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: Calcite Monitoring Program 2015 Report

Overview: This report presents the 2015 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**

LOTIC ENVIRONMENTAL
SPECIALISTS IN FRESHWATER ECOSYSTEMS

TECK COAL LTD.
2015 CALCITE MONITORING ANNUAL & STATISTICAL POWER REPORT

ELK VALLEY

MAY 2016

PREPARED BY

LOTIC ENVIRONMENTAL LTD.
2193 MAZUR ROAD
CRANBROOK BC
V1C 6V9

Suggested citation

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.

On behalf of Lotic Environmental,

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

Acknowledgements

We would like to thank Kevin Atherton and Leigh Stickney for their involvement in this program and in particular with reviewing the initial work plans, field work, and final site selection. We would also like to thank Dr. Carl Schwarz (Department of Statistics & Actuarial Science – Simon Fraser University) for reviewing the statistical assessments in this report.

Table of Contents

List of Figures

List of Tables

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.
- Site – A location within a reach where observations of calcite deposition were made. These are replicate observations (sample units) within the treatment unit (reach).

1 Introduction

Teck Coal Ltd (Teck) has been documenting calcite occurrence in the Elk Valley since 2008 (Berdusco 2009). The current Calcite Monitoring Program (the Program) was established in 2013 to refine Teck's ability to estimate the linear extent of calcite deposition downstream of mine operations (Robinson *et al*. 2013). The Program was implemented on an annual basis from 2013 – 2015. This year (2015) marks Year 3 of monitoring following the current plan. This report presents and discusses the results of 2015, but also includes an update on the current understanding of calcite deposition and assessment of various program components.

This report is being submitted to fulfill Permit 107517 Section 10.6 which states "A Calcite Monitoring (Section 9.5) Annual Report must be submitted to the Director by May 31, of each year following the data collection calendar year." In addition, this 2015 report includes additional information to fulfill the Permit 107517 Section 10.6 requirement that "the Permittee must provide a document investigating the statistical power of the calcite monitoring program when reviewing monitoring results

There are four key objectives of the *2013-2015* Program:

1. Document the extent and degree of calcite deposition in streams downstream of Teck's coal operations and in reference streams.
2. Satisfy calcite-specific monitoring regulatory requirements, including the Elk Valley Water Quality Plan (EVWQP) commitment to assess the rate of change in calcite formation, by monitoring changes over time.
3. Provide information to support identification of "priority streams" in regards to calcite management decisions as presented in the Elk Valley Water Quality Plan (Teck 2014).
4. Provide data to facilitate an ongoing evaluation of the sampling methods used, and their effectiveness in detecting and describing calcite deposition.

Unique to this Year 3 report is the objective to critically assess the current program and provide recommendations for modifications to the field and analytical methods used in subsequent years of the Program.

A key feature of the Program was that it was designed to provide spatial estimates of calcite deposition over a continuous stream network. The Elk River watershed has been stratified into watershed, stream, reaches, and ultimately sites where observations are made on individual stream substrate particles. These results are then statistically assessed and interpreted to ensure that they are appropriately worked back up from the site level to a watershed scale to provide a holistic assessment of calcite deposition throughout the Elk Valley.

Teck is working with the EMC to develop an Adaptive Management Plan (AMP). The AMP has identified key uncertainties, or gaps in current understanding that relate to calcite management in the Elk Valley and which, if reduced, are likely to either help confirm that current management actions are appropriate or lead to refinements or changes that would better satisfy EVWQP objectives and requirements of Permit 107517. The 2013-2015 Calcite Monitoring Program informs Key Uncertainty 4.1.2 - *How can calcite degree and extent be measured effectively and consistently?*

1.1 *Study area*

The study area was defined to include each of Teck's five coal mining operations in southern British Columbia (Figure 1). Sites are located throughout the Elk Valley to encompass areas downstream of Fording River Operations, Line Creek Operations, Greenhills Operations, Elkview Operations, and Coal Mountain Operations. The downstream study limit was Reach 8 of the Elk River, which extends to Fernie, BC. This study area was consistent with Year 1 (Robinson and MacDonald 2014) and Year 2 (Robinson and MacDonald 2015) calcite monitoring field programs.

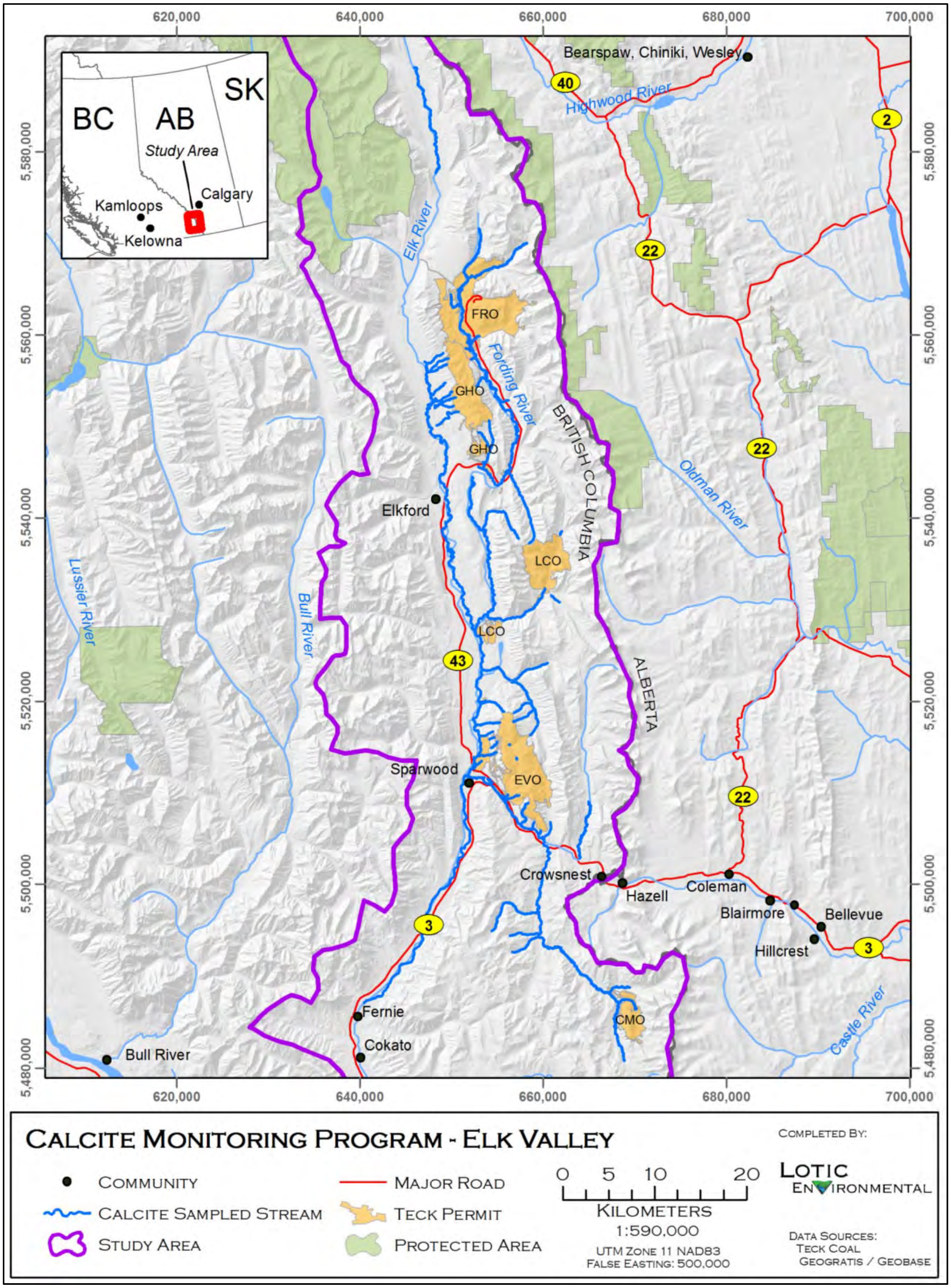


Figure 1. Elk River watershed study area map.

1.2 *2015 Monitoring site locations*

Lotic Environmental and the Teck Coal project team developed the Year 3 sampling plan to incorporate feedback received from various agencies, and to incorporate recommendations from Year 2 (Robinson and MacDonald 2015). The Year 3 sampling plan was then reviewed with each mine operation to ensure safe work conditions and to discuss changes in water management. In total, 358 sites from 124 stream reaches were surveyed in 2015. A number of changes to the Program made in the Year 3 sampling plan:

Sites removed (N=38)

- Removal of lentic sampling areas: 13 sites from 9 lentic reaches. Lentic sampling was found to be inconclusive following the Year 1 and 2 sampling protocol (Robinson *et al*. 2013). Challenges arose with access into deeper water and interpretation of spatial coverage over waterbodies that included large areas of fine sedimentation. The decision to remove lentic sites was based on their low proportion of total site representation in the Program (13/347) and the fact that adequate spatial coverage remained on the stream networks surrounding these features. Advice on this was received from the Environmental Monitoring Committee established under Permit 107517.
- Safe access: A total of 23 sites from 13 reaches were removed from the Year 2 sampling plan following an assessment that identified site access to be high risk.
- Diversions by Teck operations: Two sites on separate reaches were removed as they no longer existed as a result of water course diversions.

Sites added (N=42)

- Thirty-three sites were added for site and reach level variability assessments (see also Section 2.4).
- Two new sites were located on a stream unidentified in previous programs.
- Six sites were added to cover the proposed future Greenhills Operations Cougar Pit Extension.
- One site identified in previous programs, but unable to be sampled due to logistic limitations.

A complete list of sites sampled by program year is provided in (Appendix 1). Maps of reach locations are provided in Appendix 4.

2 Methods

2.1 *Field surveys*

Field methods followed Year 2 procedures (Robinson and MacDonald 2015). In summary, the surveys began with a visual assessment of the streambed by wading through the stream and physically inspecting individual rocks for calcite over a minimum stream length of 100 m. Where calcite was observed, a modified Wolman pebble count (Wolman 1954) was conducted to quantify the level of concretion, calcite presence/absence, and diameter of 100 rocks. The first two parameters are used to quantify the degree of calcite present, also referred to as calcite index (*CI*). Estimates of canopy cover, riparian vegetation type, and periphyton/algae cover were completed at all sites. Site specific details for all sites were delineated on a map, including photo locations and notable features. Channel morphology measurements were only collected at new sites that were not previously surveyed (Robinson 2013).

Sites added to the Year 3 sample plan for variability assessments were used to specifically assess variability in *CI*. This component was added based on advice from the PE 107517 Environmental Monitoring Committee. As such, those sites did not have particle diameter and habitat type data collected. Site data including sampling location are provided in Appendix 2.

2.2 *2015 Calcite Index and general distribution*

The *CI* was calculated at the site level by summing the following two metrics: calcite presence and calcite concretion (Table 1). Results were summarized for four stream categories: (1) Fording and Elk mainstems (reference), (2) tributaries (reference), (3) Fording and Elk mainstems (exposed), and (4) tributaries (exposed). Summary of *CI* for 2015 are provided in Appendix 3.

The same *CI* ranges or "bins" used in Year 1 and 2 were again used in Year 3 to report the distribution of *CI* by stream length. 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). Stream reach mean *CI* were mapped to depict the spatial distribution of calcite relative to each of the mines. Maps are provided in Appendix 4.

Table 1. Equations for Calcite presence (CI_p) and Calcite concretion (CI_c).

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

2.3 *Rate of change in calcite deposition*

2.3.1 Regression analysis

Change in calcite deposition has been assessed using regression as an interim measure until a longer term data set can be acquired. Regression analysis was applied on all reaches sampled in Year 1, 2, and 3. The regression analysis evaluated the relationship of *CI* versus time (year). Significance was selected to be conservative with an alpha value of $\alpha = 0.10$ when assessing slope (ΔCI/year). Reaches with statistically significant increases were mapped using red font, those with statistically significant decreases were colour coded on the maps in green font, and neutral sites remained in the traditional blue font (Appendix 4). Reaches that we not sampled in all three years were mapped in black font. Regression results are provided in Appendix 5.

.

2.3.2 ANOVA

Trend analysis typically requires long term data sets beyond three years. Therefore, reach mean *CI* from 2013-2015 was also assess using ANOVA, with year as the independent variable. ANOVA analysis was used to identify if year had a significant effect on reach mean *CI* by testing for significant differences among any year-year pairings, relative to within-reach variability. Tukey's *post hoc* analysis was run where year was reported to be significant. This identified specific year-year pairs that had significantly different reach mean *CI* values. An alpha value of α = 0.05 was used in this assessment. Bar graphs showing reach mean *CI* by year are provided in Appendix 6.

2.4 *Program assessment*

The 2013-2015 Calcite Monitoring Program proposed monitoring for three years before reassessing (Robinson *et. al* 2013); with 2015 marking the third year. As such, analyses have been completed to assess the current understanding of calcite deposition/variability, and to indicate how specific Program components are functioning in terms of accurately describing calcite deposition downstream of mining activities.

2.4.1 Site-level variability

Ten sites were sampled in triplicate to assess within site *CI* variability and the reproducibility of the pebble count method. Triplicate sampling allowed comparison of results from selection of 3 different sets of pebbles in the same site which supported analysis of how consistent results are within a site. Reaches were selected for replicate sampling if they were long enough for six sites (to ensure sites did not overlap spatially) and represented a range of *CI* scores. Reaches were selected based on historical *CI* values to evenly sample each of the low (*CI*=0-1), moderate (*CI*=1-2), and high (*CI*=2-3) categories based on historical *CI* values. Within-site standard deviations were plotted as a function of mean *CI*. Data were qualitatively assessed to describe the range of variability versus *CI*, the overall variability at a site-level, and how this related to variability at a reach-level. The results of the triplicate sampling were assessed in order to comment on the reproducibility of the pebble count method in describing *CI* at a given site.

2.4.2 Reach-level variability

Replicate sampling was completed to assess variability with a stream reach. This was done to understand the number of sites required to detect a significant change in *CI* between years and inform future sampling program design.

A subsample of nine reaches were sampled with six sites to assess within-reach variability. The six sites included the typical 25, 50, and 75% locations as described in the Program (Robinson *et al.* 2013). The Program was designed such that reach mean *CI* would be calculated by averaging *CI* values from three sites per reach, systematically distributed at 25, 50, and 75% of the reach length. Three additional sites were randomly selected from the midpoints between 12.5, 37.5, 62.5, and 87.5% of these nine reaches. Means and standard deviations were derived from three (N=3) and six (N=6) sites, and compared using a two-tailed paired t-test.

All reaches sampled at three sites in three consecutive years (2013 – 2015) were analyzed in order to characterize the within-reach sampling variability. First, the relationship between the mean reach *CI* and mean reach standard deviation was estimated using a polynomial equation. Separate equations were used for each individual year, as well as an equation derived from the entire dataset. Using the polynomial fit from the entire dataset, standard deviations (σ) were estimated using a reach-averaged *CI* for a specified number of samples (*N*), where,

$$d = \sqrt{16\sigma^2/(N-1)} \qquad (1)$$

and *d* is the detection limit (i.e., minimum difference in *CI* values per year with a specified number of samples taken, assuming a desired power of 0.8). Estimates were made for N = 2, 3, 6, 9, 12, 15, 18, and 20.

In order to test the validity of Equation 1, nine reaches were sampled at both N = 3 and N = 6 in 2015. Standard deviations from these reaches were input into Equation 1 to calculate observed detection limits. Observed detection limits were then compared with modelled detection limits obtained from standard deviations derived from the 3-year pooled polynomial fit. Observed versus modelled detection limits were compared using linear regression.

Finally, Equation 1 was re-arranged to solve for the number of samples that would be required to achieve select calcite index detection levels (d = 0.25, 0.50, 1.0) using polynomial-estimated standard deviations over a range of site-averaged calcite index.

2.4.3 Pebble count sample size assessment

Random subsampling was completed to assess the effect of sample size on *CI* at a site level. The objective was to determine how many rocks one would need to sample to achieve a *CI* comparable (+/- 20%) to that obtained with 100 rocks. Reaches were iteratively subsampled to acquire samples from N=10 to 99, using script developed in R statistical software. For each iteration, CI_p, CI_c, *and CI* were calculated as described above (Table 1). The absolute difference for all three metrics was calculated as the difference between the random sample and the full sample (100 rocks). The absolute difference of each reach was then averaged over the whole dataset to find the average absolute percent difference for a given number of rocks sampled. A loess smoothing curve was overlain to find the average change in absolute percentage difference over the range of samples.

3 Results

3.1 *Summary of QA/QC Issues*

Quality assurance was completed in the field by having field crews perform calcite measurements at multiple sites over the two days as a group. The exercise is used to calibrate observers and standardize collection methods. *CI* field forms were all reviewed and signed by the crew leaders at the end of each day. Data were reviewed for completeness and for logical values entered.

Quality checks were performed in the office following data entry. All 400 spreadsheet cells of a pebble count were checked for every tenth site (i.e., 10% QA/QC). The error rate was >1% and below the predetermined criteria of <5%.

A final data quality assurance step was performed using automated methods. A computer script using Python was written to check that cells were populated with values acceptable for the type of data being reported and that data entry met certain logical arguments. Data were reviewed for:

- Calcite presence score can only be 0 or 1 If diameter = C, then concretion must = 2 and presence must =1
- Concreted scores can only be 0, 1, or 2
- Diameter needs to be a positive value (greater than 0), F, B, or C.
- Concreted score must be 0 if calcite presence is 0.
- If diameter = C, then concretion must = 2 and presence must =1

3.2 *2015 Calcite Index and general distribution*

Calcite surveys were conducted from September 23 to November 6, 2015. A total of 374 km of stream were assessed and mapped. A total of 295 km were considered exposed and downstream of mining activities. A total of 79 km were considered reference (Table 2). Results are presented as either mainstem 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 2015.

	Reference				Exposed			
	Fording and Elk		Tributaries		Fording and Elk		Tributaries	
***CI* Range**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**
0.00 - 0.50	21.8	100.0%	57.2	100.0%	130.4	85.2%	116.1	82.0%
0.51 - 1.00	0	0.0%	0	0.0%	17.9	11.7%	6.2	4.4%
1.01 - 1.50	0	0.0%	0	0.0%	0	0.0%	4.0	2.8%
1.51 - 2.00	0	0.0%	0	0.0%	4.7	3.1%	3.8	2.7%
2.01 - 2.50	0	0.0%	0	0.0%	0	0.0%	6.5	4.6%
2.51 - 3.00	0	0.0%	0	0.0%	0	0.0%	4.8	3.4%
Total (2015)	**21.8**	**100.0%**	**57.2**	**100.0%**	**153.0**	**100.0%**	**141.5**	**100.0%**
Total (2014)	**21.8**	**100.0%**	**56.3**	**100.0%**	**153.1**	**100.0%**	**136.7**	**100.0%**
Total (2013)	**21.8**	**100.0%**	**42.9**	**100.0%**	**147.7**	**100.0%**	**139.8**	**100.0%**

Calcite distribution in Year 3 followed previous results with the majority of exposed stream kilometers in the 0.00-0.50 *CI* bin for all categories (Figure 2). The Fording and Elk mainstem stream categories had 85% of exposed stream length occur in the 0.00-0.50 *CI* bin. The amount of stream in the 0.51 – 1.00 *CI* bin increased from approximately 2% in 2014 to 11.7 % in 2015. Comparably, 82% of tributary stream kilometers occurred in the 0.00-0.50 *CI* bin, while all other bins were represented by less than 5% of the total tributary stream length surveyed. All reference mainstem and tributary stream kilometers were classified into the 0.00-0.50 *CI* bin, similar to previous years (Figure 3).

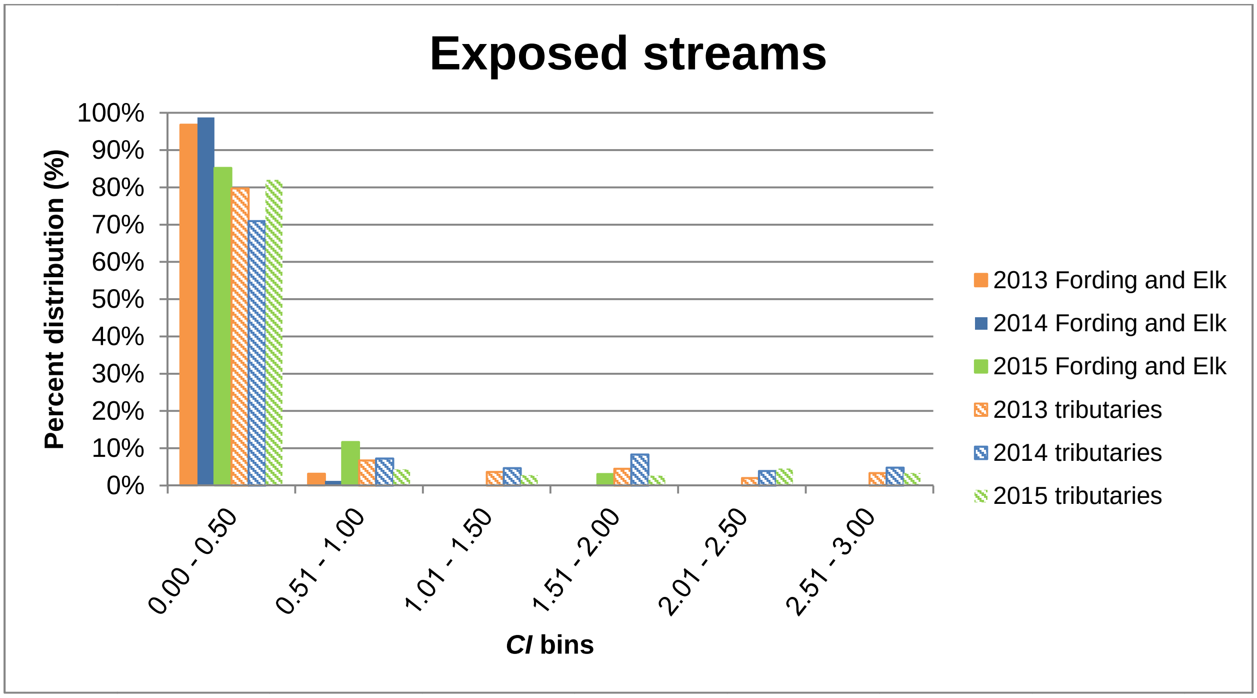


Figure 2. Percent distribution of exposed stream kilometers among *CI* bins by stream category and year (each year sum to 100% for the stream category).

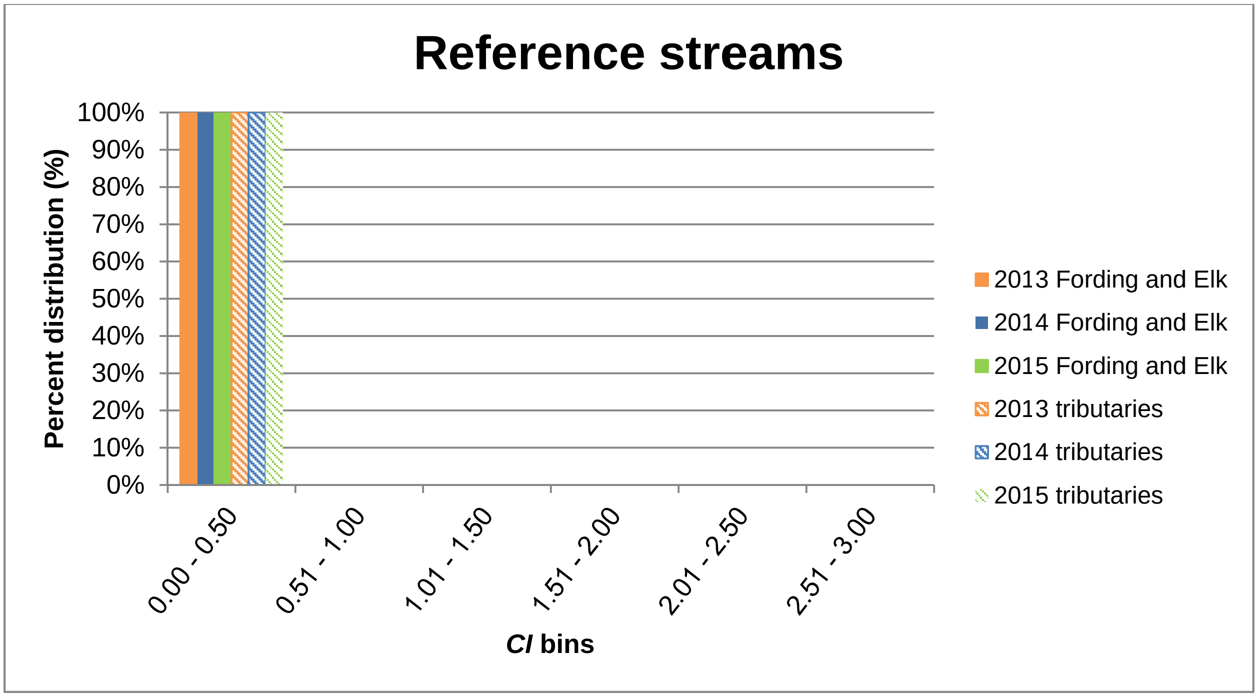


Figure 3. Percent distribution of reference stream kilometers among *CI* bins by stream category and year (each year sum to 100% for the stream category).

3.3 *Rate of change in calcite deposition*

3.3.1 Regression

Of the 124 stream reaches sampled in 2015, 119 were sampled in all three years (2013-2015). Of the 119, 51 reaches had constant values in each year. All of these had either *CI* = 0 or 3. These sites were excluded from the regression analysis and were assigned a neutral rate of change. The remaining 68 reaches showed variability in *CI* by year, and were assessed using regression analysis. Four reaches were found to have statistically significant changes over the three year period (α=0.10, df = 2) (Table 3). The absolute rate of change (Δ*CI*/year) varied from 0.10 to 0.66.

Table 3. Reaches with significant changes from 2013 – 2015.

Reach	p-value	Slope (Δ*CI*/year)	Change
ERIC3 (Erickson Creek)	0.09	0.32	Increase
EPOU1 (Eagle Pond Outlet)	0.04	-0.66	Decrease
GRAC1 (Grace Creek)	0.06	-0.13	Decrease
OTTO1 (Otto Creek)	0.07	-0.10	Decrease

Reaches with significant changes covered a range of mean *CI* values from 0.19 – 2.65, and included one reference reach (Grace Creek; GRAC1) (Table 4).

Table 4. Mean *CI* values by year for reaches with significant changes.

Reach	Mean CI 2013	Mean CI 2014	Mean CI 2015	Overall mean
ERIC3	2.36	2.60	3.00	**2.65**
EPOU1	1.90	1.31	0.58	**1.26**
GRAC1	0.31	0.20	0.05	**0.19**
OTTO1	0.30	0.22	0.10	**0.21**

3.3.2 ANOVA

Of the 124 stream reaches sampled in 2015, 94 were sampled with two or more sites in all three years (2013-2015), facilitating assessment using ANOVA. Results showed the reach mean *CI* varied significantly by year in 13 reaches (Table 5): CORB1, ERIC1, GODD3, GRAC1, GRAS1, GREE3, HARM1, LINE1, LINE4, SIXM1, SWOL1, and WOLF3. Of these, GRAC1 was the only reach reported to have a significant change using both regression and ANOVA methods. However, the other three reaches (ERIC3, EPOU1, OTTO1) with significant regression results were not included in ANOVA because they were only sampled with one site per year.

Table 5. ANOVA results for reaches with statistically significant changes between years. Significant year-year pairings identified from Tukey's HSD test are also indicated.

Reach	p-value	Tukey's HSD results
CORB1	0.011	2013<2015 (p=0.038) 2014<2015 (p=0.011)
ERIC1	0.039	2013<2015 (p=0.036)
GODD3	<0.001	2013<2014 (p<0.001) 2013<2015 (p<0.001)
GRAC1	0.032	2013>2015 (p=0.027)
GRAS1	0.045	2013<2014 (p=0.065)* 2014>2015 (p=0.065)*
GREE3	<0.001	2013<2014 (p=0.002) 2013<2015 (p<0.001)
GREE4	0.001	2013<2014 (p=0.002) 2013<2015 (p=0.002)
HARM1	0.005	2014>2015 (p=0.004)
LINE1	0.008	2013>2014 (p=0.014) 2013>2015 (p=0.014)
LINE4	0.021	2014<2015 (p=0.019)
SIXM1	0.010	2014>2015 (p=0.008)
SWOL1	0.034	2013>2015 (p=0.05) 2014>2015 (p=0.05)
WOLF3	<0.001	2013>2014 (p=0.002) 2013>2015 (p<0.001) 2014>2015 (p=0.036)

* Tukey's post hoc adjusts p-values for multiple comparisons.

Of those, GODD3 had no calcite in 2013, while GRAS1 had calcite present only in 2014 and LINE1 had calcite present only in 2013. Figures showing the CI values and the Tukey's post hoc results are given in Appendix 6.

3.4 *Program assessment*

3.4.1 Within site variability

Triplicate sampling was completed at 10 sites ranging in *CI* from 0.12 to 2.71, with an even distribution over that range (Table 6). Standard deviation (SD) of site means ranged from 0.03 – 0.14 (Figure 4). The variability in *CI* at a site-level is low (<0.14 SD), providing confidence in the site-level data.

Table 6. Site-mean *CI* values for ten sites sampled in triplicate.

Site	Site mean *CI*	SD
GRAC1-75	0.12	0.04
HARM4-12.5	0.18	0.05
FORD5-37.5	0.63	0.12
ERIC4-75	0.64	0.04
NTHO1-62.5	1.38	0.14
CORB2-12.5	1.76	0.03
DRYE3-99	2.35	0.09
GREE3-50	2.53	0.05
CORB1-25	2.54	0.07
GREE4-75	2.71	0.04

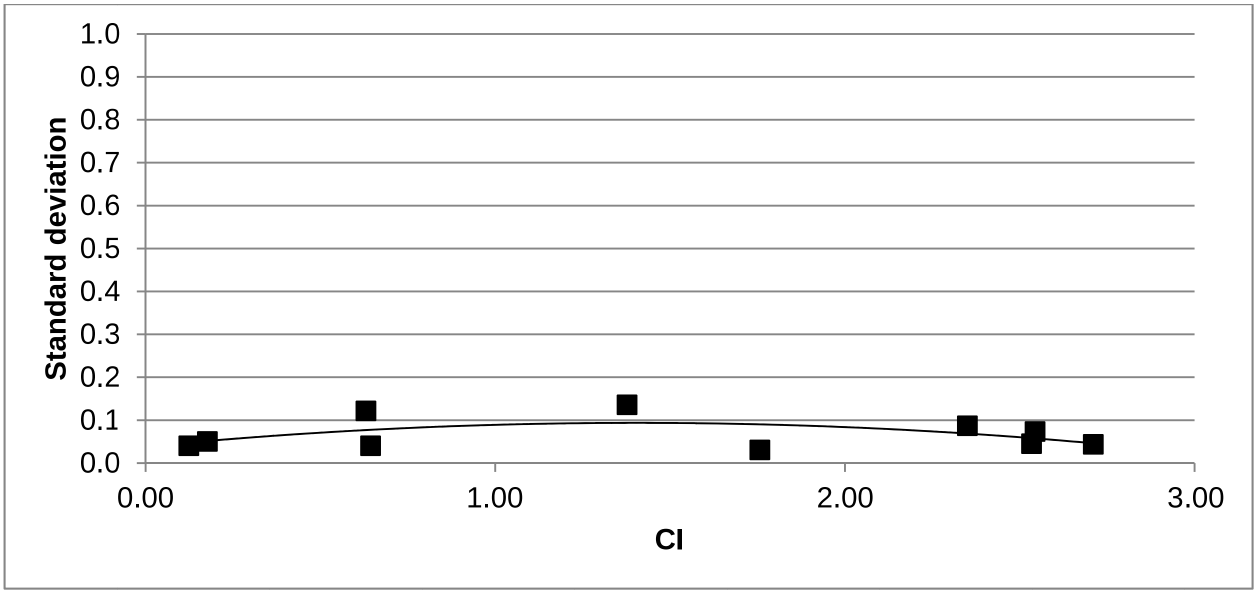


Figure 4. Within-site standard deviation versus *CI*.

3.4.2 Within-reach variability

Replicate sampling occurred at nine reaches covering a mean *CI* range of 0.05 – 2.80 (N=3) (Table 7). Reach-mean *CI* was not significantly different when estimated from three sites or six sites (p=0.33, df=8).

Table 7. Reach-mean *CI* values for nine reaches sampled at three and six sites (SD=standard deviation).

	N=3		N=6	
Reach	**Mean CI**	**SD**	**Mean CI**	**SD**
GRAC1	0.05	0.04	0.07	0.05
HARM4	0.17	0.12	0.16	0.10
FORD5	0.53	0.22	0.58	0.20
ERIC4	1.15	0.66	1.02	0.61
NTHO1	1.31	0.60	1.22	0.58
KILM1	1.97	0.29	1.97	0.29
DRYE3	2.20	0.34	2.25	0.30
CORB1	2.62	0.35	2.59	0.30
GREE4	2.80	0.07	2.77	0.08
Mean	**1.42**	**0.30**	**1.40**	**0.28**

Polynomial fits of reach-mean *CI* and standard deviations by year showed no statistical difference at 95% confidence (Figure 5). Therefore, a single polynomial was developed from all three years of data and showed good fit and was found to be highly statistically significant (r^2 = 0.39, *p*<0.001); the polynomial was used in all further analyses.

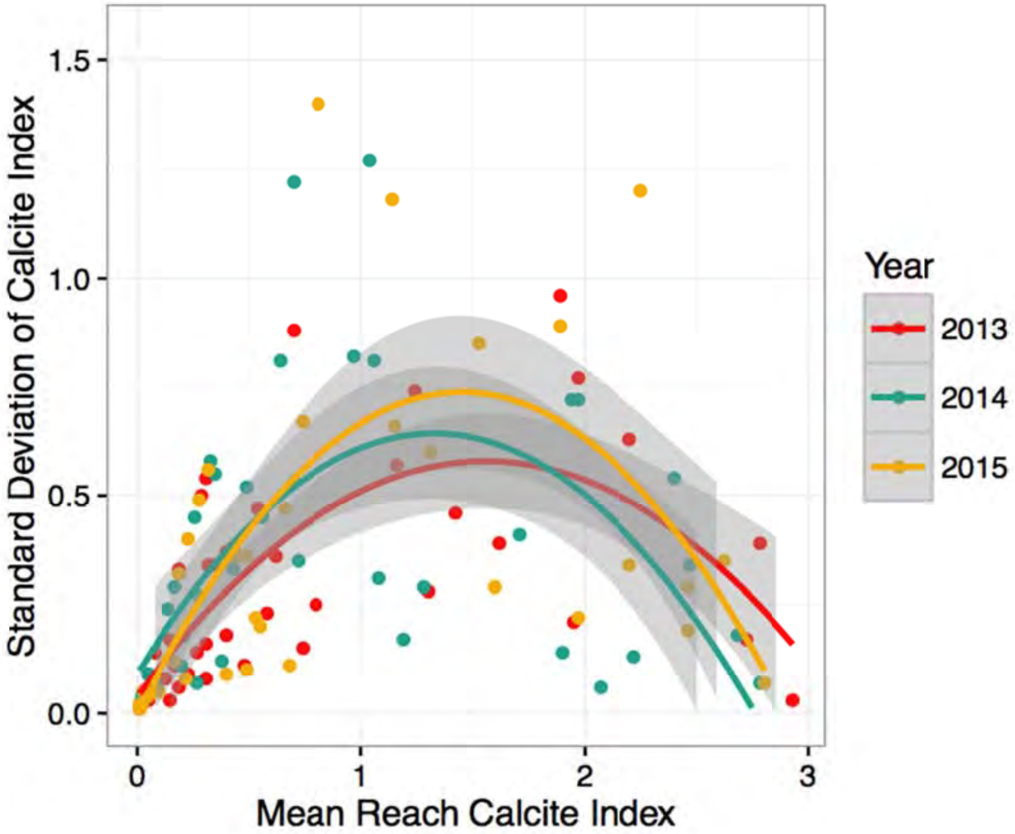


Figure 5. Empirical polynomial relations for each year of record. Shaded areas correspond to 95% confidence intervals.

Minimum detectable differences (Δ*CI*/year) were largest for streams with reach-mean *CI* between 0.5 and 2.5, peaking at 1.5 for all sample sizes modelled (Figure 6). While the minimum detectable differences improved (i.e., decreased) with increased sample size, the relative improvement decreased as sample sizes increased. For example, at a reach-mean *CI* of 1.5, an increase in sampling from N = 2 to N = 3 resulted in an average decrease in minimum detection of 0.6, while an increase in sampling from N = 9 to N = 12 resulted in an average decrease of only 0.1. Furthermore, although increases in sampling had a relatively large effect at mid-range reach-mean *CI* values, decreases in minimum detectable differences were much more modest at the tails of the *CI* range. The standard error of the polynomial fit was 0.14. Error decreased with sample size. For N = 2, the calculated error was 0.55, while the error was 0.19 for N = 9. Improvements were increasingly low for more than 6 samples.

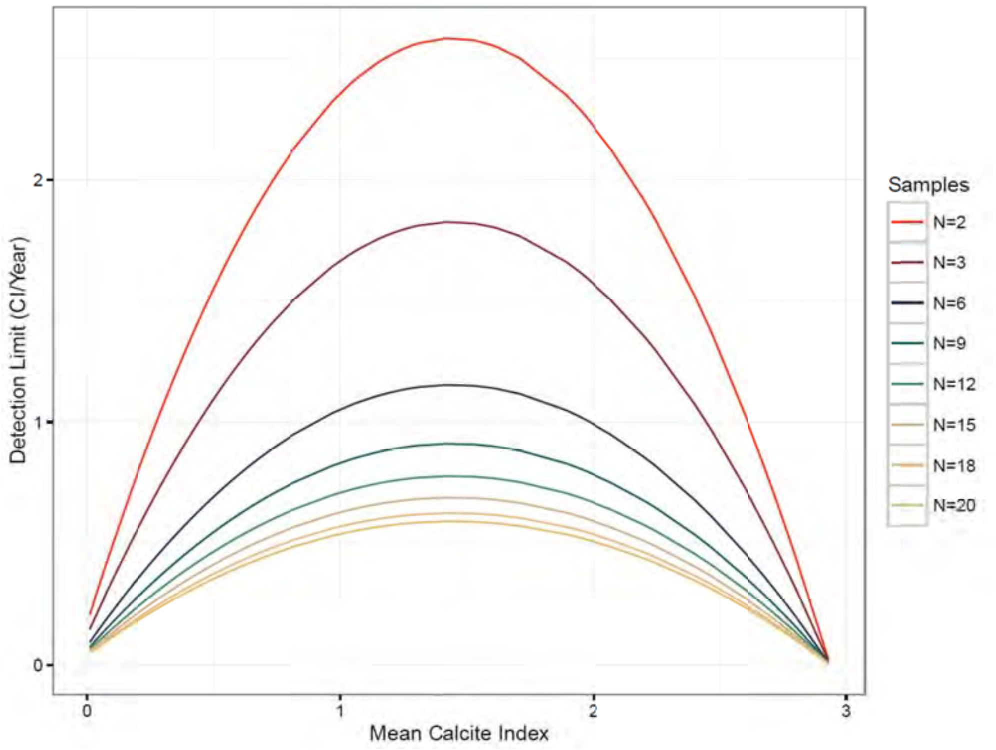


Figure 6. Modelled differences (CI/year) as a function of the reach-averaged calcite index for a selected number of samples per site.

Minimum detectable differences modelled with the polynomial function and those calculated from the site data from nine reaches sampled with N=6 (i.e., observed) were found to agree well with each other. A linear regression forced through the origin had an r^2 of 0.91 that was significant at 99.9% confidence (Figure 7).

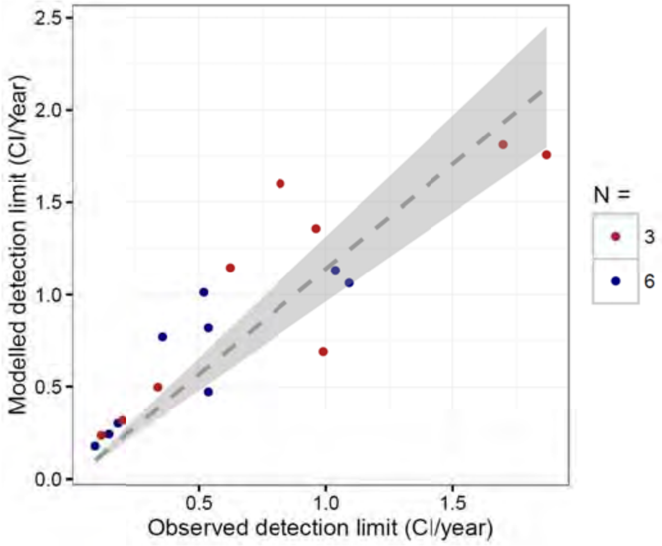


Figure 7. Modelled and observed detection levels for nine sites with N = 3 and N = 6 (grey shading indicates 95% confidence interval).

The number of sites required to detect statistical differences in reach-mean *CI* is reliant on the previously observed reach-mean *CI*. For reaches with extremely low or high *CI* values (<0.25 or >2.75), even one sample was most likely enough to detect a change of 0.25 (Table 8). Conversely, detecting the same magnitude of change for sites with intermediate *CI*'s is likely to require more samples than is feasible, both logistically and statistically. Given that Figure 6 demonstrates that an increase in sampling effort past a certain threshold yields increasingly small improvements in accuracy (and therefore negligible increases in the potential to detect small differences), it is unlikely that a low detectable differences of 0.25 is realistic for sites with *CI*'s between 0.5 and 2.5. However, detectable differences of up to 1.0 are more realistically attainable over the intermediate range of *CI* (1.00-2.00).

Table 8. Estimated number of samples (N) as well as 90% confidence intervals required to achieve select detectable differences (*d*).

CI	**d = 0.25**		**d = 0.50**		**d = 1.0**	
	N	Conf. Interval	N	Conf. Interval	N	Conf. Interval
0.00	1*	N/A	1*	N/A	1*	N/A
0.25	14	9 - 20	10	8 - 12	1	1 - 1
0.50	39	30 - 48	16	13 - 20	2	2 - 3
0.75	66	53 - 80	22	18 - 27	4	3 - 5
1.00	89	71 - 108	26	21 - 32	6	4 - 7
1.25	103	82 - 126	27	21 - 33	6	5 - 8
1.50	106	85 - 130	24	20 - 30	7	5 - 8
1.75	98	78 - 120	20	15 - 25	6	5 - 8
2.00	79	62 - 99	13	10 - 18	5	4 - 6
2.25	54	38 - 71	7	4 - 11	3	2 - 4
2.50	27	14 - 43	2	0 - 5	2	1 - 3
2.75	6	0 - 19	1*	0 - 3	1*	0 - 1
3.00	1*	N/A	1*	N/A	1*	N/A

*Indicates estimated value is < 1.0, and is approximated due to rounding.

3.4.3 Pebble count sample size assessment

The absolute difference between values obtained from 100 rocks and 10 rocks sampled was between 27 and 30% for all three metrics (CI_c, CI_p, *CI*) (Figure 8). Increasing the sample size from 10 to 50 rocks resulted in a sizeable decrease in the absolute difference, where sampling 50 rocks resulted in an average 10% difference compared to the full 100 rock samples. From 50 to 75 rocks sampled, the decrease in percent difference was only 2 – 4%, while the difference between 75 and 100 rock samples was approximately 4%.

