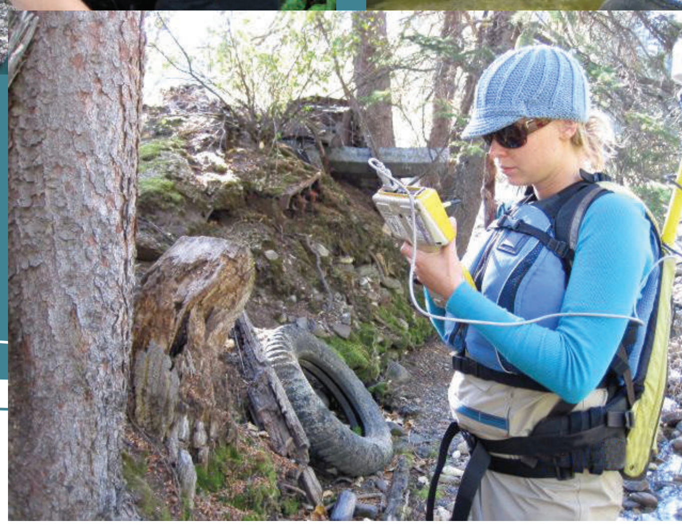

ELK RIVER ALLIANCE

Community-Based Water Quality Monitoring Report

LIZARD CREEK & ALEXANDER CREEK

December 15, 2013

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Elk River Alliance, Program Coordinator

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THANKS TO OUR FUNDERS & PARTNERS!

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Monitoring decisions and the resulting impacts is important to the long-term health of the watershed and to relationship building. Substantive data is needed to determine the effects of human actions on the watershed, and standardized monitoring protocols agreed at the outset will provide confidence that impacts will be tracked. This 'feedback loop' of monitoring and assessment is important to achieving this vision for a healthy watershed.

(Walker, 2009, p. 24)

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COMMUNITY-BASED WATER QUALITY MONITORING REPORT - EXECUTIVE SUMMARY

The Community-based Water Quality Monitoring Report outlines the results of the efforts of the Elk River Alliance since the spring of 2011. This report is written with the goal of sharing information and supporting the public's right to know about their water quality. The data is presented in a succinct format in order to be accessible to a broad range of individuals, ranging from interested citizens to civic leaders and biologists.

Elk River Alliance (ERA)

The ERA is an independent society and community-based water group that aims to connect people to the Elk River ensuring it is drinkable, fishable and swimmable for future generations. The goals of the ERA are to increase watershed literacy, strengthen meaningful participation in the water decision-making process affecting the Elk River watershed, and encourage public participation to monitor, enhance and restore aquatic ecosystems, wetlands and riparian areas.

Healthy tributaries contribute to the health of the Elk River watershed. In 2011, ERA launched a pilot community-based water-monitoring project on Lizard Creek to examine the health of this particular tributary utilizing a citizen science approach. In 2012, this program was expanded to include Alexander Creek, a tributary of Michel Creek, which is a significant tributary of the Elk.

Community-based Water Monitoring (CBWM)

CBWM is a rising movement of grassroots water monitoring efforts completed by citizen scientists supervised and coordinated by ERA staff. In many cases, trained citizen scientists volunteer their time to collect data. CBWM is a useful way to fill information gaps within existing watershed data and to increase public access to this information. This data is collected according to Streamkeepers, Sensitive Habitat Inventory Mapping (SHIM) and Canadian Aquatic Biomonitoring Network (CABIN) protocols. The scientifically collected data is then submitted to the appropriate organization/authority and made available to the public through ERA events and communications e.g. website. CBWM is an excellent way to foster community water literacy, participation in water decision-making and encourage stewardship of our water.

ERA's CBWM efforts have accomplished the following goals:

1. ERA has released a water quality report with community-based water monitoring results, available free of charge from www.elkriveralliance.ca or in hard copy upon request. This data is also submitted to other organizations (see below).

2. ERA has facilitated Streamkeepers training (standardized citizen science water monitoring course) for over 20 participants in the Elk Valley since 2010.

3. Streamkeepers have dedicated hundreds of hours in the collection of high and low flow monitoring.

4. Completion of data gathering have identified areas of concern resulting in restoration and enhancement project grants.

Key Observations

- Water quality in Lizard Creek and Alexander Creek was assessed using physical, chemical and biological parameters.

- Physical parameters measured include turbidity, temperature and general stream characteristics. Measured temperatures were not a concern to stream health. Turbidity is high during the spring and after heavy rain events, which is typical of mountain-fed streams. There are some erosion concerns at both streams, which have the potential to impact water quality by increasing sediment load in the water. These areas will continue to be monitored and may be flagged as potential restoration or enhancement sites in the future.

- Chemical parameters measured include dissolved oxygen, pH, conductance and metals. Healthy levels of dissolved oxygen were measured. The pH was on the high end of a healthy range, however this alkalinity is expected due to the surrounding (mostly limestone) geology in the area. All metals, with the exception of aluminium at Lizard Creek, were within BC guidelines for aquatic health, where such guidelines exist.

- Biological parameters measured include aquatic invertebrates and coliforms. Aquatic invertebrates are bugs that live in the streams, usually on or beneath rocks on the streambed. These invertebrates can give an indication of stream health based on the population composition, because different species sharing similar habitat requirements are more or less sensitive to pollution. Based on CABIN protocols, both Lizard and Alexander Creeks are considered 'slightly divergent'. In other words, they differ slightly from what would be expected in a pristine stream in similar geographic conditions, due to human influence. Coliform levels in 2012 were below BC recreation guidelines (primary contact) for both creeks.

For full data, please refer to the *Elk River Alliance's Community-Based Water Quality Monitoring Report*, available at www.elkriveralliance.ca or in hard copy upon request. Water monitoring data is also available in the Streamkeepers database at www.streamkeepers.info as well as in the Community Mapping Network atlas gallery at http://cmnmaps.ca/ELKVALLEY/. Detailed directions to access the data from these sources are also in report if required.

It is important to note that the data collected and shared in this report only gives a snapshot of stream conditions and health. These aquatic environments are dynamic and ever changing. For this reason, long-term monitoring is essential to establish and monitor trends, which will give more significance to results.

ERA strives to provide water-monitoring data that may be used in decision-making, for example incorporation in municipal official community planning, approval for land use changes, and in the development of a comprehensive watershed management strategy for the Elk Valley. Therefore, ERA will continue to develop, improve and expand monitoring efforts locally.

Please direct any questions or comments to Ayla Bennett, ERA Program Coordinator at ayla@elkriveralliance.ca. (250) 423-3322.

INTRODUCTION

The following report outlines the results of the community-based water monitoring efforts of the Elk River Alliance since the spring of 2011. This report is written with the goal of sharing information and supporting the public's right to know about their water quality. The data is presented in a succinct format in order to be accessible to a broad range of individuals, ranging from interested citizens to civic leaders and biologists.

Elk River Alliance

The Elk River Alliance (ERA) is a community-based water group that promotes watershed health. ERA's strives to **connect people to the Elk River, ensuring it is drinkable, fishable and swimmable for future generations**. Healthy tributaries contribute to the health of the Elk River. In 2011, ERA launched a pilot community-based water-monitoring project on Lizard Creek to examine the health of this particular tributary utilizing a citizen science approach. In 2012, this program was expanded to include Alexander Creek, a tributary of Michel Creek, which is a significant tributary of the Elk.

Community-based Water Monitoring

Community-based water monitoring (CBWM) is a rising movement of grassroots water monitoring efforts completed by citizen scientists. In many cases, trained citizen scientists volunteer their time to collect data. Due to restrictions in provincial and federal government budgets for water monitoring, there are significant gaps in water quality data. CBWM is a useful way to fill these knowledge gaps and to make data more available to the public. There are many examples of CBWM across Canada. Health Canada works with First Nations to provide funding for CBWM of drinking water sources (NCCEH, 2013). Regionally, the Columbia Basin Watershed Network (CBWN) works with several watershed groups in the Columbia Basin to support CBWM programs and share information among the network members (CBWN, 2012). CBWM is an excellent way to foster community leadership, increase grassroots water literacy and encourage stewardship of our water.

Project Goals

There are four main goals of this project, which are:

1. To use an effective, successful and scientific water monitoring approach that may be replicated by other community groups/organizations.
2. To involve community members in water monitoring and educate the public about watershed health.
3. To obtain a set of 'baseline' data on monitored creeks, so that water quality may be compared with creeks in similar environments (will require reference condition approach techniques, as outlined in CABIN protocols).
4. To collaborate with other stakeholders, share information and make data available to community and decision makers.

MONITORING & MAPPING

Protocols

ERA incorporates Pacific Streamkeepers Federation (Streamkeepers), Sensitive Habitat Inventory Mapping (SHIM) and Canadian Aquatic Biomonitoring Network (CABIN) protocols in its community-based water monitoring approach in order to obtain a more complete picture of the health of each stream.

Streamkeepers

FIGURE 1. Streamkeepers testing water quality

The Pacific Streamkeepers Federation (PSKF) was started in 1995 at a meeting of various BC water stewardship groups in Vancouver, BC. Streamkeepers is a stream stewardship program that provides guidance to help protect and restore local waterways in British Columbia. This non-profit organization supports over 150 volunteer-based groups throughout BC and the Yukon. The goals of the PSKF are: to educate and provide training for Streamkeepers volunteers; to help coordinate and support watershed enhancement efforts; as well as, to encourage communication and cooperation in watershed management (Taccogna & Munro, 1995). Streamkeepers protocols include various modules to measure different water quality parameters and habitat features. One benefit of Streamkeepers modules is that they include an on-site assessment. Once the module is complete, the site is rated as poor, marginal, acceptable or good for each category. Streamkeepers protocols were incorporated into ERA's water monitoring project, and locally trained Streamkeepers volunteers were involved in some aspects of data collection. Since October 2010, twenty Streamkeepers have received certification for community-based water monitoring, coordinated and hosted by ERA. Streamkeepers methods are hands-on and clearly defined so that the general public is able to participate and compare results, once they complete the 2-day training course. Elk River Alliance Streamkeepers results are available on the Streamkeepers Central Database, at www.streamkeepers.info. To view data, click 'Reports', choose a module and using the 'next' button to locate Elk River Alliance data on either Lizard Creek or Alexander Creek.

FIGURE 2. Sensitive Habitat Inventory Mapping (SHIM) centerline survey

Sensitive Habitat Inventory Mapping (SHIM)

The SHIM method was developed within British Columbia to provide the information and tools required to "precisely map and compile data for BC urban and rural watercourses" (Mason & Knight, 2001). The SHIM method was incorporated into the CBWN project since it includes scientifically robust standards which have been recognized and jointly developed by various government agencies: Fisheries and Oceans Canada, BC Ministry of Water, Lands and Air Protection, as well as numerous other groups (Mason & Knight, 2001). SHIM uses high precision GPS to accurately map stream features such as fish habitat, erosion and riparian areas.

Sensitive Habitat Inventory Mapping (SHIM) protocols require a centreline survey to be conducted on a stream of interest. During this survey, the centreline (mid point of bankfull width) was mapped using a Trimble XR Pro GPS unit and habitat features were recorded. In 2011, Elk River Alliance (ERA) partnered with Selkirk Geospatial Resource Centre through the Columbia Basin Watershed Network's 'Mapping Support for Stewardship Groups' program to create a 1:5000 scale features map from the data collected on Lizard Creek. See Figure 5 for the final map product. In 2012, ERA partnered with Teck Coal Limited's GIS department to complete a 1:5000 scale features map of the portion of Alexander Creek that was monitored. See Figure 7 for final map product. Data is also available online at http://cmnbc.ca/atlas_gallery. Select 'Kootenay' under region option, click Elk River Alliance logo and use 'click here for atlas' hyperlink. Once atlas has loaded, expand either Lizard Creek or Alexander Creek in legend (by clicking '+' symbol) and select features to view.

Canadian Aquatic Biomonitoring Network (CABIN)

CABIN protocols use organisms, such as freshwater invertebrates, as environmental indicators to assess stream health. This is based on the fact that different organisms are more or less sensitive to environmental stressors. Therefore, a diverse invertebrate population including sensitive species will likely indicate a healthy stream. CABIN protocols use a reference condition approach (RCA). RCAs compare invertebrate populations at study areas to reference streams with similar characteristics to determine the health of the aquatic ecosystem. Reference streams have very little to no anthropogenic influences. Test sites are classified as 'similar' to, 'mildly divergent' from, 'divergent' from or 'highly divergent' from reference sites.

FIGURE 3. Taking a water sample to submit to lab, results included in CABIN data

Benthic invertebrate (i.e. bottom dwelling spineless aquatic animal) populations are made up of larval insects, nymphs, worms and other aquatic organisms. These are useful when assessing stream health, because they can indicate the health of the aquatic ecosystem, they give local information (because they are much less mobile than fish), they exist in all freshwater ecosystems, they indicate environmental stressors and cumulative impacts (Environment Canada, 2013). CABIN is quickly becoming the standard in both government and aquatic consulting for assessing wadeable streams. Utilizing this method will allow ERA's data to be compared to many other streams across Canada as the methods will be consistent.

Parameters Considered

The parameters examined to assess stream health fall under three categories: physical, chemical, and biological. For a more complete description of methods, see Appendix A.

Physical Parameters

Physical parameters include temperature, turbidity and general stream characteristics (i.e. width, depth, discharge).

Fish and other aquatic organisms are generally sensitive to temperature since they are cold-blooded. Therefore, their body temperatures change as water temperature changes. In the summer, water temperature in unshaded streams can increase as much as 10oC throughout the day (Taccogna & Munro, 1995). Salmonid species (including westslope cutthroat and bull trout) require cool water with sufficient shade cover. When water temperatures are between 5-13oC, fish have a lower risk of contracting diseases (Taccogna & Munro, 1995). Additionally, cooler water can hold higher amounts of dissolved oxygen, which all aquatic organisms require.

Relatively clear water is also essential for fish spawning and survival. Turbidity is a measure of water clarity due to suspended sediment in the water. Fish eggs and larvae (i.e. alevins) spend months living in gravel substrate. If sediment increases beyond a certain threshold, they will suffocate (Taccogna & Munro, 1995). High sediment load can also clog the gills of fish and other aquatic invertebrates; as well as fill in interstitial spaces where aquatic invertebrates live. Turbidity increases with heavy rainfall; therefore, in the Elk Valley it is more of a concern during spring high flow.

