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Environmental Protection Division

Ministry of Environment

Okanagan Stream Trend Monitoring Program

Coldstream Creek Summary Report 2009

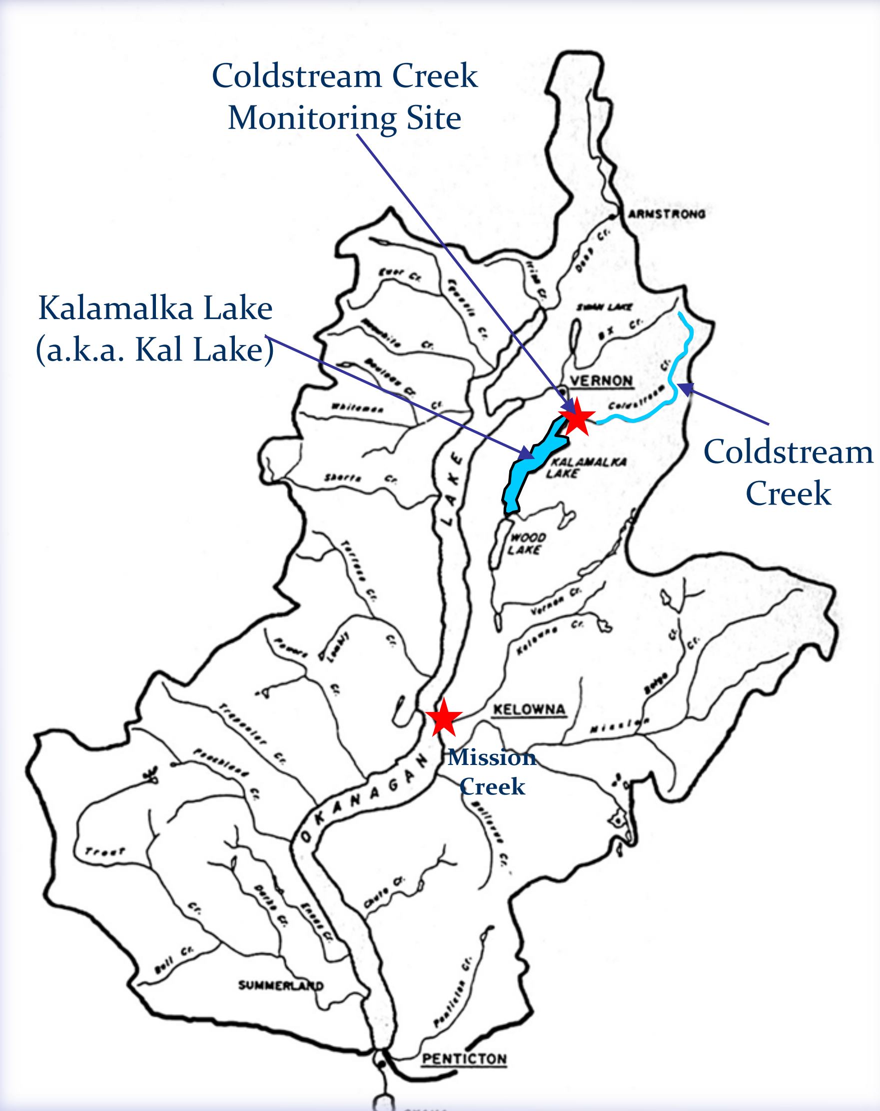
Contents

Purpose of this Report

- To summarize results of microbiological and water chemistry data collected over the course of three decades near the mouth of Coldstream Creek.
- To describe water quality status, long-term trends and seasonal patterns in lower Coldstream Creek for key parameters, including:
  - ✓ Microbiological Indicators
    - Fecal coliforms
    - *E. coli*
    - Enterococci
  - ✓ Nitrate
  - ✓ Chloride
  - ✓ Temperature
- To assess water quality conditions using established *BC Water Quality Guidelines* (http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html).

Summary of Findings

- ✓ Concentrations of microbiological indicators (fecal coliforms, *E. coli* and enterococci) were extremely variable and consistently exceeded Water Quality Guideline levels.
- ✓ Nitrate values displayed a clear seasonal pattern, inversely related to stream discharge. Maximum nitrate concentrations have increased gradually since the 1970's and have begun to reach, and in some cases exceed, guideline levels for the protection of aquatic life.
- ✓ Dissolved chloride concentrations experienced a gradual but steady increase over time, however, values have remained well below recommended Water Quality Guideline levels.
- ✓ Temperatures have followed a predictable and consistent seasonal pattern, and have remained within the acceptable range of guideline values for the protection of aquatic life. Stream temperatures have not indicated an increasing or decreasing trend.



Why We Sample Coldstream Creek

Coldstream Creek was sampled as part the *Okanagan Stream Trend Monitoring Program,* which also includes a sampling site on Mission Creek.

Stream Trend Monitoring results are used to…

- **Describe and understand long-term variations in water quality on a regional scale.**
- **Evaluate cumulative effects of the watershed response to human activity and climate.**
- **Identify long-term trend signals and compare trends to other streams in the Okanagan valley.**
- **Provide timely, high-quality data for other users.**
- **For Coldstream Creek specifically;**
  - **Assess potential impacts to Kal Lake in terms of:**
    - **Bacteria Loading**
    - **Nutrient Loading**
  - **Obtain data that will assist in the development of Water Quality Objectives.**

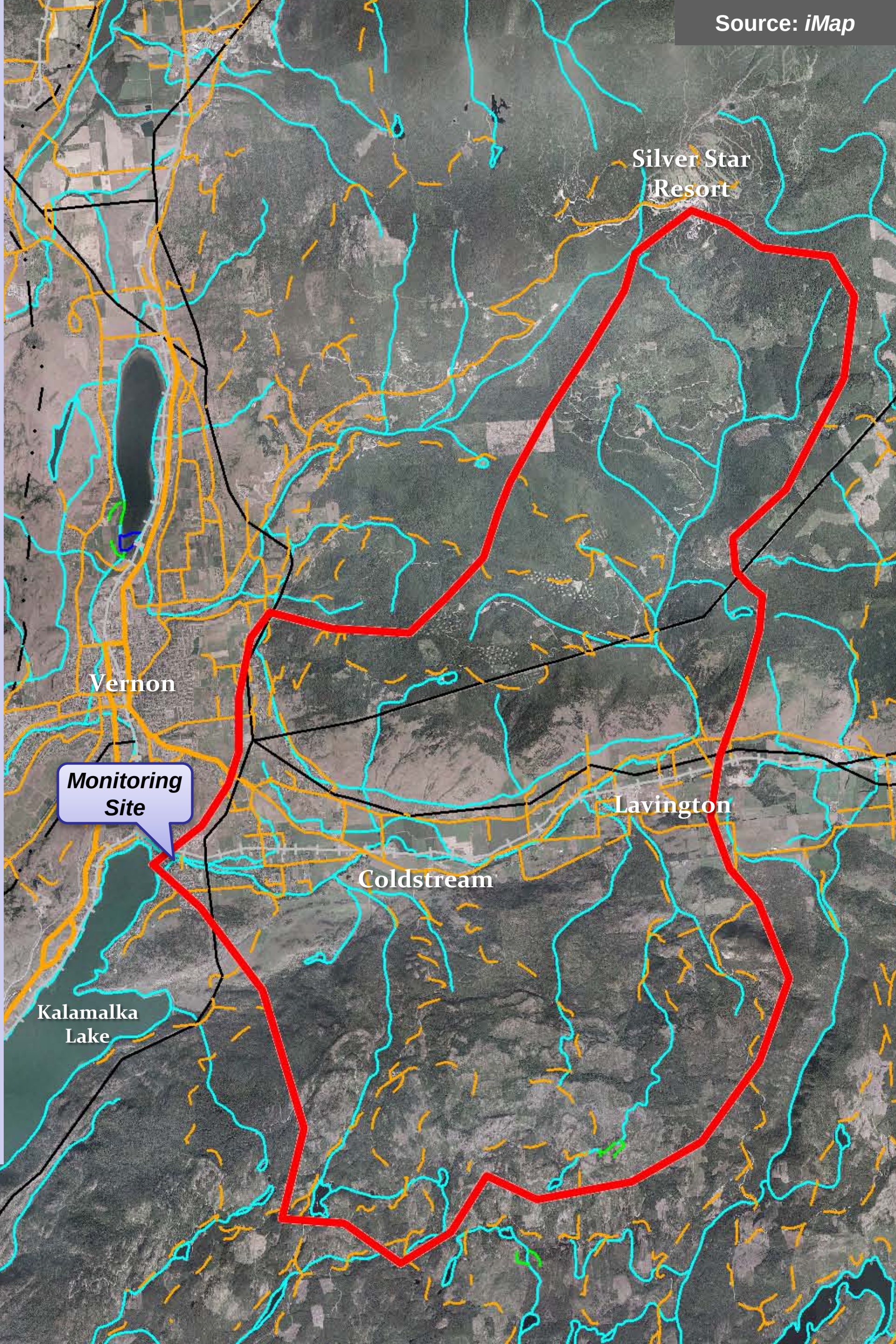
Grab samples being collected from Coldstream Creek for laboratory analysis.

How We Sample

- **Sampling was conducted near the mouth of Coldstream Creek in order to capture cumulative effects of land use activities within the watershed, over time.**
- **Data were collected by Ministry of Environment staff, following established sampling protocols:**
  - **Grab samples – sent for laboratory analysis**
  - **Standard field measurements**
- **Sampling was conducted on a monthly basis throughout the year, and weekly (over 5 weeks) during spring freshet (early- to mid-May).**
- **Data are stored in the Provincial *Environmental Monitoring System* (EMS) database. EMS data is available to the public and local governments, upon request.**

