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Subject Matter Expert Report: FOOD AVAILABILITY. Evaluation of Cause - Decline in Upper Fording River Westslope Cutthroat Trout Population

Prepared for:
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March 2021

Subject Matter Expert Report:
FOOD AVAILABILITY.
Evaluation of Cause - Decline in Upper Fording River Westslope Cutthroat Trout Population

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Suggested Citation:

Orr, P. and Ings, J. 2021. Subject Matter Expert Report: Food Availability. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population. Prepared for Teck Coal Limited. Prepared by Minnow Environmental Inc. March.

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EXECUTIVE SUMMARY

In 2012, Teck Coal Limited (Teck Coal) commissioned the Upper Fording River Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) Population Assessment and Telemetry Project, which took place from August 2012 to November 2015 (Cope et al. 2016). The project concluded that the upper Fording River population metrics of adult abundance (2,552 to 3,874 fish greater than 20 cm), habitat availability (57.5 km of mainstem river plus 59 km of tributary), and genetic integrity (pure strain) represented a viable Westslope Cutthroat Trout population. Trend monitoring continued after 2015 in alternate years, consistent with recommendations from Cope et al. (2016). Adults decreased from 1,573 counted fish in 2017 to 104 counted fish in 2019, representing a 93% decline (Cope 2020). Teck Coal immediately assembled a team of Subject Matter Experts (SME) and a project leader to undertake an Evaluation of Cause (EoC). This document, which evaluates if a reduction in food availability contributed to the population decline, is one of a series of SME reports undertaken as part of the EoC.

Westslope Cutthroat Trout forage opportunistically on whatever prey items are seasonally abundant, typically feeding on drifting or benthic aquatic invertebrates, with summer supplements of terrestrial invertebrates. Aquatic invertebrates of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), and Diptera (true flies) are important dietary items.

This study evaluates three hypotheses related to food availability:

1. Did starvation cause or contribute to the Westslope Cutthroat Trout population decline?
2. Did aquatic invertebrates decrease sufficiently to cause or contribute to the Westslope Cutthroat Trout population decline through starvation?
3. Did terrestrial invertebrates decrease sufficiently to cause or contribute to the Westslope Cutthroat Trout population decline through starvation?

The first tier of the study evaluated fish condition, which is the relationship between fish weight and length, to address Hypothesis #1. Such data represent direct evidence of potential Westslope Cutthroat Trout starvation. Body condition, measured as mean weight-at-length, of 192 juvenile Westslope Cutthroat Trout (> 6 cm to about 30 cm) sampled throughout the upper Fording River in August 2019 was within the range of means observed for juvenile trout monitored in 2013 through 2015. Although the data set was spatially limited for 2018, mean weights-at-length of juvenile trout sampled in lower Greenhills Creek and lower LCO Dry Creek, which are important spawning and rearing areas in the upper Fording River (Cope et al. 2016), did not differ in 2018 from 2017. Moreover, the consistency of juvenile trout condition factors (K) reported since 1983 suggest a single-year decline in food availability in 2018, followed by full recovery in 2019, would be unlikely. Also, sixteen mature[1] trout sampled non-lethally in September 2018 as part of the Regional Aquatic Effects Monitoring Program (RAEMP; Minnow 2020c) had condition factors within the range reported by Cope et al. (2016) for 726 mature trout sampled throughout the upper Fording River in 2012 through 2014. Nine mature trout captured in Henretta Lake in February-March 2019 also had condition factors in the range reported for the mature trout sampled in 2012 through 2014. However, condition factors for 23 of 25 (92%) of the mature fish captured in 2018-2019 were less than the median of condition factors for fish captured in 2012-2014, and 14 of 25 fish (56%) captured in 2018-2019 had condition factors less than the 10th percentile of 2012-2014 values.

The second tier of the study involved evaluation of potential changes in food supply. Aquatic invertebrate food supply (Hypothesis #2) was evaluated by comparing benthic invertebrate biomass, density, and community characteristics in 2018 and 2019 to those observed in previous years. Fourteen (14) of 17 comparisons for biomass (82%) and 13 of 17 comparisons for density (76%) indicated no change in 2018 or 2019 compared to 2017 based on Hess sampling. This means that any differences in biomass or density observed in September 2018 or 2019 compared to 2017 were few and localized. Six benthic community endpoints derived from kick and sweep sampling were assessed for 16 monitoring areas in the upper Fording River in September of both 2018 and 2019 compared to both the previous year and the mean of all prior years since September 2012. Four of the 384 comparisons (1%) showed a decrease in 2018 or 2019, whereas 99% of comparisons showed no change or an increase. These results indicated that the quantity and quality of benthic invertebrates in the upper Fording River during the summer growing period has remained stable since 2012. Benthic invertebrate abundances were monitored in additional months of 2018 and 2019. In 65 of 68 comparisons (91%), benthic abundances at mine-exposed areas in June, September and December were either comparable to, or higher than, invertebrate abundances at reference areas that were monitored in the same month. This included high total aquatic invertebrate abundances and high Ephemeroptera, Plecoptera, and Trichoptera (EPT; mayfly, stonefly, and caddisfly) abundances in December 2018 and 2019 in the Westslope Cutthroat Trout overwintering area upstream from Chauncey Creek relative to the single reference area monitored that month.

To evaluate potential reductions in terrestrial invertebrate supply to aquatic drift (Hypothesis #3), riparian habitat and mine disturbance areas in 2019 were compared to conditions prior to September 2017. Total riparian habitat area in the upper Fording River watershed in 2019 was reduced by 0.7 km^2 in 2019 compared to 2015, representing a change of 2.3%. Broader land

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[1] Mature is defined as > 20 cm to be consistent with Cope et al. (2016)

disturbances due to mining and other causes (e.g., fire, forestry) both increased by about 6% over the same four-year period, representing an overall decline in undisturbed habitat of 2.4%. These changes were not large enough to infer reduction of terrestrial invertebrate inputs causing Westslope Cutthroat Trout starvation, especially considering their ability to also forage on drifting and benthic aquatic invertebrates.

It is concluded that the Westslope Cutthroat Trout population decline was not likely caused by starvation due to lack of food availability. The various lines of evidence presented in this report all corroborated each other, giving strength to this conclusion.

However, it cannot be concluded with certainty that starvation was not a contributing factor in the upper Fording River Westslope Cutthroat Trout population decline. Factors such as low flow and early drying of portions of the upper Fording River in summer-fall 2018 may have resulted in below-average lipid storage among trout in the fall of 2018. Subsequent extreme cold in February 2019 potentially resulted in reduced foraging and digestion efficiencies and increased energy demands leading to above-average winter mortality rates.

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ACRONYMS, ABBREVIATIONS, AND UNITS

ANOVA – Analysis of Variance

ANCOVA – Analysis of Covariance

BC – British Columbia

BEC - Biogeoclimatic Ecosystem Classifications

°C – degrees Celsius

CABIN – Canadian Aquatic Biomonitoring Network (Environment Canada 2012a).

cm - centimetres

CWB – Corporate Watershed Base

DC – direct current (electrofisher)

EPT – Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies)

EVWQP – Elk Valley Water Quality Plan

FRO – Fording River Operation

g - grams

GIS – Geographic Information System

GHO – Greenhills Operation

K – condition factor

KS – Kolmogorov-Smirnov statistical test

km – kilometres

L - litre

LAEMP – Local Aquatic Effects Monitoring Program

LCO – Line Creek Operation

LPL – Lowest Practical Level, referring to taxonomic identification of benthic invertebrates

m - metres

mL - millilitre

mm - millimetre

MOD – magnitude of difference

ppm – parts per million

r – correlation coefficient

RAEMP – Regional Aquatic Effects Monitoring Program

SME – Subject Matter Expert

TRIM - Terrain Resource Information Management

µm – micrometres

% - percent

READER'S NOTE

What is the Evaluation of Cause and what is its purpose?

The Evaluation of Cause is the process used to investigate, evaluate, and report on the reasons the Westslope Cutthroat Trout population declined in the upper Fording River between fall 2017 and fall 2019.

Background

The Elk Valley is located in the southeast corner of British Columbia (BC), Canada. It contains the main stem of the Elk River (220 km long) and many tributaries, including the Fording River (70 km long). This report focuses on the upper Fording River, which starts 20 km upstream from its confluence with the Elk River at Josephine Falls. The Ktunaxa First Nation has occupied lands in the region for more than 10,000 years. Rivers and streams of the region provide culturally important sources of fish and plants.

The upper Fording River watershed is at a high elevation and is occupied by only one fish species, a genetically pure population of Westslope Cutthroat Trout *(Oncorhynchus clarkii lewisi)* — an iconic fish species that is highly valued in the area. This population is physically isolated because Josephine Falls is a natural barrier to fish movement. The species is protected under the federal Fisheries Act and the Species at Risk Act. In BC, the Conservation Data Center categorized Westslope Cutthroat Trout as "*imperiled or of special concern, vulnerable to extirpation or extinction.*" Finally, it has been identified as a priority sport fish species by the Province of BC.

The upper Fording River watershed is influenced by various human-caused disturbances including roads, a railway, a natural gas pipeline, forest harvesting and coal mining. Teck Coal Limited (Teck Coal) operates the three surface coal mines within the upper Fording River watershed, upstream of Josephine Falls: Fording River Operations, Greenhills Operations and Line Creek Operations.

Evaluation of Cause

Following identification of the decline in the Westslope Cutthroat Trout population, Teck Coal initiated an Evaluation of Cause process. The overall results of this process are reported in a separate document (Evaluation of Cause Team 2021) and are supported by a series of Subject Matter Expert reports.

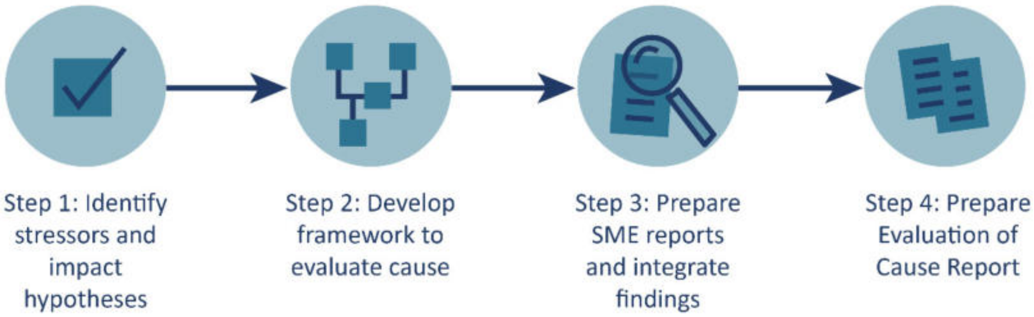
The report that follows this Reader's Note is one of those Subject Matter Expert Reports.

Monitoring conducted for Teck Coal in the fall of 2019 found that the abundance of Westslope Cutthroat Trout adults and sub-adults in the upper Fording River had declined significantly since previous sampling in fall 2017. In addition, there was evidence that juvenile fish density had decreased. Teck Coal initiated an Evaluation of Cause process. The overall results of this process are reported separately (Evaluation of Cause Team 2021) and are supported by a series of Subject Matter Expert reports such as this one. The full list of Subject Matter Expert reports follows at the end of this Reader's Note.

Building on, and in addition to the Evaluation of Cause, there are ongoing efforts to support fish population recovery and implement environmental improvements in the upper Fording River.

How the Evaluation of Cause was approached

When the fish decline was identified, Teck Coal established an Evaluation of Cause Team (the Team), composed of Subject Matter Experts and coordinated by an Evaluation of Cause Team Lead. Further details about the Team are provided in the Evaluation of Cause report. The Team developed a systematic and objective approach (see figure below) that included developing a Framework for Subject Matter Experts to apply in their specific work. All work was subjected to rigorous peer review.



Conceptual approach to the Evaluation of Cause for the decline in the upper Fording River Westslope Cutthroat Trout population.

With input from representatives of various regulatory agencies and the Ktunaxa Nation Council, the Team initially identified potential stressors and impact hypotheses that might explain the cause(s) of the population decline. Two overarching hypotheses (essentially, questions for the Team to evaluate) were used:

- Overarching Hypothesis #1: The significant decline in the upper Fording River Westslope Cutthroat Trout population was a result of a single acute stressor[2] or a single chronic stressor[3].
- Overarching Hypothesis #2: The significant decline in the upper Fording River Westslope Cutthroat Trout population was a result of a combination of acute and/or chronic stressors, which individually may not account for reduced fish numbers, but cumulatively caused the decline.

The Evaluation of Cause examined numerous stressors in the upper Fording River to determine if, and to what extent, those stressors and various conditions played a role in the Westslope Cutthroat Trout's decline. Given that the purpose was to evaluate the cause of the decline in abundance from 2017 to 2019[4], it was important to identify stressors or conditions that changed or were different during that period. It was equally important to identify the potential stressors or conditions that did not change during the decline window but may, nevertheless, have been important constraints on the population with respect to their ability to respond to or recover from the stressors. Finally, interactions between stressors and conditions had to be considered in an integrated fashion. Where an impact hypothesis depended on or may have been exacerbated by interactions among stressors or conditions, the interaction mechanisms were also considered.

The Evaluation of Cause process produced two types of deliverables:

1. **Individual Subject Matter Expert (SME) reports** (such as the one that follows this Note): These reports mostly focus on impact hypotheses under Overarching Hypothesis #1 (see list, following). A Framework was used to align SME work for all the potential stressors, and, for consistency, most SME reports have the same overall format. The format covers: (1) rationale for impact hypotheses, (2) methods, (3) analysis and (4) findings, particularly whether the requisite conditions[5] were met for the stressor(s) to be the sole cause of the fish population decline, or a contributor to it. In addition to the report, each SME provided a summary table of findings, generated according to the Framework. These summaries were used to integrate information for the Evaluation of Cause report. Note that some SME reports did not investigate specific stressors; instead, they evaluated other information considered potentially useful for supporting SME reports and the overall Evaluation of Cause, or added context (such as in the SME report that describes climate (Wright et al. 2021).

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[2] Implies September 2017 to September 2019.

[3] Implies a chronic, slow change in the stressor (using 2012–2019 timeframe, data dependent).

[4] Abundance estimates for adults/sub-adults are based on surveys in September of each year, while estimates for juveniles are based on surveys in August.

[5] These are the conditions that would need to have occurred for the impact hypothesis to have resulted in the observed decline of Westslope Cutthroat Trout population in the upper Fording River.

2. **The Evaluation of Cause report** (prepared by a subset of the Team, with input from SMEs): This overall report summarizes the findings of the SME reports and further considers interactions between stressors (Overarching Hypothesis #2). It describes the reasons that most likely account for the decline in the Westslope Cutthroat Trout population in the upper Fording River.

Participation, Engagement & Transparency

To support transparency, the Team engaged frequently throughout the Evaluation of Cause process. Participants in the Evaluation of Cause process, through various committees, included:

Ktunaxa Nation Council
BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
BC Ministry of Environment and Climate Change Strategy
Ministry of Energy, Mines, and Low Carbon Innovation
Environmental Assessment Office

Citation for the Evaluation of Cause Report

When citing the Evaluation of Cause Report use:

Evaluation of Cause Team. 2021. Evaluation of Cause — Decline in upper Fording River Westslope Cutthroat Trout population. Report prepared for Teck Coal Limited by Evaluation of Cause Team.

Citations for Subject Matter Expert Reports

Focus	**Citation for Subject Matter Expert Reports**
Climate, temperature, and streamflow	Wright, N., Greenacre, D., & Hatfield, T. (2021). *Subject Matter Expert Report: Climate, temperature, and streamflow trends. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.
Ice	Hatfield, T., & Whelan, C. (2021). *Subject Matter Expert Report: Ice. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. Report Prepared by Ecofish Research Ltd.

Focus	**Citation for** **Subject Matter Expert Reports**
Habitat availability (instream flow)	Healey, K., Little, P., & Hatfield, T. (2021). *Subject Matter Expert Report: Habitat availability. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – ramping	Faulkner, S., Carter, J., Sparling, M., Hatfield, T., & Nicholl, S. (2021). *Subject Matter Expert Report: Ramping and stranding. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – channel dewatering	Hatfield, T., Ammerlaan, J., Regehr, H., Carter, J., & Faulkner, S. (2021). *Subject Matter Expert Report: Channel dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited by Ecofish Research Ltd.
Stranding – mainstem dewatering	Hocking M., Ammerlaan, J., Healey, K., Akaoka, K., & Hatfield T. (2021). *Subject Matter Expert Report: Mainstem dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd. Zathey, N., & Robinson, M.D. (2021). *Summary of ephemeral conditions in the upper Fording River Watershed. In Hocking et al. (2021). Subject Matter Expert Report: Mainstem dewatering. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd.
Calcite	Hocking, M., Tamminga, A., Arnett, T., Robinson M., Larratt, H., & Hatfield, T. (2021). *Subject Matter Expert Report: Calcite. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd., Lotic Environmental Ltd., and Larratt Aquatic Consulting Ltd.
Total suspended solids	Durston, D., Greenacre, D., Ganshorn, K & Hatfield, T. (2021). *Subject Matter Expert Report: Total suspended solids. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.
Fish passage (habitat connectivity)	Harwood, A., Suzanne, C., Whelan, C., & Hatfield, T. (2021). *Subject Matter Expert Report: Fish passage. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. Akaoka, K., & Hatfield, T. (2021). Telemetry Movement Analysis. In Harwood et al. (2021). *Subject Matter Expert Report: Fish passage. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Ltd. by Ecofish Research Ltd.

Focus	**Citation for Subject Matter Expert Reports**
Cyanobacteria Algae / macrophytes	Larratt, H., & Self, J. (2021). *Subject Matter Expert Report: Cyanobacteria, periphyton and aquatic macrophytes. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Larratt Aquatic Consulting Ltd.
Water quality (all parameters except water temperature and TSS [Ecofish])	Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Water quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd. Healey, K., & Hatfield, T. (2021). *Calculator to assess Potential for cryoconcentration in upper Fording River.* In Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Water quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd.
Industrial chemicals, spills and unauthorized releases	Van Geest, J., Hart, V., Costa, EJ., & de Bruyn, A. (2021). *Subject Matter Expert Report: Industrial chemicals, spills and unauthorized releases. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd. Branton, M., & Power, B. (2021). *Stressor Evaluation – Sewage.* In Van Geest et al. (2021). *Subject Matter Expert Report: Industrial chemicals and unintended releases. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Golder Associates Ltd.
Wildlife predators	Dean, D. (2021). *Subject Matter Expert Report: Wildlife predation. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by VAST Resource Solutions Inc.
Poaching	Dean, D. (2021). *Subject Matter Expert Report: Poaching. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by VAST Resource Solutions Inc.
Food availability	Orr, P., & Ings, J. (2021). *Subject Matter Expert Report: Food availability. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Minnow Environmental Inc.

Focus	**Citation for** **Subject Matter Expert Reports**
Fish handling	Cope, S. (2020). *Subject Matter Expert Report: Fish handling. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Westslope Fisheries Ltd.
	Korman, J. (2021). *Effects of capture and handling on Westslope Cutthroat Trout in the upper Fording River: A brief review of Cope (2020) and additional calculations.* Report prepared for Teck Coal Limited. Prepared by Ecometric Research.
Infectious disease	Bollinger, T. (2021). *Subject Matter Expert Report: Infectious disease. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by TKB Ecosystem Health Services Ltd.
Pathophysiology	Bollinger, T. (2021). *Subject Matter Expert Report: Pathophysiology of stressors on fish. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by TKB Ecosystem Health Services Ltd.
Coal dust and sediment quality	DiMauro, M., Branton, M., & Franz, E. (2021). *Subject Matter Expert Report: Coal dust and sediment quality. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population.* Report prepared for Teck Coal Limited. Prepared by Azimuth Consulting Group Inc.
Groundwater quality and quantity	Henry, C., & Humphries, S. (2021). *Subject Matter Expert Report: Hydrogeological stressors. Evaluation of Cause - Decline in upper Fording River Westslope Cutthroat Trout population.* Report Prepared for Teck Coal Limited. Prepared by SNC-Lavalin Inc.

1 INTRODUCTION

1.1 Background

1.1.1 Overall Background

This document is one of a series of Subject Matter Expert (SME) reports that supports the overall Evaluation of Cause into the upper Fording River Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) population decline (Evaluation of Cause Team 2021). For further general background information, see the preceding Reader's Note.

1.1.2 Report-specific Background

This report describes the investigation of a potential reduction in food availability as a factor that may have caused or contributed to the upper Fording River Westslope Cutthroat Trout population decline reported by Cope (2020).

Westslope Cutthroat Trout, like other salmonids, are considered visual hunters that feed mainly on invertebrates drifting in the water column (Elliot 1973; Nakano et al. 1992; Fraser and Metcalfe 1997; BCMWLAP 2004). They forage opportunistically on whatever prey items are seasonally abundant (COSEWIC 2006, 2016; BCMWLAP 2004). Unlike the coastal variety (Nowak et al. 2004), inland cutthroat trout are not highly piscivorous and tend to be invertebrate specialists (Shepard et al. 1984). Young-of-the-year (age 0+ years) Westslope Cutthroat Trout, which inhabit stream margins, off-channel habitats, and small tributaries (Kelly et al. 1988; BCMWLAP 2004) tend to consume small prey such as chironomid larvae (Costello 2006; COSEWIC 2006, 2016). Adult Westslope Cutthroat Trout typically occupy deeper pools and runs with abundant cover and low to moderate gradients where they feed on a variety of aquatic and terrestrial invertebrates (BCMWLAP 2004). Rarely, Westslope Cutthroat Trout will consume other fish and even small mammals (Lister and KWL 1980; BCMWLAP 2004). There are considerable overlaps of the taxa and sizes of invertebrate prey consumed by different life stages of cutthroat trout (Borzek et al. 1994).

As is typical for this species (BCMWLAP 2004; Costello 2006; COSEWIC 2006, 2016), aquatic invertebrate prey of Westslope Cutthroat Trout in the Elk River watershed are mainly larval or adult forms of one or more of the following aquatic invertebrate groups: true flies (Diptera), mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) (Lister and KWL 1980; Minnow 2004; EVS-Golder 2005; unpublished data from Minnow et al. 2011). Terrestrial invertebrates are also consumed when present, particularly in late summer and early autumn (Lister and KWL 1980; McDonald and Strosher 1998). Other studies of the dietary habits of trout have similarly reported increased consumption of terrestrial invertebrates in summer or autumn (Allan 1981; Kelly-Quinn and Bracken 1990; Wipfli 1997; Li et al. 2016), which may reflect greater relative size and/or availability of terrestrial compared to aquatic invertebrates in drift at those times of year (Romaniszyn et al. 2007; Sweka and Hartman 2008; Li et al. 2016). In temperate streams, overall drift abundance typically decreases from maxima in spring, to lows in fall or winter (Rincón and Lobón-Cerviá 1997; Nakano et al. 1999; Syrjanen et al. 2011; Leeseberg and Keeley 2014). Fish consumption and assimilation rates tend to be highest in summer and decline in fall/winter when water temperatures decrease (Li et al. 2016; Thayer 2016). The relative proportions of aquatic versus terrestrial prey in trout diets can vary widely among streams and years (Baxter et al. 2005; Wilson et al. 2014; Sepulveda 2017).

Based on the overall understanding of Westslope Cutthroat Trout and their dietary habits, this project investigated two potential causal pathways related to Westslope Cutthroat Trout population decline in the upper Fording River:

1. Decline in abundance and/or quality of aquatic invertebrates.
2. Decline in abundance and/or quality of terrestrial invertebrates.

1.1.3 Author Qualifications

This project was managed by Ms. Patricia Orr, who has a Master of Science degree from the University of Waterloo, specializing in aquatic biology and toxicology. She has been working in aquatic environmental consulting since 1986 and was a co-founder of Minnow Environmental Inc. (Minnow) in 2000. Ms. Orr has been a consultant to Teck Coal Limited (Teck Coal) and previous owners of the Elk Valley coal mines since 2002, managing a variety of projects such as: investigation of the bioaccumulation and potential effects of aqueous selenium in lotic (flowing) and lentic (slow-flowing or stagnant) aquatic habitats of the Elk River watershed downstream from coal mining; the design and implementation of local and regional aquatic effects monitoring programs; design and completion of various supporting studies; and provision of technical support to Teck Coal's Elk Valley Water Quality Plan (EVWQP), Adaptive Management Plan, and Tributary Management Plan. In addition to projects in the Elk River watershed, Ms. Orr has worked extensively across Canada to design and undertake studies evaluating the effects of effluents from metal mines (operating and closed/abandoned sites) and pulp and paper mills on aquatic receiving environments. She was the project manager responsible for developing the first Technical Guidance Document for Environmental Effects Monitoring studies completed under the federal *Fisheries Act* and has also participated in the development of generic (federal and provincial) water quality guidelines, and various site-specific guidelines.

Dr. Jennifer Ings is acting as the senior project advisor. Dr. Ings has a Doctor of Philosophy degree from the University of Waterloo, specializing in aquatic ecotoxicology, and completed two postdoctoral fellowships with renowned researchers in the field. She has worked on a large variety of projects related to the impact of anthropogenic effluence on the aquatic environment since 2001, including but not limited to pulp and paper mill effluent, municipal wastewater effluent, and oilsands process-affected waters. Dr. Ings has been working at Minnow since 2015, and has been managing projects for Teck Coal since 2017. She is currently the project manager for the Regional Aquatic Effects Monitoring Program (RAEMP), and senior project advisor for the Fording River Operation (FRO) Local Aquatic Effects Monitoring Program (LAEMP), among other projects.

1.2 Objective

The objective of this study was to investigate a potential decline in food availability to Westslope Cutthroat Trout. The implicit, overarching concern associated with food availability is that starvation may have caused or contributed to the precipitous decline in Westslope Cutthroat Trout population size observed between September 2017 and September 2019 (Cope 2020). Therefore, the specific impact hypotheses that were investigated were:

1. Did starvation cause or contribute to the Westslope Cutthroat Trout population decline?
2. Did aquatic invertebrates decrease sufficiently to cause or contribute to Westslope Cutthroat Trout population decline through starvation?
3. Did terrestrial invertebrates decrease sufficiently to cause or contribute to Westslope Cutthroat Trout population decline through starvation?

1.3 Approach

The evaluation of potential changes in food availability to Westslope Cutthroat Trout followed a top-down, tiered approach (Table 1.1).

The first tier involved evaluation of fish condition, which is the relationship between fish weight and length. Fish condition represents direct evidence of potential starvation as a factor causing or contributing to the observed population decline.

The second tier involved evaluation of potential changes in food supply. To evaluate potential reduction in aquatic invertebrate supply to drift in the upper Fording River, benthic invertebrate biomass, density, and community characteristics in 2018 and 2019 were compared to those of previous years. To evaluate potential reduction in terrestrial invertebrate supply to aquatic drift, riparian habitat, and mine disturbance areas in 2019 were compared to conditions prior to September 2017 (more background and rationale are provided in Sections 2.2.1 and 2.3.1, respectively).

Table 1.1: Approach for Evaluation of Potential Decrease in Food Availability

Evaluation Steps	Hypotheses	Information Evaluated
Tier 1 Evaluate data representing directly relevant evidence of starvation	1. Did starvation cause or contribute to the Westslope Cutthroat Trout (WCT) population decline?	Potential decrease in WCT condition after September 2017 compared to before: • Condition factors (K) • Weight at length
Tier 2 Evaluate most relevant, available supporting information (i.e., food supply)	2. Did aquatic invertebrates decrease sufficiently to cause or contribute to WCT population decline through starvation?	Scientific literature regarding WCT food preferences and feeding behaviour. Potential decreases in benthic invertebrates after September 2017 compared to before: • Total invertebrate biomass • Total invertebrate density • Abundances of taxa preferred by WCT
	3. Did terrestrial invertebrates decrease sufficiently to cause or contribute to WCT population decline through starvation?	Scientific literature regarding WCT food preferences and feeding behaviour. Potential decrease in riparian habitat or vegetated land cover that may have reduced terrestrial invertebrate inputs to the upper Fording River system after September 2017 compared to before
Tier 3 (if needed) Evaluate other supporting information if combined results for Tier 1 and Tier 2 are inconclusive or provide evidence of WCT starvation due to reduced food availability (i.e., potential causes of decreased food supply)	4. What factor(s) caused decreased food availability?	Spatial and temporal patterns for stressors: • Water quality; • Calcite; • Water flow/drying cycles; • Water temperature; • Productivity; and/or • Other factors as applicable

All externally feeding life stages (fry, juvenile, adult) occupying habitats throughout the mainstem upper Fording River and tributaries accessible from the mainstem upper Fording River were relevant to this investigation. For a reduction in food availability to explain the Westslope Cutthroat Trout population decline, the data evaluation would be expected to show the following results:

- A reduction in Westslope Cutthroat Trout body condition in 2018 or 2019 compared to previous years;
- Reduction in abundance of aquatic prey organisms (e.g., EPT and Diptera);

- Substantial effects to the food base over a large area during the ice-free period, or at overwintering locations, for a sustained period (e.g., a month or more), to explain such a large magnitude of effect on the Westslope Cutthroat Trout population. This is because trout foraging can shift between both aquatic and terrestrial invertebrates in drift, or even to benthic invertebrates, depending on availability (Nakano et al. 1999; Dunham et al. 2000; Zhang and Richardson 2011; Syrjanen et al. 2011; Kraus et al. 2016; Studinskiet al. 2017), and trout will move in search of food when local resources become limited (Wilzbach 1985; Gowan and Fausch 2002; Baxter et al. 2005; COSEWIC 2006); and
- Changes to the food base after September 2017, because the monitoring in September 2017 indicated a robust Westslope Cutthroat Trout population with individuals in good condition (Cope 2020).

The “requisite conditions”, listed above, provided a framework for interpretation of the results from data analyses.

A possible third tier of evaluation was identified involving evaluation of other supporting information if combined results for the first two tiers were inconclusive or provided evidence of Westslope Cutthroat Trout starvation due to reduced food availability. The objective of this tier would be to investigate the factor(s) causing effects to food availability, but would not be pursued in the absence of evidence for fish starvation or effects on food availability during the September 2017 to 2019 period compared to previous years.

