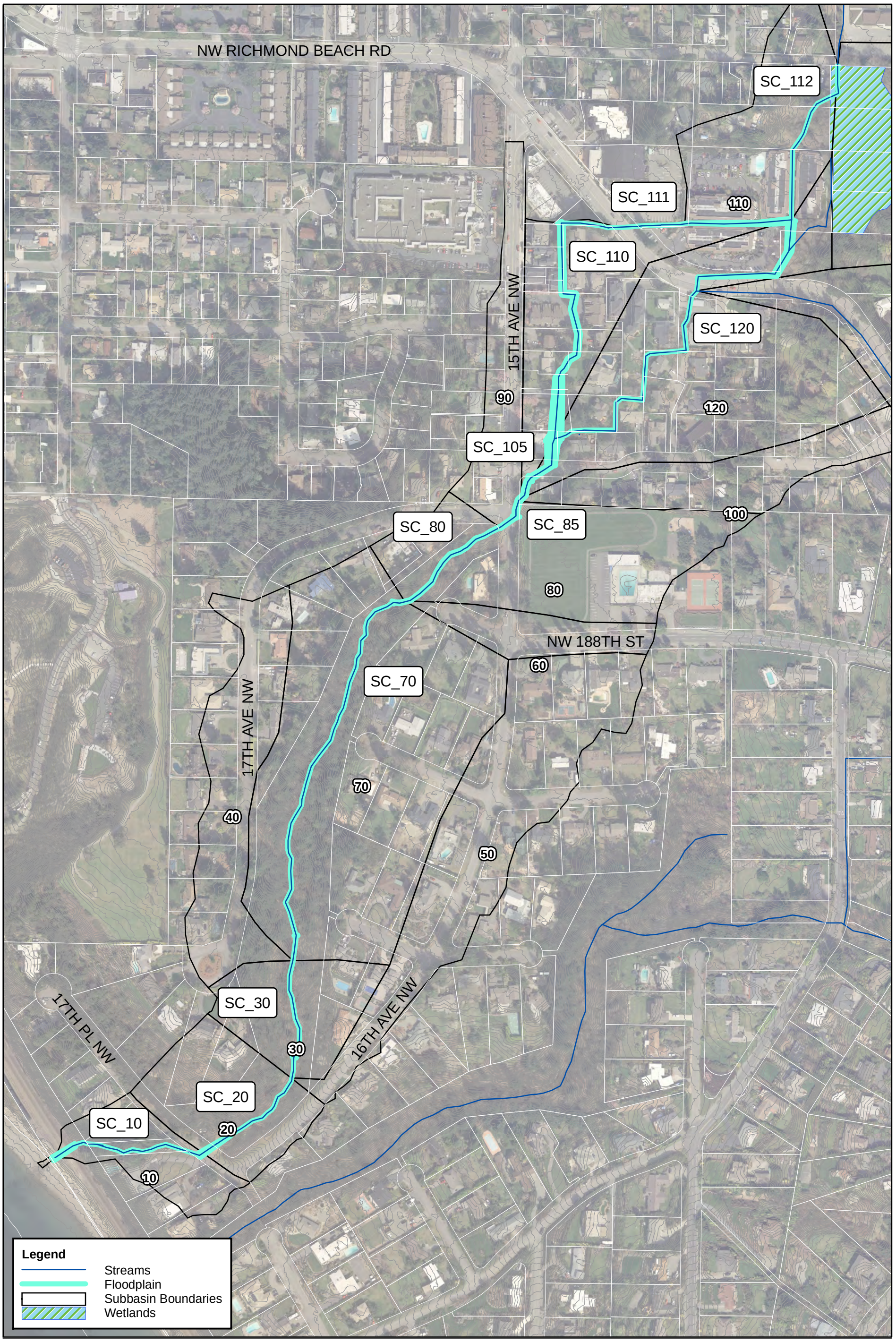


OSBORN CONSULTING INCORPORATED

Figure 6. Locations of predicted flooding

Storm Creek Basin - Shoreline, WA

Prepared by MLP, 6/22/12; FIG 6



OSBORN CONSULTING INCORPORATED

Prepared by MLP, 6/22/12, FIG 7

Figure 7. Preliminary 100-year flood map based on EPA SWMM model

Storm Creek Basin - Shoreline, WA

3.5.1 Rainfall

The National Oceanic and Atmospheric Administration (NOAA) publishes weather extremes and has data for the Seattle area between 1948 and 2011 (NOAA 2012). Table 5 lists the 10 greatest precipitation events within 24-hour periods in Seattle. Weather patterns can vary greatly even between short distances, so these precipitation statistics may not be directly applicable to the City, but they do give an idea of regional precipitation history. Of the 10 precipitation events, 7 have occurred since 1990.

Table 5. Ten greatest precipitation events in Seattle between 1948 and 2011

Date	Inches of Precipitation in 24 hours
October 2003	5.02
December 2007	3.77
November 1959	3.41
November 2006	3.29
February 1996	3.06
January 1986	2.98
February 1951	2.98
November 1990	2.95
November 1990	2.93
January 1990	2.83

3.5.2 Water withdrawals

Do water withdrawals have an effect on Storm Creek?

If all of the known surface water rights holders exercised their rights to withdraw water from Storm Creek during the summer months, the flow in Storm Creek could be diminished. However, Windward did not find any indication that this is a problem.

Windward reviewed the Washington State Department of Ecology's (Ecology's) water rights records to determine if there are any surface or groundwater rights holders in the basin and if so, their rates of withdrawals. Based on the review, there are eight entities that retain water rights for surface or groundwater withdrawals, ranging in age of priority from 1950 to 1975 (Table 6). Six are for surface water withdrawals ranging from 0.01 to 0.02 cfs, and the other two are for groundwater withdrawals of up to 50 gallons per minute (gpm). The surface water rights are primarily for irrigation, so such withdrawals likely occur during the summer months.

Table 6. List of water rights holders in Storm Creek basin

Number	Owner	Date of priority	Type	Amount	Address
S1-22560CWRIS	George Mauer	1975	surface	0.01 cfs	1430 Northwest 191st
S1-20487CWRIS	Julian Robarge	1967	surface	0.02 cfs	19116 15th Northwest
S1-16748CWRIS	Harold Wick	1961	surface	0.02 cfs	unknown
S1-13981CWRIS	Lundberg	1956	surface	0.015 cfs	unknown
S1-13982CWRIS	Wood	1956	surface	0.01 cfs	unknown
S1-11234CWRIS	Brown	1952	surface	0.02 cfs	unknown
G1-01612CWRIS	Northwest Utilities	1950	groundwater	50 gpm	unknown
G1-01613CWRIS	Northwest Utilities	1950	groundwater	50 gpm	unknown

cfs – cubic feet per second
gpm – gallons per minute

3.6 STORMWATER INFRASTRUCTURE

In addition to Storm Creek, which conveys surface water and stormwater runoff from the natural and built environment, the City maintains a series of pipes, ditches, and connecting structures (i.e., catch basins and manholes) that convey and route stormwater through the basin away from houses, road surfaces, and parking lots (Figure 8). The infrastructure condition and any associated problems were assessed through video inspection of the pipe network and a review of service requests. Table 7 summarizes the types and lengths of conveyance that are present in the basin.

Table 7. Summary of conveyance types, materials, and lengths

Conveyance Type	Material	Approximate Linear Feet
Open channel	na	5,200
Ditch	na	8,700
Pipe	CMP	6,600
	ADS®-1	1,600
	plastic	680
	concrete	21,000
	CPP	700
Total conveyance length		44,480

ADS® – Advanced Drainage System
CMP – corrugated metal pipe
CPP – corrugated plastic pipe
na – not applicable

Woodway Shoreline

Edmonds Shoreline

20TH AVE NW

Kruckeberg Garden

15TH AVE NW

Syre Elementary School

NW 195TH ST

City of Shoreline Public Open Space

NW RICHMOND BEACH RD

8TH AVE NW

NW 188TH ST

SPRINGDALE CT NW

Eagle Reserve

Storm Creek

17TH PL NW

Channel
Ditch
Pipe
Wetlands
Storm Creek basin
Tax parcel

Wind Ward environmental LLC

N

0 125 250 Yards

0 100 200 Meters

Figure 8. Storm Creek drainage system

Prepared by craigh, 3/8/2013, W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps and Analysis\Storm Crk Basin Plan\Fig 08 5162 Drainage system.mxd

The Storm Creek basin does not have any formal water quality treatment or flow control facilities, which are now commonly used methods for reducing stormwater flows and minimizing transport of pollutants to local receiving waters (such as Storm Creek and Puget Sound). However, it is likely that some water quality treatment and possibly some flow control is being provided by wetlands and vegetated ditches, which filter some types of pollutants from the stormwater runoff.

3.6.1 Condition assessment

The condition assessment included inspection of all pipes with a diameter of 12 in. or more within the Storm Creek basin boundaries. Bravo Environmental (Bravo) was the vendor selected to inspect (through closed circuit television [CCTV]) and rate the pipes. Bravo began the CCTV inspections on November 7, 2011, and completed the final inspections in January 2012. The CCTV inspection videos and reports were processed and organized, and the City's Geographic Information System (GIS) database was updated with the results.

How will the condition assessment results be used?

The condition assessment results will help the City plan for future stormwater infrastructure maintenance, repair, and replacement. Recommended projects to repair pipes are included in Section 5.

The CCTV inspection included a qualitative inspection rating following the National Association of Sewer Service Companies (NASSCO) system of rating. The City decided that the ratings most useful to add to the City's GIS database included the Structural Pipe Ratings Index (SPRI), the Maintenance Pipe Ratings Index (MPRI), and the Overall Pipe Ratings Index (OPRI). The SPRI indicates the structural damage present in the pipe; examples include cracks, deformation, intruding objects, and joint offsets. The MPRI indicates maintenance issues present in the pipe which impede the flow of stormwater; examples include debris, sediment, and roots. The OPRI is a combination of the SPRI and MPRI. These ratings are based on a 0 to 5 scale (Table 8).

Table 8. NASSCO rating criteria

NASSCO Grade	Description	Estimated Time to Failure
0	EXCELLENT: no defects.	unlikely in the foreseeable future
1	EXCELLENT: minor defects.	unlikely in the foreseeable future
2	GOOD: defects that have not begun to deteriorate	20 years or more
3	FAIR: moderate defects that will continue to deteriorate	10 to 20 years
4	POOR: severe defects that will become grade 5 defects within the foreseeable future	5 to 10 years
5	IMMEDIATE ATTENTION: defects requiring immediate attention	has failed or will likely fail within the next 5 years

NASSCO – National Association of Sewer Service Companies

Table 9 summarizes the number of pipes and structures inspected by Bravo, and Table 10 lists the length of number pipes within each rating category. In general, the pipes' conditions are fairly good, with 82% of the inventoried pipes having 20 years of life or more left; however, 7% require immediate attention. The majority of the pipes requiring immediate attention are in need of repair or replacement with a few pipes needing only maintenance. Specific pipes and recommendations for the type of immediate action needed is summarized in Section 5.1.3. Figure 9 shows all the pipes in Storm Creek basin, with pipes scoring a 4 or higher in SPRI and MPRI highlighted.

Table 9. Summary of pipes and structures inspected by CCTV in Storm Creek basin

Number of Pipes	Number of Structures[a]	Length of Inspected Pipes (linear feet)	% of Total Pipes Inspected in Basin
271	366	27,400	89

[a] Structures refers to manholes and catch basins that connect lengths of stormwater pipe.

CCTV – closed-circuit television

Table 10. Pipe condition summary

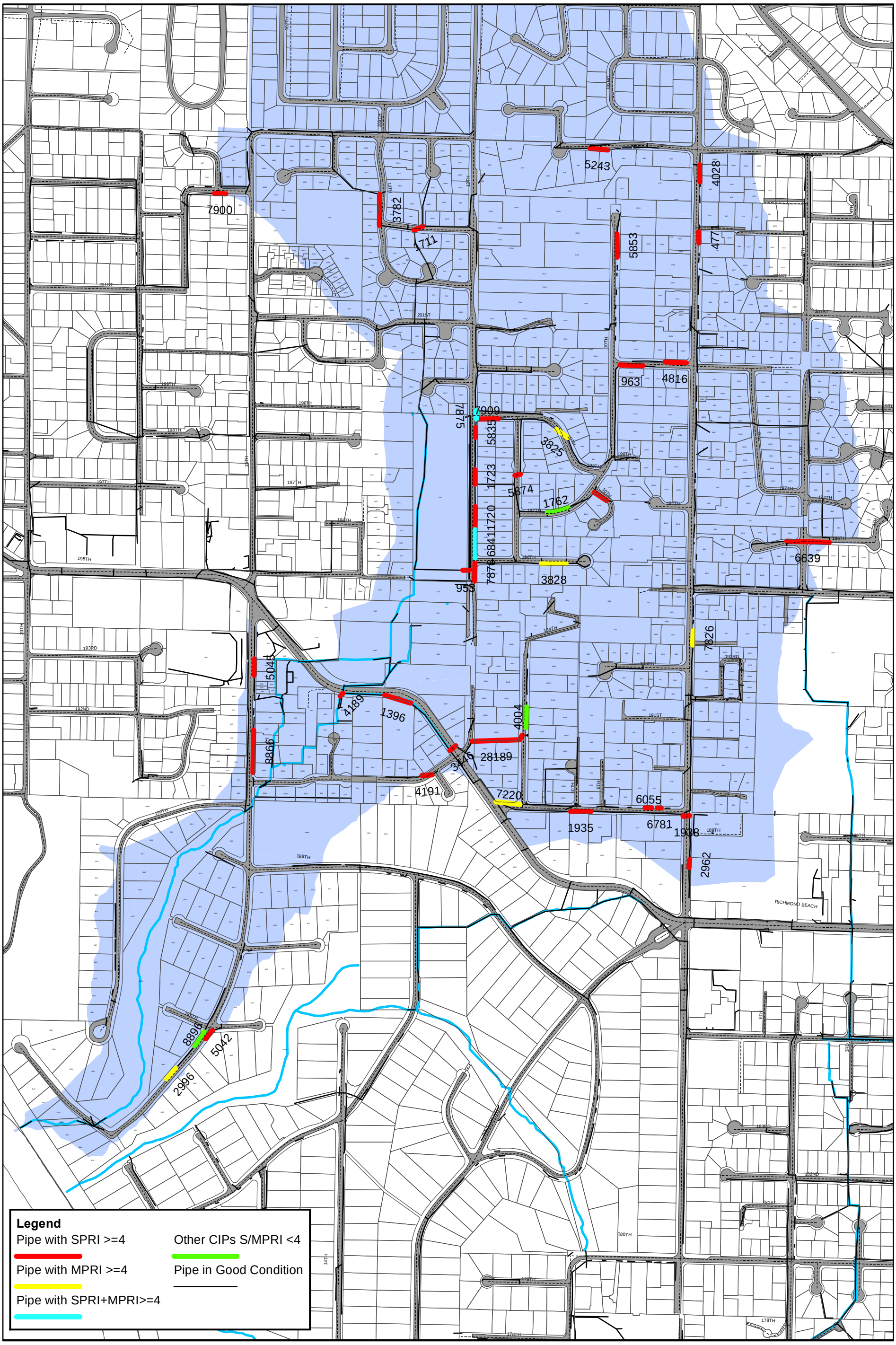
Type of Rating	Number of Pipes Inspected	Number of Pipes within each Category of Rating[a]				
		<1	≥1 and <2	≥2 and <3	≥3 and <4	≥4
SPRI	271	147	19	36	37	32
MPRI	271	130	38	79	18	7
OPRI	271	82	37	100	34	18

[a] Pipes scoring 4 or higher are in poor condition and may need immediate attention. See Table 8 for full description of category ratings.

MPRI – Maintenance Pipe Rating Index

OPRI – Overall Pipe Rating Index

SPRI – Structural Pipe Rating Index



OSBORN CONSULTING INCORPORATED

Figure 9. Locations of pipes rated higher than 4 in condition assessment

Storm Creek Basin - Shoreline, WA

Prepared by MLP, 6/22/12, FIG 9

3.6.2 Infrastructure service requests

Windward reviewed City service requests received between April 2001 and November 2011 to identify problematic areas in the basin and potential causes. As shown in Figure 10, 91 calls were received for locations in the Storm Creek basin during this time period. Major precipitation events occurred in the Seattle and Shoreline area during October 2003, November 2006, and December 2007.

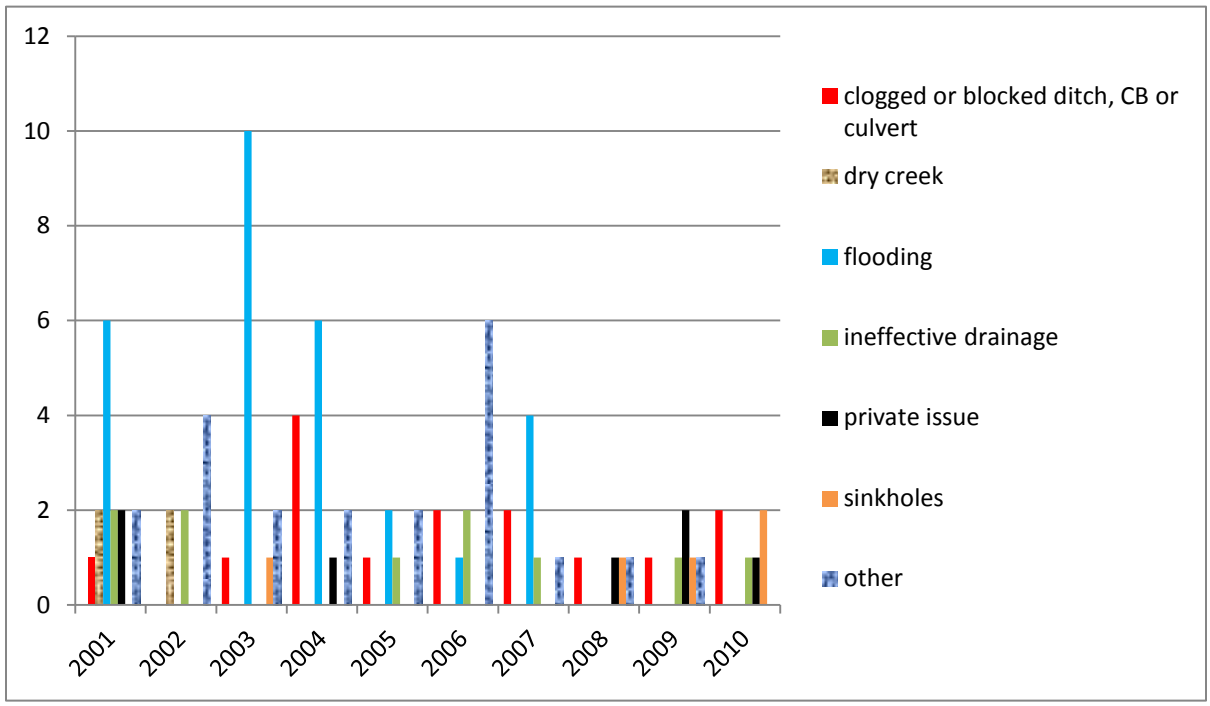


Figure 10. Number of service calls in Storm Creek basin by year and type

Approximately 30 of the calls (32%) were private issues that were not the City's responsibility, or were unrelated to the functionality of the stormwater and surface water system. Figure 10 shows the types of calls received over the 10 years for which records were reviewed. The greatest number of calls was related to localized flooding.

Figure 11 shows the months that calls are typically received. Generally, the most calls are received during the months with the greatest rainfall, between October and March; however, a large number of calls were also received in August. More than half of the August service calls were in a single year (2001), likely corresponding with higher-than-average summer rainfall for that year. In 2001, 2.32 in. of rain fell during August, the fifth largest amount of precipitation for this month over a 59-year record of Seattle area rainfall (WRCC 2006). December 2007 included the second largest storm event on record between 1948 and 2011, and there were a number of flooding problems reported in the basin.

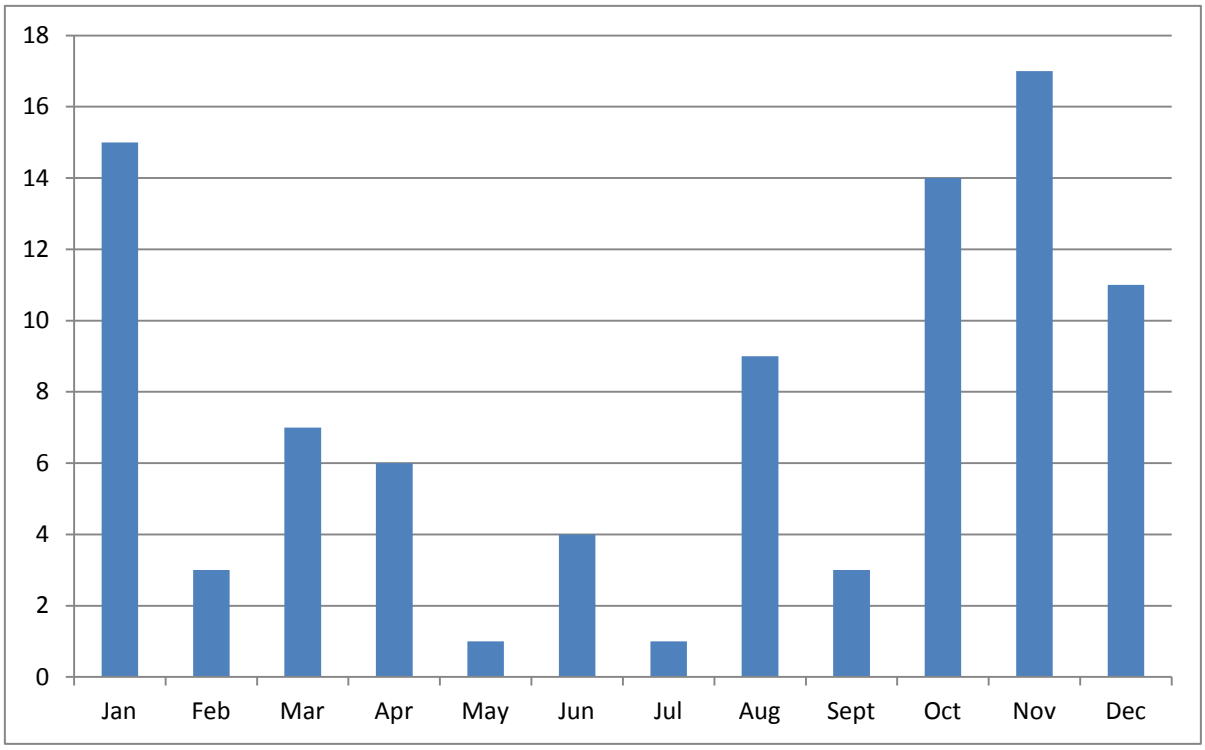
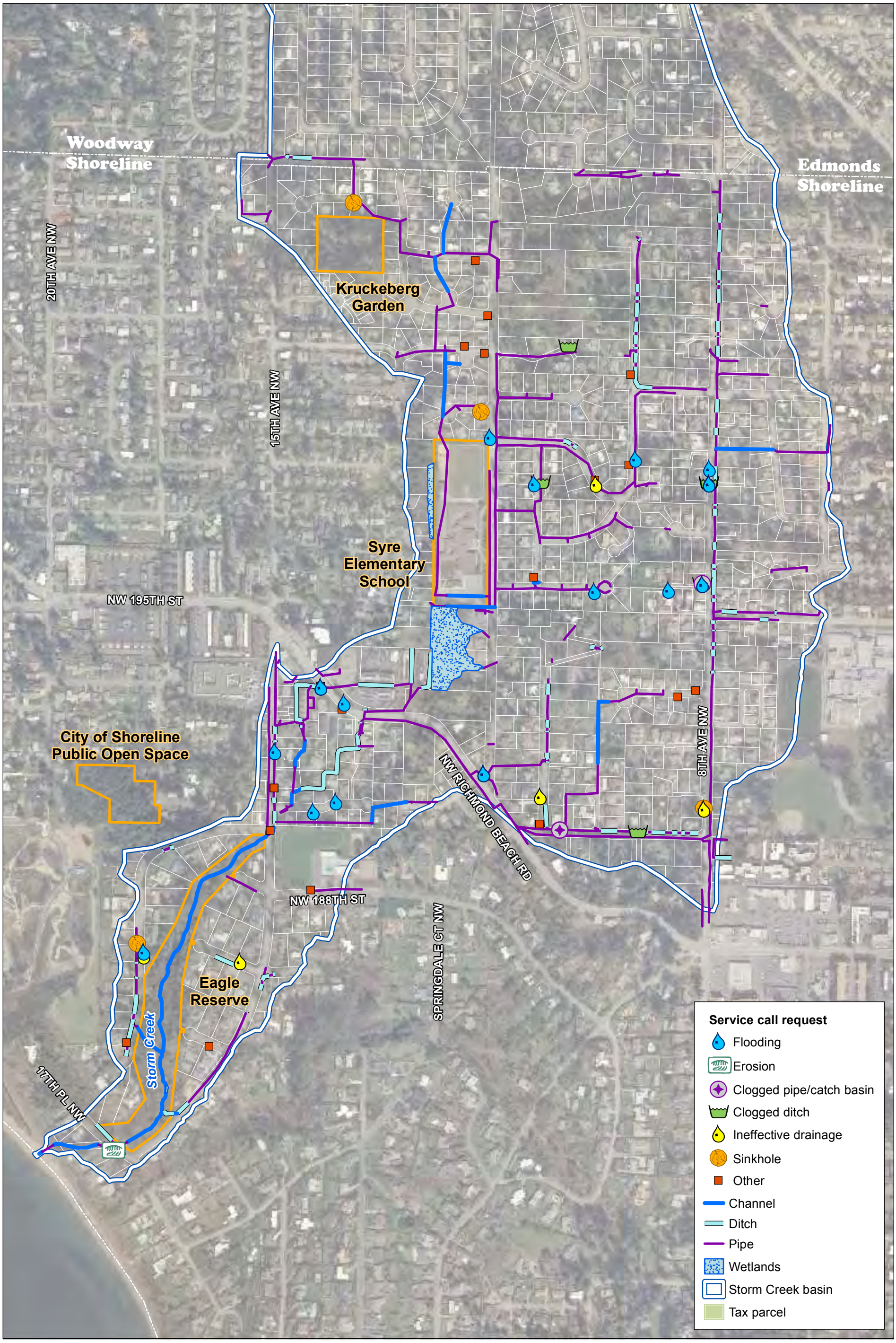


Figure 11. Number of calls by month

Figure 12 shows the locations and types of service calls, indicating where some of the main surface water issues are in the Storm Creek basin. Calls pertaining to ineffective drainage include those regarding surface water not being conveyed to the nearest catch basin, pipe, or ditch because of changes to pavement (during road overlays or other projects), berms that caused the water to flow in a different direction, or other obstructions. Service calls reporting flooding along Richmond Beach Road and in the vicinity of 15th Avenue NW and NW 191st Street are consistent with the findings of the EPA SWMM Model; these locations are shown on Figure 6. Other calls pertaining to flooding appeared to be related to clogged pipes or ditches, rather than pipes that lacked hydraulic capacity. The remaining service calls throughout the basin cannot be confirmed because a detailed hydraulic model was not developed for this basin plan. A table of all of the service calls for the Storm Creek basin is included in Appendix C.



Wind Ward environmental LLC

N

0 125 250 Yards

0 100 200 Meters

Figure 12. City of Shoreline utility service calls

Prepared by craigh, 3/8/2013. W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig 12 5128 Stormwater utility service calls.mxd

3.7 BIOLOGICAL CONDITIONS

3.7.1 Wetlands

The following three wetlands, each of which is discussed in the following sections and shown on Figure 13, were noted in the Storm Creek basin:

- A small (< 0.1 ac), seep-supported slope wetland in Eagle Reserve
- A large (approximately 2 ac) wetland south of Syre Elementary School (subdivided into Syre Wetlands 1 and 2)
- A linear remnant wetland (approximately 0.5 ac) immediately west of the Syre playground

Under the Ecology wetland rating system for Western Washington (Hruby 2004), the wetlands were scored according to wetland functions (water quality, hydrology and habitat) and assigned a rating. Table 11 provides general wetland characteristics and functional points associated with the different wetland categories.

Table 11. General characteristics of Ecology wetland categories

Category	Wetland Function Points	General Characteristics
I	> 70	unique or rare wetland type more sensitive to disturbance than most wetlands relatively undisturbed and contains ecological attributes that are impossible to replace within a human lifetime provides a high level of functions (> 70 points)
II	51 – 69	difficult, though not impossible, to replace provides high levels of some functions (51 – 69 points)
III	30 – 50	provides a moderate level of functions (30 – 50 points) inter-dune wetlands between 0.1 and 1 acre in size
IV	< 30	provides lowest level of functions (less than 30 points) often significantly disturbed

Ecology – Washington State Department of Ecology

3.7.1.1 Eagle Reserve wetland

The Eagle Reserve wetland area is a narrow, slope-type wetland located above and adjacent to the left bank of Storm Creek. The wetland is less than 1/10 of an acre, and wetland hydrology is supported by groundwater seeps. It is dominated by a shrub layer of salmonberry with an understory of lady fern and piggy-back plant. Under the Ecology wetland rating system for Western Washington (Hruby 2004), the Eagle Reserve wetland scores 4 water quality points, 4 hydrologic points, and 16 habitat points for a total score of 24 and a rating of Category IV (Table 11).

3.7.1.2 Syre Wetland 1

The Syre Wetland 1 is a slope-type wetland located on private property immediately south of Syre Elementary School. Vegetation in this approximately 2-acre wetland includes a mix of deciduous trees with a minor coniferous component. Understory species include native shrubs mixed with invasive weeds such as Himalayan blackberry. Invasive vegetation appears to be more prevalent near the eastern wetland boundary, adjacent to residential development. The wetland is supported by groundwater seeps, which form at least two short channels near the toe of the slope. The northernmost channel has a confluence with Storm Creek immediately downstream of where it emerges from the culvert beneath the Syre Elementary School parking lot/playground at the east end of Northwest 195th Street. The other channel(s) appears to drain towards a ditch that eventually directs water past the eastern property line of the Meadowbrook Apartments. Syre Wetland 1 appears to supply a large fraction of the water within Storm Creek, and likely contributes significant baseflow support in this urbanized basin. Under the Ecology wetland rating system for Western Washington (Hruby 2004), Syre Wetland 1 scores 4 water quality points, 16 hydrologic points, and 16 habitat points for a total score of 36 and a rating of Category III (see Table 11).

What hydrologic benefits do wetlands in Storm Creek basin provide?

Syre Wetland 1 is the largest wetland in the Storm Creek basin, and probably provides some minor water storage during lower flow events, as well as some water quality treatment through pollutant filtering. However, wetlands probably played a much greater role in the Storm Creek basin hydrology prior to large-scale development and associated wetland filling.

3.7.1.3 Syre Wetland 2

The Syre Wetland 2 is a depressional wetland located on private property in a narrow, linear area immediately west of Syre Elementary School's western property line. The wetland is one-half an acre in size. For this report, the boundaries of this wetland were approximated. Syre Wetland 2 was not rated, as it is fenced to prevent access and difficult to view. The wetland is dominated by lawn grasses at its northern edge and transitions to sparse shrub vegetation in the southern portions. It has a canopy of red alder and other deciduous trees. Storm Creek flows within a 24-in.-diameter concrete pipe just within and parallel to the school's western property line. Syre Wetland 2 appears to have formed along the edge of the fill placed when the culvert was installed in conjunction with the school's construction.

Prepared by craigh, 3/6/2013; W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps and Analysis\Storm Crk Basin Plan\Fig 13 5146 Biological features.mxd

Wind Ward environmental LLC

Figure 13. Wetland and fish passage barrier locations

3.7.2 Fish passage barriers

3.7.2.1 Anadromous fish barriers

Although sections of Storm Creek may include potentially suitable habitat for resident salmonid fish, such as cutthroat trout, a very steep bluff section approaching Puget Sound near the stream's mouth precludes its use by anadromous (sea-going) fish, such as coho salmon. Even prior to the road, railroad, and residential construction that has occurred over the past century or so, it is likely that this section was too steep to allow anadromous fish to pass up and over the bluff along the shore of the Puget Sound. Accordingly, this steep section may be considered a natural fish migration barrier. This barrier is situated just upstream of the BNSF railroad tracks along the shore of Puget Sound and downstream of 17th Place Northwest (Figure 13). It consists of a chasm with cascades and high plunges carved into hard glacial till materials with adjoining bluffs 25–30 ft in height.

Additional complete or partial barriers to upstream fish movements have been identified along Storm Creek (Figure 13), including:

- Railroad crossing culvert near the high-tide line of Puget Sound at Storm Creek's mouth
- Gabion basket grade control downstream of 17th Place Northwest
- 17th Place Northwest culvert crossing and associated stormwater manhole on upstream end of Storm Creek

The existing railroad crossing culvert is a 42-in.-long corrugated metal pipe (CMP), which is steep inside with a 6-in. plunge at the outfall. The galvanizing has worn off the bottom, which is now corroded. High tides reach the downstream end of the culvert, and may push backwater most or all of the way through it. The culvert may be passable for fish under certain high-tide conditions, but the steep, chasm-like barrier described above lies immediately upstream (Photo 2).

What kinds of obstacles prevent fish movement?

Different species of fish have different abilities to swim upstream and jump over barriers. In general, steeply graded channels (steeper than 20%) are considered impassable. The Storm Creek ravine through the bluff to Puget Sound has likely never been passable by fish due to the steep grade.

Photo 2. Culvert under BNSF railroad, mouth of Storm Creek

Stream flow plunges several feet as it crosses over the two separate gabion weirs that were likely installed to provide grade control and protect sewer infrastructure.

The culvert at 17th Place Northwest may also have slope and associated velocity characteristics unfavorable for fish passage.

3.7.2.2 Resident fish barriers

Upstream of 17th Place Northwest, within the Eagle Reserve, is a sewer line crossing that has been grouted extensively with concrete to protect it from exposure and damage resulting from streambed erosion (Figure 13). As a result, several plunges of up to 3 ft have formed as the stream flows across the resulting grade control (Photo 3). These plunges are impassable to upstream-bound fish, primarily due to stream size and channel geometry; normally, a pool somewhat deeper than the height of a corresponding plunge is required immediately below to allow passage (Reiser and Bjornn 1979). In addition, larger fish can generally leap higher than smaller fish, and any resident cutthroat trout in the stream would be fairly small. The channel continues to incise downstream of the grade control, but is prevented from doing so immediately upstream of the grade control.

Photo 3. Concrete poured over sanitary sewer line in Storm Creek – likely fish passage barrier

At the upstream limit of Eagle Reserve, at the culvert outfall at 15th Avenue Northwest and Northwest 190th Street, is a hanging 30-in.-long CMP culvert with an erosive drop at its outfall (Figure 13). The drop is greater than 1 ft and ends in riprap cascades with no plunge pool. These conditions, if not impassable, at best represent an inferior fish passage situation. Subject to confirmation, this culvert may also have slope and associated velocity characteristics unfavorable for fish passage.

Additional partial migration barriers or hindrances to fish movements occur in association with various piped sections and flow diversions. For example, a flow splitter occurs at the Meadowbrook Apartments. The splitter itself and the various associated piped sections may affect potential fish movements.

3.7.3 Current fish usage

There is some question as to whether or not fish currently inhabit Storm Creek. Anadromous fish do not use the creek due to the barrier near the mouth and additional upstream barriers , as described above. Though some habitat suitable for resident fish may be available in the creek (Section 3.7.4), it is not clear if any such fish are now present. In September 1995, two King County staff biologists conducted electrofishing along the Storm Creek section in Eagle Reserve, but did not detect the presence of any fish (Hartley 1995). However, Washington Department of Fish and Wildlife (WDFW) biologist Doug Hennick trapped cutthroat trout upstream (north) of the Meadowbrook Apartments during the summer of 1999 (Hennick 1999).

3.7.4 General habitat conditions

Notwithstanding the barriers to upstream migration listed and described above, Storm Creek appears to be moderately well suited to supporting a small population of resident salmonid fish, namely cutthroat trout. Despite Storm Creek's apparent lack or low level of documented fish use, the City's 2004 surface water master plan (SAIC 2011)

included Storm Creek among four City streams that "have the best habitat available and/or potential for fish habitat within the City."

Are habitat conditions in Storm Creek adequate to support resident fish populations?

Yes, likely. However, improvements to migration barriers would be needed to support a sustainable population.

Particularly through the Innis Arden portion Eagle Reserve, which extends along the ravine from 17th Place Northwest upstream to 15th Avenue Northwest, the creek exhibits perennial flows with low enough temperatures and adequate water quality to support such fish. The open-channel stream sections between 15th Avenue Northwest and Richmond Beach Road, and again from the Meadowbrook Apartments to Syre Elementary School, may also provide similar potential fish habitat. It was along this latter section that Doug Hennick of WDFW trapped cutthroat trout in 1999 (Hennick 1999).

This is not to say, however, that habitat conditions along these reaches or for the creek in general are ideal and without substantial room for improvement. Furthermore, the migration barriers discussed above would limit the movements even of resident fish within the basin, exacerbating the tendency of very small populations in small, isolated habitats to die out from time to time due to even normal population fluctuations. Also, given the migration barriers present, re-colonization following such episodes would be problematic. If such cutthroat trout use of Storm Creek is determined to be desirable and worth maintaining, then periodic monitoring for presence and supplementation as needed should be considered.

3.7.5 Vegetation/forested cover

Two significant undeveloped forested areas remain within the Storm Creek basin: Eagle Reserve and six Syre Wetland 1 properties.

3.7.5.1 Eagle Reserve

The nearly 8-acre Eagle Reserve is a neighborhood tract preserved for open space, recreation, and native growth protection. The reserve contains a trail for the private use of the Innis Arden neighborhood. The trail lies within a forested ravine flanking Storm Creek. The ravine is largely vegetated with a diverse assemblage of native tree, shrub, and groundcover species, but notable non-native species are present as well, including laurel, English ivy, holly, and Himalayan blackberry. Native plant species observed within the Eagle Reserve ravine include species such as western red cedar, bigleaf maple, red alder, bitter cherry, paper birch, Pacific madrona, hazelnut, Pacific willow, evergreen huckleberry, thimbleberry, Pacific trailing blackberry (Pacific dewberry), red elderberry, salmonberry, ocean spray, Oregon grape, sword fern, and salal.

3.7.5.2 Syre Wetland 1 properties

Portions of six contiguous, privately owned parcels are located between Syre Elementary School and Northwest Richmond Beach Road. This forested area is more

than 4 acres in size and contains the upper extent of the open channel portions of Storm Creek. It is also the location of Syre Wetland 1 (Section 3.7.1.2). The area is dominated by deciduous trees with some coniferous trees at the southern end. The understory is a mix of native and non-native shrub and groundcover species. Each of these parcels is developed with a single-family residence on the non-forested portions.

3.8 WATER QUALITY

The City has been monitoring the ecological health of Storm Creek in several ways, including the collection and analysis of water and benthic invertebrate samples. Water quality samples have been collected monthly at two stations in Storm Creek since 2001: ST-1, located just upstream of the intersection of 17th Place Northwest and 16th Avenue Northwest; and ST-2, located just downstream of the intersection of 15th Avenue Northwest and Northwest 190th Street (Figure 14). Benthic macroinvertebrates were also sampled at ST-1 in 2002 and 2007.

3.8.1 Storm Creek

Water quality samples from Storm Creek are analyzed monthly *in situ* for pH, dissolved oxygen (DO), temperature, turbidity, conductivity/specific conductivity, and flow rate (estimated visually). Since 2007, water samples from ST-2 have also been collected and analyzed for fecal coliform (FC) bacteria, nitrogen, phosphorus, and total suspended solids (TSS), so that water quality in Storm Creek could be assessed using Ecology's water quality index (WQI) scoring matrix. Table 12 presents a summary of the water quality parameters identified for evaluation in Storm Creek. Raw monitoring data are included in Appendix D and summary statistics are presented in Figure 14.

Table 12. Water quality monitoring conducted by City of Shoreline

Monitoring Station ID and Location	Portion of Stream Measured for Water Quality	Ambient Parameters (2001–2011)	WQI Parameters (2007–2011)
		pH, DO, Temp., Turb., Conductivity, Spec. Cond., Flow	FC, TN, TP, TSS
ST-1	lower Storm Creek	yes[a]	no
ST-2	upper Storm Creek	yes	yes

[a] Data only collected at this location from 2001 to 2004.

DO – dissolved oxygen
FC – fecal coliform
ID - identification
TN – total nitrogen
TP – total phosphorus
TSS – total suspended solids
WQI – water quality index

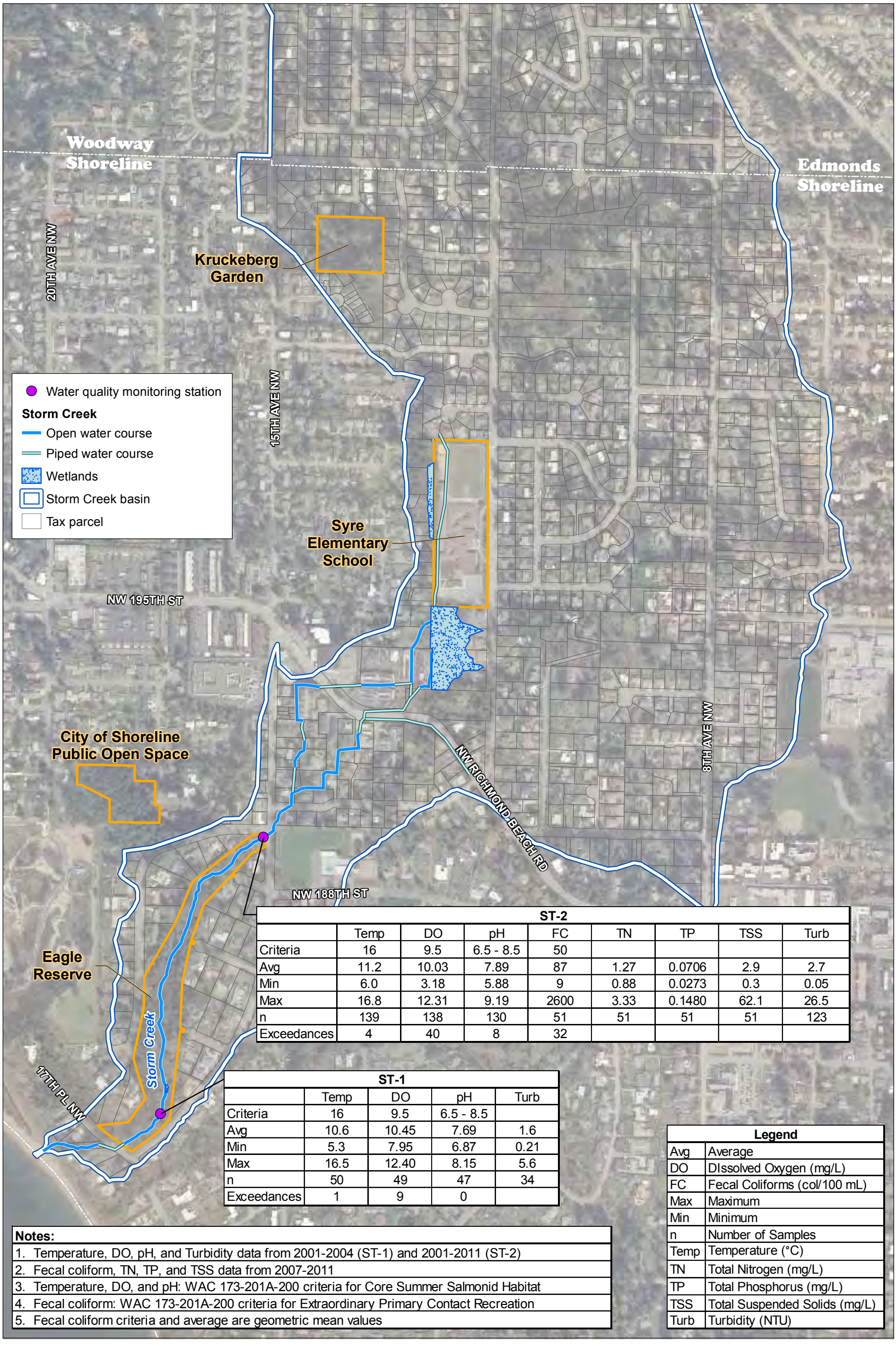
Monitoring results are compared to state water quality standards, which are designed to protect public health and aquatic life. Washington Administrative Code (WAC) 173-201A-602 (*Use designations for fresh waters by water resource inventory area*) does not specifically identify Storm Creek; however, it does identify "fresh surface waters that are tributaries to extraordinary aquatic life marine waters (WAC 173-201A-610 through 173-201A-612)." WAC 173-201A-612 (*Use designations for marine waters*) designates Puget Sound as one such extraordinary aquatic life marine water: therefore, as a tributary to Puget Sound with no supplemental spawning requirements, Storm Creek is to be protected for the designated uses of core summer salmonid habitat; extraordinary primary contact recreation; domestic, industrial, and agricultural water supply; stock watering; wildlife habitat; harvesting; commerce and navigation; boating; and aesthetic values.

