EBRIGHT CREEK
BIOLOGICAL AND WATER QUALTY
MONITORING REPORT (YEAR 2)

PREPARED FOR:

THE CITY OF SAMMAMISH

801 228th Ave SE

Sammamish, Washington 98075

Prepared by

48 north solutions

December 14, 2016

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BIOLOGICAL AND WATER QUALITY MONITORING REPORT (YEAR 2)

Prepared for:

City of Sammamish Washington

By

48 north solutions

909 NE Boat Street
Seattle, Washington 98105

Supported By

Geosyntec consultants

1201 3rd Ave # 330
Seattle, WA 98101

December 14, 2016

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TABLE OF CONTENTS

Section **Page**

LIST OF FIGURES

Figure **Page**

LIST OF PHOTOGRAPHS

Photograph **Page**

LIST OF TABLES

Table **Page**

ACRONYMS AND ABBREVIATIONS

48 NORTH	48 North Solutions, Inc.
B-IBI	Benthic Index of Biotic Integrity
City (the)	City of Sammamish
cm	centimeter
Crossings (the)	Crossings at Pine Lakes
Ecology	Washington Department of Ecology
EPT	Ephemeroptera, Plecoptera, and Trichoptera
Geosyntec	Geosyntec Consultants
IBI	Index of Biotic Integrity
km	kilometer
LWD	large woody debris
m	meter
PFC	properly functioning conditions
Qpf	Pre-Vashon undifferentiated unconsolidated deposits
sq. ft.	square foot
USGC	U.S. Geological Survey

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1. Introduction

Ebright Creek is home to kokanee salmon (*Oncorhynchus nerka*), the non-anadromous (non-migrating) and smaller form of sockeye salmon. Kokanee, unlike sockeye, do not migrate to the ocean and instead spend their entire lives in freshwater. Lake Sammamish kokanee migrate from tributaries in the spring to mature for three or four years before returning to their natal stream (e.g., Ebright Creek) to spawn in the fall and early winter (Berge and Higgins, 2003). Unfortunately, due to a number of limiting factors, kokanee numbers have been declining rapidly over the past few decades (HDR, 2009).

As a result of the decline, local and county governments (including the City of Sammamish [the City]) are working together with Federal, state, tribal, and non-governmental organizations to conserve native kokanee, and have formed the Kokanee Work Group. One important tenet of this group is conservation and restoration of key kokanee habitats within the Lake Sammamish Basin.

Ebright Creek is the primary stream for the Thompson Basin, draining east to west from the Sammamish Plateau into Lake Sammamish. The stream flows through a second-growth forest above the project site through a relatively steep ravine on the side of the plateau. The stream habitat along the lower reaches of Ebright Creek is in relatively good condition in that the stream has not been extensively ditched or channelized, native riparian vegetation and large woody debris (LWD) are present, and overall habitat complexity is relatively high for a stream in an urban environment. However, adjacent land use activities upstream have altered stream habitat conditions and the riparian corridor. Ebright Creek now passes through a mixed use area consisting of a single-family residence, and areas with both native and non-native vegetation.

With the increase in urbanization surrounding Ebright Creek, including the development of Chestnut Lanes and the Crossings at Pine Lake (the Crossings), it has been hypothesized that degradation of habitat could potentially be occurring. This degradation, through increased erosion or changes in water quality, could result in alterations to fish habitat conditions within stream channel, including changes in temperature, dissolved oxygen, overhead canopy cover, flow velocity, hydraulic diversity, macroinvertebrate abundance and diversity, substrate composition, water depth, and fish community structure.

With the potential for environmental degradation and sustainable development in the watershed, there is an increased awareness for the need to monitor and assess the long-term conditions of this valuable natural resource. Successful monitoring and assessment of biological and water quality conditions require effective tools that can be easily understood by both the constituents living in the surrounding communities and the City's managers.

The intent of this biological and water quality monitoring plan is the meet the "Mitigated Determination of Non-Significant" conditions set for both Chestnut Lanes and the Crossings, and evaluate whether the fish habitat of Ebright Creek is being degraded by increased erosion and sedimentation.

1.1 Background

Ebright Creek is located in the Thompson Sub-basin on the east side of Lake Sammamish in east King County. It is the main channel for the Thompson Basin, draining east to west from the Sammamish Plateau into Lake Sammamish. Ebright Creek is the main drainage in an approximately 3.37-square kilometer (1.3-square-mile) watershed that is composed of an area of mixed residential and commercial in the upper watershed and low intensity development in the lower, steeply-sloped areas. Approximately 32 percent of the basin is forested, with much of the forested area located in the riparian corridor adjacent to Ebright Creek (City of Sammamish, 2011). The upper wetlands and stream corridors are relatively undisturbed, and the watershed has a relatively low impervious area, estimated around 8 percent (City of Sammamish, 2011).

The geology of the Sammamish Plateau was mapped by the U.S. Geological Survey (USGS) and shows a geologic sequence of layered Vashon tills and outwashes with an underlying layer of Pre-Vashon undifferentiated unconsolidated deposits (Qpf) (USGS 2006). The lower reach of Ebright Creek cuts through these Qpf deposits, which is also mapped as a landslide hazard area (City of Sammamish, 2011). In the lower reaches of Ebright Creek and on the west-facing slopes above Lake Sammamish, the surficial geologic deposits are mapped as mass-wastage deposits formed by erosion on the steep slopes, described as colluvium; this soil and landslide debris is typically up to 3 meters (m; 10 feet thick). The geologic setting of a stream flowing through landslide hazard areas above a geologically recent colluvium has a strong influence on the geomorphology of the channel through the lower reaches of Ebright Creek.

Lower Ebright Creek flows through a second-growth forest in a relatively steep ravine on the east side of the plateau. As the stream exits the ravine, it passes through a mixed use area consisting of a single-family residence, pasture, and areas with both native and non-native vegetation (City of Sammamish, 2011). After crossing the East Lake Sammamish Parkway, the stream continues through a narrow, shallow ravine to Lake Sammamish.

Ebright Creek is unchannelized along the lower stream reaches and exhibits an overall complex stream habitat of native riparian vegetation and LWD, especially considering its location as a stream in an urban environment. However, adjacent land use activities that have degraded stream habitat conditions in the surveyed lower reaches are primarily associated with cleared land for pasture and addition of fill material for site access. A major stream enhancement was conducted in 2012 in the stream reach on the north side of East Lake Sammamish Parkway where native trees and shrubs were planted in the riparian corridor. Native and non-native vegetation have become established in previously disturbed areas and in the restored stream reach and a fish passage improvement project reestablished natural sediment transport in this portion of Ebright Creek.

Upstream of the ravine, adjacent land use activities upstream have altered stream habitat conditions and the riparian corridor. Upper Ebright Creek now passes through a mixed use area consisting of a single-family residences and areas with both native and non-native vegetation.

1.2 Project Description

Long-term monitoring of macroinvertebrate, aquatic and riparian habitats, and water quality was initiated in 2015 in response to interest in better understanding the relationship between the ecological condition of Ebright Creek and development activities of Chestnut Lanes and the Crossings. The intent of this report is to document the stream habitat conditions in Ebright Creek as part of a 10-year monitoring and assessment of environmental conditions of the stream.

From August 3 to 13, 2015, 48 North Solutions, Inc., (48 NORTH) completed this comprehensive baseline stream habitat assessment to better understand the relationship between stormwater, hydrology, and natural conditions in Ebright Creek as a means to evaluate whether the stream habitat of Ebright Creek is being degraded by any increased erosion and sedimentation resulting from the construction of these developments. This habitat monitoring is a long-term effort, with the next data collection scheduled to occur in August, 2017. In addition to mapping the stream habitat, 48 NORTH also collected macroinvertebrate samples at four established locations along Ebright Creek. This macroinvertebrate sampling is conducted annually, with sampling occurring in August 2015 and September 2016.

Geosyntec Consultants (Geosyntec) teamed with 48 NORTH to monitor the stream's water temperature, flow, and turbidity values, and to document if water level fluctuations in the surrounding wetland features exceed predetermined minimum or maximum limits. In November 2014, Geosyntec provided the City recommendations for instrumentation at each monitoring site and provided the basis for the equipment that was installed. Following these recommendations, in February 2015, Geosyntec installed monitoring equipment, development of rating curves, and initiation of continuous monitoring. In 2016, flow (via water level), water level, and temperature were monitored by instrumentation installed by Geosyntec as part of the long term monitoring project.

2. METHODOLOGY

2.1 Stream Habitat Mapping

Protocols used by the Washington Department of Ecology's (Ecology) stream monitoring projects were used to maintain consistency with work occurring statewide (Ecology, 2009). The purpose of this work was to specifically evaluate downstream conditions in Ebright Creek in order to evaluate whether fish habitat is or has been degraded by increased erosion and sedimentation from the Chestnut Lanes and the Crossings developments. Due to the timing of this study, pre-construction baseline cannot be conducted as both Chestnut Lanes and the Crossings have been built. However, a 10-year monitoring period would likely enable detection of what, if any, changes are occurring in water quality and habitat disturbance. Following Ecology's protocols will also allow for comparison of stream monitoring data among similar streams within the Lake Sammamish/Lake Washington drainage.