2 METHODS

2.1 Westslope Cutthroat Trout Condition (Tier 1)

2.1.1 Upper Fording River

Weights and lengths were measured for fry and juvenile life stages of Westslope Cutthroat Trout monitored in 2012, 2013, 2014, 2015, 2017, and 2019 as part of the upper Fording River Westslope Cutthroat Trout population assessment and monitoring programs (Cope et al. 2016; Cope 2020)[6]. Monitoring areas are shown in Figure 2.1. The Westslope Cutthroat Trout population was not monitored in 2018, consistent with the decision to continue trend monitoring in alternate years after completion of the original upper Fording River Westslope Cutthroat Trout population assessment in 2015 (Cope et al. 2016). Detailed methods regarding capture and fish processing are presented in Cope et al. (2016) and Cope (2020) and briefly summarized below.

Fry and juvenile Westslope Cutthroat Trout (fish less than 20 cm) were sampled in late August through early October of each year when water temperatures were greater than 5.0°C. Sampling was completed by a 3-person crew using a direct current (DC) backpack electrofishing unit (Smith Root LR24). Sampling involved removal-depletion methods that require three successive passes of declining catch for population estimation methods. Captured fish were allowed to recover their oxygen deficit (created during capture) in 20-L capture buckets prior to being anaesthetized and processed. Fish were anaesthetized in a 40-L bath of river water containing 2.0 mL clove oil yielding bath concentrations of 50 ppm. All fish captured during electrofishing were anaesthetized, weighed (g), measured (fork length mm), and examined externally for any signs of deformity. Fish were allowed to recover within fish sleeves, totes, or 20-L buckets placed downstream from the sampling area and then released back into their respective meso-habitat units upon completion of sampling.

Raw fish weight and length data were provided to Minnow by S. Cope, Westslope Fisheries, to support evaluation of fish condition. Fulton condition factors (K)[7] were also computed for 2017 and 2019 by S. Cope and used to update Table 3.2.18 of Cope et al. (2016) for presentation in this report. Malfunction of a balance in 2017 resulted in an unknown number of erroneously

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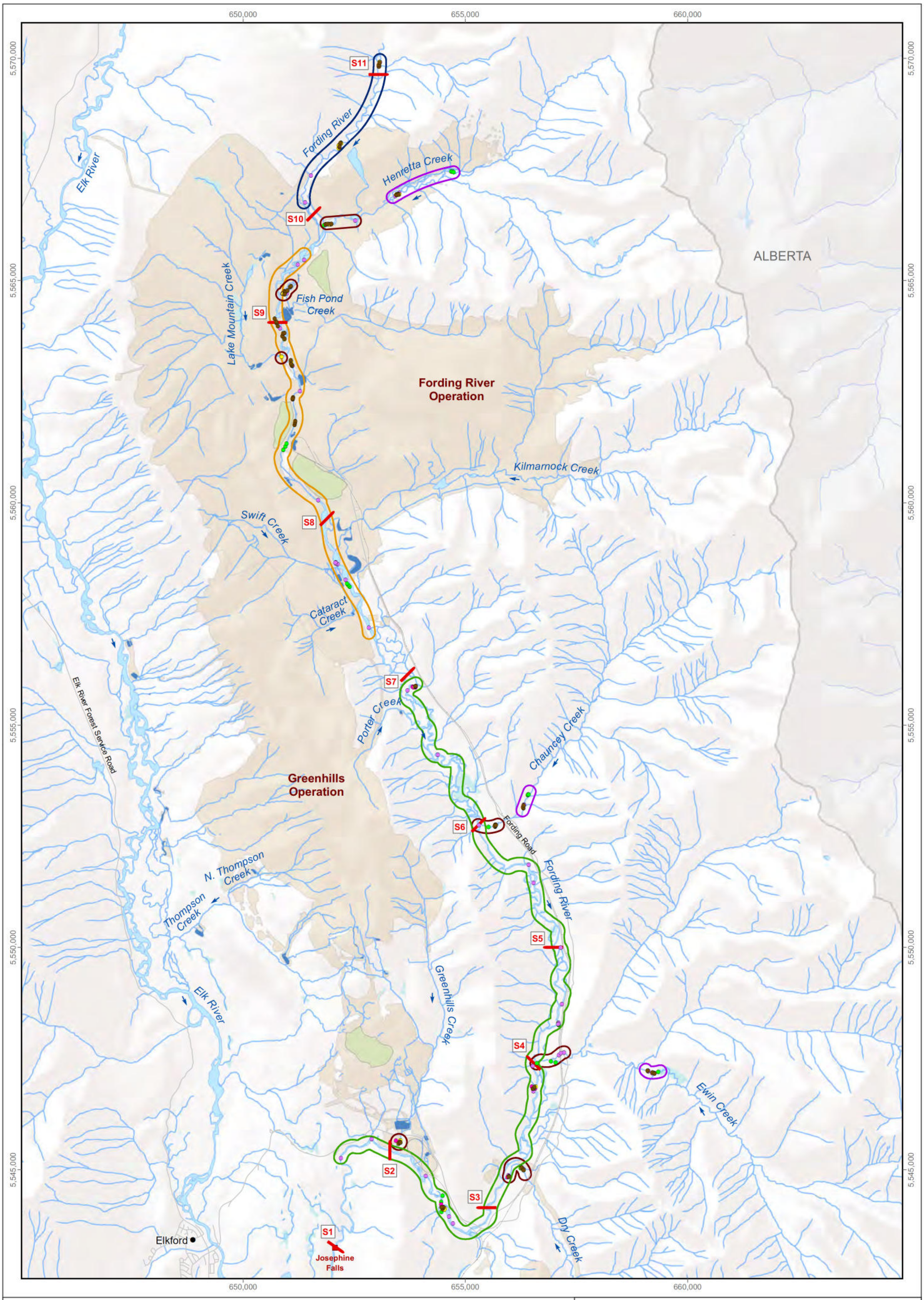
[6] Lengths and weights of adults were not monitored after 2014. Smaller fish have higher basal metabolism and lower lipid content per unit weight than larger fish (Handy 1997; Biro et al. 2004). The metabolic requirements as water temperatures decrease in fall and winter are thought to result in more rapid lipid depletion and higher overwinter mortality among smaller individuals (Reimers 1963; Hunt 1969; Shuter and Post 1990; Smith and Griffith 1994; Handy 1997; Hurst 2007). Therefore, late summer condition provides an indication of overwinter survival (Reimers 1963; Hunt 1969; Smith and Griffith 1994; Quinn and Peterson 1996; McGrath 2003; Biro et al. 2004).

[7] $K = (\text{Weight g}/(\text{fork length}^3\text{ mm})) * 100{,}000$



LEGEND

Monitoring Location

● 2013
● 2014
● 2015
● 2017
● 2019

Juvenile Westslope Cutthroat Trout Monitoring Area

○ Mainstem Headwaters
○ Mid-Mainstem
○ Lower Mainstem
○ Upper Tributary
○ Lower Tributary

— Fording River Segment
■ Settling Pond
■ Tailings Pond
■ Teck Coal Mine Operation

Juvenile Westslope Cutthroat Trout Monitoring Locations (Cope et al. 2016, Cope 2020)

0 1 2 4
km

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Figure 2.1

Document Path: S:\Projects\197202\197202.0071 - FRO WCT Counts\4 - GIS\Report\19-71 Figure 2.1 Juvenile WCT Monitoring Locations.mxd high fish weights. Obvious outliers (i.e., weights resulting in K > 2.0) were removed from the data set, but less obvious errors may still have caused high bias of mean K values for that year and results should be interpreted with caution.

The same data obtained from Westslope Fisheries were plotted to visually compare fish weights relative to length among years. Statistical analyses were undertaken to compare mean weight relative to length among years using analysis of covariance (ANCOVA) with $\log_{10}$-transformed variables. Fish <6 cm in length (i.e., age 0+ or fry, as defined in Table 3.2.7 of Cope et al. 2016) were removed from the analysis to maximize overlap of data sets with respect to the size of fish being compared. This resulted in evaluation of fish ranging in size from 6 to about 23 cm (i.e., ages 1+ to 4+ years as per Cope et al. 2016[8]). Data from 2017 were not included in the ANCOVA due to issues with weight measurements described above.

Regression slopes were considered parallel when the interaction term of the ANCOVA model was not significant ($\alpha = 0.05$). When the interaction term was significant, then the coefficients of determination (R^2) of the interaction model and parallel slope model were compared to assess whether the slopes were practically significant. If the R^2 was > 0.8 and differed by 0.02 or less between the two models, then the conclusion was that the interaction model and parallel slope models were practically the same (Environment Canada 2012b) and the ANCOVA proceeded with the parallel slope model. Outliers with a Studentized residual magnitude greater than four were removed from the analysis. A magnitude of difference (MOD) was calculated for 2019 relative to all other years using the covariate adjusted means (ANCOVA, anti-logged), or medians (Kruskal-Wallis) as (2019 Value - Earlier Year Value)/Earlier Year Value x 100%. All statistical analyses were conducted in R (R Core Team 2019).

When there was a significant interaction in the ANCOVA model, (i.e., regression slopes were not parallel between years) then the MOD was calculated at two values of the covariate: the minimum and maximum values of the overlap in covariate values between areas. The values of the response variable at these two covariate values were estimated as the predicted values on the regression lines and the MOD calculated as (2019 Value - Earlier Year Value)/Earlier Year Value × 100% as described above.

A reduction in Westslope Cutthroat Trout condition 2019 compared to all previous years would support a hypothesis of reduced food availability to Westslope Cutthroat Trout.

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[8] Largest fish in the older age groups (3+ and 4+) were also referred to as "sub-adult" by Cope et al. (2016) but, for simplicity, all fish in these age groups are referred to as juveniles in this report.

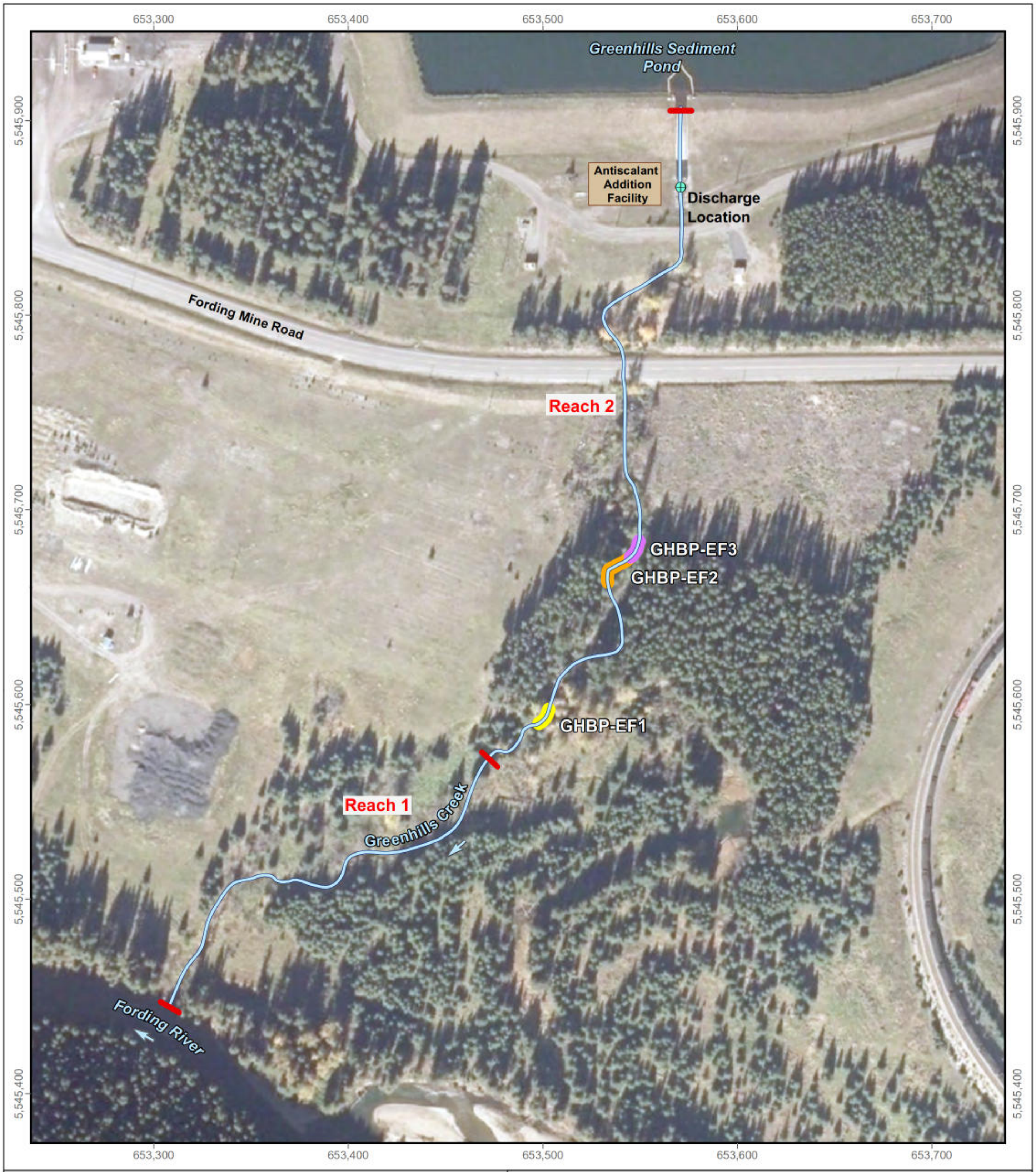
2.1.2 Lower Greenhills Creek and Lower LCO Dry Creek

Westslope Cutthroat Trout were sampled by Minnow in three areas of lower Greenhills Creek on September 13 2017, September 10 2018, and September 13 2019, in relation to Teck Coal's investigations of calcite effects and proposed mitigation (Figure 2.2; Minnow 2018c, 2019b, 2020b). This area was also monitored by Cope in 2017 and 2019, but comparison of data between the two programs showed that fish captured by Cope (2020) in 2019 were significantly (28%) lighter at length, likely because sampling occurred in August, about one month prior to sampling by Minnow (2020b; Table 2.1; Appendix Figure A.1). Based on this, and also considering the lack of Cope data for 2018 and issues with Cope weight measurements in 2017 (discussed above), only the Minnow data were compared among years for lower Greenhills Creek.

Fishing by Minnow in lower Greenhills Creek involved the same removal-depletion electrofishing methods used in the upper Fording River Westslope Cutthroat Trout population study (Cope et al. 2016; Cope 2020). Sampling was completed by a two-person crew using a DC backpack electrofishing unit (Smith Root LR24). The anode operator worked closely with the netter to frequently turn over rocks to hand-recover fish that drifted into interstitial spaces. Length and weight of each fish were measured to the nearest hundredth of a millimetre using digital calipers. Fish body weight was measured using a Scout Pro balance (to the nearest 0.001 gram with ± 1% precision). Fish were held in aerated containers until sampling was completed at which time individuals were released back into the respective areas where they were captured.

Westslope Cutthroat Trout were also monitored in lower LCO Dry Creek to support permit conditions for the Dry Creek Water Management Plan (Faulkner et al. 2019, 2020). Sampling involved three-pass closed-station electrofishing as described above. Sampling was completed in September of 2017, 2018, and 2019. The most downstream sampling area on LCO Dry Creek, downstream from the road crossing (DRY-EF01 in Faulkner et al. 2019, 2020), corresponds to the area typically monitored for the upper Fording River population study (Cope et al. 2016; Cope 2020; Figure 2.1). Data from DRY-EF01 were the data evaluated for this study.

Westslope Cutthroat Trout weights versus lengths were plotted. For the lower Greenhills Creek data set, there was poor overlap of fish smaller than 7 cm among years, and very few fish with lengths between 7 and 8.5 cm in any year. Therefore, fish with lengths < 8 cm (assumed to be age 0+ based on Cope et al. 2016) were removed from the data set prior to statistical analyses to maximize overlap of data sets among years. Due to limited sample sizes and good overlap of data among years, all available data for lower LCO Dry Creek (DRY-EF01) were included in the analysis. Mean weights-at-length were compared among years (2017-2019) for each area



LEGEND

Electrofishing Area

🟨 GHBP-EF1
🟧 GHBP-EF2
🟪 GHBP-EF3
⊕ Discharge Location
🟫 Antiscalant Addition Facility
▬ Reach Break

Juvenile Westslope Cutthroat Trout Monitoring Locations in Lower Greenhills Creek, 2017-2019

0 50 100 200
Meters

Datum: NAD 83 Map Projection: UTM Zone 11N Data Source: Reproduced under licence from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada, GeoBase and BCGov, GeoBC. All rights reserved.

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Figure 2.2

Document Path: S:\Projects\197202\197202.0071 - FRO WCT Counts\4 - GIS\Report\19-71 Figure 2.2 Juvenile WCT Monitoring Locations in Lower Greenhills Ck.mxd using ANCOVA as described above (Section 2.1.1) but including post-hoc pairwise comparisons among all years of data.

Table 2.1: Difference in the Relationship Between Weight and Fork Length for Westslope Cutthroat Trout between Minnow (2020b) and Westslope Fisheries (Cope 2020)

Endpoint	ANCOVA Model P-Values			Fork Length Mean	n		Mean		MOD[a] (%)
	Year x Log_{10}(Fork Length)	Fork Length	Study		Minnow	Westslope	Minnow	Westslope	
Condition	0.309	<0.001	<0.001	11.8	41	18	17.6	12.7	-28

▨ Significant difference (P < 0.1) in condition between studies for juvenile trout sampled in lower Greenhills Creek in 2019.

[a] MOD (magnitude of difference) was calculated as Minnow-Westslope/Minnow*100%.

Reduced Westslope Cutthroat Trout condition in 2018 or 2019 compared to 2017 would support a hypothesis of reduced food availability to Westslope Cutthroat Trout.

2.1.3 Other Westslope Cutthroat Trout Monitoring

Non-lethal sampling undertaken in September 2018 targeted collection of Westslope Cutthroat Trout for analysis of selenium in muscle plugs as part of the RAEMP (Minnow 2020c). Sixteen mature[9] trout were captured in the upper Fording River, eight near the Multiplate[10] and eight downstream from Chauncey Creek.

Sampling undertaken in February and March 2019 targeted collection of Westslope Cutthroat Trout for the purpose of assessing winter tissue selenium concentrations (Appendix B). Nine mature trout were captured in Henretta Lake.

Fulton condition factors (K) were computed for each fish as described in Section 2.1.1 and compared to results for upper Fording River Westslope Cutthroat Trout sampled in 2012 through 2014 by Cope et al. (2016).

2.1.4 Water Temperatures and Degree-days

The optimal water temperature range for Westslope Cutthroat Trout spawning and incubation is 9.0 to 12.0 °C, and for rearing is 7.0 to 16 °C (Oliver and Fidler 2001). Guidelines for the protection of aquatic life (Oliver and Fidler 2001) consider <1°C to be the lower extreme temperature. The upper incipient lethal temperature is 19.6 °C (95% confidence interval of 19.1 to 19.9 °C; Bear et al. 2007). Degree-days are sometimes used to explain variation in fish

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[9] Greater than 20 cm fork length as defined by Cope et al. (2016).

[10] Location RG_MP1 in Figure 2.3.

growth and development (Coleman and Fausch 2007; McMillan et al. 2012; Chezik et al. 2014). Degree-days in the Fording River in 2018 and 2019 (as summarized by Wright et al. 2021) were evaluated to provide further insight into Westslope Cutthroat Trout growth and condition during the window of population decline. For the calculation of degree-days, the beginning of the growing season was defined as the first week with average stream temperatures above 7°C. The end of the growing season was defined as the last day of the first week that average temperatures dropped below 7°C. Degree-days were defined as the sum of daily average water temperatures for the intervening period.

2.2 Aquatic Invertebrates (Tier 2)

2.2.1 Background and Approach

Aquatic invertebrates in drift have not been measured directly in streams of the Elk River watershed. However, benthic invertebrate communities, which represent the source of aquatic invertebrate drift, have been monitored in the upper Fording River since 2012 (Minnow 2014, 2017a, 2018a; Minnow and Lotic 2018, 2019, 2020).

Positive relationships have been described between benthic invertebrate and drift abundance/composition (Rincón and Lobón-Cerviá 1997; Esteban and Marchetti 2004; Syrjanen et al. 2011; Tonkin and Death 2013), as well as between drift abundance/composition and trout diet (Elliot 1973; Allan 1981; Esteban and Marchetti 2004; Syrjanen 2011; Eros et al. 2012), although some studies did not show such relationships (Shearer et al. 2003; Naman et al. 2016). When invertebrate drift abundance is low, trout will feed directly on benthic invertebrates (Fausch et al. 1997; Nislow et al. 1998; Nakano et al. 1999; Dunham et al. 2000; Zhang and Richardson 2011). Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies; collectively referred to as EPT) and Diptera (true flies) have been identified as important components of salmonid diets in temperate, swift-flowing streams where these taxa dominate benthic invertebrate communities (Brittain and Eikeland 1988; Nislow et al. 1999; Fochetti et al. 2003; Shearer et al. 2003; Barbero 2013; Leeseberg and Keeley 2014).

Upper Fording River benthic invertebrate communities are dominated by EPT (Appendix Figures A.2 and A.3), as is typical of relatively undisturbed mountain streams in southeastern British Columbia and southwestern Alberta (Minnow 2018a). EPT taxa were found, along with Diptera, in the stomachs of Westslope Cutthroat Trout sampled in the Elk River watershed (Lister and KWL 1980; McDonald and Strosher 1998; Minnow 2004; EVS-Golder 2005; unpublished data from Minnow et al. 2011). Ephemeroptera in particular, which have been identified as a sensitive indicator group in the Elk River watershed (Minnow

2017a, 2018a; Minnow and Lotic 2018, 2019, 2020), represent an important energy source to trout in some streams and seasons (Fochetti et al. 2003; Wilson et al. 2014; Studinski et al. 2017).

Based on the above, it is reasonable to assume that a change in food availability sufficient to cause or contribute to a large Westslope Cutthroat Trout population decline in the upper Fording River would be associated with a significant and spatially broad change in benthic invertebrate communities. Therefore, the evaluation of aquatic invertebrate food availability focused on identifying potential changes in benthic invertebrate biomass, density, and community structure in 2018 and 2019 compared to earlier years.

2.2.2 Biomass and Density

Benthic invertebrate biomass and density have been measured annually in the upper Fording River since 2016 as part of the FRO LAEMP (Minnow and Lotic 2018, 2019, 2020). The purpose of this sampling has been to characterize aquatic productivity prior to and after future commissioning of an Active Water Treatment Facility near Kilmarnock Creek (Minnow and Lotic 2018, 2019, 2020). Eight to 10 areas of the upper Fording River were sampled in each year, include two reference areas (Table 2.2; Figure 2.3). Benthic invertebrates were collected using a Hess sampler with 500 µm mesh, for measurement of biomass and community endpoints relative to the area sampled. Stations were located a minimum of 5 m apart, to characterize each monitoring area overall. A single sample was collected at each station by carefully inserting the base of the Hess sampler into the substrate to a depth of approximately 5 to 10 cm. Gravel or cobble enclosed within the Hess sampler was carefully washed while allowing the current to carry dislodged organisms into the mesh collection net. Organisms collected into the net were rinsed into the bottom of the net, and then into a labelled wide-mouth plastic jar. Samples were preserved to a level of 10% buffered formalin in ambient water within approximately 6 hours of collection to ensure that biomass was not lost through predation or decomposition of tissues before the samples were sorted at the laboratory.

Benthic invertebrate biomass samples were sent to ZEAS Inc. in Nobleton, Ontario (ON), for sorting and taxonomic identification. Preserved organisms in each sample were sorted from the sample debris into groups separated at the family-level of taxonomy for weighing. Each family group of organisms was placed onto a fine cloth to drain excess surface moisture before being weighed to the nearest 0.0001 g. Total biomass and density were reported for each sample as preserved wet weight. Laboratory data for benthic invertebrate Hess samples were converted to units of number of organisms per square metre (org/m^2) based on the known area sampled. Baseline biomass and density data from 2017, 2018 and 2019 were plotted and changes in biomass and density were quantified using an Analysis of Variance (ANOVA) with factors *Area* and *Year* and their interaction. Appropriate transformations were made to meet the assumptions of the test. Model terms were interpreted using an α of 0.05. Post-hoc Tukey's Honestly Significant Difference (HSD) Test was conducted (α = 0.05) to test for differences among years within areas due to the presence of significant interactions between *Area* and *Year* for both biomass and density.

Table 2.2: Summary of Benthic Invertebrate Samples Collected for the FRO LAEMP, RAEMP and LCO Dry Creek LAEMP, 2012 to 2019

Program		Biological Monitoring Area (see Figures 2.3 and 2.4)	Biomass (# of samples; Hess)				Community (# of samples; kick and sweep)													
			2016	2017	2018	2019	2012	2014	2015	2016	2017	2018				2019				
			Sep	Sep	Sep	Sep	Sep	Sep	Sep	Sep	Sep	Jun	Aug	Sep	Dec	Feb	Apr	Jun	Sep	Dec
FRO LAEMP /RAEMP	Reference	RG_HENUP	-	10	10	10	1	-	1	-	1	1	1	3	-	-	-	3	3	-
		RG_FO26	-	10	10	10	1	-	1	-	1	1	-	3	-	-	-	3	3	-
		RG_UFR1[a]	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	3
	Mine-exposed	RG_FODHE	-	-	-	-	1	-	1	-	1	1	1	3	-	-	-	3	3	-
		RG_FOUCL[c]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
		RG_FOUNGD	-	-	-	-	1	-	1	-	1	1	1	3	-	-	-	3	3	-
		RG_FODNGD	-	-	-	-	-	-	-	-	1	1	1	3	-	-	-	3	3	-
		RG_MP1	-	-	-	-	-	-	-	-	1	1	1	3	-	-	-	3	3	-
		RG_FOUSH	-	-	-	-	1	-	1	-	1	1	1	3	-	-	-	3	3	-
		RG_FOUKI	10	10	10	10	1	-	1	-	3	1	1	3	3	3	-	3	3	3
		RG_SCOUTDS[c]	-	-	-	10	-	-	-	-		-	-	-	-	-	-	-	3	3
		RG_FOBKS	-	10	10	10	1	-	1	-	3	1	1	3	-	-	-	3	3	-
		RG_FOBSC[d]	-	10	10	10	1	-	1	-	1	1	1	3	3	-	-	3	3	-
		RG_FOBCP[d]	10	10	10	10	1	-	1	-	1	1	1	5	3	-	-	3	5	-
		RG_FRCP1SW[b]	-	10	-	10	-	-	-	-	1	1	1	3	-	-	-	3	3	-
		RG_FRUPO	-	10	10	10	-	-	-	-	1	1	1	3	3	3	-	3	3	3
		RG_FODPO	-	-	-	-	1	-	1	-	1	1	1	3	3	3	-	3	3	3
		RG_FO22	-	10	10	10	1	-	1	-	1	1	1	5	-	-	-	3	5	-
		RG_FOUEW	-	-	-	-	1	-	1	-	1	1	1	3	3	3	-	3	3	3
Dry Creek LAEMP/ RAEMP		LC_FRUS (RG_FO28)	-	-	-	-	-	2	1	1	1	-	-	3	-	-	3	-	3	-
		LC_FRB (RG_FO29)	-	-	-	-	-	1	3	1	1	-	-	3	-	-	3	-	3	-
RAEMP		RG_FODGH	-	-	-	-	1	-	1	1	1	-	-	5	-	-	-	-	5	-

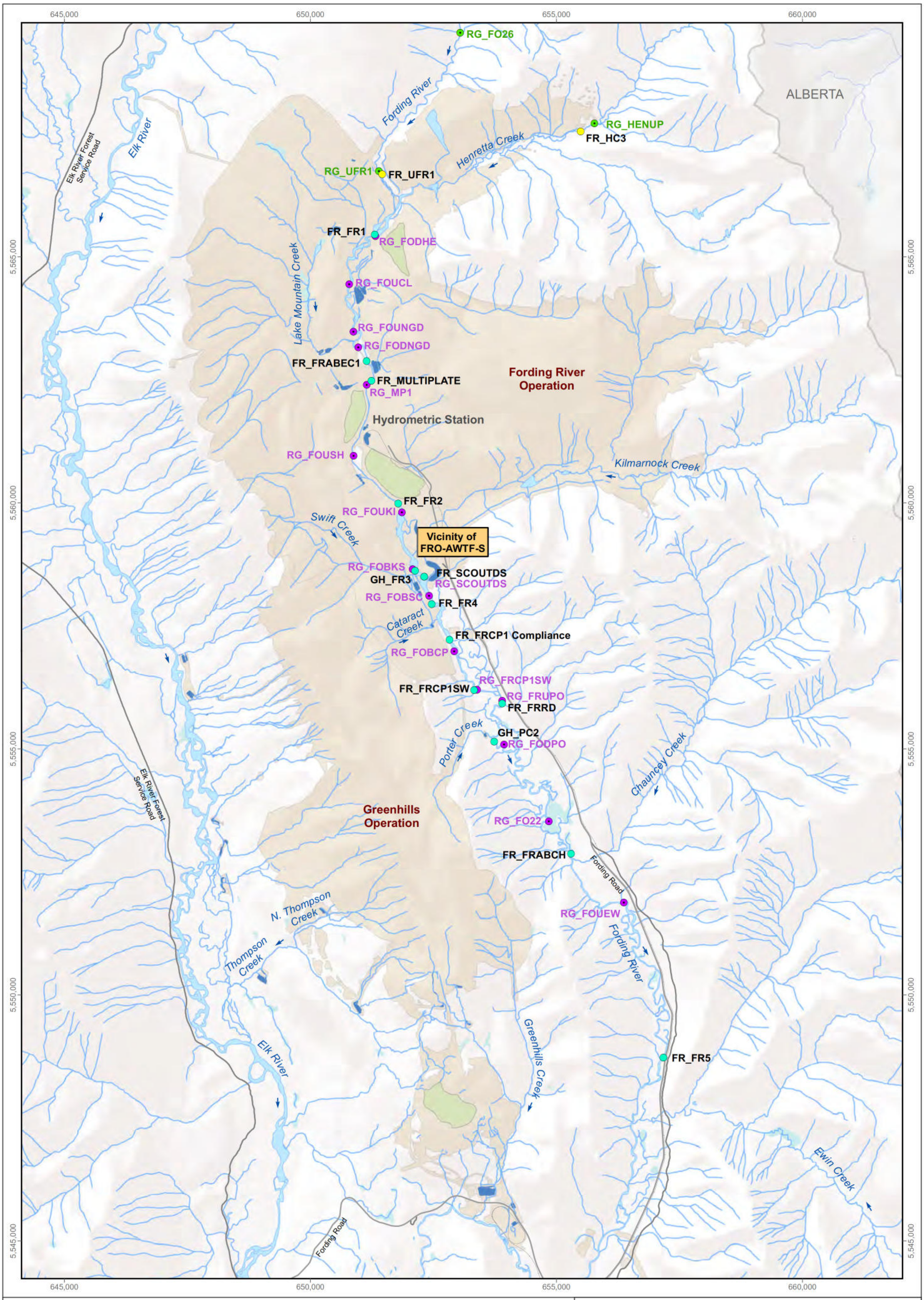
Note: "-" indicates no sample collected.

