Teck

Teck Coal Environmental Office
Bag Service 2000, 421 Pine Avenue
Sparwood, B.C. Canada V0B 2G0

+1 250 425 3331 Tel
www.teck.com

Technical Report Overview

Report: 2018 Calcite Monitoring Program Annual Report and Program Assessment

Overview: This report presents the 2018 results of the calcite monitoring program required under Permit 107517. This report summarizes the degree and extent of calcite formation in specific stream reaches within the Elk Valley watershed.

This report was prepared for Teck by Lotic Environmental Ltd.

For More Information

If you have questions regarding this report, please:

• Phone toll-free to 1.855.806.6854

• Email **feedbackteckcoal@teck.com**

Future studies will be made available at **teck.com/elkvalley**

Teck Coal Ltd.
2018 Calcite Monitoring Program Annual Report and Program Assessment

Elk Valley

April 2019

Prepared by

Lotic Environmental Ltd.
2193 Mazur Road
Cranbrook BC
V1C 6V9

Suggested citation

Smithson, J., Robinson, M.D. and K. Baranowska. 2019. Teck Coal Ltd – Elk Valley 2018 Calcite Monitoring Program Annual Report and Program Assessment. Prepared for Teck Coal Ltd. by Lotic Environmental Ltd. 30 pp + appendices.

On behalf of Lotic Environmental,

Mike Robinson MSc, RPBio
Senior Aquatic Ecologist
mike.robinson@lotic.co

Acknowledgements

We would like to thank Cait Good, Allison Ferguson, Carlie Meyer, and Daniel Bairos for their involvement in this program and in particular with reviewing the initial work plans, field work, and final site selection.

Table of Contents

List of Tables

List of Figures

List of Appendices

Definitions

- Degree – The amount of calcite deposition estimated by the level of concretion.
- Exposed – Stream locations with mine-influenced water. Areas downstream of mining.
- Extent – The spatial coverage of calcite deposition which can be expressed as an area covered at a specific location or linear coverage over a stream profile.
- Habitat unit – A distinct channel unit possessing homogeneous geomorphological characteristics (e.g., riffle, pool, glide, cascade). Also referred to as channel unit or mesohabitat.
- Reach – A relatively homogeneous section of stream in terms of channel morphology, riparian cover and flow (RISC 2001).
- Reference – An area without upstream mining activity.
- Sampling unit – A single unit used to describe a larger entity. For example, a site could be considered the sampling unit for estimating the average calcite coverage over an entire reach.
- Segment - Combines adjacent reaches that have similar calcite indexes identified from previous sampling and have the same exposure to mining.
- Site – A location within a reach where observations of calcite deposition were made. These are replicate observations (sample units) within the treatment unit (reach).

Executive Summary

Teck Coal Ltd. (Teck) continues to conduct an annual Calcite Monitoring Program (the Program) in part to satisfy monitoring and reporting requirements of the Environmental Management Act Permit 107517 (the Permit) (Teck 2014), but also to inform management actions to address calcite formation as per objectives of the Permit. Sampling in 2018 followed the updates made to the Program for 2016 – 2018, which was submitted to the British Columbia (BC) Ministry of Environment and Climate Change Strategy (ENV) and the Environmental Monitoring Committee (EMC) as required by Section 12.2 by the Environmental Management Act Permit 107517 (Robinson and Atherton 2016).

The work plan for 2018 was more extensive than 2016-2017, in that all reaches sampled in 2013-2015 were again sampled in 2018. The work plan for 2016-2017 used a streamlined method based on “stream segments” that used an indicator reach to estimate Calcite Index (*CI*) over a larger area. This was done to assess the appropriateness of the stream segment/indicator reach approach.

The 2018 Program was conducted from October 9 – November 6, 2018. In 2018, a total of 117 reaches and 312 sites were surveyed. This was in comparison to 2017 when a total of 85 indicator reaches and 232 sites were surveyed. A total of 354.2 km of stream segments were assessed and mapped. Calcite distribution observed in 2018 was consistent with previous observations, with the majority of exposed stream kilometers classified as low calcite deposition (i.e. *CI* values from 0.00-0.50) for both main stem and tributary categories. A decreasing trend in the percentage of stream kilometers in both exposed main stem and exposed tributaries in the 0.00-0.50 CI bin appeared to be decreasing with time. This trend was found to be significant for the main stem ($p=0.006$, $df=4$), but not the tributaries ($p=0.13$, $df=4$). The significant decrease in stream kilometers in the main stem was suspected to be producing an increasing trend in the 0.51-1.00 *CI* bin for the main stem. Indeed, this was found to be a significant linear trend ($p=0.003$, $df=4$).

Mann-Kendall analysis was run on all reaches without constant values over the period of record ($N=118$). A total of 22 reaches were found to have significant changes in *CI* over the five year period ($\alpha=0.10$) (19%). This is proportionally similar to the number of significant trends detected in 2017 (12/85 or 14%).

An ANOVA assessment was completed to test for step-wise changes in the data. A total of 42 reaches of the 88 tested in 2018 varied significantly ($\alpha = 0.05$) by *Year* (i.e., 42%). This is higher than the 2017 results where 17/50 reaches assessed produced significant ANOVA results (i.e. 34%). In summary, eleven reaches were found to have significant changes in CI since 2013 in both the Mann-Kendall and the ANOVA assessments

The inter-program comparison showed generally good agreement between three independent sampling programs within Greenhills Creek. This suggests that in this specific watercourse, the number of habitat units sampled and sampling crew members do not significantly affect *CI* values reported. The larger, regional dataset suggests similar results for approximately 60% of the reaches assessed. Clear differences were identified in Michel Creek in all reaches including one reference reach. Differences on the Fording River were identified in 2017 (Smithson *et al.* 2018). Reaches near Fording River Operations have been previously reported to be quite

variable. It is unclear to what extent sampling at a different scale (reach vs. habitat unit) contributes to the reported differences as opposed to detection between sampling crews. This will also be investigated.

A total of 30 reaches are above the 0.5 CI_c Site Performance Objective listed in Permit 107517. Teck is currently working on an update to the Calcite Management Plan due to the Ministry of Environment by July 31, 2019. Results from the Program, including streams with concretion scores above 0.5 will form part of the criteria for informing calcite management associated with section 6.1 of Permit 107517. Teck will continue to work with ENV, EMPR and KNC to update the Calcite Management Plan including stream selection criteria.

1 Introduction

Teck Coal Ltd. (Teck) continues to monitor the occurrence of calcite deposition downstream of its coal mining operations throughout the Elk Valley to support understanding and evaluation of potential effects of calcite on aquatic biota (e.g., benthic invertebrates, periphyton, and fish) and habitat (Teck 2016). Calcite is a calcium carbonate deposit that precipitates out in freshwater streams, and can cause a hardening of the substrate, which can influence components of fish habitat such as benthic invertebrate communities and fish spawning habitat. Open pit mining has been shown to increase the presence in calcite downstream of operations. Teck has been documenting the calcite occurrence in the Elk Valley since 2008 (Berdusco 2009). A formal calcite monitoring program (the Program) was established in 2013 with the objective to monitor the degree and extent of calcite for a three year period (i.e., 2013-2015). In 2015, the Program was re-assessed to determine its effectiveness in monitoring calcite in streams associated with Teck Coal mining operations (Robinson *et al.* 2016). The 2015 re-assessment lead to the current condensed Program (2016 – 2018) where each stream is broken out into segments and sampled accordingly based on historical calcite surveys (Robinson and Atherton 2016). Sampling in 2018 marked the third year under the updated Program, and is re-assessed in this report.

As per Section 9.5 of Environmental Management Act Permit 107517 (the Permit), a 2016 – 2018 study design for this Program was submitted to the British Columbia Ministry of Environment and Climate Change Strategy (ENV) on May 31, 2016. The study design was also provided to the Environmental Monitoring Committee (EMC) as required by Section 12.2 of the Permit. The EMC is a committee made up of members from Teck, Ktunaxa Nation Council (KNC), ENV, Ministry of Energy, Mines and Petroleum Resources (EMPR), Interior Health Authority, and Independent Scientist) which provides technical advice and input on monitoring submissions associated with the Permit. This report is being submitted to fulfill Section 10.7 of the Permit which states:

"*A Calcite Monitoring Annual Report must be submitted to the Director by April 15, of each year following the data collection calendar year.*"

Table 1 outlines the Permit 107517 Section 10.7 annual reporting requirements and which section of this report fulfills each requirement (Smithson et al. 2018). The Program followed the methods outlined in the Teck Coal Ltd 2016 - 2018 Calcite Monitoring Program (Robinson and Atherton 2016) and the amended approval letter (Calcite 2016 study design approval letter, dated October 19, 2016).

This report will also be used to provide data to support Teck's Adaptive Management Plan (Teck 2016) for the monitoring and evaluation phases (Robinson and Atherton 2016). This data will also provide information to aid in the Adaptive Management Plan prioritization of streams for future treatment methods (Robinson and Atherton 2016; Teck 2016).

Table 1. Permit 107517 annual reporting requirements as presented in Smithson et al. (2018).

Requirement Number	Description	Report Section Reference
i	A map of monitoring locations	Appendix 3
ii	A summary of background information on that year's program, including discussion of program modifications relative to previous years	2.1 & 2.5
iii	Results of stream selection reassessment – highlight streams added/removed	2.3 & 2.4
iv	Summary of where sampling followed the methodology in the monitoring plan document, and details where sampling deviated from the approved methodology	3.1
v	Statement of results for the period over which sampling was conducted	3.1
vi	Reference to the raw data, provided as appendices	2.6
vii	General discussion of observations, including summary tables of sites with increasing and decreasing deposition indices	3.1, 3.2
viii	Interpretation of location, extent, and any other observations	3.1
ix	A summary of any QA/QC issues during the year	3.3
x	Recommendations for sites to add, sites to remove, modifications to methodology, monitoring frequency adjustments	5

1.1 *Program Objectives*

The objectives of the Teck 2016 - 2018 *Calcite Monitoring Program* (Robinson and Atherton 2016, Smithson et al. 2018) are:

1. Document the extent and degree of calcite deposition in streams downstream of Teck's coal operations (e.g., streams influenced by mining, calcite treatment, water treatment and in reference streams);
2. Satisfy the requirements for annual calcite monitoring in Environmental Management Act Permit 107517; and,
3. Provide data to support the re-evaluation of Big Question 4 ("Is calcite being managed effectively to meet site performance objectives and protect aquatic ecosystem health?") and specific Key Questions in Teck's Adaptive Management Plan as they relate to calcite.

1.2 *Linkage to Adaptive Management*

As required in Permit 107517 Section 11, Teck has developed an Adaptive Management Plan (AMP) to support implementation of the EVWQP to achieve water quality targets including calcite targets, ensure that human health and the environment are protected and, where necessary, restored, and to facilitate continuous improvement of water quality in the Elk Valley. Following an adaptive management framework, the AMP identifies six Management Questions (MQs) that will be re-evaluated at regular intervals as part of AMP updates throughout EVWQP implementation. Triggers also have been identified for specific MQs, which if reached, initiate action under the AMP Response Framework. The AMP also identifies key uncertainties that need to be reduced to fill gaps in current understanding and support achievement of the EVWQP objectives.

The results presented in this report provide information relevant to one of the six MQs and many of the key uncertainties identified in the AMP. Calcite monitoring data along with data collected from other programs are needed for re-evaluating the answer to MQ 4 ("Is calcite being managed effectively to meet site performance objectives and to protect the aquatic ecosystem?").

Results from this report will be used in the development of calcite triggers. Reaching a trigger, or an answer of "no" or "uncertain" to a Management Question, would lead to action under the Response Framework in the AMP. This report is not the main report for the development of calcite triggers. Progress on calcite trigger development will be reported on in the Calcite Management Plan Update, July 2019.

Calcite monitoring data assist in reducing KU 4.1 ("Are calcite SPOs protective of fish and aquatic life?"), KU 4.2 ("What are the most effective management methods for calcite"), KU 4.3 ("Are there interrelationships with calcite and select constituents of interest in surface water that need to be considered for calcite management?") and KU 4.4 ("Can early-warning trigger (EWTs) be established for calcite that support calcite management?"). Progress on reducing these key uncertainties, and associated learnings, will be described in Annual AMP Reports.

Please refer to the 2018 AMP for more information on the adaptive management framework, the Management Questions, the key uncertainties, the Response Framework, Continuous Improvement, linkages between the AMP and other EVWQP programs, and AMP reporting.

2 Methods

2.1 *Study area*

The study area was defined to include each of Teck's five metallurgical coal mining operations in southern British Columbia (Figure 1). Sites are located throughout the Elk Valley to encompass areas downstream of Fording River Operations (FRO), Greenhills Operations (GHO), Line Creek Operations (LCO), Elkview Operations (EVO), and Coal Mountain Operations (CMO). The downstream study limit was Reach 8 of the Elk River, which extends to Fernie, BC. This study area is consistent with study areas for the 2013 - 2015 calcite monitoring programs.

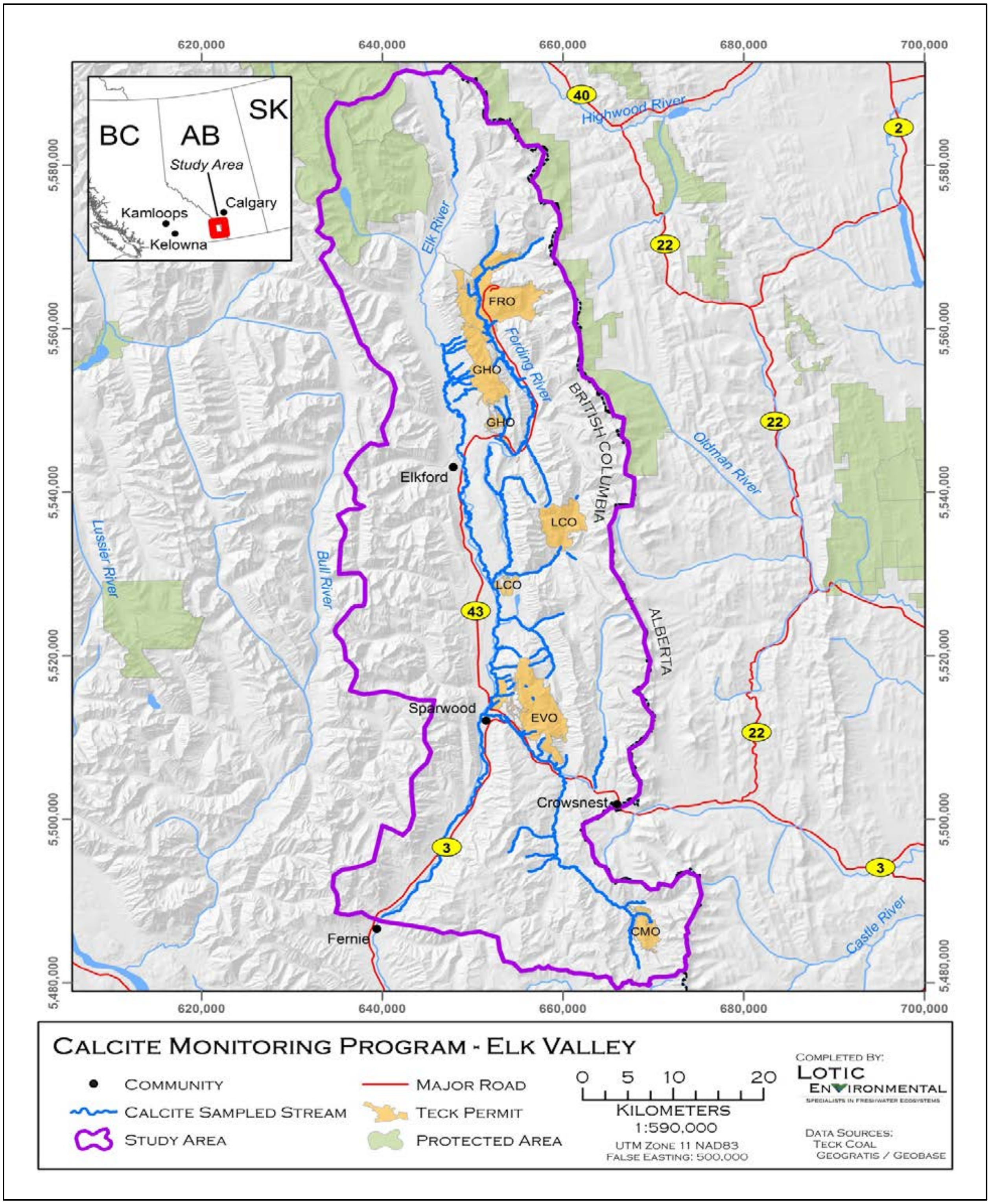


Figure 1. Elk River watershed study area map.

2.2 *Updates for the 2018 Program*

The Program was completed as per the work plan with only minor changes to sites sampled:

- At Fording River Operations (FRO) a new site was created on Lake Mountain Creek (LMOU1-0). LMOU1-0 is located at the outflow of a long culvert that was constructed in 2017, which led to the removal of LMOU1-25. With the current and future waste rock dumping in the upper reaches of Lake Mountain Creek the sites LMOU3-25, 3-50, 3-75, LMOU4-25- 4-50, and 4-75 were all dropped in 2018. Moving forward only LMOU1-0 will be sampled.
- The Swift Creek area of FRO has undergone multiple anthropogenic changes to the stream channel, especially upstream of the settling pond. The crew had noted that much of the substrate appeared new at SWIF2-75 and there was a seep coming out of the ground where calcite was present. Downstream of the historical settling pond a new settling pond was also being constructed.
- At EVO Qualteri Creek and two sites (STR14-50 and STR14-75) on Stream #14 were dry and were not sampled.

2.3 *Additional sampling*

In 2016 and 2017, FORD5-12.5 was added to the sampling as an additional Fording River site downstream of Dry Creek (LCO). FORD5-12.5 was added to monitor potential changes in calcite deposition overtime within the Fording River caused by increasing mining activity in Dry Creek (LCO). The additional sampling of FORD5-12.5 was continued in 2018.

2.4 *Field surveys*

Field survey methods followed those reported in Smithson et al. (2018). Every site had a pebble count completed regardless of calcite presence or absence. The pebble count was a modified Wolman pebble count (Wolman 1954) to quantify the degree of calcite presence using two metrics to calculate a site-specific Calcite Index (*CI)*:

- Calcite presence: $CI_p = Calcite\ Presence\ Score\ = \frac{Number\ of\ pebbles\ with\ calcite}{Number\ of\ pebbles\ counted}$
- Calcite concretion: $CI_c = Calcite\ Concretion\ Score = \frac{Sum\ of\ pebble\ concretion\ scores}{Number\ of\ pebbles\ counted}$
- Calcite index: $CI = Calcite\ Index = CI_p + CI_c$

Results were summarized for four stream categories: (1) Fording and Elk main stems (reference), (2) tributaries (reference), (3) Fording and Elk main stems (exposed), and (4) tributaries (exposed).

The same *CI* ranges or "bins" used in the previous years to report the distribution of *CI* by stream length were used. Six bins of 0.5 *CI* intervals were used to divide the range of *CI* scores from 0.00 – 3.00 (representing low to high calcite levels). Reach mean *CIs* were mapped to depict the spatial distribution of calcite relative to each of the mines, which are presented in Appendix 3.

2.5 *Data analysis*

2.5.1 2018 general distribution

CI values were calculated for all reaches sampled in 2018 and added to the long-term dataset (Appendix 1). The 2018 *CI*, CI_p, and CI_c scores for indicator reaches are presented in Appendix 2. Maps of calcite distribution were prepared to provide a spatial reference to the Program results. Maps show the mean *CI* value for a segment, as calculated at the indicator reach for that segment. Maps are provided in Appendix 3.

2.5.2 Calcite Index, calcite concretion and Permit 107517 Site Performance Objectives

A comparison of the *CI*, CI_p, and CI_c scores was completed in the initial year of this current regional calcite monitoring (2013) to describe the relationships of these metrics, but more importantly to determine what was the appropriate formula for a calcite index (Robinson and MacDonald 2014). To accomplish this, Robinson and MacDonald (2014) assessed the correlation of three calcite metrics collected at the time. The assessment showed strong correlation of CI_p to *CI* at the lower range of *CI* values (>1) and CI_c contributing to the overall *CI* more strongly at *CI* values greater than 1.00. It also demonstrated that concretion is essentially absent at *CI* values less than 0.75-1.00. Teck and the EMC expressed interest in reassessing these relationships to determine if they remain consistent with current data and to understand what level of concretion is expected across CI values. The relationships of the *CI* components where plotted to *CI* and to each other utilizing 2018 data.

The EVWQP (Permit 107517) provides Site Performance Objectives (SPOs) for various water quality related constituents, including calcite. The EVWQP states SPOs for short term (December 31, 2024) and long term (December 31, 2029). The short-term SPO states that "streams that are fish bearing, provide fish habitat or flow directly into fish bearing streams and are not scheduled by an Environmental Assessment Certificate or Mines Act Permit to be buried" must be managed to a CI_c equal to or less than 0.5. This report lists streams with a CI_c greater than 0.5. Teck is currently working on an update to the Calcite Management Plan due to the Ministry of Environment by July 31, 2019. Results from the Program, including streams with concretion scores above 0.5 will form part of the criteria for informing calcite management associated with section 6.1 of Permit 107517. Teck will continue to work with ENV, EMPR and KNC to update the Calcite Management Plan including stream selection criteria.

2.5.3 Rate of change in calcite deposition (Mann-Kendall and ANOVA)

The 2017 annual calcite monitoring report included an assessment of the rate of change in calcite index over time using five variations of three statistical methods (Smithson *et al.* 2018). The five tests ran were: Mann-Kendall – individual reaches; Mann-Kendall – Block design; One-way Analysis of Variance (ANOVA) – Tukey's HSD post-hoc; ANOVA – Contrast of each year against all previous years; and, ANOVA – Contrast of each year against all years (pre and post) excluding the year in question.

An assessment of these statistical methods suggested that Mann-Kendall was an appropriate method to assess for linear trends overtime, with the caveat that the current data set is likely still too short, although improving (Smithson *et al.* 2018). It also suggested that the ANOVA with the Tukey's HSD post-hoc analysis was the most accurate statistical method for assessing step-wise changes within a reach. As such, this report used these two methods to assess changes in *CI* overtime.

In March 2018, the EMC recommended dropping the block design assessment. The block design grouped reaches into categories of historical mine exposure, recent mine exposure, future mine exposure, streams with water treatment, and reference. This assessment had been completed for multiple years and was not considered to be providing any additional insight.

2.5.4 Stream segment assessment

In 2016, stream segments were created by grouping contiguous reaches of similar historical calcite scores and mining exposures (Appendix 6). The segments streamlined the sampling effort and increased the sampling focus on reaches with higher calcite variability (e.g., *CI* = 1.00 – 2.00). Each indicator reach was sampled in both 2016 and 2017 to represent the stream segment, recognizing that calcite presence remains variable throughout the reach and stream segment. In 2018, every reach was sampled regardless of the indicator reach status or stream segment grouping. How well the indicator reach represents calcite deposition throughout all reaches of that segment was evaluated by first qualitatively assessing graphs of all reaches sampled within a segment, and secondarily by testing the effect of reach within each segment (followed by Tukey's post hoc). A significant effect would suggest that at least one reach pairing was significantly different, indicating that the segment may not be grouped appropriately. This assessment was run on segments with multiple reaches and multiple sites within a reach.

2.5.5 Inter-program comparisons

Calcite data have been collected as part of other biological monitoring programs that Teck and it's consulting teams are implementing. The 2017 calcite report included a comparison of calcite values collected in this regional program to those collected in the biological programs (Smithson et al. 2018). A similar comparison was completed with 2018 data. The purpose of inter-program comparison is to assess consistency of methods and results between programs. Also, with the different programs collecting data with some program-specific approaches (i.e., single habitat units versus multi-habitat units) an inter-program comparison may provide a more comprehensive view of spatial variability of the stream over time. In 2018, biological sampling programs were completed by Minnow Environmental and Ecofish Research Ltd along Greenhills Creek and regionally by Minnow Environmental. These data were compared to regional calcite monitoring data collected by Lotic Environmental both within Greenhills Creek and regionally. The comparison began by mapping sample locations of those programs and identifying if those sampling sites were within similar reaches with the regional monitoring locations. Data were then plotted for qualitative comparison and assessed using t-tests to assess for statistical differences.

2.5.6 Data quality assurance

Data quality assurance steps follow that of the earlier Programs (Robinson *et al.* 2016). Quality assurance steps included:

- Having field crews perform calcite measurements at multiple sites as a group during the onset of the Program. The exercise is used to calibrate observers, standardize collection methods, and review changes to the current Program.
- *CI* scores were calculated in the field to compare with previous *CI* scores and determine if additional sampling sites needed to be added.

- A computer script using R Programming Language was written to check that cells were populated with acceptable values (e.g., calcite presence score can only be 0 or 1; concreted scores can only be 0, 1, or 2; concreted score must be 0 if calcite presence is 0). Any cells that had errors or were left blank, flagged, and corrected.

3 Results

3.1 *2018 Calcite Index and general distribution*

The Program was conducted from October 9 – November 6, 2018. In 2018, a total of 117 reaches and 312 sites were surveyed. This was in comparison to 2017 when a total of 85 indicator reaches and 232 sites were surveyed. A total of 354.2 km of stream segments were assessed and mapped. A total of 288 km were considered exposed and downstream of mining activities (Table 2). A total of 66.2 km were considered reference. Results are presented by four stream categories as either main stem Fording River and Elk River sections versus tributaries; and reference versus exposed.

Table 2. Stream calcite distribution (km) estimates for the four stream categories, by *CI* ranges for 2018.

	Reference				***Exposed***			
	Fording and Elk		***Tributaries***		***Fording and Elk***		***Tributaries***	
CI Range	***km***	***%***	***km***	***%***	***km***	***%***	***km***	***%***
0.00 - 0.50	21.8	100%	44.4	100%	114.8	75%	87.5	65%
0.51 - 1.00	0	0%	0	0%	38.2	25%	13.2	10%
1.01 - 1.50	0	0%	0	0%	0	0%	6.9	5%
1.51 - 2.00	0	0%	0	0%	0	0%	5.2	4%
2.01 - 2.50	0	0%	0	0%	0	0%	8.1	6%
2.51 - 3.00	0	0%	0	0%	0	0%	14.2	11%
Total (2018)	**21.8**	**100%**	**44.4**	**100%**	**153.0**	**100%**	**135.0**	**100%**

Calcite distribution observed in 2018 was consistent with previous observations, with the majority of exposed stream kilometers in the 0.00-0.50 *CI* bin for both main stem and tributary categories (Figure 2). Qualitative assessment of trends was also consistent with previous observations in that the percentage of stream kilometers in both exposed main stem and exposed tributaries in the 0.00-0.50 CI bin appeared to be decreasing with time. This trend was found to be significant for the main stem ($p=0.006$, $df=4$), but not the tributaries ($p=0.13$, $df=4$). The significant decrease in stream kilometers in the main stem was suspected to be producing an increasing trend in the 0.51-1.00 *CI* bin for the main stem. Indeed, this was found to be a significant linear trend ($p=0.003$, $df=4$).

Previously 100% of the reference main stem and tributaries stream kilometers had been categorized into the 0.00 - 0.50 *CI* bin (Figure 3). This was observed again in 2018.

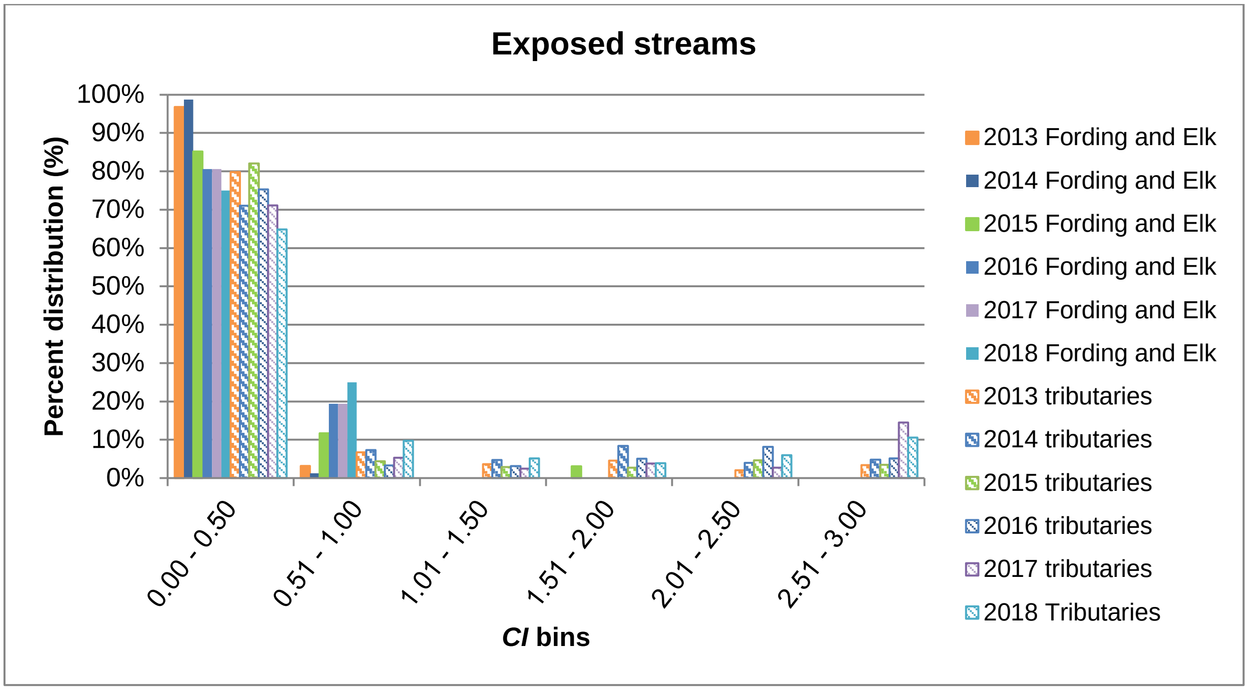


Figure 2. Percent distribution of exposed stream kilometers among *CI* bins by stream category and year (each year sum to 100% for the stream category).

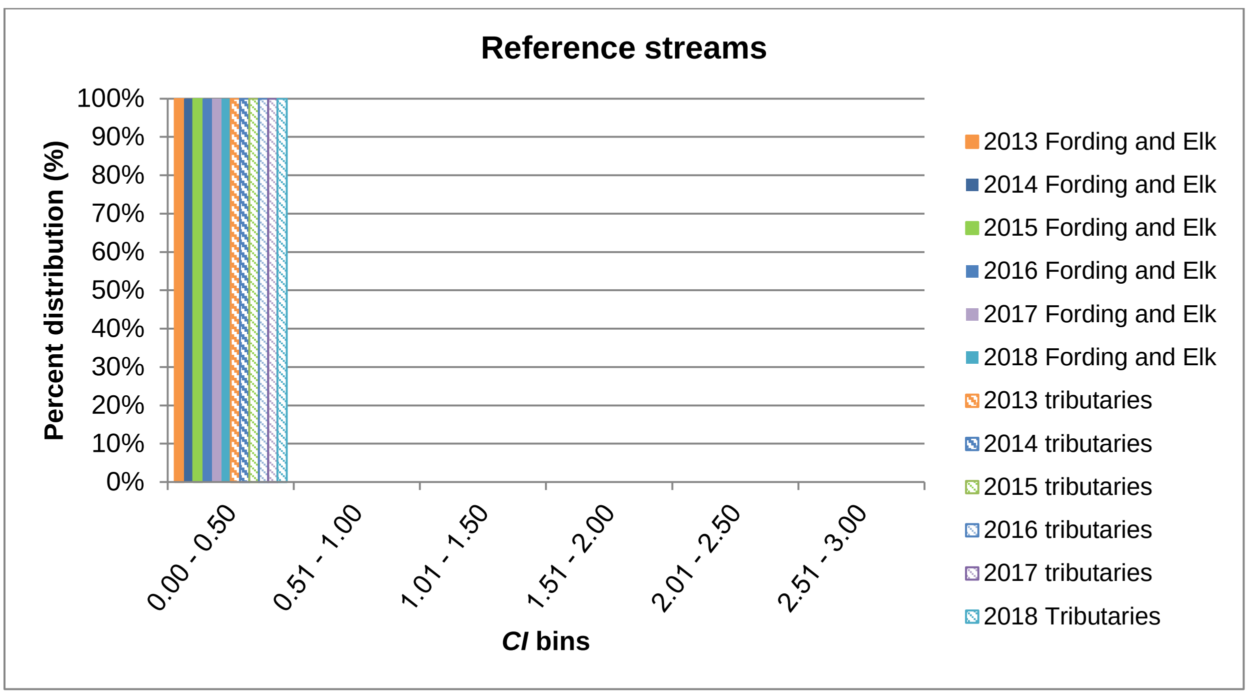


Figure 3. Percent distribution of reference stream kilometers among *CI* bins by stream category and year (each year sum to 100% for the stream category).

3.1.1 Calcite Index, calcite concretion and Permit 107517 Site Performance Objectives

The relationships of *CI* to CI_p and CI_c first reported in 2013 remain consistent with those derived using site-level data from 309 sites sampled in 2018 (Robinson and MacDonald 2014). *CI* scores below 1.00 are largely driven by CI_p (Figure 4). As the maximum CI_p is 1.00, any increase in *CI* beyond that is primarily driven by increased CI_c (Figure 5). The SPO value of 0.5 CI_c again appears not to be met when *CI* approaches the 0.75 level. The plot of CI_p versus CI_c also agrees with previous reports (Figure 6). Concretion does not appear until high levels of calcite presence, suggesting that this is a more advanced state of calcite deposition. However, these plots do indicate that concretion can occur in some lower calcite presence streams. These plots also illustrate the degree to which the SPOs change over time. For example, the 2024 SPO of Cc < 0.5 correlates to approximately CI of 1-1.5 and decreases for an SPO of CI<0.5 in 2029. A total of 30 reaches had CI_c ≥0.5 (Table 3).

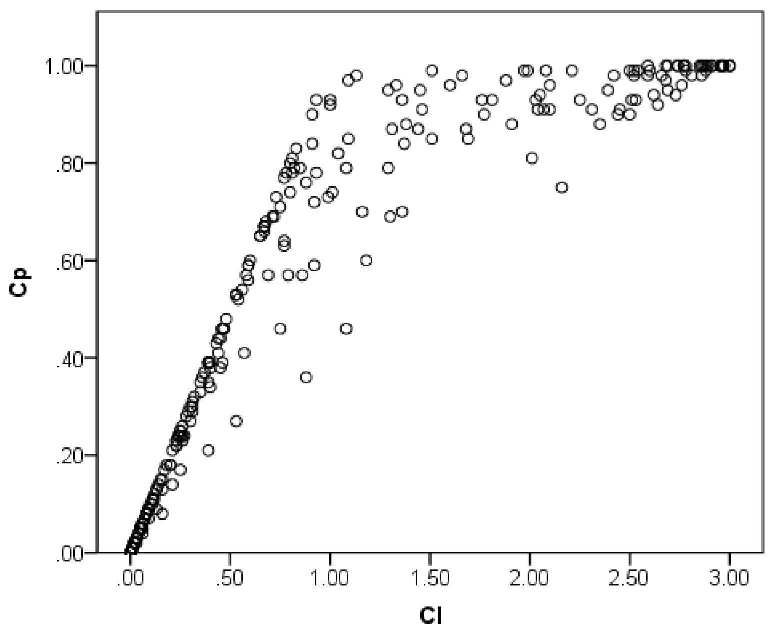


Figure 4. Calcite Index versus calcite presence scores from 2018 data.

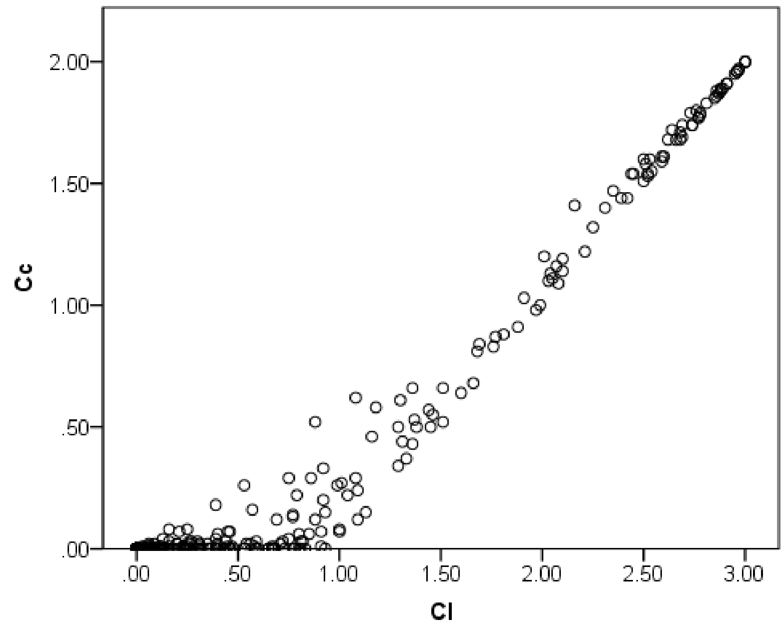


Figure 5. Calcite Index versus calcite concretion scores from 2018 data.

