

2008 Water Quality Objectives Attainment: Bessette Creek Watershed (Summary Report)



Ministry of
Environment

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Source: Google Earth

Acknowledgements

The Ministry of Environment, Environmental Protection Division, would like to thank the following partners for their collaboration on this project.

➤ **STELLA-JONES:**

- Provided access to the Bell Pole property
- Conducted simultaneous replicate sampling at sites near the Bell Pole property and shared sampling results
- Funded additional sediment sampling

➤ **THE VILLAGE OF LUMBY:**

- Conducted simultaneous replicate sampling at sites near the waste water treatment plant and shared sampling results

➤ **TOLKO INDUSTRIES & VALLEY WOOD:**

- Provided access to the Lawson/Duteau Creek area for site reconnaissance and sampling

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Summary of Key Findings

- Concentrations of microbiological indicators, fecal, *E. coli*, enterococci bacteria, (in particular, Enterococci) consistently exceeded Objective levels for raw drinking water used with only partial treatment, in the areas sampled along Lawson, Duteau, Harris and Bessette creeks.
- Lawson and Duteau creeks were not affected by woodwaste leachate from the Tolko log yard and woodwaste landfill operation.
- No chlorophenol (CP), or Polycyclic aromatic hydrocarbon (PAH) compounds of significance, were detected in Harris or Duteau creek waters or sediments near the Stella Jones (Bell Pole) property. Similarly, PAHs and chlorophenols were not detected in mussel tissues downstream of the Stella Jones property. Detection limits complicated the interpretation of sediment PAH results, however, levels were generally below Provincial Guidelines. Many PAH compounds exceeded the more stringent Canadian guideline levels for sediment, however, upstream concentrations were similar or greater than downstream, suggesting inputs of hydrocarbons from upstream sources. Traces of pentachlorophenol were detected in Harris Creek sediments, and increased slightly below the Stella Jones property. CP concentrations were near the detection limit (Objective level) and significantly lower than provincial Contaminated Site sediment criteria.
- Although sulphate, chloride, ammonia and ortho-phosphorus concentrations increase in Bessette Creek downstream of the Lumby Wastewater Treatment Plant, concentrations remain well below Objective and Guideline levels. Ortho-phosphorus concentrations, however, may contribute to increased algal growth and additional monitoring is recommended should algal growth become an issue.
- Benthic invertebrate community composition at key sites suggests valley bottom streams are partially stressed compared to upstream conditions.

Water Quality Objectives and Guidelines

- Water Quality Objectives are site specific target levels for water quality parameters (physical, biological or chemical) developed by the Ministry of Environment.
- Objectives are adapted from Federal and Provincial “Water Quality Guidelines” and are established in watersheds with the potential for human impacts on water quality.
- Objectives are water-body specific and are established to protect the most sensitive water uses designated for a given water body.
- Designated water uses within the Bessette Creek watershed include: aquatic life, wildlife, livestock watering, irrigation and drinking water (receiving partial treatment).
- Objectives were established for Bessette Creek and tributaries in 1991 for bacteriological indicators, dissolved and suspended solids, turbidity, substrate sedimentation, nutrients, pH, colour, temperature, dissolved oxygen, resin acids and chlorophenols.



Bessette Creek Upstream of WWTP



Duteau Creek near Lawson Creek Confluence



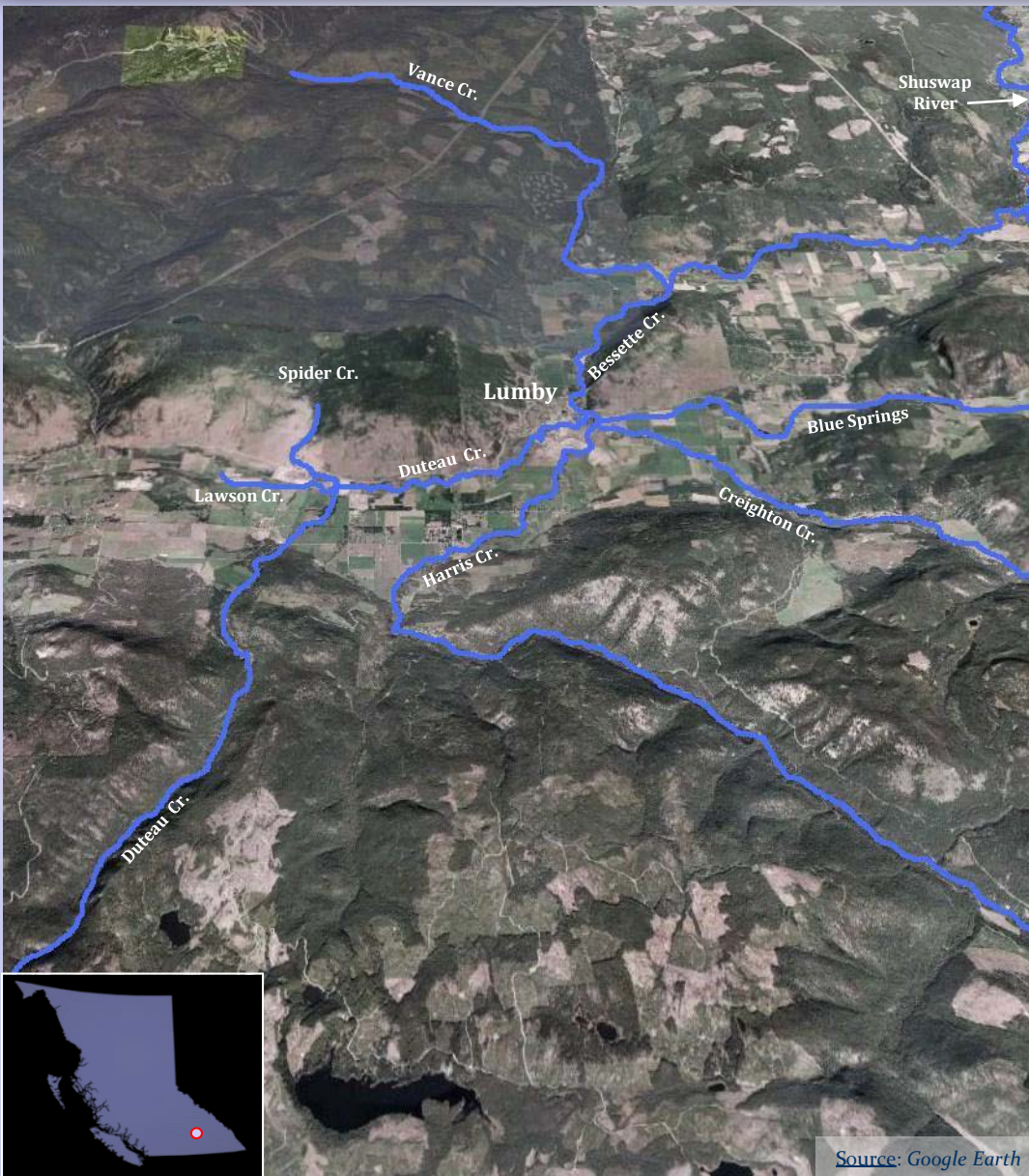
Duteau Creek Downstream of Hwy 6

Objectives Attainment Monitoring

- Attainment monitoring is repeated every three to five years; subject to regional priorities, available funding and logistics.
- Samples are obtained at weekly intervals, over a period of one month (five samples over a 30-day period), under base-flow conditions (late summer to fall).
- Results are compared to Water Quality Objective values, to determine attainment.
- Depending on the water quality parameter, attainment may be measured against a maximum, average, and/or 90th percentile value for the five samples collected, or by comparing increases in results between upstream and downstream sites (increase over background level).
- When site-specific Objectives are not available, results in this report have been compared to Provincial and/or Federal water quality guidelines to provide an indication water quality status.



Duteau Creek near the confluence with Lawson Creek



The Bessette Creek Watershed

- The Watershed drains the area in and around the Village of Lumby and empties into the Shuswap River to the northeast.
- The Watershed includes Bessette, Vance, Duteau, Creighton, Blue Springs, Harris, Lawson and Spider creeks.
- The Watershed provides important aquatic habitat including spawning and rearing for resident and anadromous salmonids.
- Land-use within the lower valley includes urban and rural residential development, agriculture (crops and livestock), and industrial activities.
- Land-use activities in the upper watershed include forestry and recreation.

Bessette Creek Watershed: Objectives and Sample Design

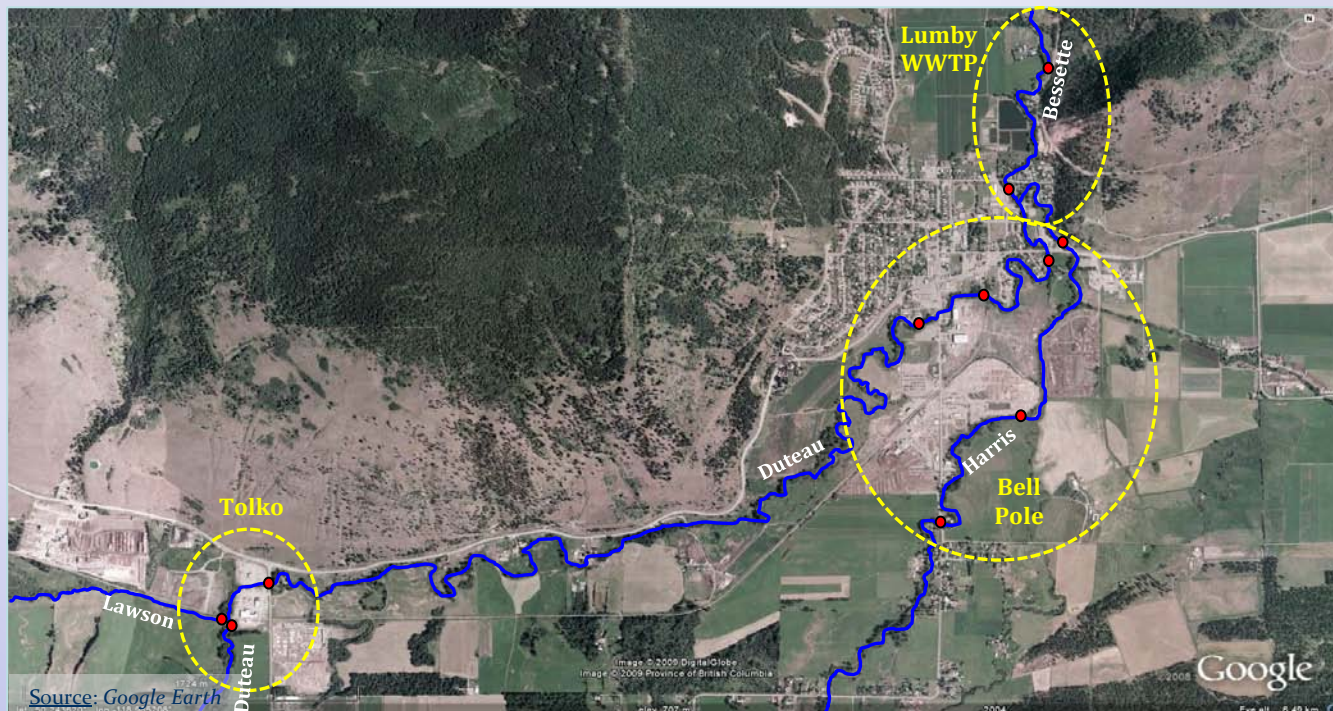
- Objectives were developed in 1991, for:
 - ✓ Bessette Creek
 - ✓ Harris Creek
 - ✓ Duteau Creek
 - ✓ Lawson and Spider Creeks
- Attainment monitoring in the watershed has been conducted previously, from 1992 through 1997.
- In 2008, sampling efforts were intended to assess Objectives attainment and determine the influence of various land use activities within the watershed, including non-point sources (agriculture, land development), and known point source discharges.
- Three sites, regulated under the Environmental Management Act, are present in the Watershed:
 - A wood waste landfill area, associated with the former *Riverside Forest Products* sawmill, which is now operated by *Tolko Industries Ltd.* This area is situated between Spider and Lawson creeks to the west of the Village of Lumby.
 - The former *Bell Pole* property (now owned by *Stella-Jones*) is located between Harris and Duteau creeks, on the south side of the Village of Lumby. This area was the site of a wood preserving plant; telephone poles were treated using creosote (west yard) from the early 1930's through the mid 1970's, and later using pentachlorophenol (east yard). The site is now under remediation.
 - The Village's Waste Water Treatment Plant (WWTP) is situated along Bessette Creek, to the north of the Village of Lumby, and discharges treated waste water to Bessette Creek.



Bessette Creek: Confluence of Duteau & Harris Creeks

2008 Attainment Sampling

- The 2008 Attainment Sampling project focused on three areas near Tolko, Bell Pole, and the Lumby WWTP. Water sampling was conducted near Tolko and WWTP between July 29 and August 26, during times of low flow, thus limited dilution, and high temperature conditions.
- Water and sediment sampling were conducted near the Bell Pole operation between September 30 and October 28, also periods of low flow.
- Biological samples (freshwater mussel tissue) and periphyton chlorophyll-*a* samples were collected from all areas in mid-September. Benthic invertebrates were collected at key sites in September.
- Results for select parameters are presented by area, followed by summary tables for all parameters sampled.



Tolko Sampling Area

- Located southwest of the Village of Lumby, east of the Tolko log yard.
- Three sample sites were established: upstream and downstream sites on Duteau Creek, and one site at the mouth of Lawson Creek (at the confluence with Duteau Creek).
- Sampling was conducted to assess the potential influence of the wood waste landfill on stream water, as well as impacts from surrounding and upstream diffuse sources, including bacteria and nutrients inputs from agricultural activities.
- Important Parameters: Bacteria, Phenols, Resin Acids, True Colour.

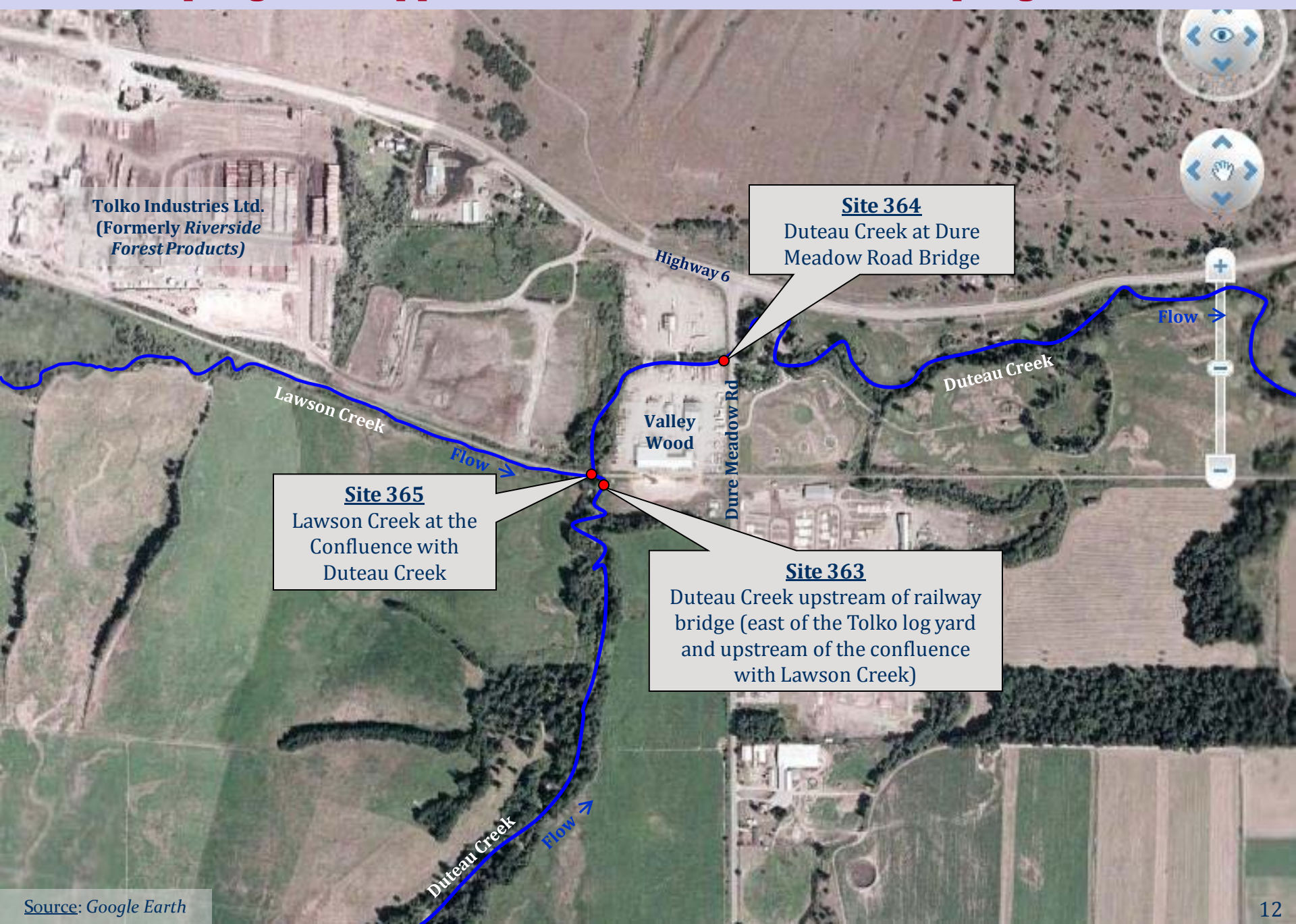


Tolko Sampling Area

- Although Objectives were established for both Lawson and Spider creeks in 1991 (same values for both), Spider Creek was not sampled in 2008. Spider Creek is almost entirely contained within a pipe and routed around the Tolko yard. As well, the path of Lawson Creek has been changed (re-located to the south of the railway tracks) as part of a fish habitat improvement project conducted in the mid 1990s. The confluence of Spider Creek with the former path of Lawson Creek could not be located during field reconnaissance. Surface water and shallow groundwater movement may no longer have a direct connection to Duteau Creek because of these changes.