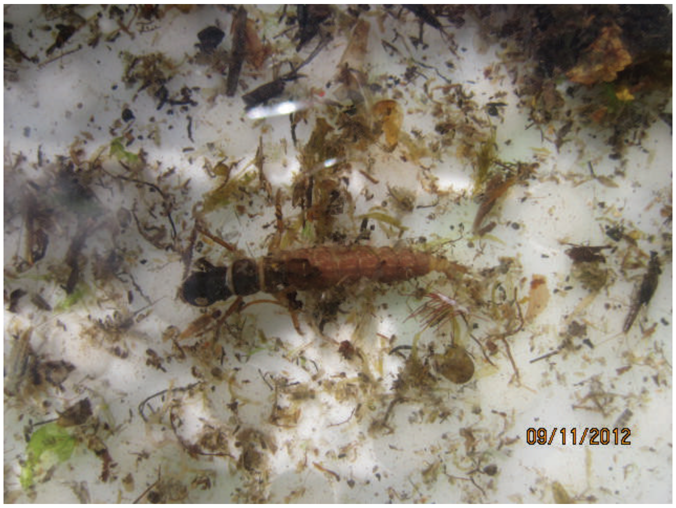

FIGURE 4. A 'benthic macro invertebrates' sample

Chemical Parameters

Chemical parameters include pH, dissolved oxygen and conductivity.

Oxygen is as essential to aquatic life as it is to terrestrial life. Therefore, the amount of oxygen dissolved in a stream will determine which aquatic organisms are present. In a healthy stream, oxygen saturation ranges from 90-110% for the majority of the year (Taccogna & Munro, 1995). However, lowest oxygen levels usually occur in late summer when temperatures are high and water levels are low.

Most aquatic organisms can only survive within a narrow range of pH conditions. Generally, streams with pH levels below 6.0 or above 8.5 cannot support aquatic life. A pH level of 7.5 is the optimum for most fish (Mitchell & Stapp, 1995). Although cutthroat trout preferences vary between populations, most can likely survive in a pH range from 5-9.5 (Hickman & Raileigh, 1982). In a 1968 study in British Columbia, cutthroat trout were found in streams with pH values ranging from 6.0-8.8 (Hartman & Gill). PH is controlled by factors such as geology, rainfall and human contaminants.

The conductivity of water measures the amount of dissolved ions in the water, but does not indicate the type of ion. All streams will contain dissolved ions from the surrounding rock and soil. An increased amount of dissolved ions could be due to pollutants, such as nitrates and phosphates, entering the stream. Conductivity is measured in microsiemens per centimetre (µS/cm). In healthy streams, conductivity is typically between 150-500 µS/cm (Behar, 1997).

Biological Parameters

Benthic macro-invertebrates can be a useful indication of stream health. Different invertebrate species are more or less sensitive to environmental factors. Therefore, the ratio of sensitive to non-sensitive organisms can provide information on water quality. Since macro-invertebrates generally do not move a great distance, they are especially valuable in indicating local water quality (as opposed to fish, which are mobile in their environment). Invertebrates that are least tolerant to pollution are the larvae of stoneflies (*Plecoptera*), caddisflies (*Tricoptera*) and mayflies (*Ephemeroptera*). They require water that is sufficiently clean and clear with adequate dissolved oxygen. Therefore, an abundance of these organisms will likely only be found in healthy streams (Taccogna & Munro, 1995). That being said, the biological diversity of the invertebrate population is also a significant factor to consider.

Coliforms are a type of bacteria used to assess water quality, as they may indicate the presence of disease causing pathogens. Fecal coliforms originate from the feces of humans or other mammals. Escherichia coli (E. coli) is a particular group of fecal coliform bacterium, which includes some strains that are known to cause illnesses in humans (CDC, 2011). Total coliforms include fecal, as well as coliforms originating from plant matter (Fong & Lipp, 2005). Although there is no recognized coliform limit to protect aquatic life in BC, an over-abundance of coliforms could negatively impact aquatic organisms by decreasing the amount of dissolved oxygen. Coliforms are measured in number of colonies per 100mL. Some sources recommend fecal coliform maximum of 100 colonies/100mL, with 50/100mL or less being ideal in freshwater ecosystems (Maun & Moulton, n.d.).

Site Overviews

Lizard Creek

ERA chose to begin community-based water monitoring on Lizard Creek, as it is believed to be relatively pristine. This natural condition is due to the lower section being a protected area (Mount Fernie Provincial Park) with little development and industrial activity (e.g. mining, logging), compared to other tributaries in the Elk River watershed. Additionally up the valley is Island Lake Resort's "Cedar Valley Old Growth Reserve" promoting stewardship of this rare ecosystem and informal guidelines, which restrict timber removal and off road vehicles.

Figure 5, right, shows the Sensitive Habitat Inventory Mapping (SHIM) map created for Lizard Creek, which is located approximately 3 km southwest of Fernie, BC. A base map was underlain to give a visual reference to stream centreline and features mapping data collected during the SHIM survey.

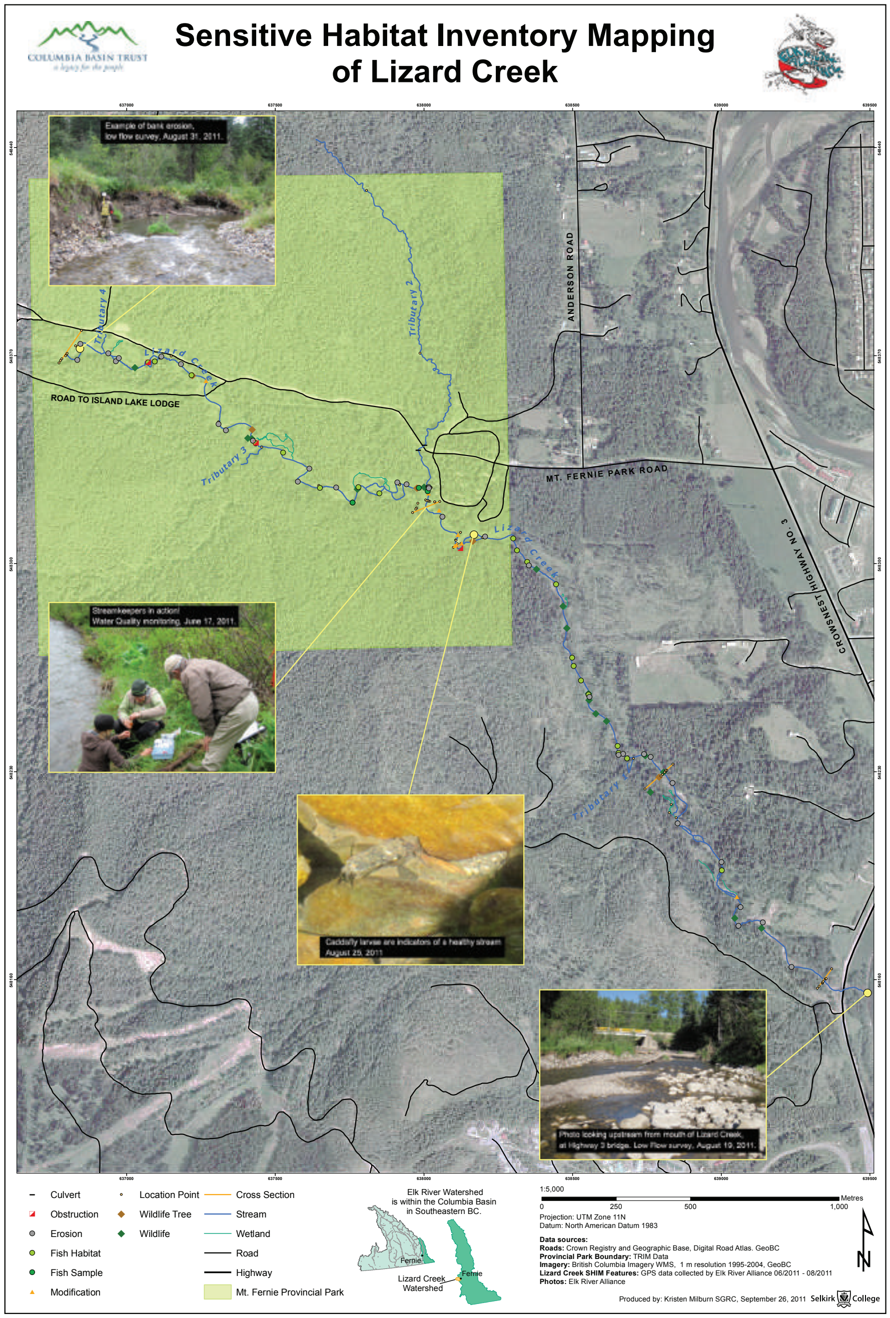

FIGURE 5. Lizard Creek SHIM map, completed in 2011 with assistance from Selkirk College's Geospatial Research Centre and the Columbia Basin Watershed Network

Background Information

Lizard Creek is located within the biogeoclimatic zone of Interior Cedar/Hemlock (ICH) forest. The oldest trees in Mount Fernie Provincial Park are approximately 100 years old as the forest was logged prior to and then burnt during the August 1, 1908 fire that devastated much of the area, including the town of Fernie. Within the forest, there are several standing, dead charred Western red cedars remaining from this fire, providing excellent habitat for wildlife.

The riparian zone, the transition forest between Lizard Creek and the dry upland forest, immediately adjacent to Lizard Creek is dominated by deciduous vegetation. The dominant shrubs include mountain alder, black hawthorn and red-osier dogwood. Deciduous trees are mainly black cottonwood and trembling aspen, with some paper birch. Further from the creek, the Western red cedar and Engelmann spruce dominate the forest; however, Western larch and lodgepole pine are abundant in some areas.

Lizard Creek is a third order stream throughout the study area. The tributaries enter from both sides of the Cedar Valley (Mount Fernie to the north and Iron Pass at the western end, with Lizard Range to the south) as well as Island Lake. The elevation of Lizard Creek site 1, near confluence with Elk River, is 990 metres (3248 feet). The GPS coordinates of site 1 are: 49.47128 N, 115.07707 W.

FIGURE 6. Lizard Creek site 1, looking downstream towards highway 3 bridge and confluence with the Elk River

The majority of Lizard Creek's annual flow is attributed to snow melt. Flows in the Elk River watershed are highest in May and June and lowest from August to March (generally decreasing over winter). This is consistent with other interior rivers in the area (Swain, 2007, p.5).

The Cedar Valley geology is predominantly limestone ($CaCO_3$). This sedimentary rock was originally deposited in a deep sea, marine environment. Limestone is easily eroded over time, which contributes to more alkaline water. The average slope of Lizard Creek is approximately 1%. The Cedar Valley is somewhat confined by natural terraces on both sides and artificially stabilized banks in areas adjacent to Island Lake Road and within Mount Fernie Provincial Park.

Alexander Creek

In 2012, monitoring efforts were expanded to Alexander Creek, east of Sparwood, BC. This creek is of interest as it is a significant tributary to Michel Creek, which converges with the Elk River near Sparwood. This creek is on the eastern slope of the valley and will therefore provide additional contrasting information in the Elk River watershed. It is in an area with more human impacts including proximity to highway 3, recent logging activities, road-building, grazing lease for cattle and potentially coal mining in adjacent valleys. Alexander Creek was also selected for monitoring to engage another Elk Valley community, for its different geologic features, greater human influence and as a potential contrast for Lizard Creek.

Figure 7 is the final SHIM map of Alexander Creek, which is located approximately 15 km east of Sparwood, BC. A base map was underlain to give a visual reference to stream centreline and features mapping data collected during the Sensitive Habitat Inventory Mapping (SHIM) survey.

Alexander Creek is located within an Engelmann spruce/Subalpine fir bioclimatic zone, and the oldest trees in the area are approximately 80 years. The riparian zone is generally dominated by coniferous trees; including abundant Engelmann spruce, Douglas and subalpine fir. Major deciduous trees and shrubs include red osier dogwood, trembling aspen and black cottonwood.

Alexander Creek is a fourth order stream throughout the study area. The valley runs north to south and tributaries enter from both sides of the valley. The elevation of Alexander Creek at site 1, near the confluence with Michel Creek, is 1220 metres (4004 feet). The GPS coordinates of the site are: 49.67396 N, 114.77993 W.

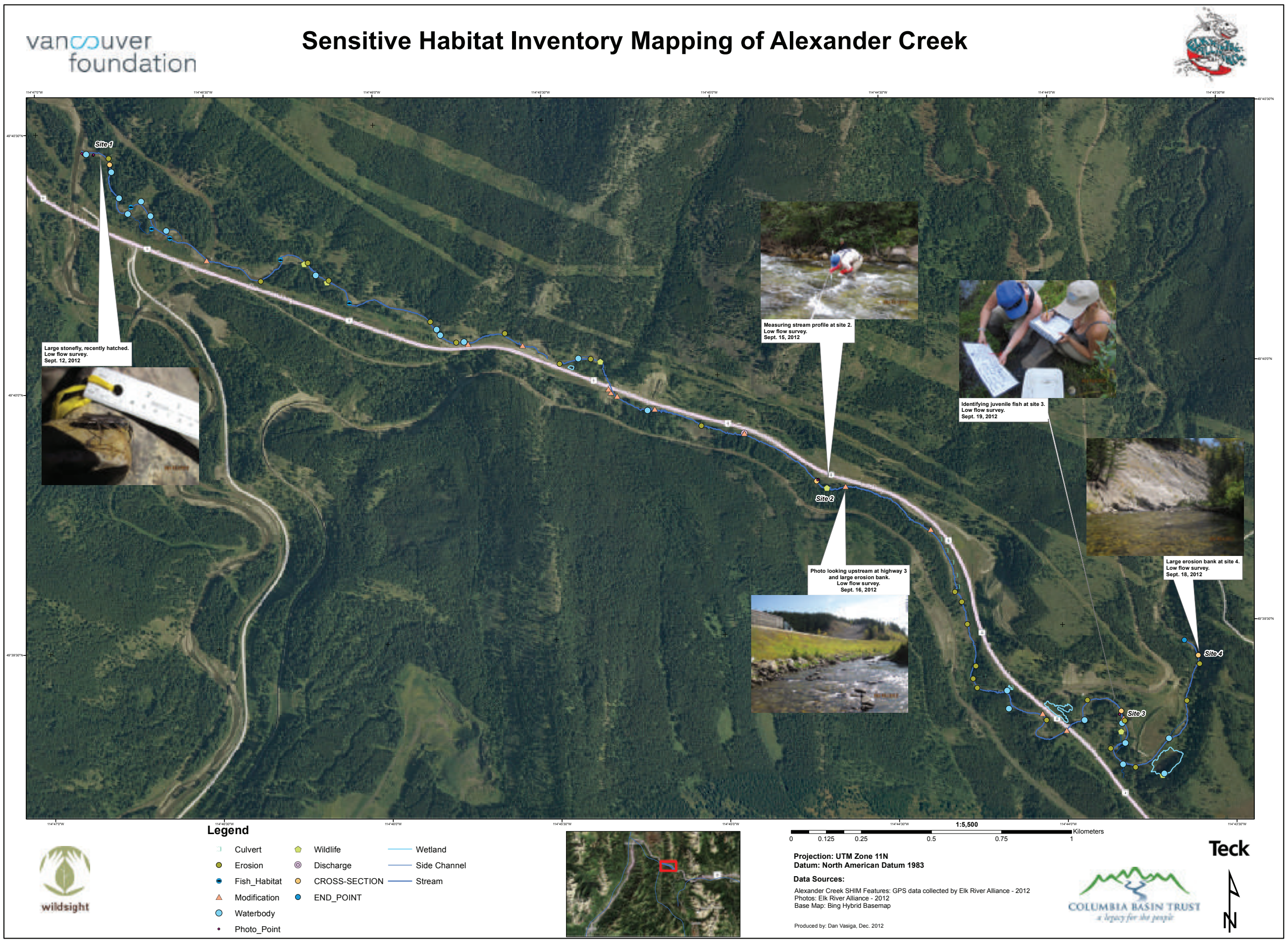

FIGURE 7. Alexander Creek SHIM map, completed in 2012 with assistance from Teck's GIS Department

The majority of Alexander Creek's annual flow is attributed to snow melt. Flows in the Elk River watershed are highest in May and June and lowest from August to March (generally decreasing over winter). This is consistent with other interior rivers in the area (Swain, 2007, p.5). The total length of Alexander Creek from the source to the mouth is over 30 km long; however, due to access, time and funding constraints, only the bottom 6.5 km were monitored. The average slope of the survey section is 0.8%.