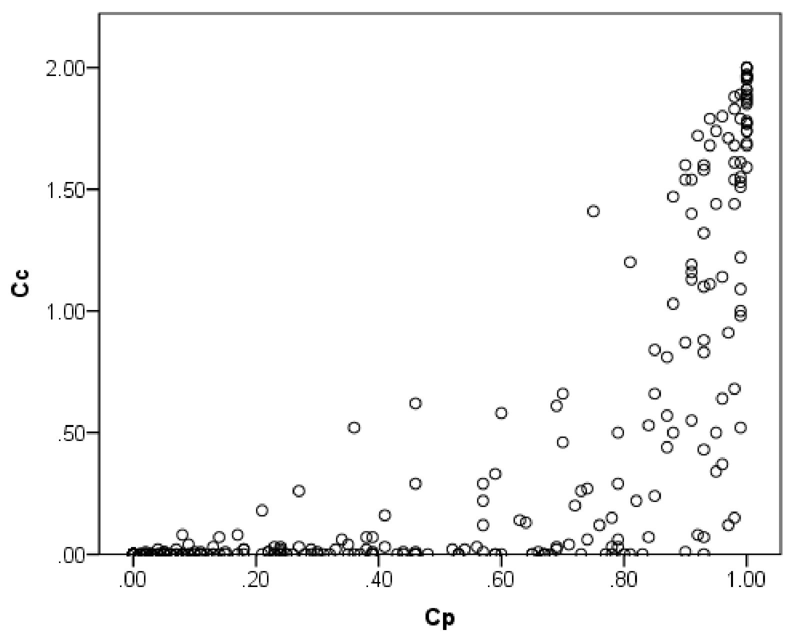


Figure 6. Calcite presence versus calcite concretion scores from 2018.

Table 3. Reaches with mean CI_c ≥0.5.

Stream	Reach	2018 CI_c
Bodie	BODI1	0.64
	BODI3	1.41
Cataract	CATA1	1.96
Clode Outlet Channel	COUT1	0.55
Corbin	CORB1	1.72
	CORB2	1.92
EVO Dry	DRYE1	1.96
	DRYE3	1.76
	DRYE4	2.00
Erickson	ERIC1	1.60
	ERIC2	1.90
	ERIC3	1.95
	ERIC4	0.88
Gate	GATE2	0.55
Goddard	GODD3	1.66
Greenhills	GREE3	1.51
	GREE4	1.75
Kilmarnock	KILM1	1.40
LCO Dry	DRYL1	0.57
Leask	LEAS2	1.61
Mickelson	MICK2	0.58
Milligan	MILL1	0.87
North Thompson	NTHO1	0.96
Porter	PORT3	0.88
Site 18	SITE	2.00
Smith Pond Outlet	SPOU1	1.53
South Pit	SPIT1	0.89
South Wolfram	SWOL1	1.43
Swift	SWIF1	1.16
Wolfram	WOLF3	1.75

3.2 *Rate of change in calcite deposition*

3.2.1 Mann-Kendall

Mann-Kendall analysis was run on all reaches without constant values over the period of record (N=118). A total of 22 reaches were found to have significant changes in *CI* over the five year period (α=0.10) (Figure 7). There were 12 reaches with significant trends in 2017 (Smithson et al. 2018) and 10 reaches in 2016 (Smithson and Robinson 2017). Of these, PENG1 and EPOU1 were the only reaches with significant trends since 2016. These were also the only reaches with decreasing trends (Table 4). Reaches GRAC2, MILL2, DRYE4, and MILL1 were not sampled in 2016 or 2017 using the stream segment approach.

A total of 19 reaches were found to have significant increasing trends from 2013-2018 (Table 4). Five of these were also detected as significantly increasing in 2017 (Smithson et al. 2018). Notable in these 19 reaches is that four of the reaches occur on the Fording River. This includes the Fording River reference reach (FORD12) located upstream of all mining activity. Also of note are two reaches on Dry Creek – LCO. Reaches DRYL1 and DRYL3 had calcite reported in them for the first time in 2017. Calcite was again reported in these reaches in 2018, and at higher index scores than in 2017. Lastly of interest is the significant increase in the reference reaches located on South Line Creek (SLIN2) and Grace Creek Reach 2 (GRAC2). This is the first year that these reaches have shown a significant trend in calcite deposition.

The tau value represents the ranking of the correlation coefficient between two variables. A tau of 1 shows a strong agreement while a value of -1 shows a strong disagreement.

Table 4. Reaches with significant changes in *CI* from 2013 – 2017 using Mann-Kendall.

Reach	Exposure	p-value	tau value	Change	Significant in 2017
PENG1	Exposed	0.04	-0.86	Decreasing	Yes
EPOU1	Exposed	0.06	-0.73	Decreasing	Yes
GRAC2	Reference	0.09	-1.00	Decreasing	-
SPIT1	Exposed	0.01	0.97	Increasing	No
DRYE3	Exposed	0.02	0.87	Increasing	Yes
FORD5	Exposed	0.02	0.87	Increasing	Yes
GODD3	Exposed	0.02	0.87	Increasing	Yes
FORD12	Reference	0.03	0.89	Increasing	Yes
LEAS2	Exposed	0.06	0.73	Increasing	Yes
BODI1	Exposed	0.07	0.75	Increasing	No
GODD1	Exposed	0.07	0.75	Increasing	No
MILL2	Exposed	0.07	0.75	Increasing	-
DRYL1	Exposed	0.07	0.77	Increasing	No
DRYL3	Exposed	0.07	0.77	Increasing	No
FORD2	Exposed	0.07	0.77	Increasing	No
FORD9	Exposed	0.07	0.77	Increasing	No
HENR1	Exposed	0.07	0.77	Increasing	No
MICH4	Exposed	0.07	0.77	Increasing	No
SLIN2	Reference	0.07	0.77	Increasing	No
FPON1	Exposed	0.09	0.69	Increasing	No
DRYE4	Exposed	0.09	1.00	Increasing	-
MILL1	Exposed	0.10	0.84	Increasing	-

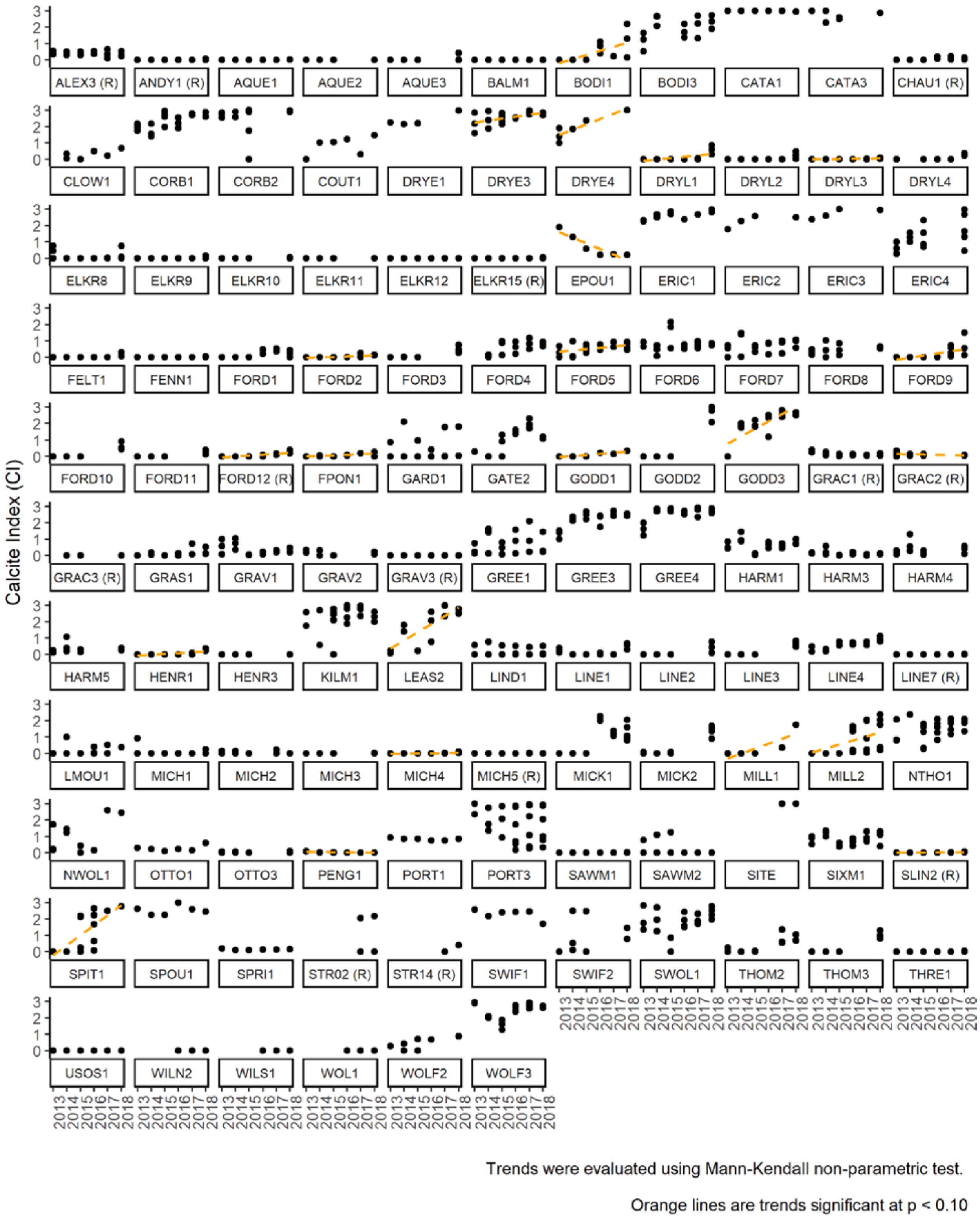


Figure 7. Reach mean *CI* from 2013 – 2018 from the Mann-Kendall test.

3.2.2 ANOVA (Tukey's HSD post-hoc)

An ANOVA assessment was completed on 88 reaches sampled in 2018 (Appendix 5). The 88 reaches were selected for ANOVA as they were sampled with two or more sites in all six years (2013 to 2018) and did not have constant values (i.e. identical values each year) over the period of record. Results showed the reach mean *CI* varied significantly (α = 0.05) by *Year* in 42 reaches (Figure 8), with 22 of them not being sampled since 2015. The 20 that have been sampled every year since 2013, is comparable to the 17 reaches in 2017 (Smithson et al. 2018) and 2016 (Smithson and Robinson 2017). Notable observations are again the significant increase in *CI* in Dry Creek – Line Creek (DRYL). The CI values in DRYL from reaches 1, 2, 3, and 4 were all significantly higher in 2018 than all previous years. Also observed is the increase in multiple reaches of the Fording River, including reference reach FORD12. This was also detected in the Mann-Kendall analysis. Lastly of note was the significant effect of *Year* within five reference reaches. Reaches ANDY1, CHAU1, FORD12, and SLIN2 all show recent increases in *CI*. FORD12 and SLIN2 also had significant Mann-Kendall results. The significant effect of *Year* at GRAC1 appears to be a decrease in *CI* that occurred in 2015 and has remained until present.

In 2017, Greenhills Creek Reach 1 (GREE1) started to receive calcite prevention treatments (Teck 2019). In 2017, GREE1 had a mean CI of 1.07 but in 2018 it was 0.64. This change was not found to be significant; however, it is likely too soon to detect this statistically.

In summary, eleven reaches were found to have significant changes in *CI* since 2013 in both Mann-Kendall and ANOVA assessments (Table 5).

Table 5. Summary of reaches with both significant Mann-Kendall and ANOVA results.

Site	Significant Mann-Kendall	Significant ANOVA
BODI1	Y	Y
DRYL1	Y	Y
DRYL3	Y	Y
FORD9	Y	Y
FORD12	Y	Y
GODD3	Y	Y
HENR1	Y	Y
LEAS2	Y	Y
MICH4	Y	Y
PENG1	Y	Y
SLIN2	Y	Y

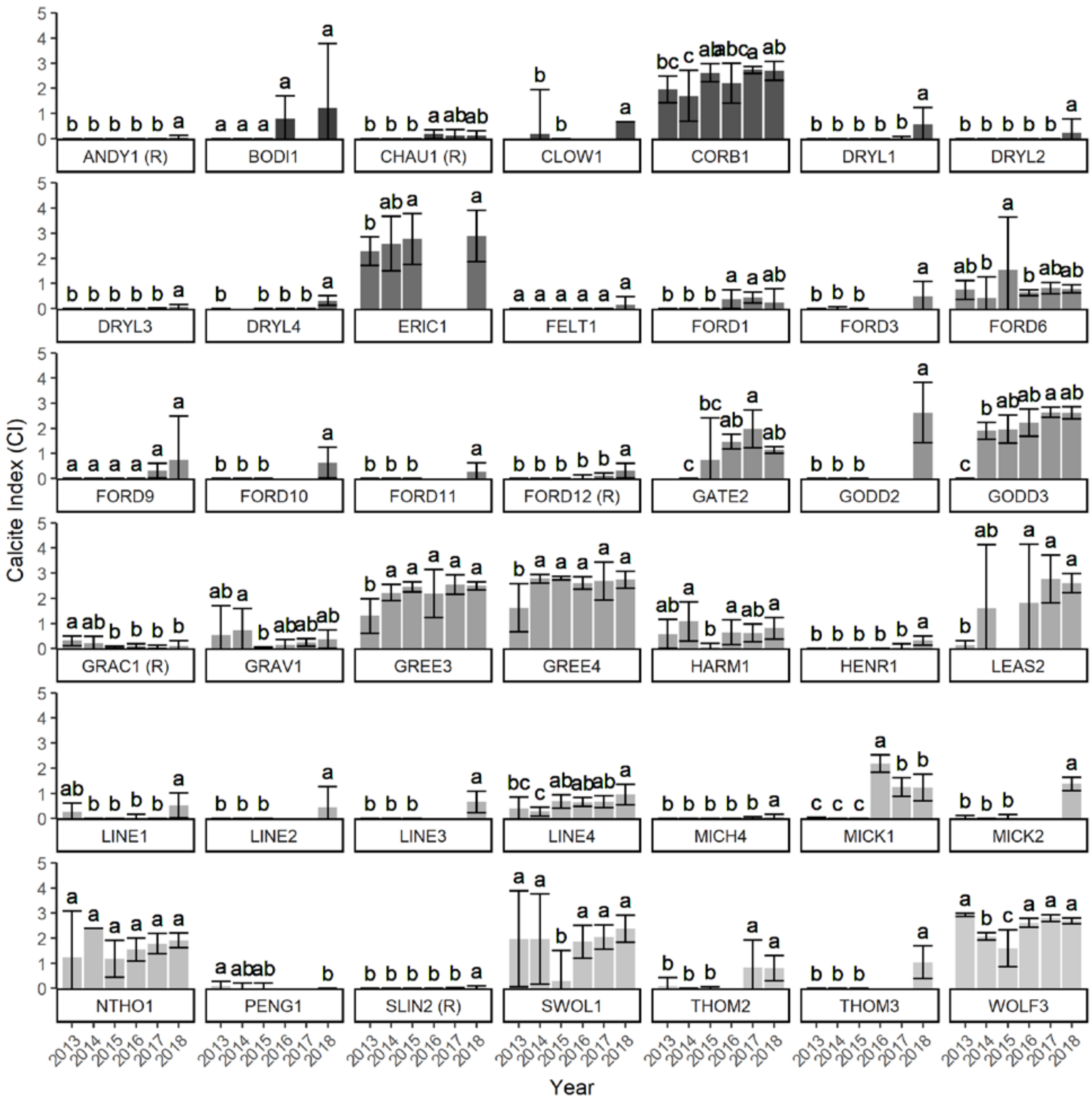


Figure 8. Bar graphs showing results of significant one-way ANOVA tests. Same letters on graphs denotes no significant differences in mean *CI* among years, with reach.

3.2.3 Stream Segment Assessment

The stream segment assessment was able to be completed on 17 of the 87 segments. A total of 63 stream segments consisted of one reach (Appendix 6). Seven had at least one reach that had only one site, precluding the ability to perform statistical comparison. Qualitative assessment of plots suggested that the majority of segments appeared appropriate in that the variability between reaches was low (Appendix 7). The assessment did however; suggest that one segment may contain reaches that were different in *CI* to the extent that one indicator reach could not be representative of the entire segment. This segment was Erickson Creek (ERIK_A) (Figure 9). Erickson Creek has been delineated into four reaches. Based on being less than 300m long, reaches 2 and 3 have only one sample site and were not included in this assessment. Reach 1 had a mean *CI* of 2.76 and was the indicator reach. Reach 4 had a mean *CI* of 1.73. However, this difference was not found to be significant (p=0.15; df=7). For context, the mean *CI* score for Reach 2 was 2.50 and Reach 3 was 2.95. Overall, the indicator reach of Erickson Creek appears to be accurately representing the segment. All other of the 17 segments assessed appeared to have similar reach mean values within each segment and none of these showed a significant effect of reach following ANOVA analysis (Table 6).

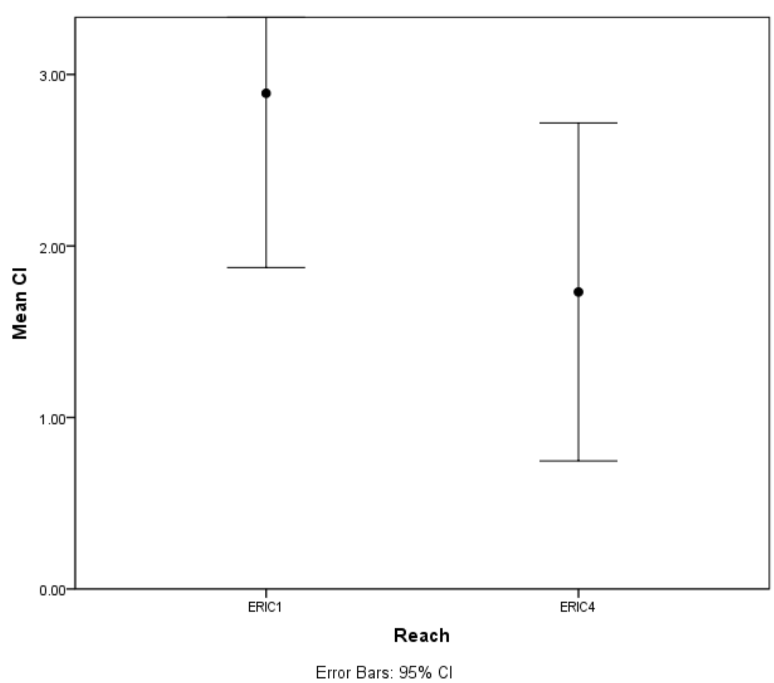


Figure 9. Plot of reach mean *CI* for Erickson Creek reaches 1 (indicator) and 4.

Table 6. Summary of multi-reach segments, reaches, CI and ANOVA results.

Segment	Reach	CI	p-value
AQUE_A	AQUE1*	0.03	0.495
	AQUE2	0.00	
	AQUE3	0.14	
CORB_A	CORB1*	2.70	0.071
	CORB2	2.92	
ELKR_B	ELKR9*	0.07	0.466
	ELKR10	0.03	
ELKR_C	ELKR11	0.00	n/a
	ELKR12*	0.00	
ERIC_A	ERIC1*	2.89	0.150
	ERIC4	1.73	
FORD_B	FORD2*	0.13	0.056
	FORD3	0.49	
FORD_C	FORD4*	0.80	0.508
	FORD5	0.70	
FORD_E	FORD7*	0.89	0.159
	FORD8	0.61	
FORD_F	FORD9*	0.73	0.455
	FORD10	0.63	
	FORD11	0.27	
GRAC_A	GRAC1*	0.10	0.151
	GRAC2	0.06	
	GRAC3	0.00	
GRAV_A	GRAV1*	0.37	0.080
	GRAV2	0.14	
HARM_B	HARM3*	0.08	0.142
	HARM4	0.35	
	HARM5	0.31	
LINE_A	LINE1*	0.52	0.592
	LINE2	0.45	
	LINE3	0.66	
MICH_A	MICH1*	0.08	0.490
	MICH2	0.02	
MICH_B	MICH3	0.01	0.123
	MICH4*	0.06	
MICK_A	MICK1*	1.14	0.786
	MICK2	1.22	
THOM_A	THOM2*	0.81	0.295
	THOM3	1.04	

*indicator reach

3.2.4 Inter-program comparisons

Biological sampling completed in 2018 by Minnow Environmental (Minnow) occurred at four distinct locations along Greenhills Creek (Table 7). These corresponded to regional stream Reaches 1, 3, and two locations within Reach 4 of Greenhills Creek (See map in Appendix 8). Sampling completed by Ecofish Research Ltd. (Ecofish) was restricted to Reach 1 in 2018. Both programs require calcite data to be closely coupled with other data (biological and physical) and therefore obtain *CI* estimates from the mesohabitat scale (i.e. single habitat units - riffle, pool, glide etc.). Whereas the regional calcite monitoring program completed by Lotic Environmental for the Program, obtains *CI* estimates from longer sites (minimum 100 m) comprised of multiple habitat unit types to provide data more representative of all habitat types present in a reach. All other methods are understood to be comparable between programs..

Table 7. Comparable sample locations between regional calcite and biological sampling programs completed in 2018.

Stream	Reach	Regional sites	Minnow sites	Ecofish sites
Greenhills Creek	1	GREE1-25 GREE1-50 GREE1-75	RG_GHBP-1 RG_GHBP-2 RG_GHBP-3 RG_GHBP-4 RG_GHBP-5 RG_GHBP-6	GRE-CI17-sp GRE-CI25-sp GRE-CI29-ns GRE-CI32-ns GRE-CI34A-ns GRE-CI34-sp GRE-CI35-ns GRE-CI38-ns GRE-CI39-sp GRE-CI40-sp
	3	GREE3-25 GREE3-50 GREE3-75	GHFF-1 GHFF-2 GHFF-3 GHFF-4 GHFF-5 GHFF-6	None
	4	GREE4-25 GREE4-50 GREE4-75	GHNF-1 GHNF-2 GHNF-3 GHNF-4 GHNF-5 GHNF-6 GHUT-1 GHUT-2 GHUT-3 GHUT-4 GHUT-5 GHUT-6	None

All three programs occurred only in Reach 1, whereas the regional and Minnow programs included reaches 3 and 4 (Figure 10). Results within Reach 1 were comparable with all three programs suggesting reach mean CI values within the 0.50-1.00 bin. The regional and Minnow programs both documented high variability over the site, while the Ecofish data were more consistent. This may be explained by the number of sites per program within this reach. This is suspected because the overall range in *CI* of each of the programs was similar (Regional = 0.23 - 1.44; Minnow = 0.24 - 2.01; Ecofish = 0.16 - 1.23). Reach 1 *CI* values reported by Lotic Environmental and Minnow both showed high variability. This reach has historically been found to have high variability likely due to a combination of *CI* values approaching an intermediate range and the confounding factor of high fine sediment loading along a gradient increasing downstream. The substrate is dominated by fines and the lower end of Reach 1 and the *CI* score is lower. Near the top of the reach, the substrate changes to cobble and gravel that shows higher *CI* scores.

Both presence (Figure 11) and concretion (Figure 12) also showed general consistency between programs. The variability within each Reach 1 value again mirrored the number of sites. The consistency in results was observed between the regional and Minnow programs throughout all three reaches.

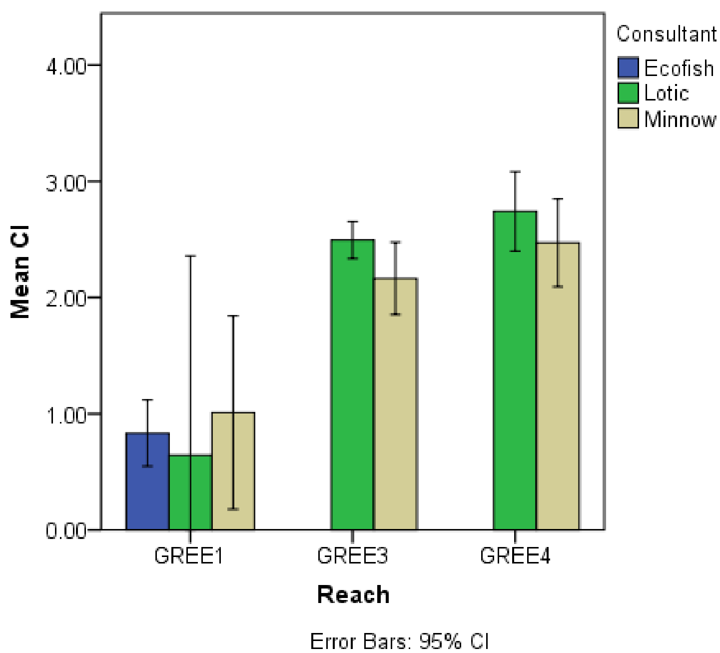


Figure 10. Inter-program comparison of CI values for Greenhills Creek.

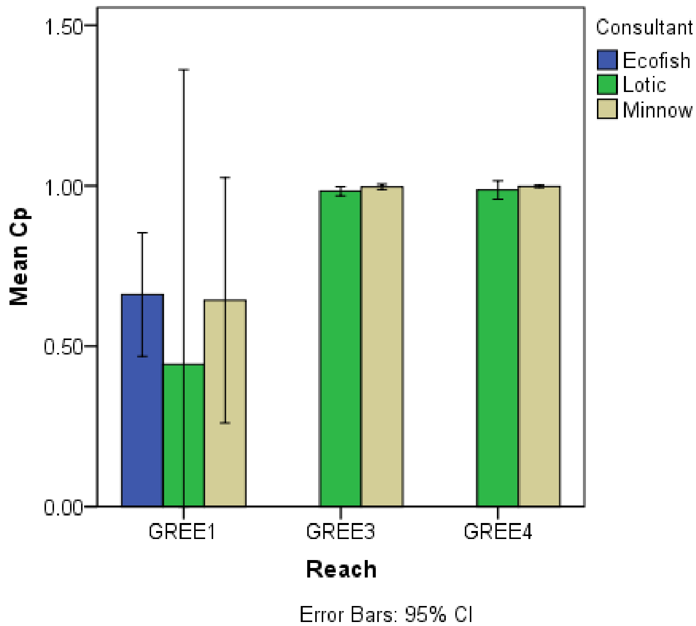


Figure 11. Inter-program comparison of CI_p values for Greenhills Creek.

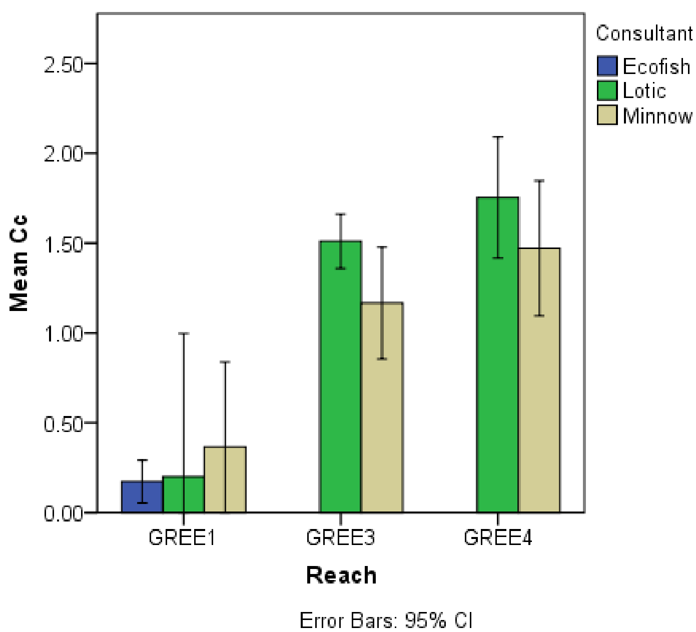


Figure 12. Inter-program comparison of CI_c values for Greenhills Creek.

Regional data were matched between programs completed by Minnow and Lotic Environmental at 43 reaches (Appendix 9). The number of sites used to generate a reach mean *CI* score ranged between 1-11 for data collected by Minnow and 1-4 for data collected by Lotic Environmental. ANOVA results generate show 26 of these pairing do not produce significantly different reach mean *CI* values (Figure 13). Qualitative examination of the reach mean plots does show some results may be the result of high within reach variability, but generally the results appear correct. Seventeen reaches were found to be significantly different between programs (Figure 14). Six of the reaches (35%) were distributed over the study area with no obvious pattern. Four of these had one reach represented by a single site, precluding drawing any strong conclusion on the comparison. Two spatial groups did appear notable in the comparison. Five reaches on each of the Fording River and Michel Creek were found to be significantly different. The Michel Creek reaches included four reaches downstream of mining and the one reference reach. In each pairing the Minnow data showed close to 100% presence and the Lotic Environmental data were generally less than 10% calcite presence at a site level. Similarly, the data collected by Minnow along Fording River reaches typically produced higher *CI* scores relative to data collected by Lotic Environmental. However, unlike Michel Creek, the Fording River had as many reaches where results did not vary significantly between sampling programs. Furthermore, the non-significant reaches were interspaced among the significant reaches, precluding any concentrated areas where differences were more likely to occur.

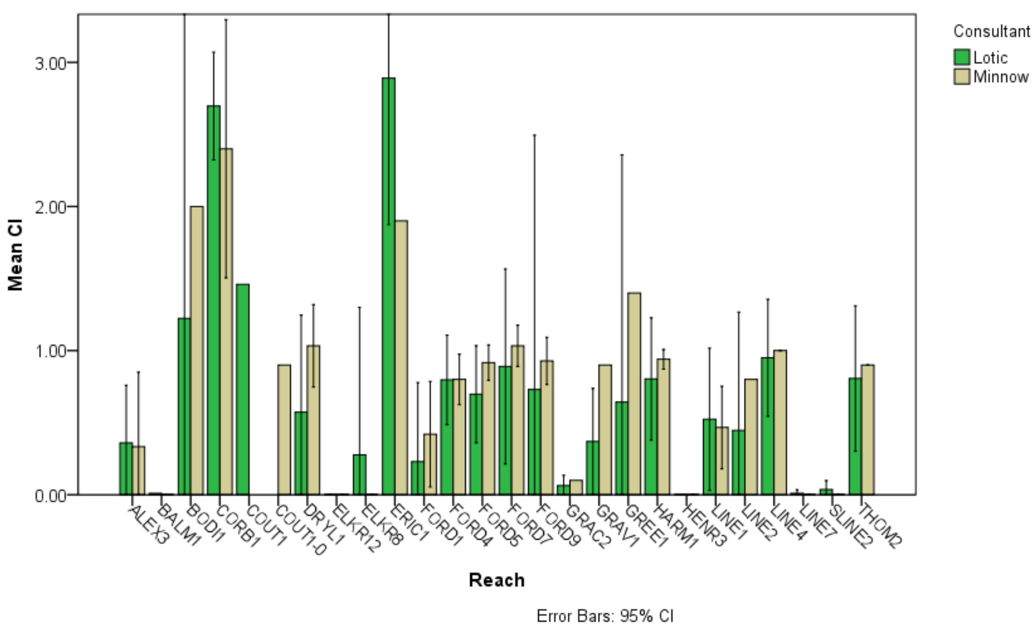


Figure 13. Reach mean *CI* values for non-significantly different inter-program comparisons.

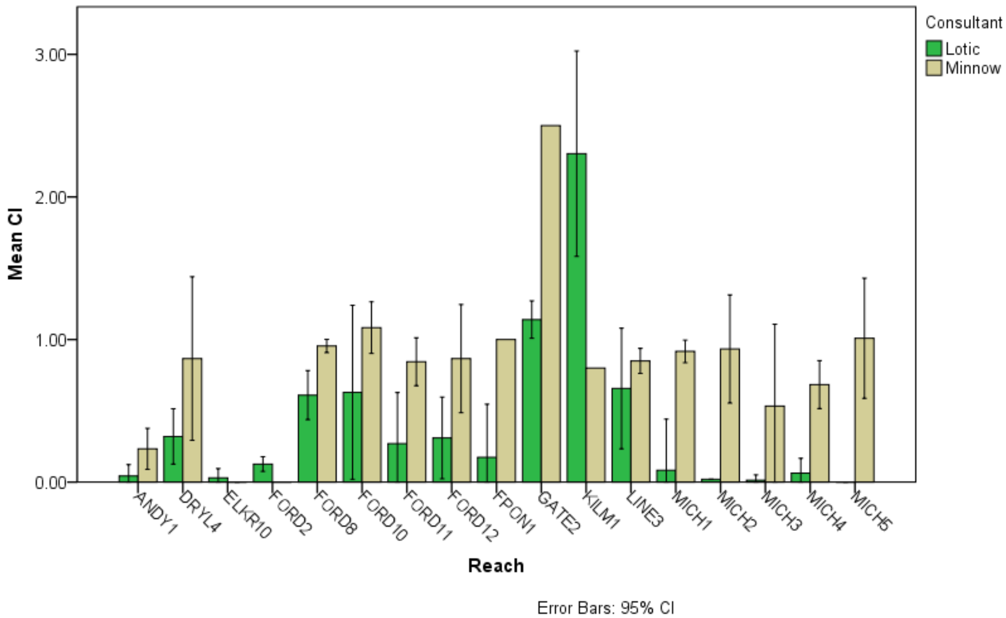


Figure 14. Reach mean *CI* values for significantly different inter-program comparisons.

3.3 *Data quality assurance*

Data quality assurance steps were completed as described in Section. 2.5.6. Crews visited sites as a group to calibrate calcite observations and data collection. All raw pebble count data were screened for data entry errors using the Python computer script to confirm that cells were populated with acceptable (i.e., valid) values. No data entry errors were detected.

4 Discussion

The 2018 Regional Calcite Monitoring Program was completed as per the work plan. The number of reaches sampled increased from 85 to 117, with the primary objective of assessing the effectiveness of using indicator reaches to describe changes in *CI* for a segment. When using the stream segment and indicator reach approach, there are 87 segments identified. In that 63 consist of only one reach meaning that segments represent multiple reaches only 28% of the time. A qualitative and statistical review of each reach within multi-reach segments suggests that in all cases but one, the indicator reach is not generating a *CI* score that is different from any other reach in that segment. This suggests the indicator reach approach is an appropriate means of monitoring an extensive spatial area as the Elk Valley.

Changes in the distribution of calcite within the six bins were similar to that detected after 2017 sampling. The amount of stream kilometers represented in the lowest bin (0.00-0.50) was found to have significantly decreased from 2013-2018 for exposed main stem reaches. This resulted in a significant proportion of exposed main stem reaches moving into the 0.50-1.00 bin. While reference reaches continue to largely group in the 0.00-0.50 bin, there are a number of reference reaches that are showing either linear or step-wise increases in calcite deposition. This suggests that the theory presented in Smithson et al. (2018) that the system is returning to pre-2013 flood calcite index values, remains plausible.

The statistical methods used in this year's report continue to provide direct, effective ways to test for both linear and step-wise changes in calcite distribution. Three main observations were: the continued increase in extent of calcite deposition in Dry Creek – LCO, the increase along much of the Fording River including the reference reaches in the headwaters, and the continued increasing trend among reference areas. Spoiling began in the Dry Creek watershed in 2014 as part of the LCO Phase II mine extension project. Increases along the Fording River appear to be more readily explained by environmental variability. Given that increases are occurring in exposed and reference reaches, as well as, reference tributaries to the Fording River. Freshet 2018 again did not produce flows that would be considered channel forming with the potential to affect the degree of calcite deposition observed within the Fording River or any streams in the Elk River watershed.

The relationships between CI to CI_p and CI_c, as well as that between CI_p and CI_c remain consistent with those first reported in 2013. This assessment suggests that calcite formation begins with basic presence of calcite on individual particles that later progressing to the extent that particles begin to bind together. Although rare, concretion is reported at low calcite presence scores.

The inter-program comparison showed generally good agreement between three independent sampling programs within Greenhills Creek. This suggests that in this specific watercourse, the number of habitat units sampled and sampling crew members do not significantly affect CI values reported. The larger, regional dataset suggests similar results for approximately 60% of the reaches assessed. Clear differences were identified in Michel Creek in all reaches including one reference reach. Differences on the Fording River were identified in 2017 (Smithson *et al.* 2018). Reaches near Fording River Operations have been previously reported to be quite variable. It is unclear to what extent sampling a different number of habitat units contributes to the reported differences as opposed to detection between sampling crews. This will be investigated.

A total of 30 reaches exceeded the 0.5 CI_c SPO. Teck is currently working on an update to the Calcite Management Plan due to the Ministry of Environment by July 31, 2019. Results from the Program, including streams with concretion scores above 0.5 will form part of the criteria for informing calcite management associated with section 6.1 of Permit 107517. Teck will continue to work with ENV, EMPR and KNC to update the Calcite Management Plan including stream selection criteria.

5 Future Monitoring

The 2016-2018 Calcite Monitoring Program was evaluated in this 2018 report. The evaluation suggests that a stream segment/indicator reach approach is accurately describing calcite deposition and trends, while balancing effort to provide an efficient field program. The Program has been proven capable of detecting the occurrence of new calcite deposition in a relatively short time frame, as indicated by the results in Dry Creek – LCO. The program has also demonstrated its ability to detect both linear and step-wise changes in calcite deposition overtime.

The 2015 Calcite Monitoring Report discussed how annual rates of change in calcite deposition are generally low to non-detectable, and how that suggested that a form of annual surveillance monitoring would be appropriate (Robinson et al. 2016). Surveillance monitoring is a lower intensity style of monitoring that would be capable of detecting larger changes. This is how the stream segment/indicator reach approach was designed to function. Robinson et al. (2016) also suggested that for smaller-scale changes, more intense periodic monitoring (spatially) may also be beneficial to confirm that changes were not going undetected by the less intense surveillance monitoring. This is what the current 2018 Regional Calcite Monitoring Program represented. Given that this combination of surveillance monitoring coupled with a larger program every three years has only been completed once, but shows promising results, we recommend completing another three-year program for 2019-2021, that is consistent with the work plans employed from 2016-2018. In 2021, the program can again be reassessed. In order to support detailed understanding of changes in streams that may receive management actions, the reaches which are selected for mitigation in the Calcite Management Plan from the list in Table 3 (i.e., $C_c > 0.5$) will have sampling for all reaches within the identified segments in all years for the next three years.