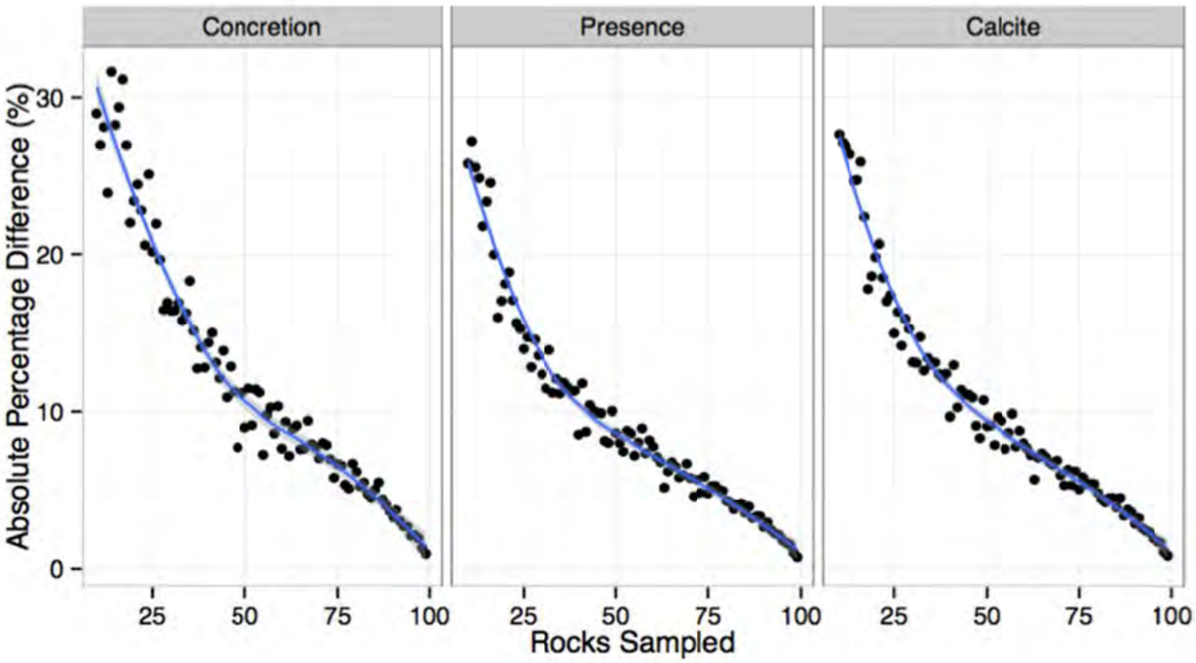


Figure 8. Absolute percentage difference for concretion, presence, and calcite index scores for the entire dataset (2013-2015). Blue lines correspond to the loess-smoothed best-fit, while grey shaded areas correspond to 95% confidence intervals.

4 Summary

Year 3 of the 2013-2015 *Calcite Monitoring Program* was successfully completed as per the monitoring Program (Robinson *et al.* 2013) with the Year 3 changes noted in this report. Calcite deposition was described at 124 reaches throughout the Elk Valley. General observed deposition patterns were similar to Years 1 and 2 with 83% of the stream kilometers classifying to the low *CI* bin (0-0.5); the same bin that all reference stream kilometers are classified into. The majority of exposed stream kilometers surveyed were not distinguishable from reference conditions. It also indicates that calcite influences are highly localized.

Changes in calcite deposition were assessed using the three years of data collected from 2013-2015. The ability to detect change was improved with three years of data and statistically significant inter-annual changes were detected in reach-mean *CI*. Four reaches were found to have a significant change in reach mean *CI*/year from 2013 – 2015. Erickson Creek – Reach 3 was found to increase. The other three (Eagle Pond Outlet, Otto Creek – Reach 1, and Grace Creek – Reach 1) showed decreases in reach-mean *CI* values. The range in reach-mean *CI* values represented by these reaches cover much of the range of possible reach-mean *CI* values. This is indication that the program is capable of detecting change at a range of *CI* values. Furthermore, the rate of change that was detected in these reaches was as low as 0.10 *CI*/year. This is also evidence of the Program's ability to describe and monitor change in calcite deposition.

Assessing calcite deposition over time requires some consideration of what the monitoring Program objectives are and how calcite deposition is expected to progress (increase and decrease). Spatial and temporal heterogeneity make calcite deposition trends difficult to detect over short observation periods, such as three years. The power to meaningfully describe trends improves over time as additional data are collected. This limits the confidence of linear regression to detect trends at first. As well, it is unknown at this time if a change in calcite over time is linear; an assumption required by this assessment.

ANOVA appears to be more appropriate with the initial data set of just three years as it tests each year to every other year providing a type of weight-of-evidence approach to testing if *CI* is changing over time, or if one year seems to be driving an apparent trend. ANOVA tests changes from Year 1 to 2, then 2 to 3, and finally 1 to 3. If all pairings showed a significant increase, then the weight of evidence would suggest that the increase is true. If only one year-year pairing was significant, then the evidence would be less certain.

ANOVA also does not require the change to be linear. It does however, require some estimate of within-year variability, meaning either multiple sites within a reach each year or estimating variance from the polynomial relationship described in Section 3.4.2.

A critical assessment of the program was completed as part of this report. The assessment looked at site-level *CI* variability, reach-level *CI* variability, pebble count methods, and overall field methods to inform design of future monitoring programs. Site-level *CI* variability was found to be low. Site-level *CI* scores were found to be highly reproducible through triplicate sampling. This result was corroborated by the results generated from the pebble count subsampling assessment. Subsampling suggests that a 25 particle pebble count has an 80% chance of reproducing the *CI* value derived from 100 counts, while reproducibility improves to 90% with a

50 rock pebble count. Low site-level variability provides the opportunity to reallocate effort; improving monitoring accuracy without increasing field effort and costs.

The reach-level *CI* variability assessment confirmed the relationship of reach-level variation in *CI* and mean *CI* scores that has been observed in Years 1 and 2. Robinson and MacDonald (2014) presented a predictive assessment on the effect of sample size on within-reach variability. Empirical data collected in 2015 by subsampling nine reaches with six sites validated those predictions and found them to be accurate (statistically significant) relative to data collected in the field. Predictions were then generated over a range of sample sizes to illustrate what the level of effort would need to be as a function of the desired minimum detection limit and *CI*. Sample effort (in terms of number of sites per reach) increases as the desired minimum detection limit increases. Reaches with intermediate *CI* values, where within-reach variability is highest, are predicted to require a higher number of sites relative to sites with *CI* near 0 or 3.

The Program results can provide guidance for future monitoring efforts. If future monitoring is intended to detect large changes, then frequent (i.e., annual) sampling is appropriate, but can afford a lesser degree of power in change detection (C. Scwarz *per. comm.*). Such a program would sample a large area with less intensive surveys. As it relates to calcite monitoring, this style of program would occur annually and may only require one site within many reaches. If future monitoring is intended to detect long-term trends, then less frequent, but more intensive sampling is required. As it relates to the calcite monitoring program, monitoring for trends would require sampling every second or third year, but would require more sampling effort (three or six sites) within reaches.

This Program has met the four objectives of the 2013-2015 monitoring program. Specifically, the program has:

1. Documented “the extent and degree of calcite deposition in streams downstream of Teck’s coal operations and in reference streams”.
2. Satisfied the calcite specific monitoring regulatory requirements, including the EVWQP requirement to assess the rate of change in calcite formation.
3. Supported the identification of a priority stream for calcite management.
4. Provided data to evaluate the sampling methods.

The Program has also addressed Key Uncertainty 4.1.2 of the AMP regarding calcite monitoring. This report has demonstrated that calcite degree and extent can be measured effectively and consistently. The calcite degree is described using the calcite index; the extents are reported at the stream reach level, after sampling those reaches with the appropriate sample size.

5 Recommendations

The 2013-2015 Calcite monitoring program has advanced the understanding of spatial and temporal variability in calcite deposition throughout the Elk Valley.

Over the previous three years, the program has demonstrated that annual rates of change are generally low to non-detectable; therefore a form of annual surveillance monitoring to detect large-scale changes is appropriate. Furthermore, the surveillance monitoring can be accomplished with lower spatial resolution (i.e. with fewer samples).

Calcite trends, where they exist, seem to be at a low rate; therefore it is more important to get data over time than to get data at a higher resolution annually. Therefore, in addition to the surveillance monitoring, long-term trend monitoring is recommended at a three-year interval. To increase the likelihood of detecting trends, a higher spatial resolution (i.e. more samples) is required.

Based on the information collected and the analysis in this report, we recommend considering the following in developing a long term program:

- Establish a program with (1) annual monitoring; and, (2) long-term trend monitoring every three years
- **Annual monitoring:** Identify the focus for and the associated appropriate level of effort required for annual monitoring. The annual program should have the intent of sampling frequently (i.e. annually), but with reduced effort.
    - Reduce the total number of reaches sampled by combining two or more adjacent reaches with similar *CI* into “stream segments”. It is also possible for a segment to be comprised of one reach if conditions warrant. Features such as major stream confluences or suspected changes in water quality (e.g., upstream versus downstream of a particular operation) would also be used to differentiate segments where the potential exists for reaches to change over time.
    - Sample all streams identified in the 2013-2015 Program. Ensure at least one segment is sampled per tributary.
    - Identify an indicator reach that would be sampled and assumed representative of the entire segment, based on an assessment of historical monitoring results.
    - Consider a higher resolution (i.e., reach-based sampling) in areas of interest, such as downstream of treatment facilities or newly affected streams where it is unknown what reach would be an appropriate indicator reach.
    - Set the number of sites per segment based on the relationship between reach mean *CI* and reach-level site variability developed over the 2013-2015 Program. Reallocate field effort by reducing the number of sites in reaches with *CI* values near 0 or 3 and increase the number of sites for reaches with intermediate *CI* values.
    - Conduct 100 rock pebble counts to maintain accurate site-level *CI* measurements.

- **Long-term trend monitoring:** Develop a long-term trend monitoring component. The objective would be to conduct less frequent, but higher intensity sampling to support the annual program and assess long-term trends.
    - Complete long-term sampling in 2018.
    - Sample all reaches sampled in 2015 and any added in 2016-2017.
    - Conduct 100 rock pebble counts.
    - Set the number of sites per reach as described above for annual monitoring.
    - Use results to assess
        - appropriateness of indicator reach in describing a segment (e.g., are results in a segment different from 2016 – 2018 if a different reach was selected as the indicator?)
        - is the long-term trend component providing value and is so is a three-year interval appropriate?
- Define the minimum detection limit (∆*CI*/year) that the Program should achieve.
- Revisit the Program study design once management and/or biological thresholds become available to see if effort needs to be reallocated to reaches within a certain *CI* range.

The relationship between calcite and the habitat measurements, rock diameter, and habitat unit were tested in the first year of the program and was found to be not significant. Therefore these data do not need to be collected in future.

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.

RISC (Resource Inventory Standards Committee). 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory Standards and Procedures, Version 2.0. Prepared by BC Fisheries Information Services Branch for the Resources Inventory Committee.

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

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. 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, MD., MacDonald, RJ., Day, S., Swanson, J., and S. McPherson. 2013. Teck Coal Ltd – Calcite Monitoring Plan, vers. 1. Prepared for Teck Coal Ltd by Lotic Environmental Ltd, SRK Consulting Inc and Swanson Environmental Strategies Ltd. 24 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.

Appendix 1. Sites visited by program year

Region	***Reach***	***Site***	***CI 2013***	***CI 2014***	***CI 2015***
ELK	ALEX3	ALEX3-25	0.55	0.52	0.50
ELK	ALEX3	ALEX3-50	0.35	0.32	0.32
ELK	ALEX3	ALEX3-75	0.53	0.30	0.37
ELK	ANDY1	ANDY1-25	0.00	0.00	0.00
ELK	ANDY1	ANDY1-50	0.00	0.00	0.00
ELK	ANDY1	ANDY1-75	0.00	0.00	0.00
ELK	AQUE1	AQUE1-0	0.00	0.00	0.00
ELK	AQUE2	AQUE2-0	0.00	0.00	0.00
ELK	AQUE2	AQUE2-50	0.00	0.00	0.00
ELK	AQUE3	AQUE3-25	0.00	0.00	0.00
ELK	AQUE3	AQUE3-50	0.00	0.00	0.00
ELK	AQUE3	AQUE3-75	0.00	0.00	0.00
ELK	BALM1	BALM1-25	0.00	0.00	0.00
ELK	BODI1	BODI1-25	0.00	0.00	0.00
ELK	BODI1	BODI1-50	0.00	0.00	0.00
ELK	BODI1	BODI1-75	0.00	0.00	0.00
ELK	BODI2	BODI2-0	0.06	0.00	--
ELK	BODI3	BODI3-25	0.54	2.65	--
ELK	BODI3	BODI3-50	1.67	2.69	--
ELK	BODI3	BODI3-75	1.27	2.08	--
ELK	CARB1	CARB1-25	0.00	0.00	0.00
ELK	CARB1	CARB1-50	0.00	0.00	0.00
ELK	CARB1	CARB1-75	0.00	0.00	0.00
ELK	CARB2	CARB2-25	0.00	0.00	0.00
ELK	CARB2	CARB2-50	0.00	0.00	0.00
ELK	CARB2	CARB2-75	0.00	0.00	0.00
ELK	CATA1	CATA1-0	3.00	3.00	3.00
ELK	CATA2	CATA2-25	3.00	0.18	--
ELK	CATA2	CATA2-50	1.35	1.57	--
ELK	CATA2	CATA2-75	1.33	0.16	--
ELK	CATA3	CATA3-0	3.00	2.28	2.51
ELK	CATA3	CATA3-50	3.00	3.00	2.61
ELK	CHAU1	CHAU1-25	0.00	0.00	0.00
ELK	CHAU1	CHAU1-50	0.00	0.00	0.00
ELK	CHAU1	CHAU1-75	0.00	0.00	0.00
ELK	CLOW1	CLOW1-0	--	0.32	0.00
ELK	CLOW1	CLOW1-50	--	0.04	0.00
ELK	CORB1	CORB1-25	1.74	1.55	2.60
ELK	CORB1	CORB1-37.5	--	--	2.83
ELK	CORB1	CORB1-50	2.16	2.17	2.93
ELK	CORB1	CORB1-62.5	--	--	2.76
ELK	CORB1	CORB1-75	1.96	1.40	2.63
ELK	CORB1	CORB1-87.5	--	--	1.96
ELK	CORB2	CORB2-12.5	--	--	1.75
ELK	CORB2	CORB2-25	2.53	2.56	2.88

Region	*Reach*	*Site*	*CI 2013*	*CI 2014*	*CI 2015*
ELK	CORB2	CORB2-37.5	--	--	2.99
ELK	CORB2	CORB2-50	2.83	2.60	2.92
ELK	CORB2	CORB2-75	2.80	2.89	2.96
ELK	CORB2	CORB2-87.5	--	--	0.00
ELK	COUT1	COUT1-0	0.00	1.01	1.03
ELK	CPOS1	CPOS1-0	0.92	0.84	--
ELK	CPOU1	CPOU1-0	0.93	0.94	--
ELK	CSEE1	CSEE1-0	0.00	0.00	0.85
ELK	DRYE1	DRYE1-0	2.23	2.13	2.19
ELK	DRYE2	DRYE2-0	2.23	0.03	--
ELK	DRYE3	DRYE3-25	2.17	2.40	2.28
ELK	DRYE3	DRYE3-37.5	--	--	2.76
ELK	DRYE3	DRYE3-50	2.85	1.86	2.82
ELK	DRYE3	DRYE3-62.5	--	--	2.15
ELK	DRYE3	DRYE3-75	1.59	2.93	2.31
ELK	DRYE3	DRYE3-99	--	--	2.56
ELK	DRYE4	DRYE4-25	1.90	1.84	2.37
ELK	DRYE4	DRYE4-50	1.39	--	--
ELK	DRYE4	DRYE4-75	0.98	--	--
ELK	DRYL1	DRYL1-25	0.00	0.00	0.00
ELK	DRYL1	DRYL1-50	0.00	0.00	0.00
ELK	DRYL1	DRYL1-75	0.00	0.00	0.00
ELK	DRYL2	DRYL2-25	0.00	0.00	0.00
ELK	DRYL2	DRYL2-50	0.00	0.00	0.00
ELK	DRYL2	DRYL2-75	0.00	0.00	0.00
ELK	DRYL3	DRYL3-25	0.00	0.00	0.00
ELK	DRYL3	DRYL3-50	0.00	0.00	0.00
ELK	DRYL3	DRYL3-75	0.00	0.00	0.00
ELK	DRYL4	DRYL4-25	0.00	--	0.00
ELK	DRYL4	DRYL4-50	0.00	--	0.00
ELK	DRYL4	DRYL4-75	0.00	--	0.00
ELK	DRYL5	DRYL5-0	--	--	--
ELK	DRYL5	DRYL5-25	0.00	--	--
ELK	DRYL5	DRYL5-50	0.00	--	--
ELK	DRYL5	DRYL5-75	0.00	--	--
ELK	DRYL6	DRYL6-25	0.00	--	--
ELK	DRYL6	DRYL6-50	0.00	--	--
ELK	DRYL6	DRYL6-75	0.00	--	--
ELK	ELKR10	ELKR10-25	0.00	0.00	0.00
ELK	ELKR10	ELKR10-50	0.00	0.00	0.00
ELK	ELKR10	ELKR10-75	0.00	0.00	0.00
ELK	ELKR11	ELKR11-25	0.00	0.00	0.00
ELK	ELKR11	ELKR11-50	0.00	0.00	0.00
ELK	ELKR11	ELKR11-75	--	--	0.00
ELK	ELKR12	ELKR12-25	0.00	0.00	0.00

Region	*Reach*	*Site*	*CI 2013*	*CI 2014*	*CI 2015*
ELK	ELKR12	ELKR12-50	0.00	0.00	0.00
ELK	ELKR12	ELKR12-75	0.00	0.00	0.00
ELK	ELKR15	ELKR15-25	0.00	0.00	0.00
ELK	ELKR15	ELKR15-50	0.00	0.00	0.00
ELK	ELKR15	ELKR15-75	0.00	0.00	0.00
ELK	ELKR8	ELKR8-25	0.00	0.00	0.00
ELK	ELKR8	ELKR8-50	0.74	0.00	0.00
ELK	ELKR8	ELKR8-75	0.46	0.00	0.00
ELK	ELKR9	ELKR9-25	0.00	0.00	0.00
ELK	ELKR9	ELKR9-50	0.00	0.00	0.00
ELK	ELKR9	ELKR9-75	0.00	0.00	0.00
ELK	EPOU1	EPOU1-0	1.90	1.31	0.58
ELK	ERIC1	ERIC1-0	2.33	2.67	2.69
ELK	ERIC1	ERIC1-50	2.24	2.50	2.85
ELK	ERIC2	ERIC2-0	1.78	2.27	2.58
ELK	ERIC3	ERIC3-0	2.36	2.60	3.00
ELK	ERIC4	ERIC4-12.5	--	--	2.33
ELK	ERIC4	ERIC4-25	0.99	1.56	1.56
ELK	ERIC4	ERIC4-37.5	--	--	0.85
ELK	ERIC4	ERIC4-50	0.60	1.28	0.71
ELK	ERIC4	ERIC4-62.5	--	--	0.83
ELK	ERIC4	ERIC4-75	0.27	0.99	0.74
ELK	FELT1	FELT1-25	0.00	0.00	0.00
ELK	FELT1	FELT1-50	0.00	0.00	0.00
ELK	FELT1	FELT1-75	0.00	0.00	0.00
ELK	FENN1	FENN1-25	0.00	0.00	0.00
ELK	FENN1	FENN1-50	0.00	0.00	0.00
ELK	FENN1	FENN1-75	0.00	0.00	0.00
ELK	FORD10	FORD10-25	0.00	0.00	0.00
ELK	FORD10	FORD10-50	0.00	0.00	0.00
ELK	FORD10	FORD10-75	0.00	0.00	0.00
ELK	FORD11	FORD11-25	0.00	0.00	0.00
ELK	FORD11	FORD11-50	0.00	0.00	0.00
ELK	FORD11	FORD11-75	0.00	0.00	0.00
ELK	FORD12	FORD12-25	0.00	0.00	0.00
ELK	FORD12	FORD12-50	0.00	0.00	0.00
ELK	FORD12	FORD12-75	--	0.00	0.00
ELK	FORD1	FORD1-25	0.00	0.00	0.00
ELK	FORD1	FORD1-50	0.00	0.00	0.00
ELK	FORD1	FORD1-75	0.00	0.00	0.00
ELK	FORD2	FORD2-25	0.00	0.00	0.00
ELK	FORD2	FORD2-50	--	0.00	0.00
ELK	FORD2	FORD2-75	--	0.00	0.00
ELK	FORD3	FORD3-25	0.00	0.00	0.00
ELK	FORD3	FORD3-50	0.00	0.00	0.00

Region	***Reach***	***Site***	***CI 2013***	***CI 2014***	***CI 2015***
ELK	FORD3	FORD3-75	--	0.04	0.00
ELK	FORD4	FORD4-25	--	0.00	0.13
ELK	FORD4	FORD4-50	--	0.16	0.99
ELK	FORD4	FORD4-75	--	0.00	0.87
ELK	FORD5	FORD5-12.5	--	--	0.29
ELK	FORD5	FORD5-25	0.00	0.00	0.27
ELK	FORD5	FORD5-37.5	--	--	0.49
ELK	FORD5	FORD5-50	0.28	0.98	0.69
ELK	FORD5	FORD5-75	0.68	0.06	0.68
ELK	FORD5	FORD5-87.5	--	--	0.78
ELK	FORD6	FORD6-25	0.92	0.48	2.16
ELK	FORD6	FORD6-50	0.65	0.73	1.86
ELK	FORD6	FORD6-75	0.66	0.07	0.56
ELK	FORD7	FORD7-25	0.74	1.49	0.72
ELK	FORD7	FORD7-50	0.00	0.03	0.33
ELK	FORD7	FORD7-75	0.55	1.40	0.60
ELK	FORD8	FORD8-25	0.16	0.00	0.14
ELK	FORD8	FORD8-50	0.28	1.04	0.86
ELK	FORD8	FORD8-75	0.48	0.43	0.44
ELK	FORD9	FORD9-25	0.00	0.00	0.00
ELK	FORD9	FORD9-50	0.00	0.00	0.00
ELK	FORD9	FORD9-75	0.00	0.00	0.00
ELK	FPON1	FPON1-25	0.00	0.03	0.00
ELK	FPON1	FPON1-50	0.00	0.06	0.00
ELK	FPON1	FPON1-75	0.00	0.00	0.00
ELK	GARD1	GARD1-25	0.86	2.11	0.97
ELK	GARD1	GARD1-50	0.00	0.00	0.00
ELK	GARD1	GARD1-75	0.00	0.00	0.00
ELK	GATE1	GATE1-0	0.05	0.05	--
ELK	GATE2	GATE2-25	0.29	0.00	0.00
ELK	GATE2	GATE2-50	0.00	0.00	1.31
ELK	GATE2	GATE2-75	--	0.00	0.91
ELK	GODD1	GODD1-0	0.00	0.00	0.00
ELK	GODD2	GODD2-25	0.00	0.00	0.00
ELK	GODD2	GODD2-50	0.00	0.00	0.00
ELK	GODD2	GODD2-75	0.00	0.00	0.00
ELK	GODD3	GODD3-25	0.00	2.02	2.22
ELK	GODD3	GODD3-50	0.00	1.75	1.88
ELK	GODD3	GODD3-75	0.00	1.92	1.80
ELK	GRAC1	GRAC1-12.5	--	--	0.04
ELK	GRAC1	GRAC1-25	0.39	0.07	0.04
ELK	GRAC1	GRAC1-37.5	--	--	0.08
ELK	GRAC1	GRAC1-50	0.24	0.25	0.02
ELK	GRAC1	GRAC1-75	0.30	0.27	0.13
ELK	GRAC1	GRAC1-87.5	--	--	0.01

Region	*Reach*	*Site*	*CI 2013*	*CI 2014*	*CI 2015*
ELK	GRAC2	GRAC2-25	0.33	0.12	0.10
ELK	GRAC2	GRAC2-50	0.13	0.14	0.14
ELK	GRAC2	GRAC2-75	0.00	0.04	0.05
ELK	GRAC3	GRAC3-25	--	0.00	0.00
ELK	GRAC3	GRAC3-50	--	0.00	0.00
ELK	GRAC3	GRAC3-75	--	0.00	0.00
ELK	GRAS1	GRAS1-25	0.00	0.16	0.00
ELK	GRAS1	GRAS1-50	0.00	0.04	0.00
ELK	GRAS1	GRAS1-75	0.00	0.06	0.00
ELK	GRAV1	GRAV1-25	0.56	0.35	0.01
ELK	GRAV1	GRAV1-50	0.07	0.75	0.04
ELK	GRAV1	GRAV1-75	1.00	1.05	0.01
ELK	GRAV2	GRAV2-25	0.34	0.32	0.00
ELK	GRAV2	GRAV2-50	0.16	0.30	0.00
ELK	GRAV2	GRAV2-75	0.20	0.00	0.00
ELK	GRAV3	GRAV3-25	0.00	0.00	0.00
ELK	GRAV3	GRAV3-50	0.00	0.00	0.00
ELK	GRAV3	GRAV3-75	0.00	0.00	0.00
ELK	GREE1	GREE1-25	0.11	0.13	0.06
ELK	GREE1	GREE1-50	0.21	1.43	0.48
ELK	GREE1	GREE1-75	0.74	1.61	0.80
ELK	GREE2	GREE2-25	0.60	0.00	--
ELK	GREE3	GREE3-12.5	--	--	2.23
ELK	GREE3	GREE3-25	0.99	2.37	2.55
ELK	GREE3	GREE3-37.5	--	--	2.22
ELK	GREE3	GREE3-50	1.39	2.12	2.53
ELK	GREE3	GREE3-62.5	--	--	2.68
ELK	GREE3	GREE3-75	1.52	2.18	2.52
ELK	GREE4	GREE4-12.5	--	--	2.86
ELK	GREE4	GREE4-25	2.00	2.70	2.77
ELK	GREE4	GREE4-37.5	--	--	2.81
ELK	GREE4	GREE4-50	1.62	2.79	2.88
ELK	GREE4	GREE4-62.5	--	--	2.70
ELK	GREE4	GREE4-75	1.23	2.84	2.76
ELK	HARM1	HARM1-25	0.47	0.88	0.03
ELK	HARM1	HARM1-50	0.42	0.92	0.04
ELK	HARM1	HARM1-75	0.84	1.44	0.13
ELK	HARM2	HARM2-0	0.31	0.15	--
ELK	HARM2	HARM2-50	0.03	0.05	--
ELK	HARM3	HARM3-25	0.16	0.58	0.02
ELK	HARM3	HARM3-50	0.12	0.17	0.00
ELK	HARM3	HARM3-75	0.18	0.08	0.00
ELK	HARM4	HARM4-12.5	--	--	0.23
ELK	HARM4	HARM4-25	0.07	0.54	0.05
ELK	HARM4	HARM4-37.5	--	--	0.10

Region	***Reach***	***Site***	***CI 2013***	***CI 2014***	***CI 2015***
ELK	HARM4	HARM4-50	0.29	1.29	0.28
ELK	HARM4	HARM4-62.5	--	--	0.29
ELK	HARM4	HARM4-75	0.14	0.26	0.04
ELK	HARM5	HARM5-25	0.26	1.07	0.31
ELK	HARM5	HARM5-50	0.14	0.40	0.19
ELK	HARM5	HARM5-75	0.16	0.21	0.16
ELK	HDSE1	HDSE1-0	0.52	--	--
ELK	HENR1	HENR1-25	0.00	0.00	0.00
ELK	HENR1	HENR1-50	0.00	0.00	0.00
ELK	HENR1	HENR1-75	0.00	0.00	0.00
ELK	HENR2	HENR2-25	0.00	0.00	0.00
ELK	HENR2	HENR2-50	0.00	0.00	0.00
ELK	HENR2	HENR2-75	0.00	0.00	0.00
ELK	HENR3	HENR3-25	0.00	0.00	0.00
ELK	HENR3	HENR3-50	0.00	0.00	--
ELK	KILM1	KILM1-25	--	--	2.56
ELK	KILM1	KILM1-50	2.57	2.70	2.77
ELK	KILM1	KILM1-62.5	--	--	2.44
ELK	KILM1	KILM1-75	1.74	0.57	2.09
ELK	KILM1	KILM1-87.5	--	--	0.00
ELK	LCSE1	LCSE1-0	0.39	--	--
ELK	LEAS1	LEAS1-25	0.00	0.00	--
ELK	LEAS1	LEAS1-50	0.00	0.00	--
ELK	LEAS1	LEAS1-75	0.09	0.51	--
ELK	LEAS2	LEAS2-25	0.08	1.40	0.24
ELK	LEAS2	LEAS2-50	0.10	1.80	--
ELK	LEAS3	LEAS2-75	0.22	--	--
ELK	LIND1	LIND1-25	0.58	0.78	0.56
ELK	LIND1	LIND1-50	0.00	0.00	0.00
ELK	LIND1	LIND1-75	0.00	0.00	0.00
ELK	LINE1	LINE1-25	0.13	0.00	0.00
ELK	LINE1	LINE1-50	0.27	0.00	0.00
ELK	LINE1	LINE1-75	0.40	0.00	0.00
ELK	LINE2	LINE2-25	0.00	0.00	0.00
ELK	LINE2	LINE2-50	0.00	0.00	0.00
ELK	LINE2	LINE2-75	0.00	0.00	0.00
ELK	LINE3	LINE3-25	0.00	0.00	0.00
ELK	LINE3	LINE3-50	0.00	0.00	0.00
ELK	LINE3	LINE3-75	0.00	0.00	0.00
ELK	LINE4	LINE4-25	0.51	0.34	0.77
ELK	LINE4	LINE4-50	0.19	0.20	0.56
ELK	LINE4	LINE4-75	0.49	0.28	0.70
ELK	LINE7	LINE7-25	0.00	0.00	0.00
ELK	LINE7	LINE7-50	0.00	0.00	0.00
ELK	LINE7	LINE7-75	0.00	0.00	0.00

Region	*Reach*	*Site*	*CI 2013*	*CI 2014*	*CI 2015*
ELK	LMOU1	LMOU1-25	0.00	0.00	0.00
ELK	LMOU1	LMOU1-50	0.00	0.00	0.00
ELK	LMOU1	LMOU1-75	0.00	1.00	0.00
ELK	LMOU2	LMOU2-0	0.00	0.09	--
ELK	LMOU3	LMOU3-25	0.00	0.00	0.00
ELK	LMOU3	LMOU3-50	0.00	0.00	0.00
ELK	LMOU3	LMOU3-75	0.00	0.00	0.00
ELK	LMOU4	LMOU4-25	0.00	0.00	0.00
ELK	LMOU4	LMOU4-50	0.00	0.00	0.00
ELK	LMOU4	LMOU4-75	0.00	0.00	0.00
ELK	MICH1	MICH1-25	0.00	0.00	0.00
ELK	MICH1	MICH1-50	0.00	0.00	0.00
ELK	MICH1	MICH1-75	0.93	0.00	0.00
ELK	MICH2	MICH2-25	0.00	0.00	0.00
ELK	MICH2	MICH2-50	0.16	0.00	0.00
ELK	MICH2	MICH2-75	0.00	0.15	0.00
ELK	MICH3	MICH3-25	0.00	0.00	0.00
ELK	MICH3	MICH3-50	--	0.00	0.00
ELK	MICH3	MICH3-75	0.00	0.00	0.00
ELK	MICH4	MICH4-25	0.00	0.00	0.00
ELK	MICH4	MICH4-50	0.00	0.00	0.00
ELK	MICH4	MICH4-75	0.00	0.00	0.00
ELK	MICH5	MICH5-25	0.00	0.00	0.00
ELK	MICH5	MICH5-50	0.00	0.00	0.00
ELK	MICH5	MICH5-75	0.00	0.00	0.00
ELK	MICK1	MICK1-25	0.00	0.00	0.00
ELK	MICK1	MICK1-50	0.00	0.00	0.00
ELK	MICK1	MICK1-75	0.02	0.00	0.00
ELK	MICK2	MICK2-25	0.05	0.00	0.00
ELK	MICK2	MICK2-50	0.08	0.00	0.09
ELK	MICK2	MICK2-75	0.02	--	0.00
ELK	MILL1	MILL1-0	0.00	0.00	0.00
ELK	MILL2	MILL2-0	0.00	0.00	0.00
ELK	NTHO1	NTHO1-12.5	--	--	0.29
ELK	NTHO1	NTHO1-25	0.83	2.39	1.81
ELK	NTHO1	NTHO1-37.5	--	--	1.66
ELK	NTHO1	NTHO1-50	2.09	2.39	1.64
ELK	NTHO1	NTHO1-62.5	--	--	1.33
ELK	NTHO1	NTHO1-75	0.80	--	0.33
ELK	NWOL1	NWOL1-25	1.72	1.22	0.42
ELK	NWOL1	NWOL1-50	0.16	1.43	0.00
ELK	NWOL1	NWOL1-75	0.22	--	--
ELK	OTTO1	OTTO1-0	0.30	0.22	0.10
ELK	OTTO2	OTTO2-25	0.08	0.00	0.00
ELK	OTTO2	OTTO2-50	0.00	0.00	0.00

Region	*Reach*	*Site*	*CI 2013*	*CI 2014*	*CI 2015*
ELK	OTTO2	OTTO2-75	0.00	0.00	0.00
ELK	OTTO3	OTTO3-25	0.06	0.07	0.00
ELK	OTTO3	OTTO3-50	0.00	0.00	0.00
ELK	OTTO3	OTTO3-75	0.00	0.00	0.00
ELK	P12S1	P12S1-0	0.00	--	--
ELK	P12S1	P12S1-50	0.00	--	--
ELK	PENG1	PENG1-0	0.10	0.03	0.03
ELK	PENG1	PENG1-50	0.07	0.00	0.00
ELK	PORT1	PORT1-0	0.92	0.84	0.85
ELK	PORT2	PORT2-0	0.11	0.10	--
ELK	PORT3	PORT3-25	2.33	1.34	0.92
ELK	PORT3	PORT3-50	3.00	1.74	2.07
ELK	PORT3	PORT3-75	3.00	2.73	2.83
ELK	QUAL1	QUAL1-0	0.00	0.00	0.00
ELK	SAWM1	SAWM1-0	0.00	0.00	0.00
ELK	SAWM1	SAWM1-50	0.00	0.00	0.00
ELK	SAWM2	SAWM2-25	0.00	0.00	0.00
ELK	SAWM2	SAWM2-50	0.76	1.08	1.24
ELK	SIXM1	SIXM1-25	0.98	1.34	0.58
ELK	SIXM1	SIXM1-50	0.90	1.24	0.38
ELK	SIXM1	SIXM1-75	0.51	1.00	0.50
ELK	SIXM2	SIXM2-25	0.00	--	--
ELK	SIXM2	SIXM2-50	0.00	--	--
ELK	SIXM2	SIXM2-75	0.00	--	--
ELK	SLIN2	SLIN2-25	0.00	0.00	0.00
ELK	SLIN2	SLIN2-50	0.00	0.00	0.00
ELK	SLIN2	SLIN2-75	0.00	0.00	0.00
ELK	SNOW1	SNOW1-25	0.00	0.00	0.00
ELK	SNOW1	SNOW1-50	0.00	0.00	0.00
ELK	SNOW1	SNOW1-75	0.00	0.00	0.00
ELK	SPIT1	SPIT1-0	--	--	2.13
ELK	SPIT1	SPIT1-25	0.00	0.00	2.19
ELK	SPIT1	SPIT1-50	0.00	0.00	0.24
ELK	SPIT1	SPIT1-75	0.00	0.00	0.00
ELK	SPIT2	SPIT2-25	0.00	0.00	0.00
ELK	SPIT2	SPIT2-50	0.00	--	--
ELK	SPIT2	SPIT2-75	0.09	0.00	0.00
ELK	SPOU1	SPOU1-0	2.61	2.24	2.24
ELK	SPRI1	SPRI1-0	0.20	0.11	0.11
ELK	SPSE1	SPSE1-50	0.00	1.50	0.10
ELK	SWIF1	SWIF1-0	2.58	2.18	2.39
ELK	SWIF2	SWIF2-25	0.00	0.10	0.00
ELK	SWIF2	SWIF2-50	--	0.53	0.00
ELK	SWIF2	SWIF2-75	0.00	2.49	2.46
ELK	SWOL1	SWOL1-25	2.83	1.26	0.85

Region	*Reach*	*Site*	*CI 2013*	*CI 2014*	*CI 2015*
ELK	SWOL1	SWOL1-50	1.34	1.95	0.00
ELK	SWOL1	SWOL1-75	1.74	2.70	0.00
ELK	THOM1	THOM1-0	0.00	0.00	0.00
ELK	THOM2	THOM2-25	0.00	0.00	0.00
ELK	THOM2	THOM2-50	0.24	0.00	0.04
ELK	THOM2	THOM2-75	0.00	0.00	0.00
ELK	THOM3	THOM3-25	0.00	0.00	0.00
ELK	THOM3	THOM3-50	0.00	0.00	0.00
ELK	THOM3	THOM3-75	0.00	0.00	0.00
ELK	THRE1	THRE1-25	0.00	0.00	0.00
ELK	THRE1	THRE1-50	0.00	0.00	0.00
ELK	USOS1	USOS1-25	0.00	0.00	0.00
ELK	USOS1	USOS1-50	0.00	0.00	0.00
ELK	WILN2	WILN2-25	--	--	0.00
ELK	WILN2	WILN2-50	--	--	0.00
ELK	WILS1	WILS1-25	--	--	0.00
ELK	WILS1	WILS1-50	--	--	0.00
ELK	WHEE1	WHEE1-25	0.00	0.00	0.00
ELK	WHEE1	WHEE1-50	0.00	0.00	0.00
ELK	WHEE1	WHEE1-75	0.00	0.00	0.00
ELK	WHEE2	WHEE2-25	0.00	0.00	0.00
ELK	WHEE2	WHEE2-50	0.00	0.00	0.00
ELK	WHEE2	WHEE2-75	0.00	0.00	0.00
ELK	WHEE3	WHEE3-25	0.00	0.00	0.00
ELK	WHEE3	WHEE3-50	0.00	0.00	0.00
ELK	WHEE3	WHEE3-75	0.00	0.00	0.00
ELK	WOL1	WOL1-25	--	--	0.00
ELK	WOL1	WOL1-50	--	--	0.00
ELK	WOLF2	WOLF2-25	--	0.00	0.00
ELK	WOLF2	WOLF2-50	--	0.00	0.00
ELK	WOLF2	WOLF2-75	0.27	0.42	0.70
ELK	WOLF3	WOLF3-25	2.90	2.00	1.29
ELK	WOLF3	WOLF3-50	2.94	2.10	1.87
ELK	WOLF3	WOLF3-75	2.95	2.11	1.64

Appendix 2. Calcite site data.

Reach Name	Reach Code	Site Code	Spatial reference	Easting	Northing	Zone	Operation	Type	Calcite present	Calcite type
Kilmamock Creek R1	KILM1	KILM1-25	UTM Zone11 NAD83	652416	5559480	Elk Valley	FRO	Exposed	Yes	calcite scale
Kilmamock Creek R1	KILM1	KILM1-50	UTM Zone11 NAD83	652442	5559534	Elk Valley	FRO	Exposed	Yes	calcite scale
Kilmamock Creek R1	KILM1	KILM1-75	UTM Zone11 NAD83	652704	5559764	Elk Valley	FRO	Exposed	Yes	calcite scale
Leask R2	LEAS2	LEAS2-25	UTM Zone11 NAD83	648763	5552881	Elk Valley	GHO	Exposed	Yes	calcite scale
Lindsay Creek R1	LIND1	LIND1-25	UTM Zone11 NAD83	654526	5515017	Elk Valley	EVO	Exposed	Yes	calcite scale
Lindsay Creek R1	LIND1	LIND1-50	UTM Zone11 NAD83	654687	5515222	Elk Valley	EVO	Exposed	No	n/a
Lindsay Creek R1	LIND1	LIND1-75	UTM Zone11 NAD83	654888	5515423	Elk Valley	EVO	Exposed	No	n/a
Line Creek R1	LINE1	LINE1-25	UTM Zone11 NAD83	654200	5529047	Elk Valley	LCO	Exposed	No	n/a
Line Creek R1	LINE1	LINE1-50	UTM Zone11 NAD83	654711	5528956	Elk Valley	LCO	Exposed	No	n/a
Line Creek R1	LINE1	LINE1-75	UTM Zone11 NAD83	655213	5529091	Elk Valley	LCO	Exposed	No	n/a
Line Creek R2	LINE2	LINE2-25	UTM Zone11 NAD83	656502	5529046	Elk Valley	LCO	Exposed	No	n/a
Line Creek R2	LINE2	LINE2-50	UTM Zone11 NAD83	657254	5529214	Elk Valley	LCO	Exposed	No	n/a
Line Creek R2	LINE2	LINE2-75	UTM Zone11 NAD83	657925	5529475	Elk Valley	LCO	Exposed	No	n/a
Line Creek R3	LINE3	LINE3-25	UTM Zone11 NAD83	658973	5530185	Elk Valley	LCO	Exposed	No	n/a
Line Creek R3	LINE3	LINE3-50	UTM Zone11 NAD83	659309	5530587	Elk Valley	LCO	Exposed	No	n/a
Line Creek R3	LINE3	LINE3-75	UTM Zone11 NAD83	659578	5531063	Elk Valley	LCO	Exposed	No	n/a
Line Creek R4	LINE4	LINE4-25	UTM Zone11 NAD83	659847	5531710	Elk Valley	LCO	Exposed	Yes	calcified algae
Line Creek R4	LINE4	LINE4-50	UTM Zone11 NAD83	660002	5531934	Elk Valley	LCO	Exposed	Yes	calcified algae
Line Creek R4	LINE4	LINE4-75	UTM Zone11 NAD83	660070	5532015	Elk Valley	LCO	Exposed	Yes	calcified algae
Line Creek R7	LINE7	LINE7-25	UTM Zone11 NAD83	661923	5538298	Elk Valley	LCO	Reference	No	n/a
Line Creek R7	LINE7	LINE7-50	UTM Zone11 NAD83	661951	5538340	Elk Valley	LCO	Reference	No	n/a
Line Creek R7	LINE7	LINE7-75	UTM Zone11 NAD83	662009	5538457	Elk Valley	LCO	Reference	No	n/a
Lake Mountain Creek R1	LMOU1	LMOU1-25	UTM Zone11 NAD83	650760	5563296	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R1	LMOU1	LMOU1-50	UTM Zone11 NAD83	650643	5563312	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R1	LMOU1	LMOU1-75	UTM Zone11 NAD83	650543	5563221	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R3	LMOU3	LMOU3-25	UTM Zone11 NAD83	650103	5563122	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R3	LMOU3	LMOU3-50	UTM Zone11 NAD83	649955	5563349	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R3	LMOU3	LMOU3-75	UTM Zone11 NAD83	649962	5563622	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R4	LMOU4	LMOU4-25	UTM Zone11 NAD83	649943	5564016	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R4	LMOU4	LMOU4-50	UTM Zone11 NAD83	649947	5564139	Elk Valley	FRO	Exposed	No	n/a
Lake Mountain Creek R4	LMOU4	LMOU4-75	UTM Zone11 NAD83	649943	5564283	Elk Valley	FRO	Exposed	No	n/a
Michel Creek R1	MICH1	MICH1-25	UTM Zone11 NAD83	652366	5511653	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R1	MICH1	MICH1-50	UTM Zone11 NAD83	653083	5511691	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R1	MICH1	MICH1-75	UTM Zone11 NAD83	653644	5511239	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R2	MICH2	MICH2-25	UTM Zone11 NAD83	655772	5509086	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R2	MICH2	MICH2-50	UTM Zone11 NAD83	656991	5507317	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R2	MICH2	MICH2-75	UTM Zone11 NAD83	658602	5506054	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R3	MICH3	MICH3-25	UTM Zone11 NAD83	660364	5502437	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R3	MICH3	MICH3-50	UTM Zone11 NAD83	659705	5499439	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R3	MICH3	MICH3-75	UTM Zone11 NAD83	659464	5496940	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R4	MICH4	MICH4-25	UTM Zone11 NAD83	661761	5493058	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R4	MICH4	MICH4-50	UTM Zone11 NAD83	663664	5490968	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R4	MICH4	MICH4-75	UTM Zone11 NAD83	665768	5488794	Elk Valley	Regional	Exposed	No	n/a
Michel Creek R5	MICH5	MICH5-25	UTM Zone11 NAD83	667899	5485586	Elk Valley	Regional	Reference	No	n/a
Michel Creek R5	MICH5	MICH5-50	UTM Zone11 NAD83	667933	5484333	Elk Valley	Regional	Reference	No	n/a
Michel Creek R5	MICH5	MICH5-75	UTM Zone11 NAD83	668277	5482458	Elk Valley	Regional	Reference	No	n/a
Mickelson Creek R1	MICK1	MICK1-25	UTM Zone11 NAD83	648023	5553511	Elk Valley	GHO	Exposed	No	n/a
Mickelson Creek R1	MICK1	MICK1-50	UTM Zone11 NAD83	648108	5553683	Elk Valley	GHO	Exposed	No	n/a

