EBRIGHT CREEK
BIOLOGICAL AND WATER QUALTY
MONITORING BASELINE REPORT

PREPARED FOR:

THE CITY OF SAMMAMISH

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Sammamish, Washington 98075

Prepared by

48 north solutions

December 15, 2015

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BIOLOGICAL AND WATER QUALITY MONITORING BASELINE REPORT

Prepared for:

City of Sammamish Washington

By

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TABLE OF CONTENTS

Section **Page**

LIST OF FIGURES

Figure **Page**

List of Photographs

List of Tables

List of Appendices

ACRONYMS AND ABBREVIATIONS

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
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 baseline stream habitat conditions in Ebright Creek as the initial step of a 10-year monitoring and assessment of environmental conditions of Ebright Creek.

From August 3 to 13, 2015, Ebright Creek was surveyed to collect data on general ecological conditions, channel shape and form, and to measure water quality and hydrologic conditions. 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.

Geosyntec Consultants (Geosyntec) teamed with 48 NORTH to ensure the stream's water temperature and turbidity limits are not exceeded and that water level fluctuations in the surrounding wetland features do not exceed 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.

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 will 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. 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.

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.

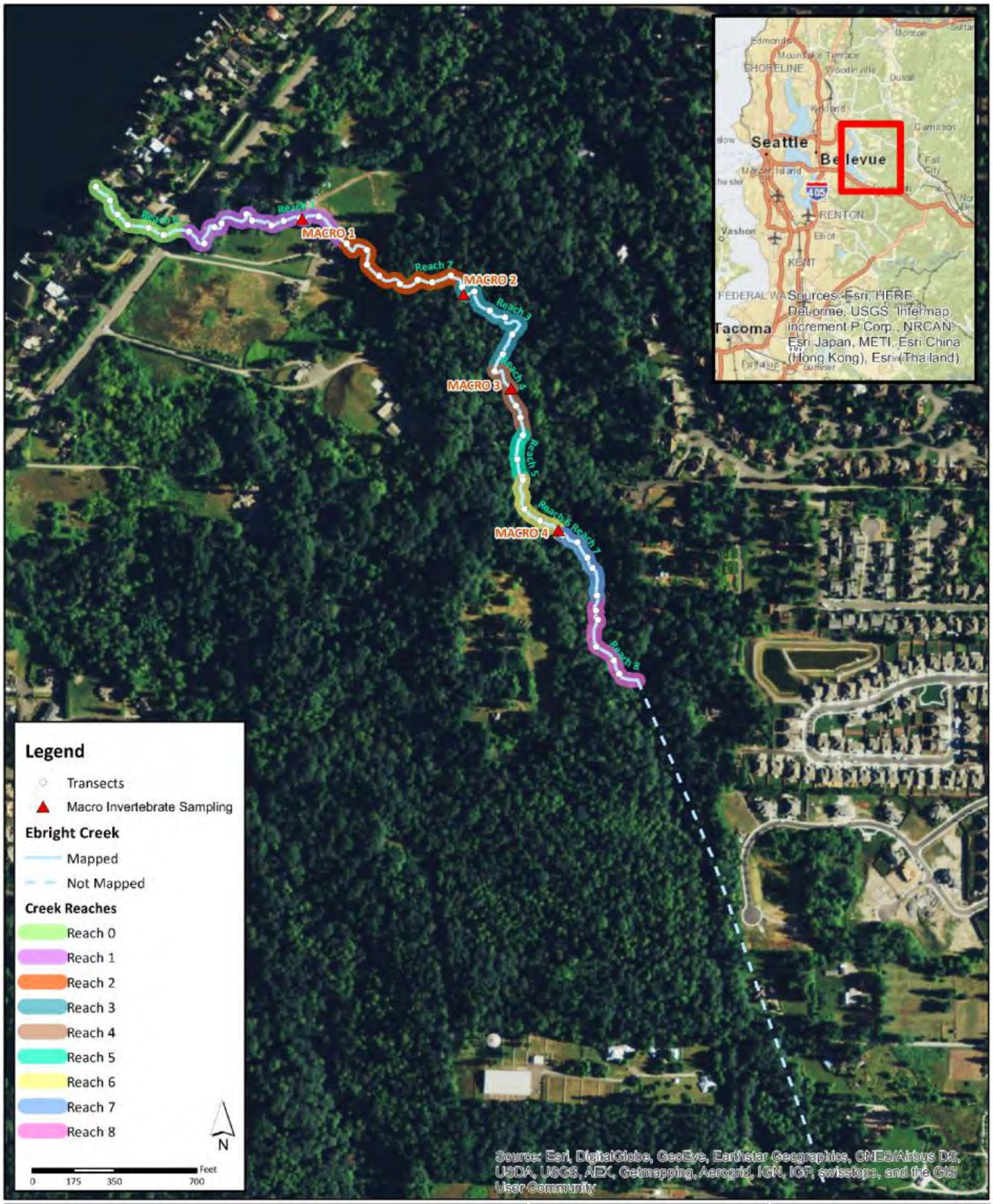

Figure 1:
Ebright Creek Assessment
Reach Breaks & Macro Invertebrate Sampling Sites

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.

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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)		

Macroinvertebrates were collected during summer-low flow (August) 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.

Samples were collected at four locations in Ebright Creek, none of which had been sampled previously (see Figure 1 for locations). 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 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 installation, 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. As part of this overall monitoring effort, the City is committing to monitor that temperature and turbidity limits are not exceeded and that water level fluctuations in the wetland features do not exceed minimum or maximum limits. Six monitoring stations were installed, 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
1. Ebright Creek Near Mouth	Yes	Yes	Yes	No
2. Discharge from Chestnut Pond	Yes	Yes	Yes	Yes
3. Wetland 61	Yes	No	Yes[1]	No
4. Wetland 17	Yes	No	Yes[1]	No
5. Crossings at Pine Lake - West	Yes	Yes	Yes	Yes
6. Crossings at Pine Lake - East	Yes	Yes	Yes	Yes

* Temperature is recorded at these sites, but is not a required parameter and is not considered to be representative of the overall temperature in the wetland. Therefore, temperature is not reported in the project dashboard.