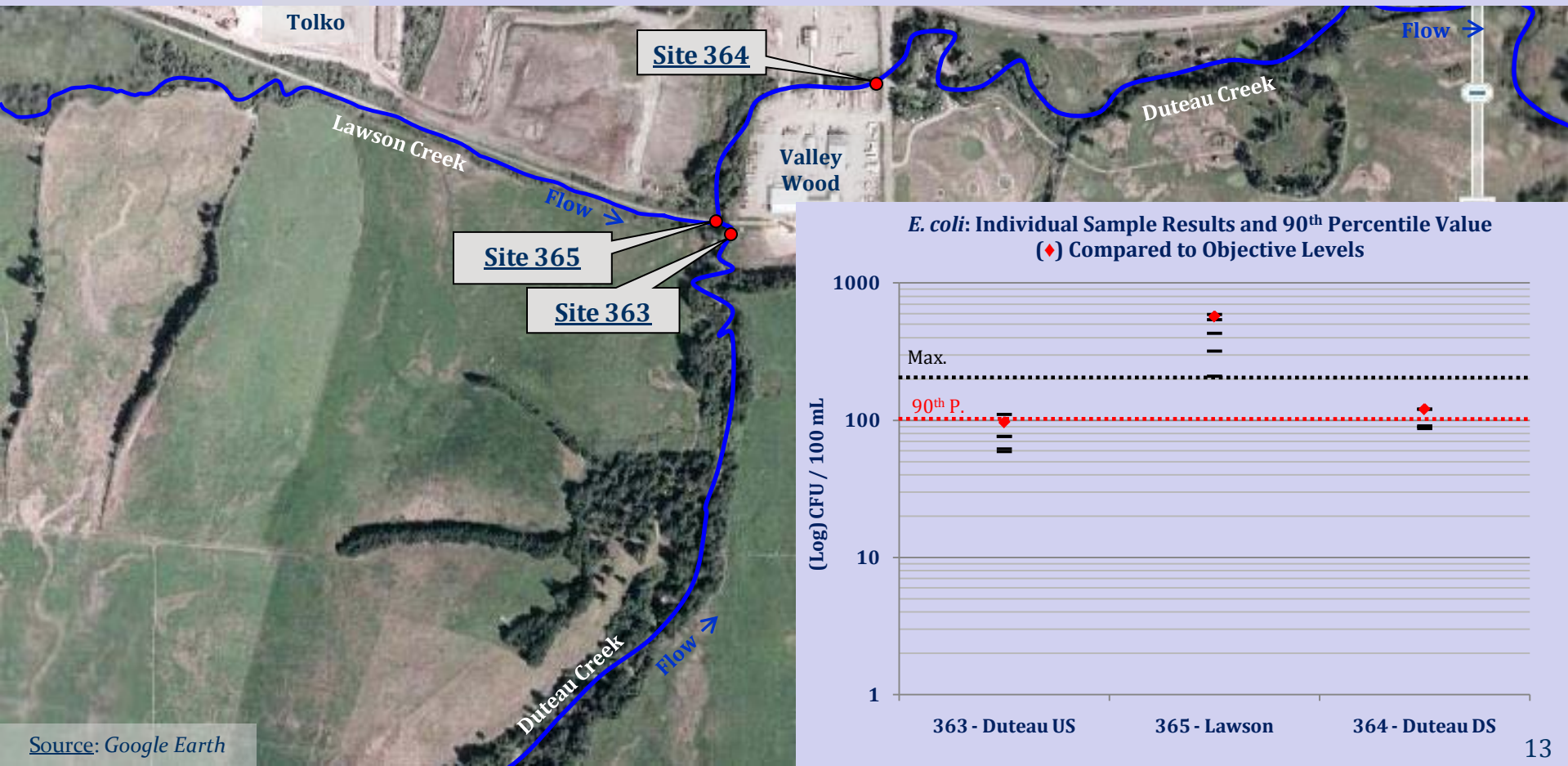


Tolko Sampling Area: Upper Duteau & Lawson Creek Sampling Sites



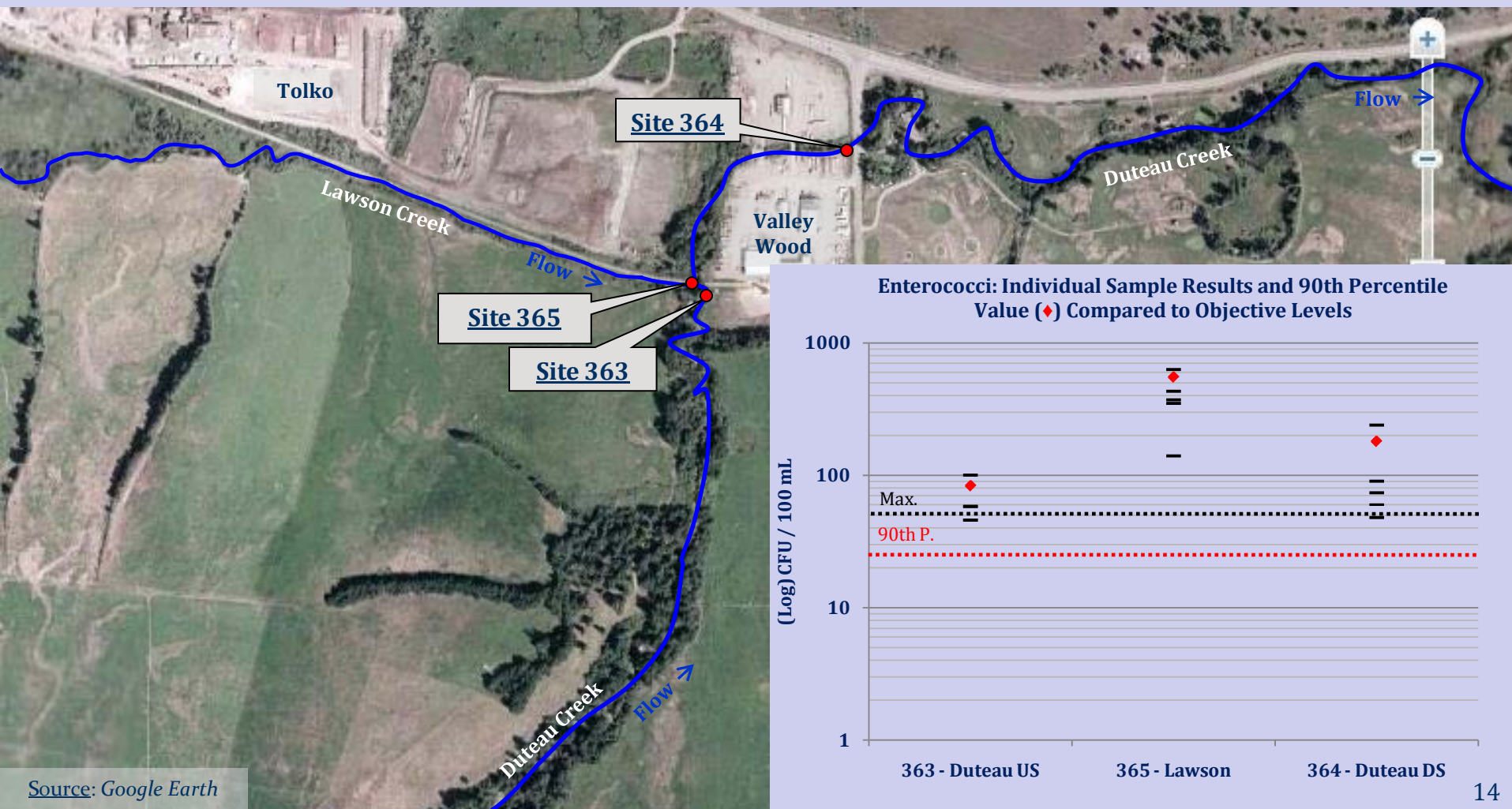
Tolko Sampling Area: Results (Fecal Coliforms / *E. Coli*)

- Fecal and *E. Coli* water quality objectives as maximum and 90th percentile values were set to *protect livestock use and drinking water use with partial treatment* respectively.
- Fecal coliforms and *E. coli* (see graph below) were very similar for all sites sampled, suggesting that *E. Coli* represents the dominant type of fecal coliform in the system.
- The maximum Objective was met at both the upstream (363) and downstream (364) sites on Duteau Creek, however; all five samples on Lawson Creek (365) exceeded the maximum Objective of 200 CFU/100 mL.
- The 90th percentile Objective (100 CFU/100 mL) was barely achieved at the upstream site on Duteau Creek, but was exceeded at both the Lawson Creek and downstream Duteau Creek sites.
- Despite the low flow of Lawson Creek relative to Duteau, bacteria concentrations in Lawson Creek are at times sufficiently high to increase levels in Duteau Creek above the 90th percentile Objective.



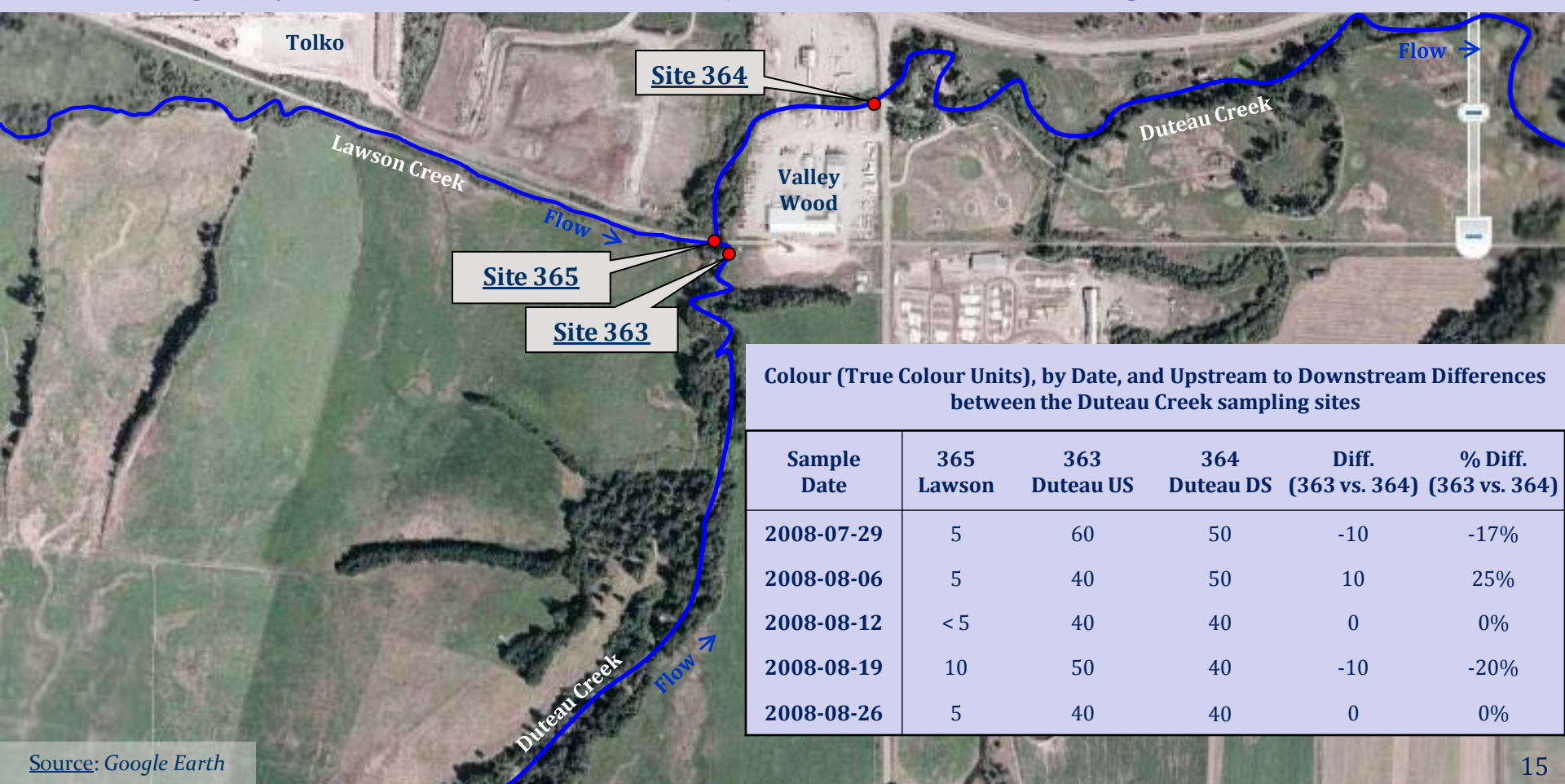
Tolko Sampling Area: Results (Enterococci)

- Enterococci water quality Objectives as maximum and 90th percentile values were set *to protect drinking water use* with partial treatment.
- Maximum and 90th percentile Objectives for enterococci have been set considerably lower than those for fecal coliforms and *E. coli*, since enterococci have shown a higher correlation with the risk of certain types of disease under specific conditions.
- Enterococci results for all sites exceeded both the maximum (50 CFU/100 mL) and 90th percentile (25 CFU/100 mL) Objectives. Only 2 enterococci results at Site 363 were below the maximum Objective level, at 46 CFU/100 mL each.
- As with fecal coliforms and *E. coli*, concentrations of enterococci increase in Duteau Creek downstream of Lawson Creek, despite the low flow of Lawson Creek.



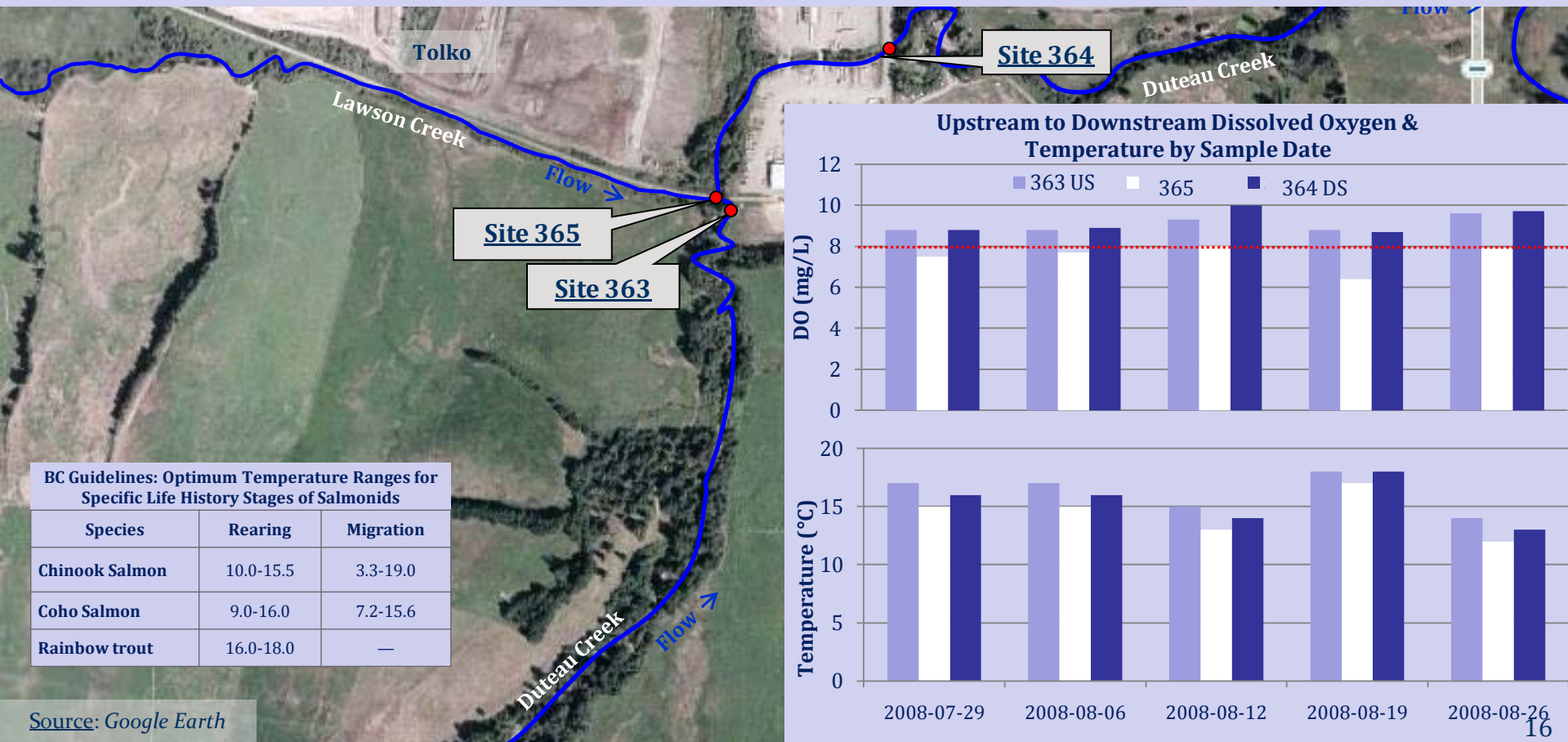
Tolko Sampling Area: Results (Resin Acids, Phenols, True Colour)

- Resin Acid concentrations were all below detection limit, and therefore; well below maximum Objectives *to protect aquatic life*.
- Phenols were also below both Provincial and Federal Guidelines *to protect aquatic life* at all 3 samples sites, on each of the 5 dates sampled.
- The recommended maximum Objective of 15 true colour units (TCU) *to protect raw drinking water* was met on all dates at the Lawson Creek site (see table below). Although the colour Objective was established for Lawson Creek only, Duteau Creek values were also measured against this Objective, for comparison. All Duteau Creek samples (upstream and downstream) exceeded the maximum 15 TCU Objective, suggesting high background levels. Upstream to downstream, TCU on Duteau Creek decreased or remained unchanged on 4 of the 5 dates sampled; the fifth date showed an increase of 10 TCU (or 25% over background) which exceeds the recommended Objective of 20% increase over background.