Ebright Creek is considered an "F" type stream by the Washington State Department of Natural Resources. The "F" classification is assigned to "*streams and waterbodies that are known to be used by fish, or meet the physical criteria to be potentially used by fish. Fish streams may or may not have flowing water all year; they may be perennial or seasonal*" (Washington Administrative Code 222-16-030 2001).

Ebright Creek aquatic habitat was characterized from the stream mouth at Lake Sammamish upstream to the furthest extent of flowing water during the low flow conditions observed in August, 2015. The next stream mapping effort is scheduled for Year 3 (2017).

A total of 1,300 m (4,265 feet) of the stream was delineated. For the purposes of this project, Ebright Creek was divided into nine survey reaches representing obvious changes in the riparian zone, stream channel gradient and confinement, and human influence adjacent to the stream (Figure 1).

Habitat units (pools, riffles and other) were mapped for each stream reach. Channel cross sections were recorded at several locations within each stream reach to characterize the physical environment of the channel. Cross sectional data such as bank-full width, wetted width, sediment characteristics, large woody debris, and riparian vegetation provide insight into the function and processes occurring within each tributary and are important indicators of habitat integrity.

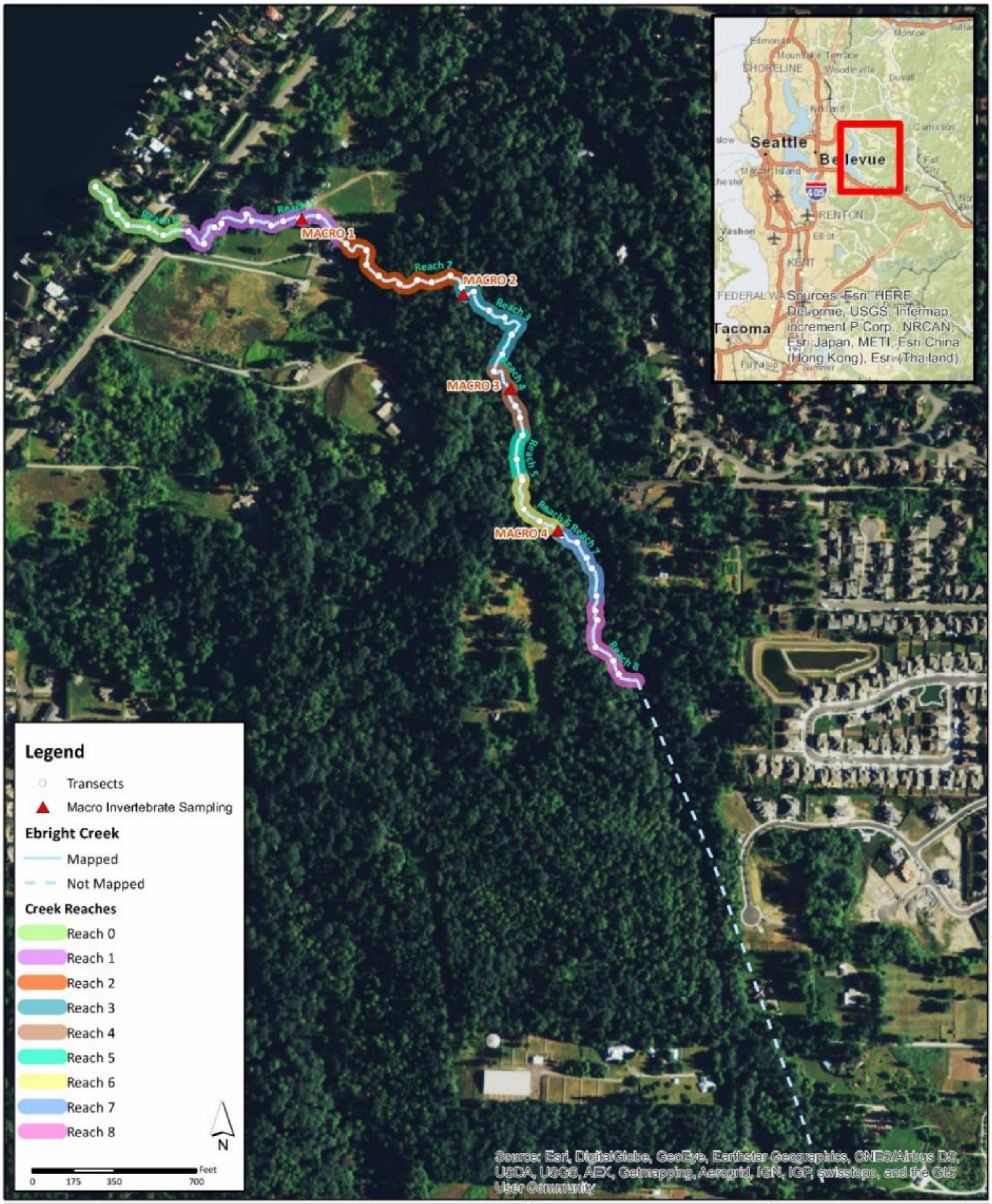

Figure 1:
Ebright Creek Assessment
Reach Breaks & Macro Invertebrate Sampling Sites

Notes:
Source: Image Esri
Projection: State Plane, NAD 83 HARN
The accuracy of source information cannot be verified, therefore all linework, labeling, and markings appearing on this map may be subject to errors or omissions in positions, classifications, and interpretations. This map should only be used as a visual guide for general overview purposes.

48 north solutions

In addition to channel dimensions, the number of pools and pieces of LWD were counted in each sample reach. Additionally, substrate classification and riparian vegetation was described in an effort to understand the condition of the stream to support salmonids. Mapping efforts focused on identifying pool frequency and stream complexity along Ebright Creek, the riparian condition and shade, sediment/substrate of the stream, and relative stream bed stability.

Size composition of the substrate was visually estimated along each sampled reach using Ecology's *Wadeable Stream Protocols* (Ecology, 2009). Categories were expressed as percent bedrock, boulders (30 to 91 centimeters [cm; 12 to 36 inches] in diameter), cobble (7 to 30 cm [3 to 12 inches] in diameter), coarse gravel (2.5 to 7 cm [1 to 3 inches] in diameter), fine gravel (0.02 to 2.5 cm [0.01 to 1 inch] in diameter), and sand/fines. Substrate classification was summarized using a visual estimate of the percent of each substrate type throughout each cross section. This data was then tabulated and a general percent score for each substrate type per cross section was produced. A general percent score was then tabulated for each reach based on the number of transects per individual reach.

Similarly, the riparian community was also described by visually estimating the general percentage of ground cover (such as manicured lawn, reed canary grass [*Phalaris arundinacea*], ivy, native shrubs), and riparian cover (deciduous or coniferous) on the left and right banks. Also any non-native vegetation, if known, was also recorded for each bank. Riparian vegetation and canopy cover were assessed at each stream transect and summed together for each individual stream reach.

All individual pieces of LWD greater than 1.8 m (6 feet) in length and 10 cm (4 inches) in diameter was counted for each reach in both streams following standard classifications (NMFS 1996; Merritt and Hartman 2012). NMFS (1996) cites a stream with greater than 80 percent forest, LWD frequency greater than 150 pieces per kilometer (km), and pool frequency greater than 35 per km as properly functioning conditions (PFC) for salmonid-bearing streams.

2.2 Macroinvertebrate Sampling

Resource availability and basic productivity of streams have been recognized as major controlling factors in regulating fish populations (Karr, 1998; Karr and Chu, 1999). In large part, food resources for juvenile salmonids in lotic systems consist of benthos and invertebrates in the drift. In conjunction with acting as a primary food resources for juvenile salmonids, benthic macroinvertebrates are also monitored because they are good indicators of the biological health of stream systems.

Ecological indicators, including physical and biological components, are tools that can be used to characterize the condition of a stream's health. An index of biotic integrity (IBI) can be used to integrate multiple measurements of biological attributes (or "metrics") to assess the condition at a specific location. Metrics typically measure assemblage attributes related to a species richness; tolerance to specific stressors, such as changes in water quality; trophic guilds; reproductive strategies; habitat preferences; and abundance.

In the Puget Sound region, a Benthic Index of Biotic Integrity (B-IBI) has been used extensively as an indicator of stream health by federal, state, and local agencies (Fore et al. 1996). These agencies have used it to indirectly monitor changes in water quality impairment, habitat degradation, and hydrologic alteration, and more specifically changes in channel morphology, streambed material, and water temperature. Macroinvertebrate data provides information on habitat qualities and information on the potential for survival and growth of juvenile anadromous salmonids, such as kokanee, that inhabit Lake Sammamish and its tributaries. The purpose of macroinvertebrate sampling of Ebright Creek was to assess the ecological condition of the stream using B-IBI.

The B-IBI is a quantitative method for determining and comparing the biological condition of streams. The B-IBI was developed as a multi-metric index to quantify the ecological condition of streams in the Pacific Northwest (Kleindl 1995). This index is based on 10 metrics that represent the presence of important taxa at the sampling location. These metric values include the following:

- Taxa Richness
- Ephemeroptera Richness
- Plecoptera Richness
- Trichoptera Richness
- Clinger Taxa Richness
- Long-Lived Taxa Richness
- Intolerant Richness
- Percent Dominant
- Predator Percent
- Tolerant Percent

Each metric is assigned a score between 1 and 5, and the individual metric scores are summed to calculate a score for a given site, between 10 and 50. Total scores are combined and assigned qualitative descriptions of condition (Table 1).