[a] RG_UFR1 was used as a reference location in December and February when there was no access to RG_FO26 or RG_HENUP.

[b] RG_FRCP1SW was dry during February and December sampling periods so was not sampled.

[c] RG_FOUCL and RG_SCOUTDS were added for September 2019 sampling program.

[d] RG_FOBSC and RG_FOBCP were dry or frozen in February and in some cases December.



Monitoring Locations in the FRO LAEMP

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Figure 2.3

2.2.3 Community Characteristics

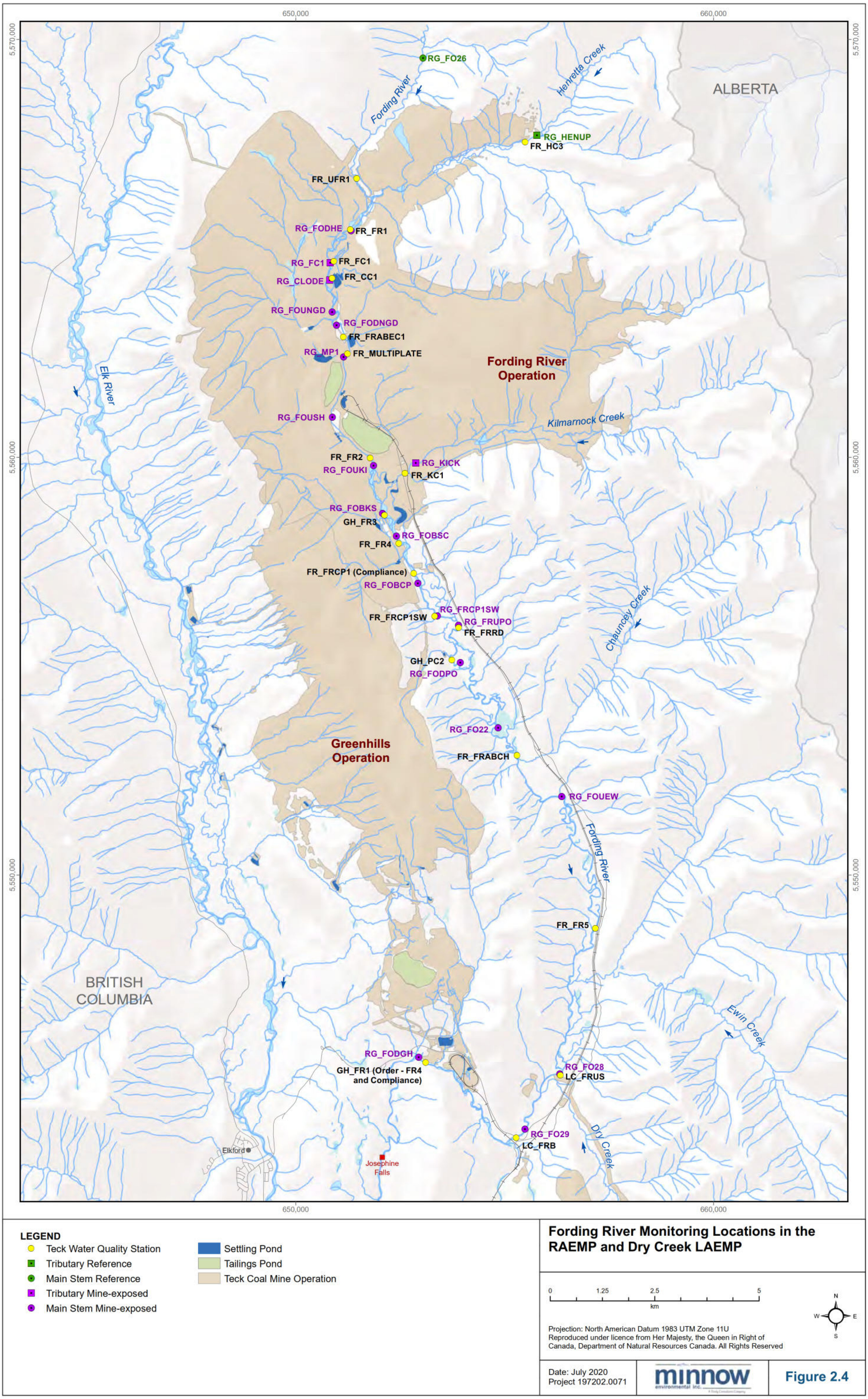
Benthic invertebrate community characteristics have been measured in the upper Fording River since 2012 as part of the FRO LAEMP (Minnow 2017a; Minnow and Lotic 2018, 2019, 2020), the LCO Dry Creek LAEMP (Minnow 2015, 2016b, 2017b, 2018b, 2019a, 2020a) and the RAEMP (Minnow et al. 2014, Minnow 2018a, Minnow 2020c). The purpose of this sampling has been to monitor and evaluate potential mine-related effects on benthic invertebrate community characteristics over time. One to five samples were collected per area (Table 2.2; Figures 2.3 and 2.4).

Routine benthic invertebrate community monitoring has normally taken place in September, but additional sampling was undertaken in some areas of the upper Fording River in other months of 2018 and 2019 to serve the objectives of the FRO LAEMP. Winter sampling could not always be completed at targeted areas due to ice conditions; all available data are presented in this report.

Sampling followed the Canadian Aquatic Biomonitoring Network (CABIN) method, which involved three-minute travelling kick sampling in riffle habitats into a net with a triangular aperture measuring 36 cm per side and mesh having 400 µm openings (Environment Canada 2012a). During sampling, the field technician moved across the stream channel (from bank to bank, depending on stream depth and width) in an upstream direction. With the net being held immediately downstream of the technician's feet, the detritus and invertebrates disturbed from the substrate were passively collected in the kick-net by the stream current. After three minutes of sampling time, the sampler returned to the stream bank with the sample. The kick-net was rinsed with water to move debris and invertebrates into the collection cup at the bottom of the net. The collection cup was then removed, and the contents poured into a labelled plastic jar and preserved to a level of 10% buffered formalin in ambient water.

Benthic invertebrate samples were sent to Cordillera Consulting, in Summerland, BC for sorting and taxonomic identification. Organisms were identified to the lowest practical level (LPL) (typically genus or species). At the beginning of the sorting process, each sample was examined and evaluated for estimation of total invertebrate numbers. If the total number was estimated to be greater than 600, then the laboratory's sub-sampling protocol was followed. Community endpoints, such as percent (%) and total abundance of EPT combined, as well as Ephemeroptera, Plecoptera, and Trichoptera individually, were computed for each monitoring area.

An overall ANOVA with factors *Year*, *Area* and *Year* × *Area* was fit to test for differences over time (2012 to 2019). The best transformation for each endpoint was chosen as the transformation for which a Shapiro-Wilk's test on the residuals gave the highest P-value (i.e., most normally distributed). If there was a significant *Year* term, the variability within years



Fording River Monitoring Locations in the RAEMP and Dry Creek LAEMP

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Figure 2.4

Document Path: S:\Projects\197202\197202.0071 - FRO WCT Counts\4 - GIS\Report\19-71 Figure 2.4 Monitoring Locations in the RAEMP.mxd and areas from the full model was used to test for significant differences between all pairwise comparisons of year for each area (i.e., is the difference between year *i* and year *j* greater than would be expected given the variability within areas for all stations for which we have replicates). This assumes the variability to be consistent among areas and years, but allows for comparisons between years without replicates. Significance of the pairwise comparisons was assessed with an α of 0.05 in a Tukey's HSD test, which corrects for the number of comparisons.

For each year, a percent MOD from the base year (i.e., first year with data) was calculated as:

$$\frac{Year_i - Base\ Year}{Pooled\ SD}$$

Where SD was the standard deviation and the significant difference between 2018 and previous years was assessed. All statistics were conducted in R (R Core Team 2019).

The data were also plotted to visually depict results. To assist in interpreting magnitudes of change over time, values were presented relative to normal (reference area) ranges defined as the 2.5th and 97.5th percentiles of the distribution of reference area data for about 40 reference areas sampled in September of both 2012 and 2015 (Minnow 2018a).

Potential differences between mine-exposed and reference areas were evaluated for total benthic and EPT abundances within months sampled in 2018 and 2019. Months when replicate samples were collected at one or more reference areas were evaluated (June, September, December). An overall ANOVA was fit with factors *Year, Area,* and *Month* and their interactions. If there was a significant *Month x Area* term, the within-area-within-month variability from the full model was used to test for significant differences between each mine-exposed area and each reference area sampled in the same month and year. Assuming the within-area-within-month variability to be consistent among areas allowed for comparisons between reference and mine-exposed areas even when replicates were lacking. Significance of the pairwise comparisons was assessed using an α of 0.05 and with a Bonferroni test correcting for the number of comparisons (reference versus mine-exposed pairs) conducted within a given month and year (0.05/number of comparisons). Abundances were $\log_{10}$ transformed to meet the assumptions of normality. For each sampling event, a MOD between reference and mine-exposed areas was calculated in terms of standard deviation as:

$$\frac{Exposed - Reference}{Pooled\ SD}$$

where exposed and reference were the back-transformed least-squares means (equivalent to geometric means) and the pooled standard deviation was the residual standard deviation estimated from the full model. All statistics were conducted in R (R Core Team 2019).

2.3 Terrestrial Invertebrates (Tier 2)

2.3.1 Background and Approach

The overall mean proportion of terrestrial prey abundance in salmonid diets is typically low (17%; review by Syrjanen et al. 2011). However, terrestrial invertebrates can sometimes represent a large proportion of the dietary abundance or biomass of salmonids (Kawaguchi et al. 2003; Sweka and Hartman 2008; Wipfli and Baxter 2010; Courtwright and May 2013; Li et al. 2016; Albertson et al. 2018), which can positively influence fish growth or condition (Baxter et al. 2005; Sweka and Hartman 2008; Eros et al. 2012; Studinski et al. 2017). Also, the relative proportions of aquatic versus terrestrial prey in trout diets can vary widely among closely located streams or among years (Baxter et al. 2005; Wilson et al. 2014; Sepulveda 2017; Studinski et al. 2017).

Relative consumption of terrestrial versus aquatic prey is sometimes a simple reflection of relative availability in drift (Esteban and Marchetti 2004; Wilson et al. 2014). In other cases, the relative abundance or biomass of terrestrial invertebrates in trout diet exceeds relative abundance in drift, suggesting dietary selectivity (Romero et al. 2005; Courtwright and May 2013; Kraus et al. 2016). This may be because terrestrial invertebrates are often larger than aquatic prey, making terrestrial prey conspicuous targets and energetically profitable relative to capture effort (Marcarelli et al. 2011; Naman et al. 2017). Consumption of terrestrial invertebrates is likely most important in streams when and where benthic invertebrate biomass is low (Courtwright and May 2013; Wilson et al. 2014; Albertson et al. 2018) or aquatic invertebrate drift density is low (Kraus et al. 2016). Aquatic invertebrate drift density tends to decline from spring to fall in temperate streams (Rincón and Lobón-Cerviá 1997; Nakano et al. 1999; Leeseberg and Keeley 2014) as flows and current velocities decline (Courtwright and May 2013; Wilson et al. 2014). By comparison, terrestrial invertebrate drift abundance (Mason and MacDonald 1982; Nakano et al. 1999; Romaniszyn et al. 2007; Eros et al. 2012) and consumption by trout (Baxter et al. 2005; Thayer 2016; Li et al. 2016; Studinski et al. 2017) tend to peak in summer.

Terrestrial invertebrate inputs to drift have not been measured in the Elk River watershed. However, inputs of terrestrial invertebrates to streams are strongly linked to the amount and type of riparian vegetation (Wipfli 1997, 2005; Allan et al. 2003; Romero et al. 2005; Wipfli and Baxter 2010; Wilson et al. 2014; Studinski et al. 2017; Albertson et al. 2018) and surrounding land use (Edwards and Huryn 1996; Eros et al. 2012). In the context of the upper Fording River, it is reasonable to expect that a large enough change in terrestrial invertebrate inputs to affect survival of Westslope Cutthroat Trout would be unlikely unless associated with spatially broad changes in riparian habitat amounts and/or land use after September 2017. Teck Coal monitors riparian habitat and land use patterns and examples of such data were assembled in a data report produced to support development of Teck Coal's Tributary Management Plan (Minnow 2016a). The data presented by Minnow (2016a) pertained to the 2015 monitoring year. Therefore, total riparian habitat and mine-disturbance footprint areas within the upper Fording River watershed were compared between 2019 and 2015. If large increases in the disturbance footprint was identified (e.g., >10%), additional data evaluation would be undertaken to determine the specific year(s) in which the changes occurred within the 2015-2019 period.

In the context of food for fish, the specific location of disturbances is relatively unimportant. The drift structure at a given place in a stream depends not only on local production, but also on upstream distant areas (Wipfli 1997, 2005; Wipfli and Gregovich 2002; Wipfli and Baxter 2010; Barbero et al. 2013). For example, terrestrial invertebrates falling or washing into streams in a headwater may be consumed by fish farther downstream (previous references).

2.3.2 Catchment Areas

Strictly speaking, "watershed" refers to the high ground or ridge that divides waters flowing to adjacent river systems, whereas terms such as "catchment", "basin", and "drainage area" refer to the area bounded by the watershed. However, these terms are often used interchangeably, as is usually the case when referring to the Elk River watershed. Likewise, this document uses the word "watershed" interchangeably with those referring to catchment area, so the term "watershed boundary" is used to refer to the line dividing adjacent catchments.

The catchment areas for each tributary and the upper Fording River as a whole, were determined using the Corporate Watershed Base (CWB) dataset provided by the Province. The CWB dataset, formerly known as the Terrain Resource Information Management (TRIM) Watershed Atlas, is a watershed atlas that defines watersheds and provides an associated stream and lake network. The CWB dataset adds functionality to TRIM 1:20,000 digital topographic base map data by providing a connected feature-coded stream network, hydrographic information, and associated watershed boundaries. The total catchment area (km^2) from the Province's CWB dataset is provided in the first matrix and is used for all calculations (i.e., ownership and mine-related, forestry, and road disturbances).

2.3.3 Riparian Habitat Area

Methods from the Baldy Ridge Extension Project for ecosystems environmental assessment for riparian habitat (Golder 2015) were used to quantify the amounts of riparian habitat within each catchment area presented in the matrices of this report. Data are reported as total square kilometres of riparian habitat. Riparian habitat amount was calculated using both the hydrologic and stream adjacency approaches. By including both approaches, calculations include riparian habitat that may sometimes not be directly adjacent to the watercourse (hydrologic approach) and riparian habitat connected to the watercourse (stream adjacency approach) since both types were deemed as riparian habitat in the baseline studies prepared for the Baldy Ridge Extension Project Environmental Assessment. Both approaches are described in the following paragraphs.

2.3.3.1 Hydrologic Approach

The hydrologic approach defined riparian habitat as deciduous floodplain and wet forest ecosystem classes (i.e., site series 110, 111, 111x, 112x [i.e., wet forest] where soil moisture regime is 5 or 6 [MacKillop 2012], and flooded low bench tall shrub types [Fl] and flooded middle bench deciduous forest [Fm] types [Mackenzie and Moran 2004]) that intersected a buffer area around streams and waterbodies. Buffers were 200 m for stream orders 7 and 8, 100 m for stream orders 5 and 6, 50 m for stream orders 3 and 4 and all other waterbodies, and no buffer for stream orders 1 and 2 (i.e., the stream must intersect the wet forest or floodplain). Deciduous floodplain and wet forest polygons outside the buffer were not included. Similarly, ecosystems within the buffer that were not wet forests or floodplains were not considered riparian habitat using the hydrologic approach.

The hydrologic approach was selected to capture riparian habitat that is not necessarily intersecting a watercourse but is still defined as riparian habitat because it exists in low-lying areas that may be periodically inundated when water levels are high, and ecological connectivity with the watercourse is thereby maintained.

2.3.3.2 Stream Adjacency Approach

The stream adjacency approach applied a variable width buffer to streams, ponds, and lakes to define riparian habitat, as follows:

- stream orders 7 and 8 = 50 m;
- stream orders 4, 5 and 6, waterbodies and wetlands = 30 m;
- stream order 3 = 20 m; and
- stream orders 1 and 2 = 10 m.

High-elevation streams with Biogeoclimatic Ecosystem Classifications (BEC) of Englemann Spruce- Subalpine Fir (e.g., ESSF dkp, ESSF dkw, ESSF wpm, ESSF wmw) and Undifferentiated Interior Mountain (IMA un) were excluded from the analysis because conditions do not support riparian attributes in the ecological context of providing structure and function to support riparian dependent vegetation and wildlife species. Such areas are sub-alpine to alpine ecosystems with extremely harsh conditions that hamper survival of vegetation and, specifically, riparian assemblages. To better understand the availability of intact riparian systems (Environment Canada 2013), the amount of riparian habitat in areas affected by disturbances that remove vegetation (e.g., mining) was calculated. Riparian habitats near clear-cuts were assumed to be vegetated because of regulations (Tschaplinski and Pike 2010) and best management practices implemented by industry to maintain natural vegetation in riparian habitat (Tembec 2005).

The adjacency approach was selected to capture habitat that plays a role in riparian and aquatic health or function (e.g., shading, streamside deadfall), but that is not necessarily identified as a riparian ecosystem in the BEC system.

2.3.4 Disturbance Areas

The disturbance areas were determined from three datasets, two of which were provided by Golder Associates (Golder) and were developed at regional scales to support environmental assessments for Teck Coal's projects in the Elk River watershed. The third data set used for disturbance was Teck Coal's in-house disturbance Geographic Information System (GIS) layer which tracks cumulative mine-related disturbance for Teck Coal's mines in the Elk River watershed.

These three datasets were processed so that the 2018 data from Golder were updated with 2019 mine disturbance data from the in-house mine disturbance layer. These data were tagged with a disturbance year of "2019". This GIS layer was then updated with the 2014 disturbance layer from Golder which had its disturbance year set to "2015" (having been disturbed on or before 2015). In this way total disturbance could be calculated for the 2015 state and for the 2019 state, and the difference between the two disturbance years calculated.

The 2018 disturbance feature class for the Elk River watershed was compiled using publicly available datasets, Teck Coal proprietary datasets, previous Golder 2014 disturbance mapping from high resolution imagery, and Canfor Forestry data. Disturbances were then reviewed against high-resolution 2018 orthophoto mosaic where coverage was available, and 3-m 2018 satellite imagery obtained from Planet Imagery in the remainder of the Elk River watershed. Additional disturbances visible at approximately 1:10,000 scale were digitized, and road segments not apparent on imagery or that were duplicated were removed. Undated cutblocks were then reviewed against 2018 historic Google Earth imagery and dated back to the 1980's. Structural stages of cutblocks were assigned based on disturbance dates. Wildfire younger than 80 years old were reviewed against 2018 imagery and assigned a structural stage where damage to the tree crown was apparent. Where the damage was not apparent, the structural stage of the overlaying provincial predictive ecosystem map (PEM) data was assigned. Cutblocks and wildfires were then combined based on their disturbance dates, with most recent disturbances prioritized.

2.3.5 Terrestrial Data Evaluation

Total watershed area for the upper Fording River, as well as total riparian and disturbance areas were tabulated for 2015 and 2019. The difference was computed and expressed as a percentage relative to 2015.

3 RESULTS

3.1 Westslope Cutthroat Trout Condition (Tier 1)

Mature Westslope Cutthroat Trout assessed in 2012 through 2014 reflected body condition comparable to or greater than the body condition observed in four other upper Kootenay River populations sampled using similar methods (Table 3.1). These data suggest that food availability within the upper Fording River was relatively good prior to the population decline.

Table 3.1: Summary of Fulton Condition Factor (K) For Select Upper Kootenay River Populations of Mature Westslope Cutthroat Trout Captured Using Similar Methods (from Cope et al. 2016)

Location and Year	Fulton K			N	Fork Length (cm)	
	Min	Max	Average		Average	Range
Upper Fording River (2012)	1.10	1.80	1.41	229	28.9	16.0 - 48.5
Upper Fording River (2013)	0.77	2.58	1.37	244	25.2	14.9 - 45.0
Upper Fording River (2014)	0.91	2.33	1.52	253	26.8	13.4 - 45.6
Upper Bull River (2010) [a]	0.89	2.14	1.18	65	31.6	23.0 - 43.3
Elk River (2000 to 2001) [b]	1.17	1.84	1.44	40	37.4	32.5 - 42.2
St. Mary River (2001 to 2002) [c]	1.08	1.89	1.28	40	38.6	34.0 - 43.0
Wigwam River (2001) [d]	0.95	1.40	1.14	31	39.3	34.0 - 45.0

[a] Cope and Prince 2012.
[b] Prince and Morris 2003.
[c] Morris and Prince 2004.
[d] Baxter and Hagen 2003.

Condition factors (K) for juvenile Westslope Cutthroat Trout presented in Table 3.2.18 by Cope et al. (2016) were updated for this report by adding monitoring data for 2017 and 2019 (Table 3.2). The fish sampled in 2017 and 2019 had condition factors comparable to those observed in previous years.

Table 3.2: Summary of Fulton Condition Factor (K) for Westslope Cutthroat Trout Approximating Juvenile Size Ranges Within the Upper Fording River for the Period 1983 to 2019 (from Cope et al. 2016, Cope 2020)

Location and Year	Fulton K			N	Fork Length (cm)	
	Min	Max	Average		Average	Range
Upper Fording River (1983) [a]	0.63	1.63	1.15	-	-	-
Upper Fording River (1999) [b]	0.93	1.79	1.18	95	-	7.4 - 25.0
Upper Fording River (2013)	0.96	1.31	1.13	103	12.0	6.2 - 22.3
Upper Fording River (2014)	0.79	1.65	1.18	183	12.8	6.5 - 24.4
Upper Fording River (2015)	0.70	1.63	1.07	313	11.7	6.5 - 26.0
Upper Fording River (2017) [c]	0.52	2.00	1.29	325	12.6	6.1 - 25.9
Upper Fording River (2019)	0.66	1.56	1.13	195	12.0	6.0 - 23.3

Notes: Table from Cope et al. 2016, with additional data from S. Cope for 2017 and 2019, "-" indicates no data.

[a] Norecol (1983).

[b] Amos and Wright (2000).

[c] Measurement errors for an unknown number of fish occurred in 2017 because a weigh scale malfunctioned. Exclusion of all K values greater than 2 (n=88) eliminated obvious outliers but the data set may still be biased by measurement errors.

Using the same data set reflected in Table 3.2, mean weights-at-length of juvenile Westslope Cutthroat Trout were also evaluated using ANCOVA (Table 3.3). Westslope Cutthroat Trout with length > 6 cm that were captured in 2019 were compared to fish of similar length captured in 2013, 2014, and 2015[11]. Mean weight-at-length in 2019 was not different from that measured in 2013, and was 4.1% lower and 5.3% greater than in 2014 and 2015, respectively (Figure 3.1; Table 3.3). These results indicate that mean juvenile weights-at-length can vary by 4-5% among years. That weight-at-length in 2019 was not lower than all earlier years indicates that Westslope Cutthroat Trout were in good condition in 2019. Therefore, the ANCOVA supported

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[11] As noted in footnote #3 of Table 3.2, and explained in Section 2.1.1, malfunction of a scale in 2017 resulted in an unknown number of suspect weight measurements, so data for that year were not included in the ANCOVA.

conclusions from the comparison of condition factors in Table 3.2 that condition of juveniles in 2019 was similar to that of previous years and that the fish were not starving in September 2019.

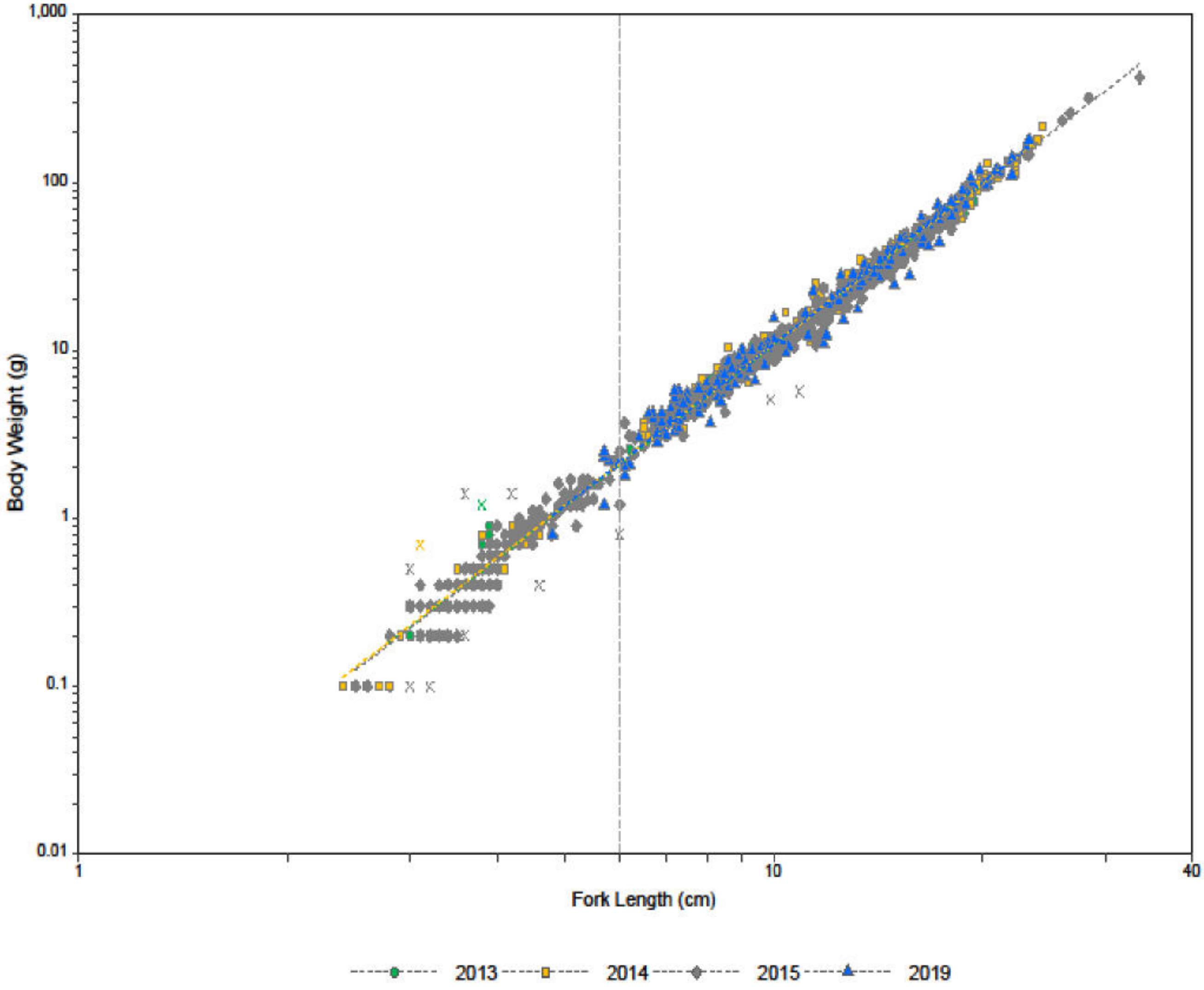

Figure 3.1: Upper Fording River Juvenile Westslope Cutthroat Trout Body Weight Relative to Fork Length, 2019 Compared to 2013 to 2015

Notes: Outliers removed from analysis plotted with an 'X'. Fish with lengths less than 6 cm (vertical line) were excluded from analysis

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Table 3.3: Juvenile Westslope Cutthroat Trout Weight at Length from Upper Fording River, 2013 to 2015 and 2019

Model	Sample Size				ANCOVA Model P-Values			Mean Fork Length (cm) for Comparison	Adjusted Mean Body Weight (g)				P-Values of Pairwise Difference to 2019			MOD[a] (%) to 2019		
	2013	2014	2015	2019	Year x $\log_{10}$(Fork Length)	Fork Length	Year		2013	2014	2015	2019	2013	2014	2015	2013	2014	2015
All data[b]	139	228	483	200	<0.001[d]	<0.001	0.010	8.88	7.30	7.44	7.18	7.45	0.677	1.000	0.035	2.0	0.13	3.8
Fork Length > 6 cm[c]	103	183	317	192	0.044[e]	<0.001	<0.001	11.5	16.9	17.6	16.1	16.9	1.000	0.004	<0.001	-0.16	-4.1	5.3

▨ P-Value < 0.1

[a] MOD (magnitude of difference) calculated as (x_n-x_b)/x_b*100% where x_n is the adjusted mean body weight of fish in 2019, and x_b is the mean for the year being compared.

[b] Fourteen outliers with studentized residuals > 4 were removed from the ANCOVA model.

[c] Two outliers with studentized residuals > 4 were removed from the ANCOVA model.

[d] ANCOVA proceeded under the assumption that the slopes are practically parallel (R^2 of interaction model = 0.9920 and R^2 of parallel slope model = 0.9917; a difference < 0.02) following Environment Canada (2012b).

[e] ANCOVA proceeded under the assumption that the slopes are practically parallel (R^2 of interaction model = 0.9867 and R^2 of parallel slope model = 0.9866; a difference < 0.02) following Environment Canada (2012b).