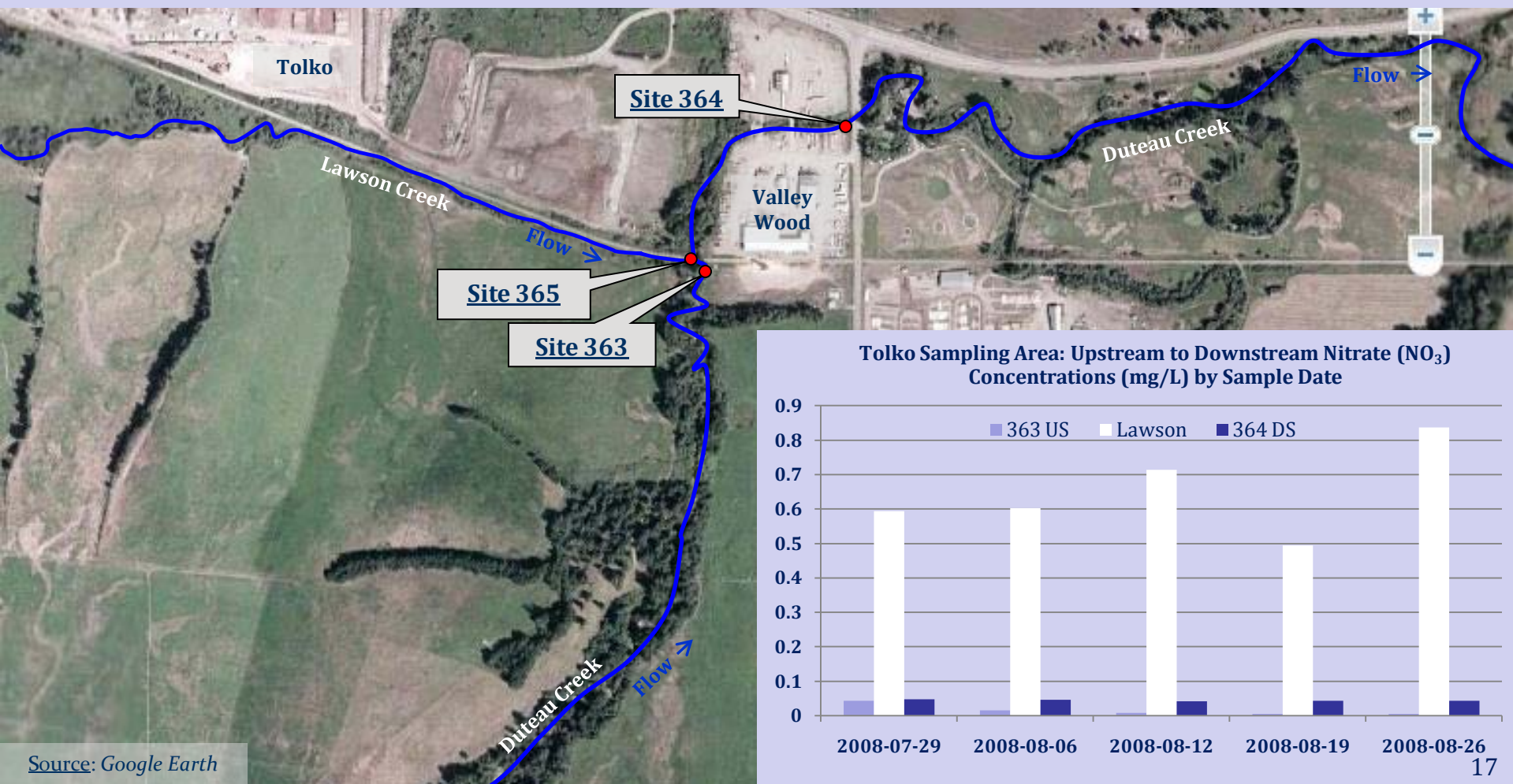
Tolko Sampling Area: Results (Dissolved Oxygen, Temperature)

- The minimum dissolved oxygen (DO) Objective of 8 mg/L to protect aquatic life was met on Duteau Creek (both sites/all dates).
- Four of five DO values recorded on Lawson Creek (see graphs below) were below this minimum value, possibly due to slow flow and little circulation. Despite this, DO concentrations at the lower Duteau Creek site (364) were unaffected.
- The temperature Objective to protect aquatic life (maximum 1°C increase over background) was met on Duteau Creek, in fact, temperatures were typically lower by 1°C at the downstream site (see graphs below). Lower stream temperatures recorded at site 364 on Duteau Creek, were likely the result of ground water inputs as well as cooler water entering from Lawson Creek.
- Provincial Guidelines for stream temperatures are set by species and life stage (incubation, rearing, migration and spawning). Based on sampling dates, only rearing and migration are considered here. Temperatures on both Lawson and Duteau creeks exceeded the desired range for certain salmonid species (see table) on certain dates, albeit by 3 °C or less.



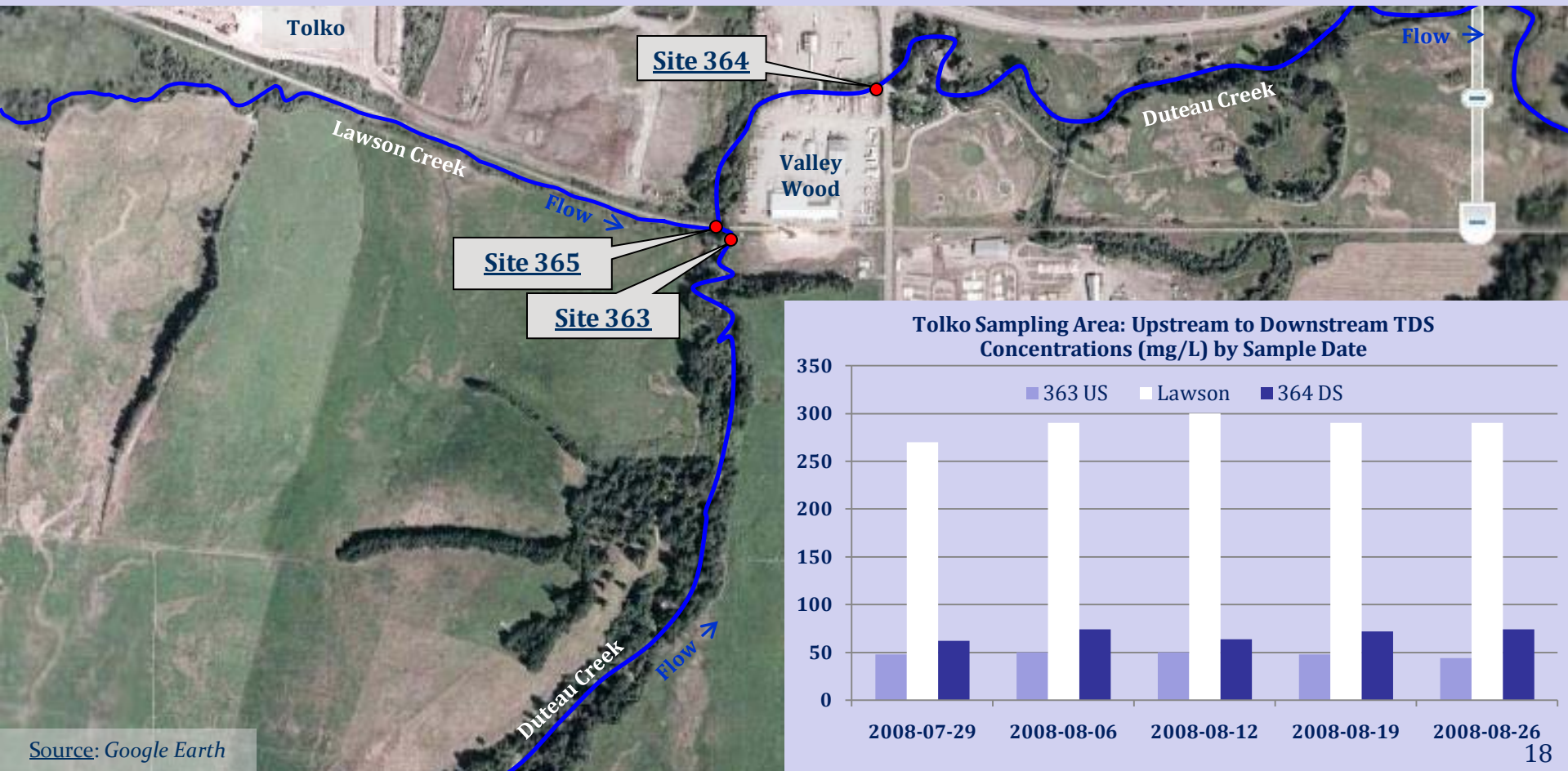
Tolko Sampling Area: Results (Nitrate, Ammonia, Chlorophyll-a)

- Nitrate concentrations (see graph below) were significantly higher in Lawson Creek, compared to either of the Duteau Creek sites. Although inputs from Lawson Creek contributed to slight increases at the downstream Duteau site, nitrate concentrations at each of the three sites remained well below both the *maximum drinking water Objective* of 10.0 mg/L, and the BC Guideline *for the protection of aquatic life* of 3.0 mg/L (30-day average).
- Ammonia concentrations were higher in Lawson Creek than either of the Duteau Creek sites (both Duteau Creek sites values were below detection limit 0.005 mg/L); however, values at each of the three sites were well below maximum Objective levels *to protect aquatic life*.
- Periphyton chlorophyll-a was only obtained at the upstream Duteau Creek site; results (21.3 mg/m²), were well below the maximum Objective level of 100 mg/m² *to protect aquatic life* against excessive algal growth.



Tolko Sampling Area: Results (TDS, TSS)

- A Total Dissolved Solids (TDS) Objective of 500 mg/L was set for Lawson Creek to *protect downstream drinking water* from log yard leachate. Concentrations at the Lawson Creek site were below this Objective level, but were significantly higher than at either of the Duteau Creek sites (see graph below). Thus, elevated TDS in Lawson Creek contributes to slightly elevated TDS levels at the downstream Duteau Creek site.
- Higher TDS concentrations in Lawson Creek may be from log yard leachate, or natural groundwater which may be high in dissolved solids.
- Total Suspended Solid (TSS) concentrations in Lawson Creek were also higher than Duteau Creek levels, however, inputs from Lawson Creek did not result in an increase in TSS at the downstream Duteau Creek site: each of the 5 downstream samples returned below the detection limit of 4 mg/L.
- All other parameters sampled met established Objective levels. A summary table is presented on the following slide.



Toilko Sampling Area (Duteau & Lawson Creeks) Summary of Parameters Monitored and Objectives Attainment (Met / Not Met)										
Parameter	Site(s)	Target Value		Source ¹			Water Use ²	Met	Not Met	Comments
		Calculation	Value	Obj	BCGL	CCME				
Fecal Coliforms	363 Duteau US	Maximum	200 CFU/100 mL	•			DW	X		No Objective set for Microbiological Indicators on Duteau Creek. Attainment measured against Objectives established for Lawson Creek.
		90th Percentile	100 CFU/100 mL	•				X		
	364 Duteau DS	Maximum	200 CFU/100 mL	•				X		
		90th Percentile	100 CFU/100 mL	•					X	
	365 Lawson Cr.	Maximum	200 CFU/100 mL	•					X	
		90th Percentile	100 CFU/100 mL	•					X	
<i>E. coli</i>	363 Duteau US	Maximum	200 CFU/100 mL	•				X		
		90th Percentile	100 CFU/100 mL	•				X		
	364 Duteau DS	Maximum	200 CFU/100 mL	•				X		
		90th Percentile	100 CFU/100 mL	•					X	
	365 Lawson Cr.	Maximum	200 CFU/100 mL	•					X	
		90th Percentile	100 CFU/100 mL	•					X	
Enterococci	363 Duteau US	Maximum	50 CFU/100 mL	•					X	
		90th Percentile	25 CFU/100 mL	•					X	
	364 Duteau DS	Maximum	50 CFU/100 mL	•					X	
		90th Percentile	25 CFU/100 mL	•					X	
	365 Lawson Cr.	Maximum	50 CFU/100 mL	•					X	
		90th Percentile	25 CFU/100 mL	•					X	
TDS	365 Lawson Cr.	The Greater of: 500 mg/L Max. OR 20% increase over background		•			DW	X		
TSS	All	10 mg/L increase (when US ≤ 100 mg/L) 10% increase (when US > 100 mg/L)		•			AL	X		
Turbidity	363 Duteau US & 364 Duteau DS	Increase over background (upstream)	5 NTU Max.	•			DW	X		
Ammonia	All	Temp. & pH dependent		•			AL	X		All values on Duteau below detection limit. 4 out of 5 samples dates on Lawson Creek returned detectable values (notably higher than Duteau Creek), but still well below Objective Levels.
Nitrate	All	Maximum	10 mg/L	•			DW	X		Well below the 10 mg/L drinking water Objective level, and also the 3.0 mg/L Prov. Guideline for the protection of aquatic life
		30-Day Average	3 mg/L		•		AL	X		
Periphyton Chl- <i>a</i>	363 Duteau US	Maximum	100 mg/m2	•			AL	X		Min. 17.7 / Max 25.5 / Avg 21.3
Temperature	363 US vs. 364 DS	Increase over background (upstream)	1°C	•			AL	X		Downstream temperatures generally 1°C <i>lower</i> than upstream
	All	Species and Life-Stage Dependant			•				X	Exceeded 15 °C Max Guideline for rearing; 6 out of 15 samples
DO	363 US & 364 DS	Minimum	8 - 11 mg/L	•			AL	X		Min. 8.7 / Max 10.0 / Avg 9.14
	365 Lawson Cr.			•					X	Min. 6.4 / Max 8.0 / Avg 7.5
True Colour	365 Lawson Cr.	Maximum	15 TCU or 20% Increase over background	•			DW	X		Colour Objective set for Lawson Creek only. Duteau Creek sites exceeded 20% increase over background on one sample date, exceeded maximum Objective on all dates - US and DS
	363 Duteau US & 364 Duteau DS			•					X	
pH	All	Range	6.5 - 8.5	•			AL	X		Lawson Creek Objective also applied to Duteau Creek
Phenols	All	4-hydroxyphenol	0.0045 mg/L		•		AL	X		
		3-hydroxyphenol	0.0125 mg/L		•			X		
		total non-halogenated phenols	0.0500 mg/L		•			X		
		Maximum: mono- and dihydric phenols	0.0040 mg/L			•		X		
Total Resin Acids	365 Lawson & 364 Duteau DS	pH Dependant		•			AL	X		
Dehydroabietic Acid				•				X		

¹Source: *Obj* = Bessette Cr. Water Quality Objectives *BCGL* = Provincial Water Quality Guidelines *CCME* = Canadian Council of Environment Ministers Water Quality Guidelines

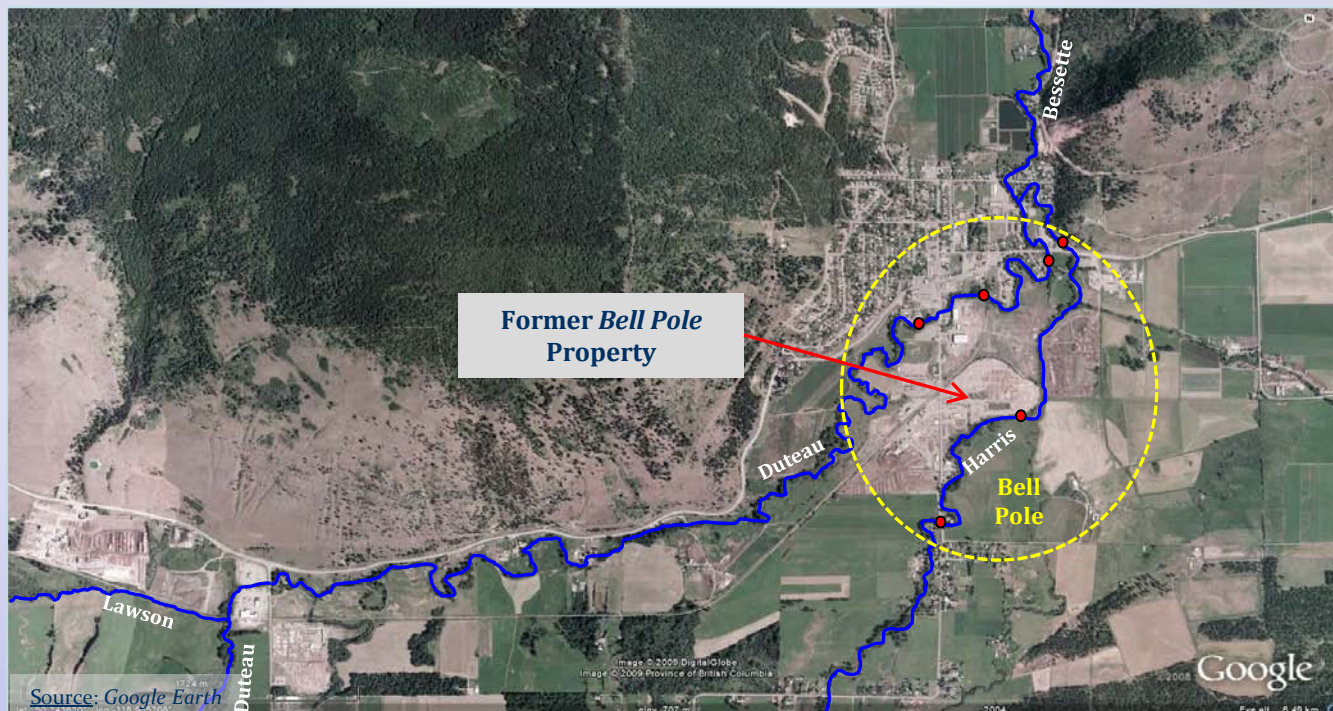
²Most sensitive water use designated for protection : *DW* = Drinking Water (partial treatment), *AL* = Aquatic Life