The water quality criteria (WQC) for temperature, DO, pH, and FC bacteria corresponding to the designated uses (WAC 173-201A-200) are listed in Table 13.

Table 13. Water quality criteria (WAC 173-201A-200) for unnamed freshwater tributaries to extraordinary aquatic life marine waters

Category	DO (Lowest 1-Day Min.)	Temperature (Highest 7-Day Max.)	pH	FC
Core summer salmonid habitat	9.5 mg/L	16°C (60.8°F)	6.5 – 8.5	na
Extraordinary primary contact recreation	na	na	na	geomean < 50 colonies/ 100 mL, with < 10% of samples > 100 colonies/100 mL

DO – dissolved oxygen
FC – fecal coliform
na – not applicable
WAC – Washington Administrative Code



ST-2								
	Temp	DO	pH	FC	TN	TP	TSS	Turb
Criteria	16	9.5	6.5 - 8.5	50				
Avg	11.2	10.03	7.89	87	1.27	0.0706	2.9	2.7
Min	6.0	3.18	5.88	9	0.88	0.0273	0.3	0.05
Max	16.8	12.31	9.19	2600	3.33	0.1480	62.1	26.5
n	139	138	130	51	51	51	51	123
Exceedances	4	40	8	32				

ST-1				
	Temp	DO	pH	Turb
Criteria	16	9.5	6.5 - 8.5	
Avg	10.6	10.45	7.69	1.6
Min	5.3	7.95	6.87	0.21
Max	16.5	12.40	8.15	5.6
n	50	49	47	34
Exceedances	1	9	0	

Legend	
Avg	Average
DO	DIssolved Oxygen (mg/L)
FC	Fecal Coliforms (col/100 mL)
Max	Maximum
Min	Minimum
n	Number of Samples
Temp	Temperature (°C)
TN	Total Nitrogen (mg/L)
TP	Total Phosphorus (mg/L)
TSS	Total Suspended Solids (mg/L)
Turb	Turbidity (NTU)

Notes:

1. Temperature, DO, pH, and Turbidity data from 2001-2004 (ST-1) and 2001-2011 (ST-2)
2. Fecal coliform, TN, TP, and TSS data from 2007-2011
3. Temperature, DO, and pH: WAC 173-201A-200 criteria for Core Summer Salmonid Habitat
4. Fecal coliform: WAC 173-201A-200 criteria for Extraordinary Primary Contact Recreation
5. Fecal coliform criteria and average are geometric mean values

Wind Ward LLC environmental

N

0 125 250 Yards

0 100 200 Meters

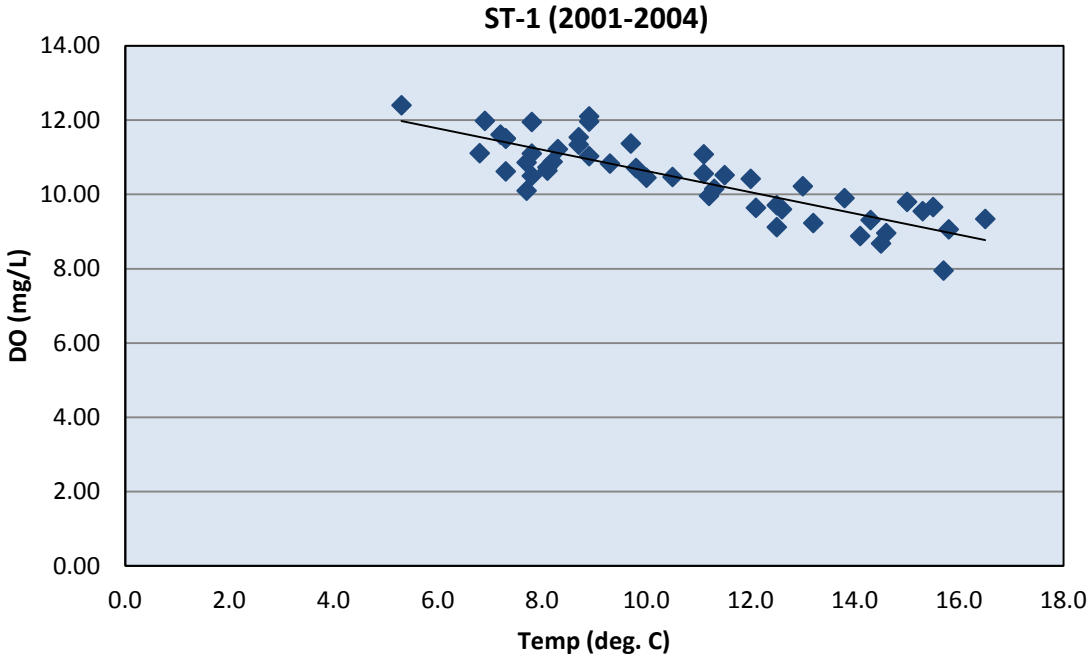
Figure 14. Storm Creek monitoring stations and data

Prepared by craigh, 3/8/2013, W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps and Analysis\Storm Crk Basin Plan\Fig 14 5147 Water quality.mxd

- DO was inversely correlated with temperature (Figure 15). At both ST-1 and ST-2, DO concentrations less than the 9.5 mg/L criterion were often (but not always) observed at warmer water temperatures, usually 10°C or above. The majority of exceedances occurred at ST-2, although that may reflect the limited data available for ST-1 rather than any real trend. When DO was observed below the criterion, it usually remained above 8 mg/L, less than 2 mg/L below the criterion.
- FC counts exceeded the criterion (50 colonies/100 mL) in more than half the samples collected at ST-2 from 2007 to 2011. Additionally, the overall geometric mean (87.3 colonies/100 mL) exceeded the primary criterion, and 18% of the samples collected exceeded the secondary criterion (100 colonies/100 mL). The maximum value observed (2,600 colonies/100 mL), while of concern, does not typically indicate severe pollution.

Ecology did not include the City's data in its 2008 water quality assessment (i.e., the "303(d) list," or determination of impaired water bodies) (Ecology 2008). No impaired water body segments are identified for Storm Creek; however, this may have been due to a lack of available data, rather than definitive data showing that Storm Creek met tested standards.

In 2007, in order to evaluate the relative condition of City streams, the City started collecting the additional data required to use Ecology's WQI scoring matrix (Hallock 2002) at Station ST-2. The WQI parameters are FC, total phosphorous, total nitrogen, TSS, DO, pH, temperature, and turbidity. Monthly data for each water year are entered into a formula spreadsheet, and a water quality score is calculated for each stream. Temperature, pH, FC, and DO data are compared to state WQC (WAC 173-201A-200). Nutrient and sediment data with no specific criteria are compared to expected conditions for the stream eco-region (Omernik 1987).



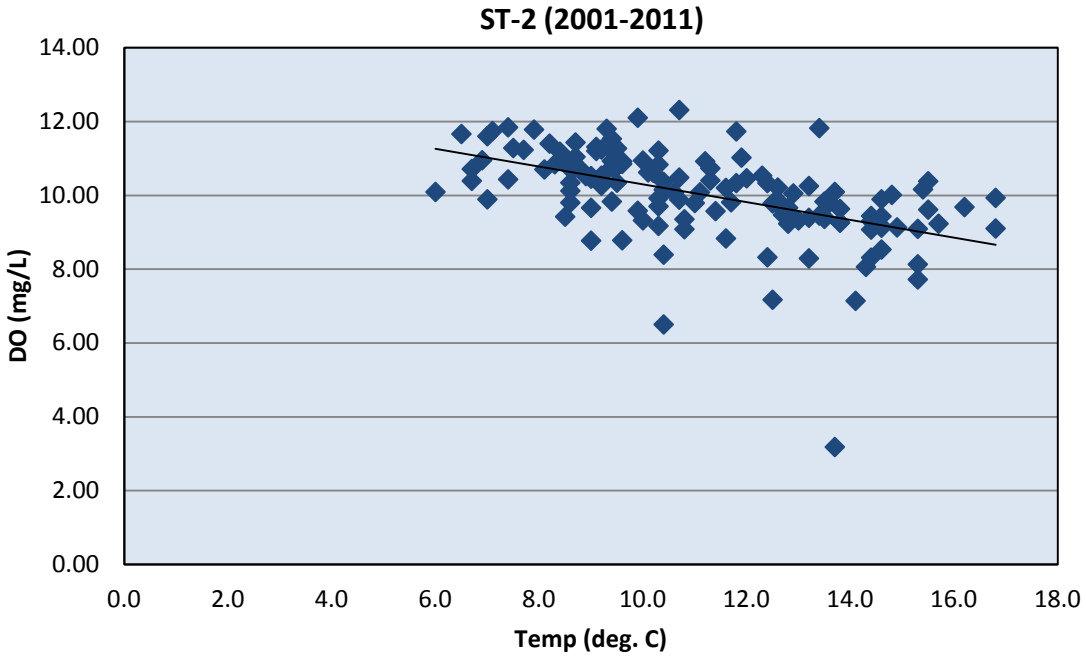


Figure 15. Dissolved oxygen versus ambient water temperature at ST-1 and ST-2

The WQI score is a unitless number ranging from 1 to 100, with higher numbers indicating better water quality. Scores of 80 or greater mean expectations for water quality are generally met, and the streams are considered to be of lowest concern (i.e., the least impaired). Scores of 40 to 80 indicate marginal concern (i.e., moderate impairment), while scores of 40 or less indicate that the stream "did not meet expectations" (i.e., most impaired). Table 14 shows the WQI scores for Station ST-2 for the water years 2007/2008 through 2010/2011, calculated using the most recent version of the matrix (version 5, updated on 9/9/2009). Copies of the WQI spreadsheets are included in Appendix E.

Table 14. Water quality index scores and impairment levels for Storm Creek

Station	Water Year	WQI Score[a]	Impairment Level
Storm Creek (ST-2)	2007–2008	29	high concern
	2008–2009	40	moderate concern
	2009–2010	15	high concern
	2010–2011	24	high concern

[a] Calculated using Ecology WQI Spreadsheet Version 5: 2009.09.09.

Ecology – Washington State Department of Ecology

WQI – water quality index

WQI scores for Storm Creek ranged from 15 to 40, indicating that the water quality in Storm Creek is generally of high concern due to impacts from urbanization. A breakdown of the WQI scores by parameter is shown in Figure 16.

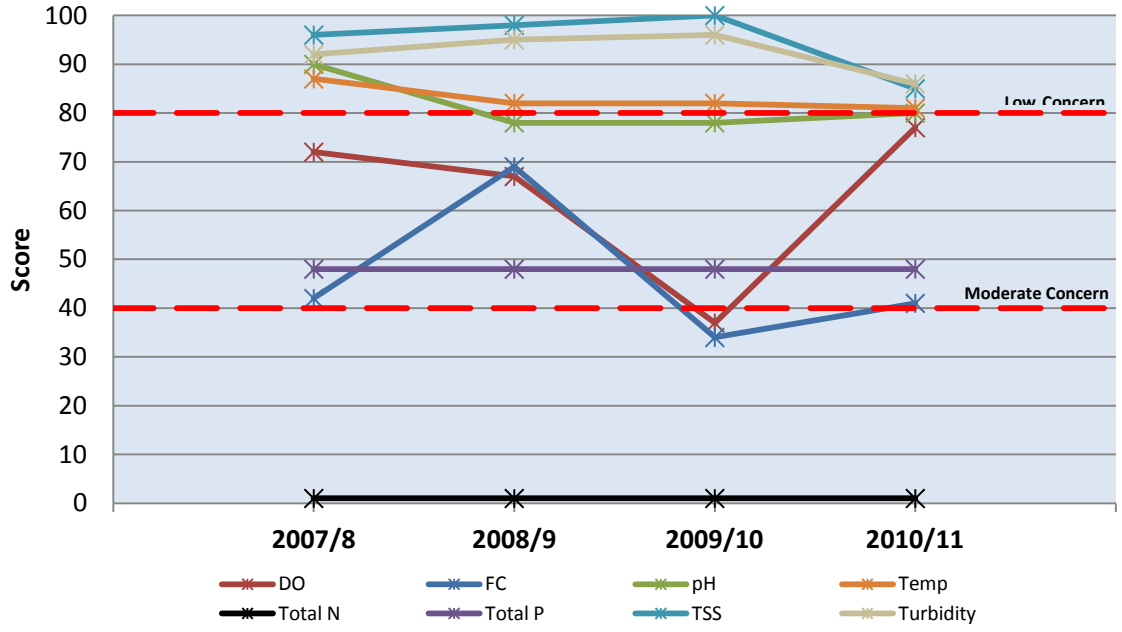


Figure 16. Storm Creek water quality index scores by parameter

WQI scores for individual parameters show that DO, FC, phosphorus, and nitrogen levels have the greatest impact on water quality in Storm Creek. DO levels were found to be less than the 9.5 mg/L criterion in 26% of the samples collected from 2001 to 2011. FC counts exceeded the state water quality criterion (50 colonies/100 mL) in 63% of the samples collected from 2007 to 2011. Phosphorus and nitrogen do not have Washington State WQC; the WQI scores for these parameters are based on a comparison of a distribution of historical monitoring data during high- and low-flow seasons from stations within a similar eco-region. Poor index scores for these constituents indicate poor water quality relative to other stations in the same eco-region, and may not necessarily indicate impairment or inability to support beneficial uses (Hallock 2002). However, an EPA (2000) guidance document for supporting the development of state and tribal nutrient criteria in the Puget Sound lowlands (eco-region 2) presents reference values for both total phosphorus (0.0195 mg/L) and total nitrogen (0.24 mg/L), based on historical monitoring data at reference locations within the lowlands region (EPA 2000). It should be noted that these values are not laws or regulations—they are only guidance that states and tribes may use as a starting point to develop water quality standards. However, when compared to these values, all of the samples collected from Storm Creek from 2007 to 2011 exceeded the reference levels for both parameters.

The WQI is designed to indicate how well water quality at a given station meets expectations, not how good the absolute quality is. However, the parameters are compared to state water quality standards and take into account critical parameters for which no standards currently exist. The WQI summaries present data in an easily understood format that can demonstrate overall water quality conditions to political decision makers, non-technical water managers, and the general public. Further details about the WQI, as well as the latest version of the spreadsheet developed for WQI calculations, can be found on Ecology's website (http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html).

3.8.2 Benthic invertebrates

The City has also monitored stream health in Storm Creek by collecting samples of benthic invertebrates for assessment. Benthic invertebrates are an important link in the food chain for fish in the creek, and are an excellent indicator of stream health. In both 2003 and 2007, benthic invertebrate samples were collected and analyzed, and benthic invertebrate index scores were calculated for Storm Creek.

Why are benthic invertebrates good indicators of stream health?

Benthic invertebrates are an important link in the food chain and their presence/absence, diversity, species type , and population densities provide important information about water quality and aquatic habitat conditions.

The overall effects of urbanization were most evident in the Benthic Indices of Biotic Integrity (B-IBI), wherein biological impairment of Storm Creek was rated as "extreme" (ST-1 B-IBI = 18) in 2007. The 2007 results differed little from those

reported in 2003, when station ST-1 a rating of 14, another "extreme" B-IBI score (Watershed Company 2009). Other observations from the 2007 study included:

- Overall macroinvertebrate taxa richness in Storm Creek was very low; community compositions suggested that nutrient enrichment or organic pollutants were present in the stream system.
- Fine sediment deposition has likely limited access to stony substrate habitats.
- Very few individuals of species that are long-lived or sensitive to degraded conditions were found to be present, suggesting that catastrophic events may periodically interrupt long life cycles.
- Pool habitats in Storm Creek were infrequent and poorly formed, indicative of generally poor physical habitat quality in the survey reach. Additionally, the stream corridor showed evidence of episodic, channel-scouring, high-flow events, with stormwater runoff likely accentuating peak flows (Watershed Company 2009).

4 Community and Regulatory Framework

4.1 COMMUNITY STAKEHOLDERS

The Storm Creek basin encompasses portions of the following City neighborhoods: Innis Arden, Hillwood, and Richmond Beach. The Innis Arden neighborhood has the most direct connection to Storm Creek, its Eagle Reserve community property being located along the largest open channel and most natural section of the creek. Erosion in this reach of Storm Creek (described in Section 3 and Appendix A) has been a major issue for Innis Arden residents, who were the primary attendees at two public open houses to discuss this basin plan effort.

4.1.1 Public meetings and outreach

Two public open houses were held at Shoreline City Hall on September 14, 2011, and April 11, 2012. The purpose of the first open house was to solicit input from Storm Creek basin residents and interested parties as to stormwater-related issues in the basin. The primary concern voiced by residents was the erosion near 17th Place Northwest within Eagle Reserve. The second open house was to present draft findings and potential solutions to the Storm Creek stormwater issues. Again, the primary concern voiced at the meeting was erosion at 17th Place Northwest. The initial findings for the Storm Creek basin plan were presented to the City Council on March 26, 2011. In that meeting, City staff indicated that City policy states that projects are not to be completed on private property. If there is sufficient public benefit or risk to public infrastructure, property interests will be dedicated or acquired for a public project.

4.1.2 Comments on draft basin plan

The City posted the draft basin plan on its website for public comment in January 2013, and received comments from the Ronald Wastewater District and several citizens. Copies of the comments received are attached in Appendix F.

4.2 REGULATORY FRAMEWORK

The City governs land use, stormwater, and the use of natural resources through codes and ordinances that are specific to the City, or dictated by overarching state and federal regulations. These regulations, along with the goals outlined in the City's comprehensive plan (City of Shoreline 2011c), were considered in the development of solutions to address stormwater management issues in the Storm Creek basin. Table 15 summarizes existing federal, state, and local regulations related to stormwater runoff and natural resources, and the relevance of these regulations to the Storm Creek basin.

Table 15. Regulatory framework of surface water management in the Storm Creek basin

Law	Implementing Entity	Regulatory Programs	Intent and Specifics	Relevance to Storm Creek Basin
CWA	Ecology	NPDES Phase II Municipal Separate Storm Sewer System Permit	Eliminate discharge of pollutants into the nation's water, and achieve water quality levels that are protective of beneficial uses.	The City is a NPDES Phase II permittee and must comply with conditions of the permit. The permit is currently entering its second cycle, and new conditions are likely in the next phase of the permit (beginning in 2013).
	Ecology	Surface Water Quality Standards	Protect and regulate the quality of surface water in Washington State by 1) sustaining designated uses, 2) meeting numeric WQC, and 3) implementing anti-degradation policies.	Storm Creek is not listed on the state's 303(d) list for non-compliance with water quality standards.
	Ecology and USACE	Sections 401 and 404	Requires a permit of activities classified by the USACE for dredge or discharge of fill material to Waters of the United States.	Storm Creek and associated wetlands and Puget Sound are considered Waters of the United States. In-water activities that meet minimum dredge and fill limits require a permit.
Tribal Agreements and Related Case Law	Muckleshoot Tribe	na	Protect fish populations in traditional fishing grounds of Native American tribes.	The Muckleshoot Tribe is party to SEPA review of development proposals within the Storm Creek basin.
ESA	USFWS and NOAA Fisheries in consultation with lead federal agencies	na	Prevent further decline of listed terrestrial and aquatic species.	There are no documented endangered species within the Storm Creek basin; however, Storm Creek discharges to Puget Sound, which does have endangered aquatic species, including Chinook Salmon.
SEPA	City conducts review and issues SEPA determinations on proposed projects within its jurisdiction	na	Identify and require mitigation of the environmental impacts of proposals and programs.	SEPA is used to address impacts from projects in the Storm Creek basin that are not covered in other City code requirements.
Shoreline Management Act	City (master plan)	na	Protect use and functions (economic, ecological, aesthetic) of shoreline areas.	Storm Creek discharges to Puget Sound, which is included in the City's Master Program.

Law	Implementing Entity	Regulatory Programs	Intent and Specifics	Relevance to Storm Creek Basin
Washington State Hydraulic Code	WDFW	na	Set requirements for placement of culverts and other hydraulic devices that may affect fish use.	Projects within the ordinary high water mark of streams must obtain a Hydraulic Project Approval permit from WDFW. Culverts must be fish passable where fish are present.
GMA	City	City comprehensive plan	Regulate land use to meet growth targets while providing necessary services and protecting sensitive environmental resources.	na
Water Quality Protection Act	Ecology	Puget Sound Partnership	Provide an integrated stormwater management program to protect and restore Puget Sound.	Storm Creek discharges to Puget Sound and has a small but direct effect.
Chapter 13.10 Surface Water Utility	City	drainage standards for new and redevelopment	Promote public health, safety, and welfare by providing design, construction, and maintenance criteria for permanent and temporary surface water drainage facilities for development and redevelopment activities.	The City has adopted the most recent version (2005) of the *Stormwater Management Manual for Western Washington* (Ecology 2005). A new draft version (2012) is currently out for review.

City – City of Shoreline
CWA – Clean Water Act
Ecology – Washington State Department of Ecology
ESA - Endangered Species Act
GMA – Growth Management Act
na – not applicable
NOAA – National Oceanic and Atmospheric Administration
NPDES – National Pollutant Discharge Elimination System
SEPA – State Environmental Policy Act
USACE – US Army Corps of Engineers
USFWS – US Fish and Wildlife Service
WDFS - Washington State Department of Fish and Wildlife
WQC – water quality criteria

A thorough review and description of relevant codes and their relationship to the City can be found in the City's *Surface Water Master Plan Update* (SAIC 2011). Additionally, key National Pollutant Discharge Elimination System (NPDES) permit changes that may affect the City's stormwater management activities in the Storm Creek basin, as well as the rest of the City, are discussed in that report.

4.3 CITY'S COMPREHENSIVE PLAN AND THE STORM CREEK BASIN

The following statement is an excerpt from the City's Vision Statement in the comprehensive plan:

> *Shoreline is a regional and national leader for living sustainably. Everywhere you look there are examples of sustainable, low impact, climate-friendly practices come to life- cutting edge energy-efficient homes and businesses, vegetated roofs, rain gardens, bioswales along neighborhood streets, green buildings, solar-powered utilities, rainwater harvesting systems, and local food production to name only a few. Shoreline is deeply committed to caring for its seashore, protecting and restoring its streams to bring back the salmon, and to making sure its children can enjoy the wonder of nature in their own neighborhoods.*

Several elements of this vision statement relate directly to stormwater management and the implementation of LID opportunities. As discussed in Section 3.1, the Storm Creek basin was developed at a time when stormwater management facilities were not required nor routinely constructed with new development. Today, state, regional, and local leaders understand the impact of development without stormwater mitigation. That being said, it is a monumental task to retrofit areas such as Storm Creek with current stormwater controls, let alone LID alternatives, which typically require space where none may exist. As lots are redeveloped over time, the Storm Creek basin will slowly be retrofit with stormwater controls. However, realistic expectations that balance resources against potential benefits must be considered in the short-term future. The list of recommended projects and solutions in Section 5 has been compared to goals outlined in the City's comprehensive plan, where applicable, in an effort to promote consistency.

5 Summary of Basin Issues and Recommended Strategies

The specific built and natural characteristics of the Storm Creek basin, along with associated issues and potential solutions, are shown in Figure 17. With respect to stormwater management, the following beneficial characteristics and deficiencies are noted:

Beneficial characteristics:

- Large wetland near Richmond Beach Road provides stormwater filtration and a minor amount of storage during smaller precipitation events.
- Eagle Reserve provides some fish habitat (resident, such as cutthroat trout), and forest canopy in this area may help prevent high water temperatures, resulting in better water quality.
- Glacial advance outwash geology in the central part of the basin provides infiltration opportunities for stormwater retrofit. Currently, stormwater runoff from impervious surfaces in this area (that are not connected to stormwater pipes) is likely infiltrated (similar to the situation in the City of Edmonds).
- Very few pipes in the basin require immediate repair or replacement.

Deficiencies

- Stormwater management facilities to mitigate runoff from developed areas are not present in the Storm Creek basin.
- Glacial outwash geology in areas of steeper slopes is very erodible and has contributed to channel downcutting in Eagle Reserve.
- Water quality is of moderate concern, primarily because of FC bacteria and nutrients.
- Localized flooding appears to be related primarily to clogged culverts and ditches, rather than hydraulic constrictions in the system.

The existing stormwater-related issues are mostly connected to urbanization that largely occurred prior to the City's incorporation in 1995. The Storm Creek basin was mostly built out prior to 1990, when modern stormwater management techniques started to be employed in order to reduce water quality problems and erosion in small stream channels. These issues are exacerbated by more frequent and higher peak flows that result from urbanization.

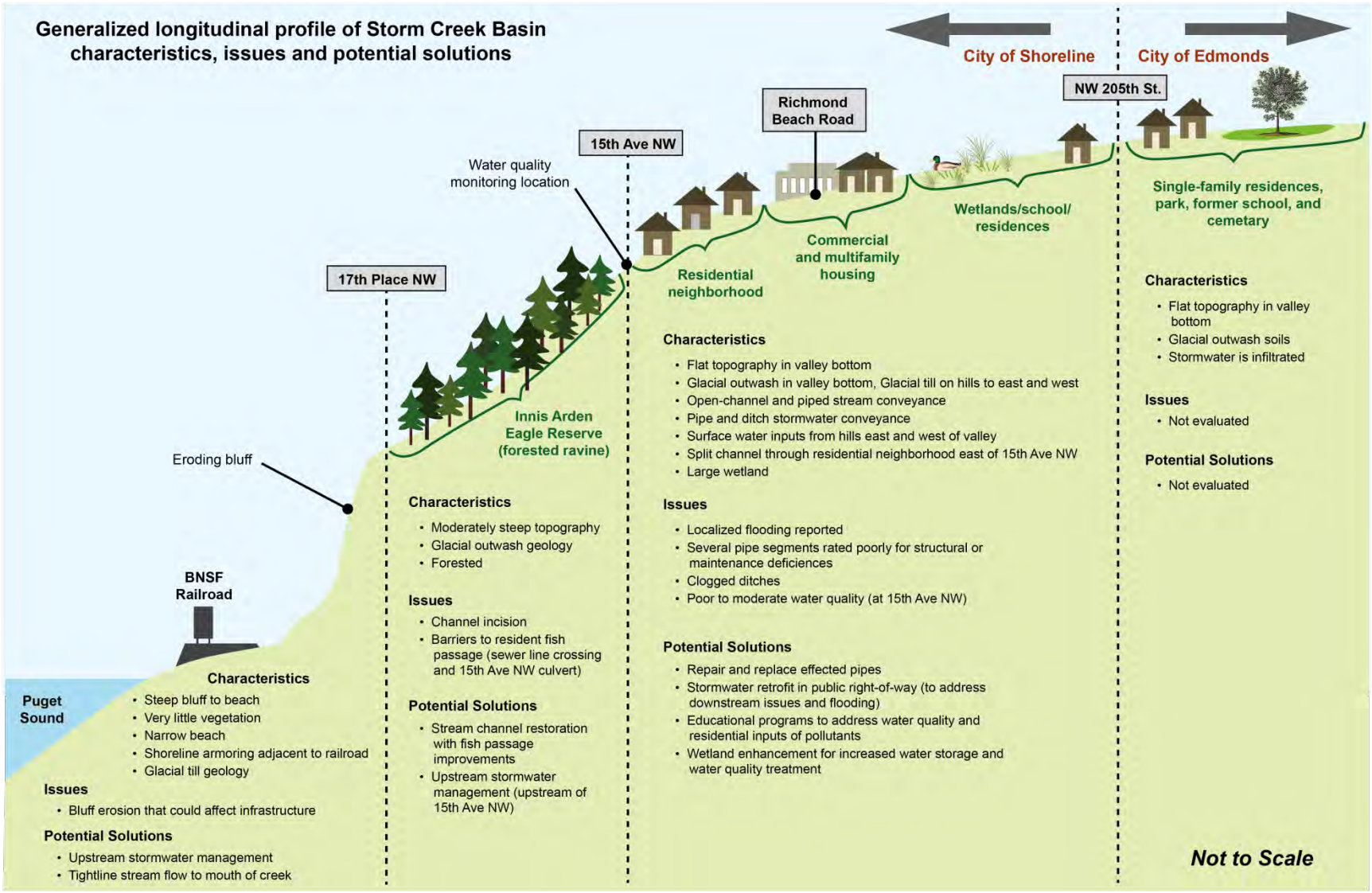


Figure 17. Schematic of Storm Creek basin characteristics, issues, and potential solutions

The basin is largely developed, and the larger undeveloped properties (Eagle Reserve and private parcels between Syre Elementary School and Richmond Beach Road) will likely not be developed in the future, because they are either considered private park land (e.g., Innis Arden reserve property) or wetlands. The potential for significant land use changes in this basin is from the redevelopment of properties that are not currently developed to their full zoning potential. Under current stormwater regulations, as redevelopment occurs, stormwater management practices will be implemented where none currently exist. In order to accelerate the process, Windward has recommended some potential options for stormwater retrofit.

The following comprehensive plan (City of Shoreline 2011c) goals apply to many of the strategies recommended below:

Goal LU XVII: Manage the stormwater and surface water system through a combination of engineered solutions and the preservation of natural systems in order to:

- Provide for public safety
- Prevent property damage
- Protect water quality
- Preserve and enhance fish and wildlife habitat and critical areas
- Maintain a hydrologic balance

Goal LU XVIII: Preserve, protect, and where feasible, restore wetlands, shoreline, surface water, and ground water for wildlife, appropriate human use, and the maintenance of hydrological and ecological processes.

Goal LU XIX: Use education as a tool to increase protection of critical areas and understanding of environmental values.

5.1 RECOMMENDED STRATEGIES

The recommended strategies discussed in this section include capital projects, programmatic and policy-oriented changes, and educational programs to affect social change for improved water quality and stormwater management functions. The projects are discussed according to the type issues addressed by the recommendation (i.e., water quality improvement, minimize erosion, improve fish passage, infrastructure maintenance and repair, etc.). However, most recommendations to solve particular issues will also have secondary benefits and those are described as well. Table 16 and Figure 18 list the recommended stormwater management strategies. Individual recommendations are also discussed below.

Table 16. Summary list of recommended projects

Issue	How was it Identified?	Specifics	Projects					
			 Capital	 Monitoring	 Education	 Studies	 Habitat	 Maintenance
Water quality	City-led water quality monitoring	High FC, TN, and TP; low DO	water quality could be incorporated into other projects	(ST-Mon-1) Improve water quality monitoring program	(ST-Ed-1) improve buffer soils and vegetation	(ST-Study-1) evaluate City landscaping policies	na	na
			na	(ST-Mon-2) inspect sanitary sewers	(ST-Ed-2) Pet waste control and education	na	na	na
			na	na	(ST-Ed-3) education on alternative yard care	na	na	na
Erosion at mouth of Storm Creek	Field evidence	Incised channel/ravine migrating east toward 17th Place Northwest	(ST-CIP-1) tightline Storm Creek	(ST-Mon-3) monitor erosion	(ST-Ed-4) bluff landscaping	(ST-Study-2) evaluate deep infiltration of stormwater	na	na
			(ST-CIP-2) convert roadside ditches to bio-infiltration swales	na	(ST-Ed-5) voluntary rain garden program	(ST-Study-3) evaluate out-of-basin routing and infiltration	na	na

Issue	How was it Identified?	Specifics	Projects					
			 Capital	 Monitoring	 Education	 Studies	 Habitat	 Maintenance
Conveyance pipe maintenance and structural deficiencies	CCTV inspection	500 – 700 ft of pipe in central part of basin in need of repair or replacement; other pipes required significant cleaning and may need modified maintenance frequency	(ST-CIP-3) stormwater upgrades 11th Avenue Northwest	(ST-Mon-4) monitor pipes not recommended for immediate replacement	na	na	na	(ST-Main-1) pipe maintenance modifications
			(ST-CIP-4) stormwater upgrades 196th Street	na	na	na	na	na
			(ST-CIP-5) Open cut pipe replacement and modification of drainage structures	na	na	na	na	na
			(ST-CIP-6) trenchless pipe repair	na	na	na	na	na
			(ST-CIP-7) remove utility crossings	na	na	na	na	na

Issue	How was it Identified?	Specifics	Projects					
			 Capital	 Monitoring	 Education	 Studies	 Habitat	 Maintenance
Habitat and fish passage	field evidence	multiple barriers, degraded stream channel habitat	na	(ST-Mon-5) cross section monitoring	na	na	(ST-Hab-1) Eagle Reserve channel restoration and fish passage improvements	(ST-Main-2) Eagle Reserve removal of non-native vegetation
			na	na	na	na	(St-Hab-2) daylight Storm Creek upstream of Richmond Beach Road	na
			na	na	na	na	(ST-Hab-3) wetland enhancement	na
			na	na	na	na	(ST-Hab-4) conservation of open space	na
Flooding	service requests and model prediction		na	na	(ST-Ed-6) ditch education program	(ST-Study-4) evaluate flooding issues at Richmond Beach Road	na	na
			na	na	(ST-Ed-7) flood education program	na	na	na

Issue	How was it Identified?	Specifics	Projects					
			 Capital	 Monitoring	 Education	 Studies	 Habitat	 Maintenance
Transportation Master Plan opportunity projects	City Transportation Master Plan	Potential roundabouts at intersection of 15th Avenue Northwest and Richmond Beach Road, and 8th Avenue Northwest and Richmond Beach Road; sidewalk improvement project on 15th Ave Northwest	(ST-CIP-8) incorporation of water quality improvements, such as rain gardens in conjunction with roundabout projects	na	na	na	na	na
			(ST-CIP-9) utilize LID techniques for new sidewalk projects; incorporate stormwater retrofit into projects	na	na	na	na	na

CCTV – closed circuit television
DO – dissolved oxygen
FC – fecal coliform
LID – low-impact development
na – not applicable
TN – total nitrogen
TP – total phosphorus

Basin-wide Projects

- ST-Ed-2
- ST-Ed-3
- ST-Study-1
- ST-Mon-4 (see Appendix F)
- ST-CIP-5 (see Appendix F)
- ST-CIP-6 (see Appendix F)
- ST-CIP-7 (see Appendix F)
- ST-Main-1 (see Appendix F)
- ST-Ed-6

Woodway Shoreline
Edmonds Shoreline
20TH AVE NW
15TH AVE NW
8TH AVE NW
NW 196TH ST
NW 195TH ST
NW 188TH ST
NW RICHMOND BEACH RD
SPRINGDALE CT NW
17TH PL NW
Storm Creek
PUGET SOUND
Kruckeberg Garden
City of Shoreline Public Open Space
Eagle Reserve
Syre Elementary School
ST-Ed-5
ST-CIP-2
ST-CIP-4
ST-Ed-5
ST-CIP-3
ST-CIP-8(b)
ST-Study-2
ST-CIP-8(a)
ST-Hab-3
ST-Hab-4
ST-Study-4
ST-Ed-7
ST-CIP-9
ST-Hab-2
ST-Ed-1
ST-Study-3
ST-Mon-1
ST-Main-2
ST-Hab-1
ST-Mon-2
ST-Mon-5
ST-CIP-1
ST-Mon-3
ST-Ed-4

Storm Creek
- Open water course
- Piped water course
- Storm Creek basin

N
0 140 280 Yards
0 100 200 Meters

Wind Ward environmental LLC

Figure 18. Locations of recommended projects

Prepared by craigh, 3/8/2013: W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig 18 5187 Recommended projects.mxd

5.1.1 Water quality

Among the sections of Storm Creek that appear to be most vulnerable to water quality impacts is the section between Richmond Beach Road and 15th Avenue Northwest. Here, the stream flow has been split between several widely separated channels, which pass though numerous back yard areas in an intensely developed residential area with little or no functional buffer area remaining. Since the potential for water quality impacts in this area is considered especially high, it is recommended that a basin-wide education and outreach program be implemented, with emphasis on this section, whereby residents can learn how to reduce and prevent impacts on the stream that passes across their properties.

Water quality concerns in the Storm Creek basin are related to high levels of FC bacteria and nutrients. The purpose of the projects listed below is to improve water quality conditions in Storm Creek, focusing on these particular constituents. Additionally, recommendations for modifications to the water quality monitoring program in Storm Creek should be considered (Section 5.1.1.1). Projects that reduce flow to Storm Creek are discussed in Section 5.1.2. Whereas the primary goal of flow reduction projects is to prevent flooding and erosion, a secondary benefit is improved water quality, since surface pollutants are less likely to be routed to receiving waters such as Storm Creek and Puget Sound when there is less flow.

5.1.1.1 Improve current water quality monitoring program (ST-Mon-1)

Stormwater runoff has a significant impact on surface water quality in urban area streams. To get the best overall picture of water body health and trends, monitoring data must be collected and tracked over several years. The City has a substantial monitoring program in place for all City-area water bodies, and has been collecting water quality data in Storm Creek since 2007; however, several potential improvements to the current monitoring program are recommended, including the following:

- Minimize data gaps—If field meters become inoperable during sampling events, or if results appear abnormal, confirmatory sampling should be re-scheduled, or grab samples should be collected and submitted to a laboratory for analysis of the parameters of interest.
- Additional monitoring—Add a monitoring location upstream of ST-2 to evaluate water quality conditions in the upper, more urbanized reaches of the Storm Creek basin.
- Improve control programs—Evaluate and expand (if necessary) City programs designed to control contaminant sources and the amount of stormwater runoff being produced. This includes the Illicit Discharge Detection and Elimination

(IDDE) Program, the Car Wash Kit Program, and the Commercial Storm Drain Inspection Program.

5.1.1.2 Reduce bacterial (FC) contamination

Sources of bacterial contamination of Storm Creek are unknown. Most homes in the Storm Creek basin are connected to a sanitary sewer, so septic systems are not anticipated to be a source. The most likely sources are thought to be domestic and wild animals, as indicated by a study of bacterial sources in a similar urban Seattle stream (City of Seattle 1993). Several potential approaches to reducing FC bacteria are listed below.

Improve Soils and Ground Vegetation in Buffers (ST-Ed-1)

Provide educational information for private citizens and City staff on the importance of soils and ground vegetation near the Storm Creek stream corridor. Improving vegetation and soils conditions would provide filtering and infiltration of runoff from areas adjacent to the riparian zone (i.e., reduce the direct input of bacteria-contaminated runoff to the creek). A similar project was also recommended in the City's 2011 Surface Water Master Plan Update (SAIC 2011).

Implement Targeted Pet Waste Control Education and Outreach (ST-Ed-2)

Review and expand ongoing education, outreach, and incentive programs to inform the public on improved pet waste control. This project could also involve installation of signs and pet waste bags at the primary access points to the Eagle Reserve trail running alongside the creek.

Inspect Sanitary Sewer Crossings over Storm Creek for Leaks (ST-Mon-2)

This project involves coordination with the Ronald Wastewater District regarding the inspection of sewer pipes in the vicinity of Storm Creek for leaks. A main sewer line crosses Storm Creek within Eagle Reserve, and there are a number of other locations where sewer lines are in close proximity to the stream channel. Ronald Wastewater District routinely inspects its entire sanitary sewer system. No leaks have been detected in the sanitary sewer lines in the Storm Creek basin.

5.1.1.3 Reduce nutrient (total nitrogen and phosphorus) concentrations

Nutrient sources in urban stormwater include fertilizer, pet waste, erosion, atmospheric deposition, and sludge. These sources are able to reach surface waters easily in urban areas due to the large amount of impervious surfaces, which do not allow runoff and its associated pollutants to be absorbed into the ground. Developed areas within the Storm

Creek basin have the most potential for increased nutrient levels in stormwater runoff. Projects to reduce nutrient levels are recommended below.

Evaluate City Procedures for Landscape Maintenance on Public Properties (ST-Study-1)

Evaluate City procedures for parks or other public properties in the basin. Determine if reductions in the application of fertilizers and pesticides are possible, and if native vegetation could be planted to improve habitat, reduce maintenance costs, and filter runoff.

Partner with Local Community Groups to Educate People on Alternative Yard Care (ST-Ed-3)

Review and expand ongoing education, outreach, and incentive programs to inform landowners on improved vegetation management techniques to reduce applications of fertilizers, properly dispose of yard waste, and improve riparian buffer conditions in the upper reaches of Storm Creek that flow through highly developed residential areas. Potential community partnerships could be with ***Birds, Bees, Fish and Trees***, or other local groups.

5.1.2 Erosion near the mouth of Storm Creek

Bluff erosion near the mouth of Storm Creek is located within Eagle Reserve and bordered by homes on either side of the stream channel. As described in the erosion memorandum (Appendix A), this erosion has resulted from a number of factors and will likely continue unabated. Although there are two homes adjacent to the channel and private property is impacted, the focus of this plan is on the public infrastructure, including the City's road, 17th Place Northwest. Public infrastructure does not appear to be imminently threatened by the stream erosion. The projects discussed below are described in more detail in Appendix G.

5.1.2.1 Monitor erosion (ST-Mon-3)

It is recommended that the rate of bluff erosion and retreat be measured on a minimum frequency of once per year, and following major storm events. Annual measurements would help the City gauge how quickly erosion is occurring, both vertically and horizontally. This information would help City staff determine when more a more aggressive approach is necessary to protect the public infrastructure.

5.1.2.2 Tightline Storm Creek (ST-CIP-1)

When bluff erosion begins to threaten public infrastructure, an alternative to reduce the rate of erosion in the vicinity of the road and sewer line is to divert all of the Storm Creek flow into a tightline between the western edge of 17th Place Northwest and the outfall onto Richmond Beach. The purpose of this project would be to reduce erosive processes being caused by stream flow. Eliminating surface flow in this reach of Storm Creek would not eliminate the ongoing bluff erosion; however, it would likely minimize the current rate at which the erosion is occurring.

5.1.2.3 Bluff education (ST-Ed-4)

Residents living on steep, eroding bluffs within the City may benefit from educational materials regarding landscaping, yard care, and other topics that may affect the stability of their property. There are several publically available documents that could be modified for City residents, or a targeted outreach program could be geared toward residential properties located on the bluffs overlooking Puget Sound. Ecology provides resources for landscaping for slope stabilization and erosion control on its website (http://www.ecy.wa.gov/programs/sea/pubs/93-30/index.html). This is one of many potential references that could be linked to the City's website or provided to Shoreline residents.

5.1.2.4 Reduce flows via basin stormwater retrofit

The lack of stormwater management facilities to control runoff from impervious surfaces is one of the factors contributing to erosion in Storm Creek within Eagle Reserve, both at the bluff and upstream of 17th Place Northwest. If the basin were to be retrofit to current stormwater management standards, it would require up to 29 acres of land being converted to stormwater management facilities at logical points in the basin, where flow could be collected and detained or infiltrated. Since the undeveloped right-of-way (ROW) (non-paved) and undeveloped properties (Eagle Reserve) only add up to 15 acres, it would not be practical to completely retrofit the basin to current stormwater standards. However, retrofit can begin through voluntary private actions (e.g., installation of rain gardens to collect and infiltrate individual roof runoff), and installation of infiltrative stormwater management techniques in City ROWs (e.g., in association with road or sidewalk improvement projects).

Voluntary Rain Garden Program (ST-Ed-5)

This project involves targeting neighborhoods where rain gardens could make a difference in the amount of flow that is routed to Storm Creek. Ideal locations for infiltration are relatively flat areas underlain by glacial outwash or thin glacial till over outwash. The northeast part of the basin, immediately east and west of 8th Avenue

Northwest, would be an ideal location from a stormwater perspective. The City could provide incentives for neighbors in this area, or technical assistance or rebates to those willing to reroute roof and or driveway runoff away from the City's stormwater infrastructure. This program could also improve the overall habitat conditions in the Storm Creek basin, providing more habitat for birds and insects and improved water quality.

Study Potential for Deep Injection of Stormwater (ST-Study-2)

This project involves conducting an evaluation of alternative sites for injection of stormwater into deep, subsurface infiltrative zones. Shorewood High School is currently implementing an underground injection program for stormwater on that school's property in the Boeing Creek basin. Deep injection of stormwater could be an option in the Storm Creek basin as well. Inferred geologic cross sections (Figures 4 and 5) indicate that the advance outwash geologic unit underlying much of the Storm Creek basin may be as thick as 200 ft in some locations. Geotechnical borings and an evaluation of potential downstream issues would need to be investigated prior to implementing such a program. One preliminary location for underground injection could be Syre Elementary School because of its large space, location in the central part of the basin, and advance outwash surface geology.

