Cumulative Effects Monitoring of Okanagan Streams using Benthic Invertebrates, 1999 to 2004

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EXECUTIVE SUMMARY

Biological monitoring is essential to describing and protecting biological resources. Chemical measurements, or habitat assessments are useful to aquatic resource management, but the primary sentinels and objects requiring protection are organisms living in the stream. The merits of using benthic invertebrate measures as cumulative effects indicators are many. Foremost is that biological condition of the streams is being directly assessed. Benthic invertebrates are useful integrators of various stressors and are acknowledged as useful cumulative effects indicators. Secondly, the ranking of stream condition using a benthic invertebrate index or metric, is a defensible objective statement describing stream health, which may be more readily understood by resource managers and the public, than chemical concentrations or habitat statements. Lastly, this process of regional correlation or calibration of benthic health to watershed condition factors can provide opportunities to collaborate across disciplines and integrate and strengthen cumulative effects assessments of aquatic ecosystem condition in the Okanagan.

In this study, benthic invertebrates were collected from 23 low elevation Okanagan stream sites between 1999 and 2004. Replicate sampling used a Surber net and data analysis followed the Benthic Index of Biological Integrity concept developed by Karr (Karr and Chu, 1999). Streams representing a gradient of conditions from low stress to high stress due to human alteration or use of the watershed were examined. Potential stress levels were established through GIS analysis at the watershed level and at the sampling reach for in-stream and near stream habitat condition. Low stress or reference sites and watersheds had low urban, agriculture, timber harvest factors, as well as low instream and near stream habitat alteration. High stress or high impact sites were chosen in watersheds and locations with high urban and agriculture landuse, and demonstrated degraded near and instream habitat. Categorical ranking by upper and lower relative stressor levels allowed calibration of a benthic index of biological integrity (B-IBI) for Okanagan streams. Five benthic invertebrate measures responded predictably over space and time to cumulative stress in valley bottom stream locations. These metric included total taxa, number of plecoptera taxa, number of ephemeroptera taxa, number of intolerant taxa, and number of clinger taxa. These metrics were found to respond predictably to cumulative watershed disturbance and clearly distinguished urban and highly altered sites from low impact sites. Secondary metrics, which responded predictably but did not clearly distinguish high and low stress categories were: number of trichoptera, Hilsenhoff biotic index, percent tolerant, percent predators and percent dominance. Primary metrics were summed into a multimetric index (B-IBI) and partitioned into excellent, good, fair, poor and very poor stream condition categories. The primary and secondary metrics correspond well to metrics used in B-IBI systems employed elsewhere in the Pacific Northwest.

B-IBI scores were highest for stream sites on Equesis, Peachland, Shorts, Whiteman, Ellis upstream of Penticton, Chute, McDougall ups of Hwy 97, Coldstream and Lambly Creek (see Table 6 for site details). These sites were considered good to excellent, having a full range of biological diversity and presence of species sensitive to variety of stressors such as thermal, flow, sediment and toxic contaminants. B-IBI scores were lowest for Kelowna, Ellis near Okanagan River, Vernon at 25th Avenue in Vernon, Trout Creek near Hwy 97, Shuttleworth in Ok Falls, Eneas and Prairie Creeks in Summerland and BX Creek at 30th Avenue in Vernon. These sites were judged to be in poor or very poor condition, having almost half the species diversity as the reference group and very few intolerant taxa. A large number of stream sites were ranked as fair (see Table 6) and have some loss of biodiversity.

Water and sediment chemistry samples were collected during the study to complement the biological sampling. Water quality data indicated that in urban and agriculture settings, bacteriological measures frequently exceed drinking and recreational water quality guidelines. Aquatic life protection guidelines were rarely challenged. Nitrate nitrogen was often orders of magnitude higher in streams flowing through urban and agriculture settings. Reduced sediment quality was more common in urban streams. Polycyclic aromatic hydrocarbons (PAHs) were often elevated in urban stream sediments of BX, Kelowna, Ellis and Eneas creeks. PAHs in BX Creek at 30th Avenue were consistently above Canadian Council of Ministers of the Environment (CCME) aquatic life interim sediment guidelines but below probable effects levels. Lead and zinc were higher in BX and Kelowna creek sediments than other streams, and average values were between the CCME interim and probable effect levels. Pesticide analysis of stream sediments in 2003 found DDE (a breakdown product of DDT) above CCME aquatic life probable effects levels in Kelowna and Eneas creeks. Endosulphan was also detected in Eneas Creek. PCBs were not detected in urban sediments above detection limits. Further sampling and analysis would be required to describe variation in water and sediment quality for these study sites.

Re-evaluation of the same habitat, water and sediment chemistry, and benthic invertebrate data set was carried out by Perrin (2006) using the Environment Canada's Benthic Assessment of Sediment (BEAST) software in CABIN (Canadian Aquatic Biomonitoring Network). Okanagan streams were classified by BEAST using the Fraser Basin reference groups as either unstressed, potentially stressed, stressed or severely stressed relative to Fraser Basin reference conditions, and then compared to B-IBI scores. BEAST was conservative in showing a better condition for 13% of the sites but a worse condition for 55% of the sites than was determined using the B-IBI process. Complete agreement of BEAST and B-IBI scores occurred for 29% of the sites, and 81% of the sites were within one stress category. No sites were more than 2 stress categories apart.

The Okanagan CABIN data set and sediment quality data was further evaluated by Perrin (2006) using cluster analysis and multidimensional scaling. These analyses confirmed the B-IBI classification of sites into the upper and lower stressor groups which were used in calibrating the Okanagan benthic index of biological integrity. Discriminant function analysis identified sediment PAH, nickel, manganese and water alkalinity as best discrimiants of the reference group and two high stress groups. Polycyclic aromatic hydrocarbons (PAHs) in sediments were identified as the strongest discriminator of benthic community in high impact stations. Cause and effect can not be presumed as other stressors such as impervious surface area or measures of stream flow variation are often associated with deteriorating biological condition.

Given the specificity of the CABIN model to the Fraser basin and travelling kick net collection method, the overall agreement between the two methods of analysis is encouraging. The comparability of the B-IBI and CABIN outputs suggests that either the B-IBI or BEAST can be used with confidence on Okanagan low elevation streams. Both methods will detect impairment when applied in riffle habitats. Perrin suggests Surber collected data can be used for BEAST assessment but notes assessment error potentially increases. Data compiled for a B-IBI analysis may also be used for more in-depth analysis, including multivariate analysis of habitat variables and anthropogenic stressors.

Methods of benthic invertebrate collection and data analysis will continue to evolve. Although metric scoring criteria and metric selection varies somewhat between areas in the Pacific Northwest (Skeena, Fraser Valley, Puget Sound and Washington Cascade areas) the overall commonality in chosen metrics, enables comparable statements of aquatic ecosystem health among these study areas and could enable broad environmental reporting. Comparability of different methods applied in overlaping or adjacent areas through examination of performance characteristics (e.g., precision, sensitivity) known as a performance-based method system. The demonstrated common response of the Okanagan B-IBI with the Fraser Basin models and CABIN protocols may further allow harmonized reporting of environmental conditions across geographic and methodological boundaries. To this end, focused comparison of kick and surber net collections, and increased sampling of reference sites to develop an Okanagan model within CABIN is recommended. Defining benthic community response to stressors is potentially more powerful when spatial scales are reduced, and linking this work to probabilistic surveys would enable broader estimation of regional stream conditions.

While harmonization of collection methods and analysis tools between jurisdictions and across borders is a worthy goal it is equally important to apply available information in a timely manner. Given that the B-IBI method has been calibrated for the Okanagan, it can be used to communicate aquatic ecological health and cumulative effects. Further effort must be made on a provincial scale to translate these and other indicator measurements into socially valued descriptors of the environment.

Urban streams in the Okanagan are clearly degraded relative to Okanagan B-IBI reference sites, as well as Fraser Basin reference conditions. Reference condition assessments whether based on B-IBI or RCA may not necessarily require high specificity to be used to differentiate highly stressed sites from reference conditions, and provide better aquatic ecosystem condition definition than chemical measures. This information can be particularly useful to watershed and stormwater management efforts in the Okanagan Basin. As resource, site specificity or consequences of decisions increase, the burden of proof will necessarily rise and more stressor based assessments will be required.

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LIST OF ABBREVIATIONS

ASCI – Alaska Stream Condition Index
B-IBI – Benthic Index of Biological Integrity
BACI – Before After Control Impact (monitoring design concept)
BEAST – Benthic Assessment of Sediment (found in CABIN)
CABIN – Canadian Aquatic Biomonitoring Network
CCME – Canadian Council of Ministers of the Environment
CEA – Cumulative Effects Assessment
DDT – dichlorodiphenyltrichloroethane (organochlorine insecticide)
ILMB – Integrated Land Management Bureau
ISQG – Interim Sediment Quality Guidelines (CCME)
mg/L– milligrams per litre (parts per million)
MMI – multi-metric index
NPS – non-point source
PAH – Polycyclic Aromatic Hydrocarbons
PEL – Probably Effects Level (CCME)
ug/g – micrograms per gram (parts per million)
WQI – Water Quality Index

1 INTRODUCTION

Biological diversity is threatened in freshwater habitats throughout North America. In British Columbia, more aquatic organisms (>30% of fish) are classed as rare or extinct than terrestrial organisms (~12% of mammals) (Anon, 2000). The Province of B.C. has identified sustainable environmental management as a priority, and through regulatory tools, partnerships and education, the B.C. Ministry of Environment seeks to ensure healthy and diverse ecosystems and sustainable environmental practices in communities. The B.C. *Freshwater Strategy* primary long term goal is stated as healthy aquatic ecosystems. The Ministry of Environment, Environmental Protection Division core business areas include strategies to reduce toxins and waste, enhance stewardship actions, and conduct monitoring and reporting to ensure guidelines and standards are met.

Monitoring and reporting the progress of these diverse, but connected environmental protection initiatives, requires a variety of tools and performance measures. Assessment of cumulative effects is considered an essential step towards environmentally sustainable development. Sustainable development of the aquatic environment however, depends on routine and defensible cumulative effects assessment (CEA) (Dube, 2003). Currently there is only limited information to determine the present ecological status or biological condition of Okanagan streams.

A doubling of the Okanagan population in the past 30 years has put increasing pressure on water resources. Portions of many rivers and streams in the Okanagan, have been dammed, dyked, straightened, dredged, or buried in culverts or pipes. Many streams also receive urban stormwater inputs, septic tank and fertilizer seepage, and other point and non-point source contaminant inputs. Rapidly urbanizing landscapes in the Okanagan has increased impervious surface areas (eg. City of Kelowna 2003 SOE report) and associated stormwater inputs to some streams. Within-stream and near-stream habitat impacts due to farming, urban or other development can also affect water quality and quantity. The cumulative effects of these watershed processes on stream health or integrity is largely unknown and complex to evaluate.

Water quality monitoring of Okanagan streams to describe compliance or the state of environment has generally relied on chemical and bacteriological indicators. Degraded water quality and water quality index scores for Okanagan streams have often been associated with bacterial contamination rather than elevated chemical indicators. These measures can directly indicate water quality status relative to drinking water or recreational water use. Aquatic life protection is less certain due to the range of potential non-point source and habitat change stressors encountered within a significantly altered landscape. The significance of the elevated chemical indicators to aquatic life may be speculative given that the chemicals are surrogates for direct biological indicators and at times are naturally occurring elements of groundwater entering the streams. Unless a particular chemical stressor is anticipated, it may not be tested, as the list of possible water or sediment tests is large and expensive to undertake. Further complicating reliance on these measures is that many aquatic contaminants are transient in nature and due to intermittent release are difficult to capture in routine monitoring programs.

Biological indicators, and in particular the use of benthic invertebrates and indices of biological integrity are advocated for cumulative effects assessment because the biota integrate the effects of multiple stressors over time (http://ceq.eh.doe.gov/nepa/ccenepa/sec1.pdf). Recently the Canadian Council of Ministers of the Environment (CCME) acknowledged the merits of establishing biological criteria (biocriteria) to complement chemical and toxicological criteria for assessing environmental quality and ecosystem integrity (McElligott,2006). The cost effectiveness of benthic invertebrates for environmental effects monitoring in B.C. has been noted (Heise, 2005; Reiberger and Sharpe,2006).

Regional or drainage specific studies of benthic invertebrates in tributaries to the Skeena River (Bennett, 2004) and tributaries to the Fraser River (Rosenberg, et al. 1999) have explored benthic indicators of aquatic ecosystem integrity using metrics and reference condition methods. It is unclear if these methods and indices are appropriate for the Okanagan Basin area.

2 PURPOSE

The initial and primary purpose of this pilot study was to test and calibrate a multimetric index, or in this case a benthic invertebrate index of biological integrity (B-IBI) for Okanagan streams. A multimetric index, as the term implies, is the sum of a number of individual metrics or measures. A metric is one attribute or measure of a subject of interest such as fish, benthic invertebrates etc., which is empirically shown to change in value along a gradient of human influence or disturbance. In this case, the attributes are measures of the benthic invertebrate community living in the stream bottom. Examples of a metric for benthic invertebrates could be the total number of individuals, taxa richness, functional feeding groups, presence or absence of tolerant or intolerant species or relative dominance of taxa.

Metrics are known to respond predictably and in similar ways to anthropogenic stress on the east and west sides of the Cascade Mountains. Examples of these responses include decreasing taxa richness, decreases in intolerant and sediment sensitive taxa, and increasing dominance of a few taxa. (Karr, 1999). However, not all metrics work equally well in all areas. Each landscape or 'ecozone' requires verification of metric response because biological assemblages vary with biogeoclimatic factors. The goal is to generate a set of metrics that are reliable in a range of places with known attributes (J. Karr, Pers. Comm.). Metrics evaluated in this study included those successfully used in formulating B-IBI's (benthic index of biological integrity) for areas in Washington, Oregon, Tennessee, Wyoming, Japan (Karr and Chu, 1999) and Smithers B.C. (Bennett, 2004). A good or poor condition statement may have broad geographic application but the metric evaluation and multimetric value or score (B-IBI) can only be assumed representative of the geographic area for which it was verified. This report provides the necessary calibration analysis of a B-IBI for low elevation stream sites in the Okanagan valley.

The second purpose of this work was to examine other tools available for collection and analysis of benthic invertebrates as estimates of aquatic ecosystem health. A number of multivariate methods of benthic data analysis exist and have been reviewed relative to multimetric approach (Bennett and Richardson, 2004; Reynoldson et al, 1997). Multivariate bioassessment approaches typically rely on multivariate statistics to model the relationship between environmental variables and biological communities at unimpacted sites (Reyonldson, et al. 1997). The expected community structure of a test site based on its habitat characteristics is then compared with that of the expected community under the reference condition. The main multivariate bioassessment programs currently in use worldwide are the UK's River Invertebrate Prediction and Classification System (RIVPACS), and the Australian River Assessment Scheme (AUSRIVAS), Environment Canada's Reference Condition Approach (RCA) and the Canadian Aquatic Biomonitoring Network (CABIN).

Re-analysis of this 1999 to 2004 data set has been carried out using BEAST (Benthic Assessment of Sediment) software in CABIN, as well as cluster and multidimensional scaling and discriminant function analysis has been previously reported by Perrin (2006). The purpose of the multivariate analysis was to examine congruency between the CABIN and B-IBI findings as well as to evaluate which environmental variables might be related to benthic invertebrate community structure. The findings of that work are summarized and discussed in this report.

3 METHODS

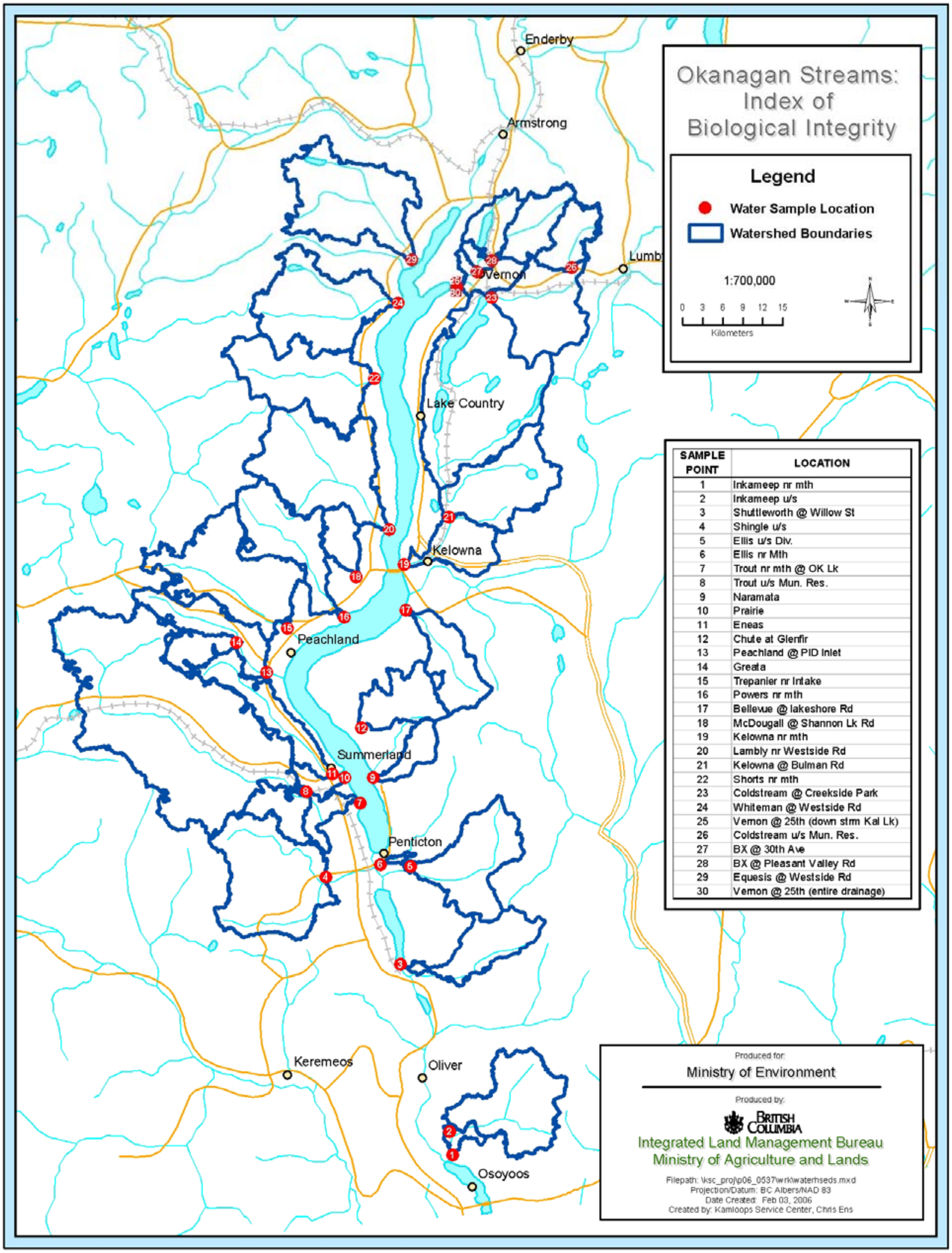
3.1 Site Selection

Benthic invertebrates, water and sediment chemistry samples, and in-stream and near-stream habitat records were collected for Okanagan stream sites between 1999 and 2004. Sampling in 2005 is partially considered in this report. Stream sites were selected from a list of candidates representing a gradient of human influence. Fundamental to calibration of the benthic index of biological integrity (B-IBI) is comparison of benthos measures or metrics found at stream sites with low human influence, with those from high human influence sites. This subset of sites used to calibrate the B-IBI, was chosen initially from discussions with staff in Okanagan provincial fisheries, habitat and water management programs. In particular, these discussions helped to locate relatively unaffected drainages and sites.

Few, if any, Okanagan valley bottom stream locations are completely free of human influence given the history of settlement and multiple uses of watersheds in the Okanagan. To some extent, logging, settlement, road building, and cattle grazing, are present in varying degrees in all Okanagan watersheds. This made it particularly difficult to find ideal reference sites at low elevations. As the scope of this study was to examine cumulative effects at a downstream point in the watershed, all sites were selected as close to the Okanagan valley bottom as practical and had similar broad biogeoclimactic attributes such as stream order, substrate size, elevation, and gradient.

Over the study period, thirty-two sites on twenty three streams were sampled. New sites were added each year but only a portion of the total number were sampled in any one year. Due to changing resources and water conditions only BX Creek at 30th Avenue in Vernon was sampled

Figure 1: Okanagan streams sampled to develop a Benthic Index of Biological Integrity.



SAMPLE POINT	LOCATION
1	Inkameep nr mth
2	Inkameep u/s
3	Shuttleworth @ Willow St
4	Shingle u/s
5	Ellis u/s Div.
6	Ellis nr Mth
7	Trout nr mth @ OK Lk
8	Trout u/s Mun. Res.
9	Naramata
10	Prairie
11	Eneas
12	Chute at Glenfir
13	Peachland @ PID Inlet
14	Greata
15	Trepanier nr Intake
16	Powers nr mth
17	Bellevue @ lakeshore Rd
18	McDougall @ Shannon Lk Rd
19	Kelowna nr mth
20	Lambly nr Westside Rd
21	Kelowna @ Bulman Rd
22	Shorts nr mth
23	Coldstream @ Creekside Park
24	Whiteman @ Westside Rd
25	Vernon @ 25th (down strm Kal Lk)
26	Coldstream u/s Mun. Res.
27	BX @ 30th Ave
28	BX @ Pleasant Valley Rd
29	Equesis @ Westside Rd
30	Vernon @ 25th (entire drainage)

in all six years (1999 to 2004). Sixteen sites were sampled in 1999, 22 in 2000, 13 in 2001, 15 in 2002, 16 in 2003 and 8 in 2004. Three sites were sampled only once during the study period. Figure 1 shows the approximate sampling site location and watershed boundaries for the drainages examined. Two sites not shown on Figure 1 are Peachland Creek at the upstream Peachland Irrigation Diversion (PID) location and Shorts Creek upstream (ups) Westside Rd. These two sites replaced downstream (dns) locations to better match site and watershed condition.

Sites were selected at 1st to 3rd order stream locations (1:250,000 map sheets), and were between 307 metres and approximately 920 metres above sea level. Most sites were along low to moderate gradients, and samples were collected from the riffle habitat with cobble substrates.

