AECOM

University Endowment Lands

Integrated Stormwater Management Plan
Stage 4 Report

Prepared by:

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Project Number:

60222155

Date:

May 19, 2017

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May 19, 2017

Jonn Braman
Manager
University Endowment Lands
5495 Chancellor Boulevard
Vancouver, BC V6T 1E3

Dear Jonn:

Project No: 60222155
Regarding: Integrated Stormwater Management Plan Stage 4 Report

Please find attached our DRAFT report for Stage 4 of the UEL ISMP. Please let me know when you are available to discuss this report.

Sincerely,
AECOM Canada Ltd.

Graham Walker
Project Manager
Graham.walker2@aecom.com

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AECOM Signatures

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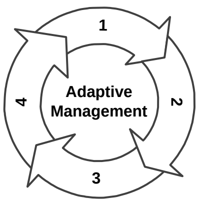
1. Introduction

The UEL has retained AECOM Canada Inc. to develop the Integrated Stormwater Management Plan (ISMP) in line with the requirements of Metro Vancouver's Integrated Liquid Waste and Resource Management Plan (ILWRMP) and British Columbia's Environmental Management Act. Development of the ISMP will occur in four stages and is based on the approach outlined in Chapter 9: Developing and Implementing an ISMP in Stormwater Planning: A Guidebook for British Columbia.



The ISMP contains long-term goals and objectives that have a planning horizon of up to 30 years. Changes in factors such as the economy, technology, policy, land-use and public opinion over the long term horizon can be addressed through an Adaptive Management approach in which the ISMP is periodically updated to ensure that it remains relevant and applicable. The adaptive process is iterative - the last stage in the cycle focuses on monitoring, and will generate new information that should be reviewed in the first stage of the next cycle.

Table 1: Summary of ISMP Approach

Stage	Question Answered	Description of tasks	Relevant ISMP Sections
1	What do we have?	Review background information and summarize existing conditions	• Study Area • Regulatory Context • Land Use • Hydrology • Stormwater System • Hydrogeology and Soils • Environment • Hydraulic Modelling and Assessment
2	What do we want?	Establish the vision for future development	• Vision and Goals
3	How do we put this into action?	Development of an implementation plan, funding and enforcement strategies	• Implementation Plan
4	How do we stay on target?	Development of a monitoring and assessment program	• Adaptive Management Plan

1.1 UEL Integrated Stormwater Management Plan

During Stage 1 of the UEL ISMP, AECOM reviewed background information and summarized existing conditions of stormwater management within the UEL. The Stage 1 report included a water quality and benthic sampling report that provided an understanding of "current" baseline conditions within the existing creeks.

In Stage 2 of the Integrated Stormwater Management Plan, the UEL and the key stakeholders (Metro Vancouver, City of Vancouver, Spanish Bank Streamkeepers, the University Golf Course, and the University of British Columbia), established five (5) goals to guide the stormwater management for the UEL:

Goal 1: The UEL community is engaged in stormwater management.
Goal 2: Healthy streams and a natural environment are part of the UEL.
Goal 3: Stormwater infrastructure provides an adequate level of service, while protecting life and property.
Goal 4: The UEL provides guidelines and a regulatory framework for stormwater management.
Goal 5: Stormwater management at UEL adapts to change.

These goals were established to achieve the vision of "*A stormwater management plan that protects the natural and built environment through enhancement of natural watercourses, and provides opportunities for collaboration and engagement with community and residents on stormwater issues*".

The Implementation Plan document (Stage 3) identified opportunities to develop planning, environmental and engineering controls that would allow the UEL to achieve the above mentioned vision and goals. The document provided a list of ten (10) action items that UEL should consider for implementation:

1. Promote stormwater management awareness and engagement opportunities.
2. Continue with the combined sewer separation strategy in Area B.
3. Manage the quantity of road runoff.
4. Treat stormwater runoff from the roadways and upgrade stormwater treatment at the UEL Works Yard.
5. Identify stormwater infrastructure that is poorly located for maintenance and develop plans for management or replacement (i.e. the 300mm diameter storm sewer in Pacific Spirit Park east of Acadia Road).
6. Continue to upgrade system capacity and renew aging infrastructure in a proactive manner through the capital planning process.
7. Develop mitigation measures to address slope stability in Area B.
8. Integrate stormwater asset maintenance with work order management using a GIS-centric system.
9. Develop Erosion and Sediment Control requirements.
10. Limit the rate of stormwater runoff from private properties.

This document (Stage 4 report) provides guidelines for monitoring and tracking water quality, quantity, and instream habitat through the lens of the UEL Watershed Health Monitoring and Adaptive Management Framework. The proposed Framework is a condensed version of the Metro Vancouver's Monitoring and Adaptive Management Framework document and consists of recommendations that are most applicable to the UEL.