Figure 2: Ebright Creek Monitoring Locations

A memorandum in Appendix A summarizes the water quality and hydrologic monitoring activities completed in calendar year 2015 in the Ebright Creek Watershed. Because of the limited period of monitoring completed to date (late February 2015 through present), this memorandum does not include analysis or interpretation of the data that have been collected in 2015.

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.

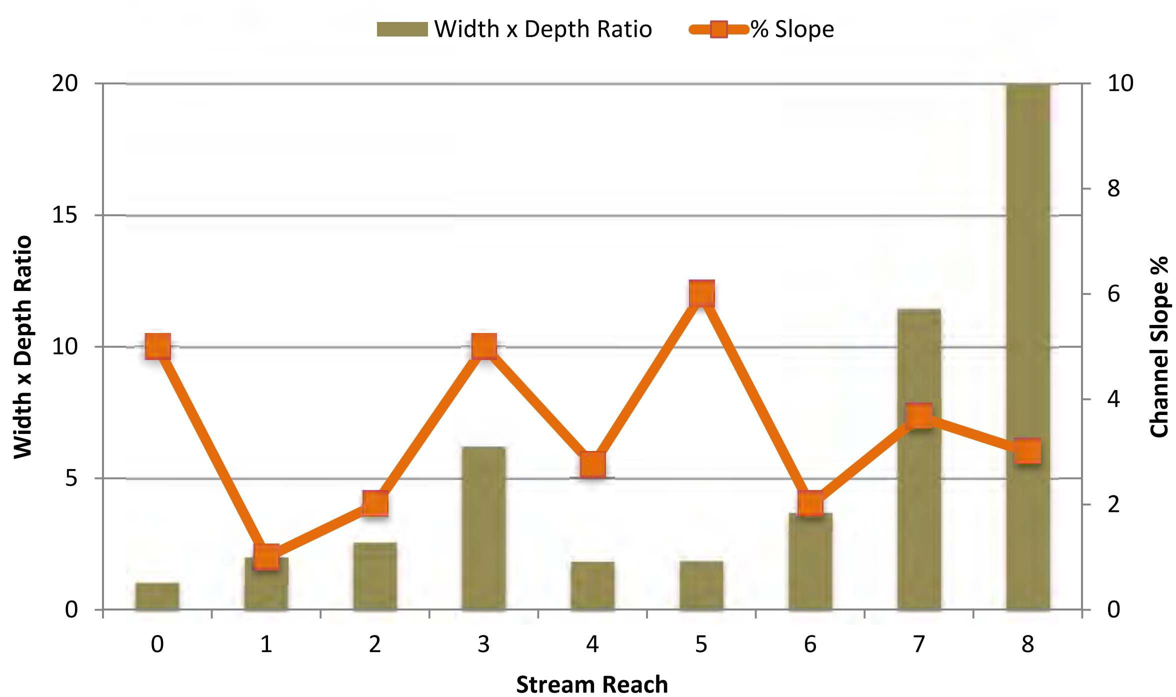

Figure 3: Width-to-depth Ratio and Stream Channel Slope for Each Reach Section

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.

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

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.

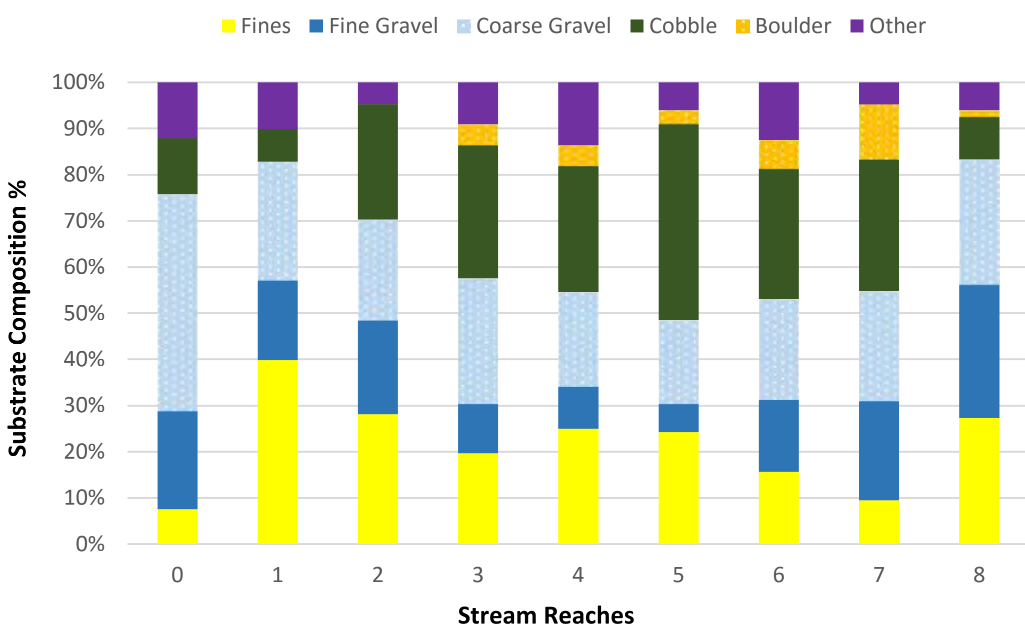

Figure 4: Stream Substrate Composition by Reach

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

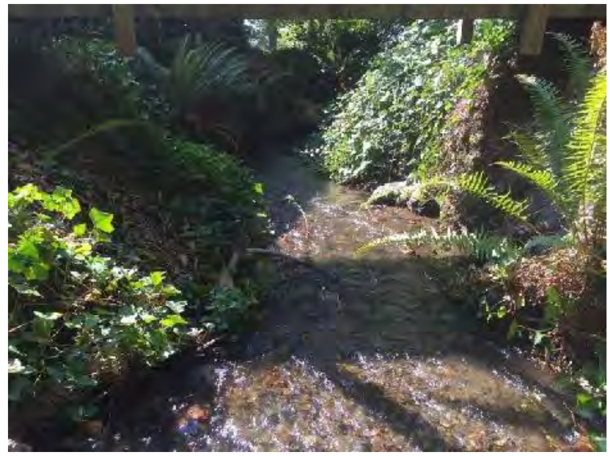

Photo 3: Typical Ground Cover and Riparian Habitat along Reach 0

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).