The geology of the Alexander Creek area is also sedimentary. However, this valley differs from the Cedar Valley in that there are expressions of coal-bearing rock from the Lewis thrust sheet (Grieve & Price, 1987).

FIGURE 8. Alexander Creek site 1, looking downstream towards confluence with Michel Creek (a major tributary to the Elk River)

Results

Below is a concise and mainly graphical description of results. For more detailed information, see Appendix B.

Physical Parameters

WATER TEMPERATURE

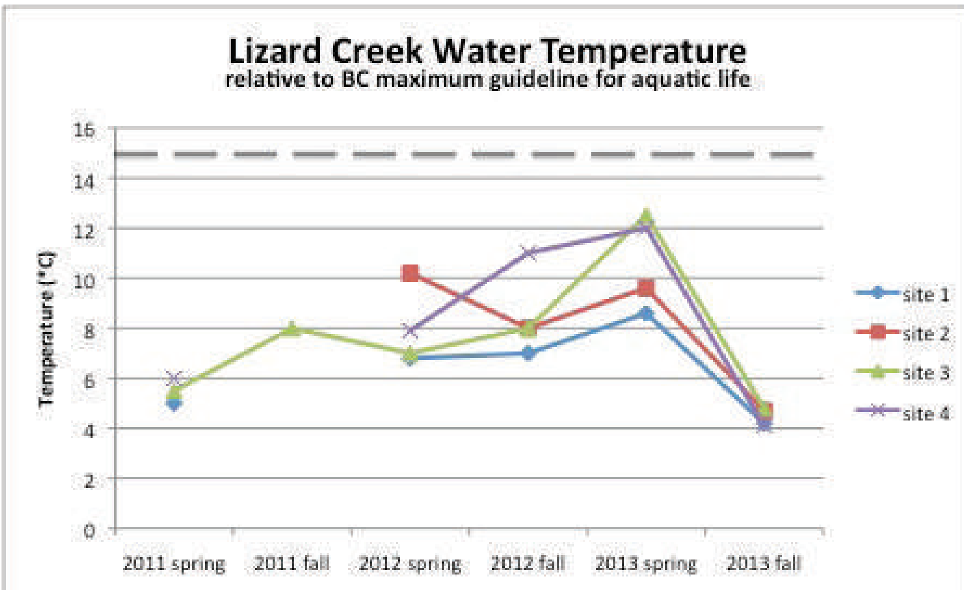

FIGURE 9. Lizard Creek water temperatures, relative to BC maximum guideline for aquatic health (15°C), results range from 4-12.5°C (Oliver & Fidler, 2001)

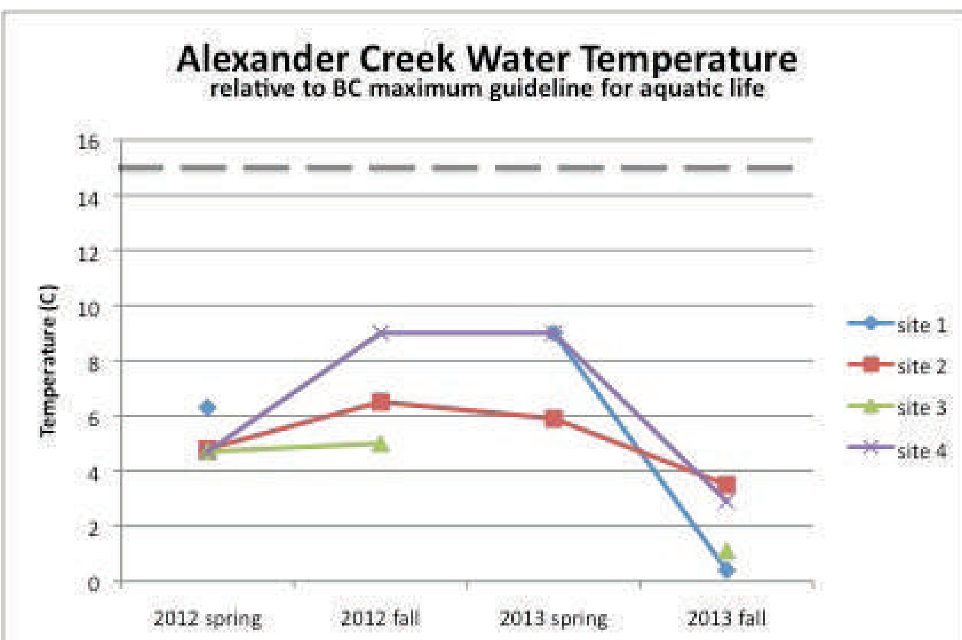

FIGURE 10. Alexander Creek water temperatures, relative to BC maximum guideline for aquatic health (15°C), results range from 0.4-9°C (Oliver & Fidler, 2001)

AIR TEMPERATURE

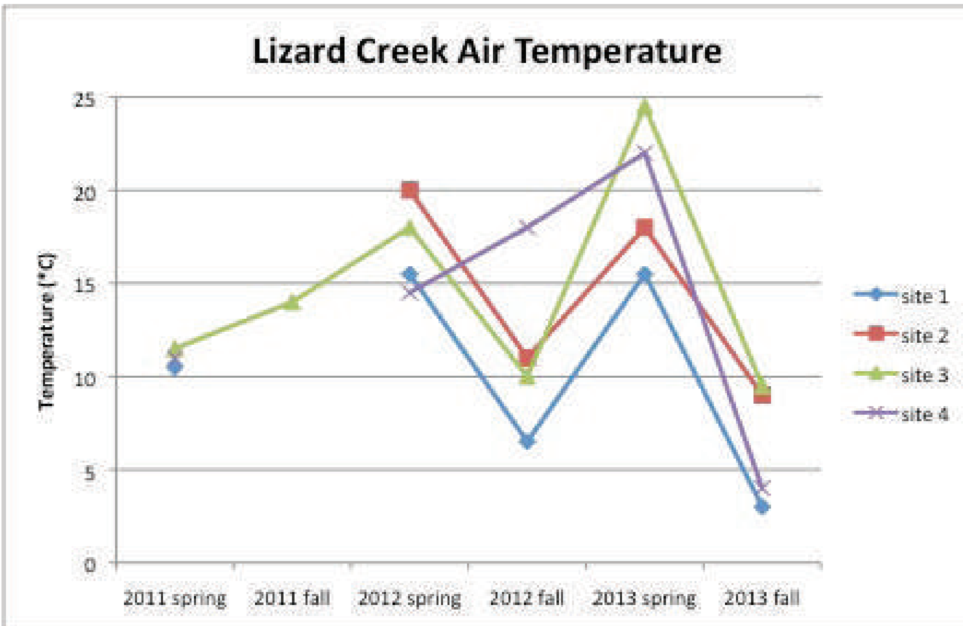

FIGURE 11.
Lizard Creek air temperatures, results range from 3-10°C

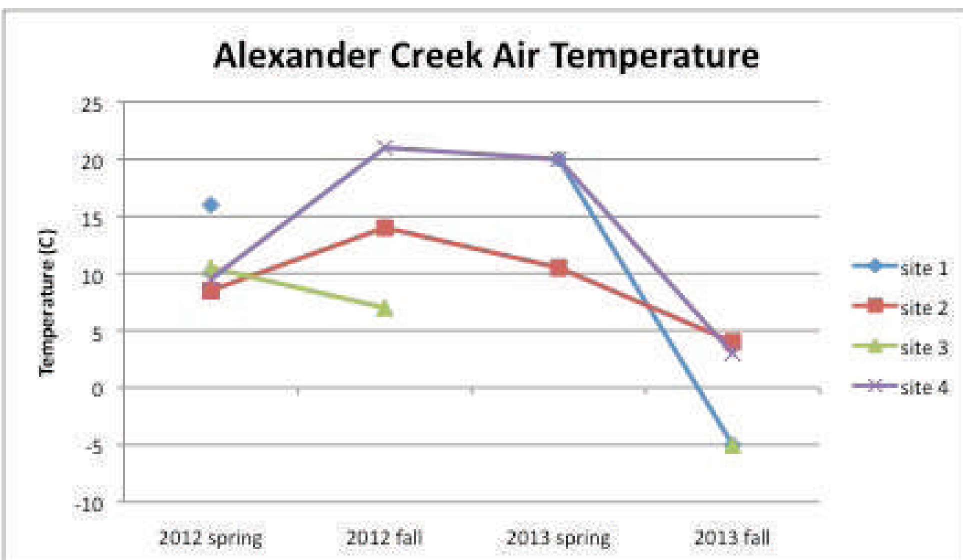

FIGURE 12.
Alexander Creek air temperatures, results range from -5-21°C

TURBIDITY

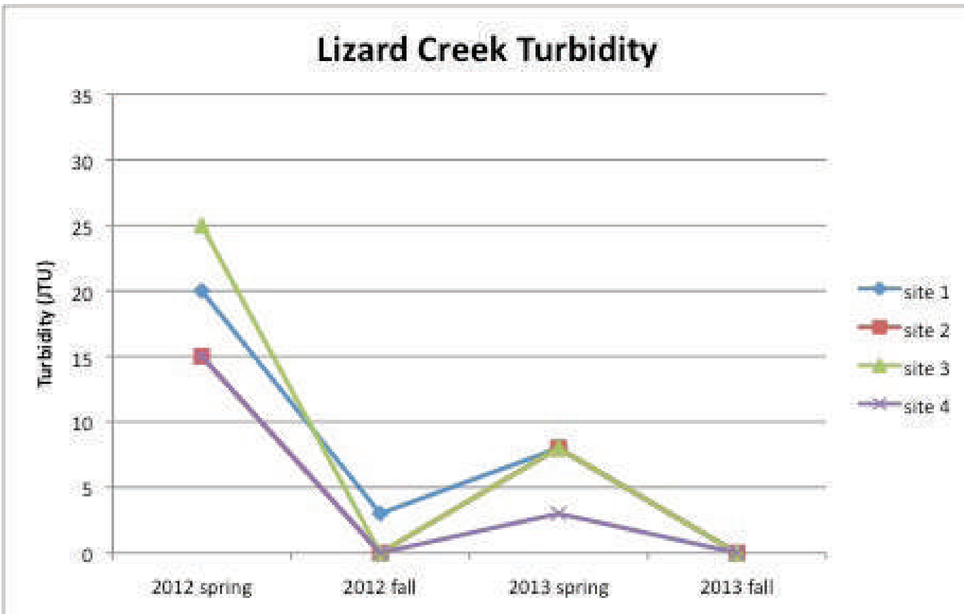

FIGURE 13.
Lizard Creek turbidity measurements, results range from 0-25 JTU

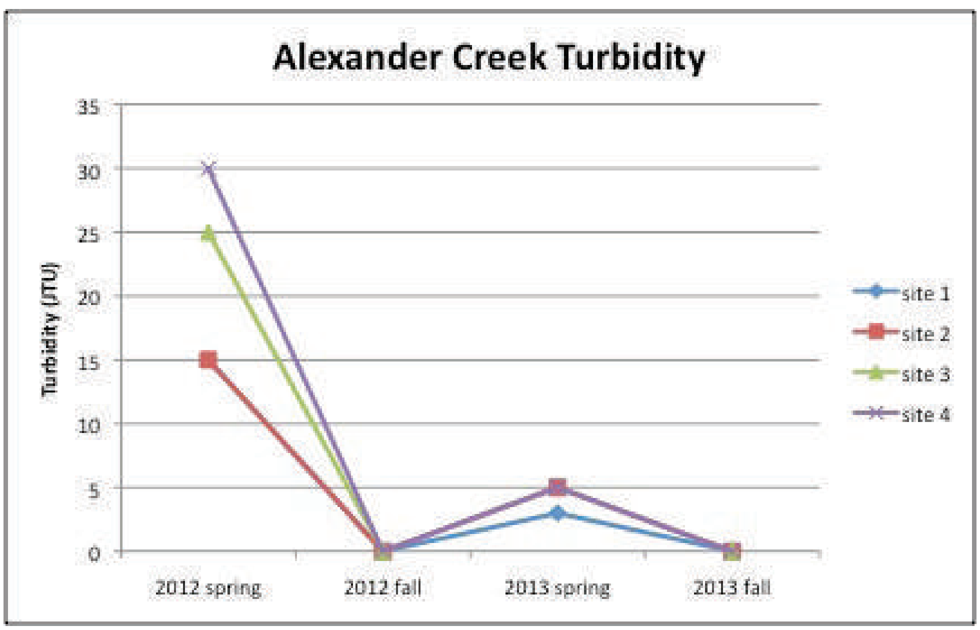

FIGURE 14.
Alexander Creek turbidity measurements, results range from 0-30 JTU

STREAM WETTED AREA

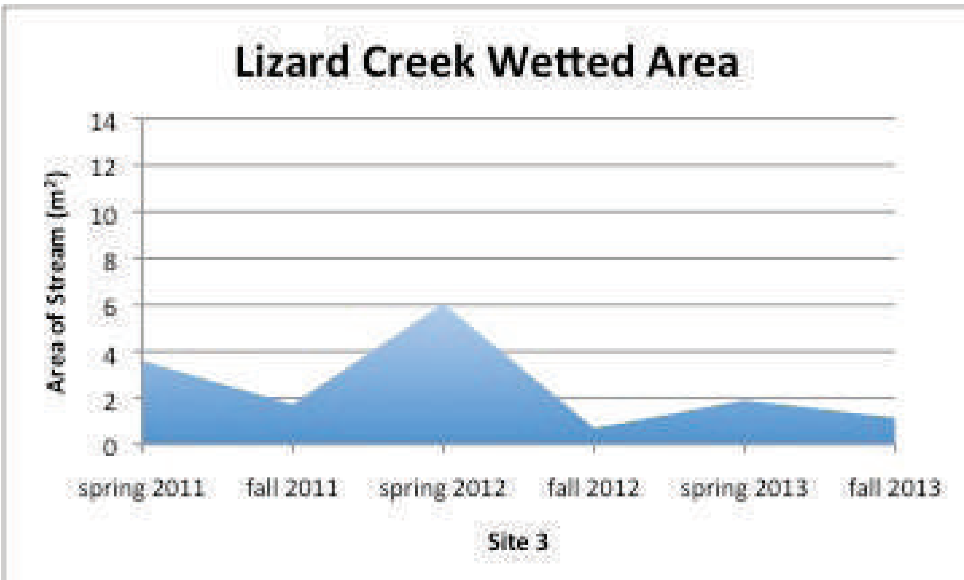

FIGURE 15. Lizard Creek site 3 stream area (m2), estimated by multiplying the wetted width by average depth, results range from 0.7-6.0 m^2