Table 3.4: Juvenile Westslope Cutthroat Trout Weight at Length in Lower Greenhills Creek and Lower Dry

Creek	Model	n			ANCOVA Model P-Values			Mean Fork Length (cm) for Comparison	Adjusted Mean Body Weight (g)			P-Values of Pairwise Difference to 2017		MOD[a] (%) to 2017	
		2017	2018	2019	Year x $\log_{10}$(Fork Length)	Fork Length	Year		2017	2018	2019	2018	2019	2018	2019
Lower Greenhils	All data[b]	110	111	30	0.005[d]	<0.001	<0.00	8.35	6.50	6.29	6.87	0.034	0.036	-3.3	5.6
	Fork Length > 6 cm[c]	64	92	34	<0.001[f]	<0.001	0.09	9.82	10.5	10.1	10.4	0.095	0.963	-3.9	-0.69
	Fork Length > 8 cm[b]	42	67	34	0.005[c]	<0.001	0.22	11.3	16.2	15.8	16.6	-	-	-	-
Lower Dry	All Data	10	9	11	0.197	<0.001	0.195	10.9	13.7	12.8	13.4	-	-	-	-

▨ P-Value < 0.1

[a] MOD (magnitude of difference) calculated as (x_n-x_b)/x_b*100% where x_b is the adjusted mean body weight of fish in 2017, and x_n is the mean for the year being compared.

[b] Five outliers with studentized residuals > 4 were removed from the ANCOVA model.

[c] ANCOVA proceeded under the assumption that the slopes are practically parallel (R^2 of interaction model = 0.952 and R^2 of parallel slope model = 0.948; a difference

Juvenile Westslope Cutthroat Trout weights and lengths were also monitored annually in lower Greenhills Creek from September 2017 to 2019 (Minnow 2018c, 2019b, 2020b). Mean weights-at-length for Westslope Cutthroat Trout > 8 cm in length were not significantly different in 2018 or 2019 compared to 2017 (Table 3.4; Figure 3.2). Similarly, weights-at-length for juvenile trout captured in lower LCO Dry Creek did not differ in September 2018 or 2019 compared to 2017 (Table 3.4; Figure 3.2).

Sixteen mature Westslope Cutthroat trout were sampled non-lethally in September 2018 for tissue selenium monitoring in the RAEMP (Minnow 2020c). These fish had condition factors within the range reported by Cope et al. (2016) for 726 mature trout sampled throughout the upper Fording River in 2012 through 2014 (Table 3.5). Condition factors for the fish sampled in September 2018 were also comparable to condition factors reported for other upper Kootenay populations (Table 3.1).

Degree-days can be used to explain variation in fish growth and development (Coleman and Fausch 2007; McMillan et al. 2012; Chezik et al. 2014). Continuous water temperature measurements at three stations in the upper Fording River indicated there were more degree-days[12] in 2018 than 2019 (Wright et al. 2021), and no days with mean temperature above 18°C, which is below the incipient lethal level to Westslope Cutthroat Trout of 19.6°C (Bear et al. 2005). These data suggest that conditions were at least as favourable for growth in 2018 as 2019, providing further evidence contrary to a reduction in fish condition in summer 2018.

Nine mature Westslope Cutthroat Trout non-lethally sampled in Henretta Lake in February-March 2019 (Appendix B) had condition factors within the range reported by Cope et al. (2016) for mature trout sampled throughout the upper Fording River in 2012 through 2014 (Table 3.5). Growth rate estimates for two fish that were previously floy tagged were consistent with the growth model developed for the upper Fording River population by Cope et al. (2016; Appendix B).

Although mature trout sampled in fall 2018 and winter 2019 had condition factors within ranges reported previously for the upper Fording River (Table 3.5) and other nearby watersheds (Table 3.1), the condition factors observed in 2018 and 2019 were at the low end of the other ranges. Twelve of 16 fish (75%) sampled in September 2018 had condition factors in the lower 10% of the overall range reported by Cope et al. (2016) for trout of comparable lengths (> 20 cm; n = 668) previously sampled in late summer and early fall. The single fish sampled in Henretta Lake in February 2019 had a condition factor representing the 52nd percentile of the 2012-2014

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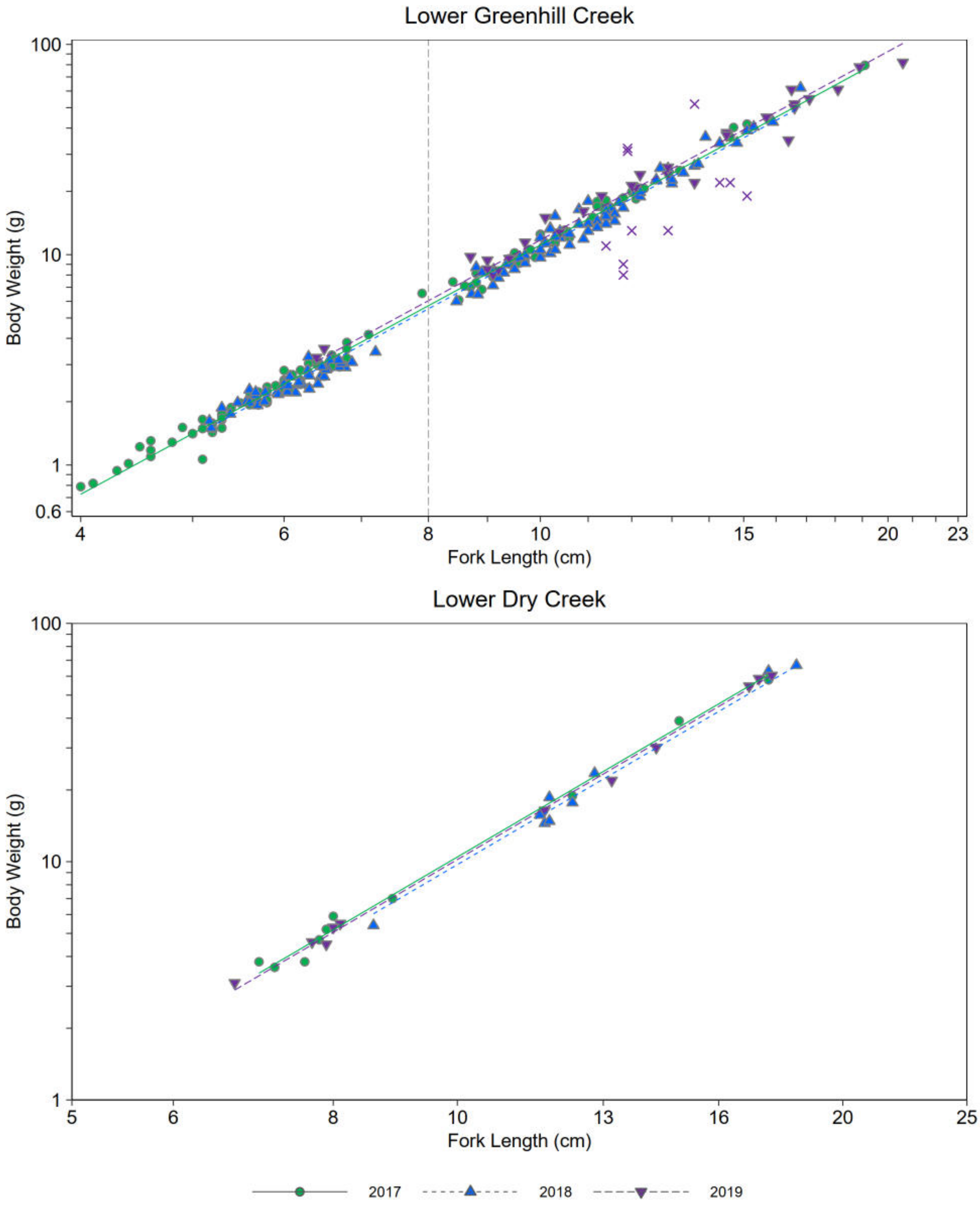
[12] Computed as the sum of daily mean water temperatures from the first week when average stream temperature remains above 5°C until the last day of the first week when average stream temperature decreases below 4°C.


Lower Greenhill Creek

Lower Dry Creek

Figure 3.2: Weight at Length of Juvenile Westslope Cutthroat Trout in Lower Greenhills Creek and Lower Cry Creek 2017 to 2019

Notes: Outliers removed from analysis plotted with an 'X'. Fish with lengths less than 8 cm were excluded from analysis at Greenhills Creek.

Table 3.5: Condition Factors for Westslope Cutthroat Trout Captured 2018 and 2019 in Upper Fording River Watershed

Area	Sample Identifier	Date Sampled	Length (mm)	Weight (g)	Sex	Age	Condition Factor (K)	Comments
Fording at Multiplate	RG_MP1_WCT-01	11-Sep-18	413	1,020	-	-	1.45	PIT tag recapture 3D9.1C2D701134
	RG_MP1_WCT-02	11-Sep-18	390	705	-	-	1.19	
	RG_MP1_WCT-03	11-Sep-18	386	735	-	-	1.28	
	RG_MP1_WCT-04	11-Sep-18	325	405	-	-	1.18	
	RG_MP1_WCT-05	11-Sep-18	468	1,200	-	-	1.17	
	RG_MP1_WCT-06	11-Sep-18	332	415	-	-	1.13	
	RG_MP1_WCT-07	11-Sep-18	392	820	-	-	1.36	Floy tag 0911 pink/orange
	RG_MP1_WCT-08	11-Sep-18	358	530	-	-	1.16	
					MEAN K		**1.24**	
Fording Downstream Chauncey	RG_FODCH_WCT-01	09-Sep-18	299	265	-	-	0.99	
	RG_FODCH_WCT-02	09-Sep-18	314	350	-	-	1.13	
	RG_FODCH_WCT-03	09-Sep-18	322	355	-	-	1.06	
	RG_FODCH_WCT-04	09-Sep-18	322	360	-	-	1.08	
	RG_FODCH_WCT-05	09-Sep-18	356	550	-	-	1.22	
	RG_FODCH_WCT-06	11-Sep-18	333	375	-	-	1.02	
	RG_FODCH_WCT-07	11-Sep-18	301	295	-	-	1.08	
	RG_FODCH_WCT-08	11-Sep-18	292	250	-	-	1.00	
					MEAN K		**1.07**	
Henretta Lake	RG_HE27_WCT_01_M20190214	14-Feb-19	445	1240	M	-	1.41	PIT tag recapture 90011800158149
	RG_HE27_WCT_01_M20190325	25-Mar-19	393	680	-	-	1.12	
	RG_HE27_WCT_02_M20190325	25-Mar-19	392	740	-	-	1.23	
	RG_HE27_WCT_03_M20190325	25-Mar-19	395	710	M	11+	1.15	Floy tag 0610 blue. Radio tag. Age known from recapture history dating to June 2012.
	RG_HE27_WCT_04_M20190325	25-Mar-19	439	1070	-	-	1.26	Floy tag 0793 green.
	RG_HE27_WCT_05_M20190325	25-Mar-19	412	880	M	-	1.26	
	RG_HE27_WCT_06_M20190325	25-Mar-19	424	960	-	-	1.26	PIT tag recapture 900118001580512
	RG_HE27_WCT_07_M20190325	25-Mar-19	467	1340	M	-	1.32	
	RG_HE27_WCT_08_M20190325	25-Mar-19	428	1020	-	-	1.30	PIT tag recapture 985121021328816
					MEAN K		**1.26**	
Condition Factors for Mature Westslope Cutthroat Trout, Upper Fording River 2012-2014 (Table 3.1; n=726)					Mean		**1.43**	Mean of annual means
					Min		**0.77**	2013
					Max		**2.58**	2013

Notes: "-" indicates no data. PIT - passive integrated transponder

data set (i.e., about average), but the eight fish sampled in March 2019 had condition factors representing the 4th to 33rd percentiles of the 2012 to 2014 data set for fish >20 cm (i.e., relatively low condition). However, sample sizes in 2018 to 2019 were very small and spatial representation was limited. Also, similarly low condition factors were reported for fish captured at the Multiplate in 2013 and 2014 by Cope et al. (2016), and at both the Multiplate and near Chauncey Creek in September 2015 as part of the RAEMP (Figure 3.3).

In summary, juvenile Westslope Cutthroat Trout in the upper Fording River in late summer 2019 had body condition comparable to annual observations for 2013 to 2015. Although the data set was spatially limited for 2018, juvenile fish condition in lower Greenhills Creek and lower LCO Dry Creek, which are important spawning and rearing areas in the upper Fording River (Cope et al. 2016), did not differ from 2017. More degree-days in the upper Fording River in 2018 compared to 2019 provided further indication that conditions were favourable for trout growth in 2018. Furthermore, the consistency of late-summer juvenile Westslope Cutthroat Trout condition factors reported since 1983 (Table 3.2) suggest against a single-year decline in food availability in 2018, followed by full recovery in 2019. However, mature trout sampled in September 2018 and February-March 2019 as part of the RAEMP had condition factors at the low end of the range reported for trout sampled prior to the population decline (i.e., 2012 to 2014; Cope et al. 2016). Therefore, the data do not preclude the possibility that energy storage (lipid) levels were below-average in fall-winter 2018 to 2019 for some unknown proportion of the population. Data gaps and uncertainties are discussed in Section 3.5.

3.2 Aquatic Invertebrates (Tier 2)

Mean benthic invertebrate biomass and density measured in Hess samples were not significantly different in 2018 or 2019 compared to 2017 at most upper Fording River monitoring areas (Figures 3.4 and 3.5; Tables 3.6 and 3.7). Mean biomass was reduced in the Fording River between Kilmarnock and Swift creeks (RG_FOBKS) in 2019 compared to both 2017 and 2018. Biomass was also lower in the Fording River upstream from Porter Creek (RG_FRUPO) in both 2018 and 2019 compared to 2017 (Table 3.6). The only significant reductions in density observed in 2018 compared to 2017 occurred at reference areas upstream from mine influence (Table 3.7). In 2019, density was reduced at both RG_FRUPO and farther downstream at RG_FO22 (Table 3.7). Overall, 14 of 17 comparisons for biomass (82%) and 13 of 17 comparisons for density (76%) indicated no change in 2018 or 2019 compared to 2017 (Tables 3.6 and 3.7).

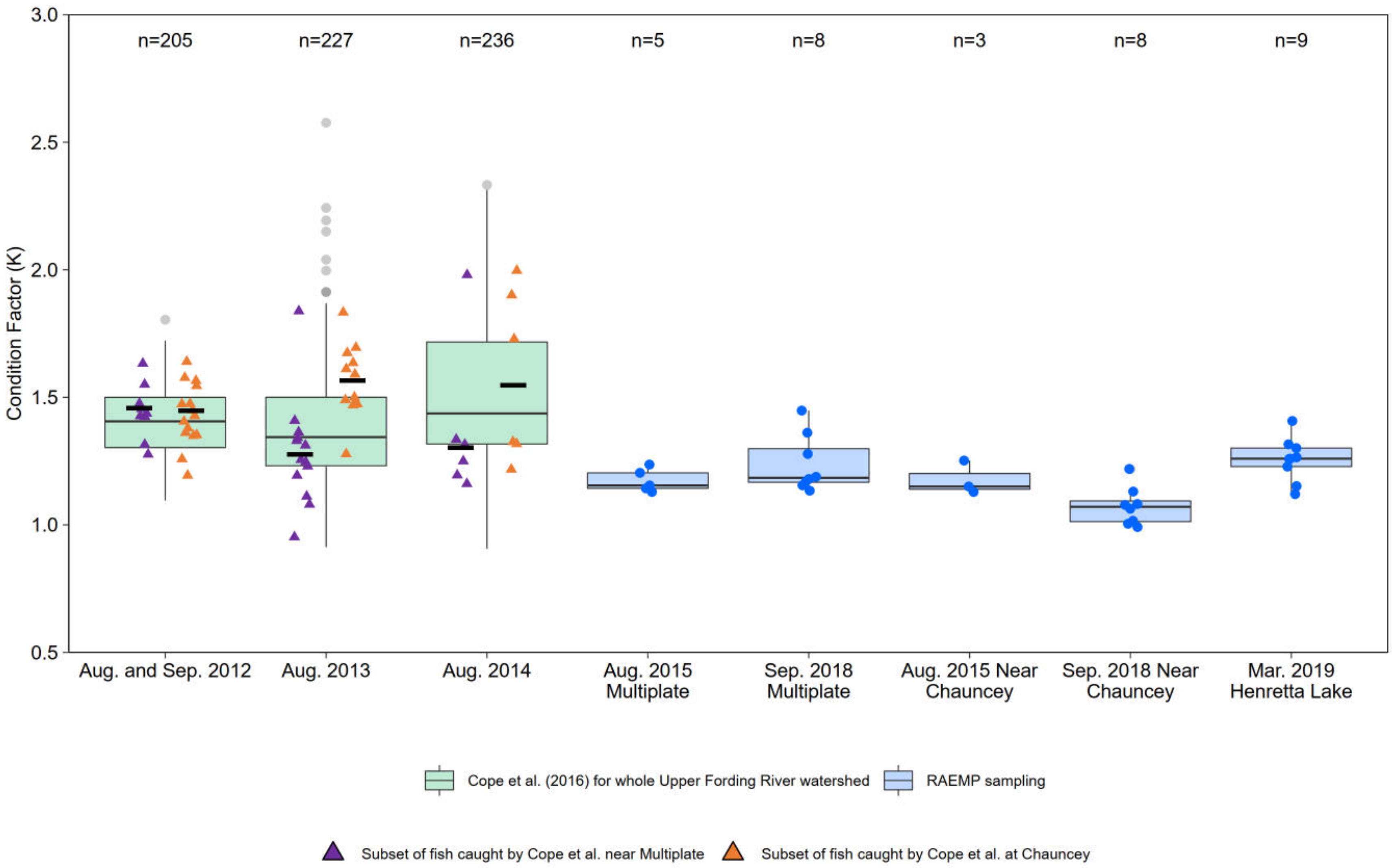


Figure 3.3: Boxplot of Condition Factors for Westslope Cutthroat Trout > 200 mm Sampled 2012 to 2019

Notes: Boxplots represent the full range of data for Cope at al. (2016) and RAEMP samples. Blue dots represent individual fish collected from the RAEMP, orange and purple triangles represent individual fish caught by Cope et al. within the RAEMP sampling areas. Black bars represent median values of data subsets from Cope et al.

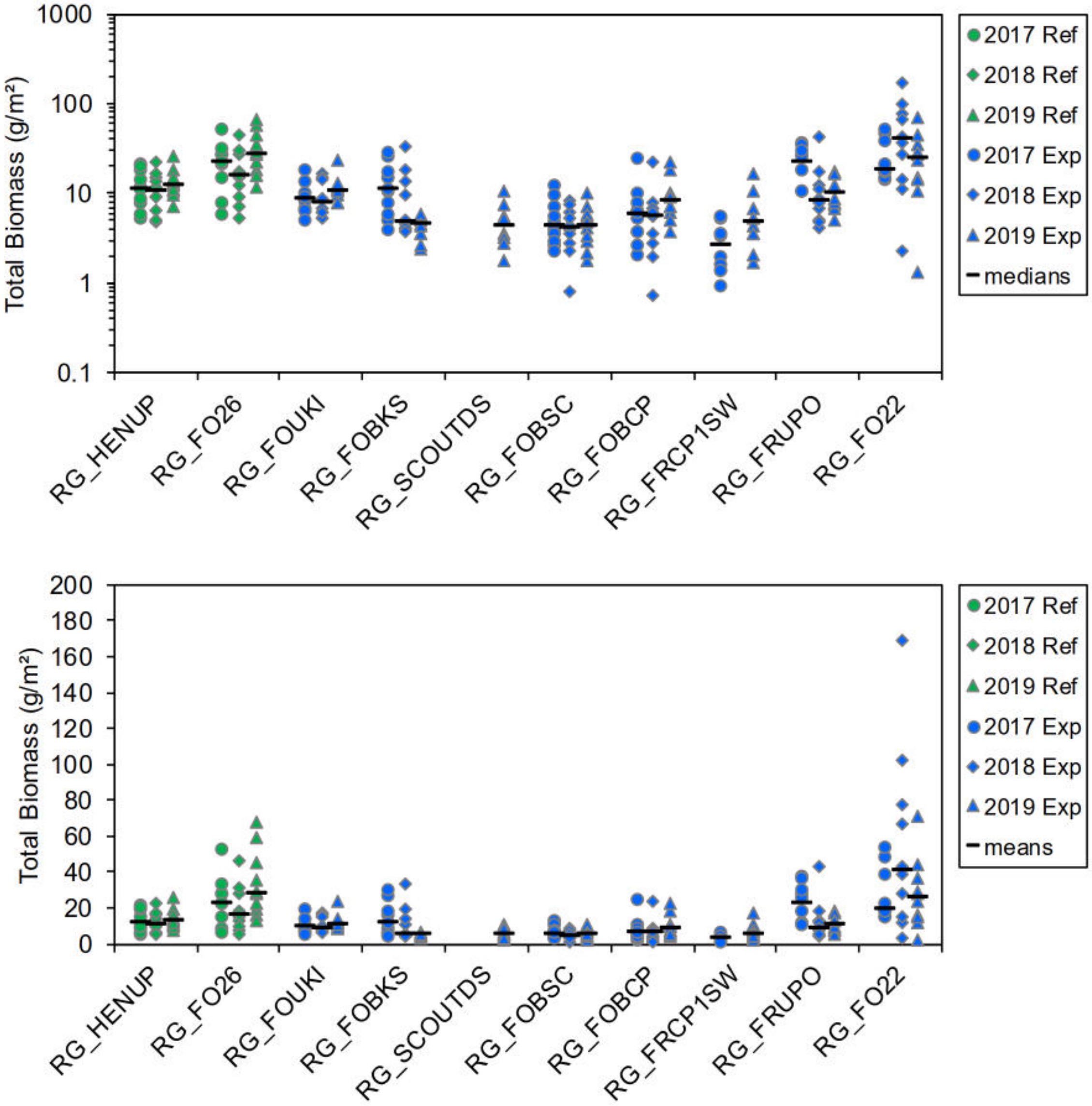


Figure 3.4: **Benthic Invertebrate Biomass, Upper Fording River, 2017 to 2019: a) $\log_{10}$ scale; b) untransformed scale**

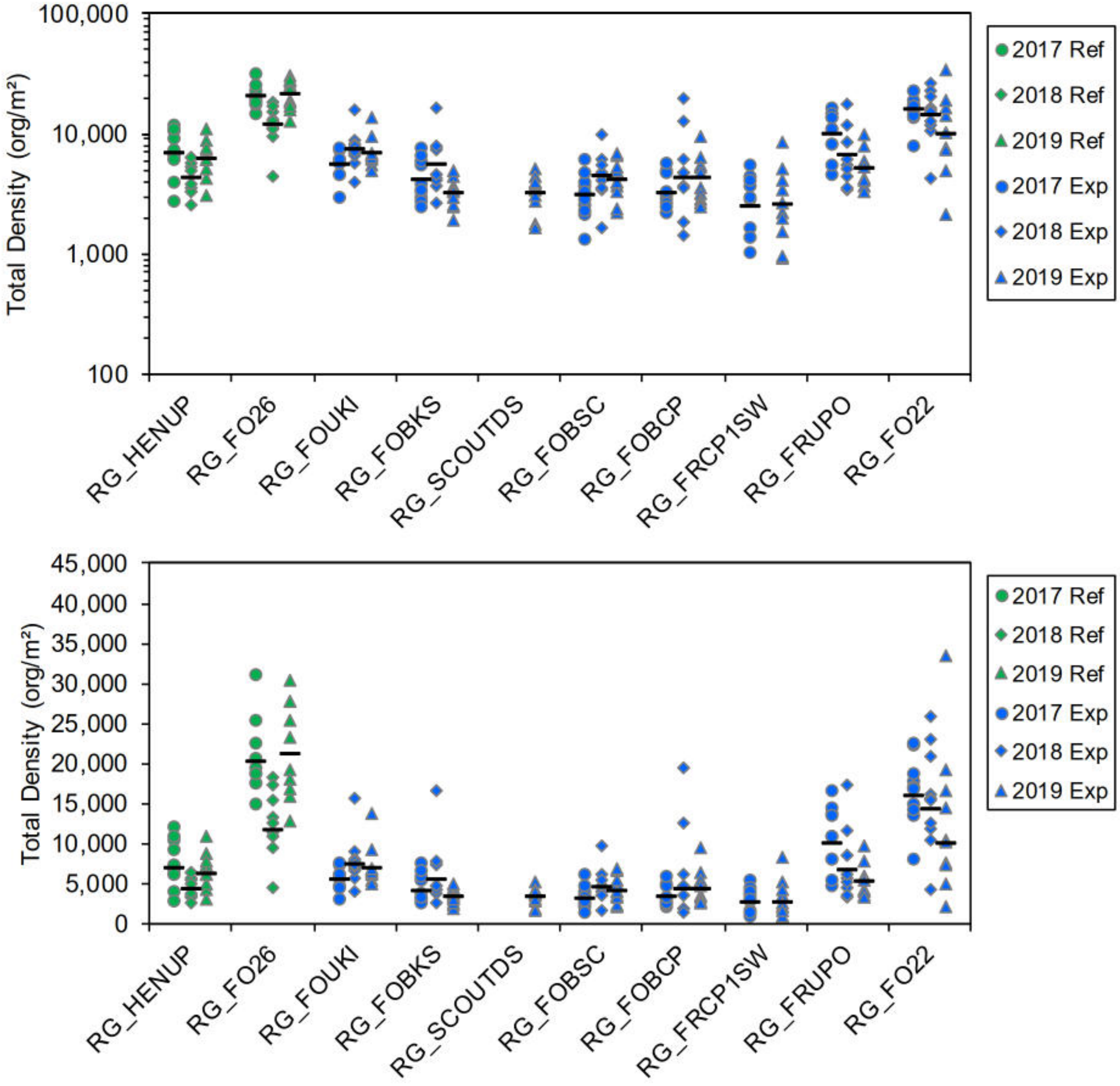


Figure 3.5: Benthic Invertebrate Density, Upper Fording River, 2017 to 2019: a) $\log_{10}$ scale; b) untransformed scale

Table 3.6: Benthic Invertebrate Biomass in Upper Fording River in 2018 and 2019 Compared to 2017

Area Type	ANOVA Model			
	Transformation	**Area**	**Year**	**Area × Year**
	Rank	<0.001	0.061	0.001
	Post-hoc Contrasts and Magnitude of Difference (MOD [a])			
	Area	**2018 vs 2017**	**2019 vs 2017**	**2019 vs 2018**
Reference	RG_HENUP	-8.0	11	21
	RG_FO26	-30	25	78
Mine-Exposed	RG_FOUKI	-8.6	23	35.0
	RG_FOBKS	-56	-59	-6.9
	RG_FOBSC	-6.0	1.6	8.1
	RG_FOBCP	-3.7	43	48
	RG_FRCP1SW	-	75	-
	RG_FRUPO	-63	-53	26
	RG_FO22	118	38	-37

▨ Relevant P-value < 0.1

🟦 Significant and Negative MOD (temporal drop in biomass)

🟩 Significant and Positive MOD (temporal increase in biomass)

[a] MOD calculated as the median of the later year minus the median of the earlier year divided by the median of the earlier year and multiplied by 100.

Table 3.7: Benthic Invertebrate Density in Upper Fording River 2018 and 2019 Compared to 2017

Area Type	ANOVA Model			
	Transformation	**Area**	**Year**	**Area × Year**
	Log_{10}	<0.001	0.542	<0.001
	Post-hoc Contrasts and Magnitude of Difference (MOD [a])			
	Area	**2018 vs 2017**	**2019 vs 2017**	**2019 vs 2018**
Reference	RG_HENUP	-38	-11	43
	RG_FO26	-42	3.8	81
Mine-Exposed	RG_FOUKI	34	26	-5.8
	RG_FOBKS	35	-23	-43
	RG_FOBSC	46	34	-8.2
	RG_FOBCP	32	30	-1.8
	RG_FRCP1SW	-	0.57	-
	RG_FRUPO	-34	-48	-21
	RG_FO22	-12	-38	-30

▨ Relevant P-value < 0.05

🟦 Significant and Negative MOD (temporal drop in density)

🟩 Significant and Positive MOD (temporal increase in density)

[a] MOD calculated as the geometric mean of the later year minus the geometric mean of the earlier year divided by the geometric mean of the earlier year and multiplied by 100.

Benthic invertebrate abundances measured in three-minute kick samples, were within or above the normal (reference area) range at all monitoring areas in the Fording River sampled as part of the FRO LAEMP (Figure 2.3) in September 2017, 2018, and 2019 (Figure 3.6). Areas sampled farther downstream as part of the LCO Dry Creek LAEMP (RG_FO28 and RG_FO29; Figure 2.4) and RAEMP (RG_FODGH; between Josephine Falls and Greenhills Creek; Figure 2.4) also showed total invertebrate abundances that were within or above the normal range (Appendix Figure A.4).