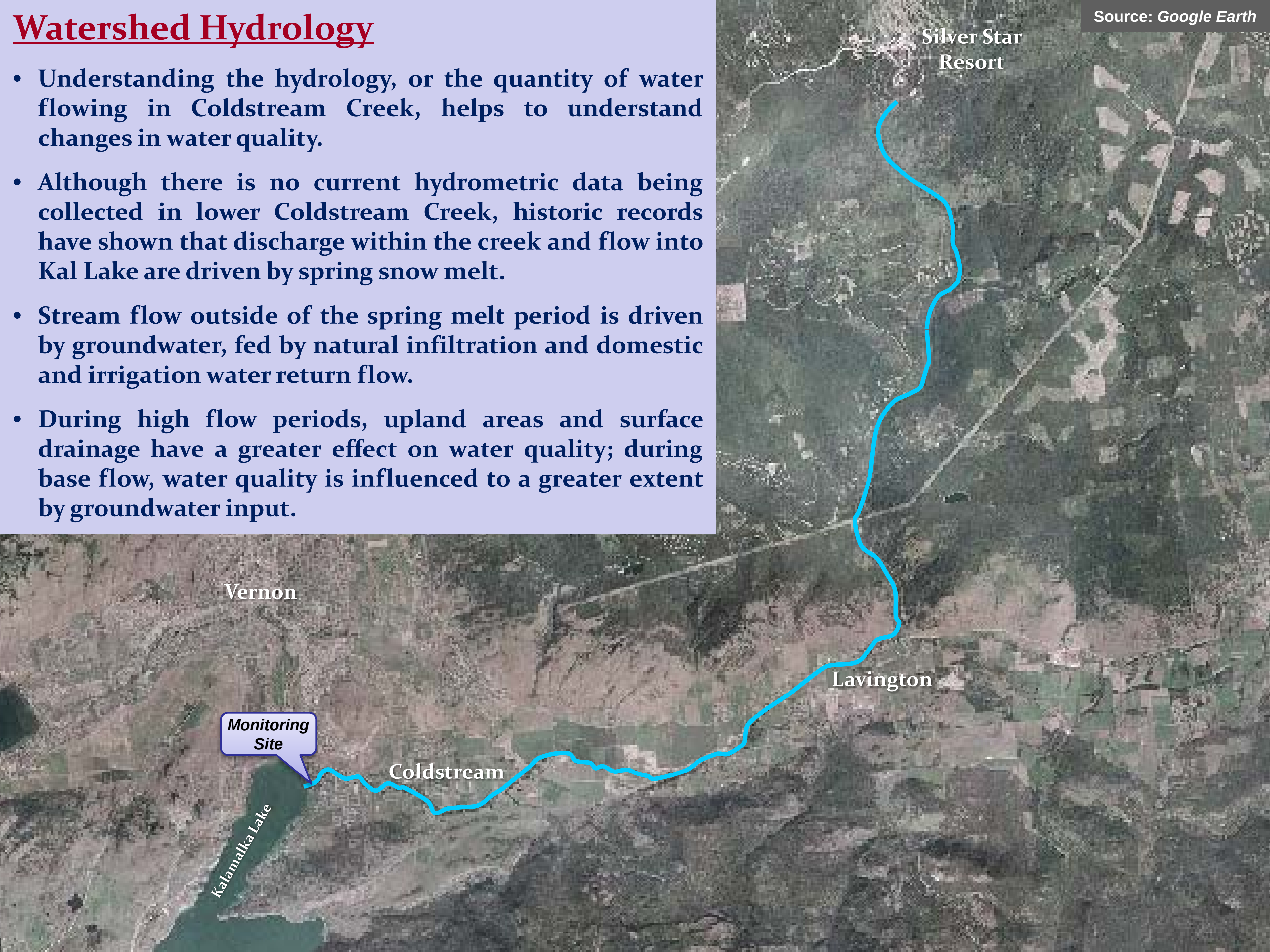
The Coldstream Creek Watershed

- Mainstem length: Approximately 30 km
- Gross drainage area: 207 km^2.
- Coldstream Creek flows south from its higher-elevation, higher-gradient headwaters (near Silver Star Resort) towards the town of Lavington, then west through the low gradient valley bottom (roughly parallel to Highway 6), until it empties into the north end of Kalamalka Lake, near Vernon.
- The Watershed provides a source of community drinking water and an irrigation supply. The Creek provides important habitat for aquatic life, including kokanee spawning within the lower 6 km.
- Coldstream Creek is the main source of inflow to Kalamalka Lake (roughly 80% of the total input).
- Land use within the watershed includes forestry and recreation (primarily in the upper watershed), along with agriculture and urban development along the valley bottom.
- Kal Beach, at the north end of Kalamalka Lake near the mouth of Coldstream Creek, is a popular recreation area during the summer.

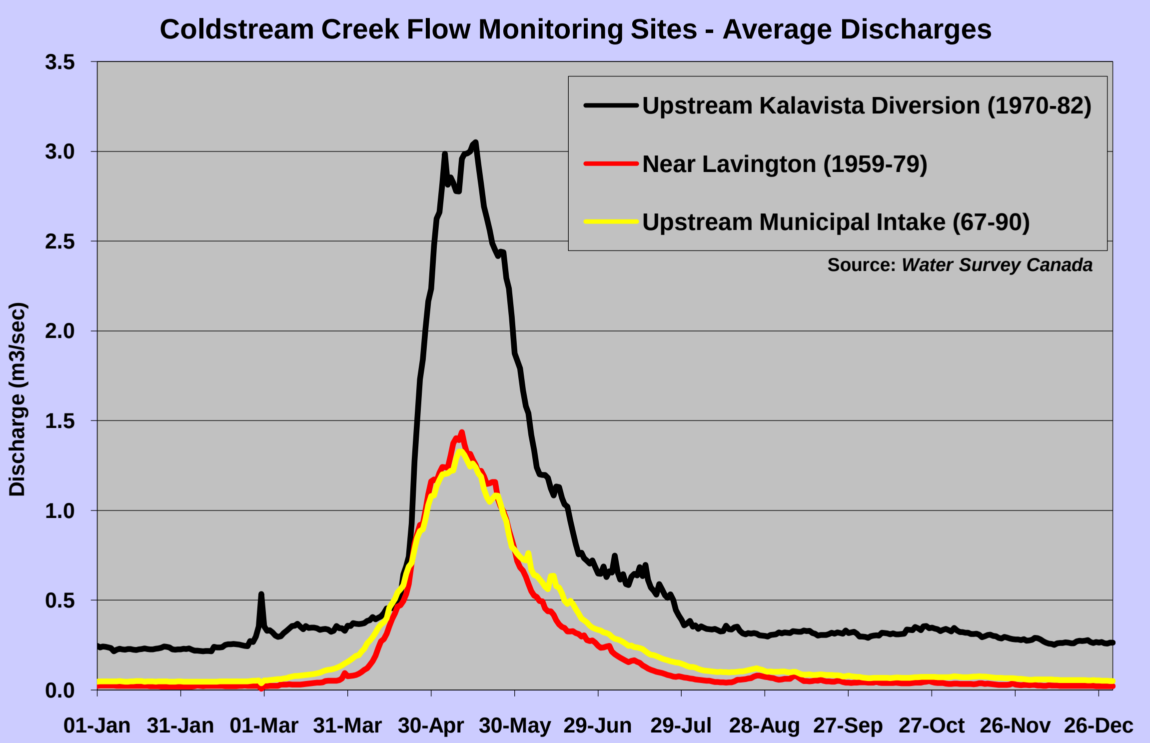


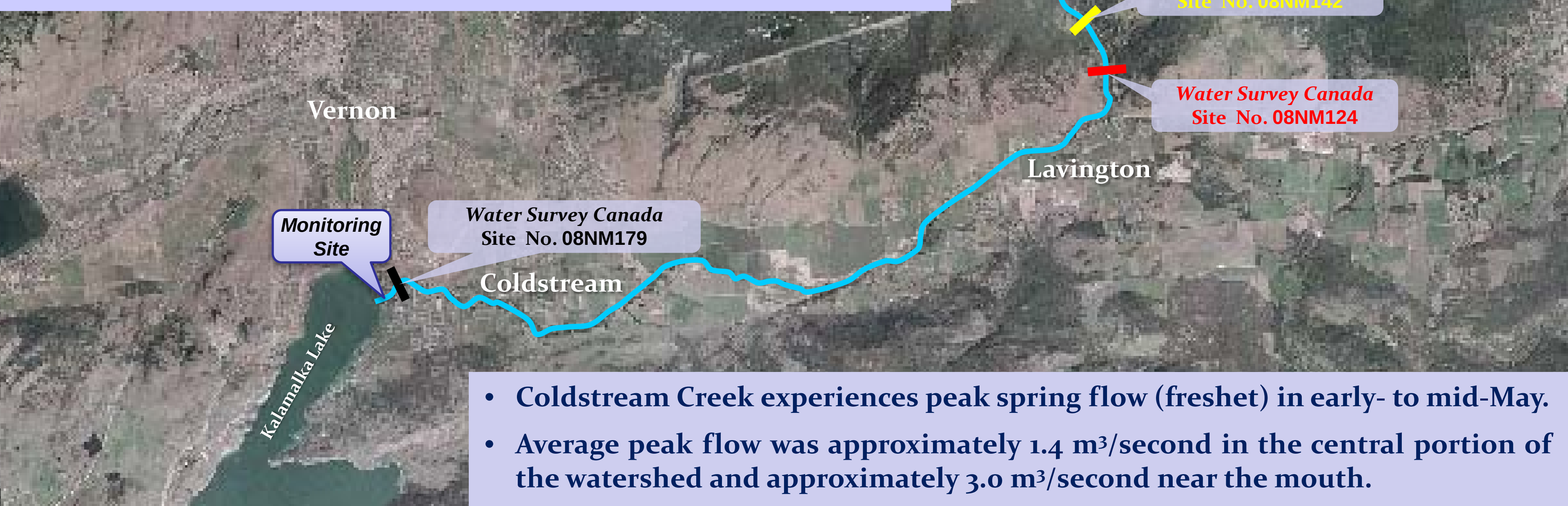
Watershed Hydrology

- Understanding the hydrology, or the quantity of water flowing in Coldstream Creek, helps to understand changes in water quality.
- Although there is no current hydrometric data being collected in lower Coldstream Creek, historic records have shown that discharge within the creek and flow into Kal Lake are driven by spring snow melt.
- Stream flow outside of the spring melt period is driven by groundwater, fed by natural infiltration and domestic and irrigation water return flow.
- During high flow periods, upland areas and surface drainage have a greater effect on water quality; during base flow, water quality is influenced to a greater extent by groundwater input.



Watershed Hydrology

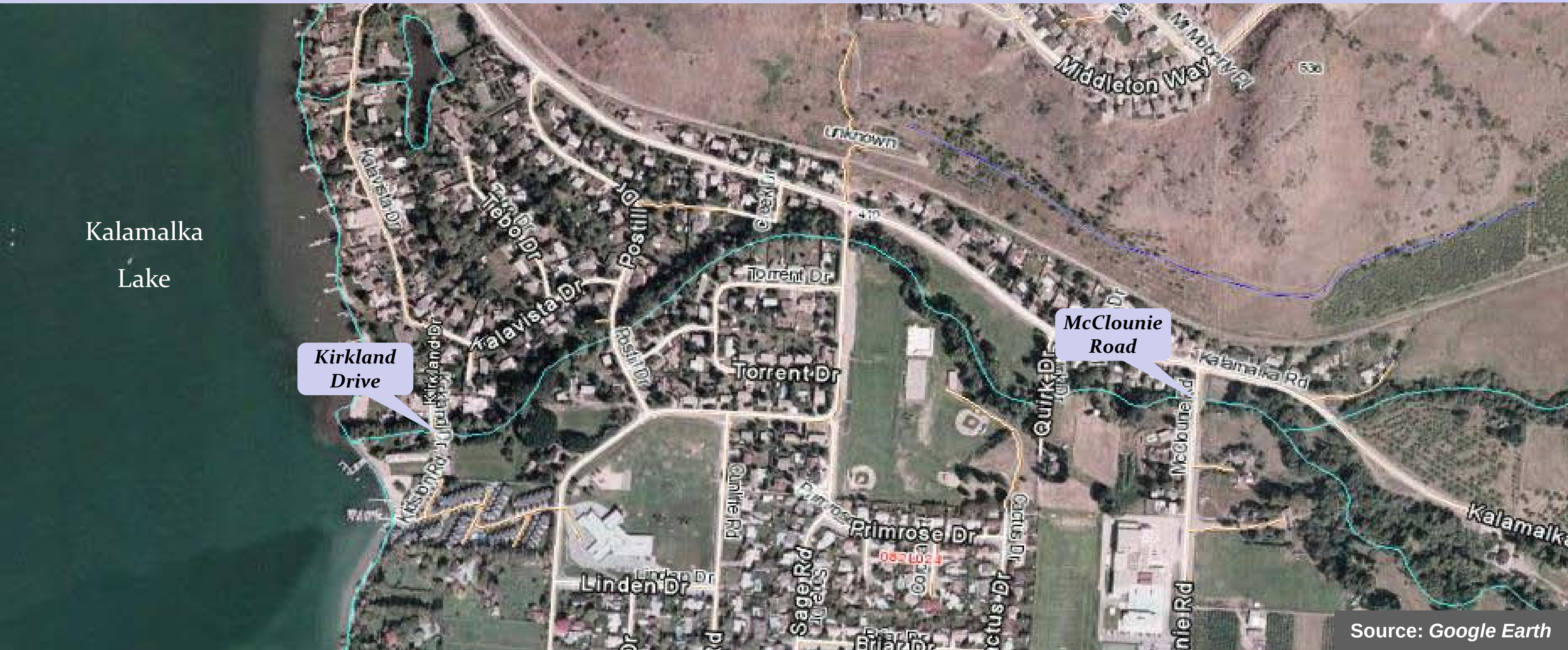




- Coldstream Creek experiences peak spring flow (freshet) in early- to mid-May.
- Average peak flow was approximately 1.4 m³/second in the central portion of the watershed and approximately 3.0 m³/second near the mouth.