3.2 Sampling Reach Condition Estimation

On-going refinement of the calibration site groups was based on sampling reach habitat condition assessed as well as consideration of watershed land use factors summarized in the B.C. Watershed Atlas and GIS analysis described below. Physical characteristics of the sampling site and sampling reach (7-10x bank full width) were recorded at the time of sample collection using the Alaska Stream Condition Index (ASCI) and Bulkley IBI Field Data Sheet Assessment Procedure (Rysavy, 2000). Examples of these field sheets are provided in Appendix 1. Field crew scored habitat variables using the ASCI process on a 0 to 20 scale with respect to a description of each variable. In 2005, sampling and field records also utilized the Environment Canada CABIN protocols in order to allow comparison of the Okanagan reference and test states against those developed for the Fraser Basin (http://cabin.cciw.ca/cabin). Data collected in 2005 are only partially considered in this report. For example, habitat data gathered in 2005 which was considered to be constant (gradient, bankfull width, canopy etc.) over the study period was entered into CABIN. Habitat factors such as stream depth, and wetted width which are variable from year to year have been entered into CABIN, as year specific data. Stream flow data in CABIN for all years is 2005 site specific data as stream flow (m/s) was not consistently gathered prior to 2005. Reference or minimal disturbance sites generally had natural and stable stream channels, and intact deep riparian zones.

3.3 Watershed Condition Estimation

Many streams in the Okanagan are affected by a mixture of land use activities and have unknown or intermediate levels of human impact. Similar to the work of Karr and Chu (1999), and Bennett (2004), sites were grouped into broad human influence categories to facilitate index calibration. Stressor groups were defined as low human influence, moderate or unknown impact, and higher impact. Clearly distinguishing the high and low stress groups is fundamental to index calibration. Habitat and watershed assessement was not intended to be definitive enough in a predictive sense to allow more gradations grouped by landuse activity, nor describe cause and effect of specific land use or intensity of use. Cumulative aquatic effects may be anticipated in watersheds where intensive landuse occurs.

For each watershed, a human influence ranking was initially assigned using data provided by the B.C. Watershed Atlas (1998), interpretation of orthophotographs, and from discussion with ministry staff with field knowledge regarding past human encroachment or impact on streams in the Okanagan. Further refinement and confirmation of these land use estimates was provided in 2005 by Chris Ens, Acting Land Information Coordinator at the Integrated Land Management Bureau, Ministry of Agriculture and Lands, Kamloops. In this GIS analysis, Agriculture Land Reserve (ALR) boundaries were used to estimate extent of potential agricultural activity in the watershed without consideration for intensity of land cultivation or proximity to water course or whether the land was currently in agricultural production. Estimates of forest harvest in the past 20 years were made from the 2001 Timber Supply Review # 2 (TSR 2) data set. TSR 2 refers to the second TSR for an area. A TSR reviews the timber supply for an area and adjusts the annual allowable cut. The GIS dataset produced from a TSR is often used for other GIS analysis because it already incorporates many useful datasets including vegetation and habitat type data (C. Ens, Pers. Comm.). Percent urban area was estimated from Terrain and Resource Information Management mapping (TRIM) for build-up areas and TRIM buildings within 100 metres of the streams. Road density (km/ha) within 100 metres of the streams and number of road crossings was estimated from TRIM mapping. These estimates were made for the entire watershed area upstream of the sampling point, as well as within a 5 km radius of the sampling point.

3.4 Benthic Invertebrate Collection and Identification

Sampling of benthic invertebrates in Okanagan area streams was carried out in the month of October in years 1999, 2000, 2001, 2003, 2004 and August-September in 2002. Working in a downstream to upstream sequence, three separate, one minute Surber samples were collected with a 210 micron mesh Surber sampler. Placement of the Surber sampler on the stream bottom was done randomly within riffle habitat but rocks larger than 250mm were avoided. Otherwise, the Surber was positioned on the stream bottom and stones larger than 50mm within the quadrate were rubbed lightly in front of the Surber, and then placed in a bucket for more careful inspection later. Once all stones larger than approximately 50mm were removed, the finer sediments below were mixed with a hand trowel to a depth of 15 cm for one minute to dislodge benthic invertebrates. Contents of the cod end of the Surber sampler were deposited in a bucket and washed and decanted through a 210 micron sieve bucket. This process of washing with clean water and decanting suspended matter into the mesh bottom bucket was conducted at least 5 times or until all visible organisms were collected in the sieve bucket. Samples were finally washed off the screen bottom bucket into 250ml bottles and were preserved in 10% formalin.

Taxonomic identification and counting of invertebrates was conducted by Sue Salter and Linda Curry of Fraser Environmental Services. Each sample was washed and sieved through two brass screens (1 mm and 0.250 mm) to remove formalin, clay particles and separate the material into two different size fractions for analysis. The separated fractions were all transferred to an 80% ethanol solution. Where practical the large macroscopic organism fraction was sorted in its entirety because of the taxonomic resolution given by larger and more mature organisms. The small microscopic fraction was subsampled using a surface area based method when the number of organisms in the fraction was estimated to be greater than 400. Balancing the cost of identification against diminishing discriminatory power of the index with reduce organism subsamples (Doberstein et al. 2000), the goal of the subsampling was to achieve a subsample of at least 200 organisms. Where the numbers in the coarse fraction were estimated to be more than 400, a subsample was also taken. Taxonomic identification was to the lowest practical level which was commonly genus in most cases except for chironomidae and oligochaeta.

Sorting and identification was done using a Nikon SMZ800 binocular microscope and taxonomic keys noted in Appendix 2. The subsampling guidelines prescribed a minimum number of 400 organisms per sample to be counted with greater taxonomic effort given to the coarse fraction of the sample. When samples contained extremely high numbers of organisms in the fine fraction, efforts were made where practical to not subsample beyond the level of $1/16^{th}$. The numbers reported were for the whole sample. Sorting QA/QC was done according to Environment Canada Environmental Effects Monitoring (EEM) guidelines. A reference collection was prepared during the course of the study and all invertebrates were transferred to individual vials with 80% ethanol and the debris is stored in the original containers for taxonomic QA/QC.

In 2005 samples were collected by both the Surber method (B-IBI) as described above, as well as the CABIN protocol using 400 micron mesh kick net. The single kick net sample was collected as a three minute composite travelling kick sample from an adjacent riffle section of the stream. These samples and the corresponding CABIN habitat records were collected at all sites. Once taxonomic data is available for the 2005 samples, a full comparison and evaluation of the two methods can occur for streams in the Okanagan area. Preliminary comparison of the B-IBI and CABIN analysis of Surber collected data from 1999 to 2004 has been carried out (Perrin, 2006) and is summarized in Section 5.

3.5 Water and Sediment Chemistry Sampling

In some years of this study, single grab samples of water for analysis of general ions, nutrients, bacteria and metals were taken mid stream and mid depth at the sampling sites. This limited data only provides general characterization of the water quality during the base flow conditions normally present in the fall. *In situ* measurements for temperature, dissolved oxygen, specific conductivity and pH were also taken at the stream bank. For the purposes of characterizing the stream environment inhabited by benthic invertebrates, the single water sample is clearly limited to documentation of site conditions on the day of collection. For some streams, more extensive water chemistry exists for proximate or upstream sites and could be used at a later date to more fully describe stream water chemistry variation.

Each year a number of sites were sampled for sediment quality. Collection targeted shallow depositional areas along the margins of the streams. Composite samples of fine grain stream sediments were collected directly into lab prepared containers. Because trace elements are more likely to be associated with fine grained fractions, sieving (< 70u) at the lab can help to "normalize" the samples (Bonn, 1999). Sediment samples were analyzed for percent organic carbon (2001-04), metals and polycyclic aromatic hydrocarbons (PAHs). Normalizing the sediment PAH values for total organic carbon (TOC) in this study is compromised by a lack of TOC data in 1999 and 2000. Further, TOC values of 2 to 3% in 2001-02 are at odds with results ranging from 63-100% in 2003-04. This incongruity is unresolved although it appears that in 2001-02 the samples were ground and thus included a higher proportion of sand, whereas in 2003-04 the samples were sieved to <70 microns before analysis thereby increasing the organic content often associated with smaller particle sizes. Pesticide scans were conducted in 2003 on sediments from ten sites with high agriculture or urban exposure. As the benthic invertebrate samples were from mid stream cobble or gravel riffles, the sediment chemistry data serves to indicate the relative potential exposure of invertebrates to hydrophobic and sediment bound contaminants such as PAHs and metals rather than actual exposure.

In order to obtain representative and uncontaminated samples, the sequence of collection activities involved water sampling, then benthic invertebrate sampling, sediment sampling, and finally habitat assessment and photo documentation. Care was taken during sampling sediments and benthos to avoid foot traffic through or upstream of subsequent collection areas.

All samples were either preserved on site, or chilled on ice prior to preservation, storage or transport to the appropriate laboratory. Water and sediment chemistry and benthic invertebrate taxonomy are stored in the provincial EMS data archive. All taxonomic data (1999-2004) is also stored in the CABIN database.

3.6 Benthic Invertebrate Metric Definitions and Calculation

Research on diverse taxonomic groups has shown that many of the same biological attributes indicate human-induced disturbance (Karr and Chu, 1999). As human influence increases, taxa richness declines, the relative abundance of generally tolerant organisms increases, and sensitive taxa disappear. The anticipated response of benthic invertebrate metrics to human impact, are shown in Appendix 3. These metrics are well studied and represent a variety of metric types such as taxon richness, community composition, tolerance-intolerance, feeding and other habits (Doberstein et al. 2000). Twenty three metrics were calculated on an annual basis for each stream site. Benthic invertebrate metrics (eg. number of plecoptera or stoneflies) were calculated for each replicate to the lowest possible level. This process was carried out each year of this study by BioLogic Consulting. Methods used to calculate metrics followed those used for the Skeena Region Forest Science Project (Bennett, 2005). All non-aquatic, adult or pupae counts were removed from the raw data sets prior to metric calculation. As well, zooplankton and any invertebrates not identified to family level, were excluded prior to metric calculation. Chironomids which were keyed to family and non-insects keyed to order or family level. Most B-IBI metrics are expressed as a cumulative count or average across the three Surber samples collected at a site. Metrics were averaged over the years of study for verification of predictable response to the human stressor gradient.

3.7 Species of Special Note

The inventory of aquatic invertebrate species distribution in British Columbia and Canada is not comprehensive. Only a few molluscs (Rocky Moutain Ridge Muscle) and dragonflies or mayflies (Odonata) are designated on the national Species at Risk (SARA) list or the provincial Endangered Species list (http://srmapps.gov.bc.ca/apps/eswp/). The dragonfly *Argia vivida* is Red listed and *Argia emma* is Blue listed in the provincial system. The *Argia* sp. found in BX Creek in Vernon and in Eneas Creek in Summerland is either *Argia vivida* or *emma*. *Argia vivida* has been found near Penticton in Max Lake. *Argia vivida* is often associated with thermal spring habitat in southern British Columbia (Salter, Pers. Comm. 2006).

4 RESULTS

4.1 Water Quality

Only water chemistry data pertinent to determining nutrient concentrations, conductivity and temperature were gathered during this specific study. Summary statistics for September and October low flow conditions during the study period (1999-2004) were retrieved from EMS and used to populate the CABIN database and enable the multivariate analysis conducted by Perrin (2006). A summary of this data is given in Appendix 4.

Data from other concurrent water quality studies do exist for some of the drainages and will be reported more fully with respect to water quality objective attainment at some future date. Water quality monitoring on some of these streams in the 1990's has been previously reported (http://www.env.gov.bc.ca/wat/wq/public/bcwqsr/bcwqsr1.html). The findings at that time, indicated the non-attainment of water quality objectives was generally confined to bacteriological parameters, and a few metals such as aluminium, iron and manganese, which could be from groundwater inputs naturally enriched in these metals. In this study, higher conductivities and nitrate levels are generally encountered in streams travelling through Okanagan urban and agricultural areas during the fall sampling period. Preliminary review of the 2005 water quality objective attainment monitoring program on lower Vernon, Deep, Kelowna, Trepanier and Peachland creeks (data not shown) suggests that some non-attainment of objectives occurred for bacteriological parameters. Metals were below aquatic life guidelines during fall sampling periods (data not shown in this report). Multivariate analysis of water quality measures (see Section 5 below) found alkalinity as a potential influence on benthic assemblages. Other surveys have found nitrogen and phosphorus to be associated with reduced ecological status of streams in the western US (Stoddard et al. 2005). Further examination of the data is warranted to ensure it is representative and to examine association to benthic invertebrate measures.

4.2 Sediment Quality

Sediments originating from human activities are considered the largest contaminant of U.S. waters (Waters, 1995). Apart from physical effects of smothering aquatic habitat, eroded sediments often transport metals, organic compounds and other materials entering from direct discharges, atmospheric sources and erosion run-off (Bonn, 1999). Two principal groups of sediment contaminants considered briefly in this study are metals and polycyclic aromatic hydrocarbons (PAHs). Sediments can serve as long term sinks and sources of these substances, which can be either acutely or chronically toxic to aquatic organisms (Salomons, 1987).

Metals can be elevated in the aquatic environment due to natural and anthropogenic effects. Metals may leach from culverts and conduits, vehicles, paints, metal fabrication or machining operations, as well as naturally occurring mineralogy of the watershed. Heavy metals such as zinc, lead, and copper (Richardson et al. 1998, Marselek et al. 1997) are commonly elevated in stormwaters from urban roadways and are toxic to aquatic life.

Urban stream sediments in B.C., and elsewhere often contain elevated PAHs (Grey and Tuominen, 1999; Bonn, 1999) and are useful indicators of stream contamination from urban run-off. Polycyclic aromatic hydrocarbons (PAHs) are largely combustion by-products from natural (forest fires, volcanics) or anthropogenic sources (petroleum product spillage, urban run-off, vehicle exhaust, waste and wood incineration). PAHs are largely hydrophobic and bind to organic sediments in the aquatic environment.

4.2.1 METALS IN STREAM SEDIMENTS

Table 1 provides average values for selected heavy metal elements found in sediments of low and high impact stream groups. All metals data are given in Appendix 5a. Data are presented in both cases relative to Canadian Council of Ministers of the Environment (CCME) interim and probable effect level guidelines for the protection of aquatic life. Arsenic, cadmium, selenium and silver were below or near detection levels. Only a few elements of concern were found at some stream sites. Comparison of arsenic and cadmium data to guidelines was also compromised due to elevated detection limits. Chromium was occasionally elevated above the interim sediment quality guidelines (ISQG: 37.3 ug/g) in sediments in Powers, Trout, Lambly, Shorts, BX @ 30th, McDougall, Peachland, Trepanier, and Equesis. Many of these streams are on the northwest side of Okanagan Lake, suggesting common naturally occurring anomalies due to geology. Average chromium values exceeded the ISQG at Shorts Creek (89 ug/g; n=2).

Copper exceeded ISQ guidelines (35.7 ug/g) at BX @ 30th three times, and at Lambly, Peachland, and Eneas Creek once. The average value for BX @30th also exceeded the ISQ guideline (46.3 ug/g).

Lead was consistently elevated at BX @ 30th and exceeded the probable effect level (PEL: 91.3 ug/g) in 1999 and the ISQ guidelines (35 ug/g) in 2000, 2001, 2004. The average lead value for BX @ 30th (52.3 ug/g) also exceeded the ISQ guideline but not the PEL. The lead ISQ guideline was exceeded in 2000 at Trout Creek @ Hwy 97, and at Lambly Creek @ Westside Road suggesting a combination of natural and anthropogenic inputs.

Zinc was consistently high, and exceeded the ISQ guidelines (123 ug/g) at BX Creek at 30th Ave. in 1999, 2002 and 2004. Average zinc concentrations in BX Creek sediments at 30th Ave (165.5 ug/g) exceed the ISQ guideline. Upstream values on BX were elevated in 2004 suggesting upstream sources. Zinc ISQ guidelines were exceeded in 2003 at Eneas Creek (138 ug/g), and Kelown Creek @ Bulman Rd (129 ug/g).

Table 1: A summary of average metals (ug/g dry wt.) in Okanagan stream sediments for high and low influence stream sites used in B-IBI calibration

Influence Group ↓	Metal	Arsenic	Cadmium	Chromium	Copper	Lead	Zinc
	CCME ISQ Guideline (ug/g)	5.9	0.60	37.30	35.70	35.00	123.00
	CCME PEL Guideline (ug/g)	17	3.50	90.00	197.00	91.30	315.00
High	BX Cr @ 30th	4.1 (n=4)	0.56 (n=3)	35.4 (n=6)	46.3 (n=5)	52.3 (n=6)	165.5 (n=6)
	Kelowna Cr nr mth.	1.2 (n=3)	0.21 (n=3)	21.3 (n=5)	15.3 (n=5)	15.6 (n=5)	89.7 (n=5)
	Eneas Cr	1.0 (n=1)	0.42 (n=3)	15.4 (n=5)	17.3 (n=4)	17.0 (n=5)	87.9 (n=4)
	Prairie Cr	<MDC	0.8 (n=2)	19.6 (n=2)	13.6 (n=2)	16.5 (n=2)	68.5 (n=2)
Low	Peachland	6.1* (n=4)	0.33 (n=2)	31.6 (n=5)	22.8 (n=5)	17.3 (n=4)	78.0 (n=5)
	Shorts Cr	ND	ND	89 (n=2)	25.6 (n=2)	22.5 (n=2)	79.8 (n=2)
	Chute Cr	<8 (n=3)	1 (n=1)[1]	7.6 (n=3)	6.8 (n=3)	14.0 (n=1)	33.2 (n=3)
	Whiteman Cr	1.6 (n=1)	0.06 (n=1)	14.4 (n=1)	7.2 (n=1)	5.4 (n=1)	44.8 (n=1)

Non detect records for arsenic and lead in years 1999 to 2001 not included in calculation of mean due to elevated MDC of 8 ug/g
Non detect records for cadmium values in years 1999 to 2001 not included in calculation of mean due to elevated MDC of 0.8 ug/g
CCME ISQG: Canadian Council of Ministers of Environment Interim Sediment Quality Guideline (same as BC Guidelines).
CCME PEL: Canadian Council of Ministers of Environment Probable Effects Level (same as BC Guidelines).
* Peachland arsenic elevated due to detection at or near 8 ug/g MDC in 1999 and 2001.
<MDC indicates all data below various detection limits
ND indicates no data available
n = number of samples used for calculating mean
[1] value maybe an artifact of elevated MDC of 0.8 ug/g in 1999

Sediments in BX Creek at 30th typically contained 2 to 3 fold more copper, lead and zinc than the other urban streams in the Okanagan. Further analysis of this stream and potential metal inputs is warranted.

Appendix 5b shows evaluation of sediment quality data using the CCME water quality index (WQI) calculation and B.C. Working Guidelines for arsenic, chromium, cadmium, copper, iron, lead, manganese, nickel, silver and zinc (Nagpal, 1998). It is cautioned that the CCME WQI should not replace a detailed analysis of monitoring data and is intended to provide a broad overview of environmental performance. Although this WQI is of only one media (sediment) and only one test per year, it does contain more than 4 parameters and comparisons between sites are appropriate given the common time frame, detection limits, and parameter list. Of the low influence group, Shorts Creek ranked as marginal, Equesis and Peachland creeks as Fair, Chute and Whiteman creeks were good and excellent respectively. Exceedances for groundwater related metals such as iron and manganese were common to most sites. Good WQI scores were given for sediments at high impact sites such as Eneas and Prairie creeks; a fair score for Kelowna Creek near mouth and marginal for BX at 30th.

4.2.2 PAHs in Stream Sediments

Polycyclic aromatic hydrocarbons were frequently detected in urban stream sediments. A summary of total PAH data for the high and low impact calibration groups of sites is shown in Table 2 relative to the CCME guidelines. PAH data for all sites and years is tabulated in Appendix 6 relative to CCME and B.C. Freshwater Sediment Guidelines. Comparison to B.C. guidelines, which require normalizing to 1% organic carbon, is cautioned due to uncertainty of sediment total organic carbon (TOC) content as noted above. When B.C. guidelines are not available, CCME values can used which do not account for organic carbon content (N. Nagpal, Pers. Comm.). Highest total and individual PAH levels were consistently found in BX Creek @ 30th Ave. in Vernon. Total PAHs at this site ranged from 6.6 to 12 ug/g (mean 8.9 ug/g) and in all five years exceeded the CCME total PAH interim sediment quality guidelines to protect aquatic life. Interpretation of this data relative to the B.C. PAH guidelines is compromised by inconsistent sample preparation and organic carbon estimates as noted previously. For example in 2001, in sediments containing 2.64% TOC, the benzo(a)pyrene (B(a)P) was 0.67 ug/g, and exceeded the normalized B.C. guideline for B(a)P of 0.6 ug/g. In 2003 and 2004, the higher sediment TOC levels allowed B(a)P and many other PAHs to remain below the B.C. guidelines.

Ellis near mouth, Shuttleworth, Eneas, Prairie, and Vernon creeks also contained elevated PAH compounds. Although Kelowna Creek drains a moderately large urban area, elevated PAHs above guidelines (without normalization for TOC) were only found in three of five years of monitoring. Lower incidence of elevated PAHs in Kelowna Creek (0.23-2.36 ug/g) than BX Creek (both highly urbanized drainages) may be related to storm water control practices, street maintenance, hydrographic factors or landuse/contaminant generation differences between the two watersheds. At a hypothetical organic carbon of 2%, none of the sites would indicate PAH values in excess of the CCME Probable Effect Levels (PELs). Only trace amounts of PAH were found in sediments of the non-urbanized streams.

Table 2: Total PAHs in sediments of selected high and low impact Okanagan streams.

Influence Group ↓		1999	2000	2001	2002	2003	2004
	CCME ISQ Guideline (ug/g)	4	4	4	4	4	4
	CCME PEL Guideline (ug/g)	22	22	22	22	22	22
High	BX Cr @ 30th	6.82	8.80	8.95	6.60	10.00	12.00
	Kelowna Cr nr mth.	2.36	0.65	ND	0.23	0.98	2.00
	Eneas Cr	0.48	0.37	3.01	0.25	0.44	ND
	Prairie Cr	<0.02	3.37	ND	ND	ND	ND
Low	Peachland	<0.02	<0.02	<0.02	0.08	ND	<0.01
	Shorts Cr	<0.02	<0.02	ND	ND	ND	ND
	Chute Cr	<0.02	0.07	<0.02	ND	ND	ND
	Whiteman Cr	ND	ND	ND	<0.01	ND	ND

CCME ISQG: Canadian Council of Ministers of Environment Interim Sediment Quality Guideline (same as BC Guidelines).
CCME PEL: Canadian Council of Ministers of Environment Probable Effects Level
ND indicates no data available

Given the usually high PAH levels in BX Creek relative to other urban stream sites in the Okanagan, further investigation of sources of PAH and stormwater management in this drainage is warranted.

