7.0 MONITORING PROGRAM

A monitoring program will provide feedback on the effectiveness of ongoing actions in meeting the Bowker Creek Watershed Management Plan goals and objectives. It will also allow for adaptive management opportunities as the Blueprint is implemented.

7.1 MONITORING VARIABLES

The health of Bowker Creek and its watershed, and the successful implementation of the Bowker Creek Blueprint, will be monitored over time using the variables below. Baseline (2009) data is presented in section 7.2. The methodology for each monitoring variable is outlined in Appendix D.

A. WATERSHED WIDE MONITORING VARIABLES

1. **Watershed Health Tracking System**: This system uses the measures of riparian forest integrity, benthic index of biotic integrity, and total effective impervious area to track overall watershed health. This is a reproducible, low-cost system that can be used to track improvements to Bowker Creek and provide a framework for understanding how future changes to these factors can improve or degrade watershed health. Using this system also allows comparisons between Bowker Creek to other creeks in the region and to creeks in other jurisdictions such as the Lower Mainland and Washington State that also use the Watershed Health Tracking System. More information is found in Kerr Wood Leidal (2005).

    a) ***Total Impervious Area*****:** (%TIA) a measurement of the area of the watershed that is covered by impervious surfaces expressed as a percent of total watershed area. It is the area within a watershed that is comprised of hardened surfaces resisting infiltration (i.e. roads, parking lots/driveways and rooftops.). The amount of impervious surface is a direct measure of the degree of urbanization, and it strongly affects both water quality in urban peak flow areas and replenishment of groundwater. In general, the negative impact on creeks increases as the percentage of impervious surface in a watershed increases (Page, 1999).

    b) ***Effective Impervious Area*****:** (%EIA) a measurement of the impervious area that is connected directly to the drainage network through stormwater systems or surface runoff expressed as a percent of total watershed area. It is the impervious area calculated in the same manner as percent total impervious area (TIA), minus the areas that drain to terrain where rainwater infiltrates (Page, 1999). As re-development that employs Low Impact Development (green infrastructure) techniques (i.e. permeable pavement, green roofs, green streets, etc.) takes place and other low impact development measures are implemented, effective impervious area will need to be calculated. For these baseline values it is assumed there is no difference between percentage of impervious area and effective impervious area as the data was not available. More information can be found in Kerr Wood Leidal, (2005)

    c) ***Riparian Forest Integrity*****:** (%RFI) a measurement of the forested area with 30m on either side of the creek (with the middle of the creek as the centre line) expressed as a percent of riparian forested area over the entire length of the creek. Riparian trees provide large organic debris for fish habitat, bank stabilization to reduce erosion, shading to moderate water temperature, and food for aquatic life. More information is found in Page (1999).

    d) ***Benthic Index of Biotic Integrity*****:** (B-IBI) is a score that reflects the health of the benthic microinvertebrate (bottom dwelling, spineless organisms ranging from midge larva at 1 mm to an adult crayfish of 15 cm) communities within the creek. The invertebrates found are an effective measure of a creek's year-round ecological health (biological integrity), as influenced by water quality and habitat quality issues caused by human activities. B-IBI is a biological indicator providing insight into a creeks ability to provide a healthy place for aquatic organisms to live. More information is found in (Stallard, 2007), Kerr Wood Leidal (2005), Karr and Chu (1998), and EVS (2003). NOTE: it is recommended that an alternative to this variable is used due to the high cost of conducting this variable. A possible alternative could be fish box monitoring.

2. **Urban Tree Cover:** (ha and %) a measurement of the estimated area of tree cover within the entire watershed, not just riparian area, and thus does not include other vegetative areas such as shrubs, grass/lawns or gardens, etc. expressed in hectares and as percentage of total watershed. Tree cover density can also be measured (i.e. 0>5% in increments to >75% per hectares). There are numerous benefits to a healthy urban tree cover, including reduced surface flood water run-off, habitat for wildlife, shade and reduced ambient temperature, lower levels of noise and dust, oxygen production and reduced carbon dioxide, and a sense of place and community. More information can be found in Urban Forest Canopy Cover Mapping and Analysis in the Capital Regional District, British Columbia 1986-2005 (Caslys Consulting Ltd., 2008).