How we Compile and Assess Data

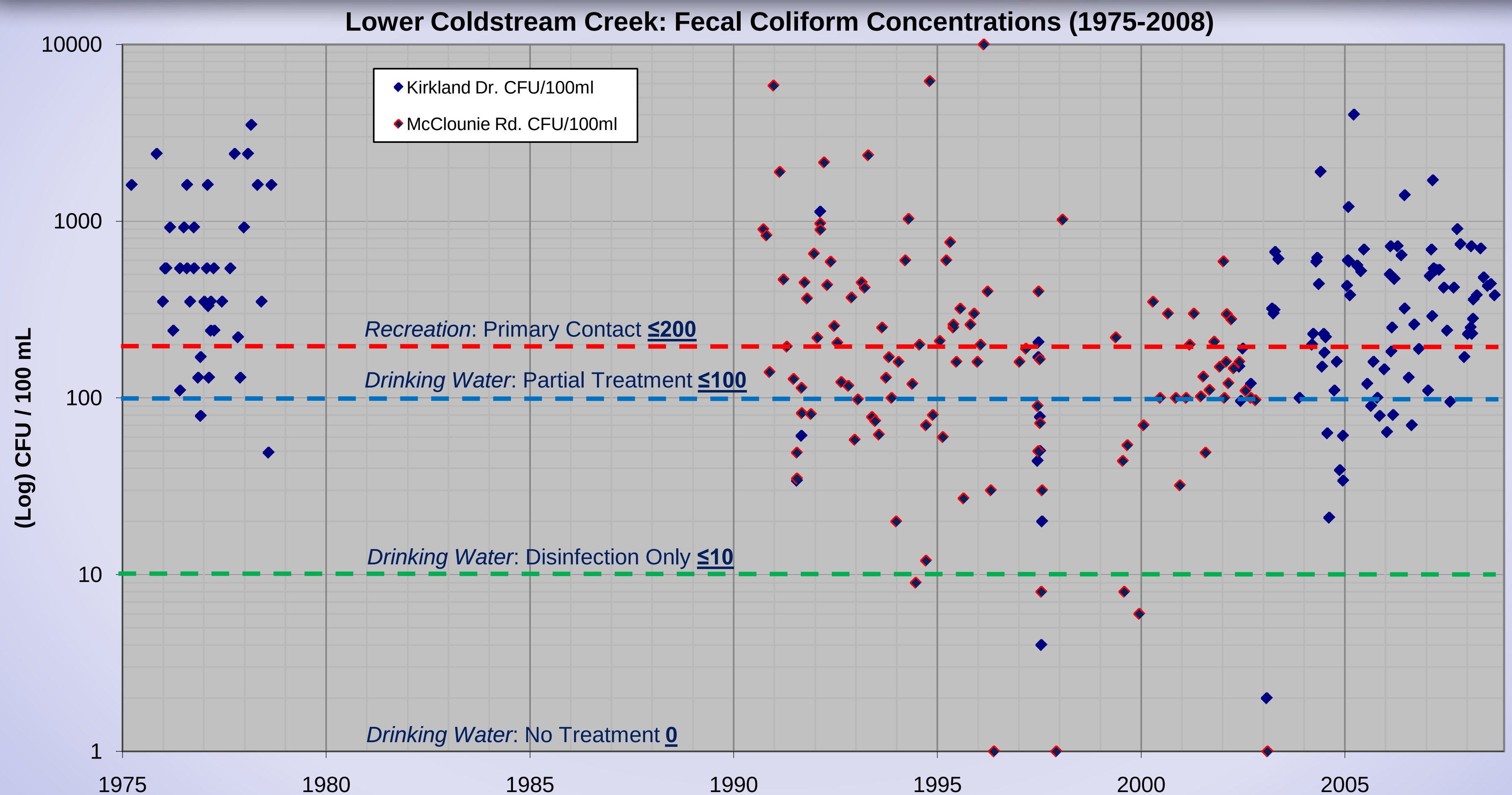
- The *Stream Trend Monitoring Program* began in 2002, however, data for Coldstream Creek dates back to the early 1970's.
- The current site at Kirkland Drive has a long but fragmented data collection history: 1972 to 1978, and 2003 to present.
- Data collected at McClounie Road (roughly 1.25 km upstream of Kirkland Drive), have also been included (when available), in order to provide a more complete data set.
- In the following slides, the importance of microbiological indicators, nitrate, chloride and water temperature, as water quality indicators, are described and relevant Water Quality Guidelines presented.
- Slides 31 to 35 provide summary statistics for additional parameters routinely collected.



Microbiological Indicators

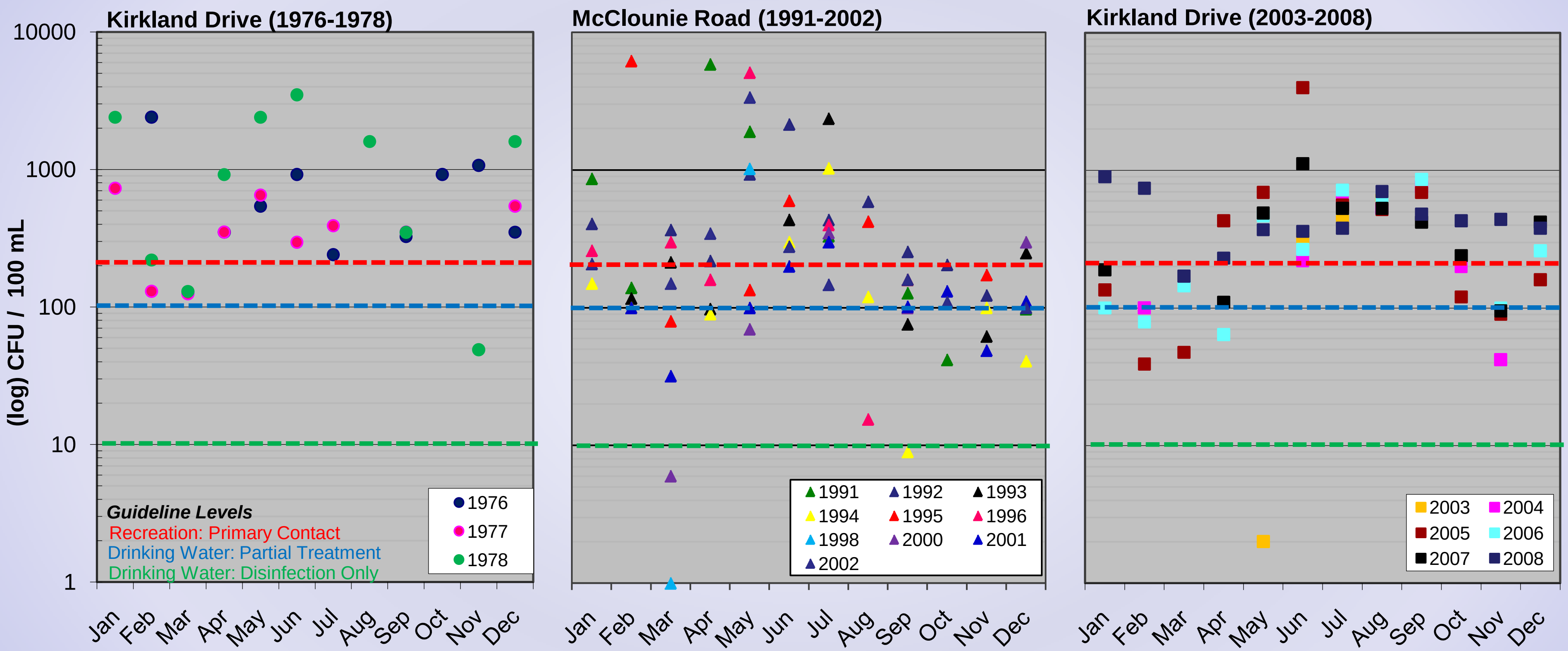
- These parameters are monitored as *indicators of the risk of disease*.
- Fecal coliform bacteria have been monitored in Coldstream Creek since the mid-70's. Monitoring for *Escherichia coli* (*E. coli*) and enterococci began in 1997 and 2005, respectively.
- *E. coli* and enterococci, correlate more closely with the incidence of disease than do fecal coliforms (historically used as the primary indicator of contamination).
- Common Sources: wild and domestic animal feces, as well as seepage from septic systems. These bacteria often enter surface waters via *non-point sources*.
- Provincial Guidelines for *Drinking Water* and *Recreational Use* are shown below. [1]

Water Use	Level of Treatment/Contact	Guideline (CFU/100 mL)			Calculation
		Fecal Coliforms	*E. coli*	Enterococci	
Raw Drinking Water	None	0	0	0	Absolute value
	Disinfection only	≤ 10	≤ 10	≤ 3	90th percentile
	Partial	≤ 100	≤ 100	≤ 25	
	Complete	N/A	N/A	N/A	N/A
Recreation	Primary Contact	≤ 200	≤ 77	≤ 20	Geometric mean

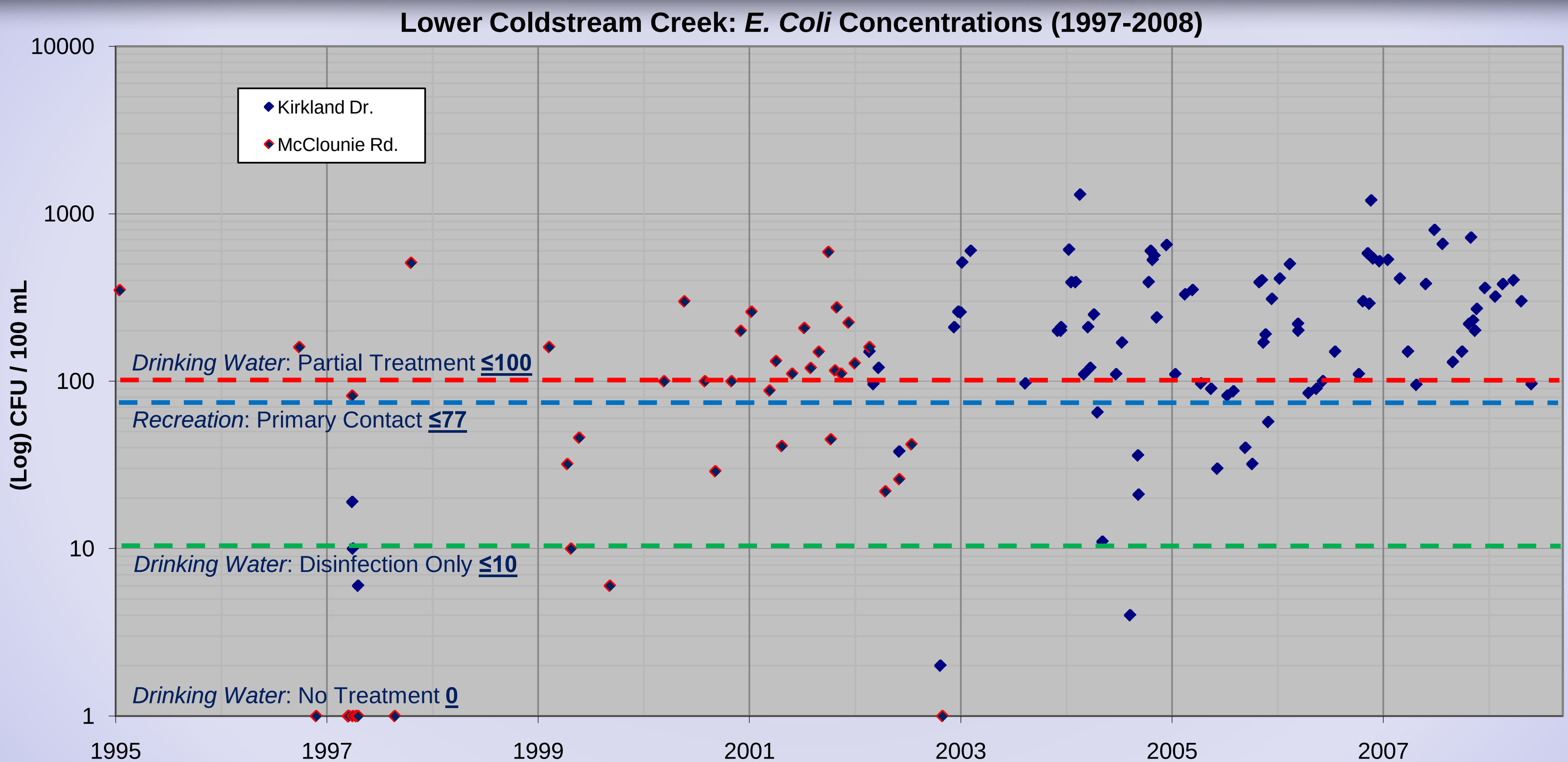


Fecal coliform values over time suggested a slight decreasing trend during the 90's, however, a shift to an increasing trend appears to have begun in 1999. Concentrations were extremely variable and consistently well above guideline levels for designated water uses.