Study Potential for Routing Stormwater to Closed Depression (ST-Study-3)

This project involves conducting an evaluation of potential infiltration of stormwater in an adjacent closed depression basin located west of the Storm Creek basin in City public open space. This park property is approximately 2.6 acres in size; the surface geology is mapped as glacial recessional outwash. It may be possible to infiltrate some of the Storm Creek water to this closed depression; however, a basin transfer would need to occur, and a geotechnical analysis would need to be completed to ensure that infiltrated water didn't daylight at a location that would cause additional problems, such as slope instability.

Convert Stormwater Conveyance Ditches to Bio-infiltration Facilities (ST-CIP-2)

This project involves conversion of roadside drainage ditches to bio-infiltration facilities. There are a few roads in the Storm Creek basin where drainage is conveyed by a series of ditches and cross culverts under driveways, including 8th Avenue Northwest and 10th Avenue Northwest. These roads are relatively flat and have existing issues with ditch filling and or flooding. These areas may be appropriate for conversion to roadside infiltration facilities, which would provide water quality and quantity benefits.

5.1.3 Repair and replacement of conveyance pipes

Several hundred linear feet of pipe were identified has having poor structural or maintenance ratings scores during the condition assessment. Additionally, other types of problems were identified during the condition assessment, including utility crossings that cut right through the stormwater pipe, and improper storm drain connections. For the purpose of recommending projects to improve stormwater conveyance infrastructure, similar projects have been grouped together as one. The benefit to this approach is that several small repairs or replacement projects could be completed under one contract with the same equipment.

5.1.3.1 Stormwater upgrades 11th Avenue Northwest (ST-CIP-3)

This project includes replacing a failing CMP pipe that runs through private property, replacing a failing concrete pipe in the ROW, providing asphalt berms to prevent roadway runoff from entering private property, and other general stormwater upgrades along 11th Avenue Northwest.

5.1.3.2 Stormwater upgrades Northwest 196th Street (ST-CIP-4)

This project includes replacing the pipe under the intersection of Northwest 196th Street and 5th Avenue Northwest, along with providing a new stormwater conveyance system along 5th Avenue between 196th and 197th. There is currently no formal stormwater system to convey runoff from 197th, 196th, and 5th Avenue downstream.

5.1.3.3 Open cut pipe replacement and modification of drainage structures (ST-CIP-5)

There are 7 pipe segments (totaling 650 ft) recommended for complete replacement using an open cut technique. Most of these pipe segments were rated very poorly (greater than 4 on the SPRI) and require immediate attention within the next few years, either because of their location or the type of failure. Lateral or side storm connections improperly connected to the storm mainline is a common issue throughout the basin. Several of the connections were made with different pipe material and/or have not been grouted in, resulting in a severe structural deficiency of the storm mainline. Generally, the recommended solution for pipes in this category is to install a structure, such as a catch basin or manhole, and properly connect the incoming and outgoing pipes to the new structure. Appendix G lists the specific problems, proposed solutions, and locations of the pipes and drainage structures recommended for replacement.

5.1.3.4 Trenchless pipe repair (ST-CIP-6)

There are 10 pipe segments (totaling 775 ft) recommended for trenchless repair. This category includes pipes that received a poor structural rating, were relatively high risk and, upon further investigation, were identified to be candidates for a trenchless solution. Trenchless solutions include slip-lining, cured in place pipe (CIPP), pipe bursting, pipe reaming, and others. Appendix G lists the specific problems, proposed solutions, and locations of the pipes recommended to be repaired with trenchless solutions.

5.1.3.5 Remove utility crossings (ST-CIP-7)

Structural deficiencies have resulted directly from utility crossings through the storm drain pipe. Unidentified conduit, likely containing cable, fiber optic, or electrical services, were the primary crossing issues, but there were also some waterlines identified. It is recommended that the City identify the likely utility owner and coordinate relocation of the utility crossings and repair of the stormwater pipe. Appendix G lists the specific utility crossing locations and size of conduit.

5.1.3.6 Monitor pipes not recommended for immediate repair (ST-Mon-4)

Pipes that did not fall into the categories described above, yet received a poor structural rating, are included in this category. Structural deficiencies in this category include pipes with fractures, holes, minor deformity, and other problems. It is recommended that the City actively monitor these pipes to ensure the structural deficiency does not worsen. Appendix G lists the specific problems, proposed solutions, and locations recommended for monitoring.

5.1.3.7 Maintenance modifications (ST-Main-1)

The pipes identified as having a poor maintenance rating (≥ 4.0) were reviewed carefully. The majority of the pipes in the Storm Creek basin were cleaned prior to the CCTV work, and therefore only seven pipes received poor maintenance ratings. A map and table showing pipes that required extensive cleaning prior to CCTV are provided in Appendix G.

From the condition assessment, several pipes were identified as likely to need frequent maintenance or pipe jetting. Potentially, these pipes may also need to be replaced in the future if the frequent sedimentation is due to an inadequate design. Appendix G lists the specific problems, proposed solutions, and locations recommended for monitoring.

5.1.4 Habitat

Stormwater quality and quantity are foremost considerations with respect to in-stream habitat along Storm Creek. High-quality stream and wetland habitat are generally not attainable if flows are too flashy and/or water quality suffers from high turbidity, heavy sedimentation, and/or high levels of chemical contaminants. For small basins such as Storm Creek's, with relatively little (and marginal) fish habitat, projects that emphasize stormwater quality and quantity retrofit (discussed above) will result in higher quality water being discharged to Puget Sound. Relatively wide and well-vegetated stream and wetland buffers are key elements contributing to detention and bio-filtration functions, leading to the desired result of providing clean water to Puget Sound.

The projects listed below are primarily habitat related, but would also provide water quality benefits and, in some cases, improved water quantity control functions. The projects listed in Eagle Reserve are not recommended to be final, but rather to be placeholders as possible mitigation opportunities for other projects in the basin.

5.1.4.1 Eagle Reserve channel restoration and fish passage improvements (ST-Hab-1)

This project involves installation of grade control, such as large wood or other structures, to minimize incision, trap sediment, and form pools. Specific locations are not identified (other than Eagle Reserve), but as it would be important to minimize construction disturbance associated with the restoration work, locations near road access (such as 17th Place Northwest or 15th Avenue Northwest) would be better than locations in the middle of the reserve. In association with any restoration project, it would be beneficial to provide fish passage improvements where passage is impaired. Currently, the sewer line crossing Eagle Reserve is a barrier to resident fish passage, and modifications should be made to improve passage for resident fish. In the City's *Surface Water Master Plan Update* (SAIC 2011), installation of large wood was recommended to help stabilize stream banks in this reach.

5.1.4.2 Eagle Reserve removal of non-native vegetation (ST-Main-2)

This project involves removal of non-native vegetation within Eagle Reserve. Typically non-native vegetation, such as Himalayan blackberries and other invasive species, will prevent the growth of more desirable native vegetation. Removal and maintenance of invasive species will improve the riparian corridor in Eagle Reserve to the benefit of birds and wildlife as well as water quality.

5.1.4.3 Daylight Storm Creek upstream of Richmond Beach Road (ST-Hab-2)

This project involves daylighting an existing piped channel near the Meadowbrook Apartments to create a combination stream channel, floodplain, and wetland. The potential benefits of this type of project include increased water storage during storm events and water quality filtration. The City has an existing stormwater easement in this location that could be utilized for the project. Additionally, this project could be combined with the wetland enhancement (ST-Hab-3) discussed below.

5.1.4.4 Wetland enhancement between Meadowbrook Apartments and Syre Elementary School (ST-Hab-3)

This project involves acquisition of undeveloped, partially wooded parcels for the purposes of stream enhancement, wetland enhancement, non-native plant species removal, passive recreation, trails, and other park uses. This project would provide a minor amount of flow reduction benefit (Appendix B), and there could be opportunities for mitigation credits to pay for restoration and park improvements.

5.1.4.5 Conservation of open space (ST-Hab-4)

Of the three large forested areas in the basin, the six contiguous properties downstream of Syre Elementary School are the least protected, and therefore have the most habitat vulnerability. Protection of this area could involve implementation of conservation easements or separation of the area into open space tracts. The incentives for property owners could include acquisition transactions and/or the potential for lowered property tax burdens.

5.1.4.6 Cross section monitoring (ST-Mon-5)

This project involves annual evaluation of physical channel conditions in Eagle Reserve to monitor changes for the purpose of understanding the stability of the existing channel. Annual monitoring will help answer the question of whether Storm Creek within Eagle Reserve is actively causing incision, or whether the current channel has already adjusted to a changed flow regime.

Implied and encompassed within the above projects is the preservation and enhancement of areas of existing, mostly native vegetation along the stream. These well-vegetated buffer areas provide important bio-filtration and infiltration functions to improve water quality and provide flow attenuation for the stream and its receiving water, Puget Sound.

5.1.5 Flooding

As described in Sections 4.5 and 4.6.2, much of the flooding in the Storm Creek basin has resulted from clogged ditches or pipes. Chronic flooding used to occur at the Meadowbrook Apartments near the intersection of 15th Avenue Northwest and Richmond Beach Road, but a project to increase pipe capacity in this area appears to have alleviated the problem in all but the very largest storm events. This area flooded again in December 2007, when the second largest 24-hour rain event in the last 60 years occurred. Modeling conducted for this basin study does not definitively indicate major flooding problems resulting from undersized or inappropriately designed infrastructure. The one location where an additional study might be conducted is near the Meadowbrook Apartments east of 14th Place Northwest on Richmond Beach Road. The following projects address flooding.

5.1.5.1 Ditch education program (ST-Ed-6)

This project involves educating residents located adjacent to drainage ditches about their responsibility to keep the ditches clear and free of debris, including yard waste and trash. Additionally, providing information to homeowners on the importance of the drainage ditches to the overall stormwater infrastructure functionality would be useful.

5.1.5.2 Flooding assessment at Richmond Beach Road, east of 14th Place Northwest (ST-Study-4)

The EPA SWMM analysis predicts flooding at this location during a 25-year event. Additional study will be necessary to confirm if a flood reduction project should be implemented at this location.

5.1.5.3 Flood education program (ST-Ed-7)

Residents in the vicinity of Richmond Beach Road and 15th Avenue Northwest might benefit from information on flooding, and how they can protect themselves and their property against damages. Information of obtained flood insurance and what to do in the event of flooding would be useful, especially to apartment residents who may not be aware of available resources.

5.1.6 Transportation Master Plan opportunities

The City's Transportation Master Plan (City of Shoreline 2011b) was reviewed for potential project opportunities in connection with identified road and pedestrian projects. Two projects are located immediately adjacent to the Storm Creek basin and one is within the basin. Potential stormwater enhancements are recommended in association with these projects.

5.1.6.2 Water quality improvements in conjunction with traffic roundabouts (ST-CIP-8[a] and [b])

Two potential roundabout projects are identified in the Transportation Master Plan (City of Shoreline 2011b): one at 15th Avenue Northwest and Richmond Beach Road, and the other at 8th Avenue Northwest and Richmond Beach Road. While both of these locations are just outside of the Storm Creek basin boundary, portions of these intersections could drain to Storm Creek. Incorporation of a water quality treatment method, such as a rain garden in the center of the roundabout, would provide aesthetic landscaping as well as water of improved quality to receiving waters.

5.1.6.3 Utilize LID techniques for sidewalk improvements along 15th Avenue Northwest in the 188th Street vicinity (ST-CIP-9)

A pedestrian improvement project is identified in the City's Transportation Master Plan (City of Shoreline 2011b) on 15th Avenue Northwest between Northwest 188th Street and Northwest 192nd Street. There are several potential LID opportunities in conjunction with new sidewalks, including installation of roadside bio-infiltration swales for water quality treatment, and construction of sidewalks utilizing permeable materials.

6 Project Prioritization and Costs

The projects recommended in Section 6 represent a variety of strategies to manage stormwater in the Storm Creek basin. Many of the projects involve specific infrastructure repair and replacement opportunities based on the results of the condition assessment; others require longer-term commitments to reduce the effects of past development practices that occurred when stormwater best management practices were less known and infrequently used. Several criteria were used to prioritize the projects within the context of just the Storm Creek basin. These projects will no doubt be prioritized with regard to the City's entire stormwater management program, and may rank lower with respect to other City-wide issues.

6.1 CRITERIA

Table 17 lists the criteria for project prioritization and shows the conditions under which each criterion's score will rank as high, medium, or low.

Table 17. Criteria and scoring for project prioritization

Criteria	Rank Scores		
	High (5 points)	Medium (3 points)	Low (1 point)
Likelihood of success	proven in other cases	mixed results	unproven
Number of issues addressed (water quality, habitat, erosion, flooding)	three	two	one
Protects infrastructure and public safety	both	one or the other	none
On public property	in ROW or existing easement	requires easement on other public property	private property
Cost	low (< $20,000)	medium ($20K to $50K)	high (> $50,000)

ROW – right-of-way

The combined scores of individual criteria were ranked according to the following total points:

- Low priority (13 points or fewer)
- Medium priority (13 to 18 points)
- High priority (19 points or more)

6.2 MATRIX OF PROJECTS

Table 18 lists the recommended projects according to issue addressed, cost, and prioritization criteria from highest to lowest.

Table 18. Matrix of prioritized projects

Issue	Project Name	Type	Prioritization Criteria					Total Score and Priority
			Likelihood of Success	Number of Issues Addressed	Protects Infrastructure or Public Safety	On Public Property	Cost	
WQ	(ST-Mon-1) improve WQ monitoring program		medium (3)	low (1)	low (1)	high (5)	low $ (5)	MEDIUM (15)
	(ST-Ed-1) improve buffer soils and vegetation		medium (3)	medium (3)	low (1)	low (1)	low $ (5)	LOW (12)
	(ST-Study-1) evaluate City landscaping policies		medium (3)	low (1)	medium (3)	high (5)	low $ (5)	MEDIUM (17)
	(ST-Mon-2) inspect sanitary sewers		high (5)	low (1)	medium (3)	medium (3)	moderate $ (3)	MEDIUM (15)
	(ST-Ed-2) pet waste control and education		medium (3)	low (1)	medium (3)	medium (3)	low $ (5)	MEDIUM (15)
	(ST-Ed-3) education on alternative yard care		medium (3)	low (1)	low (1)	low (1)	low $ (5)	LOW (11)

Issue	Project Name	Type	Prioritization Criteria					Total Score and Priority
			Likelihood of Success	Number of Issues Addressed	Protects Infrastructure or Public Safety	On Public Property	Cost	
Erosion at mouth of Storm Creek	(ST-CIP-1) tightline Storm Creek		medium (3)	medium (3)	high (5)	low (1)	high $ (1)	LOW (13)
	(ST-Mon-3) monitor erosion		medium (3)	medium (3)	high (5)	low (1)	low $ (5)	MEDIUM (17)
	(ST-Ed-4) bluff landscaping		medium (3)	low (1)	medium (3)	low (1)	low $ (5)	LOW (13)
	(ST-CIP-2) convert roadside ditches to bio-infiltration swales		medium (3)	high (5)	medium (3)	high (5)	high $ (1)	MEDIUM (17)
	(ST-Ed-5) voluntary rain garden program		medium (3)	high (5)	medium (3)	low (1)	medium (3)	MEDIUM (15)
	(ST-Study-2) evaluate deep infiltration of stormwater		high (5)	high (5)	high (5)	medium (3)	high $ (1)	HIGH (19)
	(ST-Study-3) evaluate out of basin routing and infiltration		high (5)	high (5)	high (5)	high (5)	high $ (1)	HIGH (19)

Issue	Project Name	Type	Prioritization Criteria					Total Score and Priority
			Likelihood of Success	Number of Issues Addressed	Protects Infrastructure or Public Safety	On Public Property	Cost	
Conveyance pipe maintenance and structural deficiencies	(ST-CIP-3) stormwater upgrades at 11th Avenue Northwest		high (5)	high (5)	high (5)	high (5)	high $ (1)	HIGH (21)
	(ST-Mon-4) monitor pipes not recommended for immediate replacement		high (5)	low (1)	medium (3)	high (5)	low $ (5)	HIGH (19)
	(ST-Main-1) pipe maintenance modifications		medium (3)	medium (3)	high (5)	high (5)	medium $ (3)	HIGH (19)
	(ST-CIP-4) stormwater upgrades on 196th Street		medium (3)	low (1)	medium (3)	high (5)	high $ (1)	LOW (13)
	(ST-CIP-5) open cut pipe replacement and modification of drainage structures		high (5)	medium (3)	high (5)	high (5)	high $ (1)	HIGH (19)
	(ST-CIP-6) trenchless pipe repair		high (5)	medium (3)	high (5)	high (5)	high $ (1)	HIGH (19)
	(ST-CIP-7) remove utility crossings		high (5)	low (1)	high (5)	high (5)	low $ (5)	HIGH (21)

Issue	Project Name	Type	Prioritization Criteria					Total Score and Priority
			Likelihood of Success	Number of Issues Addressed	Protects Infrastructure or Public Safety	On Public Property	Cost	
Habitat and fish passage	(ST-Mon-5) cross section monitoring		high (5)	medium (3)	low (1)	medium (3)	low $ (5)	MEDIUM (17)
	(ST-Hab-1) Eagle Reserve channel restoration and fish passage improvements		medium (3)	high (5)	low (1)	low (1)	high $ (1)	LOW (11)
	(ST-Main-2) Eagle Reserve removal of non-native vegetation		high (5)	medium (3)	low (1)	low (1)	low $ (5)	MEDIUM (15)
	(St-Hab-2) daylight Storm Creek upstream of Richmond Beach Road		medium (3)	high (5)	high (5)	high (5)	high $ (1)	HIGH (19)
	(ST-Hab-3) wetland enhancement		medium (3)	high (5)	medium (3)	low (1)	high $ (1)	LOW (13)
	(ST-Hab-4) conservation of open Space		high (5)	medium (3)	low (1)	low (1)	high $ (1)	LOW (11)

Issue	Project Name	Type	Prioritization Criteria					Total Score and Priority
			Likelihood of Success	Number of Issues Addressed	Protects Infrastructure or Public Safety	On Public Property	Cost	
Flooding	(ST-Ed-6) ditch education program		medium (3)	high (5)	high (5)	high (5)	low $ (5)	HIGH (23)
	(ST-Study-4) evaluate flooding issues at Richmond Beach Road		medium (3)	low (1)	medium (3)	high (5)	medium $ (1)	LOW (13)
	(ST-Ed-7) flood education program		high (5)	low (1)	medium (3)	high (5)	low $ (5)	HIGH (19)
Transportation Master Plan opportunity projects	(ST-CIP-8) incorporation of water quality improvements, such as rain gardens in conjunction with roundabout projects		medium (3)	medium (3)	medium (3)	high (5)	high $ (1)	MEDIUM (15)
	(ST-CIP-9) utilize LID techniques for new sidewalk projects; incorporate stormwater retrofit into project		medium (3)	medium (3)	medium (3)	high (5)	high $ (1)	MEDIUM (15)

City – City of Shoreline
LID – low-impact development
WQ – water quality

6.3 ESTIMATED COSTS FOR HIGH PRIORITY PROJECTS AND PROGRAMS

The estimated cost for the projects and program elements that ranked highest in priority is approximately $800,000. Table 19 summarizes the projects and issues that would be addressed through implementation of these projects. Conveyance pipe maintenance and repair projects account for half of the $800,000 estimate. Some of these conveyance pipe projects could be deferred for a few years, but should be addressed within the next five years to minimize the chance of failure or other associated problems.

Infiltration or out of basin routing of stormwater could minimize future erosion in Storm Creek and potentially help minimize erosion at the mouth of Storm Creek. It appears that either of these options might be viable based on surface geology and limited subsurface geologic information, however, more information would be needed to assess actual subsurface conditions. Recommended projects (ST-Study-2 and ST-Study-3) could be combined to evaluate these options.

Two relatively low cost educational efforts are recommended to help minimize localized flooding in roadside ditches and help residents in the Richmond Beach Road at 15th Avenue NW neighborhood (ST-Ed-6 and ST-Ed-7). These education efforts could be implemented by City staff and would cost approximately $16,000 for materials and staff time.

Table 19. Summary list of highest priority projects and estimated costs

Issue	Project Name	Type	Total Score and Priority	Estimated Cost
Erosion at the mouth of Storm Creek	(ST-Study-2) evaluate deep infiltration of stormwater		HIGH (19)	$50,000
	(ST-Study-3) evaluate out of basin routing and infiltration		HIGH (19)	$30,000
Conveyance pipe maintenance and structural deficiencies	(ST-CIP-3) stormwater upgrades at 11th Avenue Northwest		HIGH (21)	$103,000
	(ST-Mon-4) monitor pipes not recommended for immediate replacement		HIGH (19)	$1,500/year
	(ST-Main-1) pipe maintenance modifications		HIGH (19)	$10,000

Issue	Project Name	Type	Total Score and Priority	Estimated Cost
	(ST-CIP-5) open cut pipe replacement and modification of drainage structures		HIGH (19)	$293,000
	(ST-CIP-6) trenchless pipe repair		HIGH (19)	$180,000
	(ST-CIP-7) remove utility crossings		HIGH (21)	$2,000 – $5,000 (City staff time to coordinate utility crossing removals and follow-up)
Habitat and fish passage	(St-Hab-2) daylight Storm Creek upstream of Richmond Beach Road		HIGH (19)	> $100,000
Flooding	(ST-Ed-6) ditch education program		HIGH (23)	$8,000
	(ST-Ed-7) flood education program		HIGH (19)	$8,000

City – City of Shoreline

Four additional projects were ranked on the high end of medium priority, three of which are relatively low cost and should be considered if there is additional funding available. These additional projects include two monitoring projects to assess changes in the erosion near the mouth of Storm Creek (ST-Mon-3) and geomorphic changes in the channel within Eagle Reserve (ST-Mon-5), and an evaluation of City landscaping policies (ST-Study-1). Additionally, a project to convert roadside ditches to bio-infiltration facilities (ST-CIP-2) would reduce stormwater runoff to Storm Creek, and could potentially help minimize downstream erosion. Table 20 lists these higher ranked medium priority projects and associated costs.

Table 20. Summary list of highest-ranked medium priority projects and estimated costs

Issue	Project Name	Type	Total Score and Priority	Estimated Cost
Water quality	(ST-Study-1) evaluate City landscaping policies		MEDIUM (17)	$4,000
Erosion at mouth of Storm Creek	(ST-Mon-3) monitor erosion		MEDIUM (17)	$6,000 first year, $1,000/annually in subsequent years
	(ST-CIP-2) convert roadside ditches to bio-infiltration swales		MEDIUM (17)	$617,000
Habitat and fish passage	(ST-Mon-5) cross section monitoring		MEDIUM (17)	$4,000/year

City – City of Shoreline

7 Partnerships/Grant Opportunities

Funding stormwater management programs in addition to other City functions has been a challenge in recent years. Increasingly, many communities are looking to partnerships and grant funding to relieve some of the financial strain. For the various projects recommended in this plan, there are opportunities to partner with other community and educational organizations for implementation, as well as to pursue grant opportunities from a myriad of organizations. Potential community groups and organizations that could be partnered with for some of the recommended options are shown in Table 21.

Table 21. Recommended projects with opportunities for partnerships

Recommended Project	Potential Partners							
	Master Gardeners and Composters	Neighborhood Groups	Shoreline Community College	Shoreline School District	Ronald Wastewater District	Birds, Bees, Fish and Trees	City Transportation Department	Shoreline Residents
ST-Ed-1	√	√						
ST-Ed-2		√						
ST-Ed-3	√					√		
ST-Mon-2					√			
ST-Ed-4	√							
ST-Ed-5	√		√	√				
ST-CIP-1		√						
ST-CIP-2								√
ST-CIP-3								√
ST-Mon-5			√					
ST-Main-2		√						
ST-Hab-1		√			√			
ST-Hab-2		√				√		
ST-Hab-3		√				√		
ST-Hab-4								√
ST-Ed-7								√
ST-CIP-8(a) and (b)							√	
ST-CIP-9							√	

Grant opportunities that could be utilized for some of the projects, particularly those related to water quality, are listed in Table 22.

Table 22. Potential grant opportunities for Storm Creek basin recommended projects

Title of Grant	Granting Agency	Website	Timeframe	Requirements (Matching Funds, Nonprofit, etc.)	Types of Projects Covered
Centennial Clean Water Fund	Ecology	http://www.ecy.wa.gov/programs/wq/funding/funding.html	September – November, annually	varies	non-point source pollution reduction, stormwater, LID
Clean Water Act Section 319 Grant Program	Ecology	http://www.ecy.wa.gov/programs/wq/funding/funding.html	September – November, annually	varies	high priority on load reductions of nutrients, phosphorus, and sediment
Washington State Pollution Control Board Revolving fund	Ecology	http://www.ecy.wa.gov/programs/wq/funding/funding.html	September – November, annually	varies, requires state matching	varies
Invasive Plant Management Fund	Center for Invasive Plant Management	http://www.weedcenter.org	varies	varies	water quality, habitat restoration/improvements, community involvement
Environmental Education Grants	EPA	http://www.epa.gov/education/grants/index.html	fall	match, typically $25,000 maximum	education
Land and Water Conservation Fund	Washington State Conservation Commission	http://www.rco.wa.gov/grants/lwcf.shtml	fall	50% match	acquisition and development of passive and active recreation areas

Ecology – Washington State Department of Ecology
EPA – US Environmental Protection Agency
LID – low-impact development

8 References

Booth DB, Cox BF, Troost KG, Shimel SA, cartographers. 2004. Composite geologic map of the Sno-King area. Scale: 1:24,000. Seattle-Area Geologic Mapping Project, University of Washington, Seattle, WA. Available from: http://geomapnw.ess.washington.edu/services/publications/map/data/Geology_SnoKing_Draft.pdf.

City of Seattle. 1993. Pipers Creek bacteriological source tracking investigation. Prepared by Herrera Environmental Consultants, Inc. and University of Washington Department of Environmental Health for Seattle Engineering Department, Drainage and Wastewater Utility. Seattle, WA.

City of Shoreline. 2011a. 2011-2017 parks, recreation and open space plan. City of Shoreline, WA.

City of Shoreline. 2011b. 2011 transportation master plan. Draft. City of Shoreline, WA.

City of Shoreline. 2011c. Comprehensive plan [online]. City of Shoreline, WA. Available from: http://www.cityofshoreline.com/index.aspx?page=478.

Ecology. 2005. Stormwater management manual for Western Washington. Water Quality Program, Washington State Department of Ecology, Olympia, WA.

Ecology. 2008. Washington State's water quality assessment [303(d)] database: Category 5 waters in Elliott Bay and Duwamish Waterway [online]. Washington State Department of Ecology, Olympia, WA. [Cited March 1, 2009.] Available from: http://www.ecy.wa.gov/PROGRAMS/wq/303d/index.html.

Ecology. 2012. Water resources explorer: Welcome to the Department of Ecology's statewide water rights web map [online]. Washington State Department of Ecology, Seattle, WA. Available from: http://www.ecy.wa.gov/programs/wr/info/webmap.html.

EPA. 2000. Ambient water quality criteria recommendations: Information supporting the development of State and Tribal nutrient criteria for rivers and streams in nutrient ecoregion II. EPA 822-B-00-015. US Environmental Protection Agency, Washington, DC.

ESA Adolfson. 2010. Shoreline inventory and characterization. Prepared for City of Shoreline. ESA Adolfson, Seattle, WA.

Hallock D. 2002. A water quality index for Ecology's stream monitoring program. Pub no 02-03-052. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA.

Hartley J. 1995. Letter report addressing Innis Arden salmonids. King County SWM.

Hennick D. 1999. Letter report addressing wetland violation on Storm Creek. Washington Department of Fish and Wildlife.

Hruby T. 2004. Washington State wetland rating system for Western Washington. Revised. Annotated Version August 2006. Ecology publication #04-06-025. Washington State Department of Ecology, Olympia, WA.

NOAA. 2012. National Climatic Data Center: climate data online [online database]. National Oceanic and Atmospheric Administration Satellite and Information Service, Washington, DC. Available from: http://www.ncdc.noaa.gov/cdo-web/search;jsessionid=C3A945D6FA40F7FE94F0F24A4D607F0A.lwf3.

Omernik JM. 1987. Ecoregions of the conterminous United States. Ann Assoc Amer Geogr 77(1):118-125.

Reiser DW, Bjornn TC. 1979. Habitat requirements of anadromous salmonids. In: Meehan WR, ed, Influence of forest and rangeland management on anadromous fish habitat in western North America. GTR PNW-96. American Fisheries Society, Bethesda, MD, pp 83-138.

SAIC. 2011. Surface water master plan update, City of Shoreline. Draft report. Science Applications International Corporation, Bothell, WA.

Tetra Tech/KCM. 2004. City of Shoreline stream and wetland inventory and assessment. Appendices. Tetra Tech/KCM, Inc., Seattle, WA.

Watershed Company. 2009. 2007 Bioassessment report: biological and habitat assessment of Shoreline streams. Final. The Watershed Company, Kirkland, WA.

Williams J. 2010. 2009 fresh water assessment report: state of the water quality in Shoreline streams, lakes and wetlands. Public Works Department, City of Shoreline, WA.

WRCC. 2006. Seattle Tacoma WSCMO AP, Washington: monthly total precipitation (inches) [online]. Western Regional Climate Center. Updated July 25, 2006. Available from: http://www.wrcc.dri.edu/cgi-bin/cliMONtpre.pl?waseat.

APPENDIX A. FINAL DRAFT MEMORANDUM: EROSION IN LOWER STORM CREEK

200 West Mercer St. • Suite 401 • Seattle, WA 98119
Phone: 206.378.1364 • Fax: 206.973.3048 • www.windwardenv.com

FINAL MEMORANDUM

To: Brian Landau, PE, LEG, City of Shoreline

From: Erin Nelson, PE, LG, Windward Environmental LLC
Derek Booth PhD, PG, PE, Cambria Science and Communication

Subject: Erosion in Lower Storm Creek

Date: January 25, 2012

BACKGROUND AND PURPOSE

Erosion in the lower reach of Storm Creek has been part of the geologic changes that have accelerated in the past few decades, which is a cause for concern for local residents who have homes on the adjacent bluffs. The City of Shoreline and Ronald Wastewater are also interested in the erosion because of the public facilities (road and wastewater line) in the lower reach of Storm Creek This memorandum summarizes the results of an erosion assessment conducted at the mouth of Storm Creek and throughout the upstream watershed to identify potential causes of this erosion and possible solutions to reduce the erosion.

PAST AND EXISTING CONDITIONS

In the assessment of Storm Creek, several previous studies, investigations, photos, and maps were reviewed to better understand the historical conditions and potential causes of the erosion that is now being manifest. A list of these documents and their general findings are presented in Table 1. A timeline for various events relevant to the Storm Creek basin are identified in Figure 1.

Table 1. Documents reviewed and general findings

Document	Date	Author(s)	Focus	Findings and Significance
Storm Creek Phase I Study (Foley 1993)	1993	Steve Foley, King County	flooding at Meadowbrook Apartments	No stormwater/erosion complaints in the vicinity of current erosion were documented by King County. Reference to "waterfall above the railroad tracks" indicates Storm Creek had not started downcutting at the mouth as of 1993. Alternatives that were evaluated acknowledged increased peak flows and erosion if these alternatives were implemented**.**
Storm Creek Drainage Improvements As-Built Plans (King County 1994)	1994	King County	flooding at Meadowbrook Apartments	Conveyance system in vicinity of Meadowbrook Apartments was modified with new, larger-capacity pipes and diversions to prevent apartment building flooding.
Storm Creek Ravine Preliminary Analysis (Otak 2009)	2009	Russ Gaston and Michelle Claassen, Otak	slope stability and erosion in lower reach of Storm Creek	The stream has "incised several vertical steps into the glacial till and is likely undergoing episodic headward erosion toward the road crossing…." Instability of ravine is "…due to fractures in the glacial till and oversteepening of the slope from stream erosion." Recommendations included further geotechnical investigation to determine if the ravine walls (private property) were stable, and then: • Repositioning existing debris to outside edges to protect toe of slope. from further erosion • Excavating a channel with step pools to keep water concentrated in the center, or filling ravine and creating a fishway
Preliminary Report on the Hydrology of the Storm Creek Basin (NHC 2010)	2010	Malcolm Leytham, NHC	hydrology of Storm Creek and causes of erosion	"The hydrologic regime has been significantly altered by land use change in the watershed." "Increased flows have resulted in serious erosion in the reach of Storm Creek downstream from 17th Place NW and have caused downcutting or incision of the channel…" "…runoff contribution from Innis Arden is …not a significant factor in the current serious erosional problems…."
Storm Creek Erosion with Photo Documentation (Harrington [undated])	2010?	Peter Harrington	ravine erosion in lower Storm Creek and safety issues	Significant erosion occurred between 2002 and 2010, as documented by photos. There is concern for the safety of trespassers who use the "cave" in the ravine for bonfires, drinking, and smoking on this section of private property "…25 years ago, the lower part of Eagle Reserve from 17th Place NW to almost the edge of the bluff was a shallow depression, ending in a 20-ft waterfall near the RR tracks."

Document	Date	Author(s)	Focus	Findings and Significance
Erosion Issues in the Lower Section of Eagle Reserve (Leary 2009a)	2009	T Richard Leary, Innis Arden Club	documentation of erosion in Eagle Reserve, including causes and consequences	"Within Innis Arden II a wetland existing prior to 1970…This wetland was filled…to create the soccer field and play area.…" "A series of Gabions have been placed along the lower section of Storm Creek to help stabilize the erosion problems." Gabions near 17th Place NW were installed in 2003, after the road washed out. Gabions were installed by either King County or Ronald Waste Water to protect the sewer line. Photos show cracks in the surface on the south side of the bluff (Akers property), indicating instability and evidence of movement.
Statement of Compelling Environmental Benefit: Eagle Reserve (Leary 2009b)	2009	T Richard Leary, Innis Arden Club	stormwater and erosion issues from Storm Creek in Eagle Reserve	Upper end of the Eagle Reserve trail was washed out in the winter of 2007-2008, exposing an old sanitary sewer line that had run through the reserve and been replaced approximately 10 years earlier.
USGS Sno-King Composite Geologic Map (Booth et al. 2004)	2004	Booth et al.	geologic map	Glacial drift, a very compact, heterogeneous mixture of gravel, sand and silt is the geologic material that forms the bluff that is being eroded in the lower Storm Creek ravine. Detailed material properties were not specified in this reference.
King County i-Map parcel viewer (http://www.kingcounty.gov/operations/gis/proprese arch/parcelviewer , accessed Sept. 2011)	2011	King County	information on the age of development	Approximately 90% of the existing homes and businesses in the Storm Creek basin in Shoreline were constructed before 1980, and 70% were constructed before 1970. This does not include the portion of the basin in Edmonds.
GIS data layers	2011	City of Shoreline	stormwater and sanitary sewer infrastructure	Upstream of 15th Avenue NW, Storm Creek consists of short sections of open channel and pipes. Stormwater conveyance to the stream is mostly in ditches and pipes. Sanitary sewer lines in the vicinity of Storm Creek erosion were installed in 1970.
Aerial photographs	1936 1941 1970 1988 1995 2001 2007	Various sources (e.g., USGS, King County, Google® Earth)	historical imagery (land use changes)	Significant development occurred between 1941 and 1970 (area was mostly rural in 1941). Approximately 70% of the basin was developed prior to 1970 and 90% of the basin was developed before 1990. This does not include the portion of the basin in Edmonds.

GIS – geographic information system
NHC – Northwest Hydraulic Consultants
USGS – US Geological Survey

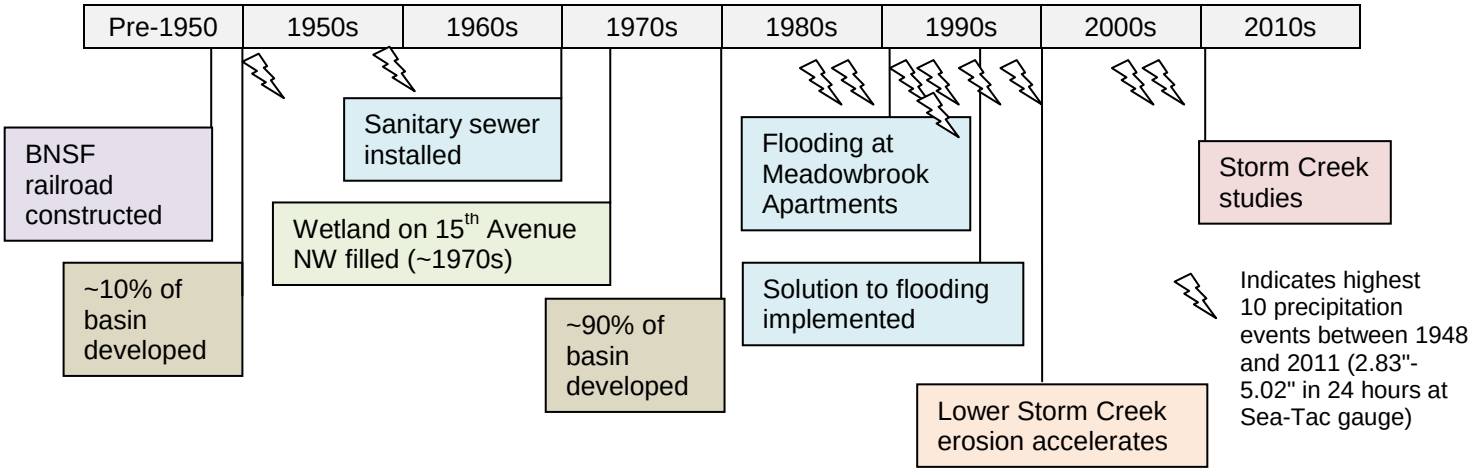


Figure 1. Timeline of events relevant to Storm Creek Basin

FIELD RECONNAISSANCE

Windward Environmental LLC (Windward) conducted a field reconnaissance on September 20, 2011, to observe current conditions and field-check information obtained from documents described detailed in Table 1. Windward staff walked along the Storm Creek stream channel from the mouth at the Burlington Northern Santa Fe (BNSF) railroad tracks to 15th Avenue NW in the Eagle Reserve (owned by the Innis Arden Club). For comparison purposes, staff also walked along the Heron Creek stream channel in the Heron Reserve (which is also owned by the Innis Arden Club). The Heron Creek basin is similar to Storm Creek basin in age of development, geologic setting, and topography, although it has a smaller drainage area.

ASSESSMENT OF EROSION FACTORS IN STORM CREEK

Erosion along the lowermost 300 ft of Storm Creek, from 17th Place NW to the BNSF railroad tracks, has been active for at least a decade. The form of the developing ravine is reminiscent of literally dozens of such features throughout King County and the entire Puget Sound lowlands, many of which were observed to form over a period of a few years in the immediate aftermath of upstream urban development in the early to mid-1980s (e.g., Booth 1989). What makes Storm Creek unusual in the context of the regional record is the long period of relative land-use stability, in that the vast majority of the contributing watershed was built out in the 1960s and has undergone little apparent change since that time. Although a few additional parcels have been infilled and/or developed since the 1990s after City incorporation, they appear to be quantitatively insufficient to serve as an obvious source of increased runoff. The only modification to drainage in the Storm Creek basin appears to be improvements constructed in 1994 at the Meadowbrook Apartments to alleviate flooding. These improvements are potential source of increased peak flows, although no hydrologic modeling has been conducted to confirm this. Nonetheless, any explanation for the

current conditions in Storm Creek (which, in turn, may lead to a potential alleviation of those conditions) could involve a variety of factors. These have been considered and are detailed below.

Topography

The longitudinal profile of Storm Creek has a natural break in slope, approximately at the location of the 17th Place NW crossing. Above this point, the stream flows in a moderately confined upland channel at an average gradient of about 3 to 4%, which is typical for lowland streams in this general topography. Below the road crossing, the bed steepens abruptly, with an average gradient of almost 30%, and includes short reaches of near-vertical falls interspersed with short, relatively flat reaches (Figure 2). In general, such a slope is not stable over the long term and will continue to seek a lower course with a flatter gradient. This process is now occurring on an annual basis along the lower reach of Storm Creek. As the bottom of the channel has lowered, the canyon sidewalls have become progressively higher and steeper, and they, in turn, have begun to fail by landsliding, which serves to flatten their angle and regain a stable slope. This can only be accomplished through a widening of the canyon across its top, with attendant risk to developed upland properties on both sides of the canyon.

Figure 2. View of lower Storm Creek in the canyon reach, showing a portion of the steep reach about 100 ft upstream of the railroad tracks

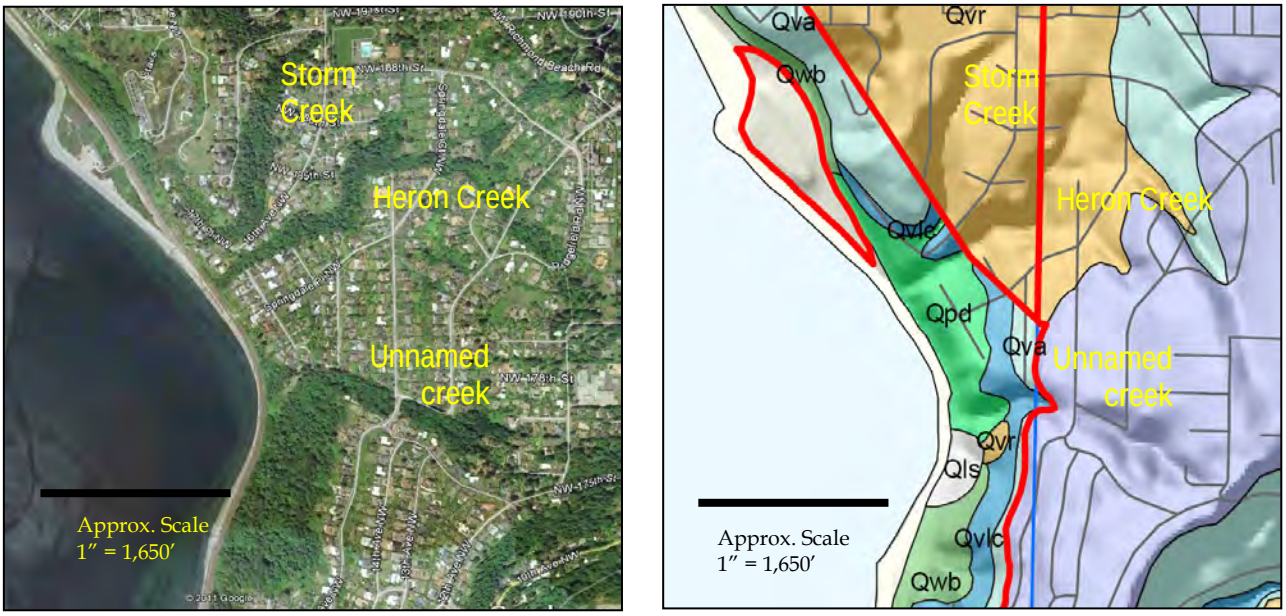
This process of channel downcutting and valley widening is an inevitable consequence of the coastal topography of Puget Sound, with an upland plateau that stands (in this area) anywhere from 80 to 200 ft above the coastline and is separated from the coastline by a steep coastal bluff. Over time, the downcutting of streams to "smooth" their course from upland to shoreline is inevitable, but there is no fixed rule for how long this process will take. An inspection of the drainages both north and south of Storm Creek,

most immediately at Heron Creek just south but also at nearby Boeing Creek and Pipers Creek, indicate that Storm Creek is anomalous—every other channel in the region has already created a relatively smooth grade down to Puget Sound, over a sufficient amount of time for mature trees to have become well-established in their valley bottoms (Figure 3). Such a differential cannot be obviously explained by "human" factors, such as the age of development (which is roughly the same throughout this portion of the coast) or direct channel modification, and so other explanations must be explored.

Figure 3. View of lower Heron Creek, showing trees of sufficient maturity to suggest that the broader, deeper canyon here has existed in its present form for at least several decades (and possibly much longer)

Geology

The geologic materials that underlie this part of the lowland are, in part, quite uncommon (Figure 4). They include a sedimentary deposit from a regional ice advance about 60,000 years ago, which was named the "Possession Drift" (its deposits are denoted as "Qpd" on geologic maps of the region). In the exposed ravines of both Storm and Heron Creeks, the deposit is primarily till, a very compact, heterogeneous mixture of gravel, sand, and silt reminiscent of concrete (Figure 5, Photo A). However, it has abundant zones of nearly pure sand and a variety of transecting fractures, which provide avenues of weakness for the action of stream or wave erosion (Figure 5, Photo B).



Sources: Google® Earth 2011; Booth et al. (2004)

Note: Each image shows an area that is approximately 1 mile wide. The two creeks (and a smaller unnamed channel just south) drain across a localized body of unit Qpd, a deposit composed of glacial sediment correlated to the second-to-last glacial advance across the region (locally named the "Possession" glacial advance).