Since macroinvertebrates are extremely sensitive to change in water quality and/or habitat change, collecting samples each year over a 10-year period will enable identification of both short-term acute changes, as well as any long-term trends.

TABLE 1: FIVE QUALITATIVE CATEGORIES OF BIOLOGICAL CONDITIONS

CONDITION	GENERAL DESCRIPTION	B-IBI RANGE
Excellent	Comparable to least disturbed reference condition; overall high taxa diversity, particularly of mayflies, stoneflies, caddis flies, long-lived, clinger, and intolerant taxa. Relative abundance of predators high.	46-50
Good	Slightly divergent from least disturbed condition; absence of some long-lived and intolerant taxa; slight decline in richness of mayflies, stoneflies, and caddis flies; proportion of tolerant taxa increases.	38-44
Fair	Total taxa richness reduced – particularly intolerant, long-lived, stonefly, and clinger taxa; relative abundance of predators declines; proportion of tolerant taxa continues to increase.	28-36
Poor	Overall taxa diversity depressed; proportion of predators greatly reduced as is long-lived taxa richness; few stoneflies or intolerant taxa present; dominance by three most abundant taxa often very high.	18-26
Very Poor	Overall taxa diversity very low and dominated by a few highly tolerant taxa; mayfly, stonefly, caddis fly, clinger, long-lived, and intolerant taxa largely absent; relative abundance of predators very low.	10-16
Reference: Morley (2000)		

Four sampling locations along Ebright Creek were established in August of Year 1 (2015) (Figure 1). Samples were collected at these locations during the 2015 baseline sampling, none of which had been sampled previously. Year 2 (2016) samples were collected at the four index locations on September 2, 2016.

Macroinvertebrates were collected during summer-low flow (August/September) conditions following the protocols of Karr and Chu (1999). Samples were collected during this time as rainfall is less frequent and intense, antecedent soil moisture is lowest, and flows are expected to be relatively stable. Taxa richness and abundance is also high at this time of year.

A 930-square cm (1-square foot [sq. ft.]) Surber net, with 500 µm mesh, was used to collect macroinvertebrates, starting at the lowest (downstream) sample site and working upstream (Photo 1). The Surber net is a 30 cm by 30 cm (12 x 12-inch) frame that is horizontally placed into the face of the flow on gravel/cobble substrate to delineate a 930-square cm (1 sq. ft.) area. The vertical section of the frame has a net attached and captures any dislodged organisms from the sampling area. A total of 0.74 m^2 (8 sq. ft.) were sampled at each location following the methods of Hayslip (2007).

Photo 1: Suber Net Set-up

Macroinvertebrate samples from each of the four sampling locations were analyzed in the laboratory. King County Department of Natural Resources has also conducted macroinvertebrate sampling at a station located upstream of East Lake Sammamish Road and downstream of the four sampled sites. The Ebright Creek B-IBI results were uploaded to the Puget Sound Stream Benthos online database (http://www.pugetsoundstreambenthos.org/) and will help contribute the monitoring of health of streams within Puget Sound.

2.3 Water Quality Monitoring

Using the instrumentation Geosyntec installed during 2015, the City is currently monitoring water quality and water flow at various sites along Ebright Creek, and water elevations in two wetland complexes associated with the stream. Six monitoring stations were installed in 2015, measuring four parameters (see Table 2 and Figure 2).

TABLE 2: WATER MONITORING LOCATIONS AND PARAMETERS

MONITORING LOCATIONS	**MONITORING PARAMETERS**			
	WATER LEVEL	FLOW RATE	TEMPERATURE	TURBIDITY
Site 1: Ebright Creek Near Mouth	No	Yes	Yes	No
Site 2: Discharge from Chestnut Lane Pond	No	Yes	Yes	Yes
Site 3: Wetland 61	Yes	No	No	No
Site 4: Wetland 17	Yes	No	No	No
Site 5: Crossings at Pine Lake – West	No	Yes	Yes	Yes
Site 6: Crossings at Pine Lake – East	No	Yes	Yes	Yes

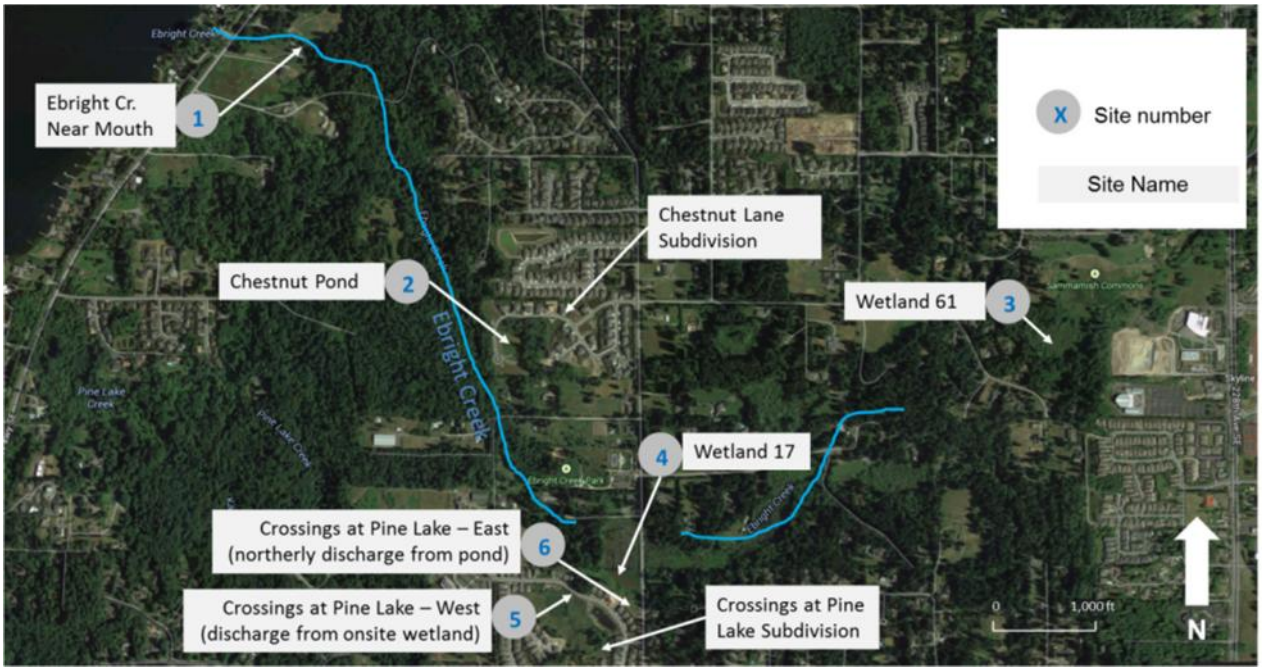

Figure 2: Ebright Creek Monitoring Locations

3. Results

3.1 Stream Habitat Mapping

Bankfull widths and depths were measured at each transect and grouped by reach (Figure 1). Bankfull width to depth ratios are a simple indicator used commonly in fluvial geomorphology as a metric to describe the relationship between peak flow discharge and the response of the channel to high flow events. Typically, the bankfull elevation is where water spills out of a channel and into the adjacent floodplain. Common indicators of bankfull width include fine sediment, rooted vegetation, and undisturbed soils. The bankfull width to depth ratio is a measurement between the bankfull mark on the left and right banks and the average depth between the bankfull width and surface of the active channel (wetted and not wetted) at that cross section. Width-to-depth ratios less than 10:1 are considered to be properly functioning for salmonid-bearing streams (NMFS, 1996). Channel widening due to bank instability (erosion) typically result in width-to-depth ratios that are larger than 10.1. In addition, channels that are simplified and lacking in deep pools also have a larger width to depth ratio. In Ebright Creek, 7 of the 9 reaches fit into that category (Figure 3). Only two reaches (7 and 8) fall outside of the PFC criteria for width-to-depth ratio of <10:1 in salmonid-bearing streams and may be indicative of channel widening due to bank instability.