1.2 Metro Vancouver's Monitoring Adaptive Management Framework

The Metro Vancouver's Monitoring and Adaptive Management Framework (MAMF; Metro Vancouver, 2014) distinguishes three types of watershed systems - Lower Gradient, Higher Gradient, and Piped Systems. Lower gradient systems are defined as natural watercourses, ditches, and canals with gradient less than one percent (<1%). Higher gradient systems are defined as natural watercourses, ditches, and canals with gradient more than one percent (>1%). The piped systems consist of predominantly buried storm sewer infrastructure. Depending on the system type, MAMF prescribes monitoring programs specific for each type (Figure 1). The UEL has a mix of piped system, lower gradient system and higher gradient system.

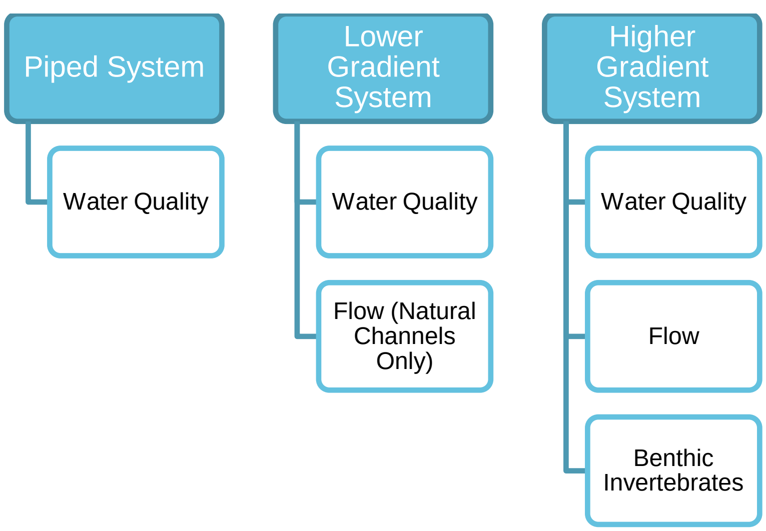


Figure 1: Monitoring programs based on system type (Adapted from Metro Vancouver MAMF, 2014)

1.3 AECOM Water Quality Sampling 2015

AECOM conducted a water quality sampling program for the purposes of establishing baseline conditions in the UEL watersheds. The sampling program identified system types and conducted sampling and analysis in four (4) locations. Water quality sampling locations are presented in Figure 2 and system type at each sampling location is described in Table 2. The rationale for choosing each location is also provided in Table 2.

Table 2: 2015 Watercourse Sampling Locations and Rationale

Station ID	Location	System Type	Parameters	Rationale
UEL-001	Lower Spanish Bank Creek	High Gradient	Water Quality, Benthos	Reflects the impact of residential development within the area.
UEL-002	Lower Canyon Creek	High Gradient	Water Quality	Reflects the impact of residential development within the area.
UEL-003	Lower Salish Creek	High Gradient	Water Quality, Benthos	Reflects the impact of residential and institutional development (i.e. school, trail, works yard) within the area.
UEL-004	Upper Salish Creek	Low Gradient	Water Quality	Characterizes the impacts from the golf course.

Flow (i.e. quantity) data was not collected during the sampling period in 2015. However, Metro Vancouver recommends that, as a minimum, one year of continuous flow data is collected for high gradient systems. Urbanized watersheds with increased impervious areas have a direct effect on the flows in watercourses such as increased peak flows, lower baseflows, and increased frequency of high flow events (flashier streams).

The water quality sampling program provided the baseline conditions of the watershed's health in the UEL. The following recommendations have stemmed from the study:

- Consideration of alternative benthic invertebrate sampling and reporting protocols at sites with low water levels. Under the current B-IBI sampling protocols the benthic invertebrate sampling was not possible at sampling site UEL-002 due to low water levels.
- Conduct benthic invertebrate sampling every 3-5 years to track long term trends.
- Add a new sampling location downstream of UEL-004 and upstream of UEL-003 sites to gain a more discrete understanding of water quality concerns within the UEL watershed, such as the point source for elevated occurrences of fecal coliforms and E. coli upstream of the UEL-003 sampling location.

Basemapping from Government of BC, Natural Resources Canada, Metro Vancouver and AECOM 2016.

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0 50 100 150 200
Metres

1:10,000

NAD 1983 UTM Zone 10N

Legend

- Water Quality Sampling Location
- Water Quality and Benthic Sampling Location
- Public Trails (Active) - Metro Vancouver

Overview Map

University Endowment Lands
Water Quality and Bentic Sampling
Location: University Endowment Lands

University Endowment Lands Sampling Locations

28 June 2016

AECOM

Figure 2

File Location: P:\60222155\900-Work\920-GIS\03 Maps\ISMP Figures\2016-02-03\Fig1-2016-02-03-SampleLocation60222155-001.mxd Date Revised: June 28, 2016 Reviewed by: MM

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2. Watershed Health Monitoring

The primary objectives of the watershed health monitoring framework for the UEL are to monitor and protect watershed health, to assess the effectiveness of the ISMP's implementation strategies and to determine if any changes need to be made to these strategies.