4.2.3 PESTICIDES AND POLYCHLORINATED BIPHENYLS (PCB) IN STREAM SEDIMENTS

Organochlorine and organophosphate pesticide scans and PCB analyses were run on fine grain depositional sediments from a number of urban and agricultural stream sites in 2003. These streams included Eneas and Shingle, and upstream-downstream pairs on Kelowna, BX, Trout, and Ellis. Detection limits were generally 0.04 ug/g (ppb) or lower (eg. DDE,p,p' MDL 0.02 ug/g; endosulfan 0.04 ug/g; see Appendix 7 for parameter list and detection limits). No PCBs (MDCs: 0.02-0.2 ug/g) or organophosphate pesticides (MDCs: 0.01-0.05 ug/g) were detected in the samples. Of the organochlorine compounds surveyed, only a few were detected. DDE,p,p', a metabolite of DDT, was found at 0.046 ug/g in Kelowna Creek near Sutherland Avenue and 0.044 ug/g at the Bulman Road site. Higher levels of DDE, p,p' (2.1 ug/g) and endosulfan II (0.34 ug/g) were found in Eneas Creek. In the later case, ambient concentrations were further removed from the detection limits and less likely to be false positive values. The CCME freshwater sediment ISQ and PEL guidelines for DDE, p,p' are 1.42 ug/kg and 6.75 ug/kg (no correction for %TOC) or three orders of magnitude lower than concentrations in Eneas Creek. Further evaluation of sediments in Eneas Creek should be considered, particularly as endosulfan was also detected. Endosulfan is currently used for orchard pest control and is a moderately hydrophobic organochlorine pesticide with a sediment half life of more than 30 days (http://ca.water.usgs.gov/pnsp/rep/fs09200). No freshwater sediment guidelines exist for this material. Additional pesticide data for Eneas and other streams in the Okanagan is currently being gathered and evaluated by Environment Canada (T. Tuominen, Pers. Comm.).

4.3 Habitat Condition Evaluation

Table 3 provides a summary of average sampling reach condition (ASCI scores), 1998 Watershed Atlas estimates of watershed use and 2005 ILMB estimates for land use factors in the reference and high impact groups used for calibration of the Okanagan B-IBI. These values are relative indicators of potential human influence or environmental stress. ASCI scores for all stations and years is provided in Appendix 8. Appendix 9 gives ILMB (2005) GIS statistics for all sites and Appendix 10 provides GIS maps for the entire drainage and 5km radius projections.

4.3.1 SAMPLING REACH HABITAT INTER ANNUAL VARIATION

Alaska Stream Condition Index scores of 130 or greater out of 200, were considered as an indication of lower relative site disturbance. Sites chosen as low influence with high ASCI scores were Peachland, Chute, Equesis, Shorts and Whiteman creeks. Sites with ASCI scores below 65 were considered high impact. These included BX @30th, Eneas, Prairie, and Kelowna creeks. Coefficients of variation for sites with three or more years of data show low variation around the mean but increasing from approximately 10% in the low impact group, to 20% in the high impact group.

4.3.2 METRIC EVALUATION

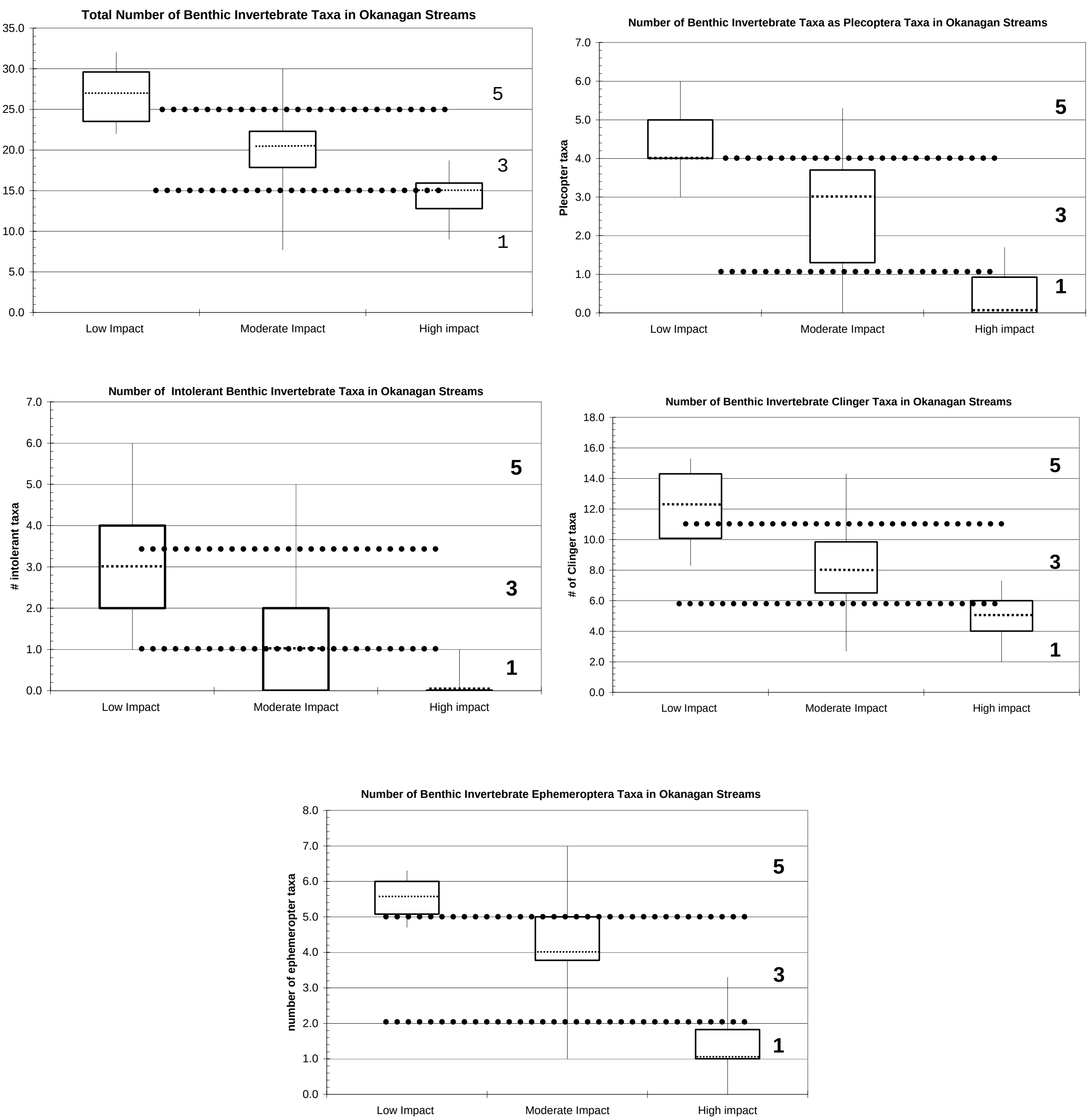
Prior to the calibration of the B-IBI, year to year variability of 13 individual metrics were evaluated for Bellevue, BX, Chute, Peachland, Ellis d/s, Eneas, Shingle, Trout d/s and McDougall. Metrics examined included number of individuals, Hilsenhoff Biotic Index, taxa richness, percent predators, clinger taxa richness, long lived taxa richness, percent dominance, Simpson's diversity index and evenness (Bennett, 2005). From a series of two-way analysis of variance (ANOVA) tests, Bennett concluded there was no significant difference in metric results between years for the data groupings with the exception of number of individuals which decreased significantly from 2000 to 2003. This could be due to the drying trend and very low flows encountered over that time period.

Twenty three metric's (see Appendix 3 for list of metrics) were plotted against sites grouped by estimated degree of human impact. Invertebrate metrics for potential inclusion in an index must respond predictably to increasing human influence, and show clear separation of metric values in the low and high influence groups. Box plots were prepared for each metric using all data for all years and grouped by human influence level. The metrics which varied predictably, and clearly distinguished between watersheds with higher and lower levels of cumulative stress were total number of taxa, number of plecoptera taxa, number of ephemeroptera taxa, number of clinger taxa and total number of intolerant taxa (Figure 2).

Table 3. Watershed disturbance factors of calibration sites. Alaska Stream Condition Index (ASCI), Watershed Atlas and Integrated Land Management Bureau GIS estimates of watershed condition.

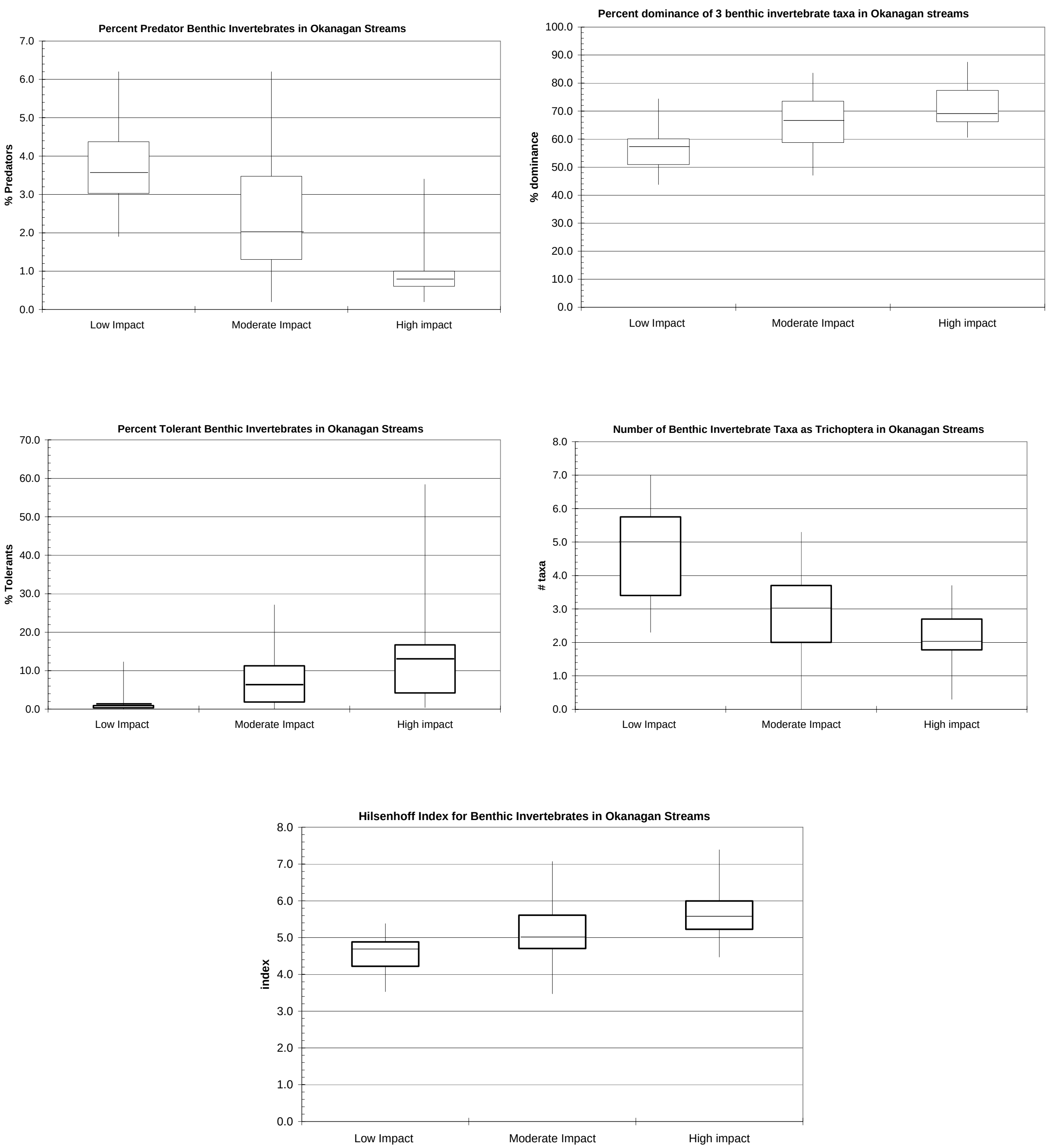
Location	ASCI mean score	Watershed Atlas Estimate			ILMB GIS Estimated % Land Use for Entire Watershed and within 5km of sampling point					
Low Impact Sites	n/200	Logged	Ag	Urban	Logged	Log <5km	Ag	Ag <5km	Urban	Urban <5km
Peachland Cr d/s PID intake	171	5.4	0	0.7	7	0	10	20	0.4	0.2
Chute Cr @ Glenfir Rd	158	13	0.1	0	13	5	0	0	0.4	0.7
Equesis Cr at Westside Rd	139	14	3.1	0	6	0	4	28	0.5	3.5
Shorts Cr ups Westside Rd	163	15	0	0	8	1	3.6	6	0.1	1
Whiteman Cr at Westside Rd	137	16.5	0.5	0.4	8	0	5.5	55	0.1	0.9
High Impact Sites										
Eneas Cr ups Hwy 97	63	2.8	12	1.6	0	0.5	21.5	27	5.1	30.5
Kelowna Cr nr Pandosy St	62	15	15.5	18.5	7	0	25.3	0	17.3	77.6
BX Creek at 30th Ave Vernon	62	0	20	80	0	0	16.7	17	52	52
Prairie Cr nr mouth	60	0	60	40	0	0	35.1	36	29.6	51.9

Figure 2. Benthic invertebrate metrics which varied predictably when plotted against human influence gradient or stream condition. Boxes show upper and lower quartiles; line within box is the median and whiskers outside are the maximum and minimums. Dotted line indicates scoring cut-off point and bold number to left indicates metric score for values above below or between the 2 diamond lines (5=low impact, 3=medium, 1=high impact).



The Hilsenhoff Biotic Index, number of tricoptera taxa, percent tolerant taxa, the percent predator taxa, and the percent dominance of the three most abundant taxa, varied predictably, and presented good or complete separation of the upper two quartiles of the low impact group and lower two quartiles of the high impact group, but lacked complete separation between high and low impact groupings (Figure 3). Thirteen other metrics responded unpredictably to the human influence stressor gradient.

Figure 3. Benthic invertebrate metrics which gave moderate response when plotted against human influence gradient or stream condition. Boxes show upper and lower quartiles; bar within box the median and whiskers the maximum and minimums.



4.3.3 METRIC SCORING

The five metrics which provided a predictable and logical response to the gradient of human impact were further examined by looking at scatter plots (not shown) of all metric data over the stressor range to judge whether abrupt changes were evident in the data series across the site series. Box plots in Figure 3 were divided by two scoring lines ensuring the scoring separated lower quartile of the low impact group from the upper quartile of the high impact group. As only a few sites at low elevations in the Okanagan valley may represent low stress, the middle score (3) was expanded to include low scores of the low impact group and upper scores of the high impact group. In these plots five points are assigned to the metric values in the lower impact section of the series, three points given to intermediate metric values and 1 point for those metrics which group into a higher impact category.

Value ranges corresponding to portions of the metric spread are summarised in Table 4, for each of the responsive metrics.

Table 4: Five metrics and scoring cut-off points for the Okanagan watershed benthic invertebrate index of biological integrity (B-IBI).

Metric Scoring Cut-off Points	**1**	**3**	**5**
Total Number Taxa	≤14.9	15-24.9	≥25
Number Plecoptera Taxa	≤1	1.1—3.9	≥4
Number Ephemeroptera Taxa	≤2	2.1-4.9	≥5
Average Number Clinger Taxa	≤5.9	6-9.9	≥10
Number of Intolerant Taxa	≤0.49	0.5-2.9	>3.0

Following on the protocol developed by Karr and Chu (1999), utilized in the Puget Sound Salmonweb monitoring program, and the Upper Bulkely watershed (Bennett and Ohland, 2001), the potential total metric score was divided into five relatively equal portions as shown in Table 5.

The five portions are not exactly equal, as a small number of low elevation Okanagan stream sites are likely to be either very poor or excellent. The majority are likely fall in between the two extremes.

Table 5: Five metric Okanagan B-IBI and estimated stream condition

Okanagan Multimetric B-IBI Score	**Stream Condition**
23-25	Excellent
19-22	Good
14-18	Fair
9-13	Poor
5-8	Very poor

A complete list of Okanagan streams and associated multimetric benthic index of biological integrity (B-IBI) scores and corresponding stream condition statements are provided in Table 6. Refinement of stream condition statements have been used elsewhere to provide more biological context (http://www.clallam.net/streamkeepers/html/benthic_index.html)

Table 6: Okanagan stream sites, Metric IBI scores, total B-IBI scores and stream condition.

Stream Name	# Taxa	Number of Taxa Metric Cut-off Points	# Ephemeroptera	Number of Ephemeroptera Metric Cut-off Points	# Plecoptera	Number of Plecoptera Metric Cut-off Points	# Intolerant	Number of Intolerant Taxa Metric Cut-off Points	# Clinger	Number of Clinger Metric Cut-off Points	Total IBI Score	Stream Condition
Equesis Cr at Westside Rd	26.0	5.0	5.8	5.0	5.4	5.0	3.5	5.0	12.9	5.0	25.0	excellent
Peachland Cr dns PID intake	29.4	5.0	5.5	5.0	4.4	5.0	3.6	5.0	13.3	5.0	25.0	excellent
Shorts Cr ups Westside Rd	27.3	5.0	5.7	5.0	4.0	5.0	4.0	5.0	12.7	5.0	25.0	excellent
Whiteman Cr at Westside Rd	26.4	5.0	5.9	5.0	5.2	5.0	2.0	3.0	12.0	5.0	23.0	excellent
Ellis Cr ups @ Diversion	22.4	3.0	6.7	5.0	4.7	5.0	3.5	5.0	11.5	5.0	23.0	excellent
Chute Cr at Glenfir Rd	24.3	3.0	5.3	5.0	3.5	3.0	1.8	3.0	10.4	5.0	19.0	good
McDougall Cr at Shannon Rd	23.9	3.0	4.4	3.0	4.2	5.0	3.0	5.0	8.5	3.0	19.0	good
Coldstream Cr @ Creekside Prk	22.7	3.0	4.3	3.0	4.0	5.0	1.0	3.0	10.0	5.0	19.0	good
Lambly Cr nr mth	22.6	3.0	5.3	5.0	4.0	5.0	2.0	3.0	8.4	3.0	19.0	good
Coldstream Cr u/s Mun Res	20.0	3.0	3.8	3.0	4.2	5.0	5.0	5.0	8.0	3.0	19.0	fair
Greata Creek	23.0	3.0	3.3	3.0	3.3	3.0	2.0	3.0	10.0	5.0	17.0	fair
Bellevue Cr at Lakeshore Rd	20.0	3.0	5.1	5.0	2.4	3.0	1.3	3.0	8.2	3.0	17.0	fair
BX Cr nr PV Rd	21.3	3.0	3.2	3.0	3.8	3.0	3.5	5.0	8.6	3.0	17.0	fair
Inkameep Cr nr mth	21.8	3.0	4.8	3.0	2.2	3.0	1.0	3.0	10.9	5.0	17.0	fair
Peachland Cr nr mth	22.3	3.0	4.3	3.0	3.7	3.0	2.0	3.0	9.3	3.0	15.0	fair
Shorts Cr nr mth	21.1	3.0	4.5	3.0	2.5	3.0	1.0	3.0	7.3	3.0	15.0	fair
Inkameep Cr u/s	20.7	3.0	4.9	3.0	1.5	3.0	0.5	3.0	8.7	3.0	15.0	fair
Powers Cr nr mth	20.3	3.0	4.3	3.0	2.5	3.0	0.7	3.0	8.2	3.0	15.0	fair
Trepanier Cr @ Hwy 5c	19.3	3.0	4.7	3.0	3.0	3.0	2.0	3.0	8.7	3.0	15.0	fair
BX Cr dns PV Rd	24.3	3.0	2.3	3.0	3.0	3.0	1.0	3.0	9.3	3.0	15.0	fair
Trout Cr ups Mun. Res	22.7	3.0	4.4	3.0	3.1	3.0	1.8	3.0	8.9	3.0	15.0	fair
Naramata Cr	20.7	3.0	4.5	3.0	2.5	3.0	1.3	3.0	8.6	3.0	15.0	fair
Shingle Cr ups mth	21.3	3.0	5.1	5.0	2.7	3.0	0.3	1.0	9.5	3.0	15.0	fair
Ellis Cr nr mth	17.5	3.0	4.0	3.0	1.0	1.0	0.2	1.0	7.2	3.0	11.0	poor
Vernon Cr at 25th	15.0	3.0	2.3	3.0	1.0	1.0	0.0	1.0	6.0	3.0	11.0	poor
Prairie Cr nr mth	15.9	3.0	3.2	3.0	0.9	1.0	0.0	1.0	6.4	3.0	11.0	poor
Kelowna Cr at Bulman Rd	17.0	3.0	1.0	1.0	1.0	1.0	0.7	3.0	5.8	1.0	9.0	poor
Trout Cr nr mth Okanagan L	14.3	1.0	3.3	3.0	0.9	1.0	1.0	3.0	5.9	1.0	9.0	poor
Shuttleworth Cr nr mth	17.3	3.0	3.9	3.0	1.2	1.0	0.3	1.0	5.6	1.0	9.0	poor
Eneas Cr	16.0	3.0	1.4	1.0	0.4	1.0	0.2	1.0	5.4	1.0	7.0	very poor
Kelowna Cr nr mth	14.6	1.0	1.0	1.0	1.1	1.0	0.2	1.0	4.9	1.0	5.0	very poor
BX at 25th Ave	12.7	1.0	1.3	1.0	0.1	1.0	0.3	1.0	4.0	1.0	5.0	very poor

5 DETAILED SITE ANALYSIS

Examination of the low impact group and high impact groups, as well as upstream downstream station pairs provides additional insight into application of the B-IBI within the Okanagan basin. Chute, Peachland, Shorts and Whiteman creeks were selected to represent the low influence group for calibration purposes. Each was judged to have comparatively low urban, agriculture, or forest harvest near the site, and in the watershed as a whole. These sites invariably had high scores for metrics known to occur in streams with little contamination or alteration. Downstream locations on Kelowna, Prairie, Eneas and BX creeks were used as high influence sites for calibration. These sites typically had higher urban and agriculture influence, received stormwater inputs and have highly altered riparian and instream habitats. Discussion of stream condition below shows that lowest metric scores were invariably recorded for these sites. Concurrently sampled upstream downstream pairs of sites were available on BX, Kelowna, Trout, Ellis and Inkameep creeks. In each circumstance, the downstream site B-IBI scores were lower than that of the upstream site. Two sites sampled in different years on Coldstream Creek found lower B-IBI scores at the upstream site. Nutrient inputs from agriculture and septic tank leachate to the downstream site and a natural slide introducing sediment to the upstream site or year to year variance may account for this anomaly.