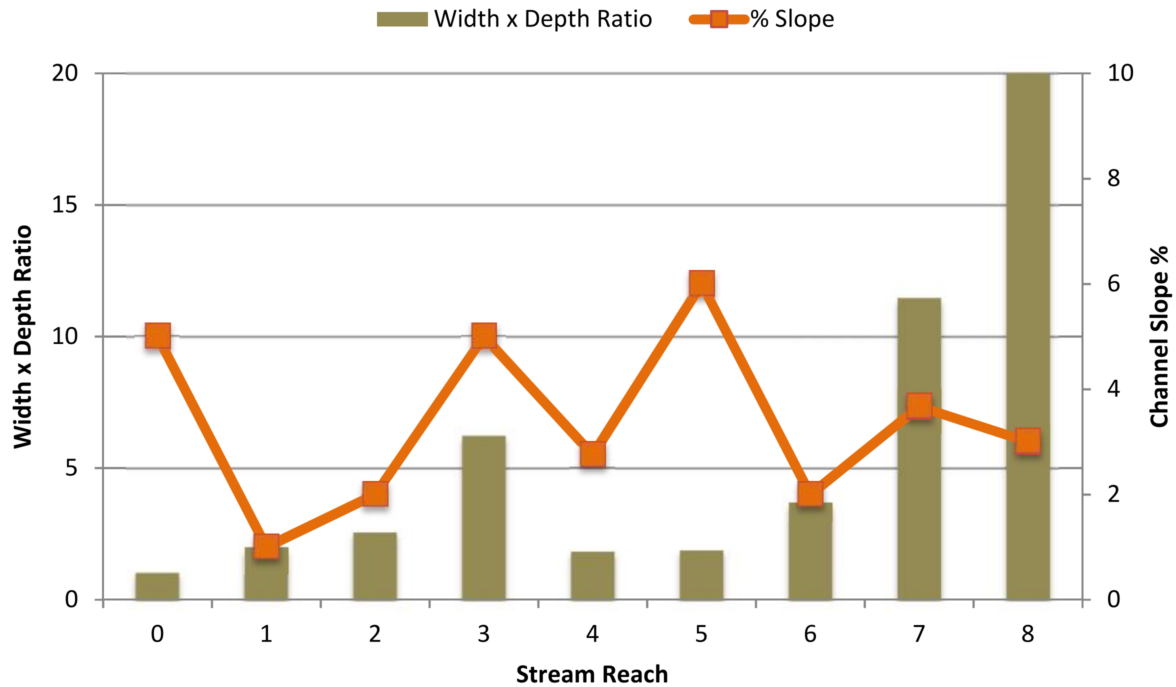

Figure 3: Width-to-depth Ratio and Stream Channel Slope for Each Reach Section

Photo 2: Typical Stream Substrates Observed in Reaches 4 to 6

Substrate composition is a useful indicator to describe how a channel stores and transports sediment. All measures of substrate were taken at transects every 25 m (82 feet) within representative reaches. The most common substrates in Reach 0 were coarse gravels, interspersed with some cobble and fine gravel typical of higher gradient streams (Figure 4). Substrate in Reach 1 was finer than Reach 0. Reaches 2, 3, 4 and 5 were located in a second growth forest where riparian vegetation provided channel stability. The stream bed in these reaches contained less fine gravels than the other reaches and the substrate coarseness increased progressively upstream (Figure 4). Reaches 6 and 7 were dominated by coarse gravels, cobbles, and boulders with fines (Photo 2). Reach 8 was dominated by fines and gravels that are typical of lower gradient reaches. These fine sediments are probably the result of erosion in this reach from landslides, which increases the rate of fine sediment and gravel recruitment into this stream reach and causes the stream channel to expand in a manner similar to an alluvial fan. The steep ravines of the canyon reaches are located within an erosion hazard area and are prone to landslides.

Reaches 0 through 8 are thought to support kokanee salmon and cutthroat trout. Suitable spawning substrate for salmonids was observed in all reaches during the time of surveying, with the exception of Reaches 6 and 7. In these reaches, spawning substrate was at a premium (Figure 4). Fines and gravels are ideal sediment for kokanee salmon spawning, suggesting that Reaches 1 to 5, and 8 are best suited for spawning.

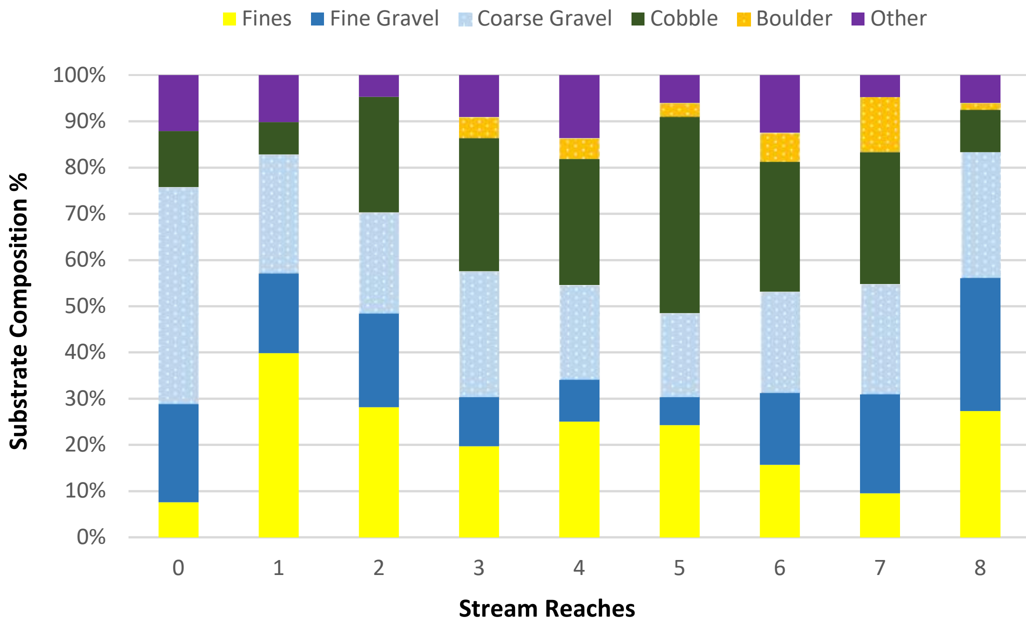

Figure 4: Stream Substrate Composition by Reach

Overall, the riparian buffers appear to be functioning properly and the stream channel is generally stable. Riparian vegetation provides important shade for the stream, a source of recruitment for wood, and reduced rates of erosion. The riparian condition in Reaches 0 and 1 was mostly restored mixed deciduous forest, shrubs, and invasive species with lawns, driveways and residential areas adjacent to the narrow stream riparian corridor. Reach 0 was located in a steeper ravine with a limited number of second growth coniferous trees present in the riparian zone (Photo 3). Riparian condition from Reaches 2 to 6 consisted of second growth mixed forest of big leaf maple (*Acer macrophyllum*), cedar, and Douglas fir (*Pseudotsuga menziesii*) with a fairly closed canopy (Photo 4). Riparian conditions in Reaches 7 and 8 consisted of a second growth forest in a steep ravine, but the canopy was comprised of tall shrubs and small trees (e.g., salmonberry [*Rubus spectabilis*]) due to disturbance regime caused by landslides (Photo 5).

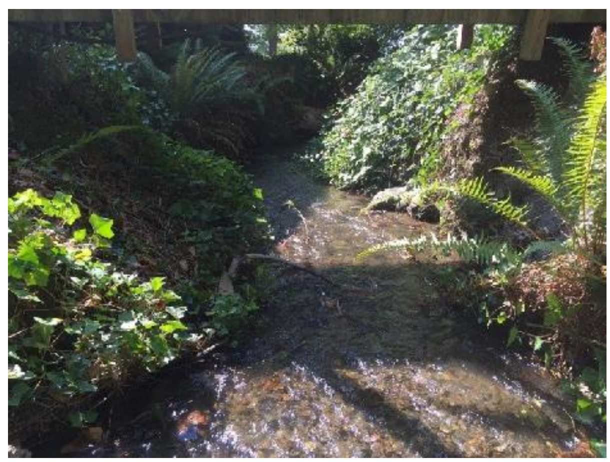

Photo 3: Typical Ground Cover and Riparian Habitat along Reach 0

The PFCs suggest >80% forest is necessary to support salmonids (NMFS, 1996), and six of nine reaches meet this criteria. In Ebright Creek, PFC criteria (>80% forested) were not met in Reaches 0, 1, and 7, and was barely met in Reach 8. Reaches 0 and 1 had extensive residential development adjacent to the stream and are proximate to East Lake Sammamish Parkway (Figure 5). Reaches 7 and 8 were located in a slide hazard area and have extensive landslide activity that has altered the riparian vegetation and stream canopy.

While Reaches 4, 5, and 6, exhibited good riparian condition, they lacked pool habitat. King County (1990) noted that the stream gradient sometimes approaches 5 percent through these canyon reaches, forming tiered, or staircase, features that result in patchy gravel areas and small volume pools that are favored by resident cutthroat trout.

Several landslides were observed adjacent to Ebright Creek along Reaches 6 to 8 (Photo 5). These landslides contributed significant amounts of material to the stream bed. Bank stability was measured at the Reach level using the method described by Booth (1994). Reaches 0 and 1 were armored with rip-rap in many sections of these two reaches (Photo 3). Reaches 2 to 6 were stable and had vegetated or low bars to level of low flow (Photo 4). Reaches 7 and 8 were unstable and showed imminent signs of erosion such as sluffed banks or fallen trees (Photos 5 and 6). Channel widening along these reaches were also likely due to bank instability (erosion), typically resulting in width to depth ratios that are larger than 10.1 (Photo 6). In addition, channels that are simplified and lacking in deep pools also have a larger width to depth ratio.