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

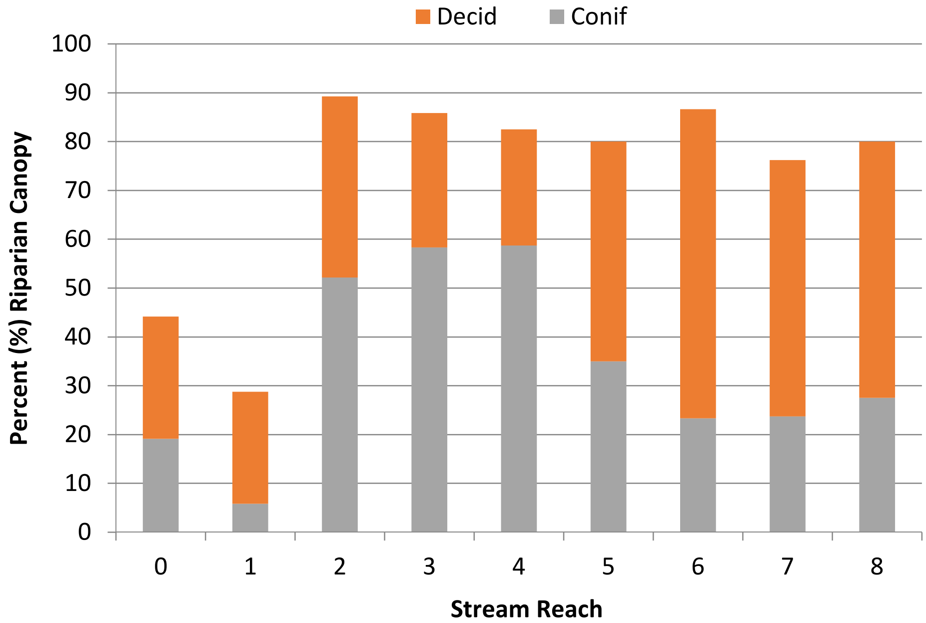

Figure 5: Percent of Riparian Forest Comprised of Deciduous and Coniferous Trees along Each Reach

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.