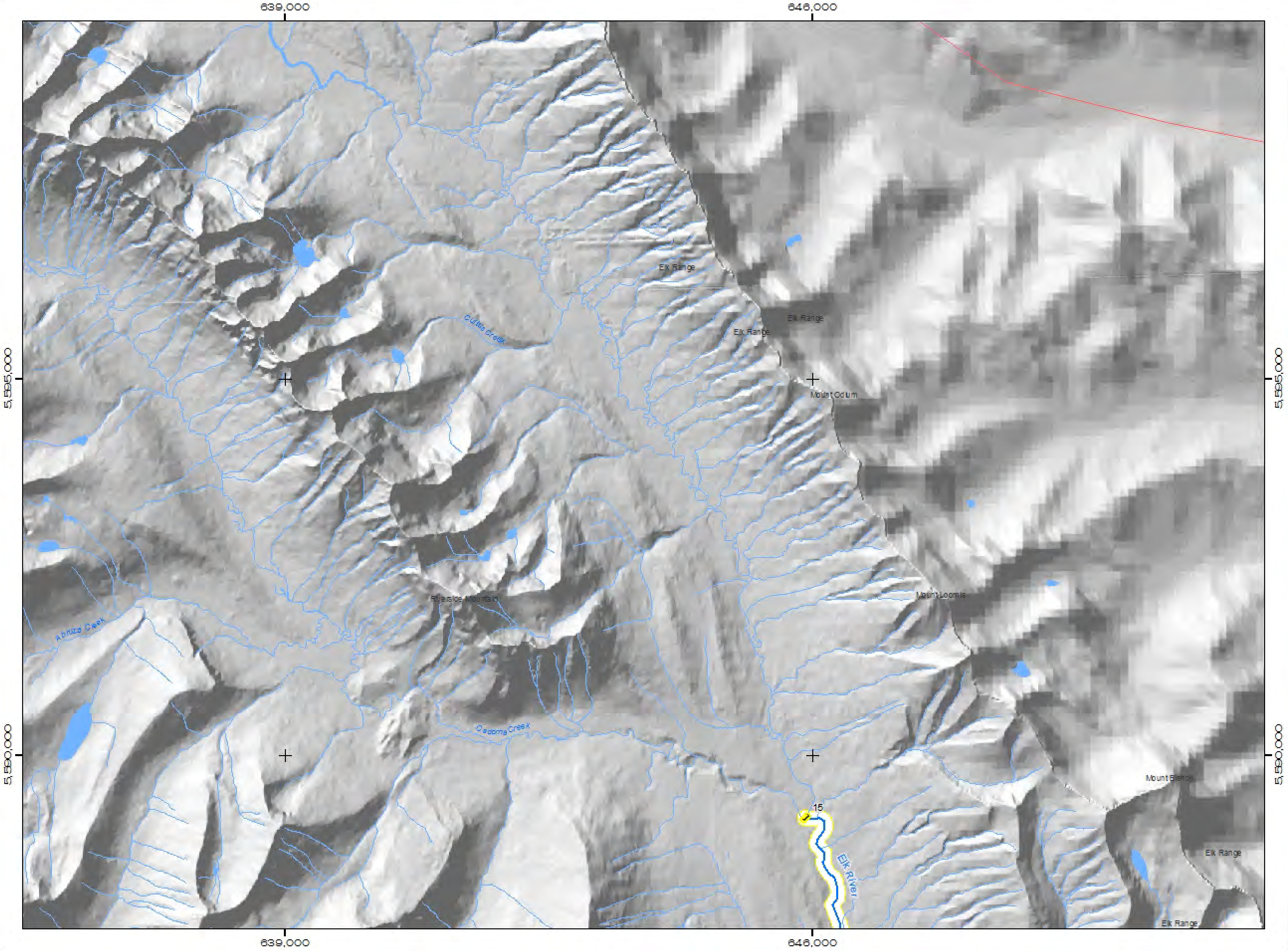
Appendix 3. 2015 Elk Valley calcite monitoring results by stream reach

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	0.01	0.39	0.40
Reference	Andy Good	ANDY1	0.00	0.00	0.00
Exposed	Aqueduct	AQUE1	0.00	0.00	0.00
Exposed	Aqueduct	AQUE2	0.00	0.00	0.00
Exposed	Aqueduct	AQUE3	0.00	0.00	0.00
Exposed	Balmer	BALM1	0.00	0.00	0.00
Exposed	Bodie	BODI1	0.00	0.00	0.00
Exposed	CCR Seep	CSEE1	0.54	0.31	0.85
Proposed	Carbon	CARB1	0.00	0.00	0.00
Proposed	Carbon	CARB2	0.00	0.00	0.00
Exposed	Cataract	CATA1	2.00	1.00	3.00
Exposed	Cataract	CATA3	1.58	0.99	2.56
Reference	Chauncey	CHAU1	0.00	0.00	0.00
Exposed	Clode Pond Outlet	COUT1	0.16	0.87	1.03
Exposed	Clode West Infiltration	CLOW1	0.00	0.00	0.00
Exposed	Corbin	CORB1	1.63	0.99	2.62
Exposed	Corbin	CORB2	1.42	0.83	2.25
Exposed	Dry (EVO)	DRYE1	1.25	0.94	2.19
Exposed	Dry (EVO)	DRYE3	1.56	0.92	2.48
Exposed	Dry (EVO)	DRYE4	1.43	0.94	2.37
Proposed	Dry (LCO)	DRYL1	0.00	0.00	0.00
Proposed	Dry (LCO)	DRYL2	0.00	0.00	0.00
Proposed	Dry (LCO)	DRYL3	0.00	0.00	0.00
Proposed	Dry (LCO)	DRYL4	0.00	0.00	0.00
Exposed	Eagle Pond Outlet	EPOU1	0.32	0.26	0.58
Exposed	Elk	ELKR10	0.00	0.00	0.00
Exposed	Elk	ELKR11	0.00	0.00	0.00
Exposed	Elk	ELKR12	0.00	0.00	0.00
Reference	Elk	ELKR15	0.00	0.00	0.00
Exposed	Elk	ELKR8	0.00	0.00	0.00
Exposed	Elk	ELKR9	0.00	0.00	0.00
Exposed	Erickson	ERIC1	1.82	0.96	2.77
Exposed	Erickson	ERIC2	1.68	0.90	2.58
Exposed	Erickson	ERIC3	2.00	1.00	3.00
Exposed	Erickson	ERIC4	0.46	0.71	1.17
Exposed	Feltham	FELT1	0.00	0.00	0.00
Exposed	Fennelon	FENN1	0.00	0.00	0.00
Exposed	Fish Pond	FPON1	0.00	0.00	0.00
Exposed	Fording	FORD1	0.00	0.00	0.00
Exposed	Fording	FORD10	0.00	0.00	0.00
Exposed	Fording	FORD11	0.00	0.00	0.00
Reference	Fording	FORD12	0.00	0.00	0.00
Exposed	Fording	FORD2	0.00	0.00	0.00
Exposed	Fording	FORD3	0.00	0.00	0.00
Exposed	Fording	FORD4	0.00	0.66	0.66
Exposed	Fording	FORD5	0.00	0.53	0.53
Exposed	Fording	FORD6	0.70	0.83	1.53
Exposed	Fording	FORD7	0.00	0.55	0.55
Exposed	Fording	FORD8	0.01	0.47	0.48
Exposed	Fording	FORD9	0.00	0.00	0.00
Exposed	Gardine	GARD1	0.06	0.27	0.32
Exposed	Gate	GATE2	0.38	0.36	0.74
Exposed	Goddard	GODD1	0.00	0.00	0.00
Exposed	Goddard	GODD2	0.00	0.00	0.00
Exposed	Goddard	GODD3	1.21	0.76	1.97
Reference	Grace	GRAC1	0.00	0.05	0.05

Type (exposed or reference)	Stream	Reach	Mean CI_p Score (0-1)	Mean CI_c Score (0-2)	CI (C_p+C_c)
Reference	Grace	GRAC2	0.00	0.10	0.10
Reference	Grace	GRAC3	0.00	0.00	0.00
Exposed	Grassy	GRAS1	0.00	0.00	0.00
Exposed	Grave	GRAV1	0.00	0.02	0.02
Exposed	Grave	GRAV2	0.00	0.00	0.00
Reference	Grave	GRAV3	0.00	0.00	0.00
Exposed	Greenhills	GREE1	0.04	0.41	0.45
Exposed	Greenhills	GREE3	1.52	0.94	2.46
Exposed	Greenhills	GREE4	1.84	0.96	2.80
Exposed	Harmer	HARM1	0.00	0.07	0.07
Exposed	Harmer	HARM3	0.00	0.01	0.01
Exposed	Harmer	HARM4	0.00	0.17	0.17
Exposed	Harmer	HARM5	0.00	0.22	0.22
Exposed	Henretta	HENR1	0.00	0.00	0.00
Exposed	Henretta	HENR2	0.00	0.00	0.00
Exposed	Henretta	HENR3	0.00	0.00	0.00
Exposed	Kilmamock	KILM1	1.28	0.69	1.97
Exposed	Lake Mountain	LMOU1	0.00	0.00	0.00
Exposed	Lake Mountain	LMOU3	0.00	0.00	0.00
Exposed	Lake Mountain	LMOU4	0.00	0.00	0.00
Exposed	Leask	LEAS2	0.00	0.24	0.24
Exposed	Lindsay	LIND1	0.02	0.17	0.19
Exposed	Line	LINE1	0.00	0.00	0.00
Exposed	Line	LINE2	0.00	0.00	0.00
Exposed	Line	LINE3	0.00	0.00	0.00
Exposed	Line	LINE4	0.14	0.54	0.68
Reference	Line	LINE7	0.00	0.00	0.00
Exposed	Michel	MICH1	0.00	0.00	0.00
Exposed	Michel	MICH2	0.00	0.00	0.00
Exposed	Michel	MICH3	0.00	0.00	0.00
Exposed	Michel	MICH4	0.00	0.00	0.00
Reference	Michel	MICH5	0.00	0.00	0.00
Exposed	Mickelson	MICK1	0.00	0.00	0.00
Exposed	Mickelson	MICK2	0.00	0.03	0.03
Exposed	Milligan	MILL1	0.00	0.00	0.00
Exposed	Milligan	MILL2	0.00	0.00	0.00
Exposed	North Thompson	NTHO1	0.57	0.61	1.18
Exposed	North Wolfram	NWOL1	0.04	0.17	0.21
Exposed	Otto	OTTO1	0.00	0.10	0.10
Exposed	Otto	OTTO2	0.00	0.00	0.00
Exposed	Otto	OTTO3	0.00	0.00	0.00
Exposed	Pengally	PENG1	0.00	0.02	0.02
Exposed	Porter	PORT1	0.23	0.62	0.85
Exposed	Porter	PORT3	1.16	0.78	1.94
Exposed	Qualteri	QUAL1	0.00	0.00	0.00
Exposed	Sawmill	SAWM1	0.00	0.00	0.00
Exposed	Sawmill	SAWM2	0.32	0.31	0.62
Exposed	Six Mile	SIXM1	0.00	0.49	0.49
Exposed	Smith Pond Outlet	SPOU1	1.39	0.85	2.24
Proposed	Snowslide	SNOW1	0.00	0.00	0.00
Reference	South Line	SLINE2	0.00	0.00	0.00
Exposed	South Pit	SPIT1	0.68	0.47	1.14
Exposed	South Pit	SPIT2	0.00	0.00	0.00
Exposed	South Pond Seep	SPSE1	0.02	0.08	0.10
Exposed	South Wolfram Creek	SWOL1	0.07	0.21	0.28
Exposed	Spring	SPRI1	0.00	0.11	0.11

Type (exposed or reference)	**Stream**	**Reach**	**Mean *CI* $_p$ Score (0-1)**	**Mean *CI* $_c$ Score (0-2)**	***CI* (C_p+C_c)**
Exposed	Swift	SWIF1	1.53	0.86	2.39
Exposed	Swift	SWIF2	0.51	0.31	0.82
Exposed	Thompson	THOM1	0.00	0.00	0.00
Exposed	Thompson	THOM2	0.00	0.01	0.01
Exposed	Thompson	THOM3	0.00	0.00	0.00
Exposed	Thresher	THRE1	0.00	0.00	0.00
Exposed	Unnamed South of Sawmill	USOS1	0.00	0.00	0.00
Proposed	Wheeler	WHEE1	0.00	0.00	0.00
Proposed	Wheeler	WHEE2	0.00	0.00	0.00
Proposed	Wheeler	WHEE3	0.00	0.00	0.00
Exposed	Wolfram	WOLF2	0.02	0.21	0.23
Exposed	Wolfram	WOLF3	0.73	0.87	1.60

Appendix 4. Calcite distribution maps



2015 Calcite Monitoring Program

Elk Valley - Map # 1

▬ Reach Break

〰 Reference Stream

〰 Proposed Stream

〰 Exposed Stream

— Road - Regional

┼┼ Railway

▨ Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)

1.50 → Current calcite index (with increasing trend)

1.50 → Current calcite index (with decreasing trend)

1.50 → Current calcite index (with no trend analysis)

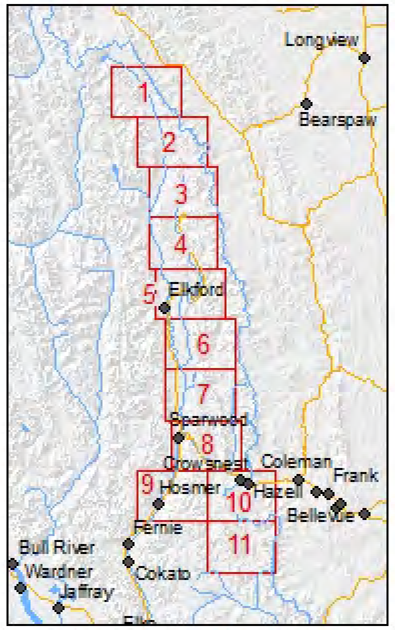
0 1 2

Kilometers

1:50,000

UTM Zone 11 NAD83

Elk Valley Index Map

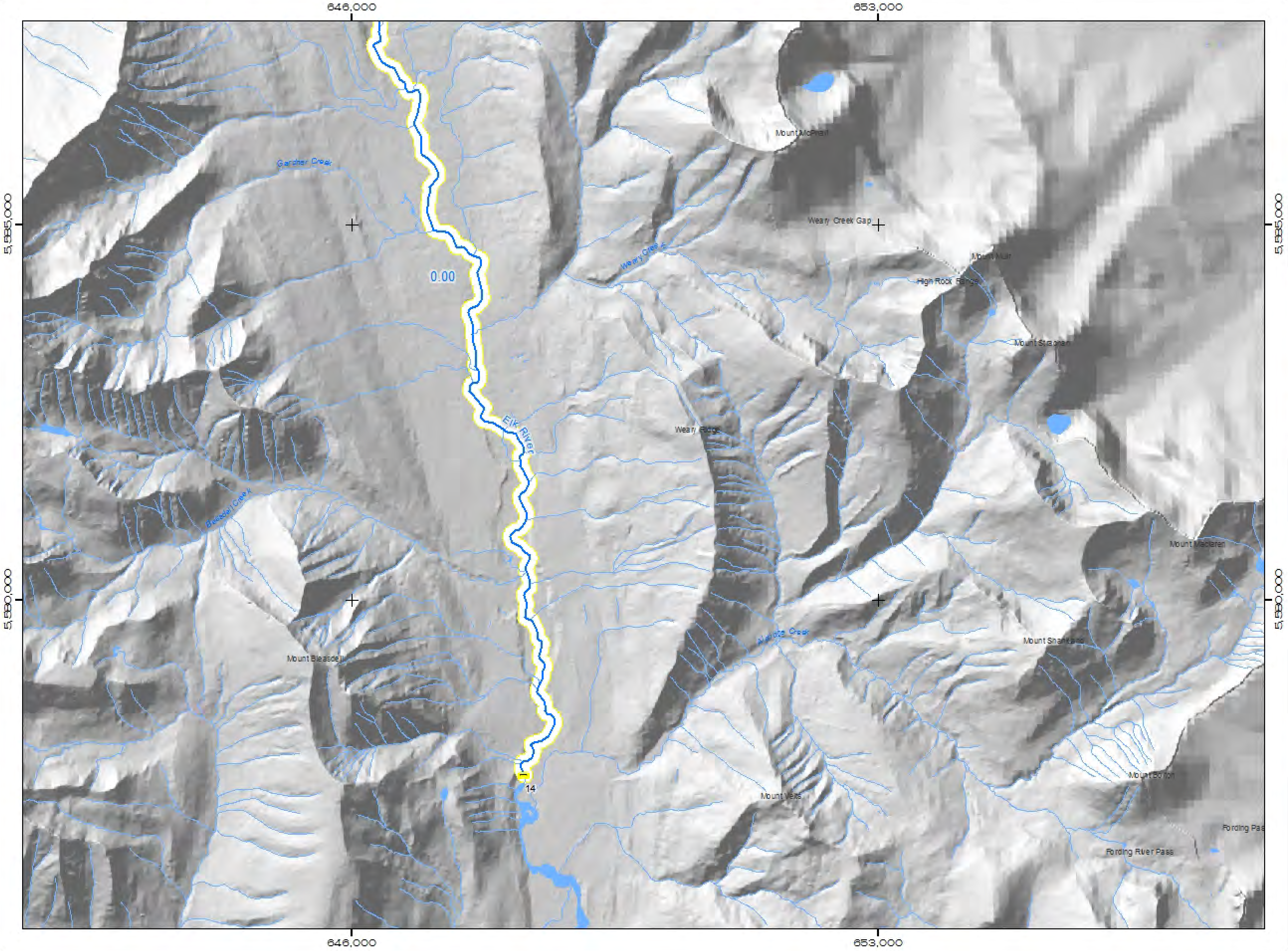


Client: Teck

Mapping by: Lotic Environmental

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

Date Last Revised: Feb 15, 2016



2015 CALCITE MONITORING PROGRAM

ELK VALLEY - MAP #2

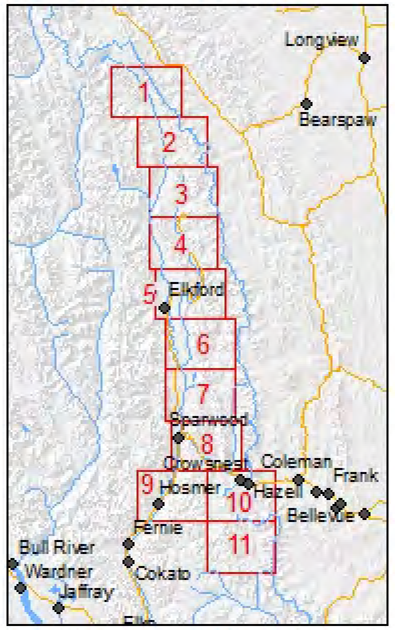
- REACH BREAK
- REFERENCE STREAM
- PROPOSED STREAM
- EXPOSED STREAM
- ROAD - REGIONAL
- RAILWAY
- TECK COAL OPERATIONS

LABEL EXAMPLES:

1.50	CURRENT CALCITE INDEX (WITH NEUTRAL TREND)
1.50	CURRENT CALCITE INDEX (WITH INCREASING TREND)
1.50	CURRENT CALCITE INDEX (WITH DECREASING TREND)
1.50	CURRENT CALCITE INDEX (WITH NO TREND ANALYSIS)

0 1 2
KILOMETERS
1:50,000
UTM ZONE 11 NAD83

ELK VALLEY INDEX MAP

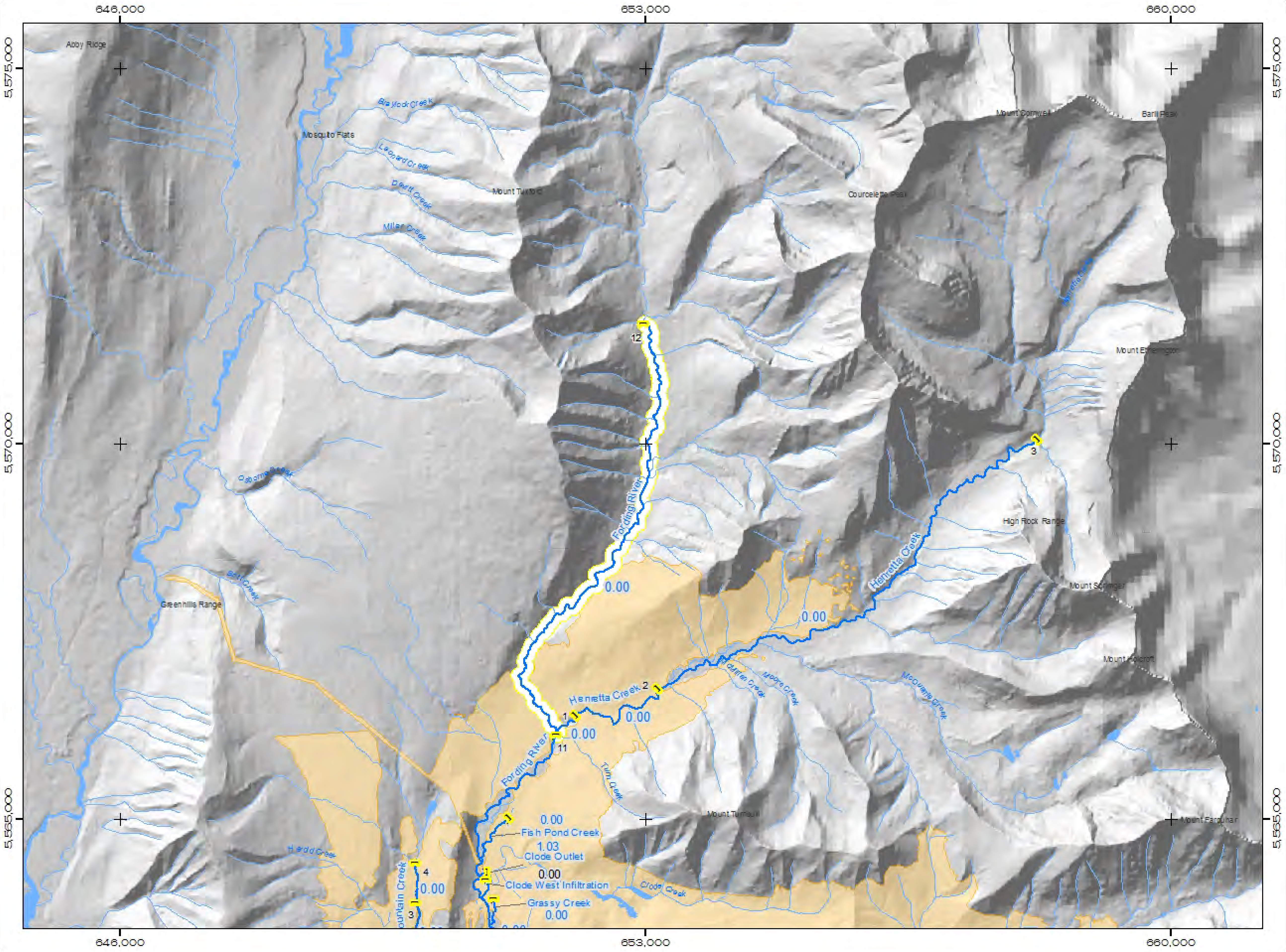


CLIENT: Teck

MAPPING BY: LOTIC ENVIRONMENTAL

DATA SOURCES:
- STREAM / RIVER - TECK WATER NETWORK
- ROAD / RAIL - TECK TRANSPORTATION
- HILLSHADE - GEOBASE

DATE LAST REVISED: FEB 15, 2016



2015 CALCITE MONITORING PROGRAM

ELK VALLEY - MAP #3

REACH BREAK

REFERENCE STREAM

PROPOSED STREAM

EXPOSED STREAM

ROAD - REGIONAL

RAILWAY

TECK COAL OPERATIONS

LABEL EXAMPLES:

1.50 → CURRENT CALCITE INDEX (WITH NEUTRAL TREND)

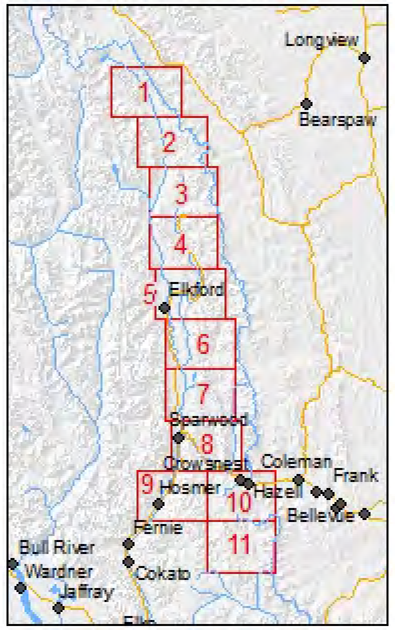
1.50 → CURRENT CALCITE INDEX (WITH INCREASING TREND)

1.50 → CURRENT CALCITE INDEX (WITH DECREASING TREND)

1.50 → CURRENT CALCITE INDEX (WITH NO TREND ANALYSIS)

0 1 2
KILOMETERS
1:50,000
UTM ZONE 11 NAD83

ELK VALLEY INDEX MAP

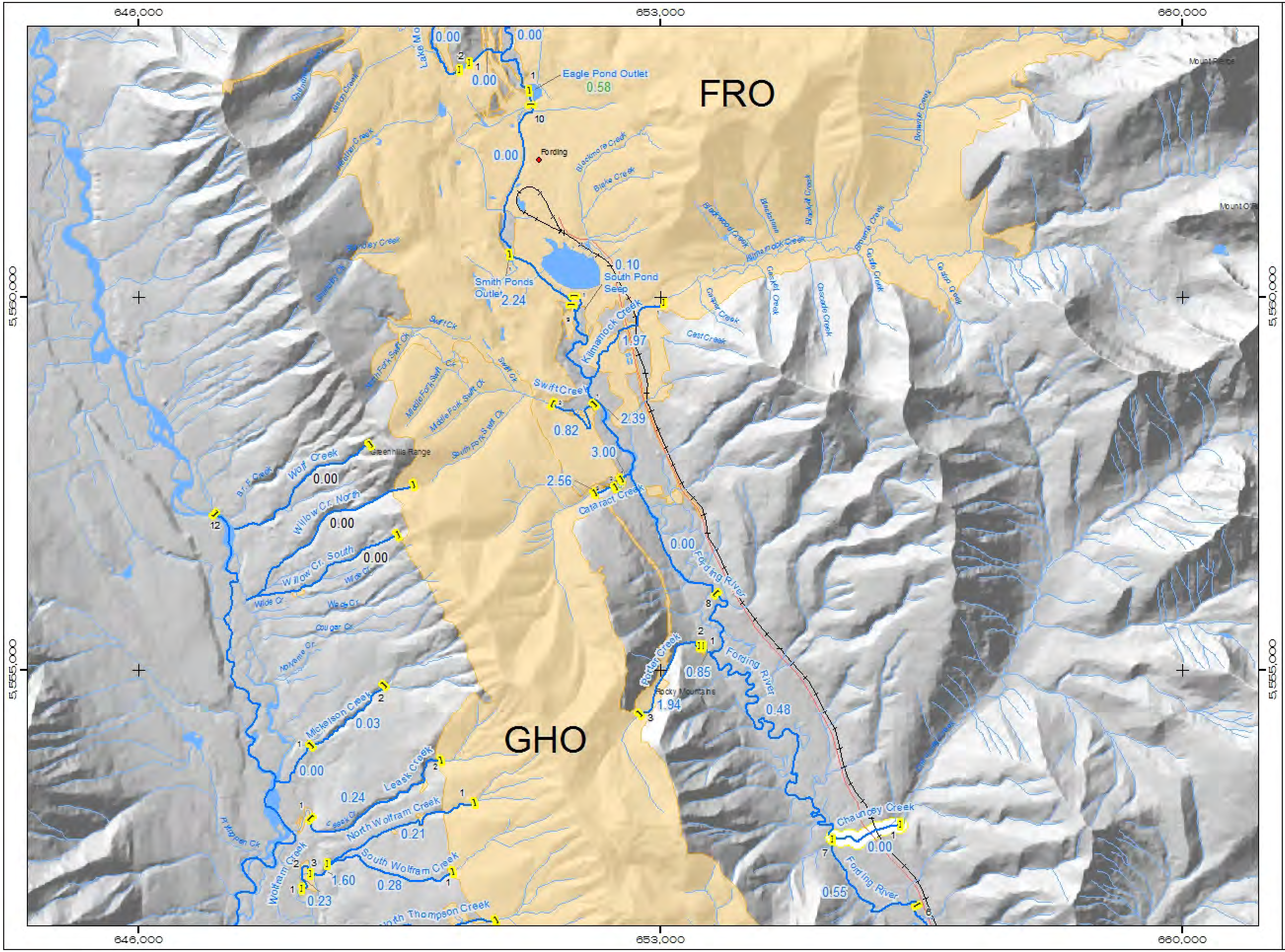


CLIENT: Teck

MAPPING BY: LOTIC ENVIRONMENTAL

DATA SOURCES:
- STREAM / RIVER - TECK WATER NETWORK
- ROAD / RAIL - TECK TRANSPORTATION
- HILLSHADE - GEOBASE

DATE LAST REVISED: FEB 15, 2016



2015 Calcite Monitoring Program

Elk Valley - Map #4

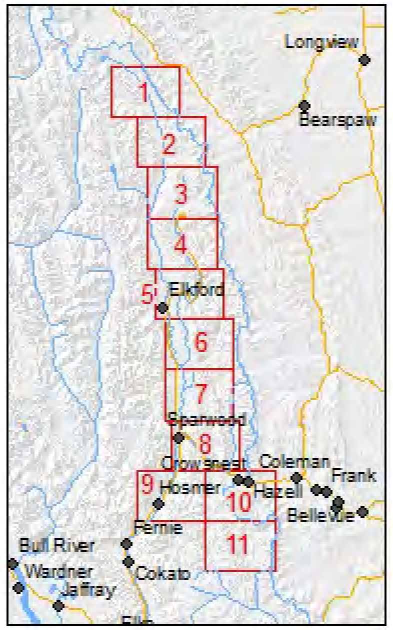
▬	Reach Break
〰	Reference Stream
〰	Proposed Stream
〰	Exposed Stream
—	Road - Regional
┼	Railway
▨	Teck Coal Operations

Label Examples:

1.50	Current calcite index (with neutral trend)
1.50	Current calcite index (with increasing trend)
1.50	Current calcite index (with decreasing trend)
1.50	Current calcite index (with no trend analysis)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

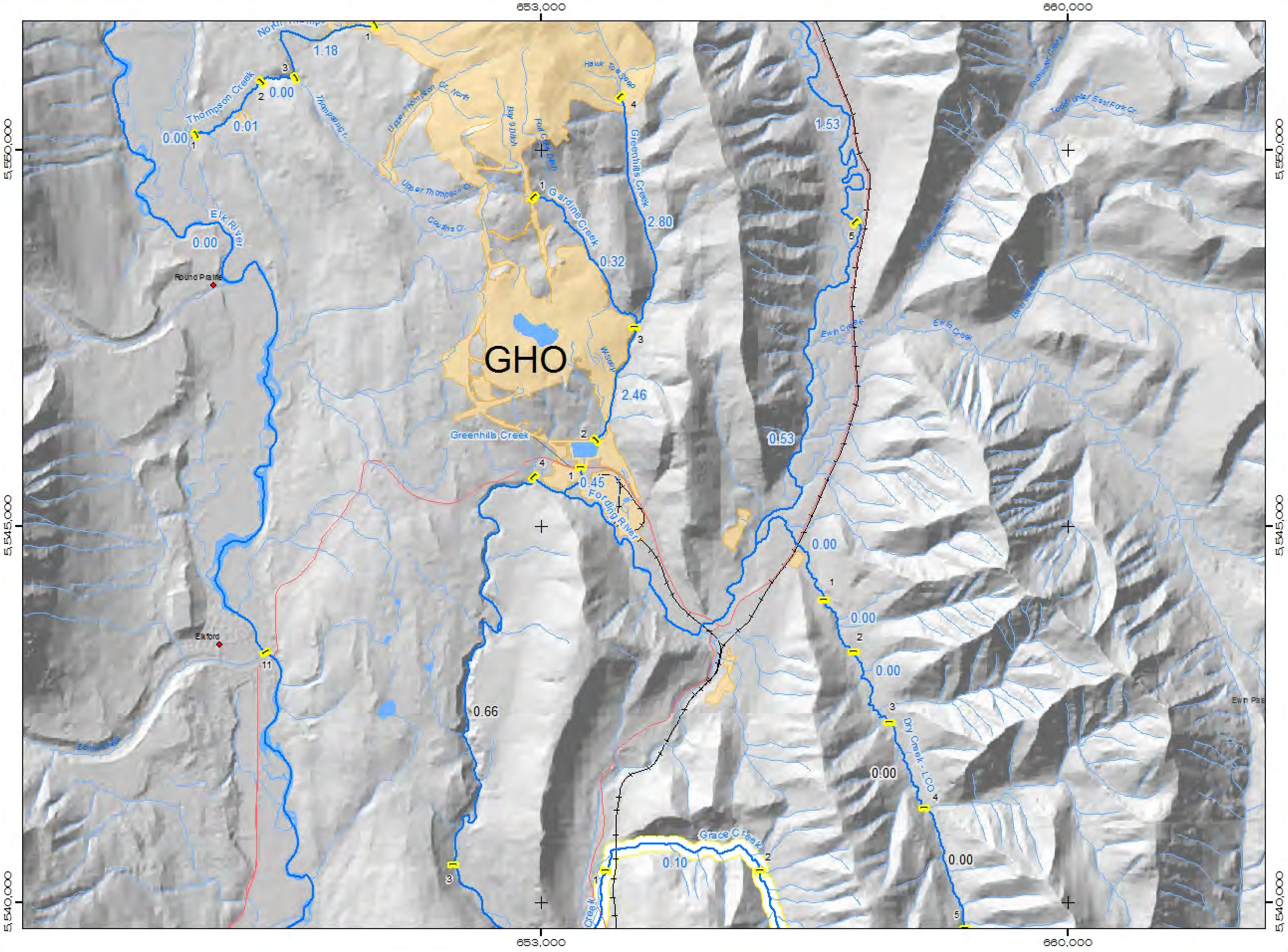


Client: Teck

Mapping by: Lotic Environmental

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

Date Last Revised: Feb 15, 2016



2015 CALCITE MONITORING PROGRAM

ELK VALLEY - MAP #5

▬ REACH BREAK

〰 REFERENCE STREAM

〰 PROPOSED STREAM

〰 EXPOSED STREAM

— ROAD - REGIONAL

┼─┼ RAILWAY

TECK COAL OPERATIONS

LABEL EXAMPLES:

1.50 → CURRENT CALCITE INDEX (WITH NEUTRAL TREND)

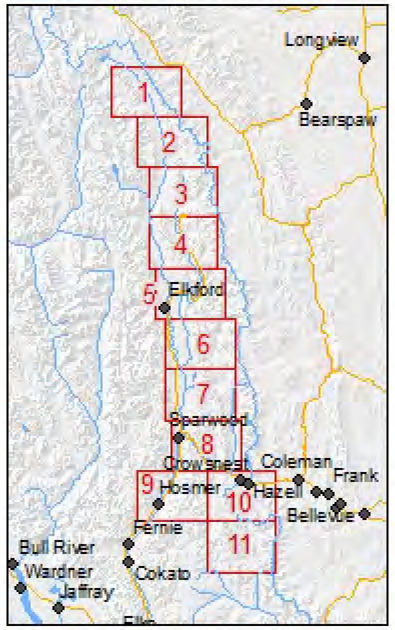
1.50 → CURRENT CALCITE INDEX (WITH INCREASING TREND)

1.50 → CURRENT CALCITE INDEX (WITH DECREASING TREND)

1.50 → CURRENT CALCITE INDEX (WITH NO TREND ANALYSIS)

0 1 2
KILOMETERS
1:50,000
UTM ZONE 11 NAD83

ELK VALLEY INDEX MAP

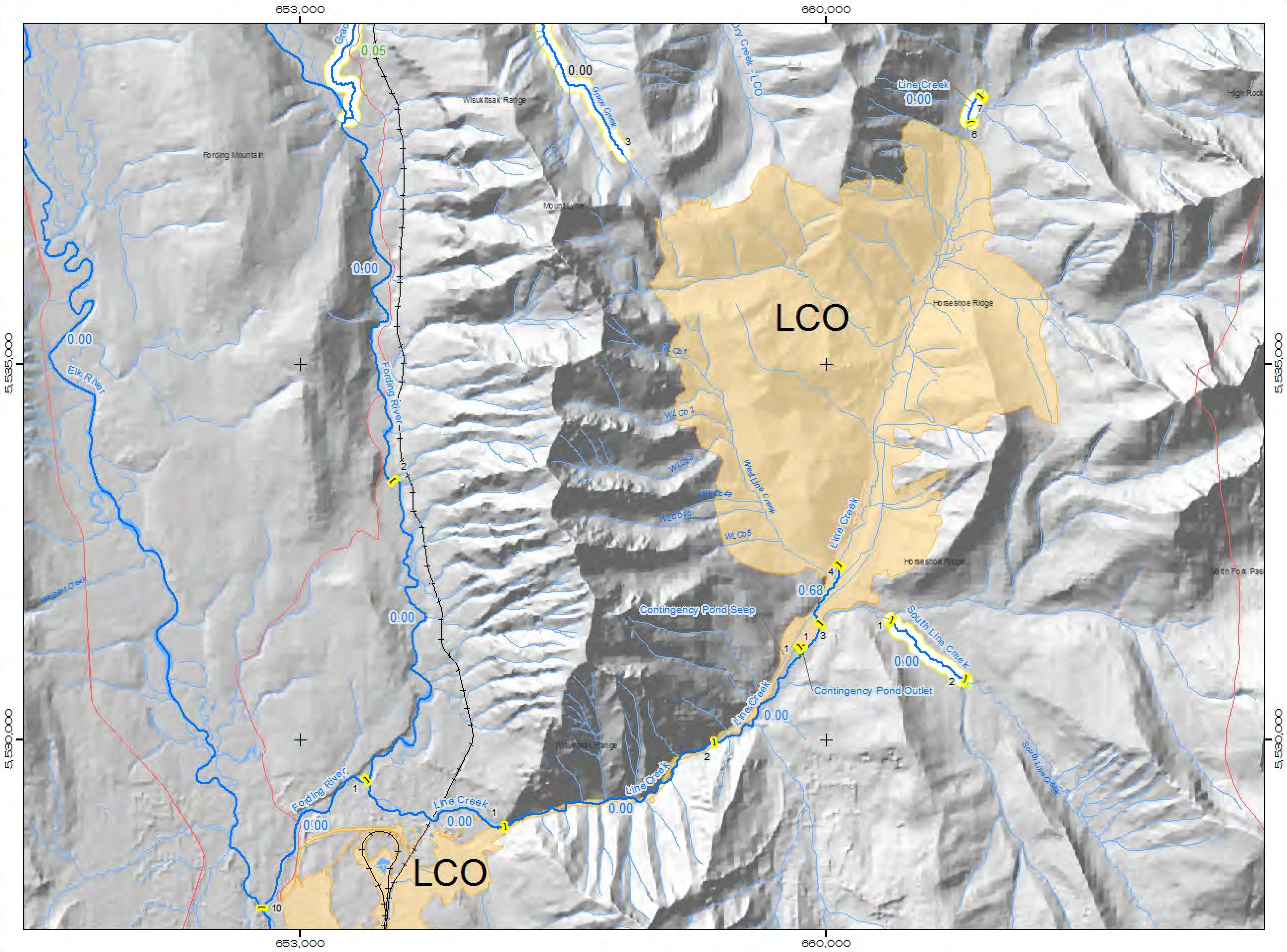


CLIENT:
Teck

MAPPING BY:
LOTIC ENVIRONMENTAL

DATA SOURCES:
- STREAM / RIVER - TECK WATER NETWORK
- ROAD / RAIL - TECK TRANSPORTATION
- HILLSHADE - GEOBASE

DATE LAST REVISED: FEB 15, 2016



2015 Calcite Monitoring Program

Elk Valley - Map #6

- ▬ Reach Break
- 🟨 Reference Stream
- 🟩 Proposed Stream
- Exposed Stream
- Road - Regional
- Railway
- Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)

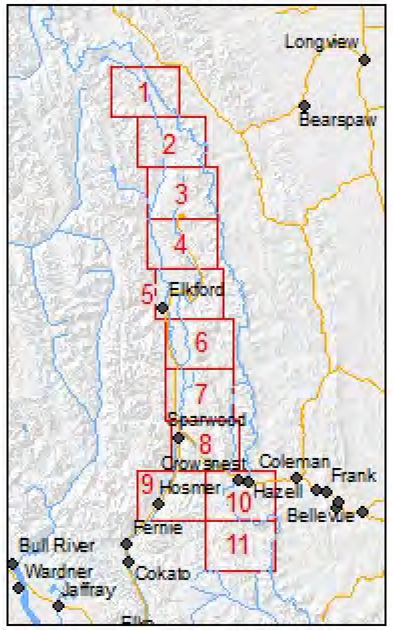
1.50 → Current calcite index (with increasing trend)

1.50 → Current calcite index (with decreasing trend)

1.50 → Current calcite index (with no trend analysis)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

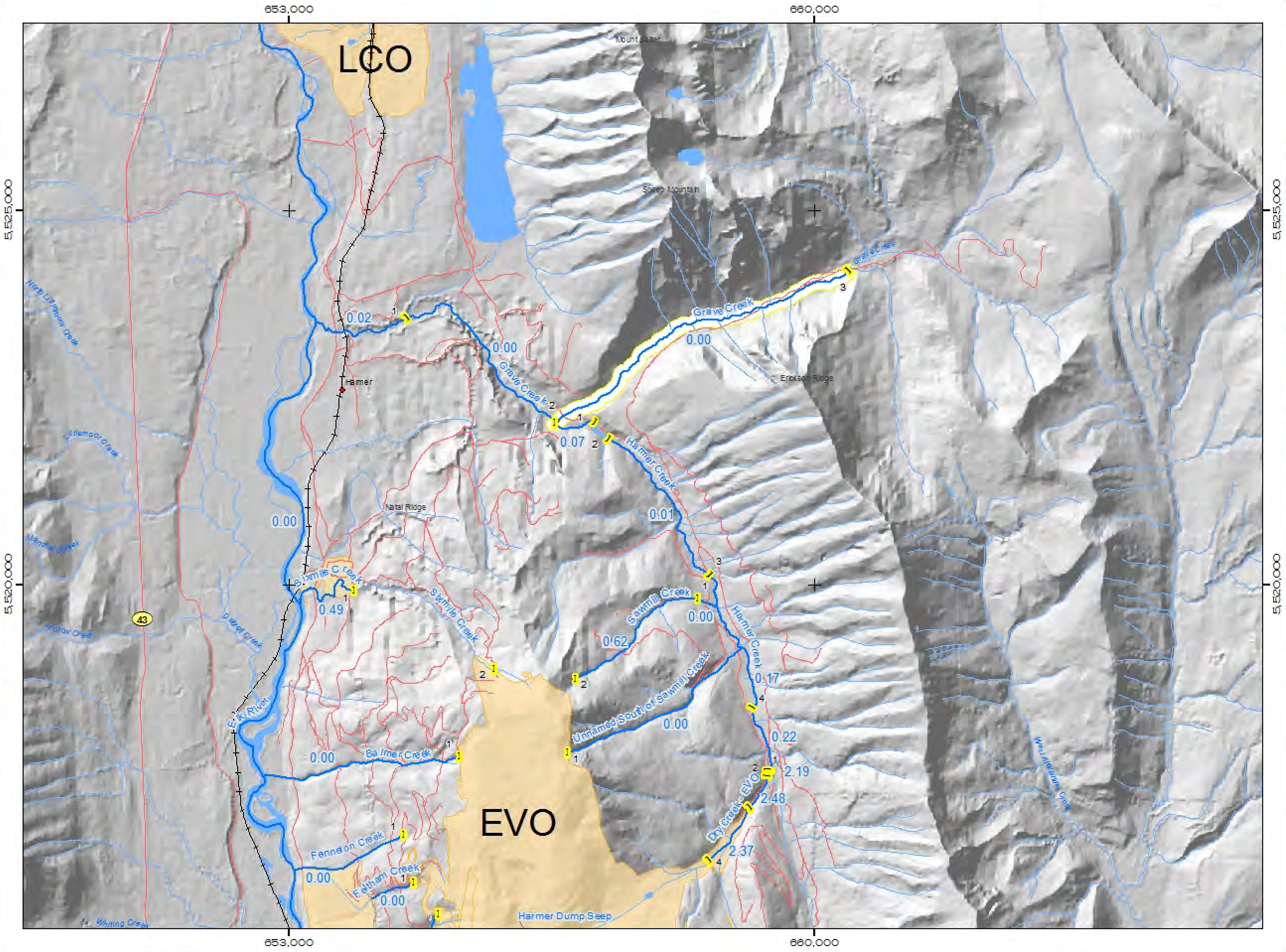


Client: Teck

Mapping by: Lotic Environmental

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

Date Last Revised: Feb 15, 2016



2015 Calcite Monitoring Program

Elk Valley - Map #7

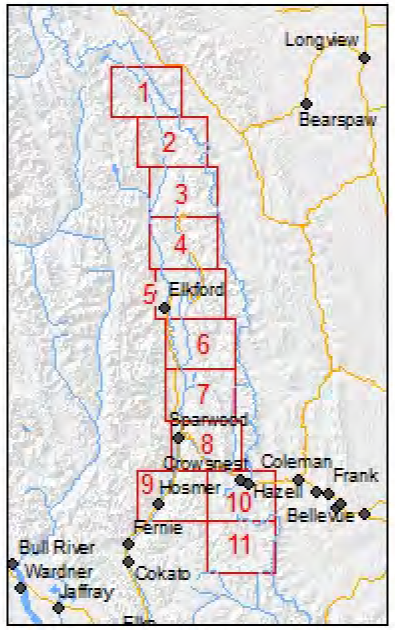
▬	Reach Break
〰	Reference Stream
〰	Proposed Stream
〰	Exposed Stream
―	Road - Regional
┼┼	Railway
▨	Teck Coal Operations