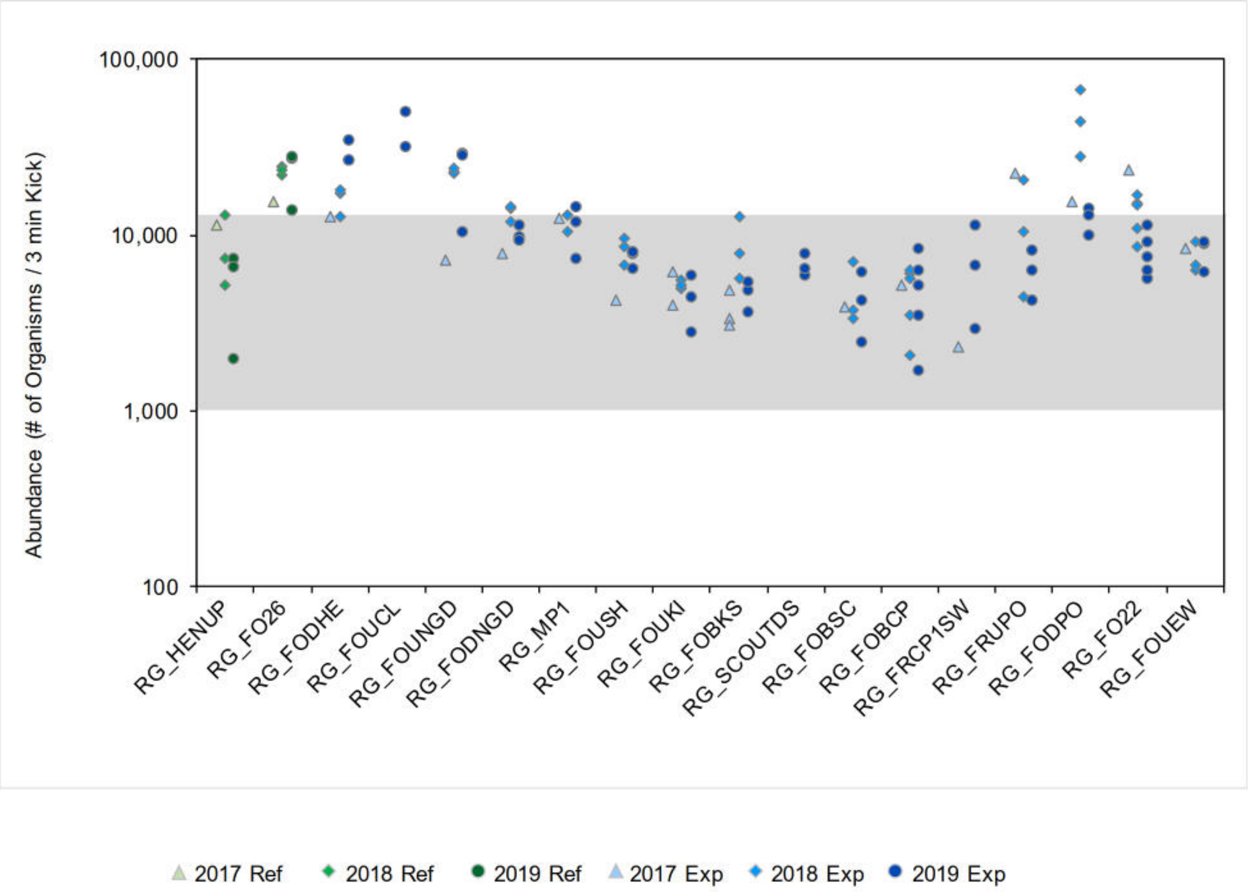


Figure 3.6: Total Abundance of Benthic Invertebrates in Kick and Sweep Samples of the Upper Fording River, 2017 to 2019

Note: Grey shading represents the upper and lower limits of the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP).

Benthic invertebrate community composition was also evaluated because a shift could indicate a change in food quality. Communities in undisturbed lotic habitats of the Elk River watershed and adjacent watersheds are dominated by EPT (Appendix Figures A.2 and A.3). As noted in Section 1.1.2, EPT and chironomids are important dietary organisms for Westslope Cutthroat Trout of all ages. EPT and chironomid abundances measured in 2017 to 2019 were consistently within or greater than respective normal ranges, except for a single sample collected at RG_FOBSC (Fording River between Swift and Cataract creeks) where low chironomid abundance was observed in 2018 (Figure 3.7).

Analysis of potential changes over time was based on 16 monitoring areas, for which conditions were assessed in both 2018 and 2019 compared to the previous year as well as the mean of all prior years since 2012. This resulted in a total of 384 temporal comparisons among six benthic community abundance endpoints (Appendix Tables A.1 to A.6). Four comparisons (1%) showed a decrease in 2018 or 2019 compared to either the previous year or mean of prior years since 2012, whereas 99% of comparisons showed no change or an increase. Comparability of benthic invertebrate abundances in 2018 and 2019 relative to previous years was also evident in temporal plots for each upper Fording River LAEMP monitoring area, including the three additional areas monitored in other programs that extend downstream almost to Josephine Falls (RG_FO28, RG_FO29, and RG_FODGH; Appendix Figures A.4 to A.9).

Routine benthic invertebrate community monitoring has normally taken place in September but additional sampling was undertaken in the upper Fording River in other months of 2018 and 2019 to serve the objectives of the FRO LAEMP (Appendix Figures A.10 to A.15). The data generally suggested lowest invertebrate abundances in June compared to the other months which could be because: a) of losses due to spring insect emergence; b) turbulent freshet flow causing suspension of benthic organisms into the drift; and/or c) wadeable habitats sampled during June freshet may be areas along the stream margins that were dry during winter low flows (i.e., newly wetted and not yet fully recolonized in June[13]). Regardless, this pattern of lower benthic abundance in June compared to September was also evident at the upstream reference areas (RG_FO26 and RG_HENUP), suggesting lower values may be "normal" for that time of year, whereas the regional normal ranges depicted by the grey shade on these figures are based on samples collected in September. In other words, low values other than in September do not necessarily represent low food supply and the shading is presented on the figures for context.

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[13] Reports from field crews indicate that kick samples likely corresponded with permanently wetted areas in June 2018. Although still considered unlikely by field crews, it could not be ruled out that higher flows in June 2019 resulted in some samples being collected in areas that were dry in winter and/or that the higher flows may have reduced kick sample capture efficiency.

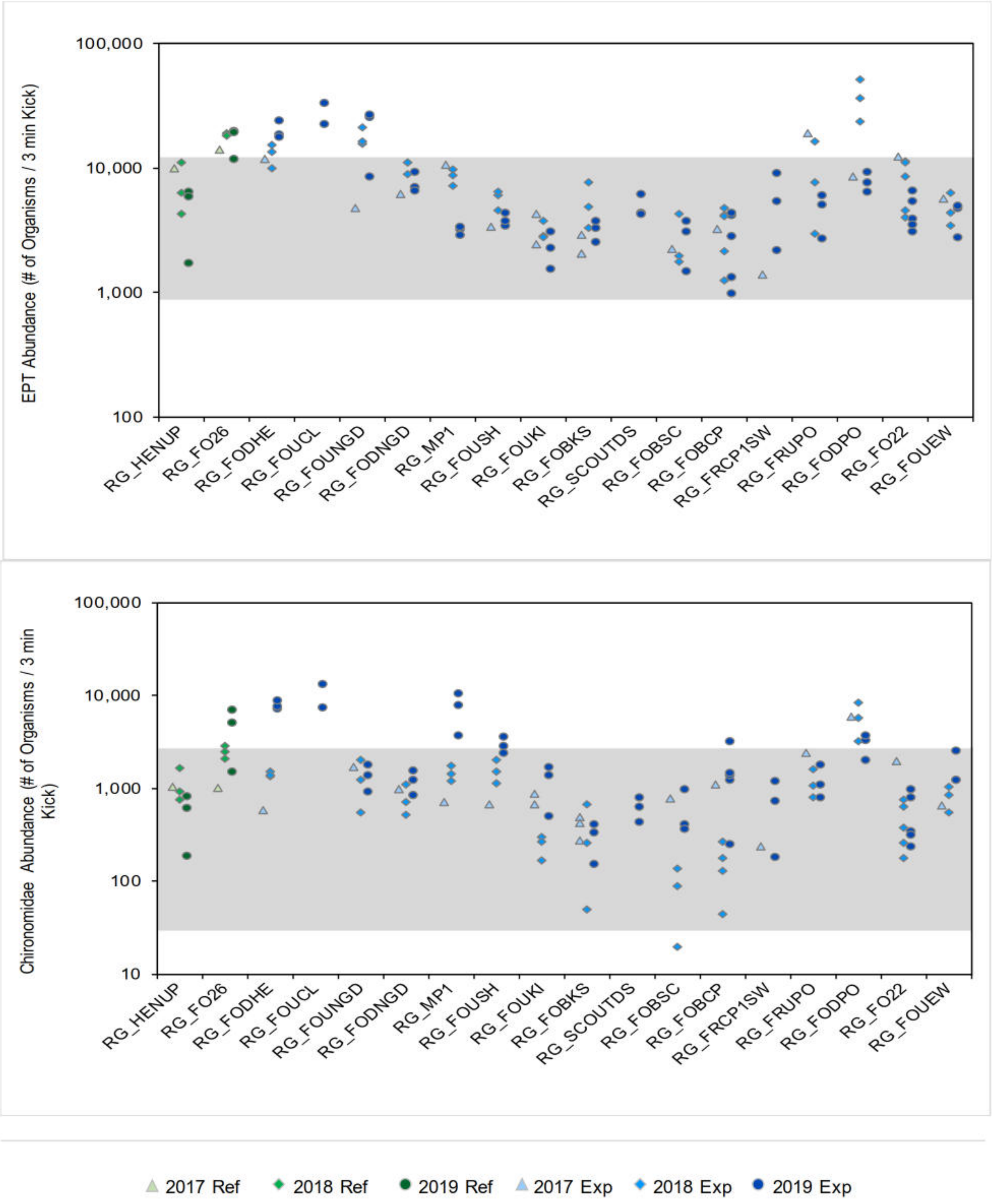

Figure 3.7: Abundance of a) Ephemeroptera, Plecoptera, Trichoptera (EPT), and b) Chironomids in Kick and Sweep Samples of the Upper Fording River, 2017 to 2019

Note: Grey shading represent the upper and lower limits of the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP).

Total benthic invertebrate abundances at areas downstream from mining in June, September, and December of 2018 and 2019 were comparable to or higher than at one or both upstream reference areas monitored in the same month in 65 of 68 comparisons (91%) between mine-exposed and reference areas across the three months (Appendix Figures A.10 to A.15; Appendix Table A.7). There was a pattern of low benthic invertebrate abundance at areas near Cataract Creek (RG_FOBSC and RG_FOBCP), particularly in December 2018. A hydrology survey of this portion of the Fording River in December 2018 indicated lack of surface water flow upstream and downstream from RG_FOBSC (Appendix Figure A.18). Although there was flow at RG_FOBCP, the surface water at this location was mainly composed of discharge from Cataract Creek. Loss of surface water during winter base flow periods make this portion of the river inhospitable for Westslope Cutthroat Trout overwintering. The pools upstream from Chauncey Creek, which are used by a large proportion (>40%) of the upper Fording River Westslope Cutthroat Trout population for overwintering[14] (Cope et al. 2016), are located farther downstream extending roughly from RG_FRUPO to Chauncey Creek (Figure 2.3). Total invertebrate and EPT abundances at RG_FRUPO, RG_FODPO and RG_FOUEW in December 2018 and 2019 were comparable to or higher than at the upstream reference area (Appendix Table A.7; Appendix Figures A.10; RG_FO22 was not sampled in December).

In summary, although aquatic invertebrate biomass and density were not measured in stream drift, benthic invertebrate community data indicate that the quantity and quality of source organisms has remained stable since 2012. Differences in biomass or density observed in September 2018 or 2019 compared to 2017 were few and localized. The abundances of key dietary organisms for Westslope Cutthroat Trout September 2018 or 2019 were comparable to previous years. Seasonal benthic invertebrate abundances at areas downstream from mining in June, September, and December of 2018 and 2019 were usually comparable to or higher than at least one of the upstream reference areas monitored in the same month, including in the Westslope Cutthroat Trout overwintering area upstream from Chauncey Creek in December 2018 and 2019. Overall, the benthic invertebrate monitoring results provide evidence contrary to the hypothesis that the quantity and/or quality of aquatic invertebrates decreased sufficiently to cause or contribute to the Westslope Cutthroat Trout population decline observed after September 2017. Data gaps and uncertainties are discussed in Section 3.5.

3.3 Terrestrial Invertebrates (Tier 2)

Inputs of terrestrial invertebrates to streams are strongly linked to the amount and type of riparian vegetation (Wipfli 1997; 2005; Allan et al. 2003; Romero et al. 2005; Wipfli and Baxter 2010;

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[14] The section of overwintering pools is in Segment 6, or S6, of the upper Fording River, as identified by Cope et al. (2016) and Cope (2020).

Wilson et al. 2014; Studinski et al. 2017; Albertson et al. 2018) and surrounding land use (Edwards and Huryn 1996; Eros et al. 2012).

Total riparian area in the upper Fording River watershed in 2019 was reduced by 0.7 km^2 in 2019 compared to 2015, representing a change of 2.3% (Table 3.8). Broader land disturbances due to mining and other causes (e.g., fire, forestry) each increased by about 6% over the same four-year period, representing an overall decline in undisturbed habitat of 2.4%. These changes are not large enough to infer reduction of terrestrial invertebrate inputs sufficient to cause Westslope Cutthroat Trout starvation, especially considering the opportunistic feeding strategy of this species (e.g., ability to also forage on aquatic invertebrate drift and benthic invertebrates).

Table 3.8: **Changes in Riparian and Disturbance Areas Between 2015 and 2019**

Terrestrial Characteristics	Area (km^2)			% Change
	2015	2019	Difference	
Riparian habitat	31	30.3	0.71	2.3
Total Upper Fording River watershed area	425.5	425.5	0	0
Total catchment areas for tributaries in the Tributary Data Report (Minnow 2016)	330.5	330.5	0	0
Total mine disturbance footprint	62.3	66.0	3.7	5.9
Footprint of other disturbances (e.g., fire, forestry cutblocks)	56.5	60.1	3.6	6.4
Undisturbed	306.7	299.4	-7.3	-2.4

3.4 Summary

Juvenile Westslope Cutthroat Trout in the upper Fording River sampled in August 2019 had body condition comparable to annual observations for 2013 through 2015. Although the data set was spatially limited for 2018, juvenile fish condition in lower Greenhills Creek and lower LCO Dry Creek, which are important spawning and rearing areas in the upper Fording River (Cope et al. 2016), did not differ from 2017, which suggested adequate food availability in 2018. More degree-days in the upper Fording River in 2018 compared to 2019 provided further indication that conditions were favourable for trout growth in 2018. Furthermore, the consistency of juvenile trout condition factors reported since 1983 suggest a single-year decline in food availability in 2018, followed by full recovery in 2019, would be unlikely. However, mature trout sampled in September 2018 and February-March 2019 as part of the RAEMP (n = 25) had condition factors at the low end of the range reported for trout of similar size sampled prior to the population decline (i.e., 2012 to 2014; Cope et al. 2016; n = 668). Therefore, the data do not preclude the possibility that energy storage (lipid) levels were below-average in fall 2018 and winter 2019 for some unknown proportion of the population.

Fourteen (14) of 17 comparisons for total invertebrate biomass (82%) and 13 of 17 comparisons for density (76%) indicated no change in 2018 or 2019 compared to 2017. This means that any differences in biomass or density observed in September 2018 or 2019 compared to 2017 were few and localized. No change or an increase in kick sample abundance was observed in 99% of temporal comparisons for six benthic community abundance endpoints at 16 monitoring areas in 2018 and 2019 relative to the previous year or mean of all previous years since 2012 (384 comparisons in total). These results indicate that the late-summer abundances of benthic invertebrates, including EPT and chironomids, have remained stable since 2012. Total benthic invertebrate abundances were monitored in additional months of 2018 and 2019. In 65 of 68 comparisons (91%), benthic abundances at mine-exposed areas in June, September, and December were either comparable to, or higher than, reference areas that were monitored in the same month. This included high total and EPT abundances in December 2018 and 2019 at the Westslope Cutthroat Trout overwintering area upstream from Chauncey Creek relative to the single reference area monitored that month.

Changes in total riparian habitat (2.3% reduction) and the area disturbed by mining and other factors (i.e., 2.4% reduction in total undisturbed habitat) between 2015 and 2019 were not large enough to infer reduction of terrestrial invertebrate inputs after September 2017 sufficient to cause Westslope Cutthroat Trout starvation, especially considering their ability to also forage on drifting and benthic aquatic invertebrate invertebrates.

All of the monitoring data that were evaluated provide evidence contrary to the hypothesis that the quantity and/or quality of dietary invertebrates decreased sufficiently to cause or contribute to the Westslope Cutthroat Trout population decline observed after September 2017. Consequently, the evaluation did not progress to Tier 3 (evaluation of the causes of reduced food availability). However, the data did not preclude the possibility of energy deficits contributing to mortality during the harsh winter of 2019.

3.5 Data Gaps and Uncertainties

3.5.1 Fish Condition Data for 2018

Although the data set for juvenile fish condition was spatially limited for 2018, juvenile Westslope Cutthroat Trout in lower Greenhills Creek and lower LCO Dry Creek, which are important spawning and rearing areas within the upper Fording River, had body condition comparable to juveniles assessed in 2017. Also, the consistency of condition factors reported for upper Fording River Westslope Cutthroat Trout since 1983 suggest a single-year decline in food availability in 2018, followed by full recovery in 2019, would be unlikely. There was also good seasonal abundance of benthic invertebrates in most areas, including the Westslope Cutthroat Trout overwintering area upstream from Chauncey Creek. Mature fish sampled in September 2018 (Multiplate and upstream from Chauncey) and in February-March 2019 (Henretta Lake) as part of the RAEMP (n = 25) had condition factors within, but at the low end of, ranges reported for trout of similar size sampled prior to the population decline (i.e., 2012 to 2014; Cope et al. 2016; n = 668). Therefore, the data do not preclude the possibility that energy storage (lipid) levels were below-average in fall 2018 and winter 2019 for some unknown proportion of the population. The significance of this finding is uncertain because sample sizes and spatial representation were very limited in 2018 and 2019.

3.5.2 Sensitivity of Small versus Larger Fish

Fish condition during the population decline period was broadly assessed for juveniles (in 2019), but not adults. However, the metabolic requirements as water temperatures decrease in fall and winter usually result in more rapid lipid depletion and higher overwinter mortality among smaller individuals (Reimers 1963; Hunt 1969; Shuter and Post 1990; Smith and Griffith 1994; Handy 1997; Hurst 2007). Therefore, juvenile fish are often considered to be a sensitive indicator of energy storage among the broader population.

3.5.3 Fall Fish Condition as Indicator of Winter Survival

Native species that are adapted to winter survival increase body size and store lipids in summer, and these factors contribute to greater overwinter survivorship, particularly for juveniles (Reimers 1963; Hunt 1969; Smith and Griffith 1994; Quinn and Peterson 1996; McGrath 2003; Biro et al. 2004). Therefore, late summer body condition of trout is an indicator of overwinter survival.

Body condition of juvenile Westslope Cutthroat Trout in the upper Fording River was assessed in late summer, whereas the largest seasonal decline in body energy stores typically occurs in fall or early winter, associated with physiological adjustment to lower water temperatures and freezing, as well as decreased photoperiod (Cunjak and Power 1987; Cunjak et al. 1987; Metcalfe and Thorpe 1992; Handy 1997; Brown et al. 2011; Koljonen et al. 2012). Although colder water temperatures reduce metabolic demand (Cunjak et al. 1987; Hebdon and Hubert 2001; Brown et al. 2011), and salmonids continue to feed in winter (Cunjak and Power 1987; Cunjak et al. 1987; Brown et al. 2011), appetite, prey capture efficiency, and digestion efficiency may decline (Cunjak and Power 1987; Cunjak et al. 1987; Metcalfe and Thorpe 1992; Brown et al. 2011). Therefore, energy deficits can still occur and contribute to winter mortality (Handy 1997; Hebdon and Hubert 2001; Biro et al. 2004; Hurst 2007; Brown et al. 2011).

Although declines in body condition based on length and weight measurements have been used to indicate starvation processes among salmonids during winter, body condition is not always a reliable indicator of energy reserves and survival (Handy 1997; Hebdon and Hubert 2001; Simpkins et al. 2000, 2003; Robinson 2010). This is because body condition does not only reflect lipid reserves but is also related to the amount of moisture stored in tissues (Handy 1997; Robinson 2010).

There were fewer degree-days (defined in Section 2.1.4) in 2018 and 2019 than other years on record at FR_HC1 (except for 2012, which was lower) and FR_FRNTP (Wright et al. 2021). This suggests conditions were less optimal for summer growth during the population decline window. Also, low flows and early onset of drying in portions of the upper Fording River in the fall of 2018 potentially impaired access to food, reduced foraging time or efficiency, or resulted in greater fall migration effort compared to other years. Most (75%) of the 16 mature trout captured in September 2018 had condition factors less than the 10th percentile of condition factors for fish longer than 20 cm sampled in 2012 to 2014. These data indicate potential for below-average lipid storage among trout entering the winter of 2018-2019.

Also, water temperatures were below 1°C more frequently in 2019 (101 days) compared to other years at FR_HC1 (65 to 98 days), and in 2018 (93 days) and 2019 (107 days) compared to other years (0 to 88 days in other years) at FR_FRNTP (Wright et al. 2021). Furthermore, water temperatures less than 0°C were reported at FR_FRNTP for several weeks from mid-February through early March 2019, which may have resulted unusual ice formations, such as frazil ice, in portions of the upper Fording River (Hatfield and Whelan 2021). The unusual cold may have reduced the appetite, prey capture efficiency, and digestion efficiency of trout (Cunjak and Power 1987; Cunjak et al. 1987; Metcalfe and Thorpe 1992; Brown et al. 2011) and caused environmental conditions (e.g., ice, crowding; Hatfield and Whelan 2021) that may have increased fish stress and energy expenditure (also see next section for further discussion about fish energetics in winter).

3.5.4 Availability of Winter Fish Data

Winter monitoring data for Westslope Cutthroat Trout in the upper Fording River are sparse, and studies of the winter ecology of fish in the literature are also very limited, especially for ice-covered streams (Huusko et al. 2007; Weber et al. 2013; Watz 2015). The presence of Westslope Cutthroat Trout in montane streams of western Canada and the northern United States indicate this species is well adapted to winter conditions. The mean (and standard deviation) Critical Thermal Minima (CTMin) of Westslope Cutthroat Trout acclimated to 15°C and subjected to a rapid decline in water temperature (0.3 °C/minute) was 1.0°C (± 0.8; Yau and Taylor 2014), indicating tolerance to a rapid reduction in water temperature. Native trout adapted to local conditions can withstand near-zero water temperatures.

Salmonids continue to feed in winter (Cunjak and Power 1987; Cunjak et al. 1987; Hebdon and Hubert 2001; Brown et al. 2011) but appetite, prey capture, and digestion efficiencies are reduced in cold water (Cunjak and Power 1987; Cunjak et al. 1987; Metcalfe and Thorpe 1992; Hebdon and Hubert 2001; Biro et al. 2004; Brown et al. 2011). Depending on the state of energy (lipid) stores and level of activity, salmonids can survive weeks or months with little to no food, particularly at low water temperatures (Toneys and Coble 1980; Navarro and Gutierrez 1995; Pottinger et al. 2003; Simpkins et al. 2003; Biro et al. 2004; Waagbo et al. 2017). This is because starvation occurs gradually over three stages (Simpkins et al. 2003; Bar 2014). Liver glycogen reserves are used as an energy sources in the early days of food deprivation, after which the body uses stored lipids. In later stages of starvation, when lipids are depleted, the body begins to use proteins, which compromises vital organ functions, eventually leading to death.

Survival rates for salmonids in their first winter can exceed 80%, although mortality rates can be equally high (Biro et al. 2004; Huusko et al. 2007). Some salmonid populations can grow and maintain good condition through winter (Hebdon and Hubert 2001; Biro et al. 2004), particularly in locations experiencing warming from groundwater (French et al. 2017). The overwintering area on the upper Fording River upstream from Chauncey Creek, which supports more than 40% of the population in winter, is influenced by groundwater warming (Cope et al. 2016). Water temperatures were <1°C for fewer days at FR_FRABCH (21 and 36 days in 2018 and 2019, respectively) than at upstream stations FR_FRNTP (93 and 107 days, respectively) and FR_HC1 (83 and 101 days, respectively; Wright et al. 2021).

Although studies of winter ecology of fish are rare, studies evaluating potential interactions among winter stressors are even rarer (Hurst 2007). Overwinter survival may not only depend on food availability and body energy reserves but may also co-vary with environmental factors and predation (Huusko et al. 2007). For example, studies suggest that energy depletion of fish is less, and survival is greater, under ice-cover than ice-free conditions (Finstad et al. 2004; Hedger et al. 2013). The presence of surface ice may also increase food intake rates, reduce stress, reduce predation, and affect social interactions (Watz 2015). Low flow and ice conditions may confine fish to more limited habitat areas (Brown et al. 2011) and increase competition for space, oxygen, and food (Huusko et al. 2007). Fish with limited or depleted energy reserves are less able to withstand other environmental stresses (Hurst 2007). Therefore, winter fish survival may depend on a combination of summer growth and energy storage, and stochastic variations in winter duration and severity (Huusko et al. 2007).

In summary, despite evidence of good seasonal food availability in the upper Fording River and consistency of fish condition factors over time, it cannot be concluded with certainty that starvation was not a contributing factor in the upper Fording River Westslope Cutthroat population decline. Factors such as low flow and early drying of portions of the upper Fording River in summer-fall 2018 may have resulted in below-average lipid storage among trout during the fall of 2018. Subsequent extreme cold in February 2019 potentially reduced foraging and digestion efficiencies and increased energy demands, which may have contributed to above-average winter mortality rates.

3.5.5 Abundance of Invertebrates in Drift

The relative abundance of taxa in drift may not directly correlate to that of the benthic community (Shearer et al. 2003; Naman et al. 2016). Also, trout diet does not always reflect the proportional abundance of invertebrates in drift, indicating prey selectivity (Gutierrez 2011). The specific occurrence of aquatic invertebrate taxa in drift at any given time is determined by complex, interdependent factors including life cycle, illumination, stream discharge, population density, water chemistry (e.g., oxygen, pH), and behavioural characteristics (Pearson and Franklin 1968; Lehmkuhl and Anderson 1972; Brittain and Eikeland 1988; Barbero et al. 2013; Naman et al. 2016). Nevertheless, positive correlations have been reported between benthic and drift densities for dominant drifting orders (Ephemeroptera, Diptera, and Trichoptera; Shearer et al. 2003). Seasonal changes in drift composition have been associated with seasonal shifts in the assemblage of benthic macroinvertebrates (Rincón and Lobón-Cerviá 1997) but monitoring data for the upper Fording River indicated benthic invertebrate abundances have been stable since 2012, and that communities were dominated by EPT taxa throughout the year.

An assessment of ephemeral reaches in the upper Fording River indicated that the southern drying reach, upstream from the S6 overwintering area, has gone dry between December and February or March in most years since 1976 (Zathey and Robinson 2021). These drying events may influence the dietary availability of invertebrates in drift. Although the spatial extent of drying varies among years, any dry section would eliminate drift from upstream reaches to the S6 pools. Formation of anchor ice in some years would also represent a barrier to downstream invertebrate drift. However, drift distances for aquatic invertebrates are typically short (i.e., centimetres to meters; Brittain and Eikeland 1988), so the effects of drying or ice formation on drift abundance would extend only a short distance downstream.

Salmonids can switch dietary reliance from terrestrial invertebrates to aquatic (Nakano et al. 1999; Baxter et al. 2005; Studinski et al. 2017), or the reverse (Kraus et al. 2016), and from drift to benthic organisms (Fausch et al. 1997; Nislow et al. 1998; Nakano et al. 1999; Dunham et al. 2000; Zhang and Richardson 2011) in response to availability and quality. Fish will also move in search of food if local resources are limited (Wilzbach 1985; Gowan and Fausch 2002; Baxter et al. 2005; COSEWIC 2006). The literature also indicates that stream invertebrate drift is usually lowest in winter (Brittain and Eikland 1988; Riehle and Griffith 1993) and that salmonids often shift to benthic foraging in winter (Cunjak and Power 1987; Johansen et al. 2010; Anderson et al. 2016; Johnson et al. 2017). Therefore, benthic invertebrate abundances provide a reasonable basis for assessing changes in food availability in the 2017 to 2019 period when the Westslope Cutthroat Trout population declined.

Potential changes in terrestrial drift abundance were inferred from landscape indicators rather than direct measurement and did not consider potential localized effects. However, the diet of Westslope Cutthroat Trout in the Elk River watershed is dominated by aquatic invertebrates and, as noted above, trout can shift foraging behaviour from terrestrial to either drifting or benthic aquatic invertebrates and will also move in search of food. Wilson et al. (2014) concluded that benthic invertebrate biomass in streams, not the magnitude of terrestrial invertebrate inputs, determined the proportional use of terrestrial and aquatic invertebrates by trout during summer months. Therefore, a decline in terrestrial invertebrates may have little effect on trout in a system with good benthic invertebrate abundance, such as the upper Fording River. Also, the drift structure at a given place in a stream depends not only on local production but also on upstream distant areas (Wipfli 1997, 2005; Wipfli and Gregovich 2002; Wipfli and Baxter 2010; Barbero et al. 2013). For example, terrestrial invertebrates falling or washing into streams in a headwater may be consumed by fish farther downstream (previous references). So, the specific locations of riparian or terrestrial disturbances are not as important for assessing potential effects on fish as the overall amount of undisturbed riparian and upland habitat.

3.6 Conclusions and Strength of Evidence

The data evaluation indicated the requisite conditions for sufficient starvation of Westslope Cutthroat Trout to be the sole cause of a population decline were not met. Specifically:

- The condition of juvenile Westslope Cutthroat Trout throughout the upper Fording River in 2019 was not reduced compared to previous years, and various lines of evidence (fish condition in lower Greenhills Creek and lower LCO Dry Creek in 2018, and temporal consistency of juvenile and adult condition factors) suggest against reduced condition in 2018;

- The total abundance of aquatic invertebrate food organisms, and abundances of taxa that are important dietary items, in September 2018 and 2019 were comparable to previous years throughout the upper Fording River and were seasonally available; and
- Changes in riparian habitat and the area disturbed by mining and other factors were not large enough to expect that Westslope Cutthroat Trout starved, especially considering their ability to also forage on aquatic invertebrate drift and benthic invertebrates.

Therefore, it is concluded that starvation due to lack of food availability cannot explain the Westslope Cutthroat Trout population decline. The various lines of evidence presented in this report all corroborated each other, giving strength to this conclusion.

However, there are uncertainties related to:

- The limited data respecting Westslope Cutthroat Trout population size and body condition in 2018 and winter 2019;
- The reliability of fish condition as an indicator of lipid reserves, and direct measurements of lipid content have not been made;
- The effects on fish lipid reserves of contending with low flows and early drying in the fall 2018, followed by extreme cold in February 2019; and
- Limited understanding of the site-specific winter ecology of Westslope Cutthroat Trout and potential interaction among stressors within compared to outside of the window of population decline.