Although the effect of habitat unit type was assessed in the initial year of the regional Calcite Monitoring Program and found to not significantly affect *CI,* Teck wishes to return to collecting what habitat unit type individual particles are sampled from. This may become helpful for investigating differences between monitoring programs further.

6 Literature Cited

Berdusco, J. 2009. Teck Coal Ltd. Mine Site Calcite Deposition Mapping Project. Consultant report prepared for Teck Coal Ltd. Prepared by Interior Reforestation Co. Ltd., Cranbrook, BC.

Hipel, K.W. and McLeod, A.I., (2005), Time Series Modelling of Water Resources and Environmental Systems. Electronic reprint of our book orginally published in 1994. http://www.stats.uwo. ca/faculty/aim/1994Book/.

Holm, S. (1979). A simple sequentially rejective multiple test procedure. Scandinavian Journal of Statistics 6, 65–70.

Lenth, R V (2016). Least-Squares Means: The R Package lsmeans. Journal of Statistical Software, 69(1), 1-33

Pohlert, T (2017). trend: Non-Parametric Trend Tests and Change-Point Detection. R package version 1.0.1. https://CRAN.R-project.org/package=trend

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Robinson, M.D. and K. Atherton. 2016. Teck Coal Ltd – 2016-2018 Calcite Monitoring Program. Prepared by Lotic Environmental Ltd. and Teck Coal Ltd. 10 pp + appendices.

Robinson, M.D. M. Chernos, K. Baranowska, and R.J. MacDonald. 2016. Teck Coal Ltd – Elk Valley 2015 Calcite Monitoring Program Annual Report and Program Assessment. Prepared for Teck Coal Ltd by Lotic Environmental Ltd. 17 pp + appendices.

Robinson, M.D. and R.J. MacDonald. 2015. Teck Coal Ltd 2013 Calcite Monitoring Program – Elk Valley operations summary report. Prepared by Lotic Environmental Ltd. 14 pp + appendices.

Robinson, M.D. and R.J. MacDonald. 2014. Teck Coal Ltd 2013 Calcite Monitoring Program – Elk Valley operations summary report. Prepared by Lotic Environmental Ltd. 12 pp + appendices.

Robinson, M.D. 2013. Teck Coal Ltd - Calcite Monitoring Plan Field Manual. Prepared by Lotic Environmental Ltd. 11 pp.

Smithson, J. and M. D. Robinson. 2017. Teck Coal Ltd – Elk Valley 2017 Calcite Monitoring Program Annual Report and Program Assessment. Prepared for Teck Coal Ltd. by Lotic Environmental Ltd. 26 pp + appendices.

Smithson, J., Robinson, M.D. and K. Baranowska. 2018. Teck Coal Ltd – Elk Valley 2017 Calcite Monitoring Program Annual Report and Program Assessment. Prepared for Teck Coal Ltd. by Lotic Environmental Ltd. 27 pp + appendices.

Teck. 2019. Lower Greenhills Creek Calcite Management - 2018 Operations Report. Teck Coal Limited. 61pp.

Teck. 2016. Water Quality Adaptive Management Plan for Teck Coal Operations in the Elk Valley. 111 pp + appendices.

Teck. 2014. Elk Valley Water Quality Plan. Teck Coal Limited. 290 pp.

Wolman, MG. 1954. A Method of Sampling Coarse River-Bed Material. Transactions of the American Geophysical Union. 35(6):951-956.

7 Appendices

Appendix 1. Summary of reach-level results by program year.

Stream name	Reach Site Code	Site type	Block type	2013 CI	2014 CI	2015 CI	2016 CI	2017 CI	2018 CI	Mann-Kendall p-value (sig = 0.10)
Alexander	ALEX3	Reference	Reference	0.48	0.38	0.40	0.46	0.38	0.36	0.18
Andy Good	ANDY1	Reference	Reference	0.00	0.00	0.00	0.00	0.00	0.04	0.24
Aqueduct	AQUE1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.03	0.24
Aqueduct	AQUE2	Exposed	Historical	0.00	0.00	0.00	-	-	0.00	N/A
Aqueduct	AQUE3	Exposed	Historical	0.00	0.00	0.00	-	-	0.14	0.37
Balmer	BALM1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.01	0.24
Bodie	BODI1	Exposed	Historical	0.00	0.00	0.00	0.79	0.23	1.22	0.07
Bodie	BODI3	Exposed	Historical	1.16	2.47	N/A	1.77	2.09	2.33	0.46
Cataract	CATA1	Exposed	Historical	3.00	3.00	3.00	3.00	3.00	2.96	0.24
Cataract	CATA3	Exposed	Historical	3.00	2.64	2.56	-	-	2.89	0.73
Chauncey	CHAU1	Reference	Reference	0.00	0.00	0.00	0.17	0.12	0.12	0.31
Clode Pond Outlet	COUT1	Exposed	Historical	0.00	1.01	1.03	1.21	0.29	1.46	0.13
Clode West Infiltration	CLOW1	Exposed	Historical	N/A	0.18	0.00	0.50	0.21	0.67	0.22
Corbin	CORB1	Exposed	Historical	1.95	1.71	2.62	2.21	2.74	2.70	0.13
Corbin	CORB2	Exposed	Historical	2.72	2.68	2.25	-	-	2.92	1
Dry (EVO)	DRYE1	Exposed	Historical	2.23	2.13	2.19	-	-	2.96	0.73
Dry (EVO)	DRYE3	Exposed	Historical	2.20	2.40	2.48	2.51	2.85	2.76	0.02
Dry (EVO)	DRYE4	Exposed	Historical	1.42	1.84	2.37	-	-	3.00	0.09
Dry (LCO)	DRYL1	Proposed	Recent	0.00	0.00	0.00	0.00	0.02	0.57	0.07
Dry (LCO)	DRYL2	Proposed	Recent	0.00	0.00	0.00	0.00	0.00	0.24	0.24
Dry (LCO)	DRYL3	Proposed	Recent	0.00	0.00	0.00	0.00	0.00	0.06	0.07
Dry (LCO)	DRYL4	Proposed	Recent	0.00	N/A	0.00	0.00	0.00	0.32	0.29
Eagle Pond Outlet	EPOU1	Exposed	Historical	1.90	1.31	0.58	0.20	0.25	0.21	0.06
Elk	ELKR10	Exposed	Historical	0.00	0.00	0.00	-	-	0.03	0.37
Elk	ELKR11	Exposed	Historical	0.00	0.00	0.00	-	-	0.00	N/A
Elk	ELKR12	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.00	N/A
Elk	ELKR15	Reference	Reference	0.00	0.00	0.00	0.00	0.00	0.02	0.24
Elk	ELKR8	Exposed	Historical	0.40	0.00	0.00	0.00	0.01	0.28	0.84
Elk	ELKR9	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.07	0.24
Erickson	ERIC1	Exposed	Historical	2.29	2.59	2.77	2.36	2.67	2.89	0.13
Erickson	ERIC2	Exposed	Historical	1.78	2.27	2.58	-	-	2.50	0.31
Erickson	ERIC3	Exposed	Historical	2.36	2.60	3.00	-	-	2.95	0.31
Erickson	ERIC4	Exposed	Historical	0.62	1.28	1.17	-	-	1.73	0.31
Feltham	FELT1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.15	0.24
Fennelon	FENN1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.02	0.24
Fish Pond	FPON1	Exposed	Historical	0.00	0.03	0.00	0.08	0.20	0.17	0.09
Fording	FORD1	Exposed	Historical	0.00	0.00	0.00	0.37	0.44	0.23	0.16
Fording	FORD10	Exposed	Historical	0.00	0.00	0.00	-	-	0.63	0.37
Fording	FORD11	Exposed	Historical	0.00	0.00	0.00	-	-	0.27	0.37
Fording	FORD12	Reference	Reference	0.00	0.00	0.00	0.08	0.11	0.31	0.03
Fording	FORD2	Exposed	Historical	0.00	0.00	0.00	0.00	0.10	0.13	0.07
Fording	FORD3	Exposed	Historical	0.00	0.01	0.00	-	-	0.49	0.47

Stream name	Reach Site Code	Site type	Block type	2013 CI	2014 CI	2015 CI	2016 CI	2017 CI	2018 CI	Mann-Kendall p-value (sig = 0.10)
Fording	FORD4	Exposed	Historical	N/A	0.05	0.66	0.60	0.84	0.80	0.22
Fording	FORD5	Exposed	Historical	0.32	0.35	0.53	0.58	0.73	0.70	0.02
Fording	FORD6	Exposed	Historical	0.74	0.43	1.53	0.64	0.68	0.79	0.71
Fording	FORD7	Exposed	Historical	0.43	0.97	0.55	0.63	0.71	0.89	0.26
Fording	FORD8	Exposed	Historical	0.31	0.49	0.48	-	-	0.61	0.31
Fording	FORD9	Exposed	Historical	0.00	0.00	0.00	0.00	0.32	0.73	0.07
Gardine	GARD1	Exposed	Historical	0.29	0.70	0.32	0.14	0.60	0.64	0.71
Gate	GATE2	Exposed	Historical	0.15	0.00	0.74	1.47	1.98	1.14	0.13
Goddard	GODD1	Exposed	Historical	0.00	0.00	0.00	0.22	0.13	0.35	0.07
Goddard	GODD2	Exposed	Historical	0.00	0.00	0.00	-	-	2.62	0.37
Goddard	GODD3	Exposed	Historical	0.00	1.90	1.97	2.22	2.64	2.62	0.02
Grace	GRAC1	Reference	Reference	0.31	0.20	0.05	0.09	0.06	0.10	0.45
Grace	GRAC2	Reference	Reference	0.15	0.10	0.10	-	-	0.06	0.09
Grace	GRAC3	Reference	Reference	N/A	0.00	0.00	-	-	0.00	N/A
Grassy	GRAS1	Exposed	Historical	0.00	0.09	0.00	0.04	0.29	0.25	0.18
Grave	GRAV1	Exposed	Historical	0.54	0.72	0.02	0.14	0.24	0.37	1
Grave	GRAV2	Exposed	Historical	0.23	0.21	0.00	-	-	0.14	0.31
Grave	GRAV3	Reference	Reference	0.00	0.00	0.00	0.00	0.00	0.00	N/A
Greenhills	GREE1	Exposed	Historical	0.35	1.06	0.45	0.86	1.07	0.64	0.45
Greenhills	GREE3	Exposed	Historical	1.30	2.22	2.46	2.18	2.55	2.49	0.13
Greenhills	GREE4	Exposed	Historical	1.62	2.78	2.80	2.61	2.68	2.74	0.71
Harmer	HARM1	Exposed	Historical	0.58	1.08	0.07	0.64	0.61	0.80	0.71
Harmer	HARM3	Exposed	Historical	0.15	0.28	0.01	0.12	0.03	0.08	0.45
Harmer	HARM4	Exposed	Historical	0.17	0.70	0.17	-	-	0.35	1
Harmer	HARM5	Exposed	Historical	0.19	0.56	0.22	-	-	0.31	0.73
Henretta	HENR1	Exposed	Historical	0.00	0.00	0.00	0.00	0.04	0.32	0.07
Henretta	HENR3	Exposed	Historical	0.00	0.00	0.00	-	-	0.00	N/A
Kilmamock	KILM1	Exposed	Historical	2.16	1.64	1.97	2.59	2.77	2.30	0.26
Lake Mountain	LMOU1	Exposed	Historical	0.00	0.33	0.00	0.15	0.18	0.39	0.18
Leask	LEAS2	Exposed	Historical	0.13	1.60	0.24	1.82	2.76	2.60	0.06
Lindsay	LIND1	Exposed	Historical	0.19	0.26	0.19	0.19	0.15	0.19	0.84
Line	LINE1	Exposed	Treated	0.27	0.00	0.00	0.03	0.00	0.52	0.84
Line	LINE2	Exposed	Treated	0.00	0.00	0.00	-	-	0.45	0.37
Line	LINE3	Exposed	Treated	0.00	0.00	0.00	-	-	0.66	0.37
Line	LINE4	Exposed	Treated	0.40	0.27	0.68	0.65	0.66	0.95	0.13
Line	LINE7	Reference	Reference	0.00	0.00	0.00	0.00	0.00	0.01	0.24
Michel	MICH1	Exposed	Historical	0.31	0.00	0.00	0.00	0.00	0.08	1
Michel	MICH2	Exposed	Historical	0.05	0.05	0.00	N/A	0.08	0.02	0.81
Michel	MICH3	Exposed	Historical	0.00	0.00	0.00	-	-	0.01	0.37
Michel	MICH4	Exposed	Historical	0.00	0.00	0.00	0.00	0.01	0.06	0.07
Michel	MICH5	Reference	Reference	0.00	0.00	0.00	0.00	0.01	0.00	0.56
Mickelson	MICK1	Exposed	Historical	0.01	0.00	0.00	2.18	1.25	1.23	0.57
Mickelson	MICK2	Exposed	Historical	0.05	0.00	0.03	-	-	1.37	0.73
Milligan	MILL1	Exposed	Historical	0.00	0.00	0.00	N/A	0.36	1.77	0.10
Milligan	MILL2	Exposed	Historical	0.00	0.00	0.00	1.07	1.06	1.18	0.07
North Thompson	NTHO1	Exposed	Historical	1.24	2.39	1.18	1.54	1.78	1.91	0.45
North Wolfram	NWOL1	Exposed	Historical	0.70	1.33	0.21	0.14	2.59	2.44	0.71

Stream name	Reach Site Code	Site type	Block type	2013 CI	2014 CI	2015 CI	2016 CI	2017 CI	2018 CI	Mann-Kendall p-value (sig = 0.10)
Otto	OTTO1	Exposed	Historical	0.30	0.22	0.10	0.23	0.14	0.59	1
Otto	OTTO3	Exposed	Historical	0.02	0.02	0.00	-	-	0.05	0.73
Pengally	PENG1	Exposed	Historical	0.09	0.02	0.02	0.00	0.00	0.00	0.04
Porter	PORT1	Exposed	Historical	0.92	0.84	0.85	0.75	0.74	0.85	0.44
Porter	PORT3	Exposed	Historical	2.78	1.94	1.94	1.46	1.62	1.65	0.26
Qualteri	QUAL1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	N/A	N/A
Sawmill	SAWM1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.01	0.24
Sawmill	SAWM2	Exposed	Historical	0.38	0.54	0.62	0.00	0.00	0.00	0.31
SITE18	SITE18	Exposed	Historical	N/A	N/A	N/A	N/A	3.00	3.00	N/A
Six Mile	SIXM1	Exposed	Historical	0.80	1.19	0.49	0.65	0.95	0.92	1
Smith Pond Outlet	SPOU1	Exposed	Historical	2.61	2.24	2.24	3.00	2.60	2.45	1
South Line	SLINE2	Reference	Reference	0.00	0.00	0.00	0.00	0.00	0.04	0.07
South Pit	SPIT1	Exposed	Historical	0.00	0.00	1.14	1.59	2.49	2.77	0.01
South Wolfram Creek	SWOL1	Exposed	Historical	1.97	1.97	0.28	1.86	2.05	2.38	0.34
Spring	SPRI1	Exposed	Historical	0.20	0.11	0.11	0.12	0.13	0.14	0.57
Stream 02	STR02	Exposed	Historical	N/A	N/A	N/A	N/A	0.68	0.72	N/A
Stream 14	STR14	Exposed	Historical	N/A	N/A	N/A	N/A	0.00	0.40	N/A
Swift	SWIF1	Exposed	Historical	2.58	2.18	2.39	2.43	2.45	1.69	0.71
Swift	SWIF2	Exposed	Historical	0.00	1.04	0.82	-	-	1.12	0.31
Thompson	THOM2	Exposed	Historical	0.08	0.00	0.01	N/A	0.83	0.81	0.46
Thompson	THOM3	Exposed	Historical	0.00	0.00	0.00	-	-	1.04	0.37
Thresher	THRE1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.03	0.24
Unnamed South of Sawmill	USOS1	Exposed	Historical	0.00	0.00	0.00	0.00	0.00	0.00	N/A
Willow North	WILN2	Exposed	Recent	N/A	N/A	0.00	0.00	0.00	0.00	N/A
Willow South	WILS1	Exposed	Recent	N/A	N/A	0.00	0.00	0.00	0.00	N/A
Wolf	WOL1	Reference	Future	N/A	N/A	0.00	0.00	0.00	0.00	N/A
Wolfram	WOLF2	Exposed	Historical	0.27	0.42	0.70	-	-	0.88	0.22
Wolfram	WOLF3	Exposed	Historical	2.93	2.07	1.60	2.61	2.80	2.69	1

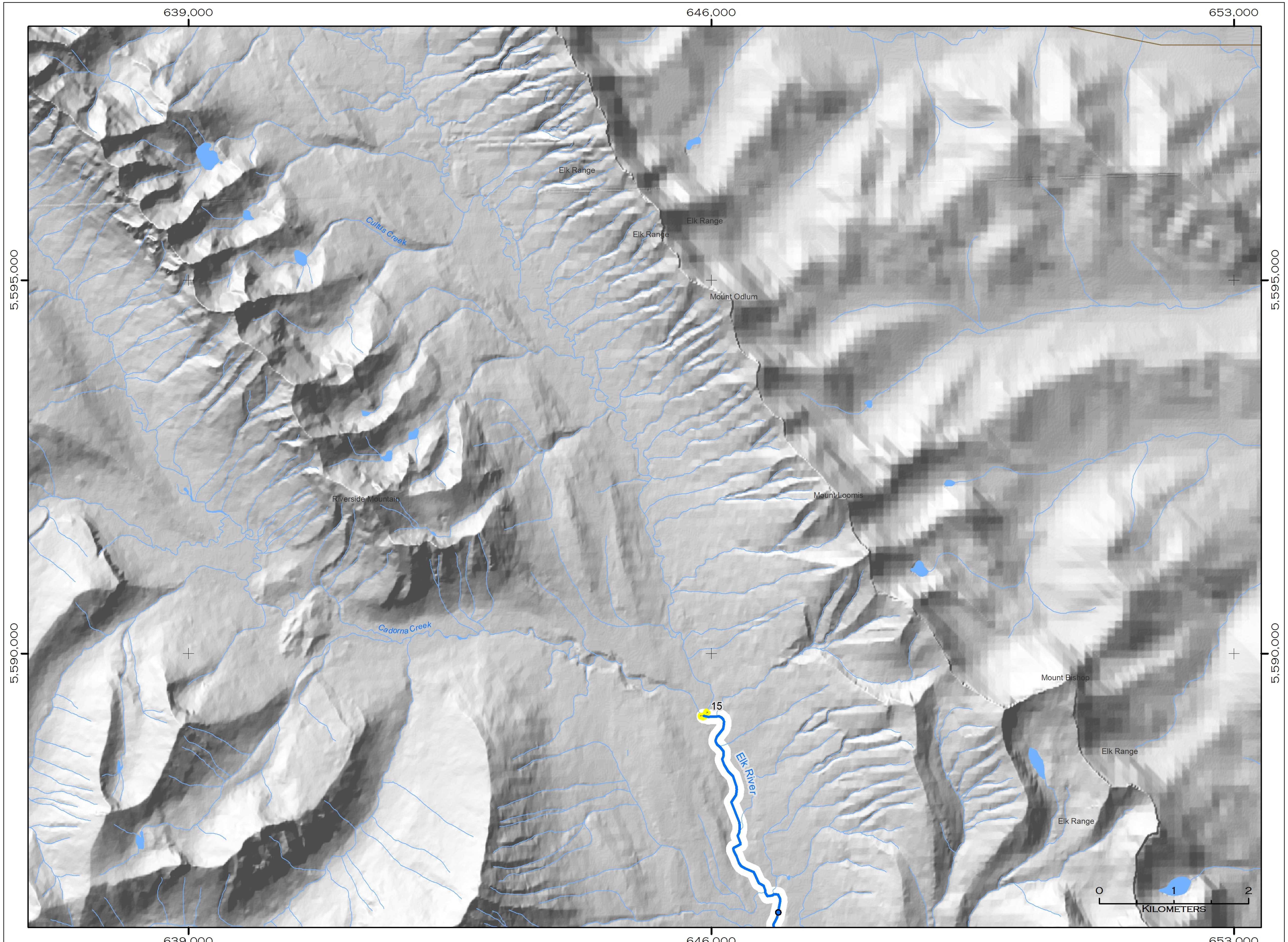
Appendix 2. 2018 Elk Valley calcite monitoring results by stream reach.

Type (exposed or reference)	Stream	Reach	Mean CI_p Score (0-1)	Mean CI_c Score (0-2)	CI (C_p+C_c)
Reference	Alexander	ALEX3	0.34	0.02	0.36
Reference	Andy Good	ANDY1	0.04	0.00	0.04
Exposed	Aqueduct	AQUE1	0.02	0.01	0.03
Exposed	Aqueduct	AQUE2	0.00	0.00	0.00
Exposed	Aqueduct	AQUE3	0.14	0.00	0.14
Exposed	Balmer	BALM1	0.01	0.00	0.01
Exposed	Bodie	BODI1	0.59	0.64	1.22
Exposed	Bodie	BODI3	0.92	1.41	2.33
Exposed	Cataract	CATA1	1.00	1.96	2.96
Exposed	Cataract	CATA3	1.00	1.89	2.89
Reference	Chauncey	CHAU1	0.11	0.01	0.12
Exposed	Clode Pond Outlet	COUT1	0.91	0.55	1.46
Exposed	Clode West Infiltration	CLOW1	0.67	0.01	0.67
Exposed	Corbin	CORB1	0.98	1.72	2.70
Exposed	Corbin	CORB2	1.00	1.92	2.92
Exposed	Dry (EVO)	DRYE1	1.00	1.96	2.96
Exposed	Dry (EVO)	DRYE3	1.00	1.76	2.76
Exposed	Dry (EVO)	DRYE4	1.00	2.00	3.00
Exposed	Dry (LCO)	DRYL1	0.57	0.00	0.57
Exposed	Dry (LCO)	DRYL2	0.24	0.00	0.24
Exposed	Dry (LCO)	DRYL3	0.06	0.00	0.06
Exposed	Dry (LCO)	DRYL4	0.32	0.00	0.32
Exposed	Eagle Pond Outlet	EPOU1	0.21	0.00	0.21
Exposed	Elk	ELKR10	0.03	0.00	0.03
Exposed	Elk	ELKR11	0.00	0.00	0.00
Exposed	Elk	ELKR12	0.00	0.00	0.00
Reference	Elk	ELKR15	0.02	0.00	0.02
Exposed	Elk	ELKR8	0.26	0.01	0.28
Exposed	Elk	ELKR9	0.07	0.00	0.07
Exposed	Erickson	ERIC1	0.99	1.90	2.89
Exposed	Erickson	ERIC2	0.90	1.60	2.50
Exposed	Erickson	ERIC3	1.00	1.95	2.95
Exposed	Erickson	ERIC4	0.85	0.88	1.73
Exposed	Feltham	FELT1	0.14	0.01	0.15
Exposed	Fennelon	FENN1	0.02	0.00	0.02
Exposed	Fish Pond	FPON1	0.17	0.01	0.17
Exposed	Fording	FORD1	0.23	0.00	0.23
Exposed	Fording	FORD10	0.60	0.03	0.63

Type (exposed or reference)	Stream	Reach	Mean CI_p Score (0-1)	Mean CI_c Score (0-2)	CI (C_p+C_c)
Exposed	Fording	FORD11	0.27	0.00	0.27
Reference	Fording	FORD12	0.30	0.01	0.31
Exposed	Fording	FORD2	0.12	0.01	0.13
Exposed	Fording	FORD3	0.37	0.12	0.49
Exposed	Fording	FORD4	0.73	0.07	0.80
Exposed	Fording	FORD5	0.69	0.01	0.70
Exposed	Fording	FORD6	0.64	0.14	0.79
Exposed	Fording	FORD7	0.82	0.07	0.89
Exposed	Fording	FORD8	0.61	0.00	0.61
Exposed	Fording	FORD9	0.55	0.18	0.73
Exposed	Gardine	GARD1	0.34	0.29	0.64
Exposed	Gate	GATE2	0.59	0.55	1.14
Exposed	Goddard	GODD1	0.35	0.00	0.35
Exposed	Goddard	GODD2	0.99	1.63	2.62
Exposed	Goddard	GODD3	0.96	1.66	2.62
Reference	Grace	GRAC1	0.09	0.01	0.10
Reference	Grace	GRAC2	0.06	0.00	0.06
Reference	Grace	GRAC3	0.00	0.00	0.00
Exposed	Grassy	GRAS1	0.16	0.09	0.25
Exposed	Grave	GRAV1	0.35	0.02	0.37
Exposed	Grave	GRAV2	0.14	0.00	0.14
Reference	Grave	GRAV3	0.00	0.00	0.00
Exposed	Greenhills	GREE1	0.44	0.20	0.64
Exposed	Greenhills	GREE3	0.98	1.51	2.49
Exposed	Greenhills	GREE4	0.99	1.75	2.74
Exposed	Harmer	HARM1	0.73	0.08	0.80
Exposed	Harmer	HARM3	0.06	0.02	0.08
Exposed	Harmer	HARM4	0.30	0.05	0.35
Exposed	Harmer	HARM5	0.29	0.01	0.31
Exposed	Henretta	HENR1	0.32	0.00	0.32
Exposed	Henretta	HENR3	0.00	0.00	0.00
Exposed	Kilmamock	KILM1	0.91	1.40	2.30
Exposed	Lake Mountain	LMOU1	0.39	0.00	0.39
Exposed	Leask	LEAS2	0.99	1.61	2.60
Exposed	Lindsay	LIND1	0.19	0.00	0.19
Exposed	Line	LINE1	0.52	0.00	0.52
Exposed	Line	LINE2	0.45	0.00	0.45
Exposed	Line	LINE3	0.65	0.01	0.66
Exposed	Line	LINE4	0.90	0.05	0.95
Reference	Line	LINE7	0.01	0.00	0.01
Exposed	Michel	MICH1	0.08	0.00	0.08

Type (exposed or reference)	Stream	Reach	Mean CI_p Score (0-1)	Mean CI_c Score (0-2)	CI (C_p+C_c)
Exposed	Michel	MICH2	0.02	0.00	0.02
Exposed	Michel	MICH3	0.01	0.00	0.01
Exposed	Michel	MICH4	0.06	0.00	0.06
Reference	Michel	MICH5	0.00	0.00	0.00
Exposed	Mickelson	MICK1	0.82	0.40	1.23
Exposed	Mickelson	MICK2	0.79	0.58	1.37
Exposed	Milligan	MILL1	0.90	0.87	1.77
Exposed	Milligan	MILL2	0.56	0.62	1.18
Exposed	North Thompson	NTHO1	0.95	0.96	1.91
Exposed	North Wolfram	NWOL1	0.90	1.54	2.44
Exposed	Otto	OTTO1	0.56	0.03	0.59
Exposed	Otto	OTTO3	0.05	0.00	0.05
Exposed	Pengally	PENG1	0.00	0.00	0.00
Exposed	Porter	PORT1	0.79	0.06	0.85
Exposed	Porter	PORT3	0.76	0.88	1.65
Exposed	Sawmill	SAWM1	0.01	0.00	0.01
Exposed	Sawmill	SAWM2	0.00	0.00	0.00
Exposed	Site18	SITE	1.00	2.00	3.00
Exposed	Six Mile	SIXM1	0.72	0.21	0.92
Exposed	Smith Pond Outlet	SPOU1	0.91	1.54	2.45
Reference	South Line	SLINE2	0.04	0.00	0.04
Exposed	South Pit	SPIT1	1.00	1.77	2.77
Exposed	South Wolfram Creek	SWOL1	0.95	1.43	2.38
Exposed	Spring	SPRI1	0.14	0.00	0.14
Exposed	Stream 02	STR02	0.25	0.47	0.72
Exposed	Stream 14	STR14	0.34	0.06	0.40
Exposed	Swift	SWIF1	0.85	0.84	1.69
Exposed	Swift	SWIF2	0.87	0.25	1.12
Exposed	Thompson	THOM2	0.73	0.08	0.81
Exposed	Thompson	THOM3	0.73	0.31	1.04
Exposed	Thresher	THRE1	0.02	0.01	0.03
Exposed	Unnamed South of Sawmill	USOS1	0.00	0.00	0.00
Exposed	Willow North	WILN2	0.00	0.00	0.00
Exposed	Willow South	WILS1	0.00	0.00	0.00
Exposed	Wolf	WOL1	0.00	0.00	0.00
Exposed	Wolfram	WOLF2	0.36	0.52	0.88
Exposed	Wolfram	WOLF3	0.94	1.75	2.69

Appendix 3. Calcite distribution maps.



2018 Calcite Monitoring Program

Calcite Index

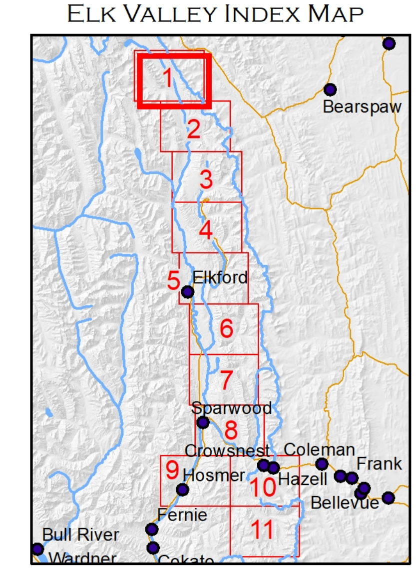
Elk Valley - Map # 1

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

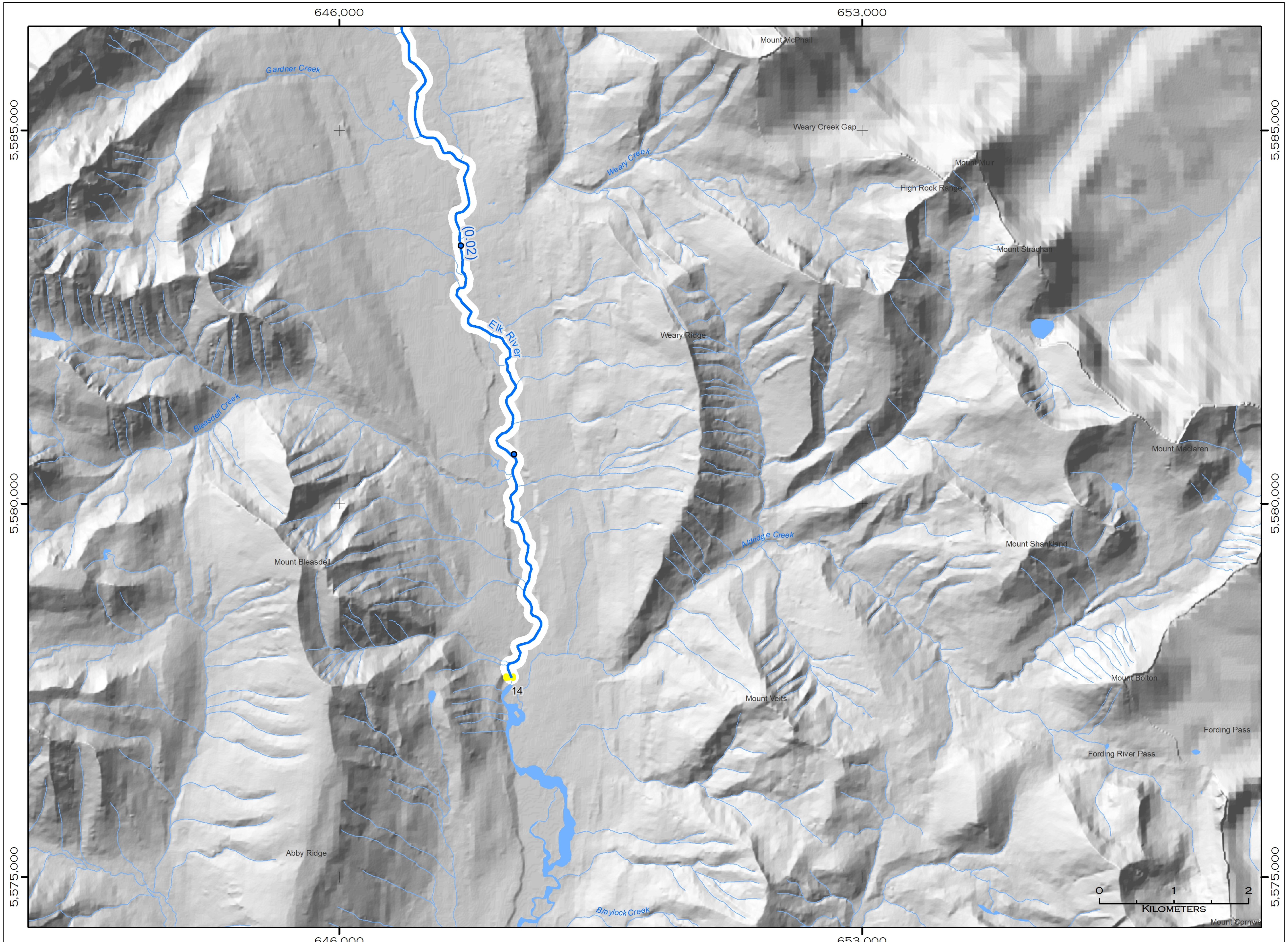


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

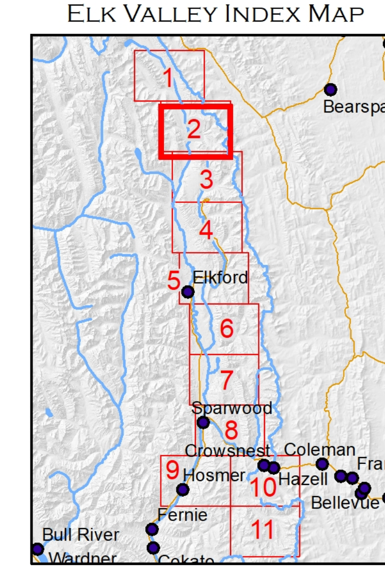
Elk Valley - Map #2

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

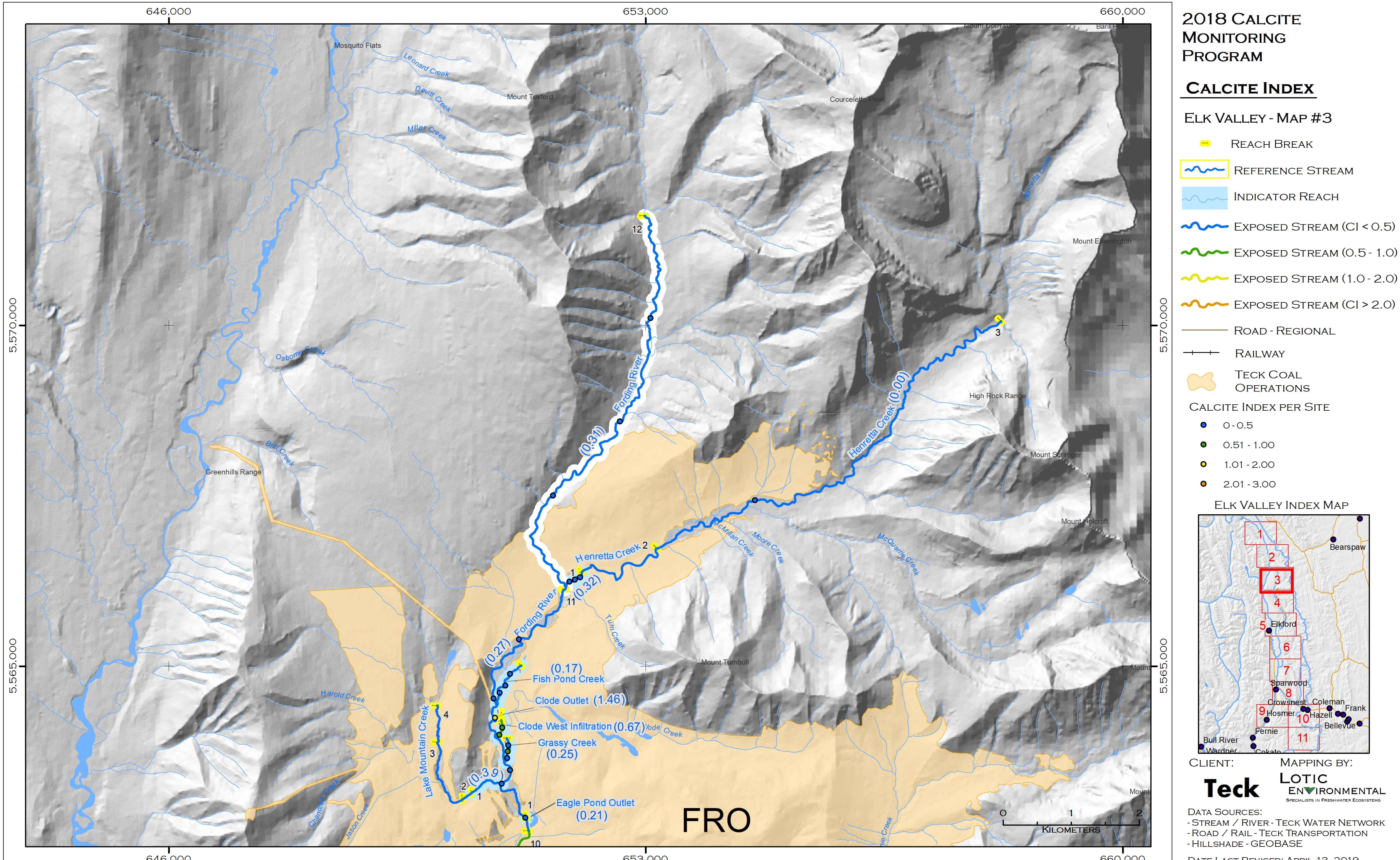


Client: Teck

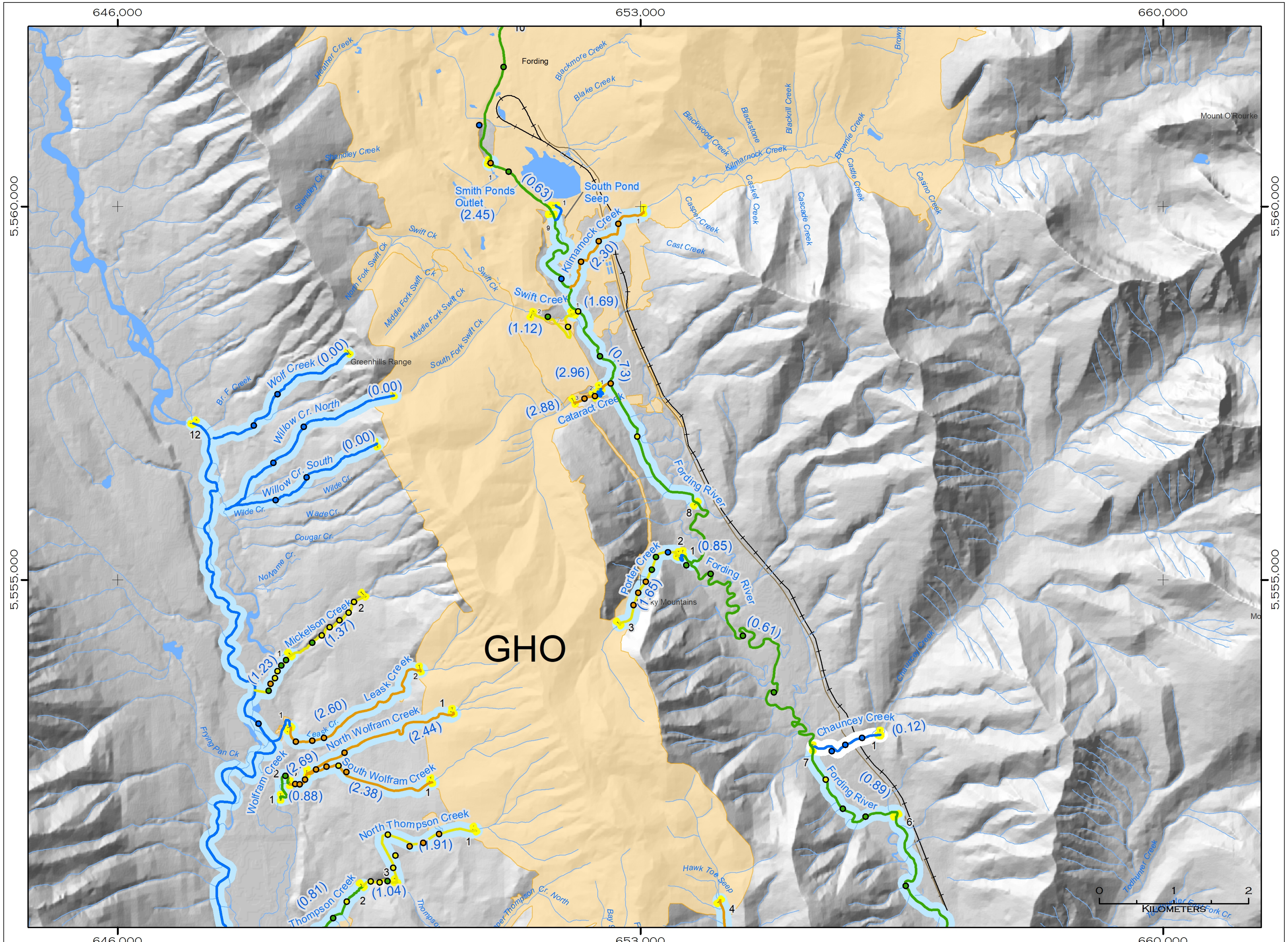
Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