Tolko Sampling Area: Summary/Discussion

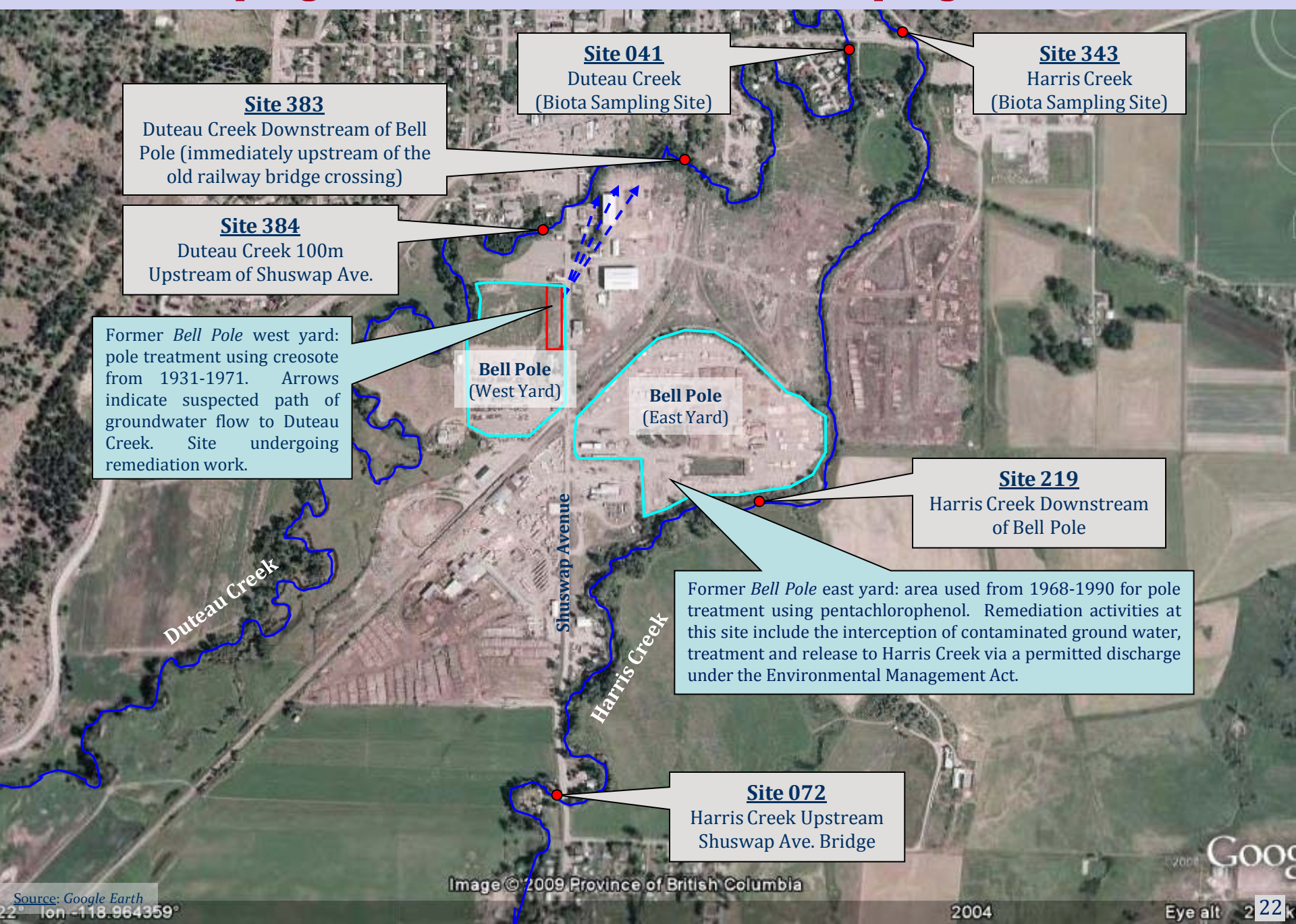
- Water quality parameters associated with wood waste leachate were either not detected or below WQ Objective and Guideline levels.
- WQ Objectives for microbial indicators to protect drinking water use after partial treatment were exceeded in Lawson and downstream in Duteau. Cattle and land-use along Lawson are possible source areas. Although Lawson Creek is fenced along the south side to prevent cattle direct access, the lack of riparian vegetation and short separation from cattle grazing may be contributing to increased bacteria concentrations in Lawson and Duteau downstream.
- Drinking water use of Duteau Creek without at least partial treatment is not recommended.
- Lower dissolved oxygen levels in Lawson Creek are likely the result of poor water flow. However, inputs of dissolved organic matter from land use on either side of the stream could also contribute to increased oxygen demand.

Bell Pole Sampling Area

- This area is located south of the Village of Lumby, straddling the former *Bell Pole* property.
- Four water/sediment sampling sites were sampled in this area: Upstream and downstream on both Harris and Duteau creeks. Two additional sampling sites (1 on Harris Creek and 1 on Duteau Creek) were established downstream near Highway 6 for mussel tissue sampling.
- Sampling was conducted for polycyclic aromatic hydrocarbons (PAH) in Duteau Creek adjacent to the *Bell Pole* west yard, and for chlorophenols (CP) in Harris Creek adjacent to the east yard.
- Bacteria and nutrients, possibly from upstream diffuse sources such as agricultural activities, were also tested.

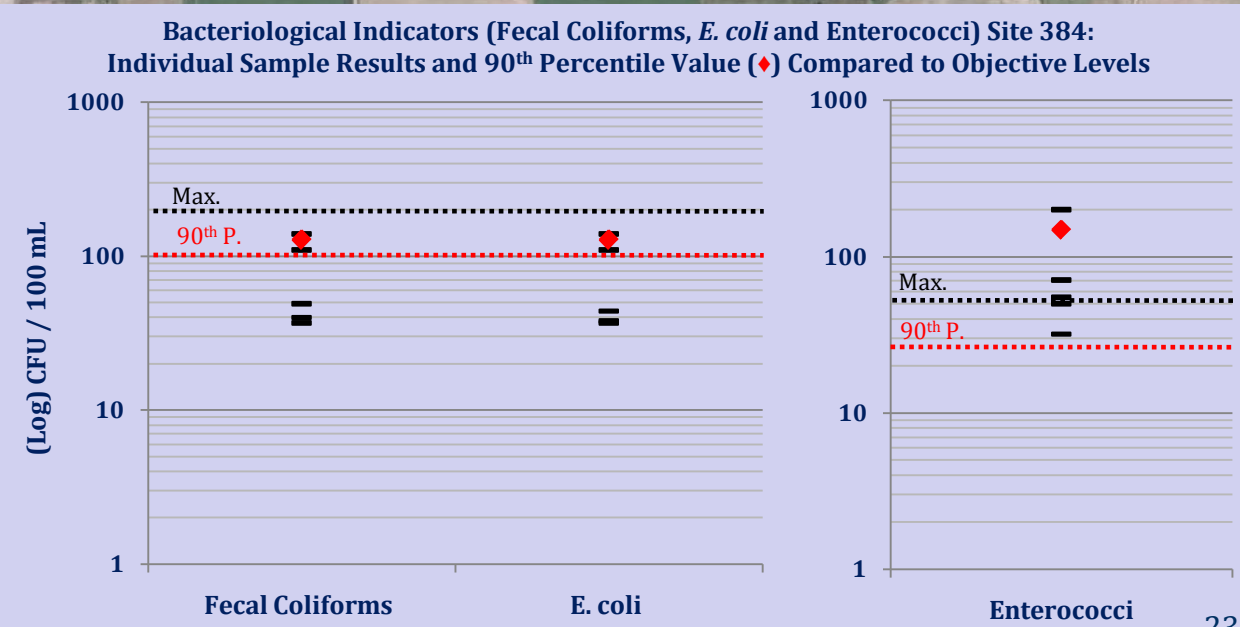


Bell Pole Sampling Area: Duteau & Harris Creek Sampling Sites



Bell Pole Sampling Area - Duteau Creek: Results (Bacteria)

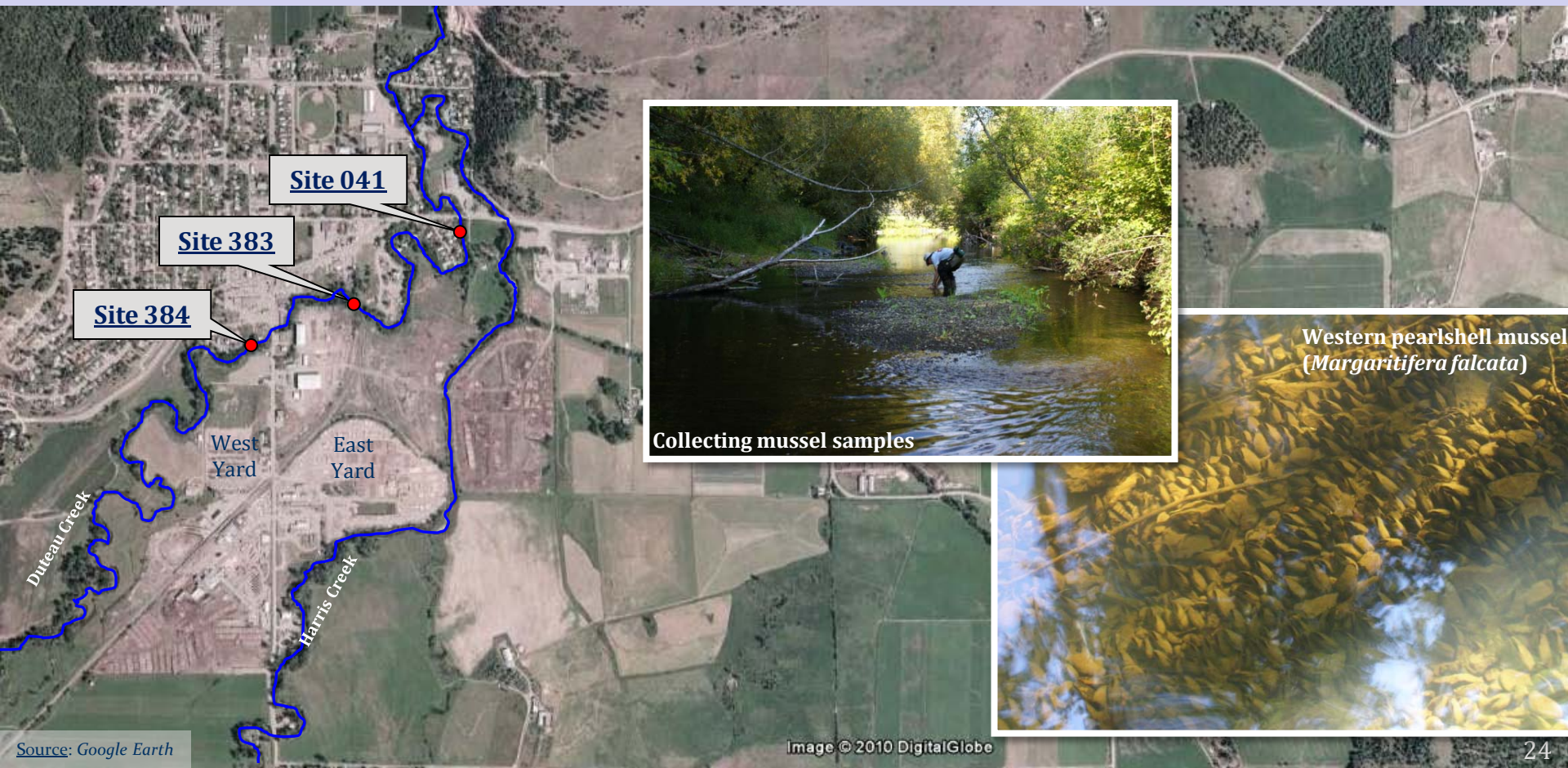
- Bacteriological indicators were sampled at the upstream Duteau Creek site (384) only.
- Fecal coliforms and *E. coli* concentrations met the maximum Objective (200 CFU/100 mL), but exceeded the 90th percentile Provincial Guideline of 100 CFU/100 mL to protect raw drinking water receiving partial treatment.
- Results for fecal coliforms and *E. coli* were nearly identical, suggesting that *E. Coli* represents the dominant type of fecal coliform in the system.
- Enterococci concentrations exceeded both the maximum (50 CFU/100 mL) and 90th percentile (25 CFU/100 mL) Objectives to protect raw drinking water receiving partial treatment.



Source: Google Earth

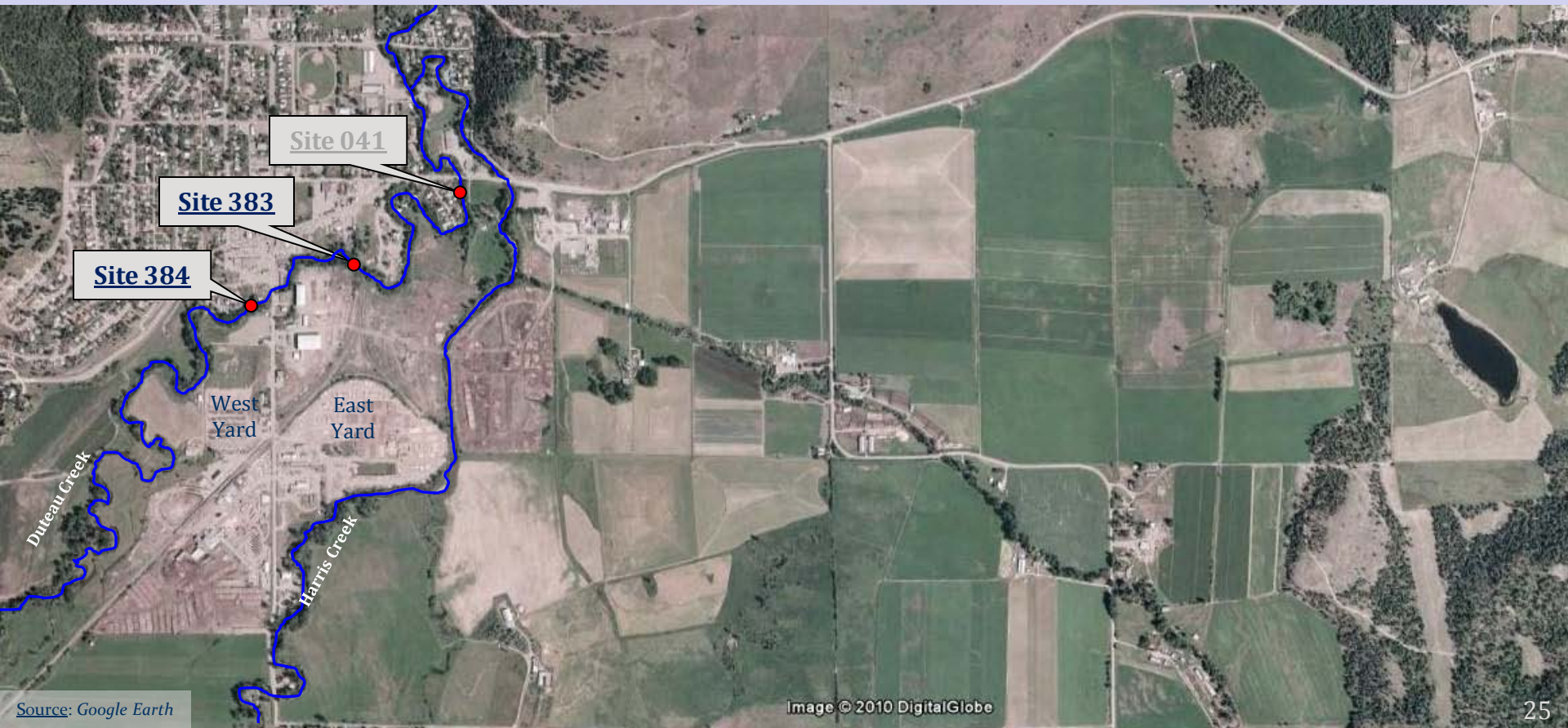
Bell Pole Sampling Area - Duteau Creek: Results (PAH in Water/Biota)

- Polycyclic aromatic hydrocarbon (PAH) concentrations were sampled in water, sediment and biota (western pearlshell mussels: *Margaritifera falcata*). PAH's could enter the stream from the Bell Pole W yard, bridge pilings, or road run-off.
- PAH concentrations in water were below both the chronic and phototoxic Provincial Guideline levels *to protect aquatic life* (no Objectives set) on all dates sampled (at sites 384 and 383). With the exception of three Naphthalene results, all PAH concentrations were below laboratory detection limits.
- Provincial Guidelines for PAH in mussel tissue are given for only Benzo[a]pyrene (B[a]P). *Note:* These are human consumption protection guidelines for the edible portions of the organism, and not aquatic life protection guidelines.
- B[a]P concentrations in mussels, at each of the three sites, were below the detection limit (0.05 µg/g); however, this detection limit is higher than Provincial Guideline levels (0.001 to 0.004 µg/g depending on rates of consumption). Therefore, mussel tissue sampling was inconclusive relative to the guideline.