Lower Coldstream Creek Average Monthly Fecal Coliform Concentrations

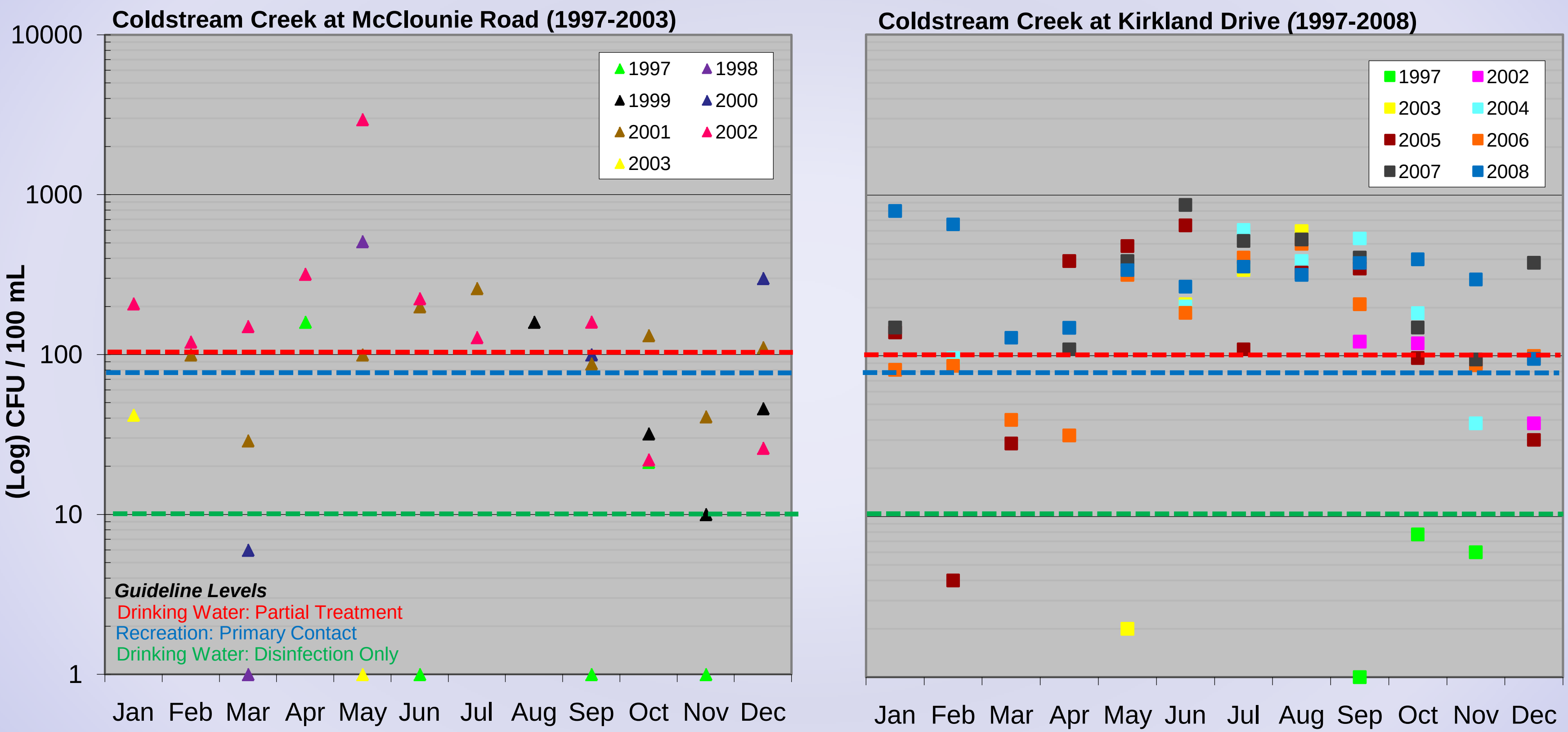


Average monthly concentrations in the 70's were extremely variable and did not exhibit a clear seasonal pattern. Values through the 90's (although still variable) began to indicate a pattern, peaking around freshet then decreasing through the summer. Between 2003 and 2008, values became somewhat less variable and a clear seasonal pattern emerged. Values increased gradually through the spring, and typically reached their highest concentrations during the summer. Unlike in the 90's, however, 2003-08 values tended to remain higher through the summer and fall.

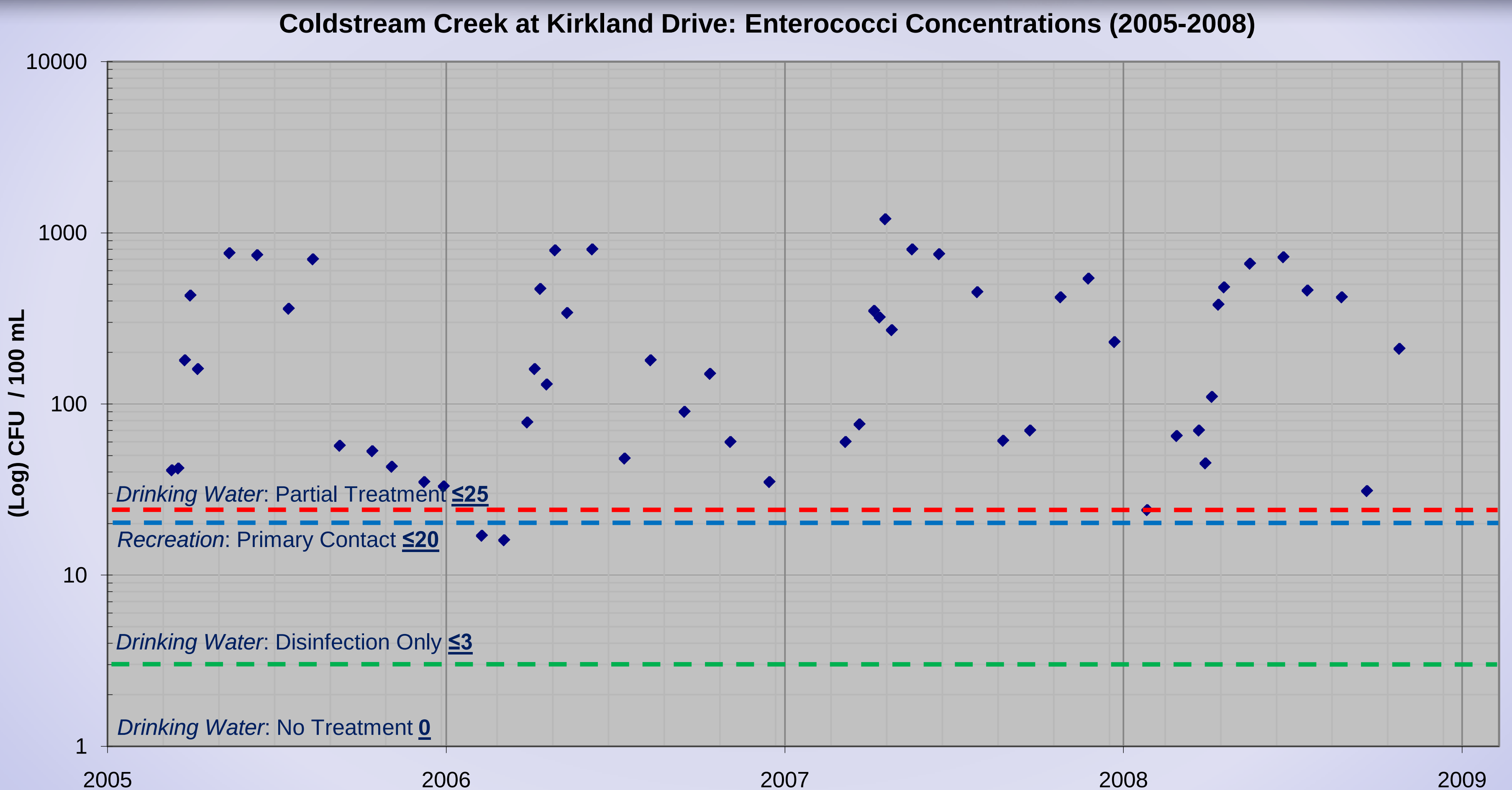


Since the late 90's, *E. coli* concentrations have been extremely variable, and suggest a gradual increasing trend. Results have been consistently above guideline levels. In 2007 and 2008 only 2 of 28 *E. coli* results were below 100 CFU/100 ml (the most liberal guideline set for drinking water receiving partial treatment).

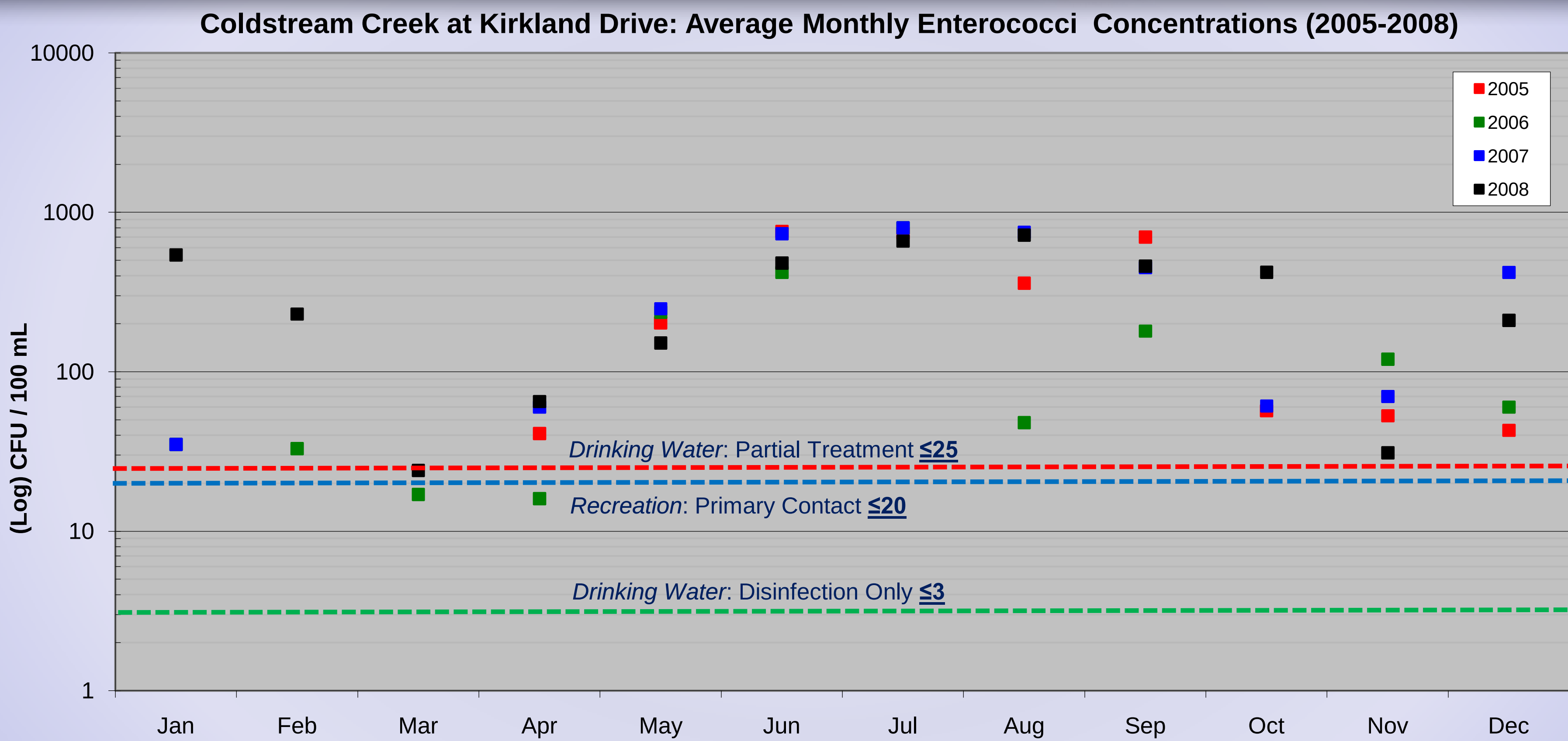
Lower Coldstream Creek Average Monthly *E. coli* Concentrations



As with fecal coliforms, *E coli* concentrations increased during freshet period and remained elevated through the summer (concentrated under low flows), decreased in the fall and remained relatively low over winter. *E coli* concentrations during the years 2004-2008 appeared to remain high for an extended period of time after freshet. Similarities in concentration, trends and seasonal patterns, suggest that *E. coli* represents the dominant type of fecal coliform bacteria in Coldstream Creek.