646,000
653,000
660,000
5,570,000
5,565,000
Mosquito Flats
Leonard Creek
Devitt Creek
Miller Creek
Mount Tuxford
Courcelette Peak
Osborne Creek
Britt Creek
Greenhills Range
Fording River
(0.31)
12
Henretta Creek (0.00)
Henretta Creek
High Rock Range
Mount Erickson
Mount Scrimger
Mount Holcroft
McMillan Creek
Moore Creek
McQuarrie Creek
(0.32)
Fording River
(0.27)
Turn Creek
Mount Turnbull
(0.17)
Fish Pond Creek
Clode Outlet (1.46)
Clode West Infiltration (0.67)
Grassy Creek
(0.25)
Lake Mountain Creek
(0.39)
Harold Creek
Eagle Pond Outlet
(0.21)
Jason Creek
FRO
0 1 2
Kilometers
2018 Calcite Monitoring Program
Calcite Index
Elk Valley - Map #3
Reach Break
Reference Stream
Indicator Reach
Exposed Stream (CI < 0.5)
Exposed Stream (0.5 - 1.0)
Exposed Stream (1.0 - 2.0)
Exposed Stream (CI > 2.0)
Road - Regional
Railway
Teck Coal Operations
Calcite Index per Site
0 - 0.5
0.51 - 1.00
1.01 - 2.00
2.01 - 3.00
Elk Valley Index Map
Bearspaw
Elkford
Sparwood
Crowsnest
Coleman
Frank
Hosmer
Hazell
Bellevue
Fernie
Bull River
Wardner
Cokato
Client:
Teck
Mapping by:
Lotic Environmental
Specialists in Freshwater Ecosystems
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase
Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

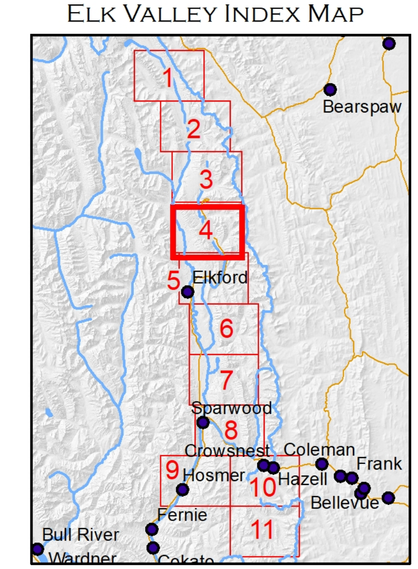
Elk Valley - Map #4

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

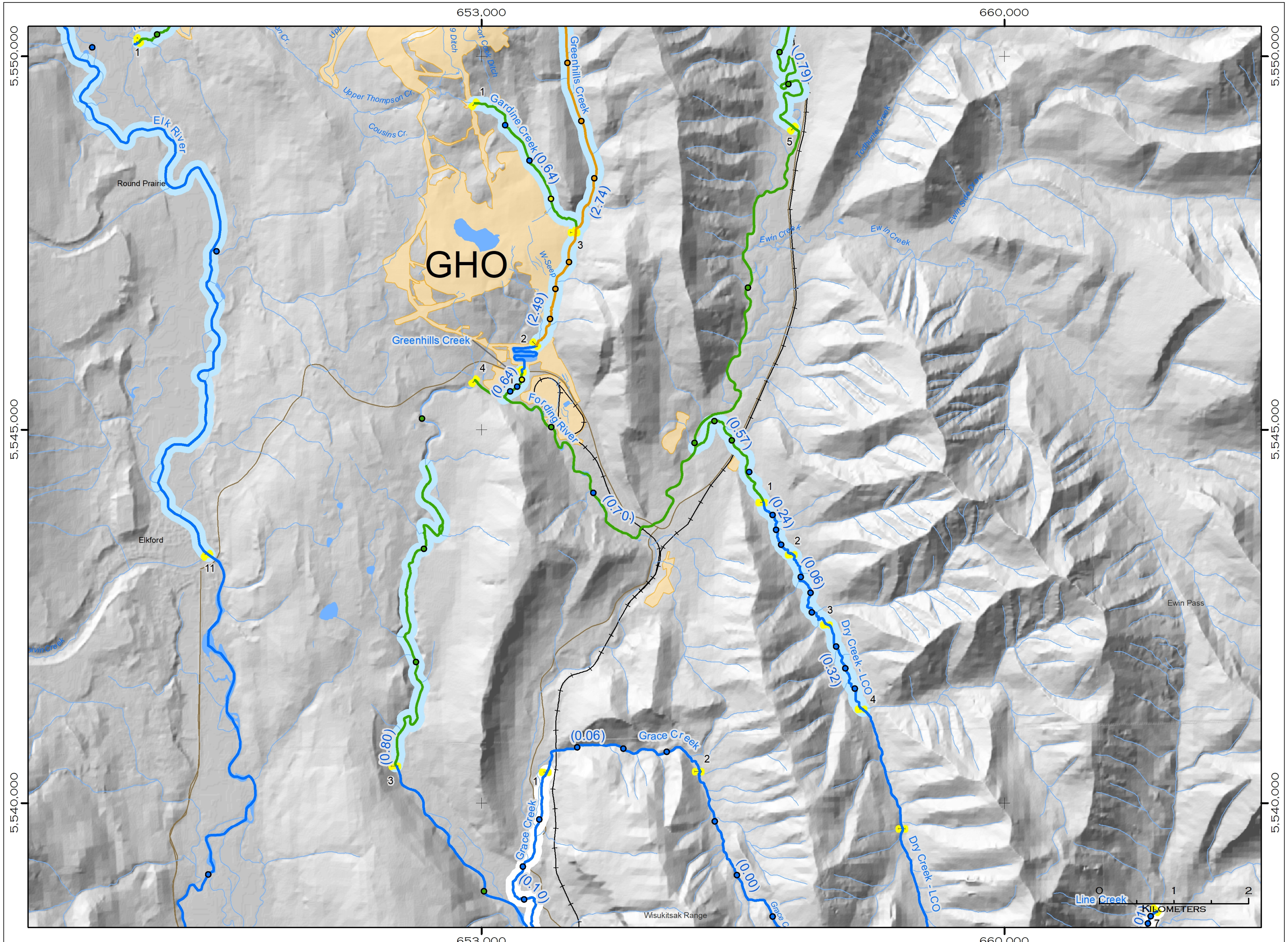


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - Geobase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

Elk Valley - Map #5

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (CI < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 2.0)

Exposed Stream (CI > 2.0)

Road - Regional

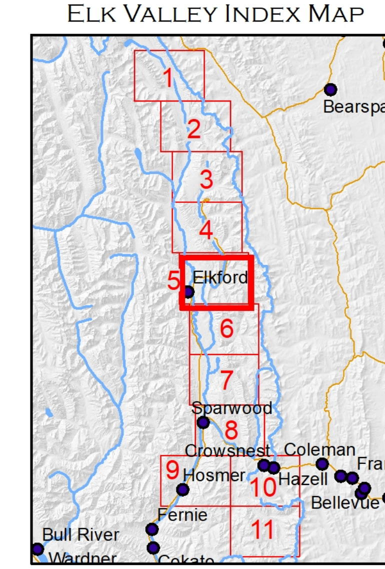
Railway

Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

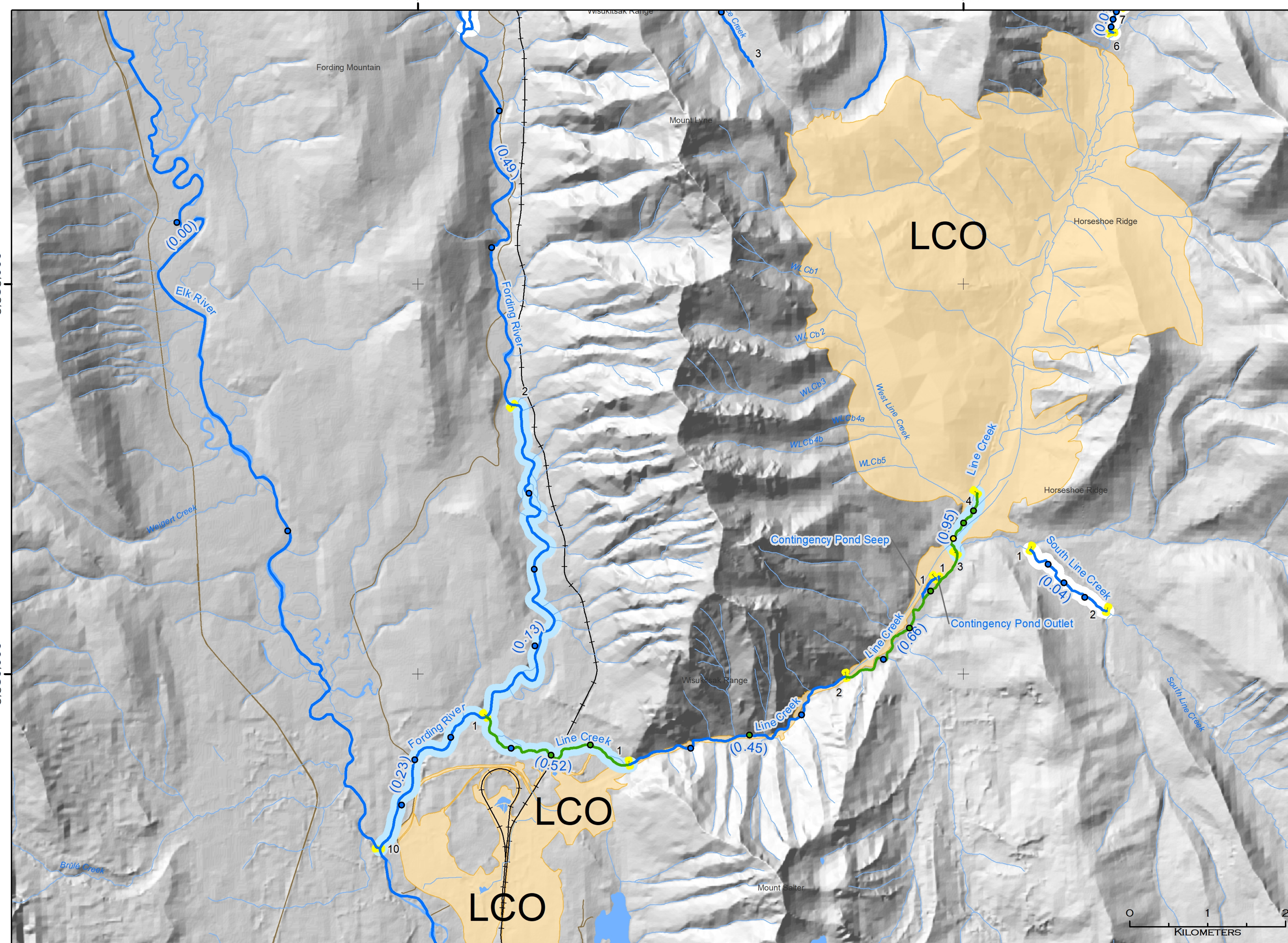


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

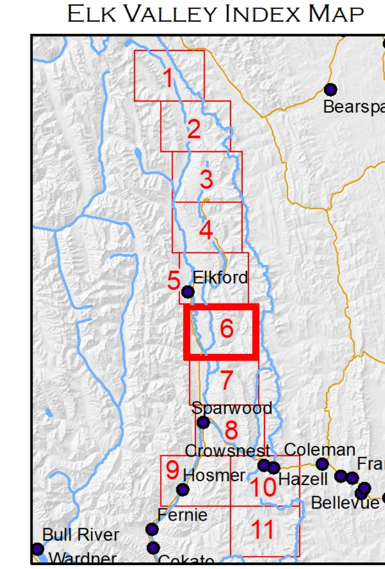
Elk Valley - Map #6

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

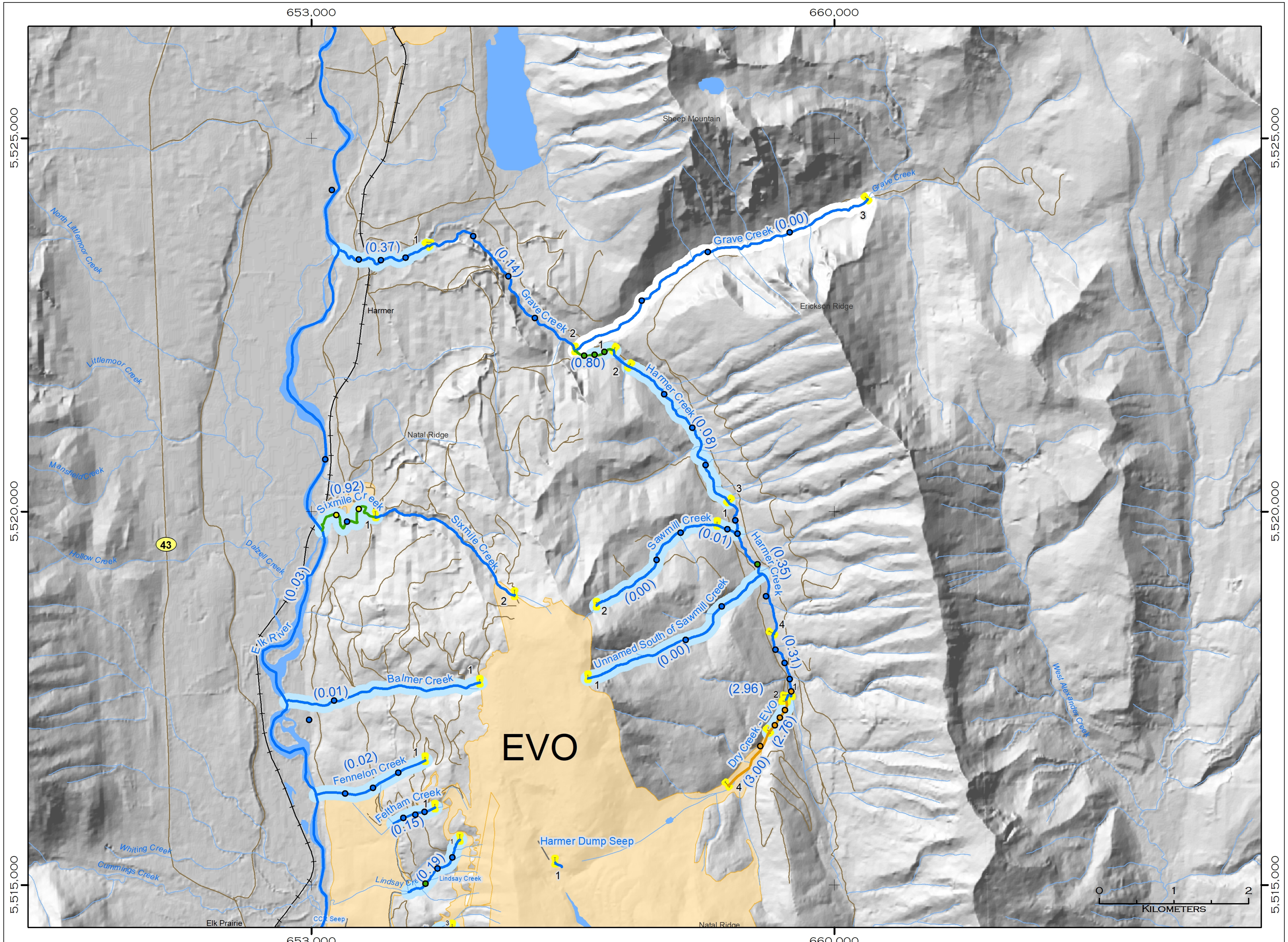


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

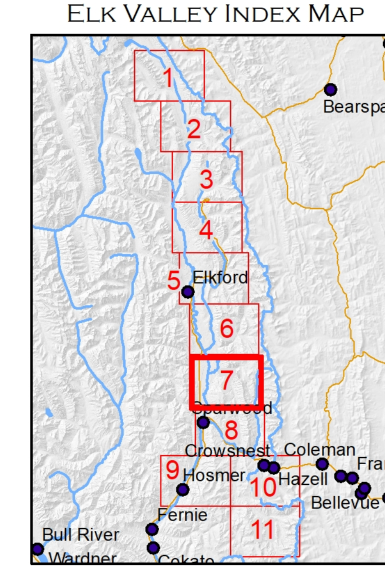
Elk Valley - Map #7

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

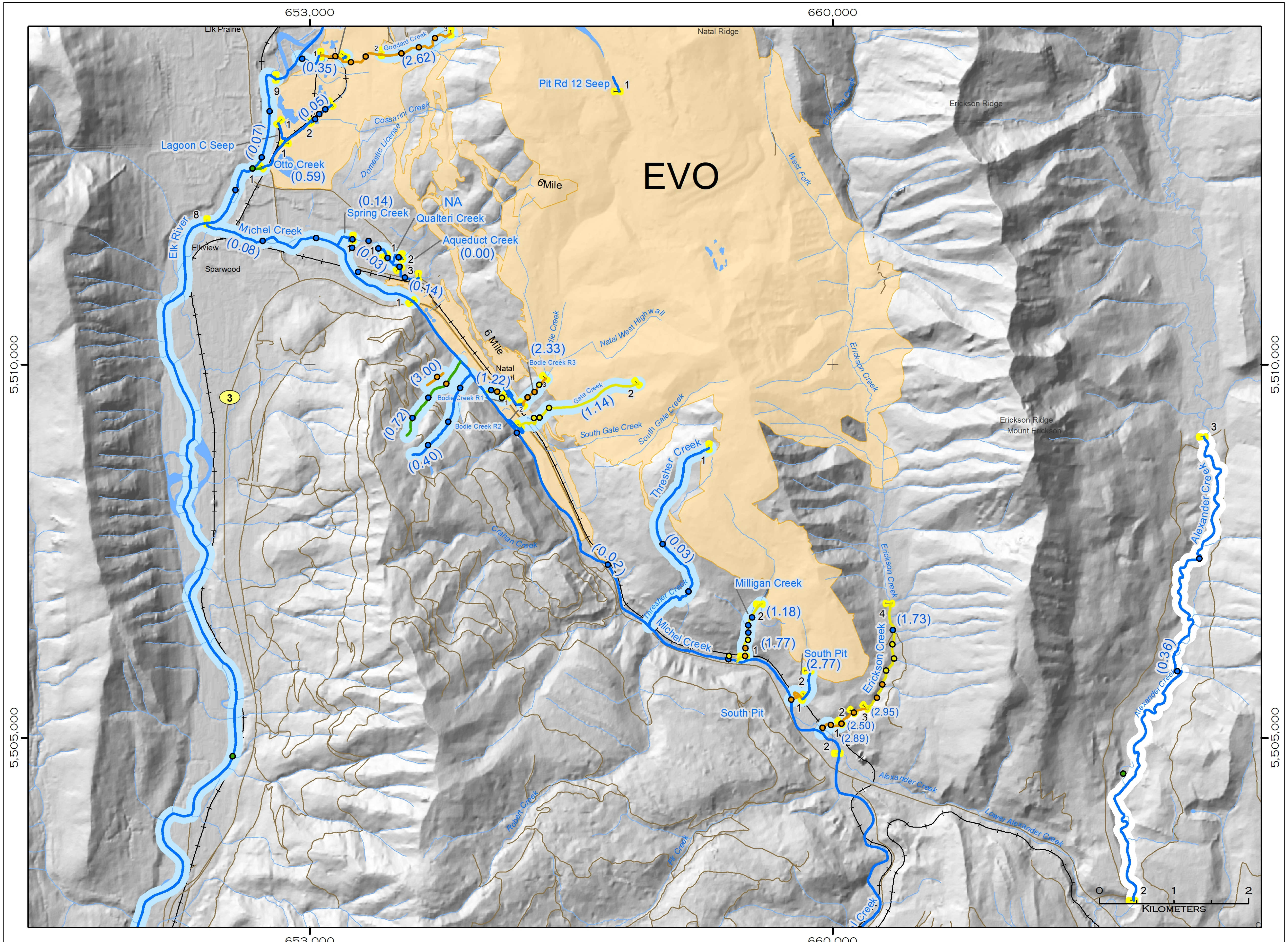


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

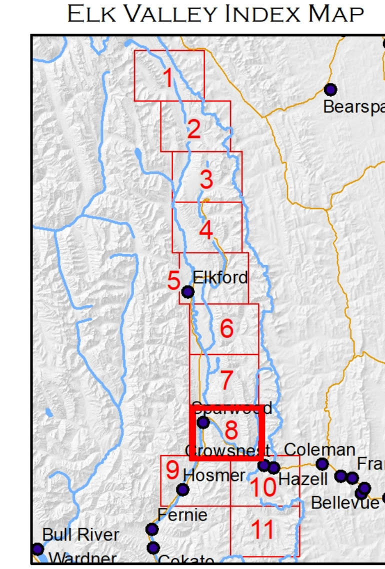
Elk Valley - Map #8

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

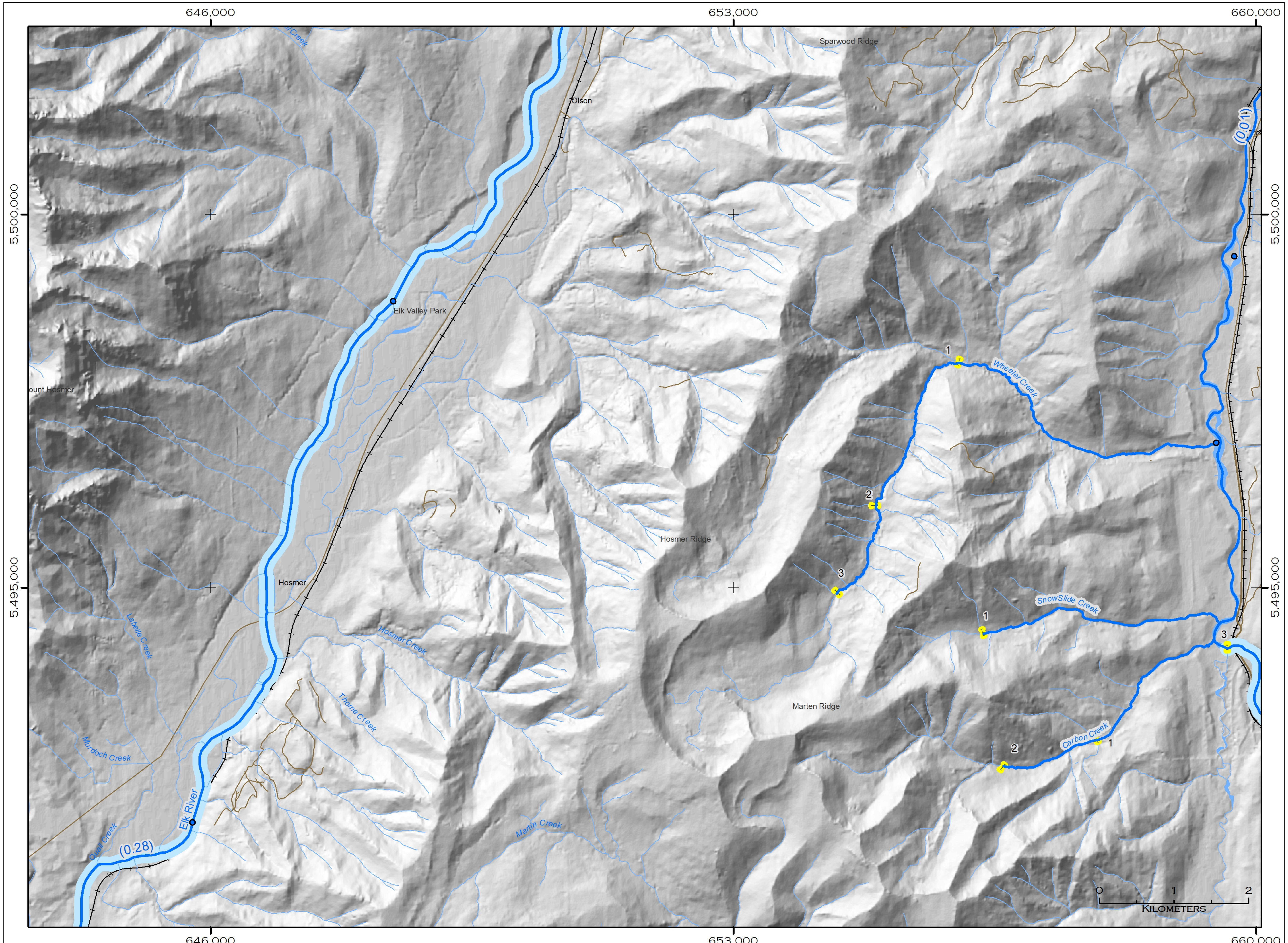


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

Elk Valley - Map #9

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (CI < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 2.0)

Exposed Stream (CI > 2.0)

Road - Regional

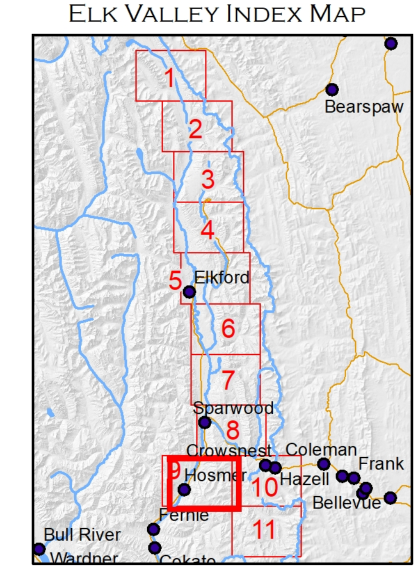
Railway

Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

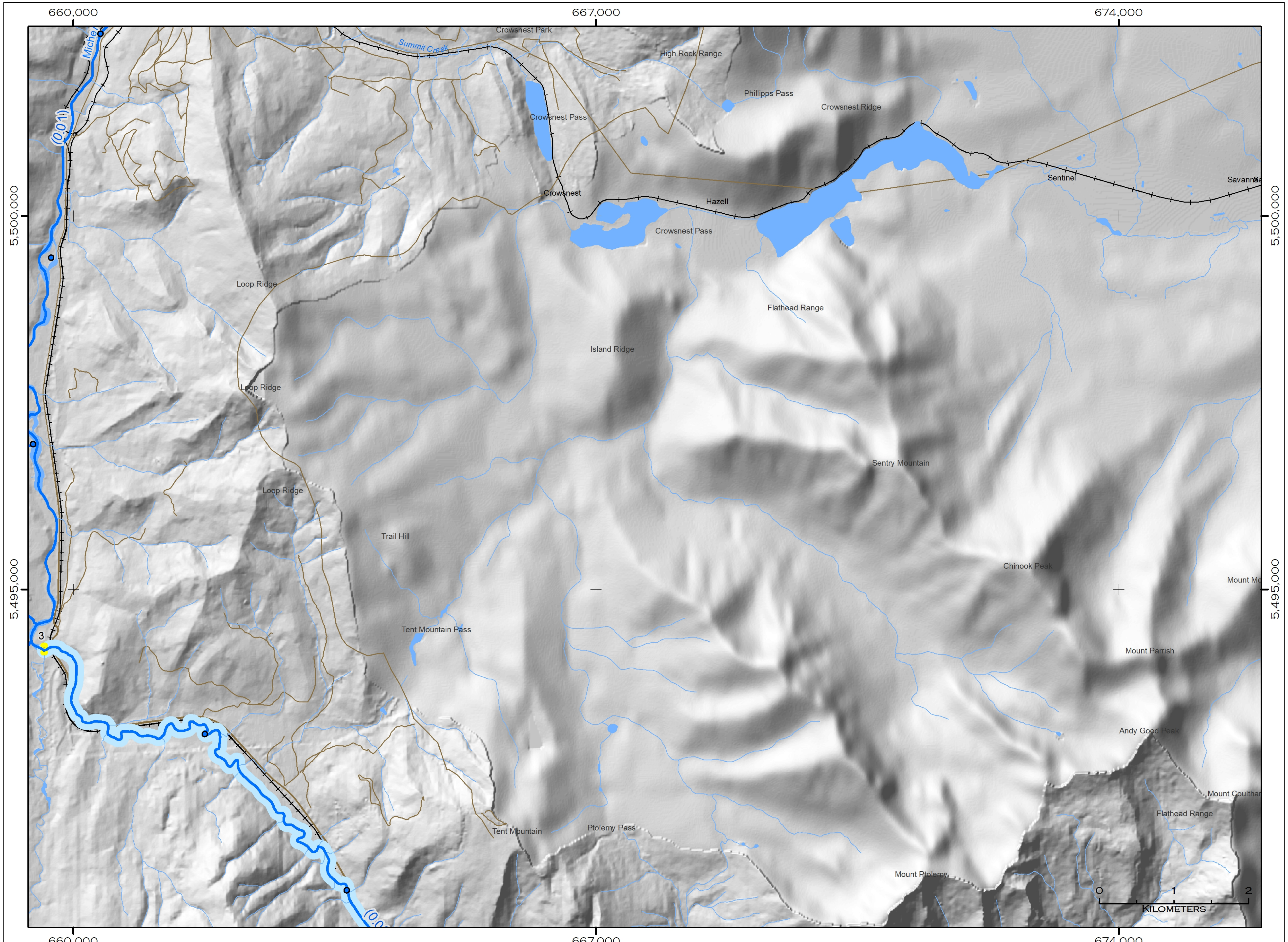


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

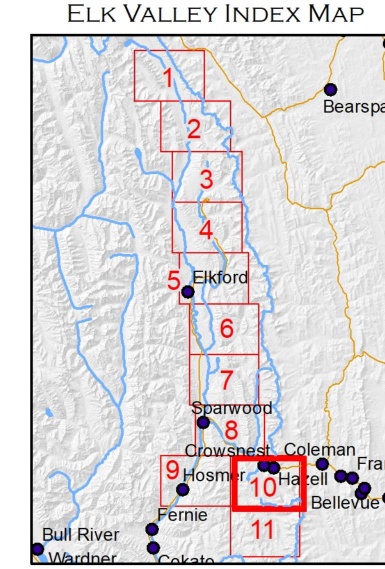
Elk Valley - Map #10

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

Elk Valley Index Map

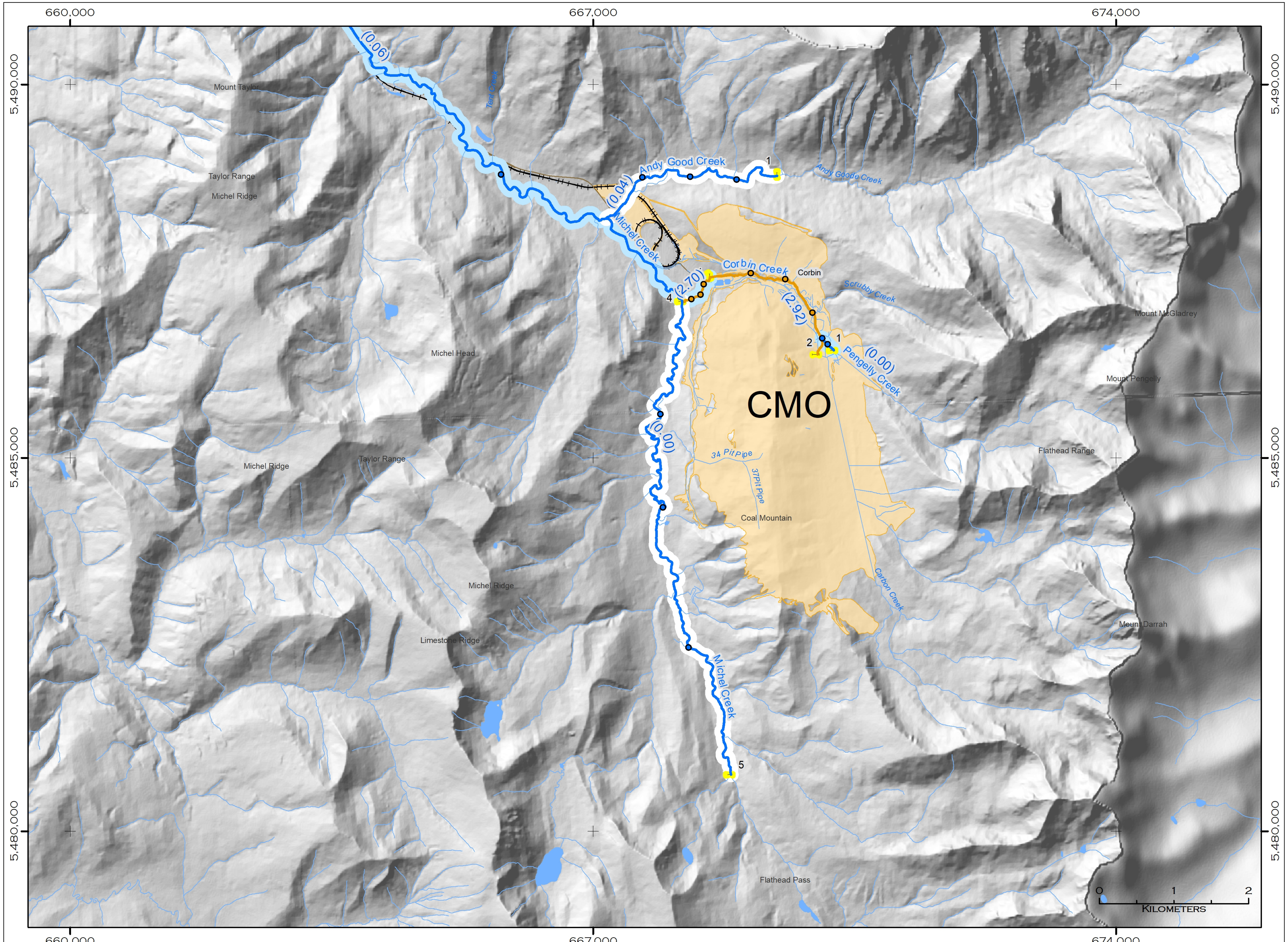


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Calcite Index

Elk Valley - Map #11

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (CI < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 2.0)