5.1 Equesis Creek

This creek drains a watershed of 214.7 km2 on the northwest side of Okanagan Lake. The creek was sampled in 2002, 2003, and 2005 and showed high conductivity (452.5 uS/cm) and low summer temperatures, suggesting significant ground water contribution during low flow periods. Low nitrate (0.154 mg/L) and modest phosphorus (0.024 mg/L) concentrations occur during low flows and may be normal for this landscape. A low to moderate stream gradient, small cobble substrate and low embeddedness furnish good instream habitat conditions. The one sediment sample collected for Equesis Creek (2002) reported chromium, manganese and nickel were above CCME ISQ guidelines. No PAHs were detected. Sampling reach habitat scores were high (ASCI:139) and GIS analysis showed low human influence for the watershed as a whole (urban:0.5 %, log:6.9%,ag: 3.9%). Although near site estimates suggest a higher stress factor for agriculture (urban: 3.5%, log:0%,ag: 27.9%) this maybe an overestimate. ALR areas appear to cover natural grasslands and forested areas which may have agricultural potential but are not currently used. As well, scattered rural residential dwellings may overestimate urban impact estimates. For the primary metrics, Equesis Creek demonstrated a high number of taxa (26), ephemeroptera (5.8) and plecoptera (5.4), high numbers of intolerant taxa (3.5) and clingers (12.9) for a B-IBI score of 25/25. Of the secondary metrics, % predators, Hilsenoff Index, % tolerants, and number of long lived taxa responded predictably, and scored better than the median for the low influence group, and thus could be considered for stream specific assessment.

5.2 Whiteman Creek:

This creek is located adjacent to Equesis Creek and drains an area of approximately 204 km2 to the sampling point. This stream was sampled in 2002 near the mouth, and near Westside Road bridge in 2003, and 2005. High conductivity (289 uS/cm) suggests significant ground water contribution during low flow periods. Low nitrate (0.02 mg/L) and modest phosphorus (0.033 mg/L) concentrations occur during low flows. Sediments collected in 2002 found no PAHs, and all metals below aquatic guidelines. A low stream gradient, cobble substrate and low embeddedness provide good in-stream habitat conditions. Portions of the stream below Westside Road are affected by encroachment or channelling, however, sampling reach habitat scores were high (ASCI:136) near the bridge and GIS analysis showed low human influence for the watershed as a whole (urban:0.1 %, log:8.9%,ag: 5.5%) (Appendix 9). Although near site estimates suggest higher stress factors for urban and agriculture (urban: 0.9%, log:0%, ag: 55.0%) these maybe overestimates. ALR areas appear to cover natural grasslands and forested areas which may have agricultural potential but are not currently used. As well, scattered rural residential dwellings may overestimate urban estimates. For the primary metrics, Whiteman Creek demonstrated a high number of taxa (26.4), ephemeroptera (5.9) and plecoptera (5.2), higher numbers of intolerant taxa (2) and clingers (12) yield a B-IBI of 23/25. Secondary metrics such as % predators, Hilsenoff Index, % tolerants, responded predictably, scored better than the median for the low influence group, and could be considered for stream specific assessment.

5.3 Shorts Creek:

Shorts Creek is located at short distance to the south of Whiteman Creek and drains an area of 184.6 km2 to the sampling point. This stream was sampled near the mouth in 1999 and 2000 in areas of moderate human disturbance. Portions of the lower watershed run through a provincial park and old farming and cottage areas on the alluvial fan. In 2003, and 2005 the site was moved further upstream above the Westside Road to better match near stream habitat conditions with those higher in the watershed. Moderate conductivity (249 uS/cm) very low nitrate (0.003 mg/L) and low phosphorus (0.017 mg/L) concentrations occurred during low flows. Shorts Creek sediments in 1999 and 2000 reported chromium, manganese, and nickel above ISQ guidelines. Chromium values in Shorts Creek were the highest of all Okanagan sites tested in 1999 and 2000, and were near the probable effects level (90 ug/g). No PAHs were detected in 1999 or 2000. A low to moderate stream gradient (2.5%) and gravel to cobble substrate with moderate embeddedness at the lower site contrasts the cobble with boulders and low embeddedness at the upper site, thus providing good in-stream habitat conditions. Sampling reach habitat scores were much higher upstream (ASCI:163u/s vs 90 d/s). The GIS analysis from the lower site still indicates low human influence for the watershed as a whole. (urban:0.1 %, log:9.1%, ag: 3.6%). Near site (5km) estimates also indicate low stress factors (urban: 1%, log: 1.7%, ag: 6%) (Appendix 10). For the primary metrics, Shorts Creek demonstrated a high number of taxa (27.3), ephemeroptera (5.7) and plecoptera (4), higher numbers of intolerant taxa (4) and clinger taxa (12.7) providing a B-IBI of 25/25. The total metric score for the lower site with compromised sampling reach habitat was 15/25. Secondary metrics such as number of trichoptera, dominant 3 taxa, Hilsenoff Index, and % tolerants, responded predictably, scored better than the median for the low influence group, and could be considered for stream specific assessment.

5.4 Peachland Creek:

Located on the west side of Okanagan Lake, Peachland Creek drains an area of approximately 134.7 km2 to the sampling point. This stream was sampled near the mouth in 1999 where some park trails, picnic areas and residential encroachment occurs. A site further upstream near the Peachland drinking water intake was sampled in subsequent years to better match near stream habitat conditions with the condition factors for the rest of the watershed. Moderate conductivity (159 uS/cm) very low nitrate (0.006 mg/L) and low phosphorus (0.011 mg/L) concentrations occurred during low flows. Sediment chemistry in 1999-2004 indicates some elevation in chromium, manganese and nickel as might be expected in a mineralized drainage, but no or low PAH content. A low to moderate stream gradient (2%), cobble substrate with moderate embeddedness at the lower site contrasts with large to small cobble substrate with low embeddedness at the upper site indicating good in-stream habitat conditions. At the lower site sampled in 1999 the substrates are smaller, resulting from spawning gravel placement for fisheries enhancement. Sampling reach habitat scores were higher upstream than downstream (ASCI:171 u/s vs 122 d/s) due to public access and proximity to housing. The GIS analysis from the upper site indicates low human influence for the watershed as a whole (urban:0.3 %, log: 8.2%, ag:9.9%). Near site (5km) estimates also indicate low stress factors (urban: 0.1%, log:0%, ag: 20.5%) as the ALR areas above the sampling point appear on air photos to be primarily forested. For the primary metrics, Peachland Creek above PID diverson demonstrated a high number of taxa (29.4), ephemeroptera (5.5) and plecoptera (4.4), higher numbers of intolerant taxa (3.6) and clinger taxa (13.3) yielding a B-IBI of 25/25. The total metric score for the lower site with compromised sampling reach habitat was 15/25. Secondary metrics such as number of trichoptera, % predators, number of long lived taxa, % dominance of 3 taxa, Hilsenoff Index, responded predictably, scored better than the median for the low influence group, and could be considered for stream specific assessment.

5.5 Chute Creek:

Located on the east side of Okanagan Lake above Naramata, Chute Creek drains an area of approximately 80 km2 to the sampling point. The stream gathers water from areas of Okanagan Mountain Park and Chute Lake, and was affected by the forest fire in 2003. In terms of size the Chute Creek watershed is in the lower quartile of the study group and the sampling site is only 10km from Chute Lake. Waters of Chute Creek are low in conductivity (55.3 uS/cm), low in nitrate (0.01 mg/L) and moderate phosphorus (0.021 mg/L) and high in colour during low flows. Chute Creek sediments were relatively low in metals and PAHs. A cadmium value in 1999 just above the higher detection limit could be a lab artefact. A low stream gradient (0.5%) and large cobble substrate with moderate embeddedness, provides good in-stream habitat conditions. Sampling reach habitat scores were high due to the natural stream configuration and intact riparian habitat (ASCI:158). The GIS analysis indicates low human influence for the watershed as a whole (urban: 0.4 %, log: 14.2%, ag:0.0%). The elevated % forest harvest overall is much reduced within 5km of the sample site at Glenfir Road (urban: 0.7%, log: 6%, ag: 0.0%). For the primary metrics, Chute Creek exhibited a high number of taxa (24.3), ephemeroptera (5.3) and plecoptera (3.5), a moderate number of intolerant taxa (1.8) and clinger taxa (10.4) yielding a B-IBI of 19/25. Secondary metrics such as % tolerants, % predators, number of long lived taxa, and % dominance of 3 taxa responded predictably, scored better than the median for the low influence group, and could be considered for stream specific assessment.

5.6 Prairie Creek:

Prairie Creek is a small (20 km2) perennial drainage on the west side Okanagan Lake. The stream runs through agricultural and urban areas of Summerland. For a considerable distance the stream runs through pipes underground or road side ditches. Waters of Prairie Creek are high in conductivity (426 uS/cm), relatively moderate levels of nitrate (0.7 mg/L) and higher levels of phosphorus (0.05 mg/L). Sediments tested in 1999 and 2000 were generally low in metals (cadmium near detection limit). PAHs were below detection in 1999 but relatively high (3.37 ug/g) the following year. At the sampling reach the stream gradient is moderate (2.5%) but is much steeper a short distance upstream. Stream sediments consist of small cobble and gravel with moderate embeddedness Sampling reach habitat scores were low due to the urban encroachment, channelization and loss of instream and near stream habitat (ASCI:61). The GIS analysis indicates high human influence for the watershed as a whole (urban:30 %, log: 0.0%,ag:35%). Within 5km of the sample site at Lakeshore Road the urban influence estimate increases considerably (urban: 52%, log:0.0%, ag: 36%). For the primary metrics, Prairie Creek exhibited a low number of taxa (15.9), ephemeroptera (3.2) and plecoptera (0.9), no (0) intolerant taxa, low numbers of clinger taxa (6.4), yielding a B-IBI of 11/25. Lower metric scores could in part be due to small substrate size and the small size of the watershed. Secondary metrics such as Hilsenhoff Biotic Index, % predators, number of long lived taxa, responded predictably, scored equal to or poorer than the median for the high influence group, and could be considered for further stream specific assessment.

5.7 Kelowna Creek:

Kelowna Creek is a moderate to large watershed on the east side Okanagan Lake draining approximately 227 km2 The stream runs through forest in the valley highlands before descending to the agricultural and urban areas of the valley bottom. For a distance the stream runs in road side ditches and receives considerable storm drainage from the City of Kelowna. Kelowna Creek has over forty storm drainage outfalls that empty into the creek and approximately 25% of the lower watershed is impervious (City of Kelowna SOE report:http://www.city.kelowna.bc.ca/citypage/docs/pdfs/Environment%20Division/Environment%20Reports/State%20of%20the%20Environment%20Report%20-%202003.pdf). Two sites were sampled on Kelowna (Mill) Creek, one just downstream of the Kelowna Airport and a golfcourse, the other near the confluence of Okanagan Lake at Sutherland Avenue. Waters of Kelowna Creek are high in conductivity (479 uS/cm u/s; 590 uS/cm d/s), relatively low levels of nitrate upstream but much higher downstream (0.08 mg/L vs 2.3 mg/L) and higher levels of phosphorus (0.06-0.08 mg/L). Sediments in Kelowna Creek near Sutherland Avenue were generally low in metals. Only manganese and periodically nickel were found above ISQ guidelines. Total PAH levels in Kelowna Creek at the downstream location were on average the third highest (1.24 ug/g) in the Okanagan after BX Creek @ 30th (8.86 ug/g) and Ellis Creek nr mth (1.93 ug/g). At both sites the stream gradient is low (1-1.5%). Stream sediments consist of small pebble and gravel with moderate to high embeddedness at the downstream site. Upstream substrates are somewhat larger with small cobble and large pebbles only partially embedded by surrounding sediments. Sampling reach habitat scores were lowest at the downstream site due to the urban encroachment, channelization and loss of instream and near stream habitat (ASCI:105 u/s vs 60 d/s). The GIS analysis indicates high human influence for the watershed as a whole (urban:17 %, log: 14.4%, ag:25%). Within 5km of the sample site at Sutherland Avenue the urban influence estimate increases to become the highest urban percentage of the study group (urban: 77.6%, log:0.0%, ag: 67.7%). For the primary metrics, Kelowna Creek exhibited a low number of taxa (14.6), ephemeroptera (1) and plecoptera (1.1), intolerant taxa (0.2) low numbers of clinger taxa (4.9), yielding a B-IBI of 5/25. Lower metric scores could in part be due to small substrate size. Metrics at the upstream site on Bulman Road were low for number of taxa (17.0), ephemeroptera (1) and plecoptera (1), intolerant taxa (0.7) and numbers of clinger taxa (5.8), yielding a B-IBI of 9/25. Secondary metrics such as number of trichoptera, % tolerant, % predators, number of long lived taxa, and % dominance responded predictably at the Sutherland Avenue site, scored equal to or poorer than the median for the high influence group, and could be considered for further stream specific assessment. At the Bulman Road site the Hilsenhoff Biotix Index, number of trichoptera and number of long live taxa scored equal to or poorer than the median for the moderate influence group, and could be considered for further stream specific assessment.

5.8 Eneas Creek:

Eneas Creek is a small (93 km2) perennial drainage on the west side Okanagan Lake. The stream runs through agricultural and urban areas of Summerland. Garnet Lake in the headwaters is approximately 12.5km upstream of the sampling site. For much of its length Eneas Creek is bordered by agricultural and urban land use. Waters of Eneas Creek are relatively high in conductivity (539 uS/cm), nitrate (0.93 mg/L) and phosphorus (0.07 mg/L). Sediment metals were not generally elevated in Eneas Creek but did exceed CCME ISQ guidelines for copper and zinc in 2003. Average total PAH levels (0.91 ug/g) in Eneas were fourth highest in the study. At the sampling reach the stream gradient is moderate (3%) but is generally lower in sections immediately upstream. Stream sediments consist of small cobble and pebble with moderate embeddedness Sampling reach habitat scores were low due to the urban encroachment, channelization and loss of instream and near stream habitat (ASCI:63). The GIS analysis indicates high agriculture influence for the watershed as a whole (urban: 5.1 %, log: 0.5%, ag: 21.5%). Within 5km of the sample site just downstream of Rosedale Avenue, the urban influence estimate increases significantly (urban: 30.5%, log: 2.2%, ag: 26.7 %). For the primary metrics, Eneas Creek exhibited a low number of taxa (16), ephemeroptera (1.4) and plecoptera (0.4), low intolerant taxa (0.2), low numbers of clinger taxa (5.4), yielding a B-IBI of 7/25. Lower metric scores could in part be due to small substrate size and the small size of the watershed. Secondary metrics such as Hilsenhoff Biotic Index, % number of trichoptera, number of long lived taxa, and % dominance of 3 taxa, responded predictably, scored equal to, or poorer than the median for the high influence group, and could be considered for further stream specific assessment. The presence of *Argia*, a genus listed on the B.C. Endangered Species List should be considered in further monitoring or management action for Eneas Creek (http://srmapps.gov.bc.ca/apps/eswp/).

5.9 BX Creek:

BX Creek is a moderate sized watershed on the east side Okanagan Lake draining approximately 68 km2 on the west slope of Silver Star Mountain and provincial park lands into Swan Lake at the valley bottom. BX Creek then flows out of the south end of Swan Lake, travelling a distance of approximately 3.7km through the City of Vernon before entering Vernon Creek a short distance downstream. Two sites were sampled on BX Creek, one near Pleasant Valley Road (PVR) on the eastern edge of the city and upstream of Swan Lake, and the other was downtown at 30th Avenue downstream of Swan Lake. A third site was sampled once at Pleasant Valley Road in 1999, immediately downstream of the drinking water pump station overflow. Chlorinated drinking water had spilled into BX Creek at this location for a number of weeks prior to sample collection. BX Creek is a community watershed and has extensive water quality data for a site upstream of PVR. Data reported here are those samples collected concurrent with the benthic sampling in the fall. Both upstream and downstream locations had high conductivity (504 uS/cm u/s; 627 uS/cm d/s), relatively high levels of nitrate upstream (1.6 mgL) and downstream (1.0 mg/L), and moderate levels of phosphorus (0.01 mg/L ups; 0.032 mg/L d/s). As described previously in this report, the sediments in BX Creek at 30th Ave. consistently contained the highest concentration of metals and PAHs in this study. At the upstream site the gradient is 1% or greater and 0.5% at the downtown location. Stream sediments consist of large and small cobble with partial embeddedness upstream, and moderately embedded small cobble and pebble at the downstream site. Sampling reach habitat scores were lowest at the downstream site due to the urban encroachment, channelization and loss of instream and near stream habitat loss (ASCI:120 u/s vs 62 d/s). The GIS analysis for the upper site indicates low to moderate human influence for the watershed as a whole (urban: 11 %, log: 0.9%, ag: 9.5%). Within 5km of the upper sample site the urban and agriculture influence estimates increase considerably (urban: 34%, log: 0.0%, ag: 30%). At the 30th Avenue site, GIS analysis indicates very high human influence for the watershed back up to Swan Lake (urban:52 %, log: 0%,ag:16.7%). For the primary metrics, BX Creek at the upstream site exhibited a moderate number of taxa (21.3), ephemeroptera (3.2) and plecoptera (3.8), intolerant taxa (3.5) low numbers of clinger taxa (8.6), yielding a B-IBI of 17/25. Metrics at the downtown site near 30th Avenue were the lowest in the study, with very low total number of taxa (12.7), ephemeroptera (1.3) almost no plecoptera (0.1), or intolerant taxa (0.3), and low numbers of clinger taxa (4.0), yielding a B-IBI of 5/25. Secondary metrics such as the

Hilsenhoff Biotic Index, the number of long lived taxa, and % dominance responded predictably at the 30th Ave. site and scored equal to or poorer than the median for the high influence group, and could be considered for further stream specific assessment. The disparity in watershed size, connectivity to upland forest habitats and smaller instream substrates at 30th Ave., suggest it unlikely that the downstream site could achieve the benthic community found upstream at the Pleasant Valley Rd. However, a considerably higher B-IBI score might be expected if lower BX Creek and the surrounding landscape were pristine. Comparison of the primary and secondary metrics above and below the 1999 chlorinated water discharge at Pleasant Valley Road shows that total taxa, plecoptera , trichoptea, decreased, while Hilsenhoff Biotic and % tolerant taxa increased. The 1999 B-IBI scores were 21 upstream and 19 downstream. Not a large separation, but use of secondary metrics would potentially further increase the differential. The presence of *Argia*, a genus listed on the B.C. Endangered Species List should be considered in further monitoring or management action for lower BX Creek (http://srmapps.gov.bc.ca/apps/eswp/).

5.10 Trout Creek:

Trout Creek is the second largest watershed in the Okanagan, draining approximately 679 km2 and entering the south basin of Okanagan Lake near Summerland. Two sites were sampled on Trout Creek, one near the diversion point to the Summerland municipal drinking water reservoir and the other downstream of Highway 97. Trout Creek upstream of the reservoir is affected by forest harvest, cattle grazing, reservoir manipulation and some rural residential development. Significant influences on downstream site are a perpetual slide releasing silts into the creek and elevating turbidity (20 NTU) during periods of low flow, channelization, and riparian habitat alteration of the lower portion of the creek bed for flood control. Specific conductivity during autumn, on average increases downstream (96 uS/cm u/s; 161 uS/cm d/s), as does nitrate (u/s: 0.007 mgL; d/s: 0.177 mg/L) and phosphorus (0.009 mg/L ups; 0.028 mg/L d/s). Chromium was elevated in sediments at both sites in 1999. In 2000 chromium, lead, manganese and nickel were elevated downstream over the ISQ guidelines. In 2003 manganese was elevated at both sites, and nickel at the downstream site, relative to the ISQ guidelines. At the upstream site the gradient is 1% or greater and 0.5% at the downtown location. Stream sediments consist of partially embedded large and small cobble upstream, and moderately embedded cobble and small pebble at the downstream site. Sampling reach habitat scores were lowest at the downstream site due to the urban encroachment, channelization and loss of instream and near stream habitat (ASCI: 142 u/s vs 59 d/s). The GIS analysis for the upper site indicates low to moderate human influence for the watershed as a whole (urban: 0.4 %, log: 16.8%, ag: 7.8%). Within 5km of the upper sample site, the urban and agriculture influence estimates increase considerably, while the logging estimates decrease (urban: 9.2%, log: 0%, ag: 18.4%). The urban estimate captures scattered rural residences and the agriculture estimate is largely ALR potential rather than intensive land use. GIS analysis for the watershed down to the Highway 97 crossing shows similar estimates to the upstream site (urban: 1 %, log: 16.7%, ag: 9.7%). The 5 km radius analysis shows much higher potential for urban and agriculture influence (urban: 41.7 %, log: 0%, ag 59.8%). In reality, the urban influence continues to be scattered rural residences. Adjacent agriculture land use is intensive but encroachment is limited given the set-back dykes installed for flood control. For the primary metrics, Trout Creek at the upstream site exhibited a moderate average number of taxa (22.7), ephemeroptera (4.4) and plecoptera (3.1), intolerant taxa (1.8) low numbers of clinger taxa (8.9), yielding a B-IBI of 15/25. Metrics at the downtown site near Highway 97 were lower with very low total number of taxa (14.3), ephemeroptera (3.3) almost no plecoptera (0.9), or intolerant taxa (1), and low numbers of clinger taxa (5.9), yielding a B-IBI of 9/25. Of the secondary metrics number of trichoptera decreased downstream (3.2-2.2), % tolerant taxa increased considerably (5.7-19.2), % predators decreased (3.3-2.5). The other metric of note for this pair of sites was % sediment tolerant taxa which increased significantly at the downstream site (6.3 u/s; 24.5 d/s).