3. **Length of greenway developed:** (m) a measurement of total length of paths (bike, pedestrian, multiuse) that runs within the watershed expressed in meters. "Greenways" are defined as linear corridors that connect green spaces to provide wildlife habitat and recreational and transportation opportunities. The greenways proposed (Map 5) may perform an important, safe alternative transportation function through busy neighbourhoods, connecting major growth centers, as well providing habitat corridors and (in some cases) enhancing and restoring Bowker Creek aquatic and riparian habitat. Some parts of the greenway would be shared use on existing roadways (cars, pedestrians and bicycles), some parts would be multi-use trails for non-motorized transport, and some areas would provide for pedestrian traffic connections to the creek separate from nearby cycle routes. (BCI, Greenways Subcommittee, 2007).

B. CREEK CORRIDOR MONITORING VARIABLES

4. **Creek length above ground:** (m and %) a measurement of the total length of creek course that flows on the surface (above ground) expressed in meters and as a percent of total creek length. This variable can change by daylighting (opening) or culverting (closing) sections of the creek. There are numerous benefits to creek daylighting. The higher the percentage of the creek that flows above ground (not culverted), the better the creek performs its natural functions as an artery of natural drainage, absorbing peak flows and reducing the risk of flooding, and providing a natural amenity for the community. Economic benefits include increased property values and commercial activity in the area and decreased stressors on storm drain infrastructure.

5. **Restoration of open creek sections:** (m and m^2) a) the measurement of the linear length (m) of creek banks restored expressed in meters of creek bank improved (banks on each side of creeks are measured independently); b) the measurement of amount (m^2) of riparian area that has been restored expressed in square meters of total area of restoration within the riparian area (30 m on either side of creek). Restoration could include wattle fencing or other means of improving bank slopes, removing invasive species and planting native species and increasing riparian buffer widths. Some above-ground sections of the creek are narrow concrete channels or banks, and buffer areas are covered with mainly invasive plant species or may not have a vegetated buffer, preventing those creek sections from performing all of their natural functions: infiltration, slowing of storm event flows, filtering and bioremediation of pollutants by soil and plants, and reducing impervious surfaces. Restoration of creek banks and buffer areas (where land is available) enable the creek to better perform its natural functions, especially in both peak and low flows, and become a greater natural community amenity.

C. Water and Sediment Quality Variables

6. **Water quality:** a measurement of key parameters including, fecal coliforms, temperature, dissolved oxygen, pH, specific conductance, turbidity, nitrate/nitrogen. The CRD samples for these water quality parameters in Bowker Creek starting as part of their larger stormwater monitoring program. Water quality in the urban environment reflects the various pollutants washed off roads and private property into the storm drain system. It may also reflect cross connections to sanitary sewer lines or leaky sanitary sewer lines that infiltrate into the storm drain system. Pollutants washing off roadways include metals from vehicle wear and leakage (e.g. copper, zinc, cadmium and lead), and fuels and other petroleum products. Elevated levels of nutrients such as phosphorus and nitrogen are also commonly found in urban runoff, as is sediment from construction activities and soil erosion (NCHRP 2006). When untreated stormwater runoff is discharged directly to receiving waters, pollutant loadings can be much higher than those attributed to domestic sewage (USEPA 2002 in NCHRP 2006), and have been found to cause significant impacts to aquatic life in receiving waters (NCHRP 2006). Stormwater runoff and pollutant discharges increase steadily with urbanization because of the increase in impervious surfaces, which reduces infiltration of rainfall and runoff (NCHRP 2006).

Sediment Quality: a measurement of certain contaminants that adhere to the sediment in the creek bottom and will accumulate over time. The CRD initiated a sampling sediment program in 1993 to better assess certain types of contaminants found in stormwater. These include metals and polycyclic aromatic hydrocarbons (PAHs). The CRD samples for eight metals and for low and high molecular weight PAHs (LPAH and HPAH). PAHs are a group of chemicals which naturally occur in coal, oil and gasoline, and as combustion by-products of these substances. PAHs are also a result of incomplete combustion of wood and tobacco. Examples of substances containing LPAHs include gasoline and diesel fuel, and HPAHs are found in substances like asphalt and tar. HPAHs are more toxic than LPAHs, which can more easily evaporate or break down.

7.2 Monitoring Frequency

It is proposed that the monitoring variables in section 7.1 be reviewed every five years to determine whether there has been any change and to determine any trends. This will require a Geographical Information Systems (GIS) exercise and a review of where channel restoration has occurred and greenways have been constructed. Water quality and benthic invertebrate data are collected on an annual or periodic basis by the CRD and these data should be reviewed as collected and also analyzed in the five-year reviews.

The cost for five-year review of key monitoring variables should be minimal but will require staff time.