Exposed Stream (CI > 2.0)

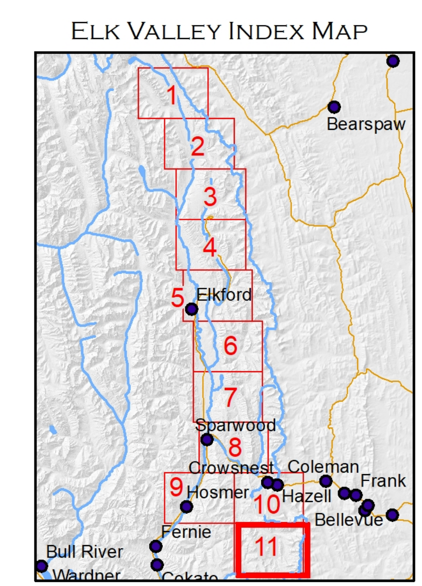
Road - Regional

Railway

Teck Coal Operations

Calcite Index per Site

- 0 - 0.5
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00

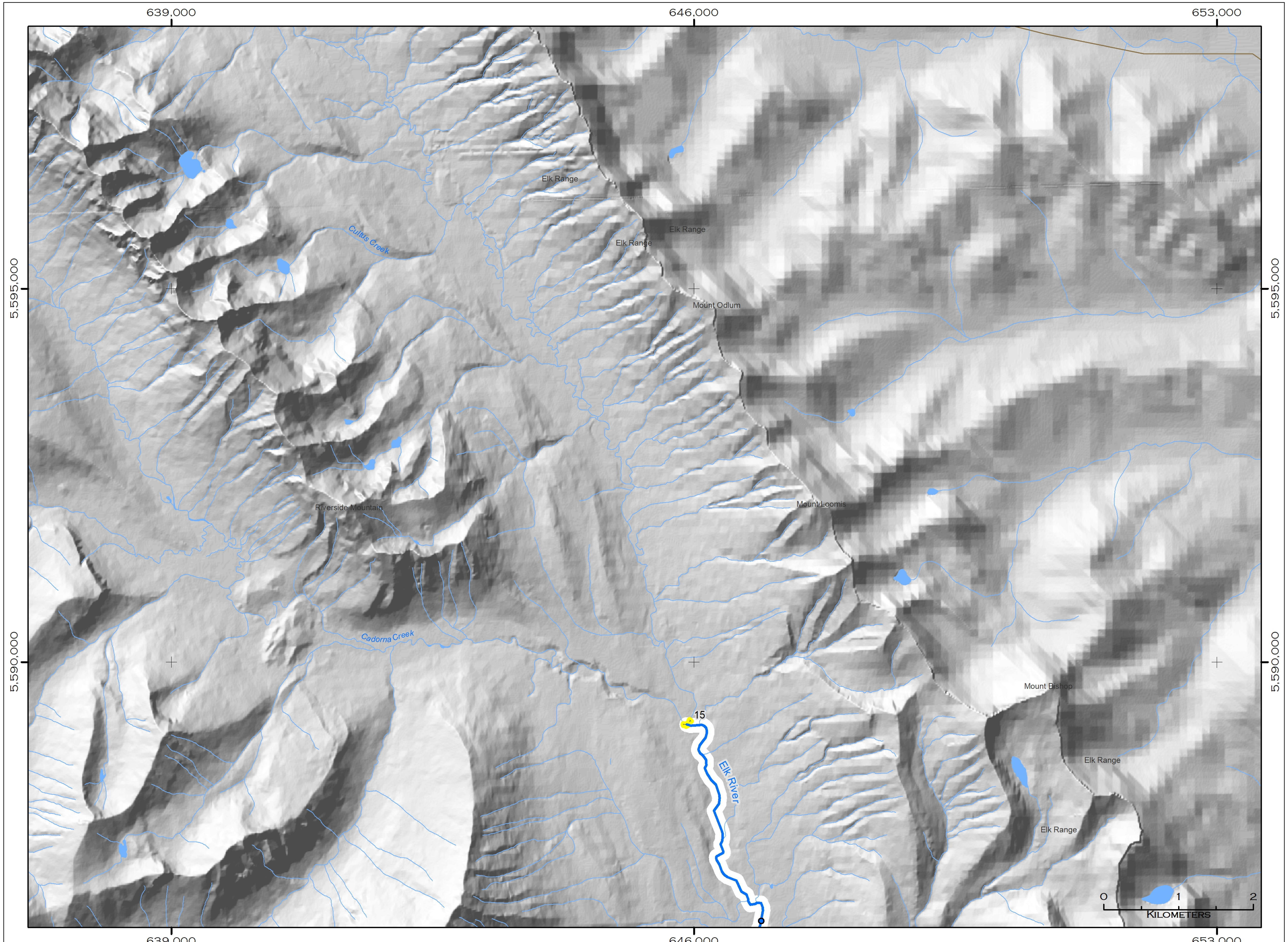


Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

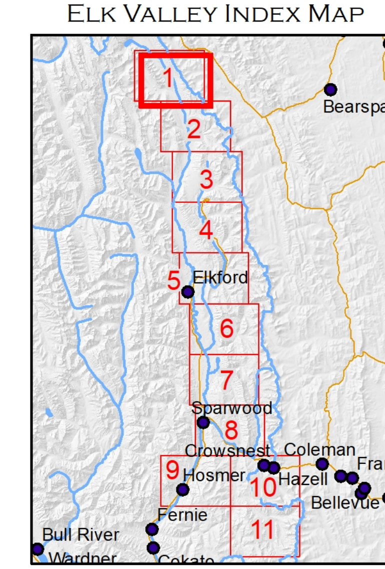
Elk Valley - Map #1

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (Conc < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 1.5)
- Exposed Stream (Conc > 1.5)
- Road - Regional
- Railway
- Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

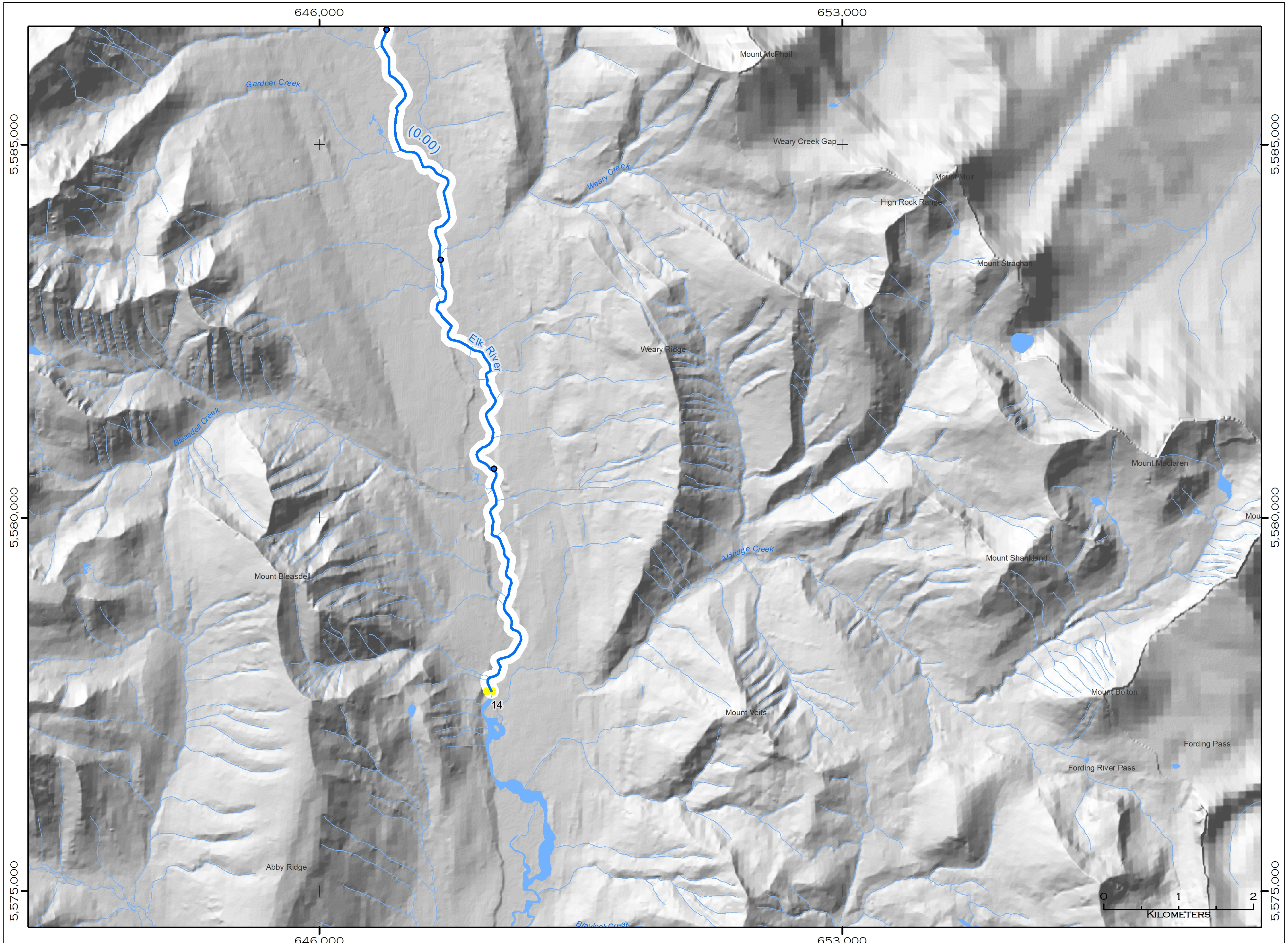


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

Elk Valley - Map #2

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (Conc < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 1.5)

Exposed Stream (Conc > 1.5)

Road - Regional

Railway

Teck Coal Operations

Concretion Index

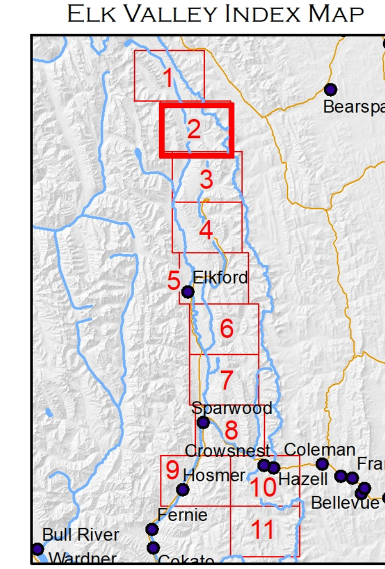
Conc < 0.5

0.5 - 1.0

1.0 - 1.5

Conc > 1.5

Elk Valley Index Map

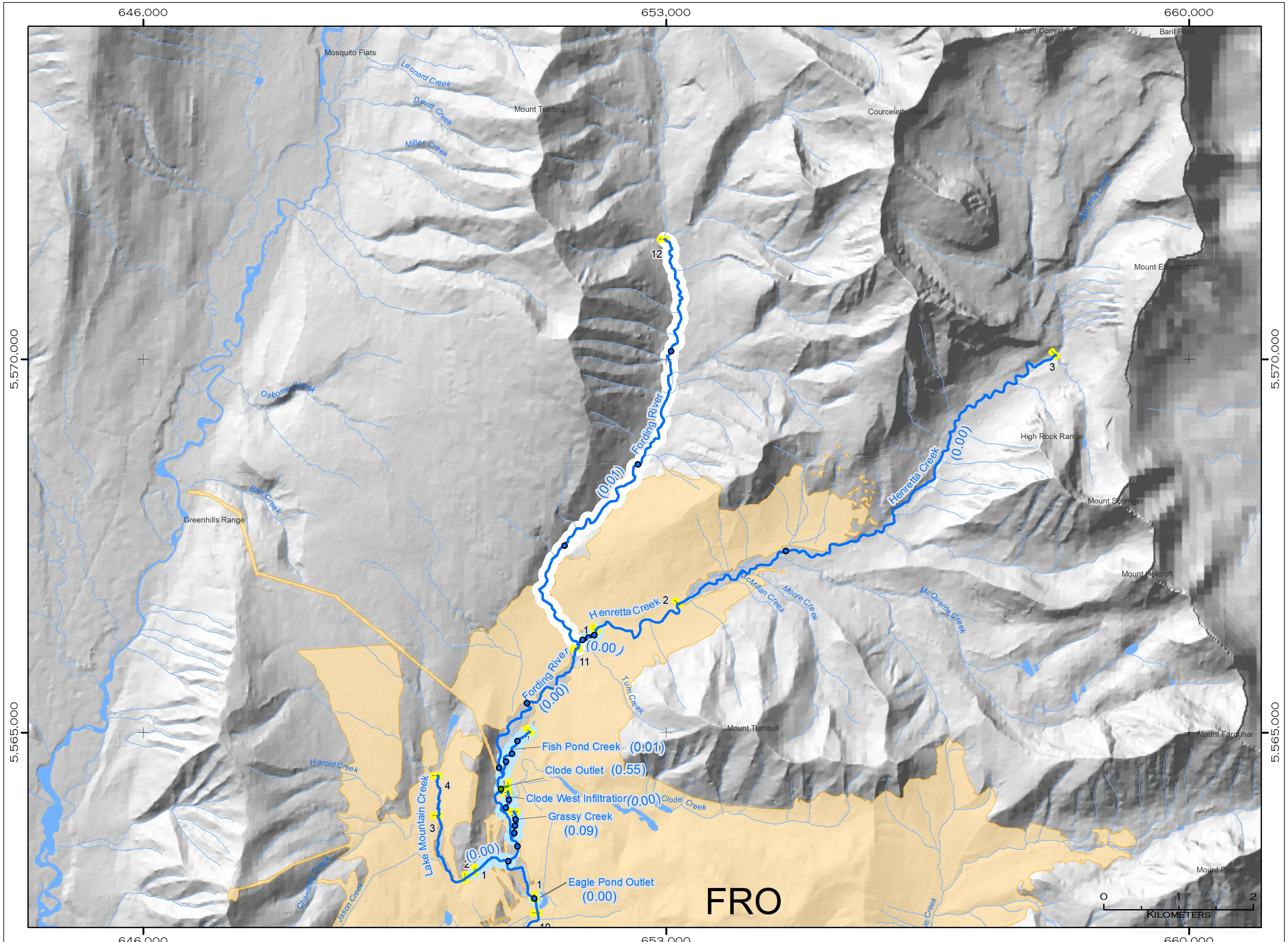


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

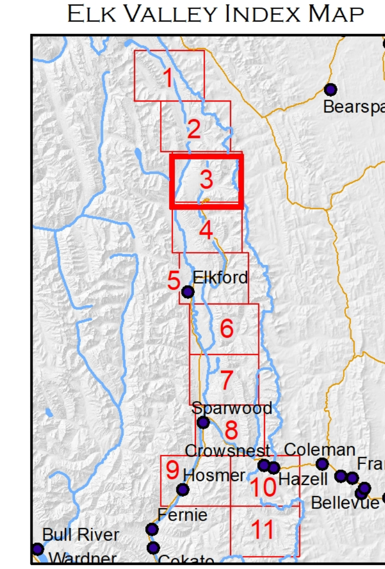
Elk Valley - Map #3

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (Conc < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 1.5)
- Exposed Stream (Conc > 1.5)
- Road - Regional
- Railway
- Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

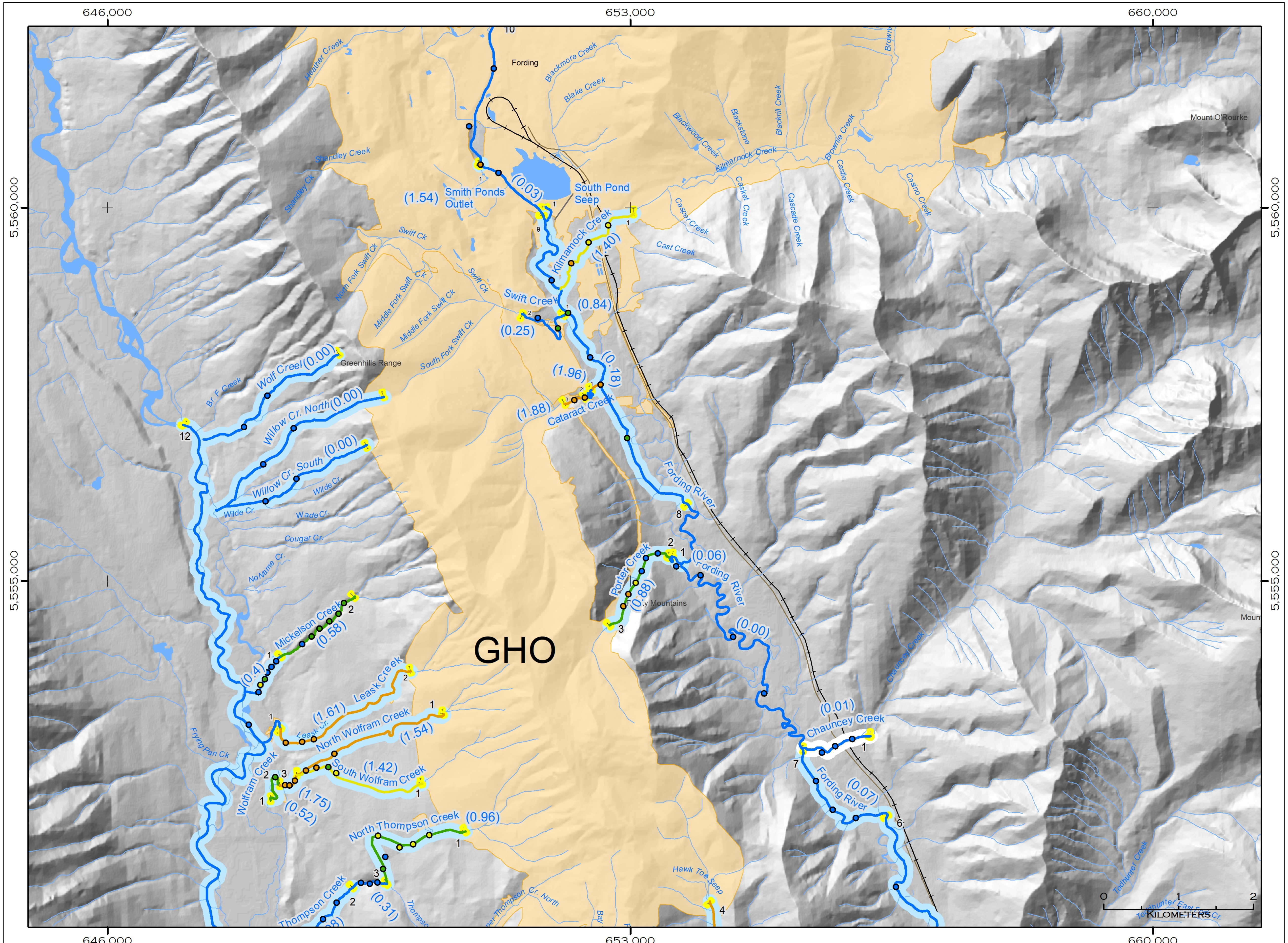


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

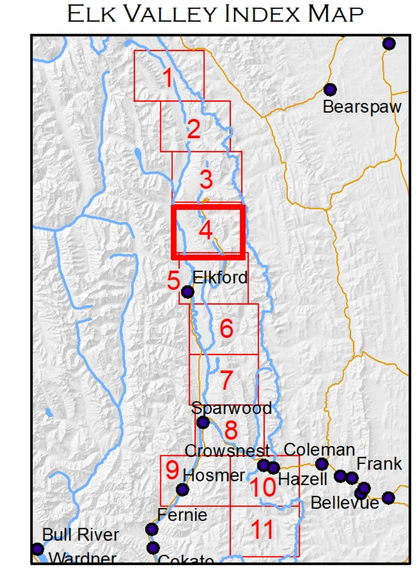
Elk Valley - Map #4

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (Conc < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 1.5)
- Exposed Stream (Conc > 1.5)
- Road - Regional
- Railway
- Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

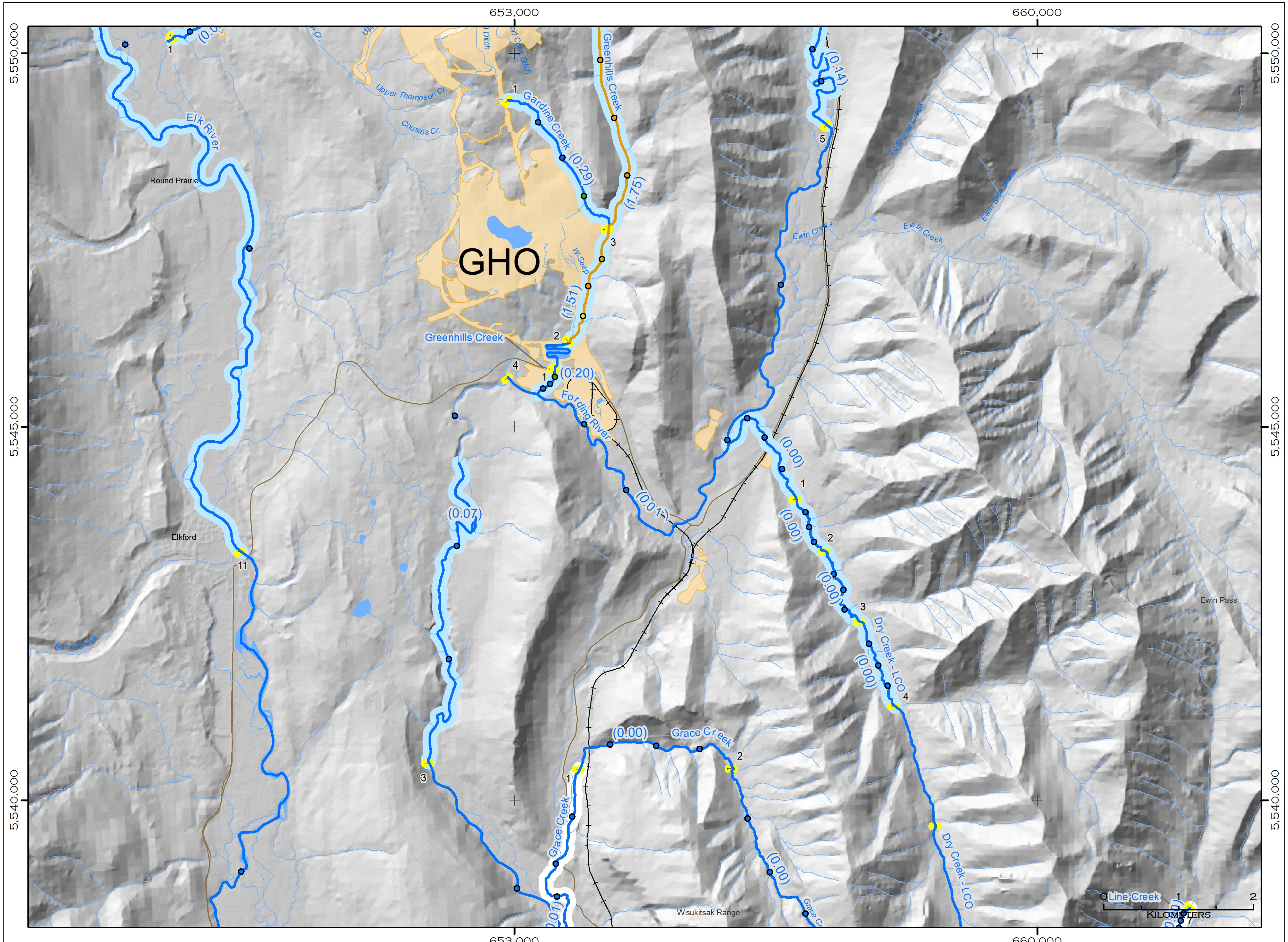


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

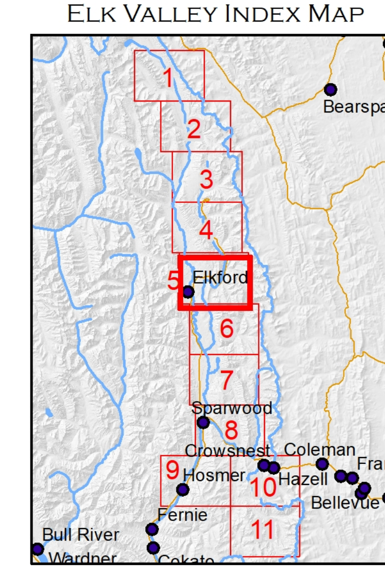
Concretion Index

Elk Valley - Map #5

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (Conc < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 1.5)
- Exposed Stream (Conc > 1.5)
- Road - Regional
- Railway
- Teck Coal Operations

Concretion Index
- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

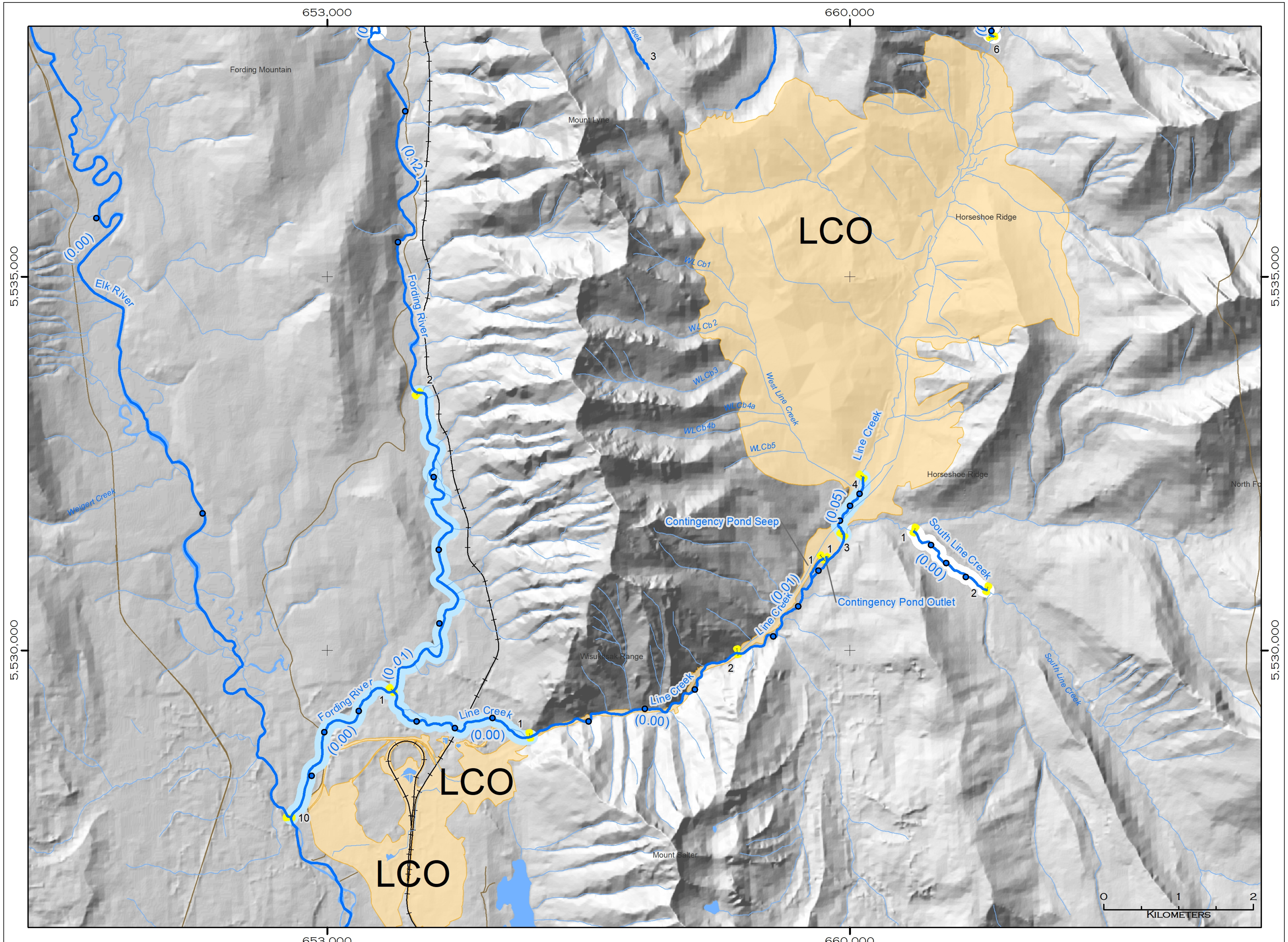


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

Elk Valley - Map #6

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (Conc < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 1.5)

Exposed Stream (Conc > 1.5)

Road - Regional

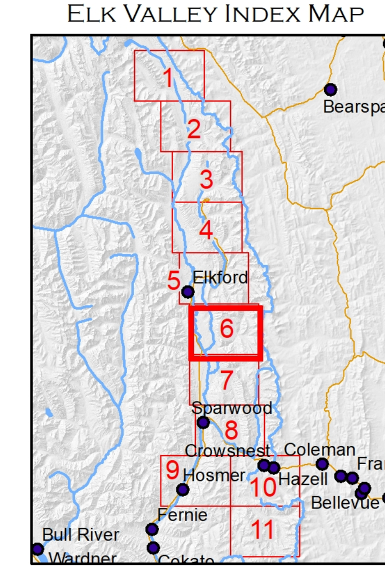
Railway

Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

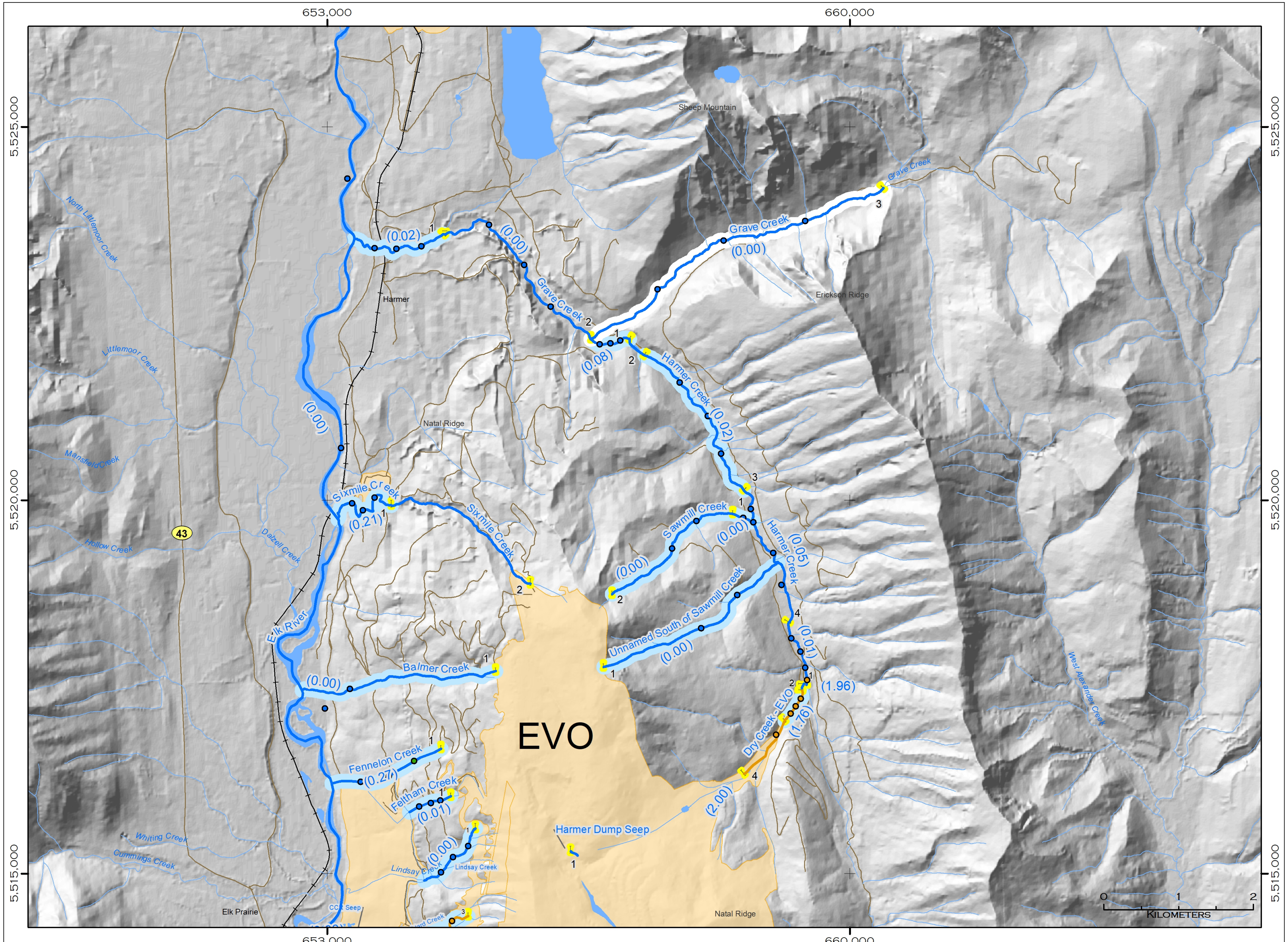


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

Elk Valley - Map #7

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (Conc < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 1.5)

Exposed Stream (Conc > 1.5)

Road - Regional

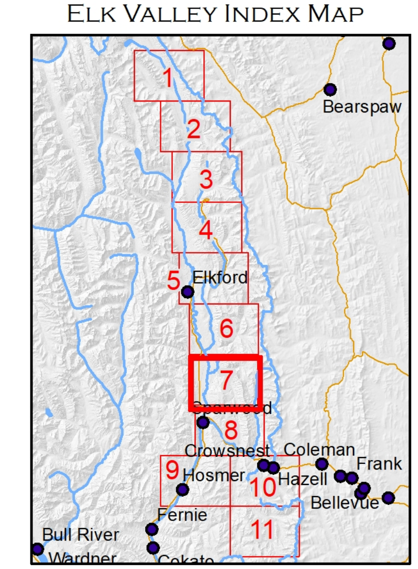
Railway

Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

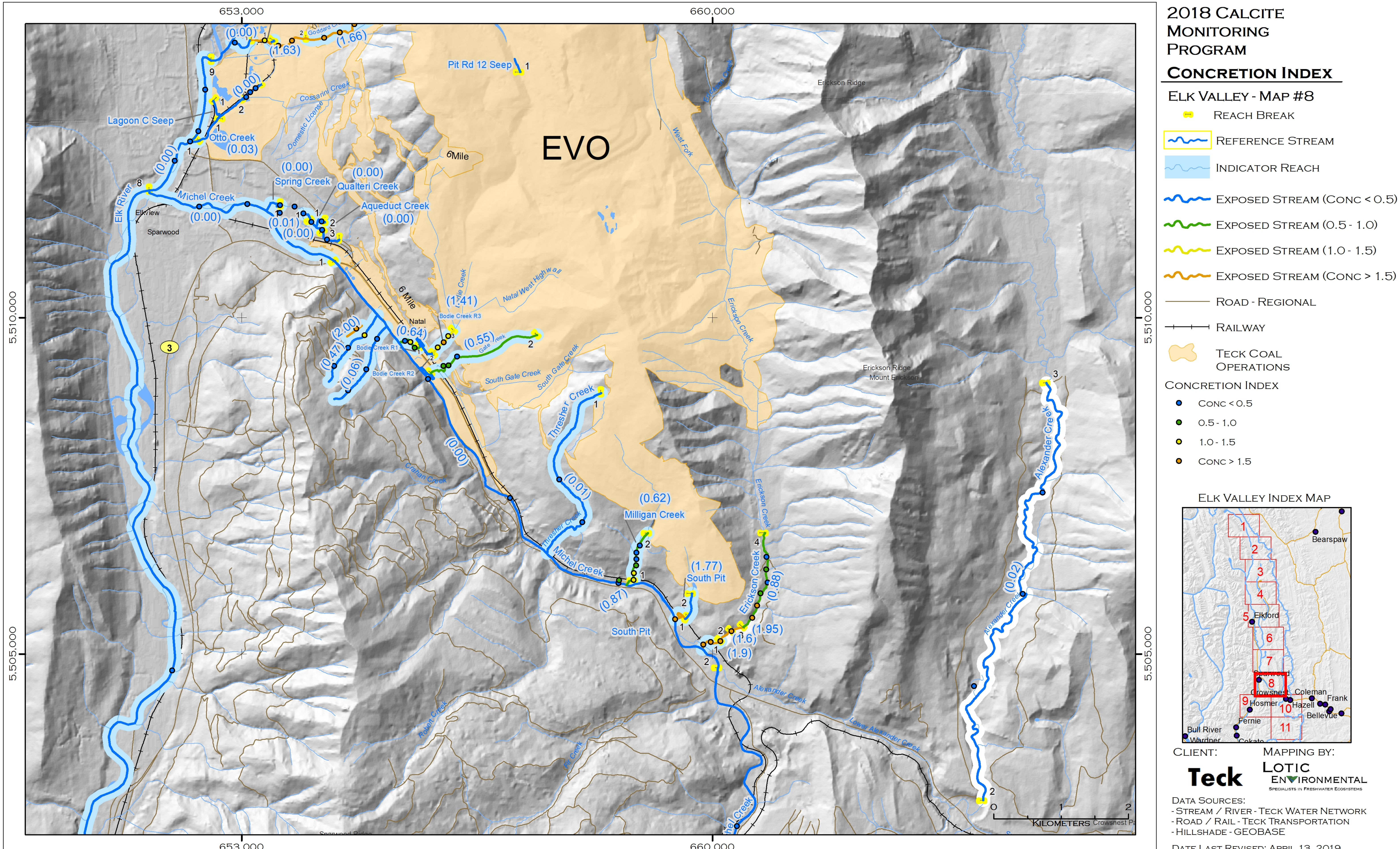


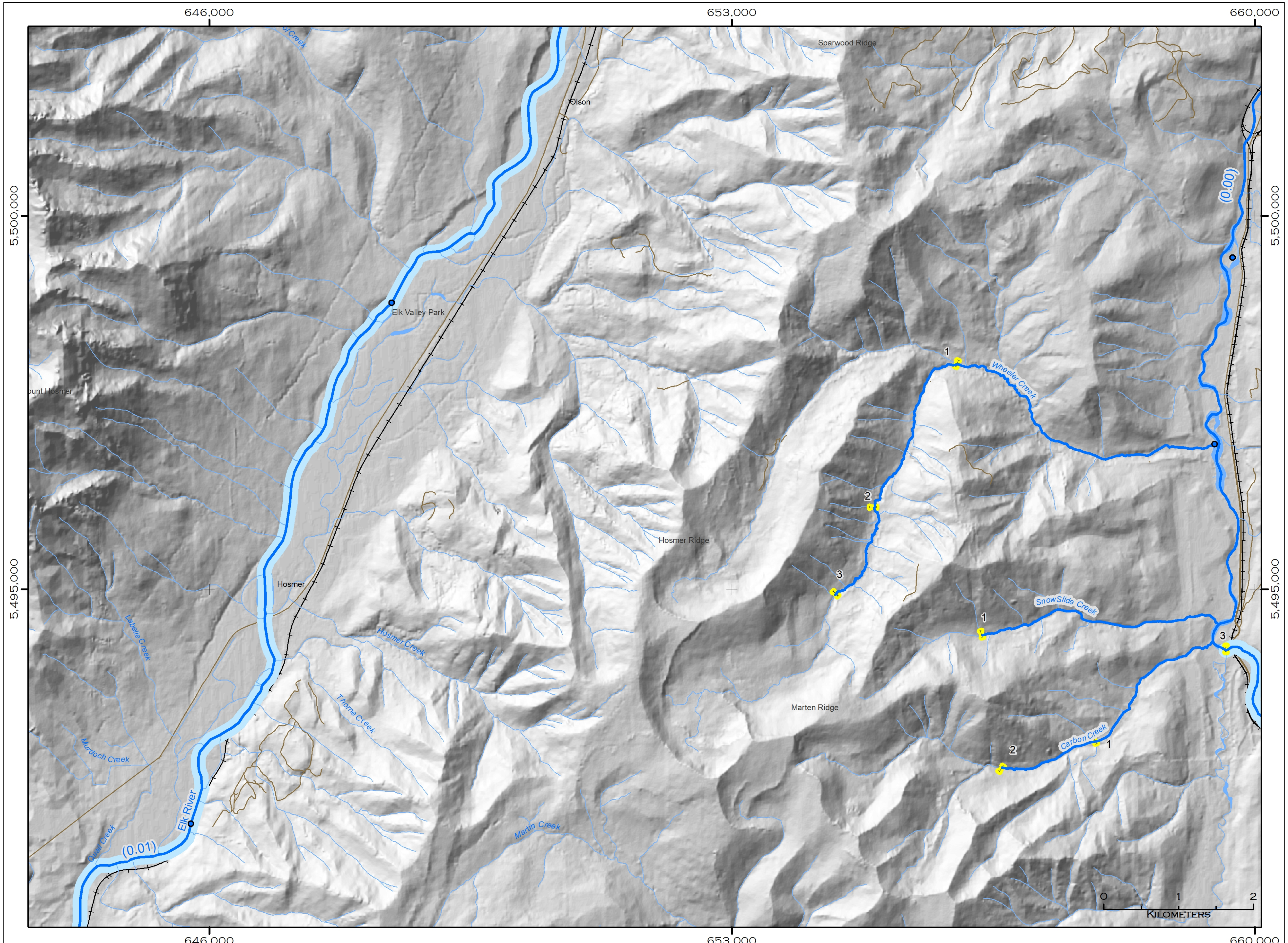
Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - Geobase