Figure 4. Aerial photograph and preliminary geologic map of the Shoreline coastal area in the vicinity of Storm and Heron Creeks

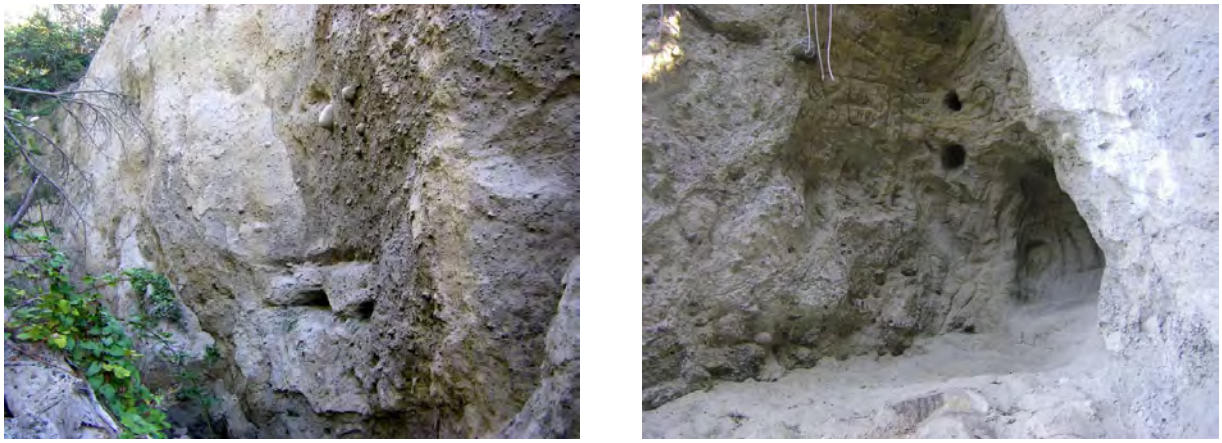


Photo A **Photo B**

Note: Photo A is the intact coherent material, with sufficient strength to stand in vertical (and locally overhanging) walls for many years without failure. Photo B shows the same geologic deposit in an adjacent area where sandier zones have permitted rapid hollowing out by natural and human agents of erosion.

Figure 5. Glacial till of the Possession age exposed in the lower canyon of Storm Creek

The local strength of the Possession till belies its ultimate weakness in the face of erosive agents acting for long periods of time. Indeed, the two other drainages that cut through this deposit (Heron Creek and the unnamed creek about 1,000 ft south) have long ago

established a smooth longitudinal profile. Only Storm Creek apparantly maintained a waterfall, dropping over a particularly resistant shelf of the Possession till, up until the last one or two decades. This condition is quite unusual across the entire region—suggesting that the appropriate question is not "Why has Storm Creek begun to erode?" but rather "Why was Storm Creek so slow in initiating that erosion?" The outcome, of course, is the same with respect to upslope developed properties, regardless of whether Storm Creek is "anamolously erosive" or "anamolously stable," but this distinction should help identify the cause of the erosion and suggest solutions that are likely to succeed.

Stormwater Runoff

The science of stormwater management, as well as the history of urban development in the Puget Sound lowland, strongly suggests that flows have increased dramatically in every urban stream since development began in earnest in this region. In the nearby Boeing Creek watershed, for example, a single commercial development (the Sears shopping center at N 160th Street) in the 1970s initiated channel downcutting and landsliding in a very non-resistant geologic deposit within a few years, leading to a long series of mostly ineffective capital projects to address the condition.

We have every reason to assume that a similar runoff response accompanied development in the Storm Creek watershed in the 1960s and 1970s. Stormwater management of that era was well-intentioned but, as is now widely recognized, ineffective at reducing downstream impacts such as flooding and stream erosion. Similar to the rest of the drainages in the region, Storm Creek has been receiving discharges well in excess of its "natural"rates. What is unusual here is that the canyon of Storm Creek is substantially narrower than those of its neighboring creeks, so much so that, for example, in the 1960s, the two houses that flank the mouth of Heron Creek were constructed 110 ft apart, but those that flank Storm Creek are only 70 ft apart (Figure 6; distances approximate as measured in Google® Earth). Although Storm Creek is a larger channel that drains a larger watershed, it had not incised nearly as deeply when the residential structures were built, and so it required (at the time) significantly less setback of structures from a significantly shallower ravine.

Note: The arrows show the spacing of houses on opposite sides of the two creeks; yellow = 70 ft across Storm Creek; orange = 110 ft across Heron Creek, undoubtedly reflecting the relative depth and width of the two ravines when this area was first developed.

Figure 6. Aerial view of the mouths of Storm Creek (upper left) and Heron Creek (lower right)

As previously noted, there are no visible indications of recent, significant changes in watershed land cover or stormwater management that would explain a "triggering" of the erosion of Storm Creek during the past decade or so. As such, it is concluded that the channel is undergoing a belated, but no less expected, response to upstream development in its watershed over the past half-century. The delay is likely a consequence of the material properties of the geologic deposit through which it must erode; the fact that it shares the same substrate with Heron Creek while following a somewhat delayed history can only be ascribed, albeit speculatively, to the heterogeneity of the deposit—more resistant across the path of Storm Creek and less resistant across the path of Heron Creek. However, without mitigation, the same final outcome is virtually assured: a relatively well-graded channel profile that rises steeply but smoothly from the coast up to the (presumably) non-eroding culvert at 17th Place NW, with a ravine whose sidewalls eventually erode back by landsliding to a stable angle of repose and a top width that is substantially wider than it is today.

RECOMMENDED ACTIONS

Wherever channel erosion occurs in an area of previous development, the potential consequences of unmitigated events can be severe. In the case of Storm Creek, the greatest threat to public infrastructure involves the potential undermining of a sewer lift station at 17th Place NW, likely only after many additional years because of the slow

pace of headward expansion. Of much greater potential public concern is the health and safety of visitors to Richmond Beach Park who are inclined to explore the adjacent coastline, complete with crumbling bluffs and overhanging caverns (Figure 7). Lastly, the catastrophic collapse of a portion of the ravine sidewalls (or the rapid flushing of previously eroded sediment during a storm) could easily clog the culvert under the railroad tracks and potentially block the tracks should sufficient material become involved.

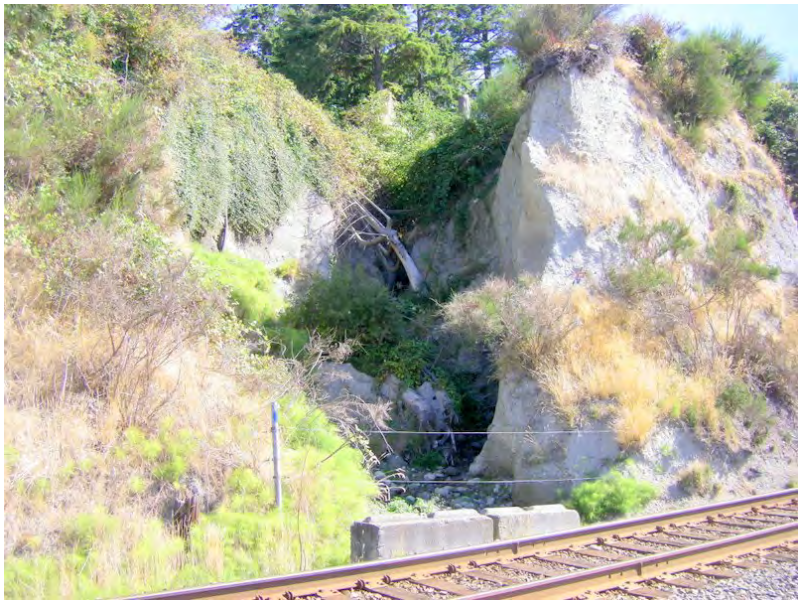


Figure 7. View of the mouth of Storm Creek, from the railroad embankment just above the southern extent of the beach at Richmond Beach Park

Potential solutions that would be effective in the short term (i.e., immediately upon implementation) require that either the channel be hardened to the effects of runoff or the runoff be separated from the channel itself. Based on existing conditions in the ravine, the first alternative (channel hardening) does not appear to be feasible—there are far too many opportunities for obstructions or armoring to be undermined, flanked, or simply swept away. The region has a long history of such efforts; and unless the entire refilling and reconstruction of the ravine bottom is contemplated, this alternative should be abandoned.

In contrast, separating runoff from the channel via a tightline is a widely used approach that has been successful under much lengthier and more challenging applications. This would require the use of high-density polyethylene pipe, likely laid along the ground surface either along the bottom of the ravine or above the sidewalls, with an intake near 17th Place NW and an outfall just upslope of the railroad tracks. Although Storm Creek was almost certainly never a fish-passable stream, the piping of the entire flow (both "natural" and urban-derived) would likely pose some permitting challenges without additional mitigation measures.

However, the alleviation of further erosion at the base of the ravine walls will not immediately halt the risk to adjacent private property. Although addressing those concerns is beyond the scope of this memorandum, the need to manage ongoing slope adjustments to the erosion that has already occurred is likely to continue for many years into the future, even if no further downcutting is allowed to occur.

Long-term solutions to reduce peak flows in a largely built-out watershed will almost certainly require the implementation of retention or infiltrative stormwater management techniques in suitable parts of the upper watershed in city-owned rights-of-way.

REFERENCES

Booth DB. 1989. Runoff and stream-channel changes following urbanization in King County, Washington. In: Gallster R, ed, Engineering geology in Washington, Vol. II. Bulletin 78. Washington Division of Geology and Earth Resources, pp 639-650.

Booth DB, Cox BF, Troost KG, Shimel SA. 2004. Composite geologic map of the Sno-King area, scale 1:24,000 [online]. Seattle-Area Geologic Mapping Project, University of Washington, Seattle, WA. [Accessed September 28. 2011.] Available from: http://geomapnw.ess.washington.edu/services/publications/map/data/Geology_SnoKing_Draft.pdf.

Foley S. 1993. Storm Creek phase 1 study. July 8, 1993. Surface Water Management Division, King County Department of Public Works, Seattle, WA.

Harrington P. [undated]. Storm Creek erosion with photodocumentation. Peter Harrington, Shoreline, WA.

King County. 1994. Storm Creek drainage improvement plan sheet, SW 1/4, Sec. 1, T.26, R.3E, W.M. #2001-72. Surface Water Management Division, King County Public Works, Seattle, WA. 12/94.

Leary TR. 2009a. Erosion issues in the lower section of Eagle Reserve. January 2009. Chairman, Innis Arden Reserves, Shoreline, WA.

Leary TR. 2009b. Statement of compelling environmental benefit: Eagle Reserve. February 2009. Chairman, Innis Arden Reserves, Shoreline, WA.

NHC. 2010. Memorandum dated 17 May 2010 to M. Jacobs, The Innis Arden Club, Inc.: Storm Creek hydrologic assessment. Northwest Hydraulic Consultants, Seattle, WA.

Otak. 2009. Technical memorandum dated March 16, 2009 from R. Gaston, PE and M. Claasen to J. Sanchez, City of Shoreline: Storm Creek Ravine preliminary analysis. Otak, Kirkland, WA.

APPENDIX B. HYDROLOGIC MODELING MEMORANDUM

OSBORN CONSULTING INCORPORATED

1800 NE 112TH AVENUE NE
SUITE 220-E
BELLEVUE, WA 98004
(425) 451-4009

Date:	August 16, 2012
To:	Erin Nelson, Windward Environmental
CC:	
From:	Laura Ruppert, P.E., Osborn Consulting, Inc.
Subject:	City of Shoreline Storm Creek Basin – Hydrologic Modeling Technical Memorandum

This memorandum presents the methods and results of the Hydrologic and Hydraulic Modeling completed as part of the development of the Storm Creek Basin Plan for the City of Shoreline. The Hydrologic and Hydraulic Modeling was conducted by Osborn Consulting Inc. (OCI) as a sub-consultant to Windward Environmental under contract to the City of Shoreline (City).

MODEL SELECTION

The best estimate of stream flow is from a stream gage. In the absence of sufficient stream gage data, simulated data from a continuous flow model is the next best source. Two continuous flow models were used to perform basin analysis and Capital Improvement Project (CIP) development. An Environmental Protection Agency (EPA) Stormwater Management Model (SWMM) was developed to model the basin wide hydrology of the Storm Creek Basin. The Western Washington Hydrology Model Version 3 (WWHM3) was used to assess site specific detention and infiltration opportunities.

EPA-SWMM

An EPA-SWMM was developed for the Storm Creek basin to simulate existing water runoff conditions for problem area identification (25-year design standard) and to test alternative stormwater management scenarios. Additionally, the model was used to identify the area inundated during a 100-year recurrence interval flow event for the City's critical areas code.

EPA-SWMM was selected because it is a continuous model that performs both hydrologic and hydraulic modeling. Continuous models, as opposed to event based models, provide a more accurate depiction of rainfall patterns in the northwest and allow for better facility sizing to meet flow duration standards in the most recent state and local stormwater management manuals. EPA-SWMM is a publically available model that could easily be updated and used by City staff as infrastructure gets replaced or upgraded throughout the basin.

WWHM

WWHM3 was used to size detention and infiltration facilities to retrofit the basin to a forested condition. WWHM3 was used instead of EPA-SWMM because EPA-SWMM does not have the auto sizing features that WWHM offers.

EPA-SWMM METHODS

The EPA-SWMM model uses local precipitation, evaporation and drainage basin characteristics to simulate the runoff response within a basin. This section describes the data sources and methodologies used to model the Storm Creek Basin.

Precipitation

Precipitation drives the response in the basin. It is important to select a precipitation record that accurately reflects the actual precipitation in your basin. The EPA-SWMM model simulates twenty one years (1990-2010) of rainfall using fifteen minute precipitation data from King County flow gage 04U, located in the Boeing Creek Basin of Shoreline. Precipitation from nearby gage 35U (Bruggers Bog) was used to fill in gaps in the 04U data set (December 2007 through June 2008). While the Seatac precipitation gage has a much longer period of record (1948-current) the Shoreline gages were used because their close proximity to the study area offers the best available representation of actual precipitation in the Storm Creek Basin.

Evaporation

Evaporation was simulated using mean monthly pan evaporation data for Puyallup, Washington as documented in *NOAA Technical Report NWS 34 Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States, 1982*. Puyallup, the closest pan evaporation data site available, is approximately 50 miles away from the Storm Creek Basin. However, since evaporation does not vary greatly within the Puget Sound lowlands this distance from the study area is not significant.

Drainage Basins

City of Shoreline Geographic Information System (GIS) data was used to delineate the 487.4 acre Storm Creek Basin into sixteen subcatchments. GIS data used includes: topography, stormwater conveyance, streams/ditches, and parcels. Basin and subcatchment boundaries were confirmed with a site visit. The sixteen Storm Creek subcatchments range in size from 1.6 acres to 168.7 acres, with an average size of 30.5 acres. Subcatchment areas are shown on Figure 1: EPA-SWMM predicted flooding. The information used to define each subcatchment in the EPA-SWMM model is defined in Table 1: EPA-SWMM Subcatchment Properties.

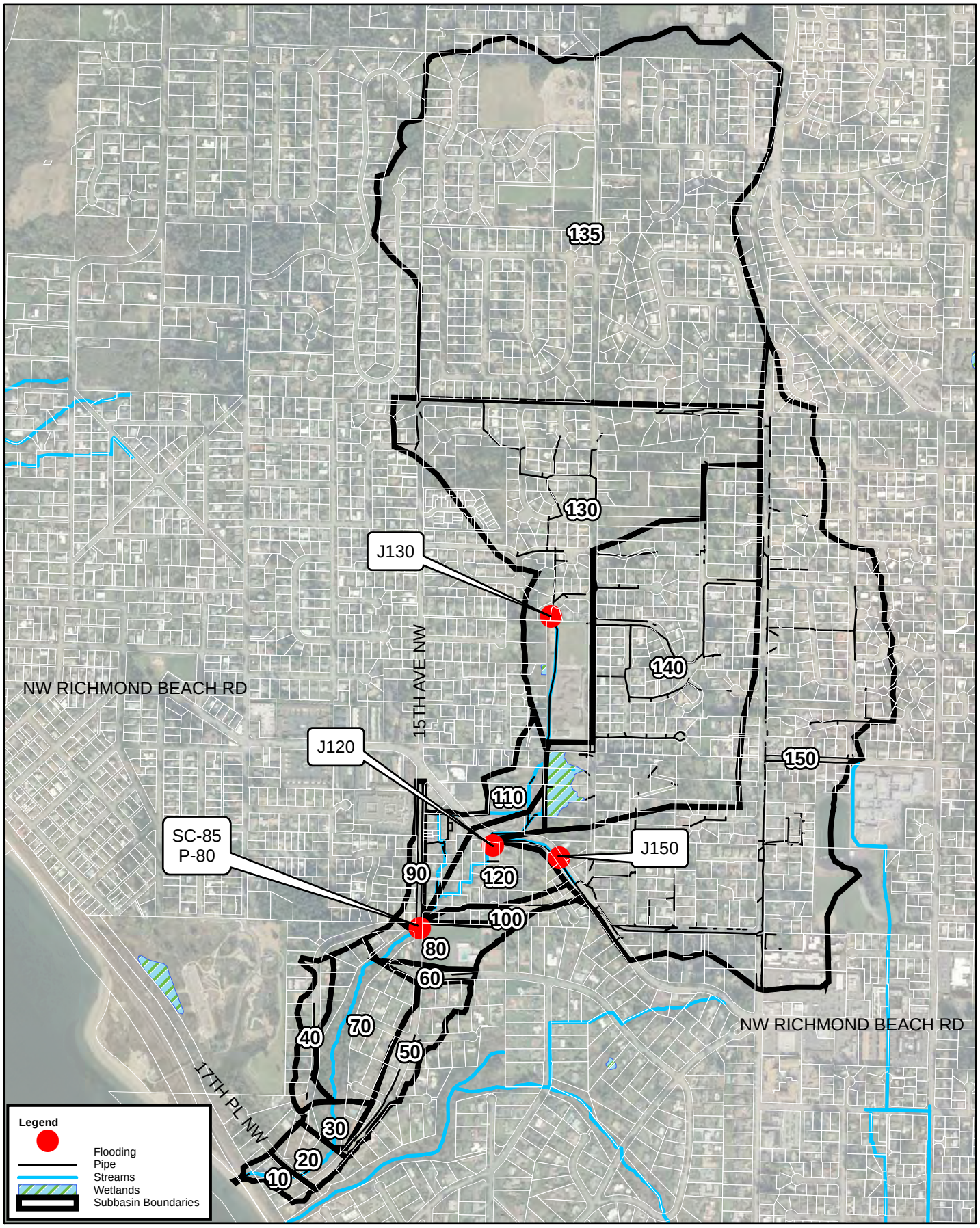
Land Use

City of Shoreline GIS data was used to estimate current and future land use conditions.

The City provided GIS land use data that was used to estimate current conditions and zoning was used to estimate the future condition. Aerial photography, City code, and King County recommendations were used to develop assumed impervious, grass and forested coverages for each land use category. Specific land use assumptions are included in the **Appendix**. The resulting typical percent impervious for the Storm Creek subcatchments is as follows:

- Current / Land Use: ranges from minimum 16-percent to maximum 77-percent with the average being 47-percent impervious.
- Future / Zoning: ranges from minimum 51-percent to maximum 79-percent with the average being 61-percent impervious.

Allowable zoning indicates the percent impervious could increase to an average of 61-percent impervious across the basin which would increase runoff and flow rates in Storm Creek (if stormwater detention is not also implemented). However, with the basin primarily built out and



OSBORN CONSULTING INCORPORATED

Prepared by MLP, 6/22/12; FIG. 6

Figure 1 - SWMM Predicted Flooding

Storm Creek Basin - Shoreline, WA

stormwater treatment and detention requirements in place for future development, such increases are not likely to actually occur so the future zoning land use condition was not modeled.

Table 1: EPA-SWMM Subcatchment Properties	
Property	Definition
Name	User-assigned subcatchment name.
Rain Gage	Name of the rain gage associated with the subcatchment.
Outlet	Name of the node or subcatchment that recieves the subcatchment's runoff.
Area	Area of the subcatchment, (acres).
Width	Characteristic width of the overland flow path for sheet flow runoff (feet).
% Slope	Average percent slope of the subcatchment.
% Imperv	Percent of the land area which is impervious.
N-Imperv	Manning's n for overland flow over the impervious portion of the subcatchment.
N-Perv	Manning's n for overland flow over the pervious portion of the subcatchment.
Dstore-Imperv	Depth of depression storage on the impervious portion of the subcatchment (inches).
Dstore-Perv	Depth of depression storage on the pervious portion of the subcatchment (inches).
% Zero-Imperv	Percent of the impervious area with no depression storage.
Subarea Routing	Choice of internal routing of runoff between pervious and impervious areas: *IMPERV:* runoff from pervious area flows to impervious area *PERV:* runoff from impervious flows to pervious area *OUTLET:* runoff from both areas flows directly to outlet
% Routed	Percent of runoff routed between subareas.
Infiltration	SCS runoff curve number and drying time.

Slope

City of Shoreline GIS data was used to calculate the average slope for each subcatchment. Storm Creek subcatchment average slopes range from a minimum 5-percent to maximum 42-percent with the average being 15-percent.

Infiltration / SCS Runoff Curve Number

Vegetation coverage and soil types were used to calculate a composite SCS Curve number for each subcatchment. Vegetation (forest or grass) coverage areas were based on the land use assumptions described above. The Storm Creek Basin is 66-percent Type A/B soil and 34-percent C/D soil. Soil data was derived from City provided GIS surface geology. Surface geology was categorized by Hydrologic Soil Group and overlaid with percent impervious to determine SCS curve numbers. The resulting composite SCS Curve number values are provided in the EPA-SWMM Subcatchment Data Table in the **Appendix.**

Hydraulics – Channels & Piped network

The scope of this project did not include hydraulic modeling of the entire Storm Creek conveyance system. The hydraulic analysis was limited to the open channel reaches of Storm Creek (from the mouth up through the Syre Wetland) plus a handful of piped locations.

Eight different cross sections were used to simulate Storm Creek. Channel characteristics are based on field measurements and data provided by Windward. Cross section dimensions are based on field measurement and Manning's roughness assumptions are based on pebble count data and/or photographs. Storm Creek cross section data is included in the **Appendix**.

The following piped conveyance was included in the model:

- Culvert crossings at arterials,
- Piped systems contributing to Syre Wetland, and
- Subcatchment piped outfalls to Storm Creek.

City provided GIS data (storm and topography) and as-built data (at select locations only) was used to estimate the conveyance network. Distances, elevations, and flow areas are a simplified approximation of the actual conveyance network. A schematic of the EPA-SWMM model is included in the **Appendix**.

CALIBRATION

Model calibration was performed by checking peak flows at culvert crossings, comparing dates of peak flows to peak rain events in the Boeing Creek gage data and comparing basin characteristics and response to other basins in Shoreline (using a Boeing Creek Basin study prepared by others). The effects of calibration are limited when gage data is not available. However, the calibration efforts described below provide confidence that the runoff and peak flows predicted by the Storm Creek EPA-SWMM model are reasonably accurate.

Peak flows at culvert crossing

Many of the subcatchment areas are separated by a conveyance network or culvert which offers an indication of how much runoff typically flows through that location. As mentioned above, the conveyance network includes culvert crossings at arterials and portions of the conveyance systems contributing to Storm Creek. Monitoring the flow depth and the amount of flooding demonstrates the runoff amounts are reasonably accurate:

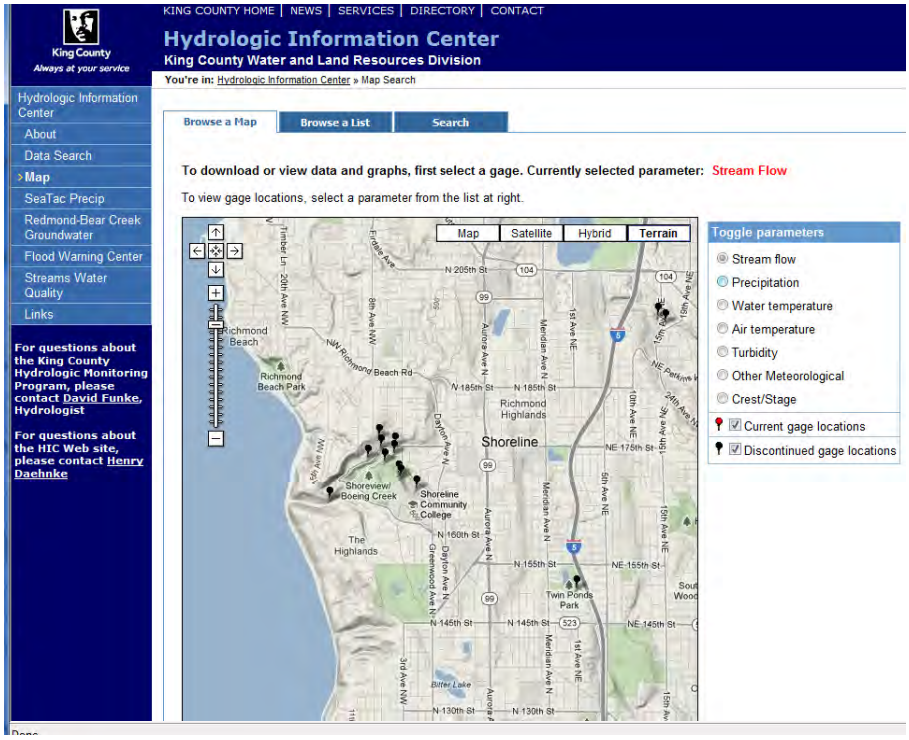
- The lack of flooding throughout the system indicates runoff flow rates are not too high
- The flooding reported below in Table 2 indicates runoff flow rates are not too low.

Since only portions of the conveyance systems for the upper subcatchments: 130, 135, 140, and 150 were included in the model, early iterations were showing flooding where these large ($\geq$70 acres) subcatchments were routed through a single pipe at the subcatchment outlet. Such flooding was suspect because conveyance networks throughout these basins (predominantly 12-inch diameter) would dampen the runoff and flow would be routed through the pipe over time.

To mitigate this effect, ponding was allowed to occur. When ponding is allowed, the model stores the entire volume of runoff and routes it through the pipe as capacity allows. This keeps all runoff in the system and essentially meters the amount of flow contibuting to Storm Creek, much like the real storm drainage system would.

Boeing Creek gage data

Boeing Creek stream flow data from multiple gaging stations is available from King County (see Figure 2). These gages are no longer in operation, but contain flow data that overlaps with our analysis period. Gage 05J flow events greater than 10-cfs were compared to predicted daily peaks above 10-cfs at the Storm Creek mouth (SC_10). EPA-SWMM predicted events correlate well with gage 04J predicted events.



Windward measured flow at three Storm Creek cross sections located within the Eagle Reserve. The average flow measured on September 27, 2011 was less than 1 cfs; on January 25, 2012 the average flow was approximately 3 cfs. These flows represent base flows and are much lower than the predicted 2-year flow (22 cfs) at the Storm Creek Mouth.

Figure 2: King County Gage Locations (Boeing Creek Basin)

Boeing Creek Basin Study

The runoff results from the *North Boeing Creek Improvements Project Final Design Report,* prepared by Otak, December 2008, were used as a referenced for runoff results from a similar basin. The 25-year runoff per acre (cfs/ac) was compared.

- Boeing Creek predicted rates range from 0.31 to 0.75 cfs/ac for subcatchments ranging in effective impervious area from 20-percent to 81-percent, respectively.
- Storm Creek predicted rates range from 0.08 to 0.36 cfs/ac for subcatchments ranging from 17-percent to 80-percent effective impervious area, respectively.

Basin characteristics (including soils, land use, and soil parameters) were reviewed to explain the higher runoff rates in Boeing Creek compared to those in Storm Creek.

- Soils: The North Boeing Creek study area is primarily Till with some Outwash. Compared to the Storm Creek basin which is 65-percent A/B soils (higher infiltration soils resulting in lower runoff than a primarily Till basin).
- Land use: The Boeing Creek study assumes 0-percent forest in residential areas. Compared to the residential areas of the Storm Creek Basin which include forest coverage ranging from 1-percent to 20-percent (based on aerial photography).
- Soil parameters: The soil parameters used in each basin were similar.

MODEL SCENARIOS

Three scenarios were modeled with EPA-SWMM: Current Land Use, Forested, and proposed modifications at the Syre Wetland. Descriptions of the three scenarios are provided in this section. Flow frequency analysis results are provided later in this memorandum.

Current Land Use

The Current Land Use model simulates the current/existing land use and conveyance condition in the Storm Creek basin. This model's development is based primarily on City GIS data as described above. This model serves as the base line condition.

Forest

A forested land use condition model was developed to assess how flow rates have changed as the basin developed. Washington State Department of Ecology Stormwater Management Manual for Western Washington (2005) has defined forest as the standard pre-developed condition. The current land use model was copied and modified to have no impervious area and SCS curve numbers and Manning's roughness for overland flow were modified to simulate forest.

Syre Wetland

A proposed condition model was developed to assess how modifications to the Syre Wetland affect peak flows in Storm Creek. The current land use model was copied and the storage unit simulating the Syre Wetland was modified to simulate an increased wetland footprint. The Syre Wetland footprint was assumed to double in size.

FLOODING: WHERE, WHY AND HOW OFTEN

Flooding identified by the EPA-SWMM analysis is presented in Table 2: EPA-SWMM – Flood Reported (25-yr Return Period) and shown on Figure 1: EPA-SWMM Predicted Flooding.

Table 2: EPA-SWMM – Flooding Reported (25-yr Return Period)

Junction	Description of Location	Significance
J120	Runoff from the north and east converge at this node located on the south side of Richmond Beach Rd. near 14th Pl. NW.	Runoff from the north and east are routed through existing conveyance systems prior to converging at J120 so their peak flows are realistic. Complaint data confirms flooding has been reported in this vicinity.
J130	This is the upstream node of the 1150 LF 24-inch Conc. Pipe behind Syre Elementary and receives runoff from subcatchments 130 and 135 (239 ac total).	This is not believed to be a real flooding problem. These nodes receive over 100 acres of runoff at one location when in reality this runoff flows through 12-inch diam. storm sewers which would dampen the peak runoff prior to reaching larger diameter pipes at the downstream end of the subcatchment. This was addressed in the EPA-SWMM model by allowing ponding to occur at these locations so the total volume of water stays in the model (as opposed to leaving the system via flooding). Complaint data does not indicate flooding at this location.
J150	This is the upstream node of 520 LF 18-inch Conc. Pipe along Richmond Beach Rd. and receives runoff from basin 150 (110 ac).	

Table 2: EPA-SWMM – Flooding Reported (25-yr Return Period) Continued		
SC_85 & P_80	30-inch. Conc. Culvert at 15th Ave. NW and upstream open channel.	Draft versions of the model reported flooding at this location; however; none is indicated in the final version of the model. Regardless, this location is a known drainage bottleneck in the basin.

Several key locations in the model were monitored for performance. EPA-SWMM Key Locations and their importance are presented in Table 3. These locations were selected for one of the following reasons:

- EPA-SWMM results indicate flooding
- Complaints of increased erosion
- Flow analysis needed to support CIP development

Table 3: EPA-SWMM – Key Locations		
Link	Description	Why Important
SC_112	Open channel flow out of Syre Wetland	Monitor the affects of proposed wetland modifications in support of CIP development.
P_120	Flow south from the diversion near the Meadowbrook Apartments (18-inch. Conc. Pipe).	Has a history of flooding; design flows for potential channel day-lighting CIP.
J120	Junction of P_120, flow from the east (basin 150 via P_150), and receives basin runoff.	Existing model shows flooding at this location.
SC_85	Open channel upstream of 15th Ave. NW.	Potential flooding at this location.
P_80	30-inch. Conc. Culvert at 15th Ave. NW.	Potential flooding at this location.
SC_10	Open channel flow through ravine downstream of 17th Ave. NW.	Monitor how changes throughout the basin affect this erosion sensitive reach near the mouth of Storm Creek. Flow comparisons at this location shown current condition peak flows exceed peak flows of a pre-developed forested condition by over 400% at the 25-yr and over 200% at the 100-yr flow frequencies.

The results of the EPA-SWMM flow frequency analysis for existing land use conditions is presented in Table 4.

Table 4: EPA-SWMM – Flow Frequency Analysis Existing Land Use			
Link	2-yr (cfs)	25-yr (cfs)	100-yr (cfs)
SC_112	17.4	33.1	41.5
P_120	10.1	15.2	17.0
SC_85	21.2	33.5	38.6
P_80	21.2	33.4	38.5
SC_10	22.0	35.8	41.8

The Pre-developed (Forested) condition was also simulated with in EPA-SWMM. Results of the Pre-developed flow frequency analysis are presented in Table 5.

Table 5: EPA-SWMM – Flow Frequency Analysis Pre-Developed (Forest)

Link	2-yr (cfs)	25-yr (cfs)	100-yr (cfs)
SC_112	0.3	6.1	14.5
P_120	0.1	2.3	5.7
SC_85	0.3	9.7	24.1
P_80	0.3	10.3	25.8
SC_10	0.4	11.1	28.2

Doubling the footprint of the Syre Wetland results in peak flow reductions of up to 10-percent compared to the existing condition. The greatest flow reductions are seen near the wetland outlet, during more frequent events (≤ 2-yr). The EPA-SWMM peak flows associated with increased wetland storage at Syre Wetland are presented in Table 6.

Table 6: EPA-SWMM – Flow Frequency Analysis Proposed Syre Wetland Modifications

Link	2-yr (cfs)	25-yr (cfs)	100-yr (cfs)
SC_112	15.5	28.7	35.5
P_120	9.1	14.6	16.7
SC_85	20.3	32.5	37.4
P_80	20.3	32.5	37.5
SC_10	21.1	34.8	40.7

100-YEAR FLOODPLAIN MAPPING

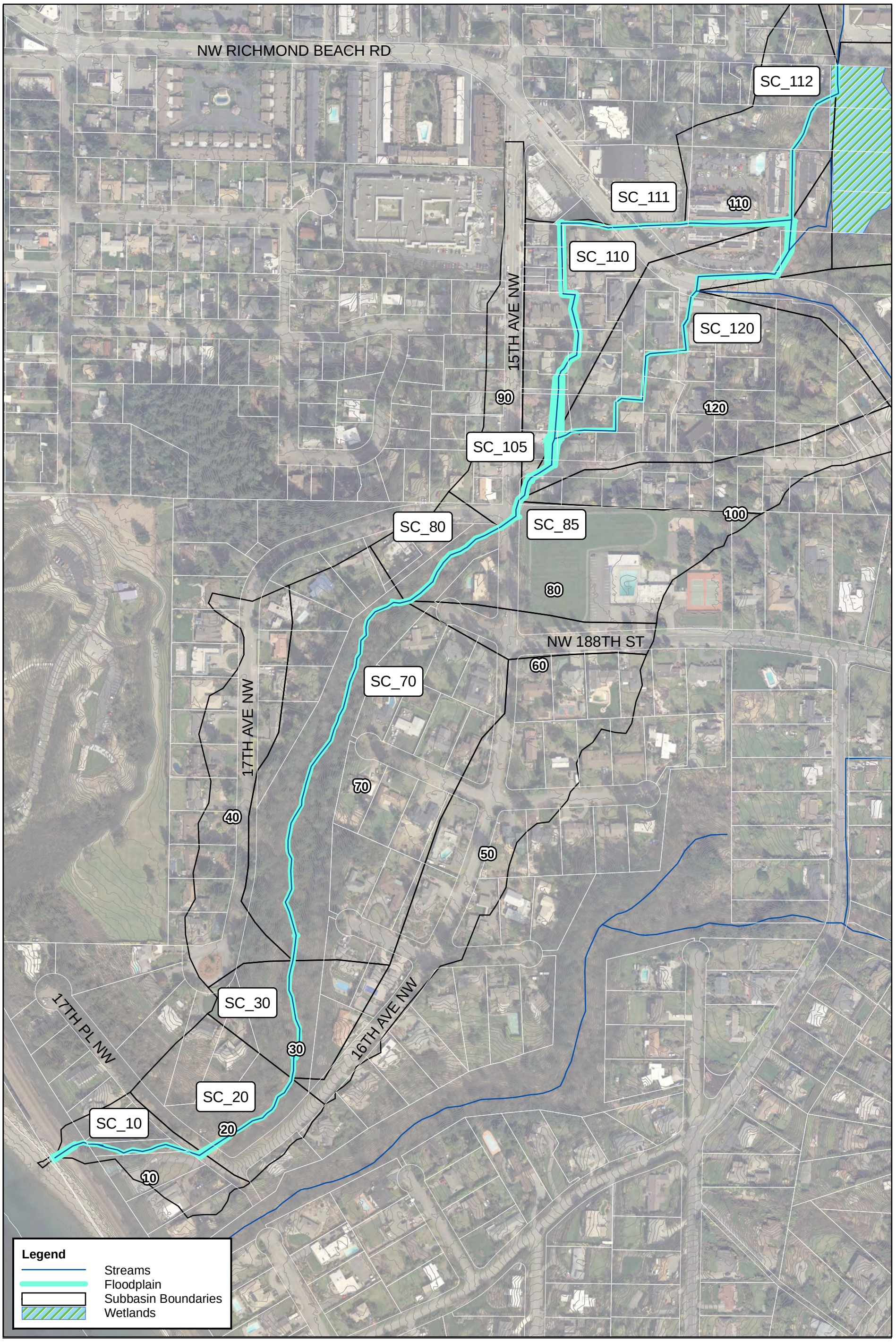
The Storm Creek EPA-SWMM model was developed with FEMA flood mapping standards in mind so that it may be used by the City to pursue a floodplain boundary. **Figure 3: Preliminary 100-yr Floodplain Map** depicts the approximate 100-yr Storm Creek Floodplain as simulated by EPA-SWMM. This map is for planning purposes only and is to provide the City a general idea of what area(s) surrounding Storm Creek might flood during a 100-year event.

WWHM3

WWHM3 was used to size detention and infiltration facilities to retrofit the basin to a forested condition. Two typical land use conditions were assessed with WWHM:

1. Residential: Soil Groups: A=58-percent, C=42-percent, Infiltration 5in/hr w/0.1 reduction factor; Moderate slope, 45-percent Impervious, 45-percent Grass, 10-percent Forest
2. Business / High Density Residential: Soil Groups: A/B=98-percent, C=2-percent, Infiltration 5in/hr w/0.1 reduction factor; Moderate slope, 80-percent Impervious, 20-percent Grass

The findings associated with this modeling are presented below in the Capital Improvements Section.



OSBORN CONSULTING INCORPORATED

Prepared by MLP, 6/22/12, FIG 7

Figure 3 - Preliminary 100-Year Flood Map

Storm Creek Basin - Shoreline, WA

CAPITAL IMPROVEMENT PROJECTS

Three CIPs are identified as part of the hydrologic and hydraulic analysis. The three CIPs include:

1. Flooding assessment at Richmond Beach Road, east of 14th Pl. NW.
2. Infiltration and detention facilities for basin wide retrofit to 2005 Ecology standards
3. Infiltration and detention facilities to retrofit City Right-of-Way to 2005 Ecology standards

CIP 1: Flooding assessment at Richmond Beach Road at 14th Pl. NW	
Issue	Potential flooding at the convergence of two stormwater conveyance systems.
How was it identified?	EPA-SWMM analysis predicts flooding at this location during the 25-yr event. Complaint data includes reports of flooding in this vicinity.
Specifics	Perform site visit to assess site for signs of flooding. Confirm source of flooding and perform alternatives analysis to identify the preferred solution. Proceed with design and PS&E for this flood improvement project.
Capital	Potential flood improvement project.
Cost	$230,000

The project cost estimate for CIP 1 assumes a typical neighborhood drainage improvement project. Actual project costs should be reevaluated after a solution recommendation has been made.

Project Cost Estimate
CIP 1: Flooding assessment at Richmond Beach Road at 14th Pl. NW

Task	**Unit**	**Cost**
Flooding assessment study to verify source of flooding, perform alternatives analysis and provide a solution recommendation.	LS	$15,000
Survey, Permitting, Design and PS&E	LS	$40,000
Estimated Construction Cost	LS	$120,000
Sub-Total		$175,000
Contingency (30%)		$52,500
Sub-Total		$227,500
Rounded Project Cost		**$230,000**

CIPs 2&3: Infiltration and detention facilities for basin wide (or right-of-way) retrofit	
Issue	Current flows are much greater than the Pre-Developed Forested Condition. Results in increased runoff.
How was it identified?	The Storm Creek basin is nearly built out to fully developed condition with little water quality or detention to mitigate the change from forested condition. EPA-SWMM analysis indicates the existing 100-yr flow rate at the Storm Creek Mouth is over 200% greater than the predicted pre-developed forest condition.
Specifics	Convert 31 to 46 acres (6.4% to 9.5% of the 487 acre basin) to infiltration and/or detention facilities to retrofit the entire Storm Creek basin to a forested condition. Infiltration facilities shall be sited in type A soils only. Detention facilities may be sited in B, C, or D soils. Conversion of approximately 4 acres to infiltration and/or detention facilities is necessary to retrofit the 43.4 acres of right-of-way in the Storm Creek Basin.
Capital	Install infiltration and detention facilities throughout the basin.
Policy	City to provide treatment and detention for all impervious areas (as opposed to just new impervious area) for road improvement projects. Provide credit to private property owners that retrofit their properties.
Education	Encourage people to disperse their roof and driveway runoff on their own property. Teach them the importance of infiltration, rain harvesting and offer rain garden classes.
Programmatic Changes	Offer credits to developers that exceed treatment and flow control requirements
Cost	Basin Wide: 487.4 ac @ $54,600/ac = $26,612,000 ROW Only: 43.4 ac @ $54,600/ac = $2,370,000 *Cost based on City of Marysville Regional Detention unit price of $3.60/CF for light industrial development (85% impervious). Unit price translates to approximately $52,000/acre of development and includes design and construction costs for a regional facility and conveyance trunkline. Increased price by 5% to account for higher property costs in Shoreline. Actual costs may vary based on project site and size.

APPENDIX C. SUMMARY OF SERVICE REQUESTS

Appendix C
Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
11/1/2010 9:39	1401 NW 204TH PL	sinkhole	Unknown	SINKHOLE IN FRONT OF THE HOUSE	THE HOLE DOES NOT MATCH UP WITH THE STORM DRAINAGE SYSTEM OR THE RONALD SEWER. THE CUSTOMER STATED THAT IT WAS BELIEVED THAT THERE WAS A BREAK IN THE SIDE SEWER AND INDICATED THAT IT RAN VERY CLOSE TO WHERE THE SINKHOLE IS. I TOLD HER THAT PLACING GRAVEL IN THE HOLE WITH THIS MUCH WATER WOULD NOT BE THE WAY TO GO. SHE IS GOING TO CALL RONALD SEWER AND SEE IF THE CAN DETECT A HOLE IN THE SIDE SEWER BEFORE ANY WORK IS DONE. WE LEFT TWO CONES.
4/22/2010 14:48	19116 17TH AVE NW	clogged culvert	clogged culvert	Culvert upstream of home is plugged.	W.O. # 61303 CATCH BASIN CLEANING - VACTOR SCHEDULED FOR
4/22/2010 15:02	19116 17TH AVE NW	clogged culvert	clogged culvert	NEARLY CLOGGED CULVERT PIPE UNDER SEVERAL DRIVEWAYS. THE PIPE'S OPENING IS 3/4 BLOCKED BY ROCKS/SAND ETC.. BLOCKED CULVERT PIPE	
3/31/2010 10:54	19104 17TH AVE NW	ineffective drainage	ineffective drainage	Drain on east side of driveway does not capture water.	W.O. # 61054 INSTALL BERM/SWALE SCHEDULED FOR
3/12/2010 15:00	837 NW 193RD ST	private issue	private issue	CUSTOMER STATES THAT THE CONSTRUCTION NEXT DOOR JUST CUT THE CURB OUT TO DRAIN THE SITE IN THE STREET AND CITY DRAINAGE SYSTEM	SPOKE WITH JILL. HE WAS GIVEN DIRECTION TO CEASE HIS WORK. THE DRAINS WERE TO BE REMOVED FROM THE ROW. RANDY WILL MAKE A SITE VISIT.
3/8/2010 11:44	1227 NW 199TH PL	sinkhole	UNknown	****A SINKHOLE IS NOW FORMING, IT IS 2FT DIAMETER AND 3FT DEEP ****	W.O. # 61322 FOR PIPE HAS BEEN COMPLETED ON 04-30-10
1/5/2010 10:55	1024 NW 190TH ST	clogged CB	clogged CB	STORM DRAINS NEAR CALLER'S SITE, AND NEIGHBORING VACANT LOT MAY BE CLOGGED BY MUD. CALLER STATED THAT HE WAS ABLE TO CLEAR SOME MUD OUT OF THE ONE NEAR HIS SITE. (DRAINS ARE ON NW 190TH ST, BETWEEN 10TH AVE NW AND 11TH AVE NW)	Went to site and cleared approx 1/2 cubic yard of soils/gravel/mud from the catch basin the caller was concerned with and several other basins. It appears that an upper basin had its grate plugg so waters were rushing down, scouring the soils, and depositing them at the basin the caller was concerned with. Left business card at callers home
11/16/2009 20:35	19845 10TH AVE NW	private issue	private issue	CALLER CONCERNED REGARDING WATER RUNNING OFF THE STREET, CLOSE TO FLOODING THE PROPERTY	Stopped by residence and spoke with resident. Informed resident that there did not appear to be concentrated flows or a compelling reason for work. Resident was very unhappy with decision but understood my reasoning.