Label Examples:

1.50	Current calcite index (with neutral trend)
1.50	Current calcite index (with increasing trend)
1.50	Current calcite index (with decreasing trend)
1.50	Current calcite index (with no trend analysis)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

Elk Valley Index Map

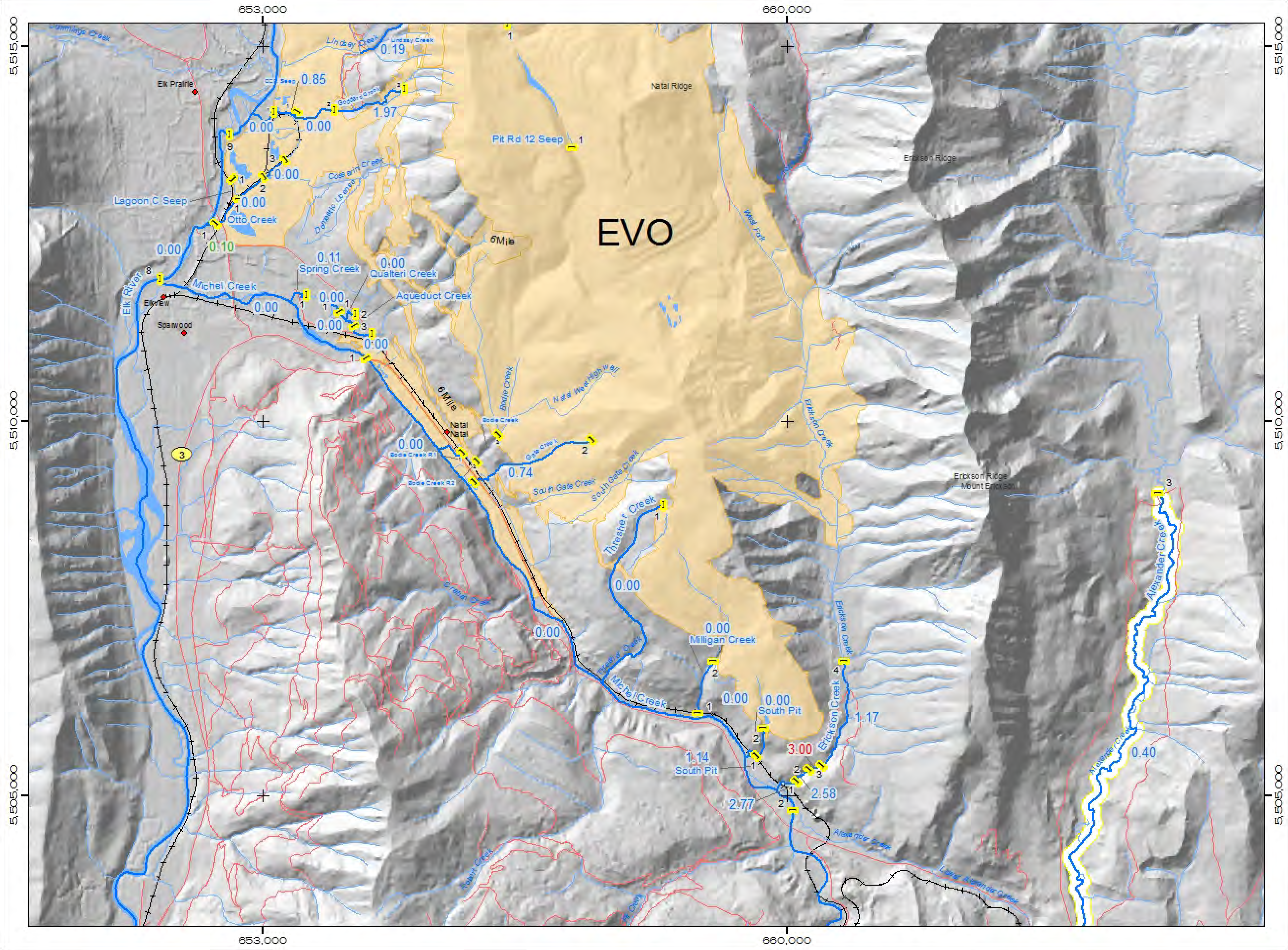


Client: Teck

Mapping by: Lotic Environmental

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

Date Last Revised: Feb 15, 2016



2015 CALCITE MONITORING PROGRAM

ELK VALLEY - MAP #8

▬ REACH BREAK

〜 REFERENCE STREAM

〜 PROPOSED STREAM

〜 EXPOSED STREAM

— ROAD - REGIONAL

┼─┼ RAILWAY

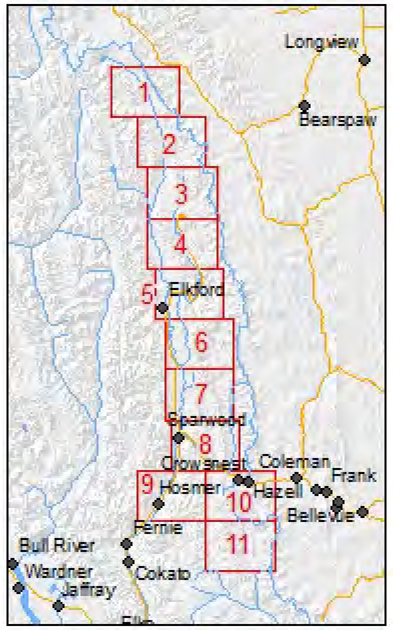
▨ TECK COAL OPERATIONS

LABEL EXAMPLES:

1.50 →	CURRENT CALCITE INDEX (WITH NEUTRAL TREND)
1.50 →	CURRENT CALCITE INDEX (WITH INCREASING TREND)
1.50 →	CURRENT CALCITE INDEX (WITH DECREASING TREND)
1.50 →	CURRENT CALCITE INDEX (WITH NO TREND ANALYSIS)

0 1 2
KILOMETERS
1:50,000
UTM ZONE 11 NAD83

ELK VALLEY INDEX MAP

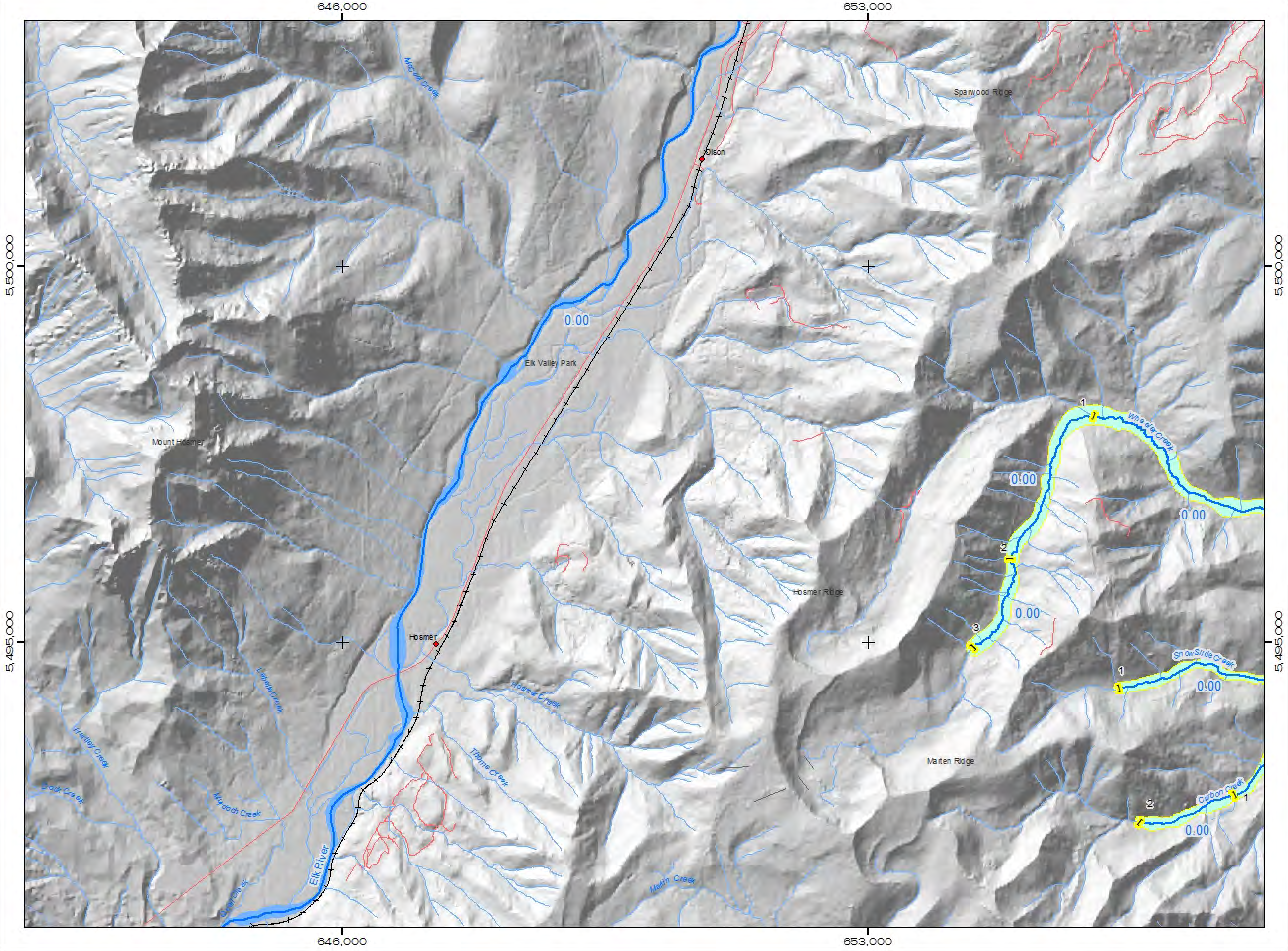


CLIENT: Teck

MAPPING BY: LOTIC ENVIRONMENTAL

DATA SOURCES:
- STREAM / RIVER - TECK WATER NETWORK
- ROAD / RAIL - TECK TRANSPORTATION
- HILLSHADE - GEOBASE

DATE LAST REVISED: FEB 15, 2016



2015 CALCITE MONITORING PROGRAM

ELK VALLEY - MAP #9

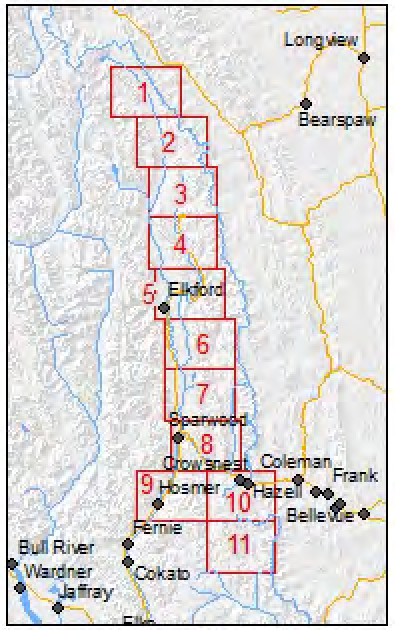
▬	REACH BREAK
〰	REFERENCE STREAM
〰	PROPOSED STREAM
〰	EXPOSED STREAM
―	ROAD - REGIONAL
+―+	RAILWAY
▨	TECK COAL OPERATIONS

LABEL EXAMPLES:

1.50	CURRENT CALCITE INDEX (WITH NEUTRAL TREND)
1.50	CURRENT CALCITE INDEX (WITH INCREASING TREND)
1.50	CURRENT CALCITE INDEX (WITH DECREASING TREND)
1.50	CURRENT CALCITE INDEX (WITH NO TREND ANALYSIS)

0 1 2
KILOMETERS
1:50,000
UTM ZONE 11 NAD83

ELK VALLEY INDEX MAP

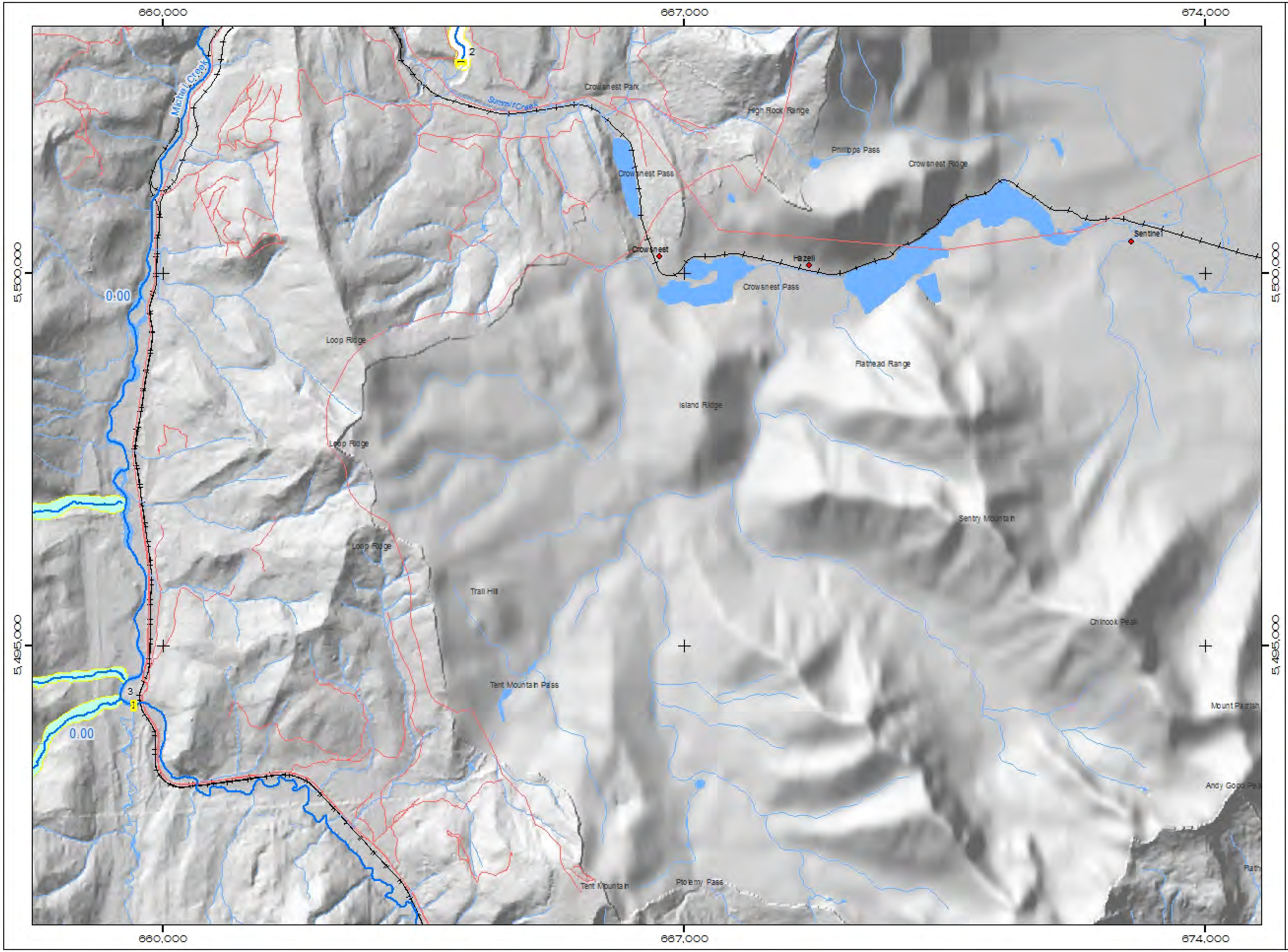


CLIENT: Teck

MAPPING BY: LOTIC ENVIRONMENTAL

DATA SOURCES:
- STREAM / RIVER - TECK WATER NETWORK
- ROAD / RAIL - TECK TRANSPORTATION
- HILLSHADE - GEOBASE

DATE LAST REVISED: FEB 15, 2016



2015 CALCITE MONITORING PROGRAM

ELK VALLEY - MAP #10

REACH BREAK

REFERENCE STREAM

PROPOSED STREAM

EXPOSED STREAM

ROAD - REGIONAL

RAILWAY

TECK COAL OPERATIONS

LABEL EXAMPLES:

1.50 → CURRENT CALCITE INDEX (WITH NEUTRAL TREND)

1.50 → CURRENT CALCITE INDEX (WITH INCREASING TREND)

1.50 → CURRENT CALCITE INDEX (WITH DECREASING TREND)

1.50 → CURRENT CALCITE INDEX (WITH NO TREND ANALYSIS)

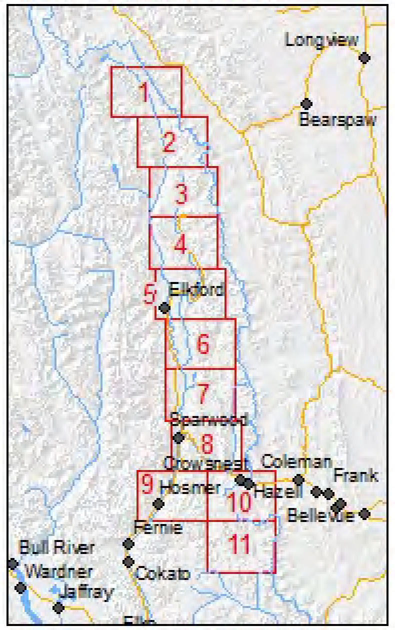
0 1 2

KILOMETERS

1:50,000

UTM ZONE 11 NAD83

ELK VALLEY INDEX MAP

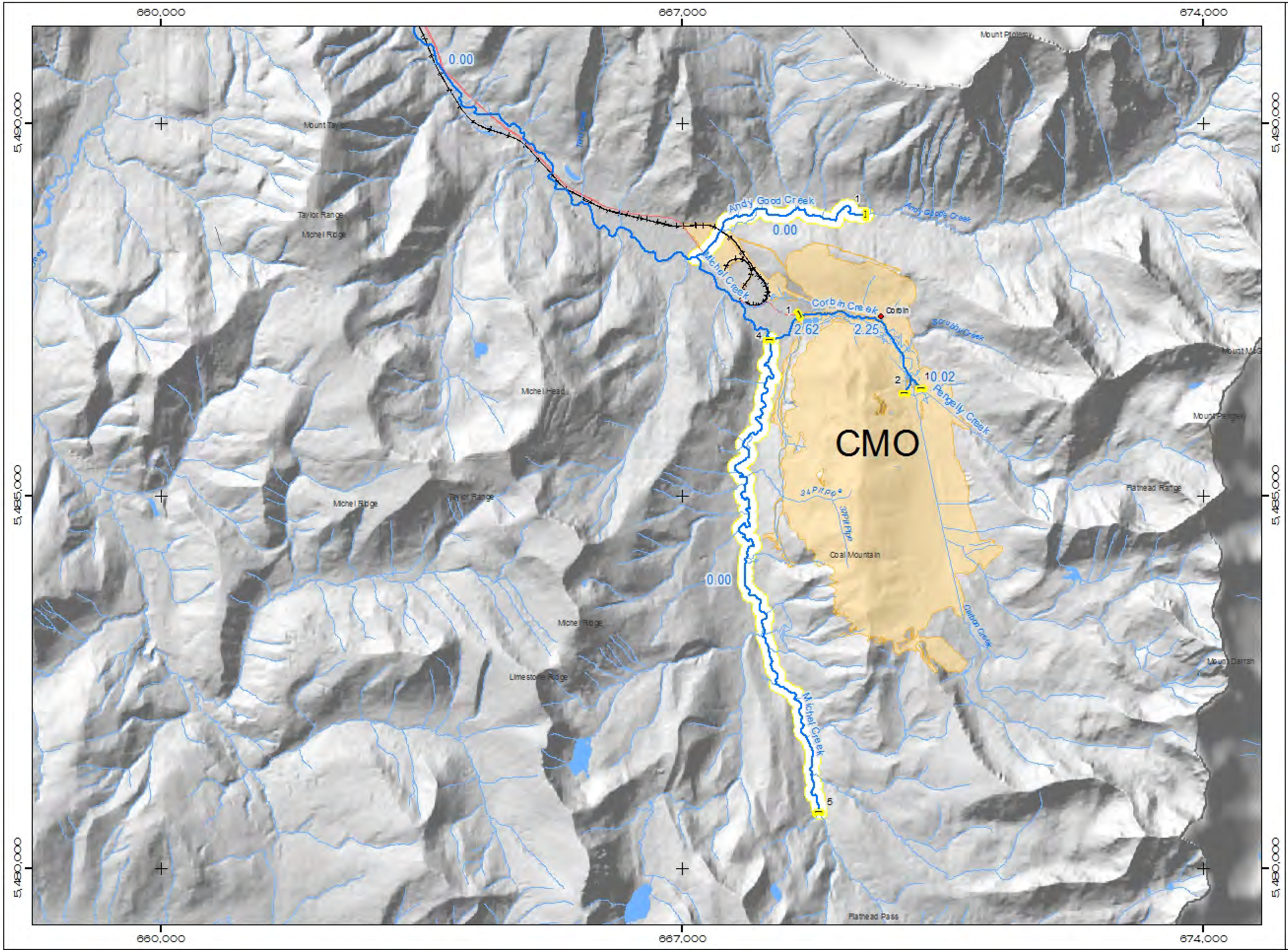


CLIENT: Teck

MAPPING BY: LOTIC ENVIRONMENTAL

DATA SOURCES:
- STREAM / RIVER - TECK WATER NETWORK
- ROAD / RAIL - TECK TRANSPORTATION
- HILLSHADE - GEOBASE

DATE LAST REVISED: FEB 15, 2016



2015 Calcite Monitoring Program

Elk Valley - Map #11

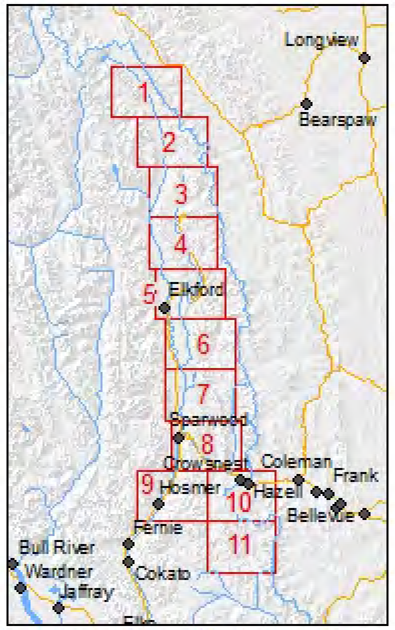
▬ Reach Break
〰 Reference Stream
〰 Proposed Stream
〰 Exposed Stream
— Road - Regional
┼ Railway
▨ Teck Coal Operations

Label Examples:

1.50 → Current calcite index (with neutral trend)
1.50 → Current calcite index (with increasing trend)
1.50 → Current calcite index (with decreasing trend)
1.50 → Current calcite index (with no trend analysis)

0 1 2
Kilometers
1:50,000
UTM Zone 11 NAD83

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: Feb 15, 2016

Appendix 5. Regression analysis results for reaches sampled in each of Year 1, 2, and 3 (2015).

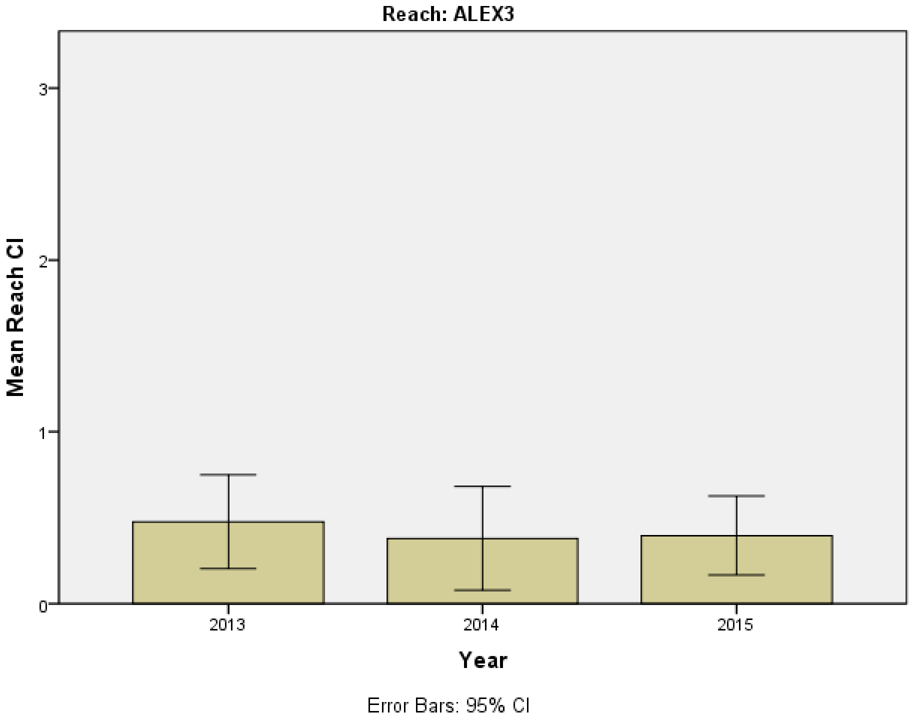
Reach	p-value	Slope (CI/year)	Change
ALEX3	0.45	-0.04	Neutral
CATA3	0.21	-0.23	Neutral
CORB1	0.50	0.34	Neutral
CORB2	0.28	-0.24	Neutral
COUT1	0.32	0.52	Neutral
CSEE1	0.33	0.42	Neutral
DRYE1	0.21	-0.24	Neutral
DRYE3	1.00	0.00	Neutral
DRYE4	0.40	0.19	Neutral
ELKR8	0.33	-0.20	Neutral
EPOU1	**0.04**	**-0.66**	**Decrease**
ERIC1	0.48	0.12	Neutral
ERIC2	0.34	0.24	Neutral
ERIC3	**0.09**	**0.32**	**Increase**
ERIC4	0.45	0.27	Neutral
FORD3	1.00	0.00	Neutral
FORD5	0.25	0.11	Neutral
FORD6	0.51	0.40	Neutral
FORD7	0.86	0.06	Neutral
FORD8	0.33	0.09	Neutral
FPON1	1.00	0.00	Neutral
GARD1	0.96	0.02	Neutral
GATE2	0.46	0.30	Neutral
GODD3	0.31	0.09	Neutral
GRAC1	**0.06**	**-0.13**	**Decrease**
GRAC2	0.33	-0.03	Neutral
GRAS1	1.00	0.00	Neutral
GRAV1	0.49	-0.26	Neutral
GRAV2	0.28	-0.12	Neutral
GREE1	0.93	0.05	Neutral
GREE3	0.21	0.58	Neutral
GREE4	0.32	0.59	Neutral
HARM1	0.66	-0.26	Neutral
HARM3	0.65	-0.07	Neutral
HARM4	1.00	0.00	Neutral
HARM5	0.95	0.02	Neutral
KILM1	0.76	0.15	Neutral
LEAS2	0.96	0.06	Neutral
LIND1	1.00	0.00	Neutral
LINE1	0.33	-0.14	Neutral
LINE4	0.53	0.14	Neutral
LMOU1	1.00	0.00	Neutral
MICH1	0.33	-0.16	Neutral
MICH2	0.33	-0.03	Neutral

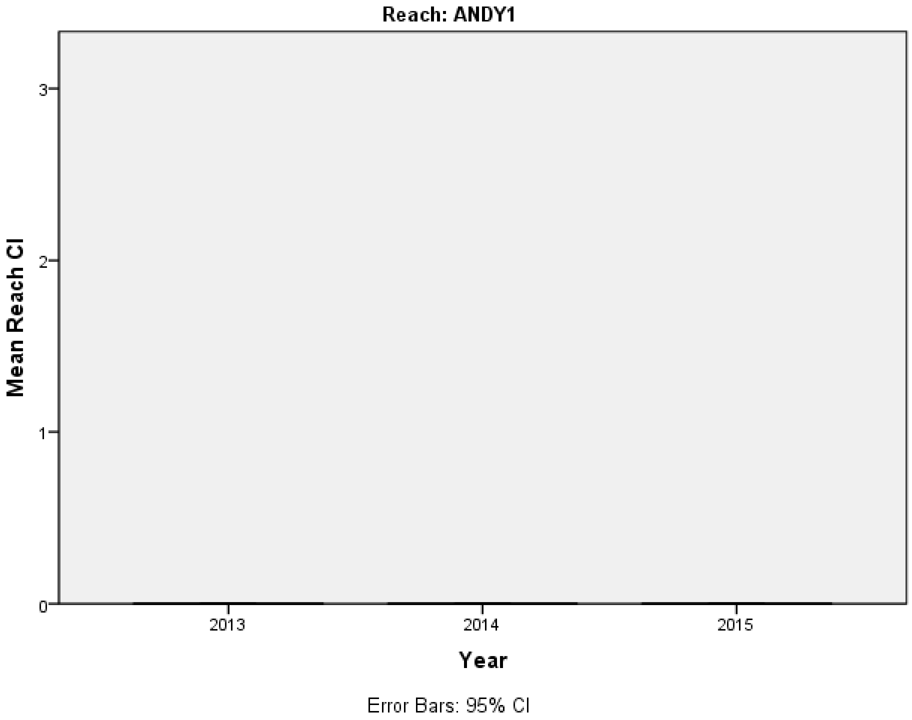
Reach	p-value	Slope (CI/year)	Change
MICK1	0.33	-0.01	Neutral
MICK2	0.74	-0.01	Neutral
NTHO1	0.97	0.04	Neutral
NWOL1	0.71	-0.25	Neutral
OTTO1	**0.07**	**-0.10**	**Decrease**
OTTO2	0.33	-0.02	Neutral
OTTO3	0.33	-0.01	Neutral
PENG1	0.33	-0.04	Neutral
PORT1	0.41	-0.04	Neutral
PORT3	0.30	-0.45	Neutral
SAWM2	0.33	0.08	Neutral
SIXM1	0.71	-0.16	Neutral
SPIT1	0.33	0.57	Neutral
SPIT2	0.33	-0.02	Neutral
SPOU1	0.33	-0.19	Neutral
SPRI1	0.33	-0.05	Neutral
SPSE1	0.96	0.05	Neutral
SWIF1	0.69	-0.10	Neutral
SWIF2	0.47	0.41	Neutral
SWOL1	0.33	-0.85	Neutral
THOM2	0.41	-0.04	Neutral
WOLF2	0.81	-0.02	Neutral
WOLF3	0.11	-0.67	Neutral
ANDY1	n/a*	0**	Neutral
AQUE1	n/a*	0**	Neutral
AQUE2	n/a*	0**	Neutral
AQUE3	n/a*	0**	Neutral
BALM1	n/a*	0**	Neutral
BODI1	n/a*	0**	Neutral
CARB1	n/a*	0**	Neutral
CARB2	n/a*	0**	Neutral
CATA1	n/a*	0**	Neutral
CHAU1	n/a*	0**	Neutral
DRYL1	n/a*	0**	Neutral
DRYL2	n/a*	0**	Neutral
DRYL3	n/a*	0**	Neutral
ELKR1	n/a*	0**	Neutral
ELKR1	n/a*	0**	Neutral
ELKR1	n/a*	0**	Neutral
ELKR1	n/a*	0**	Neutral
ELKR9	n/a*	0**	Neutral
FELT1	n/a*	0**	Neutral
FENN1	n/a*	0**	Neutral
FORD1	n/a*	0**	Neutral
FORD1	n/a*	0**	Neutral
FORD1	n/a*	0**	Neutral
FORD1	n/a*	0**	Neutral
FORD2	n/a*	0**	Neutral

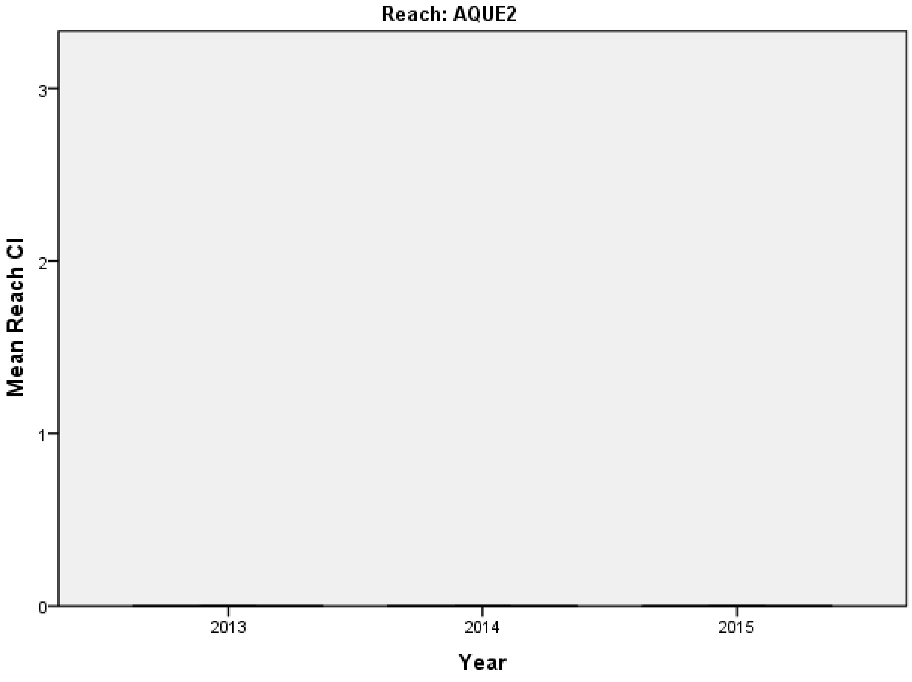
Reach	p-value	Slope (CI/year)	Change
FORD9	n/a*	0**	Neutral
GODD1	n/a*	0**	Neutral
GODD2	n/a*	0**	Neutral
GRAV3	n/a*	0**	Neutral
HENR1	n/a*	0**	Neutral
HENR2	n/a*	0**	Neutral
HENR3	n/a*	0**	Neutral
LINE2	n/a*	0**	Neutral
LINE3	n/a*	0**	Neutral
LINE7	n/a*	0**	Neutral
LMOU3	n/a*	0**	Neutral
LMOU4	n/a*	0**	Neutral
MICH3	n/a*	0**	Neutral
MICH4	n/a*	0**	Neutral
MICH5	n/a*	0**	Neutral
MILL1	n/a*	0**	Neutral
MILL2	n/a*	0**	Neutral
QUAL1	n/a*	0**	Neutral
SAWM1	n/a*	0**	Neutral
SNOW1	n/a*	0**	Neutral
THOM1	n/a*	0**	Neutral
THOM3	n/a*	0**	Neutral
THRE1	n/a*	0**	Neutral
USOS1	n/a*	0**	Neutral
WHEE1	n/a*	0**	Neutral
WHEE2	n/a*	0**	Neutral
WHEE3	n/a*	0**	Neutral

Appendix 6. Bar graphs (with 95% confidence intervals) of reach mean *CI* from 2013 – 2015.

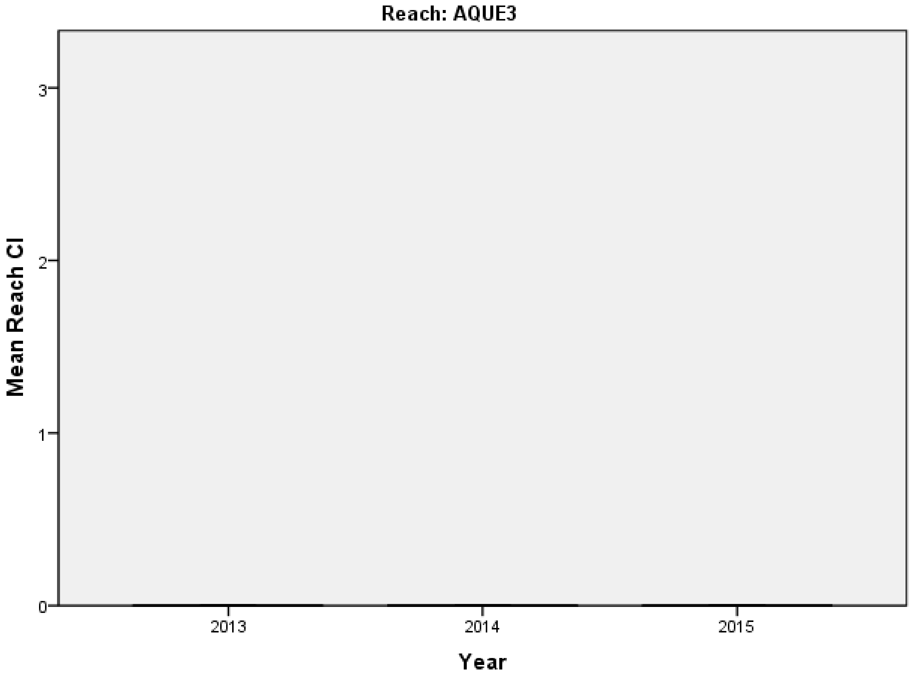
Note: Figures showing mean CI values by year for each reach. Letters above (or within) the bars were used to show the results of the Tukey's *post hoc* tests. Year-year pairs within each figure that were found to be significantly different (at an alpha level of 0.05) are denoted by the same letter. GRAS1 was the only reach where the overall ANOVA found significant differences (p=.045) between years, but the *post hoc* pairwise comparisons for both 2013-2014 and 2013-2015 had p-values slightly above 0.05 (p=.065 to be exact) due to the adjustment of p-values for multiple comparisons.