Photo 4: Second Growth and Native Shrubs Typical of Reaches 2 to 6

Photo 5: Landslide in Reach 8 Showing an Unstable Left Bank

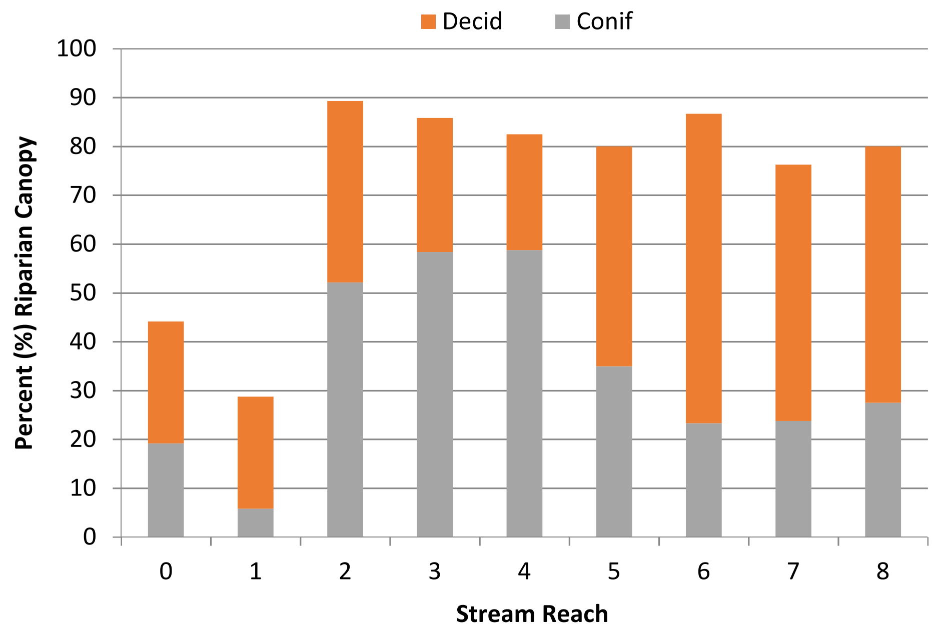

Figure 5: Percent of Riparian Forest Comprised of Deciduous and Coniferous Trees along Each Reach

Large woody debris is an important component of streams in the Pacific Northwest. It was present in good quantities during the time of surveying and was considered to be appropriate in the majority of the Ebright Creek surveyed reaches. The majority of reaches met the PFC criteria of 150 pieces of LWD per km with only two reaches (Reaches 5 and 6) marginally lacking in LWD (Figure 6). Reaches 2, 3, and 4 greatly exceeded the PFC criteria of 150 pieces of LWD per km.

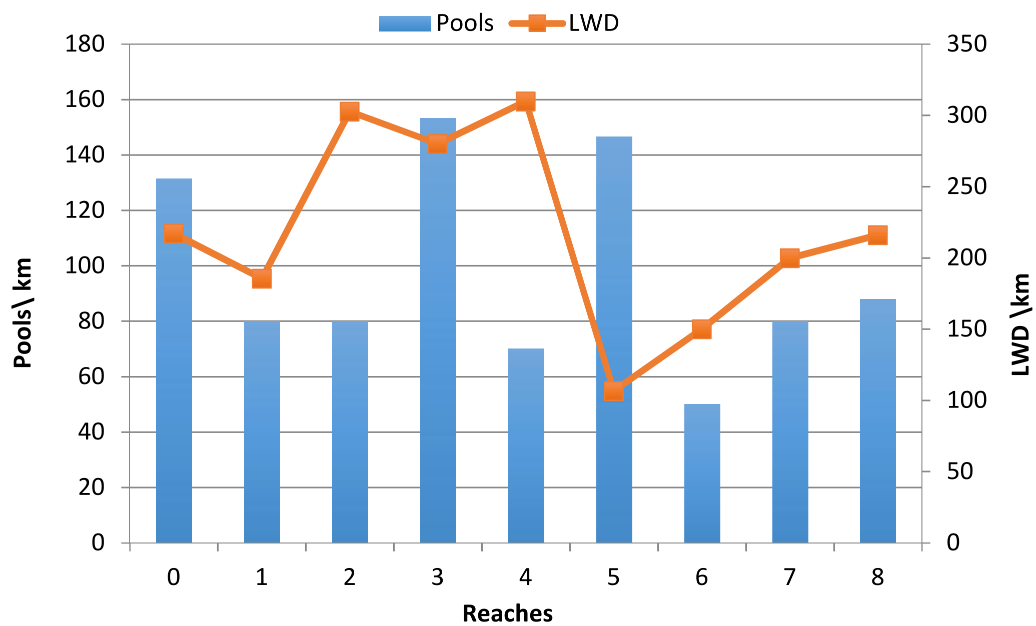

Figure 6: Number of Pools per km versus Number of Key Pieces of LWD per km

Pools are important habitats for stream fish and macroinvertebrates. Pools are often formed by pieces of LWD. The PFC criteria for streams supporting salmonids has a minimum criteria of 150 pierces of LWD per km (NMFS, 1996), which were met in this stream. NMFS' (1996) PFC criteria for pool frequency is greater than 35 pools per km It is surprising that pool frequency is high and LWD is only marginal in Reach 5 but that may be attributed to the steep nature of that reach and the fact that many of those pools are small cascade pools formed by cobble and boulders rather than LWD (Figures 7 and 8).

Photo 6: Typical Wide Stream Channel Observed in Reaches 7 and 8

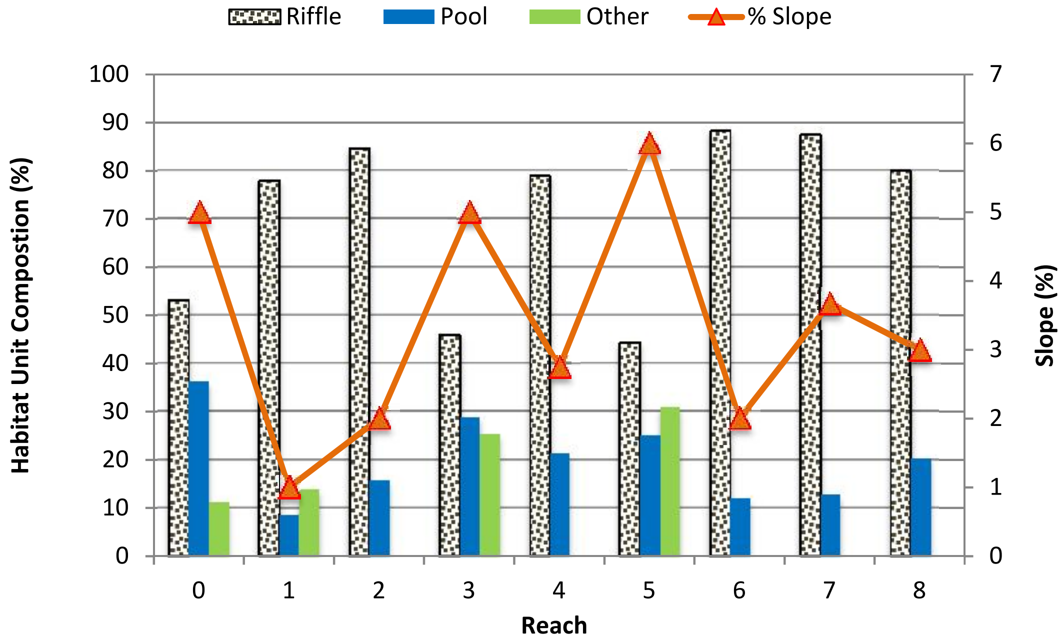

Figure 7: Habitat Unit Composition per Reach Compared to Slope

As depicted in Figure 7, Ebright Creek habitat units are dominated by riffle habitat. The steeper reaches (Reaches 0, 3, and 5) contained less riffle habitat than the stream reaches that exhibit shallower stream channel slopes (Figures 6 and 7). The steeper reaches also have many stretches of cascade-pool sections and that are depicted as "other" stream habitat. These steeper reaches also contain proportionally more pools than the less steep, riffle dominated reaches.

King County (1990) reported that there were numerous small pools in Ebright Creek and that the pool quality in the canyon reaches of the stream was more representative of trout habitat than salmon habitat. Limited pool sizes also reduce the quantity and quality of salmon spawning habitat, which typically consists of substrate at the downstream end of pools. Limited pool habitat would also restrict the capacity of the stream for supporting juvenile fish (both salmon and trout).

The pools in the lower reaches (Reaches 1 through 4) were significantly larger and deeper than the pools in the upper reaches (Figure 8). Many of the pools in Reaches 5 and 6 were small cascade pools formed by cobble and boulders while the larger pools in the lower reaches (Reaches 1 through 4) were usually formed by embedded channel spanning LWD that acted as a log sill. The shallower pool depth in the upper reaches above Reach 6 may be attributed to very low flow levels in the stream channel. Several of these larger pools in the lower sections also contained additional features such as woody debris and undercut banks that provide complex habitat structure for aquatic organisms.