Date Last Revised: April 13, 2019


2018 Calcite Monitoring Program
Concretion Index
Elk Valley - Map #8
Reach Break
Reference Stream
Indicator Reach
Exposed Stream (Conc < 0.5)
Exposed Stream (0.5 - 1.0)
Exposed Stream (1.0 - 1.5)
Exposed Stream (Conc > 1.5)
Road - Regional
Railway
Teck Coal Operations
Concretion Index
Conc < 0.5
0.5 - 1.0
1.0 - 1.5
Conc > 1.5
Elk Valley Index Map
Bearspaw
Elkford
Sparwood
Crowsnest
Coleman
Frank
Hosmer
Hazell
Bellevue
Fernie
Bull River
Wardner
Cokato
Client:
Teck
Mapping by:
Lotic Environmental
Specialists in Freshwater Ecosystems
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE
Date Last Revised: April 13, 2019
653,000
660,000
5,510,000
5,505,000
EVO
Elk River
Elkview
Sparwood
Michel Creek
Lagoon C Seep
Otto Creek
(0.03)
Spring Creek
Qualteri Creek
Aqueduct Creek
Cossarini Creek
Domestic License
Goddard Creek
Pit Rd 12 Seep
6 Mile
Natal
Natal West Highwall
Bodie Creek R1
Bodie Creek R2
Bodie Creek R3
South Gate Creek
Thresher Creek
Milligan Creek
South Pit
Erickson Creek
West Fork
Erickson Ridge
Mount Erickson
Alexander Creek
Lower Alexander Creek
Crahan Creek
Robert Creek
Sparwood Ridge
(0.00)
(1.63)
(1.66)
(0.01)
(0.64)
(1.41)
(0.55)
(2.00)
(0.47)
(0.06)
(0.62)
(0.87)
(1.77)
(0.88)
(1.95)
(1.6)
(1.9)
(0.02)
Kilometers
0
1
2



2018 Calcite Monitoring Program

Concretion Index

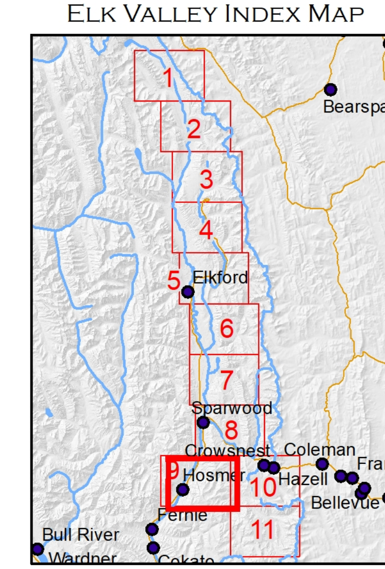
Elk Valley - Map #9

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (Conc < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 1.5)
- Exposed Stream (Conc > 1.5)
- Road - Regional
- Railway
- Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map

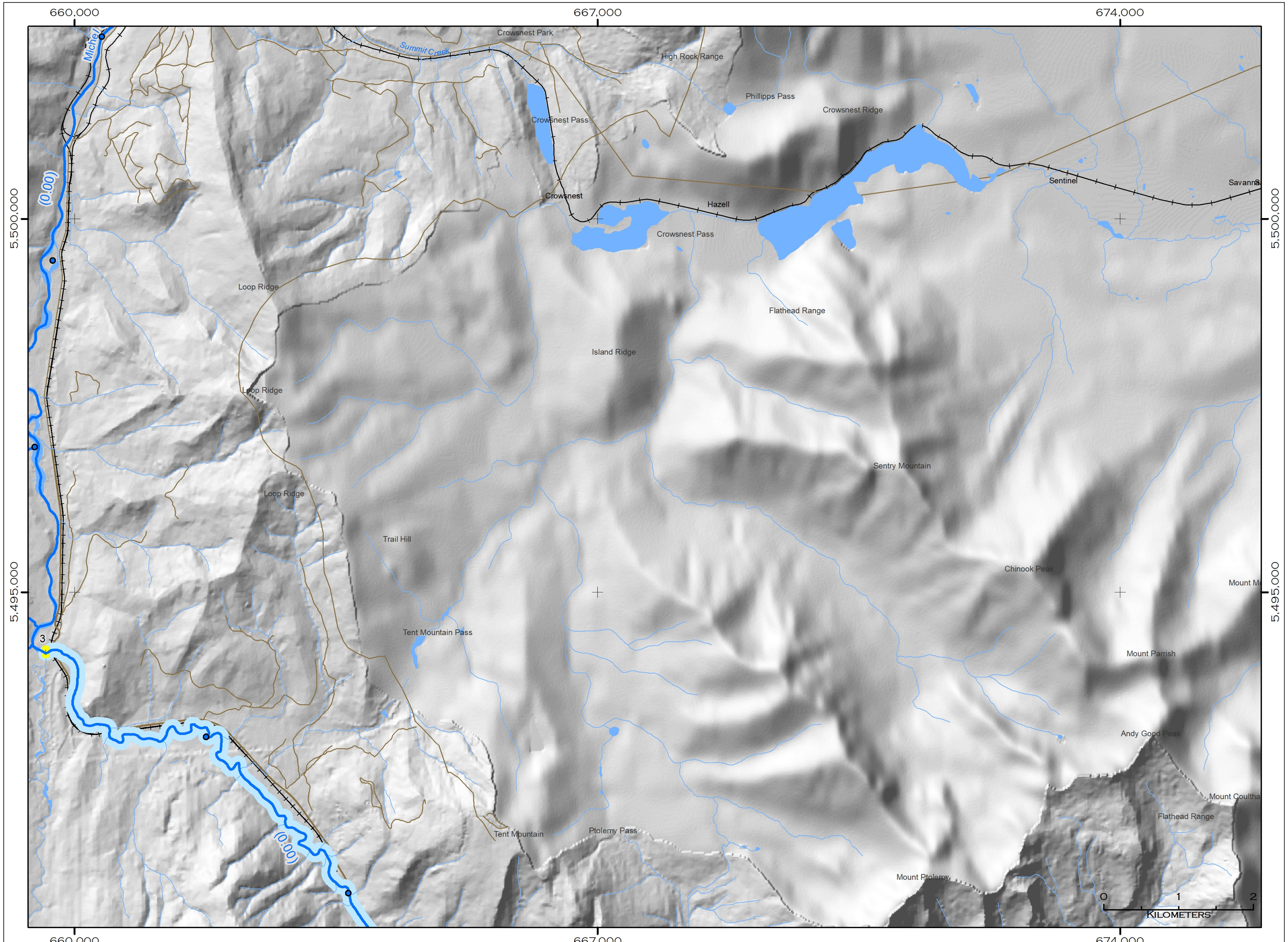


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

Elk Valley - Map #10

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (Conc < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 1.5)

Exposed Stream (Conc > 1.5)

Road - Regional

Railway

Teck Coal Operations

Concretion Index

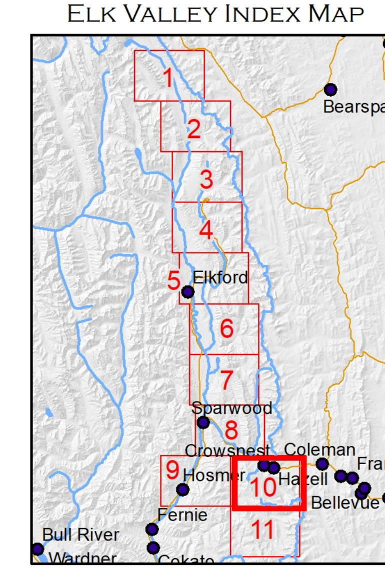
Conc < 0.5

0.5 - 1.0

1.0 - 1.5

Conc > 1.5

Elk Valley Index Map



Client:

Teck

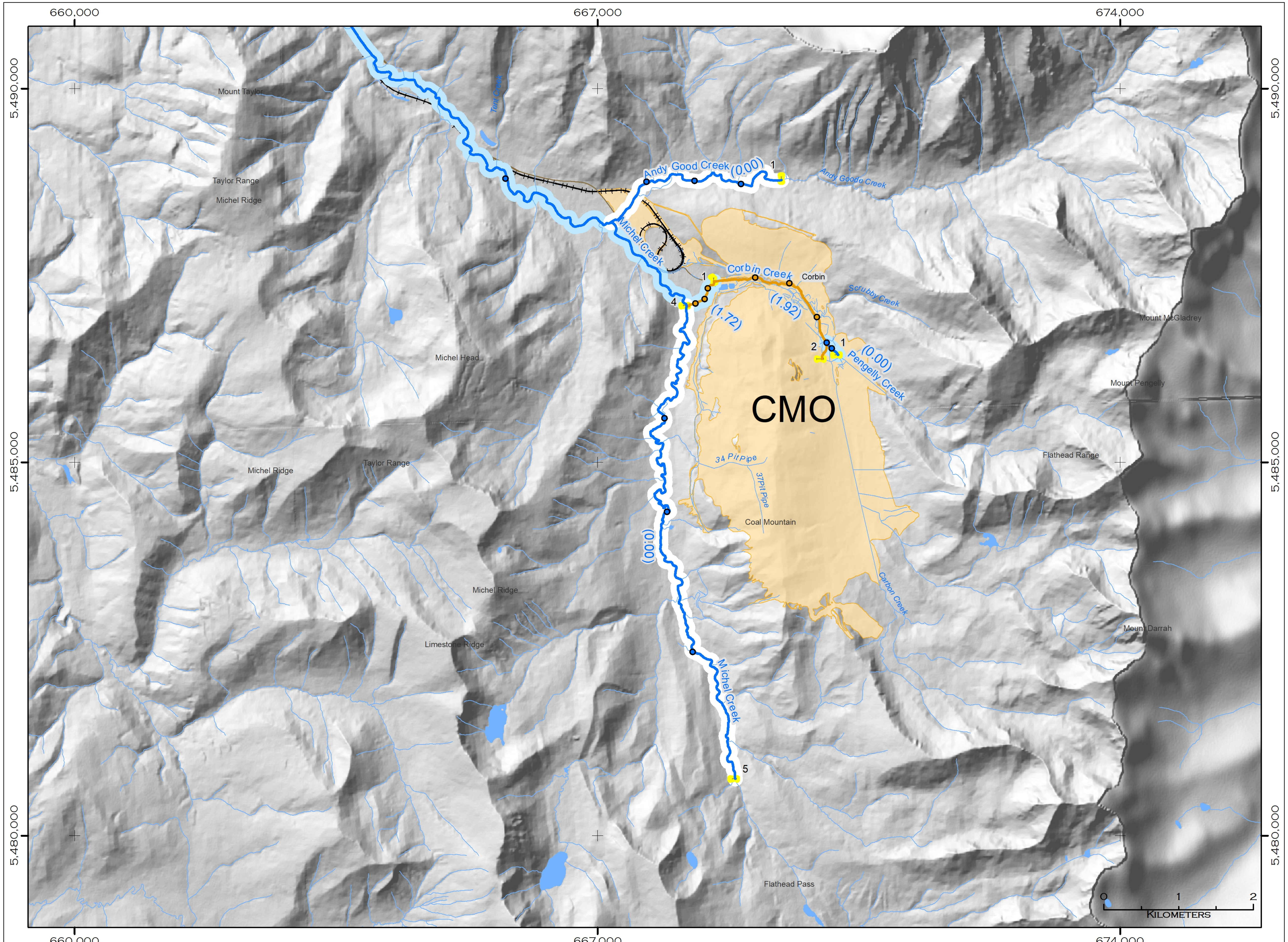
Mapping by:

Lotic Environmental

Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019



2018 Calcite Monitoring Program

Concretion Index

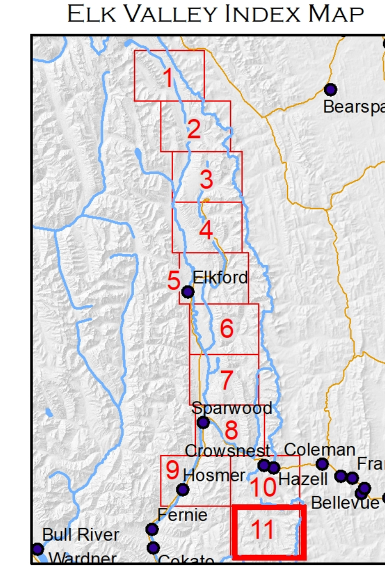
Elk Valley - Map # 11

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (Conc < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 1.5)
- Exposed Stream (Conc > 1.5)
- Road - Regional
- Railway
- Teck Coal Operations

Concretion Index

- Conc < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- Conc > 1.5

Elk Valley Index Map



Client: Teck

Mapping by: Lotic Environmental

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 13, 2019

Appendix 4. Mann-Kendall results.

Reach	p-value	tau
ALEX3 (R)	0.18	-0.55
ANDY1 (R)	0.24	0.58
AQUE1	0.24	0.58
AQUE3	0.37	0.71
BALM1	0.24	0.58
BODI1	0.07	0.75
BODI3	0.46	0.40
CATA1	0.24	-0.58
CATA3	0.73	-0.33
CHAU1 (R)	0.31	0.45
CLOW1	0.22	0.60
CORB1	0.13	0.60
CORB2	1.00	0.00
COUT1	0.13	0.60
DRYE1	0.73	0.33
DRYE3	0.02	0.87
DRYE4	0.09	1.00
DRYL1	0.07	0.77
DRYL2	0.24	0.58
DRYL3	0.07	0.77
DRYL4	0.29	0.63
ELKR10	0.37	0.71
ELKR15 (R)	0.24	0.58
ELKR8	0.84	0.15
ELKR9	0.24	0.58
EPOU1	0.06	-0.73
ERIC1	0.13	0.60
ERIC2	0.31	0.67
ERIC3	0.31	0.67
ERIC4	0.31	0.67
FELT1	0.24	0.58
FENN1	0.24	0.58
FORD1	0.16	0.60
FORD10	0.37	0.71
FORD11	0.37	0.71
FORD12 (R)	0.03	0.89
FORD2	0.07	0.77
FORD3	0.47	0.55
FORD4	0.22	0.60
FORD5	0.02	0.87
FORD6	0.71	0.20
FORD7	0.26	0.47
FORD8	0.31	0.67
FORD9	0.07	0.77
FPON1	0.09	0.69
GARD1	0.71	0.20
GATE2	0.13	0.60
GODD1	0.07	0.75
GODD2	0.37	0.71
GODD3	0.02	0.87
GRAC1 (R)	0.45	-0.33
GRAC2 (R)	0.09	-1.00

Reach	p-value	tau
GRAS1	0.18	0.55
GRAV1	1.00	-0.07
GRAV2	0.31	-0.67
GREE1	0.45	0.33
GREE3	0.13	0.60
GREE4	0.71	0.20
HARM1	0.71	0.20
HARM3	0.45	-0.33
HARM4	1.00	0.00
HARM5	0.73	0.33
HENR1	0.07	0.77
KILM1	0.26	0.47
LEAS2	0.06	0.73
LIND1	0.84	-0.15
LINE1	0.84	0.15
LINE2	0.37	0.71
LINE3	0.37	0.71
LINE4	0.13	0.60
LINE7 (R)	0.24	0.58
LMOU1	0.18	0.55
MICH1	1.00	-0.09
MICH2	0.81	-0.20
MICH3	0.37	0.71
MICH4	0.07	0.77
MICH5 (R)	0.56	0.35
MICK1	0.57	0.28
MICK2	0.73	0.33
MILL1	0.10	0.84
MILL2	0.07	0.75
NTHO1	0.45	0.33
NWOL1	0.71	0.20
OTTO1	1.00	0.07
OTTO3	0.73	0.33
PENG1	0.04	-0.86
PORT1	0.44	-0.35
PORT3	0.26	-0.47
SAWM1	0.24	0.58
SAWM2	0.31	-0.45
SIXM1	1.00	0.07
SLIN2 (R)	0.07	0.77
SPIT1	0.01	0.97
SPOU1	1.00	0.00
SPRI1	0.57	0.28
SWIF1	0.71	-0.20
SWIF2	0.31	0.67
SWOL1	0.34	0.41
THOM2	0.46	0.40
THOM3	0.37	0.71
THRE1	0.24	0.58
WOLF2	0.22	0.60
WOLF3	1.00	0.07

Appendix 5. ANOVA results by reach.

Reach	p-value	df
ALEX3 (R)	0.91	5
ANDY1 (R)	0.01	5
AQUE3	0.44	3
BODI1	0.03	4
BODI3	0.06	4
CATA3	0.39	3
CHAU1 (R)	0.01	5
CLOW1	0.02	2
CORB1	0.00	5
CORB2	0.66	3
DRYE3	0.27	5
DRYL1	0.00	5
DRYL2	0.03	5
DRYL3	0.00	5
DRYL4	0.00	4
ELKR10	0.06	3
ELKR15 (R)	0.46	5
ELKR8	0.18	5
ELKR9	0.12	5
ERIC1	0.02	3
ERIC4	0.20	3
FELT1	0.03	5
FENN1	0.46	5
FORD1	0.00	5
FORD10	0.00	3
FORD11	0.00	3
FORD12 (R)	0.00	5
FORD2	0.07	4
FORD3	0.01	3
FORD4	0.07	4
FORD5	0.39	5
FORD6	0.02	5
FORD7	0.70	5
FORD8	0.74	3
FORD9	0.04	5
FPON1	0.06	4
GARD1	0.95	5
GATE2	0.00	4
GODD2	0.00	3
GODD3	0.00	5
GRAC1 (R)	0.00	5
GRAC2 (R)	0.69	3
GRAS1	0.30	5
GRAV1	0.04	5

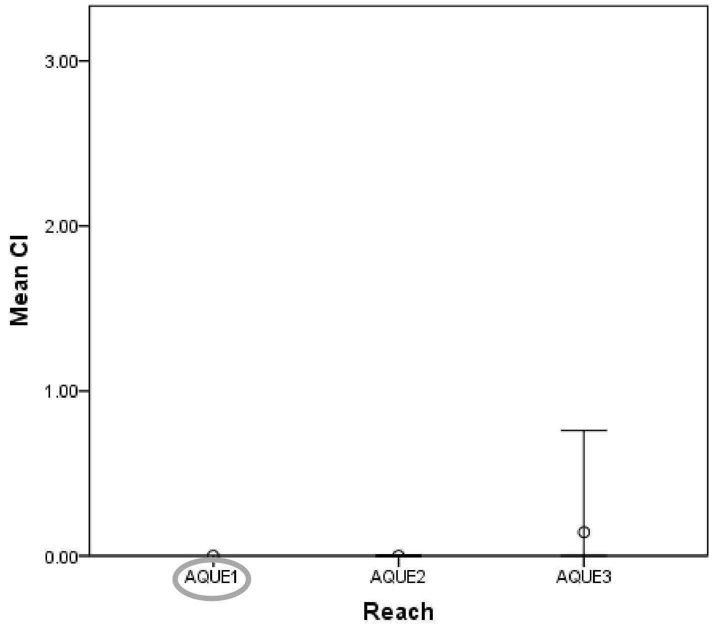
Reach	p-value	df
GRAV2	0.11	3
GREE1	0.70	5
GREE3	0.00	5
GREE4	0.00	5
HARM1	0.00	5
HARM3	0.13	5
HARM4	0.08	3
HARM5	0.28	3
HENR1	0.00	5
KILM1	0.43	5
LEAS2	0.00	4
LIND1	1.00	5
LINE1	0.00	5
LINE2	0.02	3
LINE3	0.00	3
LINE4	0.00	5
LINE7 (R)	0.06	5
LMOU1	0.64	4
MICH1	0.51	5
MICH2	0.80	4
MICH3	0.21	3
MICH4	0.01	5
MICH5 (R)	0.46	5
MICK1	0.00	5
MICK2	0.00	3
MILL2	0.97	2
NTHO1	0.04	5
NWOL1	0.33	2
OTTO3	0.52	3
PENG1	0.03	3
PORT3	0.63	5
SAWM1	0.48	3
SAWM2	0.60	5
SIXM1	0.10	5
SLIN2 (R)	0.01	5
SPIT1	0.05	3
STR02 (R)	0.97	1
SWIF2	0.73	3
SWOL1	0.00	5
THOM2	0.00	4
THOM3	0.00	3
THRE1	0.49	5
WOLF2	0.75	1
WOLF3	0.00	5

Appendix 6. Stream segment summary.

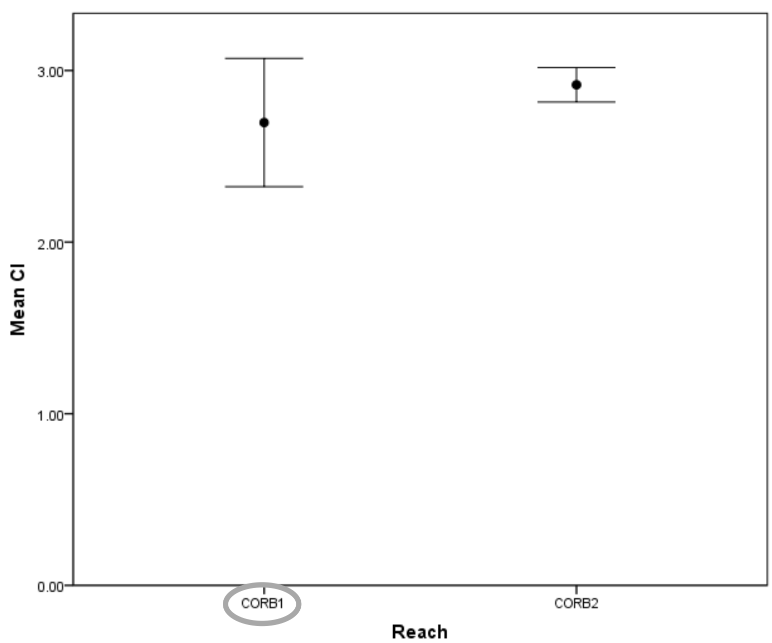
Water feature	Segment Name	Reaches Included	Indicator Reach
Alexander	ALEX_A	ALEX3	ALEX3
Andy Good	ANDY_A	ANDY1	ANDY1
Aqueduct	AQUE_A	AQUE1, AQUE2, AQUE3	AQUE1
Balmer	BALM_A	BALM1	BALM1
Bodie	BODI_A	BODI1	BODI1
	BODI_B	BODI3	BODI3
Cataract	CATA_A	CATA1, CATA3	CATA1
Chauncey	CHAU_A	CHAU1	CHAU1
Clode West Infiltration	CLOW_A	CLOW1	CLOW1
Corbin	CORB_A	CORB1, CORB2	CORB1
Clode Pond Outlet	COUT_A	COUT1	COUT1
CCR Seep	CSEE_A	CSEE1	CSEE1
Dry (EVO)	DRYE_A	DRYE1, DRYE3, DRYE4	DRYE3
Dry (LCO)	DRYL_A	DRYL1	DRYL1
	DRYL_B	DRYL2	DRYL2
	DRYL_C	DRYL3	DRYL3
	DRYL_D	DRYL4	DRYL4
Elk	ELKR_A	ELKR8	ELKR8
	ELKR_B	ELKR9, ELKR10	ELKR9
	ELKR_C	ELKR11, ELKR12	ELKR12
	ELKR_D	ELKR15	ELKR15
Eagle Pond Outlet	EPOU_A	EPOU1	EPOU1
Erickson	ERIC_A	ERIC1, ERIC2, ERIC3, ERIC4	ERIC1
Feltham	FELT_A	FELT1	FELT1
Fennelon	FENN_A	FENN1	FENN1
Fording	FORD_G	FORD12	FORD12
	FORD_A	FORD1	FORD1
	FORD_B	FORD2, FORD 3	FORD2
	FORD_C	FORD4, FORD 5	FORD4
	FORD_D	FORD6	FORD6
	FORD_E	FORD7, FORD 8	FORD7
	FORD_F	FORD9, FORD 10, FORD11	FORD9
Fish Pond	FPON_A	FPON1	FPON1
Gardine	GARD_A	GARD1	GARD1
Gate	GATE_A	GATE2	GATE2
Goddard	GODD_A	GODD1	GODD1
	GODD_B	GODD3	GODD3
Grace	GRAC_A	GRAC1, GRAC2, GRAC3	GRAC1
Grassy	GRAS_A	GRAS1	GRAS1
Grave	GRAV_A	GRAV1, GRAV2	GRAV1
	GRAV_B	GRAV3	GRAV3
Greenhills	GREE_A	GREE1	GREE1
	GREE_B	GREE3	GREE3
	GREE_C	GREE4	GREE4
Harmer	HARM_A	HARM1	HARM1
	HARM_B	HARM3, HARM4, HARM5	HARM3
Henretta	HENR_A	HENR1, HENR3	HENR1
Kilmarnock	KILM_A	KILM1	KILM1
Leask	LEAS_A	LEAS2	LEAS2
Lindsay	LIND_A	LIND1	LIND1

Water feature	Segment Name	Reaches Included	Indicator Reach
Line	LINE_A	LINE1, LINE2, LINE3	LINE1
	LINE_B	LINE4	LINE4
	LINE_C	LINE7	LINE7
Lake Mountain	LMOU_A	LMOU1, LMOU3, LMOU4	LMOU1
Michel	MICH_A	MICH1, MICH2	MICH1
	MICH_B	MICH3, MICH4	MICH4
	MICH_C	MICH5	MICH5
Mickelson	MICK_A	MICK1, MICK2	MICK1
Milligan	MILL_A	MILL1, MILL2	MILL2
North Thompson	NTHO_A	NTHO1	NTHO1
North Wolfram	NWOL_A	NWOL1	NWOL1
Otto	OTTO_A	OTTO1, OTTO3	OTTO1
Pengally	PENG_A	PENG1	PENG1
Porter	PORT_A	PORT1	PORT1
	PORT_B	PORT3	PORT3
Qualteri	QUAL_A	QUAL1	QUAL1
Sawmill	SAWM_A	SAWM1	SAWM1
	SAWM_B	SAWM2	SAWM2
Site 18	SITE_18	SITE18	SITE18
Six Mile	SIXM_A	SIXM1	SIXM1
South Line	SLIN_A	SLIN2	SLIN2
South Pit	SPIT_A	SPIT1	SPIT1
	SPIT_B	SPIT2	SPIT2
Smith Pond Outlet	SPOU_A	SPOU1	SPOU1
Spring	SPRI_A	SPRI1	SPRI1
Stream #02	STR02_A	STR02	STR02
Stream #18	STR18_A	STR18	STR18
Swift	SWIF_A	SWIF1, SWIF2	SWIF1
South Wolfram Creek	SWOL_A	SWOL1	SWOL1
Thompson	THOM_A	THOM1, THOM2, THOM3	THOM2
Thresher	THRE_A	THRE1	THRE1
Unnamed South of Sawmill	USOS_A	USOS1	USOS1
Willow Cr North	WILN_A	WILN2	WILN2
Willow Cr South	WILS_A	WILS1	WILS1
Wolf Creek	WOL1_A	WOL1	WOL1
Wolfram	WOLF_A	WOLF2	WOLF2
	WOLF_B	WOLF3	WOLF3

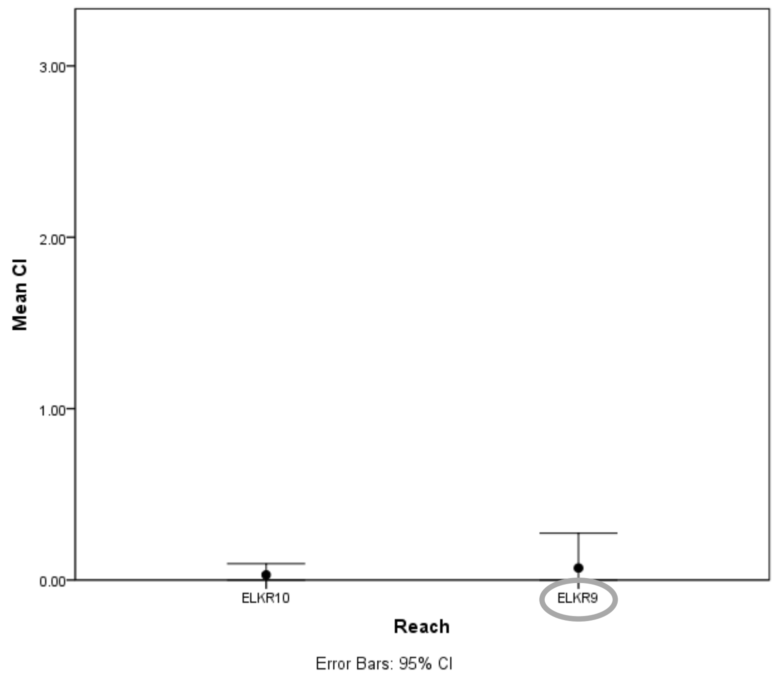
Appendix 7. Reach mean Calcite Index Plots by Segment. (red circle = indicator reach)