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
10/19/2009 8:08	804 NW 195TH PL	clogged ditch	clogged ditch	I live off 8th Avenue NW, in Richmond Beach area. The water drainage system on the east side of 8th Avenue NW is starting to overflow due to the rain for the past few days. We would like someone to come out and clean the drainage system as there might be vegetation that is causing a backup.	MESSAGE FOR THE CUSTOMER THAT SW WALKED THE DITCHLINE. THE INLET/OUTLETS WERE CHECKED AND SOME LEAVES WERE REMOVED. THIS WAS DONE FOR TWO BLOCKS. I STATED THAT THIS IS A VERY FLAT SPOT BUT SHOULD BE OK. I REQUESTED A RETURN CALL IF THERE WERE ANY FURTHER QUESTIONS OR CONCERNS.
10/16/2009 9:14	20002 13TH PL NW	sinkhole	sinkhole	Why did we not repair the third sink hole at the top of the hill where 201st meets 13th Pl NW. We fixed the other two. This one is sinking pretty fast.	CALLED AND SPOKE WITH CUSTOMER. THIS SAW CUT IS ON A FAIRLY STEEP GRADE AND OUR CONCRETE SAW WILL NOT PULL ITSELF UP THE HILL TO CUT ONE SIDE. WE WILL BE OVERHAULING THE DRIVE SYSTEM ON THE SAW IN JANUARY 2010 AND THEN SAW CUT THE REST OF THE PATCH. THIS CUT IS ON OUR WORK ORDER LIST. IT IS A DEPRESSION AND NOT A HAZARD. SHE WAS HAPPY AND WAS JUST WONDERING WHY WE DIDN'T DO IT AT THE SAME TIME AS THE OTHERS. CLOSE REQUEST.
					Neal: Good afternoon. Our Public Works team looked into your requests and I wanted to provide this response. We agree with you that there is a sight distance issue at the intersection of 190th and 11th NW. Thank you for bringing this to our attention. It looks like you originally contacted the City on April 20th and the City has since then contacted the property owner and required them to cut the vegetation. They have until June 19th to comply. Since you contacted me, our crews put out a portable stop sign to make the condition safer. If after the 19th it is not addressed, then the City will perform the work and take up the issue with the property owner. While we agree with you that providing more space for pedestrians is a high goal, we are not going to able to cover the ditch running parallel to 190th. Trimming of the vegetation around the intersection should help,

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
					but the current conditions do not rise to a priority higher than what has presently been established for our current funding. I wish I could be more optimistic for this area in the future, but our Surface Water Utility is focused on trying to solve significant private property flooding in the Thornton Creek basin (e.g. Ronald Bog – Corliss and 172nd area). I hope this addresses your concerns and once again I apologize for the City not reponding to your original request. Please feel free to call my office if you wish to discuss this
5/20/2009 14:19	8TH AVE NW	ditches	ditches	PLEASE REVIEW THE DITCHES ON THE NORTH SIDE OF NW 190TH FROM 11TH UP TO 8TH AVE NW	further. Thank you again for bringing these issues to our attention. Mark Relph
1/22/2009 12:07	19828 10TH PL NW	private issue	Not SW related	STORM DRAIN IS RIGHT BELOW THE STORM DRAIN, AND AT LEAST ONE PIECE OF MAIL (POSSIBLY A LETTER) FELL INTO THE STORM DRAIN. CALLER IS REQUESTING ASSISTANCE IN REMOVING THE STORM DRAIN LID TO REMOVE THE MAIL FROM THE DRAIN) - CALL CUSTOMER ON CELL PHONE NUMBER WHEN REP IS ON SITE.	
1/20/2009 11:24	1536 NW 186TH ST	ineffective drainage	Need berm	SURFACE WATER / DRAINAGE ISSUE: A LARGE AMOUNT OF WATER FLOWS OFF 15TH AVE NW AND ENDS UP FLOWING DOWN NW 186TH ST AND INTO CALLER'S DRIVEWAY, CAUSING SOME DRIVEWAY DAMAGE, AND CONCERNS ABOUT THE CRITICAL AREA SLOPE NEARBY.	Left msg for caller for late august early september installation of berm as per callin request
8/7/2008 9:15	1207 NW 201ST ST	private issue	Not SW related	CUSTOMER REQUESTING ASSISTANCE TO LIFT A CATCH BASIN LID TEMPORARILY. SHE STATES THAT HER YOUNG SON DROPPED SOME OF THEIR NEIGHBOR'S EXPENSIVE ROCKS INTO THE CATCH BASIN. SHE WOULD LIKE ACCESS TO THE DRAIN TO RETRIEVE THE ROCKS FOR THE NEIGHBOR.	

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
6/5/2008 12:30	19023 8TH AVE NW	sinkhole	sinkhole	CUSTOMER SAY'S THAT WATER RUNS DOWN THE ROAD AND GOES BENEATH THE UTILITY BOXES IN THE MIDDLE OF THE ROAD AND HAS UNDERMINED THE ROAD CAUSING THE BOXES TO SINK AND WATER TO POOL IN THEM. HE SAY'S THIS HAS CREATED A ROAD HAZARD. HE WOULD LIKE THEM TO BE REPAIRED.	W.O. # 82978 REPLACE/INSTALL DRAINAGE PIPE SCHEDULED FOR
1/29/2008 13:00	20023 10TH AVE NW	failed pipe	failed pipe	THE DRAINAGE SYSTEM THAT RUNS ON THE SOUTH SIDE OF THIS PROPERTY HAS FAILED. THE PIPE IS 6" CORRUGATED PLASTIC. THE FAILURE IS ON THE CREST OF THE HILL TO THE WEST. FROM THE CB ON THE STREET IS A 12" CONCRETE STUB, THIS IS REDUCED TO THE 6". THIS NEEDS TO BE REMOVED AND UPSIZED OR AN OPEN DITCH TO RECTIFY THE PROBLEM.	W.O. # 38668 FOR DRAIN HAS BEEN COMPLETED ON 01-05-09
1/14/2008 15:10	804 NW 195TH PL	blocked pipe	rock	STORM DRAIN IS OVERFLOWING, IT APPEARS THAT WATER IS NOT FLOWING THROUGH IT PROPERLY DUE TO A LOT OF VEGETATION GROWTH. DRAIN IS ON THE EAST SIDE OF 8TH AVE NW, ACROSS FROM NW 195TH PL. NOT FLOODING PROPERTY AT THIS TIME	VOICEMAIL FOR CUSTOMER EXPLAINING ROB'S ACTION / RESPONSE REGARDING REMOVING A ROCK WHICH WAS PREVENTING WATER FROM FLOWING
12/28/2007 14:29	19023 8TH AVE NW	ineffective drainage	CB needed	CUSTOMER STATES THAT WATER RUNS DOWN FROM THE STREET INTO CALLER'S PROPERTY FROM THE DRIVEWAY. HE STATES THAT THERE ARE NO DRAINS ON THE STREET, AND WATER COLLECTS NEAR THERE. CALLER STATES THAT THE ASPHALT BERM DOES NOT APPEAR TO BE SEALED, SO WATER GOES UNDER IT EVENTUALLY AND FLOODS INTO THE PROPERTY.	Went to site with David Labelle. He had a look at the berm and stated that there was no issue with water going underneath berm but a cb or other drainage was needed
12/3/2007 11:20	NW 196TH ST	flooding	Unknown	198TH TO 190TH ACROSS FROM SYRE SCHOOL 12TH AVE NW. AFRAID IS NOTHING IS DONE WATER WILL ENTER SYRE.	FOLLOW UP CALL AFTER STORM EVENT. RESIDENT STATED THAT THE FLOODING WAS CONTAINED TO THE STREET.

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
12/3/2007 10:50	19805 8TH AVE NW	clogged ditch	clogged ditch	DITCH ALON EAST SIDE OF STREET CLOSE TO CVESTING IN THE MIDDLE OF THE RAOD. WATER ABOUT TO COME IN HIS YARD.	Checked 193rd to 200th. All culverts are clear or near clear. Ditches need to be cleaned
12/3/2007 14:10	1431 NW RICHMOND BEACH RD 1	flooding	Unknown	BROOKSIDE WEST CONDOS - CREEK RUNS BEHIND CONDOS, LOOKS LIKE IT'S GOING TO OVERFLOW	LEFT VOICE MAIL MESSAGE FOR STORM FOLLOW UP CALL. UNABLE TO VERIFY IF WATER ENTERED BUILDING OR DAMAGE WAS INCURRED.
3/6/2007 12:55	19820 11TH AVE NW	clogged culvert	clogged culvert	CUSTOMER STATES THAT THE CULVERT PIPES HAVE SEPARATED OVER TIME AND ROCKS AND DIRT ARE GETTING INTO THE CULVERT	SPOKE WITH THE CUSTOMER AND LET HIM KNOW THAT WE WERE UNABLE TO FIND ANY PROBLEMS. HE STATED THAT IT WAS THERE AND HE WOULD GO LOOK AROUND. I TOLD HIM TO CALL ME IF HE FINDS THE HOLE.
12/27/2006 11:29	17TH PL NW	hillslope seepage	hillslope seepage	CUSTOMER REPORTS WATER COMING OUT OF A PATCH IN THE ROAD NEAR THE CORNER	THIS APPEARS TO BE SURFACE WATER COMING OUT OF THE HILLSIDE. MANY PATCHES HAVE SIMILAR WEEPING. WE WILL WATCH IN THE DRY TIMES TO SEE IF THIS CHANGES.
11/15/2006 16:12	1431 NW RICHMOND BEACH RD 1	surcharged pipe	UNknown	THE BASIN AT THIS LOCATION IS BOILING OVER.	ROB AND I WERE UNABLE TO CLEAR THIS BLOCKAGE FROM THE LINE. BASIN TO OUTFALL IS 75' PER THE MAP.
8/14/2006 13:10	1403 NW RICHMOND BEACH RD	Overgrown creek	Capacity	Caller is concerned about the Creek behind the condos (Storm Creek). She says it is overgrown and needs work. I told her We would evaluate the Creek in terms of whether there are any obstructions or if there is "excess" bank vegetation that can be removed. The bank vegetation should be evaluated in terms on whether removing it would cause the stream to lose an lot of shading and whether it would destabilize the banks and cause erosion.	W.O. # 15820 FOR DRAIN HAS BEEN COMPLETED ON 08-25-06
				CUSTOMER SAYS THAT SEATTLE WATER HAS DONE SOME DIGGING OUT NEAR THE INNIS ARDEN CLUBHOUSE. THEY DISCOVERED, AND POSSIBLY	LADONNA SPOKE WITH JERRY SCHUSTER ABOUT THE CUSTOMERS REQUEST AND WAS TOLD THAT THEY HAVE COMPLETED THEIR PORTION OF WORK ON

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
4/6/2006 10:40	1430 NW 188TH ST	damaged pipe	construction work	DAMAGED A STORMWATER PIPE. THEY ARE REQUESTING CRT ASSISTANCE IN LOCATING OTHER STORMWATER PIPES BEFORE MORE DAMAGE IS DONE.	THIS REQUEST. ANY ADDITIONAL WORK WILL BE COMPLETED BY SEATTLE WATER UNDER THE DIRECTION OF THE RIGHT OF WAY INSOECTOR-SUE KURNICK...
4/4/2006 12:35	Intersection8TH AVE NW	water leak	Not SW related	CUSTOMER SAYS THAT THERE IS A SLOW WATER LEAK OF SOME KIND, WHICH MAY BE RELATED TO SURFACE WATER. THE WATER IS STARTING TO CRACK THE ASPHALT, AND CUSTOMER THINKS IT MAY FORM A POTHOLE EVENTUALLY. CUSTOMER SAYS THAT SEATTLE WATER, AND RONALD WASTEWATER HAVE INVESTIGATED THIS LEAK AND DETERMINED THAT IT'S NEITHER OF THEIRS. THE LOCATION IS THE CORNER OF 8TH AVE NW @ NW 190TH LN.	SPOKE WITH THE CUST, THE WATER LEAK STARTS APPROX 15FT INTO THE PRIVATE ROAD. THERE ARE 5 HOUSES SERVED ON THIS PRIVATE ROAD AND ALL WATER METERS ARE AT THE STREET. THE LEAK COULD BE FRON ANY ONE OF THE HOUSES. I ADVISED HIM WITH HIS NEIGHBORS TO ALL SHUT OFF THEIR WATER AND THEN READ THE METERS TO LOCATE WHICH SERVICE IS LEAKING. I ALSO INFORMED HIM THIS IS A PRIVATE MATTER.
3/1/2006 13:16	Intersection15TH AVE NW NW 190TH ST	failed rockery near creek	UNknown	TRUCTURAL ROCKERY ABOVE THE CREEK HAS FAILED AND FALLEN INTO THE CREEK.	King County Completed work on 9/14.
2/7/2006 10:02	830 NW 190TH ST	clogged ditch	clogged ditch	CUSTOMER SAYS THAT THE DITCH IN FRONT OF 830 NW 190TH IS FULL OF DEBRIS, AND MAY CAUSE FLOODING PROBLEMS.	INVESTIGATED THE DITCH. THERE IS SOME VEGETATION BUT THE DITCH IS OK, NO ACTION IS NEEDED.
1/30/2006 10:58	18636 17TH AVE NW	ineffective drainage	paving issue	CUSTOMER SAYS A LARGE PUDDLE IS FORMING ON THEIR STREET. SHE SAYS IT EVENTUALLY DRAINS TO A DRAIN ON THE OTHER SIDE OF THE STREET, BUT THIS PUDDLE TAKES SEVERAL DAYS TO RECEDE. A FEW YEARS AGO THE CITY CAME OUT TO DO WORK ON A DRAIN BASIN IN FRONT OF THE SERVICE ADDRESS. THE DRAIN SYSTEM THAT WAS INSTALLED TO CATCH THE RUNNING WATER RUNS UNDER THE CUSTOMER RESIDENCE AND INTO THE BACK YARD. CALLER SAYS THE PIPE THAT WAS	Paving is such tant water puddles. No immediate threat to private property.

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
1/30/2006 10:28	19121 12TH AVE NW	ineffective drainage	Connection of storm pipe	INSTALLED IS EXPOSED AND WATER IS RUNNING INTO THE YARD. SHE IS CONCERNED ABOUT WATER SATURATION UNDERMINING THE TREES ON THE SITE CAUSING THEM TO FALL AND WOULD LIKE THE PIPE INSTALLATION TO BE EXTENDED.	Project to connect storm drain in front of the house to system further south on street completed by SW Small works projects.Cost including repaving is $57,000.
1/10/2006 12:01	Intersection8TH AVE NW	blocked pipe	debris	CUSTOMER IS REPORTING A DRAINAGE ISSUE ON 8TH AVE NW BETWEEN NW 199TH ST AND 200TH ST. HE SAYS THAT THE DITCHES ON BOTH SIDES OF THE STREET ARE NOT DRAINING PROPERLY, AND THIS MAY CAUSE FLOODING ISSUES.	They were successful in removing the chunk of concrete.
10/14/2005 14:42	19822 10TH PL NW	ineffective drainage	ineffective drainage	CUSTOMER IS REQUESTING THAT THE CITY LOOK AT A DRAIN ON 10TH PL NW ABOUT 100 FEET UP THE HILL FROM 19822 10TH PL NW. CUSTOMER SAYS THAT THE DRAIN IS RAISED ABOVE STREET LEVEL SO IT DOES NOT COLLECT ANY SURFACE WATER AT ALL.	
10/3/2005 18:00	1024 NW 190TH ST	covered CBs	covered CBs	CUSTOMER SAYS THAT THERE ARE 4 STORM DRAINS COVERED BY GRAVEL ALONG NW 190TH ST, BETWEEN 10TH AVE NW AND 11TH AVE NW	NONE NEEDED, WE WILL TALK AT DINNER
6/3/2005 15:41	Intersection8TH AVE NW	loose CB lid	Not SW related	CALLER SAYS A CIRCULAR STORM DRAIN LID IS LOOSE IN THE INTERSECTION OF 8TH AVE HEARD FROM HIS BACK YARD TWO BLOCKS AWAY.	THIS IS AN OLD REQUEST AND ALL REPAIRS WERE MADE PRIOR TO 8TH AVE NW GETTING OVERLAYED. CLOSE
1/18/2005 15:56	Intersection8TH AVE NW	clogged ditch	clogged ditch	DRAINAGE DITCH WAS PLUGGED YESTERDAY AND WATER WAS ABOUT TO GO OVER THE POTENTIAL BLOCKAGE.	W.O. # 8112 VEGETATION MOWING SCHEDULED FOR 06-07-04
11/8/2004 9:39	Intersection15TH AVE NW	clogged culvert	clogged culvert	CUSTOMER REPORTS 2 PROBLEMS AT THIS INTERSECTION 1) CLOGGED DRAINAGE PIPE 40 FT NORTH 2) PROPERTY OWNER VEGETATION GROWING ONTO SIDEWALK IMPEDING SIDEWALK 100 FT EAST OF INTERSECTION.	W.O. # 6768 DRAINAGE MAINTENANCE SCHEDULED FOR

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
9/23/2004 16:39	19805 8TH AVE NW	clogged ditch	clogged ditch	EAST SIDE OF ST FROM 194TH-200TH NEEDS TO BE CLEANED OUT. VEGETATION WAS TRIMMED AND LEFT IN DITCH. WATER IS NOT ABLE TO FLOW THRU DIT PREVIOUS FLOODING REQUEST 14959 & 15193	THIS IS A DUPLICATE, REFER TO 17303. MR MELTON IS CALLER #2 ON THAT REQUEST
9/17/2004 17:17	Intersection15TH AVE NW	private issue	private issue	CITIZEN REPORTS PARKING STRIP IN FRONT OF HOUSE WASHES OUT EVERYTIME IT RAINS CLOGGED.	Basin cleaned by CRT.No futher draiange problems reported
				DO YOU EVER CLEAN OUT DRAINAGE DITCHES? AFTER DRAIN PIPES PUT IN ON 8TH	THE DITCH AT THIS LOCATION IS IN GOOD SHAPE. IT HAS A LOT OF VEGETATION IN IT BUT FLOW IS NOT RESTRICTED.
7/16/2004 14:38	Intersection8TH AVE NW	clogged ditch	Vegetation	WEEDS-WHERE DOES THE WATER GO? I HAVE SEEN LITTLE OLD LADIES OUT TRYING TO CLEAN THE DITCHES IN THIS TRAFFIC.	THE VEGETATION HELPS WITH INFILTRATION. THE CITY DOES NOT HAVE THE MAN POWER TO ROUTINELY MAINTAIN THE DITCHES. NO RETURN INFO.
2/18/2004 0:00	18315 17TH PL NW	?		See attached response letter	
2/3/2004 13:58	1603 NW 185TH ST	stream issues	capacity, drainage routes	STREET WATER RUN OFF CREATING STREAM BETWEEN PROPERTIES 1603 & 1621 NW 185TH DURING RAINS	
1/7/2004 12:00	Intersection16TH AVE NW	clogged culvert	clogged culvert	RICHARD CALLED TO REPORT CULVERT UNDER ROADWAY WILL NEED TO BE CLEARED AFTER EMERGENCY	CUSTOMER REPORTS PLUGGED CULVERT, WATER IS ABOUT TO RUN OVER ROADWAY.
11/19/2003 14:57	1118 NW 201ST ST	clogged culvert	clogged culvert	STORM DRAIN IS CLOGGED BUBBLING WATER OUT ON STREET.	CALLED AND INFORMED CUSTOMER I WAS ABLE TO GET IN UNCLOGGED BUT IN THE FUTURE IT SHOULD BE THEIR RESPONSIBILITY TO MAINTAIN THIS DRAIN SYSTEM.
11/6/2003 15:51	18315 17TH PL NW	erosion	Creek erosion	CREEK RUNNING ON CUSTOMERS PROPERTY AND UNDERNEATH THE ROAD IS ERODING PROPERTY AND THE CULVERT	
4/9/2003 10:42	18645 17TH AVE NW	sinkhole	sinkhole	drain near this location is sinking	
12/26/2002 15:58	1431 NW RICHMOND BEACH RD 10	dry creek	dry creek	USTOMER STATES THAT THE CREEK THAT RUNS BEHIND THE MEADOWBROOK APTS IS DRY. SHE BELIEVES THAT SOMETHING IS BLOCKING THE FLOW	DAVID AND I CHECKED THE SCREENS. VERY LITTLE MATERIAL WAS BLOCKING. CLEARED ALL DEBRIS AND CLEANED OUT THE OUTFALLS
12/17/2002 15:00	1613 NW 191ST ST	ineffective drainage	asphalt curb sinking	ASPHALT CURBING HAS SUBSIDED THERE IS A DEPRESSION. CALLER IS CONCERNED ABOUT FLOODING	

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
9/25/2002 16:33	19005 11TH AVE NW	missing water manhole lid	Not SW related	STORM DRAIN/WELL 4 TO 5 FEET DEEP IN FRONT OF CALLER'S PROPERTY, CURRENTLY DOES NOT HAVE ANY KIND OF COVER ON IT. CALLER WOULD LIKE TO KNOW IF IT NEEDS A COVER ADDED	CALLED SEATTLE WATER AND EXPLAINED THE PROBLEM. THEY WILL HAVE SOMEONE RESPOND TO LOOK AT THE VAULT.
6/10/2002 10:39	1219 NW 203RD ST	surcharged pipe	Not SW related	SAYS THERE IS WATER BUBBLING UP IN FRONT OF HIS HOUSE IN THE ROAD THAT IS THEN RUNNING DOWN THE ROAD. SAYS IT HAS A BAD ODOR. WOULD LIKE TO HAVE THIS LOOKED AT.	MR POTTER CALLED AND LET ME KNOW THAT THE WATER COMING OUT OF THE GROUND IS NOW FLUCTUATING IN VOLUME. SEATTLE WATER IS GOING TO LEAVE IT FOR NOW. HE WILL MONITOR IT AND CALL ME BACK IF THINGS CHANGE. I WILL CLOSE THIS FILE FOR NOW.
6/3/2002 16:41	19126 15TH AVE NW	dry creek	dry creek	SAYS THE CREEK BEHIND HIS HOUSE IS DRIED UP. BELIEVES IT IS PLUGGED UP AT THE MEADOW BROOK APTS	THE TRASH RACKS OF THE STREAM ARE CLEAR AND FLOWING. THE STREAM IS VERY LOW AS IT HAS NOT RAINED MUCH. THIS IS AN OVER FLOW.
3/22/2002 11:10	1228 NW 201ST ST	unexplained noise	Not SW related	THERE IS A NOISE THAT HAPPENS EVERY MORNING THAT APPEARS TO BE COMING OUT OF THE STORM DRAINS, IT IS VERY LOUD AND THIS MORNING EVEN SHOOK THE HOUSE, BOTH NEIGHBORS AT THIS LOCATION HAVE HEARD IT.	SPOKE WITH THE CUST AT THE SITE, COULD NOT LOCATE CITY STORM DRAIN OR ANY OTHER CITY ISSUE ON THE SIDE OF THE HOUSE SHE SAYS HAS A NOISE. I DID NOT HEAR ANYTHING EITHER.
1/29/2002 10:55	19126 15TH AVE NW	creek is blocked	UNknown	CALLER STATED THAT THE CREEK IN FRONT OF HIS HOUSE IS PLUGGED UP. HE SAID BOB WOULD KNOW WHERE TO LOOK FOR THE SOURCE OF THE PLUG. LH	THE OUTFALLS ARE CLEAR AND WATER IS FLOWING
1/3/2002 11:00	19041 11TH AVE NW	ineffective drainage	landscaping issue	JOHN IS A FRIEND OF EVY DANIELSON WHO LIVES AT THIS ADDRESS. HE IS CALLING ON HER BEHALF REGARDING DRAINAGE PROBLEM AT THIS LOCATION. SAYS THE AREA WAS RE-LANDSCAPED RECENTLY AND NOW WATER IS FLOWING INTO THE FRONT YARD OF THIS HOUSE. THE WATER IS NOT DRAINING PROPERLY INTO THE CATCHBASINS. HE WOULD LIKE TO HAVE THIS LOOKED AT. HE CAN BE REACHED ON HIS CELL AT (206)355-5842	RESHAPED DITCH, ADDED SECTION OF PIPE AND ROCKED AROUND OUTLET FOR 19040

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
12/16/2001 20:50	Intersection15TH AVE NW	sewer issue	Sanitary sewer issue	Sunday 12/16/01 @ 8:50pm: Ron Christenson resident at 1405 NW 188th left message on unique, you've got 2 ? " of water shooting out of the manhole. All that water is going into my garage. Drain can't keep up, at this point I don't think this is all my responsibility. I've got an easement here for drainage and obviously it's not working. Can someone please come by tonight and find a better way to deal with it."	VISITED SITE. SEWAGE WAS SHOOTING OUT OF THE THREE METRO MANHOLES ON 15TH AVE NW AT NW 190TH ST. I 1405 NW 188TH ST. SEWAGE IS SHOOTING/BOILING OUT OF THE GRAVEL SHOULDER JUST ABOVE HIS DRIVEWAY. THE SEWAGE IS FLOWING DOWN THE DRIVEWAY AND INTO HIS GARAGE. I CALLED AND REPORTED TO RONALD SEWER. KIM CALLED ME BACK AND INFORMED ME IT WAS A METRO TRUNK LINE THAT CANT HANDLE THE INFILTRATION DURING HEAVY RAINS. KIM SAID HE WOULD RESPOND TO THE RESIDENCE WITH SEWAGE FLOWING INTO THE GARAGE AND WOULD ALSO CALL TO REPORT IT TO METRO. I DROVE AROUND THE AREA AND FOUND TWO OTHER MANHOLES WITH SEWAGE FLOWING OUT OF THEM. I DUG A TRENCH AT ONE TO KEEP IT FROM FLOWING DOWN A PRIVATE DRIVEWAY. NOTHING ELSE I COULD DO.
12/3/2001 16:33	19126 15TH AVE NW	dry creek	dry creek	SAYS CREEK IN FRONT OF HIS HOUSE HAS NO WATER IN IT AND IS PLUGGED UPSTREAM.	
11/26/2001 11:22	18419 17TH AVE NW	private issue	private issue	RESIDENT SAYS THE STORM SEWER DRAIN AT THE BOTTOM OF HIS DRIVEWAY NEEDS TO BE CLEANED OUT. SAYS IT IS FULL OF MUD AND DEBRIS	THIS IS A PRIVATE CATCH BASIN. NO OTHER PIPES ARE CONNECTED TO THIS C/B EXCEPT THE OUTLET LINE. HOMEOWNERS RESPONSIBILITY
				NEIGHBOR AT THIS LOCATION IS REMOVING DIRT FROM THE FRONT YARD AND CREATING A PILING. CONCERNED WITH THE RAIN THE DIRT WILL FLOW INTO THE STORM DRAIN AND CAUSE A BLOCKAGE ALSO CONCERNED DIRT WILL FLOW INTO OTHER NEIGHBOR'S (820 NW 193RD ST) DRIVEWAY. WOULD	MET SECOND CUSTOMER WHEN DOING SITE VISIT. THE NEW LANDSCAPING BEING DONE BY THE NEW OWNER AT 814 NW 193RD ST IS CAUSING A LINE OF SIGHT ISSUE WHEN BACKING OUT OF HER DRIVEWAY. SOME OF THE WORK IS ALSO BEING DONE ON CITY RIGHT OF WAY. WE TALKED A LOT ABOUT ISSUES REGARDING THE PROPERTY LINE AND HOW THE WORK IS IMPACTING HER PROPERTY. I EXPLAINED TO HER THAT THESE ARE PRIVATE ISSUES BETWEEN

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
11/15/2001 15:22	814 NW 193RD ST	private issues	private issue	LIKE TO HAVE THIS LOOKED AT, WANTS TO KNOW IF A PERMIT IS NEEDED TO DO THIS.	HER AND THE NEIGHBOR. I TOLD HER THERE IS A LINE OF SIGHT TRIANGLE FOR DRIVEWAYS INTERSECTING A ROADWAY AND WE COULD DO A FOLLOW UP VISIT TOMORROW WITH THE DIMENSIONS TO DETERMINE IF THERE IS SOMETHING WE CAN DO. SHE WAS VERY HAPPY WITH THAT. CUSTOMER HAS ALREADY SENT THE NEIGHBOR A LETTER REGARDING HER ISSUES. SHE THINKS HE HAD A LAWYER OUT TO LOOK AT IT AFTER RECEIVING HER LETTER AND SINCE HAS BEGUN TO REMOVE SOME PLANTS BUT HE STILL WILL NOT INFORM HER OF HIS PLANS.
11/2/2001 14:34	19126 15TH AVE NW	dry creek	dry creek	RESIDENT CALLED SAYS THE CREEK BY HIS HOUSE IS COMPLETELY DRY. SAYS IT HAS BEEN LIKE THIS FOR 2 WEEKS. IN THE PAST HE HAS CALLED JEFF THOMAS TO COME OUT AND LOOK AT IT WHEN THIS OCCURS. WOULD LIKE TO HAVE SOMEONE COME OUT AND TAKE A LOOK.	THIS DRAINAGE LOCATION IS BEING CHECKED BY MULTIPLE PEOPLE ON A REGULAR BASIS. ANY BLOCKAGES (USUALLY LEAVES) ARE CLEARED.
8/22/2001 15:55	Intersection13TH AVE NW	ineffective drainage	pavement	WOULD LIKE TO HAVE A DRAIN PUT IN AT THIS CORNER LOCATION. SAYS THERE IS COLLECTS ON THE ROADWAY AND RUNS ACROSS THE STREET. SHE WOULD LIKE TO HAVE SOMEONE COME OUT AND LOOK PREFERABLY WHEN IT IS RAINING TO SEE WHAT SHE IS TALKING ABOUT. AR	SPOKE WITH MRS WEEKS. I EXPLAINED TO HER THAT THIS HAS BEEN INVESTIGATED THOROUGHLY AND THAT THE TOLD HER THAT THIS IS A FAIRLY SMALL PUDDLE THAT IS NON-HAZARDOUS AND THAT THE REPAIRS TO MAKE THIS PUDDLE DISAPPEAR IS FAR TOO COSTLY. SHE THANKED ME FOR TRYING.
8/9/2001 10:17	Intersection8TH AVE NW	ineffective drainage	road overlay	Says the storm drain at the corner of this location, is too low following the recent overlay done on the road. She would like to have someone come out and check it. AR	
4/11/2001 15:50	19619 11TH AVE NW	gutter information	Not SW related	Called to get information on options for discharging his gutters. Has been asked by the sewer district to plug an existing gutter connection to the sewer line by this summer. Doesn't know what is permitted in the city for gutter runoff treatment.	

Private Property Service Requests

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
12/3/2007 10:35	823 NW 195TH PL	flooding	capacity?	WATER ON ROAD & FLOODING HOMES, WATER NOT DRAININ PROPERLY FROM 8TH	
11/15/2007 15:42	1516 NW 192ND ST	flooding	UNknown	CALLER SAYS THAT A SIGNIFICANT AMOUNT OF WATER IS RUNNING DOWN THE HILL AND INTO HER YARD	Jerry Shuster, Jill Mosqueda, and Eric Gilmore went onsite to deliver a letter and as-builts instructing Avamere to fix the drainage problem while investigating the bypass at the outfall. The bypass and infiltration tank appeared to be in good working order
3/8/2006 15:13	19805 8TH NW	flooding	debris blockage	DITCH IS FULL AND WILL BE OVERFLOWING, POSSIBLE PLUGGED CULVERT	I went out and removed fir branches from the culvert inlet. It fixed the issue.
10/3/2005 10:21	804 NW 195TH PL	flooding	road overlay	CUSTOMER SAYS HIS BASEMENT GOT FLOODED BECAUSE OF STANDING WATER IN THE STREET ON 9/1/2005 (RAIN STORM THAT DAY) - HE SAYS THAT FLOOD INSURANCE WAS NOT AVAILABLE FROM HIS INSURANCE COMPANY. CUSTOMER SAYS THE WATER WAS COMING FROM 8TH AVE NW WHICH IS NOT A PRIVATE ROAD. WATER FLOWED WEST FROM 8TH AVE NW TO THE NORTH	ROAD WAS REPAVED AND CONSTRUCTION AT 8TH AVE NW AND 195TH STREET ON THE NE CORNER FOR COTTAGE HOUSES. ONE OF THE CATCH BASINS ON 8TH WAS COVERED DURING THE OVERLAY AND IS STILL COVERED. HE HAS LIVED THERE FOR 8 YEARS AND HAS NEVER FLOODED LIKE THIS BEFORE. FIRE PROVIDED A PUMP ON SATURDAY EVENING AT 4PM. THERE WAS A RIVER COMING TOWARD HIS HOUSE. CUSTOMER WOULD LIKE SOMEONE TO COME OUT TO LOOK AT HIS SITUATION TO ALEVIATE ANY FUTURE FLOODING Visited the site today and met with home owner Mrs. Hashemi and spoke to her husband on the phone. From discussions with home owners and my field investigation I note the following. The flooding they experienced was caused by the ditch on the east side of 8th AVE NW over flowing its banks. The ditches and 8th Ave were described as standing water, ponded up. High water marks along the ditch lines confirm this. From 19532 NW 8th Ave south to 193rd NW. Found 3-blockages in the line, inlet to culvert at 19529 NW 8th, the CB at corner of NW 195th ST, and removed sediment from outfall ditch of culvert at 19338 NW 8th ave. The sediment/gravel had formed a berm in the ditch

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
					from flows that scoured and deposited the berm so that the berm was higher than to top of the outlet culvert. The ditch needs to be cleaned and reshaped from NW 197th ST south to 19324 NW 8th Ave. I noted that even in ditches with no flow blockages that they had overtopped their banks or where at capacity. This indicates the system is over capacity and any new additions will only increase the size and frequency of flooding. I speculate that even with the cleaning I did today and the future cleaning of the ditches will not eliminate the flooding in this area. The long term solution here is to apply two actions to the problem. 1) allow no more new development to tie into the system untill the system has been upgraded. CONT IN NEW ENTRY
10/18/2005 9:29	804 NW 195TH PL	flooding	ditch capacity	SIDE OF HIS HOME.	DAVID AND I CLEARED THE BLOCKAGE. THE CB IS FLOWING
11/2/2004 10:36	1015 NW 196TH ST	flooding	Plugged CB	AN APPARENT PLUGGED CB IN FRONTOF HIS SITE IS FLOODING HIS SITE.	I went to this site in November, not sure exactly when. Was responding to a similar complaint about the lack of flow in the west fork channel. I cleared out sediment from the channel to allow flow down the west fork channel. This site is a chronic source of complaints from people altering the flows. Case is closed.
10/8/2004 8:51	1431 NW RICHMOND BEACH RD 1	flooding	blocked weir	THE WEIR HAS BEEN BLOCKED, THIS WAS NOT NATURAL, IT WAS A DELIBERATE ACT. HIS APARTMENT COMPLEX WAS SEVERELY FLOODED THIS WEEKEND, 12 UNITS RECEIVED WATER DAMAGE. HE WOULD LIKE THE CITY TO ENSURE THAT THE AREA INSIDE THE FENCE TO THE SOUTH IS CLEAN, WHEN WAS IT CLEANED LAST. HE WOULD ALSO LIKE CRT TO WALK THROUGH THE SITE TO SEE	INSPECTED THE SITE 8/25/04 AND FOUND ALL TRASH RACKS CLEAN AND LITTLE SEDIMENT IN THE MANHOLES AND PIPES. SPOKE WITH HARLEY ONEAL AND HE WANTED TO KNOW WHAT ARE FREQUENCY OF CLEANING THE SITE IS. IT IS ABOUT ONCE EVERY TWO YEARS. HE WANTED TO KNOW IF I LOOKED AT THE ROAD CROSSING L OF THE PIPE SYSTEM AND INFORMED I DID NOT KNOW ITS CONDITIONS. IT WOULD APPEAR THAT THE FLOODING WAS IN-PART DUE TO A VERY UNUSUAL RAIN EVENT AND THAT HIS BUILDINGS ARE BUILT WITHIN THE HISTORIC FLOOD PLAIN OF STORM CREEK, I.E WETLANDS. THE CREEK WAS

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
8/23/2004 10:30	1404 NW RICHMOND BEACH RD	flooding	floodplain-large event	THE DAMAGE.	DIVERTED INTO 3 SEPARATE REACHES AND SURROUND AND RAN BETWEEN THE APARTMENT BUILDINGS WITH LITTLE OR NO SET BACKS THUS LEADING TO FLOODING DURING HEAVY STORM EVENTS.
8/23/2004 7:51	19116 17TH AVE NW	flooding	clogged drainage?	FLODDING IN TO GARAGE AND BASEMENT. CALLERS BASEMENT FLOODED THIS WEEKEND. THIS IS THE 5TH TIME IN THE LAST COUPLE YEARS. HE WOULD LIKE US TO COME OUT SEE THE DAMAGE, INSPECT THE STORM DRAINS AND RUN OFF AND TRY TO SOLVE THE PROBLEM.	Amanda Nodolf and I inspected the site and found that the source of flow was primarily from 17th Ave NW from almost 193 rd st and then by passed and overwhelmed the catch basins and the road side ditch. Recommend that the drainage line from 192ned St NW to the CB just south of their property be jetted to 191st street. Place a CB and T it into the line at their mailbox with a berm. This should reduce future flooding surges from running down the driveway. We also noted that downstream from their site at 191st NW on the south side adjacent to the Ronald Sewer pump station that a CB and drain pipe are no-longer working. Recommend replacing both the CB (old brick style) and the outlet pipe with new. The entire area drains to the west to infiltrate in the park. Currently the flow is backing up out of the CB and eroding the soils that have now exposed the concrete pipe. Amanda has written a work order for this to be done by our roads crew as a 1.5 priority. Spoke to the owners to let them know of our findings.
8/23/2004 8:10	19903 12TH AVE NW	flooding	clogged CBs	PLEASE CALL TO SET UP A MEETING TIME WITH CUSTOMER.	Close Request. This is not a normal problem. Two catch basins were plugged and water ran down driveway. House still may have water problems due to house below grade and driveway slopes to driveway. Drainage system has been inspected and vactored since flooding issue.
1/9/2003 0:00	1613 NW 191ST ST	??	?	Response letter- not attached	DAVID REPORTED THERE IS A BLOCKAGE IN THE PIPE AT 19850 8TH AVE NW, HE TRIED TO CLEAR IT BUT COULD NOT. THERE IS NO DRAINAGE IN FRONT OF

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
1/29/2004 14:24	19839 8TH AVE NW	flooding	pipe blockage	WATER IS FLOWING INTO HER CARPORT.	CALLERS HOUSE HOWEVER AND NOT SURE WE CAN DO ANYTHING FOR HER.
11/19/2003 10:33	2514 NW 194TH STREET	flooding	capacity?	WHEN IT RAINS THE STREET ACROSS FROM THE BOWLING ALLEY AND MEADOWBROOK APTS ALWAYS FLOODS. THIS HAS BEEN HAPPENING FOR MORE THAN 20 YEARS AND HE WOULD LIKE TO SEE THIS FIXED.	Close, 3rd Ave NW drainage to address flooding.
11/19/2003 7:42	19121 12TH AVE NW	flooding	private plugged drain	FLOODING INTO BASEMENT	HOMEOWNERS DRAIN IS PLUGGED. HOMEOWNER WILL FIX IT. PER AL UNGER CLOSE FILE
11/18/2003 13:37	18646 17TH AVE NW	flooding	overlay	CUSTOMER REPORTS PATCHES DONE TO THIS ROAD BY SEATTLE CITY LIGHT AND NOW THEY ARE POOLING IN FRONT OF CUSTOMERS HOUSE	CLEARED FLOODING OLLIE
11/18/2003 11:11	19104 17TH AVE NW	flooding	capacity	FLOODING - CATCH BASIN - 4 INCHES OF STANDING WATER - USING PUMP/DAM TO KEEP WATER OUT OF HIS AND NEIGHBOR'S YARD & BASEMENT	SANDBAGS PROVIDED, CAPACITY ISSUE, C/B CLEARED
11/18/2003 7:44	1619 NW 191ST ST	flooding	unknown	HOUSE IS FLOODING. NOV 05 PROJECT TO KING CO. FOR ESTIMATE. HOPE TO COMPLETE BY DEC 05	Project completed under Small Works CIP by KingCounty Road Maintenance. Customer is Happy!
11/18/2003 8:59	19805 8TH AVE NW	flooding	plugged culvert	DITCH OVERFLOWING, POSSIBLE PLUGGED CULVERT	CLEARED FLOODING JUSTIN
10/20/2003 14:13	19805 8TH AVE NW	flooding	unknown	DITCH OVERFLOWING ACROSS FROM HER HOUSE	BOB DID A SITE VISIT, THERE IS NO WATER OVER THE ROADWAY, THE DITCH HAS NOT OVERFLOWED AT ALL. BOB ASKED THE CUSTOMER TO ONLY CALL IF WATER IS OVER THE ROADWAY. CUSTOMER IS AWARE THAT AFTER HOURS THERE IS A PAGER HE CAN UTILIZE.
10/20/2003 11:05	1619 NW 191ST ST	flooding	capacity	WATER FLOODING HOUSE	PROBLEM ADDRESSED BY DIVERTING FLOW OF WATER AND PROVIDING SANDBAG DUE TO OVER CAPACITY ISSUE.
10/20/2003 12:10	19121 12TH AVE NW	flooding	broken pipe	FLOODING CALLED IN BY TERRI SWAN - SISTER TO MARK BUCKLEY. PER CUSTOMER THERE WAS A PIPE THAT WAS RUN OVER IN DRIVEWAY AND NEVER RECONNECTED.	SINCE THIS IS THE ONLY DRAIN AT THIS TIME FROM THE CATCH BASIN IN THE STREET. THE ROADS CREW CONNECTED THE 6" PVC PIPE SO AS NOT TO FLOOD THE HOMEOWNERS.
				STORM CREEK BANKS OVER FLOWED INTO THE RICHMOND BEACH TOWNHOMES WHICH CAUSED DAMEAGE TO THE FLOWER BEDS AND THE BACK	CALLED THE CUSTOMER AND LM ON VM THAT THIS AREA IS WATCHED CLOSELY. THE STREAM IS CHECKED TO BE SURE THAT THERE ARE NO BLOCKAGES.