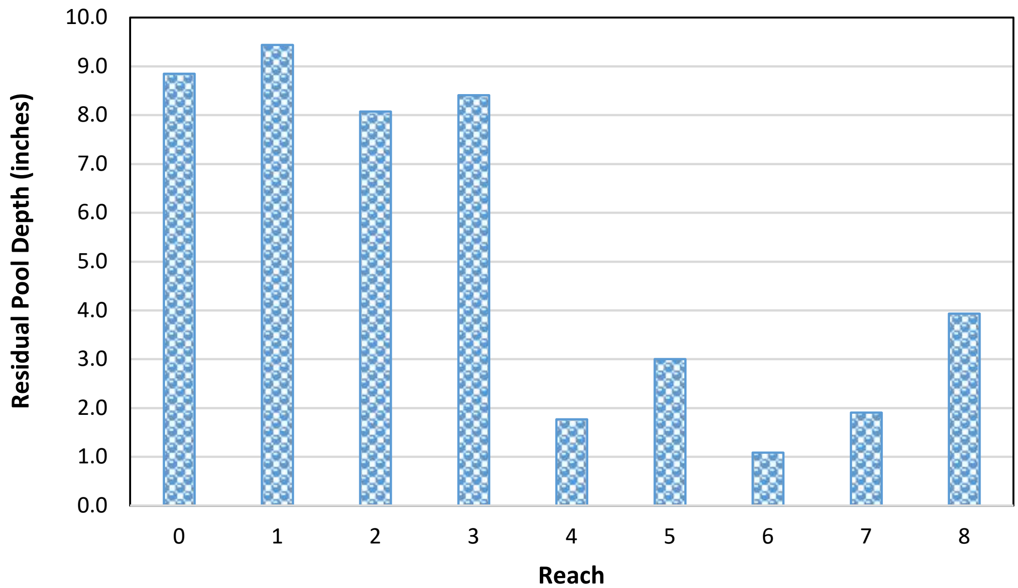

Figure 8: Average Residual Pool Depth per Reach

3.2 Macroinvertebrate Sampling

Macroinvertebrate samples were collected in August 2015 and September 2016. The B-IBI (10 to 50) scores ranged from 26 to 36 in 2015, and 18 to 36 in 2016 (see Table 3). These scores are considered "poor to fair" at the lower site (Site 1) and "fair to good" at the upstream sites (Sites 2 through 4), as described by Morley (2000).

A "good" score indicates that the biological conditions are slightly divergent from least disturbed condition. A "fair" score indicates that intolerant taxa richness, clinger richness and long lived species richness are decreased. A "poor" score indicates that overall taxa diversity is depressed, proportion of predators long-lived taxa richness are greatly reduced, and dominance by three most abundant taxa often very high (Table 3).

Site 1 is located in a section of Ebright Creek that was enhanced in 2012. The macroinvertebrate community may not have fully recovered from the streambed disturbance that was part of the enhancement project. Sites 2 to 4 are located in relatively undisturbed sections of Ebright Creek.

Macroinvertebrate samples were also collected in Ebright Creek by King County Ambient Monitoring Program in 2015 and 2016. Their collection site was located in the same enhanced reach, but approximately 150 m (492 feet) downstream of Site 1. In 2016, King County had a similar "poor" B-IBI score (26) as Site 1.

Other streams in the Lake Sammamish basin, except for Pine Lake and Laughing Jacobs Creeks, had similar “fair to good” B-IBI scores as what was observed in Ebright Creek during 2015 and 2016 (Figure 9). Pine Lake Creek had “poor” B-IBI scores during 2015 and 2016, Laughing Jacobs Creek had “poor” B-IBI scores during 2016, and the King County Ambient Monitoring site had “poor” B-IBI scores during 2015 and 2016.

Both Sites 1 and 2 had lower B-IBI scores in 2016, with Site 1 decreasing from a “fair” (2015) to “poor” (2016) condition. Site 1 B-IBI scores were similar to Pine Lake Creek and Laughing Jacobs Creek B-IBI scores for 2015 and 2016. Sites 3 and 4 did not change significantly from 2015 to 2016. The B-IBI scores for Ebright Creek’s upstream sites (Sites 2, 3, and 4) were comparable to higher B-IBI scores observed in Many Springs, Issaquah Creek and Big Bear Creek. All three upper Ebright Creek sites scored better than Laughing Jacobs Creek and Pine Lake Creek sites.

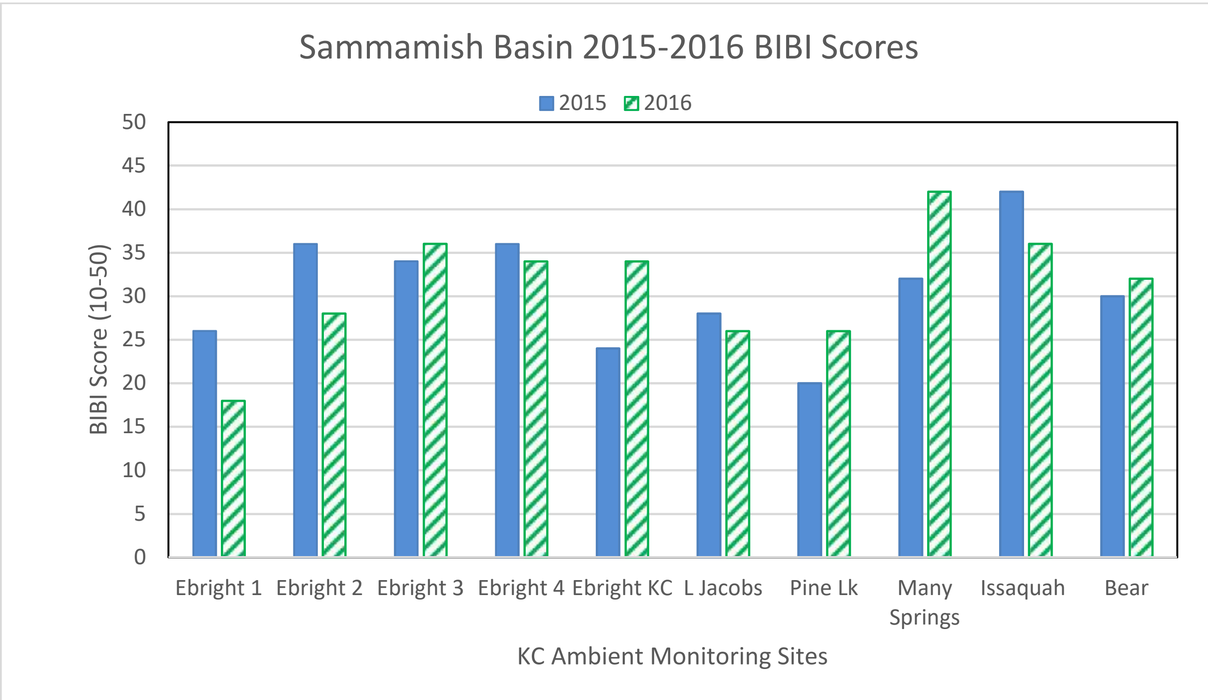

Figure 9: Benthic macroinvertebrate (B-IBI) Scores for Ebright Creek (2015-2016) compared with King County Ambient Monitoring Sites in the Sammamish Basin (2015-2016)

TABLE 3: B-IBI SCORES FOR EBRIGHT CREEK (2016) AND KING COUNTY'S LAKE SAMMAMISH SITE (2016)

Site	Year	**QUANTITIES**											**SCORES**[1]											
		Taxa Richness	Ephemeroptera Richness	Plecoptera Richness	Trichoptera Richness	EPT Richness	Clinger Richness	Long-lived Richness	Intolerant Richness	Percent (%) Dominant	Predator Percent (%)	Tolerant Percent (%)	No. of Organisms	**Overall Score**	Taxa Richness	Ephemeroptera Richness	Plecoptera Richness	Trichoptera Richness	Clinger Richness	Long-lived Richness	Intolerant Richness	Percent (%) Dominant	Predator Percent (%)	Tolerant Percent (%)
LK SA[2]	2016	46	3	5	4	12	10	3	4	0.36	0.35	0.002	500	**34**	5	1	3	1	1	3	5	5	5	5
EC 1	2016	20	3	5	2	10	6	2	1	0.77	0.09	0	500	**18**	3	1	3	1	1	1	1	1	1	5
EC 2	2016	32	3	6	6	15	9	5	2	0.60	0.18	0	500	**28**	3	1	3	3	1	5	1	3	3	5
EC 3	2016	41	3	7	6	16	12	5	5	0.58	0.11	0.002	496	**36**	5	1	3	3	3	5	5	3	3	5
EC 4	2016	38	3	5	8	16	13	6	4	0.52	0.17	0.002	493	**34**	3	1	3	3	3	5	5	3	3	5

[1] Scores based on Wisseman (1998) 10 – 50 B-IBI
[2] King County's Ebright Creek Ambient Monitoring Site (#08LAK3627)

Legend
Excellent
Excellent/Good – Good
Good/Fair – Fair
Fair/Poor – Poor
Poor/Very Poor – Very Poor

3.3 Water Quality

Flow (via water level), water level, and temperature were monitored at the upper end of Reach 1 by instrumentation installed by Geosyntec. Water level was converted to estimated flowrate based on a flow rating curve developed in February 2015.

Site 1 (Ebright Creek near Lake Sammamish) is being monitored for flow (via water level) and temperature. Water level at this site has been continuously reported since February 2015 and has been stable through the monitoring periods. Water level is being converted to estimated flowrate based on a flow rating curve. Site 2 (discharge from Chestnut Lane pond) is being monitored for flow, temperature, and turbidity of the combined discharge from the Chestnut Lane subdivision. Flowrate (via a pre-calibrated Thel Mar weir) and temperature have been reported reliably through the period of record. Wetlands 61 (Site 3) and 17 (Site 4) are being monitored for water level fluctuation. Water level has been stable and within expected ranges for the entire period of monitoring.

Site 5 (Crossings at Pine Lake – West) is being monitored for water flow, temperature, and turbidity at the location where the onsite wetland discharges below the road in the Crossings. The monitoring system at this site has performed as expected. Site 6 (Crossings at Pine Lake – East) is being monitored for flow, turbidity, and temperature of the northerly discharges from the Crossings development to Wetland 17 (Site 4). This station was revised and came online on June 30, 2015, and has reported reliably for flowrate (via a pre-calibrated Thel Mar weir), temperature, and turbidity since then. Like the turbidity sensors at sites 2 and 5, the turbidity sensor at this site reports anomalously high readings periodically which are not believed to be real.