2.1 Objectives

The goal of the UEL Watershed Health Monitoring is to establish a repeatable process for tracking changes occurring within the watershed. The MAMF (Metro Vancouver, 2014) recommended that a combination of water quality, flow monitoring, and benthic invertebrate sampling are used for monitoring a watershed's heath.

2.2 Monitoring Parameters

Water Quality

Water quality in higher gradient systems in general tends to be more amiable to salmonids and macro invertebrate populations due to more stable water temperatures, higher levels of dissolved oxygen and neutral levels of pH. However, increased imperviousness in an urban setting has the potential to introduce metals, oils, and grease from runoff. It is recommended that water quality is monitored and reported for all system types within the UEL. The MAMF (Metro Vancouver, 2014) has suggested the following water quality parameters for monitoring:

- Dissolved Oxygen
- Temperature
- Turbidity
- pH
- Conductivity
- Nitrate (as nitrogen)
- E. Coli
- Fecal coliforms
- Total Iron
- Total Copper
- Total Lead
- Total Zinc
- Total Cadmium

The best practice for monitoring water quality is to have two sampling periods annually for municipalities in Metro Vancouver. The first sampling period should be during the wet season (November-December) and the second should be during the dry season (July-August). Five (5) samples should be taken during each sampling period on a weekly basis.

All surface water samples can be taken from the watercourses as grab samples, collected mid-stream. *In situ* data can be obtained for dissolved oxygen (DO), temperature, pH, conductivity, and turbidity parameters using a YSI Pro Plus type probe and LaMotte turbidity meter.

Flow

The UEL ISMP study area contains higher and lower gradient systems. Flow monitoring is recommended for all higher gradient systems. The Metro Vancouver's MAMF recommends at least one (1) year of continuous flow data collection. Flow monitoring methodology should be consistent with the Manual of British Columbia Hydrometric Standards. Design and implementation of flow monitoring must be done by a qualified professional to ensure high quality of flow data. For high quality analysis, it is recommended to collect precipitation data for the area. The University Of British Columbia's Department of Geography collects rainfall data at UBC's Climatology Station. If this data is not available or is incomplete, then Metro Vancouver's VA01 Kitsilano High School station may be used.

Table 3: Proposed hydrological indicators for flow monitoring

Hydrological Indicator	Definition
T_{Qmean}	Proportion of the year during which daily flow exceeds the annual average discharge
Low Pulse Count (Counts)	Number of times each calendar year that daily flow drops below 0.5 times the mean annual discharge
Low Pulse Duration (Days)	Average duration of low flow pulses during the calendar year
Summer Baseflow (m^3/s)	Average of daily discharges during July through September with seven-day antecedent rainfall less than 1mm
Winter Baseflow (m^3/s)	Average of daily discharge during November through March with seven-day antecedent rainfall less than 1mm
High Pulse Count (Counts)	Number of times each water year that daily flow increases above twice the mean annual discharge
High Pulse Duration (Days)	Average duration of high flow pulses during water year

Benthic Invertebrates

The diversity and number of benthic invertebrate communities reflect site specific environmental conditions. The variability in the presence of these communities can be attributed to a number of environmental stress factors such as poor water quality, sedimentation, rapid changes in flow regime, erosion, siltation, and loss of food sources within the riparian habitat. The complete absence of macroinvertebrates indicate degraded water quality and instream habitat.

The *Benthic Index of Biological Integrity (B-IBI)* has been adopted by Metro Vancouver and remains a recommended methodology for assessment of instream health. *Ephemeroptera*, *Plecoptera* and *Trichoptera* (EPT) taxa are sensitive to environmental stress and therefore are commonly prescribed for use as indicators of watershed health. Samples are collected using a surber sampler with 250 µm mesh with substrate cleaning lasting for 3 minutes for each placement. Each placement samples an area of 0.09 m2 and each sample is a composite sample from 3 riffle surber placements. Each of the composite samples is filtered through a 250 µm screen and the sampler thoroughly washed. Washed samples are transferred to pre labeled plastic sample containers and preserved with 80% ethanol. The scoring system overview that is used for the benthic invertebrate analysis is derived from the MAMF and recommended ten B-IBI scoring system, which consisted of the following (Fore *et al.* 1994):

1. Total number of taxa
2. Number of mayfly (*Ephemeroptera*) taxa
3. Number of stonefly (*Plecoptera*) taxa
4. Number of caddisfly (*Trichoptera*) taxa
5. Number of long-lived taxa, defined as living at least 2-3 years in the immature state
6. Number of intolerant taxa
7. Percent of individuals in tolerant taxa
8. Percent of predator individuals
9. Number of clinger taxa
10. Percent dominance: the sum of individuals in the three most abundant taxa, divided by the total number of individuals found in the sample (top 3 taxa)

The 2015 AECOM Water Quality Sampling Report recommended alternatives for B-IBI protocols for some or all of the previous sample locations because sampling site UEL-002 had too low water levels for use of the surber sampler (specific methodology B-IBI sampling procedures) and samples were not able to be collected in this watercourse. One alternative recommended is the Canadian Aquatic Biomonitoring Network (CABIN) Protocol (EC 2012). The CABIN protocol is the national biomonitoring program developed by Environment Canada that provides a standardized sampling protocol and a recommended assessment approach called the Reference Condition Approach (RCA) for assessing aquatic ecosystem condition. CABIN provides the tools necessary to conduct consistent, comparable, and scientifically credible biological assessments of streams.