Reach: ALEX3
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI


Reach: ANDY1
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

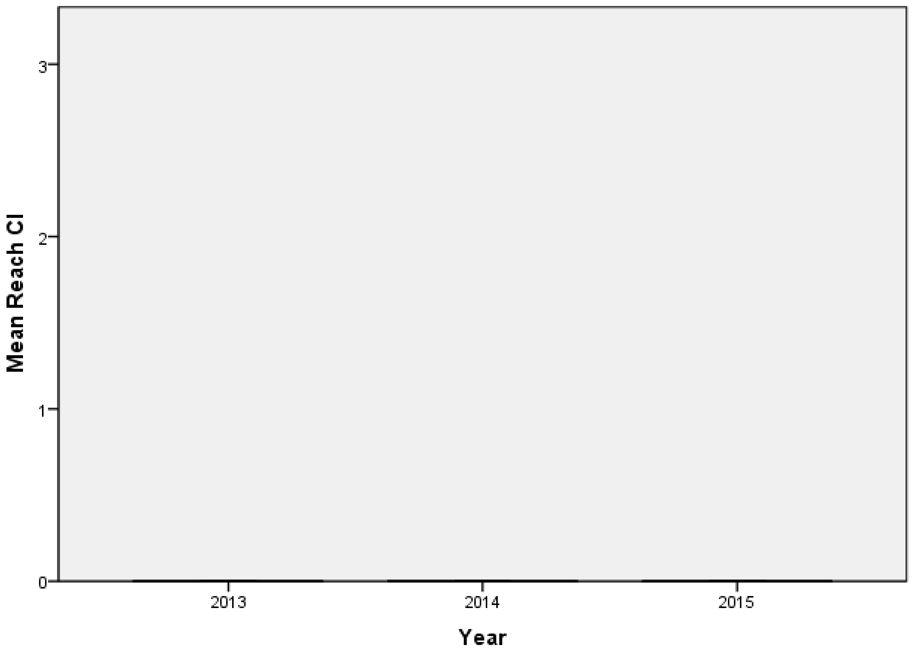


Error Bars: 95% CI



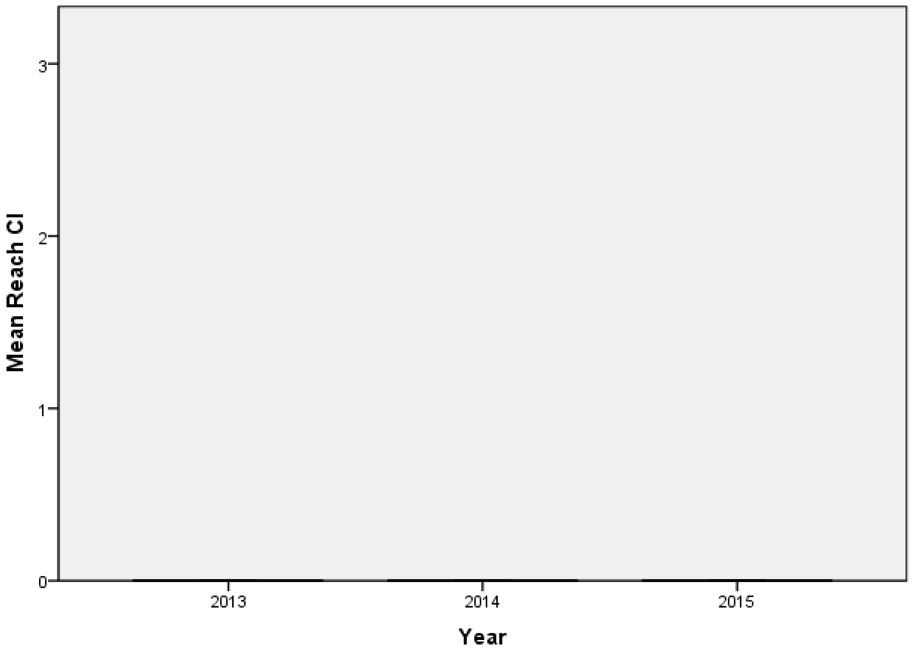
Error Bars: 95% CI

Reach: BODI1

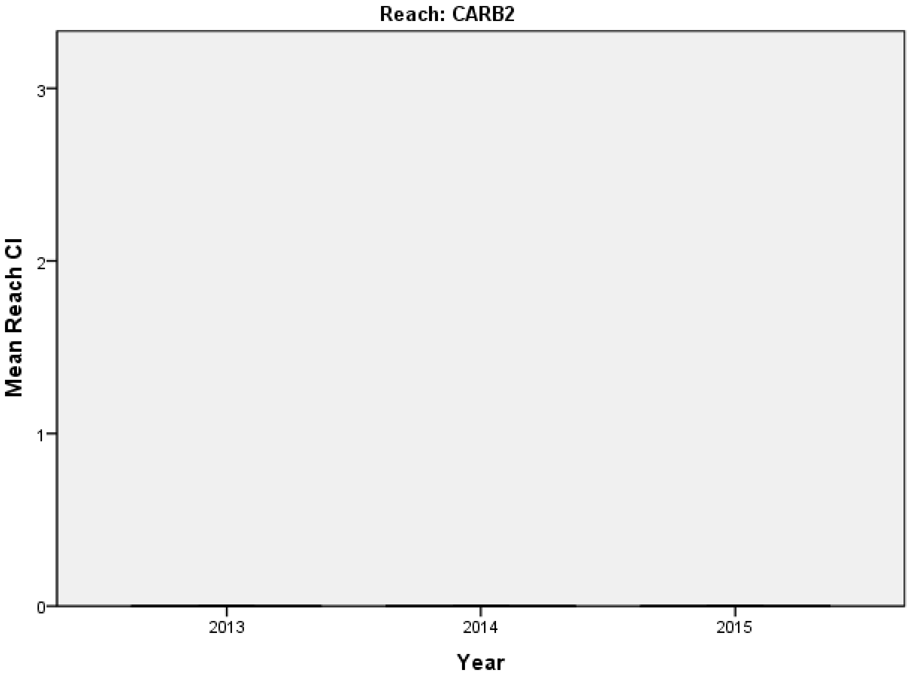


Error Bars: 95% CI

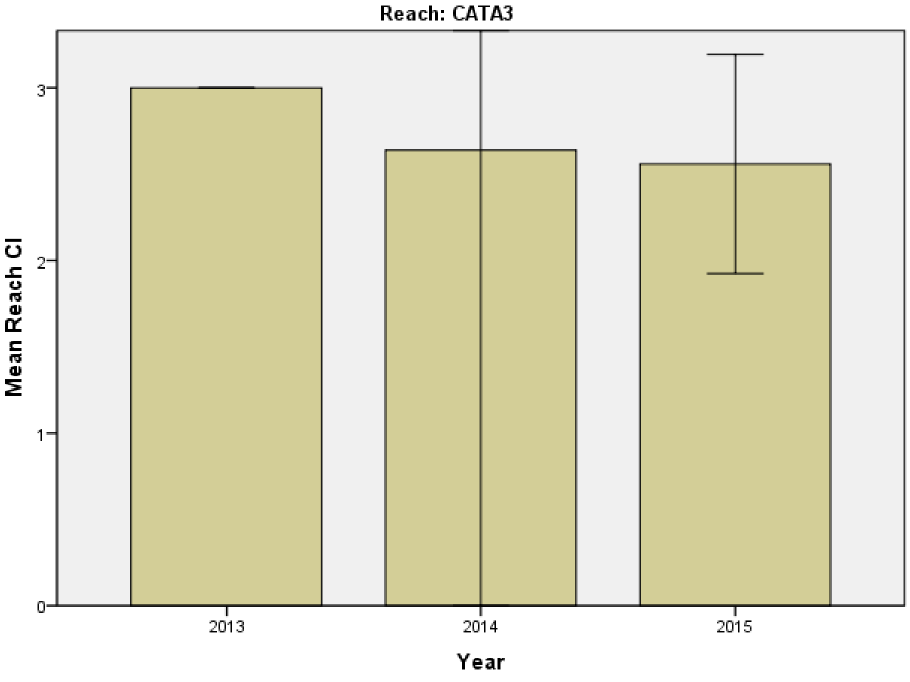
Reach: CARB1



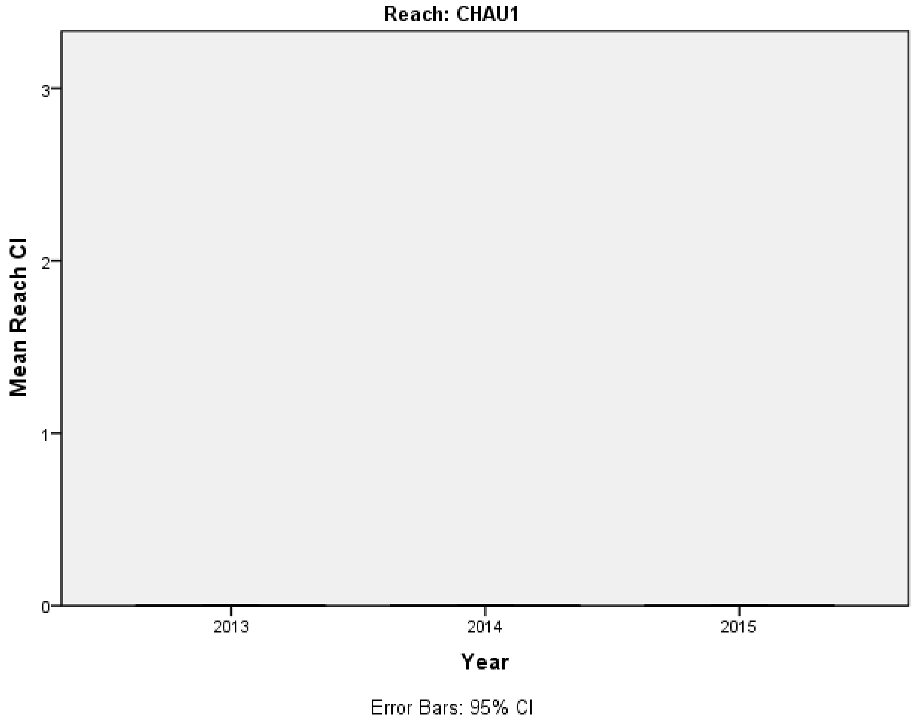
Error Bars: 95% CI

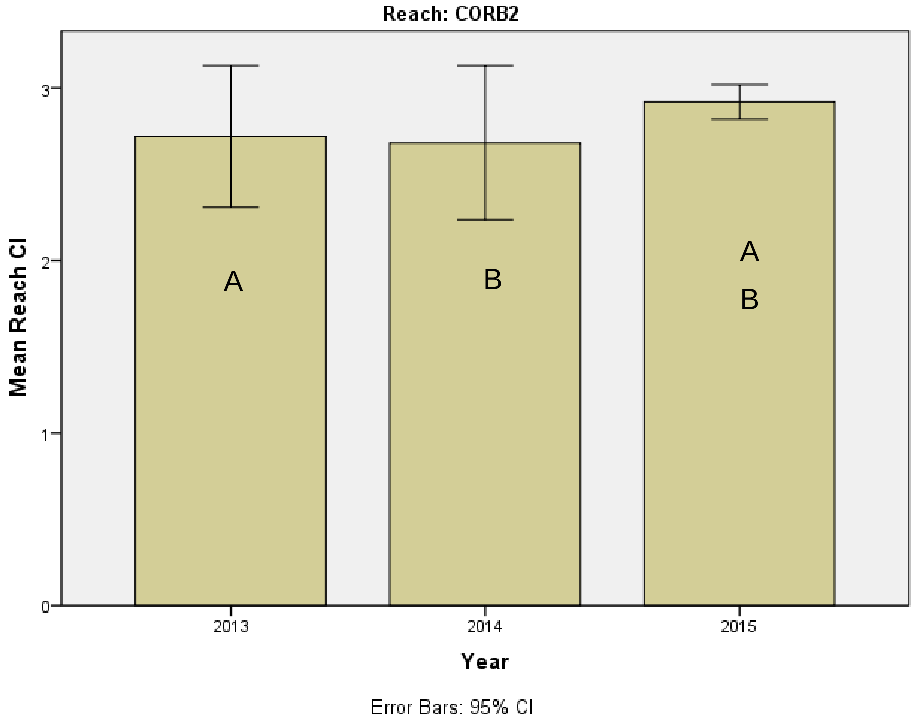


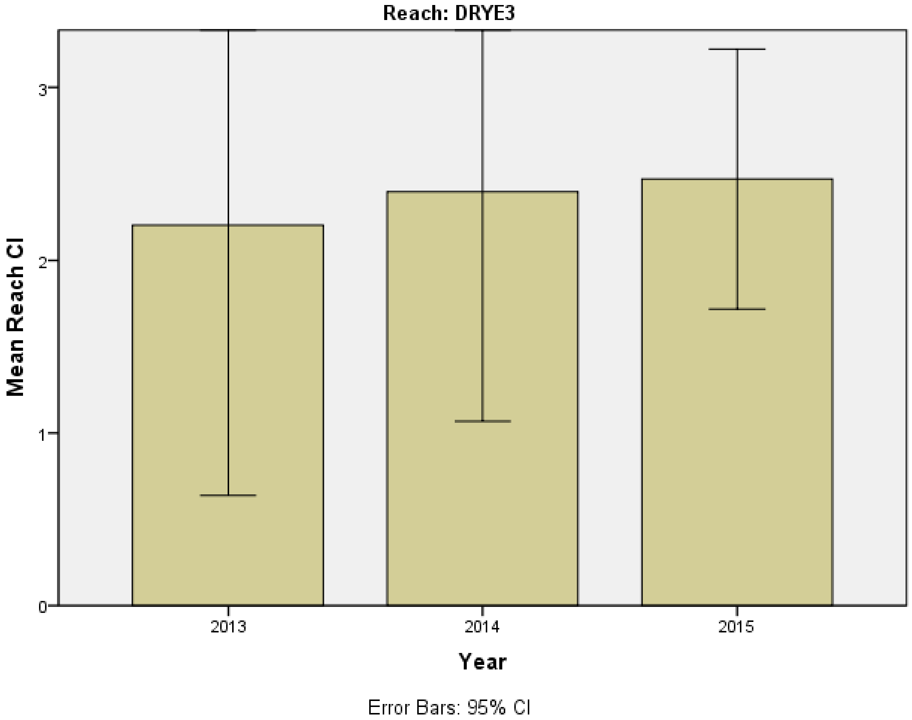
Error Bars: 95% CI

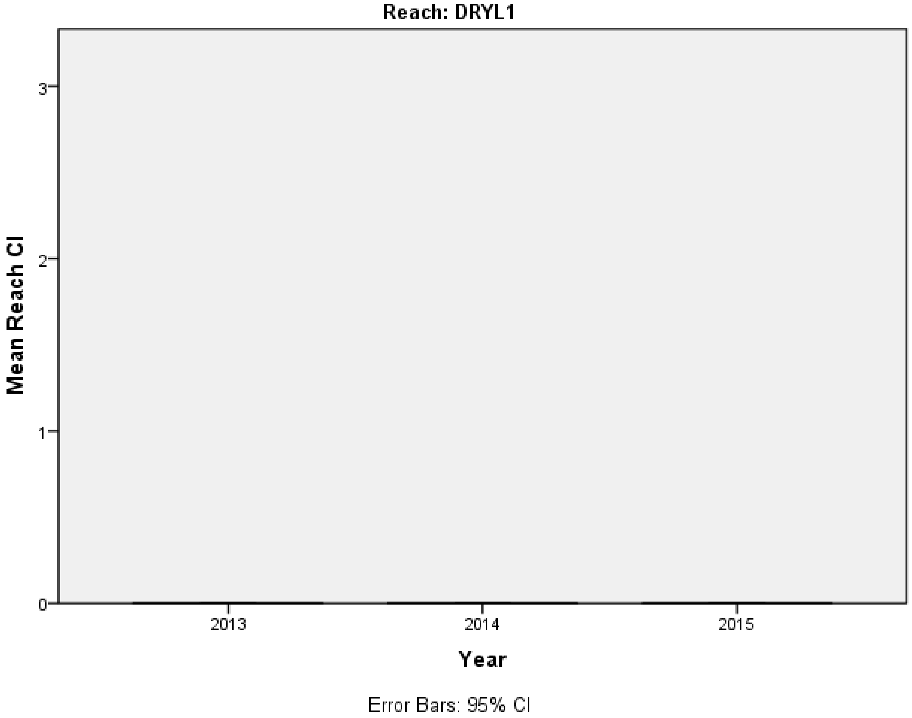


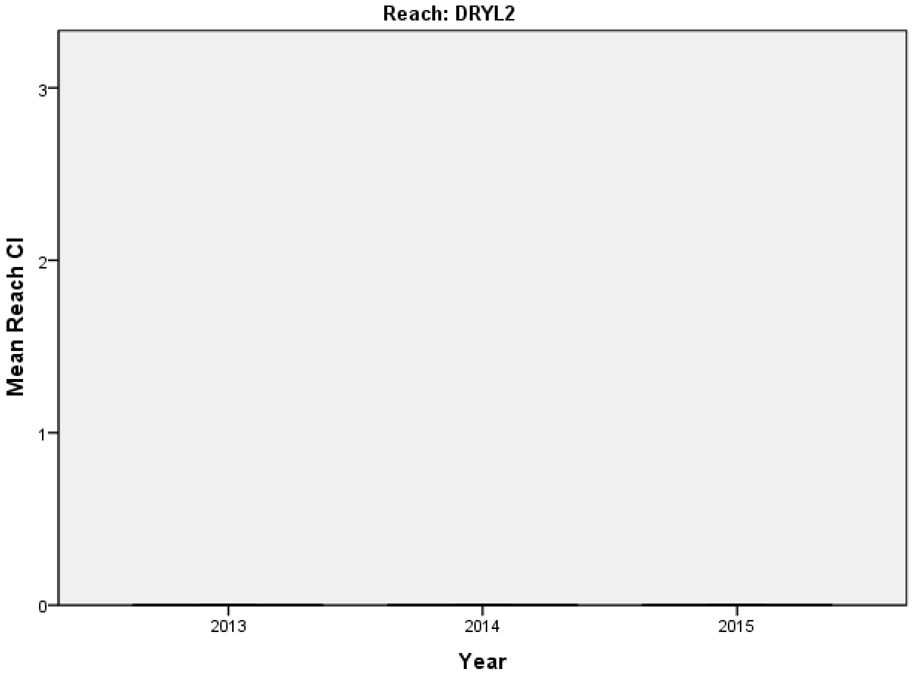
Error Bars: 95% CI


Reach: CHAU1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

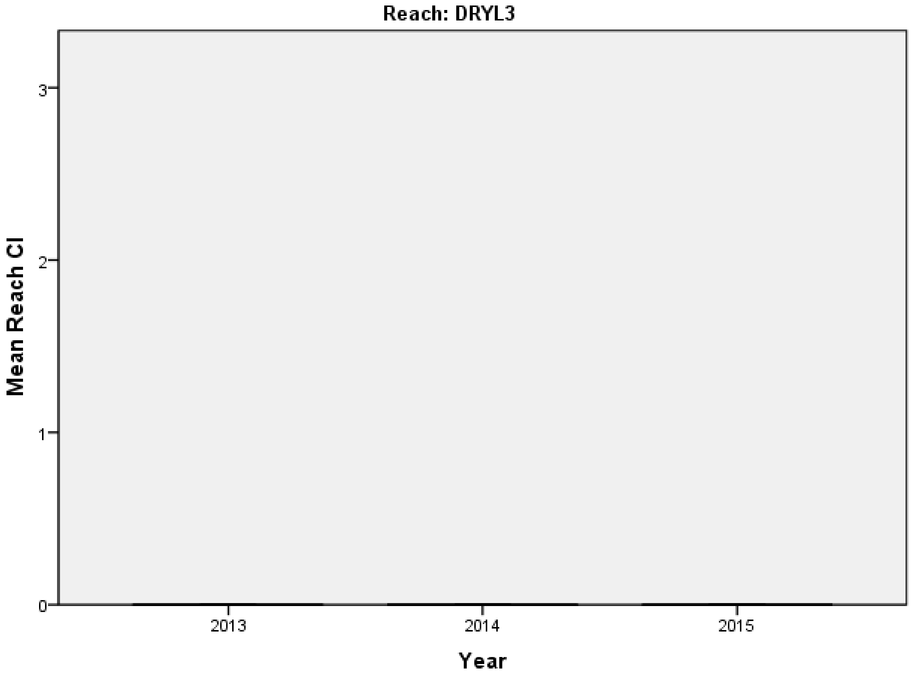

Reach: CORB2
Mean Reach CI
0
1
2
3
A
B
A
B
2013
2014
2015
Year
Error Bars: 95% CI