5.11 Ellis Creek:

Ellis Creek is a moderate sized watershed on the east side Okanagan Lake draining approximately 154 km2 into the Okanagan River channel in Penticton. Ellis Creek flows out of the Ellis Lake or reservoir, travelling a distance of approximately 14.6 km through canyon areas before reaching the first sampling location just upstream of the City of Penticton diversion reservoir. The creek then travels a further 2.75 km through a highly channelized length, bounded by industrial, commercial and residential landuse before reaching the downstream site near the confluence with the Okanagan River. Both upstream and downstream locations had low conductivity (71 uS/cm u/s; 63 uS/cm d/s), relatively low levels of nitrate (0.003 mgL u/s; 0.004 mg/L d/s) and low levels of phosphorus (0.018mg/L ups; 0.016 mg/L d/s). Sediments in Ellis Creek increased in copper, chromium, lead and zinc between upstream and downstream locations but remained below ISQ guidelines for aquatic life protection. PAHs were not detected upstream but were always detected at the downstream site and the average (1.9 ug/g) was second highest of the study group. Percent slope is moderate at both sites (1.75% u/s; 1.5% d/s). Stream sediments consist of large cobble and small pebble with partial embeddedness upstream, and moderately embedded large cobble and gravel at the downstream site. Partial embeddedness is recorded for both sites, but the substrate at the downstream site is more cemented and difficult to dislodge. Sampling reach habitat scores were lowest at the downstream site due to the urban encroachment, channelization and loss of instream and near stream habitat (ASCI:134 u/s vs 63 d/s). GIS analysis for the upper site indicates moderately high forest harvest for the watershed as a whole (urban:0 %, log: 20.3%, ag:0%). Within 5km of the upper sample site the influence estimates remain low (urban: 0%, log: 0%, ag: 0%). At the downstream site GIS analysis indicates similar influence factors as the upstream site totals (urban: 1.5 %, log: 20.1%, ag: 0.1%). Within 5km of the downstream site the urban influence estimate increases substantially (urban: 40.8%, log: 0%, ag: 2.3%) For the primary metrics, Ellis Creek upstream exhibites a high number of taxa (22.4), ephemeroptera (6.7) and plecoptera (4.7), intolerant taxa (3.5) low numbers of clinger taxa (11.5), yielding a B-IBI of 23/25. Metrics at the downtown site were substantially lower with very low total number of taxa (17.5), moderate number of ephemeroptera (4.0), very few plecoptera (1), or intolerant taxa (0.2), and low numbers of clinger taxa (7.2), yielding a B-IBI of 11/25. Secondary metrics such as the Hilsenhoff Biotic Index, number of trichoptera, % tolerants, and % predators, responded predictably at the upstream site and scored equal to or better than the median for the moderate influence group, and could be considered for further stream specific assessment. At the downstream site secondary metrics such as the Hilsenhoff Biotic Index, number of long lived taxa, % dominance of 3 taxa responded predictably, scoring equal to or lower than the median for the moderate influence group, and could be considered for further stream specific assessment.

6 MULTIVARIATE ANALYSIS RESULTS

As mentioned above, two general concepts of benthic invertebrate data assessment are the multimetric index approach evaluated above, and the multivariate approaches. These two approaches have been reviewed a number of times (Bennett and Richardson, 2004; Reynoldson et al. 1997). Both approaches have merit and can provide complementary information in the Okanagan (Perrin, 2006). As part of the Okanagan evaluation process a comparison of B-IBI stream condition scores to a derivation of stream condition using multivariate analysis following the Reference Condition Approach (RCA) (Rosenberg et al. 1999) was carried out (Perrin, 2006). In the RCA procedures, all samples were tested for degree of stress using the Benthic Assessment of Sediment (BEAST) software available on the Environment Canada CABIN (Canadian Aquatic Biomonitoring Network) website (http://cabin.cciw.ca).

Data from 90 site and year observations for the same Okanagan samples used above for B-IBI calculation, were independently tested using BEAST and compared to B-IBI results. The BEAST evaluation used family level identification while the B-IBI scores are based on taxonomic identities ranging from family to genus. Overall the BEAST assessment was conservative in showing fewer unstressed sites and more severely stressed sites than was found by the B-IBI (Perrin, 2006). There was complete agreement between the methods for 29% of the sites; BEAST assigned a worse condition than the IBI score for 55% of the sites, and assigned a better condition than IBI for 13% of the sites. Where differences in output between the methods occurred, a spread of more than two stress categories was not found and 81% of the sites were the same or one stress category apart. Both methods were good at detecting stress where a degree of disturbance was known to be present based on local knowledge of stream water quality (Perrin, 2006).

Perrin notes that the BEAST analysis can be more comprehensive because it includes all taxa in the stream communities rather than using metrics of selected parts of communities. Analyses also need to incorporate ecological context and structure function of the biota (Karr, Pers. Comm.). Differences in sample collection methods used to form the reference model in CABIN (travelling kick net) may account for some of the difference in findings. Incomplete correspondence in B-IBI and BEAST findings may also be due to BEAST orientation to reference models developed for the Fraser/Georgia Basin which may not ideally match reference conditions specific to the Okanagan basin. Despite these shortcomings, the substantial agreement between the BEAST and IBI approaches in detecting stress suggests that sampling method and geographic specificity of the BEAST model may not be critical for use in preliminary site testing (Perrin, 2006). Perrin concludes that it may be possible to use B-IBI/Surber collected samples in BEAST assessments, although error would likely be reduced if collections used a kick net as outlined in the CABIN protocols (http//cabin.cciw.ca). The converse is equally true; kicknet samples can also be used to develop B-IBIs and CABIN does provide metric calculation. Further analysis of cross over potential will be examined using the 2005 data set which employed both collection methods for a subset of Okanagan streams. Combinations of the benefits of IBI and RCA methods may be most powerful for water managers in the Okanagan if it can be shown that sample collection methods can be integrated to a single technique. Perrin recommends that both approaches be applied to surface water monitoring in the Okanagan region once further sampling occurs to develop a reference model for the Okanagan.

Using cluster analysis and non-metric multidimensional scaling (MDS) Perrin identified three sample groups. All samples from streams influenced little by disturbance, and used to calibrate the Okanagan B-IBI, were found to group tightly together. The analysis placed sites known to be affected to some degree by anthropogenic disturbance in the two other main groups. These three community groupings were distinguished by abundance and diversity of four mayfly families, six stonefly families, six caddisfly families, the naidid and lumbriculid worms, Elmid beetles, freshwater snails, and six true fly families including the chironomids. These findings may be further examined for potential enhancement of the metrics used for the Okanagan B-IBI. For example the selection of tricopterans as secondary metrics could be refined using the cluster analysis which found certain caddisflies (Hydropsychidae, Lepidostomatidae, and Limnephilidae) common in higher impact sites while Brachycentridae and Rhyacophilidae were more prevalent in low impact sites.

Perrin applied discriminant function analysis (DFA) using stream habitat and stressor data to reveal which of the measured attributes might contributing to site impairment. The output indicated that a combination of physical and chemical variables best discriminated sample groups which were defined by the biological composition among all sites. The concentration of sediment PAH, sediment manganese, sediment nickel, and alkalinity were best at discriminating between the three sample groups. Known toxicity and relatively large difference in the concentration of sediment PAH compared to the other variables suggests that PAH constituents may be most important in determining site quality at the high impact sites.

7 DISCUSSION

For decades water pollution has largely been synonymous with chemical pollution and great progress has been made at considerable expense, to remove or reduce industrial or municipal source inputs. Challenges continue in that area. However, it is increasingly apparent that despite these efforts, aquatic ecosystem integrity in many areas continues to degrade. A complex variety of changes to habitat structure and connectivity, introduction of alien species as well as chemical stressors continue to compromise aquatic ecosystem integrity (Karr and Chu, 1999). Prediction and assessment of site specific effects is often hindered due to multiple projects or stressors over space and time (Dube and Munkittrick, 2000). This is particularly relevant to streams in the Okanagan, where point source contaminant inputs are few, and the main stressors at a landscape level maybe from hydrologic, habitat alteration and non-point sources (NPS) of contamination.

Indices of biotic integrity (Karr et al. 1986; Karr 1991) are powerful tools for evaluating the cumulative effects of stressors on natural systems, because biological communities act as integrators of multiple stressors over time. Use of biological indicators of aquatic ecosystem health is not new in B.C. Fish or benthic invertebrate assessments upstream and downstream of mining, pulp mill, municipal or other significant point source discharges are widely used and guided in some cases by federal environmental effects monitoring program requirements. Before-after-control-impact (BACI) studies are generally limited to specific discharge sites and duration of operation (e.g. EnTox, 2006; Homestake Nickel Plate Mine EIA) and could be greatly strengthened through an understanding of the regional context. Enhanced understanding of condition of the upstream or downstream site condition relative to the regional norms encourages meaningful and reasonable management targets to be set for environmental protection. A parallel example might be only having upstream downstream comparisons for water chemistry and not the benefit of guidelines for comparative reference.

Where multiple stressors are involved, the strength of interpretation will increase as additional reference area information is made available (http://www.ec.gc.ca/eem/English/MetalMining/Background/AQUAMIN.cfm Chpt. 4-2). The benefits of a regional CEA framework include consistent application of science-based methods, incorporation of regional effects-based information into project or community specific stressor-based assessments, and linkage to other forms of community and regional scale environmental management, planning and reporting (Dube, 2003).

Reliance on conventional water quality measures may not provide adequate or affordable information to report aquatic ecosystem health for degraded Okanagan streams. It is not uncommon for streams to meet water objectives or guidelines (water chemistry or bacteriology) but demonstrate reduced biological integrity either quantitatively or qualitatively. Richardson et al. (1998) found urban stormwater changes to benthic community structure were more definitive than sediment metal concentrations or simulated mesocosm studies alone. Dube et al. (2006) noted incorporation of biological indicators was essential to measure changes that were not detected in northern rivers using the Water Quality Index. Booth et al. (2004) noted recent studies in the Pacific Northwest which suggest little if any relationship between water quality parameters and biological health in streams until urbanization exceeds moderate levels.

The benthic invertebrate information presented here shows more clearly than conventional meansures, the environmental condition of streams within the rapidly urbanizing landscape of the Okanagan. Table 7 below is a partial summary of data for four Okanagan streams which have specific water quality objectives and sediment quality data, and also have provisional B-IBI and CABIN scores. For Peachland, where chemical stressors and landuse stressors are low, all measures give congruent scores of high environmental quality. As watershed alteration increases in the example of Trepanier Creek, benthic measures indicate measurable change in benthos relative to reference conditions unrecognized by water quality measures. Streams in highly altered landscapes, such as Kelowna and Vernon creeks, continue to report fair water and sediment quality when the benthic communities are significantly degraded relative to reference conditions. In this study, both benthic invertebrate metrics (B-IBI) and multivariate analysis have shown that a number of low elevation stream sites in the Okanagan are in poor or very poor stream condition relative to estimates of reference conditions. Sediment chemistry partially supports these findings for only the highly altered landscape. These findings are congruent with work elsewhere but further analysis would be required of the water quality data before conclusions could be made.

Table 7: Comparison of Water and Sediment Quality Attainment and Benthic Index of Biotic Integrity

	Water Quality Attainment and status in 1993*	Water Quality Index *estimate* 2005	Sediment Quality Index using metals data 1999 - 2004	B-IBI 1999-2004	CABIN ranking 1999-2004
Peachland Creek	Good (Max Al)	Good	Fair	Excellent	Uninfluenced
Trepanier Creek	Good	Good	Fair	fair	Potentially Stressed
Kelowna Creek	Fair (Fecal)	Fair (Fecal)	Marginal	very poor	Severely Stressed
Vernon Creek	Fair (Fecal, tss, d.o.)	Fair (Fecal)	Excellent	poor	Potentially Stressed

* parameters in brackets contributed most significantly to non-attainment

Peachland, Equesis and Shorts creeks had the highest B-IBI scores of 25 or excellent indicting high biodiversity and presence of organisms intolerant of a variety of stressors. Although Peachland watershed has some logging and mining, its riparian corridor for some distance upstream of the sampling site is in very good condition. Higher reference site scores may be found in the Okanagan as more sites and years are added to the data set. Continued monitoring of low impact sites is recommended with some additional information gathered to understand the effect of elevation on benthic community measures and to provide other monitors (local governments etc) with reference information. With the exception of Peachland Creek, BEAST ranked these sites somewhat lower in condition relative to Fraser Basin reference conditions. Further evaluation of reference conditions in the Okanagan and development of an Okanagan reference model within BEAST is recommended, as it will enable provincial and national consistency. Utilization of the same data set and refinement of the Okanagan B-IBI will enable harmonization and comparative reporting with similar initiatives in the US portion of the Columbia drainage, Puget Sound, lower Fraser Valley (GVRD), and Skeena area.

Lowest B-IBI scoring streams, indicating very poor biological conditions were BX at 30^{th}, and Kelowna Creek at Sutherland Avenue. Higher scores may be found at other nearby locations on these streams where there is less intimate contact with stressors such as stormwater outfalls. It is also possible that lower scores will be encountered as urbanization of the Okanagan continues (Karr. Pers. Comm.). BX Creek at 30^{th} Ave is greatly altered by channelization, culverts, stormdrainage and agriculture and has an average B-IBI score of 5. At this location, BX Creek contained on average only 12.7 taxa, essentially no plecopterans, and 1 taxa of ephemeroptera. The high PAH levels in BX @ 30^{th} sediments and the presence of *Argia sp.* should be considered in management efforts to improve the condition of the waterway. PAH source analysis is recommended and should consider that a new and concerning source of PAHs is the increasing use of parking lot sealcoats (Van Metre et al. 2005). The discrepancy between the very poor B-IBI score for BX @ 30^{th} and BEAST assessment (potentially stressed at upstream and downstream locations) could be due to specificity of the Fraser Basin model.

Both B-IBI and BEAST assessed Kelowna Creek as severely stressed at both sites. Kelowna Creek, although receiving stormwater from the largest city in the Okanagan, has slightly better

B-IBI scores and lower sediment PAH than BX @30th St. These findings may be related to natural factors such as reduce hydrologic variation due to more constant groundwater inputs, or the greater landuse planning and stormwater control efforts within the Kelowna area.

Given the B-IBI (very poor) and BEAST (stressed) scores, and pesticide detection in Eneas Creek sediments, this catchment deserves further study of pesticide usage and sediment inputs. Both DDE and endosulfan may be entering Eneas Creek from eroding soils previously (DDT) or currently (endosulfan) exposed to these pesticides. Environmental Farm Planning, sediment source surveys and application of best management practices are recommended for this drainage.

With the exception of Hilsenoff index, the 5 primary metrics and 5 secondary metrics selected for the Okanagan are the same as the 10 metric B-IBI utilized in the Puget Sound area (http://www.cbr.washington.edu/salmonweb/). The Okanagan B-IBI is very similar to the Cascade multmetric index (MMI) proposed for eastern Washington State by the Colville Confederated Tribes; the difference being the replacement of Okanagan % predator and dominance of 3 taxa secondary metrics in the Cascade MMI by % filter feeders and % clingers. The Greater Vancouver Regional District uses a 10 metric B-IBI that is essentially the same as the primary and secondary Okanagan metrics with the replacement of the Hilsenohff index with number of long lived species. The Skeena Stikine Forest District B-IBI calibration selected 6 metrics, 3 of which correspond to the primary and 3 to the secondary Okanagan metrics. Metrics for each area are summarized in Appendix 12. Although metric scoring criteria and metric selection varies somewhat between these areas in the Pacific Northwest, the overall commonality in chosen metrics, enables comparable statements of aquatic ecosystem health among these study areas and could enable broad environmental reporting.

Cumulative effects assessment is an on-going process that improves with application of consistent collection methods, and data management and reporting frameworks for assemblages such as benthic invertebrates which integrate stressors over time. Dube (2003) advocates development of regional effects based aquatic “weather stations” that are developed by governments and expanded over time using project based assessments using common data collection and archival methods. Area specific reference models (CABIN) or indices (B-IBI) provide cumulative effects information but require investment commensurate with the resource management requirements. Reference models for the broad geographic areas such as the Fraser Basin, need to be rigorously tested to ensure adequate benchmarks and predictive accuracy at the site level where resource management decisions are being made. Predictive success of the RCA in B.C. has been estimated as 62%, (Bennett and Richardson, 2004) suggesting cautious application as resource implications or management costs increase. While the CABIN matures, implementation of regional B-IBIs can be an expedient means of providing stream ecosystem information on a variety of spatial scales. As shown here, the Okanagan B-IBI and BEAST evaluation of the Okanagan data yielded similar separation of reference and impact site groups. Continued investment in understanding the comparability of these methods will add technical flexibility, and a greater understanding of the tools and biota being studied. Inclusion of other biogical measures such as fish, amphibians, or birds can provide a more comprehensive picture of ecological condition (Stoddard et al. 2005) particularly when probability based sampling allows statistical inference of regional condition (Bryce and Hughes, 2003).

Technical refinement of benthic invertebrate indicators of Okanagan stream condition is warranted. However, others working in this discipline have cautioned that a focus on technical accuracy and methodological refinement of individual indicators may not provide information for which society is looking or able to readily utilize. Effective communication of ecological indicators involves more than simply transforming scientific phrases into easily comprehensible words (Schiller et al. 2001). A combined set of environmental measures described in short narratives focused on changes in broader environmental conditions is more effective than individual scientific measures (Schiller et al. 2001). The process of shifting from describing what is measured by the indicators, to depicting socially valued aspects of the environment is complex but critical to environmental protection. As such, this communication process deserves attention in B.C., and the application of the B-IBI and CABIN tools should be considered an opportunity to explore this challenge. Area specific biocriteria or indicators are being encouraged in Canada (McElligott, 2006). In advance of these measures, relative statements of aquatic ecosystem health can begin to more fully inform and guide community and regional environmental protection actions. Requiring proponents and local governments to follow a core monitoring standard will further enable regional cumulative assessments.

8 RECOMMENDATIONS

8.1 Communicate

- Identify stream conditions to local governments to further stream protection actions. Incorporate benthic invertebrate monitoring and reporting requirements in Liquid Waste Management Plans, Integrated Storm Water Planning, and Watershed Planning process.
- Develop concise communication products to inform the public, politicians, and stream and environmental stewardship groups, in the Okanagan Basin.
- Encourage a provincial process to develop integrated environmental measures and reporting strategies which focus on biological measures valued by society.

8.2 Improved environmental assessment through stronger science

- Compare surber and kick net data from 2005 to enhance and enable broader method application and linkage between B-IBI and CABIN methods.
- Evaluate the predictive success and index discrimination efficiency using the 2005 data set.
- Use benthic monitoring as the primary survey and assessment tool where aquatic life is the primary and most sensitive resource use. Use chemical or bacteriological monitoring as primary measures where primary water use is for drinking or recreational purposes.
- Develop an Okanagan specific reference model within CABIN concurrent with continued validation of the B-IBI to support transboundary and other comparisons.
- Require new major projects to provide benthic data appropriate for CABIN data entry and expansion of reference based cumulative effects based framework.

8.3 Collaboration with others.

- Link Okanagan B-IBI to the Environment Canada CABIN reference model expansion process and National Agriculture Environmental Standards Initiative
- Link Okanagan B-IBI to the Okanagan Nation Alliance trans-boundary water quality monitoring program use of benthic invertebrate indicators.

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Appendix 1. B-IBI Field Sheets and Alaska Stream Condition Index Field Sheets.

Riparian Vegetation

Check off the dominant vegetation type:

☐ Unvegetated (much bare mineral soil is visible) ☐ Shrub / Herb
☐ Coniferous Forest ☐ Deciduous Forest ☐ Mixed Conifer - Deciduous Forest

Record the dominant species present:

Record the Structural Stage of the dominant vegetation in the Riparian Area:

☐ Non-vegetated or initial stage following disturbance, with less than 5% cover
☐ shrub / herb stage, less than 10% tree cover
☐ pole-sapling stage, with trees overtopping the shrub layer, usually less than 15-20 years old
☐ young forest (30- 80 years) - forest canopy is differentiating into distinct layers
☐ mature forest - well developed understory

Canopy Closure (proportion of the surface area of the stream covered by the projecting riparian canopy)

☐ 0 - 20% covered ☐ 20 - 40% covered ☐ 40 - 70% covered
☐ 70 - 90% covered ☐ >90% covered

Stream Characterization

☐ Glacial
☐ Clear
☐ Stained
☐ Other

Gradient (please estimate % gradient beside box)

☐ Steep
☐ Moderate
☐ Low

Predominant Surrounding Land Use

☐ Forest ☐ Field / Pasture ☐ Agricultural ☐ Residential
☐ Logging ☐ Mining ☐ Commercial / Industrial ☐ Other

Local Watershed Erosion

☐ Heavy
☐ Moderate
☐ None

Local Watershed NPS Pollution

☐ Obvious sources Comments:_____________
☐ Some potential Sources
☐ No evidence

Stream Parameters (Record 3 measurements)

Stream Wetted Width: ____m ____m _____m Stream Bankfull Width: _____m _____m _____m
Stream Wetted Depth: ____m ____m _____m Stream Bankfull Depth: _____m _____m _____m

Primary Habitat Units Present (check any habitats that occupy more than 50% of the wetted width of the main channel)

☐ Pools ☐ Glides ☐ Riffles ☐ Cascades ☐ Other

Sediment / Substrate

Odors

☐ Sewage ☐ Petroleum ☐ Anaerobic ☐ Chemical ☐ None ☐ Other

Oils

☐ Absent ☐ Slight ☐ Moderate ☐ Profuse

Bed Material

Substrate Type	Diameter	% composition in reach (=100%)
Sands, Silts, Clays & fine Organic materials	< 2mm	
Gravels	2 - 64 mm	
Cobbles	64 - 256 mm	
Boulder	> 256 mm	
Bedrock	> 4000 mm	

Cover = __________%

(% cover is the percent of the wetted surface area that is covered by woody debris, boulders, cutbanks, deep pools, overhanging vegetation (within 1 m of water surface) or instream vegetation)

Alaska Stream Condition Index (ASCI) Habitat Assessment Field Data Sheet

Major, E.B. and M.T. Barbour. 1997. *Standard Operating Procedures for the Alaska Stream Condition Index: A Modification of the U.S. EPA Rapid Bioassessment Protocols*. Prepared for Alaska Department of Environmental Conservation, Anchorage, Alaska.