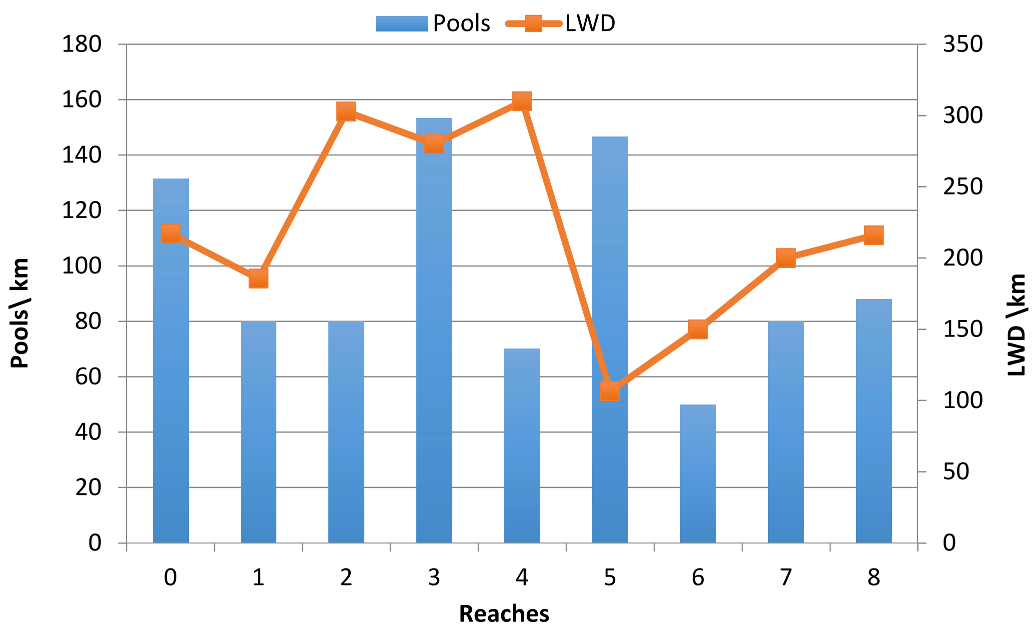

Figure 6: Number of Pools per km versus Number of Key Pieces of LWD per km

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

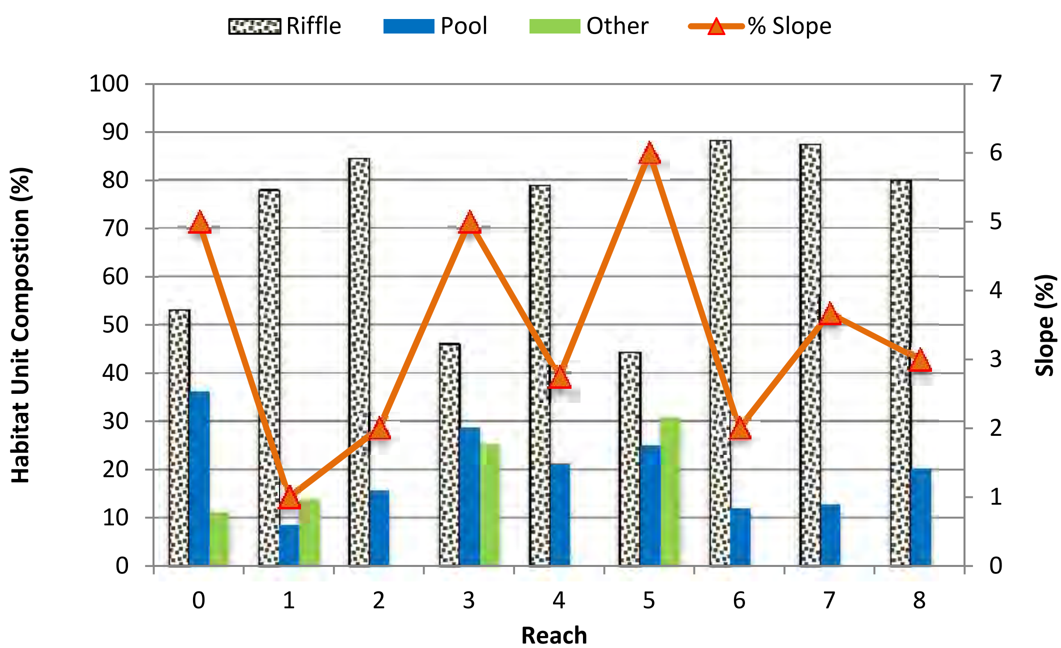

Figure 7: Habitat Unit Composition per Reach Compared to Slope

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.

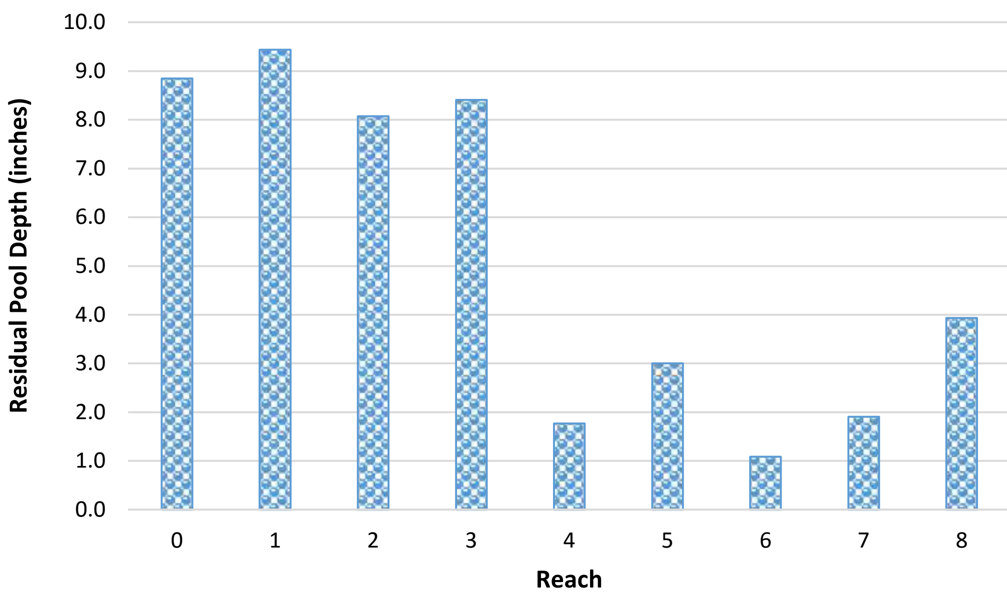

Figure 8: Average Residual Pool Depth per Reach

3.2 Macroinvertebrate Sampling

Macroinvertebrate samples were collected in August 2015. The B-IBI (10 to 50) scores ranged from 26 to 36 (see Table 3). These scores are considered “fair to poor” 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 and the macroinvertebrate community may not have fully recovered from the streambed disturbance that was part of the 2012 enhancement project. Sites 2 to 4 are located in relatively undisturbed sections of Ebright Creek. Macroinvertebrate samples collected in Ebright Creek by King County Ambient Monitoring Program in 2014 at a site located in the same enhanced reach but approximately 150 m (492 feet) downstream of Site 1 had the same B-IBI score as Site 1 (26).

Other streams in the Lake Sammamish basin had similar “fair to good” B-IBI scores as what was observed in Ebright Creek (Figure 9). The B-IBI scores for Ebright Creek’s upstream sites were comparable to higher B-IBI scores observed in both George Davis Creek and Issaquah Creek. All Ebright Creek sites scored better than Vasa Creek and Lewis Creek, with the score at Site 1 similar to Bear Creek.

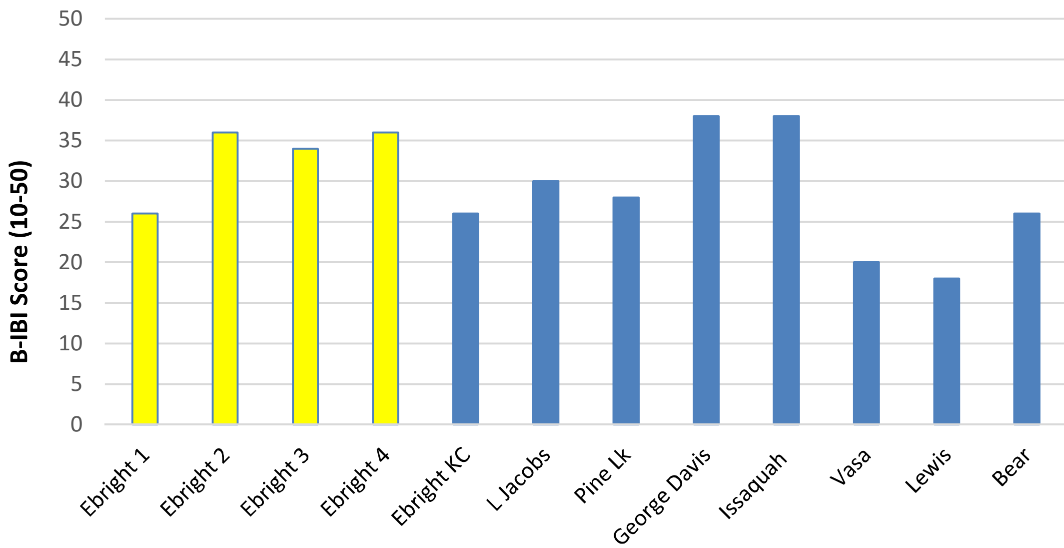

Figure 9: Benthic macroinvertebrate (B-IBI) Scores for Ebright Creek (2015) compared with King County Ambient Monitoring Sites in the Sammamish Basin (2014)