Therefore, it cannot be concluded with certainty that energy deficits did not occur in the winter of 2018 to 2019 and contribute to the upper Fording River Westslope Cutthroat Trout population decline to some degree.

4 REFERENCES

Albertson, L.K., V. Ouellet, and M.D. Daniels. 2018. Impacts of stream riparian buffer land use on water temperature and food availability for fish. Journal of Freshwater Ecology 33: 195-210.

Allan, J. D. 1981. Determinants of diet in brook trout (*Salvelinus fontinalis*) in a mountain stream. Canadian Journal of Fisheries and Aquatic Sciences 38: 184–192.

Allan, J.D., M.S. Wipfli, J.P. Caouette, A. Prussian, and J. Rodgers. 2003. Influence of streamside vegetation on inputs of terrestrial invertebrates to salmonid food webs. Canadian Journal of Fisheries and Aquatic Sciences 60: 309–320.

Amos, L. and J. Wright. 2000. 1999 Fording River fish and fish habitat monitoring program. Prepared for Fording Coal Limited, Elkford, BC. Prepared by Interior Reforestation Co. Ltd. Cranbrook, BC. 46 p. + 8 app.

Anderson, A.M., E. Mittag, B. Middleton, B. Vondracek & L. C. Ferrington Jr. 2016. Winter diets of brown trout populations in southeastern Minnesota and the significance of winter-emerging invertebrates. Transactions of the American Fisheries Society 145: 206-220.

Bar, N. 2014. Physiological and hormonal changes during prolonged starvation in fish. Canadian Journal of Fisheries and Aquatic Sciences 71: 1447-1458.

Barbero, M.D., A.M. Oberto and C.M. Gualdoni. 2013. Spatial and temporal patterns of macroinvertebrates in drift and on substrate of a mountain stream (Cordoba, Central Argentina). Acta Limnologica Brasiliensia 25: 375-386.

Baxter, C.V., K.D. Fausch, and W.C. Saunders. 2005. Tangled webs: reciprocal flows of invertebrate prey link streams and riparian zones. Freshwater Biology 50: 201–220.

Baxter, J. and J. Hagen. 2003. Population size, reproductive biology, and habitat use of Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in the Wigwam River watershed. Report prepared for Tembec Industries Inc., Cranbrook, BC. Report prepared by Baxter Environmental and J. Hagen and Associates, Nelson, BC. 20 p. +7 app.

BCMWLAP (British Columbia Ministry of Water, Land and Air Protection). 2004. "Westslope" Cutthroat Trout. In: p. 45-59, Accounts and Measures for Managing Identified Wildlife Southern Interior Forest Region. Version 2004.

Bear, E.A., T.E. McMahon and A.V. Zale. 2007. Comparative thermal requirements of Westslope Cutthroat Trout and rainbow trout: implications for species interactions and development of thermal protection standards. Transactions of the American Fisheries Society 136: 1113-1121.

Biro, P.A., A.E. Morton, J.R. Post, and E.A. Parkinson. 2004. Over-winter lipid depletion and mortality of age-0 rainbow trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 61: 1513-1519.

Bollinger, T. 2021. Subject Matter Expert Report: DISEASE. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population. Report prepared for Teck Coal Limited.

Borzek, M.A., L.D. DeBrev, and J.A. Lockwood. 1994. Diet overlap among size classes of Colorado River cutthroat trout (*Oncoryhnchus clarkii pleuriticus*) in a high-elevation mountain stream. Hydrobiologia 273: 9-17.

Brittain, J.E., and T.J. Eikeland. 1988. Invertebrate Drift – A review. Hydrobiologia 166: 77-93.

Brown, R.S., W.A. Hubert and S.F. Daly. 2011. A primer on winter, ice, and fish: what fisheries biologists should know about winter ice processes and stream-dwelling fish. Fisheries 36: 8-26.

Chezik, K.A., N.P. Lester, and P.A. Venturelli. 2014. Fish growth and degree-days I: Selecting a base temperature for a within-population study. Canadian Journal of Fisheries and Aquatic Sciences 71: 47-55.

Cope, S. 2020. Upper Fording River Westslope Cutthroat Trout Population Monitoring Project: 2019. Report Prepared for Teck Coal Limited, Sparwood, BC. Report Prepared by Westslope Fisheries Ltd., Cranbrook, BC. 48 p. + 2 app.

Cope, R.S. and A. Prince. 2012. BC Hydro Aberfeldie Dam Fish Entrainment Strategy Bull River Fish Entrainment – Telemetry Study (Unpublished Draft). Report prepared for BC Hydro, Burnaby, BC. Report prepared by Westslope Fisheries Ltd., Cranbrook, BC. 81 p. + 2 app.

Cope, S., C.J. Schwarz, A. Prince, and J. Bisset. 2016. Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project: Final Report. Report Prepared for Teck Coal Limited4, Sparwood, BC. Report Prepared by Westslope Fisheries Ltd., Cranbrook, BC. 266 p.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2006. COSEWIC Assessment and Update Status Report on the Westslope Cutthroat Trout Oncorhynchus clarkii lewisi (British Columbia and Alberta population). Committee on the Status of Endangered Wildlife in Canada. Ottawa. Vii + 67 p.

COSEWIC. 2016. COSEWIC Assessment and Status Report on the Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*, Saskatchewan-Nelson River populations and Pacific populations, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi + 83 p.

Costa, E.J. and A. deBruyn. 2021. Surface Water Quality. SME Report for Evaluation of Cause: Upper Fording River Westslope Cutthroat Trout Population Decline, Submitted to Teck Coal Limited.

Costello, A. B. 2006. Status of the Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) in Alberta. Alberta Sustainable Resource Development, Wildlife Status Report No. 61, Edmonton, AB. 34 p.

Courtwright, J. and C.L. May. 2013. Importance of terrestrial subsidies for native brook trout in Appalachian intermittent streams. Freshwater Biology 58: 2423–2438.

Cunjak, R. and G. Power. 1987. The feeding and energetics of stream-resident trout in winter. Journal of Freshwater Biology 31: 493-511.

Cunjak, R. A., R. A. Curry, and G. Power. 1987. Seasonal energy budget of brook trout in streams: implications of a possible deficit in early winter. Transactions of the American Fisheries Society 116: 817-828.

Dunham, J.B., M.E. Rahn, R.E. Schroeter, and S.W. Breck. 2000. Diets of sympatric Lahontan cutthroat trout and nonnative brook trout: implications for species interactions. Western North American Naturalist 60: 304-310.

Edwards, E.D., and A.D. Huryn. 1996. Effect of riparian land use on contributions of terrestrial invertebrates to streams. Hydrobiologia 337: 151-159.

Elliott, J.M. 1973. The food of brown and rainbow trout (*Salmo trutta* and *S. gairdneri*) in relation to the abundance of drifting invertebrates in a mountain stream. Oecologia 12: 329–347.

Elliot, J.M. 1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. Freshwater Biology 25: 61-70.

Environment Canada. 2012a. Field Manual: Wadeable Streams. Canadian Aquatic Biomonitoring Network (CABIN).

Environment Canada. 2012b. Metal Mining Technical Guidance for Environmental Effects Monitoring.

Environment Canada. 2013. How Much Habitat is Enough? Third Edition. Environment Canada, Toronto, Ontario.

Eros T., P. Gustafsson, L.A. Greenberg, and E. Bergman. 2012. Forest-Stream Linkages: Effects of Terrestrial Invertebrate Input and Light on Diet and Growth of Brown Trout (*Salmo trutta*) in a Boreal Forest Stream. PLoS ONE 7(5): e36462. doi:10.1371/journal.pone.0036462.

Esteban, E.M., and M.P. Marchetti. 2004. What's on the menu? Evaluating a food availability model with young-of-the-year Chinook salmon in the Feather River, California. Transactions of the American Fisheries Society 133: 777–788.

Evaluation of Cause Team. 2021. Evaluation of Cause – Decline in upper Fording River Westslope Cutthroat Trout population. Report prepared for Teck Coal Limited by Evaluation of Cause Team.

EVS Environment Consultants (Golder Associates). 2005. Elk Valley Selenium Lotic Monitoring Study (2001-2003). Report. Elk Valley Mines Environmental Management Committee, Elkford, BC.

Faulkner, S., N. Swain, S. Buchanan, J. Krick, and T. Hatfield. 2019. Dry Creek Fish and Fish Habitat Monitoring Program Year 1-3 Summary Report. Consultant's report prepared for Teck Coal Limited by Ecofish Research Ltd., April 25, 2019.

Faulkner, S., N. Ammerlaan, N. Swain, K. Granshorn, and T. Hatfield. 2020. Dry Creek Fish and Fish Habitat Monitoring Program Year 4 Summary Report. Consultant's report prepared for Teck Coal Limited by Ecofish Research Ltd., April 24, 2020.

Fausch. K.D., S. Nakano, and S. Kitano. 1997. Experimentally induced foraging mode shift by sympatric charrs in a Japanese mountain stream. Behavioral Ecology 8: 414–420.

Finstad, A.G., T. Forseth, T.F. Naesje, and U. Ugedal. 2004a. The importance of ice cover for energy turnover in juvenile Atlantic salmon. The Journal of Animal Ecology 73: 959–966.

Finstad, A.G., T.F. Naesje, and T. Forseth. 2004b. Seasonal variation in the thermal performance of juvenile Atlantic salmon (*Salmo salar*). Freshwater Biology 49: 1459-1467.

Fochetti, R., I. Amici and R. Argano. 2003. Seasonal Changes and Selectivity in the Diet of Brown Trout in the River Nera (Central Italy). Journal of Freshwater Ecology 18: 437-444.

Fraser, N.H.C., and N.B. Metcalfe. 1997. The costs of becoming nocturnal: feeding efficiency in relation to light intensity in juvenile Atlantic salmon. Functional Ecology 11: 385–391.

French, W.E., B. Vondracek, L.C. Ferrington Jr., J.C. Finlay, and D.J. Dieterman. 2017. Brown trout (*Salmo trutta*) growth and condition along a winter thermal gradient in temperate streams. Canadian Journal of Fisheries and Aquatic Sciences 74: 56-64.

Golder (Golder Associates Ltd.). 2015. Elkview Operations Baldy Ridge Extension Project. Annex N – Landscape and Ecosystems Baseline Report. Submitted to Teck Coal Limited, Elkview Operations. July.

Gowan, C., and K.D. Fausch. 2002. Why do foraging salmonids move during summer? Environmental Biology of Fishes 64: 139-153.

Guitierrez, L. 2011. Terrestrial Invertebrate Prey for Juvenile Chinook Salmon: Abundance and Environmental Controls in an Interior Alaska River. Master of Science Thesis, University of Alaska Fairbanks.

Handy, M.J. 1997. Overwinter survival of Westslope Cutthroat Trout in Cache Creek, Montana. Master of Science Thesis, Montana State University, Bozeman, Montana.

Hatfield, T. and C. Whelan. 2021. Subject Matter Expert Report: Ice. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population. Report prepared for Teck Coal Ltd. Report prepared by Ecofish Research Ltd.

Hebdon, J.L., and W.A. Hubert. 2001. Body conditions and stomach contents of subadult trout during fall and winter in three Wyoming tailwaters. North American Journal of Fisheries Management 21: 897–903.

Hunt, R.L. 1969. Overwinter survival of wild fingerling brook trout in Lawrence Creek, Wisconsin. Journal of the Fisheries Research Board of Canada 26: 1473-1483.

Hurst, T.P. 2007. Causes and consequences of winter mortality in fishes (Review Paper). Journal of Fish Biology 71: 315–345.

Huusko, A., L. Greenberg, M. Stickler, T. Linnansaari, M. Nykänen, T. Vehanen, S. Koljonen, P. Louhi, and K. Alfredsen. 2007. Life in the ice lane: the winter ecology of stream salmonids. River Research and Applications 23: 469-491.

Jenkins, A.R., and E.R. Keeley. 2010. Bioenergetic assessment of habitat quality for stream-dwelling cutthroat trout (*Oncorhynchus clarkii bouvieri*) with implications for climate change and nutrient supplementation. Canadian Journal of Fisheries and Aquatic Sciences 67: 371-385.

Johansen, M., E.B. Thorstad, A.H. Rikardsen, J.I. Koksvik, O. Ugedal, A.J. Jensen, L. Saksgard, and T.F. Naesje. 2010. Prey availability and juvenile Atlantic salmon feeding during winter in a regulated subarctic river subject to loss of ice cover. Hydrobiologia 644: 217-229.

Johnson, J.H., J.A. DiRado, G. Mackey, and R. Abbett. 2017. Comparative diets and foraging strategies of subyearling Atlantic salmon, brown trout, and rainbow trout during winter. Journal of Applied Icthyology 33: 1158-1165.

Kawaguchi, Y., Y. Taniguchi, and S. Nakano. 2003. Terrestrial invertebrate inputs determine the local abundance of stream fishes in a forested stream. Ecology 84: 701-708.

Kelly, M., S. Moore, and S.V. Gregory. 1988. Response of young of the year cutthroat trout to manipulation of habitat structure in a small stream. Transactions of the American Fisheries Society 117: 162-170.

Kelly-Quinn, M. and J.J. Bracken. 1990. A seasonal analysis of the diet and feeding dynamics of brown trout, *Salmo trutta* L., in a small nursery stream. Aquaculture and Fisheries Management 21: 107-124.

Koljonen, S., A. Huusko, A. Maki-Petays, H. Mykra, and T. Muotka. 2012. Body mass and growth of overwintering brown trout in relation to stream habitat complexity. River Research and Applications 28: 62-70.

Kraus, J.M., J.F. Pomeranz, A.S. Todd, D.M. Walters, T.S. Schmidt, and R.B. Wanty. 2016. Aquatic pollution increases use of terrestrial prey subsidies by stream fish. Journal of Applied Ecology 53: 44–53.

Leeseberg, C.A., and E.R. Keeley. 2014. Prey size, prey abundance, and temperature as correlates of growth in stream populations of cutthroat trout. Environmental Biology of Fishes 97: 599–614.

Lehmkuhl, D.M., and N.H. Anderson. 1972. Microdistribution and density as factors affecting the downstream drift of mayflies. Ecology 53: 661-667.

Lemly, D. 1996. Winter Stress Syndrome: An Important Consideration for Hazard Assessment of Aquatic Pollutants. Ecotoxicology and Environmental Safety 34: 223–227.

Li, J.L., W.J. Gerth, R.P. Van Driesche, D.S. Bateman, and A.T. Herlihy. 2016. Seasonal and spatial fluctuations in *Oncorhynchus* trout diet in a temperate mixed-forest watershed. Canadian Journal of Fisheries and Aquatic Sciences 73: 1642–1649.

Lister and KWL (Lister, D.B. and Associates Ltd. and Kerr Wood Leidal Associates Ltd.). 1980. Fording River Aquatic Environment Study. Fording Coal Limited.

MacKenzie, W.H. and J.R. Moran. 2004. Wetlands of British Columbia: A Guide to Identification. Land Management Handbook 52, BC Ministry of Forestry, Research Branch, Victoria, BC.

Marcarelli, A.M., C.V. Baxter, M.M. Mineau, and R.O. Hall. 2011. Quantity and quality: unifying food web and ecosystem perspectives on the role of resource subsidies in freshwaters. Ecology 92: 1215–1225.

Mason, C.F., and S.M. Macdonald. 1982. The input of terrestrial invertebrates from tree canopies to a stream. Freshwater Biology 12: 305-311.

McDonald L.E., and M.M. Strosher. 1998. Selenium Mobilization From Surface Coal Mining in the Elk River Basin, British Columbia: A survey of water, sediment and biota. Pollution Prevention, Ministry of Environment, Lands and Parks, Cranbrook, BC, Canada.

McGrath, K.E. 2003. Size Variation and Fitness Consequences in Age 0 Westslope Cutthroat Trout. A Dissertation Presented in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy, University of Idaho. December.

McMillan, J.R., J.B. Dunham, G.H. Reeves, J.S. Mills, and C.E. Jordan. 2012. Individual condition and stream temperature influence early maturation of rainbow and steelhead trout, Oncorhynchus mykiss. Environmental Biology of Fishes 93: 343-355.

MacKillop, D. 2012. Kootenay-Boundary BEC Update. Unpublished draft report by Deb Mackillop, Regional Ecologist, Kootenay-Boundary Region (March 2012).

Metcalfe, N.B., and J.E. Thorpe. 1992. Anorexia and defended energy levels in over-wintering juvenile salmon. Journal of Animal Ecology 61: 175-181.

Minnow (Minnow Environmental Inc.). 2004. Selenium uptake in biota inhabiting lentic and lotic areas of the Elk River watershed. Report. Elk Valley Selenium Task Force, Elk Valley, British Columbia, Canada. November. Project #2073.

Minnow. 2014. 2012 Biological Monitoring Program for Coal Mines in the Elk River Valley, BC. Report Prepared for Teck Coal Limited, Sparwood, BC. March. Project #2456.

Minnow. 2015. Dry Creek Local Aquatic Effects Monitoring Program, 2014. Prepared for Teck Coal Ltd., Sparwood, BC. Project #2547.

Minnow. 2016a. Data Report for the Tributary Evaluation Program. Report. Prepared for Teck Coal Limited, Sparwood, BC. June. Project #2563.

Minnow. 2016b. Dry Creek Local Aquatic Effects Monitoring Program (LAEMP) 2015. Prepared for Teck Coal Limited, Sparwood, BC. May. Project 157202.0081.

Minnow. 2017a. Fording River Operations Local Aquatic Effects Monitoring Program (LAEMP) Report, 2016. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #167202.0075.

Minnow. 2017b. Line Creek Operation's Local Aquatic Effects Monitoring Program (LAEMP) Report for Dry Creek, 2016. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #167202.0073.

Minnow. 2018a. Elk River Watershed Regional Aquatic Effects Monitoring Program (RAEMP) Final Report, 2015-2016. Prepared for Teck Coal Limited, Sparwood, BC. January. Project #2561.

Minnow. 2018b. Line Creek Operation's Local Aquatic Effects Monitoring Program (LAEMP) Report for Dry Creek, 2017. Prepared for Teck Coal Limited, Sparwood, BC. May. Project 177202.0049.

Minnow. 2018c. Lower Greenhills Creek Aquatic Baseline. Prepared for Teck Coal Limited, Sparwood, BC. June. Project #177202.0043.

Minnow. 2019a. 2018 Line Creek Operations Local Aquatic Effects Monitoring Program (LAEMP) Report for Dry Creek. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #187202.0050.

Minnow. 2019b. Lower Greenhills Creek Monitoring Program Report – 2018. Prepared for Teck Coal Limited, Sparwood, BC. October. Project #187202.0028.

Minnow. 2020a. 2019 Line Creek Operations Local Aquatic Effects Monitoring Program (LAEMP) Report for Dry Creek. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #187202.0050.

Minnow. 2020b. Greenhills Creek Aquatic Monitoring Program 2019 Report. Prepared for Teck Coal Limited, Sparwood, BC. July. Project #197202.0005.

Minnow. 2020c. Regional Aquatic Effects Monitoring Program (RAEMP) Report, 2017 to 2019. Prepared for Teck Coal Limited, Sparwood, BC. November. Project #197202.0011.

Minnow and Lotic (Minnow Environmental Inc. and Lotic Environmental Ltd.). 2018. Fording River Operations Local Aquatic Effects Monitoring Program (LAEMP) Report, 2017. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #177202.0022.

Minnow and Lotic. 2019. Fording River Operations Local Aquatic Effects Monitoring Program (LAEMP) Report, 2018. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #187202.0022.

Minnow and Lotic. 2020. Fording River Operations Local Aquatic Effects Monitoring Program (LAEMP) Report, 2019. Prepared for Teck Coal Limited, Sparwood, BC. May. Project #197202.0004.

Minnow Environmental Inc., Interior Reforestation, Paine, Ledge, and Associates. 2011. Selenium Monitoring in the Elk River Watershed, BC. (2009). Report. Elk Valley Selenium Task Force, Elk Valley, BC, Canada. February. Project #2275.

Morris, K.J. and A. Prince. 2004. St. Mary River Westslope Cutthroat Trout radio telemetry study 2001-2004. Report prepared by Westslope Fisheries Ltd., Cranbrook, BC. Report prepared for Columbia-Kootenay Fisheries Renewal Partnership, Cranbrook, BC. 39 p. + 5 app.

Nakano, S., K. D. Fausch, T. Furukawa-Tanaka, K. Maekawa, and H. Kawanabe. 1992. Resource utilization by bull char (*Salvelinus confluentus*) and cutthroat trout (*Oncorhnchus clarki lewisi*) in a mountain stream in Montana, USA. Japanese Journal of Ichthyology 39: 211–217.

Nakano S., K.D. Fausch, and S. Kitano. 1999. Flexible niche partitioning via a foraging mode shift: a proposed mechanism for coexistence in stream-dwelling charrs. Journal of Animal Ecology 68: 1079–1092.

Naman, S.M., J.S. Rosenfeld, and J.S. Richardson. 2016. Causes and consequences of invertebrate drift in running waters: from individuals to populations and trophic fluxes. Canadian Journal of Fisheries and Aquatic Sciences 73: 1292–1305.

Naman, S.M., J.S. Rosenfeld, L.C. Third, and J.S. Richardson. 2017. Habitat-specific production of aquatic and terrestrial invertebrate drift in small forest streams: implications for drift-feeding fish. Canadian Journal of Fisheries and Aquatic Sciences 74: 1208-1217.

Navarro, I., and J. Gutierrez. 1995. Fasting and starvation. In: (P.W. Hochachka, and T.P. Mommsen, Eds.), Biochemistry and Molecular Biology of Fishes, Volume 5, p.393-434. Elsevier.

Nislow, K.H., Folt, C., and Seandel, M. 1998. Food and foraging behavior in relation to microhabitat use and survival of age-0 Atlantic salmon. Canadian Journal of Fisheries and Aquatic Sciences 55: 116–127.

Nislow, K.H., C.L. Folt, and D.L. Parrish. 1999. Favorable foraging locations for young Atlantic salmon: Application to habitat and population restoration. Ecological Applications 9: 1085–1099.

Norecol Environmental Consultants Ltd. 1983. Eagle Mountain Project. Phase 2 Environmental Assessment (Volume II Appendices). Prepared for Fording Coal Limited Elkford, BC. Prepared by Norecol Environmental Consultants Ltd., Vancouver, BC.

Nowak, G.M., R.A. Tabor, E.J. Warner, K.L. Fresh, and T.P. Quinn. 2004. Ontogenetic Shifts in Habitat and Diet of Cutthroat Trout in Lake Washington, Washington. North American Journal of Fisheries Management 24: 624–635.

Oliver, G.G., and L.E. Fidler. 2001. Towards a Water Quality Guideline for Temperature in the Province of British Columbia. Prepared for Ministry of Environment, Lands and Parks, Water Management Branch, Victoria, BC. Prepared by Aspen Applied Sciences, Ltd., Cranbrook, BC.

Pearson, W.D., and D.R. Franklin. 1968. Some factors affecting drift rates of Baetis and Simuliidate in a large river. Ecology 49: 75-81.

Pottinger, T.G., M. Rand-Weaver, and J.P. Sumpter. 2003. Overwinter fasting and re-feeding in rainbow trout: plasma growth hormone and cortisol levels in relation to energy mobilisation. Comparative Biochemistry and Physiology - Part B: Biochemistry & Molecular Biology 136: 403-17.

Prince, A. and K. Morris. 2004. Upper Wigwam River water quality and quantity monitoring program 2003 data report (03-RIP-FIA-501). Report prepared for Tembec Industries Inc., Cranbrook, BC. Prepared by Westslope Fisheries Ltd., Cranbrook, BC. 68 p. + 4 app.

Quinn, T.P. and N.P. Peterson. 1996. The influence of habitat complexity and fish size on over-winter survival and growth of individually marked juvenile coho salmon (*Oncorhynchus kisutch*) in Big Beef Creek, Washington. Canadian Journal of Fisheries and Aquatic Sciences 53: 1555-1564.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Reimers, N. 1963. Body condition, water temperature, and over-winter survival of hatchery-reared trout in Convict Creek, California. Transactions of the American Fisheries Society 92: 39-46.

Riehle, M.D., and J.S. Griffith. 1993. Changes in habitat use and feeding chronology of juvenile rainbow trout (*Oncorhynchus mykiss*) in fall and the onset of winter in Silver Creek, Idaho. Canadian Journal of Fisheries and Aquatic Sciences 50: 2119-2128.

Rincón, P.A., and J. Lobón-Cerviá. 1997. Temporal patterns in macroinvertebrate drift in a northern Spanish stream. Marine and Freshwater Research 48: 455–464.

Robinson, M.L. 2010. Physiological and Genetic Factors Influencing Thermal Tolerance in the Lahontan Cutthroat Trout (*Oncorhynchus clarkii* henshawi). Ph.D. dissertation. University of Nevada, Reno. December.

Romaniszyn, E.D., J.J. Hutchens Jr., and J.B. Wallace. 2007. Aquatic and terrestrial invertebrate drift in southern Appalachian Mountain streams: implications for trout food resources. Freshwater Biology 52: 1–11.

Romero, N., R.E. Gresswell, and J.L. Li. 2005. Changing patterns in coastal cutthroat trout (*Oncorhynchus clarki clarki*) diet and prey in a gradient of deciduous canopies. Canadian Journal of Fisheries and Aquatic Sciences 62: 1797–1807.

Sepulveda, A.J. 2017. Terrestrial–aquatic linkages in spring-fed and snowmelt-dominated streams. Journal of Freshwater Ecology 32: 297-308.

Shearer, K.A., J.D. Stark, J.W. Hayes, and R.G. Young. 2003. Relationships between drifting and benthic invertebrates in three New Zealand rivers: Implications for drift-feeding fish, New Zealand Journal of Marine and Freshwater Research 37: 809-820.

Shepard, B., K. Pratt, and P. Graham. 1984. Life histories of Westslope Cutthroat Trout and Bull Trout in the Upper Flathead River Basin, Montana. Environmental Protection Agency. Reg. VIII. Water Division. Denver, CO. 85 p.

Shuter, B.J., and J.R. Post. 1990. Climate, population viability, and the zoogeography of temperate fishes. Transactions of the American Fisheries Society 119: 314-336 .

Simpkins, D.G., W.A. Hubert, and T.A. Wesche. 2000. Effects of fall-to-winter changes in habitat and frazil ice on the movements and habitat use of juvenile rainbow trout in a Wyoming tailwater. Transactions of the American Fisheries Society 129: 101–118.

Simpkins, D.G., W.A. Hubert, C.M. del Rio, and D.C. Rule. 2003. Interacting effects of water temperature and swimming activity on body composition and mortality of fasted juvenile rainbow trout. Canadian Journal of Zoology 81: 1641-1649.

Smith, R. W., and J. S. Griffith. 1994. Survival of rainbow trout during their first winter in the Henrys Fork of the Snake River, Idaho. Transactions of the American Fisheries Society 123: 747-756.

Studinski, J.M., A.W. Hafs, J.M. Niles, and K.J. Hartman. 2017. The effects of riparian disturbance on the condition and summer diets of age-0 brook trout (*Salvelinus fontinalis*) in three central Appalachian streams. Canadian Journal of Fisheries and Aquatic Sciences 74: 980–986.

Sweka, J.A., and K.J. Hartman. 2008. Contribution of terrestrial invertebrates to yearly brook trout prey consumption and growth. Transactions of the American Fisheries Society 137: 224–235.

Syrjänen, J., K. Korsu, P. Louhi, R. Paavola, and T. Muotka. 2011. Stream salmonids as opportunistic foragers: the importance of terrestrial invertebrates along a stream-size gradient. Canadian Journal of Fisheries and Aquatic Sciences 68: 2146–2156.

Tembec. 2005. Sustainable Forest Management Plan. Tembec Industries Inc. Forest Resource Management BC Division. Term: 2005-2010. Available at: http://forest.tembec.com/sites/forest.tembec.com/files/pdf/tembec_sfmp_final_sept_22_2005.pdf.

Thayer, E.E. 2016. Brook Trout (*Salvelinus fontinalis*) preference of aquatic versus terrestrial prey in Appalachian Headwater Streams. Master of Science Thesis, West Virginia University.

Toneys, M.J., and D.W. Coble. 1980. Mortality, osmolarity, electrolyte regulation, and fat deposition of young-of-year freshwater fishes under simulated winter conditions. Canadian Journal of Fisheries and Aquatic Sciences 37: 225–232.

Tonkin, J.D., and R.G. Death. 2013. Macroinvertebrate drift-benthos trends in a regulated river. Fundamental and Applied Limnology 182: 231-245.

Tschaplinski P.J., and R.G. Pike. 2010. Riparian management and effects on function. In: R.G. Pike, T.E. Redding, R.D. Moore, R.D. Winkler and K.D. Bladon (Eds.), pp: 479-525, Compendium of Forest Hydrology and Geomorphology in British Columbia. BC Ministry of Forests and Range, Land Management Handbook 66. Available at: www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66.htm.

Waagbø R, S.M. Jørgensen, G. Timmerhaus, O. Breck, and P.A. Olsvik. 2017. Short-term starvation at low temperature prior to harvest does not impact the health and acute stress response of adult Atlantic salmon. PeerJ. 5:e3273.

Watz, J. 2015. Salmonid Behaviour Under Winter Conditions. Dissertation, Faculty of Health, Science and Technology, Karlstad University, Sweden.

Watz, J. 2017. Stress responses of juvenile brown trout under winter conditions in a laboratory stream. Hydrobiologia 802: 131-140.

Watz, J. and J.J. Piccolo. 2011: The role of temperature in the prey capture probability of drift-feeding juvenile brown trout (*Salmo trutta*). Ecology of Freshwater Fish 20: 393-399.

Weber, C., C. Nilsson, L. Lind, K.T. Alfredsen, and L.E. Polvi. 2013. Winter disturbances and riverine fish in temperature and cold regions. BioScience 63: 199-2010.

Wilson, M.K., W.H. Lowe, and K.H. Nislow. 2014. What predicts the use by brook trout (*Salvelinus fontinalis*) of terrestrial invertebrate subsidies in headwater streams? Freshwater Biology 59: 187–199.