Reach: DRYE3
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

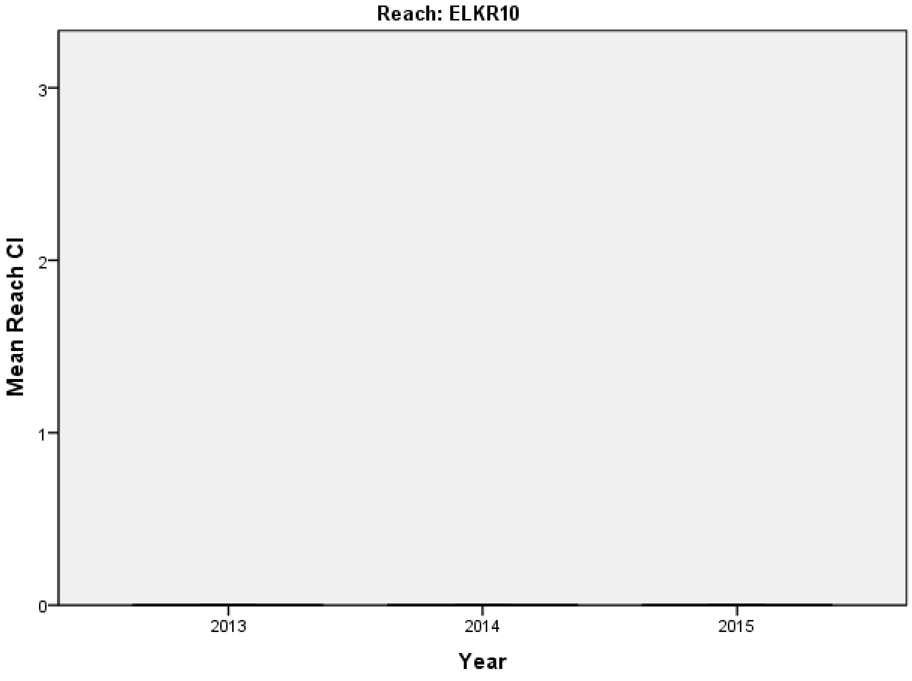

Reach: DRYL1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI



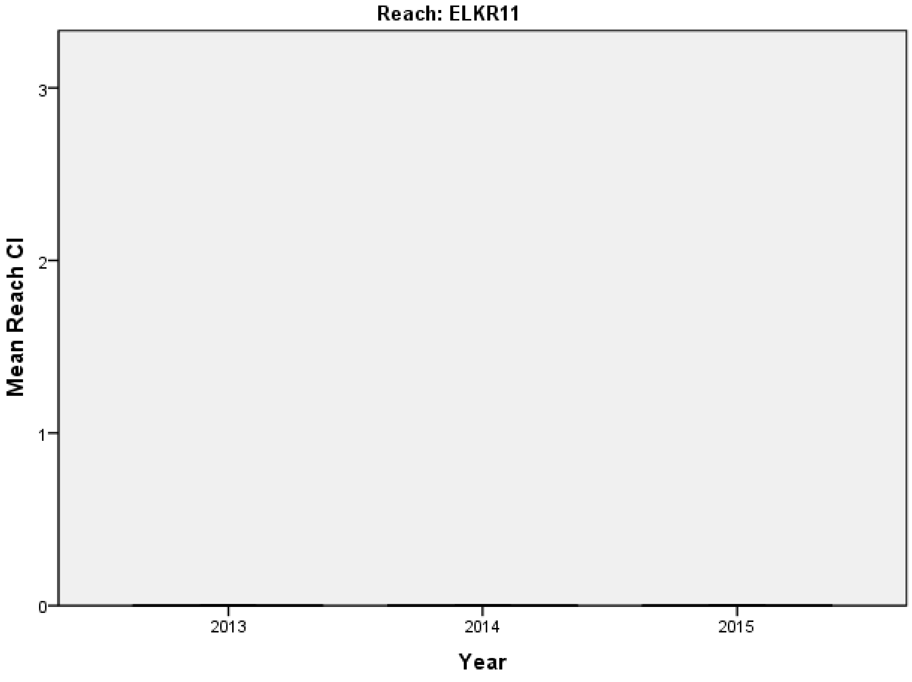
Error Bars: 95% CI



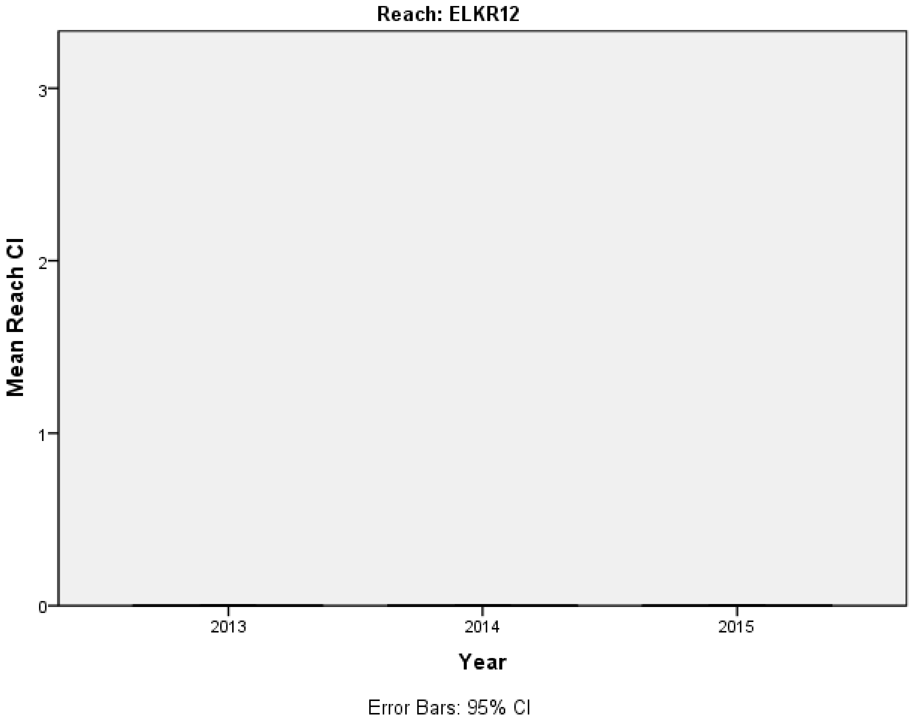
Error Bars: 95% CI

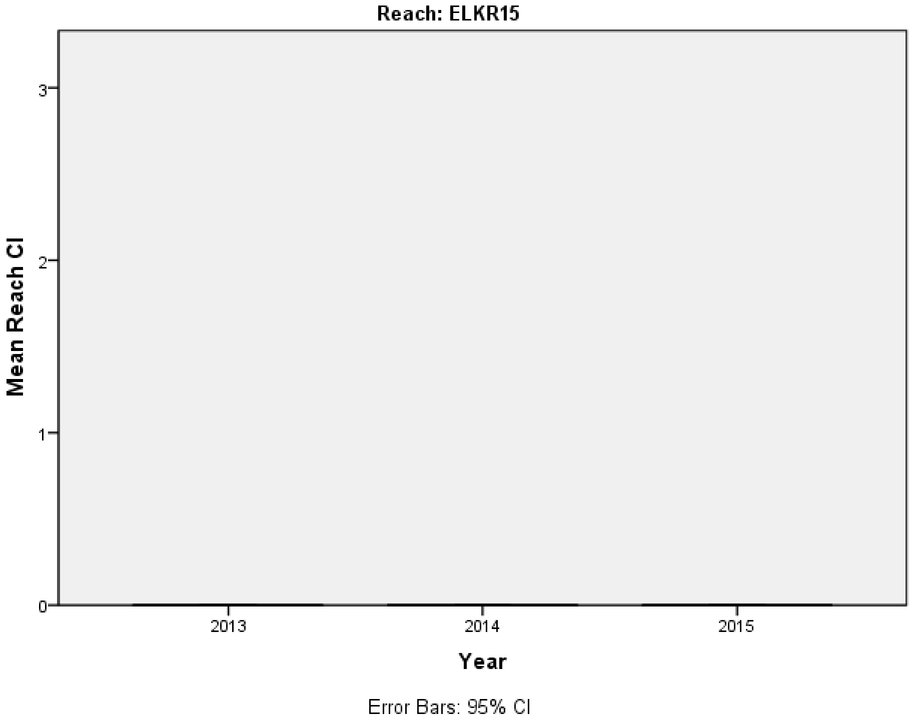


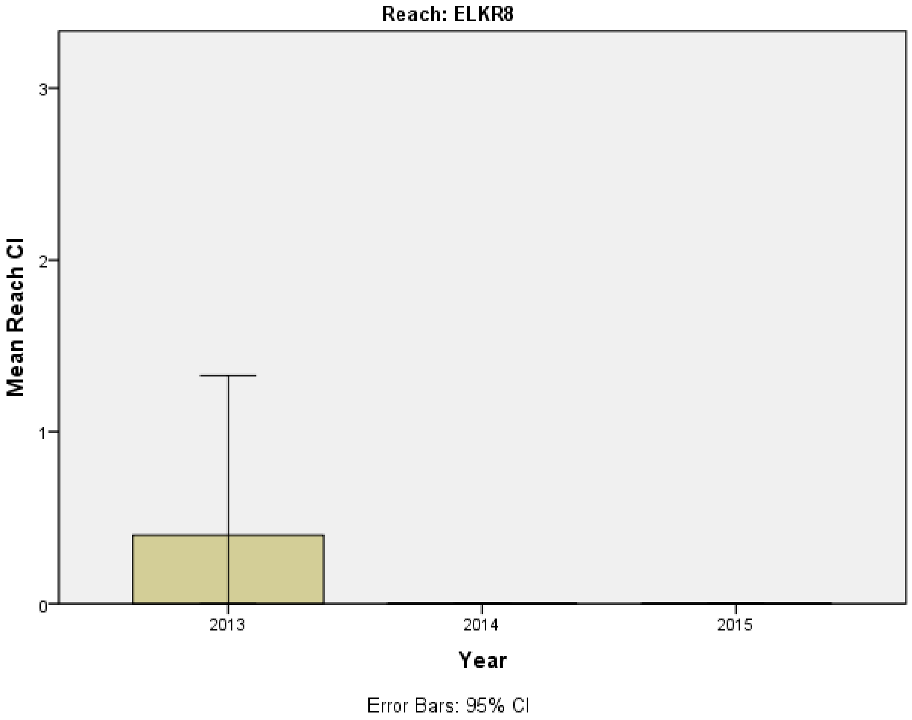
Error Bars: 95% CI

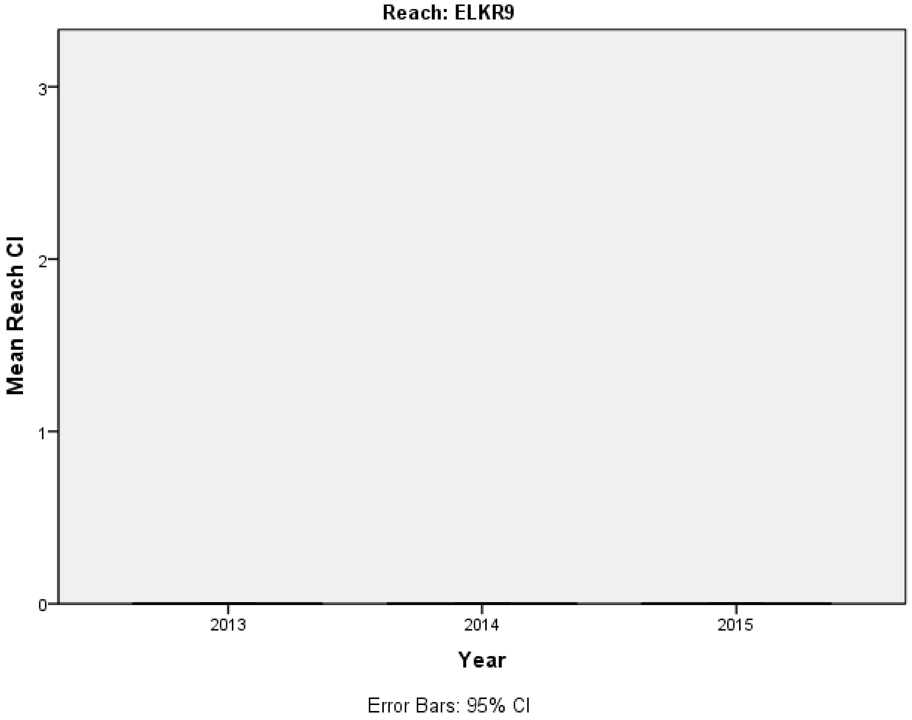


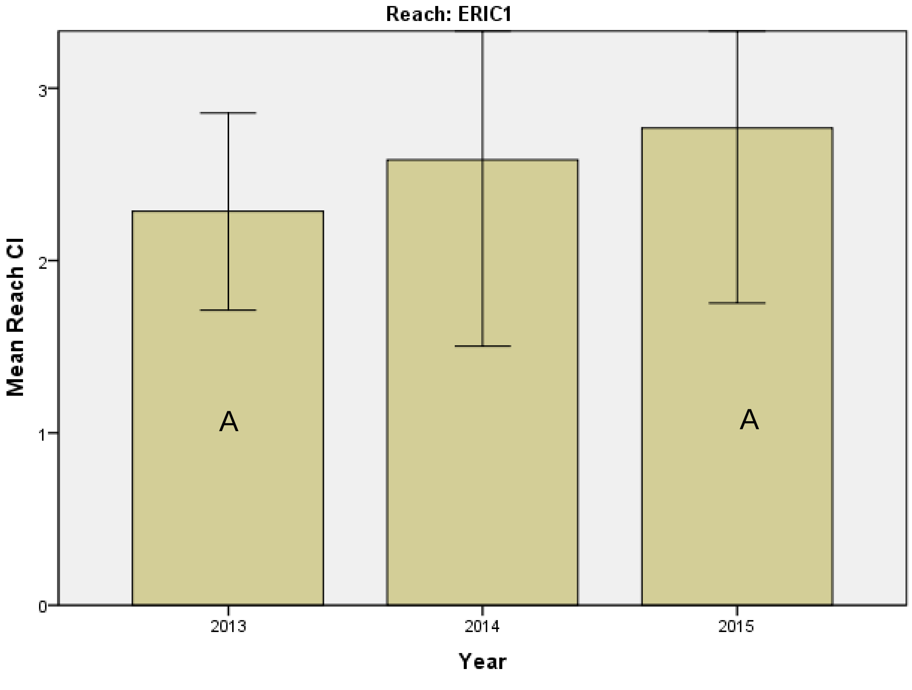
Error Bars: 95% CI


Reach: ELKR12
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

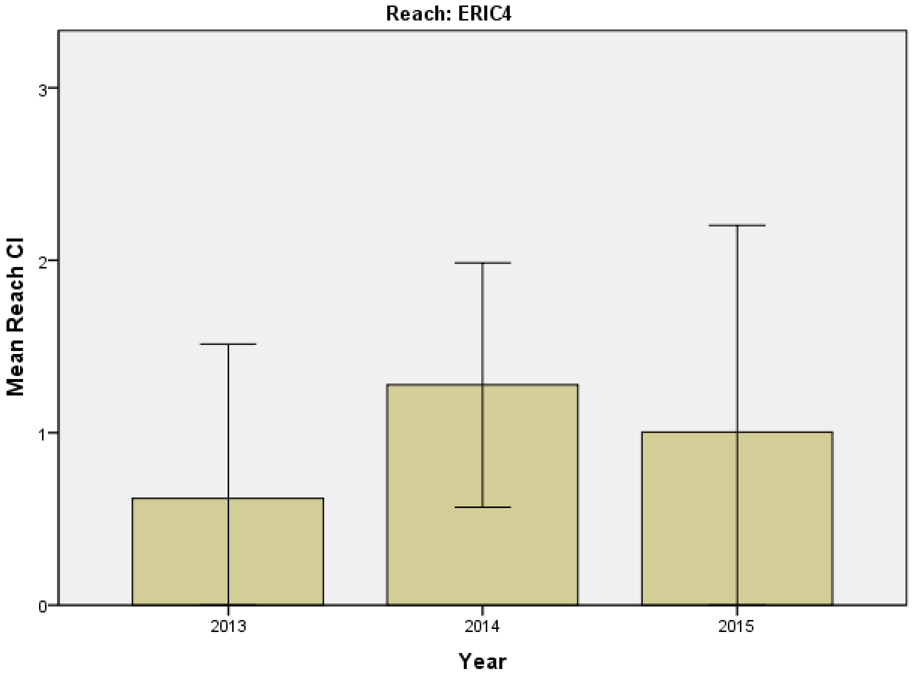

Reach: ELKR15
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI


Reach: ELKR8
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

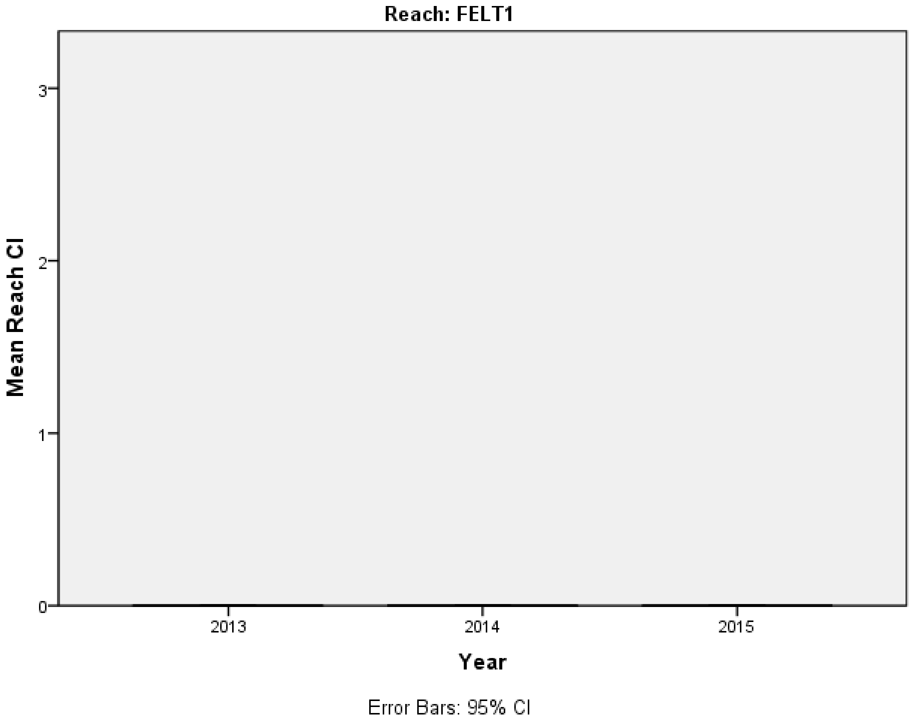

Reach: ELKR9
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

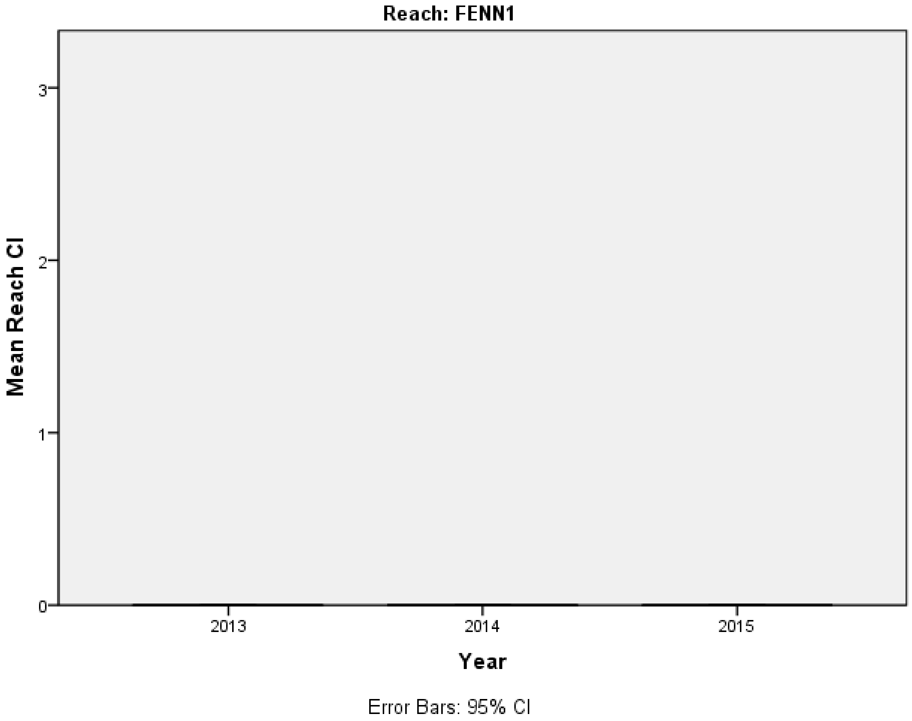


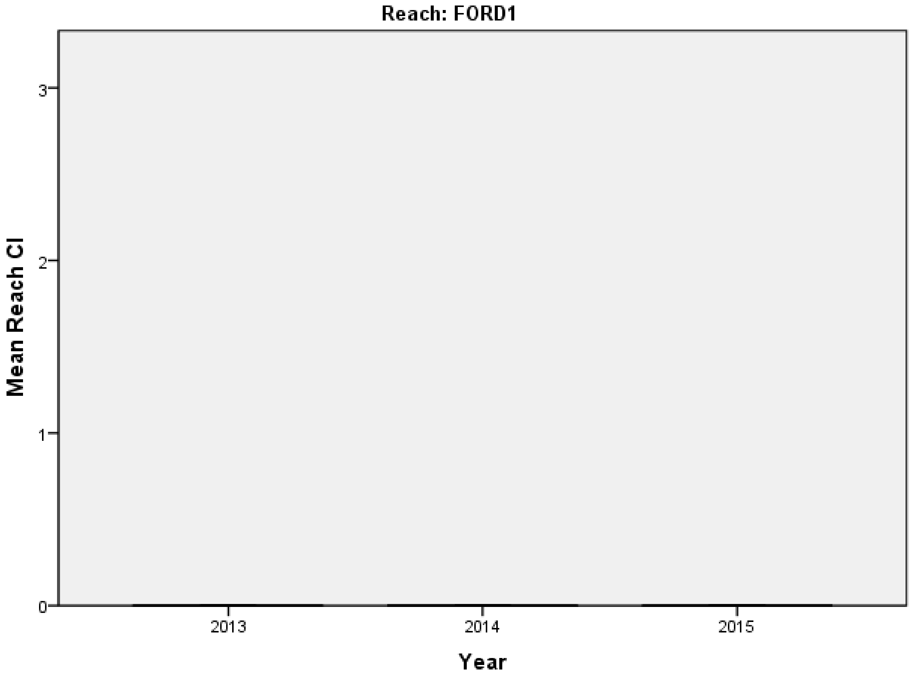
Error Bars: 95% CI



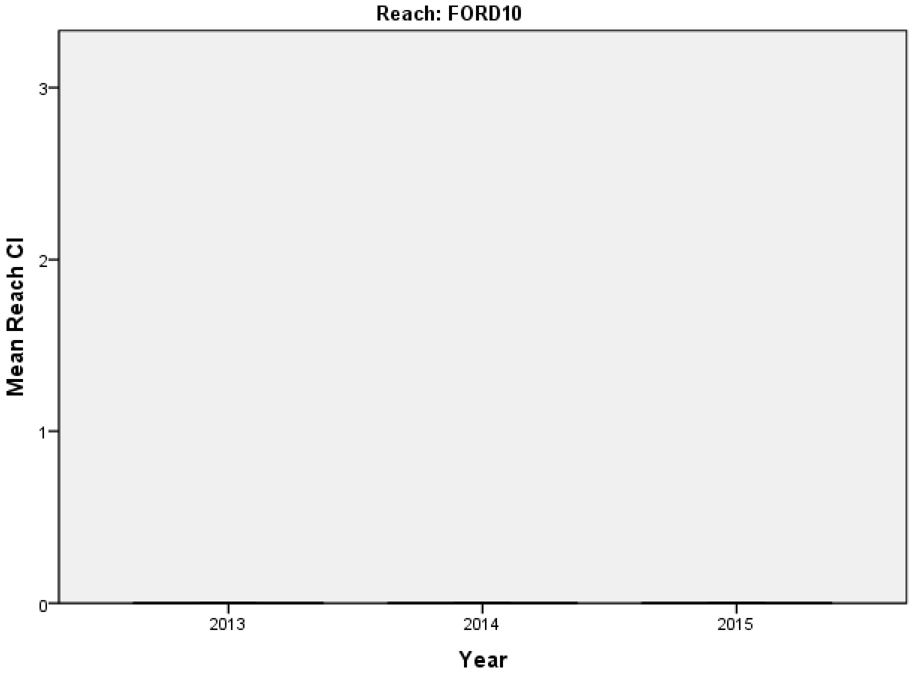
Error Bars: 95% CI


Reach: FELT1
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

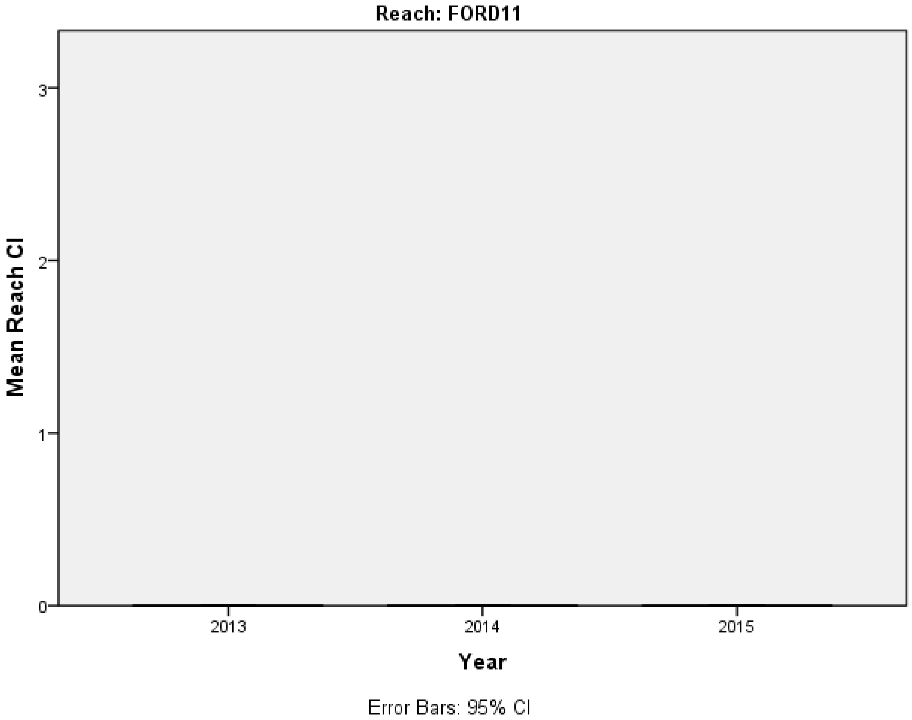

Reach: FENN1
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

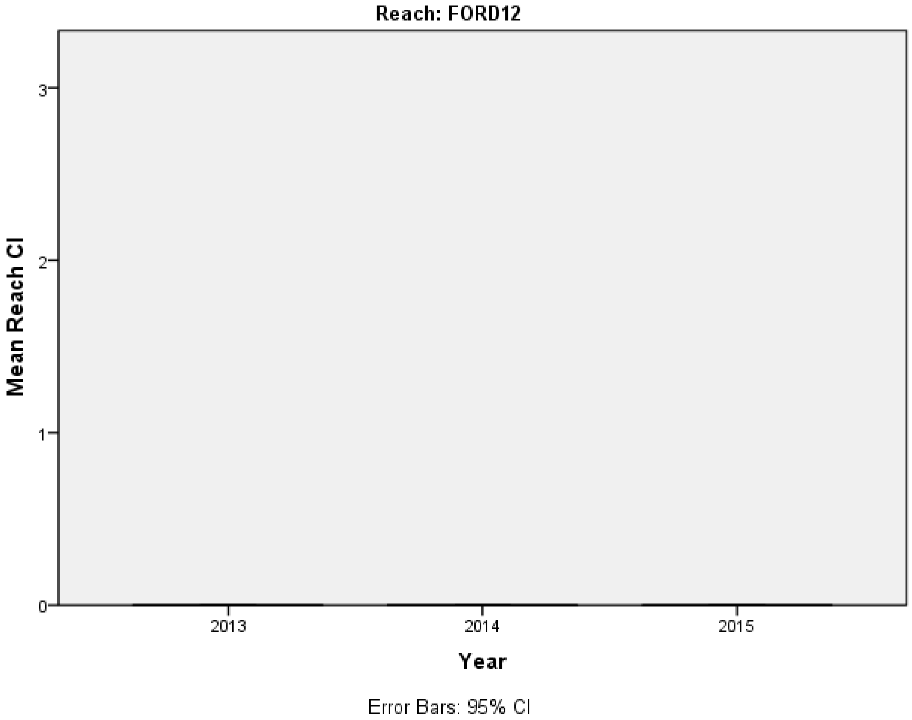


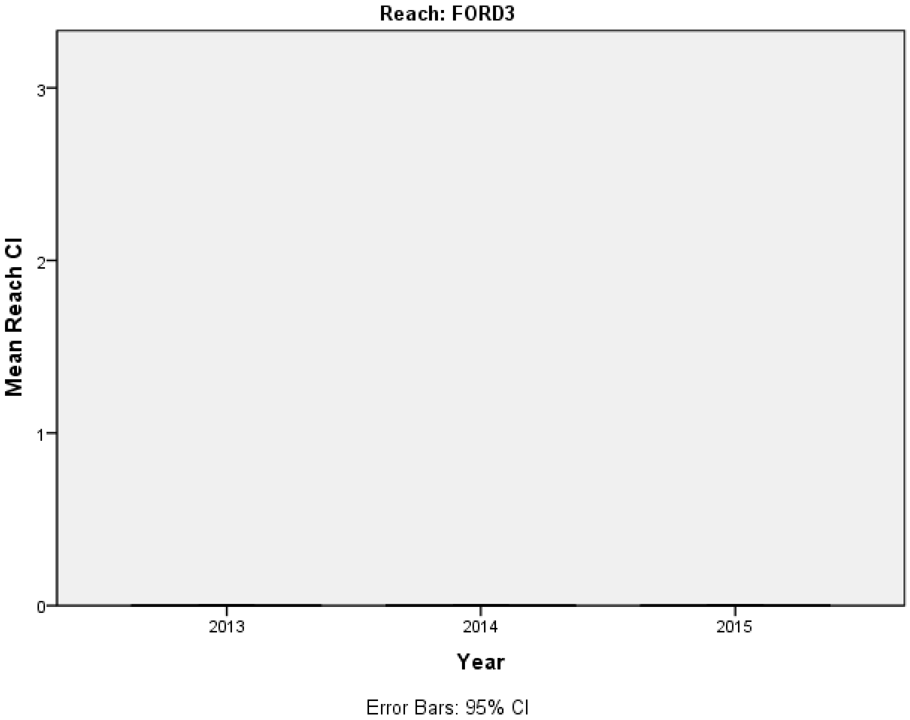
Error Bars: 95% CI

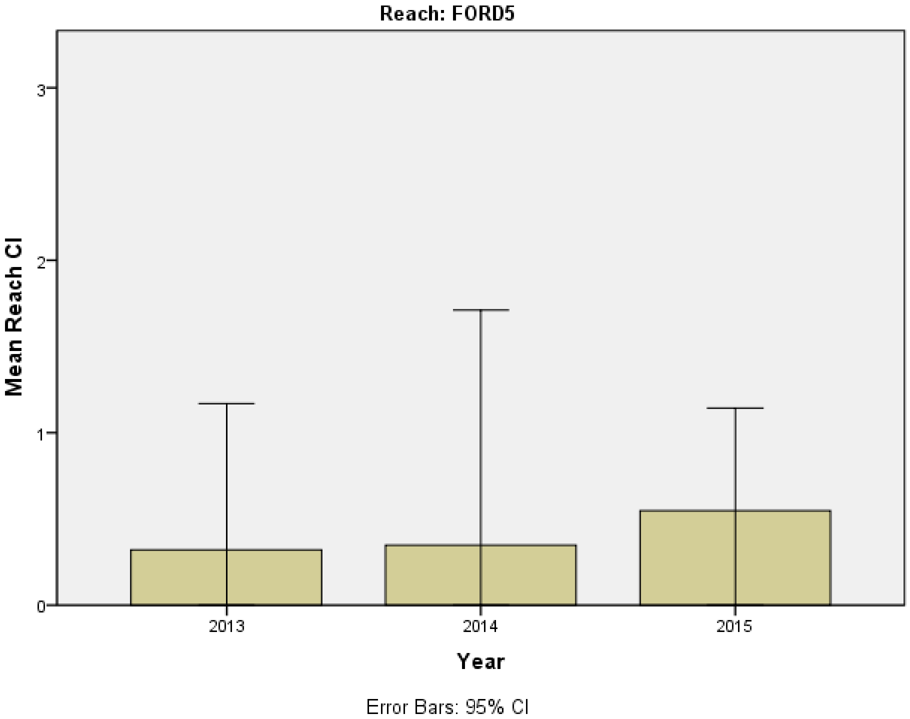


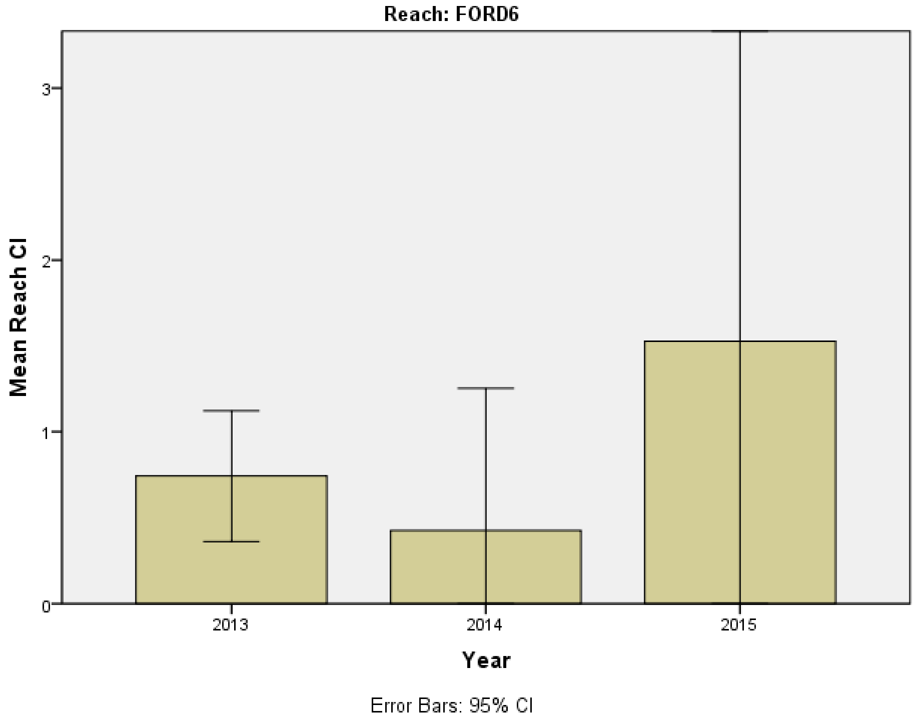
Error Bars: 95% CI

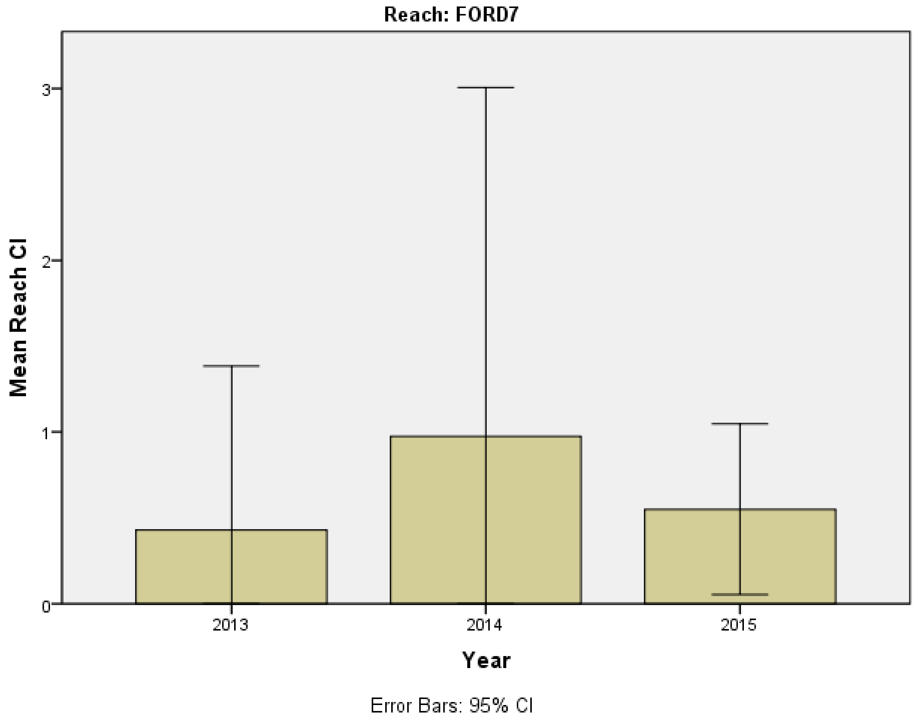

Reach: FORD11
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

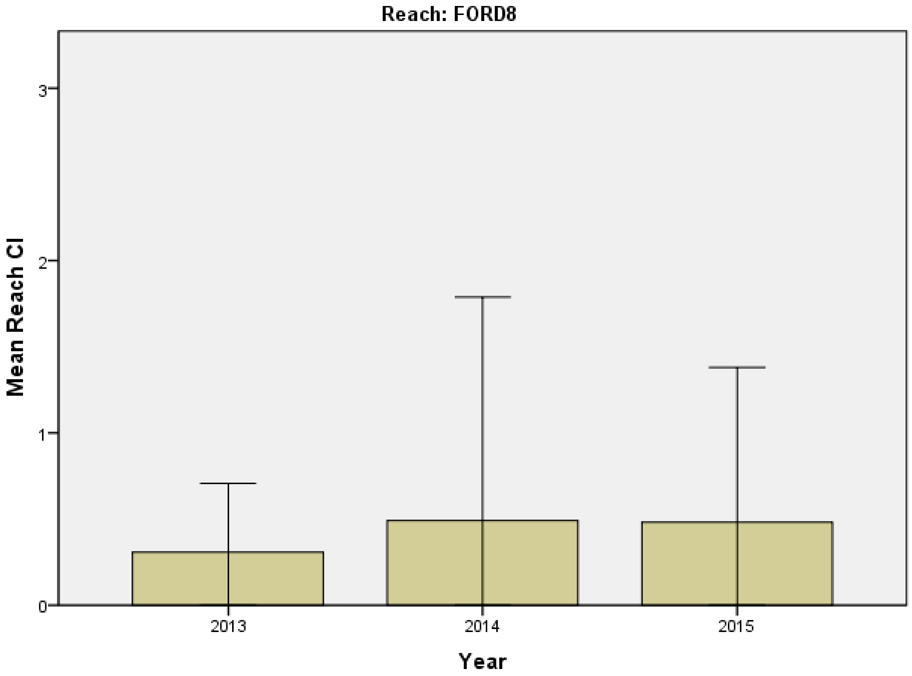

Reach: FORD12
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI


Reach: FORD3
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

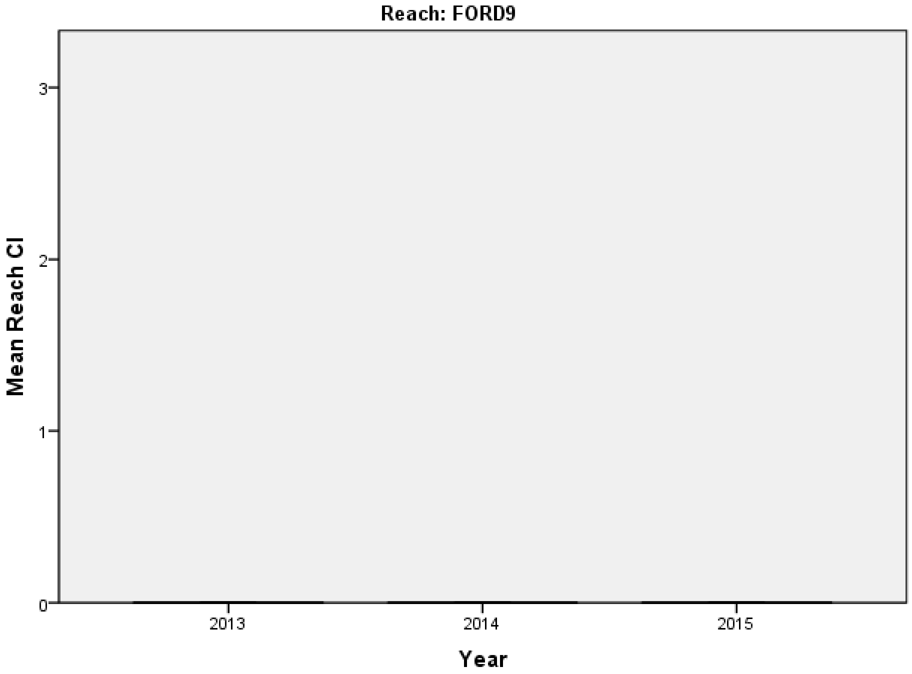

Reach: FORD5
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI


Reach: FORD6
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

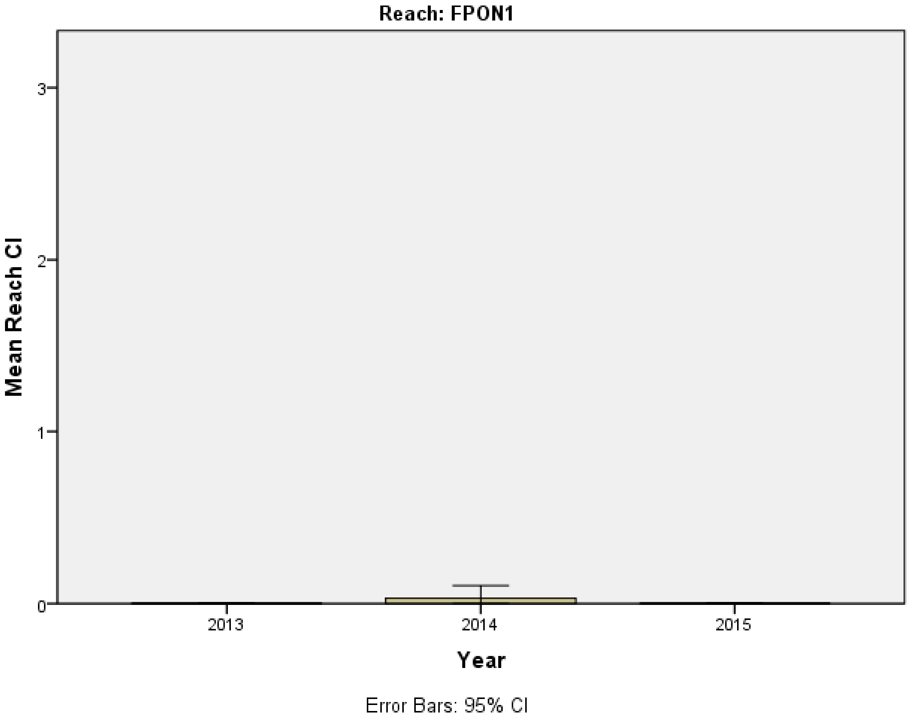

Reach: FORD7
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

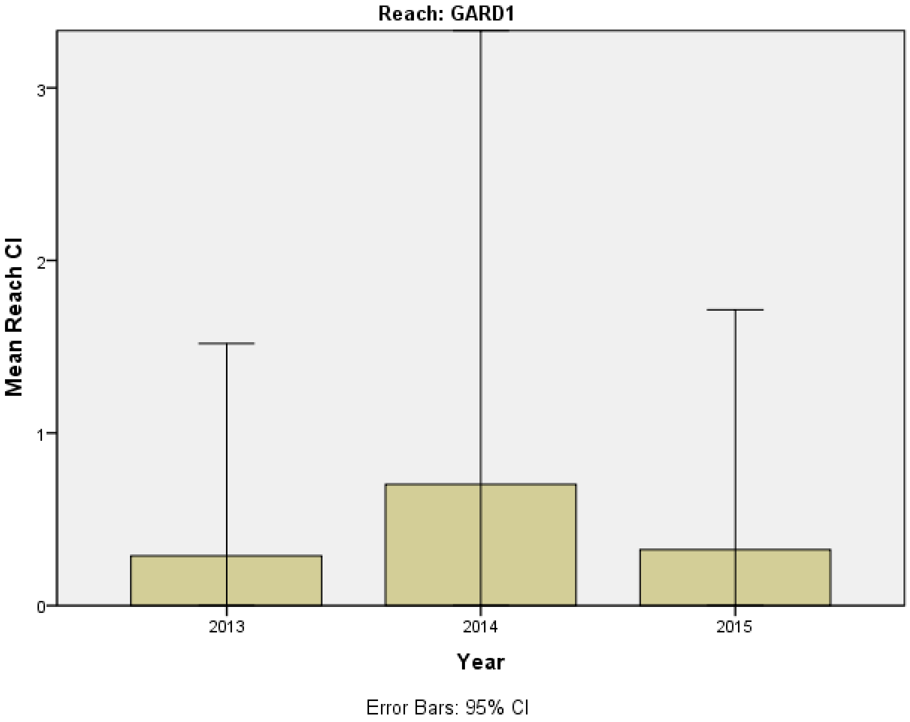


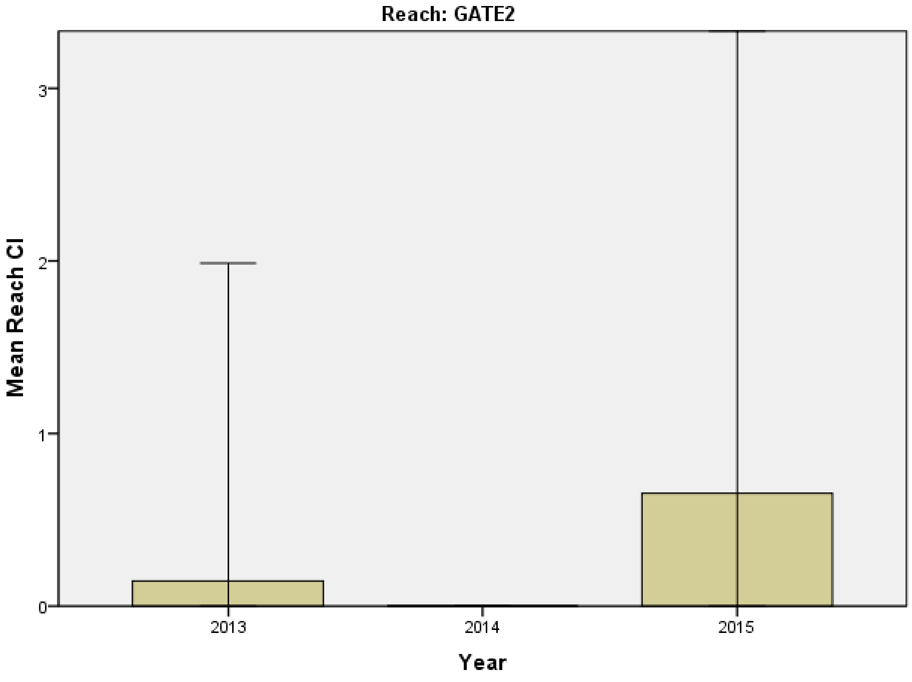
Error Bars: 95% CI



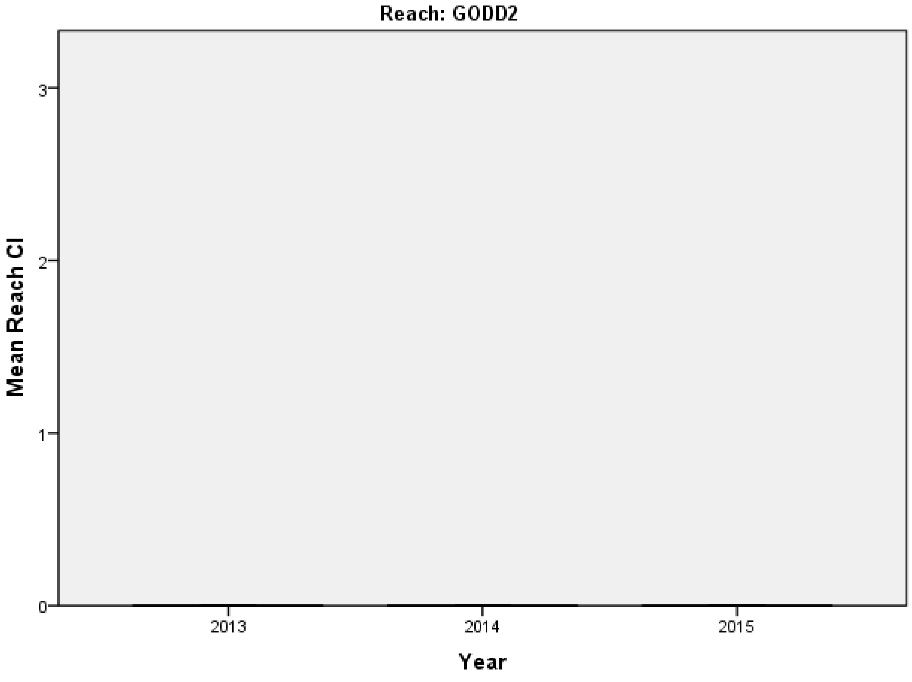
Error Bars: 95% CI


Reach: FPON1
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

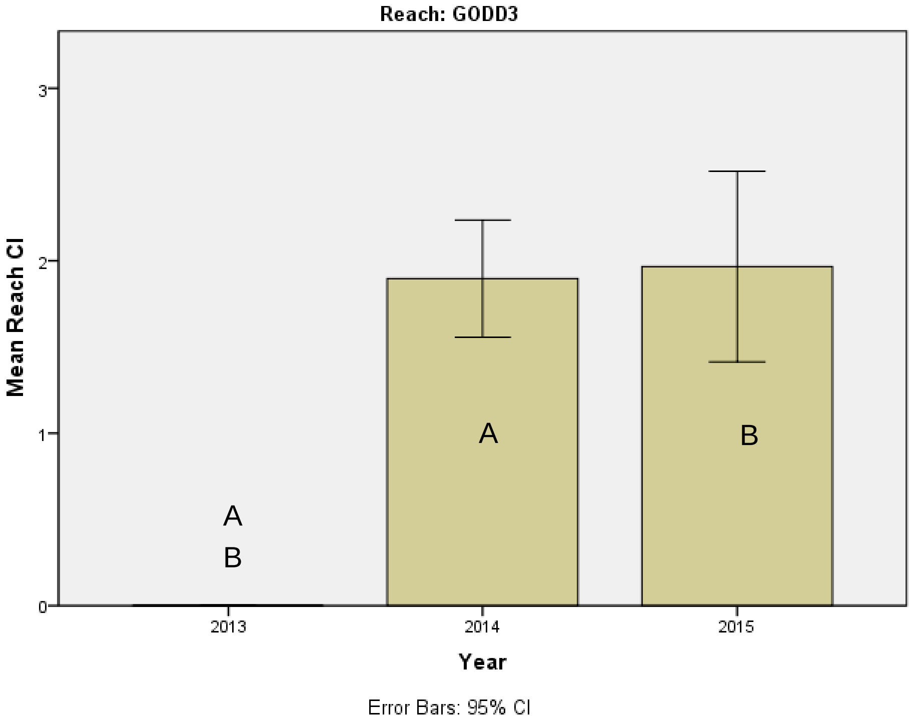

Reach: GARD1
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

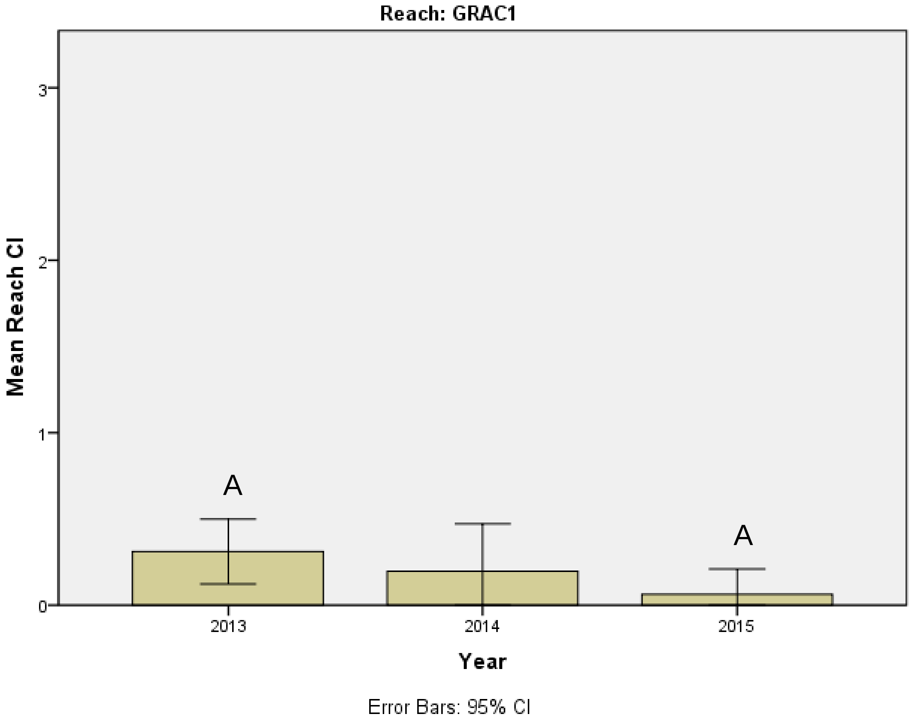


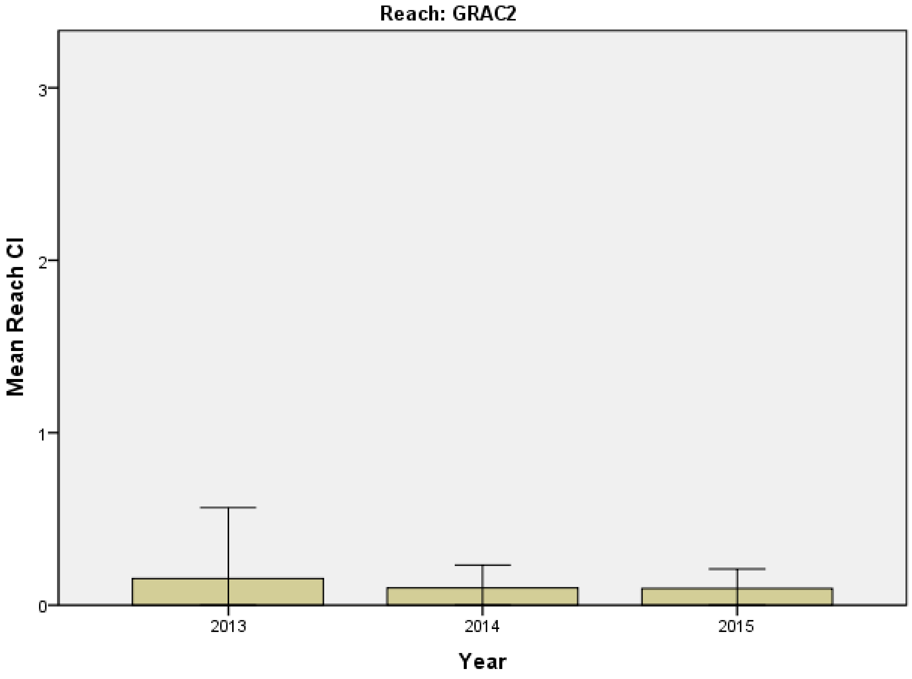
Error Bars: 95% CI



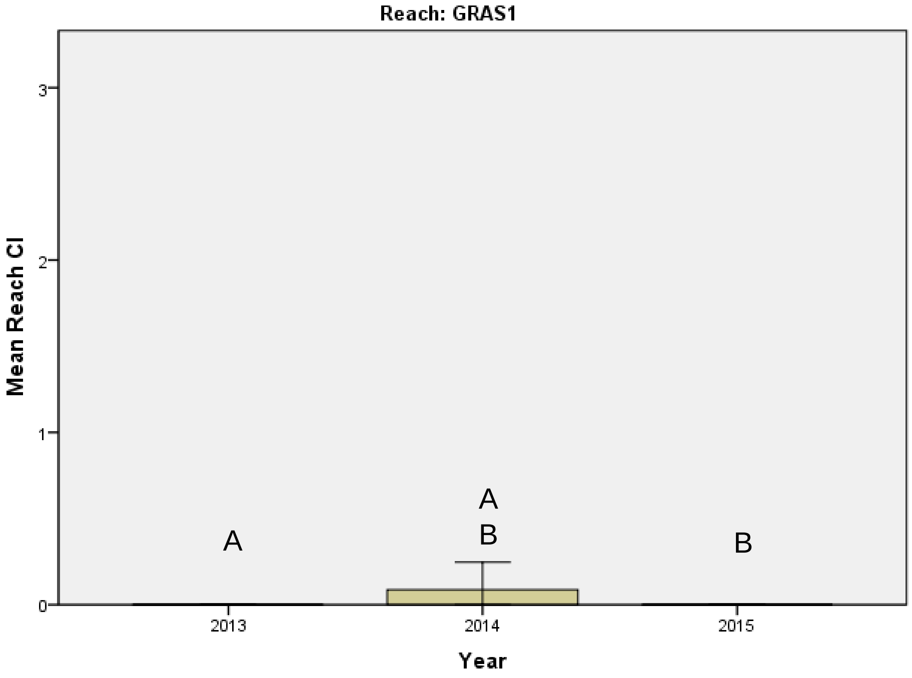
Error Bars: 95% CI


Reach: GODD3
Mean Reach CI
0
1
2
3
A
B
A
B
2013
2014
2015
Year
Error Bars: 95% CI