7.3 Baseline Conditions, 2009

This section provides the baseline results of the Bowker Creek Watershed monitoring program as of December 2009. Baseline results for watershed variables such as the watershed health tracking system score and benthic invertebrate analysis (Table 4), urban tree cover (Table 5), greenways (Table 6) and for stream corridor variables such as creek length above ground, length and area of creek restoration (Table 7) and water and sediment quality results (Table 8) are provided.

Map 6 Bowker Creek Snapshot Conditions 2009 shows the location of creek restoration sites, completed greenways and green streets, and the locations of Bowker Creek interpretive signs, major commercial centres and areas of green space. This map also shows the location of several green infrastructure features (i.e., detention/retention ponds, green roofs, permeable pavement, swales and raingardens, underground retention tanks and green streets) that have been installed at municipal, commercial and institutional lands throughout the watershed. These features are depicted on this map because the effective impervious area, for which a 2009 baseline result was not possible, can be lowered over time using green infrastructure features to approximate more natural watershed hydrology. As technology improves, this information is needed to start calculating the Effective Impervious Area percentage, therefore known locations of these technologies have been mapped here.

A. Watershed Wide Monitoring Variables Results

Table 3. Watershed health tracking system score (2009 Baseline)

(See Map 5.)

MONITORING VARIABLE	VALUE	METHODOLOGY & DATA SOURCE
1. Watershed Health Tracking System score	Poor	Template for Integrated Stormwater Management Planning 2005 (Kerr Wood Leidal, 2005)
a) Total Impervious Area (TIA)°(%)	50%	Bowker Creek Master Drainage Plan (Kerr Wood Leidal, 2007) & Urban Forest Canopy Cover Mapping and Analysis in the Capital Regional District, British Columbia 1986-2005 (Caslys Consulting Ltd., 2008)
b) Effective Impervious Area (EIA)°(%)	*50%	Suggested methodology is found in Kerr Wood Leidal (2005).
c) Riparian Forest Integrity (%) (entire creek length) • Grass/Lawns (within riparian buffer, but % of entire creek length) • Pavement, rooftops, etc. (within the riparian buffer, but % of entire creek length)	**15.6% ***11.5% 8.2%	BCI Coordinator (2010) in-part based on GIS work from, Bowker Creek, An Assessment of Riparian Habitat & Biological Species Diversity (Camosun Students Rogers & Soloducha, 2008) NOTE: data had to be calculated on GIS to include entire length of creek with buffer
d) Benthic Index of Biotic Integrity score	15 (critically impaired)	Bowker Creek Benthic Invertebrate Pilot Project (Stallard, 2009)

NOTES: *for 2009 baseline data (%), EIA is assumed the same as TIA

** this Riparian Forest Integrity (RFI) is mostly vegetation counted in this statistic is non-native, shrubby vegetation. If a more detailed inventory were taken to include only healthy, treed riparian buffers, the RFI score would be much lower.

*** These areas within the riparian buffer and could be identified for restoration (i.e. native tree planting), thus increasing the RFI with potentially minimally intensive efforts.