Wilzbach, M.A. 1985. Relative roles of food abundance and cover in determining the habitat distribution of stream-dwelling cutthroat trout (*Salmo clarki*). Canadian Journal of Fisheries and Aquatic Sciences 42: 1668-1672.

Wipfli, M.S. 1997. Terrestrial invertebrates as salmonid prey and nitrogen sources in streams: contrasting old-growth and young-growth riparian forests in southeastern Alaska, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 54: 1259-1269.

Wipfli, M.S. 2005. Trophic linkages between headwater forests and downstream fish habitats; implications for forest and fish management. Landscape and Urban Planning 72: 205-213.

Wipfli M.S., and C.V. Baxter. 2010. Linking ecosystems, food webs, and fish production: subsidies in salmonid watersheds. Fisheries 35: 373–387.

Wipfli, M.S., and D.P. Gregovich. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology 47: 957-969.

Wright, N., D. Greenacre, and T. Hatfield. 2021. Subject Matter Expert Report: Climate, Temperature, and Streamflow Trends. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population. Report prepared for Teck Coal Limited. Prepared by Ecofish Research Ltd.

Yau, M.M., and E.B. Taylor. Cold tolerance performance of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) and rainbow trout (*Oncorhynchus mykiss*) and its potential role in influencing interspecific hybridization. Canadian Journal of Zoology 92: 777-784.

Zathey, N., and M.D. Robinson. 2021. Summary of Ephemeral Conditions in the Upper Fording River Watershed. In: Hocking et al. 2021. Subject Matter Expert Report: Mainstem Dewatering. Evaluation of Cause – Decline in Upper Fording River Westslope Cutthroat Trout Population. Report prepared for Teck Coal Ltd. by Ecofish Research Ltd. and Lotic Environmental Ltd.

Zhang, Y., and J.S. Richardson. 2011. Contrasting effects of cross-ecosystem subsidies and predation on benthic invertebrates in two Pacific coastal streams. Aquatic Sciences 73: 53–62.

APPENDIX A
SUPPORTING INFORMATION

FIGURES

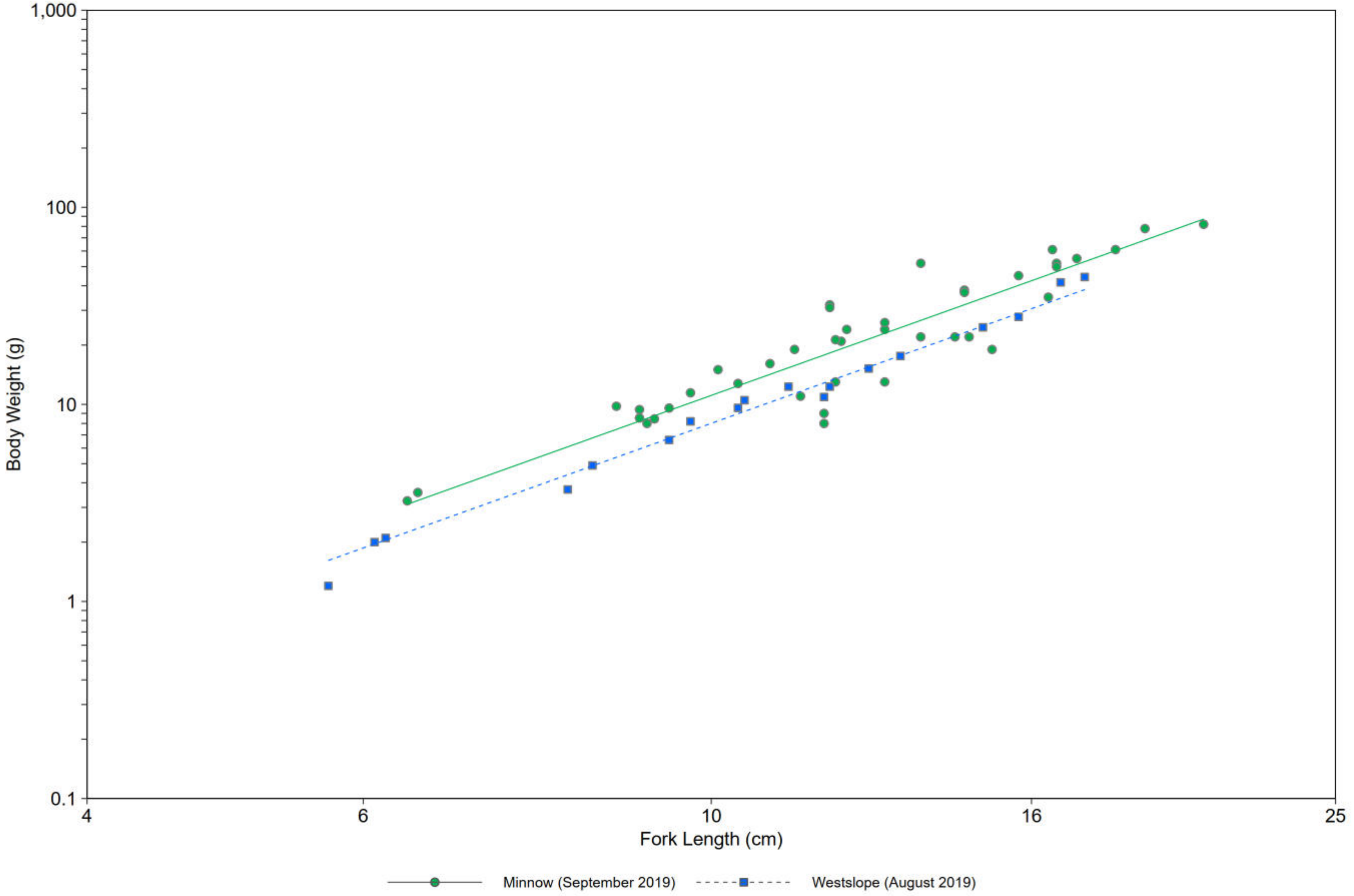


Figure A.1: Comparison of Juvenile Westslope Cutthroat Trout Weight Versus Length in Lower Greenhills Creek, 2019, between Minnow (2020b) and Westslope Fisheries (Cope 2020)

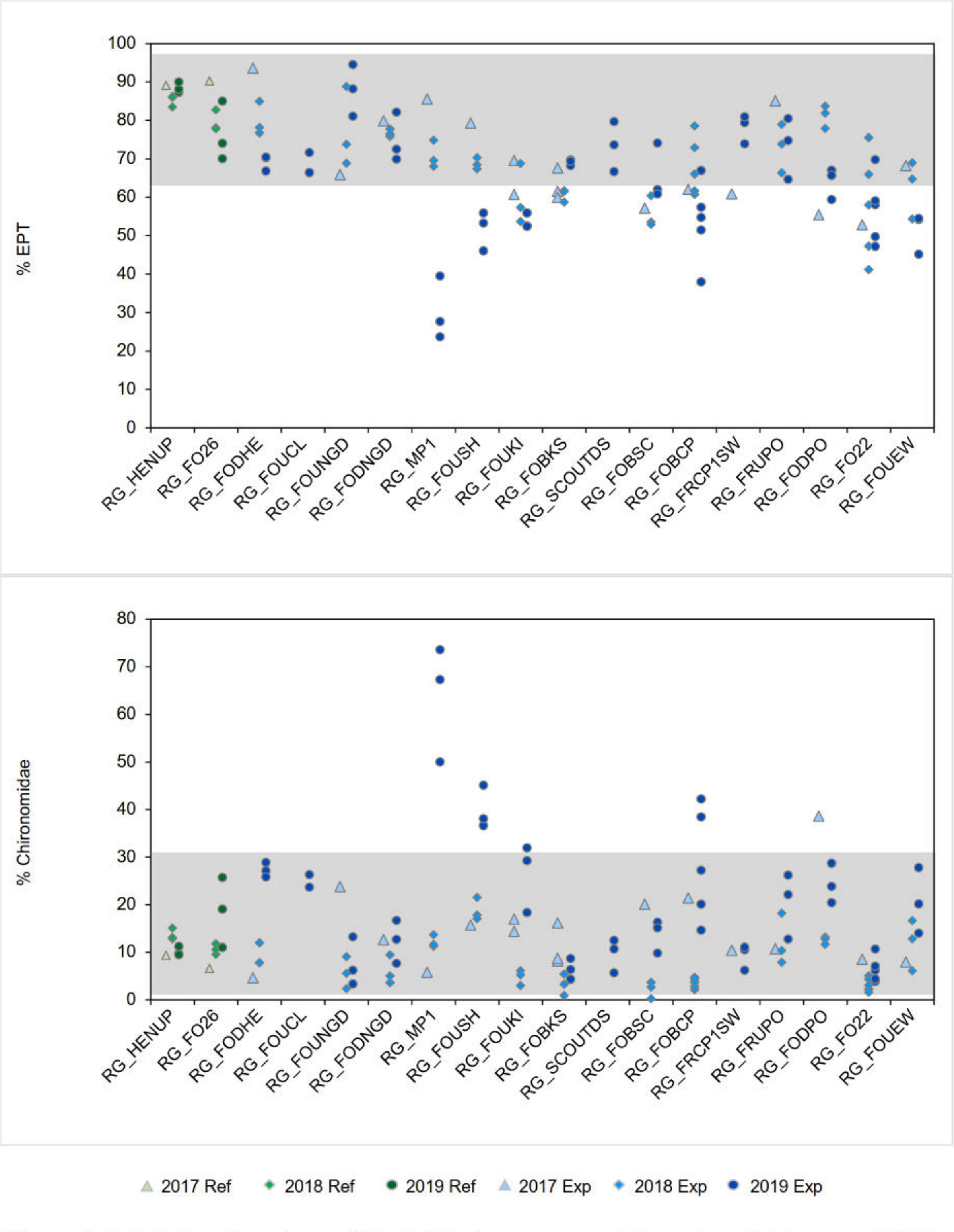


Figure A.2: **Relative Abundance (%) of a) Ephemeroptera, Plecoptera, Trichoptera (EPT), and b) Chironomids in Kick and Sweep Samples of the Upper Fording River, 2017 to 2019**

Note: Grey shading represent the upper and lower limits of the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP).

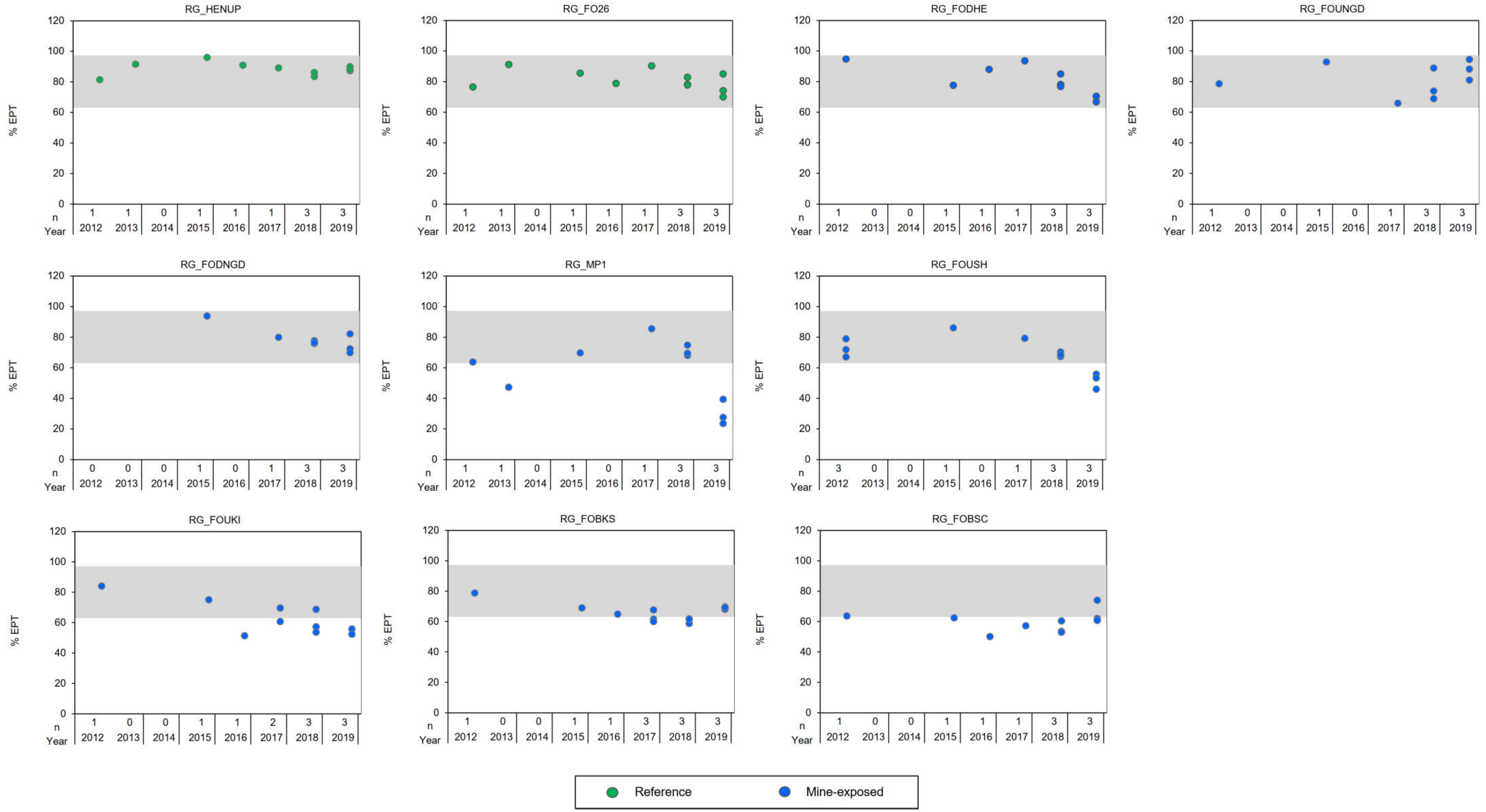


Figure A.3: **Benthic Invertebrate Community %EPT in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year. EPT stands for Ephemeroptera, Plecoptera, Trichoptera.

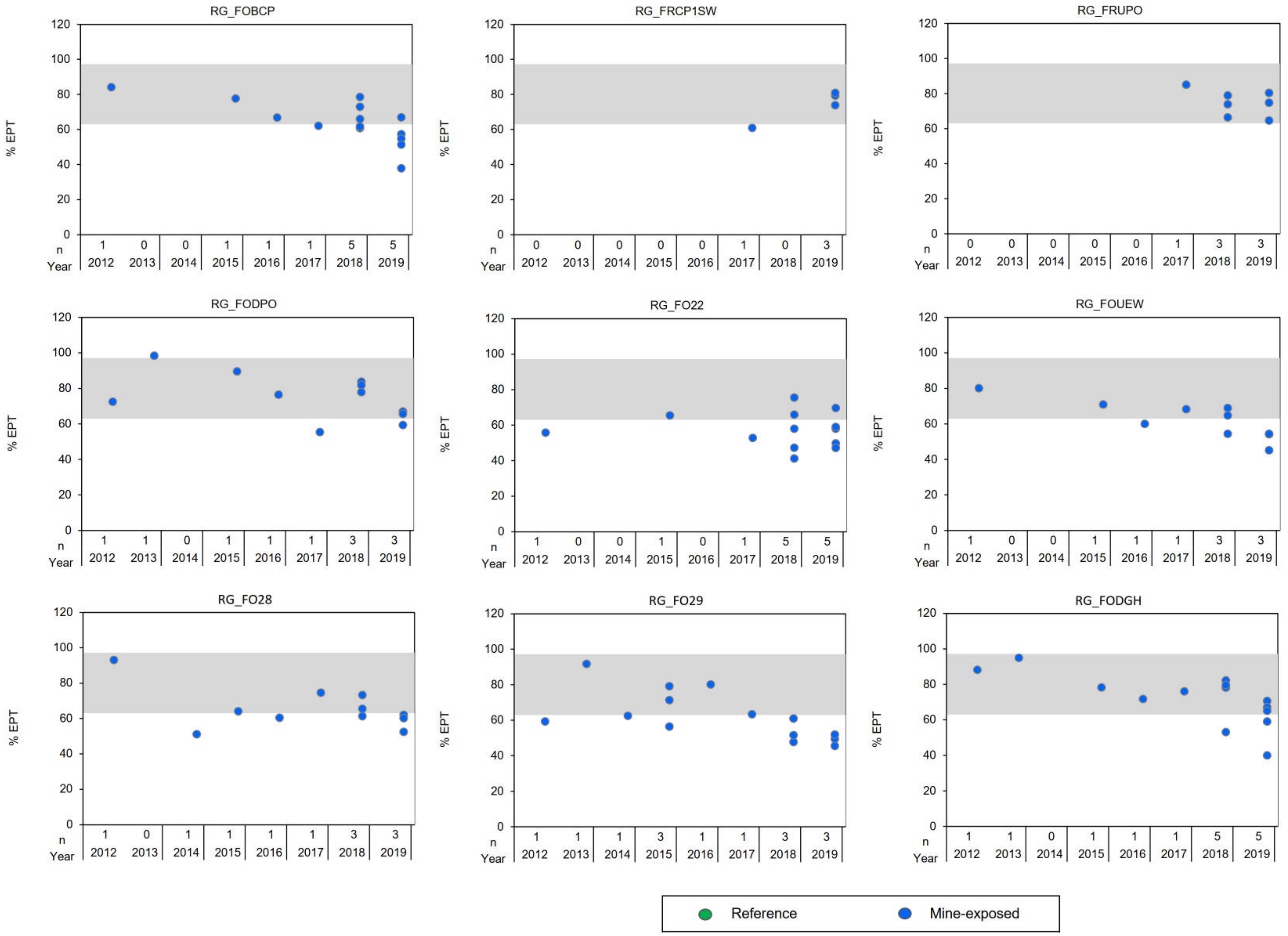


Figure A.3: **Benthic Invertebrate Community %EPT in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year. EPT stands for Ephemeroptera, Plecoptera, Trichoptera.

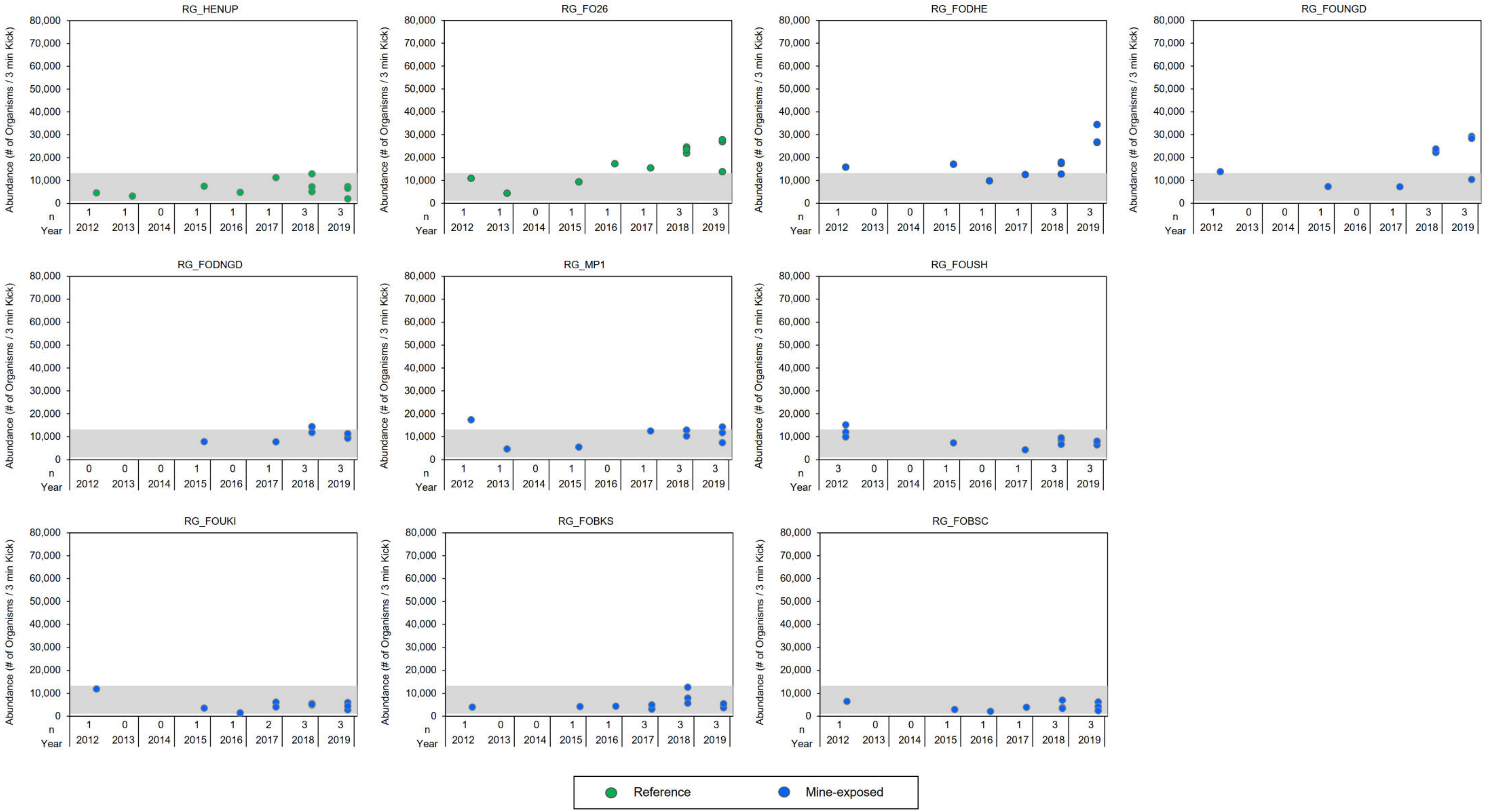


Figure A.4: **Benthic Invertebrate Community Abundance in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

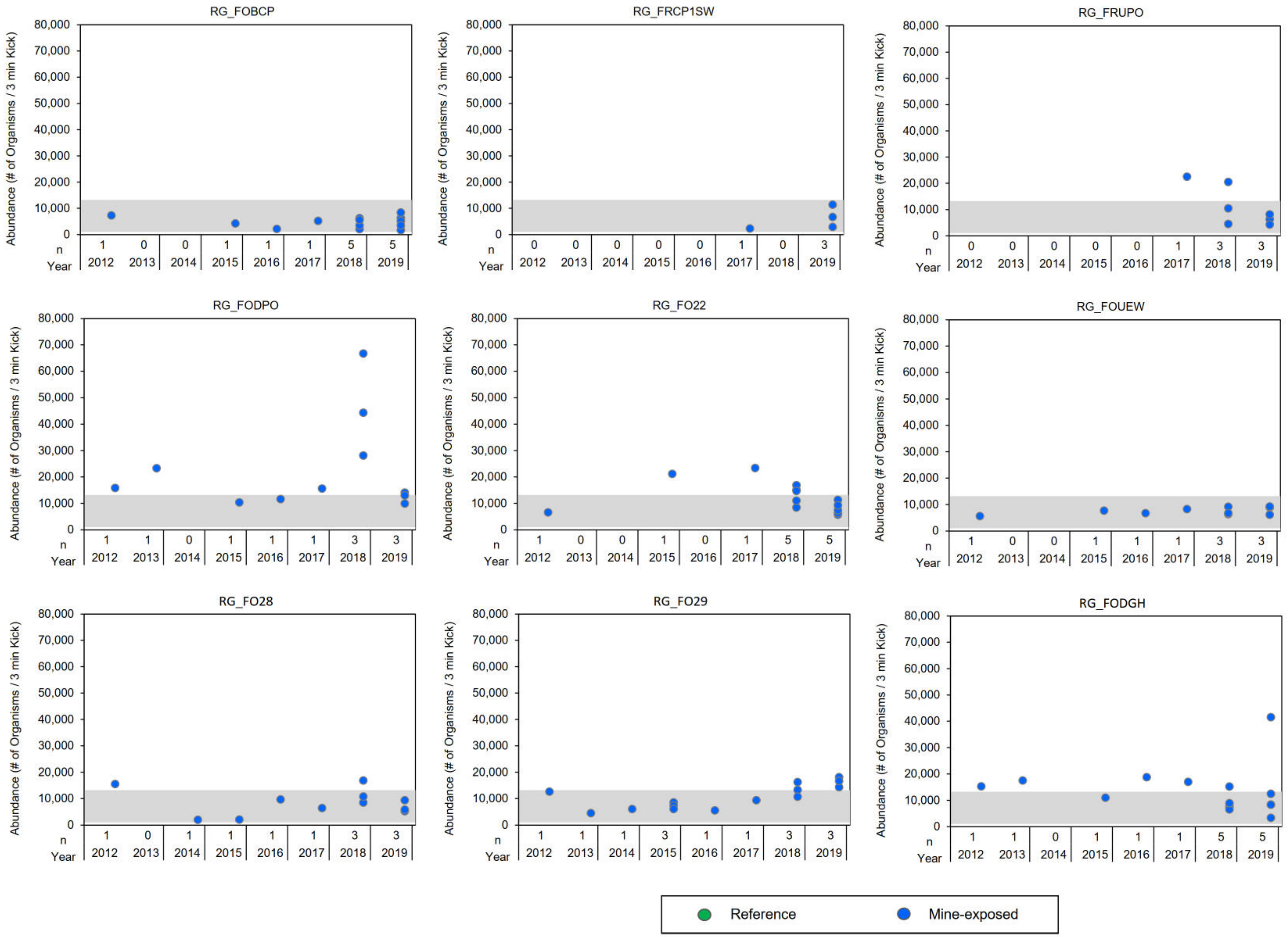


Figure A.4: Benthic Invertebrate Community Abundance in Upper Fording River September, 2012 to 2019

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

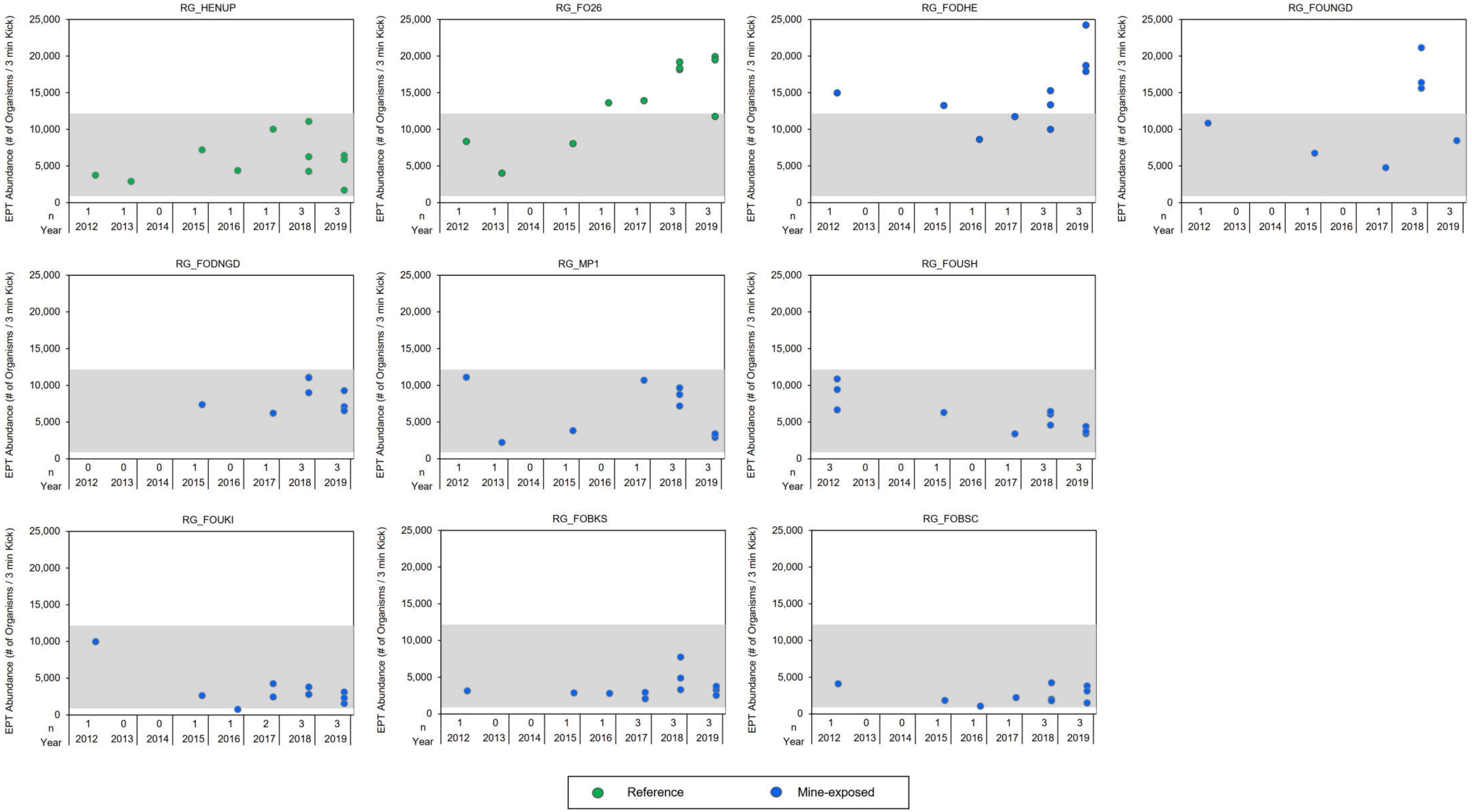


Figure A.5: **Benthic Invertebrate Community Abundance in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year. EPT stands for Ephemeroptera, Plecoptera, Trichoptera.