Spanish Bank Streamkeepers conduct bug counts each summer with a Pacific Streamkeepers Federation volunteer. This is a great event to increase public engagement with stormwater quality, which should be encouraged. However, a benthic invertebrate sampling and analysis should still be conducted by a Qualified Environmental Professional to ensure that all quality assurance and quality control procedures are followed.

Riparian Area Regulation Assessment

It is important to include erosion and slope stability assessments as part of the continuous monitoring program within the UEL watercourses. The Riparian Area Regulation Assessment allows the UEL to determine the applicable Streamside Protection and Enhancement Area (SPEA) width for the watercourses. The Detailed Assessment requires evaluation of stream width, reach banks, potential vegetation type, channel type and assessment measures to protect the integrity of the SPEA. The measures to protect the SPEA integrity that may be considered include assessment and treatment of danger trees, windthrow, slope stability, tree protection during construction, encroachment, and sediment and erosion control. Developing appropriate measures to address slope stability will require consultation with a geotechnical engineer. The Detailed Riparian Area Regulation Assessment would provide the UEL with a repeatable process for evaluating slope stability and riparian area integrity and should be considered during the next UEL ISMP iteration.

2.3 Sampling and Monitoring Locations

The AECOM Water Quality and Benthic Sampling report identified sampling locations that were used to determine the baseline conditions (Figure 2). It is recommended that these sampling locations should remain for consistent water quality monitoring in the future. Flow monitoring and benthic invertebrate sampling is proposed at three (3) locations within UEL, which are presented in Figure 3.

A Block F sampling site will be monitored by the Block F developer for 2 years after construction. The monitoring will be limited to ensuring that the Block F’s BMPs are functioning as required. The cost of monitoring at that site will be offset by the developer but the monitoring will not be as comprehensive as the recommended water quality and flow methodologies identified in Section 2.2.

2.4 Data Quality Assurance and Quality Control (QA/QC)

Standardized field forms and Chain of Custody forms are QA/QC best practices that apply to all field, laboratory and benthos monitoring programs.

Field Monitoring and Sampling QA/QC

It is recommended that water quality monitoring, sampling, analysis and reporting is done by a Qualified Professional (QP) such as a qualified aquatic biologist or environmental professional. All water samples must be collected using industry standard sampling protocols (refer to the MAMF for guidance). Appropriate measures must be taken to reduce potential for sample contamination. Field sampling best practices must be followed at all times, such as wearing disposable nitrile gloves when sampling and use of bottles and preservatives supplied by the analytical laboratory. All samples must be collected with mouth of sample bottles facing upstream with sampler standing downstream of the sample bottle. The sampling methodology should ensure that no upstream disturbance occurs within the watercourse prior to sampling. All field sampling and measurement equipment should be maintained in good condition and all instruments must be calibrated prior to use. For additional QA/QC best practices consult the MAMF (Metro Vancouver, 2014).

Laboratory Analysis QA/QC

The laboratory conducting the water quality analysis of the sample must provide documentation to support that quality checks were made and that quality control results indicate that the analysis meets the quality standards. For additional QA/QC best practices consult the MAMF (Metro Vancouver, 2014).

Benthic Invertebrate Monitoring and Sampling QA/QC

It is recommended that the Benthic Invertebrate analysis be done by taxonomic experts certified in freshwater taxonomy. It is recommended that 25% of the samples are spot checked and a reference collection is created for third party verification. Sample re-sort may also be recommended to evaluate sorting efficiency. For additional QA/QC best practices consult the MAMF (Metro Vancouver, 2014).