TABLE 3
B-IBI SCORES FOR EBRIGHT CREEK (2015) AND LAKE SAMMAMISH (2014)

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]	2014	20	1	3	3	7	8	4	1	46.5	67.7	1.0	99	**26**	3	1	1	1	1	3	1	5	5	5
EC 1	2015	33	2	5	5	12	7	4	2	70.8	13.6	0.4	500	**26**	3	1	3	3	1	3	1	3	3	5
EC 2	2015	34	1	6	6	13	12	5	4	62.0	25.4	0.0	500	**36**	3	1	3	3	3	5	5	3	5	5
EC 3	2015	36	1	5	7	13	12	6	3	50.0	27.9	0.0	498	**34**	3	1	3	3	3	5	3	3	5	5
EC 4	2015	37	2	4	8	14	13	5	4	55.0	25.6	1.2	496	**36**	3	1	3	3	3	5	5	3	5	5

[1] Scores based on Wisseman (1998) 10 – 50 B-IBI

[2] King County's Lake Sammamish 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 (Appendix A).

Site 1 (Figure 2) 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 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. Site 5 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 is being monitored for flow, turbidity, and temperature of the northerly discharges from the Crossings development to Wetland 17. This station was revised and came online on June 30th, 2015, and has reported reliably for flowrate (via a pre-calibrated Thel Mar weir), temperature, and turbidity since then. 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. Wetland 61 and 17 are being monitored for water level fluctuation. Water level has been stable and within expected ranges for the period of monitoring.

Geosyntec noted that weather conditions in 2015 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 the 2015 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.

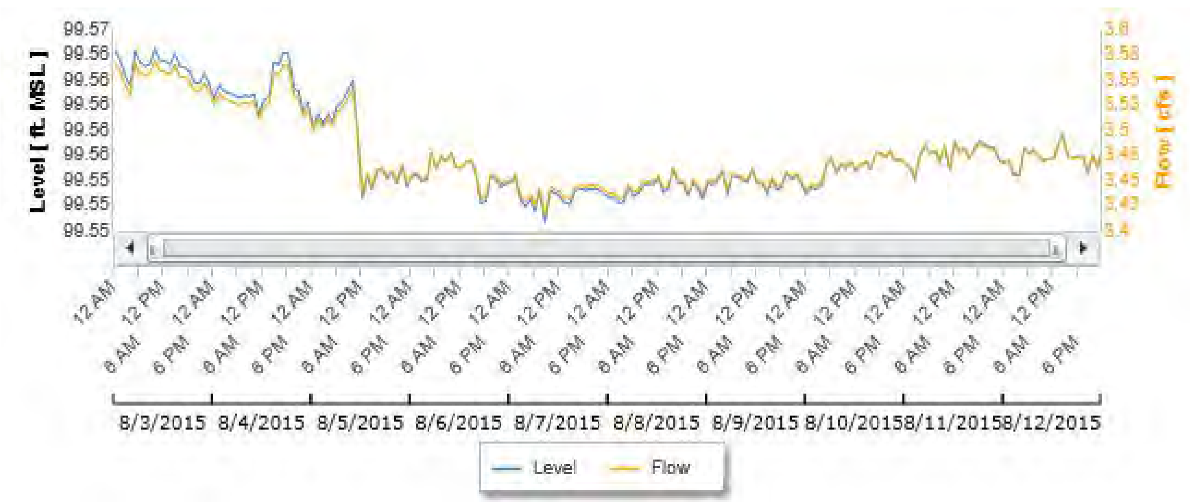

Figure 10: Flow Data from OptiRTC Online Dashboard (August 3 to 12, 2015)

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. This assessment was conducted 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 U.S. Geological Survey’s (USGC) 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. EPT richness was "poor" for the King County 2014 sample that was collected downstream of the 2015 samples. Intolerant taxa richness, clinger richness and long lived species richness were "very poor" in the lower macroinvertebrate sites (Site 1 and at the King County site in 2014) and "good to excellent" in the upper sites (Sites 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 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). For the most reliable metrics, it will take sampling annually for 10 to 20 years to reliably detect a 3 percent annual change in status or condition.

48 NORTH completed a comprehensive baseline stream habitat assessment in 2015 as part of a long-term monitoring of macroinvertebrate, aquatic and riparian habitats, and water quality conditions in Ebright Creek to better understand the relationship between stormwater, hydrology, and natural conditions in Ebright Creek. The subsequent long term monitoring effort will be assessing all the metrics identified by King County (2015) as important indicators of salmonid habitat condition (wood volume, pool area, sediment composition, canopy cover, and B-IBI) in order to evaluate whether the stream habitat of Ebright Creek is being degraded by any increased erosion and sedimentation resulting from the construction of the two upstream urban developments.

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APPENDIX A

GEOSYNTEC (2015) ANNUAL REPORT

EBRIGHT CREEK WATER MONITORING (PROJECT # PNW0234)

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MEMORANDUM

Date: 2 December 2015

To: Cameron Fisher, 48 North Solutions

From: Aaron Poresky, Geosyntec Consultants

Subject: Annual Report – 2015 – Ebright Creek Water Monitoring
Geosyntec Project: PNW0234

INTRODUCTION

The purpose of this memorandum is to summarize the water quality and hydrologic monitoring activities completed in calendar year 2015 in the Ebright Creek Watershed. Because of the limited period of monitoring completed to date (late February 2015 through present), this memorandum does not include analysis or interpretation of the data that have been collected.