Concentrations of enterococci have shown no increasing or decreasing trend from 2005 to present. However, concentrations have been extremely variable, and consistently well above guideline values. Enterococci values were not monitored at the McClounie Road site.

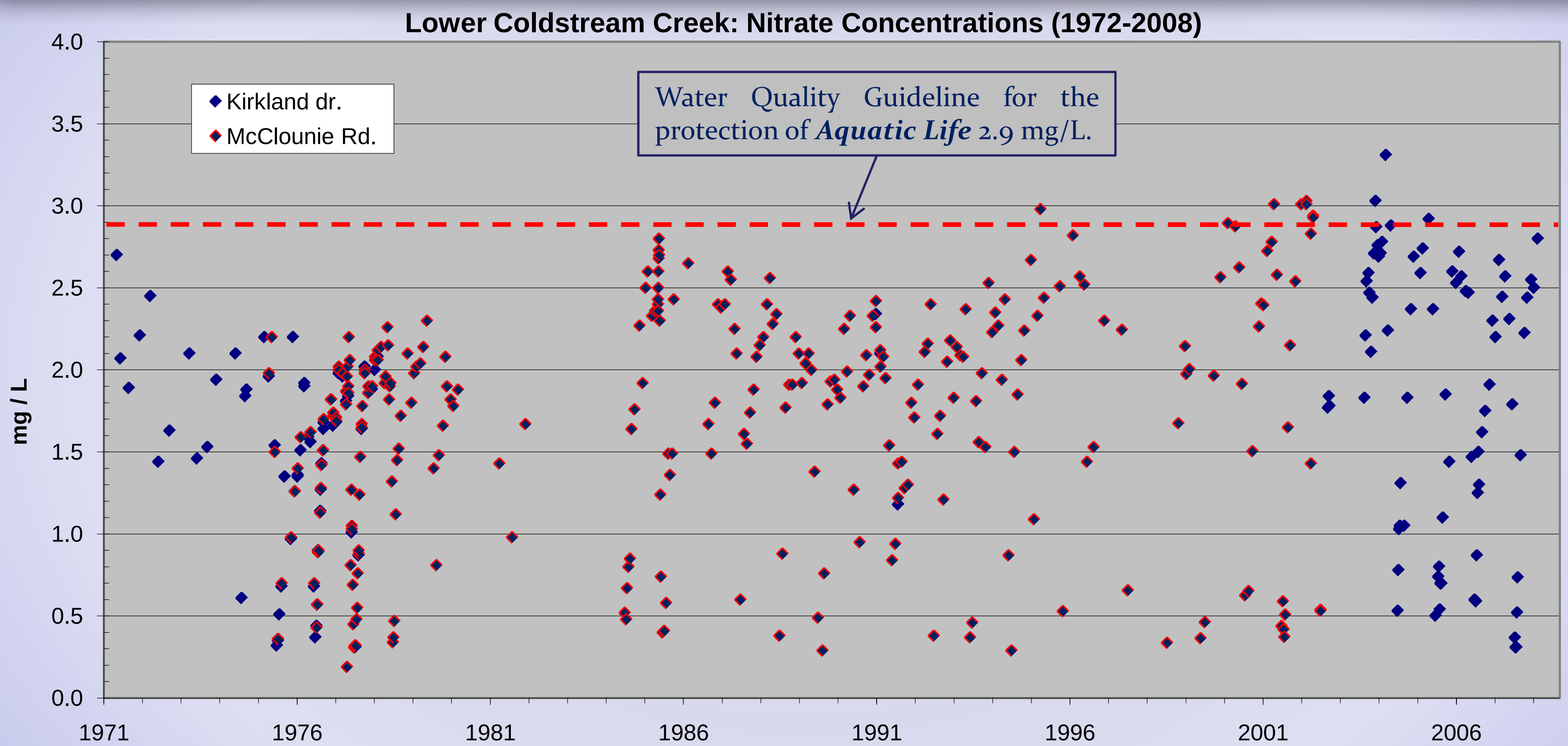


Monthly average enterococci values indicated a more pronounced seasonal pattern than the other bacterial indicators. An abrupt and consistent increase occurred from April to June (spring freshet period). Values remained high during the summer and decreased gradually through the fall. Results indicate that inputs of fecal coliforms, *E. coli*, and enterococci into Kal Lake from Coldstream Creek are at their highest during the summer months; this coincides with the period of prime recreation activity in Kal Lake.

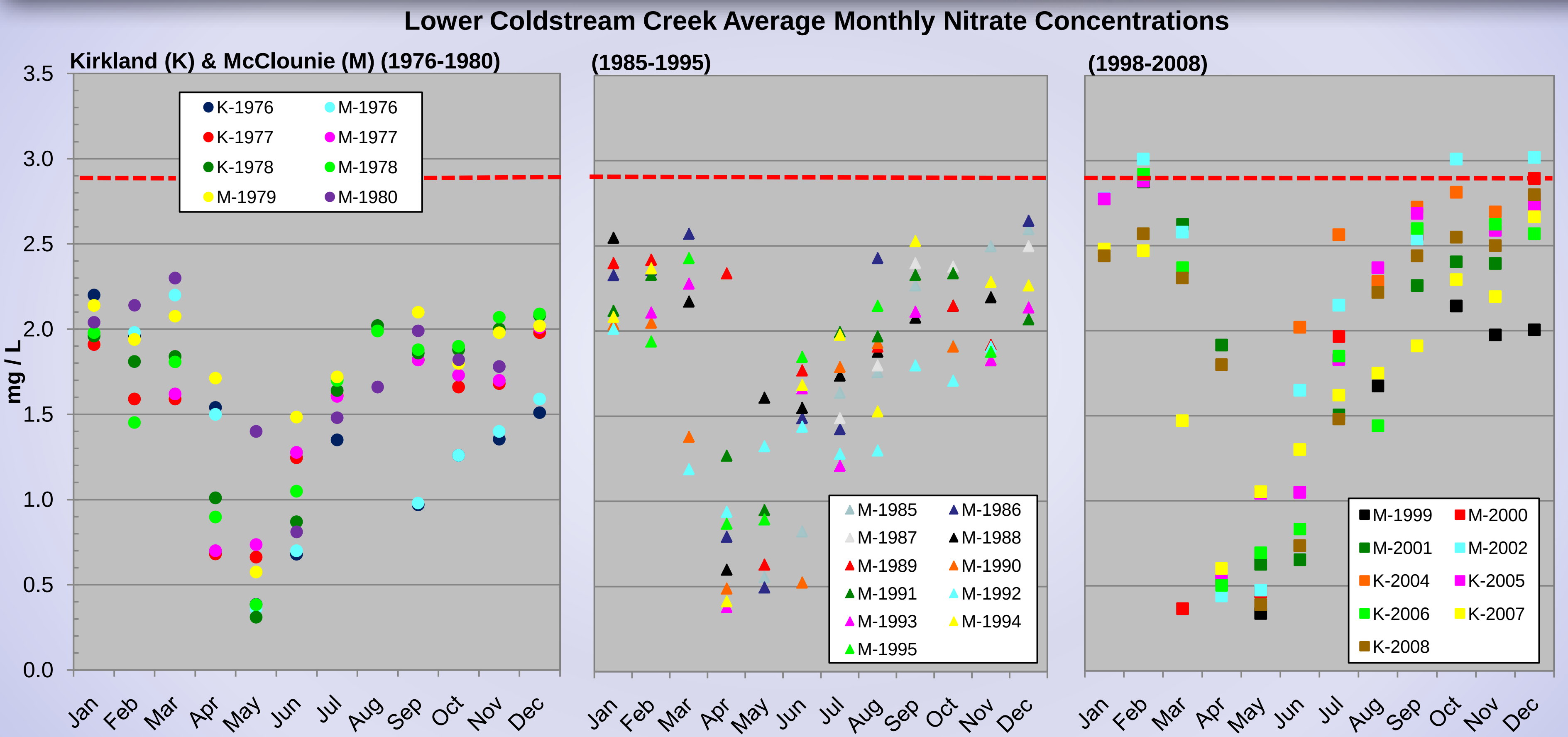
Nitrate

- A drinking water guideline for nitrate (NO3) of 10 mg/L has been established to protect children under 6 months of age (and particularly under the age of 3 months) from infantile methemoglobinemia, which reduces the blood's oxygen carrying capacity and may result in death from a lack of oxygen.
- Elevated concentrations (>23 mg/L) can result in a bitter tasting drinking water, and may cause physiological distress (diarrhea and diuresis). However, nitrate is rarely found in surface waters in concentrations above 10 mg/L.
- Common Sources: Sewage treatment plants, septic tanks, agricultural runoff from manure or fertilized fields and mining activities. Nitrate may also enter streams via the introduction of groundwater, which is more likely to contain high NO_3 concentrations.
- Water Quality Guidelines for nitrate are as follows: [2]
  - Drinking Water: <u>10 mg/L</u> (Maximum)
  - Aquatic Life (Fresh Water): <u>2.9 mg/L</u> (Maximum) (CCME Guideline: Updated 2003) [3]
  - Recreation: <u>10 mg/L</u> (Maximum)
  - Livestock Watering: <u>10 mg/L</u> (Maximum)
  - Irrigation: <u>10 mg/L</u> (Maximum)

<u>Note</u>: In the following slides, some nitrate + nitrite (NO3+NO2) values have been used as a surrogate for nitrate: nitrite comprises only of very small portion of the combined total, and drinking water guidelines for NO_2+NO_3 are the same as for nitrate.