2.5 Watershed Health Monitoring Cost Estimates

Adaptive Management Framework Monitoring cost estimates are provided for municipalities in Section 10 of the Metro Vancouver's Monitoring and Adaptive Management Framework document. The higher gradient systems have a higher cost for monitoring due to requirements to assess water quality, flow, and benthic invertebrates. Each individual monitoring program consists of labour (including field sampling), laboratory analysis, and data analysis costs. The total monitoring and sampling costs are presented in Table 4. The estimated costs are the total for a 5 year monitoring and sampling period and include:

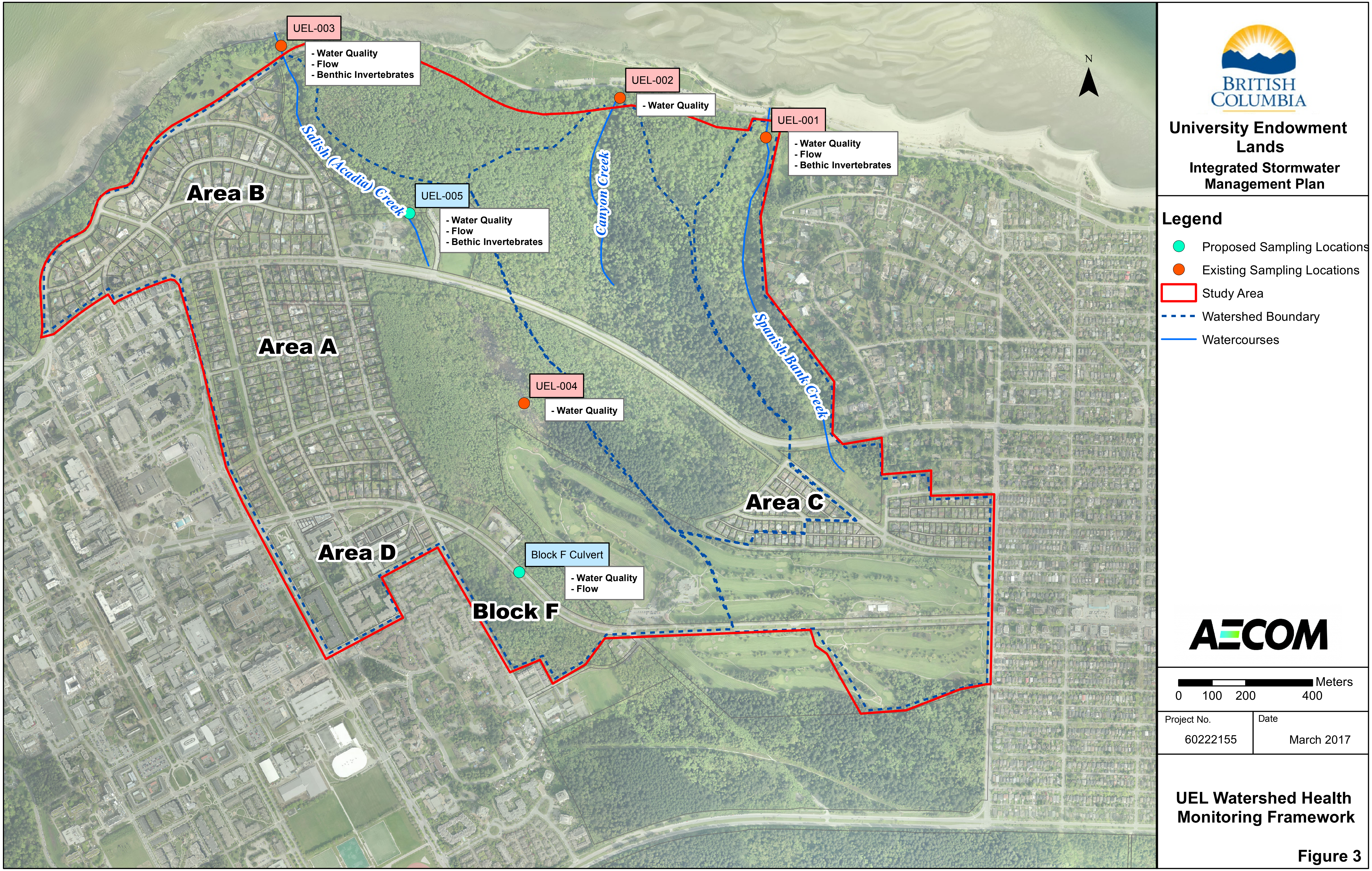
- Water quality sample collection every five years during two periods of the year (dry and wet seasons) with five samples collected over 30 days.
- Hydrometric monitoring for a single year, which includes gauge installation, discharge rating, data download and data processing.
- Benthic invertebrate sampling every 5 years.

Table 4: Total Monitoring Cost Estimates by Site for a 5 Year Period

Location	Water Quality			Benthic Invertebrates			Hydrometrics			Total
	Labour	Lab	Data Analysis	Labour	Lab	Data Analysis	Labour	Lab	Data Analysis	
UEL-001	$ 4,000	$1,500	$3,500	$1,250	$1,220	$1,500	$8,000	$4,200	$6,000	$31,170
UEL-002	$ 4,000	$1,500	$3,500							$9,000
UEL-003	$ 4,000	$1,500	$3,500	$1,250	$1,220	$1,500	$8,000	$4,200	$6,000	$31,170
UEL-004	$ 4,000	$1,500	$3,500							$9,000
Works Yard	$ 4,000	$1,500	$3,500	$1,250	$1,220	$1,500	$8,000	$4,200	$6,000	$31,170
Block F	$ 4,000	$1,500	$3,500	-	-	-	$8,000	$4,200	$6,000	$27,200
									Total	**$ 138,710**