PROJECT CHRONOLOGY

The following bullets describe key milestones in the project, including the three primary deliverables (identified in bold) which were provided to the City in 2014 and 2015. These deliverables can be consulted for more details about the monitoring systems that were installed and the monitoring data that have been obtained.

- October 2015: Site visit to develop monitoring recommendations
- November 2015: **Task 2 Site Assessment and Implementation Recommendations Memorandum** (dated November 10, 2014) – Provided recommendations for instrumentation at each monitoring site. This memorandum was submitted for review by Eric LaFrance and provided the basis for the equipment that was installed. .
- February 2015: Installation of monitoring equipment, development of rating curves, and initiation of continuous monitoring.
- March 2015: **OptiRTC online dashboard** (available at www.optirtc.com) with complete rating curves – provides access to raw and processed monitoring data, including functionality to navigate to historical periods and/or download historical data.

- April – June 2015: Identified power issues at Site 5 and turbidity probe issues at Site 6; worked with INW and City staff to resolve these issues. This resulted in relocation of sensors and power supply at Site 6 (including update of rating curves), manufacturer maintenance of Site 6 turbidity sensor, and manufacturer correction of equipment wiring defects at Site 5. Performed first maintenance inspection of sites.
- July 2015: **Operations and Maintenance Manual for Field Equipment** (dated July 30, 2015) – provides detailed description of the monitoring equipment installed at each site.
- November 2015: Performed second maintenance inspection of sites, obtained updated flow measurement at Site 2, and performed maintenance to restore function of Site 2 turbidity sensors.

Please refer to the O&M Manual for summary of monitoring requirements and the details of the installed monitoring stations.

SUMMARY OF 2015 MONITORING ACTIVITIES AND OBSERVATIONS

This section summarizes general and site-specific activities and observations related to the six water monitoring stations installed in the Ebright Creek Watershed.

General

The following general summary applies to all sites:

- Monitoring stations began reporting in late February 2015. Rating curves and other adjustments to process raw data (i.e., convert water level to flow; apply elevation offsets) were applied beginning in March 2015 and were back processed to the beginning of the monitoring in late February. Therefore, the period of record for processed monitoring data extends from late February 2015 to present.
- For sites where monitoring was previously conducted (Wetland 17 and 61), the new sensors were installed with appropriate referencing to the elevations of prior monitoring equipment. This will allow the periods of monitoring to be combined between the historic sensors and the current sensors.
- Outages of the INW (equipment manufacturer) online platform were responsible for short periods of data outage on the Opti platform. These outages did not result in data loss; data were back-filled into the Opti system once the INW platform was restored.
- Water level and temperature sensors were generally stable and provided reasonable readings throughout the period of monitoring, except when systems were offline for other reasons.

- Turbidity sensors required maintenance at Site 2 and 6, as discussed further in the site-by-site discussion below. Sensor outages at these sites resulted in periods of missing or erroneous data.
- Generally, turbidity sensors are less stable and require more maintenance than the other sensors. It appears that these sensors will require yearly or twice-yearly maintenance for the duration of the monitoring project. This maintenance will likely require cleaning of the sensor eye and wiper system and can be performed by City Staff per the manufacturer's O&M guidance.
- Each of the three turbidity sensors was observed to report spikes of unrealistic values periodically. The cause for this instability has been investigated by INW but an explanation/solution has not been identified. Analysis of these datasets will require interpretation of real versus erroneous readings.
- Power supply was stable at all sites, with the exception of a manufacturer defect at Site 5 as discussed further below.
- Weather conditions in 2015 were anomalously hot and dry; it is not possible to draw conclusions related to long term trends or performance metrics based on the data obtained during this monitoring period. The lingering effects of the 2015 drought may also be observed through the 2015/2016 wet season.

Site 1 – Downstream in Ebright Creek

Site 1 is being monitored for flow (via water level) and temperature. 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. It was our goal to obtain another flow measurement at a higher stage to improve the reliability of this rating curve. However, after the storm event that occurred around November 13-17, it appears that there have been modifications to the cross section (i.e., change in rock configurations) such that a new rating curve may need to be developed. A new flow measurement was obtained on November 24, 2015 and is currently being analyzed to determine if adjustments to the rating curve are needed.

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 through the period of record. Until approximately November 7th, turbidity reported continuously and was generally reasonable with the exception of short duration spikes that appear to be anomalous. On approximately November 7th, the turbidity sensor reported increasingly unrealistic values. As part of field maintenance on November 24th, we determined that the sensor needed to be cleaned. The sensor eye had been obscured by floating debris. The sensor is currently reporting in an expected range.

Moving forward, it may be desirable to reinstall the turbidity sensor in such a way that it can be pulled up from the ground surface for periodic maintenance without requiring confined space access.

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

Wetland 61 and 17 are being monitored for water level fluctuation. Water level has been stable and within expected ranges for the period of monitoring. Temperature is available at these stations but is not reported because the temperature at the location of the probes (inside of a stilling well) is not representative of the wetland as a whole. Additionally, this is not a required monitoring parameter at these sites.

Site 5 – Discharge under Road from On-site Wetland in Crossings at Pine Lake Subdivision

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, Site 5 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 around April 10^{th} and April 30^{th} 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.

Geosyntec performed reconnaissance of the original active control system at Site 5 and Site 6 and corresponded with original equipment vendors.

Site 6 – Discharge from Northeastern Outfall of Pond at Crossings at Pine Lake

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^{th}, 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.