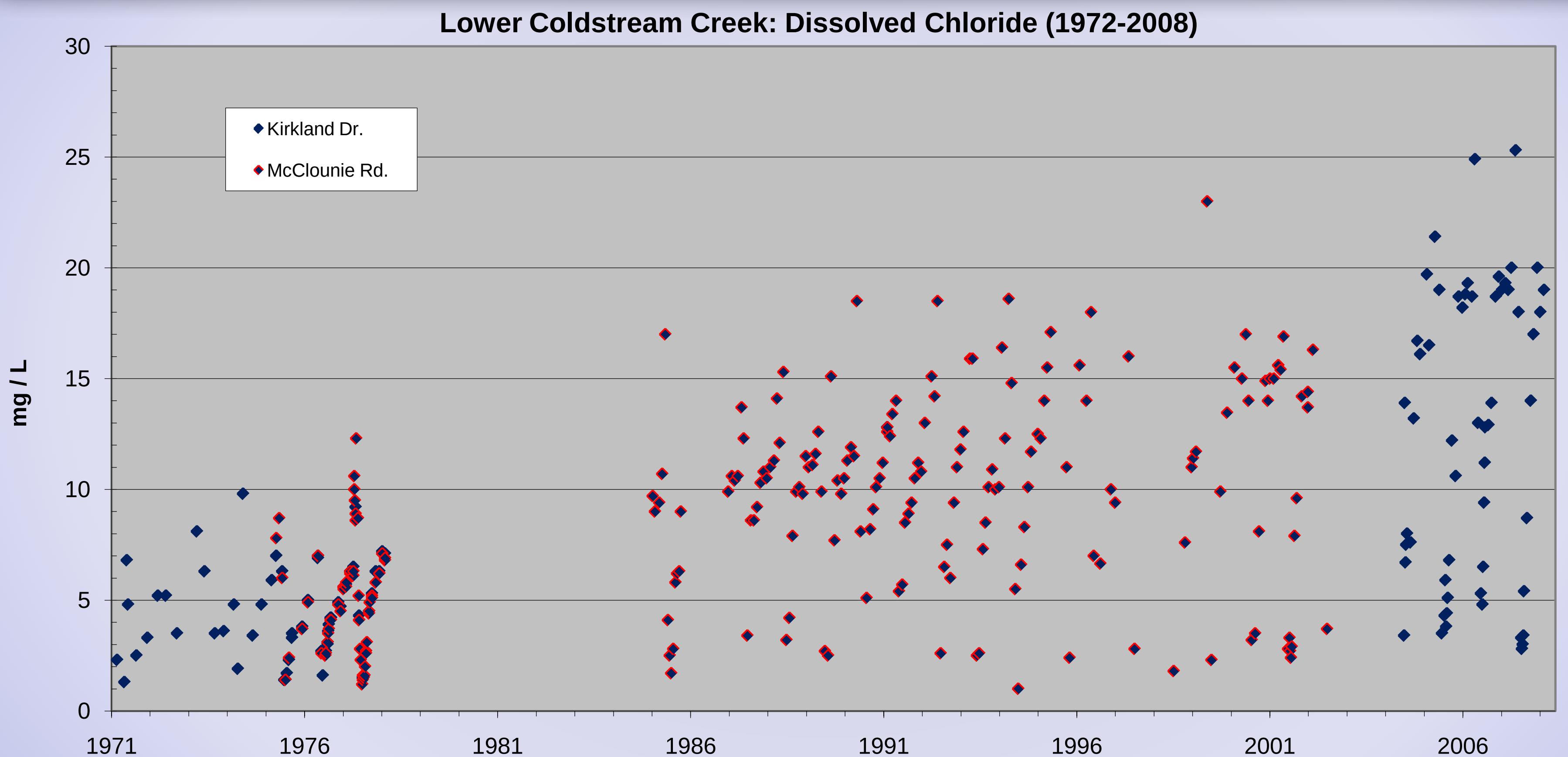
Maximum nitrate concentrations have gradually increased over time. In the 70's maximum values were in the range of 1.5 to 2.5 mg/L, while maximum values in recent years have increased to a range of 2.5 to over 3.0 mg/L. Between 1972 and 1978, none of the nitrate values recorded were greater than 2.9 mg/L, compared to 1% of value from 1985 to 1997, and 8% from 1998 to 2008: Nitrate levels have begun to reach, and in some cases exceed, guideline levels for the protection of aquatic life.



Monthly average nitrate values indicated a consistent and well defined seasonal pattern, inversely related to stream discharge. When we compare values over three time periods, we see that seasonal lows have remained fairly constant, while seasonal increases have been more pronounced and values have continued to rise through the fall and winter months (rather than leveling off during the period of August through February, as was common in the 1970's).

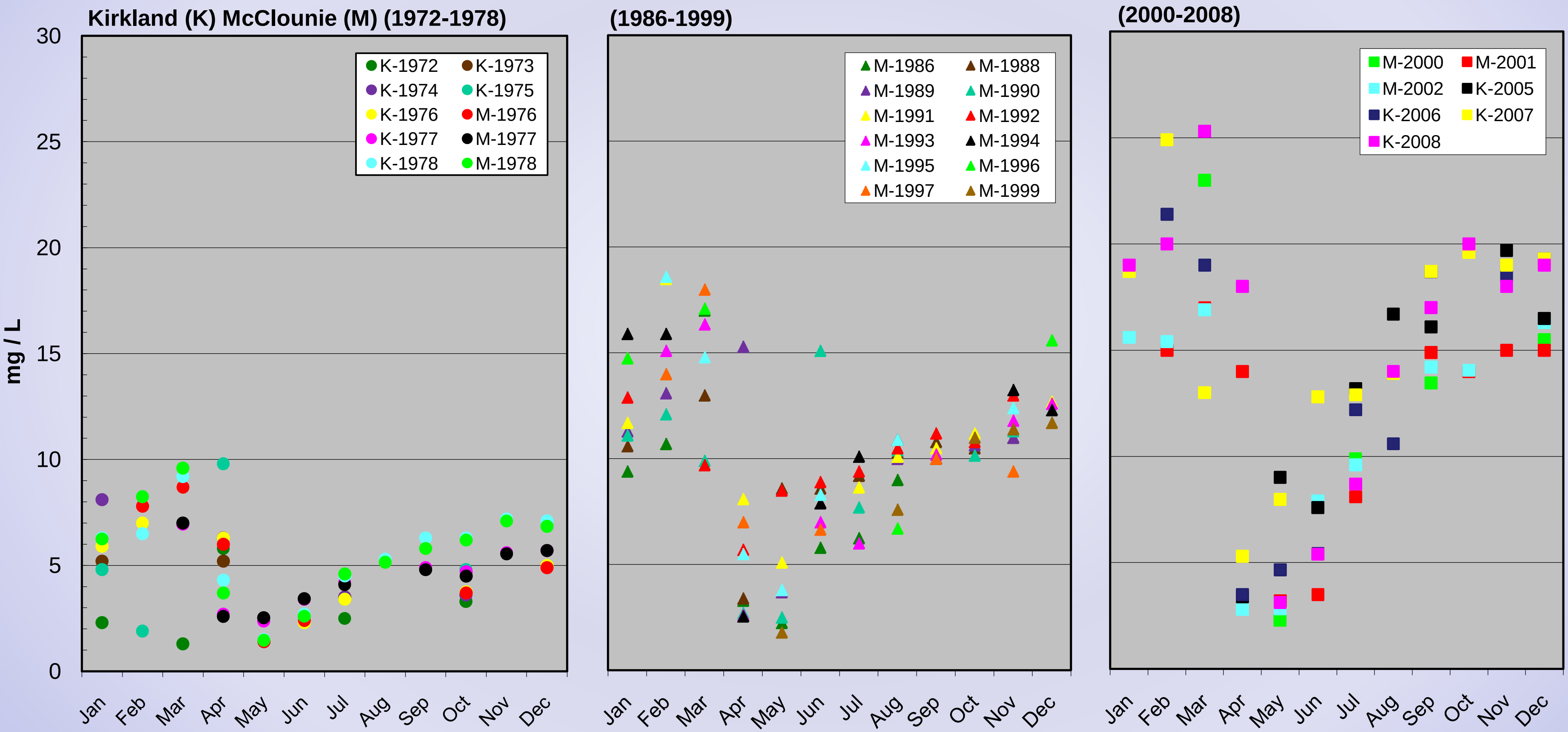
Chloride

- Chloride is an essential element for aquatic and terrestrial organisms, playing an important role in several physiological processes (renal function, neurophysiology, maintaining water balance).
- Elevated or fluctuating chloride concentrations in aquatic environments can be detrimental to resident organisms, leading to impaired survival, growth and reproduction.
- Common Sources: Road salt (most often in the form of sodium chloride), sewage, dissolution of natural salt deposits, irrigation drainage and industrial effluent.
- Because chloride ions tend to remain in solution once dissolved, and are not degraded in the environment, chloride serves as a useful indicator of human influences on water quality.
- Water Quality Guidelines for chloride are as follows: [4]
  - Drinking Water: 250 mg/L (Maximum)
  - Aquatic Life (Fresh Water): 600 mg/L (Instantaneous Maximum)
    150 mg/L (30-day Average)
  - Livestock Watering/Wildlife: 600 mg/L (Maximum)
  - Irrigation: 100 mg/L (Maximum)
  - Recreation: N/A



Dissolved chloride concentrations have remained well below guideline levels, however, concentrations have shown a gradual but steady increase since the 70's. Between 1972 and 1978, only 2% of chloride values were over 10 mg/L, while during the periods of 1985 to 1999, and 2000 to 2008, these percentages increased to 55% and 60%, respectively. **Note**: The 10 mg/L mark is used as an arbitrary reference point only.

Lower Coldstream Creek: Average Monthly Chloride Concentrations

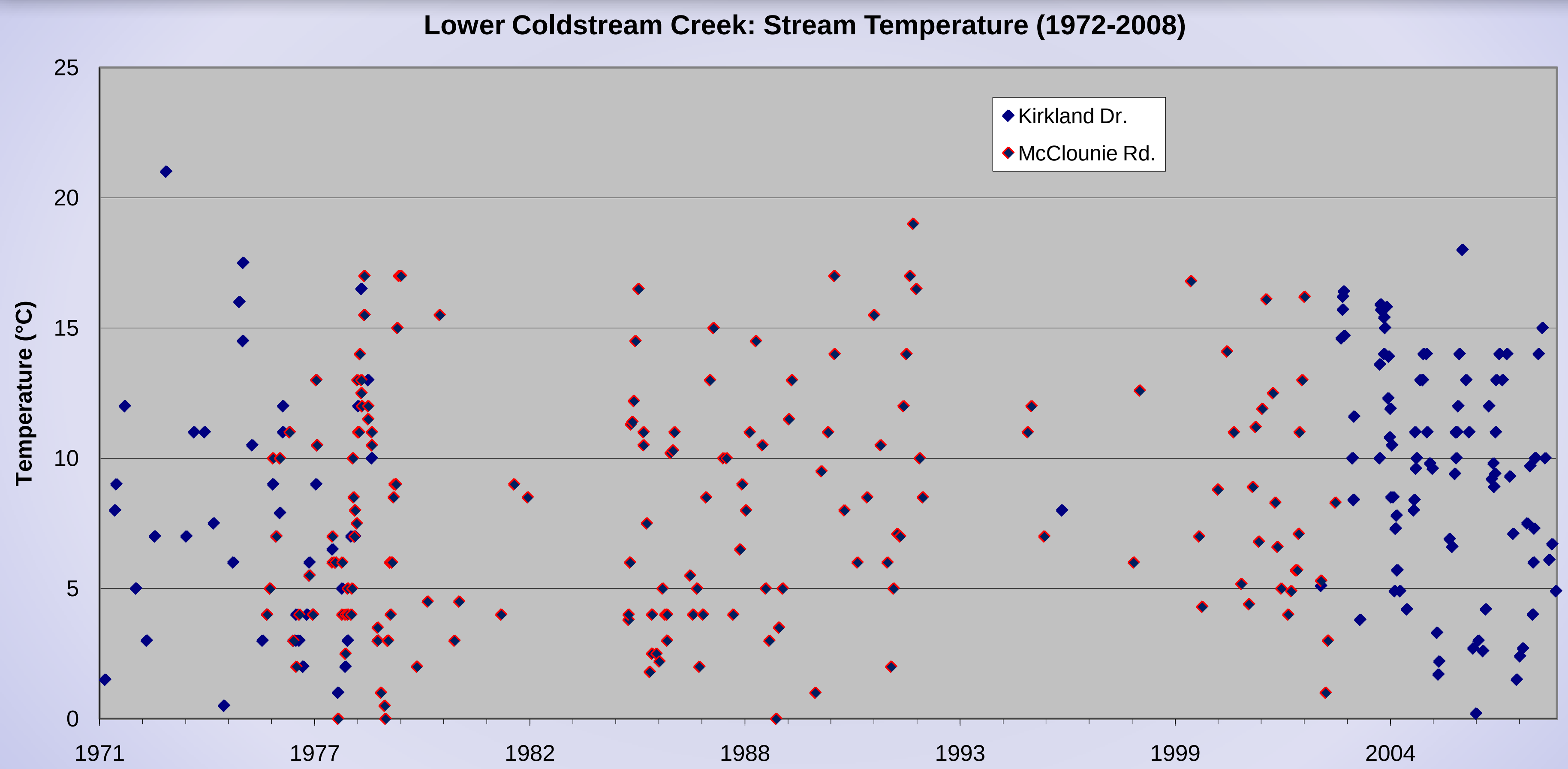


Dissolved chloride concentrations exhibited a clear seasonal pattern. Values decreased as flows increased during freshet, then increased gradually throughout the remainder of the year. Seasonal increases, however, have been far more pronounced in recent years. Increases in chloride concentrations coincide with similar increases in specific conductance (See slide #35). Although many elements can increase the specific conductance of water, chloride is likely a contributing factor.