To offset some of the labour cost for monitoring and sampling it is recommended to partner with the Pacific Streamkeepers Federation and the Pacific Spirit Park Society who already conduct some instream benthic invertebrate and water quality studies. However, the UEL needs to ensure that the partner organizations are following sampling and monitoring methodologies consistent with the Metro Vancouver MAMF document and provide a record of data QA/QC checks. Other cost-saving recommendations include:

- Adopt the same monitoring and reporting forms across all sampling locations.
- Share laboratory analysis costs with other municipalities within Metro Vancouver that adopt ISMPs and the Adaptive Management Framework.
- Purchase sampling equipment in bulk or cost share with other municipalities within Metro Vancouver.



UEL Watershed Health Monitoring Framework

Figure 3

3. Adaptive Management

The adaptive management principles allow the UEL to determine if the ISMP and its associated action items are achieving the desired benefits (i.e. maintain or improve watershed health) or whether changes are required (e.g. need to further control run-off volumes). Therefore an assessment approach is required that will allow the UEL to determine, in a simplified manner, if the conditions in the watercourses are good or if there is a concern. The MAMF includes evaluation criteria for the water quality, flow, and benthic invertebrate indicators that are proposed for the UEL watershed health monitoring.

3.1 Assessment of Watershed Health Monitoring Results

Water Quality Results

The water quality monitoring results can be evaluated against the classification table proposed by Metro Vancouver's MAMF (Table 5). This provides a straight forward method to identify if further adaptive management practices are required to address the water quality concerns.

Table 5: Classification of Water Quality Results, adapted from Table 4 of the MAMF (Metro Vancouver, 2014)

	Good Level	Satisfactory Level	Needs Attention Level
General Parameter			
Dissolved Oxygen (mg/L)	≥ 11	6.5 to < 11	< 6.5
pH	6.5 to 9.0	6.0 to < 6.5 or > 9.0 to 9.5	< 6 or > 9.5
Water Temperature (° C)			
Low flow summer	< 16	16 to 18	>18
Wet Weather	7 to 12	5 to <7 or >12 to 14	< 5 or > 14
Conductivity (µS/cm)	< 50	50 to 200	> 200
Turbidity (NTU)	≤ 5	> 5 to 25	> 25
Nutrients			
Nitrate as Nitrogen (mg/L)	≤ 2	2 to 5	> 5
Microbial Parameters			
E.coli (freshwater) (CFU/100ml)	Geomean ≤ 77	Geomean between 78 - 385	Geomean > 385
Fecal coliform (CFU/100ml)	Geomean ≤ 200	Geomean between 2201 - 1,000	Geomean > 1,000
Metals (Total Metals) (µg/L)			
Iron	< 800	800 to 5,000	> 5,000
Cadmium	< 0.06	0.06 to 0.34	> 0.34
Copper	< 3	3 to 11	> 11
Lead	< 5	5 to 30	> 30
Zinc	< 6	6 to 40	> 40

Flow Monitoring Results

Similarly to the water quality results, the MAMF provides a methodology for assessing the hydrologic monitoring results. For proper assessment of the hydrologic monitoring results, it is necessary to establish the pre-development baseline conditions. In the developed areas of the UEL, establishing pre-development baseline conditions is not viable and, therefore, trending hydrologic monitoring results will allow the UEL to rate watershed conditions as improving or degrading.

Table 6: Hydrologic response to land development or disturbance, adopted from Table 4 of the MAMF (Metro Vancouver, 2014)

Hydrological Indicator	Expected Response to Land Development or Disturbance
T_{Qmean}	Decrease
Low Pulse Count (Counts)	Increase
Low Pulse Duration (Days)	Decrease
Summer Baseflow (m^3/s)	Usually Decrease
Winter Baseflow (m^3/s)	Decrease
High Pulse Count (Counts)	Increase
High Pulse Duration (Days)	Decrease

Benthic Invertebrate Sampling Results

Assessing benthic invertebrate sampling results requires understanding the changes in the total taxa richness, total abundance of all taxa, and evaluation of the overall composition of benthic invertebrate communities. The B-IBI score and ranking can be used to determine the level of habitat degradation and the results can be used to establish trends. In general, the following trends are expected as a response to disturbance and pollution:

- Increase in pollution-tolerant species within the benthic invertebrate community.
- Decrease in pollution intolerant EPT taxa.

3.2 Adaptive Management Practices

Adaptive Management Practices (AMPs) are responses to degradation of the watershed. Table 5 outlines how water quality results can be used to evaluate the health of the watershed. If the monitoring program identifies that the watershed's health requires attention ("Need Attention Level") then a number of measures (known as adaptive management practices) can be taken to improve the health of the watershed. Appendix A provides a list of adaptive management practices that can be implemented in response to negative changes in the watershed. A more detailed description of some of the AMPs is provided below.