Site Name:____________________________ Date/Time:_______________________________
Sampling Team:_________________________Comments:________________________________

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate / Available Cover	Greater than 70% of substrate favorable for epifaunal colonization, mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (ie, logs/snags that are not new fall and not transient	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale)	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides substantial niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity-Depth Combinations	All four velocity-depth combinations present (slow-deep, slow-shallow, fast-deep, fast-shallow)	Only 3 of the 4 combinations present (if fast-shallow is missing, score lower than if missing other combinations)	Only 2 of the 4 habitat combinations present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity-depth combination (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, ie, dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuousity	Occurrence of riffles (or bends) relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important. All 4 velocity-depth patterns present.	Occurrence of riffles (or bends) infrequent; distance between riffles divided by the width of the stream is between 7 to 15. Only 3 of 4 velocity-depth pattens present (ie, slow-deep, slow-shallow, fast-deep, fast- shallow).	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles (or bends) divided by the width of the stream is between 15 to 25. Only 2 velocity-depth patterns present; usually lacking deep areas.	Generally all flat water or shallow riffles (or bends); poor habitat; distance between riffles divided by the width of the stream is a ratio of >25. Dominated by one velocity-depth pattern.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion, mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60 – 100% of bank has erosional scars.
SCORE (LB)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE (RB)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank & immediate riparian zone surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE (LB)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE (RB)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (ie parking, roadbeds, clearcuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE (LB)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
SCORE (RB)	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Appendix 2: Taxonomic resources used in benthic invertebrate identification.

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Appendix 3. Expected metric response to increasing human influence within a watershed (modified from Karr and Chu, 1999)

Category	**Metric**	**Definition**	**Expected Response to Increasing Human Influence within the Watershed**	**Reference**
Taxa richness & composition	No. of taxa	Total number of different taxa	Decrease	Karr and Chu 1999
	No. of Ephemeroptera taxa	Total number of different Ephemeroptera taxa	Decrease	Karr and Chu 1999
	% Ephemeroptera	Relative abundance of Ephemeroptera individuals	Variable	Maxted *et al* 2000
	No. of Plecoptera taxa	Total number of different Plecoptera taxa	Decrease	Karr and Chu 1999
	No. of Trichoptera taxa	Total number of different Trichoptera taxa	Decrease	Karr and Chu 1999
	No. of Long –lived taxa	Cumulative number of unique long-lived taxa	Decrease	Karr and Chu 1999
	% Long Lived	Relative abundance of long-lived individuals	Decrease	
	% Diptera & Non-insects	Relative abundance of all dipterans and non-insects.	Increase	DeShon 1995
	No. of Diptera Taxa	Total number of different Diptera taxa	Decrease	DeShon 1995
	% Dipterans	Relative abundance of Diptera individuals	Increase	Maxted *et al* 2000
	% Non-insects	Relative abundance of non-insect individuals	Increase	Maxted *et al* 2000
Tolerants/ Intolerants	# of Intolerant taxa	Cumulative number of unique intolerant taxa	Decrease	Karr and Chu 1999
	% Tolerants	Relative abundance of tolerant individuals	Increase	Karr and Chu 1999
	% Sediment Tolerants	Relative abundance of sediment tolerant individuals	Increase	Zweig and Rabeni 2001
	% Sediment Intolerants	Relative abundance of sediment intolerant individuals	Decrease	Zweig and Rabeni 2001
	% Oligochaetes	Relative abundance of Oligochaete individuals	Increase	Maxted *et al* 2000
	Hilsenhoff Biotic Index (HBI)	Weighted average based on abundance and tolerance of organisms	Increase	Maxted *et al* 2000
Feeding / Habit Metrics	% Predators	Relative abundance of predator individuals	Decrease	Karr and Chu 1999
	No. of clinger taxa	Total number of clinger taxa	Decrease	Karr and Chu 1999
	% Clingers	Relative abundance of clinger individuals	Decrease	Maxted *et al* 2000
Population Attributes	% Dominance (3 taxa)	The proportion of the three most abundant taxa relative to the sample size	Increase	Karr and Chu 1999

Appendix 4. Water quality summary for Okanagan streams sampled in the fall for benthic invertebrates

Site Name	EMS ID	Years Sampled	Alkalinity *mg/L*	Conductivity *uS/cm*	NO2NO3 *mg/L*	pH	Temp *C*	Total P *mg/L*
Bellevue	E241303	99-01, 04,	24.8	179	0.165	7.95	8.2	0.019
BX @ Pleasant Valley	E223632	99-05	176.5	504.33	1.633	8.32	8.767	0.011
BX @ 30th Ave	E242776	99-05	214	626.6	1.0026	8.04	12.88	0.0318
Chute	E239620	99-01, 03,	24.9	55.33	0.01	7.47	--	0.0207
Coldstream @ Creekside	E208089	02, 05	--	707	2	8.3	16.5	0.002
Coldstream u/s Mun Res	E206374	00, 05	--	466.77	0.0219	8.31	6.408	0.01
Ellis near Mouth	500027	00-05	31.4	63.2	0.0044	7.49	9.633	0.016
Ellis u/s	E224191	03-05	--	71.22	0.00289	7.61	9.21	0.0176
Eneas	500684	99-03, 05	324	539.25	0.928	8.36	9.5	0.07
Equesis	500028	02, 03, 05	--	452.5	0.154	8.3	9.5	0.0243
Greata	E239618	99, 05	--	303	0.007	7.4	--	0.011
Inkameep near Mouth	500180	00-02, 05	79.2	173.6	0.004	7.86	13.38	0.038
Inkameep	500179	00, 01, 05	--	75	0.0075	7.37	6.25	0.055
Kelowna @ Bulman	E223642	03-05	--	479	0.077	8	10.3	0.058
Kelowna near Mouth	500039	99, 00, 02-	--	590	2.299	8.06	11.28	0.078
Lambly	500041	99, 00, 03,	--	225.5	0.00325	7.84	11.4	0.016
McDougall	E242784	00, 01, 05	144	295.5	0.016	8.33	4.5	--
Naramata nr School	500755	00-03, 05	--	65.67	0.0098	7.75	10.53	0.0168
Naramata nr mth	--	99	--	65.67	0.0098	7.75	10.53	0.0168
Peachland @ PID Inlet	500856	00-05	90.4	158.63	0.00635	7.92	7.562	0.0108
Peachland	500056	99	90.4	158.63	0.00635	7.92	7.562	0.0108
Powers	500059	99, 00, 02,	--	298.5	2.176	8.11	12.2	0.0213
Prairie	500325	99, 00, 05	--	425.5	0.7105	8.18	8	0.05
Shingle	E242894	00-03	181	338.25	0.075	8.22	9.25	0.015
Shorts	500067	99, 00, 03,	--	248.5	0.00325	7.97	11.7	0.017
Shuttleworth	E242896	00-02, 05	66.9	147	0.0174	7.92	11.75	0.0164
Trepanier	500352	00, 05	--	471	0.0736	8.02	9.867	0.006
Trout u/s	E223131	99-03, 05	68.1	95.538	0.00694	7.71	9.211	0.0091
Trout near Mouth	500080	99, 00, 02,	--	161.5	0.1765	8.1	10.78	0.0283
Vernon	E249392	02, 05	--	671	0.803	8.4	15	0.033
Whiteman	500099	02, 03, 05	--	288.5	0.0197	8.3	12.17	0.033

Appendix 5a. Okanagan Stream Sediment Metals Analysis 1999-2004

Sediment Metals		Arsenic (ug/g)	Cadmium (ug/g)	Chromium (ug/g)	Copper (ug/g)	Iron (ug/g)	Lead (ug/g)	Manganese (ug/g)	Nickel (ug/g)	Selenium (ug/g)	Silver (ug/g)	Zinc (ug/g)
CCME ISQ Guideline (ug/g)	**bolded**	5.9	0.60	37.30	35.70	21200.00	35.00	460.00	16.00	5.00	0.50	123.00
CCME PEL Guideline (ug/g)	border	17	3.50	90.00	197.00	43766.00	91.30	1100.00	75.00			315.00
Chute Creek at Glenfir Rd	1999-10-12	<8	**1**	12	9	**22200**	<8	**750**	9	<8	<2	30.8
Powers Creek	1999-10-25	<8	<0.8	**62.4**	21.5	**40200**	16	**515**	**23**	<8	<2	76.6
BX Cr ups pump house	1999-10-27	<8	**0.8**	33	24.5	**19100**	<8	**469**	**72**	<8	<2	63.6
Bellevue Creek	1999-10-26	<8	<0.8	16	13	**25200**	22	219	5	<8	<2	34.5
Naramata Creek	1999-10-21	<8	<0.8	21.1	18.8	**83800**	10	411	4	<8	<2	38.9
Peachland Creek	1999-10-26	**10**	<0.8	36.6	19.8	**49800**	24	308	10	<8	<2	57.3
Trout Cr ups Mun. Res.	1999-10-08	<8	<0.8	**44.2**	19.4	**33200**	18	**493**	10	<8	<2	61.6
Lambly Creek	1999-10-29	<8	<0.8	**96**	**37**	**82400**	<8	**563**	**40**	<80	<20	85
Shorts Creek	1999-10-29	<8	<0.8	**89**	29.5	**58400**	19	**947**	**72**	<8	<2	85.1
Prairie Creek	1999-10-22	<8	**1**	22.6	17.5	**22600**	20	**511**	9	<8	<2	73.8
Eneas Creek	1999-10-22	<9	**0.9**	27.9	17.9	**33100**	17	295	4	<9	<2	50.5
Kelowna Creek	1999-10-19	<8	<0.8	26.5	9.8	**17700**	10	300	10	<8	<2	59.5
BX Cr at 30th Ave Vernon	1999-10-28	9	**0.9**	**51.5**	**105**	**30500**	**110**	**702**	**26**	<8	<2	**294**
Trout Creek nr mth OK L	1999-10-08	<8	<0.8	**42.9**	29.2	**40800**	10	**662**	**27**	<8	<2	62.7

Sediment Metals		Arsenic (ug/g)	Cadmium (ug/g)	Chromium (ug/g)	Copper (ug/g)	Iron (ug/g)	Lead (ug/g)	Manganese (ug/g)	Nickel (ug/g)	Selenium (ug/g)	Silver (ug/g)	Zinc (ug/g)
CCME ISQ Guideline (ug/g)	**bolded**	5.9	0.60	37.30	35.70	21200.00	35.00	460.00	16.00	5.00	0.50	123.00
CCME PEL Guideline (ug/g)	border	17	3.50	90.00	197.00	43766.00	91.30	1100.00	75.00			315.00
Powers Cr at Gellatly Rd	2000-10-11	<8	<0.8	**61.7**	8.8	**45500**	27	379	**20**	<8	<2	66.2
Coldstream C u/s Municipal Re	2000-10-04	**9**	<0.8	25.2	25.6	**23200**	<8	**530**	**28**	<8	<2	75.3
Kelowna Creek nr Abbott St.	2000-10-10	<8	<0.8	28.1	19.4	**24100**	22	**907**	**44**	<8	<2	96.6
Bellevue Creek nr mth	2000-10-10	<8	<0.8	15.4	10.2	19700	17	**511**	**23**	<8	<2	47.7
McDougall Creek at Shannon L	2000-10-10	<8	<0.8	**61.3**	12.7	**45400**	25	**591**	**24**	<8	<2	85.6
Peachland Creek @ PID Intake	2000-10-11	<8	<0.8	**64.6**	13.9	**93400**	26	**481**	**26**	<8	<2	55.2
Trout Creek nr mth	2000-10-12	<8	<0.8	**55.4**	27.3	**35300**	**41**	**716**	**43**	**14**	<2	92.3
Trout Creek nr Intake	2000-10-12	<8	<0.8	11	13.5	19980	<8	423	**18**	<8	<2	72.3
BX Creek dns Pleasant Valley	2000-10-05	<8	<0.8	25.9	23.7	17873.9	12	**521.8**	**35**	<8	<2	89.7
BX Creek at 30th Ave Vernon	2000-10-05	<8	<0.8	35.7	23	19000	38	428	**28**	<8	<2	105
Shorts Creek nr mth	2000-10-02	<8	<0.8	**88.9**	19.6	**51300**	26	**584**	**56**	<8	<2	74.5
Lambly Creek @ Westside Rd	2000-10-02	<8	<0.8	**75.9**	25.4	**83120**	**45**	488	**46**	<8	<2	107
Eneas Creek ups Hwy 97	2000-10-12	<8	<0.8	10.6	16.3	16700	18	339	**16**	**8**	<2	83.3
Inkameep Creek nr mth	2000-10-20	<8	<0.8	18.5	8.1	**24100**	16	**674.4**	15	<8	<2	33.7
Inkameep Creek at Inkameep	2000-10-20	<8	<0.8	18.1	11.5	**24600**	<8	**784**	**22**	<8	<2	43.2
Shuttleworth Creek at Willow S	2000-10-20	<8	<0.8	18.7	7.2	**42600**	<8	290	11	<8	<2	49.3
Trepanier Creek u/s Intake	2000-10-13	<8	<0.8	**54.3**	26.5	**37700**	21	406	**27**	<8	<2	39.8
Prairie Creek nr mth	2000-10-12	<8	**0.80**	16.60	9.60	19700.00	13.00	422.00	**27.00**	<8	<2	63.20
Naramata Creek ups mth	2000-10-16	<8	<0.8	15.8	24.3	**48300**	17	**475**	**18**	<8	<2	51.1
Chute Creek at Glenfir Rd	2000-10-16	<8	<0.8	4.8	7.5	**28900**	14	**887**	**37**	<8	<2	41
Shingle Creek dns Shatford Cr	2000-10-17	<8	<0.8	21.3	12	**37000**	20	**566**	**17**	<8	<2	48.1
Ellis Creek nr mth	2000-10-17	<8	1	17.8	23.7	20800	34	**299**	11	<8	<2	116

Appendix 5a continued: Okanagan Stream Sediment Metals Analysis 1999-2004

Sediment Metals		Arsenic (ug/g)	Cadmium (ug/g)	Chromium (ug/g)	Copper (ug/g)	Iron (ug/g)	Lead (ug/g)	Manganese (ug/g)	Nickel (ug/g)	Selenium (ug/g)	Silver (ug/g) [b]	Zinc (ug/g)
CCME ISQ Guideline (ug/g)	**Bolded**	5.9	0.60	37.30	35.70	21200.00	35.00	460.00	16.00	5.00	0.50	123.00
CCME PEL Guideline[a]	**Border**	17	3.50	90.00	197.00	43766.00	91.30	1100.00	75.00			315.00
Ellis Cr nr mth	2001-10-04	<8	<0.8	23.6	17.5	**21890**	13	243.4	13	<8	<2	71.4
Shingle Cr 8km ups mth	2001-10-10	<8	<0.8	36.4	11	**41740**	<8	401.6	10	<8	<2	46.2
Eneas Cr ups Hwy 97	2001-01-10	<8	<0.8	14.9	16	18320	11	322.2	5	<8	<2	79.8
Shuttleworth Creek at Willow St.	2001-10-16	<8	<0.8	17.2	10	**23110**	<8	393.4	7	<8	<2	65.7
Chute Cr at Glenfir Rd	2001-10-15	<8	<0.8	5.9	3.9	20160	<8	390.2	<3	<8	<2	27.9
BX Cr at Pleasant Valley Rd aft ra	2001-10-17	<8	<0.8	34.1	23	20760	<8	**528**	2	<8	<2	81.4
Trout Creek ups Intake	2001-10-11	<8	<0.8	18.1	10.5	**31890**	<8	427	4	<8	<2	50
BX Cr at 30th Ave	2001-10-17	<8	<0.8	**45.8**	33.9	**21710**	**58**	**541.5**	**17**	<8	<2	113.2
Inkameep Cr at Mth	2001-10-25	<8	<0.8	27.1	11.3	**28720**	<8	**722.5**	11	<8	<2	47.8
Inkameep Cr at Inkameep	2001-10-25	<8	<0.8	22.8	7.9	**25550**	<8	**710.2**	8	<8	<2	38
Bellevue Cr nr mth	2001-10-24	<8	<0.8	19.3	12.1	14490	<8	372.6	10	<8	<2	74.7
McDougall at Shannon L Rd	2001-10-24	<8	<0.8	**65.1**	15.8	**33350**	16	395.8	14	<8	<2	85
Peachland C dns PID Intake	2001-10-22	**8**	<0.8	33.9	27	**45990**	<8	**1062**	8	<8	<2	100.4

Sediment Metals		Arsenic (ug/g)	Cadmium (ug/g)	Chromium (ug/g)	Copper (ug/g)	Iron (ug/g)	Lead (ug/g)	Manganese (ug/g)	Nickel (ug/g)	Selenium (ug/g)	Silver (ug/g) [b]	Zinc (ug/g)
CCME ISQ Guideline (ug/g)		5.9	0.60	37.30	35.70	21200.00	35.00	460.00	16.00	5.00	0.50	123.00
CCME PEL Guideline[a]		17	3.50	90.00	197.00	43766.00	91.30	1100.00	75.00			315.00
Powers Cr at Gellatly Rd	2002-08-29	1.8	0.06	16.4	7	16300	4.9	178	7.4	0.5	<0.05	39.2
Coldstream C at Creekside Prk	2002-08-28	2.5	0.12	12.9	8.4	12400	1.9	197	8.1	0.5	<0.05	33.6
Kelowna Creek nr Abbott St.	2002-08-29	1	0.1	10	8.6	13400	9.2	433	6.6	0.5	<0.05	58.4
Bellevue Creek nr mth	almost dry											
McDougall Creek at Shannon Lk	dry											
Peachland Creek @ PID Intake	2002-09-12	2.1	0.13	8	12.4	15900	6.3	364	4.6	<0.5	0.08	57
Trout Creek nr mth	2002-08-26	3.4	0.06	6.5	10.8	19700	7.2	418	11.1	<0.5	0.06	38.2
Trout Creek nr Intake	2002-08-26	0.6	<0.05	3.5	10.8	11300	2.1	176	2	<0.5	0.05	42.7
BX Creek dns Pleasant Valley Rd	dry											
BX Creek at 30th Ave Vernon	2002-09-16	3.1	0.57	25.3	**37.5**	18500	29.4	**477**	**19.9**	2.7	0.29	**163**
Eneas Creek ups Hwy 97	2002-09-11	1	0.017	8.8	18.9	13900	14.6	211	5.2	0.5	0.1	73.7
Inkameep Creek nr mth	2002-09-25	1.4	0.01	10.1	13.9	18500	3.8	**822**	10.6	<0.5	0.06	44
Shuttleworth Creek at Willow St.	2002-09-25	0.7	<0.05	3.5	4.2	7480	3.3	63.9	2.8	<0.5	<0.05	24.3
Shingle Creek dns Shatford Cr	2002-09-18	2.3	<0.05	7.8	10.8	17400	3.9	457	5.4	<0.5	0.05	34.9
Ellis Creek nr mth	2002-09-18	1	0.09	5.1	8.5	13000	7.4	112	3	<0.5	<0.05	40.7
Equesis Creek at Westside Rd	2002-09-05	4.8	0.35	**40.2**	24	**31300**	7.4	**468**	**42.6**	2.5	0.18	73.6
Whiteman Creek at Westside Rd	2002-09-05	1.6	0.06	14.4	7.2	17900	5.4	328	9.8	<0.5	0.06	44.8
Vernon Creek at 25th Ave	2002-09-27	0.9	0.11	9.3	6.9	7950	5.8	176	6.3	0.9	0.07	34.1

Appendix 5a continued: Okanagan Stream Sediment Metals Analysis 1999-2004

Sediment Metals		Arsenic (ug/g)	Cadmium (ug/g)	Chromium (ug/g)	Copper (ug/g)	Iron (ug/g)	Lead (ug/g)	Manganese (ug/g)	Nickel (ug/g)	Selenium (ug/g)	Silver (ug/g) [b]	Zinc (ug/g)
CCME ISQ Guideline (ug/g)		5.9	0.60	37.30	35.70	21200.00	35.00	460.00	16.00	5.00	0.50	123.00
CCME PEL Guideline[a]		17	3.50	90.00	197.00	43766.00	91.30	1100.00	75.00			315.00
BX Cr at 30th Ave Vernon	2003-10-09	1.3	0.27	18	21	11100	23.3	183	11.9	1.4	0.13	84
Ellis C @ Mouth @ Okanagan R	2003-10-06	1.2	0.13	10	14.4	**29500**	14.4	225	5.4	<0.5	0.07	75
Trout Creek at Flume Upstream F	2003-10-15	1.4	0.32	11	26.1	20100	10.5	**731**	6.9	1	0.24	97
Trout C near Mouth @ Hwy 97 Br	2003-10-15	4.5	0.13	10	21.1	20000	15.8	**704**	**20.1**	<0.5	0.09	59
Shingle Creek 100m d/s Br	2003-10-17	1.3	<0.05	10	6.2	14400	2.8	280	4.4	<0.05	<0.05	25
Ellis Cr @ Diversion CWS	2003-10-08	<0.2	<0.05	2	3.3	7900	1.2	249	2.5	<0.5	<0.05	17
Kelowna Cr @ Bulman Rd Bridge	2003-10-20	**9.5**	0.2	19	21.7	**39600**	6.3	10100	**17.6**	1.1	0.11	**129**
Kelowna C @ Mouth @ Abbott St	2003-10-09	1.2	0.25	20	20.1	18400	19	4520	13.8	1.2	0.1	116
Eneas C u/s Mission Bottle E of H	2003-10-08	2.1	0.33	15	**36.3**	17500	24.6	308	8.5	1.7	0.18	**138**