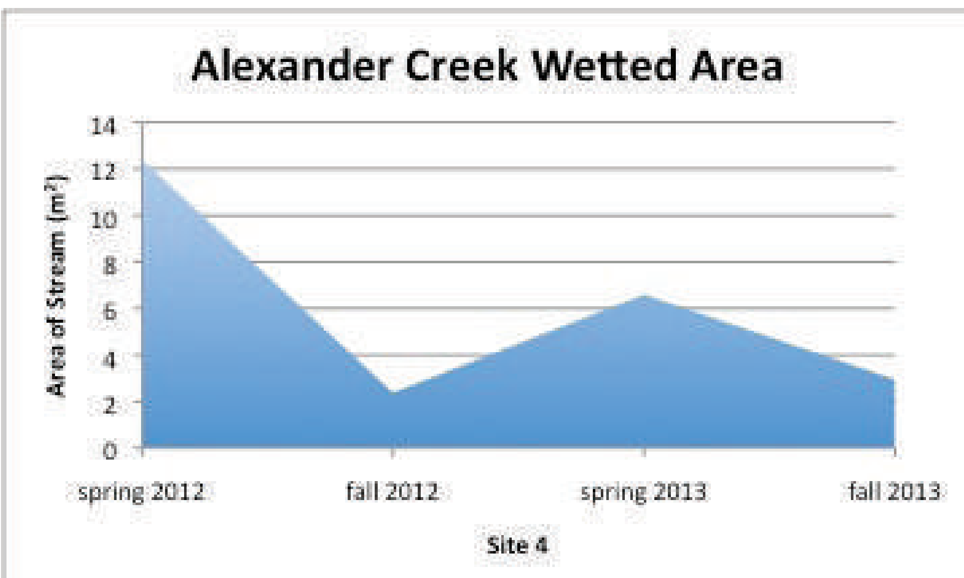

FIGURE 16. Alexander Creek site 4 stream area (m2), estimated by multiplying the wetted width by average depth, results range from 2.4-12.4 m2

n.b. Alexander Creek high flow measurements are estimates, as crossing the stream during freshet is too dangerous

STREAM DISCHARGE

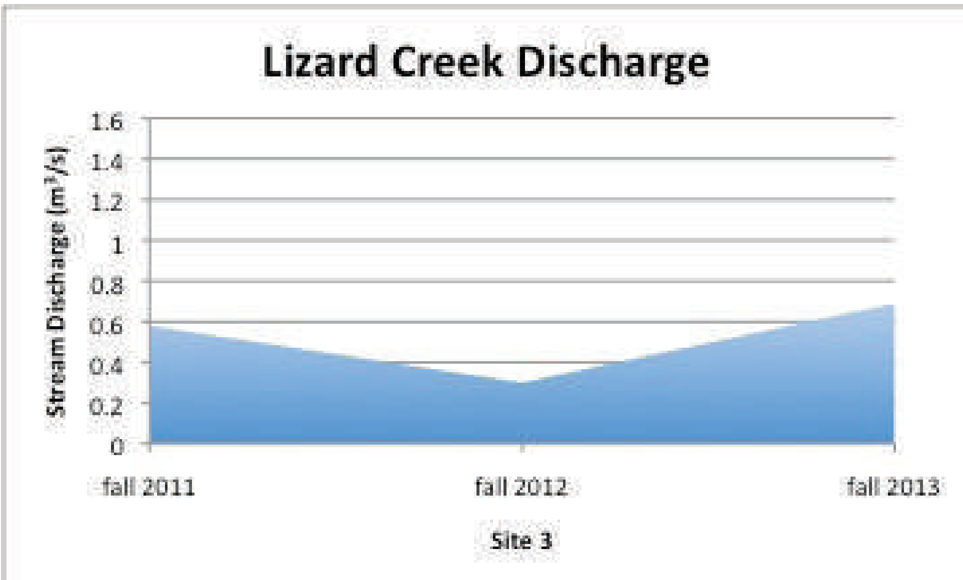

FIGURE 17.
Lizard Creek site 3 low flow stream discharge (m3/s), calculated by multiplying the cross-sectional stream area (m2) by the velocity (m/s), results range from 0.3-0.7 m^3/s

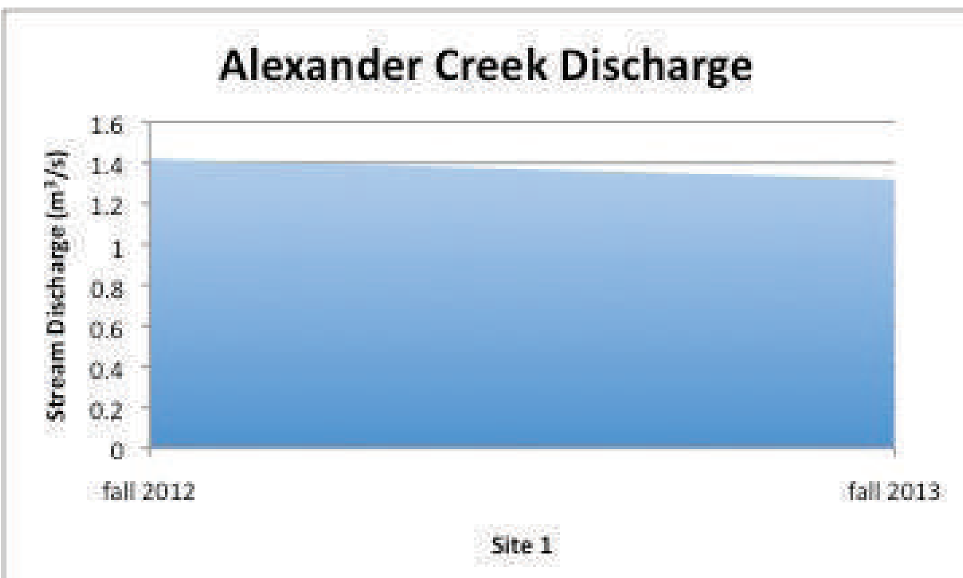

FIGURE 18.
Alexander Creek site 1 low flow stream discharge (m3/s), calculated by multiplying the cross-sectional stream area (m2) by the velocity (m/s), results range from 1.3-1.4 m^3/s

Chemical Parameters

Dissolved Oxygen (% oxygen saturation)

The dissolved oxygen percent saturation incorporates dissolved oxygen results in mg/L and temperature to compare the amount of dissolved oxygen relative to the holding capacity of the water.

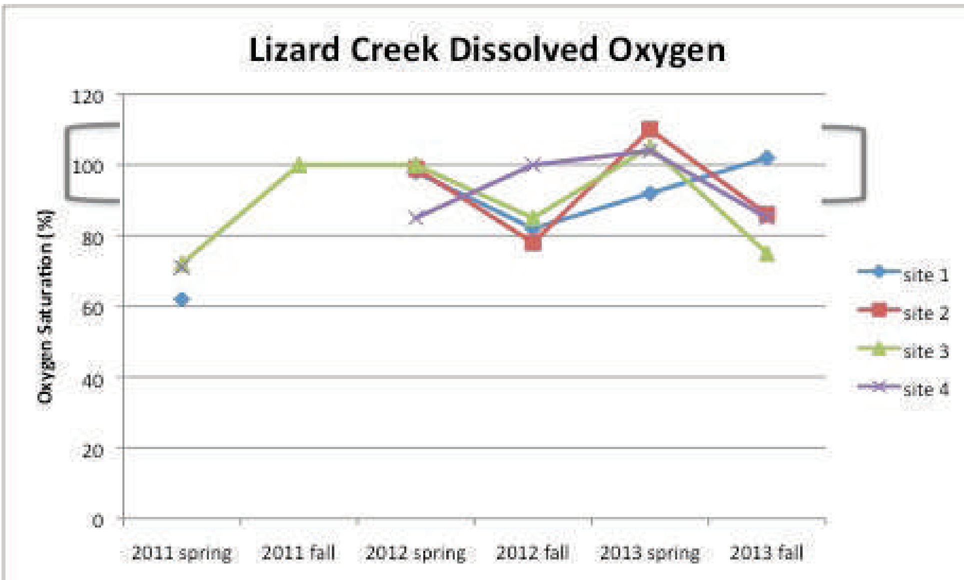

FIGURE 19.
Lizard Creek dissolved oxygen as percent saturation, relative to healthy stream levels of 90-110%, results range from 60-110%

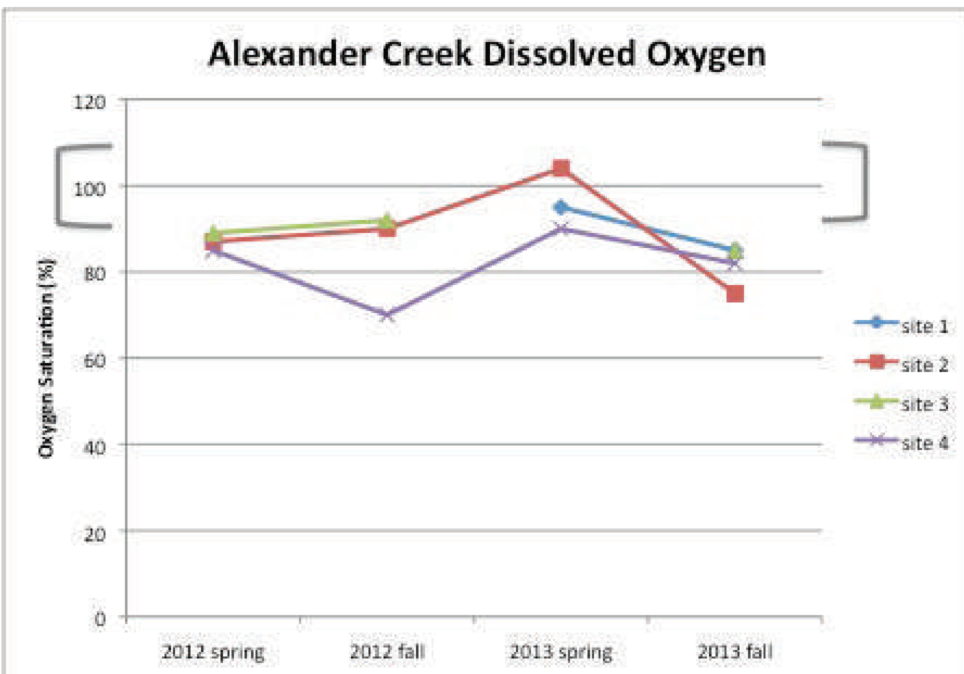

FIGURE 20.
Alexander Creek dissolved oxygen as percent saturation, relative to healthy stream levels of 90-110%, results range from 70-105%

pH level

The pH values above are exclusively from 2013, taken using a properly calibrated pH meter. Previous pH values were deemed inaccurate.