Source Control Measures

Source Control measures reduce the volume of stormwater flow through attenuation of runoff from impervious surfaces. In turn, a reduction in stormwater runoff may also reduce the negative impacts on water quality, watercourse morphology, and biological health. Stormwater source control measures are also known as Best Management Practices (BMPs). As part of the Stage 3 UEL ISMP implementation plan, AECOM evaluated six stormwater BMPs:

- Absorbent Landscaping
- Rain Garden
- Infiltration Swale
- Infiltration Trench
- Pervious Pavement
- Green Roof

Other BMPs that are recommended as source control measures in the Metro Vancouver AMF Guideline are:

- Disconnection of roof leaders and downspouts;
- Rainwater harvesting; and
- Tree retention and re-establishment.

Education and Public Outreach

Education and public outreach regarding stormwater issues can encourage the local residents to take ownership and responsibility for stormwater management. Implementation of signage in areas of concern, outreach to homeowners, developers, and industry are some of the examples of effort that may be required to increase awareness of stormwater issues and change the habits that may be detrimental to a watershed's health. Currently, the Spanish Bank Streamkeepers, in partnership with the Pacific Streamkeepers Federation and Pacific Spirit Park Society, play an integral role in stormwater education

Cross Connection Control

As the sewer system in Area B of the UEL is planned to be separated it is important to ensure that the private side separation strategy is well established and is in coordination with the mainline sewer separation. This means that as the new sewer is built, the private properties are being connected to the right sewer line (sanitary vs. storm). For areas where sewers are already separated, investigations may be conducted to determine if there are cross connection issues. For example, if a sanitary sewer flow increases significantly after a rain event then it is possible that storm runoff is entering the sanitary sewer via a wrongful connection.

Runoff Detention, Retention, and Treatment Facilities

Detention and retention facilities are typically designed to limit the runoff volume, frequency and duration in order to maintain predevelopment flow conditions. The runoff treatment facilities are designed to remove pollutants that may impact downstream habitat. Typical runoff treatment methods may include, but are not limited to, biofiltration, oil/water or oil/grit separation, bioretention, and media filtration. The Block F development at the UEL aims to maintain the functionality of the existing wetland in conjunction with an oil-grit separator and swales to treat and retain flow from the increased total impervious area of the site.

Riparian Habitat Restoration

Stream riparian areas (landscaped area on other side of the stream) serve an important ecological function. They provide nutrients for terrestrial and aquatic life, filter pollutants, maintain lower water temperatures, are a source of large woody debris for instream habitat and provide a barrier to protect the stream from humans and animals (e.g. off-leash dogs). The Riparian Area Regulation requires protection and improvement of this habitat by protecting existing riparian setbacks, removal of invasive species within the riparian areas, and development of public education and outreach programs.

Mitigation of Construction Impacts

Land development and redevelopment construction activities can impact water quality and instream habitat. Soil erosion, generation of suspended sediment, increased runoff volume and the potential presence of contaminants are some of the impacts of construction activities. The recommended development of Erosion and Sediment Control requirements in Stage 3 is aimed to equip the UEL with more tools for mitigating runoff impacts from construction sites.

4. Summary of Recommendations

In summary, we recommend that the UEL implement an adaptive management plan for its ISMP. The key components of this plan are:

- Water quality and B-IBI sampling at the same four (4) locations where previous sampling was conducted (see Figure 2).
- Consider alternative benthic sampling methodology for sampling locations where B-IBI methodology was not possible (i.e. UEL-002).
- Conduct additional flow, water quality and/or benthic invertebrate sampling at two additional locations as shown in Figure 3.
- Assess the results of monitoring with the list of Adaptive Management Practices in the MAMF document recommended for specific impacts of development or land disturbance (the list of recommended AMPs is attached in Appendix A).

- An annual review of the monitoring data and ISMP implementation strategy to determine if the ISMP and its action items need modifying and whether additional adaptive management practices are warranted.

5. References

Environment Canada (EC). (2012). *Canadian Aquatic Biomonitoring Network Field Manual for Wabeable Streams.* Retrieved from http://publications.gc.ca/collections/collection_2012/ec/En84-87-2012-eng.pdf

Fore, L., Karr, J., & Conquest, L. (1994). Statistical properties of an index of biotic integrity used to evaluate water resources. *Canadian Journal of Fisherties and Aquatic Sciences*, 212-231.