Stream Temperature

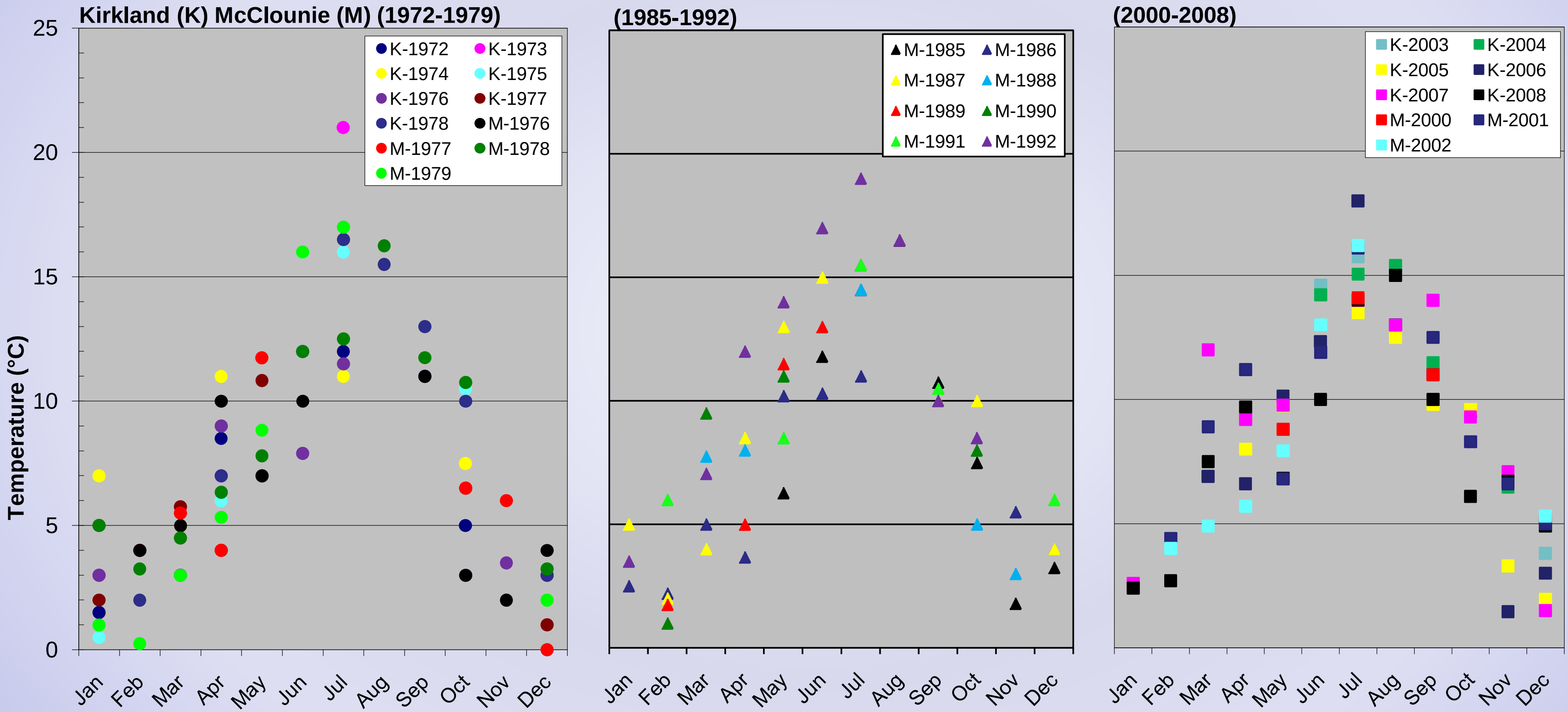
- Temperature is one of the most variable parameters in a stream, often varying by several degrees within a few hours and over very short distances.
- Ambient air temperature and solar radiation have a direct influence on stream temperature. Clearing of riparian vegetation is one of the most common, and easily avoidable, causes of increased water temperatures in streams.
- Water temperature governs solubility of oxygen in water, and influences the growth rates of aquatic organisms.
- Aquatic organisms are sensitive (to varying degrees) to changes in water temperature.
- For salmonid bearing streams guidelines have been set at ±1°C of change beyond the optimum range for each life history stage of the most sensitive species present (i.e., kokanee in Coldstream Creek). [5]

Species	Optimum Temperature Range (°C) by Life History Stage		
	Migration	Spawning	Incubation
kokanee	7.2 – 15.6	10.6 – 12.8	4.0 – 13.0



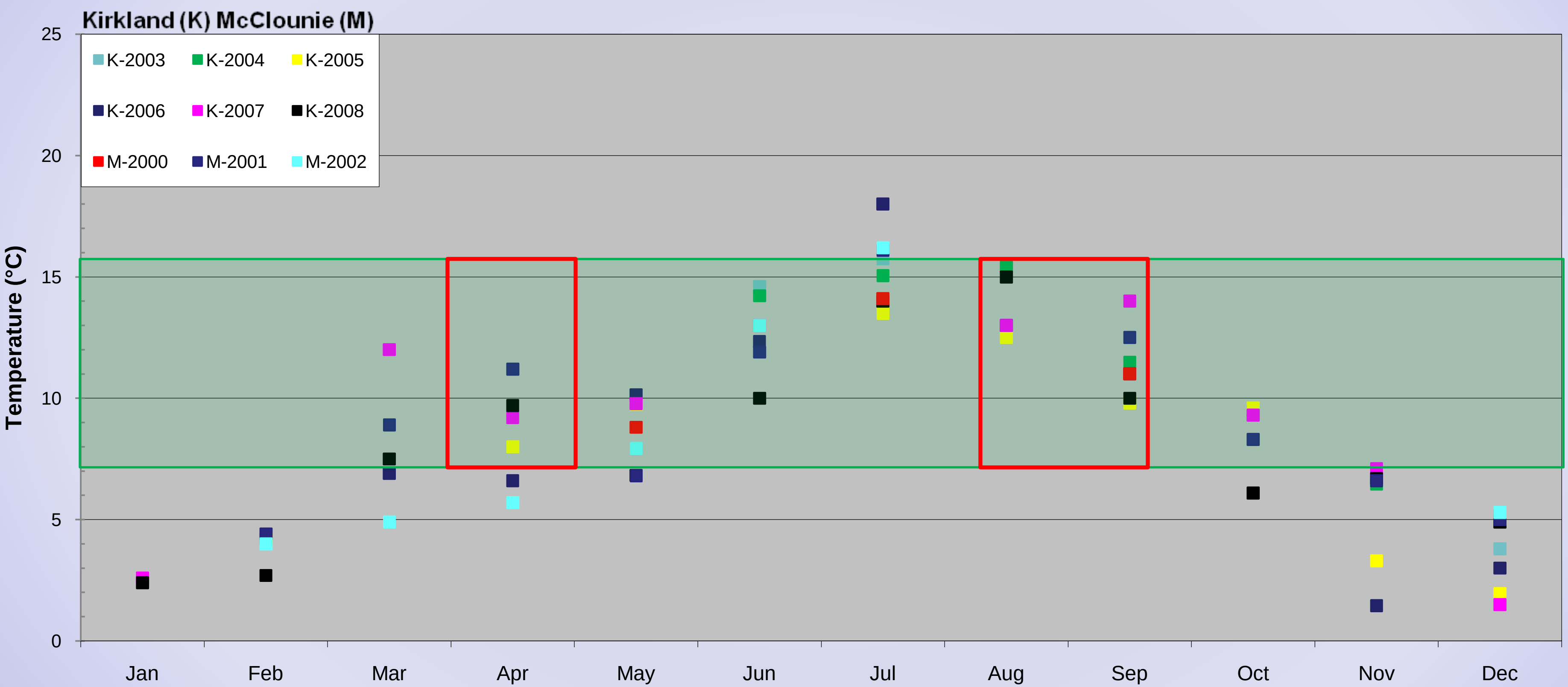
The single monthly temperature readings, collected as part of our sampling program, are not sufficient to draw meaningful conclusions regarding long-term temperature changes. This being said, no discernable trend could be observed from stream temperature data collected on Coldstream Creek between 1972 and 2008.

Lower Coldstream Creek: Average Monthly Stream Temperature



Average monthly stream temperatures demonstrated typical seasonal variation. Peak temperatures were normally recorded between June and August, and ranged from the mid-teens to low-twenties. Unlike certain other parameters, no appreciable difference in seasonal temperature patterns was observed over the three decades of monitoring.

Lower Coldstream Creek: Average Monthly Stream Temperature (2002-2008)



- Optimal temperature range for kokanee migration: 7.2 - 15.6 °C (±1)
- Adult migration period in Coldstream Creek: mid-August through September
- Juvenile outmigration period in Coldstream Creek: April
- Temperatures have typically remained within the optimal range; the exception being during the spring outmigration period when temperatures have been as much as 3.6 °C cooler.