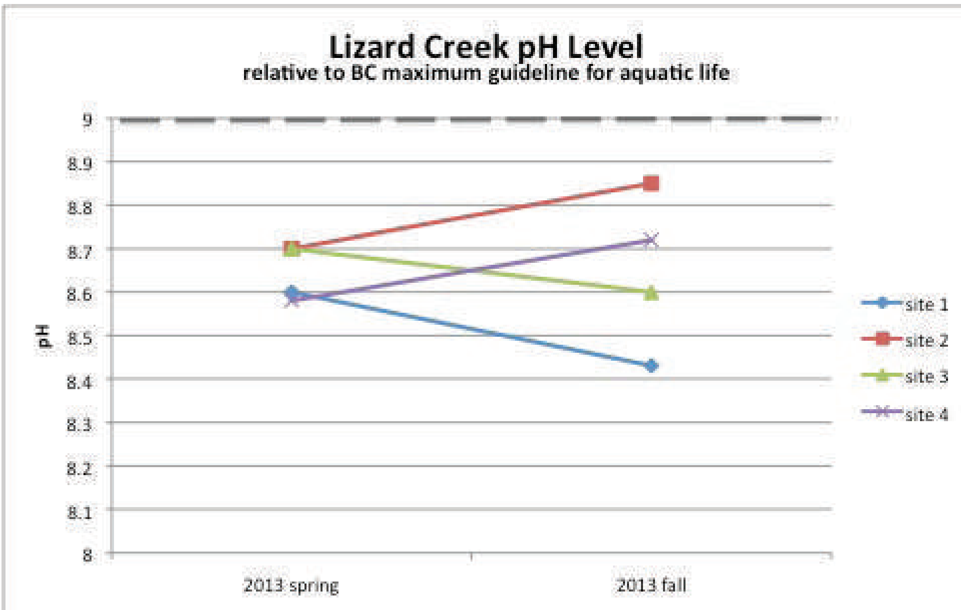

FIGURE 21. Lizard Creek pH levels, relative to BC maximum guideline for aquatic life (9.0), results range from 8.4-8.9 with an average of 8.65 (McKean & Nagpal, 1991)

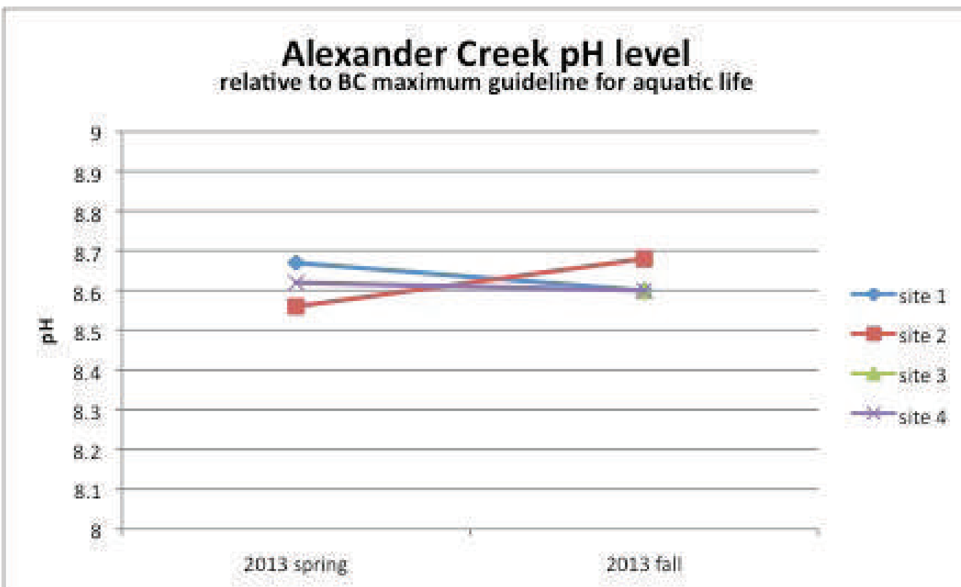

FIGURE 22. Alexander Creek pH levels, relative to BC maximum guideline for aquatic life (9.0), results range from 8.6-8.7 with an average of 8.62 (McKean & Nagpal, 1991)

Nitrogen levels

Results of nitrogen levels are from water samples taken in fall 2012, spring 2013 and fall 2013 and analyzed in the lab.

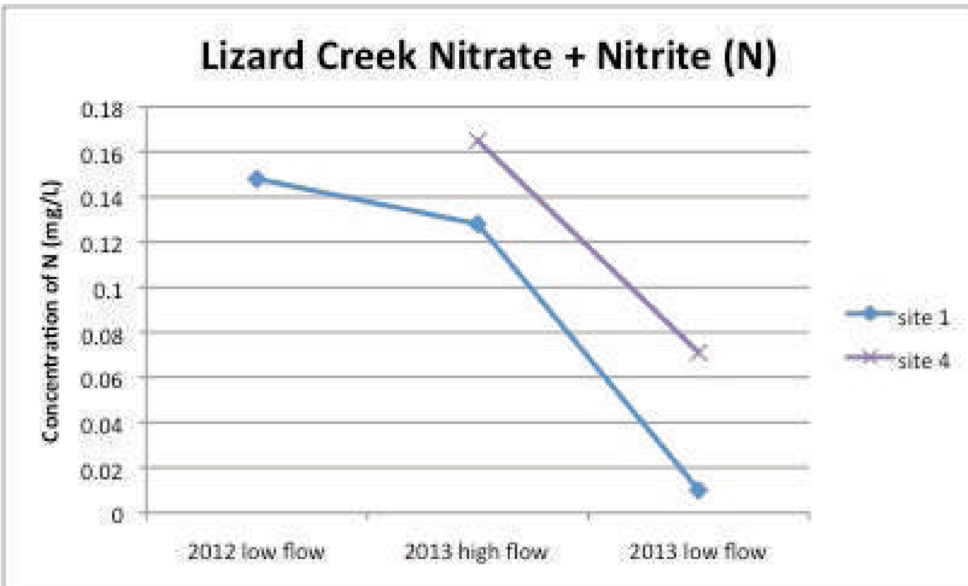

FIGURE 23. Lizard Creek nitrate + nitrite (N) levels, results range from 0.1-0.2 mg/L

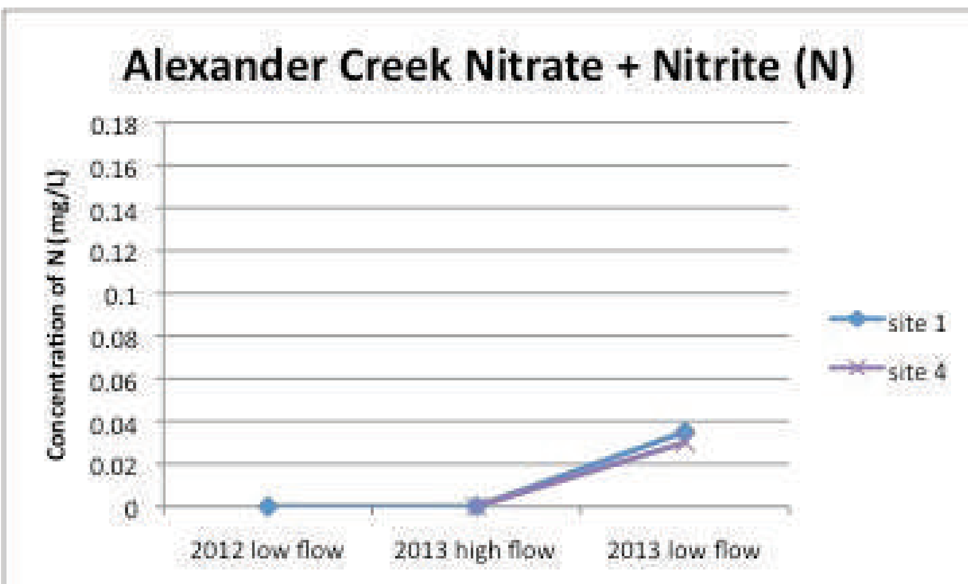

FIGURE 24. Alexander Creek nitrate + nitrite (N) levels, results range from 0-0.04 mg/L

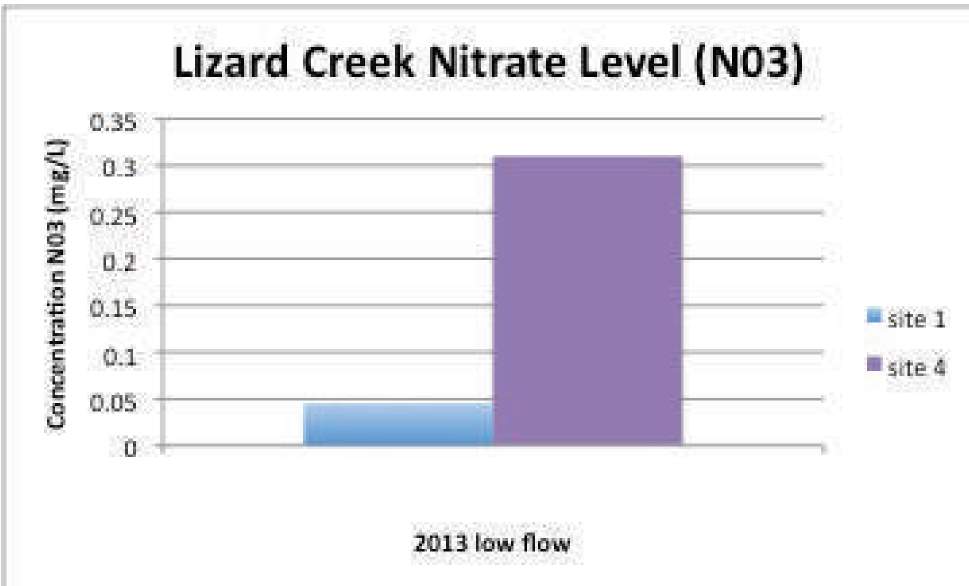

FIGURE 25.
Lizard Creek nitrate (NO3) levels, results range from 0.05-0.3 mg/L, BC guideline for freshwater aquatic life is maximum of 32.8 mg/L (acute) or 3.0 mg/L (30-day average) (Nordin et al., 2009)

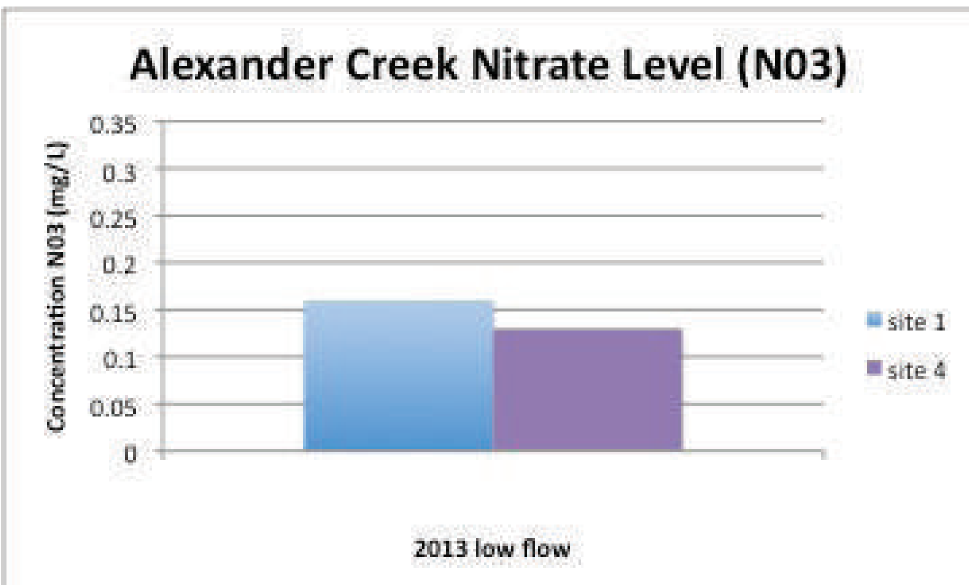

FIGURE 26.
Alexander Creek nitrate (NO3) levels, results range from 0.1-0.2 mg/L, BC guideline for freshwater aquatic life is maximum of 32.8 mg/L (acute) or 3.0 mg/L (30-day average) (Nordin et al., 2009)

Conductivity

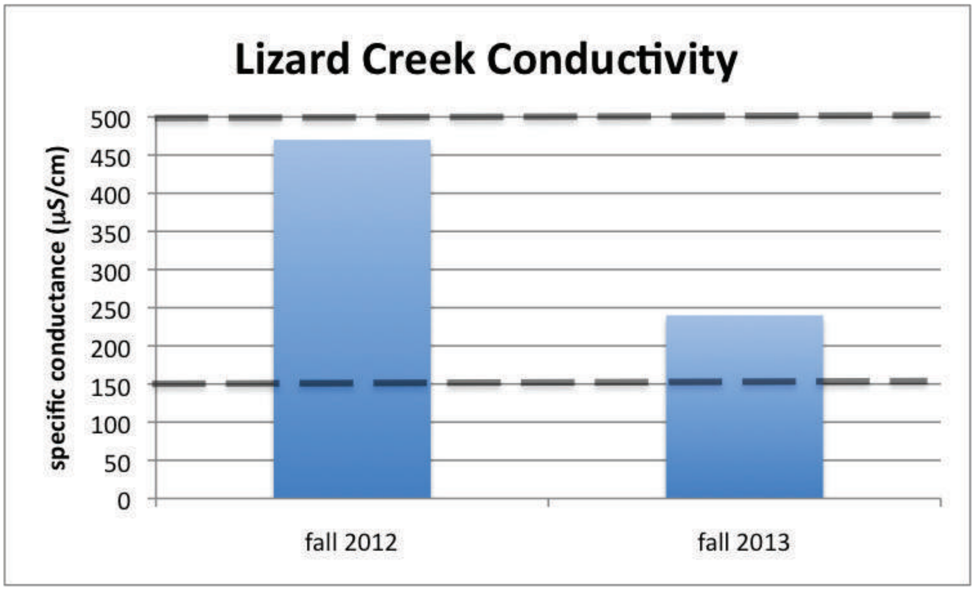

FIGURE 27.
Lizard Creek specific conductance relative to typical values in healthy streams 150-500 µS/cm (Behar, 1997), results from 240-470 µS/cm

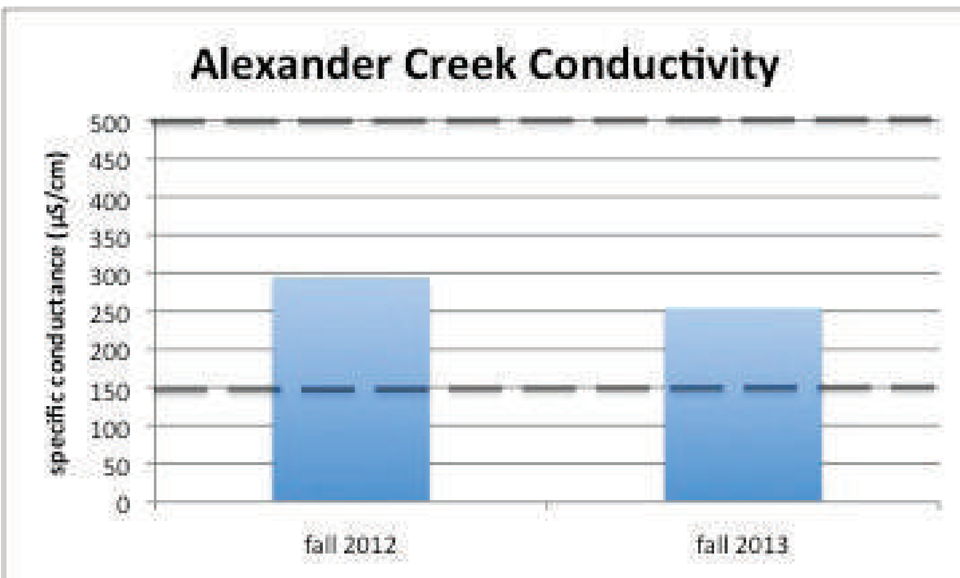

FIGURE 28.
Alexander Creek specific conductance relative to typical values in healthy streams 150-500 µS/cm (Behar, 1997), results from 254-295 µS/cm

Total metals relative to BC guidelines for aquatic life (where available)

Based on 2012 lab results, first year of CABIN water samples. BC Guidelines are depicted by dashed line and are for aquatic health only (not human drinking water). Therefore, guidelines are designed to maintain healthy aquatic ecosystems. Only elements of concern or those with significant levels relative to BC Guidelines are shown. It is important to consider that these are one-time measurements, and will become more valuable as trends are established. For results of full metal suite, see Appendix C.