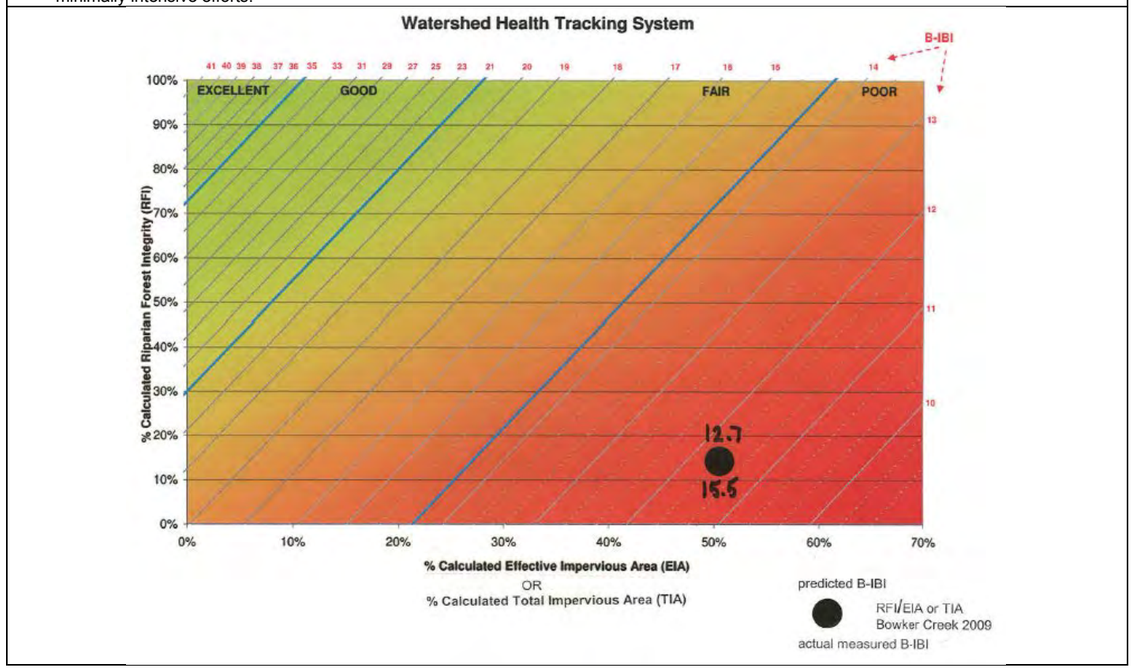

Table 3, continued: Bowker Creek B-IBI creek ratings 2007 Baseline

Metric	Site 1		2		3**		4	
	value	B-IBI score	*value*	B-IBI score	*value*	B-IBI score	*value*	B-IBI score
Taxa richness and composition								
Total number of taxa	*19*	3	*15*	1	*19*	1	*11*	1
Number of Ephemeroptera (mayfly) taxa	*0*	1	*0*	1	*0*	1	*0*	1
Number of Plecoptera (stonefly) taxa	*0*	1	*0*	1	*0*	1	*0*	1
Number of Trichoptera (caddisfly) taxa	*0*	1	*0*	1	*0*	1	*0*	1
Number of long-lived taxa	*0*	1	*0*	1	*1*	1	*0*	1
Tolerance								
Number of intolerant taxa*	*2*	1	*2*	1	*2*	1	*1.3*	1
% of individuals in tolerant taxa*	*54%*	1	*53%*	1	*60%*	1	*67%*	1
Feeding ecology								
% of predator individuals	*7.8%*	1	*6.5%*	1	*30%*	5	*2.6%*	1
Number of clinger taxa	*1*	1	*1.3*	1	*0*	1	*0%*	1
Population attributes								
% dominance (top 3 taxa)	*32%*	5	*32%*	5	*41%*	5	*35%*	5
Total Reach Scores (of possible 10-50)	**16**		**14**		**18**		**14**	
Average Score ~ Bowker Creek	**15.5**							
	10-16 = Critically Impaired							

*Chironomids are not included in these metrics.
**1 sample only, no replicates at this site

NOTE: for sampling site locations see Appendix D: Methodology

Table 4. Urban tree cover (2005 Baseline)

MONITORING VARIABLE	VALUE		METHODOLOGY and DATA SOURCE
2. Urban Tree Cover (%) (2005)	20.6%		Urban Forest Canopy Cover Mapping and Analysis in the Capital Regional District, British Columbia 1986-2005 (Caslys Consulting Ltd., 2008)
	DENSITY CLASSES WITHIN URBAN TREE COVER (%)	**DENSITY OF TREE COVER (HA)**	
	0-5%	79	
	>5-10%	138	
	>10-25%	585	
	>25-50%	293	
	>50-75%	56	
	>75-100%	8	

Further information on the Bowker Creek Watershed from the Urban Forest Canopy Cover Mapping and Analysis in the Capital Regional District, British Columbia 1986-2005 (Caslys Consulting Ltd., 2008)

LAND COVER	AREA (M^2)	AREA (HA)	PERCENTAGE (%)
agriculture	0.0	0.0	0.0
exposed soil	84,627	8.5	0.8%
grass	2,764,446	276.4	27.1%
gravel	0.0	0.0	0.0
impervious	5,090,529	509.1	49.9%
marsh	0.0	0.0	0.0
shadow	137,502	13.8	1.3%
shrubs	25,824	2.6	0.3%
trees	2,106,091	210.6	20.6%
water	1,906	0.2	0.0

Table 5. Length of Greenway Developed

MUNICIPALITY	PROPOSED LENGTH OF GREENWAY (metres)	COMPLETED LENGTH OF GREENWAY (DEC. 2009) (metres)	LOCATION OF GREENWAY COMPLETED	METHODOLOGY & DATA SOURCE
City of Victoria	3,360	92	Path between Newton St. and Kings Rd.	City of Victoria
District of Oak Bay	2,980	460	Path from Oak Bay Tennis Bubble to St. Anne's Pond at Monterey Ave.	District of Oak Bay
District of Saanich	16,750	390	Path from Knight Ave south through Browning Park across McRae Ave. aling the Wordsworth right of way to the dead end section of Wordsworth	District of Saanich

B. CREEK CORRIDOR VARIABLES RESULTS

Table 6. Creek corridor variables (2009 Baseline)

(See Map 5.)