Bell Pole Sampling Area - Duteau Creek: Results (PAH in Sediments)

- PAH concentrations in Duteau Creek sediment at sites 384 (upstream) and 383 (downstream), were below Provincial Guidelines levels (adjusted for percent total organic carbon) on each of the five dates sampled.
- Federal (CCME) Guidelines for PAH in freshwater sediment are more recent and more stringent than Provincial levels:
 - CCME Guideline levels were achieved for Napthalene and Anthracene.
 - Results for Acenaphthene and Flourene were inconclusive; nearly all results returned below detection limit, however, the detection limit was above the CCME Guideline.
 - Concentrations of four PAH compounds (Phenanthrene, Fluoranthene, Benzo[a]pyrene and Benzo[a]anthracene), exceeded CCME guideline levels on certain dates. However, concentrations were typically the same or lower at the downstream site (383) than at the upstream site (384), indicating possible inputs of these hydrocarbons upstream of the Bell Pole property; sources could include leachate from creosote treated timbers in fencing, railroad ties, bridges or other structures, as well as urban run-off.



Bell Pole Sampling Area - Duteau Creek: Results (Additional Parameters)

- Ammonia concentrations for both the upstream and downstream sites were below detection limit on all dates sampled.
- Nitrate concentrations were well below both the maximum *drinking water* Objective of 10.0 mg/L, and the 30-day average BC Guideline of 3.0 mg/L for the *protection of aquatic life*. Nitrate values were also slightly lower downstream of the Bell Pole site than upstream on four of the five dates sampled.
- Periphyton chlorophyll-*a* results obtained at the upstream Duteau Creek site (384), were near the 100 mg/m² Objective (98.4 mg/m²) but did not exceed the maximum level.
- Sampling results for temperature, dissolved oxygen and pH were within the acceptable range of established Objectives *to protect aquatic life*, and showed no appreciable difference between the upstream and downstream sites.
- Summary tables for all parameters are presented on the following slides.



Bell Pole Sampling Area (Duteau Creek) Summary of Parameters Monitored and Objectives Attainment (Met / Not Met)

Parameter	Site(s) Monitored	Target Value		Source ¹			Water Use ³	Met	Not Met	Comments
		Calculation	Value	OBJ ²	BCGL	CCME				
Fecal Coliforms	384 US	Maximum	200 CFU/100 mL	●			DW	X		No Objective set for Microbiological Indicators on Duteau Creek - Attainment measured against WQ Objective established for Bessette Creek.
		90 th Percentile	100 CFU/100 mL	●					X	
<i>E. coli</i>	384 US	Maximum	200 CFU/100 mL	●				X		
		90 th Percentile	100 CFU/100 mL	●					X	
Enterococci	384 US	Maximum	50 CFU/100 mL	●					X	
		90 th Percentile	25 CFU/100 mL	●					X	
Turbidity	384 US vs. 383 DS	Increase over background (upstream)	5 NTU Max.	●			DW	X		
Ammonia	384 US & 383 DS	Temp. & pH dependent		●			AL	X		All values returned below detection limit
Nitrate	384 US & 383 DS	Maximum	10 mg/L	●			DW	X		Well below the 10 mg/L Objective level, and also the 3.0 mg/L Provincial Guideline for the protection of aquatic life
		30-Day Average	3 mg/L		●		AL	X		
Periphyton Chl- <i>a</i>	384 US	Maximum	100 mg/m ²	●			AL	X		Min. 65 / Max 129 / Avg 98.4
Temperature	384 US & 383 DS	Increase over background (upstream)	1°C	●			AL	X		All values the same or lower at the downstream site
		Species and Life-Stage Dependant			●			X		All values within acceptable ranges for expected species and life-history stages of salmonids
DO	384 US & 383 DS	Minimum	8 - 11 mg/L	●			AL	X		Min. 11.0 / Max 14.0 / Avg 11.9
pH	384 US & 383 DS	Range	6.5 - 8.5	●			AL	X		Harris Creek Objective applied to Duteau Creek Min. 7.8 / Max 8.1 / Avg 8.0

¹ Source: *OBJ* = Bessette Cr Water Quality Objectives *BCGL* = Provincial Water Quality Guidelines *CCME* = Federal Water Quality Guidelines

² The only Objective established for Duteau Creek was for temperature. Objective values listed are those established for other streams in the Watershed.

³ Most sensitive water use designated for protection : *DW* = Drinking Water (partial treatment), *AL* = Aquatic Life

Bell Pole Sampling Area (Duteau Creek) Summary of Parameters Monitored and Objectives Attainment (Met / Not Met) ...continued

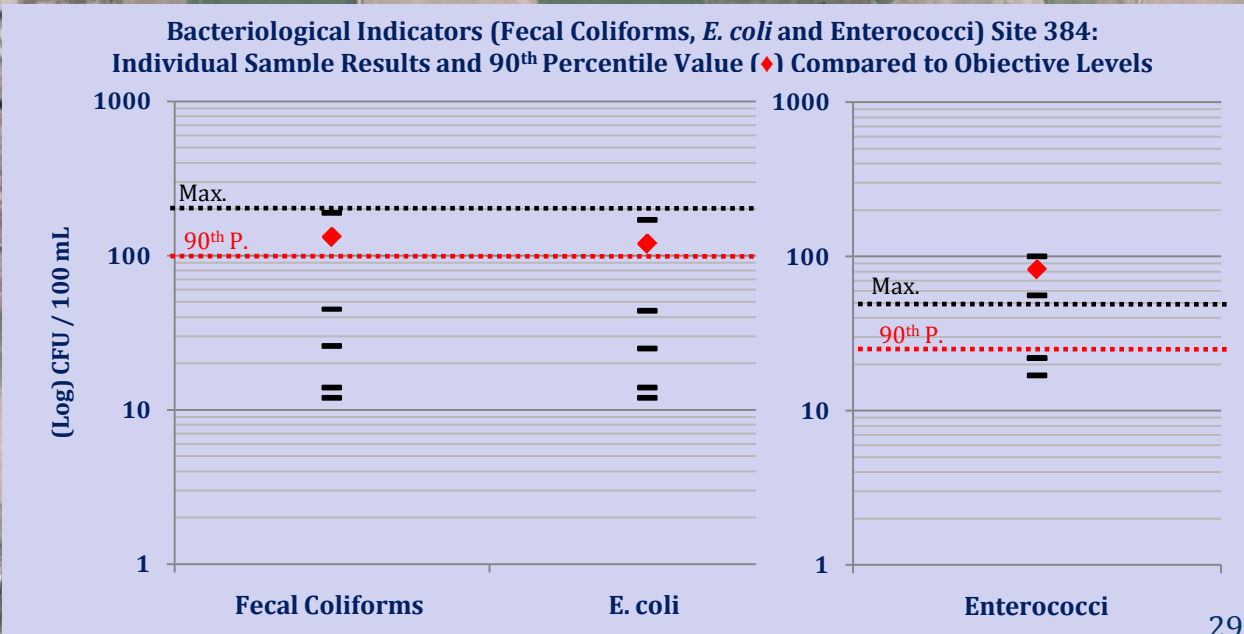
Parameter	Site(s) Monitored	Target Value		Source ¹			Water Use ²	Met	Not Met	Comments
		Calculation	Value	OBJ	BCGL	CCME				
Polycyclic Aromatic Hydrocarbons (PAH)										
> Water (Chronic)										
Naphthalene	384 US & 383 DS	Maximum	1 µg/L		●		AL	X		No Objectives set - BC Guideline used
Acenaphthene			6 µg/L		●			X		
Fluorene			12 µg/L		●			X		
Anthracene			4 µg/L		●			X		
Phenanthrene			0.3 µg/L		●			X		
Acridene			3 µg/L		●			X		
Fluoranthene			4 µg/L		●			X		
Benz[a]anthracene			0.1 µg/L		●			X		
Benzo[a]pyrene			0.01 µg/L		●			X		
> Water (Phototoxic)										
Anthracene	384 US & 383 DS	Maximum	0.1 µg/L		●		AL	X		No Objectives set - BC Guideline used
Acridene			0.05 µg/L		●			X		
Fluoranthene			0.2 µg/L		●			X		
Pyrene			0.02 µg/L		●			X		
Benz[a]anthracene			0.1 µg/L		●			X		
> Sediment										
Naphthalene	384 US & 383 DS	Maximum (Corrected for % Total Organic Carbon)	0.01 µg/g		●		AL	X		No Objectives set - BC Guideline used
Acenaphthene			0.15 µg/g		●			X		
Fluorene			0.2 µg/g		●			X		
Anthracene			0.6 µg/g		●			X		
Phenanthrene			0.04 µg/g		●			X		
Fluoranthene			2 µg/g		●			X		
Benz[a]anthracene			0.2 µg/g		●			X		
Benzo[a]pyrene			0.06 µg/g		●			X		
Acridene			1 µg/g		●		Unknown		Not Tested	
Naphthalene	384 US & 383 DS	Maximum	0.035 µg/g			●	AL	X		All values below detection limit, however; detection limit above CCME Guideline Level
Acenaphthene			0.007 µg/g			●		Inconclusive		
Fluorene			0.021 µg/g			●			X	
Anthracene			0.047 µg/g			●		X		Guideline exceeded on some dates; no increase d/s
Phenanthrene			0.042 µg/g			●			X	
Fluoranthene			0.111 µg/g			●			X	
Benz[a]anthracene			0.032 µg/g			●			X	
Benzo[a]pyrene			0.032 µg/g			●			X	
> Tissue										
Benz[a]pyrene (BaP)	384 US, 383 DS & 041 DS	Range for fish/shellfish based on human consumption, for light, moderate or heavy rates of consumption	0.001 - 0.004 µg/g		●		HC	Inconclusive		No Objectives set - BC Guideline used Detection limit above Guideline Level

¹ Source: *OBJ* = Bessette Cr Water Quality Objectives *BCGL* = Provincial Water Quality Guidelines *CCME* = Federal Water Quality Guidelines

² Most sensitive water use designated for protection : *DW* = Drinking Water (partial treatment), *AL* = Aquatic Life, *HC* = Human Consumption

Bell Pole Sampling Area – Harris Creek: Results (Bacteria)

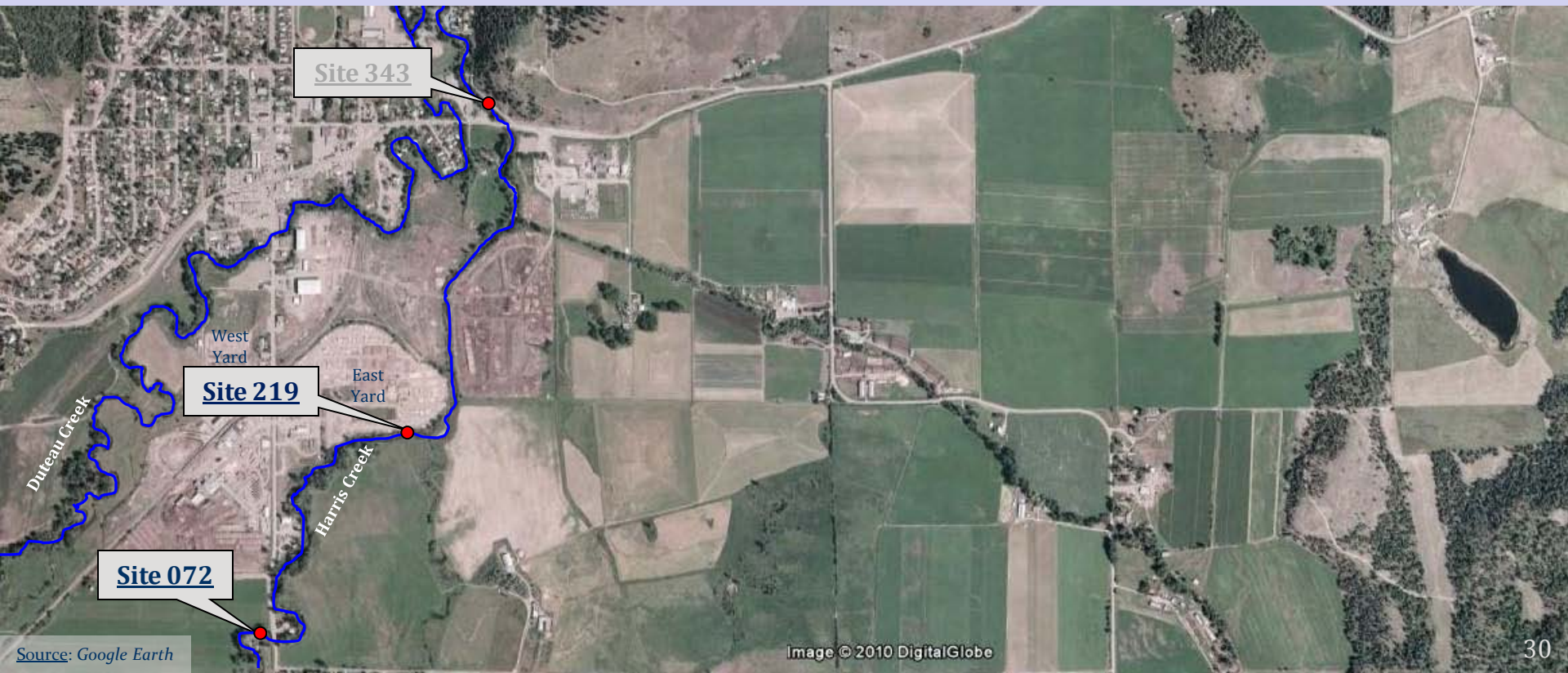
- Bacteriological indicators were only sampled at the upstream Harris Creek site (072).
- Fecal coliforms and *E. coli* concentrations varied greatly over the 30 day sampling period. Values met the maximum Objective of 200 CFU/100 mL, but exceeded the 90th percentile Objective of 100 CFU/100 mL *to protect raw drinking water used with only partial treatment*.
- Results for fecal coliforms and *E. coli* were nearly identical, suggesting that *E. Coli* represents the dominant type of fecal coliform in the system.
- Enterococci concentrations exceeded both the maximum (50 CFU/100 mL) and 90th percentile (25 CFU/100 mL) Objectives.



Source: Google Earth

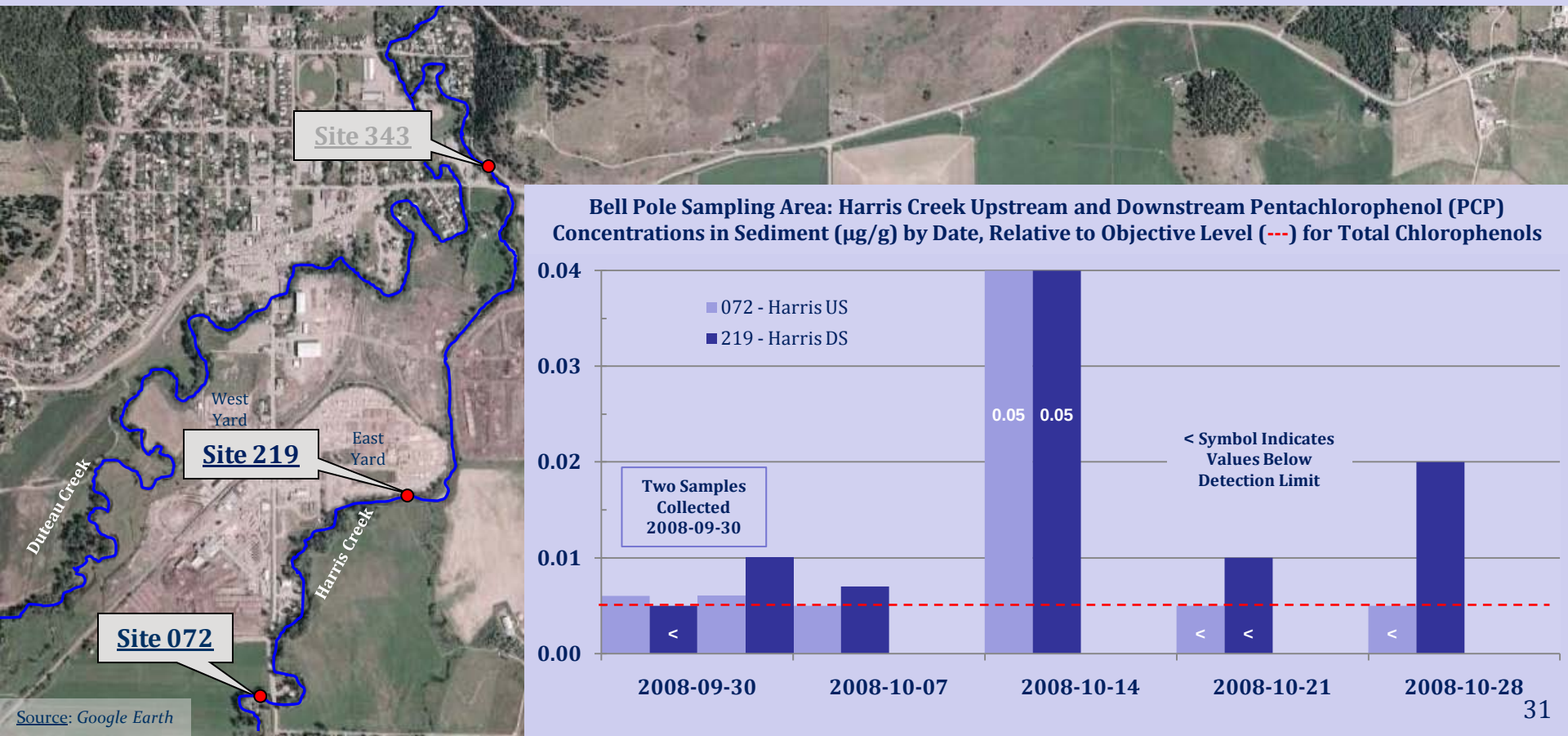
Bell Pole Sampling Area – Harris Creek: Results (Chlorophenols in Water)

- Stella Jones continues to control and treat chlorophenol contaminated groundwater within the east yard.
- *To protect aquatic life*, Objectives were established for five chlorophenol (CP) groups in water: mono-, di-, tri-, tetra- and pentachlorophenols. Monochlorophenols were not sampled as part of this project. Di- and trichlorophenols were sampled on 3 of 5 dates only (weeks 1, 2 and 4). Tetra- and pentachlorophenols (PCP) were sampled on each of the five dates.
- Results for di- and tetrachlorophenol congeners returned below detection limit ($0.1 \mu\text{g/L}$) on each of the dates sampled. The maximum Objective level for these chlorophenol groups in Harris Creek was set at $0.1 \mu\text{g/L}$; therefore, Objectives were met at both the upstream (072) and downstream (219) sites.
- Tri- and pentachlorophenol concentrations were also below detection limit ($0.1 \mu\text{g/L}$) at both the upstream and downstream sites on all sample dates. The Objective for these compounds ($0.05 \mu\text{g/L}$) was set lower than the detection limit used in this study. Subsequent to the 1991 WQOs however, Provincial Guidelines for CP's were amended to account for the influence of pH and temperature and new information. For example, the Provincial Guideline for PCP at pH 7.7 is $2.4 \mu\text{g/L}$ at 0°C and, and $0.6 \mu\text{g/L}$ at 20°C . Therefore, PCP in Harris Creek water was not above the Provincial Guidelines in 2008. This is consistent with the results of sampling carried out by Stella Jones as a requirement of their permit.