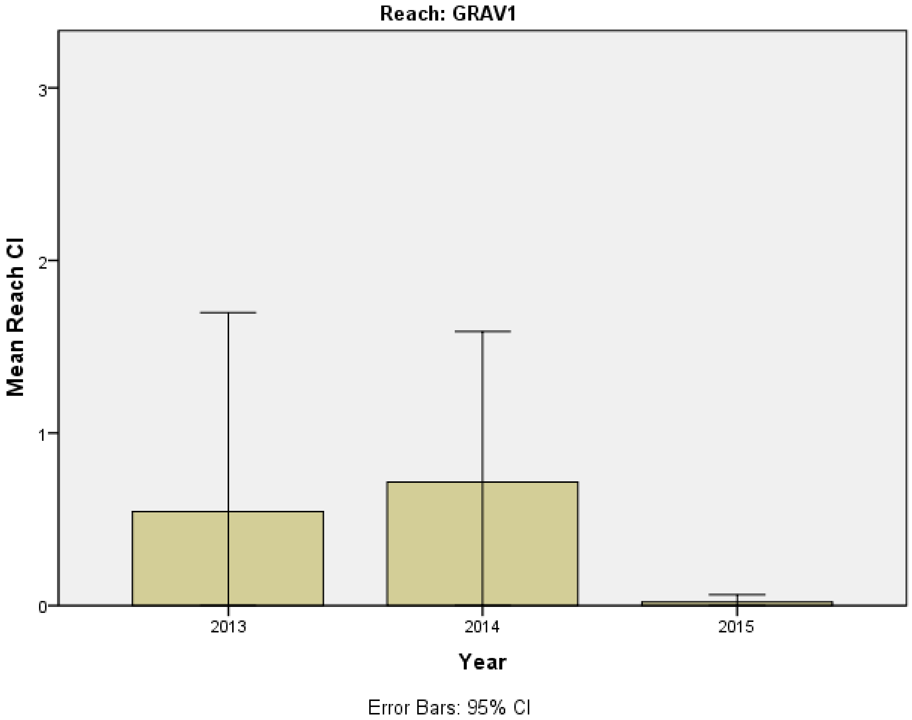

Reach: GRAC1
Mean Reach CI
0
1
2
3
A
A
2013
2014
2015
Year
Error Bars: 95% CI

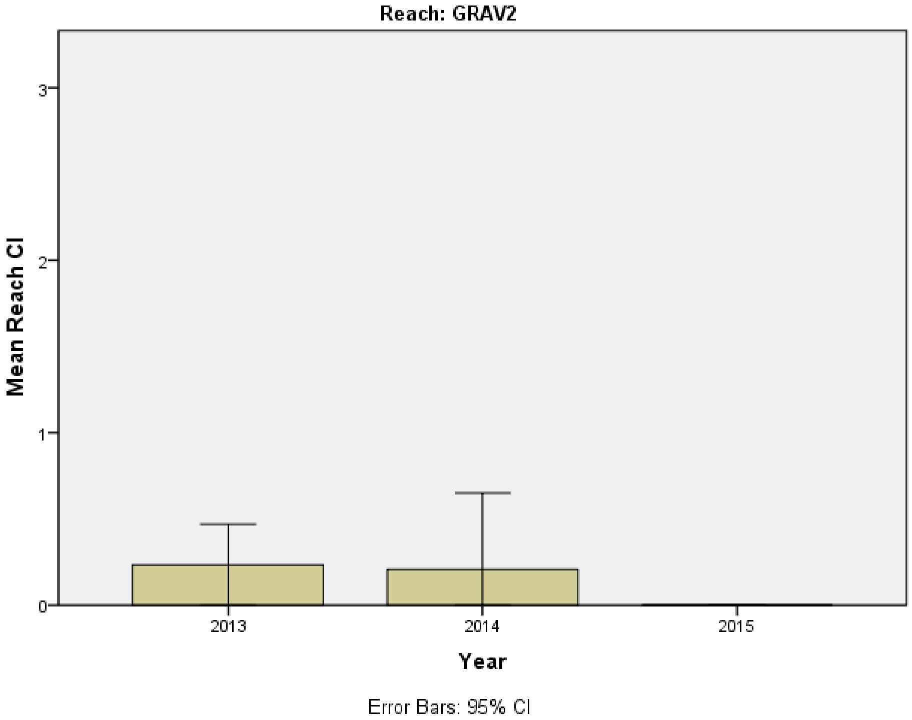


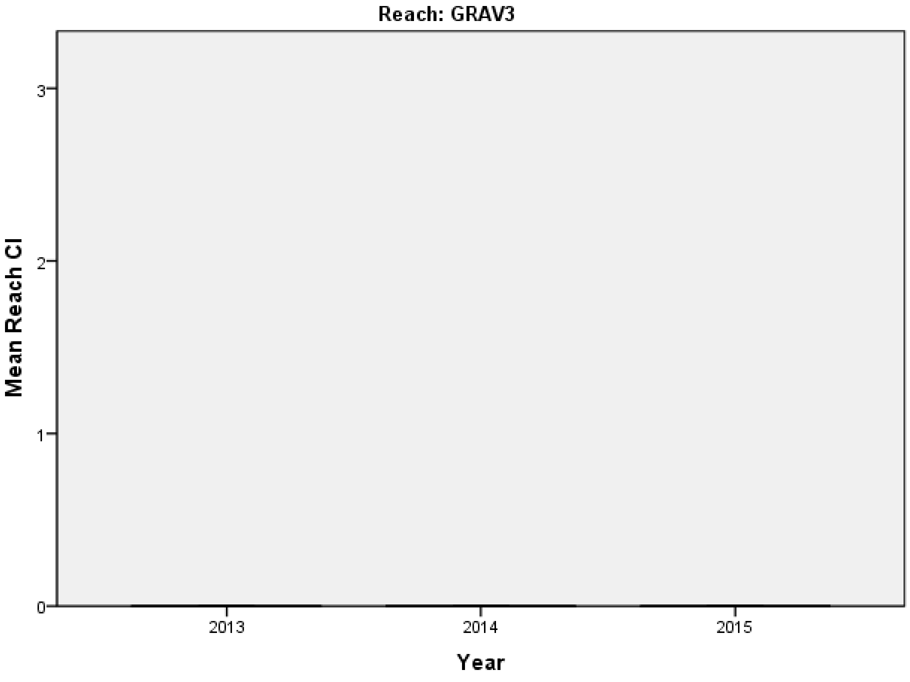
Error Bars: 95% CI



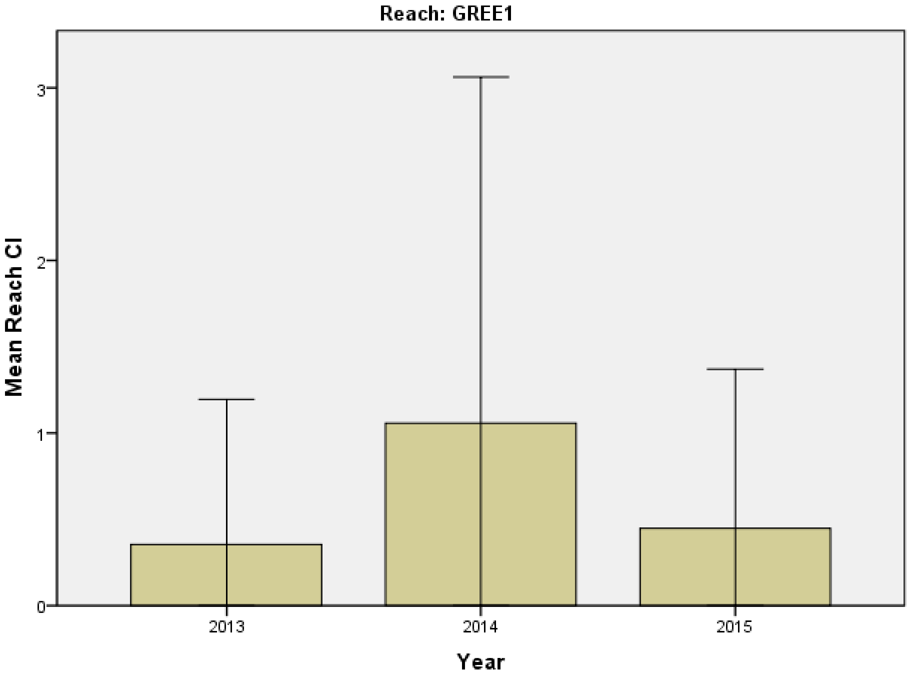
Error Bars: 95% CI


Reach: GRAV1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

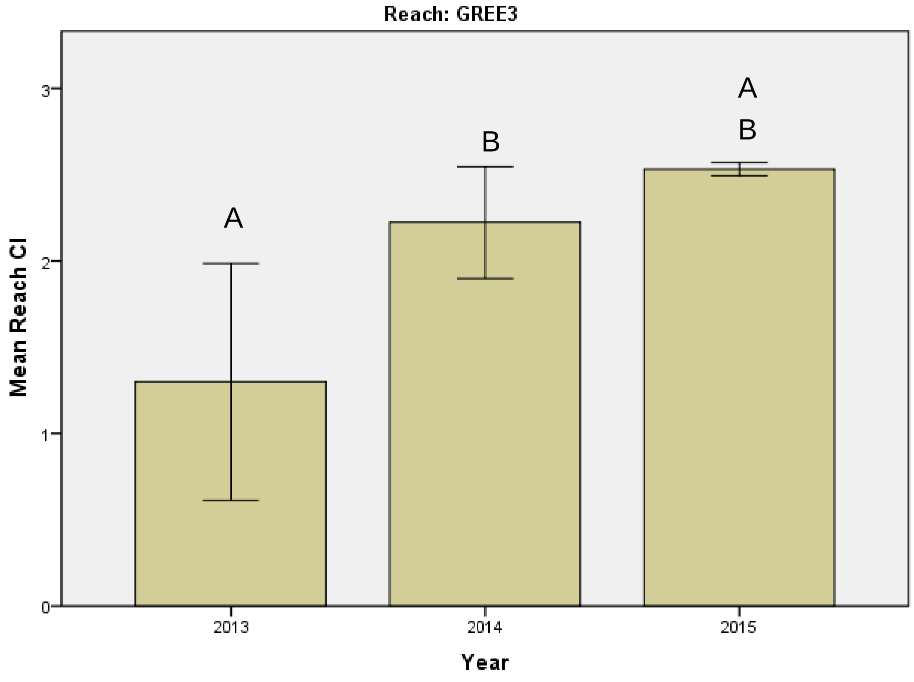

Reach: GRAV2
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI



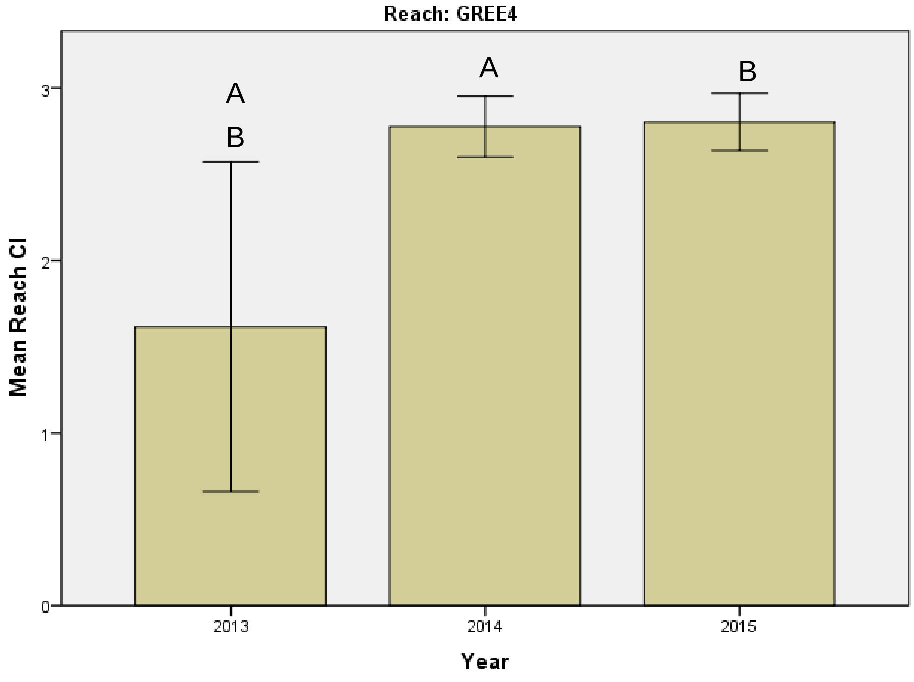
Error Bars: 95% CI



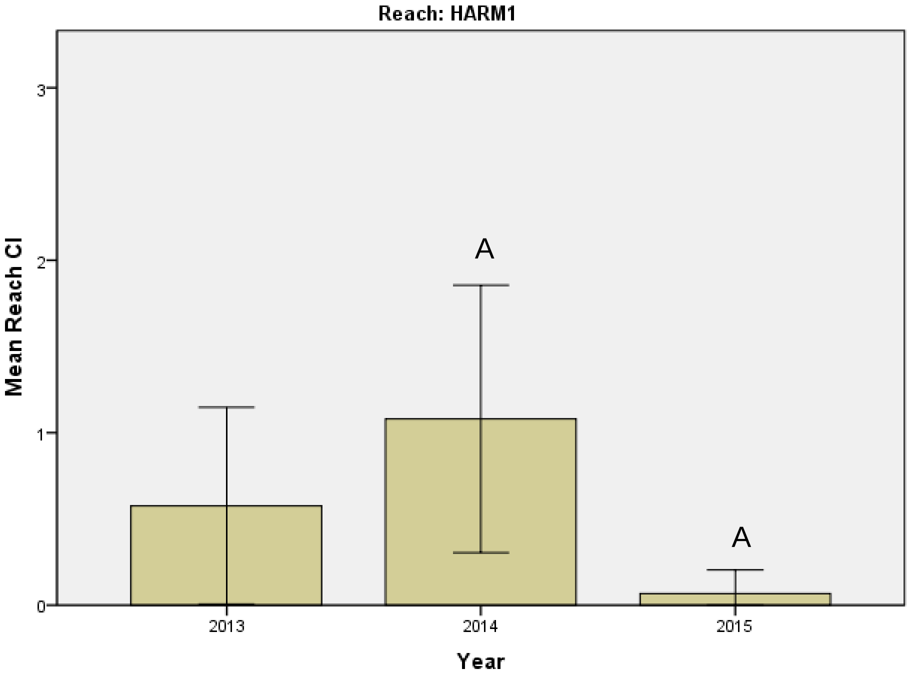
Error Bars: 95% CI



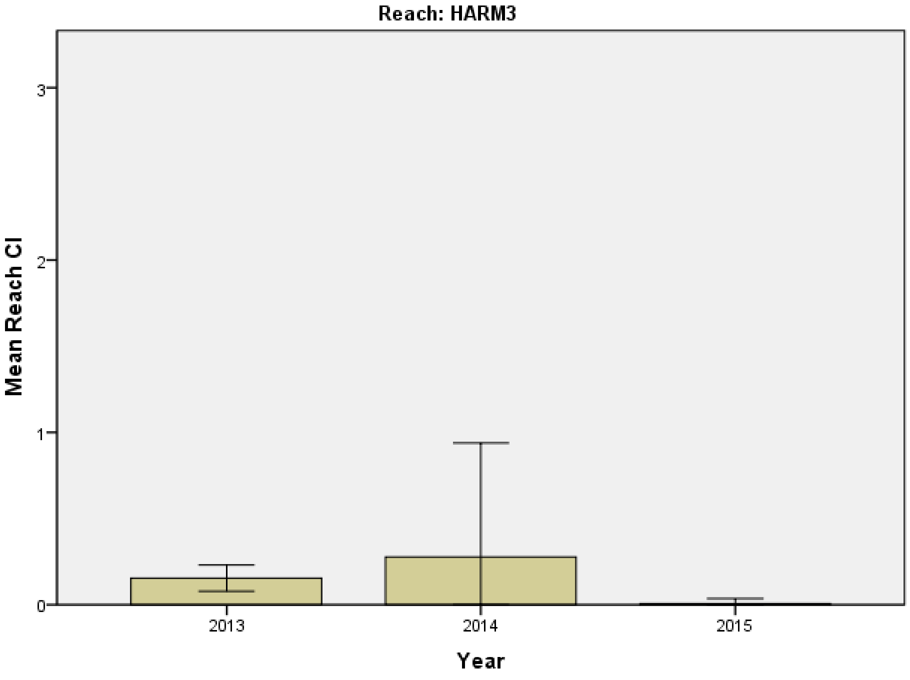
Error Bars: 95% CI



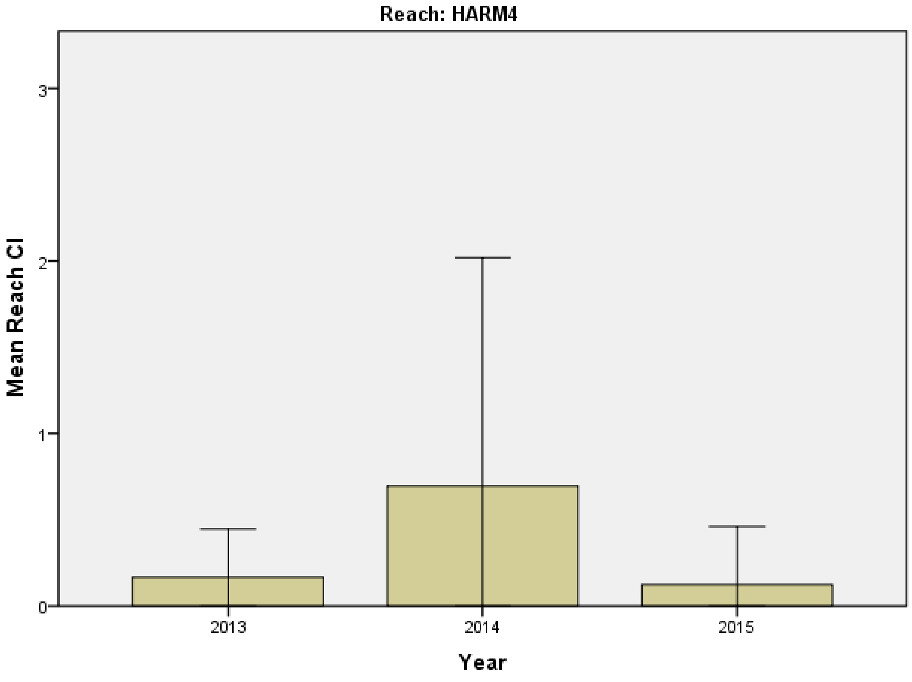
Error Bars: 95% CI



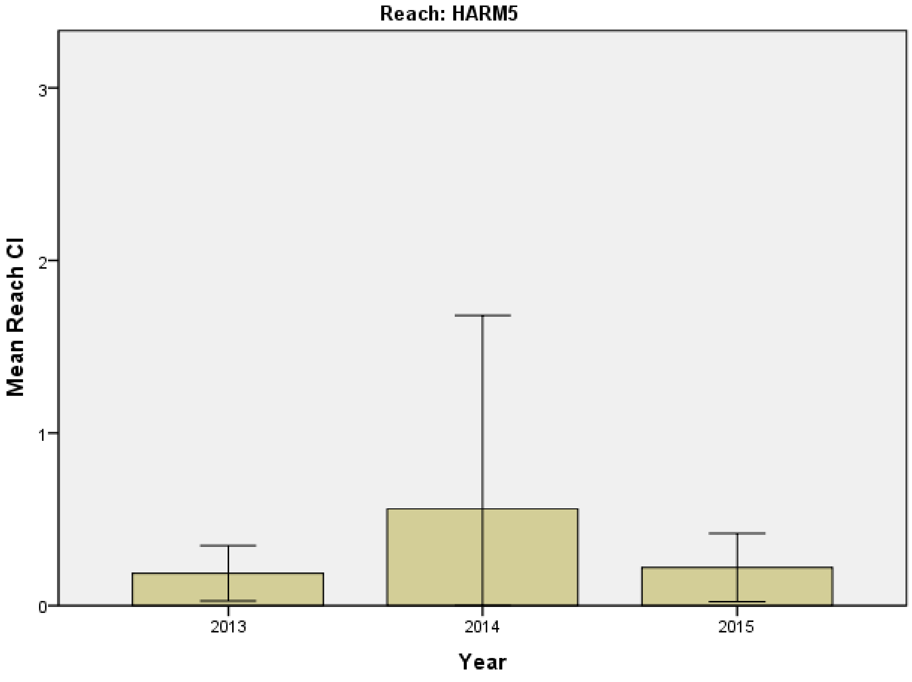
Error Bars: 95% CI



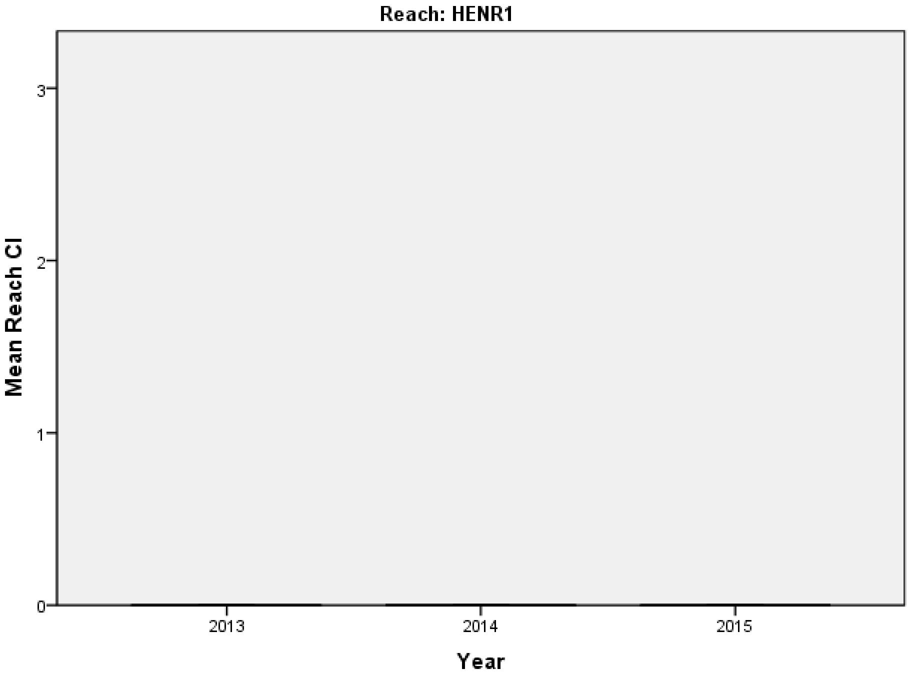
Error Bars: 95% CI



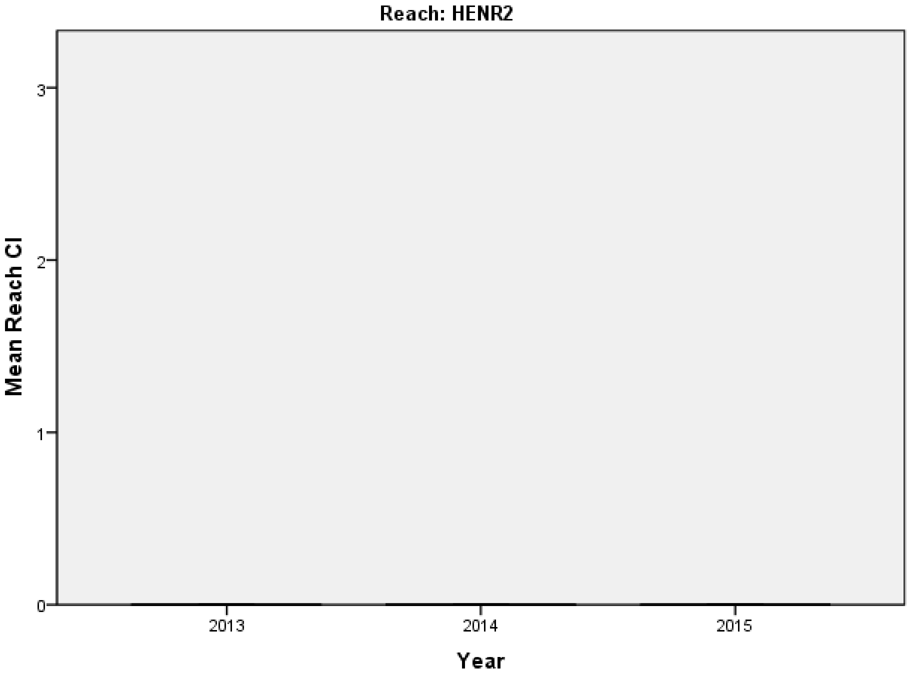
Error Bars: 95% CI



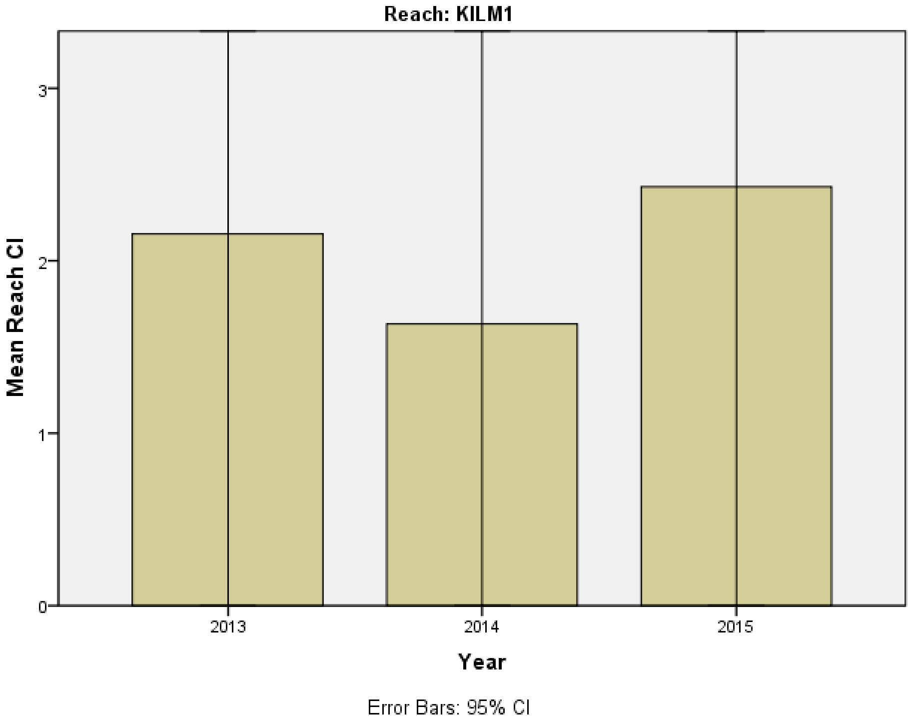
Error Bars: 95% CI

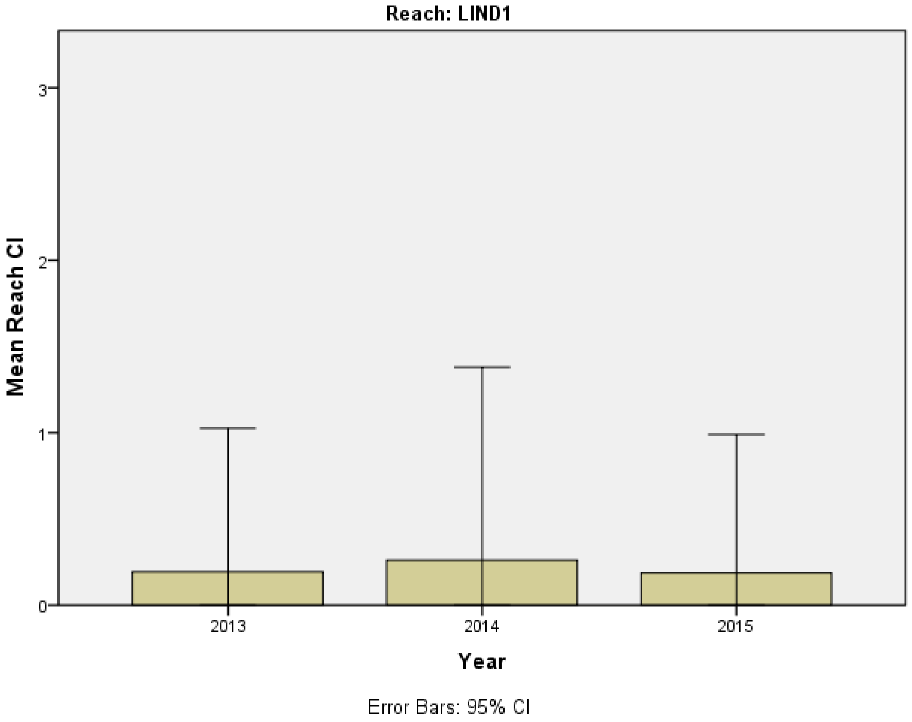


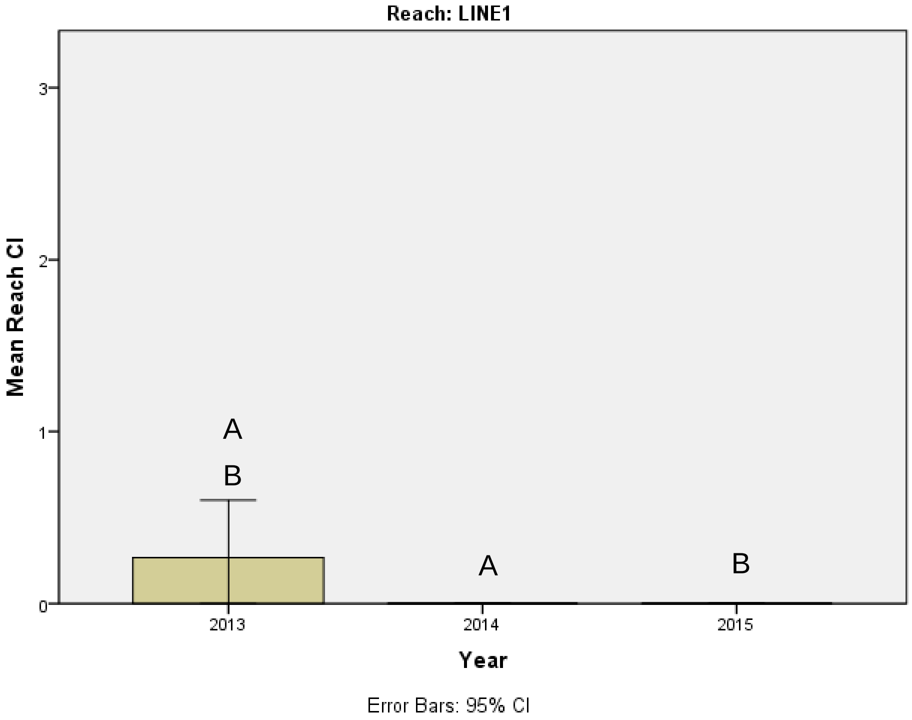
Error Bars: 95% CI

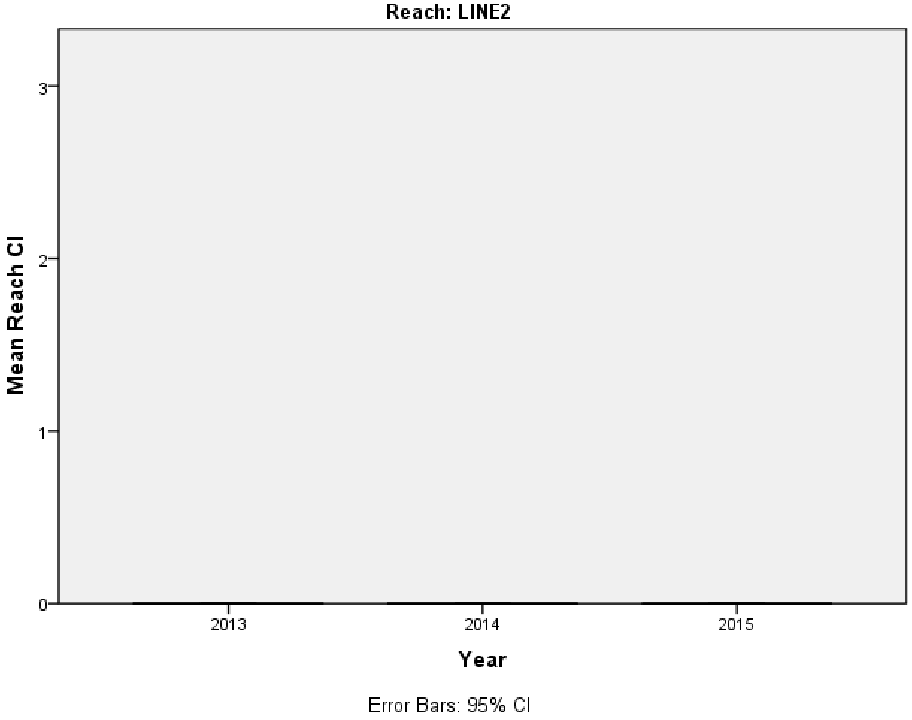


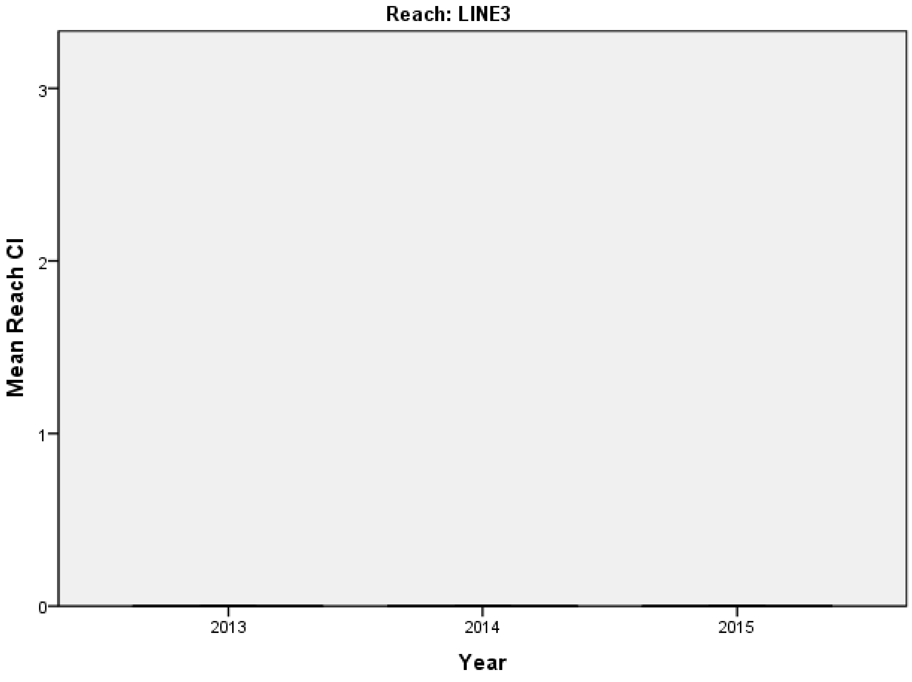
Error Bars: 95% CI


Reach: KILM1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

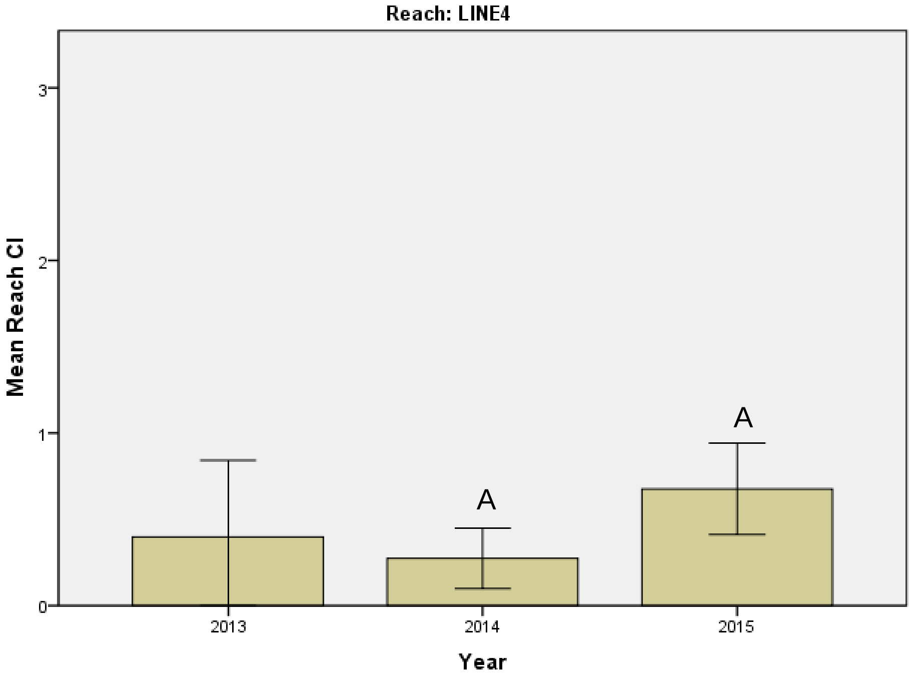

Reach: LIND1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI


Reach: LINE1
Mean Reach CI
0
1
2
3
A
B
A
B
2013
2014
2015
Year
Error Bars: 95% CI