PLANNED AND POTENTIAL ACTIVITIES

We recommend the following next steps for this project:

1. Calculate the updated rating curve for Site 1 based on November 24th measurements. If updates are needed, we will apply these updates to data starting around November 17th.
2. Consider rewiring the turbidity sensor at Site 2 so that it is in a separate conduit that can be pulled up from the ground surface for maintenance. If this is desirable to the City, then we can provide instructions and/or field assistance to make this modification.
3. Continue to work with INW to attempt to resolve turbidity sensor spikes.
4. Continue to observe the monitoring systems and respond to or notify the City of potential maintenance issues.
5. Continue to respond to requests for access to the online project dashboard.
6. Complete our final of three scoped maintenance visits to the site, likely at the beginning of the 2016 wet season unless Geosyntec's assistance with maintenance is needed sooner.
7. Continue to transition regular maintenance activities to City staff, as called for in the project scope of work.

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APPENDIX B

MACROINVERTEBRATE - RAW DATA

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Macroinvertebrate Data

				Stream	Ebright Creek	Ebright Creek	Ebright Creek	Ebright Creek	Ebright Creek	Ebright Creek	Ebright Creek	Ebright Creek
				Site ID	Macro #1	Macro #2	Macro #3	Macro #4	Macro #1	Macro #2	Macro #3	Macro #4
				Date	7-Aug-15	7-Aug-15	7-Aug-15	7-Aug-15	7-Aug-15	7-Aug-15	7-Aug-15	7-Aug-15
				Time	13:05	14:00	16:00	15:15	13:05	14:00	16:00	15:15
				Sample Size	0.744 m2	0.744 m2	0.744 m2	0.744 m2	0.744 m2	0.744 m2	0.744 m2	0.744 m2
				Collectors	B. Mavros/C. Fisher	B. Mavros/C. Fisher	B. Mavros/C. Fisher	B. Mavros/C. Fisher	B. Mavros/C. Fisher	B. Mavros/C. Fisher	B. Mavros/C. Fisher	B. Mavros/C. Fisher
				Notes	Small Cobble/gravel	gravel/cobble	gravel/coarse gravel	small cobble/large cobble	Small Cobble/gravel	gravel/cobble	gravel/coarse gravel	small cobble/large cobble
				% Sample Sorted	37.5	100	75	62.5	37.5	100	75	62.5
					Relative Abundances				**Density (ind. Per m2)**			
Order (or higher)	Family	Taxon (Lowest unit Ided)	TSN	Taxon	Sample #1	Sample #2	Sample #3	Sample #4	Sample #1	Sample #2	Sample #3	Sample #4
Acari		Acari	733321	Acari - larva or damaged	4	1	4		14.3	1.3	7.2	0.0
Coleoptera	Elmidae	Lara	114137	*Lara*		6	3	5	0.0	8.1	5.4	10.8
Coleoptera	Elmidae	Narpus	114142	*Narpus*				1	0.0	0.0	0.0	2.2
Coleoptera	Staphylinidae	Staphylinidae	113265	Staphylinidae - Adult			2	3	0.0	0.0	3.6	6.5
Coleoptera		Coleoptera	109216	Coleoptera Adult - terrestrial	1		2		3.6	0.0	3.6	0.0
Collembola		Collembola	99237	Collembola				1	0.0	0.0	0.0	2.2
Diptera	Ceratopogonidae	Atrichopogon	127113	*Atrichopogon*		2	6	2	0.0	2.7	10.8	4.3
Diptera	Ceratopogonidae	Bezzia / Palpomyia	NA	*Bezzia / Palpomyia*		6	9	11	0.0	8.1	16.1	23.7
Diptera	Ceratopogonidae	Ceratopogonidae	127076	Ceratopogonidae - damaged	1				3.6	0.0	0.0	0.0
Diptera	Chironomidae	Chironomidae	127917	Chironomidae - pupa	4	10	5	1	14.3	13.4	9.0	2.2
Diptera	Chironomidae	Chironominae	129228	Chironominae	24	2	9	33	86.0	2.7	16.1	71.0
Diptera	Chironomidae	Orthocladiinae	128457	Orthocladiinae	31	26	47	35	111.1	34.9	84.2	75.3
Diptera	Chironomidae	Tanypodinae	127994	Tanypodinae	2	1	1	8	7.2	1.3	1.8	17.2
Diptera	Dixidae	Dixa	125810	*Dixa*	1	2	1	7	3.6	2.7	1.8	15.1
Diptera	Empididae	Chelifera / Metachela	NA	*Chelifera / Metachela*	9	7	6	1	32.3	9.4	10.8	2.2
Diptera	Empididae	Clinocera	135849	*Clinocera*	3	1	6	1	10.8	1.3	10.8	2.2
Diptera	Empididae	Empididae	135830	Empididae - pupa	2	3			7.2	4.0	0.0	0.0
Diptera	Empididae	Empididae	135830	Empididae - early instar				1	0.0	0.0	0.0	2.2
Diptera	Pelecorhynchidae	Glutops	130915	*Glutops*	1	2	6	8	3.6	2.7	10.8	17.2
Diptera	Psychodidae	Pericoma / Telmatoscopus	NA	*Pericoma / Telmatoscopus*	1	1	1	5	3.6	1.3	1.8	10.8
Diptera	Simuliidae	Simuliidae	126640	Simuliidae	5				17.9	0.0	0.0	0.0
Diptera	Simuliidae	Simulium	126774	*Simulium*	19	3	2	4	68.1	4.0	3.6	8.6