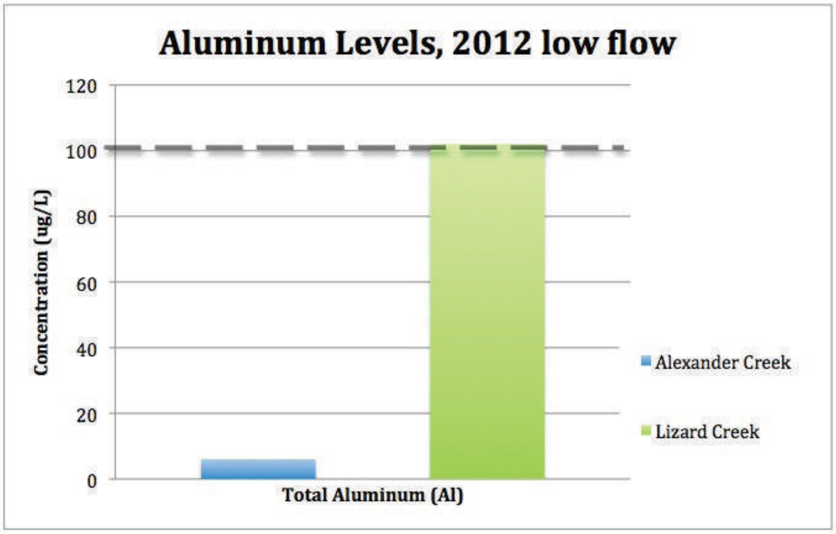

FIGURE 29.
Aluminum levels in Lizard Creek (100 µg/L) and Alexander Creek (6 µg/L) in October 2012, relative to BC maximum guideline for aquatic life (100 µg/L) (Butcher, 1988)

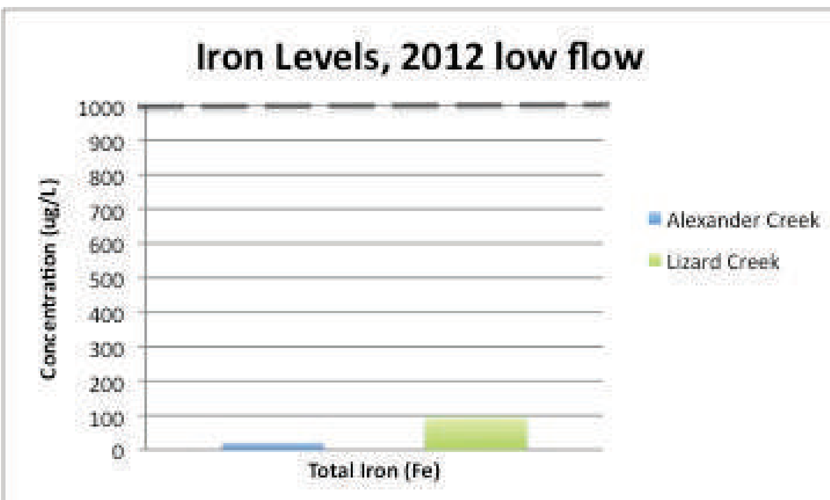

FIGURE 30.
Iron levels in Lizard Creek (21.5 µg/L) and Alexander Creek (92.8 µg/L) in October 2012, relative to BC maximum guideline for aquatic life (1000 µg/L) (Phippen et al., 2008)

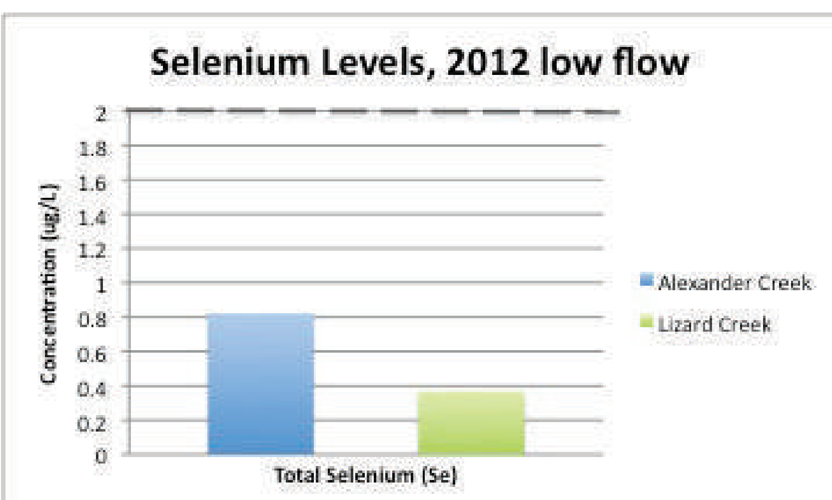

FIGURE 31.
Selenium levels in Lizard Creek (0.37 µg/L) and Alexander Creek (0.82 µg/L) in October 2012, relative to BC maximum guideline for aquatic life (2.0 µg/L) (Nagpal, 2001)

Biological Parameters

Density of Aquatic Macro-Invertebrates

Figures 32 and 33 are estimations of benthic invertebrate density obtained by extrapolating the number of organisms counted in a smaller area (either 0.009 m^2 or 0.27 m^2, depending on the number of samples collected).

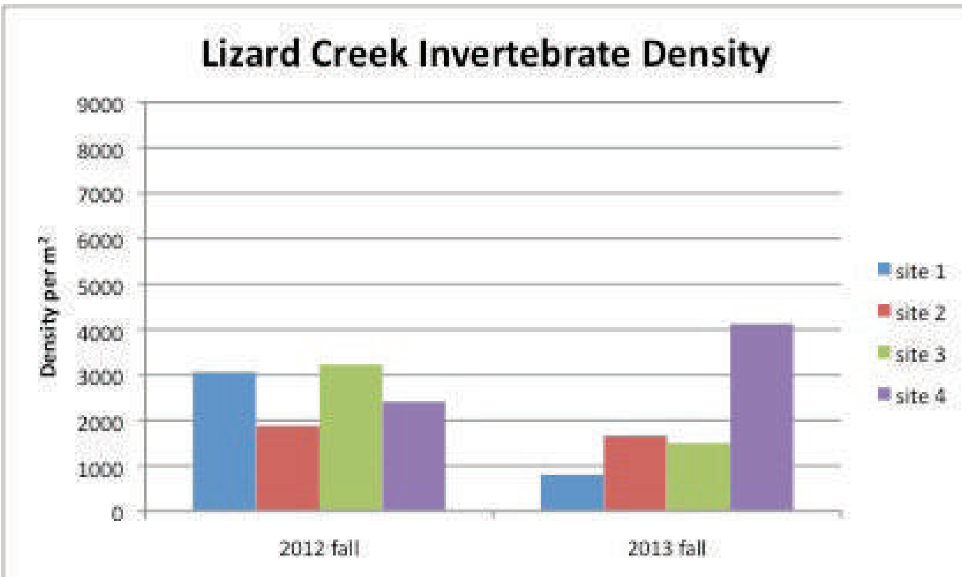

FIGURE 32. Density of macro invertebrate population in Lizard Creek, average of 2333 invertebrates/m^2

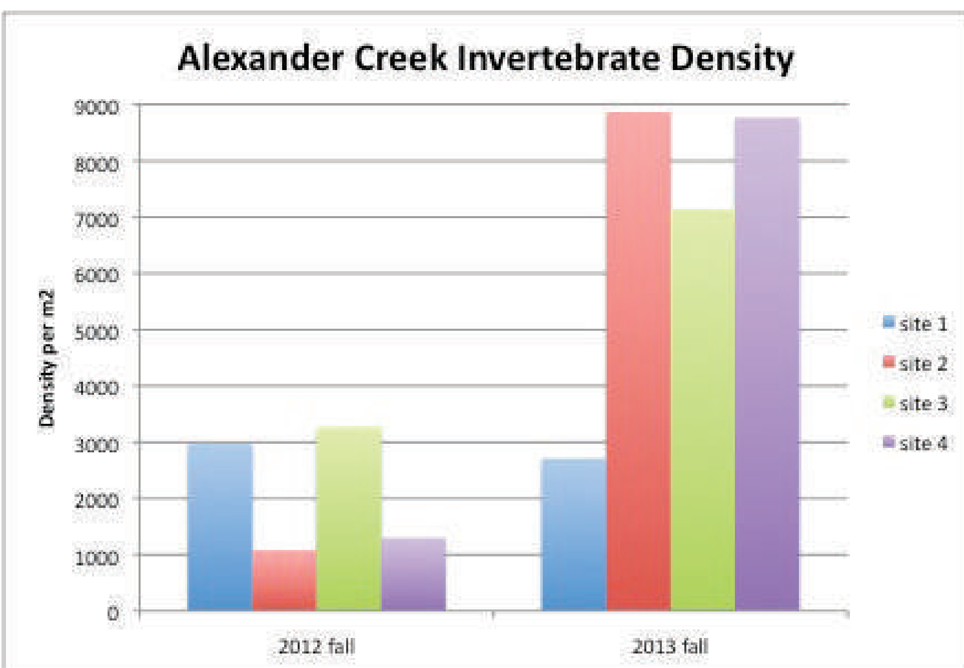

FIGURE 33. Density of macro invertebrate population in Alexander Creek, average of 4512 invertebrates/m^2

Benthic Population—Percentage of Intolerant Organisms

Figures 34 and 35 illustrate the percentage of invertebrates which are highly sensitive to degraded water quality. These numbers are an average at site 1 on both creeks and based on 2012 CABIN results.

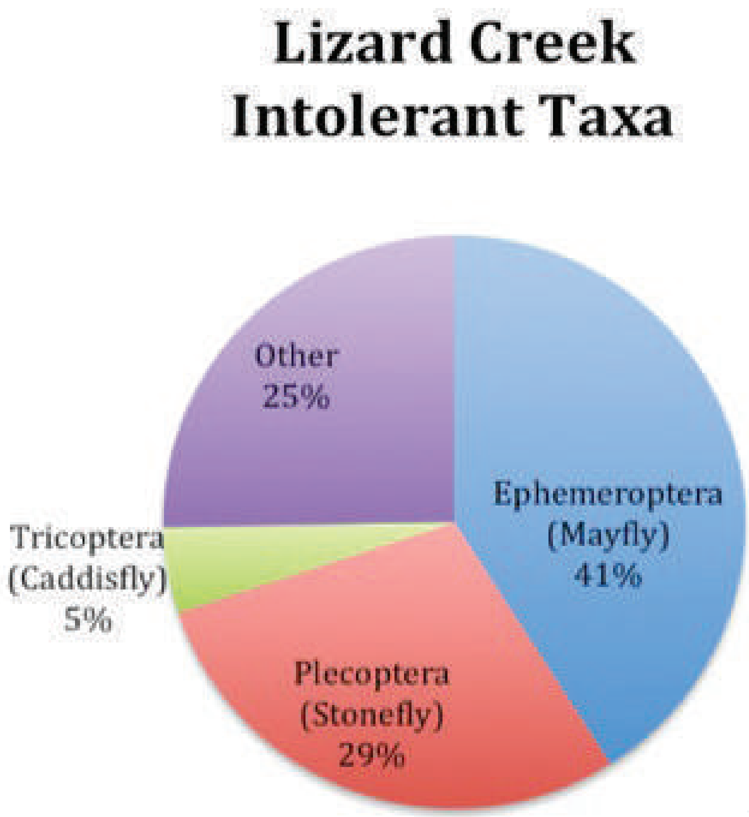

FIGURE 34.
Lizard Creek invertebrate population consisted of 75% intolerant organisms: 41% mayfly nymphs, 29% stonefly nymphs and 5% caddisfly larvae

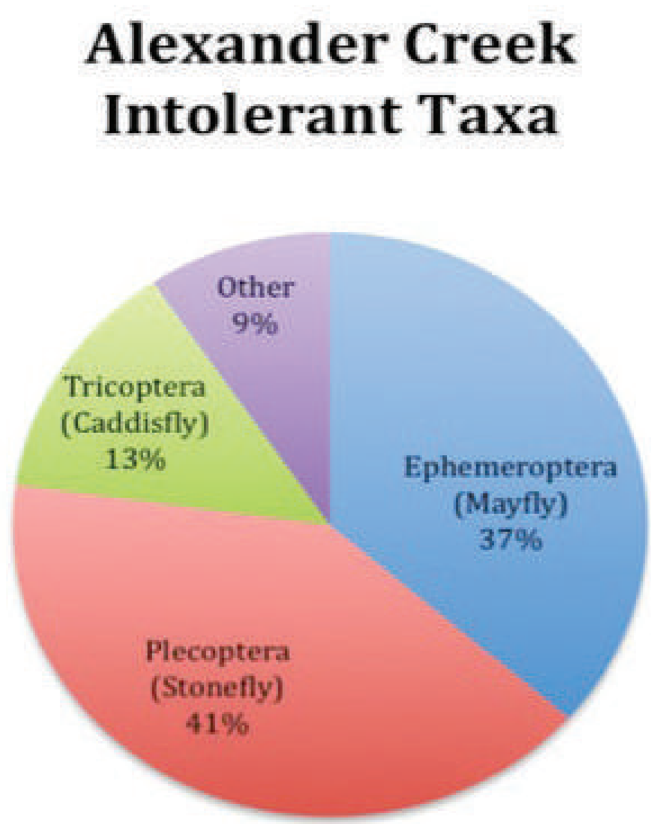

FIGURE 35.
Alexander Creek invertebrate population consisted of 91% intolerant organisms: 37% mayfly nymphs, 41% stonefly nymphs and 13% caddisfly larvae

Figure 36 illustrates the fecal, E. coli and total coliform levels at sites 1 and 4 on both Lizard Creek and Alexander Creek. There is no BC guideline for coliforms to protect aquatic life; however, the recreation with primary contact (i.e. swimming) E. coli maximum is 77/100mL and fecal coliform maximum is 200/100mL (Warrington, 1981)