Geosyntec noted that weather conditions during the 2015 summer were anomalously hot and dry, as such, it is not possible to draw conclusions related to long term water quality trends or performance metrics based on the data obtained during that monitoring period. Anecdotal hydrologic conditions observed in Ebright Creek by 48 NORTH in August 2015, during extreme and uncharacteristic drought conditions, indicated a robust low flow (Figure 10) and saturated soils in adjacent riparian areas in the canyon reach. This was supported when reviewing the rating curves and raw data on the OptiRTC online dashboard (available at www.optirtc.com). The unique geologic and hydrogeologic conditions in the basin and especially in the canyon reach area appear to support a healthy low flow regime, even during extreme drought conditions experienced during the summer of 2015.

Because of the limited period of monitoring completed to date (i.e., February 2015 through November 2016), there is no interpretation of the data, as the amount of data gathered would not provide an accurate description of any change. Upon collection of additional years of data, analysis and interpretation may be supported.

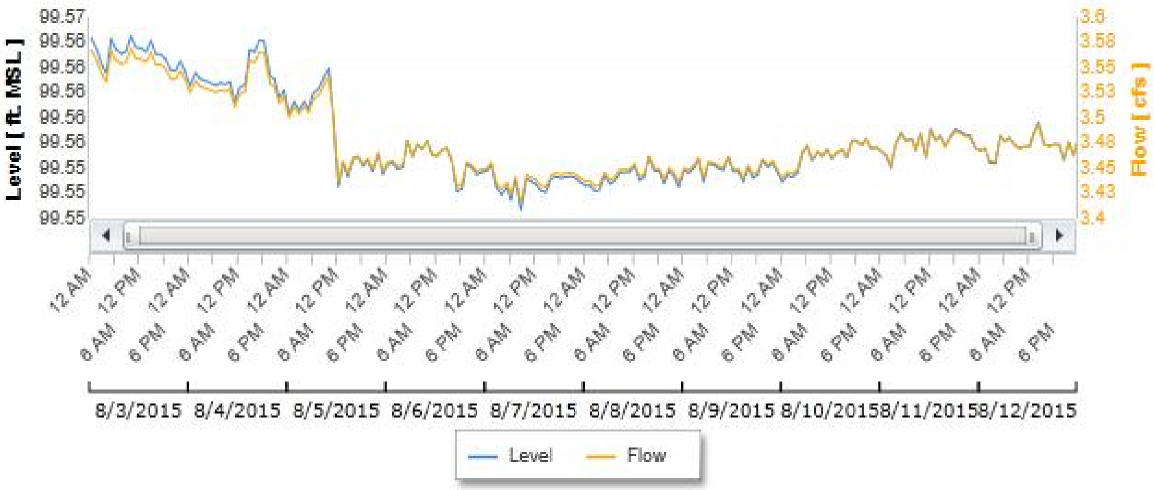

Figure 10: Flow Data from OptiRTC Online Dashboard (August 3 to 12, 2015)

3.3.1 General Hydrology Observations: 2015 – 2016

Weather conditions in the winter of 2015/2016 were wetter than the long-term climate normal and included some significant storm events in November and December 2015. Overall precipitation during the monitoring period was approximately equal to long-term normal and temperature was slightly higher than long-term normal. Table 4 provides a summary of the climate conditions for the monitoring period in comparison to long term normal values, as recorded at Renton Airport.

TABLE 4: SUMMARY OF ACTUAL AND LONG TERM AVERAGE CLIMATE VALUES AT RENTON AIRPORT FOR MONITORING PERIOD

MONTH	TOTAL MONTHLY PRECIPITATION (INCHES)	LONG TERM NORMAL MONTHLY PRECIPITATION (INCHES)	AVERAGE MEAN DAILY TEMPERATURE (°F)	LONG TERM NORMAL AVERAGE TEMPERATURE (°F)
Nov 2015	6.72	6.47	44	45.9
Dec 2015	8.79	5.39	43	40.7
Jan 2016	5.85	5.71	43	42.3
Feb 2016	4.93	4.32	49	43.5
Mar 2016	4.82	3.95	50	47.4
Apr 2016	1.17	3.09	57	51.1
May 2016	1.00	2.12	59	56.8
Jun 2016	1.48	1.59	64	61.9
Jul 2016	0.47	0.94	67	66.6
Aug 2016	0.14	0.92	69	67
Sep 2016	0.57	1.71	61	61.6
Oct 2016	5.18	3.84	55	52.9

Site 1 –Ebright Creek near the Mouth of Lake Sammamish

Water level at this site has been continuously reported and has been stable through the monitoring periods. Water level is being converted to estimated flowrate based on a flow rating curve developed in February 2015. One goal of the project is to obtain another flow measurement at a higher stage to improve the reliability of this rating curve. However, after the storm event that occurred in mid-November 2015, it appears that there have been modifications to the cross section (i.e., change in rock configurations). Further modifications to the cross section were made by the land owner to repair erosion that had occurred. This established a more stable cross section for monitoring, but also changed hydrologic conditions. As such, a new rating curve was developed. A new flow measurement was obtained in late November 2015, and analyzed to determine if adjustments to the rating curve were accurate. A survey and flow measurement was conducted in July 2016 to update the rating curve. The new rating curve was propagated back to January 2016. As is not known exactly when the modifications to the cross section occurred, the flow data during this period should be considered provision. More frequent rating curve checks and refinements would need to occur in 2017 and 2018 to improve confidence in flow rate estimates in the future.

Site 2 – Discharge from Chestnut Lane Pond

Site 2 is being monitored for flow, temperature, and turbidity of the combined discharge from the Chestnut Lane subdivision. Flowrate (via a pre-calibrated Thel Mar weir) and temperature have been reported reliably over the last two years. Until early November 2015, turbidity reported continuously and was generally reasonable with the exception of short duration spikes that appear to be anomalous. It was at this time that the turbidity sensor reported increasingly unrealistic values. As part of field maintenance in late November 2015, it was determined that the sensor needed to be cleaned. The sensor eye had been obscured by floating debris. The sensor was cleaned and reported in an expected range.

At some point during an extreme discharge event in early 2016, the Thel-Mar weir was dislodged from the location where it was originally installed by, and then later recovered, by City staff in a downstream manhole. The cause of the large discharge event and the inability of the weir to resist this flowrate is unknown. Then in March 2016, the cables for the sensors at this site were severed. The cause of this issue is unknown. After the severing of the cables, the turbidity sensor required rehabilitation, which took approximately 2 months. The weir and sensors were reinstalled in June 2016 in a downstream manhole, a location preferred by the City. As a result, flowrate estimates between January and June 2016 are not reliable, while no data are available between March and June 2016.

Since the equipment was rehabilitated and reinstalled in June 2016, all sensors have been stable and recording continuously. A more active maintenance regime for the turbidity probes has been defined and should improve reliability in the future.

Site 3 (Wetland 61) and Site 4 (Wetland 17)

Sites 3 and 4 are being monitored for water level fluctuation. Water level has been stable and within expected ranges over the last two years.

Site 5 – Crossings at Pine Lake (West)

Site 5 is being monitored for flow, temperature, and turbidity at the location where the onsite wetland discharges below the road in the Crossings at Pine Lake subdivision. In April 2015, this monitoring station experienced a power failure that was determined to be a result of a defect in the manufacturer equipment wiring. This resulted in an outage between April 10 to 30, 2015, while the manufacturer diagnosed and corrected the issue. Besides this outage, the monitoring system at this site has performed as expected. Like the turbidity sensors at Sites 2 and 6, the turbidity sensor at this site reports anomalously high readings periodically which are not believed to be real. The turbidity meter at this site has not required maintenance to date, but may also require maintenance in the coming year. The signals from this station have been generally stable and reliable throughout 2016. Quarterly inspection and maintenance of the pressure transducers and turbidity probes maintains reliability.

Site 6 – Crossings at Pine Lake (East)
Site 6 is being monitored for flow, turbidity, and temperature of the northerly discharges from the Crossings at Pine Lake subdivision to Wetland 17. In April 2015, the turbidity sensor at this site stopped reporting and was determined to be clogged with filamentous algae. In response to the elevated risk for algal biofouling at the original monitoring location, this monitoring station was relocated. The new station came online on June 30, 2015, and has reported reliably for flowrate (via a pre-calibrated Thel Mar weir), temperature, and turbidity since that time. Like the turbidity sensors at Site 2 and 5, the turbidity sensor at this site reports anomalously high readings periodically which are not believed to be real. The signals from this site have been generally stable and reliable throughout 2016, a well. Quarterly inspection and maintenance of the pressure transducers and turbidity probes maintains reliability.

4. Discussion

The effect of urbanization on stream ecosystems is a result of interrelated impacts of hydrology, water quality, and habitat (Fitzpatrick and Peppler, 2010). Urban development that occurs throughout a watershed can result in degraded habitat within a stream channel through flow alteration and sediment erosion. Urban development, such as is occurring in the headwaters of Ebright Creek, typically increases the amount of water entering a stream after a storm and decreases the time that it takes for the water to travel over altered land surfaces before entering the stream. This altered hydrology often results in deeper stream channels or an increase in the stream-channel cross-sectional area. The magnitude of these effects depends on natural environmental factors, such as the geology and soils that can influence the geomorphic characteristics of a stream and its watershed.