Diptera	Stratiomyidae	Stratiomyidae	130150	Stratiomyidae - early instar				6	0.0	0.0	0.0	12.9
Diptera	Thaumaleidae	Thaumaleidae	126624	Thaumaleidiae		1	4	3	0.0	1.3	7.2	6.5
Diptera	Tipulidae	Antocha monticola	119660	*Antocha*		1			0.0	1.3	0.0	0.0
Diptera	Tipulidae	Dicranota	121027	*Dicranota*	8	2	5	7	28.7	2.7	9.0	15.1
Diptera	Tipulidae	Rhabdomastix	120968	*Rhabdomastix*				2	0.0	0.0	0.0	4.3
Diptera	Tipulidae	Tipula	119037	*Tipula*			2	1	0.0	0.0	3.6	2.2
Diptera	Tipulidae	Tipulidae	118840	Tipuliade - early instar			1		0.0	0.0	1.8	0.0
Ephemeroptera	Baetidae	Baetidae	100755	Baetidae - damaged	29	7			103.9	9.4	0.0	0.0
Ephemeroptera	Baetidae	Baetis	100800	*Baetis*	322	192	106	53	1154.1	258.1	190.0	114.0
Ephemeroptera	Baetidae	Diphetor hageni	568598	*Diphetor hageni*	1			2	3.6	0.0	0.0	4.3
Gastropoda	Lymnaeidae	Lymnaeidae	76483	Lymnaeidae	2				7.2	0.0	0.0	0.0
Nemata		Nemata	563956	Nemata	3	3	5	7	10.8	4.0	9.0	15.1
Oligochaeta		Oligochaeta	68422	Oligochaeta	52	73	96	199	186.4	98.1	172.0	428.0
Plecoptera	Chloroperlidae	Chloroperlidae	103202	Chloroperlidae - early instar or damaged	8	27	63	10	28.7	36.3	112.9	21.5
Plecoptera	Chloroperlidae	Sweltsa	103273	*Sweltsa*	49	48	37	60	175.6	64.5	66.3	129.0
Plecoptera	Leuctridae	Leuctridae	102840	Leuctridae - prob *Despaxia augusta*		2			0.0	2.7	0.0	0.0
Plecoptera	Nemouridae	Nemouridae	102517	Nemouridae - early instar or damaged		2	2	1	0.0	2.7	3.6	2.2
Plecoptera	Nemouridae	Zapada	102591	*Zapada* - early instar	8		5		28.7	0.0	9.0	0.0
Plecoptera	Nemouridae	Zapada cinctipes	102594	*Zapada cinctipes*	7	7	2	3	25.1	9.4	3.6	6.5
Plecoptera	Perlidae	Doroneuria baumanni	103123	*Doroneuria baumanni*	2	4	12	25	7.2	5.4	21.5	53.8
Plecoptera	Perlidae	Hesperoperla pacifica	102972	*Hesperoperla pacifica*	6	5	2		21.5	6.7	3.6	0.0
Plecoptera	Perlidae	Perlidae	102914	Perlidae - early instar	2	10	14	7	7.2	13.4	25.1	15.1
Plecoptera	Pteronarcyidae	Pteronarcys	102471	*Pteronarcys*	2	1	15	8	7.2	1.3	26.9	17.2
Salmoniformes	Salmonidae	Salmonidae	161931	Salmonidae		1			0.0	1.3	0.0	0.0
Scorpaeniformes	Cottidae	Cottidae	167196	Sculpin		1			0.0	1.3	0.0	0.0
Trichoptera	Brachycentridae	Micrasema	116958	*Micrasema*			1	1	0.0	0.0	1.8	2.2
Trichoptera	Glossosomatidae	Glossosoma	117159	*Glossosoma*	6	28	35	14	21.5	37.6	62.7	30.1
Trichoptera	Hydropsychidae	Arctopsyche grandis	115530	*Arctopsyche grandis*		13	11	7	0.0	17.5	19.7	15.1
Trichoptera	Hydropsychidae	Hydropsyche	115453	*Hydropsyche*	1			2	3.6	0.0	0.0	4.3
Trichoptera	Hydropsychidae	Hydropsychidae	115398	Hydropsychidae - early instar	1		3	2	3.6	0.0	5.4	4.3
Trichoptera	Hydropsychidae	Parapsyche	115556	*Parapsyche*	3	9	13	9	10.8	12.1	23.3	19.4
Trichoptera	Lepidostomatidae	Lepidostoma	116794	*Lepidostoma*	3	3	1		10.8	4.0	1.8	0.0
Trichoptera	Limnephilidae	Psychoglypha	115974	*Psychoglypha*	1			1	3.6	0.0	0.0	2.2
Trichoptera	Philopotamidae	Wormaldia	115258	*Wormaldia*		1	1	5	0.0	1.3	1.8	10.8
Trichoptera	Rhyacophilidae	Rhyacophila	115097	*Rhyacophila* - early instar or damaged	7	11	28	21	25.1	14.8	50.2	45.2
Trichoptera	Rhyacophilidae	Rhyacophila Angelita Gr.	115099	Rhyacophila Angelita Gr.	1	23			3.6	30.9	0.0	0.0
Trichoptera	Rhyacophilidae	Rhyacophila Betteni Gr.	115101	Rhyacophila Betteni Gr.		2	16	7	0.0	2.7	28.7	15.1
Trichoptera	Rhyacophilidae	Rhyacophila Brunnea/Vemna Gr.	NA	Rhyacophila Brunnea/Vemna Gr.		1		4	0.0	1.3	0.0	8.6
Trichoptera	Rhyacophilidae	Rhyacophila Sibirica Gr.	568811	Rhyacophila Sibricia Gr.		1			0.0	1.3	0.0	0.0
Trichoptera		Trichoptera	115095	*Trichoptera - pupa*		14	4	7	0.0	18.8	7.2	15.1
Trombidiformes	Lebertiidae	Lebertia	83034	*Lebertia*	16	11	9	8	57.3	14.8	16.1	17.2
Trombidiformes	Sperchontidae	Sperchonopsis	83029	*Sperchonopsis*	3	1	4	2	10.8	1.3	7.2	4.3
Trombidiformes	Torrenticolidae	Testudacarus	83250	*Testudacarus*		1		1	0.0	1.3	0.0	2.2
Trombidiformes	Torrenticolidae	Torrenticola	83254	*Torrenticola*	1				3.6	0.0	0.0	0.0
Turbellaria		Turbellaria	53964	Turbellaria	1		4	1	3.6	0.0	7.2	2.2
Veneroida	Pisidiidae	Pisidium	81400	*Pisidium*	7	12	10	7	25.1	16.1	17.9	15.1
				Totals	**653**	**579**	**621**	**620**	**2340.5**	**778.2**	**1112.9**	**1333.3**