Bell Pole Sampling Area – Harris Creek: Results (Chlorophenols in Sediment)

- The Harris Creek Objective for chlorophenol concentrations in sediment ($0.005\text{ }\mu\text{g/g}$) was set in 1991 at the detection limit *total chlorophenols* (the sum of tri- tetra- and pentachlorophenols) based on Harris Creek upstream sediment quality. Subsequently, the provincial Contaminated Sites Regulation set a sensitive sediment criterion of $0.4\text{ }\mu\text{g/g}$ for PCP in 1997.
- The Objective was exceeded at the upstream site (072) for 3 of the 6 samples in 2008.
- With the exception of one sample date (2008-10-14 when pentachlorophenol concentrations of $0.05\text{ }\mu\text{g/g}$ were recorded at both the upstream and downstream sample sites) PCP in upstream sediments were generally near or below the $0.005\text{ }\mu\text{g/g}$ Objective level and well below the CSR criterion of $0.4\text{ }\mu\text{g/g}$.
- The Objective was exceeded at the downstream site (219) for 4 of the 6 samples. For 3 of the 6 samples, the downstream concentrations were higher than those observed upstream (see graph below); 1 result (2008-10-21) was inconclusive due to an elevated detection limit. Similarly, data for 2008-10-14 may have been confounded by a higher detection limit ($0.1\text{ }\mu\text{g/g}$). Regardless, downstream values were well below the CSR criterion to protect aquatic life.



Bell Pole Sampling Area – Harris Creek: Results (Chlorophenols in Biota)

- Western pearlshell mussels are not common in Harris Creek above Highway 6, but a few specimens were collected for chlorophenols at a single site (343) on Harris Creek, located approximately 1 km downstream of the Bell Pole Yard.
- A total chlorophenol Objective *to protect aquatic biota* in Harris Creek ($0.1 \mu\text{g/g}$) was established based on typical values reported for Fraser River fish. All mussel chlorophenol concentrations were below the laboratory detection limit of $0.5 \mu\text{g/g}$. Because of elevated detection limits and differences in depuration rates between fish and mussels, these findings can not be directly compared to the Objective level.
- Provincial Guidelines *to prevent tainting of fish flesh* by various congeners of mono- di- tri- and pentachlorophenols, ranged from 0.2 to $80 \mu\text{g/g}$.
 - Concentrations for all congeners tested were below maximum Guideline levels, except for 2,4 dichlorophenol, for which the results were inconclusive: detection limit ($0.5 \mu\text{g/g}$) above Guideline value ($0.2 \mu\text{g/g}$).
 - Note: Guideline levels established for fish muscle tissue, represent flavour impairment guidelines, not levels for the protection of aquatic life. Mussel tissue results have been compared to these values in order to provide a general indication of chlorophenol uptake in biota along Harris Creek.



Bell Pole Sampling Area – Harris Creek: Results (Additional Parameters)

- Ammonia results for both the upstream and downstream sites were below detection limit (0.005 mg/L) on all but one sample. All results were well below Objective levels *to protect aquatic life*.
- Nitrate concentrations were all well below both the *maximum drinking water* Objective of 10.0 mg/L, and the 30-day average BC Guideline level of 3.0 mg/L *for the protection of aquatic life*, at both the upstream and downstream sites. Half of the nitrate samples collected returned values below detection limit (0.002 mg/L).
- The periphyton chlorophyll-*a* average concentration obtained at the downstream sampling site (68.4 mg/m²) was nearly double that of the upstream site (36.4 mg/m²). However, values at both locations were well below the maximum Objective level of 100 mg/m².
- Sampling results for temperature, turbidity, dissolved oxygen and pH were within the acceptable range of established Objectives and showed no appreciable difference between the upstream and downstream sites.
- A summary table for all parameters sampled is presented on the following slide.



Harris Creek (near Bell Pole) Summary of Parameters Monitored and Objectives Attainment (Met / Not Met)										
Parameter	Site(s) Monitored	Target Value		Source ¹			Water Use ²	Met	Not Met	Comments
		Calculation	Value	OBJ	BCGL	CCME				
Fecal Coliforms	US Only	Maximum	200 CFU/100 mL	•			DW	X		No Objective set for Microbiological Indicators on Harris Creek - Attainment measured against Bessette Creek Objective value
		90 th Percentile	100 CFU/100 mL	•					X	
<i>E. coli</i>	US Only	Maximum	200 CFU/100 mL	•				X		
		90 th Percentile	100 CFU/100 mL	•					X	
Enterococci	US Only	Maximum	50 CFU/100 mL	•					X	
		90 th Percentile	25 CFU/100 mL	•					X	
Turbidity	US vs. DS	Increase over background (upstream)	5 NTU Max.	•			DW	X		
Ammonia	US & DS	Temp. & pH dependent		•			AL	X		Only one value above detection limit
Nitrate	US & DS	Maximum	10 mg/L	•			DW	X		Well below the 10 mg/L Objective level, and also the 3.0 mg/L Provincial Guideline for aquatic life
		30-Day Average	3 mg/L		•		AL	X		
periphyton Chl- <i>a</i>	US & DS	Maximum	100 mg/m ²	•			AL	X		
DO	US & DS	Minimum	8 - 11 mg/L	•			AL	X		Min. 9.8 / Max 14.5 / Avg 12.04
pH	US & DS	Range	6.5 - 8.5	•			AL/DWa	X		Min. 7.9 / Max 8.1 / Avg 7.95
Temperature	US & DS	Increase over background	1°C	•			AL	X		Duteau Creek Objective applied to Harris Creek
		Species and Life-Stage Dependant			•			X		Within acceptable renges for expected species/life-stages of salmonids
Chlorophenols										
> <i>Water</i>										
monochlorophenol	US & DS	Objective: Maximum Value Guideline: Range of Values (for all of the various congeners) adjusted for observed Temperatures and pH values	0.5 µg/L	•			AL	Unknown?		Not Tested
dichlorophenol			0.1 µg/L	•				X		
			5.4-32.3 µg/L		•			X		
trichlorophenol			0.05 µg/L	•				Inconclusive		Objective value below detection limit, however, results were well below Guideline values when adjusted for temperature/pH
tetrachlorophenol			2.25-25.84 µg/L		•			X		
			0.1 µg/L	•				X		
pentachlorophenol			4.5-19.8 µg/L		•			X		
			0.05 µg/L	•				Inconclusive		Objective value below detection limit, however, results were well below Guideline values when adjusted for temperature/pH
> <i>Sediment</i>										
Total Chlorophenols*	US & DS	Maximum (*Sum of Tri-, Tetra- and Pentachlorophenols)	0.005 µg/g	•			AL		X	Below detection limit for both tri- and tetrachlorophenols Based on pentachlorophenol results alone, the Objective was exceeded for 3 of 6 samples upstream, and 4 of 6 samples downstream (1 sample inconclusive) but well below CSR criterior of 0.4 ug/g.
> <i>Tissue (Fresh-Water Mussels)</i>										
Total Chlorophenols*	DS Only	Maxi. Objective: fish muscle tissue. (*Sum of Tri-, Tetra- and Penta-chlorophenols)	0.1 µg/g	•			AL	Inconclusive		Mussels not fish tissue tested; detection limit = 0.5 µg/g (5 X Objective value)
2-MCP	DS Only	Maximum (Interim Fish muscle Tissue Flavour Impairment Guidelines) wet weight	10 µg/g		•		HC	Unknown?		Not Tested
3-MCP			20 µg/g		•			Unknown?		Not Tested
4-MCP			40 µg/g		•			Unknown?		Not Tested
2,3-DCP			80 µg/g		•			X		
2,4-DCP			0.2 µg/g		•			Inconclusive		Objective value below detection limit
2,5-DCP			20 µg/g		•			X		
2,6-DCP			30 µg/g		•			X		
2,4,6-TCP			50 µg/g		•			X		
2,3,4,5,6-PCP			20 µg/g		•			X		

¹ Source: *OBJ* = Bessette Cr Water Quality Objectives *BCGL* = Provincial Water Quality Guidelines *CCME* = Federal Water Quality Guidelines

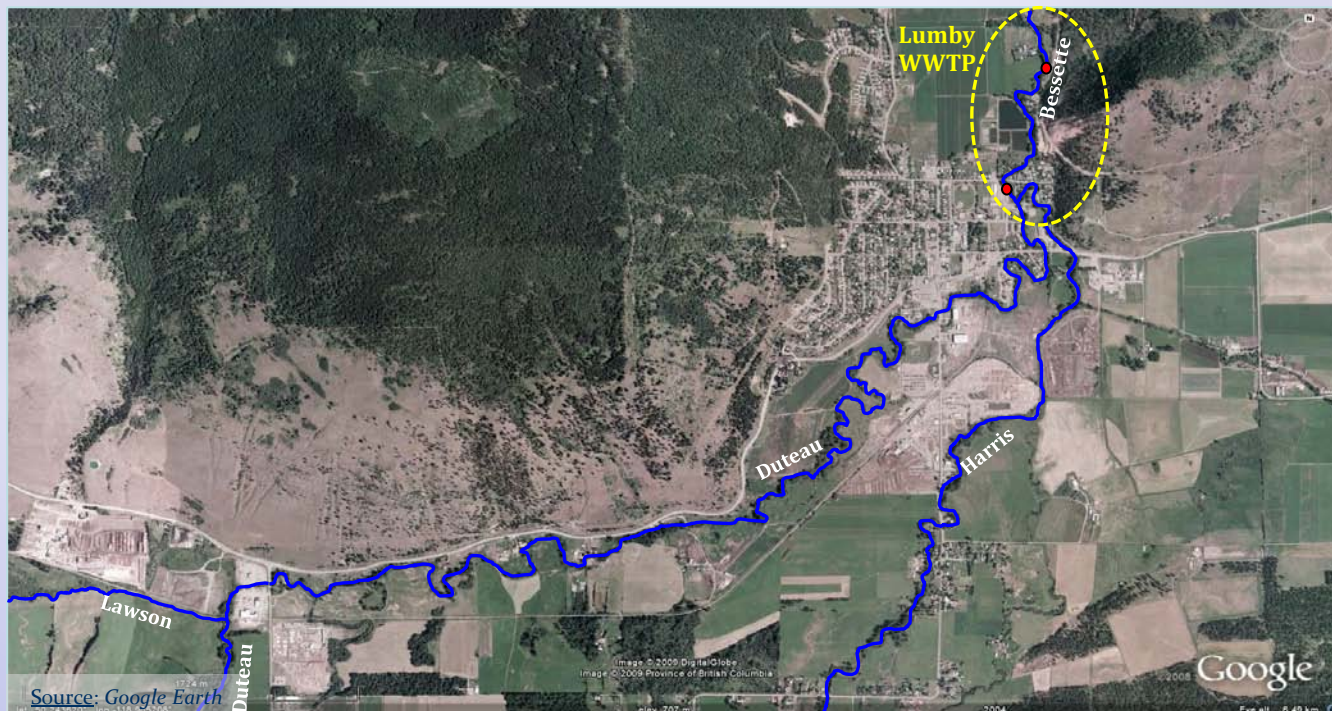
² Most sensitive water use designated for protection : *DW* = Drinking Water (partial treatment), *DWa* = Drinking Water (aesthetic), *AL* = Aquatic Life, *HC* = Human Consumption

Bell Pole Area: Summary/Discussion

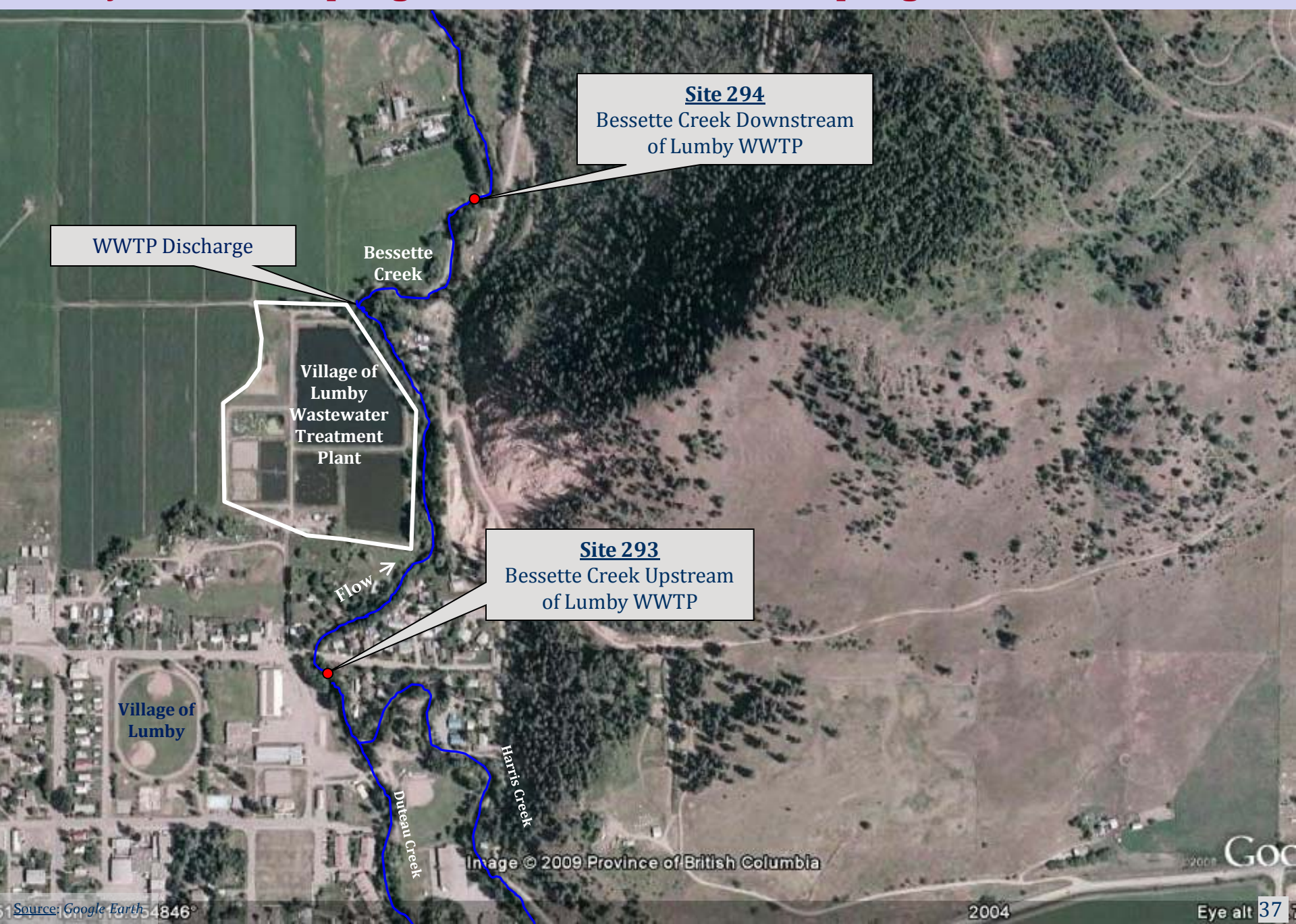
- Both Duteau and Harris creeks contained elevated fecal, *E coli* and enterococci bacteria levels, with the latter most often exceeding maximum and 90th percentile Objectives to protect raw drinking water used with partial treatment. Sources of bacteria, in order of likelihood include: agriculture, road run-off, wildlife, and septic tanks. Drinking water use without at least partial treatment is not recommended.
- Few detectable PAH concentrations were reported for Duteau Creek water. Although these compounds are hydrophobic and would most likely attach to the stream sediments, sediment PAH levels met Provincial Guidelines. Although many PAH compounds in stream sediments exceeded Federal Guidelines (and when detection limits allowed for conclusive interpretation of results), the data suggest upstream sources, rather than the Bell Pole west yard, as the origin of these of hydrocarbons. Potential sources include creosoted bridge structures, and road run-off.
- Chlorophenol concentrations in Harris Creek water were all below the detection limits in this study and PCP was below the Provincial Guidelines. Objectives Attainment could not be determined for tri- and pentachlorophenol since Objective levels were set lower than the detection limit. However, because the Objectives were consistent in 1991 with the Provincial Guidelines which were subsequently amended in 1993, it is assumed here that the Provincial Guideline continues to be appropriate. PCP was greater in downstream sediments on 3 of 6 samples and chlorophenols often exceeded the Objective and detection limit. However, PCP in sediment was much lower than the provincial Contaminated Sites sediment criterion of 0.4 ug/g for sensitive freshwater habitat. Chlorophenols were not detected in freshwater mussel tissue but direct comparison of these results to the fish protection Objectives was not possible due to elevated detection limits and differences in depuration rates between fish and mussels.