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
1/7/2003 15:03	19200 15TH AVE NW 1920	flooding	unknown	YARD OF CUSTOMERS NEIGHBORS YARD.	THE OVERFLOW WAS DUE TO LARGE VOLUMES OF RAINWATER, NOTHING MORE. I STATED THAT I WOULD CONTINUE TO WATCH THE CREEK AND WILL ALWAYS WELCOME INPUT.
10/17/2001 7:22	1457 NW 191ST ST	flooding	capacity	RUTH HUWE (206-546-6455) CALLED AND REPORTED THAT HER PROPERTY IS BEING FLOODED BY A CONSTRUCTION PROJECT UPHILL FROM HER.	MET WITH MRS HUWE. THE FLOODING WAS COMING FROM THE INNIS ARDEN CLUBHOUSE. THIS IS NOT RELATED TO ANY SORT OF CONSTRUCTION. THIS IS A STRUCTURE THAT WAS OVERWHELMED BY VOLUME. FROM HER STATEMENTS NO WATER ENTERED THE HOUSE FROM THIS PROBLEM. SHE DID STATE THAT DURING THE ICE/HAIL STORM EARLIER IN THE WEEK SHE HAD GOTTEN SOME WATER IN THE HOUSE. SHE INDICATED THAT IT WAS BECAUSE THE C/B WAS COVERED IN DEBRIS. SHE CLEARED THE DEBRIS FROM THE C/B. MS HUWE STATED THAT SHE MAY FILE A CLAIM TO THE CITY FOR DAMAGES. I TOLD HER THAT THIS DOES NOT MEAN THAT SHE WOULD RECOUP ANY MONEY AND THAT THIS WAS A VOLUME PROBLEM NOT A LACK OF MAINTENANCE. SHE THANKED ME FOR COMING OUT.
10/11/2001 14:30	1432 NW 191ST ST	flooding	capacity	WOULD LIKE TO HAVE SOMEONE COME OUT AND CHECK THE CREEK BEHIND HIS HOUSE. WOULD LIKE TO KNOW IF THERE IS A SOLUTION TO THE CREEK OVERFLOWING EACH TIME IT RAINS BECAUSE OF ALL THE EXCESS WATER RUNNING ONTO HIS PATIO. RESIDENT CALLED SAYS AFTER LAST NIGHTS STORM THERE WERE WAS WATER RUN-OFF ON THE ROAD WHICH CARRIED THE GRAVEL AND DIRT FROM THEIR PARKING STRIP AND FLOWED ONTO THE YARDS OF HIS AND HIS NEIGHBORS. SAYS THE NEIGHBORS IN THIS AREA NOW HAVE A LOT OF GRAVEL	SPOKE WITH MR LONG. I EXPLAINED TO HIM THAT HE WILL NEED A PERMIT TO DO ROCK LINING OR MET WITH RESIDENT. WE AGREED TO REMOVE PREVIOUSLY PLACED BERM (WO#1636). WILL HAVE KING COUNTY PAVE AT INTERSECTION TO CONTROL WATER FLOW KCWO#01-104. RESIDENT UNDERSTANDS THAT PAVING MAY NOT OCCUR ANYTIME SOON AND THAT REMOVAL OF BERM MAY CAUSE

Storm Creek
Summary of Service Requests

Date	Address	Type of Problem	Cause	Problem	Solution
10/11/2001 12:23	19819 11TH AVE NW	flooding	berm	AND DIRT ON THEIR FRONT YARDS. SAYS THIS HAS BEEN AND ONGOING ISSUE FOR A NUMBER OF YEARS AND WOULD LIKE TO HAVE SOMEONE COME OUT AND LOOK AT THIS AND SEE WHAT CAN BE DONE. IS REQUESTING A CALL BEFORE YOU COME OUT. SAYS YOU CAN ALSO CONTACT HIS NEIGHBOR KEITH FRESONKE @ 542-3009 (19827 11TH AVE NW).	ADDITIONAL WASHOUT OF ROW TO HIS PROPERTY.
10/11/2001 9:01	1619 NW 191ST ST	flooding	ineffective drainage	CUSTOMER STATES THAT HAIL STORM LAST NIGHT HAS WATER COMING ONTO HIS PROPERTY. HE WOULD LIKE SOMEONE TO COME OUT AND LOOK AT CLEARING THE C/B IN FRONT OF HIS HOUSE. HE SAID THERE IS ABOUT 6 INCHES OF SLUSH ACCUMULATED AT THE C/B.	INSTALL 2" BERM FROM UTILITY POLE ON EAST SIDE OF PROPERTY TO C/B; BERM AROUND C/B TO TRAP WATER & TAPER BERM ON BACKSIDE. BERM FROM C/B TO WEST PROPERTY LINE. (@ 75'). GD SLETRC SURVEY LETTER RECEIVED
8/23/2001 10:38	19858 10TH AVE NW	flooding	ineffective drainage	FLOODING AT THIS LOCATION.	THE BERM GOES ACROSS THE DRIVEWAY AND DIRECTS WATER TO THE CB. THE WORK IS COMPLETE. CALLED, NO ANSWER, NO MACHINE.
8/22/2001 16:59	1613 NW 191ST ST	flooding	Private drainage system	CUSTOMER SAYS DRAIN IS FILLING UP WITH WATER AND WILL POSSIBLY FLOW INTO THE BASEMENT.	CALL CAME OVER RADIO (8/22/01) FROM LAURIE SAYS ATTEMPTED TO DRAIN BUT WAS PRIVATE. WATER DID NOT AFFECT THE HOUSE OR THE DRIVEWAY. SHE SPOKE WITH THE OWNER OF THE HOUSE ABOUT THIS. AR
12/12/2007 9:13	1203 NW 202ND ST	private question	Not SW related	CUSTOMER INDICATED SHE HAD WATER IN HER HOUSE LAST WEEK AND WANTED TO FIND OUT WHAT RESOURCES WERE AVAILABLE FOR DISPOSAL OF RUG AND PAD.	LADONNA CHECKED WITH TINA IN SW AND SHE SAID IT WOULD BE OK FOR THE CALLER TO TAKE HER RUG AND PAD TO THE CORLISS BETWEEN 170TH AND 171ST SITE. THE DUMPSTER WILL BE THERE UNTIL FRIDAY AFTERNOON

APPENDIX D. WATER QUALITY MONITORING DATA

Water Quality Monitoring Data
City of Shoreline
Station: ST-1 (Storm Creek)

Date	Time	DO (mg/L)	pH (Std Units)	Temp (deg. C)	Turbidity (NTU)	Cond (µs)	Sp Cond (µs @ 25 C)	Salinity (ppt)
8/29/2001	3:25 PM	7.95	7.94	15.7		212.9		0.1
9/11/2001	1:30 PM	8.88	8.08	14.1		205.6	259.5	0.1
9/25/2001	3:05 PM	9.90	7.88	13.8		204.7	260.3	0.1
10/9/2001	1:15 PM	10.52	7.92	11.5		192.2	258.9	0.1
10/22/2001	1:20 PM	11.08	8.03	11.1		187.3	255.4	0.1
11/15/2001	9:40 PM	10.42	7.57	12		120.1	159.8	0.1
11/30/2001	11:25 AM	10.88	7.63	8.2	1.08	124.4	183.1	0.1
12/26/2001	10:00 AM	12.40	7.76	5.3		158.7	254.9	0.1
1/10/2002	9:50 AM	12.10	7.59	8.9	0.21	155	224.2	0.1
1/14/2002	3:00 PM			8				
1/31/2002	10:45 AM	11.98	7.74	6.9	3.96	120.6	184.6	0.1
2/14/2002	11:35 AM	11.61	7.86	7.2		153.9	232.7	0.1
3/1/2002	2:40 PM	11.95	7.93	7.8		168.4	250.7	0.1
3/15/2002	10:45 AM	11.50	7.85	7.3	1.29	130.6	197.2	0.1
3/27/2002	3:50 PM	11.96	8.15	8.9		171.7	248	0.1
4/16/2002	11:40 AM	11.34	7.83	8.7		164.1	237.9	0.1
4/29/2002	10:15 AM	11.37	7.77	9.7		177.1	250.3	0.1
5/13/2002	12:45 PM	10.56	7.71	11.1		183.8	250.6	0.1
5/28/2002	11:45 AM	10.22	7.69	13		192	249.5	0.1
6/25/2002	1:55 PM	9.55	7.11	15.3		206.5	253.5	0.1
7/17/2002	4:30 PM	9.06	7.72	15.8	2.20	208.8	253.3	0.1
8/12/2002	10:45 AM	9.66	8.02	15.5	1.90	210.3	256.9	0.1
9/24/2002	4:35 PM	9.31	7.76	14.3	1.47	204.3	256.9	0.1
10/10/2002	12:05 PM	9.96	7.8	11.2	1.34	182.2	247.2	0.1
10/21/2002	3:05 PM	9.71	7.77	12.5	1.14	221	290.3	0.1
11/13/2002	2:40 PM	10.15	7.6	11.3	1.03	184.5	249.6	0.1
11/27/2002	10:50 PM	10.62	7.79	7.3	1.42	173.6	261.8	0.1
12/17/2002	3:05 PM	11.10	7.74	7.8	3.67	123	183.5	0.1
1/3/2003	1:40 PM	10.83	7.57	9.3	4.45	143.9	205.6	0.1
1/16/2003	3:20 PM	10.86	7.7	7.7	0.80	167	249.3	0.1
2/6/2003	10:35	11.11	7.85	6.8	1.60	166.4	255.3	0.1
3/24/2003	11:30 AM	11.03	7.79	8.9	1.80	158.6	228.9	0.1
4/14/2003	2:35 PM	9.64	7.62	12.1	1.90	184.3	244.9	0.1
5/22/2003	4:20 PM	9.12		12.5	1.09	198.5	260.8	0.1
6/17/2003	1:35 PM	9.80	7.96	15	4.60	209.4	258.6	0.1
7/10/2003	10:42 AM	8.96	7.71	14.6	1.01	204.3	254.7	0.1
8/15/2003	2:40 PM	9.34	n/c	16.5	0.80	213.1	254.6	0.1
9/22/2003	3:00 PM	8.68	7.73	14.5	0.90	198.7	248.5	0.1
10/13/2003	2:10 PM	9.60	7.48	12.6	0.60	190.7	250.1	0.1
10/31/2003	2:15 PM	10.50	7.45	7.8	0.40	163.1	243.4	0.1
11/13/2003	10:10 AM	10.10	7.02	7.7	0.33	163	243.8	0.1
12/5/2003	11:45 AM	11.54	7.21	8.7	5.57	73.5	106.9	0.1
12/22/2003	10:55 AM	11.51	6.87	7.3	0.84	162.9	246.5	0.1
1/12/2004	2:05 PM	10.64	7.63	8.1	0.57	140.1	206.7	0.1
1/23/2004	10:10 AM	10.73	7.06	8.1	0.55	160.6	237.2	0.1
2/13/2004	3:40 PM	11.22	7.83	8.3	1.07	168.4	247.9	0.1
3/10/2004	3:03 PM	10.45	7.84	10	1.60	174.3	244.3	0.1
3/26/2004	2:30 PM	10.71	7.73	9.8	0.24	121	170.6	0.1
4/14/2004	10:50 AM	10.47	7.74	10.5	1.36	180.6	249.9	0.1
4/29/2004	2:30 PM	9.23	7.52	13.2	0.99	191.6	247.7	0.1

Water Quality Monitoring Data
City of Shoreline
Station: ST-2 (Storm Creek)

Date	Time	FC (col/100mL)	DO (mg/L)	pH (Std Units)	TP (mg/L)	TSS (mg/L)	Temp (deg. C)	TN (mg/L)	Turbidity (NTU)	Cond (µs)	Sp Cond (µs @ 25 C)	Salinity (ppt)
9/11/2001	13:04		9.16	8.26			14.6			214.3	267.5	0.1
9/25/2001	14:50		10.09	8.10			13.7		6.8	211.0	268.7	0.1
10/9/2001	13:05		10.53	8.17			12.3		0.4	201.4	266.2	0.1
10/22/2001	13:05		11.02	8.16			11.9		3.1	186.9	249.5	0.1
11/15/2001	9:30		10.46	7.55			12.0			126.1	167.6	0.1
11/30/2001	11:15		10.70	7.52			8.8		0.6	131.1	189.8	0.1
12/26/2001	9:50		11.84	7.90			7.4		0.1	175.6	264.3	0.1
1/10/2002	9:35		11.80	7.77			9.3			158.7	227.0	0.1
1/31/2002	10:30		11.74	7.71			7.1		8.9	115.7	175.8	0.1
2/14/2002	11:20		11.40	7.96			8.2			176.1	259.3	0.1
3/1/2002	14:20		11.21	8.00			9.4			184.0	261.7	0.1
3/15/2002	10:30		11.23	6.87			7.7		5.3	120.8	180.2	0.1
3/27/2002	15:40		11.53	7.74			9.4			177.5	253.1	0.1
4/16/2002	11:20		10.85	7.95			9.6			181.1	256.7	0.1
4/29/2002	10:00		10.83	7.92			10.3			192.1	267.4	0.1
5/13/2002	12:20		10.73	8.00			11.3			197.1	267.0	0.1
5/28/2002	11:30		10.25	7.98			13.2			206.8	266.5	0.1
6/25/2002	13:45		9.68	7.85			16.2			224.2	269.7	0.1
7/17/2002	16:20		9.10	8.08			16.8		7.1	227.5	269.9	0.1
8/12/2002	10:30		10.01	8.32			14.8		3.8	211.4	262.9	0.1
9/24/2002	16:30		9.13	7.95			14.9		2.4	216.0	267.3	0.1
10/10/2002	11:45		9.81	8.05			11.7		3.2	196.1	262.7	0.1
10/21/2002	14:58		9.66	8.02			12.8		2.1	205.0	267.2	0.1
11/13/2002	14:20		10.33	7.86			11.8		1.8	216.0	289.1	0.1
11/27/2002	10:40		10.39	7.98			9.2		1.7	187.6	268.8	0.1
12/17/2002	14:50		10.75	7.60			8.7		2.4	138.5	201.4	0.1
1/3/2003	13:20		10.93	7.61			9.4		7.1	148.2	210.9	0.1
1/16/2003	15:15		11.20	7.84			9.1		2.0	179.1	257.6	0.1
2/16/2003	10:25		10.71	7.93			8.6		2.2	180.0	261.8	0.1
3/24/2003	11:20		10.92	7.73			9.6		10.5	164.6	233.2	0.1
4/14/2003	14:20		9.78	7.76			12.5		2.5	196.1	257.5	0.1
4/30/2003	14:00		10.40	7.25			11.3		1.6	191.5	259.3	0.1
5/22/2003	16:10		9.86				12.6		1.0	204.1	267.5	0.1
6/17/2003	13:25		10.16	8.23			15.4		4.4	218.7	267.8	0.1
7/10/2003	10:30		9.44	8.14			14.4		5.2	211.2	264.9	0.1
8/15/2003	14:30		9.93				16.8		2.7	225.0	267.1	0.1
9/22/2003	10:30		9.40				13.5		1.2	204.6	261.9	0.1
9/22/2003	15:15		8.13	8.09			15.3		1.9	215.2	264.3	0.1
10/13/2003	14:30		9.32	7.62			13.0		1.2	122.3	205.6	0.1
10/31/2003	14:00		10.43	7.84			9.2		0.8	183.9	263.0	0.1
11/13/2003	10:00		10.26	7.17			9.2		0.8	180.9	258.9	0.1
12/5/2003	11:35		11.43	7.04			8.7		10.2	63.2	91.7	0.0
12/22/2003	22:45		11.04	7.10			8.7		1.0	178.2	258.8	0.1
1/12/2004	13:50		10.52	7.68			8.9		1.8	160.7	232.7	0.1
1/23/2004	10:00		10.52	6.95			9.0		2.2	169.0	249.1	0.1
2/13/2004	15:25		11.27	8.10			9.5		1.1	174.2	252.2	0.1
3/10/2004	14:57		10.08	8.24			11.1		1.7	192.9	262.9	0.1
3/26/2004	14:15		10.62	7.97			10.1		0.2	151.7	212.4	0.1
4/14/2004	11:10		10.48	8.01			10.7		1.4	193.6	265.8	0.1
4/29/2004	14:22		9.63	7.76			13.8		1.9	207.7	264.2	0.1
9/27/2004	15:30		9.12	8.19			14.6		4.1	199.7	249.0	0.1
10/12/2004	12:30		9.80	8.13			13.6		4.8	192.2	245.5	0.1
11/18/2004	11:00		9.92	7.84			10.3		2.2	171.8	239.3	0.1
12/14/2004	11:40		10.36	7.83			10.4		3.5	149.6	208.6	0.1
1/10/2005	15:15		10.43	8.07			7.4		1.2	155.1	233.7	0.1
1/31/2005	11:40		10.61	7.94			10.2		1.6	175.2	244.9	0.1
2/9/2005	13:45		11.24	8.01			9.2		13.6	167.7	240.2	0.1
2/24/2005	16:00		10.94	8.02			10.0		1.1	176.9	248.0	0.1
3/18/2005	11:15		12.10	8.16			9.9		0.9	176.5	247.8	0.1
4/28/2005	15:15		9.43	8.02			14.6		7.8	195.4	243.7	0.1
5/25/2005	16:05		10.38	8.03			15.5		2.2	203.4	248.7	0.1
6/29/2005	14:50		9.61	6.84			15.5		4.2	202.8	247.9	0.1

Water Quality Monitoring Data
City of Shoreline
Station: ST-2 (Storm Creek)

Date	Time	FC (col/100mL)	DO (mg/L)	pH (Std Units)	TP (mg/L)	TSS (mg/L)	Temp (deg. C)	TN (mg/L)	Turbidity (NTU)	Cond (µs)	Sp Cond (µs @ 25 C)	Salinity (ppt)
7/20/2005	11:10		9.30	8.16			14.4		3.2	198.3	248.6	0.1
8/18/2005	8:00		9.45	7.93			13.4		4.3	124.0	154.9	0.1
10/18/2005	10:00		9.75	7.81			12.6		2.2	190.0	249.1	0.1
11/10/2005	9:00		9.70	7.86			10.3		2.5	179.3	249.1	0.1
12/30/2005	9:00		10.45	5.88			9.0		7.6	117.7	169.9	0.1
1/19/2006	10:00		10.53	7.77			9.2		4.8	151.5	215.0	0.1
2/10/2006	14:40		10.34	7.90			9.5		3.6	168.8	240.0	0.1
3/24/2006	10:30		8.78	7.54			9.6			106.5	150.5	0.1
4/17/2006	12:10		9.88	7.98			10.7		4.4	174.3	240.1	0.1
5/31/2006	13:30		9.07	8.06			14.4			194.6	244.2	0.1
7/3/2006	10:08		3.18	7.85			13.7			160.7	204.6	0.1
8/2/2006	16:10			7.94			16.4			205.0	246.7	0.1
9/8/2006	13:22		8.31	8.10			14.4		1.8	188.5	235.5	0.0
10/13/2006	13:15		10.05	7.93			12.9		1.0	187.1	239.5	0.1
11/14/2006	13:55		12.31	7.66			10.7		1.0	169.0	232.4	0.1
12/22/2006	13:45		10.67	7.55			8.8		1.0	128.3	185.9	0.1
1/29/2007	10:10		11.28	7.82			7.5		0.9	163.2	245.2	0.1
2/26/2007	9:15		10.70	8.06			8.1		0.7	157.7	232.7	0.1
3/27/2007	9:15		8.77	9.19			9.0		1.1	126.6	182.4	0.1
4/24/2007	9:35		10.07	8.24			10.6		0.7	178.3	246.2	0.1
5/29/2007	8:25		9.57	7.66			11.4		0.8	177.2	239.1	0.1
6/26/2007	9:35		8.32	8.03			12.4		0.9	186.9	246.0	0.1
7/31/2007	10:45		8.06	7.94			14.3		1.8	188.7	237.4	0.1
8/26/2007	10:20		9.26	8.05			13.8		1.7	185.2	235.9	0.1
8/28/2007	9:50		8.29	7.89			13.2		1.1	191.7	247.1	0.1
9/24/2007	8:10		7.17	7.88			12.5		1.5	172.2	226.4	0.1
10/30/2007	9:45	78			0.0760	0.6		1.11				
10/30/2007	10:15		9.58	8.00			9.9		0.6	175.5	247.0	0.1
11/27/2007	9:45	47	9.80	8.06	0.0642	0.3	8.6	1.13	1.2	165.3	240.3	0.1
12/18/2007	9:40	1600	10.71	7.40	0.0801	18.1	6.7	0.93	18.0	51.6	79.2	0.0
1/22/2008	10:30	230	11.66	7.82	0.0642	0.5	6.5	1.39	1.2	154.5	239.3	0.1
2/26/2008	10:30	38	11.31	7.96	0.0704	1.0	9.1	1.19	1.1	167.0	240.1	0.1
3/24/2008	10:40	34	11.78	7.67	0.0592	0.3	7.9	1.24	0.2	155.6	231.0	0.1
4/22/2008	9:40	45	10.95	7.79	0.0534	0.5	8.5	1.09	0.8	161.8	236.1	0.1
5/27/2008	9:15	500	10.33	7.52	0.0768	1.4	12.4	1.23	1.5	178.6	235.4	0.1
6/24/2008	9:10	110	10.20	8.06	0.0780	0.5	11.6	1.14	1.0	182.7	245.5	0.1
7/22/2008	9:15	330	9.23	8.00	0.0824	1.4	12.8	1.16	0.6	187.8	244.6	0.1
8/26/2008	10:20	110	9.26	8.05	0.0842	0.5	13.8	1.19	1.7			
9/23/2008	9:15	61	8.83	8.11	0.0789	1.4	11.6	1.21	0.6	177.3	238.5	0.1
10/28/2008	9:30	43	9.17	8.58	0.0744	1.4	10.3	1.09	0.6	170.8	238.0	0.1
11/25/2008	10:05	11	9.32	7.82	0.0785	2.2	10.0	1.14	1.9	152.6	217.4	0.1
12/30/2008	10:00	59	9.89	6.98	0.0515	1.4	7.0	2.79	3.2	133.3	203.1	0.1
1/27/2009	9:45	33	10.09	7.52	0.0661	2.4	6.0	1.15	3.5	157.3	246.9	0.1
2/17/2009	10:45	10	9.42	7.71	0.0659	1.0	8.5	1.77	1.3	168.1	245.8	0.1
3/31/2009	10:05	210	10.34	7.55	0.0736	6.5	8.6	1.69		151.5	220.6	0.1
4/28/2009	10:30	59	8.39		0.0565	3.5	10.4	1.20	1.2	171.2	237.1	0.1
5/26/2009	10:40	46	10.21	7.85	0.0800	2.2	12.6	1.17	0.8	187.9	246.2	0.1
6/23/2009	11:20	90	9.36		0.0869	0.8	13.5	1.22	1.6	193.4	248.0	0.1
7/28/2009	9:30	39	9.09	6.74	0.0789	1.2	15.3	1.11	3.1	200.5	245.9	0.1
8/25/2009	9:20	87	9.83	4.25	0.0812	1.0	13.5	1.02	0.7	189.3	242.2	0.1
9/22/2009	10:30	95	9.40		0.0782	0.5	13.5	1.28	1.2			
10/27/2009	9:55	380	9.08		0.0758	0.6	10.8	1.47	2.2			
11/17/2009	10:45	190	6.50		0.0593	1.3	10.4	3.33	1.2	133.6	185.1	0.1
12/29/2009	9:50	17	10.95	8.26	0.0641	1.2	6.9	1.27	1.2	161.2	246.4	0.1
1/26/2010	10:30	9	11.18	8.06	0.0273	2.0	8.4	1.12	1.1	159.8	234.0	0.1
2/22/2010	9:30		10.84	8.11			8.3		1.2	168.1	246.7	0.1
2/22/2010	10:45	50			0.0616	1.1		1.23				
3/23/2010	10:05	13	10.77	8.46	0.0574	0.7	9.5	1.28	1.2	152.8	217.1	0.1
4/27/2010	9:35	2600	9.79	8.32	0.0581	0.7	11.0	1.09	1.3	149.5	203.9	0.1
5/25/2010	16:40		9.52	8.53			12.8		1.2	169.4	204.7	0.1
5/25/2010	21:20	520			0.0768	0.7		1.22				
6/22/2010	9:25	95			0.0805	0.9		1.16				

Water Quality Monitoring Data
City of Shoreline
Station: ST-2 (Storm Creek)

Date	Time	FC (col/100mL)	DO (mg/L)	pH (Std Units)	TP (mg/L)	TSS (mg/L)	Temp (deg. C)	TN (mg/L)	Turbidity (NTU)	Cond (µs)	Sp Cond (µs @ 25 C)	Salinity (ppt)
6/22/2010	13:55		7.72	8.55			15.3		2.5	203.8	249.7	0.1
7/27/2010	10:20	44	7.14	8.57	0.0786	1.2	14.1	1.18	0.8	196.5	249.9	0.1
8/24/2010	8:00	200	9.39	8.55	0.0772	0.9	13.2	1.11	0.9	186.7	242.0	0.1
9/28/2010	9:40	700	8.53	8.30	0.0886	0.8	14.6	1.09	1.2	195.9	244.3	0.1
10/26/2010	11:15	41	10.15	8.30	0.0762	2.8	10.4	1.14	1.8	174.8	241.5	0.1
11/30/2010	10:00	1100	10.39	8.04	0.1480	62.1	6.7	0.88	26.5	53.9	82.1	0.0
12/28/2010	10:30	77	10.12	7.64	0.0439	1.3	8.6	1.22	2.9	127.1	183.7	0.1
1/25/2011	10:20	62	10.76	8.18	0.0570	1.4	9.4	1.26	5.6	158.0	224.9	0.1
2/22/2011	9:45	45	11.60	8.00	0.0514	1.1	7.0	1.11	4.2	154.4	233.3	0.1
3/22/2011	9:20	11	10.92	7.84	0.0535	0.9	11.2	1.38	1.2	177.0	241.4	0.1
4/26/2011	11:00	62	11.21	8.51	0.0559	0.5	10.3	1.18	1.2	168.7	235.7	0.1
5/24/2011	10:46	180	11.73	8.39	0.0692	1.1	11.8	1.23	1.6	148.8	200.7	0.1
6/28/2011	10:20	55	11.82	8.21	0.0749	1.4	13.4	1.20	0.8	192.2	249.2	0.1
7/26/2011	10:05	490			0.0715	2.1		1.09				
7/28/2011	17:00		9.23	7.93			15.7		0.8	195.8	238.1	
8/23/2011	9:20	660	9.89	8.11	0.0812	1.1	14.6	1.19	1.1	188.6	235.2	
10/4/2011	10:40	76	9.47	7.78	0.0791	6.0	12.7	1.03	2.7	185.3	243.1	
10/25/2011	10:00	100	9.35	7.62	0.0675	0.3	10.8	1.11	0.9	176.1	241.6	
11/29/2011	10:30	23	9.83	7.46	0.0569	0.7	9.4	1.33	0.5	163.9	233.5	
12/20/2011	9:45	32	9.66	8.16	0.0696	0.6	9.0	1.24	1.5	167.9	241.7	

APPENDIX E. WATER QUALITY INDEX SCORES FOR STORM CREEK

A Water Quality Index for Washington State streams (Version 5: 2009.09.09)

Station:	ST-2
Recreation Use:	Extraordinary
Aquatic Life (Temperature):	Core(16)
Aquatic Life (Oxygen):	Core
Supplemental Spawning:	None
Ecoregion:	2

Calc Interim WQI scores

Calc Constituent & Overall Scores

KEY
Input
Low Concern
Moderate Concern
High Concern

OutSeason 5

SupSpawn 500

Water Year: **2007-2008**

	FC	Oxygen	pH	TP	TSS	Temp	TN	Turbidity	Monthly
Default Curve No.:	53	26	41	72	82	8	62	92	
Curve to Use:	53	26	41	72	82	8	62	92	
Date	col/100mL	mg/L	std. Units	mg/L	mg/L	C	mg/L	NTU	Scores
October-07	78	9.58	8	0.076	0.6	9.9	1.11	0.6	49
November-07	47	9.8	8.06	0.0642	0.3	8.6	1.13	1.2	59
December-07	1600	10.71	7.4	0.0801	18.1	6.7	0.93	18	24
January-08	230	11.66	7.82	0.0642	0.5	6.5	1.39	1.2	67
February-08	38	11.31	7.96	0.0704	1	9.1	1.19	1.1	60
March-08	34	11.78	7.67	0.0592	0.3	7.9	1.24	0.2	85
April-08	45	10.95	7.79	0.0534	0.5	8.5	1.09	0.8	85
May-08	500	10.33	7.52	0.0768	1.4	12.4	1.23	1.5	33
June-08	110	10.2	8.06	0.078	0.5	11.6	1.14	1	46
July-08	330	9.23	8	0.0824	1.4	12.8	1.16	0.6	30
August-08	110	9.26	8.05	0.0842	0.5	13.8	1.19	1.7	40
September-08	61	8.83	8.11	0.0789	1.4	11.6	1.21	0.6	42
Constituent Scores:	42	72	90	48	96	87	1	92	
							Overall Score:		**29**

A Water Quality Index for Washington State streams (Version 5: 2009.09.09)

Station:	ST-2
Recreation Use:	Extraordinary
Aquatic Life (Temperature):	Core(16)
Aquatic Life (Oxygen):	Core
Supplemental Spawning:	None
Ecoregion:	2

Calc Interim WQI scores

Calc Constituent & Overall Scores

KEY
Input
Low Concern
Moderate Concern
High Concern

OutSeason 5

SupSpawn 500

Water Year: **2008-2009**

Default Curve No.:	53	26	41	72	82	8	62	92	
Curve to Use:	53	26	41	72	82	8	62	92	
	FC	Oxygen	pH	TP	TSS	Temp	TN	Turbidity	Monthly
Date	col/100mL	mg/L	std. Units	mg/L	mg/L	C	mg/L	NTU	Scores
October-08	43	9.17	8.58	0.0744	1.4	10.3	1.09	0.6	44
November-08	11	9.32	7.82	0.0785	2.2	10	1.14	1.9	57
December-08	59	9.89	6.98	0.0515	1.4	7	2.79	3.2	79
January-09	33	10.09	7.52	0.0661	2.4	6	1.15	3.5	61
February-09	10	9.42	7.71	0.0659	1	8.5	1.77	1.3	79
March-09	210	10.34	7.55	0.0736	6.5	8.6	1.69		63
April-09	59	8.39		0.0565	3.5	10.4	1.2	1.2	63
May-09	46	10.21	7.85	0.08	2.2	12.6	1.17	0.8	58
June-09	90	9.36		0.0869	0.8	13.5	1.22	1.6	38
July-09	39	9.09	6.74	0.0789	1.2	15.3	1.11	3.1	46
August-09	87	9.83		0.0812	1	13.5	1.02	0.7	44
September-09	95	9.4		0.0782	0.5	13.5	1.28	1.2	39
Constituent Scores:	69	67	78	48	98	82	1	95	
							Overall Score:		**40**

A Water Quality Index for Washington State streams (Version 5: 2009.09.09)

Station:	ST-2
Recreation Use:	Extraordinary
Aquatic Life (Temperature):	Core(16)
Aquatic Life (Oxygen):	Core
Supplemental Spawning:	None
Ecoregion:	2

Calc Interim WQI scores

Calc Constituent & Overall Scores

KEY
Input
Low Concern
Moderate Concern
High Concern

OutSeason 5

SupSpawn 500

Water Year: **2009-2010**

	FC	Oxygen	pH	TP	TSS	Temp	TN	Turbidity	Monthly
Default Curve No.:	53	26	41	72	82	8	62	92	
Curve to Use:	53	26	41	72	82	8	62	92	
Date	col/100mL	mg/L	std. Units	mg/L	mg/L	C	mg/L	NTU	Scores
October-09	380	9.08		0.0758	0.6	10.8	1.47	2.2	22
November-09	190	6.5		0.0593	1.3	10.4	3.33	1.2	31
December-09	17	10.95	8.26	0.0641	1.2	6.9	1.27	1.2	58
January-10	9	11.18	8.06	0.0273	2	8.4	1.12	1.1	94
February-10	50	10.84	8.11	0.0616	1.1	8.3	1.23	1.2	58
March-10	13	10.77	8.46	0.0574	0.7	9.5	1.28	1.2	82
April-10	2600	9.79	8.32	0.0581	0.7	11	1.09	1.3	12
May-10	520	9.52	8.53	0.0768	0.7	12.8	1.22	1.2	25
June-10	95	7.72	8.55	0.0805	0.9	15.3	1.16	2.5	21
July-10	44	7.14	8.57	0.0786	1.2	14.1	1.18	0.8	24
August-10	200	9.39	8.55	0.0772	0.9	13.2	1.11	0.9	30
September-10	700	8.53	8.3	0.0886	0.8	14.6	1.09	1.2	13
Constituent Scores:	34	37	78	48	100	82	1	96	
								Overall Score:	**15**

A Water Quality Index for Washington State streams (Version 5: 2009.09.09)

Station:	ST-2
Recreation Use:	Extraordinary
Aquatic Life (Temperature):	Core(16)
Aquatic Life (Oxygen):	Core
Supplemental Spawning:	None
Ecoregion:	2

Calc Interim WQI scores

Calc Constituent & Overall Scores

KEY
Input
Low Concern
Moderate Concern
High Concern

OutSeason 5

SupSpawn 500

Water Year: **2010-2011**

	FC	Oxygen	pH	TP	TSS	Temp	TN	Turbidity	Monthly
Default Curve No.:	53	26	41	72	82	8	62	92	
Curve to Use:	53	26	41	72	82	8	62	92	
Date	col/100mL	mg/L	std. Units	mg/L	mg/L	C	mg/L	NTU	Scores
October-10	41	10.15	8.3	0.0762	2.8	10.4	1.14	1.8	54
November-10	1100	10.39	8.04	0.148	62.1	6.7	0.88	26.5	23
December-10	77	10.12	7.64	0.0439	1.3	8.6	1.22	2.9	81
January-11	62	10.76	8.18	0.057	1.4	9.4	1.26	5.6	77
February-11	45	11.6	8	0.0514	1.1	7	1.11	4.2	85
March-11	11	10.92	7.84	0.0535	0.9	11.2	1.38	1.2	86
April-11	62	11.21	8.51	0.0559	0.5	10.3	1.18	1.2	74
May-11	180	11.73	8.39	0.0692	1.1	11.8	1.23	1.6	43
June-11	55	11.82	8.21	0.0749	1.4	13.4	1.2	0.8	53
July-11	490	9.23	7.93	0.0715	2.1	15.7	1.09	0.8	24
August-11	660	9.89	8.11	0.0812	1.1	14.6	1.19	1.1	25
September-11	76	9.47	7.78	0.0791	6	12.7	1.03	2.7	45
Constituent Scores:	41	77	80	48	85	81	1	86	
								Overall Score:	**24**

APPENDIX F. PUBLIC COMMENTS ON DRAFT BASIN PLAN

Erin Nelson

From: Brian Landau [mailto:blandau@shorelinewa.gov]
Sent: Wednesday, January 16, 2013 1:59 PM
To: Nelson, Erin
Subject: FW: Boeing and Storm Creek Basin Plans Comments

-----Original Message----

From: webmaster@shorelinewa.gov [mailto:webmaster@shorelinewa.gov]
Sent: Thursday, September 15, 2011 11:15 AM
To: Brian Landau Subject: Boeing and Storm Creek Basin Plans Comments

Submission information

Submitter DB ID : 2078

Submitter's language : Default language
IP address : 50.46.196.65
Time to take the survey : 23 min. , 15 sec.
Submission recorded on : 9/15/2011 11:15:21 AM
Survey answers

Your Neighborhood: Innis Arden [x]

Drainage Basin (see map)
Boeing Creek Basin [x]

Name: Jon Foral

Email:

jonforal@hotmail.com

Please identify drainage, water quality, or stream habitat issues and locations important in your drainage basin:

With the Elwha Dam coming down it's an exciting time to think about restoration or our streams and creeks. It is great news that the City of Shoreline is going to make the drainage basins a priority.

I live on Hidden Lake and am directly impacted by the large amount of sediment that collects each winter. We are due for yet another "big dig" next week. The fact that the lake has to be excavated every 2 years is indication enough that the stream is not healthy and faces too much pressure from run off. I'd be in favor of any means to improve the basin -starting with turning Sears back into wetlands!

I would like to see Boeing Creek improved to the point that a native fish population could be sustained. I'm sure my neighbors would disagree but I think the damns should all be removed. At the very least, fish passages should be constructed.

Good luck with the study and I'd be happy to help in any way I can.

Erin Nelson

From: Brian Landau [blandau@shorelinewa.gov]
Sent: Monday, January 28, 2013 9:17 AM
To: Nelson, Erin
Subject: FW: Boeing and Storm Creek Projects

FYI

From: Brian Carroll [mailto:btcarroll@ringfamilylp.com]
Sent: Tuesday, January 22, 2013 3:26 PM
To: Brian Landau
Cc: Jesus Sanchez; Erin Nelson(enelson@brwncald.com); Michael Derrick (mderrick@ronaldwastewater.org); scottc@chsengineers.com; John Harris (jbh66@comcast.net)
Subject: RE: Boeing and Storm Creek Projects

Brian

I noticed during the last budget cycle that SWM money otherwise earmarked for these projects was proposed to be diverted to buy land for the public works and parks dept equipment. What is status of that decision? How was this considered if the CIP 6 year plan did not include it in their most recent CIP efforts since you had not completed the planning process yet.

Also, there were many impactful events not addressed in the report. Several upper creek timber harvest permits were issued by the City of Shoreline in these drainage basins. These permits did not appear to be listed nor chronologically analyzed vs. erosion and rainfall events. Nor even referenced as a factor in the accelerated erosion.

Furthermore, the staff of Ronald Wastewater have excellent historical files on events that have befallen their equipment in these two basins. It was alluded to but not properly explained. I would encourage the consultants who drafted this report to consult with the two Sewer Districts who have equipment in Boeing Creek: Ronald and Highlands. And with Ronald relative to Storm Creek.

From: Brian Landau [mailto:blandau@shorelinewa.gov]
Sent: Tuesday, January 22, 2013 12:14 PM
To: Brian Carroll
Cc: Jesus Sanchez; Erin Nelson(enelson@brwncald.com)
Subject: RE: Boeing and Storm Creek Projects

Brian,

Thanks for the question. The basin plans help to set the prioritization of Capital Improvement Projects (CIPs) for implementation over a 6 year CIP Plan. The expenditure of funds for projects are discussed and approved during the City's annual budget process (Capital Improvement and Operations). The identified projects in both basin plans will compete for limited funds against other priority projects within the Surface Water Management (SWM) Fund for eventual implementation. The SWM fund that supports all planned CIPs is revenue backed from Surface Water fees on each tax parcel within the City and as such, is limited in how many CIP projects it can support annually. Later this Spring, we will be in the process of developing the annual CIP 6-year plan, that will evaluate and prioritize all critical projects with understanding that our revenues are limited. The City Council makes the ultimate decision on which CIPs will be supported over a 6-year CIP Plan, based on recommendations on the SWM rates (and the revenue they generate) and approval of the capital projects proposed.

If you have further questions or need clarification on this response, please feel free to contact me again.

Thanks

Brian

Brian Landau, PE, LEG

Surface Water and Environmental Services Manager

City of Shoreline

17500 Midvale Ave N

Shoreline, WA 98133

206-801-2451

blandau@shorelinewa.gov

From: Brian Carroll [mailto:btcarroll@ringfamilylp.com]
Sent: Monday, January 21, 2013 11:06 AM
To: Brian Landau
Subject: Boeing and Storm Creek Projects

What are next steps for each of these drainage basins and when will Shoreline expend monies to improve the erosion problems in these basins?

Brian Carroll

1408 NW 186th St.

Resident of City of Shoreline

Erin Nelson

From: Brian Landau [blandau@shorelinewa.gov]
Sent: Wednesday, January 23, 2013 2:19 PM
To: Nelson, Erin
Subject: FW: Comments on Storm Creek/Eagle Reserve Surface Water Plan

Comments from Innis Arden!

From: T Richard Leary [mailto:trichardleary@gmail.com]
Sent: Wednesday, January 23, 2013 10:02 AM
To: Brian Landau
Subject: Comments on Storm Creek/Eagle Reserve Surface Water Plan

Hi Brian,

Here are a few comments that on your Storm Creek Surface Water Plan that I have worked on with the members of the Innis Arden Natural Reserves Committee. I am still waiting for final comments on the Boeing Creek Surface Water Plan. We compliment you on this fine and though review of the issues and potential solutions. I hope that you find these comments useful and that we may be able to work with the City on solving some of these problems.

Sincerely yours,

Rick Leary

Innis Arden Natural Reserves Chairman

==========

1. Restoration. (Appendix F, ST-Main-2, Page 176) The Innis Arden Reserve Committee is actively working on restoration of the Innis Arden Natural Reserves. We have contracted with EarthCorps to remove nonnative vegetation in 2012 in three of our reserves – Bear (where a permit is already in place), Running Water, and the east end of Blue Heron. We are planning to continue this removal work for the next several years. Currently, we have sufficient funds to contract 14 days of restoration work by EarthCorps in 2013. We are currently working with Shoreline Planning and Development Dept. (talking with Kimberly Lehmberg) to collect the information needed for a SEPA review and clearing and grading permit. Thus, we have limitations until the permit is issued, but we would consider any suggestions that you might have with respect to our Natural Reserves.

2. Monitor Fecal Coliforms. (Appendix F, ST-Mon-2, page 145, ST-Mon-1, Page 144, and ST-ED-2, Page 142)) In your write up on various chemical and biologic parameters monitored in Storm Creek the Fecal Coliforms were only monitored at the outlet of the pipe crossing 15th Ave NW at NW 195th St. This suggests that the count of Fecal Coliforms are representative of water coming into Eagle Reserve and do not include any water contributed by the reserve. We have not yet discovered any seeps in Eagle Reserve that we observe in some of our other Natural Reserves.

With respect to the Ronald Sewer Pipe that crosses under the Gabion approximately 500 ft up from the west of Eagle Reserve you rightly point out that testing needs to be done to determine if there is any leakage in the pipe that might contribute to the contamination of Storm Creek. The Innis Arden Natural Reserve Committee would be willing to work with the City so that your technicians could gain access to Eagle Reserve and that appropriate before-and-after pipe monitoring could be done. (Ronald Stormwater District probably should also be involved.) We would make at least two suggestions on monitoring. First, the monitoring should only be done at relatively low flows of water since a higher flow would dilute the colony count. A typical flow rate of approximately 0.2 cubic ft per minute can easily be measured with a bucket, stop watch, and large graduated cylinder at the corner of 15th Ave NW and NW 195th St. An upper limit of flow rate could be established above which no measurements would be made to preclude a serious dilution effect. (Alternately, a conductivity meter and continuous flow of a saline solution could be used to establish the flow rate of the water.) Second, a colony count of 2600 per deciliter is difficult or impossible to determine without doing dilutions using filtration technology. If the background colony count is high, it seems that an upper limit of background colony count should be established above which counts below the sanitary pipe would not be accepted. This prevents leakage from the sanitary sewer pipe being masked by a higher background of water flowing into Eagle Reserve.

Since many Innis Arden residents walk their dogs through our natural Reserves, we will place dog waste bag collection dispensers at the east and west ends of Eagle Reserve, Running Water Reserve, and Blue Heron Reserve. We will place one dog waste collection bag dispenser at the gate into Boeing Creek Reserve. While this will not prevent water contamination within the Natural Reserves due to dogs, it will decrease the probability.

3. Erosion Measurements due to High Flow Rates. (Appendix F, ST-Mon-3)

The measurement of erosion on Storm Creek is a smart thing to do. Unfortunately, the cite chosen has a fatal flaw. If you will recall the gabion protecting the Ronald Sewer District sanitary sewer pipe as it crosses Storm Creek has a cement cap. This was done because of the erosive force of water year after year. If you look behind the gabion for the first 20 to 30 yards you will notice that the only erosion that is occurring is on the steep slope as creek makes a large arc toward the gabion. There is little or no cutting down into the stream bed as observed either above or below the gabion. Thus, the gabion has stabilized the erosion of the stream bed in the immediate area behind it because the water still needs to get over the gabion.

At the proposed site near the culvert under 17th Place NW there is a cement covered gabion approximately 40 feet beyond the culvert followed by another cement covered gabion just before the stream makes the deep cuts into the bluff area. The first gabion will minimize any cutting due to the cutting force of water at high flow rates. Thus, an improper conclusion might be made about high flow rates and erosion in Storm Creek. One place that might be considered is just beyond the last gabion in lower Eagle Reserve between the Akers and Weinberg (formerly Harrington/Hackett) properties. There are many other potential positions in Eagle Reserve that we would work with the City for access.

The Innis Arden Reserve Committee would also like to propose that an alternate site might be chosen within Eagle Reserve. Again we would be willing to work on getting permission for the City to choose a site and for a technician to make the measurements.

4. Wetlands. (Appendix F, St-CIP-2, Page 158) In late 2008 several Innis Arden Reserves Committee members cut willow stakes and placed the stakes on the edge of the stream bed at various positions in the upper reach of Eagle Reserve. We periodically monitored to see if the willows would grow and help stabilize the banks. By the summer of 2009 all were sprouting leaves, although a few had disappeared. By the winter storms of 2010 all of the willow stakes were washed away.

There are several areas within Eagle Reserve where we might consider developing a wetland that would benefit water quality. While we lack the technical expertise to determine if it is feasible, we may be able to budget planting a wetland area in Eagle Reserve along Storm Creek using the expertise of Kruckeberg Botanic Garden staff and EarthCorps if an approved plan was developed and permitted.

Ronald Wastewater District
17505 Linden Avenue North • P.O. Box 33490
Shoreline, Washington 98133-0490
(206) 546-2494 • Fax (206) 546-8110
www.ronaldwastewater.org

January 29, 2013

Mr. Brian Landau
Surface Water and Environmental Services Program Manager
City of Shoreline
17500 Midvale Ave N
Shoreline, WA 98133

RE: Storm Creek and Boeing Creek Basin Plans

Dear Mr. Landau:

Ronald Wastewater District is pleased to provide comment on the Storm Creek and Boeing Creek Basin Plans.

Regarding ST-Mon-2 the District routinely inspects its entire sanitary sewer system. No leaks have been detected in the gravity lines in the Storm Creek or Boeing Creek basins.