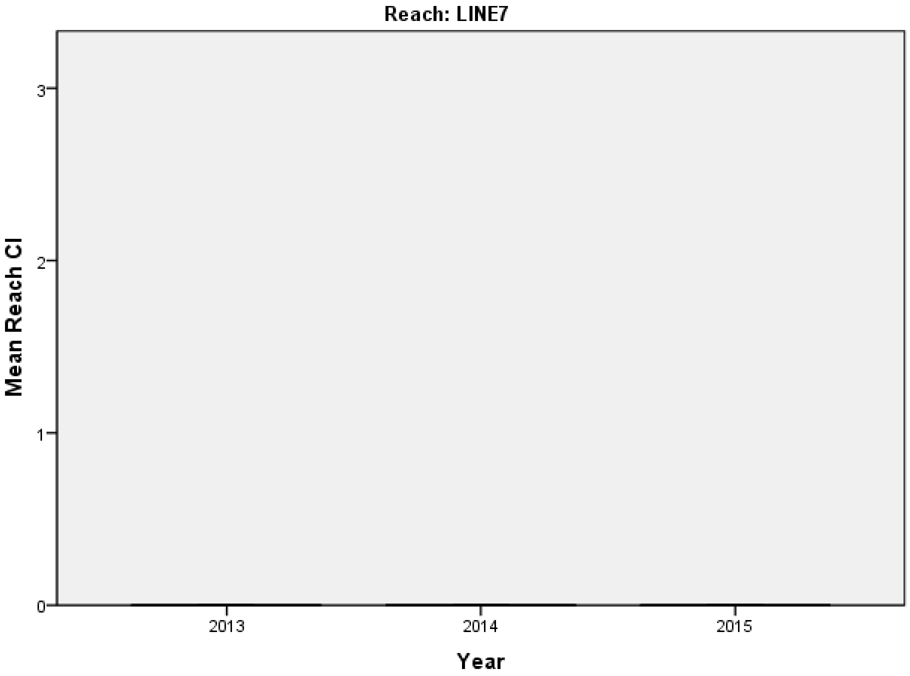

Reach: LINE2
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI



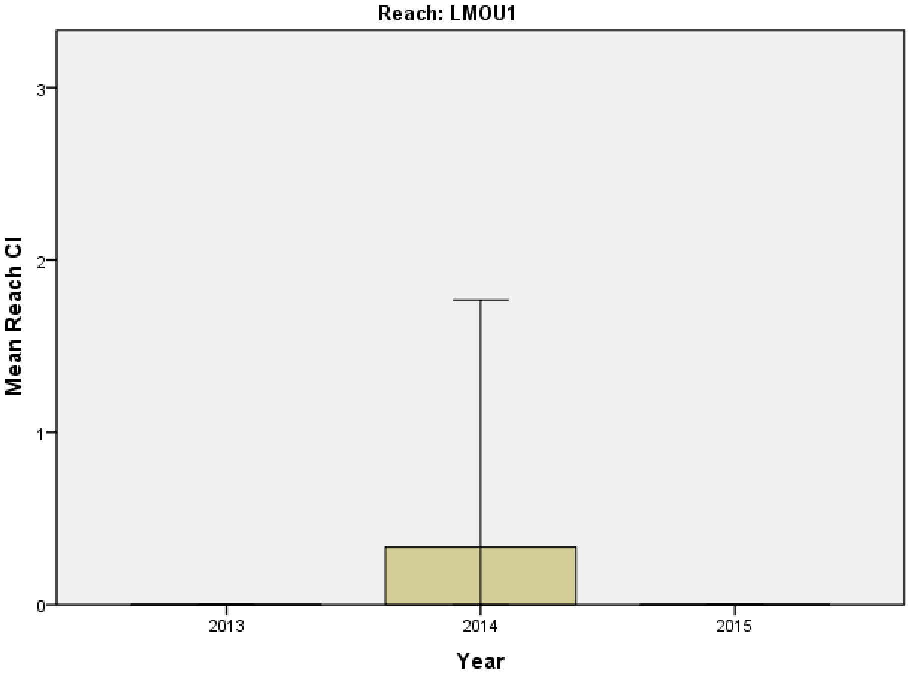
Error Bars: 95% CI



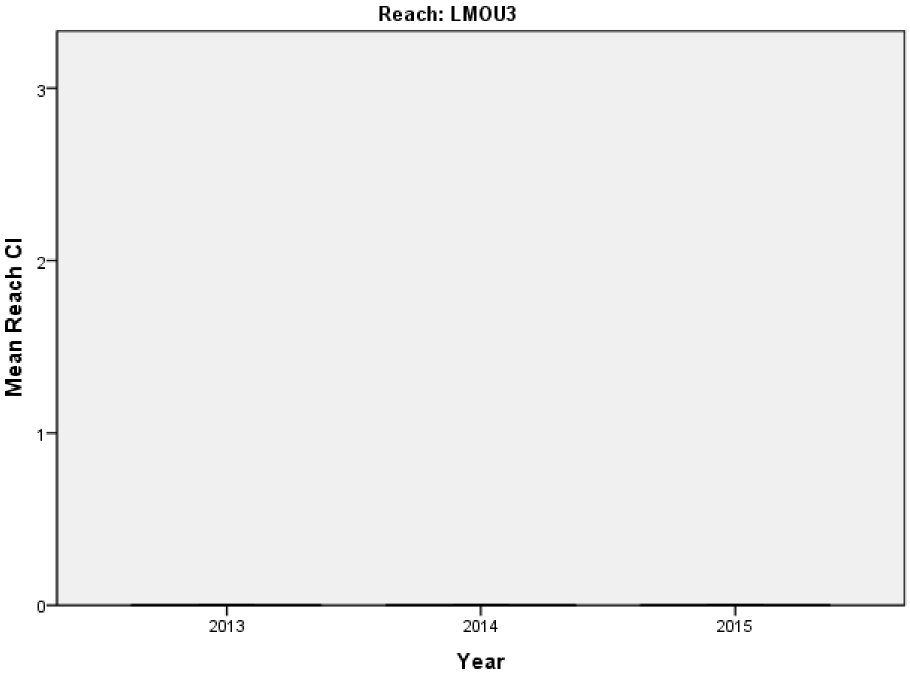
Error Bars: 95% CI



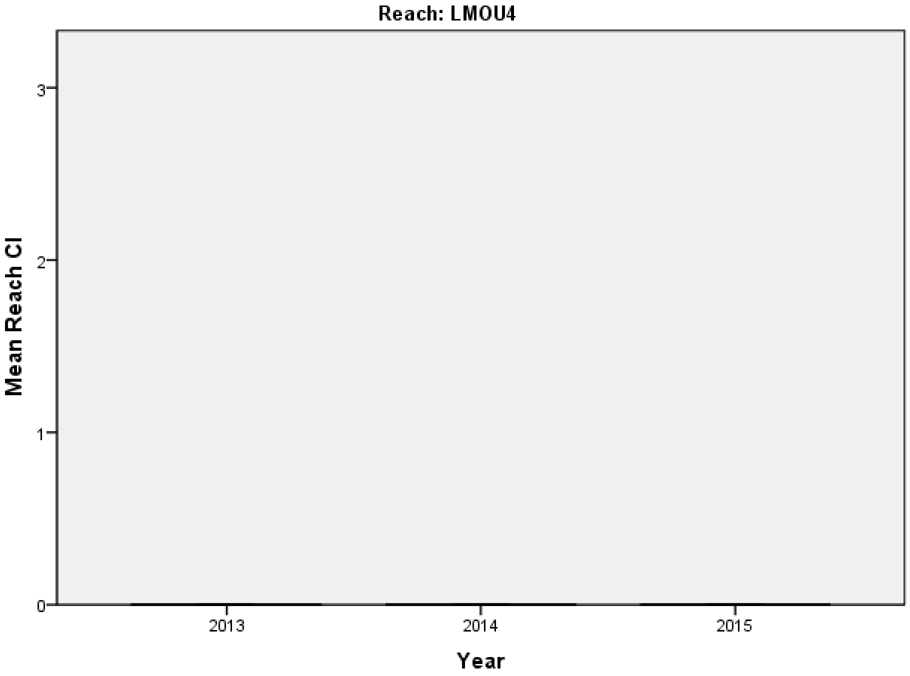
Error Bars: 95% CI



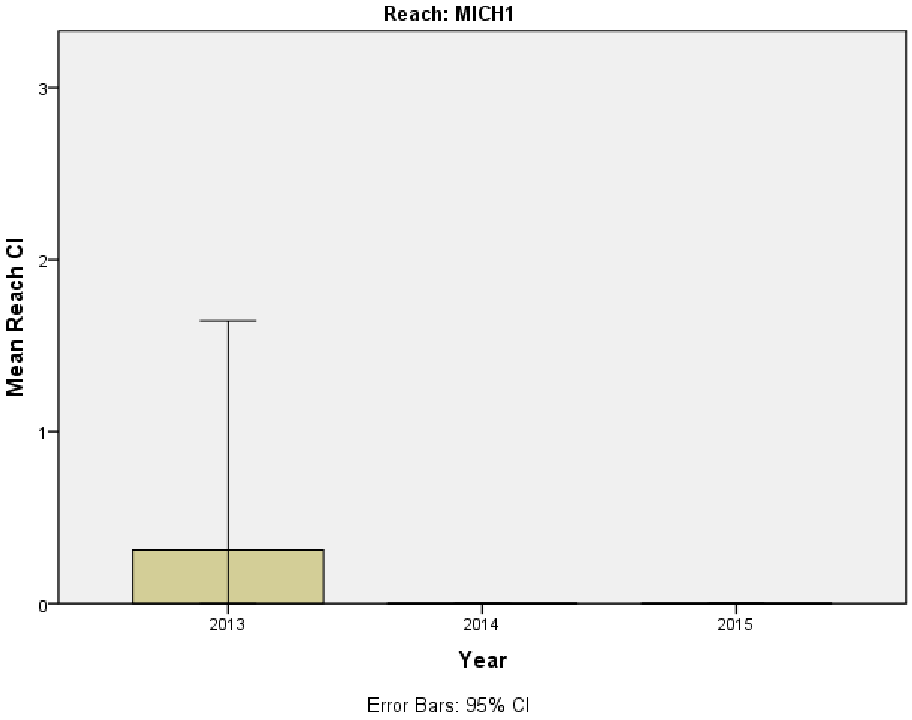
Error Bars: 95% CI

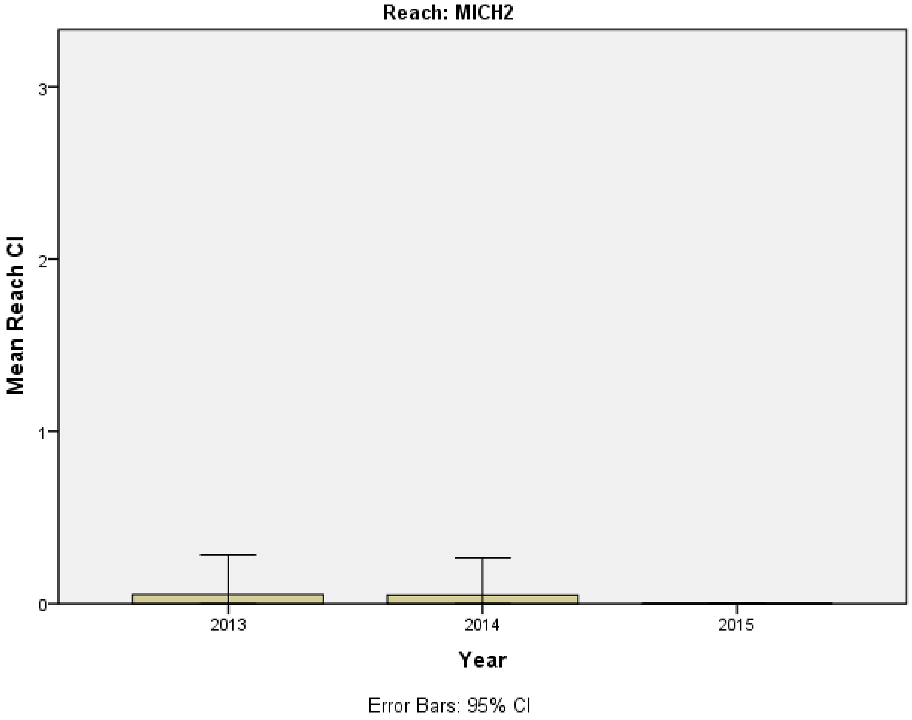


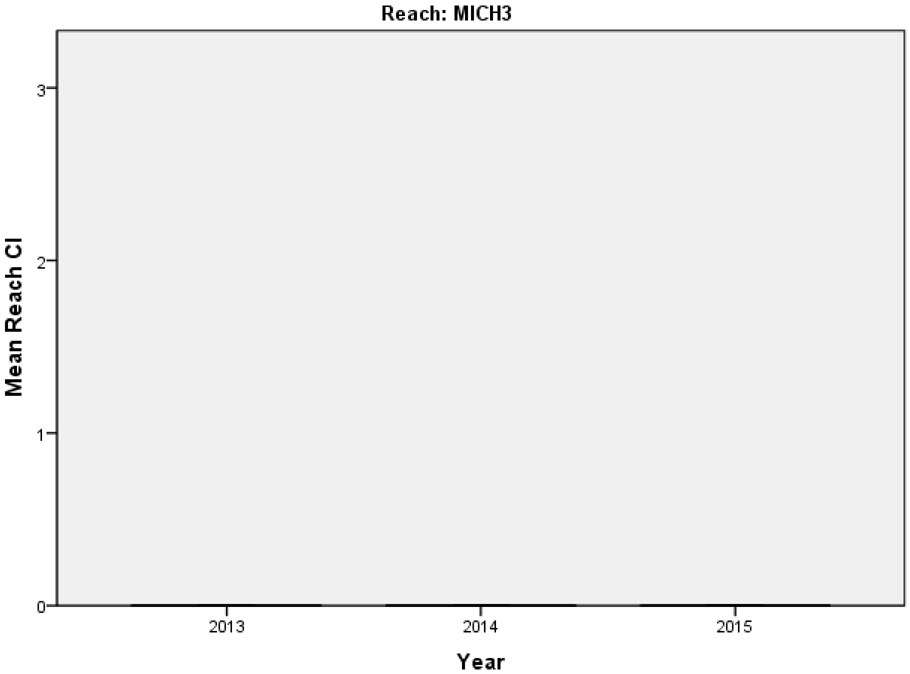
Error Bars: 95% CI



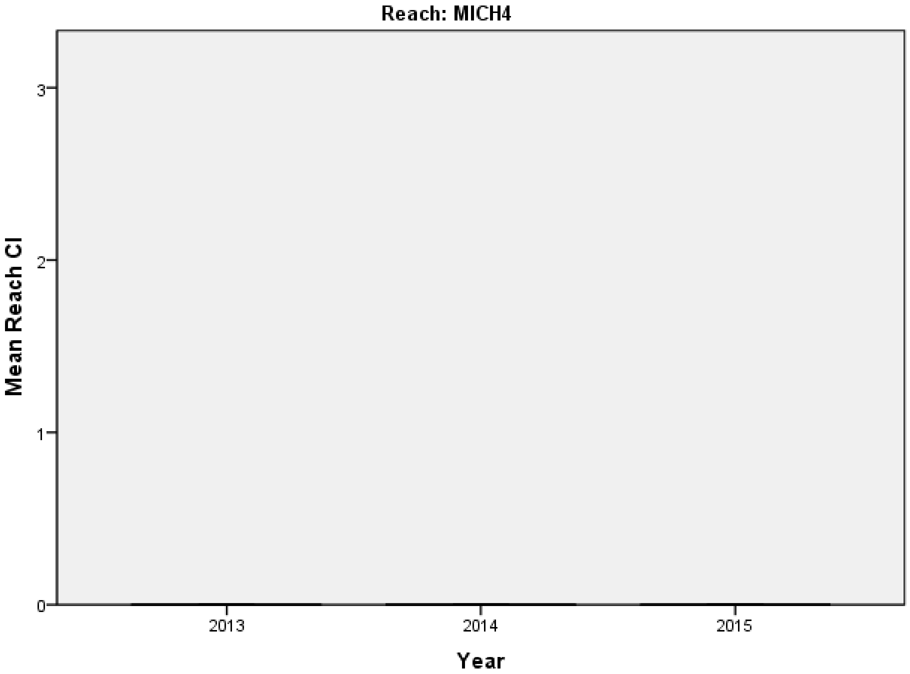
Error Bars: 95% CI


Reach: MICH1
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI

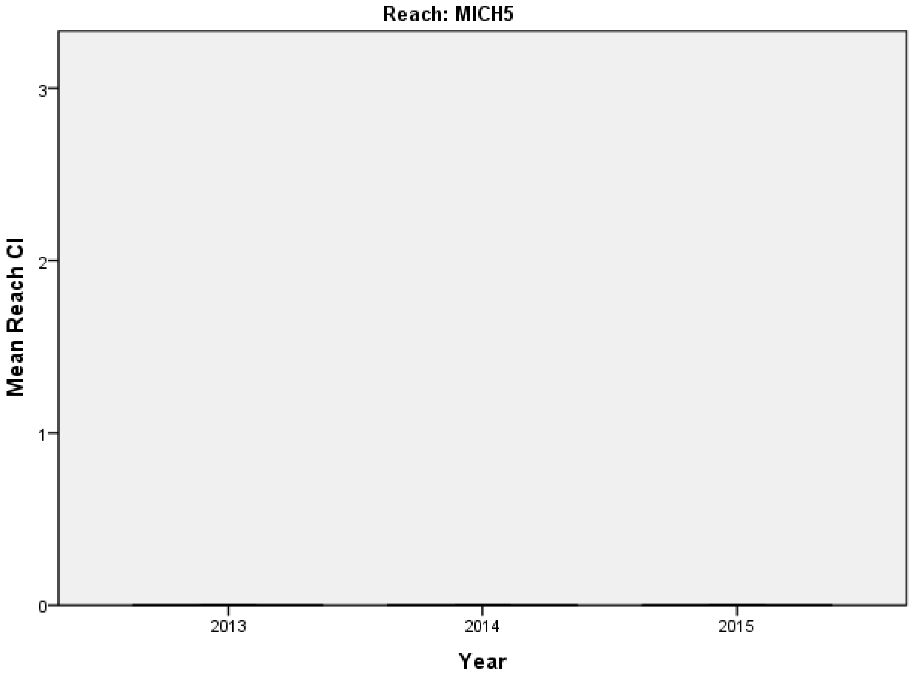

Reach: MICH2
Mean Reach CI
3
2
1
0
2013
2014
2015
Year
Error Bars: 95% CI



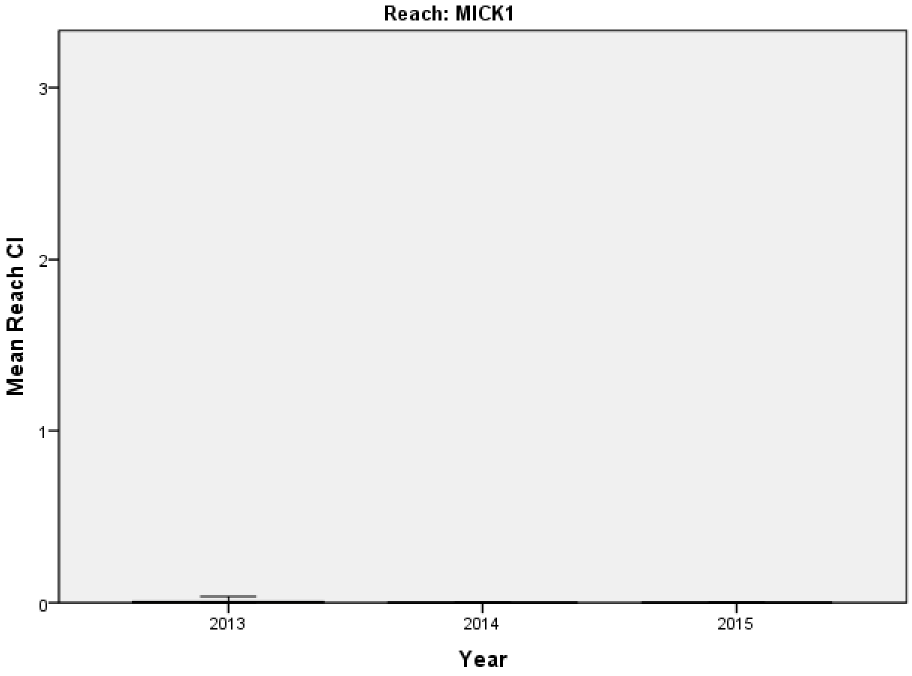
Error Bars: 95% CI



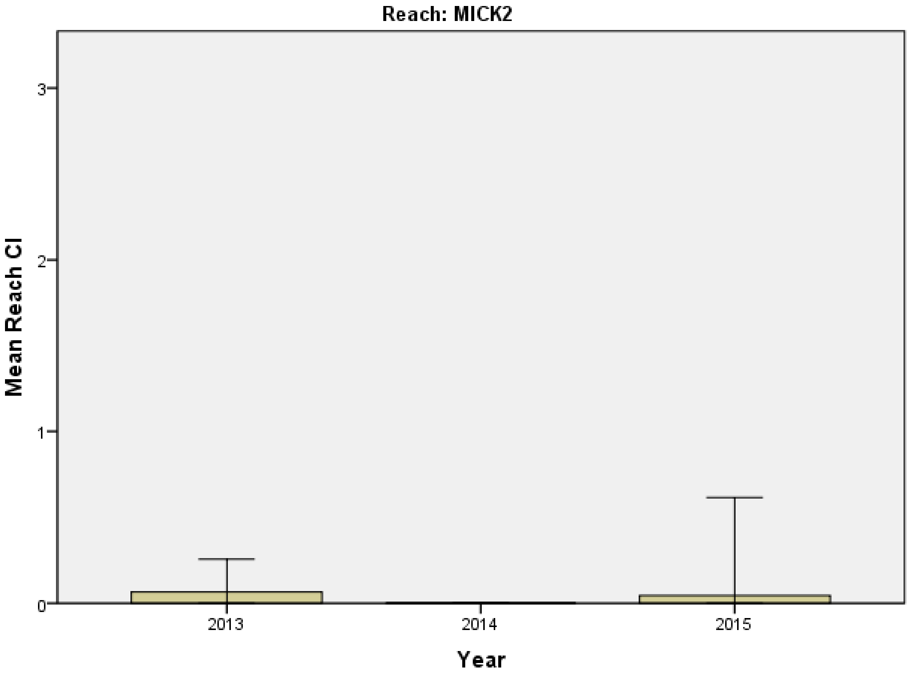
Error Bars: 95% CI



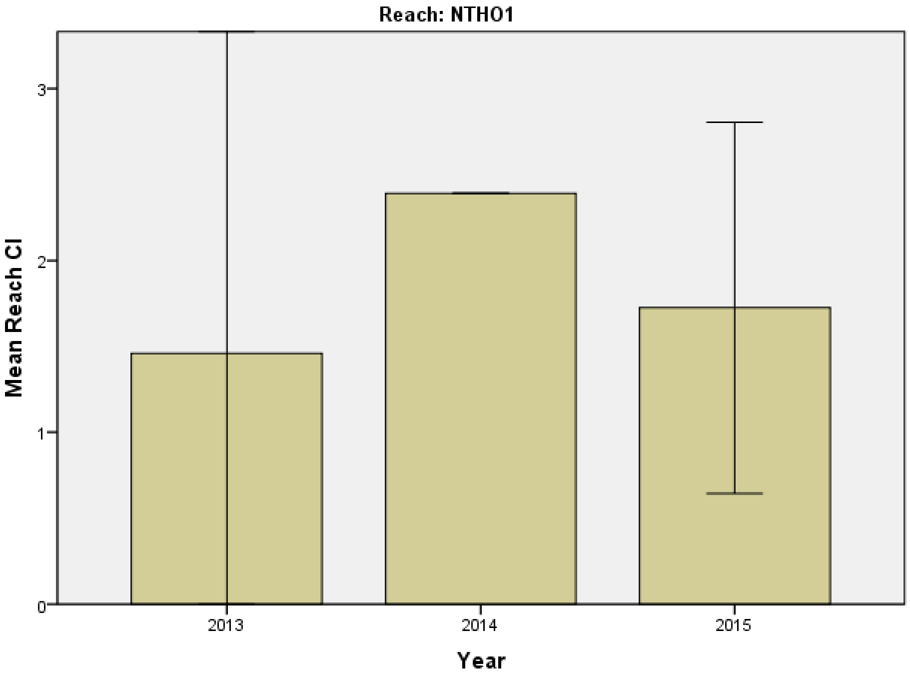
Error Bars: 95% CI



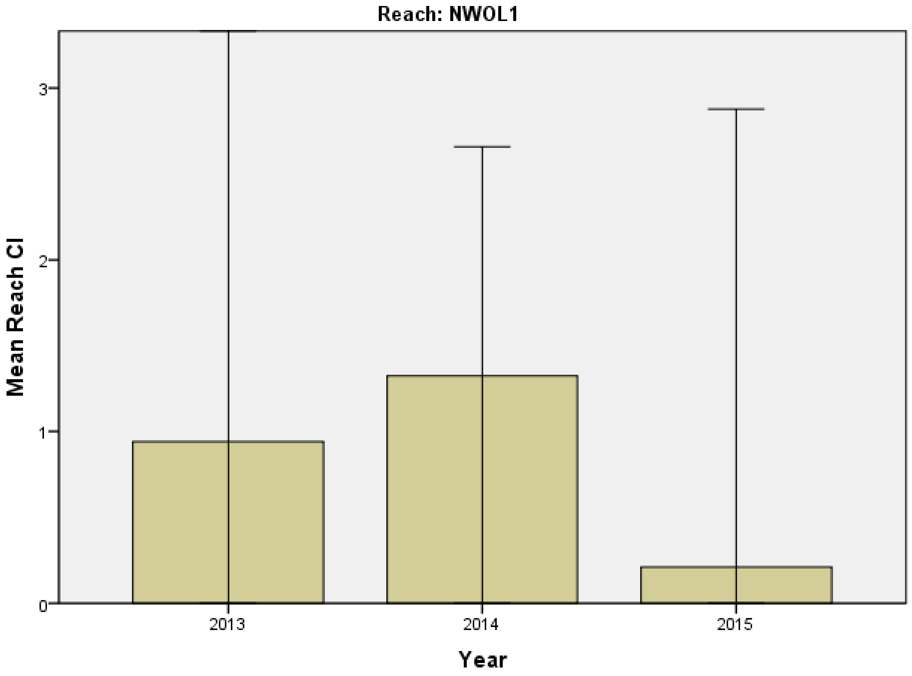
Error Bars: 95% CI



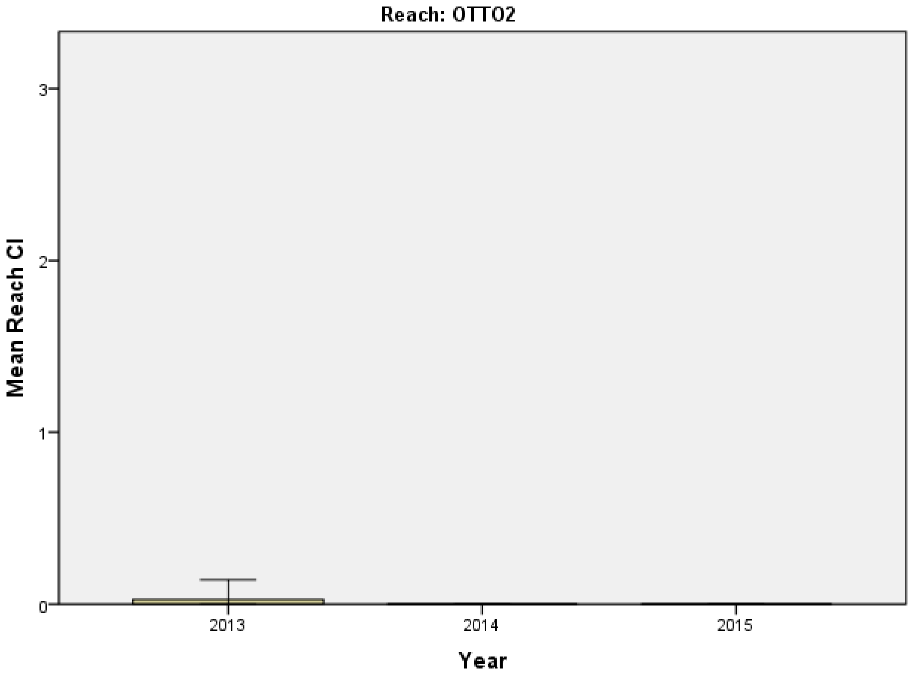
Error Bars: 95% CI



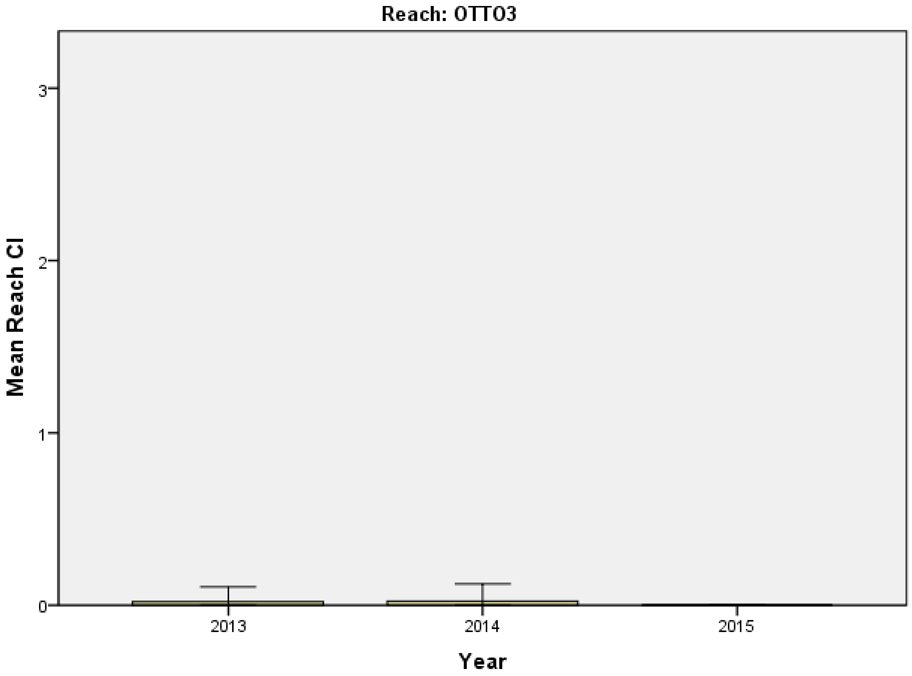
Error Bars: 95% CI



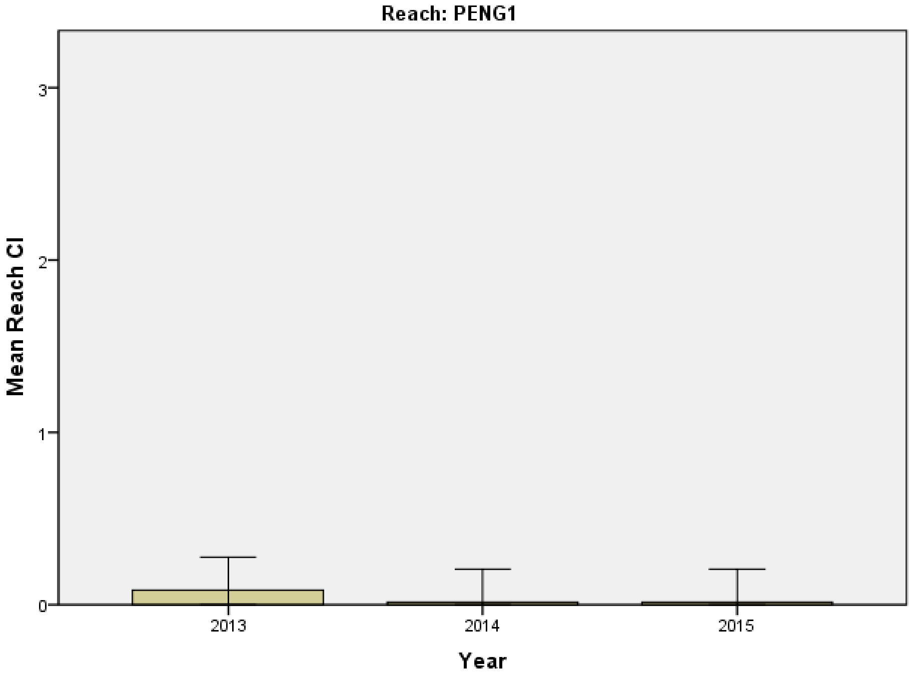
Error Bars: 95% CI



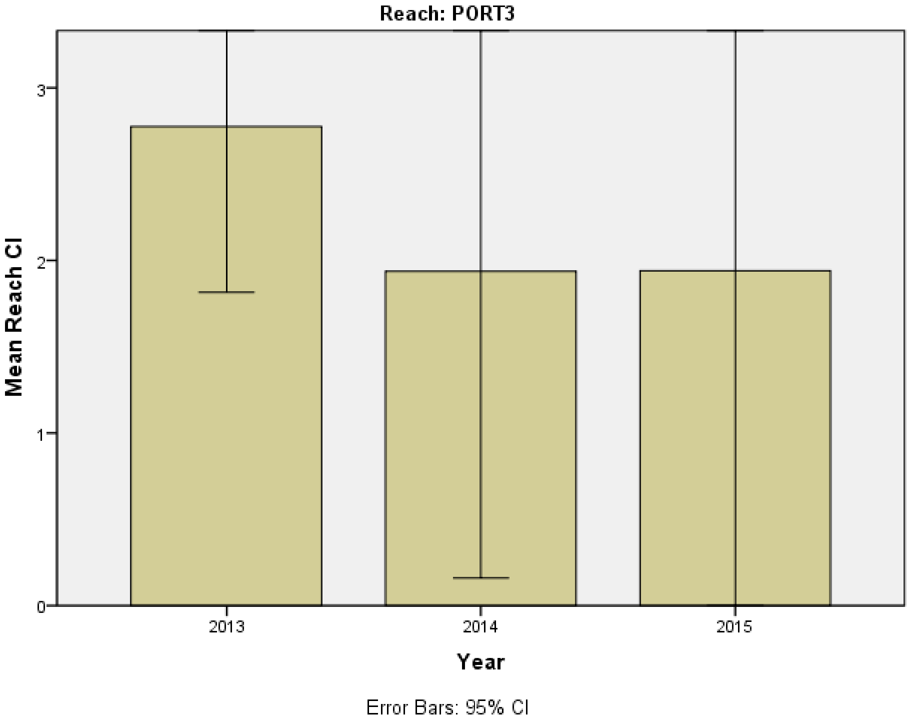
Error Bars: 95% CI

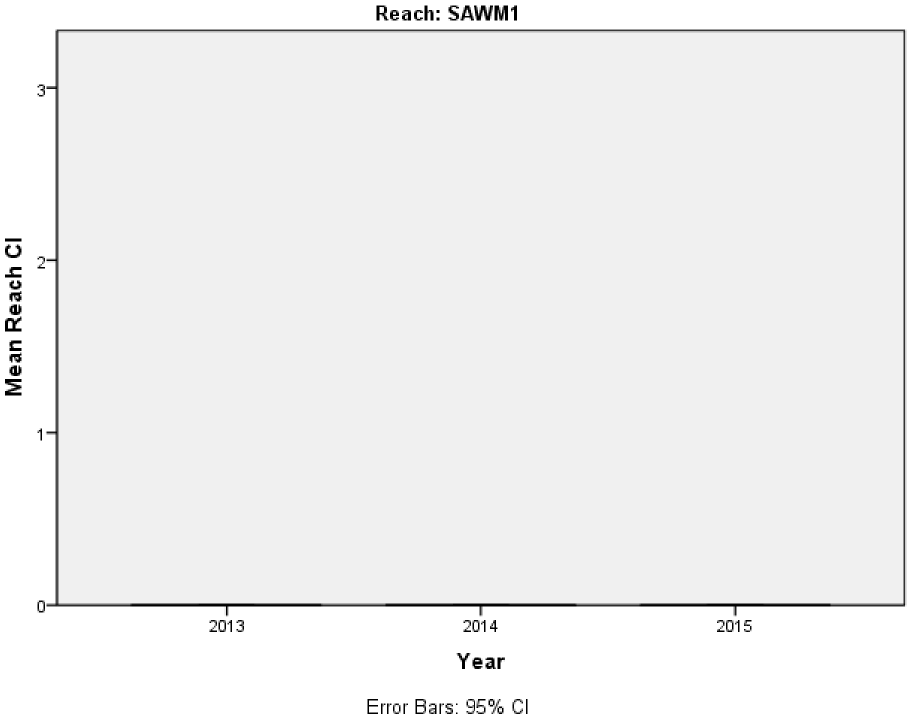


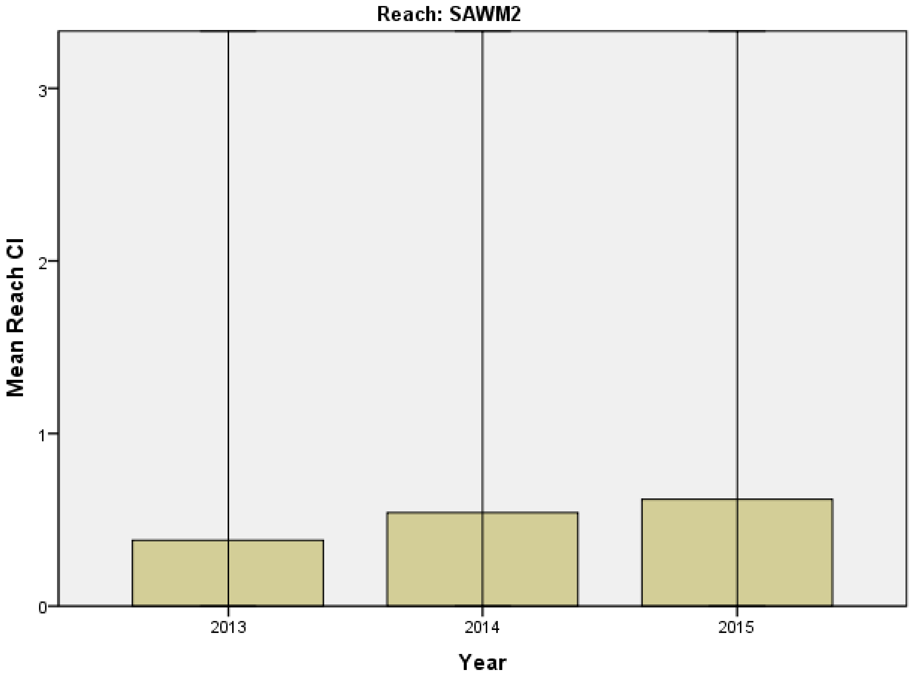
Error Bars: 95% CI



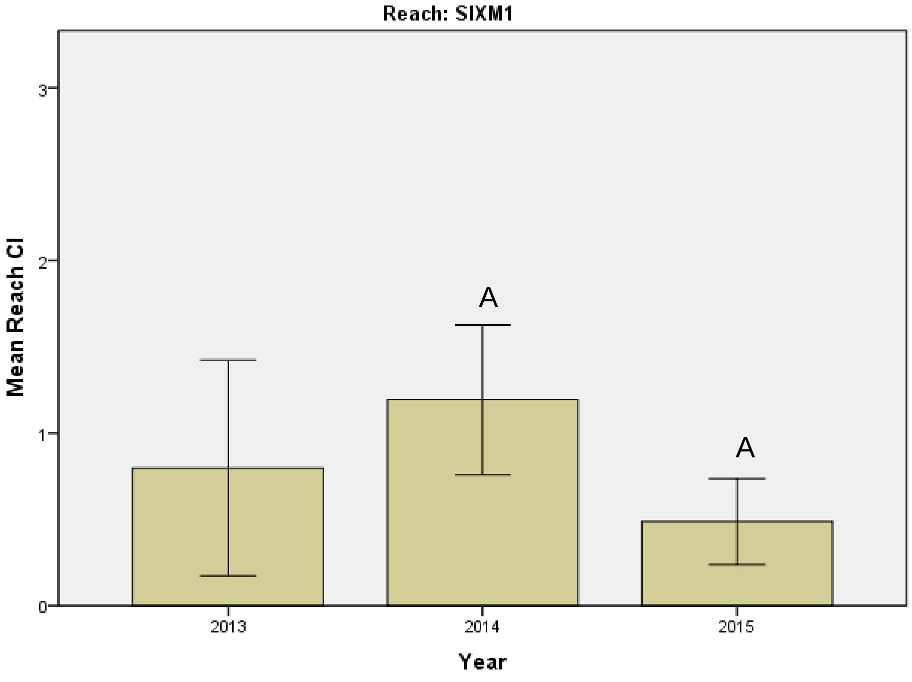
Error Bars: 95% CI


Reach: PORT3
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

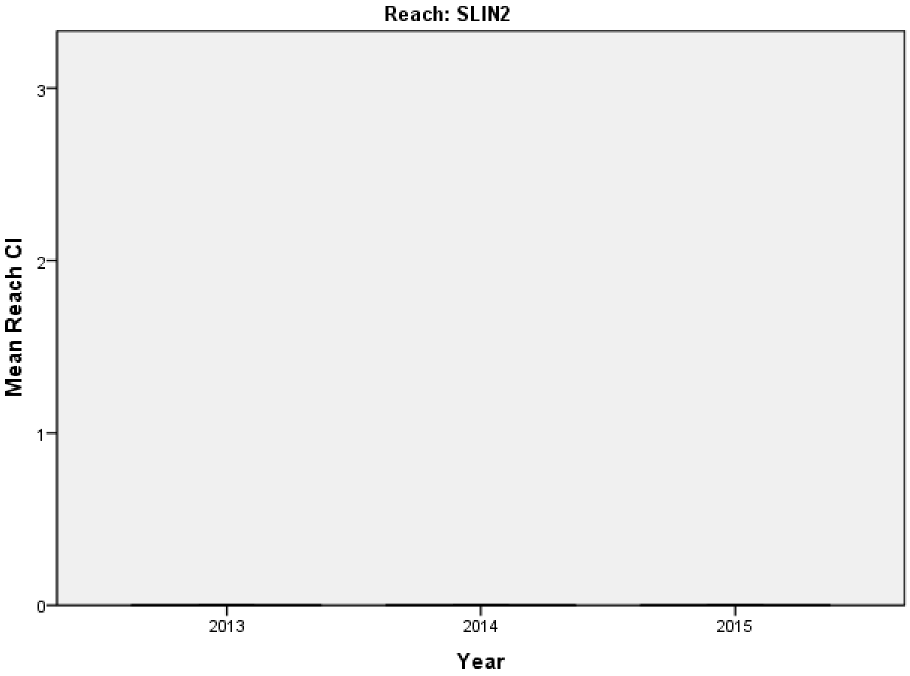

Reach: SAWM1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI



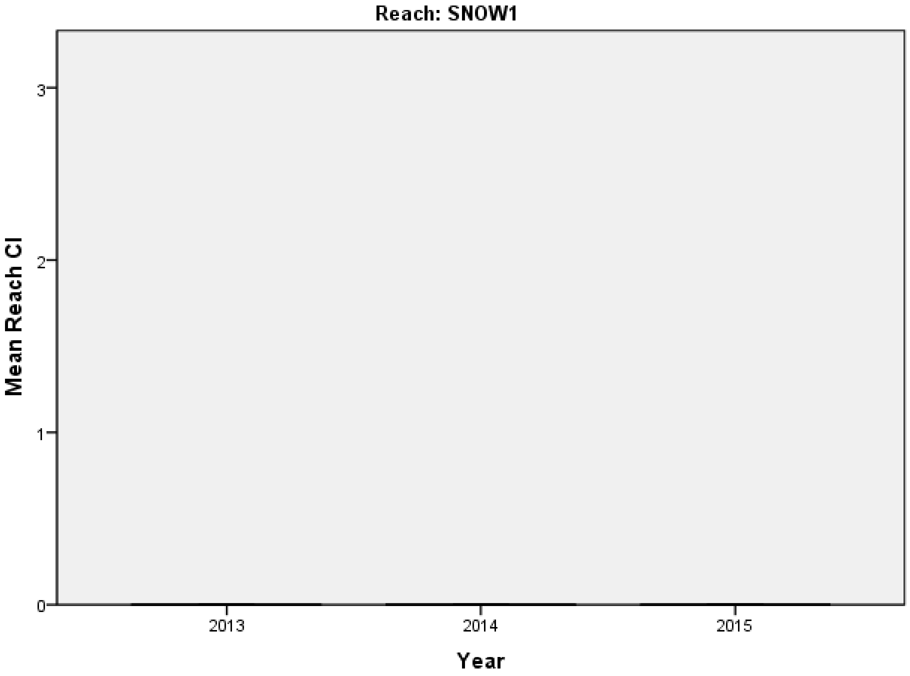
Error Bars: 95% CI



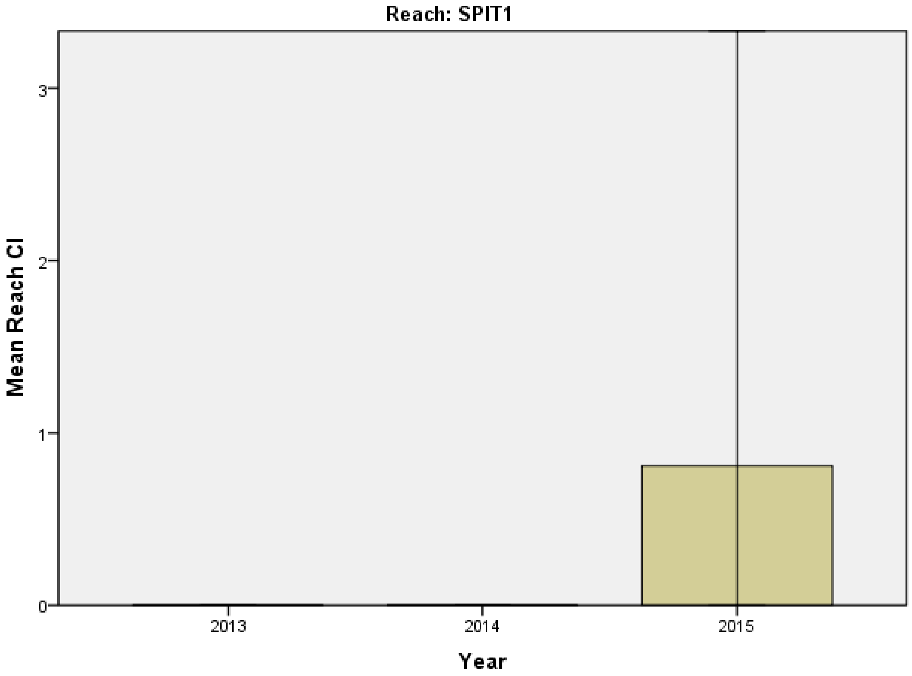
Error Bars: 95% CI



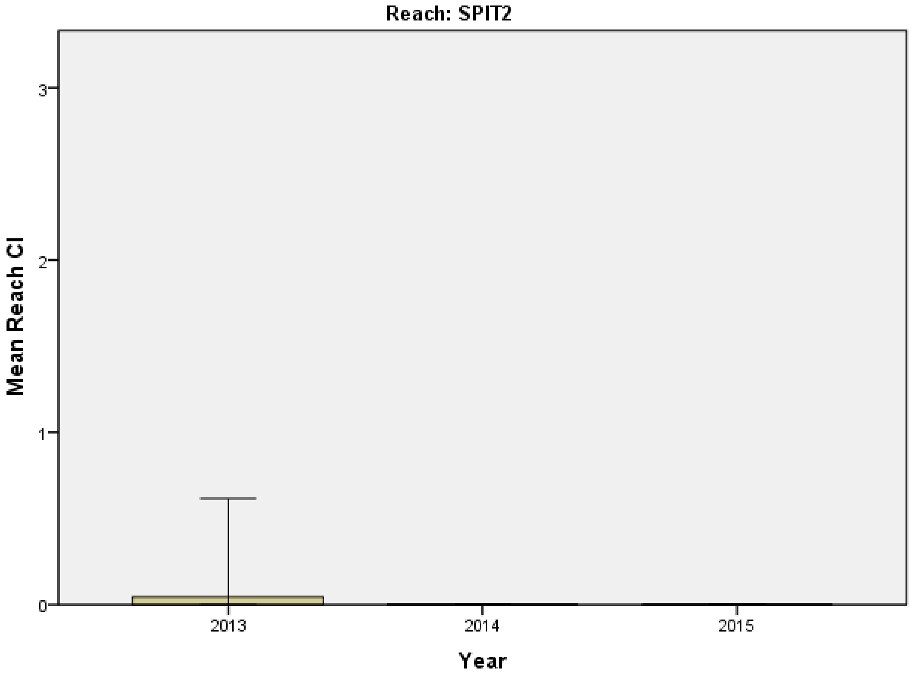
Error Bars: 95% CI



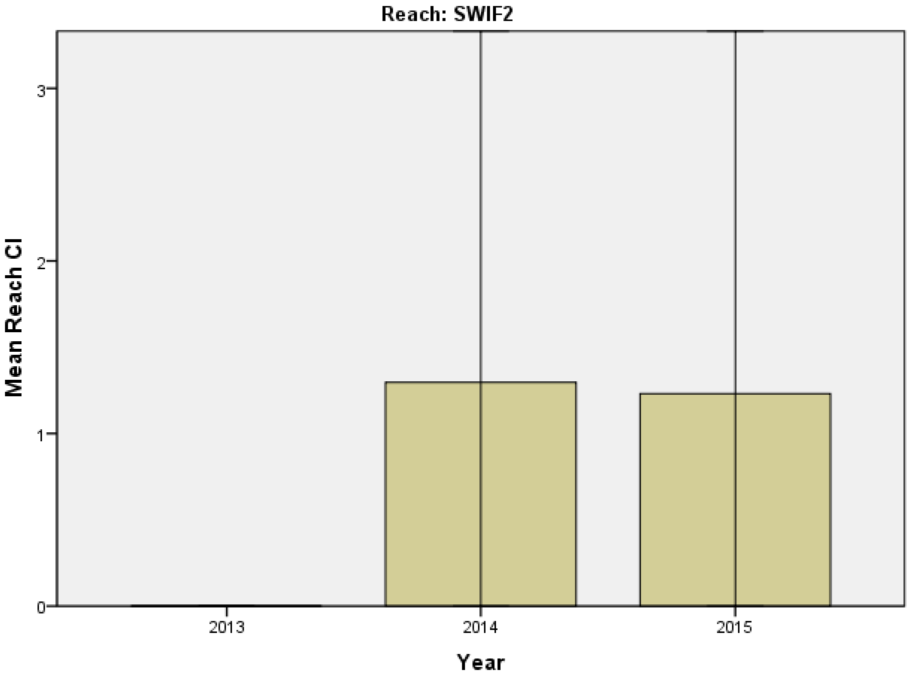
Error Bars: 95% CI



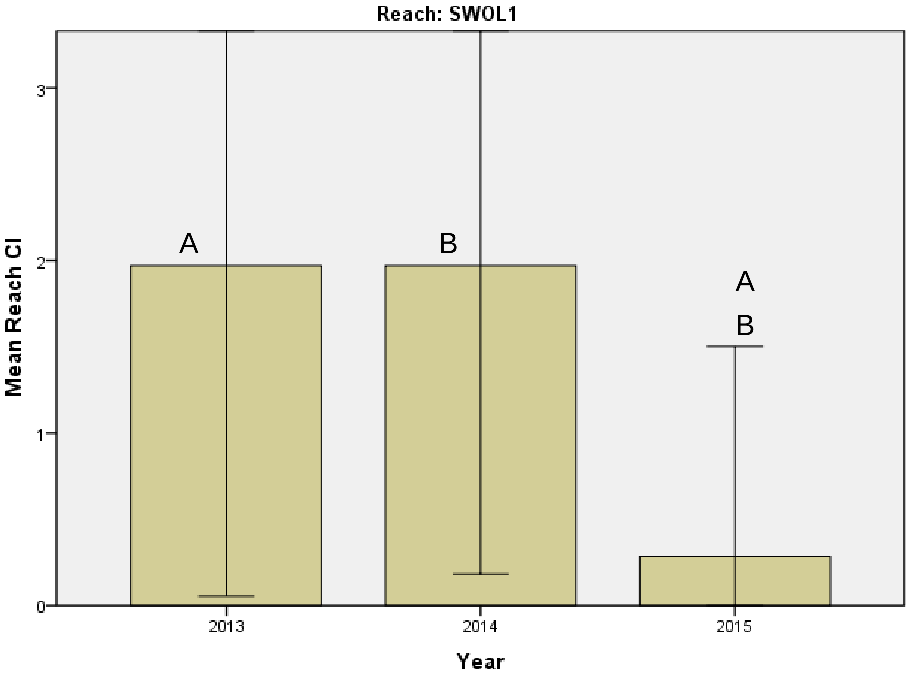
Error Bars: 95% CI



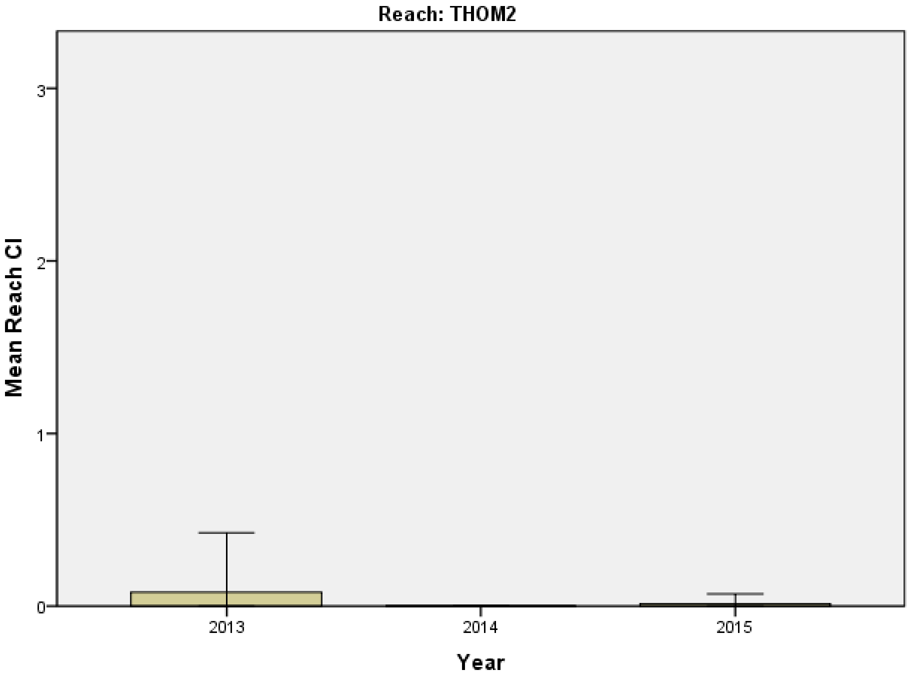
Error Bars: 95% CI



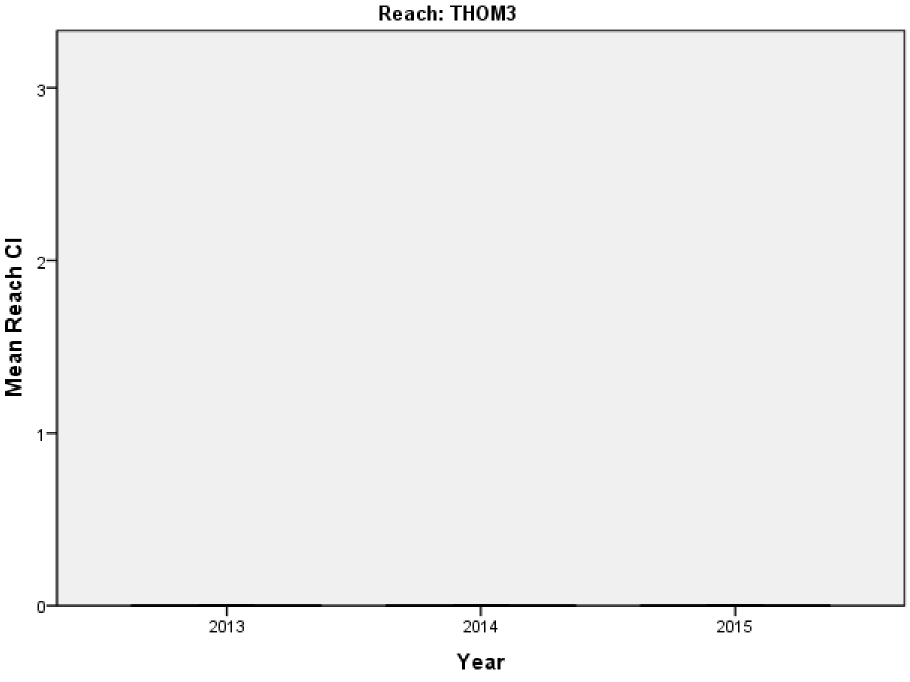
Error Bars: 95% CI



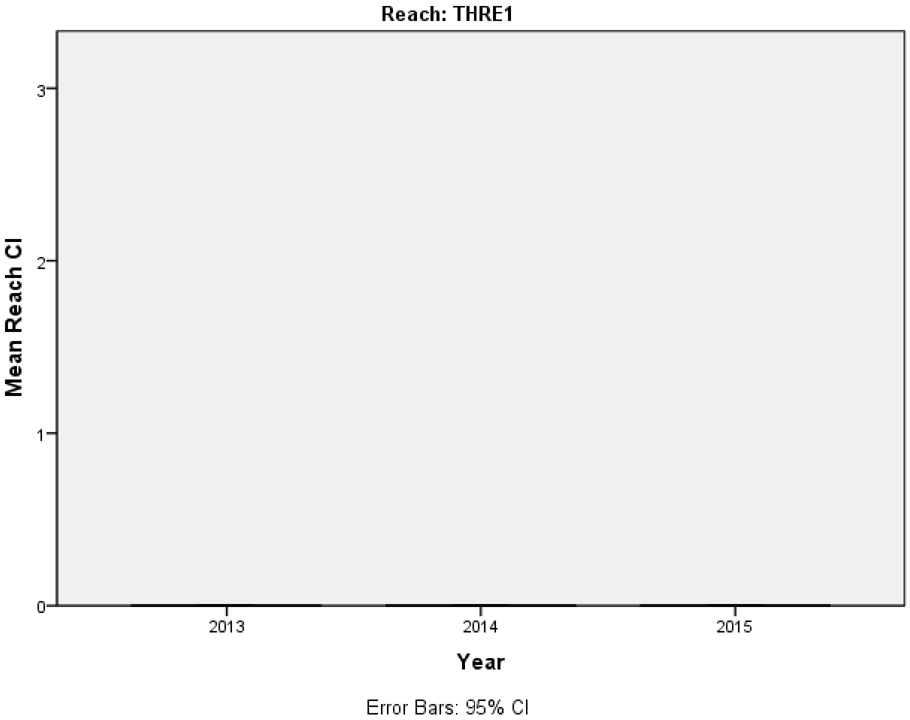
Error Bars: 95% CI

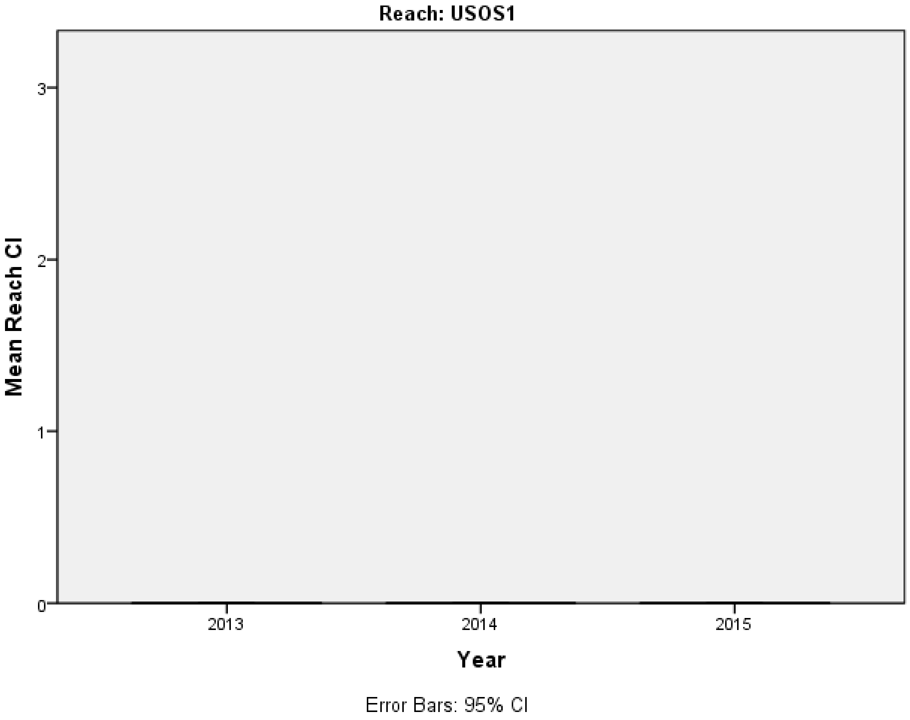


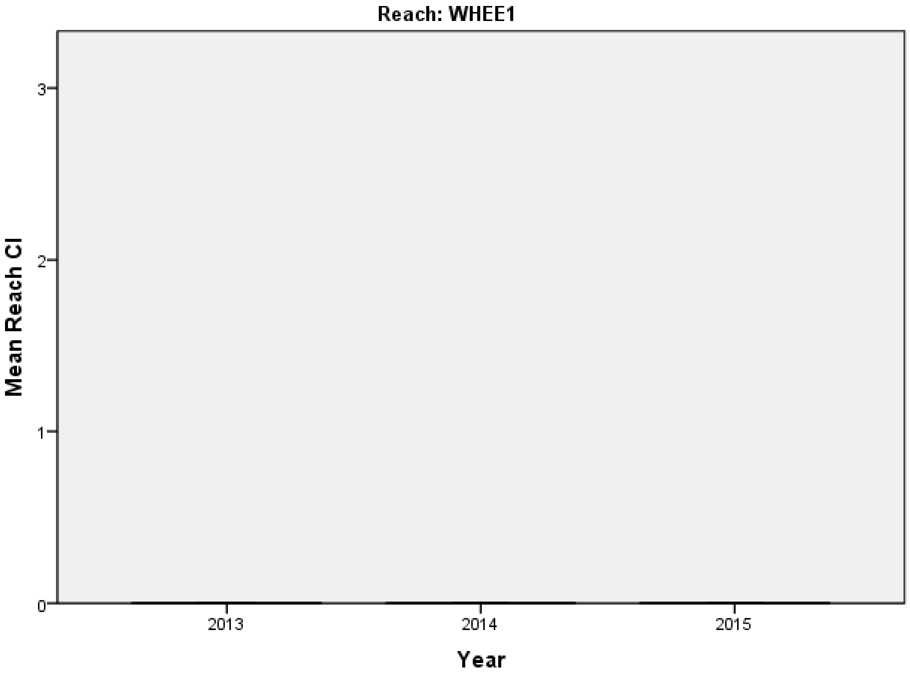
Error Bars: 95% CI



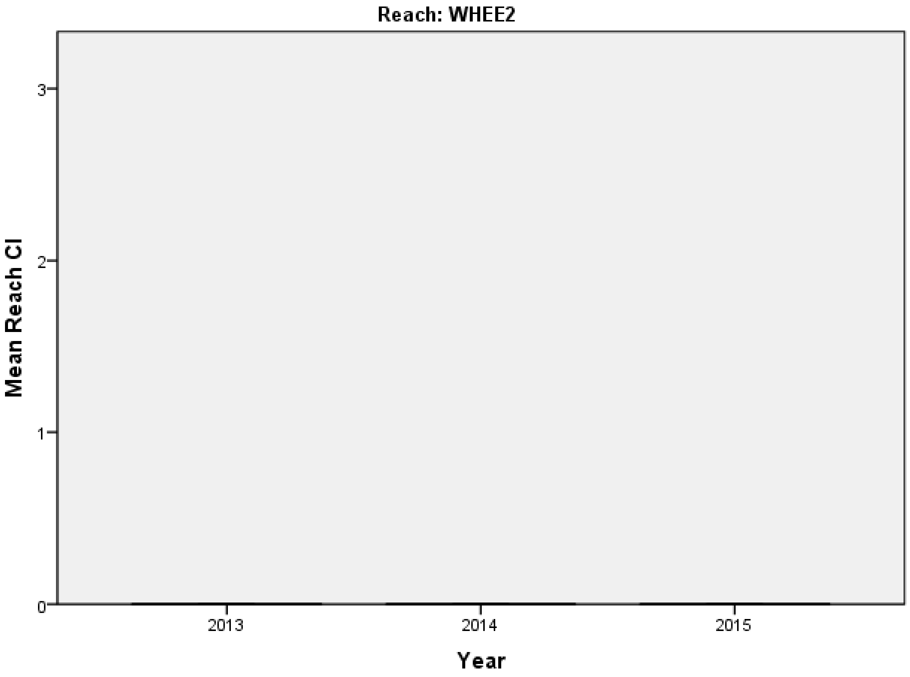
Error Bars: 95% CI


Reach: THRE1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI

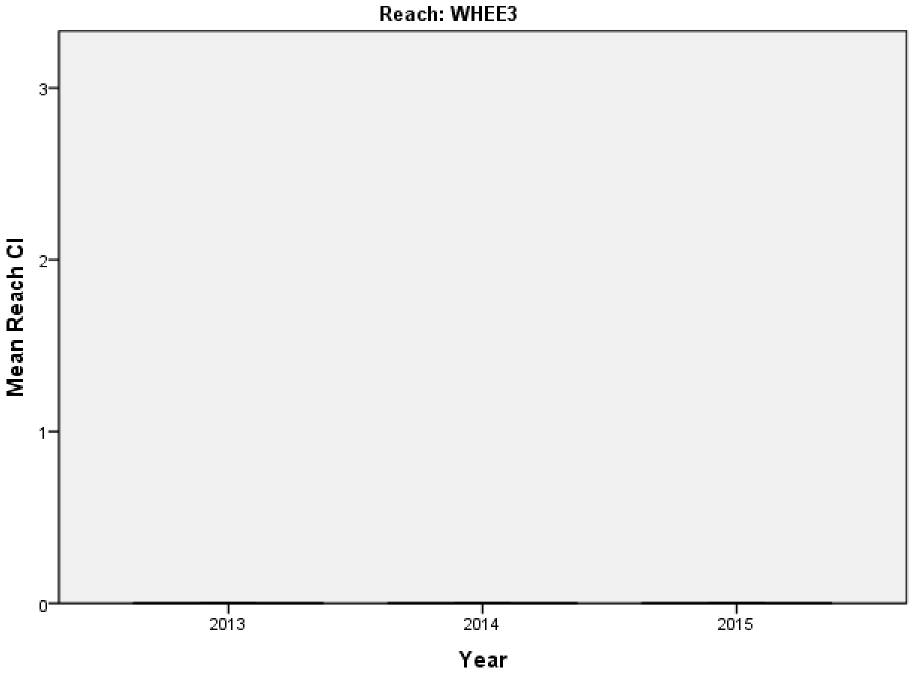

Reach: USOS1
Mean Reach CI
0
1
2
3
2013
2014
2015
Year
Error Bars: 95% CI



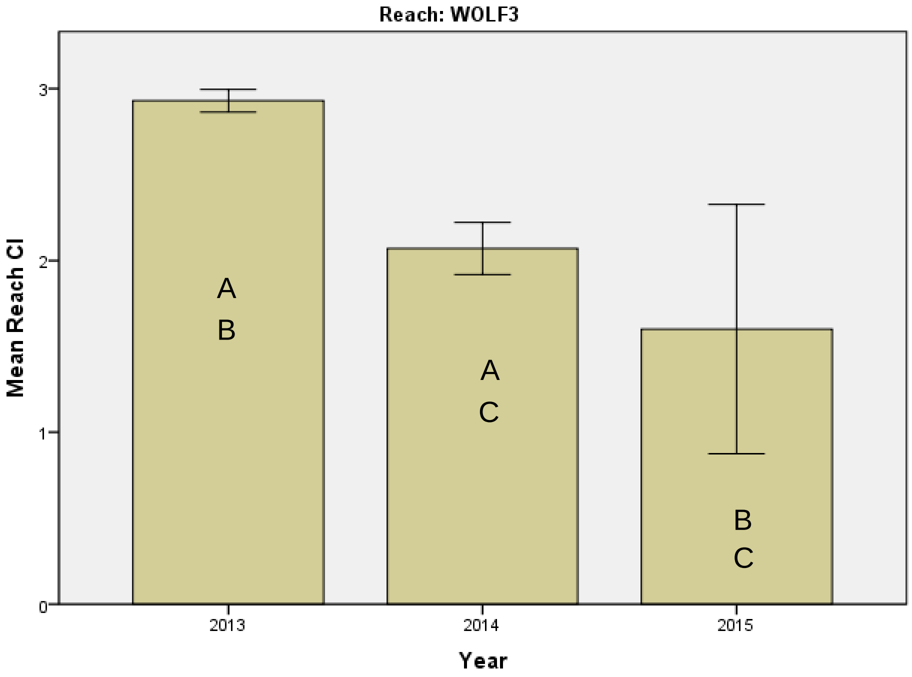
Error Bars: 95% CI



Error Bars: 95% CI



Error Bars: 95% CI



Error Bars: 95% CI