Lumby WWTP Sampling Area

- Located immediately to the north of the Village of Lumby.
- Two sites were sampled in this area: Upstream and downstream of the Waste Water Treatment Plant (WWTP).
- The Village of Lumby holds a permit under the Environmental Management Act to discharge effluent to Bessette Creek. The effluent receives secondary treatment using aerated lagoons with infiltration to ground; a mixture of effluent and groundwater are pumped from below the infiltration ponds and treated with UV prior to discharged to Bessette Creek on an annual basis.
- The Bessette Creek sample sites also provided an indication of cumulative impacts within the watershed.



Lumby WWTP Sampling Area: Bessette Creek Sampling Sites



Site 294
Bessette Creek Downstream
of Lumby WWTP

WWTP Discharge

Village of
Lumby
Wastewater
Treatment
Plant

Site 293
Bessette Creek Upstream
of Lumby WWTP

Village of
Lumby

Image © 2009 Province of British Columbia

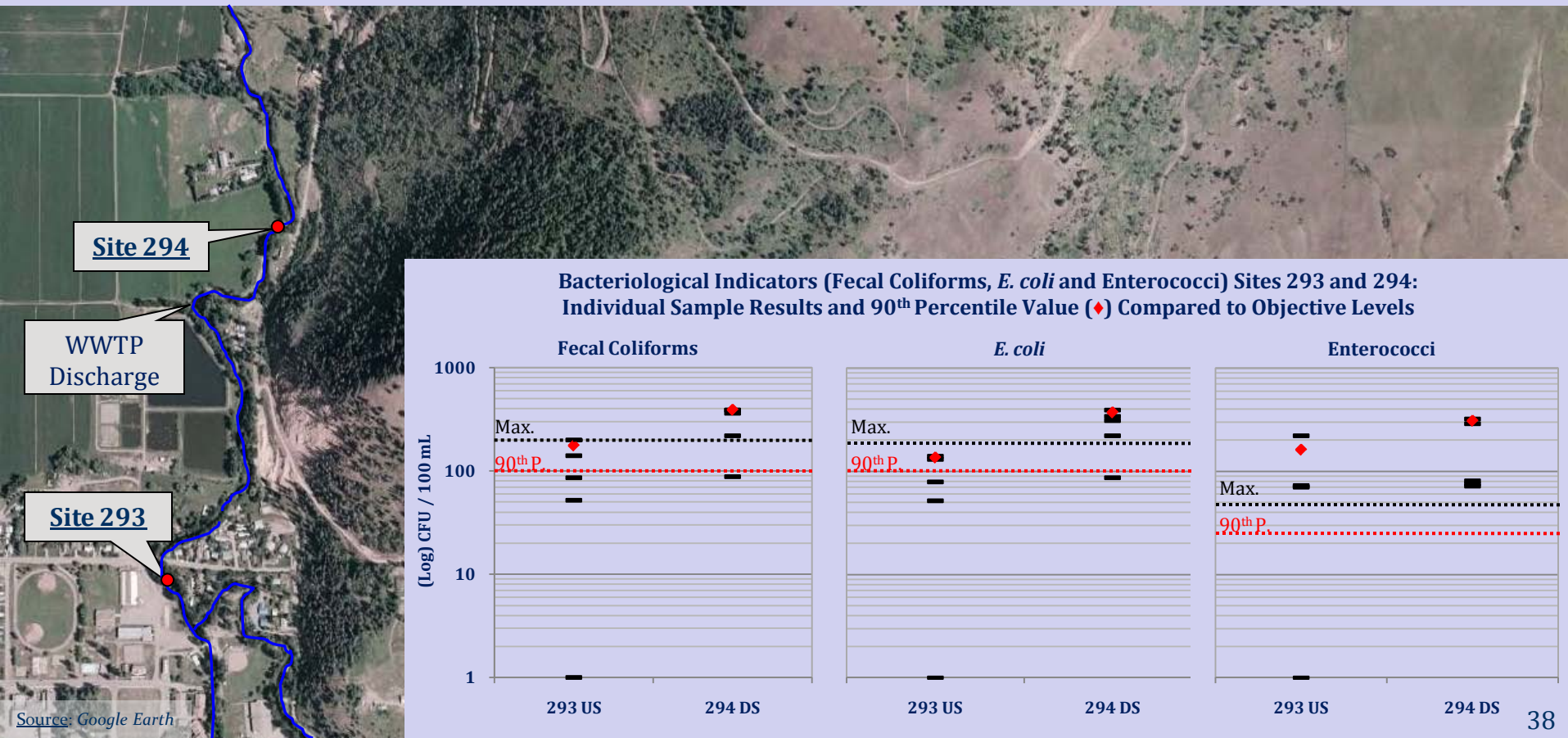
2004

Source: Google Earth 4846°

Eye alt 37

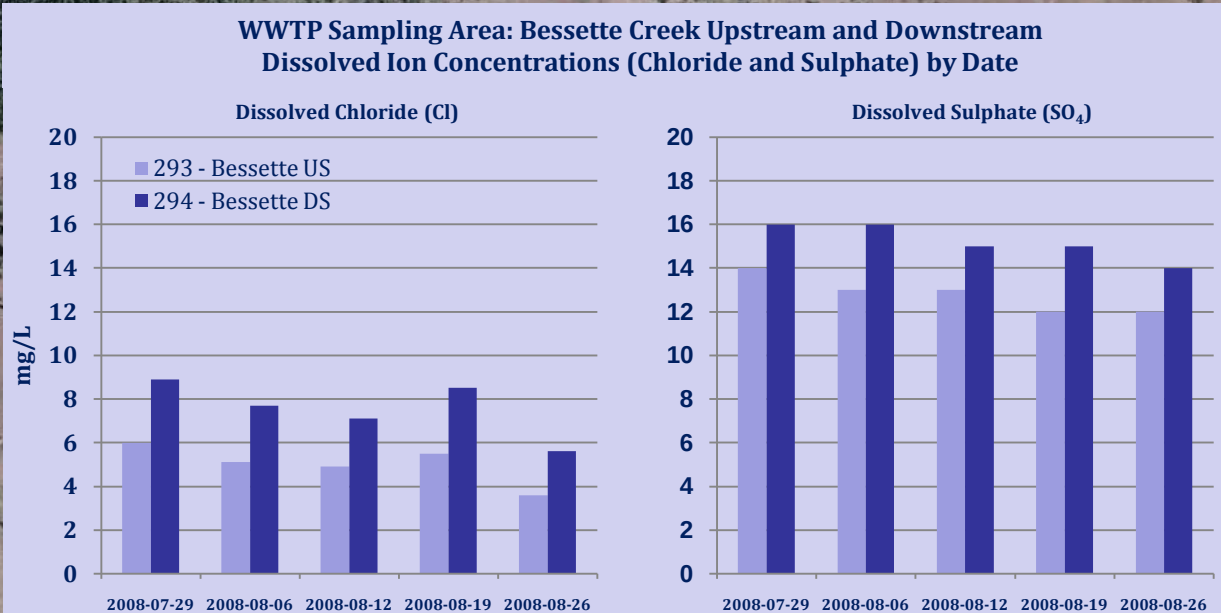
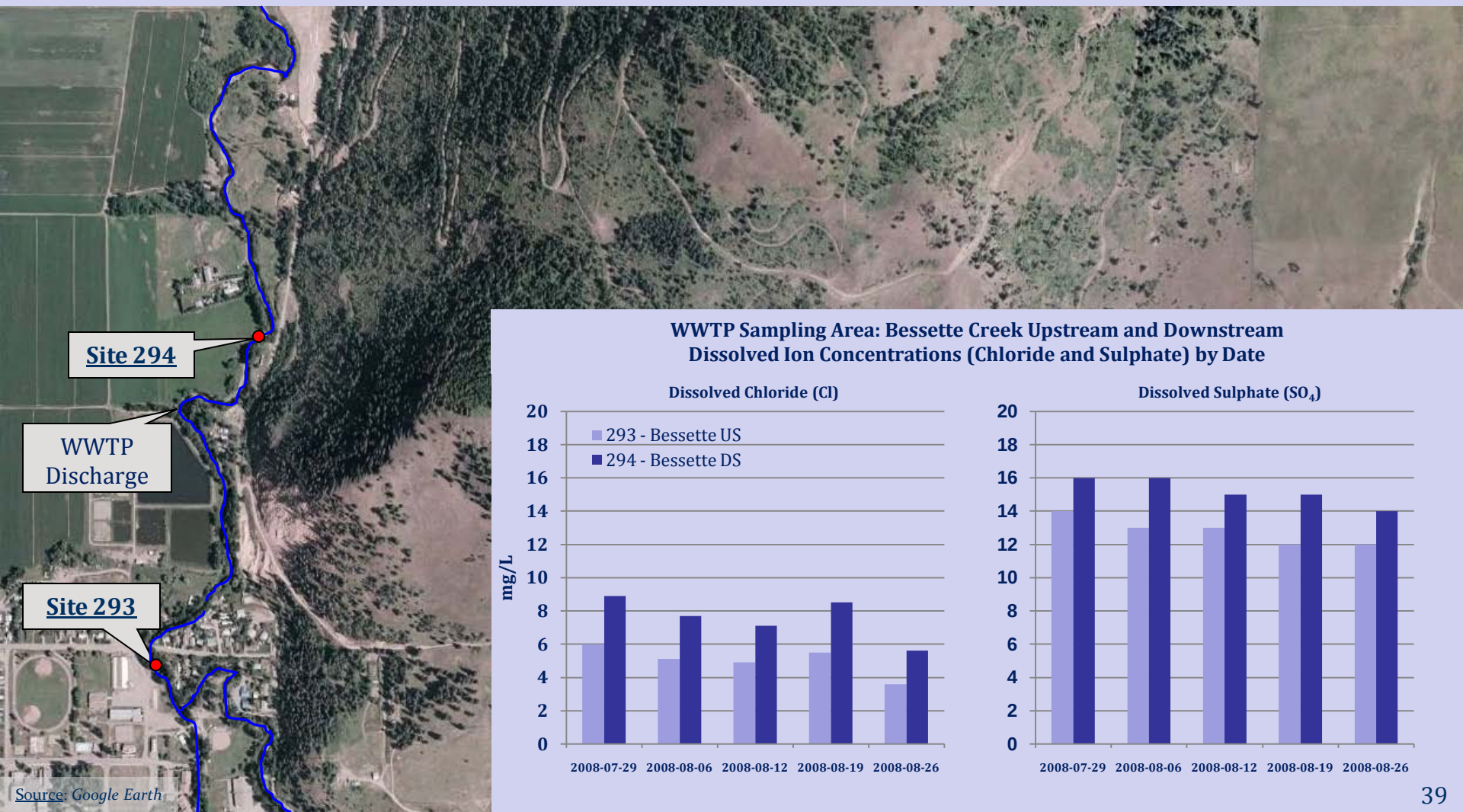
WWTP Sampling Area: Results (Bacteria)

- Bacteriological indicators (fecal coliforms, *E. coli* and enterococci) were monitored at both the upstream (293) and downstream (294) sites on Bessette Creek.
- Fecal coliform and *E. coli* concentrations generally exceeded the 90th percentile Objective (100 CFU/100 mL) upstream of the WWTP, and exceeded both the maximum (200 CFU/100 mL), and 90th percentile Objectives at the downstream site. Similarities in values between fecal coliforms and *E. coli* concentrations suggest that fecal coliforms within the system consist almost entirely of *E. coli* bacteria.
- Enterococci concentrations generally exceeded both the maximum (50 CFU/100 mL) and 90th percentile (25 CFU/100 mL) Objectives at both the upstream and downstream sampling sites.
- Higher bacteria concentrations at the downstream site may reflect inputs from the WWTP as well as coliform inputs from other sources both upstream and immediately downstream of the outfall. Bessette Creek between the WWTP discharge and site 294 is bordered by a cattle pasture with limited riparian vegetation; this area is also a likely source of bacteria.



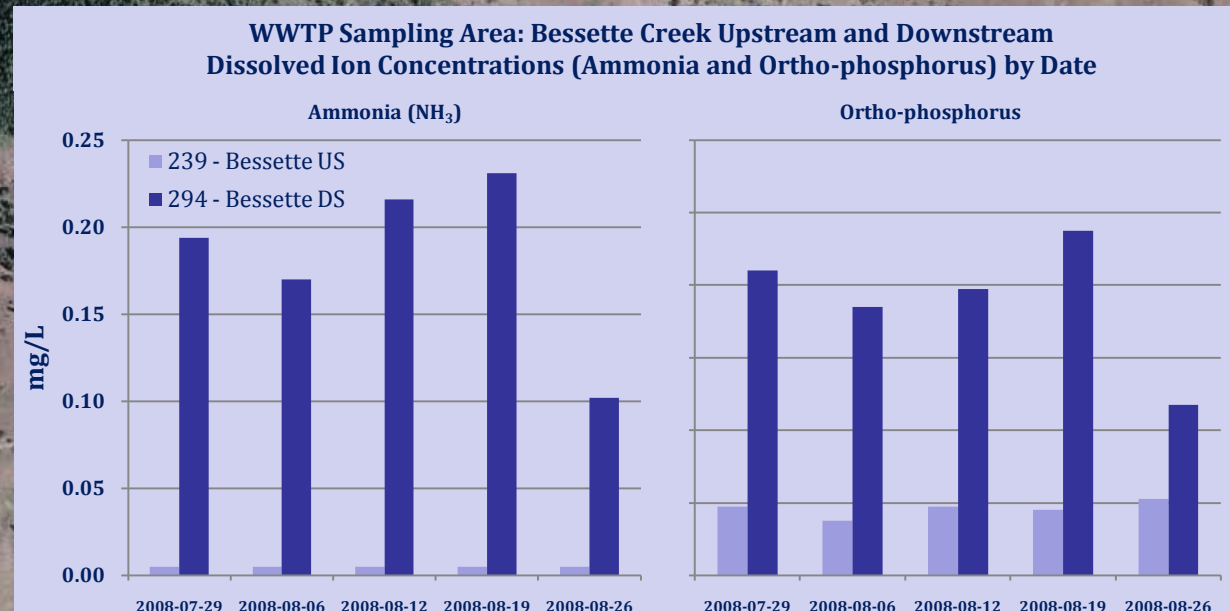
WWTP Sampling Area: Results (Dissolved Ions)

- Although no Objectives have been established, bromide, chloride and sulphate were monitored at the Bessette Creek sites as indicators of municipal waste water.
- Bromide results did not show a distinct trend from upstream to downstream, however; sulphate and chloride concentrations (see graph below) were both consistently higher at the downstream sample site.
- Despite these increases, concentrations of chloride and sulphate remained well below Provincial Guideline levels, at both the upstream and downstream sites. Provincial Guidelines *for the protection of aquatic life* are: chloride - 600 mg/L (maximum), 150 mg/L (30 day average); sulphate - 100 mg/L (maximum).



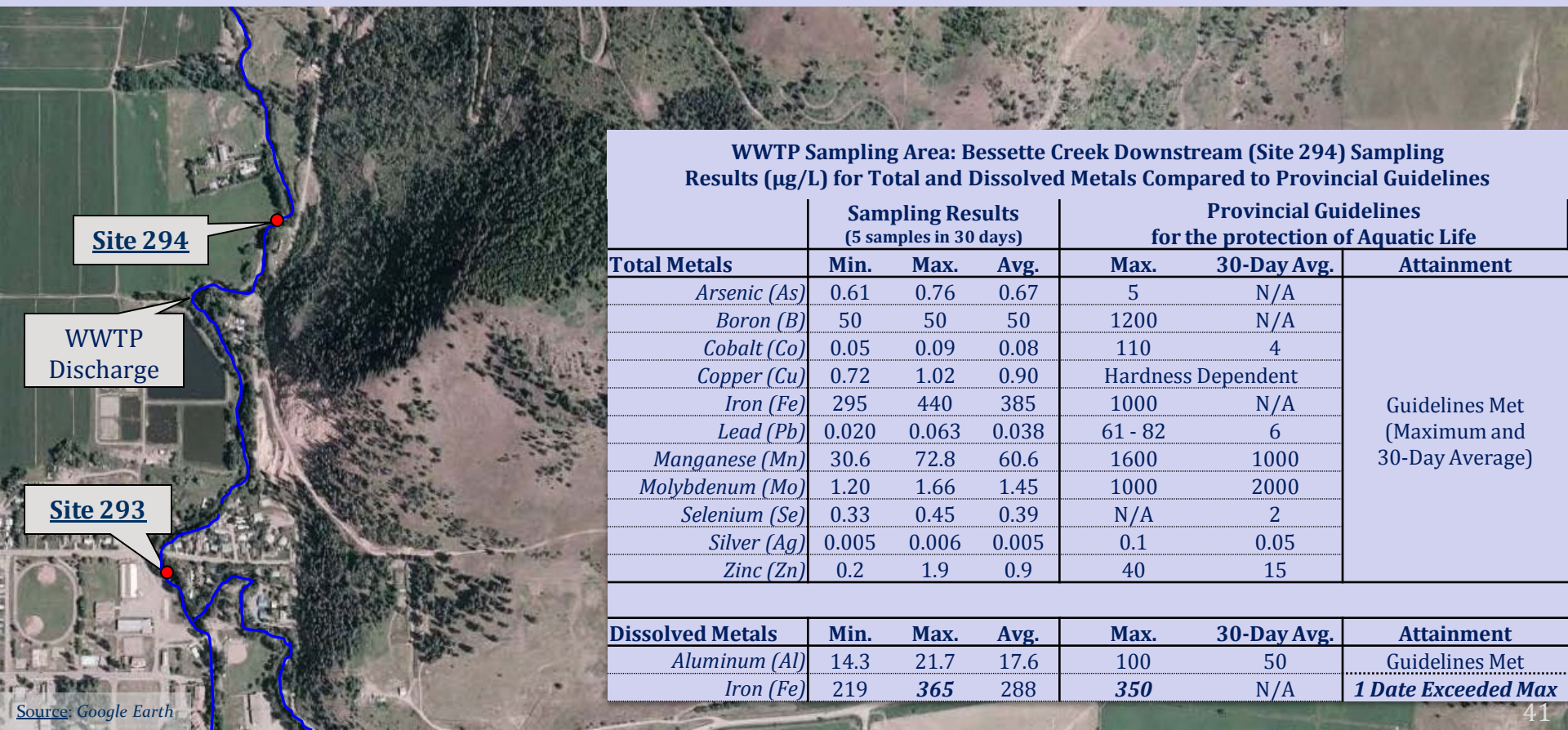
WWTP Sampling Area: Results (Nutrients)

- Nutrient monitoring within this area included nitrate, ammonia and ortho-phosphorus sampling.
- Nitrate concentrations did not indicate a distinct pattern between the upstream and downstream sampling sites, and all values were well below *the drinking water Objective of 10.0 mg/L, and the BC Guideline (30-day average) of 3 mg/L for the protection of aquatic life.*
- Significant increases in ammonia and ortho-phosphorus concentrations were observed from the upstream to downstream sites (see graphs below).
- Ammonia concentrations at the upstream site were all below the detection limit of 0.005 mg/L, while values at the downstream site ranged from 0.102 to 0.231 mg/L (averaging 0.183 mg/L). Although these increases appear dramatic, the downstream values were still well below Objective levels *to protect aquatic life* (between 4.51 and 8.02 mg/L for the temperature and pH levels observed).
- Concentrations of ortho-phosphorus at the downstream sampling site were between 2 and 5 times higher than upstream levels. Although no Objectives or Guidelines exist for ortho-phosphorus, these concentrations represent significant concentrations of a bio-available form of phosphorus, and therefore may contribute to excessive algal growth in downstream waters.