Regarding ST-Hab-1 the District notes in the description that the sewer line crossing Eagle Reserve is believed to be a barrier to fish passage. On January 28, 2013, during an inspection of the force main that crosses the creek, the District's staff and consulting engineer noted that numerous natural and man made fish barriers exist from the mouth of the creek at Puget Sound up stream to the location of the sewer line crossing and most likely farther up the creek. All these barriers make it impossible for fish to reach the sewer crossing.

Page 21, Storm Creek Basin Plan, makes reference to Section 4.7.2. The table of contents does not show Section 4.7.2 in the plan. Page 48, Storm Creek Basin Plan, makes reference to Section 4.7.4. The table of contents does not show Section 4.7.4 in the plan. Page 76, Storm Creek Basin Plan, incorrectly identifies the District as Ronald Sewer District rather than Ronald Wastewater District.

The District is aware of a few homes in the basins that are still using on site septic systems for sanitary sewage treatment. All homes in theses basins have access to the District's sanitary sewage collection system.

Thank you,

Michael U. Derrick
General Manager

Cc: Board of Commissioners
George Dicks
Scott Christensen

Working for Environmental Protection
A special purpose district formed pursuant to RCW title 57

January 30, 2013

Mr. Landau
Surface Water + Environmental Service Manager.
City of Shoreline.

Brian, I wish to give my perspective on the Wind/Ward Storm Creek Study.

As I see it our problems started to escalate when trying to relieve the flooding problems in other areas; such as the Dyer flooding and the Meadowbrook Apartment flooding. It seems to me the area of Dyer should or was a wet land area until the water was not allowed natural flow but was piped (directed, forced to flow) to the Storm Creek Area. (Storm Creek Basin Plan, August 10, 2012, page 45; Dyer wetland 1 appears to supply a large fraction of the water within Storm Creek, and likely contributes significant base flow support in this urbanized basin). The flooding at the Meadowbrook Apartment was controlled by moving the stream and piping, directing it to Storm Creek, its natural flow should have been straight

down the hill to the sea. Their flooding problems should have been taken care of on their property and not piped down to cause destruction on other peoples property. I think that just these two factors should explain the triggering of the erosion of Storm Creek during the past decade or two. The building and improvements along Aurora and down the hill toward Innis Arden had an effect on surface water in Storm Creek.

We have had higher amounts of rain fall in the last few years but it would not have caused as much damage if over 90% of the water in the creek didn't come from outside Innis Arden. I would like to know what State, County or City ruling allows the distruction of private property for the sake of Infrastructure. Please send me this information so I can look it up.

The erosion in the Creek starts up the hill from us at 15th. and 188th, the trail head. Walking the trail anyone can see the years of distruction in the Creek bed, this damage didn't happen in one year. If you look back at Mr. Sanchez's letters and

contacts its clear we have been monitoring this problem and reporting to the city for years. I don't feel that we should have to pay the price for the lack of Storm Water management. How many years does the City need to monitor this situation ??? It is clear with just the contact we have had with Mr. Sanchez this winter that the channel has not adjusted to a current flow regime and is continuing to incise (Storm Creek Basin Plan, August 2012 page 21).

From reading the report of Wind/Ward, I see that they have look at the pipe structure in the area and found that some needed to be cleaned, repaired or replaced. Also the need to clean and convert some ditches into infiltration swales. To me it sounds like its going to make all the water from above come down Storm Creek easier and faster. What will that do to the erosion ??

As for asking the Residents in the area to be educated on planting the hill sides, you should come down and look at the planting the city required Xenis Arden to do at the mouth of Storm Creek.

This winter much of the required plants fell off the cliff.

The one bright spot of the whole report was that it should have cleared up the fact that fish have never been in this ravine. I was so glad that this was pointed out a number of times. I hope that is the end of that conversation.

Thank You,-

Susan Aiken
18315 17th Pl NW
Shoreline, WA 98177
206-546-5698

Erin Nelson

From: Brian Landau [blandau@shorelinewa.gov]
Sent: Thursday, January 31, 2013 2:47 PM
To: Nelson, Erin
Subject: FW: Storm Creek Basin Plan

From: Michael derrick [mailto:mderrick@ronaldwastewater.org]
Sent: Thursday, January 31, 2013 11:50 AM
To: Brian Landau
Cc: Scott Christensen
Subject: Storm Creek Basin Plan

Mr. Landau:
RWD wants to add a bit more information to our previous letter regarding the Basin plans.
The District installed gabion baskets at Storm Creek to protect its sanitary infrastructure years ago. During 1999 and again in 2001 severe rains undermined the baskets on the west side of 17th NW and exposed the District's sanitary force mainline and electrical conduit in the Creek. This required us to repair the baskets and protect the lines in Storm Creek. We are researching the cost of the projects and will let you know.

We know that King County also installed gabion baskets but we do not have details of when or at what cost.

Thank you,
Michael

--

Michael U. Derrick
General Manager
Ronald Wastewater District
P.O. Box 33490
17505 Linden Ave N
Shoreline WA, 98133
P: 206-546-2494
F: 206-546-8110
Email: mderrick@ronaldwastewater.org

Erin Nelson

From: Brian Landau [blandau@shorelinewa.gov]
Sent: Thursday, January 31, 2013 2:47 PM
To: Nelson, Erin
Subject: FW: Storm Creek Sanitary Work

From: Michael derrick [mailto:mderrick@ronaldwastewater.org]
Sent: Thursday, January 31, 2013 1:21 PM
To: Brian Landau
Cc: Scott Christensen
Subject: Storm Creek Sanitary Work

Mr. Landau:
Between 1999 and 2001 Ronald Wastewater District spent more than $41,000.00 on repairing storm damage to the District's sanitary system in Storm Creek.

Michael
--

Michael U. Derrick
General Manager
Ronald Wastewater District
P.O. Box 33490
17505 Linden Ave N
Shoreline WA, 98133
P: 206-546-2494
F: 206-546-8110
Email: mderrick@ronaldwastewater.org

APPENDIX G. RECOMMENDED STRATEGIES TO IMPROVE STORM CREEK BASIN

Table of Contents

1 Water Quality Monitoring

Project: **ST-Ed-1**

Project Name: Improve Soils and Ground Vegetation in Buffers

Description: Provide educational information (e.g., brochures, outreach at community events, etc.) for private citizens and City staff on the importance of soils and ground vegetation near the Storm Creek stream corridor.

Benefits: Improving vegetation and soils conditions would provide filtering and infiltration of runoff from areas adjacent to the riparian zone (i.e., it would reduce the direct input of bacteria-contaminated runoff to the creek). A similar project was also recommended in the City's 2011 *Surface Water Master Plan Update* (SAIC 2011).

Assumptions: Project would be taken on by City staff. Existing materials from organizations such as Soils for Salmon are already posted on the City's website. Targeted outreach to creek-side neighborhoods could provide a more direct benefit to Storm Creek.

Estimated Cost/

Level of Effort: 40 hours to coordinate partnerships, distribute flyers to targeted neighborhoods, and attend community group meetings.

Potential Partners: Local master gardeners and master composters, and community groups.

Priority: Low

Project: **ST-Ed-2**

Project Name: Implement Targeted Pet Waste Control Education and Outreach

Description: Review and expand ongoing education, outreach, and incentive programs to inform public on improved pet waste control. This project could also involve installing signs and pet waste bags at the primary access points to the Eagle Reserve trail running alongside the creek and other public locations within the Storm Creek basin.

Example pet waste bag dispenser

Benefits: One well-known source of fecal coliform (FC) bacteria is dog poop. Encouraging residents to pick up after their pets and making it easy for them to do so would help reduce FC bacteria from pet sources. This is especially true along stream corridors, such as that in Eagle Reserve, and residential lots bordering Storm Creek.

Assumptions: Project would be taken on by City staff, who would enhance the existing pet waste reduction program. Information is already available on the City's website about the importance of picking up after your pets. Storm Creek-specific efforts could focus on locations where dogs are routinely walked, such as in the Eagle Reserve.

Estimated Cost/

Level of Effort: 20 hours per year to maintain website, distribute materials, or coordinate partnerships. Approximately $500 for pet waste bag dispensers.

Potential Partners: Innis Arden group for placement of pet waste bag dispensers in Eagle Reserve.

Priority: Medium

Project:	**ST-Ed-3**
Project Name:	Partner with Local Community Groups to Educate People on Alternative Yard Care
Description:	Review and expand ongoing education, outreach, and incentive programs to inform landowners on improved vegetation management techniques in order to reduce applications of fertilizers, properly dispose of yard waste, and improve riparian buffer conditions in the upper reaches of Storm Creek that flow through highly developed residential areas of the watershed.
Benefits:	If creek-side residents reduce fertilizer use and dispose of yard waste in locations away from the stream channel, it would directly benefit the water quality in Storm Creek. The neighborhood along Storm Creek between 15th Avenue Northwest and Richmond Beach Road should be targeted for educational opportunities, as these residents appear to be avid gardeners and several own creek-side property.
Assumptions:	Project would be taken on by City staff, who would enhance existing alternative yard care programs.
Estimated Cost/	
Level of Effort:	40 hours per year to maintain website, distribute materials, or coordinate partnerships.
Potential Partners:	Potential community partnerships could be with ***Birds, Bees, Fish and Trees***, master gardeners, or other local groups.
Priority:	Low

Project:	**ST-Mon-1**
Project Name:	Improve Water Quality Monitoring Program
Description:	The City has a substantial monitoring program in place for all Shoreline-area water bodies, and has been collecting water quality data in Storm Creek since 2001. However, several potential improvements to the current monitoring program are recommended, including the following: ◆ Minimize data gaps. If field meters become inoperable during sampling events, or if results appear abnormal, confirmatory sampling should be re-scheduled, or grab samples should be collected and submitted to a laboratory for analysis of the parameters of interest. ◆ Add a monitoring location upstream of Station ST-2 to evaluate water quality conditions in the upper, more urbanized reaches of the Storm Creek watershed. ◆ Evaluate and expand (if necessary) City programs designed to control contaminant sources and the amount of stormwater runoff being produced. This includes the Illicit Discharge Detection and Elimination (IDDE) Program, the Car Wash Kit Program, and the Commercial Storm Drain Inspection Program.
Benefits:	Project would enable more reliable interpretation of water quality trends and potential sources of pollutants.
Assumptions:	Project would be taken on by City staff.
Estimated Cost/ Level of Effort:	0 – 4 hours per month, and associated laboratory costs
Potential Partners:	None. It is difficult to ensure monitoring consistency with citizen volunteers.
Priority:	Medium

Project: **ST-Mon-2**

Project Name: Inspect Sanitary Sewer Crossings over Storm Creek for Leaks

Description: This project involves coordination with the Ronald Wastewater District to inspect sewer pipes for leaks in the vicinity of Storm Creek. A main sewer line crosses Storm Creek within Eagle Reserve, and there are a number of other locations where sewer lines are in close proximity to the stream channel.

Benefits: Project would identify potential sources of FC bacteria. If leaks are detected in the sanitary sewer lines, these leaks could be fixed, which would likely result in a direct benefit to water quality conditions in Storm Creek.

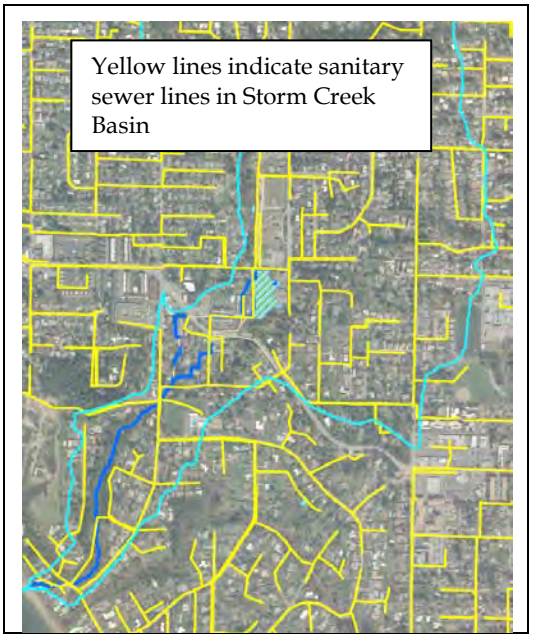
Assumptions: City staff would need to coordinate with Ronald Wastewater District's sewer line inspection program.

Estimated Cost/

Level of Effort: 40 hours of coordination and review of inspection results. Ronald Wastewater District routinely inspects the entire sanitary sewer system, so this project would involve only check-ins with the District if leaks were found.

Potential Partners: Ronald Wastewater District

Priority: Medium



Project:	**ST-Study-1**
Project Name:	Evaluate City Procedures for Landscape Maintenance on Public Properties
Description:	Evaluate City procedures for landscape maintenance in parks or other public properties in the watershed, and determine if 1) reductions in the application of fertilizers and pesticides are possible, and 2) if native vegetation could be planted to improve habitat, reduce maintenance costs, and filter runoff.
Benefits:	Reducing fertilizers and pesticides used in landscaping practices on City properties may benefit water quality in Storm Creek and other City receiving waters. This type of project would fulfill one of the requirements in the next National Pollutant Discharge Elimination System (NPDES) Phase II permit (S5.f), which is to implement policies and procedures to reduce stormwater impacts from lands owned by the Permittee. Application of fertilizer, pesticides, and herbicides is listed under this section of the permit.
Assumptions:	Project would be taken on by City staff.
Estimated Cost/	
Level of Effort:	40 hours to review current City practices and recommend alternatives, if necessary
Potential Partners:	None. This project would predominantly affect the Parks and Public Works departments.
Priority:	Medium

2 Erosion at Mouth of Storm Creek

Project: **ST-Ed-4**

Project Name: Bluff Education

Description: Residents living on steep, eroding bluffs within the City may benefit from educational materials regarding landscaping, yard care, and other topics that may affect the stability of their properties.

Benefits: The benefits of this project in the Storm Creek Basin are limited, as there are only two residential properties located on the bluff to Puget Sound in the basin. However, this project would be appropriate as a city-wide effort for all bluff-side residents within the City's jurisdiction.

Assumptions: City staff would lead this education effort. There are several publically available documents that could be modified for City residents, or a targeted outreach program could be geared toward residential properties located on the bluffs overlooking Puget Sound. The Washington State Department of Ecology (Ecology) website provides resources for landscaping for slope stabilization and erosion control: http://www.ecy.wa.gov/programs/sea/pubs/93-30/index.html. This is one of many potential references that could be linked to the City's website or provided to City residents.

Estimated Cost/

Level of Effort: 40 hours to compile information available from others and to implement website links

Potential Partners: Master gardeners and experts with knowledge of landscaping techniques for steep slopes.

Priority: Low

Project: **ST-Ed-5**

Project Name: Voluntary Rain Garden Program

Description: This project involves targeting neighborhoods where rain gardens could make a difference in the amount of flow that is routed to Storm Creek. Ideal locations for infiltration are relatively flat areas underlain by glacial outwash or thin glacial till over outwash. The northeast part of the basin, immediately east and west of 8th Avenue Northwest, would be an ideal location from a stormwater perspective.

Benefits: The benefits of this project, providing there is good participation, include:

- Reduced flow to the City's stormwater infrastructure
- Reduced erosion in Storm Creek
- Improved habitat conditions
- Improved water quality
- Compliance with NPDES permit low-impact development (LID) education and outreach

Assumptions: City staff would lead this effort, but could enlist a consultant to determine specific program goals and implementation. The City could provide either incentives for neighbors in the targeted areas, or technical assistance or rebates to those willing to reroute roof and or driveway runoff away from the City's stormwater infrastructure. This would likely be a City-wide effort.

Estimated Cost/

Level of Effort: An estimated $20,000 to determine appropriate neighborhoods and the types of incentives or technical assistance beneficial to both the City and residents.

Potential Partners: Master gardeners for landscaping expertise, and public entities such as the Shoreline School District or Shoreline Community College for demonstration projects

Priority: Medium

Project:	**ST-Study-2**
Project Name:	Study Potential for Deep Injection of Stormwater
Description:	This project involves conducting an evaluation of alternative sites for the injection of stormwater into deep subsurface infiltrative zones. Shorewood High School is currently implementing an underground injection program for stormwater on that school's property in the Boeing Creek basin; deep injection of stormwater could be an option in the Storm Creek basin as well. Inferred geologic cross sections (Figures 4 and 5 of the plan text) indicate that the advance outwash geologic unit underlying much of the Storm Creek basin may be as thick as 200 ft in some locations. Geotechnical borings and evaluation of potential downstream issues would need to be performed and investigated prior to implementing such a program. One preliminary location for underground injection could be Syre Elementary School, because of its large space, location in the central part of the basin, and advance outwash surface geology.
Benefits:	Discharge of surface water to subsurface geologic units would reduce surface flows to Storm Creek, and replenish local aquifers.
Assumptions:	This project would be subcontracted to a consultant with geological and geotechnical investigation and analysis expertise, and would involve subsurface drilling activities as deep as 200 ft, and analysis of soil samples to determine hydraulic conductivity and other parameters that would be used to determine injection potential. It would be important to understand the potential consequences of deeper infiltration, so that water injected would not cause downstream issues.
Estimated Cost/ Level of Effort:	The estimated cost of this study is $50,000, including geotechnical investigation and geotechnical laboratory analysis.
Potential Partners:	None
Priority:	High

Project:	**ST-Study-3**
Project Name:	Study Potential for Routing Stormwater to Closed Depression
Description:	This project involves conducting an evaluation of the potential infiltration of stormwater into an adjacent, closed depression basin located west of the Storm Creek basin in City public open space. This park property is approximately 2.6 ac in size, and the surface geology is mapped as glacial recessional outwash. It may be possible to infiltrate some of the Storm Creek water into this closed depression. However, a basin transfer would need to occur, and geotechnical analysis would need to be completed to ensure that infiltrated water would not daylight at a location that would cause additional problems, such as landslide activity.
Benefits:	Routing stormwater to existing open space conducive to infiltration could help reduce the high peak flows that Storm Creek currently experiences.
Assumptions:	This project would be subcontracted to a consultant with geological and geotechnical investigation and analysis expertise, and would involve subsurface drilling activities as deep as 100 ft, and analysis of soil samples to determine hydraulic conductivity and other parameters that would be used to determine injection potential. It would be important to understand the potential consequences of deeper infiltration, so that water injected would not cause downstream issues.
Estimated Cost/ Level of Effort:	The estimated cost of this study is $30,000, including geotechnical investigation and geotechnical laboratory analysis.
Potential Partners:	None
Priority:	High

Project:	**ST-CIP-1**
Project Name:	Tightline Storm Creek
Description:	When bluff erosion begins to threaten public infrastructure, one alternative to reduce the rate of erosion in the vicinity of the road and sewer line is to divert all Storm Creek flow into a tightline between the western edge of 17th Place Northwest and the outfall onto Richmond Beach.
Benefits:	Reduced erosive processes being caused by stream flow.
Assumptions:	Eliminating surface flow in this reach of Storm Creek would not eliminate the ongoing bluff erosion; however, it would likely minimize the current rate at which the erosion is occurring.
Estimated Cost/ Level of Effort:	The estimated cost for this project is $550,000, dependent on the level of mitigation necessary (see December 1, 2011, memorandum and cost estimate below).
Potential Partners:	Innis Arden Community Group. This project would need the support of the Innis Arden community, as it would be located in the privately owned Eagle Reserve.
Priority:	Low

MEMORANDUM

To: Brian Landau, PE, LEG, City of Shoreline

From: Erin Nelson, PE, LG

Subject: Draft Storm Creek Tightline Conceptual Design

Date: December 6, 2011

Erosion in the lower reach of Storm Creek has accelerated in the last few decades, causing concern for local residents on the adjacent bluffs, as well as the Ronald Wastewater District and City of Shoreline (the City) for the protection of their respective infrastructure. Windward Environmental (Windward) conducted an erosion assessment in September 2011, and at that time, identified an alternative for tightlining the stream channel to slow downcutting that is occurring in the ravine. A separate memorandum by Windward (in preparation) documents the erosion assessment, describes the general conditions that cause downcutting, and outlines the site-specific conditions that may be contributing to the current erosion occurring in the Storm Creek basin.

This memorandum describes the tightline alternative, including conceptual design considerations and assumptions, a preliminary alignment figure, and a planning level cost estimate.

Purpose and Description

The purpose of tightlining Storm Creek from the western edge of 17th Place NW to the outfall onto Richmond Beach is to reduce erosive processes that are being caused by stream flow. Eliminating surface flow in this reach of Storm Creek will not eliminate the on-going bluff erosion; however, it would likely minimize the current rate at which the erosion is occurring. For the purposes of this conceptual design, alignment and planning level cost estimate, we assumed that all of the Storm Creek flow would be tightlined through the ravine downstream of 17th Place NW.

A separate tightline alternative could be designed to capture only the peak flows using a bypass, while allowing normal flows to remain in the channel. In other words, all flows over a set rate of flow would be diverted away from the stream channel and conveyed by way of a parallel pipe line. Additionally, there are a number of different options for the configuration of the pipe inlet and outlet, as well as means of constructing the tightline. Multiple assumptions were made for cost estimating purposes, and are outlined in the section below.

The tightline alignment, configuration, and costs should be considered preliminary for the purposes of this memorandum and would be finalized during the project design phase.

The location of the preferred tightline route, including inlet and outlet structures, is shown in Figure 1 (attached). The planning level cost estimate is included in Table 1.

Assumptions

The following assumptions are included in the conceptual design of the Storm Creek tightline.

- A topographic site survey will be needed for final design of the tightline, to determine route and placement of structures.
- High density polyethylene (HDPE) solid wall pipe will be used for the tightline. This pipe material has proven to work well in similar situations, and exhibits a high degree of flexibility and strength. Solid wall HDPE pipe is specified by King County in design of stormwater pipes on steep slopes (King County Surface Water Design Manual 2009).
- The tightline will match the existing culvert at 17th Place NW. Hydrologic modeling will need to be conducted to confirm the appropriate pipe size. For estimating purposes, the pipe was assumed to be 36 in. diameter.
- The tightline will connect to the existing culvert under 17th Place NW through a new manhole structure to be installed on the west side of the roadway.
- During construction, a bypass pipe will convey stream flow around the road and construction site, until the tightline can be connected.
- The tightline will extend through the Burlington Northern railroad culvert (48 inches diameter) and discharge on the west side of the railroad culvert to the existing outlet. Final design will need to consider potential flows from the ditches on the east side of the railroad, and whether these flows are conveyed through the existing culvert. If ditch flows need to be accommodated in the railroad culvert, a manhole structure will be needed along the east side of the railroad. This structure was not included in the planning level cost estimate.
- It is assumed that the HPDE pipe can be pulled and aligned from the top of the ravine, to the railroad culvert, without heavy equipment accessing the ravine. However, railroad or beach access may be needed.
- The HDPE pipe will be welded on-site by the contractor/pipe supplier.
- Bluff access may be needed to install the pipe (e.g. a large crane could be used to hold the pipe and guide it down the ravine).

- The outlet of Storm Creek into Puget Sound currently consists of large rip rap on the west side of the Burlington Northern railroad culvert. The tightline pipe will have less resistance and cross-sectional flow area than the current stream channel, resulting in greater velocities. It was assumed that additional outlet protection may be needed because of the high velocities anticipated from the tightline pipe.
- It is unknown whether this project will be approved by resource agencies, such as Washington Department of Fish and Wildlife (WDFW) or the Department of Ecology (Ecology). If the project is approved as recommended or with modifications, it is likely that mitigation to account for lost stream habitat and potential beach modifications (e.g. outfall protection) would be needed. Without knowing how the resource agencies will respond to a proposed project such as this, it is difficult to estimate the cost of mitigation. For the purposes of this conceptual design and planning level cost estimate, mitigation was assumed to cost $100,000.
- Permitting will likely be challenging, requiring specific resource studies and coordination with personnel from WDFW, Ecology, U.S. Army Corps of Engineers (Corps), and Burlington Northern Railroad. Additionally, coordination will need to occur with the Innis Arden Association for easements and access to the ravine for which the tightline would be installed.

Table 1. Preliminary draft opinion (estimate) of probable cost

			Project No.		Date	
Project Name		City of Shoreline Storm Creek Tightline Conveyance System	City of Shoreline Storm Creek		12/01/2011	
Location		Eagle Reserve Neighborhood (183rd Block of 17th Place Northwest)				
Owner		City of Shoreline				
Estimated By:		Kris McArthur/Chad Wiggins	**Checked By:**	Erin Nelson	**Approved By:**	
Date:		12/01/2011	**Date:**	12/5/2011	**Date:**	
ITEM NO.	**SPEC SECT.**	**DESCRIPTION**	**QTY**	**UNIT**	**UNIT PRICE**	**TOTAL COST**
		Mobilization/demobilization	1	LS	10%	$13,942
		Temporary bypass to divert flow around 17th Place Northwest	1	LS	$4,000	$4,000
		Clearing and grubbing	1	LS	$5,000	$5,000
		HDPE 36-in.-diameter pipe	380	LF	$150	$57,000
		HDPE pipe fusing and placement costs	380	LF	$130	$49,400
		54-in.-diameter manhole Type II with riser (installed)	1	Each	$7,500	$7,500
		Connect to existing 36-in.-diameter culvert (upstream)	1	Each	$1,500	$1,500
		Connect or slipline railway culvert	1	EST	$3,000	$3,000
		Outlet protection	1	EST	$5,000	$5,000
		Temporary erosion and sediment control	1	EST	$4,560	$4,560
		Restoration and landscaping	1	EST	$4,560	$4,560
		Project temporary traffic control	1	EST	$1,900	$1,900
		Survey	1	EST	$20,000	$20,000
			Subtotal Project Cost			**$177,362**
			Design Allowance		**30%**	**$53,209**
			Tax		**10%**	**$21,904**
			Mitigation		**--**	**$100,000**
			Engineering Design		**30%**	**$53,209**
			Permitting		**40%**	**$70,945**
			Design and Permitting Studies		**20%**	**$35,472**
			Construction Management		**20%**	**$35,472**
			TOTAL PROJECT COST			**$547,573**

HDPE – high-density polyethylene

Project: **ST-CIP-2**

Project Name: Convert Stormwater Conveyance Ditches to Bio-infiltration Facilities

Description: This project involves converting roadside drainage ditches into bio-infiltration facilities. There are a few roads in the Storm Creek basin, including 8th Avenue Northwest and 10th Avenue Northwest, where drainage is conveyed under driveways by a series of ditches and cross culverts. These roads are relatively flat and have existing issues with ditch filling and or flooding. These areas may be appropriate for conversion into roadside infiltration facilities, which would provide water quality and quantity benefits.

Benefits: Reduced flow to downstream stormwater infrastructure and Storm Creek and improved water quality.

Assumptions: Further investigation is required to determine how roadside infiltration swales would function at the locations that could benefit from this modification.

Estimated Cost/ Level of Effort: $617,000

Cost Estimate

Item	Unit	Unit Cost	Quantity	Cost
Conversion of ditches into bio-infiltrations swales	LF	$200.00	1,775	$355,000
Total				$355,000
Contingency (20%)				$71,000
Subtotal				$426,000
Survey, permitting, design, and engineering (45%)				$191,700
Total project cost				**$617,000**

Potential Partners: Residents located adjacent to roads where ditches could be converted. It would be important to get the approval of adjacent property owners, in order for this project to be successful.

Priority: Medium

Project: ST-Mon-3

Project Name: Monitor erosion

Description: This project involves the establishment of several monitoring points in the Eagle Reserve downstream of 17th Place Northwest to monitor the rate of erosion and bluff retreat in the vicinity of the road. It is recommended that the rate of bluff erosion and retreat be measured on a minimum frequency of once per year, and following major storm events. Annual measurements would help the City gauge how quickly erosion is occurring, both vertically and horizontally. This information would help City staff determine when more a more aggressive approach is necessary to protect the public infrastructure.

Benefits: The benefits of this project include quantitative measurement of erosion rate so that decisions can be made if more substantial measures are necessary to protect 17th Place Northwest or the sanitary sewer line from damage.

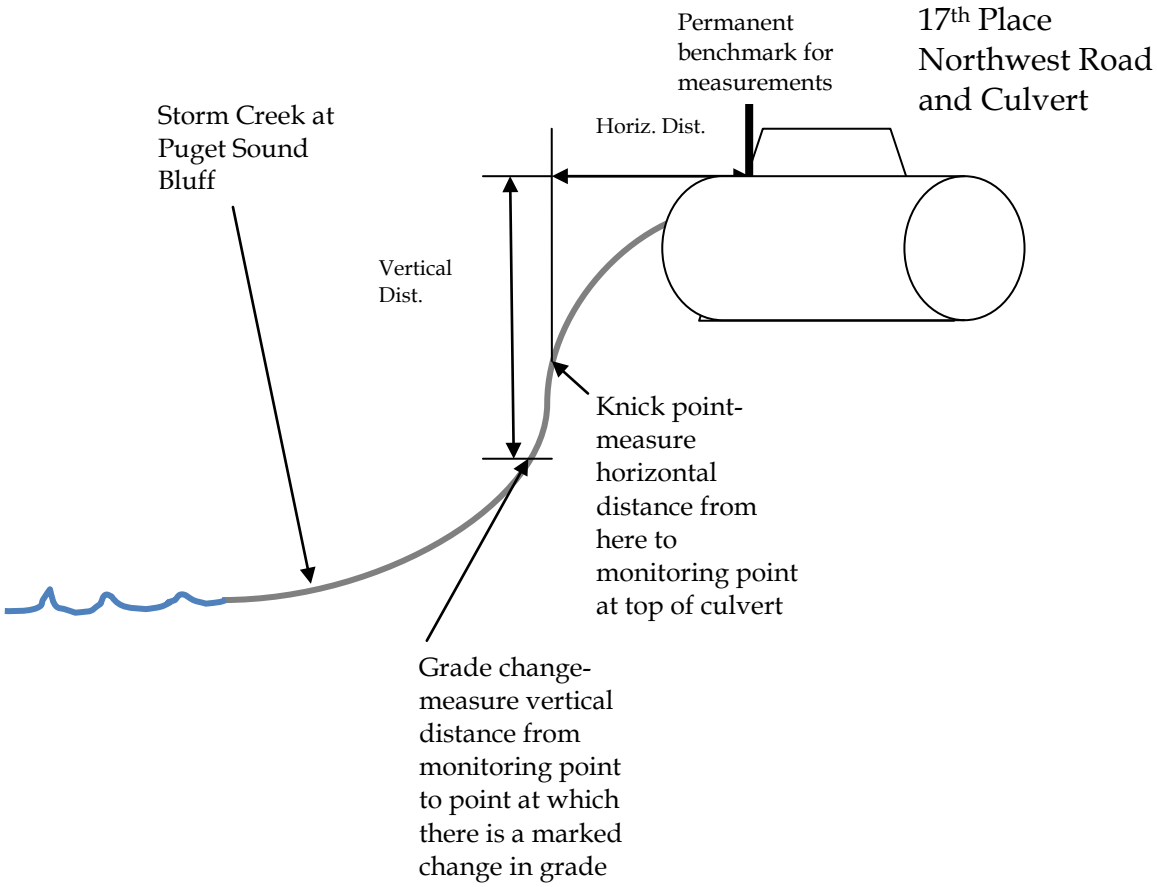
Assumptions: City of Shoreline staff would lead this effort. Monitoring points would be established from a permanent structure (such as the culvert under 17th Place Northwest or metal rebar placed far enough from the bluff so as not to be undermined). The initial measurements would be surveyed professionally to establish distance and elevation from the permanent structure. Future measurements could be made by stretching a tape from the permanent structure to the edge of the erosion knick point and measuring down from an established elevation point to determine downcutting. A schematic of how measurements could be made is shown in the figure below. The minimum frequency of measurements should be annually, with additional measurements made after large storm events. This project would also establish criteria for determining when other measures should be taken (for instance, when the knick point is within X feet of the road).

Estimated Cost/ Level of Effort: The estimated cost to establish monitoring points, including surveying is approximately $6,000. The level of effort for annual measurements is approximately 10 hours per year.

Potential Partners: None.

Priority: Medium

Schematic of Erosion Monitoring Procedure:



3 Repair and Replacement of Conveyance Pipes

Project: **ST-CIP-3**

Project Name: Stormwater Upgrades 11th Avenue Northwest

Description: This project includes replacing a failing corrugated metal pipe (CMP) that runs through private property, replacing a failing concrete pipe in the right of way (ROW), providing asphalt berms to prevent roadway runoff from entering private property, and performing other general stormwater upgrades along 11th Avenue Northwest.

Benefits: This project would reduce localized flooding that results from road runoff, and prevent catastrophic failure of the CMP and the slope through which the CMP runs.

Assumptions: This project involves multiple tasks in the same general vicinity to provide efficient use of resources; however, some elements could be effected independently if necessary (e.g., berms could be installed without repair of the CMP, or vice versa).

Estimated Cost/ Level of Effort: $103,000

Cost Estimate

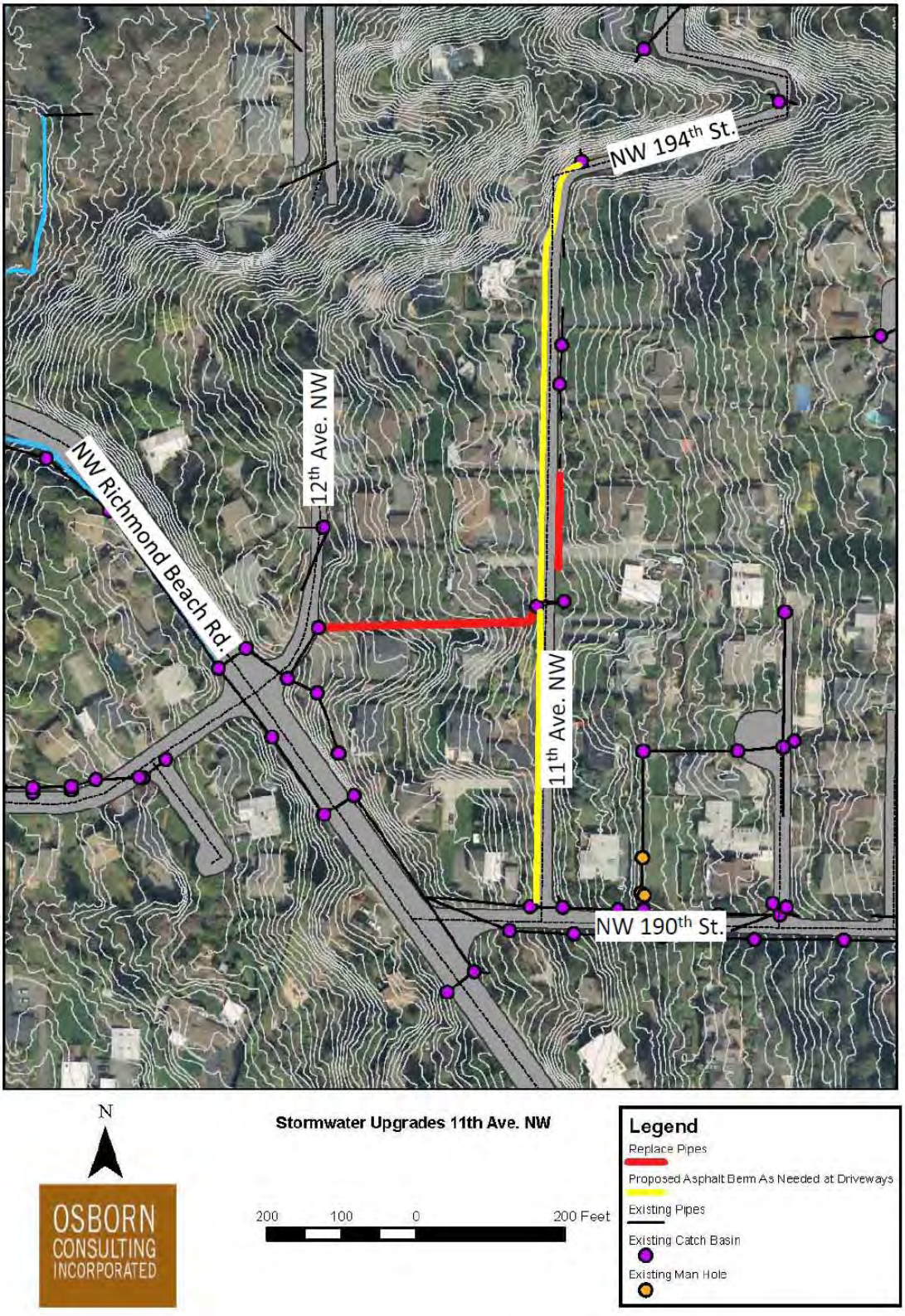
Item	Unit	Unit Cost	Quantity	Cost
Open cut storm drain replacement, PVC, 12- in.-diameter pipe	LF	$35.00	425	$14,875
Storm drain catch basin or manhole	EA	$4,000	6	$24,000
Roadway improvement/pavement patching	SY	$60.00	125	$7,500
Drainage easement	LS	$10,000.00	1	$10,000
Asphalt berm	LF	$5.00	350	$1,750
Total				$58,125
Contingency (20%)				$11,625
Subtotal				$69,750
Survey, permitting, design, and engineering (45%)				$31,400
Total project cost				**$103,000**

PVC – polyvinyl chloride

Potential Partners: This project would involve the support of neighbors adjacent to the proposed improvements.

Priority: High

Storm Creek Subbasin



Project: **ST-CIP-4**

Project Name: Stormwater Upgrades Northwest 196th Street

Description: This project includes replacing the pipe under the intersection of Northwest 196th Street and 5th Avenue Northwest, along with providing a new stormwater conveyance system along 5th Avenue between 196th and 197th. There is currently no formal stormwater system to convey runoff from 197th Street, 196th Street, and 5th Avenue downstream.

Benefits: This project would provide formal stormwater infrastructure where none currently exists and where condition assessment has indicated a pipe in need of replacement.

Assumptions: The attached figure shows the location and types of infrastructure improvements proposed for this area.

Estimated Cost/ Level of Effort: $76,000

Cost Estimate

Item	Unit	Unit Cost	Quantity	Cost
Open cut storm drain new or replaced, PVC, 12-in.-diameter pipe	LF	$35.00	520	$18,200
Storm drain catch basin or manhole	LS	$4,000	2	$8,000
Roadway improvement/pavement patching	SY	$60.00	250	$15,000
Traffic control	LS	$2,000	1	$2,000
Total				$43,200
Contingency (20%)				$8,640
Subtotal				$51,840
Survey, permitting, design, and engineering (45%)				$23,400
Total project cost				**$76,000**

PVC – polyvinyl chloride

Potential Partners: None

Priority: Low

Storm Creek Subbasin

N

OSBORN CONSULTING INCORPORATED

Stormwater Upgrades NW 196th St.

200 100 0 200 Feet

Legend

- Replace Pipe
- Proposed Catch Basin
- Proposed Pipe
- Existing Pipes
- Existing Catch Basin
- Existing Man Hole

Project: **ST-CIP-5**

Project Name: Open Cut Pipe Replacement and Modification of Drainage Structures

Description: There are seven pipe segments (totaling 650 ft) recommended for complete replacement using an open cut technique. Most of these pipe segments were rated very poor (greater than 4 on the Structural Pipe Ratings Index [SPRI]) and require immediate attention within the next few years, either because of their location or the type of failure.

Benefits: Replacing these pipe segments soon will avoid catastrophic failure in the future, when it might require an emergency action to fix the problems.

Assumptions: Tables G-1 and G-2 list specific problems and solutions for each pipe segment. Locations of the pipes are shown on Figure G-1.

Estimated Cost/ Level of Effort: $293,000

Cost Estimate

Item	Unit	Unit Cost	Quantity	Cost
Open cut storm drain replacement, PVC, 12- in.-diameter pipe	LF	$ 35.00	650	$22,750
Storm drain catch basin or manhole	EA	$4,000	23	$92,000
Roadway improvement/pavement patching	SY	$ 60.00	555	$33,300
Traffic control	LS	$20,000	1	$20,000
Total				$168,0550
Contingency (20%)				$33,610
Subtotal				$201,660
Survey, permitting, design, and engineering (45%)				$90,747
Total project cost				**$293,000**

PVC – polyvinyl chloride

Potential Partners: None

Priority: High

Table G-1. Pipes recommended for open cut pipe replacement

Table G-1: Recommended Open Cut Pipe Replacement									
OBJECTID	PIPEDIAM	PIPETYPE	LENGTH	SPRI	MPRI	OPRI	PROBLEM	PROPOSED SOLUTION	Location
4816	12	CONC	126.34	5	0	5	Collapsed pipe at 21' from downstream end, also improper storm connection at 16 feet from downstream end.	Add catch basin/structure at storm connection and replace pipe at collapse (16 feet LF).	On 200th St near 8th Ave NW
1938	12	CMP	41.27	4.5	1.17	4.15	Smashed CMP pipe, parallel concrete pipe full of sediment, at an arterial intersection.	Replace parallel pipes with single pipe.	At intersection of 8th Ave NW & NW 190th Street
8866	12	CONC/CMP	251.3	4	2	3.33	Concrete transitions to CMP. CMP portion of pipe is smashed/deformed, lots of debris.	Add structure and replace 182 linear feet of CMP pipe.	On 15th Ave NW, near NW 191st St.
28189	12	CMP	298.66	4.1	0.92	3.17	Invert gone on CMP pipe traveling through private property on a steep slope, opportunity for drainage improvements along 11th Ave NW.	Replace CMP and Concrete Pipe and add structures at stormwater connections. Provide asphalt berms along 11th Ave NW to keep runoff from entering private driveways.	On private property between 11th and 12th, North of 190th
4004	12	CONC	122.70	2	2.65	2.18	Storm connections at 21-feet and 35-feet from downstream end; multiple cracks, surface spalling, repair patches, and roots at joints.		On 11th Ave NW, north of NW 190th St. Long driveway culvert.
6639	12	CONC	253.13	4.5	2	2.31	Standing water in flat/ sagged pipe, up to 60% of pipe diameter. No downstream outlet. Holes, infiltration at 20 feet and 68 feet, from upstream end. Conduit crossing top of pipe at 38 feet. Storm connection at 72-feet from downstream, cracks and failure at 244'.	Replace pipe and provide new storm conveyance system along 5th Ave NW to provide outlet to downstream.	Under intersection of 196th and 5th
3825	12	CONC	81.83	1.67	4	2.25	Storm connection at 25-feet from upstream end, multiple joint seperation/offsets, 30 degree angle in pipe without structure,	Add catch basin/structure at storm connection and pipe bends. Replace pipe.	Pipe crosses under 10th Ave NW, near 198th.

Table G-2. Pipes with recommended new storm drain connections

Table G-2: Improper Storm Drain Connections										
OBJECTID	PIPEDIAM	PIPETYPE	LENGTH	SPRI	MPRI	OPRI	PROBLEM	PROPOSED SOLUTION	LOCATION	OTHER TABLES
2996	12	CONC	84.02	0	5	5	4-inch storm connection at 48-feet from upstream end.	Add catch basin/structure at storm connection.	On 16th Ave NW, south of NW 185th St.	Note also on Table G-2 (ST-Main-1)
5835	12	CONC	56.18	4	0	4	Storm connection at 31-feet from upstream end w/ crack.	Add catchbasin/structure at storm connection and repair pipe.	On 12th, across from School	
7912	12	CONC	90.10	4	0	4	Storm connection at 20-feet from downstream end w/ running water at top and crack.	Add catch basin/structure at storm connection and repair pipe.	At intersection of 10th Terrace NW and NW 197th Pl.	
8896	12	CPP	101.40	0	3.67	3.67	Storm connection at 42-feet from downstream end.	Add catch basin/structure at storm connection, and repair.	At the intersection of 16th Ave NW and NW 185th St.	Note also on Table G-2 (ST-Main-1)
7220	12	CONC	142.57	0	4	3	Storm connection at 101-feet from upstream end, multiple cracks.	Add catch basin/structure at storm connection, and repair and clean pipe.	At intersection of NW 190th St and NW Richmond Beach Rd.	
1762	12	CONC	126.45	3	2	2.86	Multiple storm connections/taps at 41-feet and 58-feet from the downstream end.	Add catch basins/structures at storm connections.	On NW 197th Pl between 11th Ave NW and 10th Terrace NW	Note also on Table G-5 (ST-CIP-6) and G-6 (ST-CIP-7)
6055	12	CONC	40.56	5	1.86	2.25	Storm connection at 19-feet from downstream end at bottom w/ crack, roots w/ crack.	Add catch basin/structure at storm connection, and repair and clean pipe.	On 190th, West of 8th. Small driveway culvert.	Note also on Table 8 and 9

Woodway Shoreline

Edmonds Shoreline

20TH AVE NW

15TH AVE NW

Kruckeberg Garden

Syre Elementary School

NW 195TH ST

City of Shoreline Public Open Space

NW 188TH ST

NW RICHMOND BEACH RD

8TH AVE NW

SPRINGDALE CT NW

17TH PL NW

Storm Creek

Eagle Reserve

4816

3825

5835

7912

1762

6639

4004

28189

8866

7220

6055

1938

8896

2996

Recommended open cut pipe replacement

Improper storm drain connection

Channel

Ditch

Pipe

Wetlands

Storm Creek basin

Tax parcel

N

0 125 250 Yards

0 100 200 Meters

Wind Ward environmental LLC

Figure G-1. Recommended open cut pipe replacement and improper storm drain connections

Prepared by craigh, 3/8/2013, W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig_G-1 5176 Open cut pipe repl and improper SD connections.mxd

Project: **ST-CIP-6**

Project Name: Trenchless Pipe Repair

Description: There are 10 pipe segments (totaling 774 ft) recommended for trenchless repair. This category includes pipes that received a poor structural rating, were relatively high risk and, upon further investigation, were identified as candidates for a trenchless solution. Trenchless solutions include slip-lining, cured in place pipe (CIPP), pipe bursting, pipe reaming, and others.