Efforts to reduce flooding by draining water quickly from roads and parking lots can result in increased amounts of water reaching a stream within a short period of time, which can lead to stream flashiness and altered stream channels. Additionally, rapid runoff reduces the amount of water available to infiltrate the soil and recharge the aquifers, which often results in lower sustained stream flows, especially during summer. Furthermore, when the hydrology of a stream is altered, the physical habitat of a stream often becomes degraded from channel erosion or lower summer flows that reduce spawning, feeding, and living spaces of the aquatic organisms.

With the potential for environmental degradation due to urbanization in the upper Ebright Creek watershed, there is an increased awareness to monitor and assess the long-term conditions of Ebright Creek. Stream habitat assessments are useful for measuring the physical conditions that may limit aquatic biological community health and structure. Recently, stream habitat data have been used to assess physical and geomorphic responses to watershed-scale land disturbance, such as urbanization. Physical responses include changes in channel geometry and hydraulics, substrate size, habitat complexity and cover, habitat volume, and bank/riparian conditions. These responses are caused by changes in flood characteristics and source and amount of sediment loads associated with land clearing and increased impervious surfaces (Fitzpatrick and Peppler, 2010).

To meet the “Mitigated Determination of Non-Significant” conditions for the Chestnut Lanes and the Crossings housing developments set out by the City’s hearing examiner, the City is evaluating whether

the stream habitat of Ebright Creek is being degraded by any increased erosion and sedimentation resulting from the construction of these developments.
A comprehensive baseline stream habitat and macroinvertebrate assessment was conducted in August 2015 on Ebright Creek, downstream of the Plateau. A macroinvertebrate assessment was conducted in early September 2016 to monitor aquatic invertebrate biological community trends and richness at the four index sites established in 2015. Flow (via water level), water level, and temperature were monitored in 2015 and 2016 at the upper end of Reach 1 by instrumentation installed by Geosyntec. This monitoring was initiated to better understand the relationship between stormwater, hydrology, and natural conditions in Ebright Creek as a means to evaluate whether the stream habitat and the biological community of the stream is being degraded by any increased erosion and sedimentation resulting from the construction of these developments. Effects of urbanization on instream physical, chemical, and biological characteristics, such as increased contaminants, increased streamflow flashiness, increased concentrations of chemicals, and changes in aquatic community structure toward a more tolerant community associated with organically enriched conditions, have been documented in literature (Waite et al., 2008).

There has been a considerable amount of habitat loss in the upper watershed of Ebright Creek above the study area and in the lower reaches in the study area. These losses can largely be attributed to forest loss (especially in the riparian zone) coupled with urban development resulting in altered hydrology and a reduction of channel complexity (e.g., LWD) especially in Reaches 0 and 1 and in the headwater sections of Ebright Creek, located on the Plateau. McMillan et al. (2014) found that riparian vegetation in urban streams influenced nutrient transformations, bank stability, input of woody debris, and provided direct water quality benefits (reduced stream temperature). Similarly, the presence of LWD has been shown to improve the macroinvertebrate community, as well as providing hydraulic roughness, that result in pool formation and streambed stabilization (Hilderbrand et al., 1997).

Unlike other urbanized streams in the Puget Sound lowlands, Ebright Creek is not lacking in riparian corridor, channel bed stability, LWD, and riparian vegetation in most of the reaches surveyed. The canyon reach is still in a pristine condition with excellent base flow, LWD, and riparian cover (Sammamish 2012). A stream enhancement project conducted by King County in 2012 along Reach 1 has benefited the geomorphic conditions (width-to-depth ratio, number of pools, sediment size distribution), water quality, and biological integrity of the lower section of the stream reach. Improvement in bed and bank stability, along with a reduction in flashiness of flows, could help reduce the accretion of fine sediments and gravel throughout the streambed in the upper landslide prone sections of the canyon reaches. Despite these issues, Ebright Creek still provides excellent habitat for fish, including kokanee salmon.

Fitzpatrick and Peppler (2010) noticed that an often assumed response in how a biological community degrades with urban development is by an initial resilience to change in biological condition over low levels of development. Then, after the biological community undergoes a rapid change in condition with increasing levels of urban development, an exhaustion response occurs (a “flat line” response) when only a few tolerant species are left in the community (Waite et al., 2008; Fitzpatrick and Peppler, 2010). The USGC’s National Water Quality Assessment Program scientific investigations observed a different response from this hypothetical depiction (Waite et al., 2008; Fitzpatrick and Peppler, 2010). They noticed that aquatic invertebrate communities begin to degrade with the onset of urban development, which indicates that some species are highly sensitive to physical and chemical changes associated with urban development. There was no evidence that biological communities were resilient to even low levels of urban development, based on the observation that sensitive species were being lost over the initial stages of development in relatively undisturbed watersheds (Waite et al., 2008; Cuffney et al. 2010; Fitzpatrick and Peppler, 2010).

Aquatic benthic macroinvertebrates are an important link in the food chain for salmonids and are an excellent indicator of stream health. Research indicates that a loss in the numbers of aquatic insect species that occurred in the groups Ephemeroptera (i.e., mayflies), Plecoptera (i.e., stoneflies), and Trichoptera (i.e., caddisflies), collectively called “EPT”, were a common response in study areas where urban development occurred in forested watersheds (Waite et al., 2008; Fitzpatrick and Peppler, 2010).

Longer-lived species typically take longer to reproduce and, along with sensitive species, are among the first to disappear when a stream ecosystem is altered by human activity such as urbanization. The number of EPT species is a biological-condition metric that is used in many biomonitoring programs across the country because it is sensitive to stressors from environmental degradation. A reduction of more than 50 percent of EPT species was observed by USGS in some study areas as the percentage of urban development increased in the watersheds from low to high levels (Waite, 2008). Waite et al. (2008) found that low urban intensity sites, such as Ebright Creek, had higher abundances of pollution sensitive diatoms, larger numbers of the sensitive macroinvertebrate EPT taxa, and fish assemblages with higher abundances of sensitive salmonids.

EPT richness was “good to fair” for all four of the Ebright Creek macroinvertebrate samples taken in 2015. Ephemeroptera richness was “very poor” at all sites. Intolerant taxa richness and clinger richness were “very poor” in the lower macroinvertebrate site (Macroinvertebrate Sampling Stations 1 and 2) and Trichoptera richness was “very poor” in lower sections of Ebright Creek (Macroinvertebrate Sampling Station 1 and the King County Ambient Monitoring site). Intolerant taxa richness, tolerant percentage and long lived species richness were “good to excellent” in the upper sites (Macroinvertebrate Sampling Stations 2 through 4). The lower sites were located in the restored stream channel. The upper sites were located in the forested, relatively undisturbed ravine section of the stream. A future decrease in these metric in the upper sampling sites may be predictive of upstream habitat changes due to urban land cover increase or other anthropomorphic changes.

The B-IBI values were lower in 2016 than in 2015 for the lower two stations (Macroinvertebrate Sampling Stations 1 and 2), but the values were within the historical range of B-IBI values observed at the King County Ambient Monitoring station on Ebright Creek. The lower site (Macroinvertebrate Sampling Station 1) B-IBI scores were similar to Pine Lake Creek and Laughing Jacobs Creek B-IBI scores for 2015 and 2016. The upper two stations (Macroinvertebrate Sampling Stations 3 and 4) did not change significantly from 2015 to 2016. The B-IBI scores for Ebright Creek’s upstream sites were comparable to higher B-IBI scores observed in Many Springs, Issaquah Creek and Big Bear Creek.

The findings in this study are consistent with the work of others in nearby basins where development occurred with little to no attention placed on the effects of urbanization on biological integrity of small streams (Fevold et al., 2001; Morley and Karr, 2002). Morley and Karr (2002) found that as urbanization increased, biotic integrity (B-IBI scores) decreased significantly. The B-IBI metrics may be lower in streams that are flashy due to hydrological influences resting form urbanization.

The 2015 study “*Status and Trends of Aquatic and Riparian Habitats in the Lake Washington/Cedar/ Sammamish Watershed (WRIA 8)*” noted that stream biological conditions (as measured by the B-IBI) ranged from “very poor” in heavily urbanized areas to “very good” in rural, forested areas (King County

2015). This study corroborated most other research on relationships between urbanization and benthic macroinvertebrate community condition, as measured by B-IBI. Urban land cover and population density were the strongest predictors of declining B-IBI scores. Stream habitat conditions considered important for salmon (e.g., wood volume and water temperature) were found to be below standards that are considered supportive of salmon use, even in rural areas. Specific metrics were identified that could be reliably measured over time and recommended for use in a long term trend monitoring program. These metrics included important indicators of salmon habitat condition (e.g., wood volume, pool area, sediment composition, canopy cover, and B-IBI).

Stream habitat monitoring, and water quality and hydrologic monitoring activities were completed in calendar years 2015 and/or 2016 in the lower Ebright Creek Watershed. Because of the limited period of monitoring completed to date (2015 through present), this report does not include any trend analysis or interpretation of the monitoring data that have been collected. As indicated in the literature, it takes sampling annually for at least 10 years to reliably detect a 3 percent annual change in status or condition. Upon collection of additional years of monitoring data, analysis and interpretation of the data will be included in future reports.

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