WWTP Sampling Area: Results (Metals)

- Because of historic mining activity in this area, the downstream site on Bessette Creek was sampled for the full suite of total and dissolved metals.
- No Objectives have been established for metals in the watershed, therefore; results were compared to Provincial Guidelines primarily *to protect aquatic life*.
- A summary of results for total and dissolved metals (for those with established Guidelines) are presented in the table below, along with Guideline values for the *protection of aquatic life* and attainment results.
- All metals concentrations were below the maximum and average (5 samples in 30 days) Guideline levels, with the exception of one dissolved iron sample, which exceeded the recommended maximum value by approximately 4%.
- Since only one site was tested for metals during the 2008 attainment project (Site 294: the lowermost site in the watershed), results provide an indication of cumulative metals concentrations within the watershed, rather than identifying sources of input.

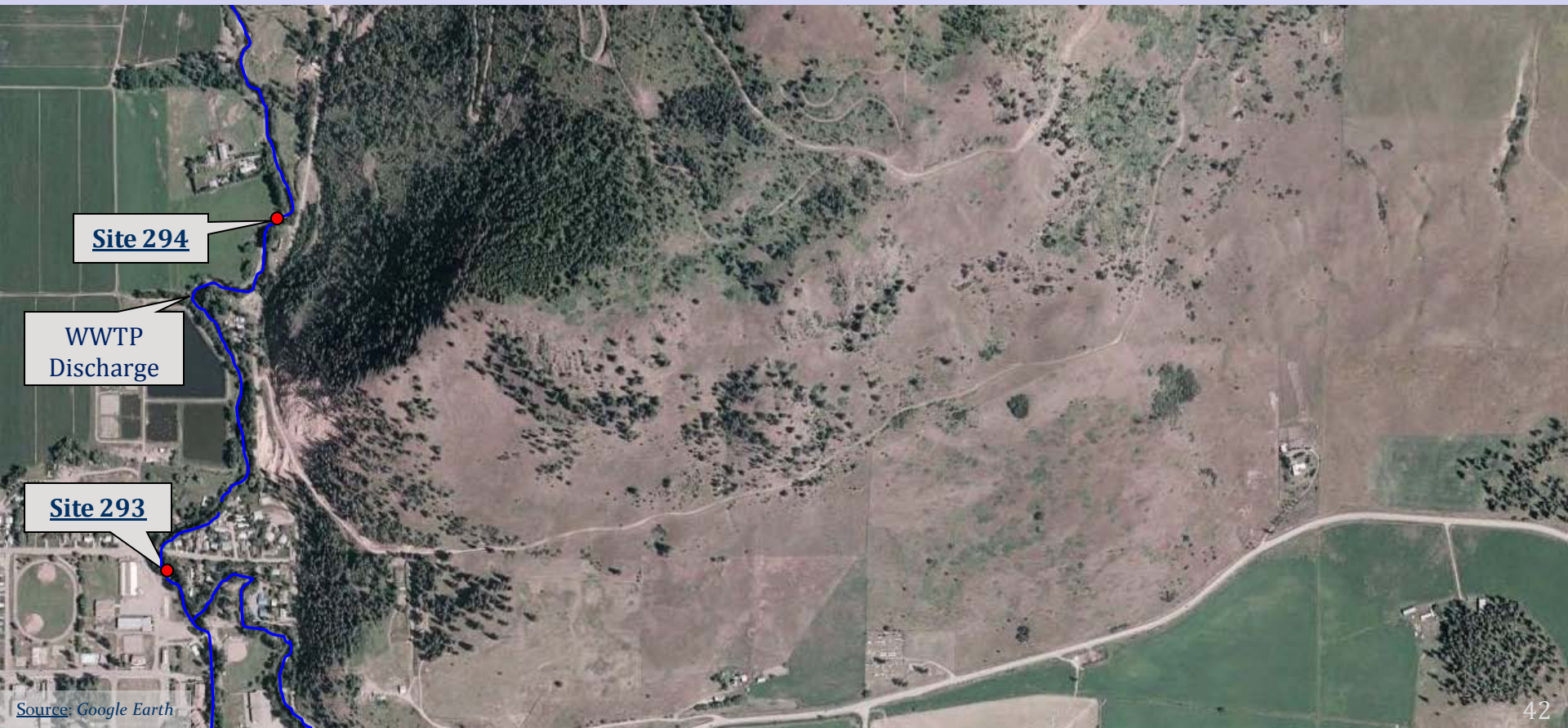


WWTP Sampling Area: Bessette Creek Downstream (Site 294) Sampling Results (µg/L) for Total and Dissolved Metals Compared to Provincial Guidelines						
	Sampling Results (5 samples in 30 days)			Provincial Guidelines for the protection of Aquatic Life		
Total Metals	Min.	Max.	Avg.	Max.	30-Day Avg.	Attainment
Arsenic (As)	0.61	0.76	0.67	5	N/A	Guidelines Met (Maximum and 30-Day Average)
Boron (B)	50	50	50	1200	N/A	
Cobalt (Co)	0.05	0.09	0.08	110	4	
Copper (Cu)	0.72	1.02	0.90	Hardness Dependent		
Iron (Fe)	295	440	385	1000	N/A	
Lead (Pb)	0.020	0.063	0.038	61 - 82	6	
Manganese (Mn)	30.6	72.8	60.6	1600	1000	
Molybdenum (Mo)	1.20	1.66	1.45	1000	2000	
Selenium (Se)	0.33	0.45	0.39	N/A	2	
Silver (Ag)	0.005	0.006	0.005	0.1	0.05	
Zinc (Zn)	0.2	1.9	0.9	40	15	
Dissolved Metals	Min.	Max.	Avg.	Max.	30-Day Avg.	Attainment
Aluminum (Al)	14.3	21.7	17.6	100	50	Guidelines Met
Iron (Fe)	219	365	288	350	N/A	1 Date Exceeded Max

Source: Google Earth

WWTP Sampling Area: Results (Additional Parameters)

- In spite of elevated nutrient values at the downstream sampling site (as previously discussed), periphyton chlorophyll-*a* concentrations were higher at the upstream site (146 mg/m²) than downstream of the WWTP (89 mg/m²) - maximum Objective level: 100 mg/m².
- Periphyton chlorophyll-*a* concentrations may be related to the interaction of availability of nutrients, solar radiation, substrate, water flow, invertebrate grazing, or a combination of these and other factors.
- Stream temperatures on Bessette Creek exceeded the maximum increase of 1°C over background (increase of 2°C from upstream to downstream), on 1 sample date. Temperatures exceeded the Provincial Guideline *for salmon rearing* (15°C) on 5 out of 10 samples, at both the upstream and downstream sites.
- Sampling results for turbidity, dissolved oxygen and pH were within the acceptable range of established Objectives and showed no appreciable difference between the upstream and downstream sites.
- A summary table for all parameters sampled is presented on the following slide.



WWTP Sampling Area (Bessette Creek) Summary of Parameters Monitored and Objectives Attainment (Met / Not Met)											
Parameter	Site(s) Monitored	Target Value		Source ¹			Water Use ²	Met	Not Met	Comments	
		Calculation	Value	OBJ	BCGL	CCME					
Fecal Coliforms	293 US & 294 DS	Max. Value	200 CFU/100 mL	•			DW	US	DS	Maximum reached but not exceeded upstream; Exceeded downstream	
		90 th Percentile	100 CFU/100 mL	•					X		
E. coli	293 US & 294 DS	Max. Value	200 CFU/100 mL	•				US	DS	Met upstream; Exceeded downstream	
		90 th Percentile	100 CFU/100 mL	•					X		
Enterococci	293 US & 294 DS	Max. Value	50 CFU/100 mL	•					X		
		90 th Percentile	25 CFU/100 mL	•					X		
TSS	293 US vs. 294 DS	Max. increase over background (upstream)	10 mg/L	•			AL	X		All values below detection limit	
Turbidity	293 US vs. 294 DS	Increase over background	10 %	•			DW	X			
Ammonia	293 US & 294 DS	Temp. & pH dependent			•			AL	X		Objective met but, significant increase from US to DS
Nitrate	293 US & 294 DS	Max. Value	10 mg/L	•			DW	X		Not only below 10 mg/L Objective level, but also well below 3.0 mg/L Provincial Guideline for aquatic life	
		30-Day Average	3 mg/L		•		AL	X			
Periphyton Chl- <i>a</i>	293 US & 294 DS	Max. Value	100 mg/L	•			AL	DS	US	Met downstream; Exceeded upstream	
Temperature	293 US vs. 294 DS	Increase over background (upstream)	1°C	•			AL	X		Duteau Creek Objective applied to Bessette Creek One sample date exceeded maximum (increase of 2°C over background)	
		Species and Life-Stage Dependant				•			X	Exceeded 15 °C Max Guideline for salmonid rearing; 5 out of 10 samples	
DO	293 US & 294 DS	Min. Value	8 mg/L	•			AL	X		Min. 8.2 / Max. 10.0 / Avg. 9.0	
pH	293 US & 294 DS	Range	6.5 - 8.5	•			AL/DW _a	X		Min. 7.8 / Max. 8.1 / Avg. 8.0	
Chloride	293 US & 294 DS	Max. Value	600 mg/L		•		AL	X		Min. 3.6 / Max. 8.9 / Avg. 6.3	
		30-day Average	150 mg/L		•			X			
Sulphate	293 US & 294 DS	Max. Value	100 mg/L		•		AL	X		Min. 12 / Max. 16 / Avg. 14	
> <i>Metals</i>											
Tot. Arsenic (As)	294 DS	Max. Value	5 µg/L		•		AL	X		Results met all established Guidelines levels for maximum and 30-Day Average (5 samples in 30 days) concentrations	
Tot. Boron (B)		Max. Value	1200 µg/L		•			X			
Tot. Cobalt (Co)		Max. Value	110 µg/L		•			X			
		30-day Average	4 µg/L		•			X			
Tot. Copper (Cu)		Max. Value	Hardness		•			X			
		30-day Average	Dependant		•			X			
Tot. Iron (Fe)		Max. Value	1000 µg/L		•			X			
Tot. Lead (Pb)		Max. Value	61 - 82 µg/L		•			X			
		30-day Average	6 µg/L		•			X			
Tot. Manganese (Mn)		Max. Value	1600 µg/L		•			X			
		30-day Average	1000 µg/L		•			X			
Tot. Molybdenum (Mo)		Max. Value	1000 µg/L		•			X			
		30-day Average	2000 µg/L		•			X			
Tot. Selenium (Se)		30-day Average	2 µg/L		•			X			
Tot. Silver (Ag)		Max. Value	0.1 µg/L		•			X			
		30-day Average	0.05 µg/L		•			X			
Tot. Zinc (Zn)		Max. Value	40 µg/L		•			X			
		30-day Average	15 µg/L		•			X			
Diss. Aluminum (Al)		294 DS	Max. Value	100 µg/L		•		AL	X		Results met all established Guidelines levels for maximum and 30-Day Average concentrations
	30-day Average		50 µg/L		•		X				
Diss. Iron (Fe)		Max. Value	350 µg/L		•			X	*	* Maximum guideline value exceeded on one of five sample dates	

¹ Source: *OBJ* = Bessette Cr Water Quality Objectives *BCGL* = Provincial Water Quality Guidelines *CCME* = Federal Water Quality Guidelines

² Most sensitive water use designated for protection : *DW* = Drinking Water (partial treatment), *DW_a* = Drinking Water (aesthetic), *AL* = Aquatic Life

WWTP Sampling Area: Summary/Discussion

- Concentrations of bacteriological indicators are higher downstream of the WWTP than at the upstream site, suggesting inputs from the treatment plant. However; elevated values (i.e., above Objective levels) at the upstream sampling location and at sampling sites throughout the watershed, as well as cattle access to Bessette Creek immediately downstream of the WWTP, indicate that inputs of fecal bacteria are widespread and likely enter the system through various and diffuse sources. Drinking water use without at least partial treatment is not recommended.
- The WWTP is a source of increased sulphate, chloride and ammonia nitrogen, as evidenced by higher downstream concentrations. Values for these parameters, however, remain well below Objective and Guideline levels, and no environmental impacts are expected.
- Although ortho-phosphorus increased significantly downstream of the WWTP discharge, periphyton chlorophyll-*a* results did not indicate excessive algal growth. Indeed, chlorophyll-*a* concentrations were greater at the upstream site. Increases in ortho-phosphorus however, may be problematic and additional monitoring for phosphorus and chlorophyll-*a* further downstream should be considered in the future.
- Results of concurrent sampling by the Village of Lumby upstream and downstream of the WWTP discharge in 2008, were consistent with the data reported here.

Benthic Invertebrate Sampling Results

- Benthic invertebrate community composition provides an indicator of cumulative effects, not only from changes in water quality over time, but also from changes in habitat and hydrologic factors near and upstream of the sampling site. Nine sites were sampled in 2008 for benthic invertebrates (see following slide).
- Stream health or stress level was determined by comparing taxa composition against an Environment Canada reference model for the Columbia/Okanagan (see: <http://ec.gc.ca/rcba-cabin/>)
- Benthic invertebrate samples indicate Duteau and Harris health are unstressed as the streams enter valley bottom. All valley bottom sites however were judged to be potentially stressed. Importantly, no sites were found to be stressed or severely stressed. Moreover, significant differences in key good water quality indicator taxa (Stonefly, Mayfly, and Caddisfly) were not apparent among sites as shown in the table below.

Site Name	Site Number	Stress Level	# Stonefly taxa	# Mayfly taxa	# Caddisfly taxa
Bessette ups Lumby WWTP	293	Potentially	5	4	3
Bessette dns Lumby WWTP	294	Potentially	4	5	2
Bessette at Mabel L Rd Bridge	697	Potentially	4	3	3
Duteau @ Headgates Rd Bridge	148	Unstressed	4	4	4
Duteau @ 100m ups Shuswap	384	Potentially	4	3	1
Duteau at foot Bridge ups Bessette Cr	150	Potentially	4	4	2
Harris @ Horner Rd	151	Unstressed	4	5	5
Harris ups Shuswap Ave Bridge	72	Potentially	5	5	4
Harris dns Bell Pole	219	Potentially	4	4	4

Benthic Invertebrate Sampling Locations



Site 697
Bessette Creek at
Mable L Rd Bridge

Site 294
Bessette Creek Downstream
of Lumby WWTP

Site 293
Bessette Creek Upstream
of Lumby WWTP

Site 150
Duteau Creek at foot bridge
ups Bessette Cr.

Site 384
Duteau Creek 100m
Upstream of Shuswap Ave.

Site 219
Harris Creek Downstream
of Bell Pole

Site 072
Harris Creek
Upstream
Shuswap Ave.

Site 148
Duteau Creek
at Headgate Rd.

Site 151
Harris Creek at
Horner Rd.

Please follow these links for more information

For general information on Water Quality Objectives, refer to:

"Ambient Water Quality Objectives for Bessette Creek - Overview Report"

<http://www.env.gov.bc.ca/wat/wq/objectives/bessette/bessette.html>

For detailed information and water quality data used to develop the Objectives, refer to:

"Shuswap-Mabel Area - Bessette Creek Water Quality Assessment and Objectives: Technical Appendix"

<http://www.env.gov.bc.ca/wat/wq/objectives/bessette/Bessettetech.pdf>

For past Objectives Attainment Results, refer to:

"1996-97 Attainment report Ambient Water Quality Objectives - August 1999"

http://www.env.gov.bc.ca/wat/wq/wq_sediment.html#attain

For Information on Specific Provincial and Federal Water Quality Guidelines, refer to:

BC Water Quality Guidelines (Criteria) Reports

http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html

CCME Canadian Environmental Quality Guidelines

<http://ceqg-rcqe.ccme.ca/>

Questions or Comments

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