Benefits: It is less expensive to repair pipes than to replace them. The benefit of implementing trenchless techniques to fix pipes such as those identified in the condition assessment is that it avoids the need for immediate replacement.

Assumptions: Table G-3 lists specific problems and solutions for each pipe segment. Locations of the pipes are shown on Figure G-2.

Estimated Cost/ Level of Effort: $180,000

Cost Estimate

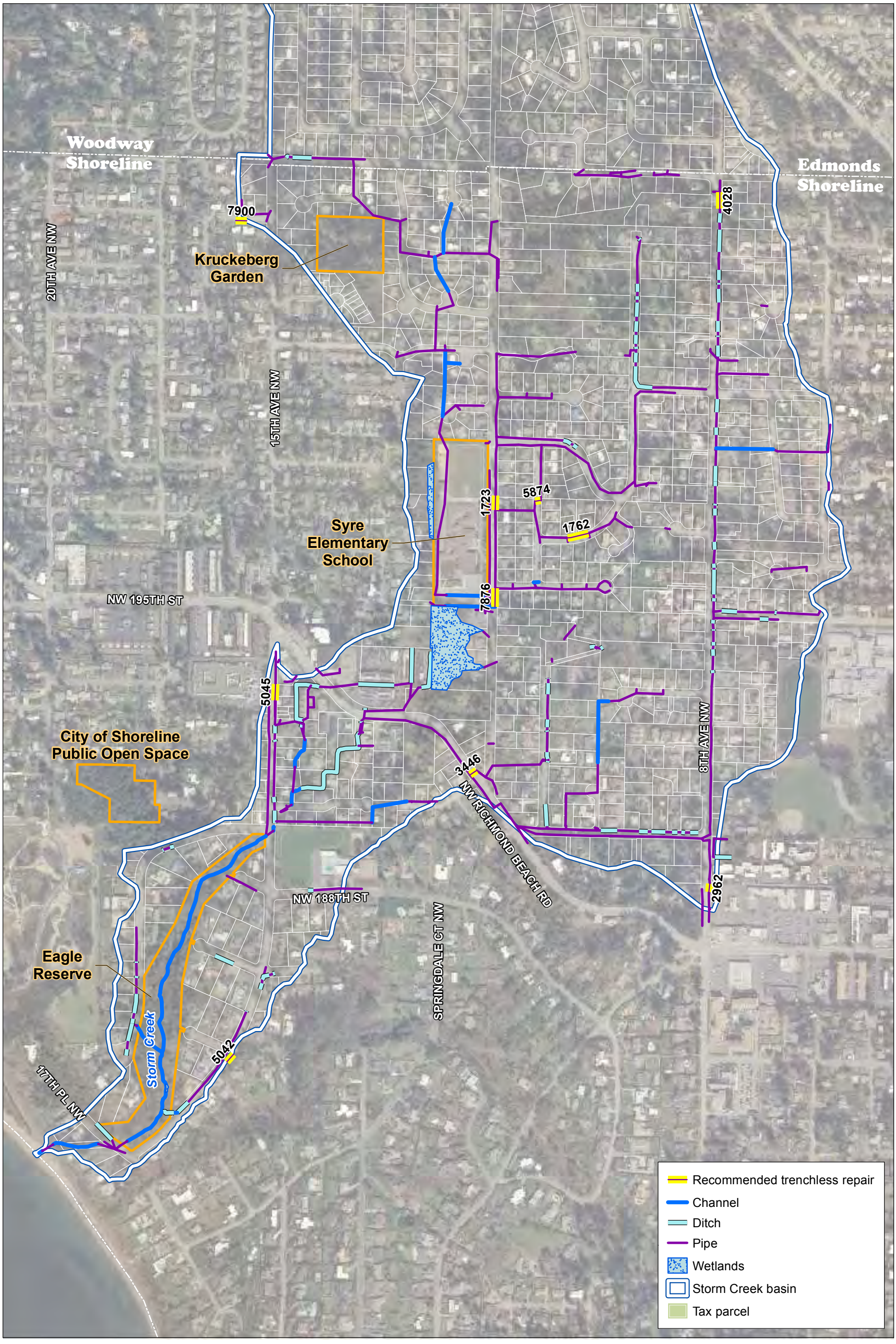
Item	Unit	Unit Cost	Quantity	Cost
Trenchless pipe replacement	LF	$50.00	775	$38,750
Storm drain catch basin or manhole	EA	$4,000	20	$80,000
Roadway improvement/pavement patching	SY	$ 60.00	225	$13,500
Traffic control	LS	$4,000	1	$4,000
Total				$136,250
Contingency (10%)				$13,625
Subtotal				$149,875
Permitting, design, and engineering (20%)				$30,000
Total project cost				**$180,000**

Potential Partners: None

Priority: High

Table G-3. Pipes recommended for trenchless repair

Table G-3: Recommended Trenchless Repair										
OBJECTID	PIPEDIAM	PIPETYPE	LENGTH	SPRI	MPRI	OPRI	PROBLEM	PROPOSED SOLUTION	LOCATION	OTHER TABLES
1723	12	CONC	86.45	5	0	5	Lateral fracture at the top of the pipe, near joint , 70' from downstream end	Repair with trenchless solution last 15 feet of pipe	On 12th across from School	
5874	12	CONC	32.92	5	0	5	Separation (3-4 inches) at the joint	Trenchless repair of entire pipe	Lateral crossing on 11th Ave, north of 197th.	
7900	12	CONC	66.57	4.33	0	4.33	Significant fractures at joints, sediment and rocks remain in pipe.	Jet pipe, verify trenchless solution is feasible.	Upper part of basin on NW 104th St	
3446	12	CONC	45.42	4	0	4	Fracture at the top 6-ft from downstream end	Trenchless repair of entire pipe	Cross culvert under NW Richmond Beach Drive, near 12th.	
7876	12	CONC	110.53	4	0	4	Fracture at the top of pipe, 90 feet from upstream end.	Trenchless repair of entire pipe	On 12th, across from School entrance	
5042	12	CONC	60.36	4	3	3.67	Hole, 3 cracks, 2 roots w/ crack, all within 20-ft from downstream end	Trenchless repair of entire pipe	Downstream end of basin, 16th Ave NW	
1762	12	CONC	126.45	3	2	2.86	Fractures near failure at 35 feet from downstream end. from downstream end.	Trenchless repair of downstream 42 feet of pipe where new structure will be installed for stormwater connection (see Table 7)	On NW 197th Pl between 11th Ave NW and 10th Terrace NW	Note also on table G-6 (ST-CIP-7) and G-4 (ST-CIP-5)
5045	12	ADS-1	97.97	4	2	2.67	Multiple cracks and holes, 1 significant hole causing sediment to fill pipe at 55 feet from upstream end.	Add structure at significant hole, jet pipe, and repair pipe with trenchless solution.	On 15th Ave NW, near NW Richmond Beach Rd.	
4028	12	CONC	99.49	4.33	1	2.43	Minor cracks and fractures throughout pipe, significant fractures and joint separation at 71 feet from downstream end.	Trenchless repair of entire pipe	On 8th Ave NW, south of NW 205th St.	
2962	12	CONC	47.68	4	1.67	2.25	Pipe has a sag. Fractures and roots at joints.	Trenchless repair of entire pipe	On 8th Ave NW, north of NW Richmond Beach Rd.	



Wind Ward environmental LLC

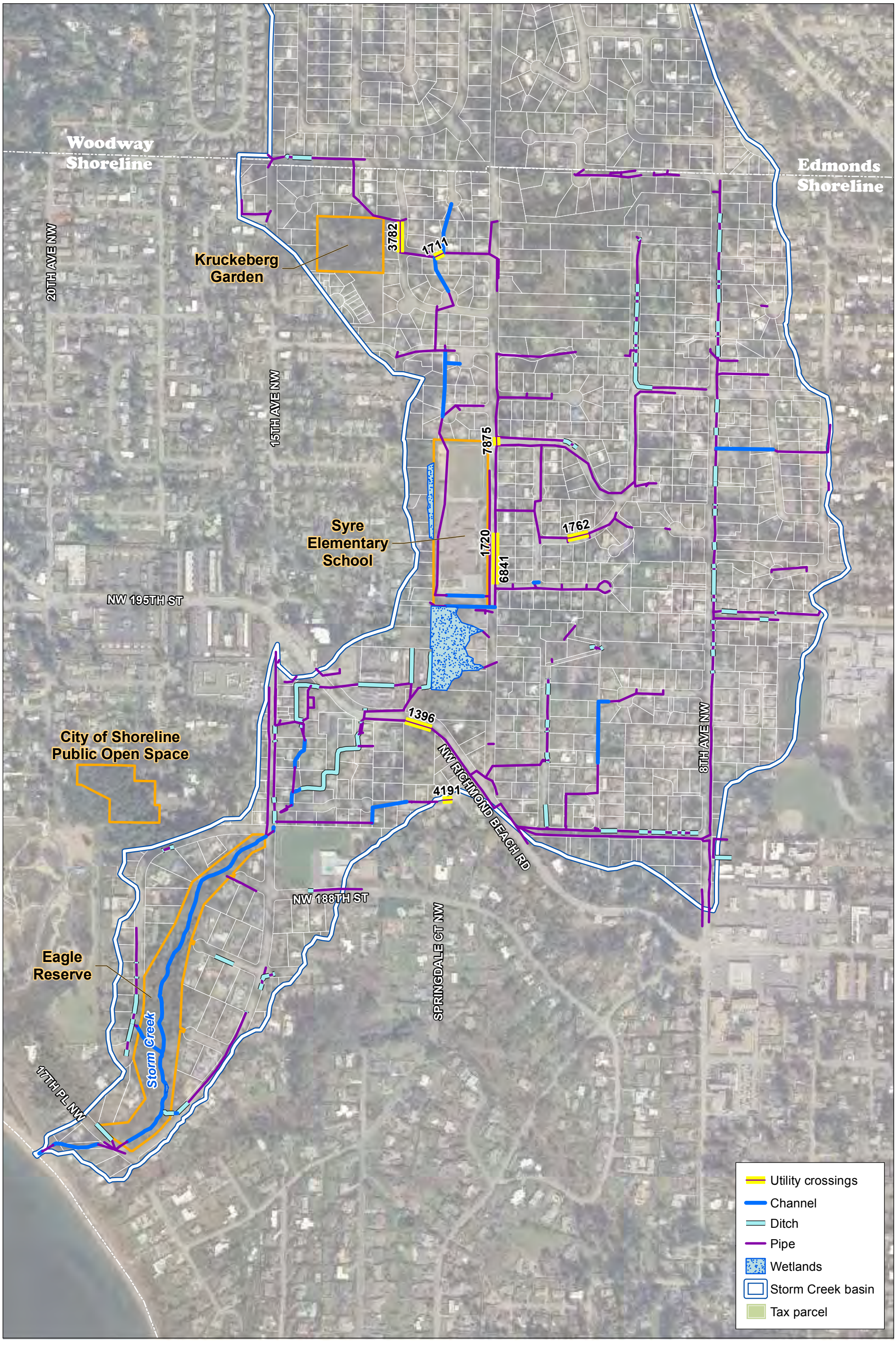
Figure G-2. Recommended trenchless repair

Prepared by craigh, 3/8/2013; W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig G-2 5177 Recommended trenchless repair.mxd

Project:	**ST-CIP-7**
Project Name:	Remove Utility Crossings
Description:	Utility crossings through the storm drain have resulted in structural deficiencies. Unidentified conduit, likely containing cable, fiber optic, or electrical services, were the primary cause of the problems, but some waterlines were also identified. It is recommended that the City identify the likely utility owner and coordinate relocation of the utility crossings and repair of the stormwater pipe.
Benefits:	This project will remove obstacles in the stormwater infrastructure, and prevent homeowner utility service interruption in the event that utility lines that cross stormwater pipes are broken or damaged.
Assumptions:	Table G-4 lists specific problems and solutions for each pipe segment. Locations of the pipes are shown on Figure G-3.
Estimated Cost/	
Level of Effort:	Forty hours of City staff time to send letters, coordinate required repairs and relocations with utility companies, and confirm that the work has been completed.
Potential Partners:	Utility companies that own lines that cross the City's stormwater pipes.
Priority:	High

Table G-4. Utility crossings that need to be removed

TableG- 4: Utility Crossings											
OBJECTID	PIPEDIAM	PIPETYPE	LENGTH	SPRI	MPRI	OPRI	PROBLEM	PROPOSED SOLUTION	UTILITY	LOCATION	OTHER TABLES
6841	12	CONC	171.45	4	4	4	3-inch conduit crossing through storm pipe, blocking invert at 80-feet from downstream end.	Verify conduit utility owner and have them relocate conduit.	Unknown, 3-in Conduit	On 12th, across from School entrance	
7875	12	CONC	49.63	4	4	4	Cross Conduit Pipe at 40-feet from upstream end from 9:00 to 3:00 of pipe, not grouted in.	Verify conduit utility owner and have them relocate conduit.	Unknown, 3-in Conduit	On 12th, across from School at 198th	
3782	12	CONC	184.49	4.5	2	3.67	Conduit on upper side of pipe at 82-feet from upstream end.	Have utility owner relocate conduit.	3-in Conduit	Upper end of Basin, South of 205th	
4191	12	CONC	58.48	5	2	3.5	Cross conduit pipe towards the invert at 32-feet from downstream end.	Verify conduit utility owner and have them relocate conduit.	Unknown, 2-in Conduit	On SW 191st, South of NW Richmond Beach Rd	
1720	12	CONC	135.93	4	3	3.5	Cross Conduit Pipe at 70-feet from upstream end from 9:00 to 2:00 of pipe, not grouted in.	Verify conduit utility owner and have them relocate conduit.	Unknown, 3-in Conduit	On 12th across from School	
1762	12	CONC	126.45	3	2	2.86	Multiple conduit crossings at 47-feet and 61-feet from downstream end.	Add catch basins/structures at storm connections. Verify utility owners and have them relocate the conduits. Repair pipe.	At 47-feet: Unknown, 3-in Conduit, with cables At 61-feet: Waterline, 3/4-in Copper	On NW 197th Pl between 11th Ave NW and 10th Terrace NW	Note also on Table G-4 (ST-CIP-5) and Table G-5 (ST-CIP-6)
1396	18	CMP	162.6	4	2.5	2.8	Storm connection at 39-feet from upstream end; 3/4-inch waterline crossing through stormpipe, 70 feet from upstream.	Add catchbasin/structure at storm connection and have utility owner relocate waterline.	At 70-feet: Waterline, 3/4-in Copper	On NW Richmond Beach Drive, north of NW 191st St and 12th Ave NW	
1711	12	CONC	58.61	4	2	2.67	Pipe/conduit on upper side of pipe at 39-feet from downstream end and fractured pipe.	Have utility owner relocate waterline. Repair pipe.	Waterline, 1-in Copper	Crosses NW 203rd St between 13th Ave NW and 12th Ave NW	



Wind Ward LLC environmental

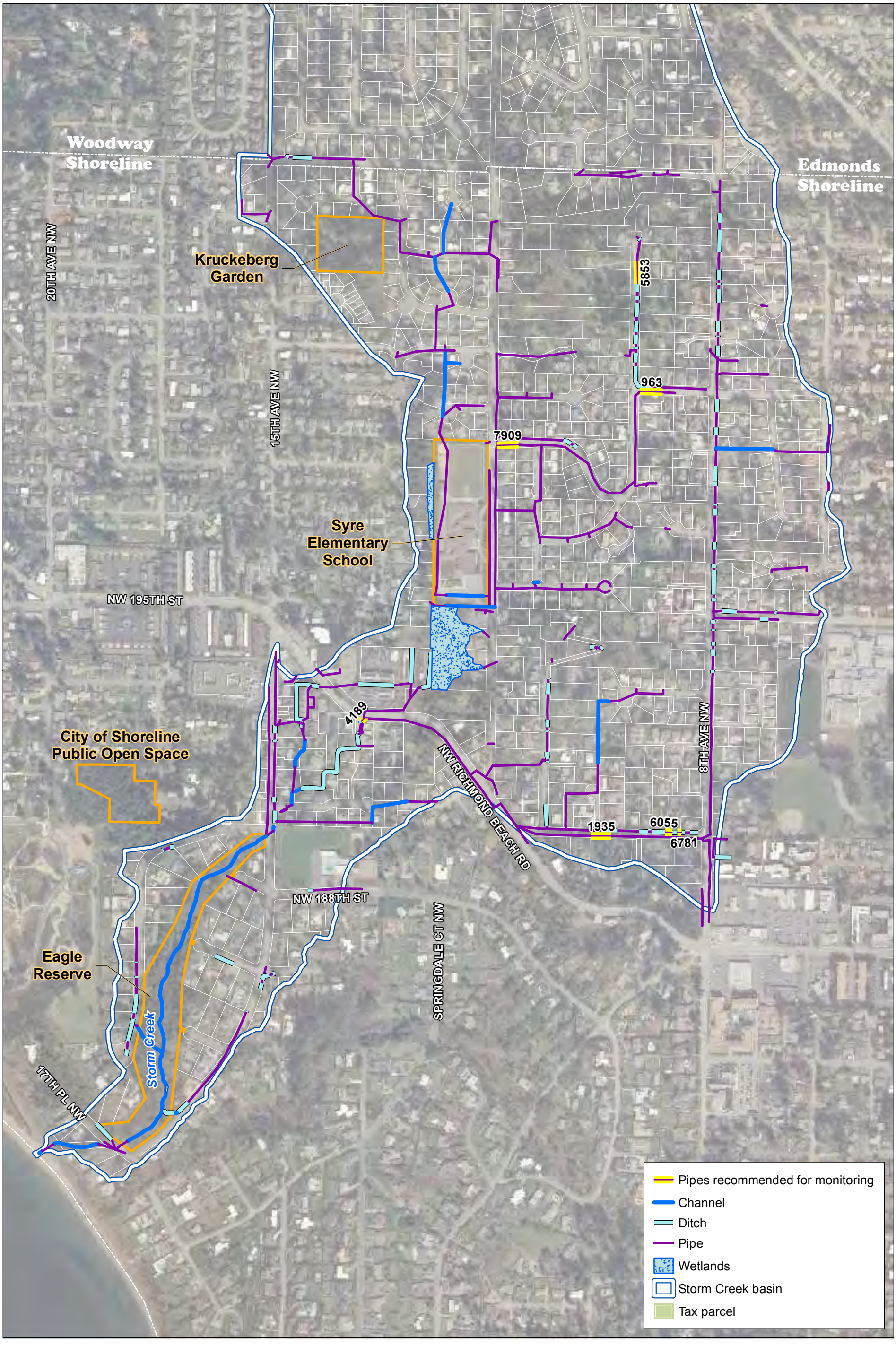
Figure G-3. Utility crossings

Prepared by craigh, 3/8/2013, W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps and Analysis\Storm Crk Basin Plan\Fig G-3 5178 Utility crossings.mxd

Project:	**ST-Mon-4**
Project Name:	Monitor Pipes Not Recommended for Immediate Repair
Description:	Pipes that did not fall into the categories described above, yet received a poor structural rating, are included in this category. Structural deficiencies in this category include fractures, holes, minor deformities, and other problems. It is recommended that the City actively monitor these pipes to ensure the structural deficiency does not worsen.
Benefits:	Proactive monitoring will prevent the necessity of reactive repair or replacement implemented because of an emergency. Also, monitoring will help the City plan for future repairs and replacements and budget accordingly.
Assumptions:	Table G-5 and Figure G-4 show locations of pipes that should be monitored. It is assumed that these pipes would be monitored via a video inspection program once every 2 years to determine if conditions have worsened.
Estimated Cost/ Level of Effort:	The estimated cost for monitoring approximately 600 linear ft of pipe is $3,000 every other year. This assumes a rate of $3/linear foot for video inspection and incidental traffic control and pipe jetting.
Potential Partners:	None
Priority:	High

Table G-5. Pipes recommended for monitoring

Table G-5: Pipes Recommended for Monitoring									
OBJECTID	PIPEDIAM	PIPETYPE	LENGTH	SPRI	MPRI	OPRI	PROBLEM	LOCATION	OTHER TABLES
963	12	CPP	125.45	5	0	5	Small hole within 8-inches of joint.	On NW 200th St., east of 10th Ave.	
5853	12	CPP	137.14	4.63	0	4.63	Lots of small holes	At north end of 10th Ave NW.	
1935	18	CMP	120.43	4	0	4	Patched CMP	On NW 190th St across from 10th Ave NW	
4189	36	CMP	23.05	4	0	4	Deformed at pipe end.	On NW Richmond Beach Rd near 14th Pl NW.	
6781	12	CONC	23.55	5	1.5	2.67	Roots w/ crack, crack from rock through wall	On 190th, West of 8th. Small driveway culvert.	
6055	12	CONC	40.56	5	1.86	2.25	Storm connection at 19-feet from downstream end at bottom w/ crack, roots w/ crack.	On 190th, West of 8th. Small driveway culvert.	Note also on Tables G-2 (ST-Main-1) and G-4 (ST-CIP-5)
7909	12	CONC	129.91	4	1	2	Minor angles in downstream last 20 feet of pipe. Morter patching last 5 feet of pipe.	On 198th Near 12th	



Wind Ward LLC environmental

Figure G-4. Pipes recommended for monitoring

Prepared by craigh, 3/8/2013, W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps and Analysis\Storm Crk Basin Plan\Fig G-4 5179 Pipes recommended for monitoring.mxd

Project:	**ST-Main-1**
Project Name:	Maintenance Modifications
Description:	The pipes identified as having a poor maintenance rating (≥ 4.0) were reviewed carefully. The majority of the pipes in the Storm Creek basin were cleaned prior to the closed circuit television (CCTV) work, and therefore only seven pipes received poor maintenance ratings. From the condition assessment, several pipes were identified as likely to need frequent maintenance or pipe jetting. Potentially, these pipes may also need to be replaced in the future if the frequent sedimentation occurs due to an inadequate design.
Benefits:	Improved functionality of pipe segments will lead to better overall functionality of the stormwater system.
Assumptions:	Table G-6 and Figure G-5 provide more detail on the types of problems and locations.
Estimated Cost/ Level of Effort:	The estimated cost to clean out pipes that were not cleaned during the condition assessment but were identified as needing excessive cleaning is $10,000 (assumes approximately 560 linear ft of pipe).
Potential Partners:	None
Priority:	High

Table G-6. Pipes recommended for more frequent maintenance

Table G-6: Pipes Recommended for Jetting or Frequent Maintenance									
OBJECTID	PIPEDIAM	PIPETYPE	LENGTH	SPRI	MPRI	OPRI	PROBLEM	LOCATION	OTHER TABLES
2996	12	CONC	84.02	0	5	5	Pipe collects a lot of sediment, sediment still in pipe needs to be removed.	On 16th Ave NW, south of NW 185th St.	Note also on Table G-4 (ST-CIP-5)
3828	12	CONC	147.35	0	5	5	Fracture at joint causing leaking into pipe.	Near east end of NW 196th St.	
953	12	CPP	37.6	5	0	5	Medium hole at top of pipe, 26-feet from downstream end.	Near 12th South of School	
8896	12	CPP	101.40	0	3.67	3.67	Multiple roots at joints.	At the intersection of 16th Ave NW and NW 185th St.	Note also on Table G-4 (ST-CIP-5)
7826	12	CONC	84.84	3	4	3.5	Multiple cracks and debris.	Across alley on 8th Ave NW, north of NW 193rd St.	
4771	12	CPP	66.24	4	2	3	Lots of sediment still in pipe, needs to be removed	On 8th Ave NW, South of 202nd.	
6055	12	CONC	40.56	5	1.86	2.25	Storm connection at 19-feet from downstream end at bottom w/ crack, roots w/ crack.	On 190th, West of 8th. Small driveway culvert.	Note also on Tables G-4 (ST-CIP-4) and G-1 (ST-Mon-4)

Woodway Shoreline

Edmonds Shoreline

20TH AVE NW

Kruckeberg Garden

15TH AVE NW

4771

Syre Elementary School

953

3828

NW 195TH ST

7826

8TH AVE NW

City of Shoreline Public Open Space

NW RICHMOND BEACH RD

6055

NW 188TH ST

SPRINGDALE CT NW

Eagle Reserve

Storm Creek

8896

2996

17TH PL NW

Pipes recommended for jetting or frequent maintenance

Channel

Ditch

Pipe

Wetlands

Storm Creek basin

Tax parcel

N

0 125 250 Yards

0 100 200 Meters

Figure G-5. Pipes recommended for jetting or frequent maintenance

Prepared by craigh, 3/8/2013, W:\Projects\City of Shoreline Basin Plan\Data\GIS\Maps_and_Analysis\Storm Crk Basin Plan\Fig_G-5 5180 Pipes recommended for jetting-freq maintenance.mxd

4 Habitat and Fish Passage

Project: **ST-Mon-5**

Project Name: Cross Section Monitoring

Description: This project involves the annual evaluation of physical channel conditions in Eagle Reserve for the purpose of understanding the stability of the existing channel.

Benefits: Annual monitoring will help answer the question of whether Storm Creek within Eagle Reserve is actively causing incision, or whether the current channel has already adjusted to a changed flow regime.

Assumptions: City staff would lead this effort. Three cross sections have already been established within Eagle Reserve for the purpose of flow monitoring during the development of this plan. These cross sections could be surveyed annually by City staff to monitor changes (i.e., erosion and sedimentation) in the channel configuration. Protocol for measuring cross sections is available in the US Department of Agriculture (USDA) General Technical Report RM-245, *Stream Channel Reference Sites: an Illustrated Guide to Field Technique* by Cheryl C. Harrelson, C.L. Rawlins, and John P. Potyondy, available online at www.**stream**.fs.fed.us/publications/.

Locations of surveyed cross sections and channel geometries are attached.

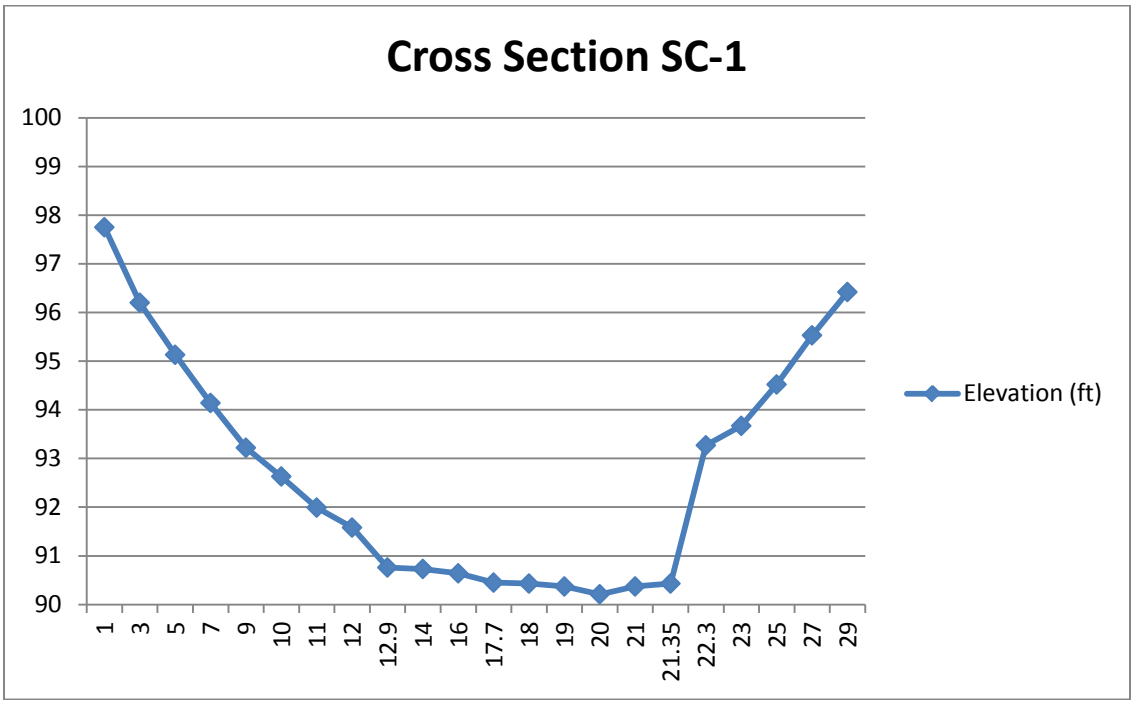
Estimated Cost/

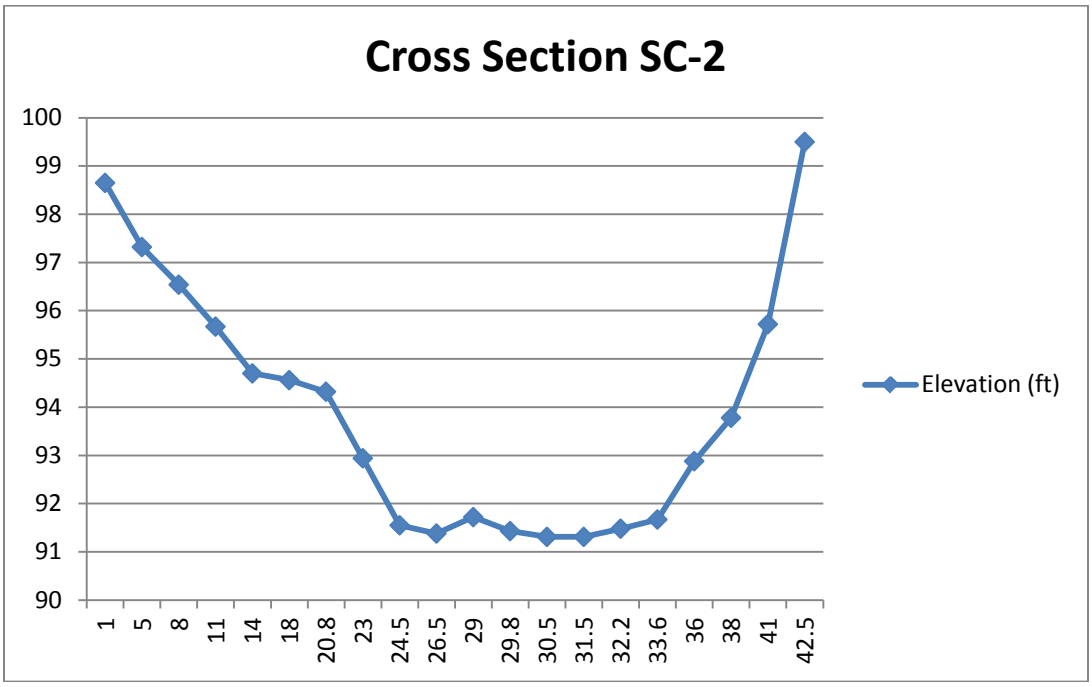
Level of Effort: The estimated level of effort to annually monitor three cross sections is approximately 20 hours per year for the field effort and data evaluation. Survey gear, including a stadia rod, laser level, and tape, would be needed to conduct the measurements.

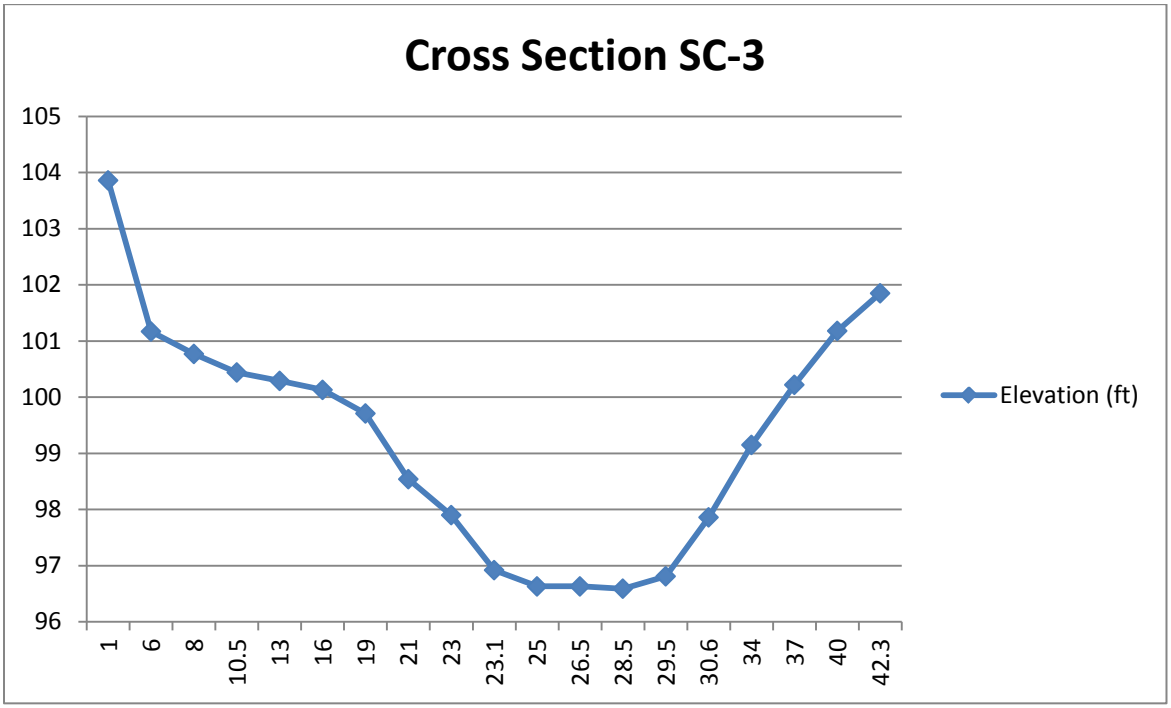
Potential Partners: Shoreline Community College students enrolled in geology or geography classes.

Priority: Medium


SC-3
SC-2
SC-1
Approximate locations of channel cross sections


Cross Section SC-1
100
99
98
97
96
95
94
93
92
91
90
1
3
5
7
9
10
11
12
12.9
14
16
17.7
18
19
20
21
21.35
22.3
23
25
27
29
Elevation (ft)


Cross Section SC-2
100
99
98
97
96
95
94
93
92
91
90
1
5
8
11
14
18
20.8
23
24.5
26.5
29
29.8
30.5
31.5
32.2
33.6
36
38
41
42.5
Elevation (ft)


Cross Section SC-3
105
104
103
102
101
100
99
98
97
96
1
6
8
10.5
13
16
19
21
23
23.1
25
26.5
28.5
29.5
30.6
34
37
40
42.3
Elevation (ft)

Project:	**ST-Main-2**
Project Name:	Eagle Reserve Removal of Non-native Vegetation
Description:	This project involves the removal of non-native vegetation within Eagle Reserve. Typically non-native vegetation, such as Himalayan blackberries and other invasive species, will prevent the growth of more desirable native vegetation.
Benefits:	Removal and maintenance of invasive species will improve the riparian corridor in Eagle Reserve to the benefit of birds and wildlife as well as water quality.
Assumptions:	This project would likely be undertaken by volunteer groups and the Innis Arden community, as the Eagle Reserve is owned by Innis Arden.
Estimated Cost/	
Level of Effort:	None for the City. Assumes a volunteer effort led and coordinated by Innis Arden.
Potential Partners:	None
Priority:	Medium

Project:	**ST-Hab-1**
Project Name:	Eagle Reserve Channel Restoration and Fish Passage Improvements
Description:	This project involves the installation of grade control, such as large wood or other structures, to minimize incision, sediment trapping, and pool formation. Specific locations are not identified (other than Eagle Reserve), but as it would be important to minimize the construction disturbance associated with the restoration work, locations near road access (such as 17th Place Northwest or 15th Avenue Northwest) would be better than locations in the middle of the reserve. In association with any restoration project, it would be beneficial to provide fish passage improvements where passage has been impaired. Currently, the sewer line crossing Eagle Reserve is a barrier to resident fish passage, and modifications should be made to improve passage for resident fish. Anadromous fish were never likely in Storm Creek, and anadromous fish passage is not being suggested.
Benefits:	In the City's *Surface Water Master Plan Update* (SAIC 2011), the installation of large wood was recommended to help stabilize stream banks in this reach.
Assumptions:	A specific concept is not presented in this plan, as this project would not likely be implemented by the City, since it is located within the privately owned Eagle Reserve. Identifying potential habitat restoration opportunities within this plan provides a placeholder for potential future mitigation, if needed.
Estimated Cost/	
Level of Effort:	Not provided.
Potential Partners:	Innis Arden community would be the project lead. Ronald Wastewater District would be a partner in providing fish passage in the vicinity of the sanitary sewer trunk line.
Priority:	Low

Project:	**ST-Hab-2**
Project Name:	Daylight Storm Creek Upstream of Richmond Beach Road
Description:	This project involves daylighting an existing piped channel near the Meadowbrook Apartments to create a combination stream channel, floodplain, and wetland.
Benefits:	The potential benefits of this type of project include increased water storage during storm events and water quality filtration. It also has the potential to minimize flooding, which would be determined by Project ST-Study-4.
Assumptions:	The City has an existing stormwater easement at this location that could be utilized for the project. Additionally, this project could be combined with wetland enhancement (ST-Hab-3).
Estimated Cost/ Level of Effort:	To be determined; likely more than $100,000.
Potential Partners:	Volunteer environmental groups and community organizations.
Priority:	High

Project:	**ST-Hab-3**
Project Name:	Wetland Enhancement Between Meadowbrook Apartments and Syre Elementary School
Description:	This project involves the acquisition of undeveloped, partially wooded parcels for the purposes of stream enhancement, wetland enhancement, non-native plant species removal, passive recreation, trail installation, and other park uses.
Benefits:	This project would provide a minor amount of flow reduction benefit (Appendix B), and there could be opportunities for mitigation credits to pay for restoration and park improvements.
Assumptions:	An alternative to acquisition would be conservation easements, in conjunction with ST-Hab-4.
Estimated Cost/ Level of Effort:	To be determined; likely more than $500,000, including property acquisition.
Potential Partners:	Volunteer environmental groups and community organizations.
Priority:	Low

Project:	**ST-Hab-4**
Project Name:	Conservation of Open Space
Description:	Of the three large forested areas in the basin, the six contiguous properties downstream of Syre Elementary School are the least protected, and therefore have the most habitat vulnerability. Protection of this area could involve the implementation of conservation easements, or separation of the area into open space tracts. Incentives for property owners could include acquisition transactions and/or the potential for lowered property tax burdens.
Benefits:	This project would reduce vulnerability to further habitat degradation.
Assumptions:	This project could done in conjunction with ST-Hab-3.
Estimated Cost/	
Level of Effort:	To be determined.
Potential Partners:	To be determined.
Priority:	Low

5 Flooding

Project: **ST-Ed-6**

Project Name: Ditch Education Program

Description: This project involves educating residents located adjacent to drainage ditches about their responsibility to keep the ditches clear and free of debris, including yard waste and trash.

Benefits: Providing information to homeowners on the importance of the drainage ditches would benefit overall stormwater infrastructure functionality; flooding due to debris would be reduced, as would the number of clogged pipes from debris moving downstream.

Assumptions: City staff would lead this education effort. Reference materials would be developed and a public campaign initiated.

Estimated Cost/

Level of Effort: 80 hours to compile information and develop brochures; additional time to distribute and target neighborhoods for education.

Potential Partners: Neighborhood groups

Priority: High

Project:	**ST-Ed-7**
Project Name:	Targeted Flood Education Program
Description:	This project involves targeting neighborhoods where flooding occurs fairly frequently, such as in the area of the Meadowbrook apartments. Information on obtaining flood insurance would be distributed, as well as how home and apartment owners can protect their properties during large storm events with the potential to cause flooding.
Benefits:	This project would proactively address the impacts of flooding and help residents to be aware of resources.
Assumptions:	City staff would lead this effort.
Estimated Cost/	
Level of Effort:	80 hours of staff time to develop informational brochures and provide links on the City's website.
Potential Partners:	National Flood Insurance Program, Richmond Beach Neighborhood Association
Priority:	High

Project:	**ST-Ed-6**
Project Name:	Ditch Education Program
Description:	This project involves educating residents located adjacent to drainage ditches about their responsibility to keep the ditches clear and free of debris, including yard waste and trash.
Benefits:	Providing information to homeowners on the importance of the drainage ditches would benefit overall stormwater infrastructure functionality; flooding due to debris would be reduced, as would the number of clogged pipes from debris moving downstream.
Assumptions:	City staff would lead this education effort. Reference materials would be developed and a public campaign initiated.
Estimated Cost/ Level of Effort:	80 hours to compile information and develop brochures; additional time to distribute and target neighborhoods for education.
Potential Partners:	Neighborhood groups
Priority:	High

Project:	**ST-Ed-7**
Project Name:	Targeted Flood Education Program
Description:	This project involves targeting neighborhoods where flooding occurs fairly frequently, such as in the area of the Meadowbrook apartments. Information on obtaining flood insurance would be distributed, as well as how home and apartment owners can protect their properties during large storm events with the potential to cause flooding.
Benefits:	This project would proactively address the impacts of flooding and help residents to be aware of resources.
Assumptions:	City staff would lead this effort.
Estimated Cost/	
Level of Effort:	80 hours of staff time to develop informational brochures and provide links on the City's website.
Potential Partners:	National Flood Insurance Program, Richmond Beach Neighborhood Association
Priority:	High

Project:	**ST-Study-4**
Project Name:	Flooding Assessment at Richmond Beach Road, East of 14th Place Northwest
Description:	The US Environmental Protection Agency (EPA) stormwater management model (SWMM) analysis predicts flooding at this location during a 25-year event. Additional study will be necessary to confirm if a flood reduction project should be implemented at this location.
Benefits:	This project would determine if structural improvements can be made to resolve flooding issues.
Assumptions:	This project would involve a more detailed hydraulic analysis in the vicinity of Richmond Beach Road and 14th Place Northwest.
Estimated Cost/	
Level of Effort:	To be determined.
Potential Partners:	None
Priority:	Low

6 Transportation Master Plan Opportunities

Project: **ST-CIP-8(a) and (b)**

Project Name: Water Quality Improvements in Conjunction with Traffic Roundabouts

Description: Two potential roundabout projects are identified in the City's Transportation Master Plan (City of Shoreline 2011): one at 15th Avenue Northwest and Richmond Beach Road, and the other at 8th Avenue Northwest and Richmond Beach Road. While both of these locations are just outside of the Storm Creek basin boundary, portions of these intersections could drain into Storm Creek.

Benefits: Incorporation of a water quality treatment method, such as a rain garden in the center of the roundabout, would provide aesthetic landscaping as well as water of improved quality to receiving waters.

Assumptions: This project element would be coordinated with transportation projects.

Estimated Cost/

Level of Effort: To be determined.

Potential Partners: City transportation staff.

Priority: Medium

Project:	**ST-CIP-9**
Project Name:	Utilize LID techniques for sidewalk improvements along 15th Avenue Northwest in the 188th Street vicinity
Description:	A pedestrian improvement project is identified in the City's Transportation Master Plan (City of Shoreline 2011) on 15th Avenue Northwest between Northwest 188th Street and Northwest 192nd Street. There are several potential LID opportunities associated with new sidewalks, including the installation of roadside bio-infiltration swales for water quality treatment, and the construction of sidewalks utilizing permeable materials.
Benefits:	Incorporation of LID techniques into new pedestrian improvement projects would include the following stormwater management benefits: ◆ Reduced flow to downstream stormwater infrastructure and Storm Creek ◆ Improved water quality
Assumptions:	These projects would be coordinated with sidewalk improvements.
Estimated Cost/ Level of Effort:	To be determined.
Potential Partners:	City transportation staff.
Priority:	Medium

7 References

City of Shoreline. 2011. 2011 transportation master plan. Draft. City of Shoreline, WA.

SAIC. 2011. Surface water master plan update, City of Shoreline. Draft report. Science Applications International Corporation, Bothell, WA.