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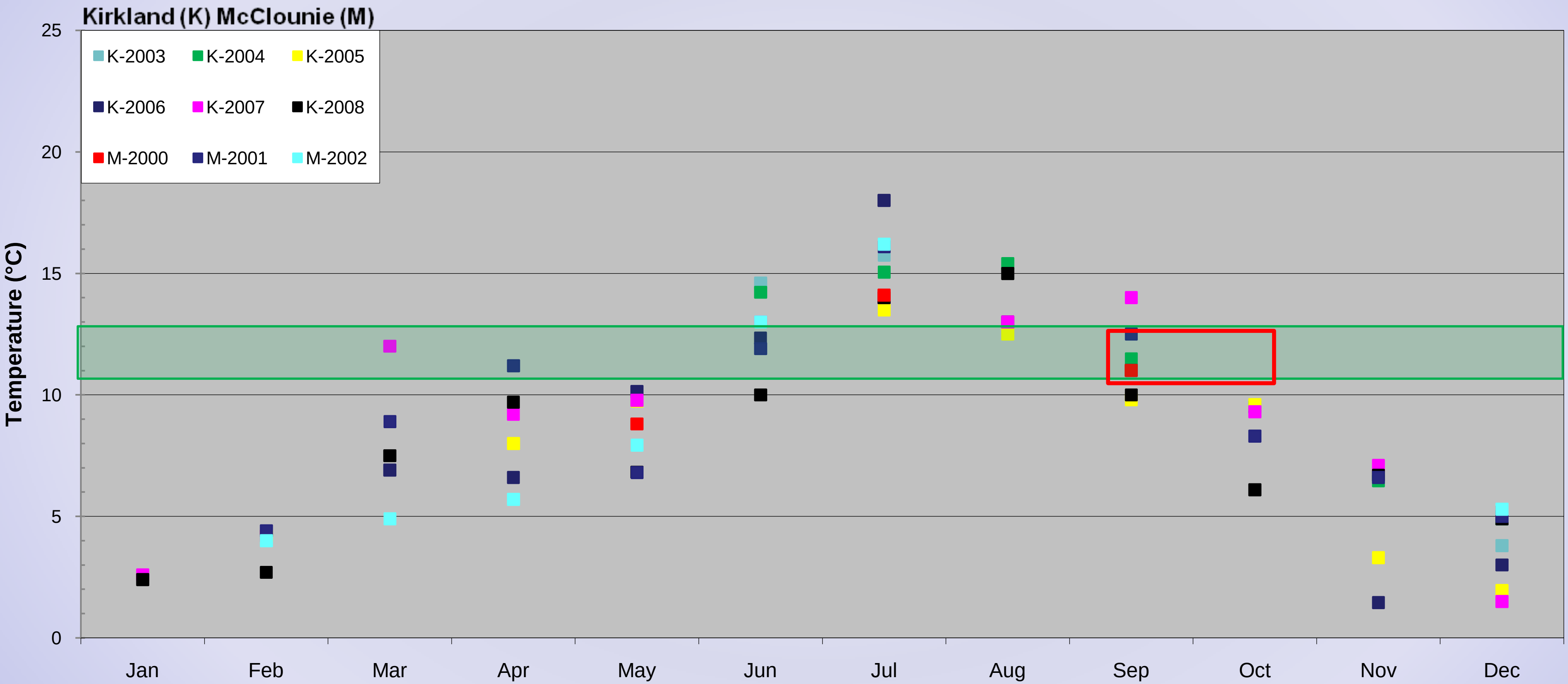
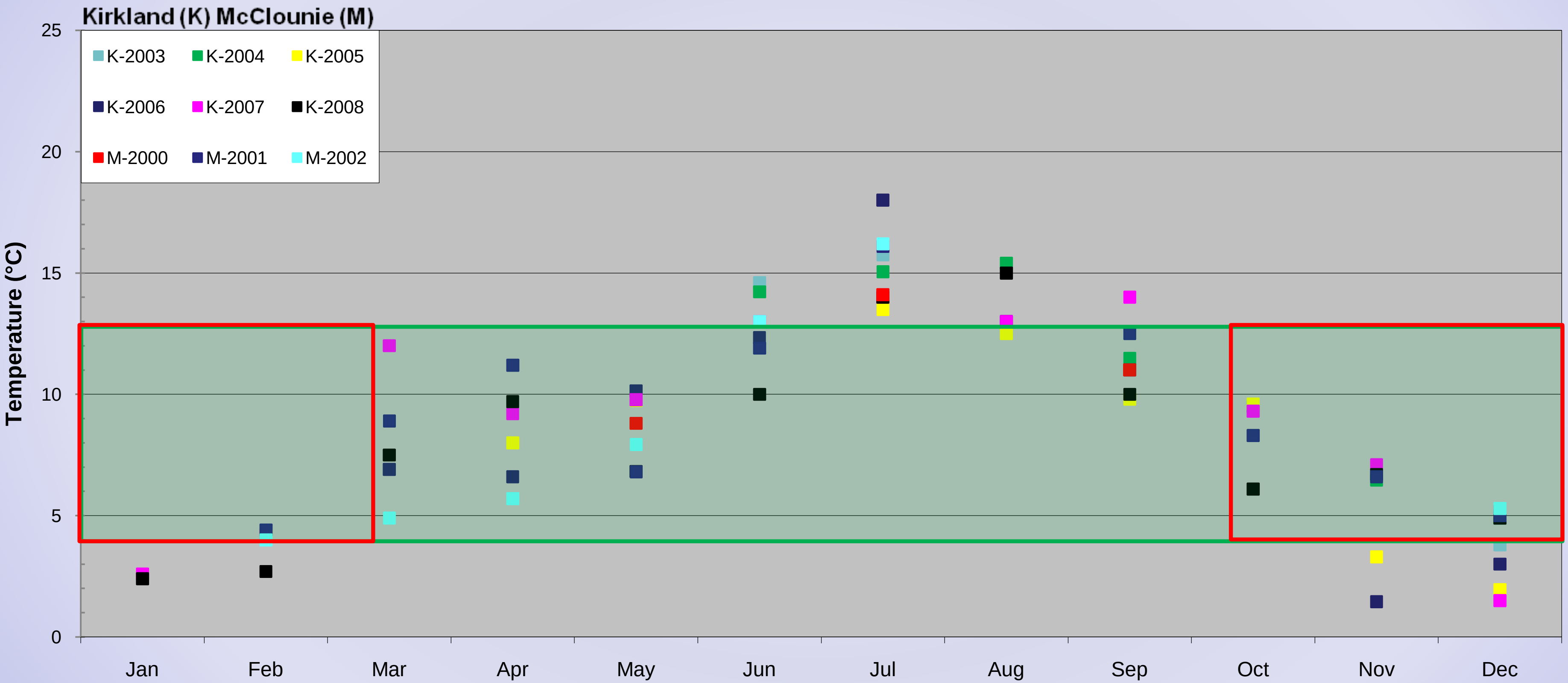
Lower Coldstream Creek: Average Monthly Stream Temperature (2002-2008)



- Optimal temperature range for kokanee spawning: 10.6 - 12.8 °C (±1)
- Spawning period in Coldstream Creek: mid-September to mid-October
- Temperatures appeared to remain within the optimal range until the latter part of the spawning period, when temperatures dropped to several degrees cooler. This late season decrease is not likely to have an adverse effect on reproduction. Mid-October is the transition period between spawning and incubation; the optimal temperature range for incubation is substantially lower.

Lower Coldstream Creek: Average Monthly Stream Temperature (2002-2008)



- Optimal temperature range for kokanee egg incubation: 4.0 - 13.0 °C.
- Egg incubation period in Coldstream Creek: mid–October through early March.
- Temperatures during this period are within the optimal range, or cooler.
- Guidelines for rearing have not been considered since kokanee migrate downstream to rear in Kalamalka Lake.

Key Findings and Next Steps

- ✓ Concentrations of microbiological indicators (fecal coliforms, *E. coli* and enterococci) consistently exceed Water Quality Guideline levels and may compromise Coldstream Creek or portions of Kalamalka Lake for recreation or drinking water uses. Coliform bacteria likely enter Coldstream Creek from a variety of locations where wild or domestic animals occur near surface water.
- ✓ Nitrate values have gradually increased since the 1970's and are now reaching or exceeding guideline levels for the protection of aquatic life. Sources of nitrate could include manure or fertilizer applications, which over time elevate nitrate in groundwater and Coldstream Creek.
- ✓ This water quality information has been used to inform land and waste management decisions, and enable local government, provincial agencies and local representatives to collaborate and seek remedial actions.
- ✓ The province will continue to provide technical guidance to these discussions, and continue monitoring at the Kirkland Drive site to track success of remedial actions.

Summary of Additional Parameters Monitored

- The following slides provide a brief discussion of additional water quality parameters monitored on Coldstream Creek, including:
  - Dissolved Oxygen
  - Total Nitrogen
  - Total Phosphorus
  - Dissolved Ammonia
  - pH (pH units)
  - Dissolved Sulphate
  - Turbidity (NTU)
  - Specific Conductance (µS/cm)
- Although these parameters are of interest, descriptive statistics did not indicate definite long-term trends, clear seasonal patterns and/or immediate concerns in terms of exceeding Water Quality Guideline values, thus, they are not presented with the same level of detail as other parameters.
- These parameters will continue to be monitored and results will be reviewed on a regular basis.
- Concentrations are expressed as mg/L unless otherwise noted.

Summary of Additional Parameters Monitored (...continued)

Dissolved Oxygen:

Values over time did not indicate an increasing or decreasing trend in dissolved oxygen (DO) concentrations. A seasonal pattern was apparent, with concentrations showing an inverse relationship to stream temperature (higher DO values typically recorded during the colder months: November – April). Concentrations were consistently within the acceptable range for the protection of aquatic life, as described in the Water Quality Guidelines.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
72-76 / 85-87 / 05-08	n = 90	8.8	14.6	11.6	Minimum 5.0-9.0 mg/L

Total Nitrogen:

Although a large data gap exists for this parameter (from 1982 to 1996), available records suggested a slight increasing trend, as well as increased variability of total nitrogen concentrations, from 1972 to 2008. Total nitrogen values exhibited a clear seasonal pattern (inversely related to discharge). Recent data indicated that total nitrogen concentrations were reaching higher maximum values than in the 70`s and 80's, and that concentrations were continuing to increase through the fall and into the winter, rather than levelling off during the months of July through December (as was the case in the 70's).

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
72-82 / 96-08	n = 299	0.27	5.96	2.04	None Established

Summary of Additional Parameters Monitored (...continued)

Total Phosphorus:

Data from the 1970's to recent years indicated a gradual decreasing trend in total phosphorus concentrations, particularly during the winter and early spring. A decrease in the variability of total phosphorus values was also apparent, beginning in the late 1990's. Monthly average values did not indicate a clear seasonal pattern, although higher annual maximum values seemed to correspond with higher spring freshet years.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
76-82 / 85-08	n = 455	<0.005	3.64	0.08	None Established

Ammonia:

Ammonia concentrations fluctuated greatly during the monitoring period and many values were below the minimum detection limit; no long-term trends could be discerned. Only a very weak seasonal pattern was observed, with lowest concentrations recorded during the summer months. All values were well below acceptable guideline levels, relative to pH and temperature.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
76-82 / 85-08	n = 365	< 0.005	1.58	0.033	Temperature and pH Dependant

Summary of Additional Parameters Monitored (...continued)

pH:

A comparison of pH values over time did not suggest an increasing or decreasing trend; however, a slight decrease in the variability of pH values was observed. Of the 451 measurements collected, less than 5% were below 8.0 and less than 7% were greater than 8.5. pH values did not exhibit a clear seasonal pattern. With very few exceptions, pH values in Coldstream Creek were within the recommended range for all designated water uses, as described in the Water Quality Guidelines.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
72-82 / 85-04 / 07-08	n = 451	7.4	9.3	8.32	Freshwater Aquatic Life: 6.5 – 9.0

Sulphate:

Sulphate concentrations over time did not suggest an increasing or decreasing trend. Sulphate concentrations followed a seasonal pattern similar to that of chloride (inversely related to stream discharge). All values recorded were well below the aesthetic drinking water guideline of 500 mg/L, and only 8 values (4%) were above the 100 mg/L maximum guideline value for the protection of aquatic life.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
72-79 / 98-01 / 05-08	n = 196	15	161	66.12	Freshwater Aquatic Life: Max. 100 mg/L

Summary of Additional Parameters Monitored (…continued)

Turbidity:

A comparison of turbidity values over time indicated extreme variability, as well as a slight decreasing trend. Turbidity values followed a clear seasonal pattern, which related directly to stream discharge.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
72-82 / 86-08	n = 502	0.1	270	10.87	Relative to Background Levels

Specific Conductance:

Specific conductance values exhibited a distinct seasonal pattern, inversely related to stream discharge. A gradual increase in specific conductance values was observed from 1972 through 2008. From 1972 to 1982, only 7.2% of values recorded were in excess of 700 µS/cm (the 700 µS/cm value is used as an arbitrary reference point only). During the periods of 1985 to 1999 and 2000 to 2008, these proportions increased to 16.2% and 25.4%, respectively: there are currently no Water Quality Guidelines in place for specific conductance.

Monitoring Period(s)	Sample Size	Min.	Max.	Avg.	Guideline
72-82 / 85-99 / 00-08	n = 581	13	818	569	None Established

References

[1] **Warrington, P. D. 2001.** Water Quality Criteria for Microbiological Indicators. BC Ministry of Environment and Parks, Resource Quality Section, Water Management Branch. Victoria, BC. March 1988 (Updated August 7, 2001). http://www.env.gov.bc.ca/wat/wq/BCguidelines/microbiology/microbiology.html

[2] **Nordin, R. N. and L. W. Pomen. 1986.** Water Quality Criteria for Nitrogen (Nitrate, Nitrite and Ammonia): Technical Appendix. BC Ministry of Environment Lands and Parks, Water Quality Unit, Resource Quality Section, Water Management Branch. Victoria, BC. November 1986. http://www.env.gov.bc.ca/wat/wq/BCguidelines/nitrogen/nitrogentech.pdf

[3] **CCME. 2003.** Canadian Water Quality Guidelines for the Protection of Aquatic Life: Nitrate Ion. http://ceqg-rcqe.ccme.ca/

[4] **Nagpal, N. K., D. A. Levy and D. D. MacDonald. 2003.** Ambient Water Quality Guidelines for Chloride: Overview Report. BC Ministry of Environment , Resource Quality Section, Water Management Branch. Victoria, BC. http://www.env.gov.bc.ca/wat/wq/BCguidelines/chloride/chloride.html

[5] **Oliver, G. G. and L. E. Fidler. 2001.** Towards a Water Quality Guideline for Temperature in the Province of British Columbia. http://www.env.gov.bc.ca/wat/wq/BCguidelines/temptech/index.html

Please follow these links for more information

Ministry of Environment Water Quality Guidelines
http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html

Ministry of Environment Field Sampling Protocols
http://www.env.gov.bc.ca/air/wamr/labsys/field_man_03.html

A similar report summarizing Stream Trend Monitoring data for Mission Creek is currently in preparation. A link to the Mission Creek report will be included in an updated version of this document, when it becomes available.

Questions or Comments

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