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Appendix A

Adaptive Management Practices recommended for specific impacts
(Table 8 in Metro Vancouver Monitoring and Adaptive Management Framework for Stormwater, 2014)

Table 8 - Adaptive Management Practices recommended for specific impacts

Indicator	AMP Trigger	Impact	Examples of Recommended AMPs
Dissolved Oxygen (DO)	Exceeds satisfactory or need attention thresholds	• potential impacts to resident fish, such as salmonids (intolerant to reduced DO) • potential alterations to benthos communities – loss of intolerant taxa	• enhancement of riparian areas to increase shading (reduce water temperatures and increase oxygen carrying capacity) • instream habitat to enhance aeration (e.g. riffles) • source controls (to reduce organic matter and associated consumption of oxygen)
Water Temperature	Exceeds satisfactory or need attention thresholds	• potential impacts to resident fish, such as salmonids (intolerant of elevated temperatures) • potential alterations to benthos communities – loss of intolerant taxa	• enhancement of riparian areas (plantings) to increase shading • retention or re-establishment of tree cover • reducing impervious surfaces • in-stream complexing to provide increased shading / cover
Turbidity	Exceeds satisfactory or need attention thresholds	• potential impacts to fish including smothering of eggs and direct impacts to fish gills; also potential impacts on fish behaviour and feeding • potential alterations to benthos communities (e.g., reduced feeding activity of filter feeders)	• inventory and assessment of erosion sites and implementation of remedial actions as applicable • operations and maintenance activities such as street cleaning and catch basin cleanout • establishment and enforcement of sediment / erosion bylaws / policies • education and outreach
Nutrients (e.g., Nitrates)	Exceeds satisfactory or need attention thresholds	• potential for increased algal growth within watercourse which could alter resident aquatic communities such as benthos • direct toxicity of nitrate to amphibians and aquatic life • potential indirect impacts to aquatic biota due to reduced dissolved oxygen levels	• identification of sources and implementation of appropriate source controls (e.g., cross connections, control of runoff from agricultural fields; application of fertilizers on fields during wet periods, septic field and yard maintenance education, etc.)
Metals	Exceeds satisfactory or need attention thresholds	• potential direct toxicological impacts to aquatic biota • potential accumulation of metals in sediments	• identification of sources and implementation of appropriate source controls (e.g., swales, infiltration galleries, disconnect downspouts, detention ponds/tanks, etc.) • educational programs
Microbiological Parameters	Exceeds satisfactory or need attention thresholds	• potential human health issues if water is used for recreation or irrigation • no direct impacts to aquatic biota, however high bacteria levels can be associated with loadings of organics and nutrients that can affect dissolved oxygen levels	• source controls, dog waste mgmt; control of agricultural and urban runoff • educational programs • cross connection ID

Metric	Simple Definition	Observed Change	Indicates	Effect	Related BMP
T_{Qmean}	Days per year that flows exceed the mean annual flow rate.	Lower than pre-development value, or decreasing trend	increased flashiness	• more frequent disturbance of benthic organisms • increased erosion and sediment deposition • increased pollutant loads	• source controls • runoff detention facilities • riparian buffer • wetland rehabilitation/construction • infiltration facilities
Low Pulse Count	Number of times per year the flow decreases below half of the mean annual flow rate	Higher than pre-development value, or increasing trend	more frequent interruption of seasonal low flows by small runoff events	• disruption of benthic organisms and salmonid alevins/fry • increased pollutant loads	• source controls • runoff detention facilities • riparian buffer • wetland rehabilitation/construction • rain gardens, infiltration facilities
Low Pulse Duration	Amount of time (days) that the flow is below half of the mean annual flow rate.	Lower than pre-development value, or decreasing trend	more frequent interruption of seasonal low flows by small runoff events	• disruption of benthic organisms and salmonid alevins/fry • increased pollutant loads	• source controls • runoff detention facilities • riparian buffer • wetland rehabilitation/construction
Summer Baseflow	Dry weather average flow rate during summer months.	Altered from pre-development value, increasing or decreasing trend	alteration of water table elevation due to groundwater pumping, surface water abstraction or diversion, drainage, or irrigation with imported water	• drying of stream channels, fish stranding, desiccation of biota • decreased flow available for water supply	• wetland rehabilitation/construction • soil augmentation • infiltration facilities • protection of groundwater recharge areas • limit groundwater pumping for foundation protection (require underground structures to be tanked)
Winter Baseflow	Dry weather average flow rate during winter months.	Lower than pre-development value, or decreasing trend	decreased shallow subsurface storage	• decreased pool habitat • decreased flow for available for water supply	• source controls • runoff detention facilities • riparian buffer • tree retention and re-establishment • wetland rehabilitation/construction • retention and re-establishment of trees
High Pulse Count	Number of times per year the flow rises above twice the mean annual flow rate	Higher than pre-development value, or increasing trend	more frequent runoff events	• more frequent disturbance of benthic organisms • increased erosion and sediment deposition • increased pollutant loads	• source controls • runoff detention facilities • riparian buffer • wetland rehabilitation/construction • retention and re-establishment of trees
High Pulse Duration	Amount of time (days) that the flow is above twice the mean annual flow rate.	Lower than pre-development value, or decreasing trend	faster rise and recession of stormflow	• more frequent disturbance of benthic organisms • increased erosion and sediment deposition • increased pollutant loads	• source controls • runoff detention facilities • riparian buffer • wetland rehabilitation/construction