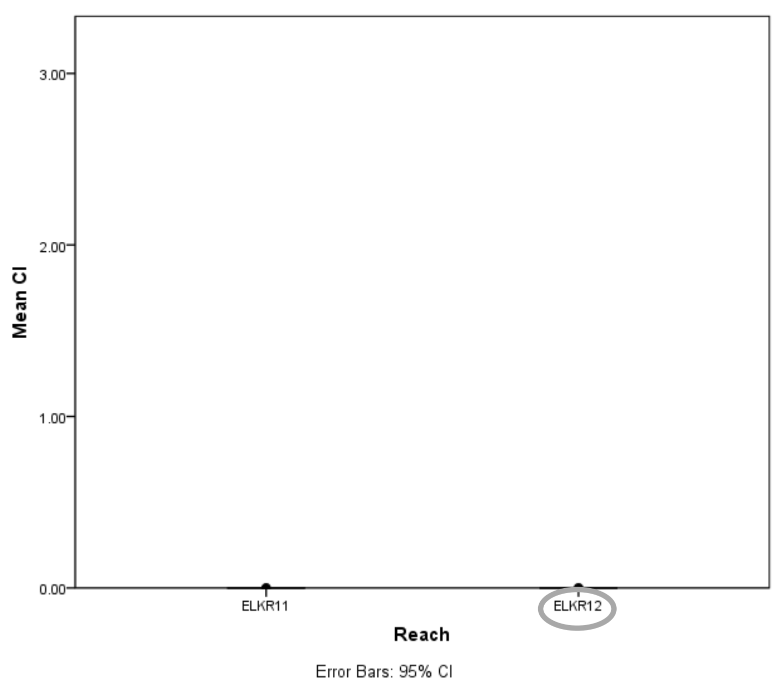


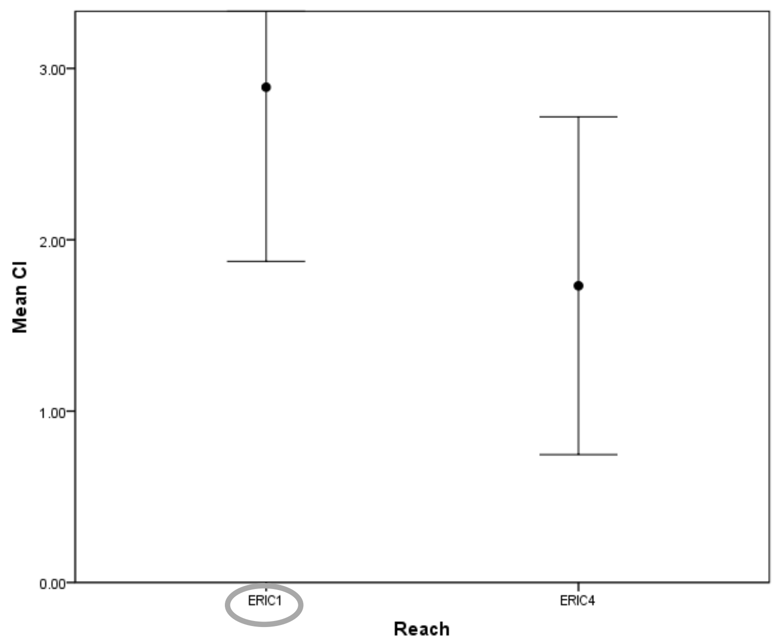
Error Bars: 95% CI



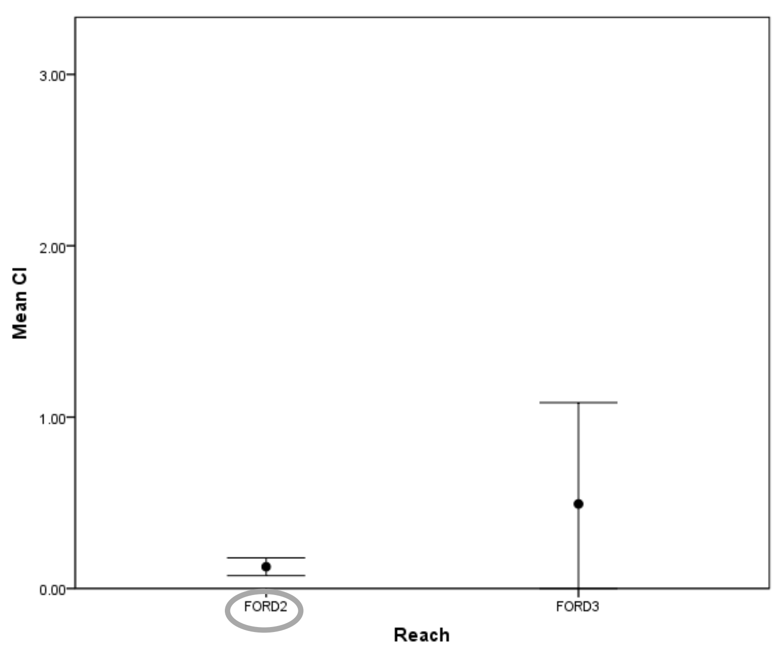
Error Bars: 95% CI


3.00
2.00
1.00
0.00
Mean CI
ELKR10
ELKR9
Reach
Error Bars: 95% CI

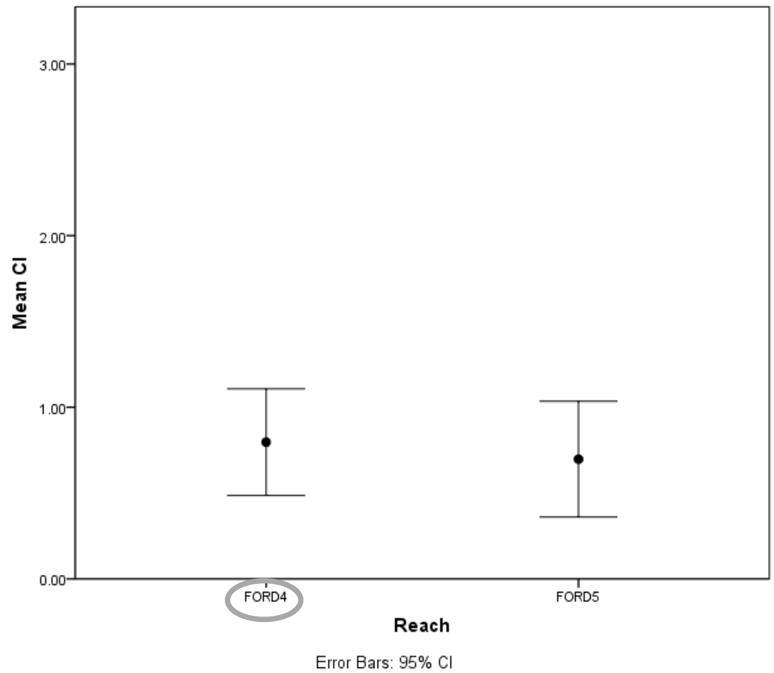

3.00
2.00
1.00
0.00
Mean CI
ELKR11
ELKR12
Reach
Error Bars: 95% CI

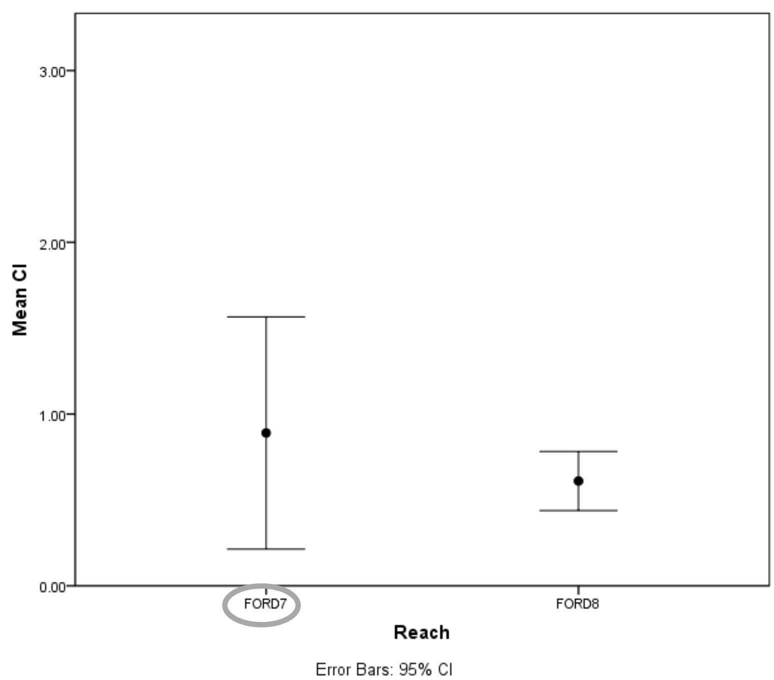


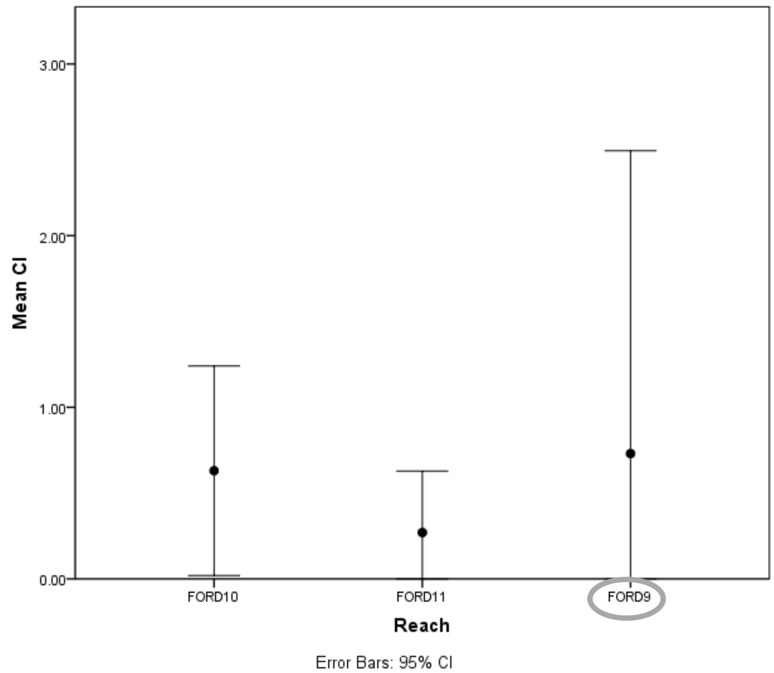
Error Bars: 95% CI

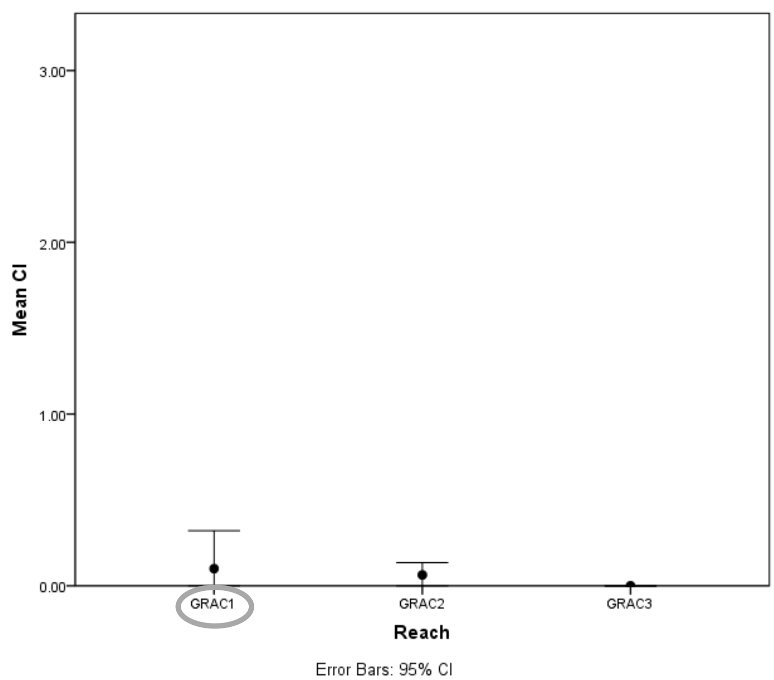


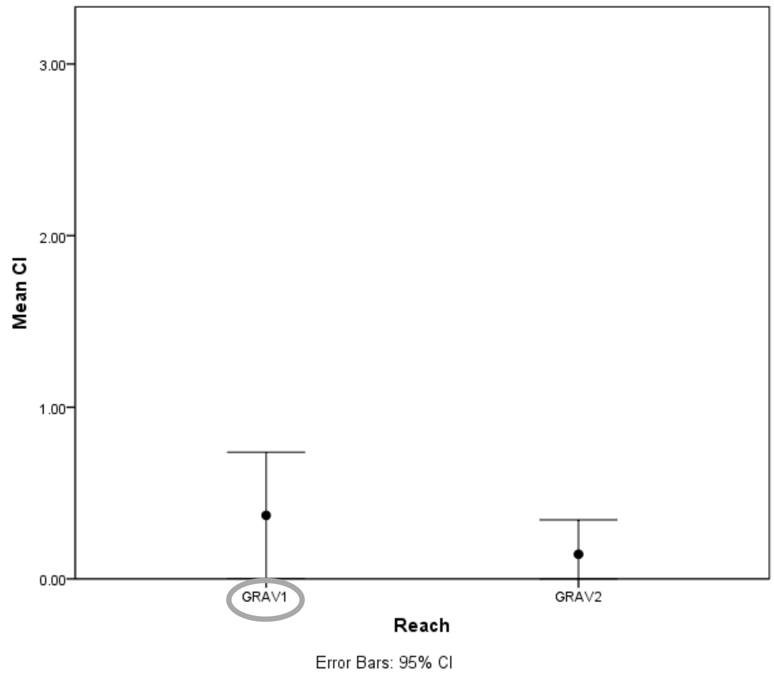
Error Bars: 95% CI

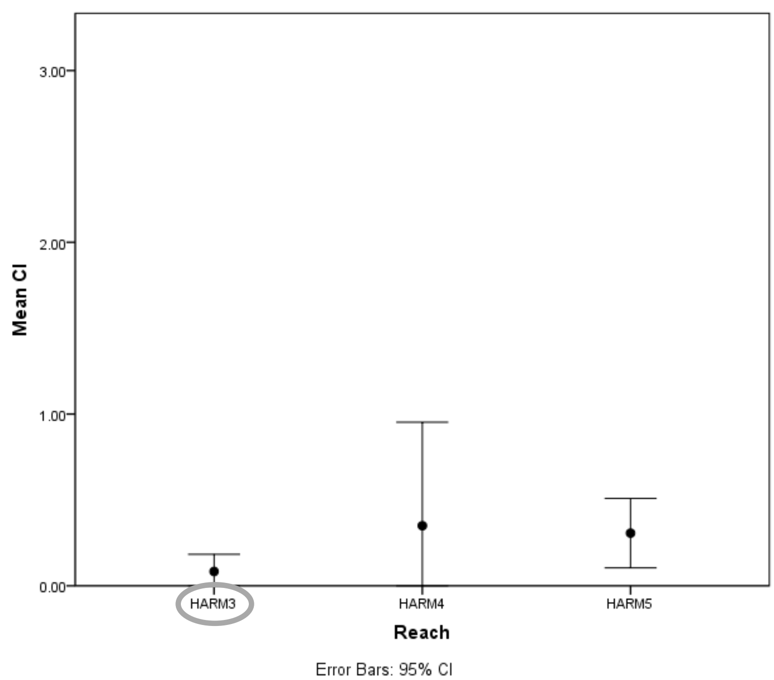

3.00
2.00
1.00
0.00
Mean CI
FORD4
FORD5
Reach
Error Bars: 95% CI

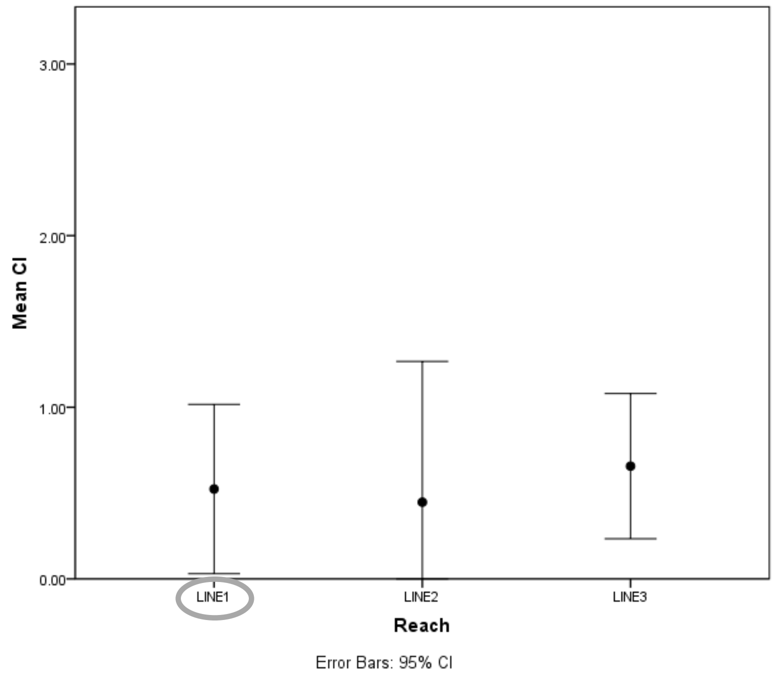

3.00
2.00
1.00
0.00
Mean CI
FORD7
FORD8
Reach
Error Bars: 95% CI

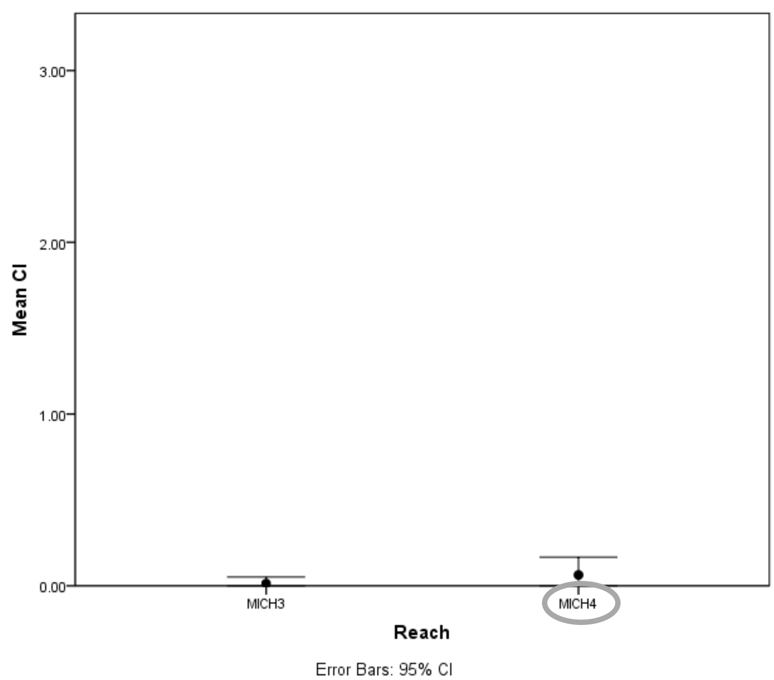

3.00
2.00
1.00
0.00
Mean CI
FORD10
FORD11
FORD9
Reach
Error Bars: 95% CI

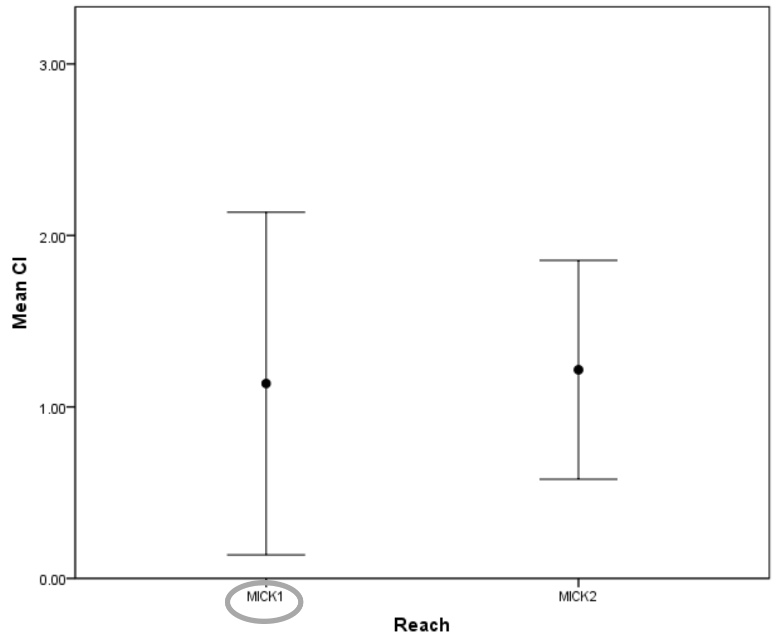

3.00
2.00
1.00
0.00
Mean CI
GRAC1
GRAC2
GRAC3
Reach
Error Bars: 95% CI


3.00
2.00
1.00
0.00
Mean CI
GRAV1
GRAV2
Reach
Error Bars: 95% CI

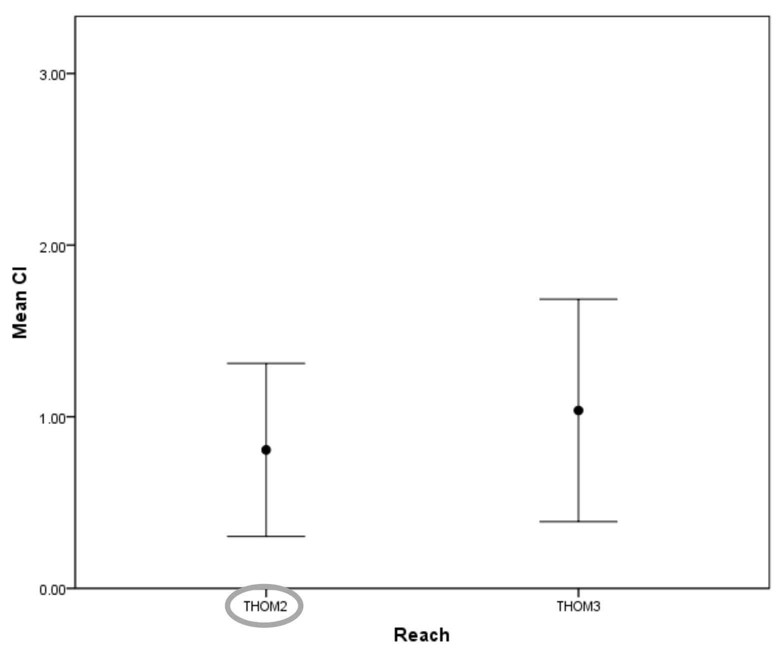

3.00
2.00
1.00
0.00
Mean CI
HARM3
HARM4
HARM5
Reach
Error Bars: 95% CI


Mean CI
3.00
2.00
1.00
0.00
LINE1
LINE2
LINE3
Reach
Error Bars: 95% CI


Mean CI
3.00
2.00
1.00
0.00
MICH3
MICH4
Reach
Error Bars: 95% CI

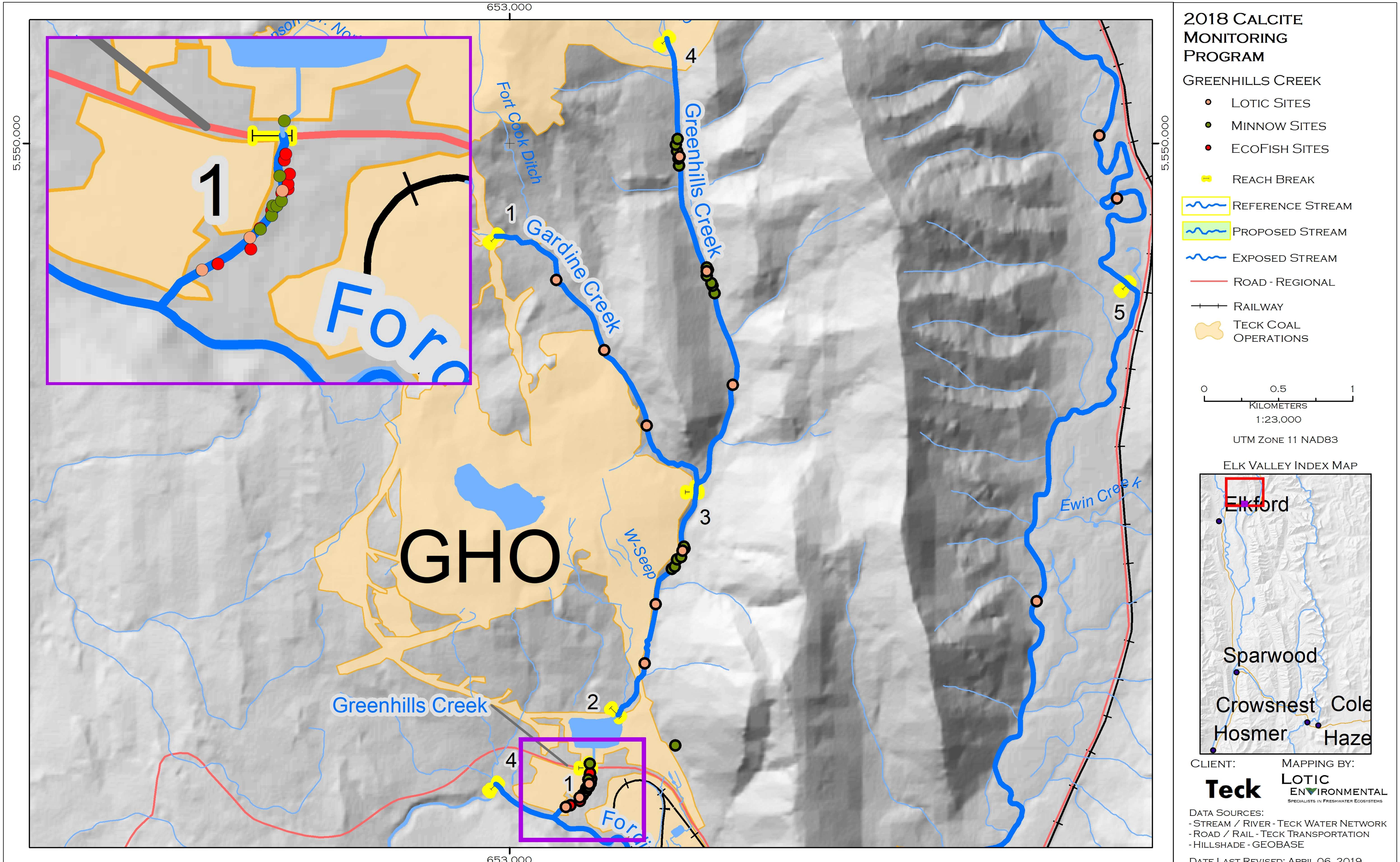


Error Bars: 95% CI

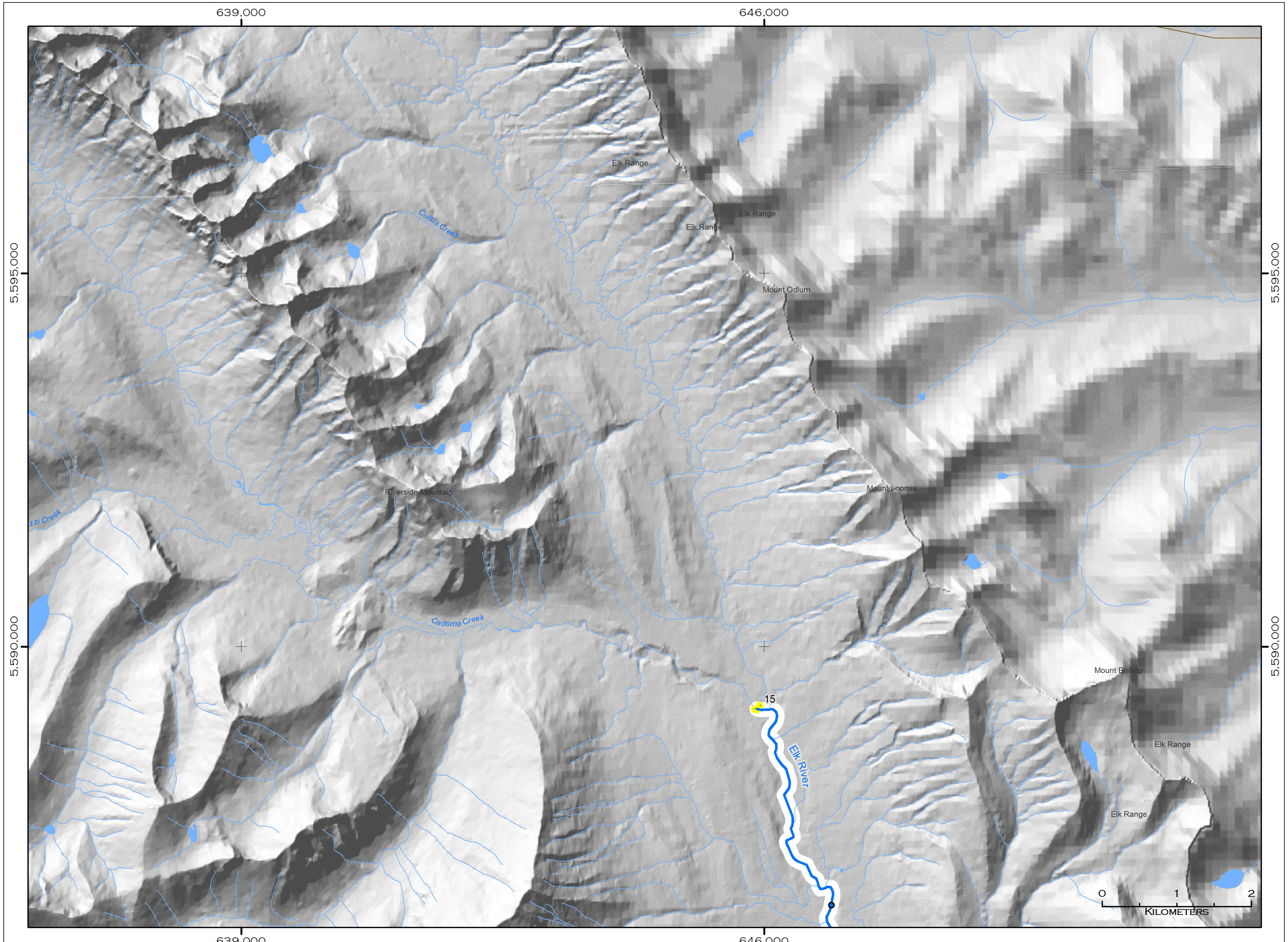


Error Bars: 95% CI

Appendix 8. Sample site location map for inter-program comparison on Greenhills Creek.


2018 Calcite Monitoring Program
Greenhills Creek
Lotic Sites
Minnow Sites
EcoFish Sites
Reach Break
Reference Stream
Proposed Stream
Exposed Stream
Road - Regional
Railway
Teck Coal Operations
0
0.5
1
Kilometers
1:23,000
UTM Zone 11 NAD83
Elk Valley Index Map
Elkford
Sparwood
Crowsnest
Cole
Hosmer
Haze
Client:
Teck
Mapping by:
Lotic Environmental
Specialists in Freshwater Ecosystems
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE
Date Last Revised: April 06, 2019
653,000
5,550,000
GHO
Gardine Creek
Greenhills Creek
Fort Cook Ditch
W-Seep
Ewin Creek
1
2
3
4
5

Appendix 9. Sample site location maps for inter-program comparison of regional sites.



2018 Calcite Interprogram Comparison

Calcite Index

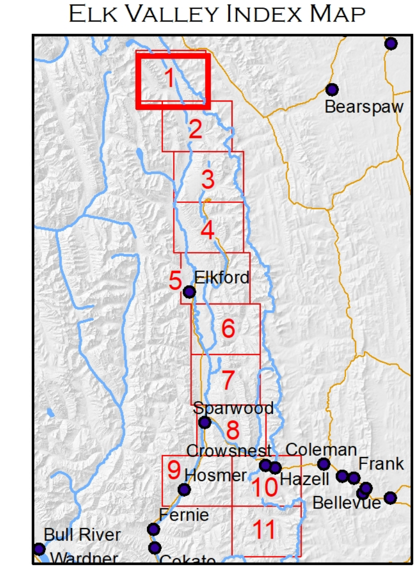
Elk Valley - Map # 1

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

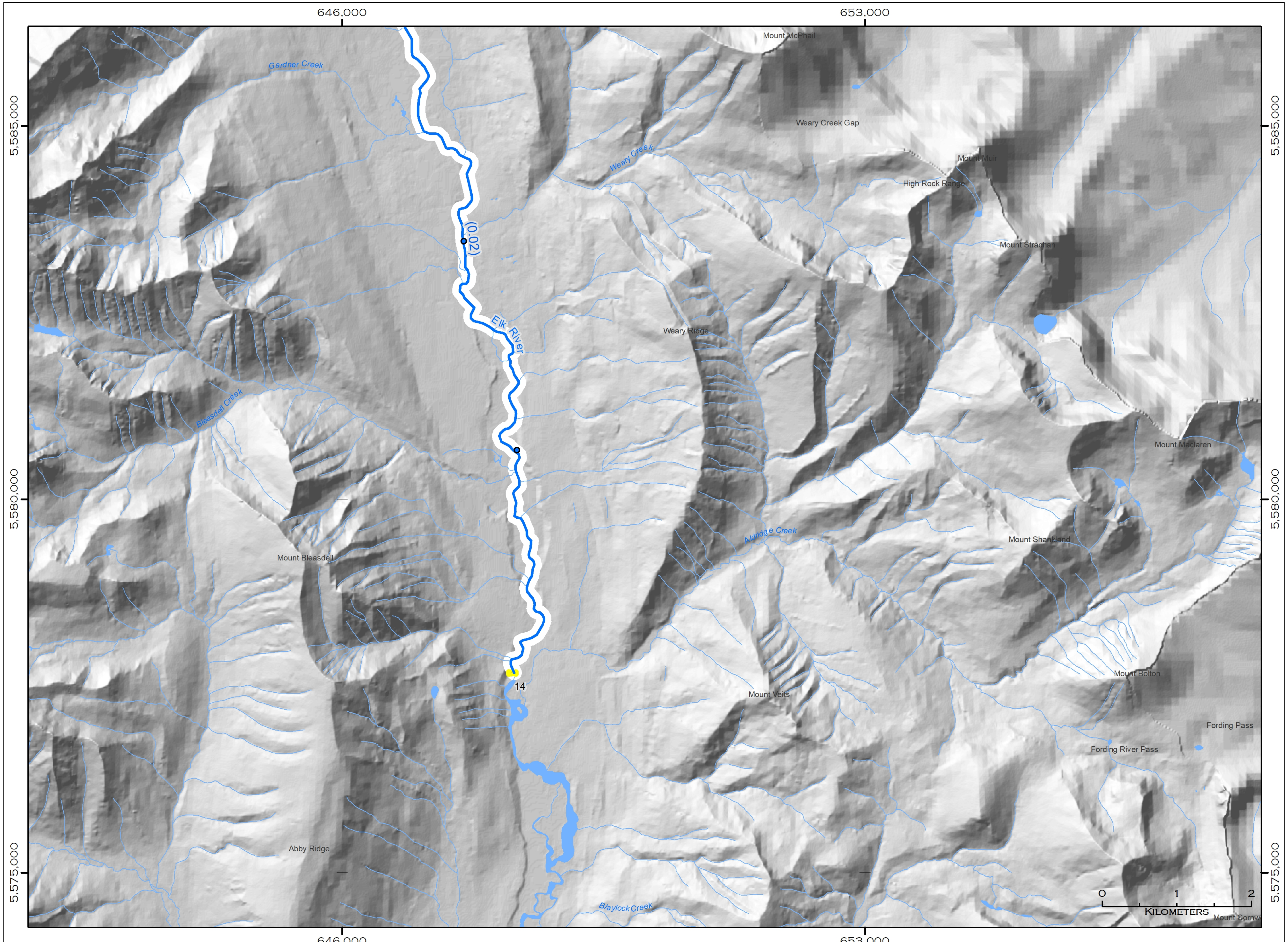


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison

Calcite Index

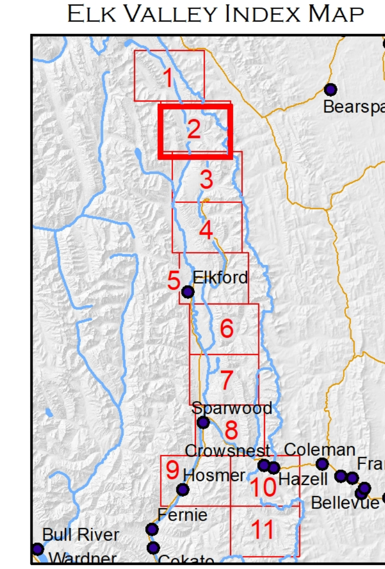
Elk Valley - Map #2

Reach Break
Reference Stream
Indicator Reach
Exposed Stream (CI < 0.5)
Exposed Stream (0.5 - 1.0)
Exposed Stream (1.0 - 2.0)
Exposed Stream (CI > 2.0)
Road - Regional
Railway
Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

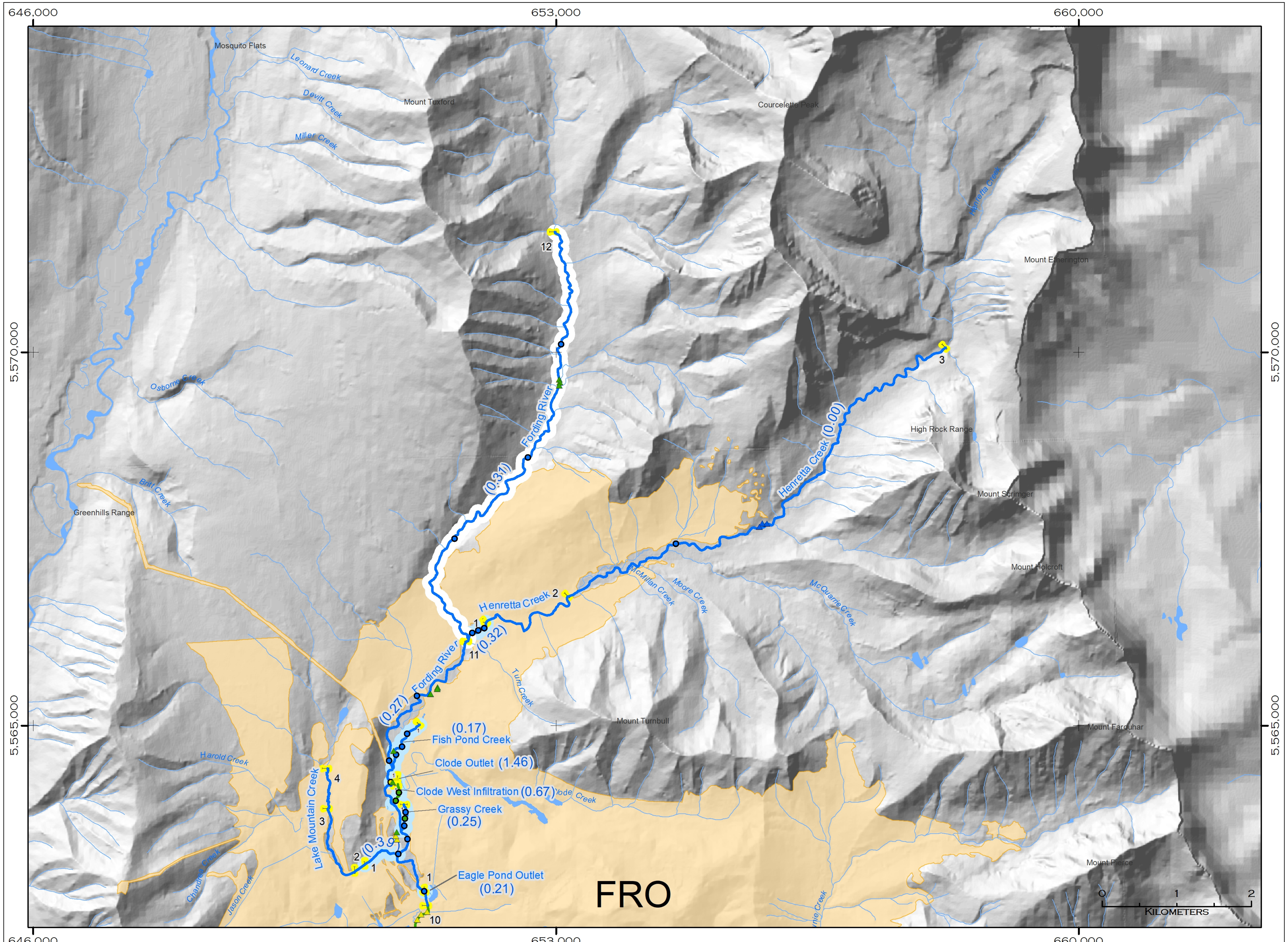


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison

Calcite Index

Elk Valley - Map #3

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (CI < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 2.0)

Exposed Stream (CI > 2.0)