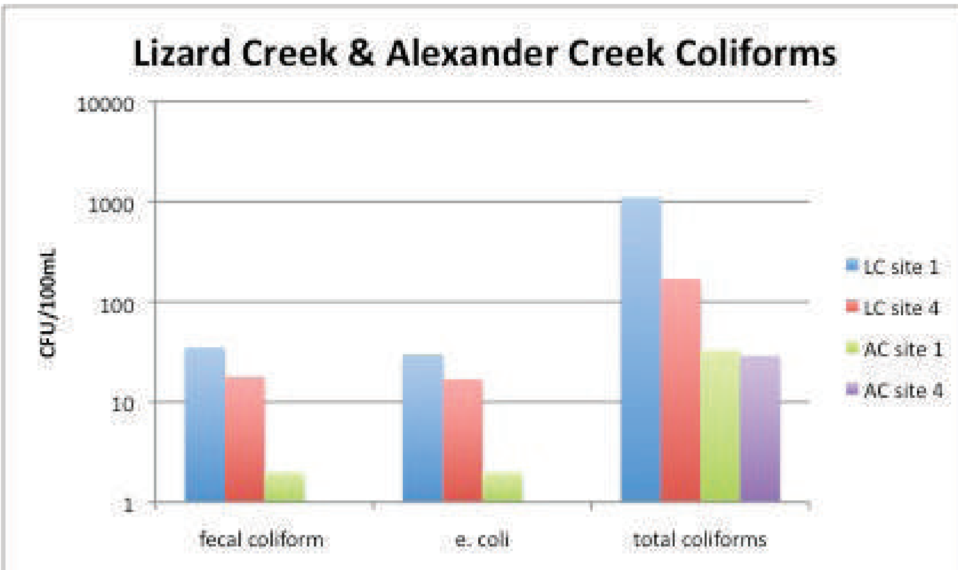

FIGURE 36. Coliform levels, at Lizard Creek site 1 were fecal 35/100mL, e. coli 30/100mL and total 1170/100mL; at Lizard Creek site 4 were fecal 18/100mL, e. coli 17/100mL and total 170/100mL; at Alexander Creek site 1 were fecal 2/100mL, e. coli 2/100mL and total 33/100mL; and, at Alexander Creek site 4 were fecal 1/100mL, e. coli 1/100mL and total 29/100mL

Streamkeepers Results

As previously mentioned, a significant benefit of Streamkeepers monitoring is that on-site assessment results are obtained. The tables below outline the results of Streamkeepers data. The Streamkeepers module is given in brackets

Table 1 - Lizard Creek water quality (module 3)

Water Quality	Spring 2011	Fall 2011	Spring 2012	Fall 2012	Spring 2013	Fall 2013
Site 1	Acceptable	-	Acceptable	Good	Acceptable	Good
Site 2	-	-	Good	Good	Acceptable	Acceptable
Site 3	Acceptable	Good	Good	Good	Acceptable	Acceptable
Site 4	Acceptable	-	Acceptable	Good	Acceptable	Good

Table 2- Alexander Creek water quality (module 3)

Water Quality	Spring 2012	Fall 2012	Spring 2013	Fall 2013
Site 1	Acceptable	-	Good	Good
Site 2	Acceptable	Good	Acceptable	Acceptable
Site 3	Acceptable	Good	-	Good
Site 4	Acceptable	Acceptable	Acceptable	Good

Table 3- Lizard Creek stream habitat survey (module 2)

Habitat Survey	Fall 2011	Fall 2012	Fall 2013
Site 1	-	Acceptable	Acceptable
Site 2	-	Acceptable	-
Site 3	Acceptable	Acceptable	Marginal
Site 4	-	Acceptable	-

Table 4- Alexander Creek stream habitat survey (module 2)

Habitat Survey	Fall 2012	Fall 2013
Site 1	Acceptable	Acceptable
Site 2	Acceptable	-
Site 3	Acceptable	Acceptable
Site 4	Marginal	-

Table 5- Lizard Creek invertebrate survey (module 4)

Invertebrate Survey	Fall 2011	Fall 2012	Fall 2013
Site 1	-	Acceptable	Good
Site 2	-	Acceptable	Acceptable
Site 3	Acceptable	Acceptable	Acceptable
Site 4	-	Acceptable	Acceptable

Table 6- Alexander Creek invertebrate survey (module 4)

Invertebrate Survey	Fall 2012	Fall 2013
Site 1	Acceptable	Acceptable
Site 2	Acceptable	Acceptable
Site 3	Acceptable	Acceptable
Site 4	Acceptable	Acceptable

Discussion of Results

Physical Parameters

The peak water temperature measured in Lizard Creek was 12.5°C, and in Alexander Creek was 9°C. The majority of temperature measurements fall within the ideal range of 5-13°C, where fish are less likely to contract diseases (Taccogna & Munro, 1995). They are also well below the BC maximum guideline for aquatic life in freshwater streams with bull trout, which is 15°C (Oliver & Fidler, 2001). During low flow monitoring in October 2013, water temperatures were below 5°C. In these conditions, trout will seek over-wintering habitat in deep, slow moving pools. It is possible that summer temperatures could exceed 13°C, but thus far, monitoring has not been conducted in July and August, which are typically the hottest months in the Kootenays. One possible improvement for comprehensive temperature data would be more frequent temperature measurements, especially on hot summer days.

Turbidity measurements are extremely variable between high and low flow monitoring periods. Measurements range from 3 to 25 JTU (≈NTU) during high flow. The BC guidelines for aquatic life are a maximum "change from background of 5 NTU at anytime when background is 8-50 NTU during high flows or in turbid waters" (Singleton, 1981). To establish whether guidelines are being exceeded, more continuous monitoring would be required. During low flow, turbidity is negligible and typically ranges from 0-3 JTU.

Other general stream characteristics are also examined during ERA's CBWM. These include: amount of erosion; canopy and in-stream vegetative coverage; in stream and off-channel habitat; stream discharge; substrate (aka streambed) composition and embededness; site slope; as well as, percentage of pools. Many of these parameters are assessed in Streamkeepers module 2, the advanced stream habitat survey.

Chemical Parameters

Dissolved oxygen values are generally 10-11 mg/L in both Lizard and Alexander Creeks. This is well above the BC instantaneous minimum guideline for most aquatic life of 5mg/L, as well as the BC 30-day mean minimum guideline of 8 mg/L (Fast, 1997). It is important to note that BC guidelines for buried embryo/alevin (immature fish) stages is an instantaneous minimum of 9 mg/L and 30-day mean minimum of 11 mg/L. Oxygen saturation is dependent on temperature and varies from approximately 60-110% during high flow and 70-100% during low flow monitoring.

The pH values obtained during monitoring vary greatly as the equipment used has changed. Initially, a LaMotte pH kit was used. This method was deemed unreliable and prone to human error/bias. Currently, ERA is using an Oakton pH Tester30 meter, which is much more accurate. The pH values obtained are quite high, ranging from 8.4-8.9 in Lizard Creek and from 8.6-8.7 in Alexander Creek, with averages of ~8.6 for both creeks. However, this is likely due to the surrounding geology (abundant limestone) so aquatic life will be well adapted to these conditions. In fact, the normal pH range in the Southern Rocky Mountains is 7.5-8.8 (McKean & Nagpal, 1991). The BC maximum guideline for the protection of aquatic life is 9.0. Therefore both sites are within the guideline.

The conductivity values, or specific conductance, of both Lizard Creek and Alexander Creek fell within the typical values for healthy streams of 150-500 µS/cm (Behar, 1997). Specific conductance was measured during CABIN monitoring in fall of 2012 and 2013. The values for Lizard Creek were 240 and 470 µS/cm. The values for Alexander Creek were 254 and 295 µS/cm.

With only one exception, all metals measured were significantly below the BC maximum guideline for aquatic health (where such guidelines exist). The exception was the Lizard Creek aluminium level in fall of 2012, which was measured at 102 µg/L (2 µg/L above the guideline). Elevated aluminium is most likely due to the local geology; however, could also be attributed to lab error (Stickney, 2013). To assess whether high aluminium is an issue in Lizard Creek, more water samples are required.

Biological Parameters

Both Lizard and Alexander Creeks demonstrate abundant macro-invertebrate populations. In some cases, diversity may be lacking; however, the presence of benthic invertebrates sensitive to pollution (intolerant taxa) is indicative of stream health. These indicator invertebrates are the mayfly nymph (*Ephemeroptera*), stonefly nymph (*Plecoptera*) and caddisfly (*Trichoptera*) species. According to CABIN standards, both Lizard and

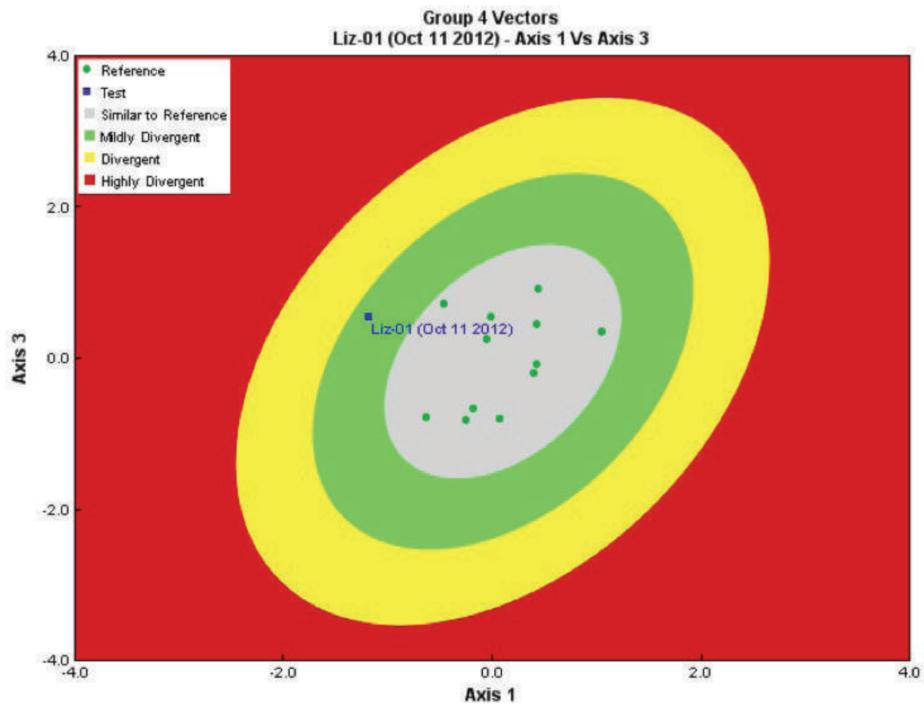

FIGURE 37. Lizard Creek site 1 relative to comparable reference sites

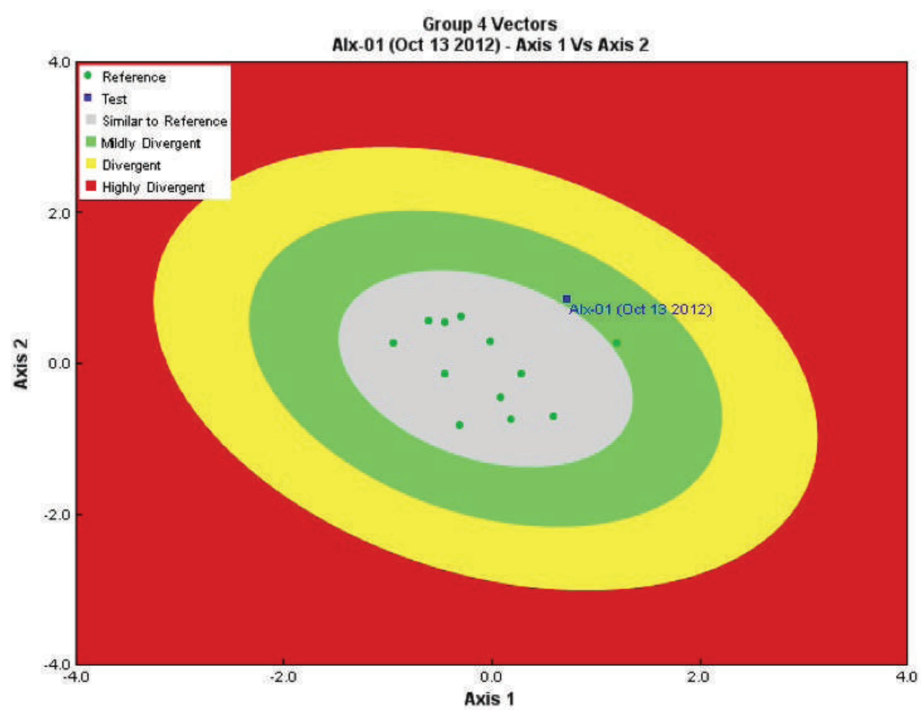

FIGURE 38. Alexander Creek site 1 relative to comparable reference sites

Alexander Creeks are considered 'mildly divergent' from reference sites. See detailed 2012 CABIN reports in Appendices D and E for Lizard and Alexander, respectively. This implies that the two test sites were slightly outside of the range of expected results of the benthic invertebrate community. Reference sites used in this analysis have negligible human impacts; therefore, benthic communities on Lizard and Alexander differ slightly from pristine streams, without human influence. This implies that human activities are impacting the macro-invertebrate populations.

There are no BC guidelines for coliform levels for aquatic health. However, for recreation with primary contact (i.e. swimming) E. coli maximum is 77/100mL and the fecal coliform maximum is 200/100mL (Warrington, 1981). Both Lizard and Alexander Creek are well below limits and recommendations for fecal coliforms and E. coli. In 2012, Lizard Creek site 1 was high in total coliforms (1170/100mL) compared to Alexander Creek site 1 (33/100mL). However, these coliforms may be naturally occurring from plant matter and are unlikely to be detrimental to aquatic health.

Conclusions & Recommendations

It is important to note that the data collected and shared in this report only give a snapshot of stream conditions and health. These aquatic environments are dynamic and ever changing. For this reason, long-term monitoring is essential to establish and monitor trends, which will give more significance to results. All results could be improved with more frequent monitoring. Therefore, if resources are available in 2014, ERA will conduct monthly water quality monitoring on one or two sites from May-October to improve continuity of data.

What's next?

The Elk River Alliance will continue to assess stream health at the 8 established monitoring sites on Lizard and Alexander Creeks, seeking opportunities and determining priorities for stream restoration/enhancement activities. Once a potential restoration site or enhancement activity is established, ERA will seek funding sources and professional advice to complete the project.