Sediment Metals		Arsenic (ug/g)	Cadmium (ug/g)	Chromium (ug/g)	Copper (ug/g)	Iron (ug/g)	Lead (ug/g)	Manganese (ug/g)	Nickel (ug/g)	Selenium (ug/g)	Silver (ug/g) [b]	Zinc (ug/g)
CCME ISQ Guideline (ug/g)		5.9	0.60	37.30	35.70	21200.00	35.00	460.00	16.00	5.00	0.50	123.00
CCME PEL Guideline[a]		17	3.50	90.00	197.00	43766.00	91.30	1100.00	75.00			315.00
Kelowna Cr @ Sutherland Ave	2004-10-08	1.3	0.27	22	18.5	21000	18	1370	14	0.7	0.1	118
Kelowna Cr @ Bulman Rd Bridge	2004-10-08	2.2	0.19	21	19.5	**31800**	6	**612**	**16.2**	0.5	0.13	106
Bellevue Cr at Lakeshore Rd	2004-10-08	<0.2	0.07	8	7.4	8150	8.7	177	5.5	<0.5	<0.05	40
Peachland Cr nr PID intake	2004-10-05	4.3	0.53	15	41	**21300**	13	**481**	8.5	2.3	0.19	120
BX Cr nr PV Rd	2004-10-06	3.1	**1.07**	27	33.3	20300	8	439	**29**	**5.4**	0.31	121
BX Cr at 30th Ave Vernon	2004-10-06	3.1	**0.83**	36	**57.5**	**21600**	**54.9**	**499**	**27.9**	4	**0.6**	**234**
Ellis C @ Mouth @ Okanagan R	2004-10-04	<0.2	0.1	10	11.6	12400	13.5	131	5	<0.5	<0.05	58
Ellis Cr @ Diversion CWS	2004-10-04	<0.2	<0.05	4	4.4	8890	2.1	244	3.7	<0.5	<0.05	24

Appendix 5b Okanagan Stream Sediment Metals Water Quality Index Summary

Station	Number of Samples	F_1	F_2	F_3	CCME WQI	Mean WQI	Water Quality Category
Bellevue Cr at Lakeshore Rd	4	0.0	0.0	0.0	100.0	100.0	Good
BX Cr at 30th Ave	6	45.5	45.5	9.5	62.5	62.5	Marginal
BX Cr at Pleasant Valley Rd a	4	9.1	9.1	1.3	92.5	92.5	Good
Chute Cr at Glenfir Rd	3	0.0	0.0	0.0	100.0	100.0	Good
Coldstream C at Creekside Pr	1	0.0	0.0	0.0	100.0	100.0	Excellent
Coldstream C u/s Municipal R	1	36.4	36.4	12.2	69.5	69.5	Fair
Ellis C @ Mouth @ Okanagan	5	9.1	9.1	3.4	92.3	92.3	Excellent
Ellis Cr @ Diversion CWS	2	0.0	0.0	0.0	100.0	100.0	Excellent
Eneas C u/s Mission Bottle E	5	18.2	18.2	1.2	85.1	85.1	Good
Equesis Creek at Westside R	1	36.4	36.4	16.9	68.7	68.7	Fair
Inkameep Creek at Inkameep	1	27.3	27.3	10.1	77.0	77.0	Good
Inkameep Cr at Mth	1	18.2	18.2	7.8	84.5	84.5	Good
Kelowna C @ Mouth @ Abbot	5	9.1	9.1	44.5	73.2	73.2	Good
Kelowna Cr @ Bulman Rd Bri	2	45.5	45.5	67.2	46.3	46.3	Marginal
Lambly Creek	2	45.5	45.5	36.1	57.4	57.4	Marginal
McDougall at Shannon L Rd	2	18.2	18.2	10.7	83.9	83.9	Fair
Naramata Creek	2	9.1	9.1	21.2	85.7	85.7	Good
Peachland Creek	1	18.2	18.2	15.7	82.6	82.6	Good
Peachland C dns PID Intake	4	27.3	27.3	20.5	74.8	74.8	Fair
Powers Cr at Gellatly Rd	3	27.3	27.3	15.7	76.0	76.0	Good
Prairie Creek nr mth	2	18.2	18.2	8.5	84.4	84.4	Good
Shingle Cr 8km ups mth	4	9.1	9.1	8.1	91.2	91.2	Good
Shorts Creek	2	36.4	36.4	41.2	62.0	62.0	Marginal
Shuttleworth Creek at Willow	3	9.1	9.1	8.4	91.1	91.1	Good
Trepanier Creek u/s Intake	1	27.3	27.3	14.9	76.1	76.1	Fair
Trout Creek ups Intake	5	9.1	9.1	4.4	92.2	92.2	Good
Trout Creek nr mth	4	54.5	54.5	32.8	51.6	51.6	Fair
Vernon Creek at 25th Ave	1	0.0	0.0	0.0	100.0	100.0	Excellent
Whiteman Creek at Westside	1	0.0	0.0	0.0	100.0	100.0	Excellent

Appendix 6. Polycyclic Aromatic Hydrocarbons (PAH) in Okanagan Stream Sediments.

Sediment PAHs		Organic Carbon % [a]	Total PAHs (ug/g)	Acenaphthene (ug/g)	Acenaphthylene (ug/g)	Anthracene (ug/g)	Benzo(a)anthracene (ug/g)	Benzo(a)pyrene (ug/g)	Benzo(b)fluoranthene (ug/g	Benzo(ghi)perylene (ug/g)	Benzo(k)fluroanthene (ug/g	Chrysene (ug/g)	Dibenz(a,h)anthracene (ug	Fluoranthene (ug/g)	Fluorene (ug/g)	Indeno(1,2,3-cd)pyrene (ug	Naphthalene (ug/g)	Phenanthrene (ug/g)	Pyrene (ug/g)
BC Water Quality Guideline (ug/g) @ 1% TOC				0.15		0.6	0.2	0.06						2	0.2		0.01	0.04	
CCME ISQ Guideline (ug/g)			4*	0.007	0.006	0.047	0.032	0.032				0.057	0.006	0.111	0.021		0.034	0.042	0.053
CCME PEL Guideline (ug/g)			22**	0.089	0.128	0.245	0.385	0.782				0.862	0.135	2.355	0.144		0.391	0.515	0.875
Chute Creek at Glenfir Rd	1999-10-12		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Powers Creek	1999-10-25		0.08	<0.02	<0.02	<0.02	<0.02	<0.02	<0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	0.05	<0.02
BX Cr ups pump house	1999-10-27		0.08	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	0.02	0.02	0.02	<0.02	<0.02	<0.02
Bellevue Creek	1999-10-26		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Naramata Creek	1999-10-21		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Peachland Creek	1999-10-26		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Trout Cr ups Mun. Res.	1999-10-08		0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02
Lambly Creek	1999-10-29		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Shorts Creek	1999-10-29		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Prairies Creek	1999-10-22		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Eneas Creek	1999-10-22		0.48	<0.02	<0.02	<0.02	0.04	0.07	0.06	0.06	0.06	0.04	<0.02	0.04	<0.02	0.07	<0.02	<0.02	0.04
Kelowna Creek	1999-10-19		2.36	<0.02	<0.02	0.02	0.14	0.18	0.20	0.18	0.22	0.20	0.05	0.44	<0.02	0.19	<0.02	0.18	0.36
BX Cr at 30th Ave Vernon	1999-10-28		6.82	<0.02	<0.02	0.12	0.53	0.55	0.44	0.36	0.47	0.63	0.09	1.37	0.02	0.36	<0.02	0.71	1.17
Trout Creek nr mth OK L	1999-10-08		0.07	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.07	<0.02

* CCME low effects range ** apparent effects thresholds

Sediment PAHs		Organic Carbon % [a]	Total PAHs (ug/g)	Acenaphthene (ug/g)	Acenaphthylene (ug/g)	Anthracene (ug/g)	Benzo(a)anthracene (ug/g	Benzo(a)pyrene (ug/g)	Benzo(b)fluoranthene (ug/	B(ghi)perylene (ug/g)	Benzo(k)fluoranthene (ug/	Chrysene (ug/g)	Dibenz(a)anthracene (ug/g	Fluoranthene (ug/g)	Fluorene (ug/g)	Indeno(1,2,3-cd)pyrene (u	Naphthalene (ug/g)	Phenanthrene (ug/g)	Pyrene (ug/g)
BC Water Quality Guideline (ug/g) @ 1% TOC				0.015		0.6	0.2	0.06						2	0.2		0.01	0.04	
CCME ISQ Guideline (ug/g)			4	0.007	0.006	0.047	0.032	0.032				0.057	0.006	0.111	0.021		0.034	0.042	0.053
CCME PEL Guideline (ug/g)			22	0.089	0.128	0.245	0.385	0.782				0.862	0.135	2.355	0.144		0.391	0.515	0.875
Powers Cr at Gellatly Rd	2000-10-11		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Coldstream C u/s Municipal Res	2000-10-04		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Kelowna Creek nr Abbott St.	2000-10-10		0.65	<0.02	<0.02	<0.02	0.05	0.06	0.07	0.05	0.06	0.07	<0.02	0.1	<0.02	0.06	<0.02	0.04	0.09
Bellevue Creek nr mth	2000-10-10		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
McDougall Creek at Shannon Lk Rc	2000-10-10		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Peachland Creek @ PID Intake	2000-10-11		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Trout Creek nr mth	2000-10-12		1.21	0.05	<0.02	<0.02	0.09	0.05	0.03	0.04	0.03	0.09	<0.02	0.05	0.06	<0.02	0.13	0.52	0.07
Trout Creek nr Intake	2000-10-12		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BX Creek dns Pleasant Valley Rd	2000-10-05		0.61	<0.02	<0.02	<0.02	0.04	0.05	0.06	0.04	0.05	0.06	<0.02	0.1	<0.02	0.05	0.05	0.03	0.08
BX Creek at 30th Ave Vernon	2000-10-05		8.80	0.06	<0.02	0.11	0.68	0.81	0.8	0.38	0.61	1.13	0.12	1.56	0.07	0.43	<0.02	0.87	1.17
Shorts Creek nr mth	2000-10-02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lambly Creek @ Westside Rd	2000-10-02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Eneas Creek ups Hwy 97	2000-10-12		0.37	<0.02	<0.02	<0.02	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.05	<0.02	0.04	<0.02	0.03	0.04
Inkameep Creek nr mth	2000-10-20		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Inkameep Creek at Inkameep	2000-10-20		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Shuttleworth Creek at Willow St.	2000-10-20		1.06	<0.02	<0.02	<0.02	0.07	0.09	0.12	0.06	0.09	0.11	0.03	0.18	<0.02	0.09	<0.02	0.08	0.14
Trepanier Creek u/s Intake	2000-10-13		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Prairie Creek nr mth	2000-10-12		3.37	0.30	<0.02	<0.02	0.18	0.20	0.23	0.11	0.20	0.29	0.04	0.66	0.03	0.15	<0.02	0.47	0.51
Naramata Creek ups mth	2000-10-16		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Chute Creek at Glenfir Rd	2000-10-16		0.07	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02
Shingle Creek dns Shatford Cr	2000-10-17		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ellis Creek nr mth	2000-10-17		2.15	<0.02	<0.02	<0.02	0.13	0.16	0.22	0.11	0.17	0.24	0.04	0.41	<0.02	0.14	<0.02	0.2	0.33

* CCME low effects range ** apparent effects thresholds

Appendix 6 continued

Sediment PAHs	Sampling Date yymmdd	Total Organic Carbon %	Total PAHs (ug/g)	Acenaphthene (ug/g)	Acenaphthylene (ug/g)	Anthracene (ug/g)	Benzo(a)anthracene (ug/g	BaP (ug/g)	Benzo(b)fluoranthene (ug/	B(ghi)perylene (ug/g)	Chrysene (ug/g)	Dibenz(a,h)anthracene (ug	Fluoranthene (ug/g)	Fluorene (ug/g)	Indeno(1,2,3-cd)pyrene (u	Naphthalene (ug/g)	Phenanthrene (ug/g)	Pyrene (ug/g)
BC Water Quality Guideline (ug/g) @ 1% TOC				0.015		0.6	0.2	0.06					2	0.2		0.01	0.04	
CCME ISQ Guideline (ug/g)			4*	0.007	0.006	0.047	0.032	0.032			0.057	0.006	0.111	0.021		0.034	0.042	0.053
CCME PEL Guideline[a]			22**	0.089	0.128	0.245	0.385	0.782			0.862	0.135	2.355	0.144		0.391	0.515	0.875
Ellis Cr nr mth	2001-10-04	3.49	3.02	0.02	<0.02	0.02	0.21	0.18	0.21	0.18	0.19	0.06	0.66	0.02	0.19	0.02	0.27	0.54
Shingle Cr 8km ups mth	2001-10-10	0.68	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Eneas Cr ups Hwy 97	2001-01-10	4.7	3.01	0.02	<0.02	0.09	0.27	0.14	0.27	0.12	0.26	0.05	0.62	0.03	0.14	<0.02	0.32	0.57
Shuttleworth Creek at Willow St.	2001-10-16	2.87	1.2	<0.02	<0.02	<0.02	0.06	0.08	0.17	0.11	0.07	0.05	0.23	<0.02	0.11	<0.02	0.08	0.21
Chute Cr at Glenfir Rd	2001-10-15	10.4	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BX Cr at Pleasant Valley Rd aft rain	2001-10-17	0.52	0.69	<0.02	<0.02	<0.02	0.04	0.04	0.03	0.1	0.04	0.03	0.14	<0.02	0.07	<0.02	0.04	0.11
BX Cr at Pleasant Valley Rd pre rain																		
Trout Creek ups Intake	2001-10-11	0.83	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BX Cr at 30th Ave	2001-10-17	2.64	8.95	0.03	0.05	0.16	0.62	0.67	0.99	0.49	0.60	0.14	1.82	0.05	0.55	0.03	1.02	1.38
Inkameep Cr at Mth	2001-10-25	0.16	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Inkameep Cr at Inkameep	2001-10-25	0.09	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Bellevue Cr nr mth	2001-10-24	0.74	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
McDougall at Shannon L Rd	2001-10-24	0.25	0.1	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Peachland C dns PID Intake	2001-10-22	1.17	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

* CCME low effects range ** apparent effects thresholds

Sediment PAHs	Sampling Date yymmdd	Percent Organic Carbon (%	Total PAHs (ug/g)	Acenaphthene (ug/g)	Acenaphthylene (ug/g)	Benzo(b)fluoranthene (ug/g	Benzo(k)fluoranthene (ug/g	Benzo(ghi)perylene (ug/g)	Benzo(a)pyrene (ug/g)	Chrysene (ug/g)	Dibenz(a,h)anthracene (ug	Fluoranthene (ug/g)	Fluorene (ug/g)	Indeno(1,2,3-cd)pyrene (ug	Naphthalene (ug/g)	Phenanthrene (ug/g)	Pyrene (ug/g)
BC Water Quality Guideline (ug/g) @ 1% TOC.				0.15					0.06			2	0.2		0.01	0.04	
CCME ISQ Guideline (ug/g)			4*	0.007	0.006		0.240	0.170	0.032	0.057	0.006	0.111	0.021		0.034	0.042	0.053
CCME PEL Guideline[a]			22**	0.089	0.128		13.4***	3.2***	0.782	0.862	0.135	2.355	0.144		0.391	0.515	0.875
Powers Cr at Gellatly Rd	2002-08-29	1.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Coldstream C at Creekside Prk	2002-08-28	0.79	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Kelowna Creek nr Abbott St.	2002-08-29	2.4	0.23	<0.01	<0.01	0.04	<0.1	0.03	0.02	0.03	<0.02	0.04	<0.01	<0.02	<0.01	0.01	0.04
Bellevue Creek nr mth	almost dry																
McDougall Creek at Shannon Lk Rc	dry																
Peachland Creek @ PID Intake	2002-09-12	3	0.08	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	0.03	<0.01	<0.02	<0.01	0.03	0.02
Trout Creek nr mth	2002-08-26	1.2	0.04	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	0.04	<0.01
Trout Creek nr Intake	2002-08-26	0.17	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
BX Creek dns Pleasant Valley Rd	dry																
BX Creek at 30th Ave Vernon	2002-09-16	3.3	6.60	0.06	<0.01	0.47	0.36	0.35	0.47	0.57	0.06	1.30	0.08	0.31	<0.01	0.86	0.97
Eneas Creek ups Hwy 97	2002-09-11	2.9	0.25	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	0.07	<0.02	0.07	<0.01	<0.02	<0.01	<0.01	0.06
Inkameep Creek nr mth	2002-09-25	7.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Shuttleworth Creek at Willow St.	2002-09-25	2.1	2.00	<0.01	<0.01	0.24	0.10	0.14	0.16	0.22	0.03	0.40	<0.01	0.14	<0.01	0.17	0.31
Shingle Creek dns Shatford Cr	2002-09-18	1.4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Ellis Creek nr mth	2002-09-18	1.9	0.72	<0.01	<0.01	0.07	0.05	0.06	0.05	0.08	<0.02	0.14	<0.01	0.05	<0.01	0.08	0.11
Equesis Creek at Westside Rd	2002-09-05	3.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Whiteman Creek at Westside Rd	2002-09-05	0.88	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Vernon Creek at 25th Ave	2002-09-27	1.7	0.72	<0.01	<0.01	0.09	0.03	0.05	0.06	0.07	<0.02	0.13	<0.01	0.05	<0.01	0.05	0.12

* CCME low effects range ** apparent effects thresholds *** severe effects threshold

Appendix 6 continued

Sediment PAHs		Percent Organic Carbon (%)??	Percent Organic Carbon (%)	Total PAHs (ug/g)	Acenaphthene (ug/g)	Acenaphthylene (ug/g)	Benzo(b)fluoranthene (ug/g)	Benzo(k)fluoranthene (ug/g)	Benzo(ghi)perylene (ug/g)	Benzo(a)pyrene (ug/g)	Chrysene (ug/g)	Dibenz(a,h)anthracene (ug/g)	Fluoranthene (ug/g)	Fluorene (ug/g)	Indeno(1,2,3-cd)pyrene (ug/g)	Naphthalene (ug/g)	Phenanthrene (ug/g)	Pyrene (ug/g)
BC Water Quality Guideline (ug/g) @ 1% TOC					0.15					0.06			2	0.2		0.01	0.04	
CCME ISQ Guideline (ug/g)				4*	0.007	0.006		0.240	0.170	0.032	0.057	0.006	0.111	0.021		0.034	0.042	0.053
CCME PEL Guideline[a]				22**	0.089	0.128		13.4***	3.2***	0.782	0.862	0.135	2.355	0.144		0.391	0.515	0.875
BX Cr at 30th Ave Vernon	2003-10-09	11	88.9	10.00	<0.01	0.04	1.40	0.44	0.79	0.91	1.00	0.16	1.80	0.05	0.79	0.03	0.79	1.40
Ellis C @ Mouth @ Okanagan R	2003-10-06	0	100	1.10	<0.01	<0.01	0.15	0.06	0.10	0.09	0.13	<0.02	0.20	<0.01	0.09	<0.01	0.09	0.15
Trout Creek at Flume Upstream Re	2003-10-15	1	99	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Trout C near Mouth @ Hwy 97 Brid	2003-10-15	37	62.7	0.48	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	0.06	<0.02	<0.01	<0.01	<0.02	0.11	0.31	<0.01
Shingle Creek 100m d/s Br	2003-10-17	0	100	0.09	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	0.04	<0.01	<0.02	<0.01	0.02	0.03
Ellis Cr @ Diversion CWS	2003-10-08	7.7	92.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Kelowna Cr @ Bulman Rd Bridge	2003-10-20	0	100	0.82	<0.01	<0.01	0.10	0.07	<0.02	0.06	0.10	<0.02	0.19	<0.02	<0.02	<0.01	0.09	0.15
Kelowna C @ Mouth @ Abbott St	2003-10-09	2.3	97.7	0.98	<0.01	<0.01	0.15	0.04	0.11	0.08	0.11	<0.02	0.14	<0.01	0.09	<0.01	0.05	0.14
Eneas C u/s Mission Bottle E of Hw	2003-10-08	23	77	0.44	<0.01	<0.01	0.06	<0.01	<0.02	0.05	0.06	<0.02	0.10	<0.01	<0.02	<0.01	0.08	0.09

* CCME low effects range ** apparent effects thresholds *** severe effects threshold

Sediment PAHs		Percent Organic Carbon (%)??	Percent Organic Carbon (%)	Total PAHs (ug/g)	Acenaphthene (ug/g)	Acenaphthylene (ug/g)	Anthracene (ug/g)	Benzo(a)anthracene (ug/g)	Benzo(b+j)fluoranthene (ug/g)	Benzo(k)fluoranthene (ug/g)	Benzo(ghi)perylene (ug/g)	Benzo(a)pyrene (ug/g)	Chrysene (ug/g)	Dibenz(a,h)anthracene (ug/g)	Fluoranthene (ug/g)	Fluorene (ug/g)	Indeno(1,2,3-cd)pyrene (ug/g)	Naphthalene (ug/g)	Phenanthrene (ug/g)	Pyrene (ug/g)
BC Water Quality Guideline (ug/g) @ 1% TOC					0.15		0.6					0.06			2	0.2		0.01	0.04	
CCME ISQ Guideline (ug/g)				4*	0.007	0.006				0.240	0.170		0.057			0.021		0.034	0.042	0.053
CCME PEL Guideline[a]				22**	0.089	0.128				13.4***	3.2***		0.862			0.144		0.391	0.515	0.875
Kelowna Cr @ Sutherland Ave	2004-10-08	98		2	<0.01	<0.01	<0.01	0.100	0.200	0.110	0.170	0.130	0.190	<0.02	0.280	<0.01	0.140	<0.1	0.110	0.280
Kelowna Cr @ Bulman Rd Bridge	2004-10-08	100		0.46	<0.01	<0.01	<0.01	<0.01	0.08	0.05	<0.02	0.04	0.08	<0.02	0.12	<0.02	<0.02	<0.01	<0.02	0.09
Bellevue Cr at Lakeshore Rd	2004-10-08	100		0.09	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.02	<0.01	0.02	<0.02	0.02	<0.01	<0.02	<0.01	<0.01	0.03
BX Cr nr PV Rd	2004-10-06	78		0.05	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.02	<0.01	0.02	<0.02	0.05	<0.01	<0.02	<0.01	<0.01	0.03
BX Cr at 30th Ave Vernon	2004-10-06	89		12.00	0.03	0.05	0.09	0.65	1.20	0.92	0.98	0.99	1.20	0.16	2.10	0.04	0.96	0.03	0.73	1.80
Ellis C @ Mouth @ Okanagan R	2004-10-04	100		1.00	<0.01	<0.01	<0.01	0.06	0.10	0.07	0.08	0.08	0.11	<0.02	0.19	<0.01	0.07	<0.01	0.08	0.16
Ellis Cr @ Diversion CWS	2004-10-04	74		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01
Peachland Cr nr PID intake	2004-10-05	100		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.02	<0.01	<0.01	<0.01

* CCME low effects range ** apparent effects thresholds *** severe effects threshold

Appendix 7: List of pesticides and detection limits performed on selected Okanagan stream sediments. Analyses performed at PSC Analytical Services Burnaby in 2003.