MONITORING VARIABLE	VALUE	METHODOLOGY & DATA SOURCE
3. Creek Length Above Ground (%, km) baseline + new daylighting		
a) Main channel	a) main channel 37% or 2.9 km	a) 7.9 km is the length of the main channel, above and below ground, from UVic Faculty Club to outlet (as defined in the Bowker Creek Master Drainage Plan, Kerr Wood Leidal, 2007)
b) Cedar Hill tributaries	b) tributaries 33% or 0.5 km	b) 1.5 km is the length of the tributaries, above and below ground, running mainly through the Cedar Hill Golf Course. (BCI Coordinator/CRD GIS, 2010)
c) Total creek (a+b)	c) 36.1% or 3.4 km	c) Total creek length is 9.4 km
4. Restoration of Open Creek		
a) Area of Open Creek Riparian Buffer Improved (m^2) baseline + new restoration	a) 492 m	Respective Municipalities & BCI Coordinator (2009)
b) Length of Open Creek Banks Improved (m)* baseline + new restoration	b) 2166 m2	

NOTE:* banks on each side of creek measured independently

Table 7. Corridor Variables Baseline

BLUEPRINT REACH NUMBERS (& jurisdiction)	STREET LOCATION	REACH LENGTH & STATUS* (M)	LENGTH OF RESTORED BANKS** (M)	RESTORED RIPARIAN FORESTED AREA (M^2)	DESCRIPTION
1 Oak Bay	Monteith St. to creek mouth	Open 254.9	40 m	120 m^2	Bioengineering by mean of willow wattle was installed in 2005. That winter was blown out and reinstalled in 2006. Approx 3 m wide.
2 Oak Bay	St. Ann St. to Monteith St.	Enclosed 311.7			
3 Oak Bay	Downstream of Oak Bay Tennis Bubble to St. Ann St.	Open 462.9			
4 Oak Bay	Oak Bay Tennis Bubble	Enclosed 101.2			
5 Oak Bay	Cadboro Bay Rd. to Oak Bay Recreation Centre	Open 149.4			
6 Victoria & Oak Bay	Trent St. to Cadboro Bay Rd.	Enclosed 236.0			
7 Saanich	Richmond to Trent (St. Patrick's School)	Open 574.3	210 m	630 m^2	3 meter wide bioengineering by Saanich PW in 2007 (30-40m south bank); 2006 (50 m north bank), 2005 (15-20m south bank); 48 m (x 2) by Community Group and BCI Coordinator; golden willow removal and thinning occurred on some of the area already included in 2009. In 1998, the PCC gave some money to Hydro to plant some shrubs and trees along the greenway.
8 Victoria	Newton St. to Richmond Rd.	Enclosed 204.0			
9 Saanich	Pearl St. to Newton St.	Open 420.6			
10 Victoria	Clawthorpe Ave. To Pearl St. (@ Hillside)	Enclosed 1015.2			
11 Saanich & Victoria	North Dairy Rd. to Clawthorpe Ave.	Enclosed 272.8			
12 Saanich	Knight to North Dairy (Browning Park)	Open 615.1	20 m	60 m^2	Bioengineering by Saanich PW 2004 at 1607 McCrae Road; 2003 at 1607 McCrae Road
13 Saanich	Garnet to Knight (@ Shelbourne)	Enclosed 1858.5			
14 Saanich	Gordon Head Rd. to Garnet Rd. (Mackenzie)	Enclosed 864.8			
15 Saanich	University Club of Victoria to Gordon Head Rd.	Open 447.7			
16 Saanich & Victoria	Cedar Hill Golf Course to Clawthorpe (@ Finlayson)	Enclosed 265.3			
17 Saanich	Cedar Hill Golf Course	Open 1540.8	222 m	666 m^2 960 m^2	Saanich Public works removed cattails and planted vegetation in 2000 Community tree planting began in 1995 Tree Appreciation Day from near the intersection where the culvert begins to the trail over the second bridge at the back NW corner of the rec centre. Over three events led by Saanich Parks, we planted most heavily both sides from the culvert to the first bridge on the North Dairy side and then along the creek on west side of the centre, the easterly side closest to the building.
		TOTAL	492 m	2166 m2	