ERA is currently exploring the possibility of changing the fishing classification of Lizard Creek as rearing habitat to protect and enhance the native westslope cutthroat trout spawning in this stream. This action was initiated when Streamkeepers noticed the abundant cutthroat fry in Lizard Creek and its tributaries.

Future Community-Based Monitoring

Ultimately, ERA strives to provide water-monitoring data that may be used in decision-making: for example, municipal official community planning, approval for land use changes, and in the development of a comprehensive watershed management strategy for the Elk Valley. Therefore, ERA will continue to develop, improve and expand monitoring efforts locally.

Since the pilot study on Lizard Creek in 2011, the Elk River Alliance has expanded quality and quantity data, as well as geographical reach. Data has been improved through the addition of CABIN protocols, which may increase the value of the data collected by ERA to government and other regulatory agencies. The CABIN methods encourage a strict adherence to Quality Assurance/Quality Control requirements and provide thorough training courses, which combine online modules with in-field training. The Ministry of Environment (MoE) currently uses these methods; however the MoE Fisheries Information Summary System (FISS) report contains data gaps, especially in the areas of resource use, values and sensitivities, as well as land use, fisheries potentials and constraints. Adding lower Alexander Creek to the study allows for comparing and contrasting data in a meaningful way to examine differences and similarities of streams in the Elk River watershed.

The Columbia Basin Watershed Network hosts a water monitoring and information-sharing database employing CABIN methods. In the future, ERA seeks to add data to this website as well, believing strongly in the public's right to know about their water and increasing community water literacy. Currently, data is hosted on ERA's website (www.elkriveralliance.ca), the Community Mapping Network's online SHIM atlas (www.cmnmaps.ca/ELKVALLEY/), as well as the Pacific Streamkeepers Federation website (http://www.streamkeepers.info/).

Community water monitoring efforts are viewed as an important water literacy tool. These efforts are fulfilling ERA's stated goals to build community water literacy and ease public access to data. The next step will be to encourage decision makers to incorporate this information in sustainable water decision-making in the Elk Valley.

Community-based water monitoring has the potential to fill existing data gaps and contribute to baseline information, provided that this data is accepted as scientifically robust.

Citizens are using many of the same scientifically defensible research protocols to gather data as decision makers… Decision makers recognize a lack of data not only on water quality but risk assessment of watershed activity and resulting impacts, but note that citizen data would only be valuable if they use standard protocols, a central database for storing data and have their techniques regularly audited for Quality Assurance/Quality Control.

(Walker, 2009, p. 20)

Please direct all questions and feedback to
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Appendix A: Complete description of methods

The following elements were measured as per Streamkeepers, CABIN or SHIM protocols; however, they are not necessarily discussed in the report body.

Physical Parameters

Temperature

Water temperature is measured by submerging a thermometer, or pH meter for a minimum of 2 minutes. It is important to measure temperature in a shady area of the stream so the meter is not influenced directly by the sun. Air temperature is measured by suspending a thermometer in the shade close to the stream for a minimum of 2 minutes.

Turbidity

Turbidity is measured using a LaMotte turbidity kit. A sample of stream water is compared to distilled/tap water to assess a difference in clarity. If the stream water appears more turbid, a solution is added by 5 mL increments to the tap water until the two samples are the same cloudiness. The turbidity value of the stream sample is calculated based on how much solution was added to the tap water sample.

Stream Width and Depth

A series of channel profiles were measured along survey length, including at all monitoring sites. Wetted widths and depths are calculated based on actual water present. Bankfull widths and depths are measured by projecting maximums based on 2-year flood event evidence.

Flow Velocity and Discharge

Two different methods were used to determine flow. The first, using Streamkeepers protocols involves measuring a distance of 10 metres along the stream bank. A tennis ball is placed into the water at the upstream end and its journey is timed. This exercise was repeated a minimum of 3 times, and an average velocity was calculated. CABIN protocols use a wooden meter stick. The depths of water are measured with the stick both parallel and perpendicular to flow. This gives the 'flowing water depth' (wide side of meter stick parallel to flow) and the 'depth of stagnation' (wide side of meter stick perpendicular to flow, so water piles up). The difference between these two depths is input into a formula to calculate velocity.

Discharge is calculated by multiplying wetted area (wetted width x average wetted depth) by average flow velocity and a correction factor of 0.8, according to Streamkeepers protocols. Discharge was calculated to be between 0.69 and 1.00 meters cubed per second, average discharge being 0.82 cubic meters per second.

Streambed Substrate

Streambed substrate composition was estimated based on both Streamkeepers and CABIN protocols. Streamkeepers methods involve measuring the diameter of 25 particles at each site. CABIN protocols also involve measuring diameters but the sample size is 100. Both methods also include a measurement of embeddedness, which can illustrate the amount of interstitial space (open space between substrate material) that aquatic organisms can occupy.

Riparian Vegetation

According to SHIM standards, a cross-sectional survey was performed at each monitoring site and riparian zone characteristics were recorded.

Chemical Parameters

Dissolved Oxygen

A Hach test kit is used to determine the dissolved oxygen (DO) levels in mg/L. This test involves taking a water sample from within the stream (ensuring the sample is free of air bubbles) and adding a series of reagents which change the colour of the sample. Lastly, a titration of sodium thiosulfate is performed on 10 mL of the sample until it is clear. The amount of drops required in the titration corresponds to the DO levels in mg/L. To calculate oxygen saturation according to Streamkeepers protocols, an oxygen saturation chart is used which compares stream water temperature to DO concentration in mg/L and establishes percent saturation.

pH

Originally, pH was measured using a LaMotte pH kit. However, this method was deemed unreliable, as it is highly prone to human bias. Therefore, a pH meter (Oakton Testr30) was purchased and is now used for all pH measurements.

Conductivity

A conductivity meter was purchased as conductivity measurements are a recommended component of CABIN monitoring.

Metals

A water sample was submitted to lab to conduct a full metals suite. Details are in Appendix C.

Biological Parameters

Benthic Macro-Invertebrates

Macro-invertebrate populations are assessed differently in Streamkeepers and CABIN protocols. In Streamkeepers, usually 3 samples are taken at each site. Using a D-net and rubbing rocks in a 30cm by 30cm area directly upstream of the net obtain samples. The invertebrate population is then analysed on site and invertebrates are released. For CABIN invertebrate samples, the invertebrates are obtained using a 3-minute kick netting technique. The invertebrates are then preserved and sent to a lab for analysis.

Coliform Bacteria

Coliforms are also assessed by sending a water sample to the lab. The sample must be preserved and received by the lab within 24 hours of taking the sample.

Appendix B: Complete results of CBWM data

Lizard Creek data

** separate document**

"CBWN report results" worksheets: LC-1, LC-2, LC-3, LC-4

Alexander Creek data

** separate document**

"CBWN report results" worksheets: AC-1, AC-2, AC-3, AC-4

Appendix C: Full metals suite/lab results

Fall 2012—Metals suite

CSR TOTAL METALS IN WATER (WATER)

Maxxam ID		EU4124		EU4129		
Sampling Date		2012/10/13 15:00		2012/10/18 08:00		
	UNITS	**ALX-01-2**	**QC Batch**	**LIZ-01-3**	**RDL**	**QC Batch**
Calculated Parameters						
Total Hardness (CaCO3)	mg/L	178	6273962	274	0.50	6273962
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	6.0	6277813	102	3.0	6280953
Total Antimony (Sb)	ug/L	<0.50	6277813	<0.50	0.50	6280953
Total Arsenic (As)	ug/L	0.14	6277813	0.20	0.10	6280953
Total Barium (Ba)	ug/L	71.4	6277813	67.8	1.0	6280953
Total Beryllium (Be)	ug/L	<0.10	6277813	<0.10	0.10	6280953
Total Bismuth (Bi)	ug/L	<1.0	6277813	<1.0	1.0	6280953
Total Boron (B)	ug/L	<50	6277813	<50	50	6280953
Total Cadmium (Cd)	ug/L	<0.010	6277813	0.021	0.010	6280953
Total Chromium (Cr)	ug/L	<1.0	6277813	<1.0	1.0	6280953
Total Cobalt (Co)	ug/L	<0.50	6277813	<0.50	0.50	6280953
Total Copper (Cu)	ug/L	0.24	6277813	0.56	0.20	6280953
Total Iron (Fe)	ug/L	21.5	6277813	92.8	5.0	6280953
Total Lead (Pb)	ug/L	<0.20	6277813	<0.20	0.20	6280953
Total Lithium (Li)	ug/L	<5.0	6277813	<5.0	5.0	6280953
Total Manganese (Mn)	ug/L	1.8	6277813	5.7	1.0	6280953
Total Mercury (Hg)	ug/L	<0.050	6277813	<0.050	0.050	6280953
Total Molybdenum (Mo)	ug/L	<1.0	6277813	1.5	1.0	6280953
Total Nickel (Ni)	ug/L	<1.0	6277813	<1.0	1.0	6280953
Total Selenium (Se)	ug/L	0.82	6277813	0.37	0.10	6280953
Total Silicon (Si)	ug/L	2270	6277813	2650	100	6280953
Total Silver (Ag)	ug/L	<0.020	6277813	0.022	0.020	6280953
Total Strontium (Sr)	ug/L	129	6277813	1160	1.0	6280953
Total Thallium (Tl)	ug/L	<0.050	6277813	<0.050	0.050	6280953
Total Tin (Sn)	ug/L	<5.0	6277813	<5.0(1)	5.0	6280953
Total Titanium (Ti)	ug/L	<5.0	6277813	<5.0(1)	5.0	6280953
Total Uranium (U)	ug/L	0.66	6277813	0.34	0.10	6280953
Total Vanadium (V)	ug/L	<5.0	6277813	<5.0	5.0	6280953
Total Zinc (Zn)	ug/L	<5.0	6277813	<5.0	5.0	6280953
Total Zirconium (Zr)	ug/L	<0.50	6277813	<0.50	0.50	6280953
Total Calcium (Ca)	mg/L	48.4	6273965	78.8	0.050	6273965
Total Magnesium (Mg)	mg/L	14.0	6273965	18.8	0.050	6273965
Total Potassium (K)	mg/L	0.428	6273965	0.459	0.050	6273965
Total Sodium (Na)	mg/L	1.93	6273965	1.53	0.050	6273965

Fall 2012—chemical analyses

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		EU4123	EU4125	EU4126	EU4127	EU4128	EU4130		
Sampling Date		2012/10/13 15:00	2012/10/13 15:00	2012/10/13 15:00	2012/10/18 08:00	2012/10/18 08:00	2012/10/18 08:00		
	UNITS	**ALX-01-1**	**ALX-01-3**	**ALX-01-4**	**LIZ-01-1**	**LIZ-01-2**	**LIZ-01-4**	**RDL**	**QC Batch**
ANIONS									
Nitrite (N)	mg/L	<0.0050(1)			<0.0050			0.0050	6274348
Calculated Parameters									
Nitrate (N)	mg/L	<0.020			0.148			0.020	6273958
Misc. Inorganics									
Alkalinity (Total as CaCO3)	mg/L			153			131	0.50	6279823
Alkalinity (PP as CaCO3)	mg/L			<0.50			<0.50	0.50	6279823
Bicarbonate (HCO3)	mg/L			187			159	0.50	6279823
Carbonate (CO3)	mg/L			<0.50			<0.50	0.50	6279823
Hydroxide (OH)	mg/L			<0.50			<0.50	0.50	6279823
Nutrients									
Nitrate plus Nitrite (N)	mg/L	<0.020(1)			0.148			0.020	6274345
Total Phosphorus (P)	mg/L		<0.0050			0.0214		0.0050	6286848

Spring 2013—chemical analyses

RESULTS OF CHEMICAL ANALYSES OF WATER							
Maxxam ID		GT5562	GT5563	GS1271	GS1272		
Sampling Date		6/25/2013 18:30	6/25/2013 19:10	6/18/2013 14:08	6/18/2013 12:11		
COC Number		G071521	G071521	G085248	G085248		
	UNITS	**LIZ-01-1**	**LIZ-04-1**	**ALX-01-1**	**ALX-04-1**	**RDL**	**QC Batch**
ANIONS							
Nitrite (N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	6944722
Calculated Parameters							
Nitrate (N)	mg/L	0.128	0.165	<0.020	<0.020	0.020	6937464
Nutrients							
Nitrate plus Nitrite (N)	mg/L	0.128	0.165	<0.020	<0.020	0.020	6946003
Total Phosphorus (P)	mg/L	0.0551	0.0333	0.0102	0.0111	0.0050	6944714
Physical Properties							
Total Suspended Solids	mg/L	23.8	7.3	4.5	4.0	4.0	6946519
RDL = Reportable Detection Limit							
EDL = Estimated Detection Limit							

Fall 2013—chemical analyses

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HY8286		HY8287	HY8288	HY8289		
Sampling Date		2013/10/29 14:15		2013/10/29 14:00	2013/10/29 16:30	2013/10/29 16:00		
COC Number		A115146		A115146	A115146	A115146		
	UNITS	**ALX-01**	**QC Batch**	**ALX-04**	**LIZ-01**	**LIZ-04**	**RDL**	**QC Batch**
Calculated Parameters								
Dissolved Nitrate (NO3)	mg/L	0.16	7255014	0.13	0.045	0.31	0.013	7255014
Nitrate plus Nitrite (N)	mg/L	0.035	7255015	0.030	0.010	0.071	0.0030	7255579
Dissolved Nitrite (NO2)	mg/L	<0.0099	7255014	<0.0099	<0.0099	<0.0099	0.0099	7255014
Misc. Inorganics								
Total Suspended Solids	mg/L	<1.0	7258839	1.3	<1.0	<1.0	1.0	7258839
Microbiological Param.								
E.Coli DST	mpn/100mL	<1.0	7256269	<1.0	3.0	5.2	1.0	7256269
Total Coliforms DST	mpn/100mL	31	7256269	31	75	130	1.0	7256269
Nutrients								
Total Phosphorus (P)	mg/L	<0.0030	7263018	<0.0030	0.0061	0.0099	0.0030	7263018
Dissolved Nitrite (N)	mg/L	<0.0030	7259001	<0.0030	<0.0030	<0.0030	0.0030	7259001
Dissolved Nitrate (N)	mg/L	0.035	7259001	0.030	0.010	0.071	0.0030	7259001

RDL = Reportable Detection Limit

Appendix D: Lizard Creek CABIN report

★★separate document★★

"CABINreportLC"

Appendix E: Alexander Creek CABIN report

★★separate document★★

"CABINreportAC"