Organochlorine Pesticides	Minimum Detectable Level ug/g	Organophosphorus Pesticides	Minimum Detectable Level ug/g
Aldrin	0.002	Acephate	0.050
BHC, alpha-	0.002	Azinphos methyl	0.050
BHC, beta-	0.002	Bromophos	0.010
BHC, delta-	0.002	Carbophenothion	0.010
Chlordane, alpha-	0.002	Chlorfenvinphos(e)	0.010
Chlordane, gamma-	0.002	Chlorpyrifos	0.010
DDD, p,p'-	0.004	Demeton	0.020
DDE, p,p'-	0.002	Diazinon	0.020
DDT, o,p'-	0.004	Dichlorvos	0.050
DDT, p,p'-	0.004	Dimethoate	0.020
Dieldrin	0.002	Ethion	0.050
Endosulfan I	0.004	Fenitrothion	0.020
Endosulfan II	0.004	Fensulfothion	0.020
Endosulphan Sulphate	0.004	Fenthion	0.020
Endrin	0.004	Fonofos	0.050
Endrin Aldehyde	0.010	Iodofenthos	0.010
Heptachlor	0.002	Malathion	0.010
Heptachlor epoxide	0.002	Mevinphos-cis	0.050
Lindane, BHC, gamma-	0.002	Methamidophos	0.050
Methidathion	0.020	Naled	0.050
Methoxychlor	0.010	Omethoate	0.050
Mirex	0.004	Parathion	0.050
Nonachlor, trans-	0.010	Parathion Methyl	0.020
Oxychlordane	0.004	Phorate	0.020
Toxaphene	0.300	Phosalone	0.050
		Phosmet	0.030
		Phosphamidon	0.050
		Sulfotep	0.020
PCB Total	0.020	Tetrachlorvinphos	0.020

Appendix 8: Alaska Stream Condition Index scores for Okanagan streams, 1999 to 2004

Sampling Location	**ASCI Score 1999**	**ASCI Score 2000**	**ASCI Score 2001**	**ASCI Score 2002**	**ASCI Score 2003**	**ASCI Score 2004**	**Mean ASCI Score**
Bellevue Cr @ Lakeshore Rd.	79*	98	142			131	113
BX Cr at 30th Ave.	72	62	61	46	72	59	62
BX Cr nr Pleasant Valley Rd	80*	111*	139			146	119
Chute Cr @ Glenfir Rd	146	150	159		178		158
Coldstream Cr at Creekside Prk				115			115
Coldstream Cr ups Mun. Res.		123					123
Ellis Cr @ Div Dam					134	134	134
Ellis Cr nr mth		59	60	69	66	63	63
Eneas Cr dns Rosedale	83	58	74	55	43		63
Equesis Cr @ Westside Rd				131	147		139
Greata Creek at WSC Stn	159						159
Inkameep Cr nr mth		88	88	122			99
Inkameep Cr ups		125	149				137
Kelowna Cr @ Bulman Rd					103	107	105
Kelowna Cr ups Pandosy	65	58		84	52	52	62
Lambly Cr @ Westside Rd	145	125			178		149
McDougall Creek @ Shannon L Rd		120	146				133
Naramata Creek @	116	108			93		106
Peachland Cr d/s PID Intake	122*	159	178	137	183	198	163
Powers Cr nr mth	79*	144		165			129
Prairie Cr nr mth	66	55					61
Shingle Cr ups mth		96	113	100	102		103
Shorts Cr @ park	80*	129*			163		124
Shuttleworth Cr @ Willow St.		69	73	66			69
Trepanier Cr @ Hwy 5C overpass	89	154					121
Trout Cr nr Hwy 97 bridge	53	61		56			57
Trout Cr ups Mun. Res.	137	135	153	143	142		142
Vernon Cr at 25th Ave Vernon				58			58
Whiteman Cr @ Westside Rd				122	151		137

* Shorts Cr location downstream in flood plane area; subsequently moved upstream to better reflect watershed condition

a Peachland C in 2002 scored lower due to reduced wetted width, and some apparent erosion or exposed banks due to low water levels.

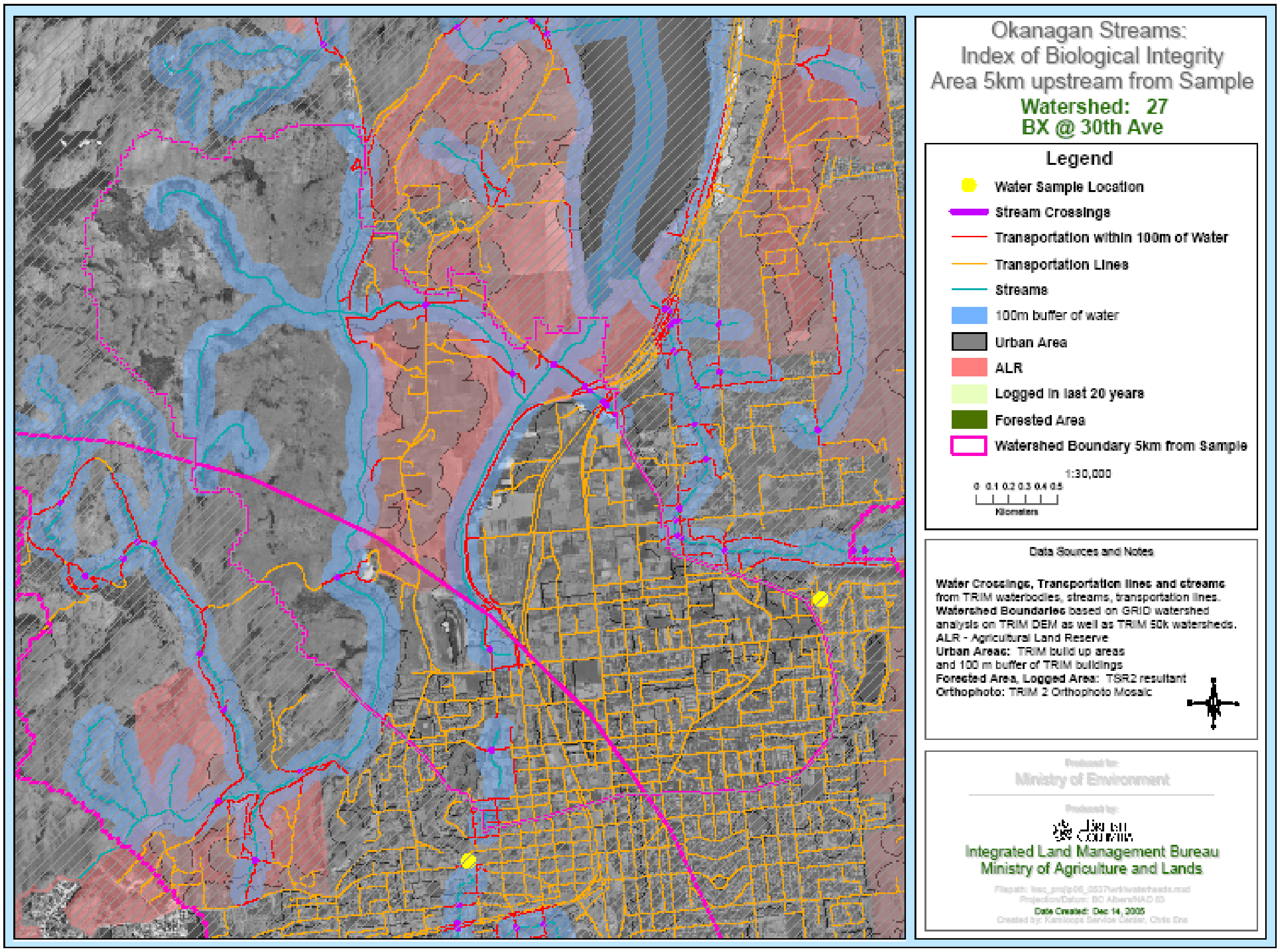
Appendix 9. Land Information Management Branch 2005 GIS summary statistics for watershed use factors for watershed area 5 kilometres above site.

SAMPLE LOCATION	EMS ID	TOTAL AREA (ha)	LOGGED AREA (ha)	PERCENT OF TOTAL LOGGED	FORESTED AREA (ha)	PERCENT FORESTED LOGGED	ALR AREA (ha)	PERCENT ALR	URBAN AREA (ha)	PERCENT URBAN	ROAD CROSSINGS	ROAD LENGTH (km)	AREA 100m FROM STREAMS (ha)	ROAD DENSITY (km/ha)
'Ellis u/s'	E224191	1425.3	0.0	0.0	1152.8	0.0	0.0	0.0	0.0	0.0	9.0	4.9	383.8	0.0
'Coldstream u/s Mun. Res.'	E206374	2720.5	19.4	0.7	2263.0	0.9	0.0	0.0	0.0	0.0	23.0	15.5	497.9	0.0
Greata	E226488	1336.4	0.0	0.0	1235.9	0.0	0.0	0.0	0.4	0.0	19.0	6.9	354.6	0.0
'Peachland @ PID Inlet'	500856.0	1921.8	0.0	0.0	1812.0	0.0	393.8	20.5	2.8	0.1	19.0	9.0	368.3	0.0
'Chute (OK Mountain Park)'	E239620	2008.7	106.7	5.3	1777.3	6.0	0.0	0.0	14.2	0.7	13.0	8.4	647.6	0.0
Lambly	500041.0	1239.2	0.0	0.0	884.7	0.0	114.4	9.2	9.2	0.7	16.0	10.7	339.5	0.0
Whiteman	500099.0	1448.7	0.0	0.0	418.0	0.0	796.4	55.0	13.1	0.9	28.0	20.2	356.3	0.1
'Inkameep u/s'	500179.0	1658.0	0.0	0.0	254.3	0.0	193.1	11.6	16.3	1.0	16.0	7.6	434.7	0.0
'Shorts near Mouth'	500067.0	2196.1	26.5	1.2	1524.9	1.7	131.6	6.0	22.2	1.0	45.0	15.4	812.7	0.0
'Trepanier near Intake'	500352.0	2199.8	20.9	1.0	1620.8	1.3	220.2	10.0	42.1	1.9	32.0	15.1	498.9	0.0
'McDougall @ Shannon Lk Rd'	E242784	1263.3	0.0	0.0	1143.4	0.0	18.9	1.5	26.3	2.1	23.0	11.9	358.9	0.0
Shingle	E242894	3953.3	0.0	0.0	893.5	0.0	828.8	21.0	94.9	2.4	86.0	34.4	1694.6	0.0
'Inkameep near Mouth'	500180.0	1451.2	0.0	0.0	98.2	0.0	240.1	16.5	36.2	2.5	20.0	11.2	431.4	0.0
Equesis	500028.0	1229.1	0.0	0.0	218.1	0.0	342.6	27.9	42.6	3.5	40.0	16.0	426.6	0.0
'Trout u/s Mun. Res.'	E223131	1012.8	0.0	0.0	485.7	0.0	186.7	18.4	92.7	9.2	27.0	18.2	325.4	0.1
Naramata	500755.0	729.6	94.1	12.9	539.0	17.5	73.4	10.1	84.2	11.5	4.0	3.2	129.1	0.0
Bellevue	E241303	974.3	0.0	0.0	364.2	0.0	101.3	10.4	141.5	14.5	22.0	9.2	267.0	0.0
'Shuttleworth @ Willow St'	E242896	425.3	3.1	0.7	29.8	10.5	177.2	41.7	83.9	19.7	17.0	7.7	172.4	0.0
'Kelowna @ Bulman Rd'	E223642	2648.5	0.0	0.0	73.8	0.0	1792.0	67.7	565.3	21.3	74.0	33.4	642.5	0.1
Eneas	500684.0	1207.5	5.9	0.5	264.3	2.2	322.4	26.7	368.4	30.5	43.0	15.2	335.5	0.0
'BX @ Pleasant Valley Rd'	E223632	1115.0	0.0	0.0	251.4	0.0	335.5	30.1	378.2	33.9	19.0	11.0	278.3	0.0
'Coldstream @ Creekside Park'	E208089	2063.6	0.0	0.0	122.2	0.0	1213.9	58.8	700.5	33.9	42.0	24.9	516.0	0.0
'Vernon @ 25th'	E249392	3257.5	0.0	0.0	0.0	0.0	991.5	30.4	1190.4	36.5	71.0	53.3	785.9	0.1
'Ellis near Mouth'	500027.0	565.6	0.0	0.0	136.8	0.0	12.8	2.3	230.7	40.8	7.0	7.5	149.9	0.0
'Trout near Mouth @ OK Lk'	500080.0	944.9	0.0	0.0	65.1	0.0	565.1	59.8	394.4	41.7	17.0	13.3	263.4	0.1
'Vernon @ 25th'	E249392	1971.0	0.0	0.0	0.0	0.0	536.5	27.2	992.7	50.4	38.0	30.3	475.4	0.1
Prairie	500325.0	1059.8	0.0	0.0	83.6	0.0	382.0	36.0	550.3	51.9	42.0	13.0	266.3	0.0
'BX @ 30th Ave'	E242776	1069.0	0.0	0.0	0.0	0.0	178.1	16.7	555.4	52.0	12.0	9.4	240.7	0.0
Powers	500059.0	933.8	0.0	0.0	57.9	0.0	73.8	7.9	514.6	55.1	12.0	7.2	170.5	0.0
'Kelowna near Mouth'	500039.0	686.0	0.0	0.0	0.0	0.0	0.0	0.0	532.5	77.6	26.0	14.8	146.7	0.1
average		1557.2	9.2	0.7	592.4	1.3	340.7	20.8	256.5	19.9	28.7	15.3	425.7	0.0
median		1263.3	0.0	0.0	254.3	0.0	193.1	16.7	92.7	11.5	23.0	13.0	356.3	0.0
75th		1980.5	0.0	0.0	886.9	0.0	429.4	30.2	519.1	37.6	40.5	16.6	481.3	0.0
25th		993.5	0.0	0.0	69.4	0.0	107.9	9.6	31.2	2.0	16.5	9.1	264.8	0.0

Appendix 10. Land Information Management Branch 2005 GIS summary statistics for watershed use.factors. for total watershed area.

SAMPLE LOCATION	EMS ID	TOTAL AREA (ha)	LOGGED AREA (ha)	PERCENT OF TOTAL LOGGED	FORESTED AREA (ha)	PERCENT FORESTED LOGGED	ALR AREA (ha)	PERCENT ALR	URBAN AREA (ha)	PERCENT URBAN	ROAD CROSSINGS	ROAD LENGTH (km)	AREA 100m FROM STREAMS (ha)	ROAD DENSITY (km/ha)
'Coldstream u/s Mun. Res.'	E206374	5939.3	338.7	5.7	5404.9	6.3	0.0	0.0	0.0	0.0	68.0	38.1	1565.7	0.02
'Ellis u/s'	E224191	14926.0	2786.4	18.7	13749.4	20.3	0.0	0.0	3.6	0.0	105.0	51.8	3513.9	0.01
Whiteman	500099	20394.9	1630.3	8.0	18382.0	8.9	1116.9	5.5	13.1	0.1	319.0	164.4	6917.7	0.02
Lambly	500041	23844.2	5241.2	22.0	21900.2	23.9	2841.8	11.9	25.0	0.1	458.0	239.6	7573.9	0.03
Shorts ups Westside Rd														
'Shorts near Mouth'	500067	18460.0	1504.9	8.2	16604.8	9.1	670.0	3.6	22.2	0.1	284.0	125.7	6315.4	0.02
Greata	E226488	4178.4	179.0	4.3	3951.7	4.5	24.8	0.6	7.7	0.2	62.0	26.5	1259.5	0.02
'Peachland @ PID Inlet'	500856	13472.5	1002.0	7.4	12259.1	8.2	1337.9	9.9	42.0	0.3	213.0	100.2	3968.8	0.03
'Inkameep u/s'	500179	16374.8	1464.0	8.9	13344.1	11.0	1657.7	10.1	60.5	0.4	262.0	138.7	4935.8	0.03
'Trepanier near Intake'	500352	21629.4	976.1	4.5	18769.3	5.2	833.4	3.9	87.1	0.4	197.0	104.3	5586.2	0.02
'Trout u/s Mun. Res.'	E223131	64776.5	9550.1	14.7	56889.5	16.8	5075.3	7.8	274.0	0.4	929.0	475.7	19497.1	0.02
'Chute (OK Mountain Park)'	E239620	7990.2	1041.0	13.0	7326.1	14.2	0.0	0.0	35.0	0.4	54.0	33.9	2117.4	0.02
'Inkameep near Mouth'	500180	17750.4	1465.7	8.3	13500.8	10.9	1846.6	10.4	86.2	0.5	280.0	148.6	5293.6	0.03
Equesis	500028	21472.4	1260.7	5.9	18170.2	6.9	829.1	3.9	113.7	0.5	329.0	163.4	7469.1	0.02
'McDougall @ Shannon Lk R	E242784	4244.6	19.1	0.5	3972.4	0.5	18.9	0.4	26.3	0.6	47.0	25.9	1088.1	0.02
Shingle	E242894	23931.9	1347.9	5.6	15986.6	8.4	2436.3	10.2	197.3	0.8	361.0	186.6	8543.1	0.02
'Trout near Mouth @ OK Lk'	500080	67934.8	9555.9	14.1	57223.7	16.7	6570.3	9.7	700.0	1.0	1001.0	509.1	20506.6	0.02
'Shuttleworth @ Willow St'	E242896	9211.6	1863.5	20.2	7920.5	23.5	1058.4	11.5	96.0	1.0	82.0	41.2	1949.2	0.02
'Ellis near Mouth'	500027	15442.9	2786.1	18.0	13838.7	20.1	12.8	0.1	234.3	1.5	112.0	59.1	3641.1	0.02
Bellevue	E241303	8750.0	1163.2	13.3	7702.4	15.1	101.3	1.2	141.5	1.6	65.0	23.8	1943.8	0.01
Naramata	500755	3616.4	600.6	16.6	3405.0	17.6	73.4	2.0	84.2	2.3	27.0	13.5	864.0	0.02
'Kelowna @ Bulman Rd'	E223642	15479.9	1495.9	9.7	10257.4	14.6	2400.1	15.5	594.6	3.8	237.0	118.0	4138.1	0.03
Powers	500059	13897.0	1617.2	11.6	11786.2	13.7	627.0	4.5	627.4	4.5	127.0	80.6	3368.7	0.02
Eneas	500684	9338.6	30.2	0.3	6368.3	0.5	2006.9	21.5	480.5	5.1	146.0	63.9	2774.7	0.02
'Coldstream @ Creekside Pa	E208089	20408.9	1708.1	8.4	11405.7	15.0	3671.7	18.0	1621.3	7.9	261.0	150.0	4964.0	0.03
'BX @ Pleasant Valley Rd'	E223632	6835.7	31.3	0.5	3382.4	0.9	647.4	9.5	753.9	11.0	90.0	47.6	1476.7	0.03
'Vernon @ 25th'	E249392	72824.4	3355.6	4.6	33910.0	9.9	13092.9	18.0	9011.0	12.4	948.0	558.0	15467.3	0.04
'Kelowna near Mouth'	500039	22706.5	1495.4	6.6	10380.7	14.4	5744.6	25.3	3918.4	17.3	386.0	194.0	5360.8	0.04
Prairie	500325	2002.5	0.0	0.0	502.3	0.0	703.7	35.1	592.0	29.6	55.0	22.8	466.9	0.05
'Vernon @ 25th'	E249392	4833.3	0.0	0.0	275.0	0.0	1466.5	30.3	2338.8	48.4	81.0	55.1	1060.3	0.05
'BX @ 30th Ave'	E242776	1069.2	0.0	0.0	0.0	0.0	178.1	16.7	555.4	51.9	12.0	9.4	240.7	0.04
average		18457.9	1850.3	8.7	13952.3	10.6	1901.5	9.9	758.1	6.8	253.3	132.3	5128.9	0.0
median		15184.5	1405.9	8.1	11596.0	10.4	945.9	9.6	127.6	0.9	171.5	90.4	3805.0	0.0
75th		21206.6	1688.6	13.2	16450.2	15.1	2301.8	14.6	593.9	5.0	310.3	160.1	6133.1	0.0
25th		7124.3	404.2	4.5	5645.7	5.5	120.5	2.4	36.8	0.4	71.3	38.9	1660.2	0.0

Appendix 11. Land Information Management Branch GIS Analysis Maps of Okanagan Streams



Due to file and document size concerns the BX @ 30th Ave. is shown as an example of the GIS image generated during exercise; other site maps for near site and entire watershed available from author.

Appendix 12. Comparison of various B-IBI metrics utilized in the Pacific Northwest.

Metrics	Okanagan	Puget Sound 10 metric B-IBI[1]	Puget Sound Family level 5 metric B-IBI[1]	GVRD[2]	Skeena Forest District[3]	Cascade MMI Colville Confederated Tribes[4]
Total # taxa	1	X	X	X	X	X
# Ephemeroptera	1	X	X	X		X (%)
# Plecoptera	1	X	X	X		X
# Clinger	1	X		X	X	X
# Intolerant	1	X		X	X	X
Hilsenhoff index	2				X	X
# Tricoptera	2	X	X	X	X	X
% Tolerants	2	X		X		X
% Predator	2	X		X		
% Dominance	2	X	X	X	X	
# Long lived		X		X		
% Clingers						X
% filters						X

1 -http://www.cbr.washington.edu/salmonweb/
2-http://www.gvrd.bc.ca/sewerage/pdf/bib_guide.pdf
3-Bennett, S. 2004. Benthic invertebrate index of biological integrity: 2003 field season results for streams in the Skeena Stikine Forest District. Report prepared for: Community Futures Development Corp. of Nadina; Pacific Inland Resources; B.C. Ministry of Environment; Kispiox B.C. Timber Sales. 47p.
4-http://nrd.colvilletribes.com/obmep/pdfs/Draft%20Biological%20Protocols%20_2_.pdf