Notes
*enclosed = underground, in culvert; open = runs on surface, may have earthen banks or channelized (open culvert, cement, etc.);daylighted = taken out of underground culvert so that it runs on surface
**each bank is measured separately

BOWKER CREEK SNAPSHOT CONDITIONS 2009

MAP 6

Interpretive Sign
Green Space
Creek Resoration Areas
Commercial Destinations

Low Impact Development
(Occurring on institutional and municipal properties; private property has not been included)
Detention/Retention Pond
Green Roof
Permeable Pavement
Swale or Rain Garden
Underground Retention Tanks
Green Street (none currently exist)

Municipal Boundaries
Lot Lines
Regional and Municipal Parks
Existing Greenways

Bowker Creek Main Channel
Underground
Open Channel
Bowker Creek Watershed Boundary
1 Reach Number
Reach Breaks

Roads based on May 2010 data
Lot lines based on 2008 data

CRD Making a difference...together

0 100 200 400 600 Meters

Projection: UTM ZONE 10N NAD 83

C. Water and Sediment Quality Results

6. Water and sediment quality sampling results

Water sampling results show that Bowker Creek is usually within the BC-Approved Water Quality Guidelines for aquatic life, though as noted above this will not be the case throughout the year. The sampled values for temperature and dissolved oxygen are often within limits that can support salmon habitat. pH varies, and is almost always within the BC-Approved Water Quality Guidelines. The location of Bowker Creek Sediment and water sampling sites are show on Map 8 (Appendix D).

The longest set of water quality data for Bowker Creek is for fecal coliforms. Over time, the trend is for decreasing but variable levels of fecal coliforms. Nevertheless, coliform levels usually exceed those deemed safe for swimming (200 fecal coliforms per 100 mL), with levels highest at the creek mouth, and dropping upstream.

There are less data points for 316-5 (6 measurements) as monitoring was initiated later (in 2005). As a result percentage data are very sensitive. For example, one measurement was in exceedence of the turbidity guideline results in a 17% exceedence rate (1/6).

Parameters of most concern are fecal coliform, phosphorus, and turbidity. Fecal coliform and phosphorus concentration indicate contamination from sewage and high turbidity is likely a result of development that reduces impervious area increasing creek flow rates. Lack of vegetation can also increase phosphorus levels.

Exceedences of the fecal coliform and phosphorus guideline tend to increase from upstream to downstream. Elevated turbidity occurs at all stations without a trend from upstream to downstream.

Sediment sampling has indicated that copper and zinc levels were elevated above the marine sediment water quality guidelines (CRD 1992) in 2005, and LPAHs and HPAHs were elevated above the guidelines in 2008. Upstream investigations to date have not determined the source. LPAHs and HPAHs are assumed to come from street runoff, and correspond to repeated observations of hydrocarbons in the creek by the Bowker Creek Coordinator, Saanich staff, and volunteers.

Table 8. Water and sediment quality: percentage of samples in exceedence of guidelines 1997–2007 Baseline in Bowker Creek

(See “sampling results” for more information.)

WATER QUALITY	PERCENTAGE OF SAMPLES IN EXCEEDENCE OF GUIDELINES*			
***CRD Stations # (upstream to downstream)	316-5	316-4	316-3	316-1
Fecal Coliform	33	67	88	100
Temperature	0	0	0	0
pH	0	5	0	5
Dissolved Oxygen	33	0	0	0
Conductivity	0	0	0	0
Turbidity	17	17	38	31
Nitrate/Nitrogen	0	0	0	0
Phosphorous	0	38	56	56
SEDIMENT QUALITY				
Percentage of sediment samples that received h high contaminant rating (n=22) from 2003-2008	13.6			

NOTES

* Data compared to BC or CCME Guidelines for protection of aquatic life, with the exception of fecal coliform data which was compared to SHWP guideline for protection of public health (200 FC/100mL). Values above the SHWP guideline indicate contamination is likely from sewage rather than wild or domestic animals and birds.

** Quantity of data differs between parameters: Monitoring was initiated for fecal coliform in 1997; temperature, pH and dissolved oxygen in 1999; conductivity in 2000; turbidity in 2003 and nitrate and phosphorus in 2005.

*** For the location of CRD station sampling sties see Appendix D: Methodology