Road - Regional

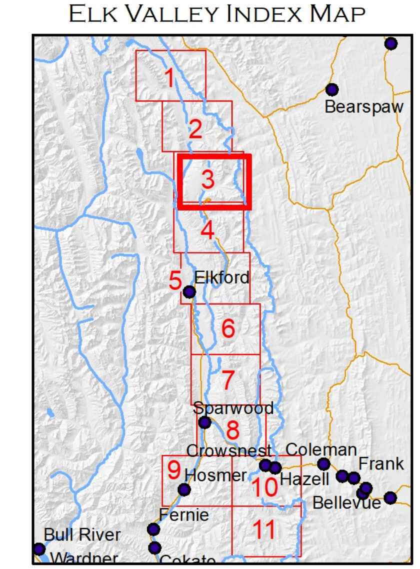
Railway

Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

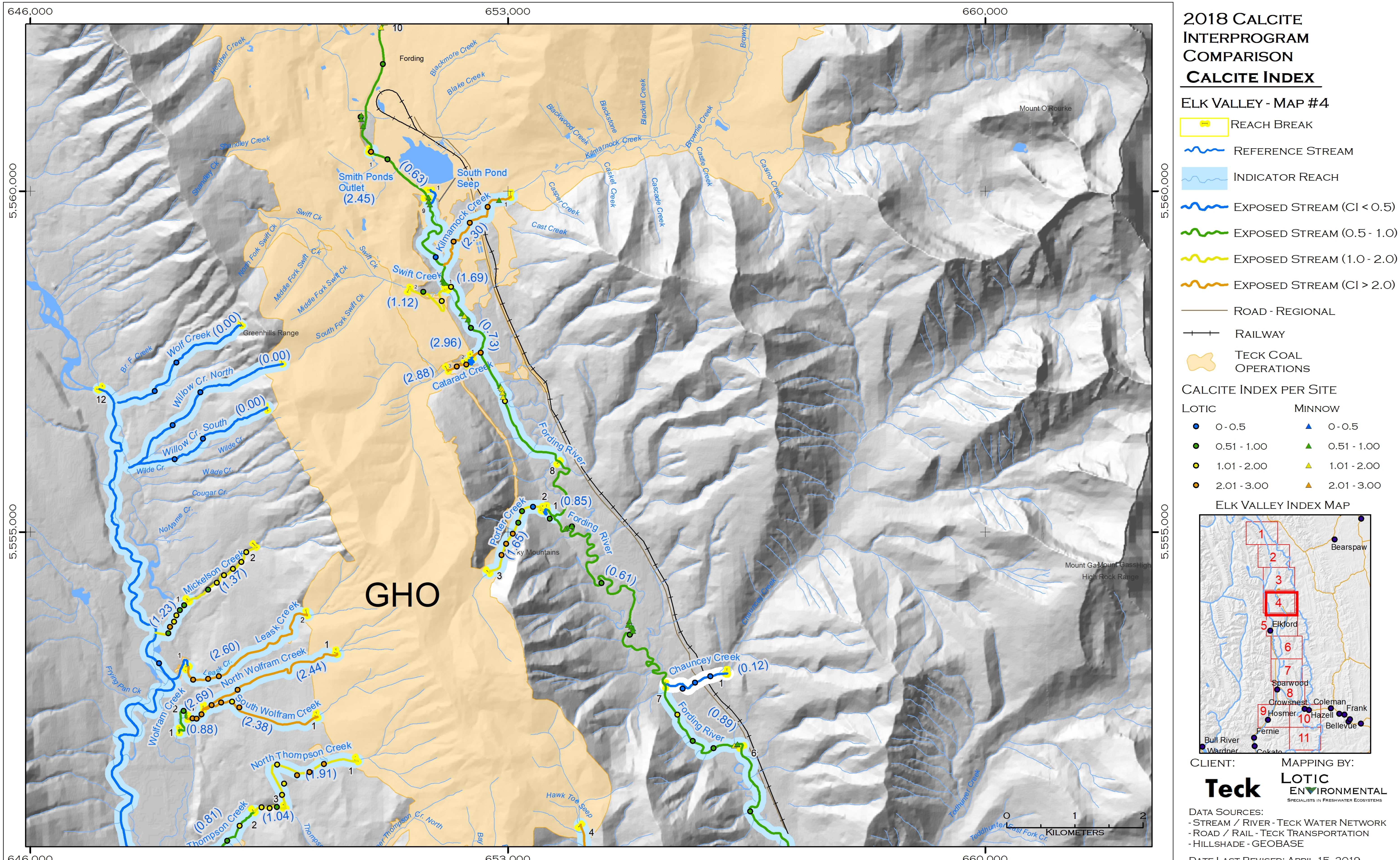


Client: Teck

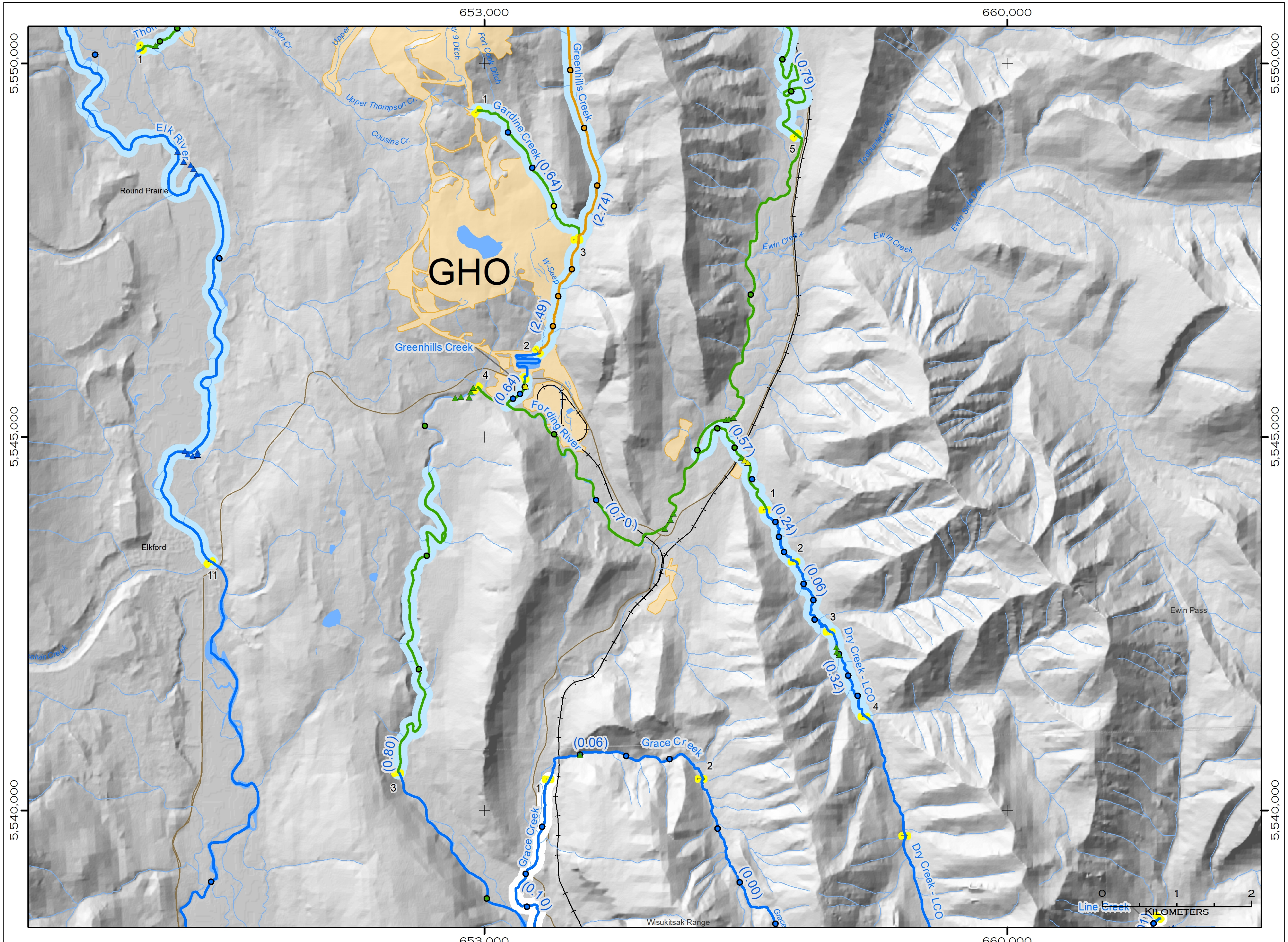
Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison
Calcite Index
Elk Valley - Map #4
Reach Break
Reference Stream
Indicator Reach
Exposed Stream (CI < 0.5)
Exposed Stream (0.5 - 1.0)
Exposed Stream (1.0 - 2.0)
Exposed Stream (CI > 2.0)
Road - Regional
Railway
Teck Coal Operations
Calcite Index per Site
Lotic
Minnow
0 - 0.5
0.51 - 1.00
1.01 - 2.00
2.01 - 3.00
Elk Valley Index Map
Client:
Teck
Mapping by:
Lotic Environmental
Specialists in Freshwater Ecosystems
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - Geobase
Date Last Revised: April 15, 2019
GHO
Fording River
Smith Ponds Outlet (2.45)
South Pond Seep
Kilmarnock Creek
Swift Creek
Cataract Creek
Porter Creek
Chauncey Creek
Wolf Creek (0.00)
Willow Cr. North (0.00)
Willow Cr. South (0.00)
Mickelson Creek
Leask Creek
North Wolfram Creek
South Wolfram Creek
Wolfram Creek
North Thompson Creek
Thompson Creek
Kilometers
646,000
653,000
660,000
5,560,000
5,555,000



2018 Calcite Interprogram Comparison

Calcite Index

Elk Valley - Map #5

Reach Break

Reference Stream

Indicator Reach

Exposed Stream (CI < 0.5)

Exposed Stream (0.5 - 1.0)

Exposed Stream (1.0 - 2.0)

Exposed Stream (CI > 2.0)

Road - Regional

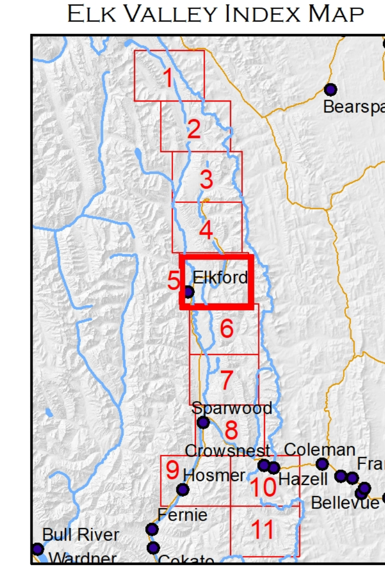
Railway

Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

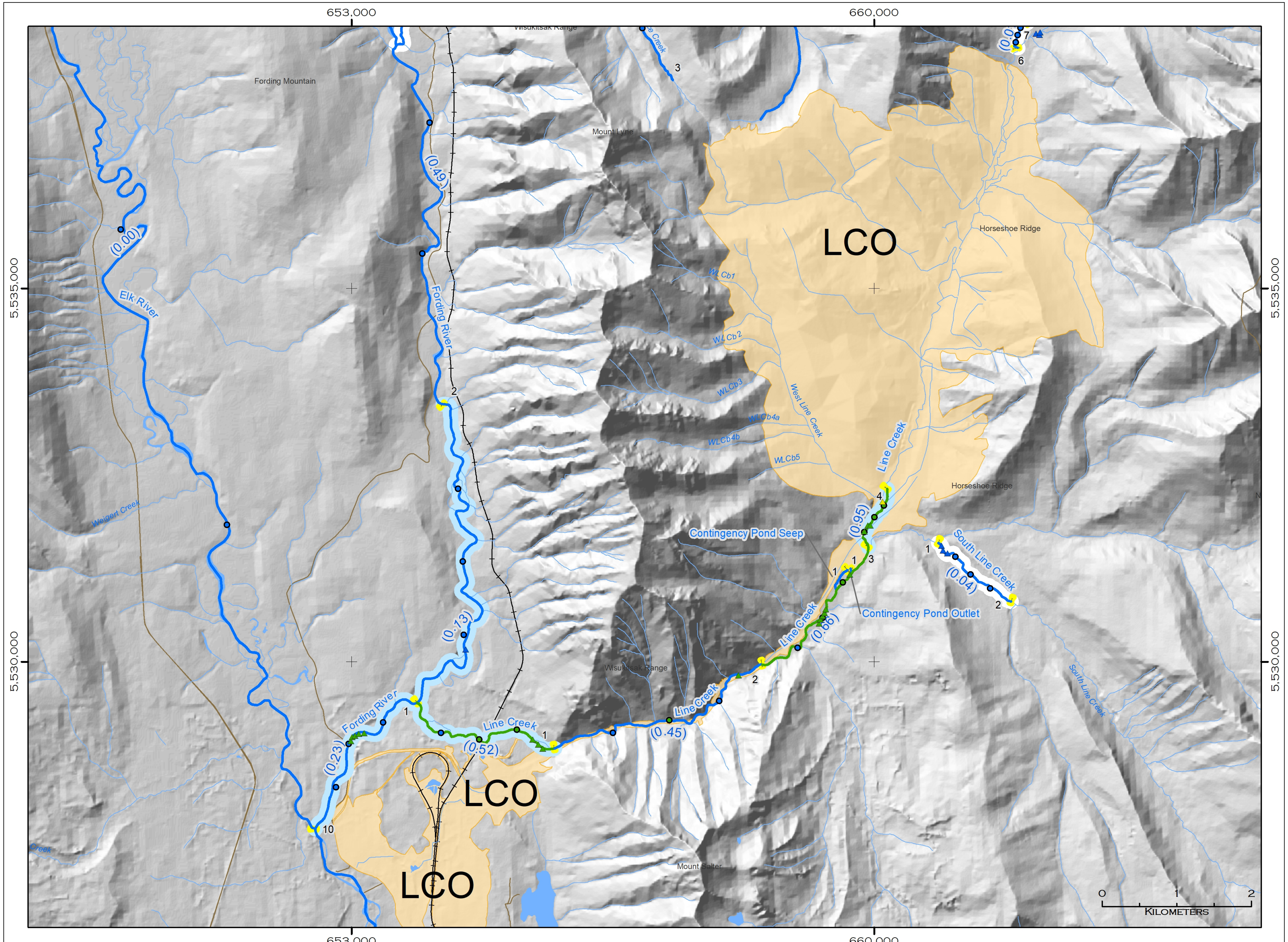


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison

Calcite Index

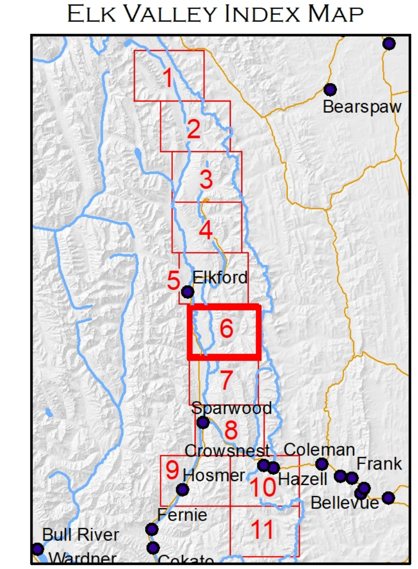
Elk Valley - Map #6

Reach Break
Reference Stream
Indicator Reach
Exposed Stream (CI < 0.5)
Exposed Stream (0.5 - 1.0)
Exposed Stream (1.0 - 2.0)
Exposed Stream (CI > 2.0)
Road - Regional
Railway
Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

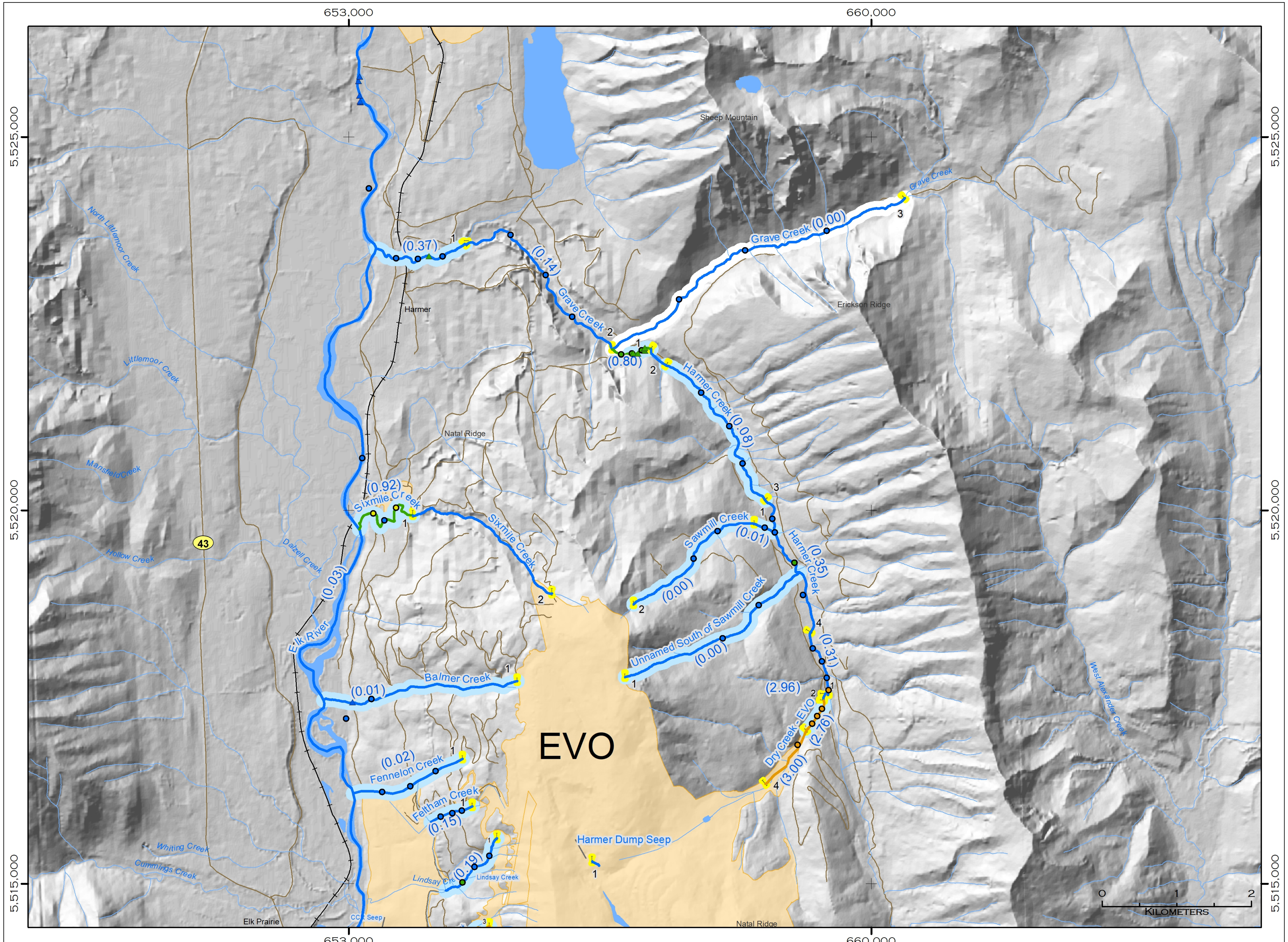


Client: Teck

Mapping by: Lotic Environmental
Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison

Calcite Index

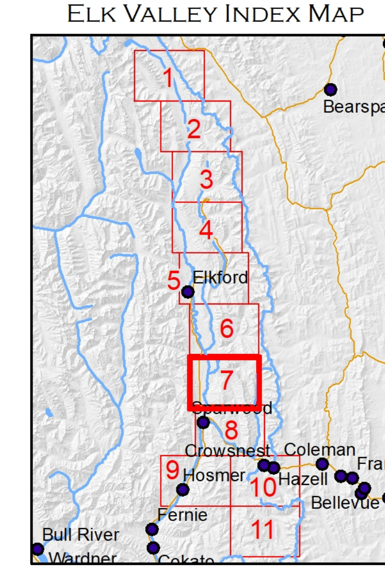
Elk Valley - Map #7

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

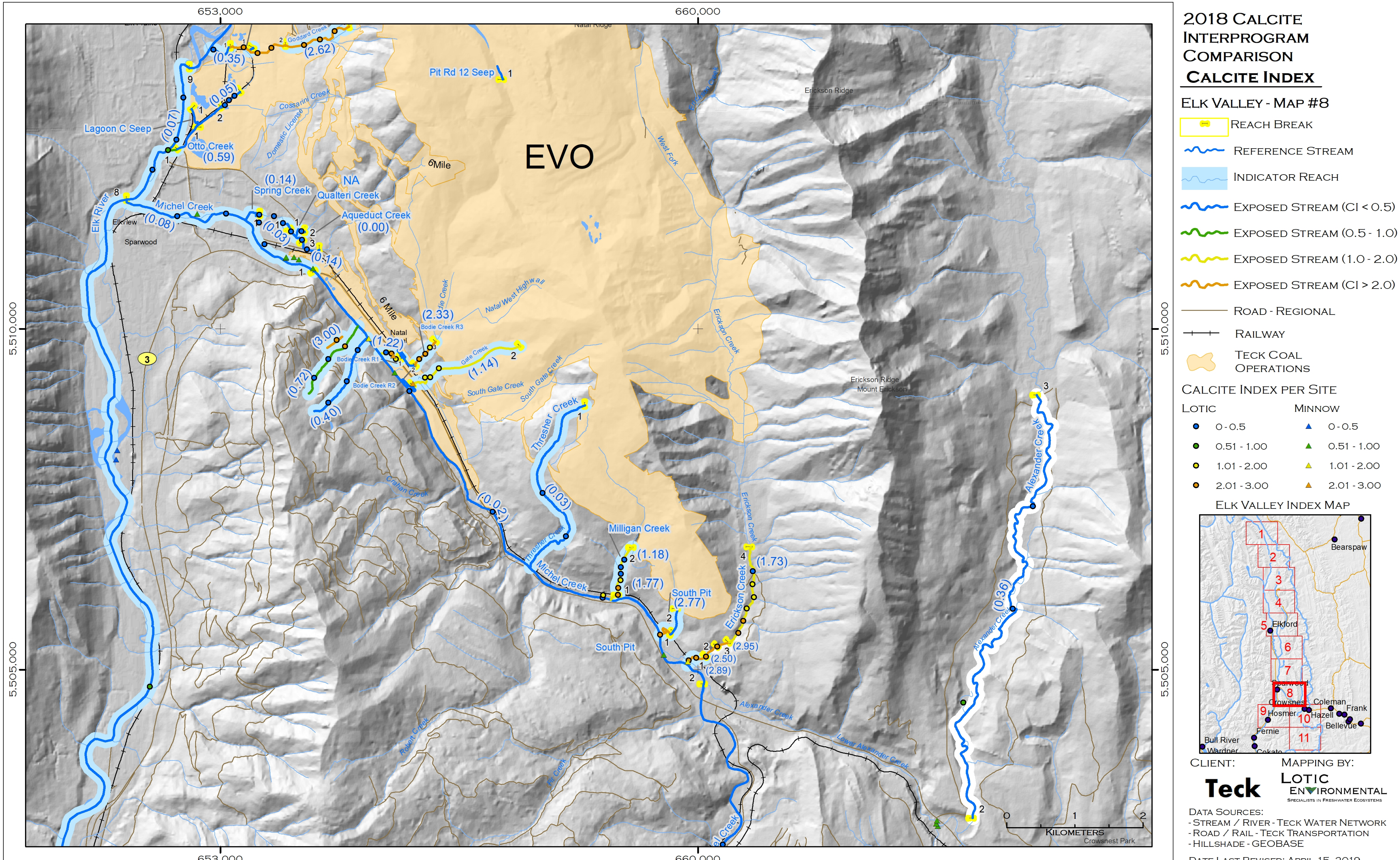


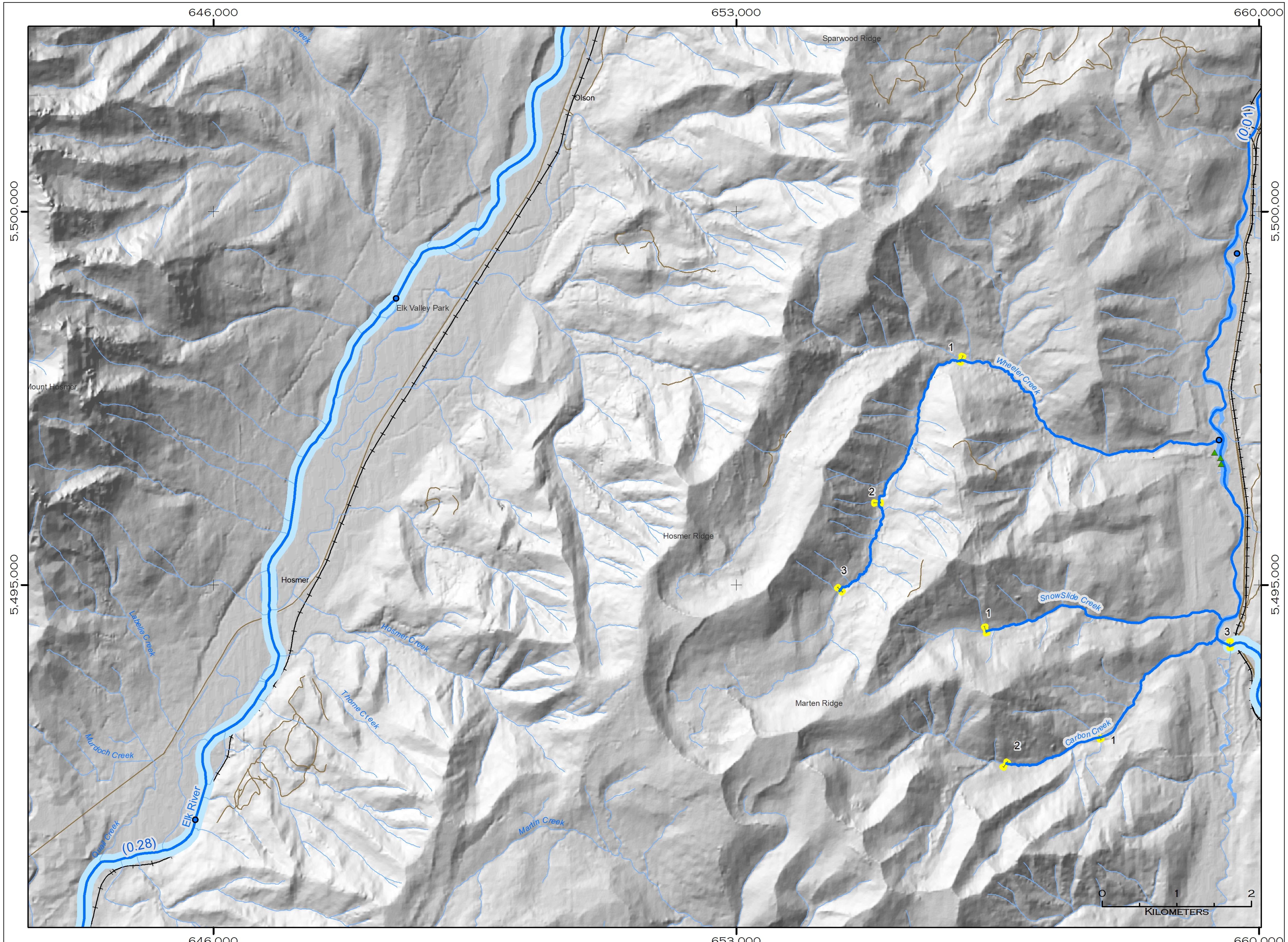
Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 15, 2019


2018 Calcite Interprogram Comparison
Calcite Index
Elk Valley - Map #8
Reach Break
Reference Stream
Indicator Reach
Exposed Stream (CI < 0.5)
Exposed Stream (0.5 - 1.0)
Exposed Stream (1.0 - 2.0)
Exposed Stream (CI > 2.0)
Road - Regional
Railway
Teck Coal Operations
Calcite Index per Site
Lotic
Minnow
0 - 0.5
0.51 - 1.00
1.01 - 2.00
2.01 - 3.00
Elk Valley Index Map
Client:
Teck
Mapping by:
Lotic Environmental
Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase
Date Last Revised: April 15, 2019
EVO
Elk River
Michel Creek
Otto Creek
Lagoon C Seep
Spring Creek
Qualteri Creek
Aqueduct Creek
Pit Rd 12 Seep
Bodie Creek R1
Bodie Creek R2
Bodie Creek R3
Gate Creek
South Gate Creek
Thresher Creek
Milligan Creek
South Pit
Erickson Creek
Alexander Creek
Lower Alexander Creek
Sparwood
Elkview
Natal
Kilometers
653,000
660,000
5,510,000
5,505,000



2018 Calcite Interprogram Comparison

Calcite Index

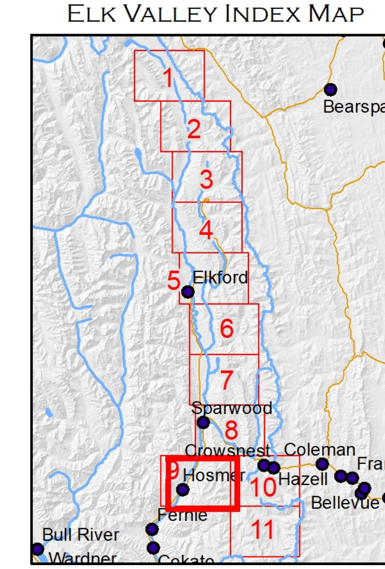
Elk Valley - Map #9

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map

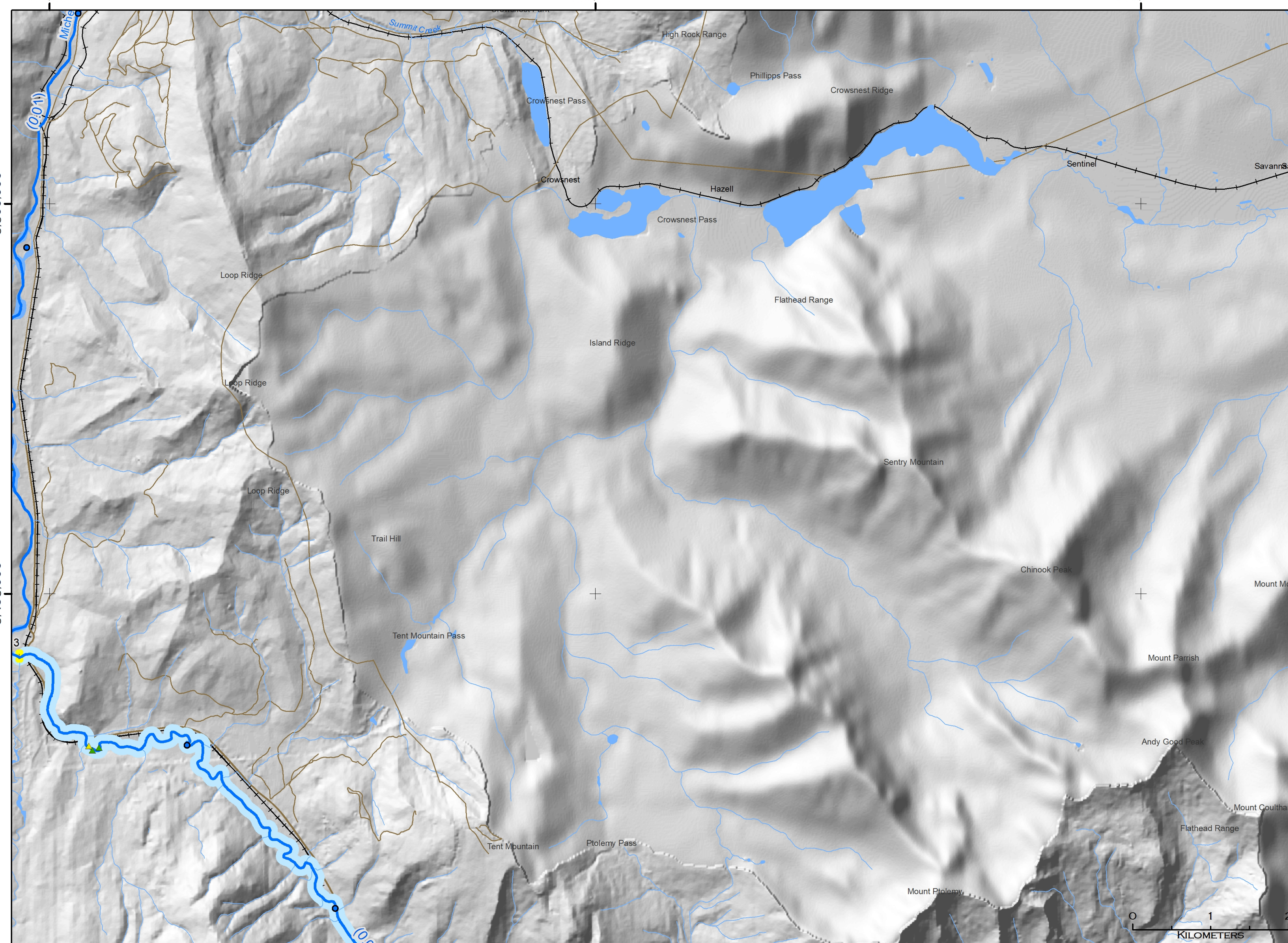


Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison

Calcite Index

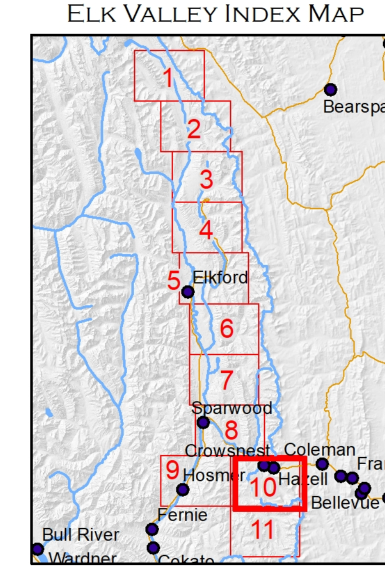
Elk Valley - Map #10

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map



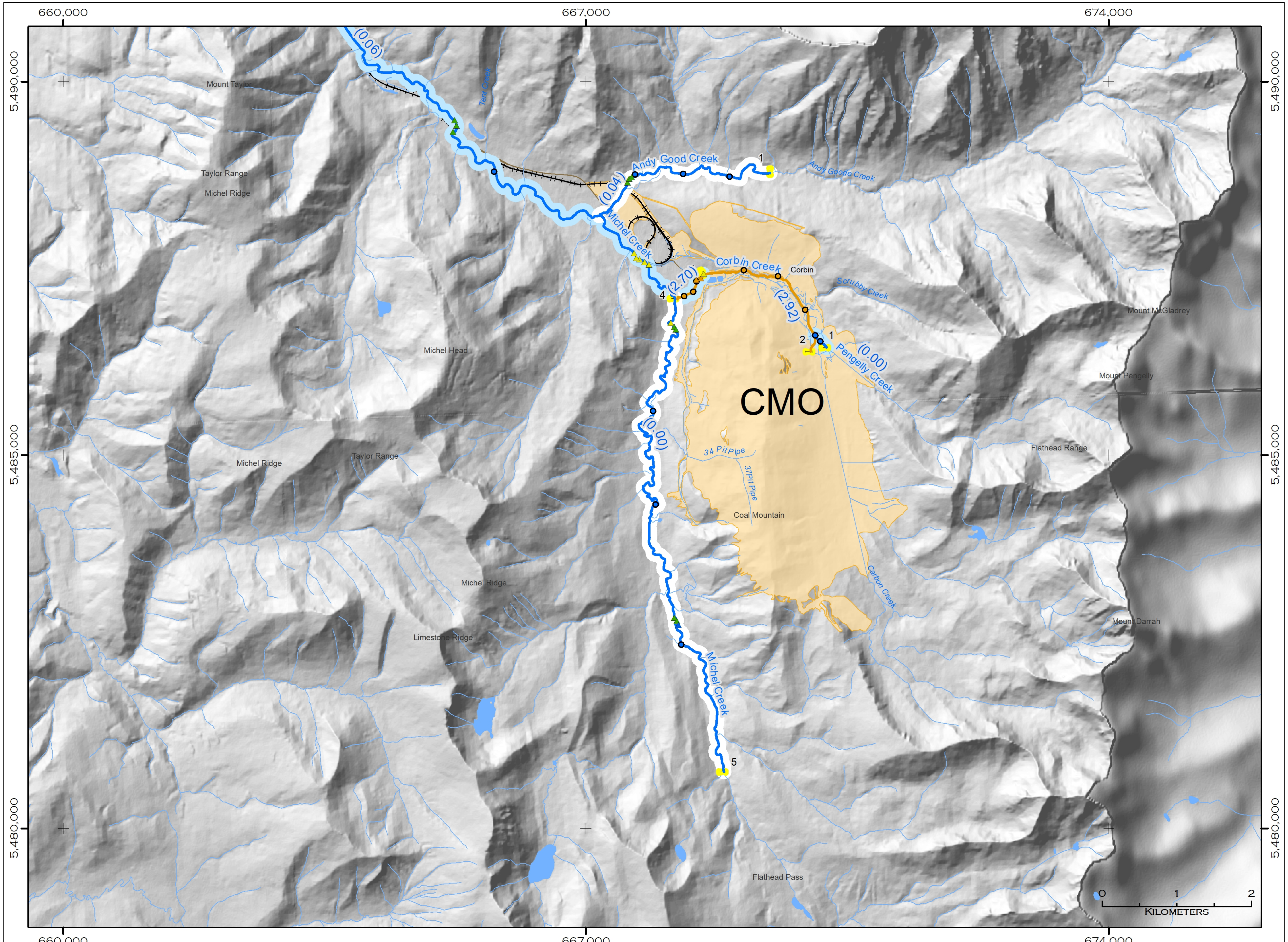
Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

0 1 2 Kilometers

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GeoBase

Date Last Revised: April 15, 2019



2018 Calcite Interprogram Comparison

Calcite Index

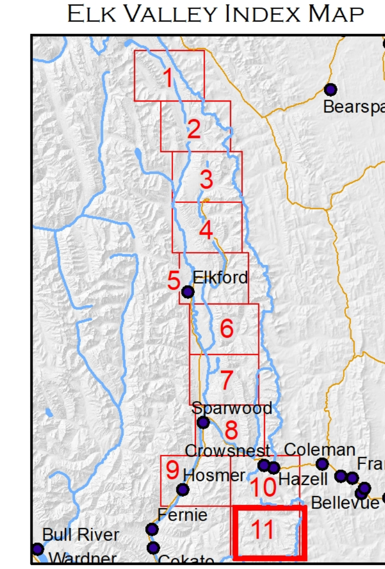
Elk Valley - Map #11

- Reach Break
- Reference Stream
- Indicator Reach
- Exposed Stream (CI < 0.5)
- Exposed Stream (0.5 - 1.0)
- Exposed Stream (1.0 - 2.0)
- Exposed Stream (CI > 2.0)
- Road - Regional
- Railway
- Teck Coal Operations

Calcite Index per Site

Lotic	Minnow
0 - 0.5	0 - 0.5
0.51 - 1.00	0.51 - 1.00
1.01 - 2.00	1.01 - 2.00
2.01 - 3.00	2.01 - 3.00

Elk Valley Index Map



Client: Teck

Mapping by: Lotic Environmental — Specialists in Freshwater Ecosystems

Data Sources:
- Stream / River - Teck Water Network
- Road / Rail - Teck Transportation
- Hillshade - GEOBASE

Date Last Revised: April 15, 2019