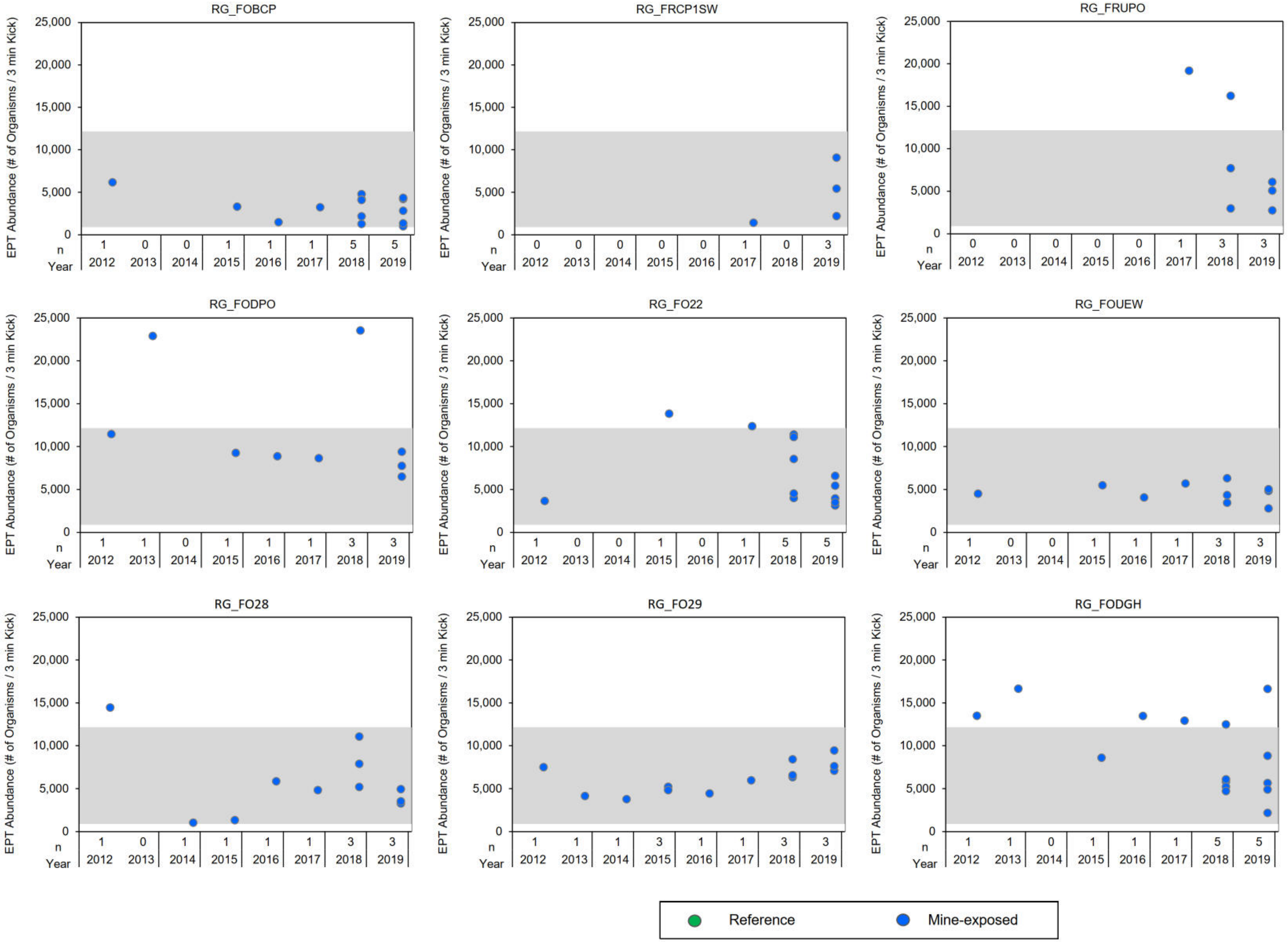


Figure A.5: Benthic Invertebrate Community Abundance in Upper Fording River, September 2012 to 2019

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year. EPT stands for Ephemeroptera, Plecoptera, Trichoptera.

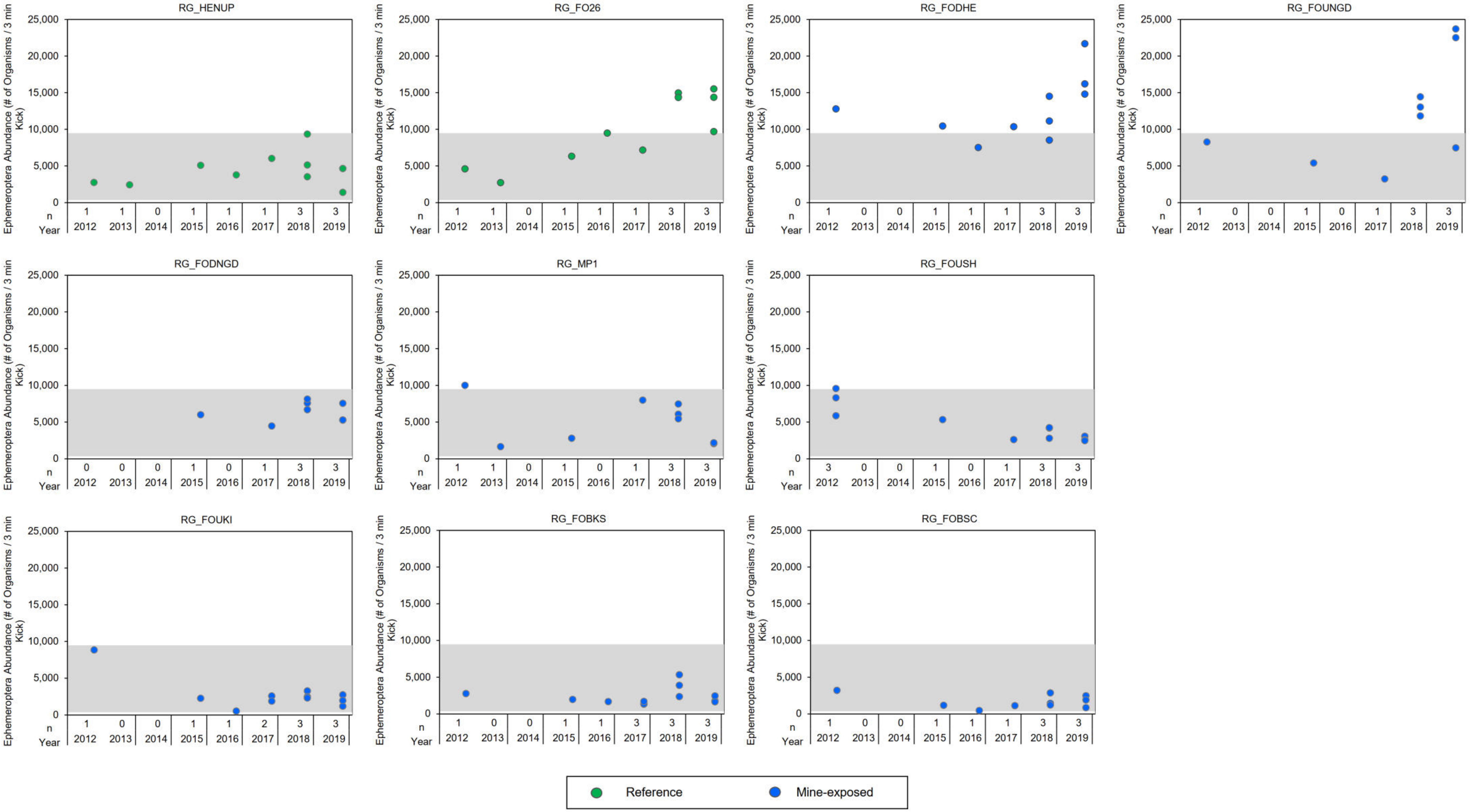


Figure A.6: **Benthic Invertebrate Community Ephemeroptera Abundance in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

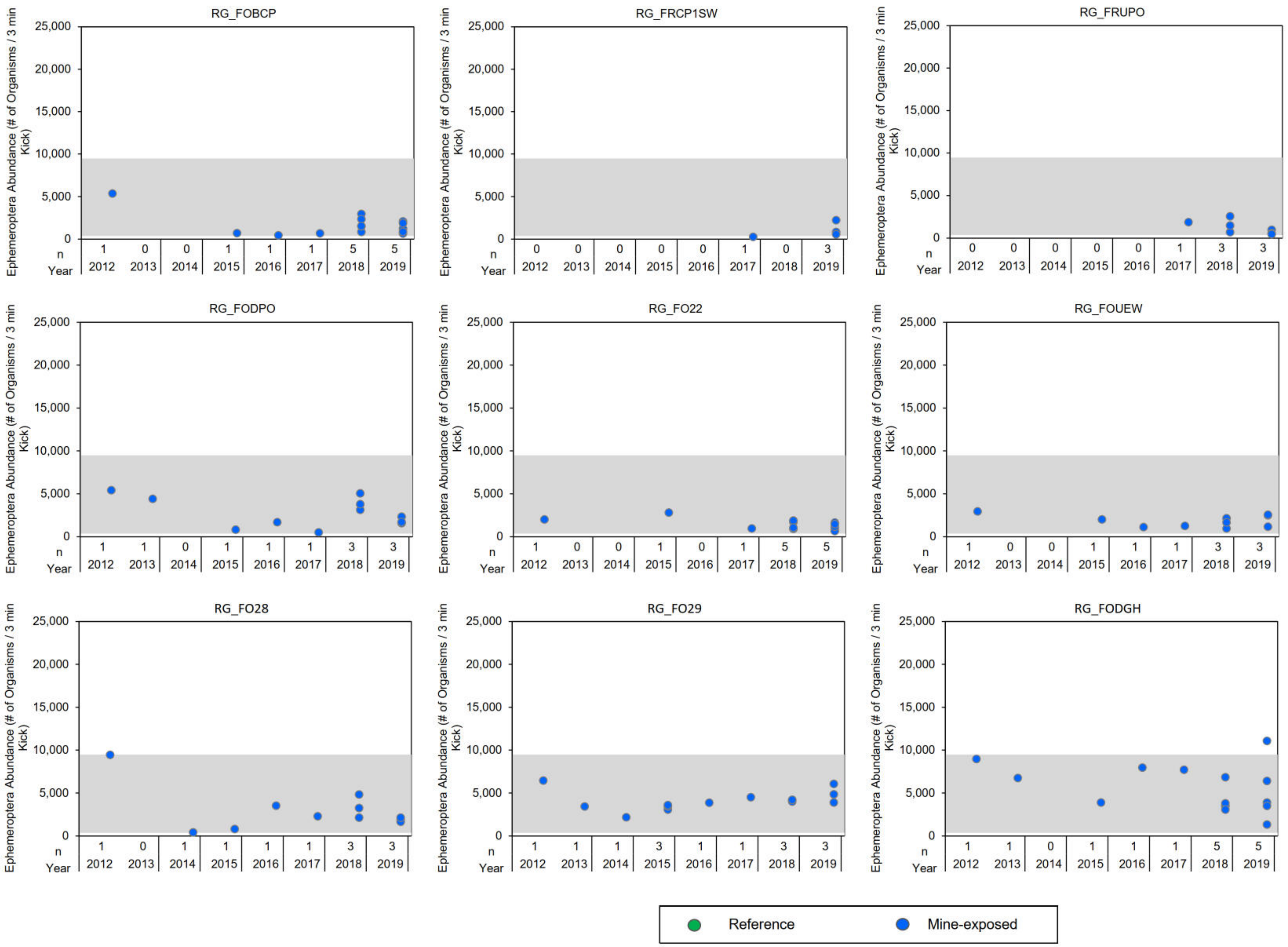


Figure A.6: **Benthic Invertebrate Community Ephemeroptera Abundance in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

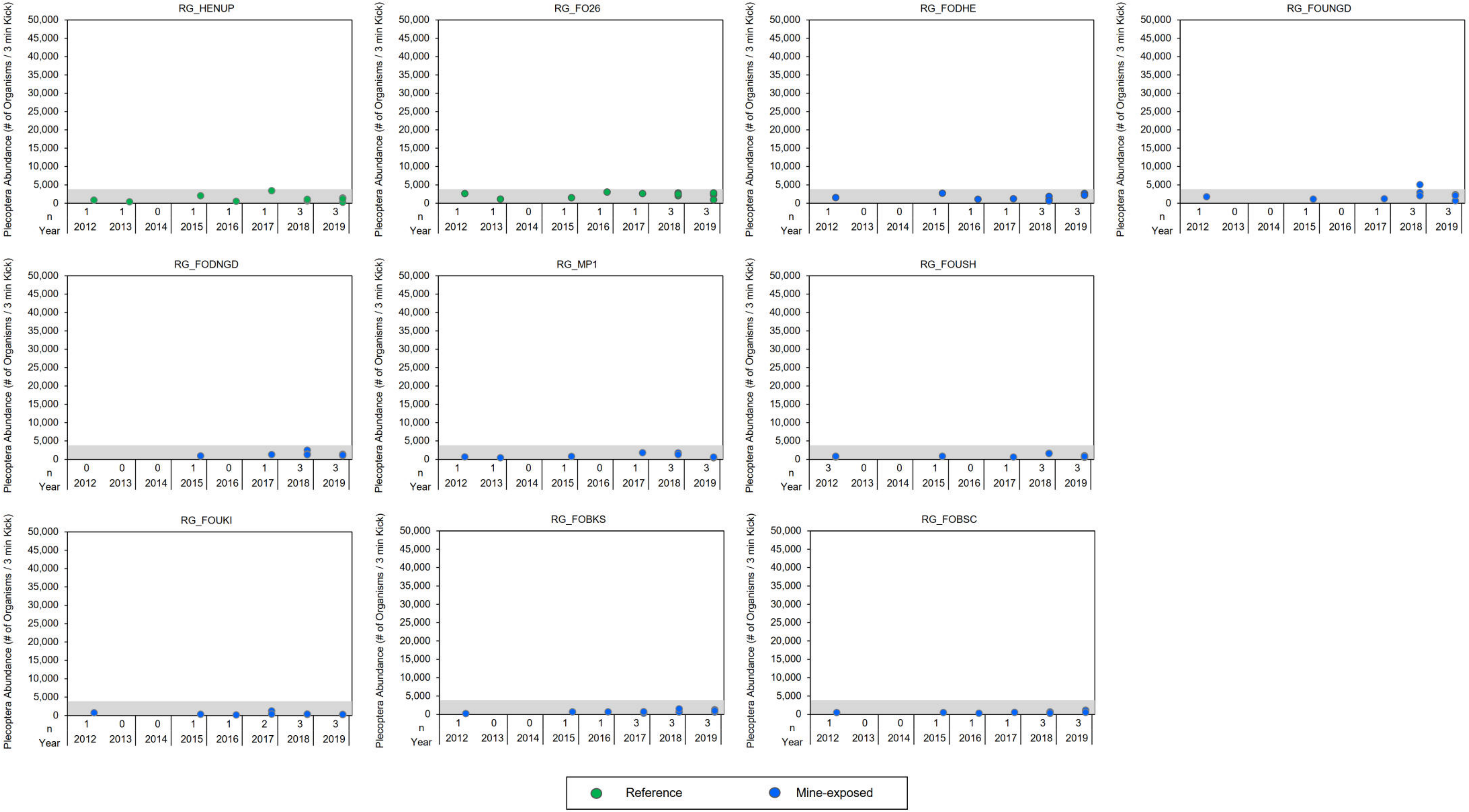


Figure A.7: **Benthic Invertebrate Community Plecoptera Abundance in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

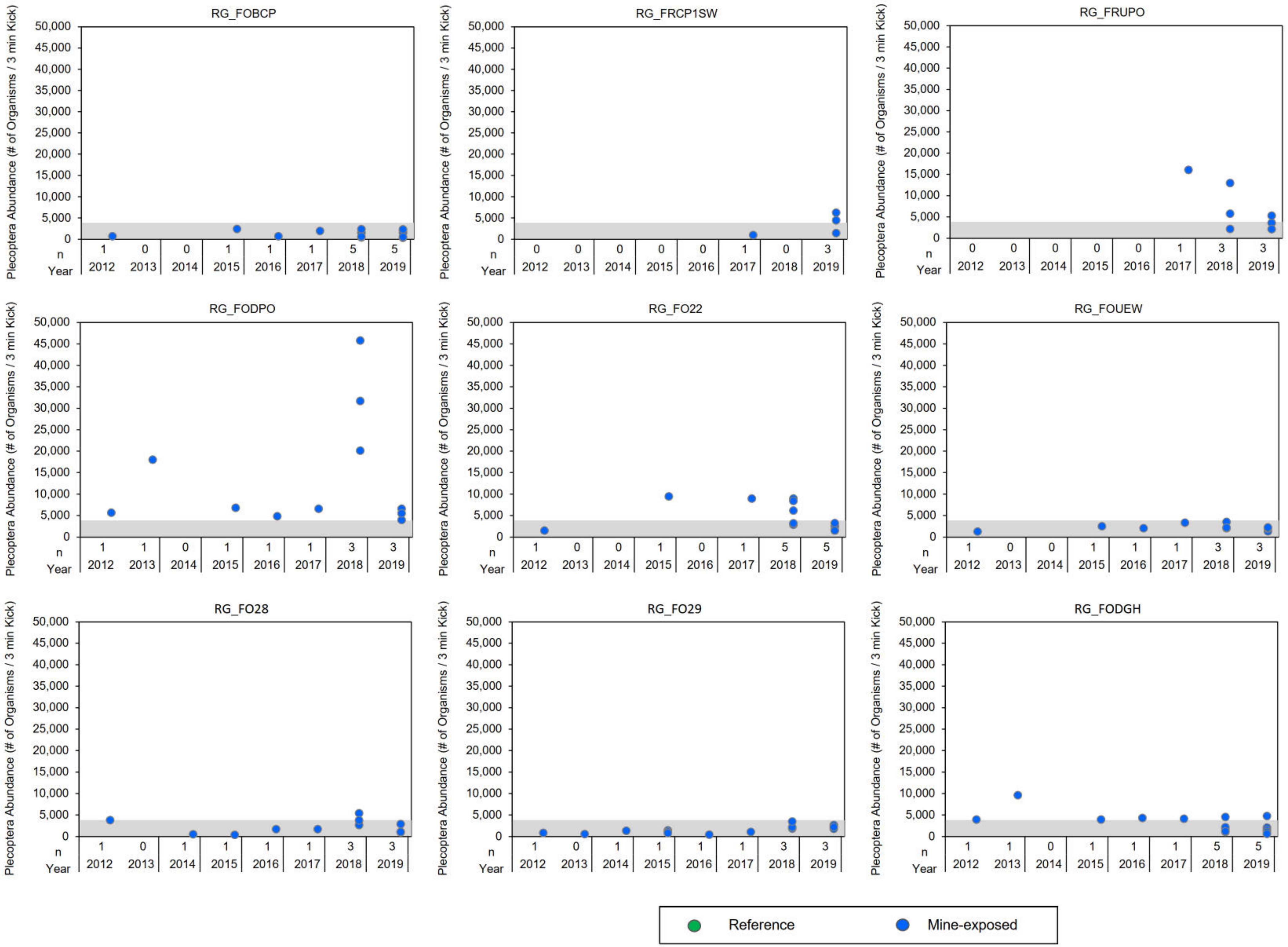


Figure A.7: **Benthic Invertebrate Community Plecoptera Abundance in Upper Fording River, September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

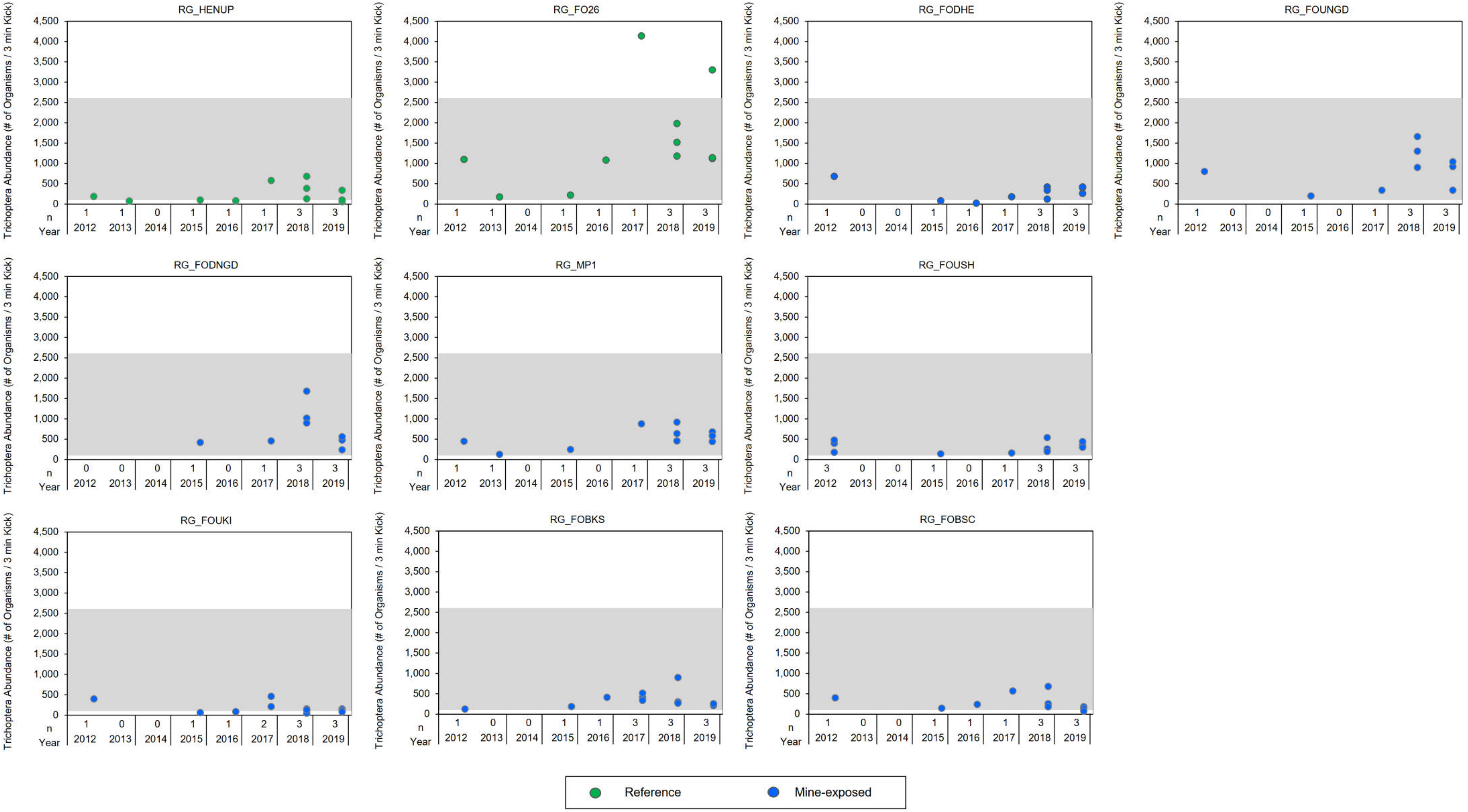


Figure A.8: **Benthic Invertebrate Community Trichoptera Abundance in Upper Fording River September, 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

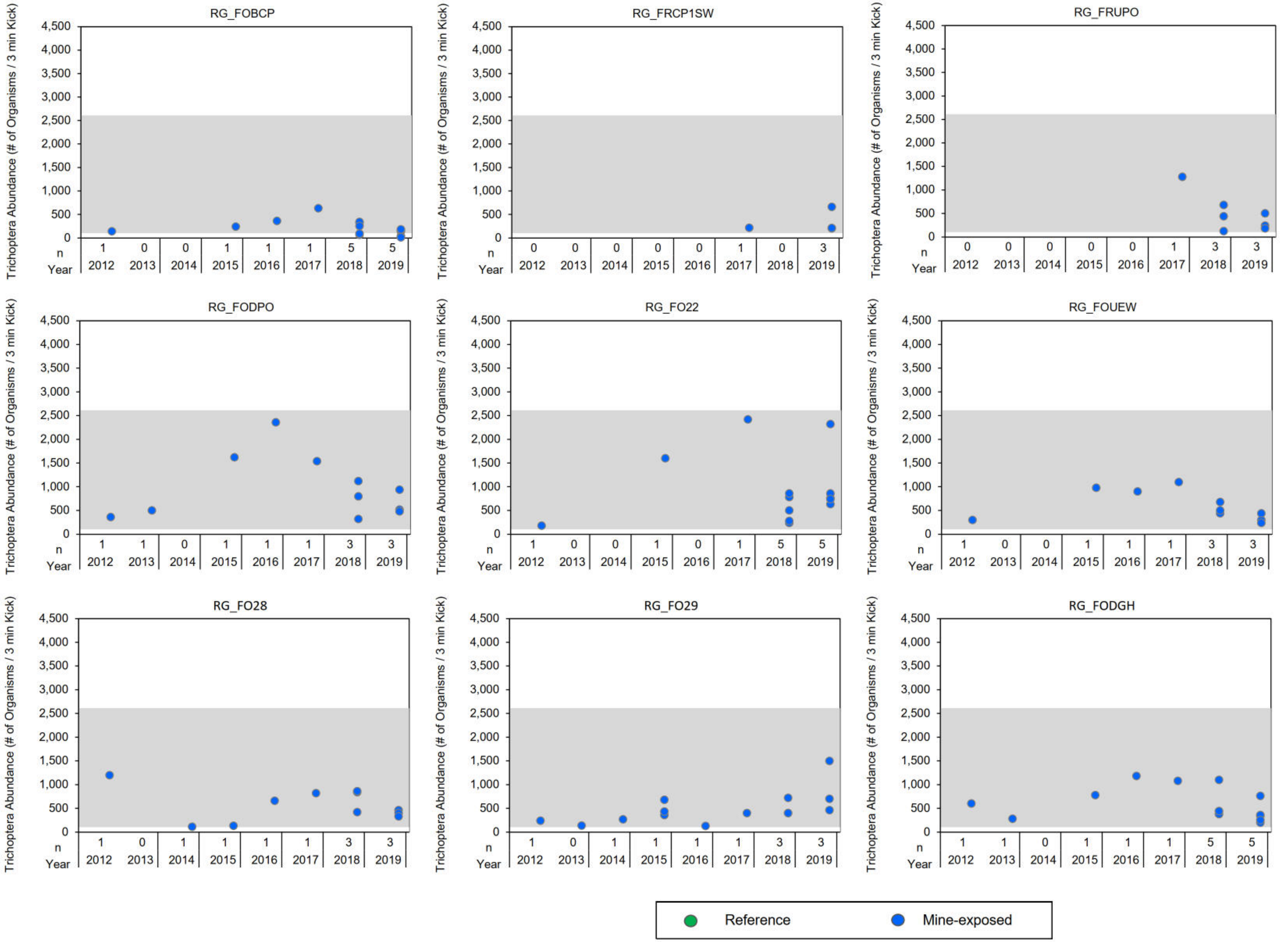


Figure A.8: **Benthic Invertebrate Community Trichoptera Abundance in Upper Fording River September, 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

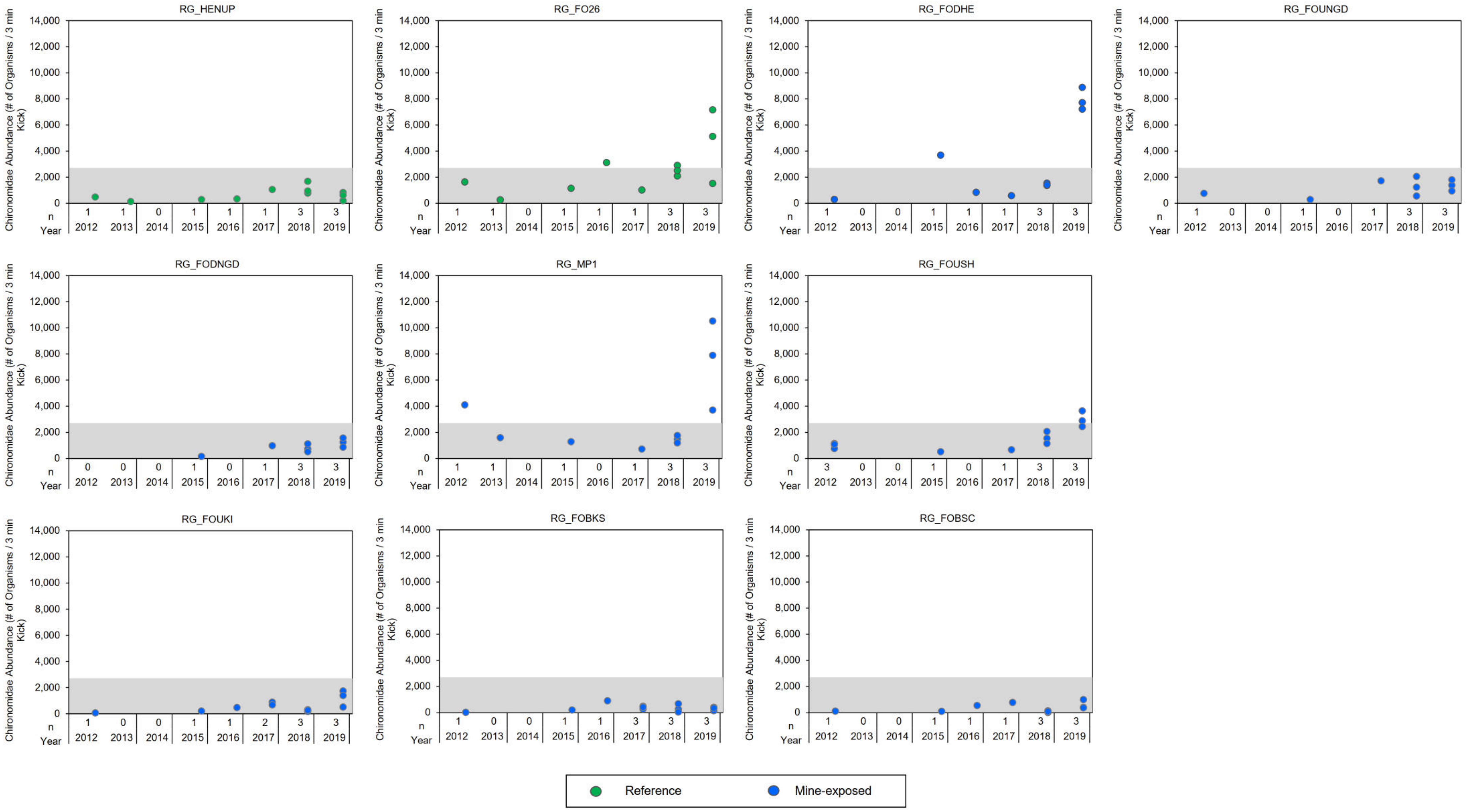


Figure A.9: **Benthic Invertebrate Community Chironomidae Abundance in Upper Fording River September,2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.

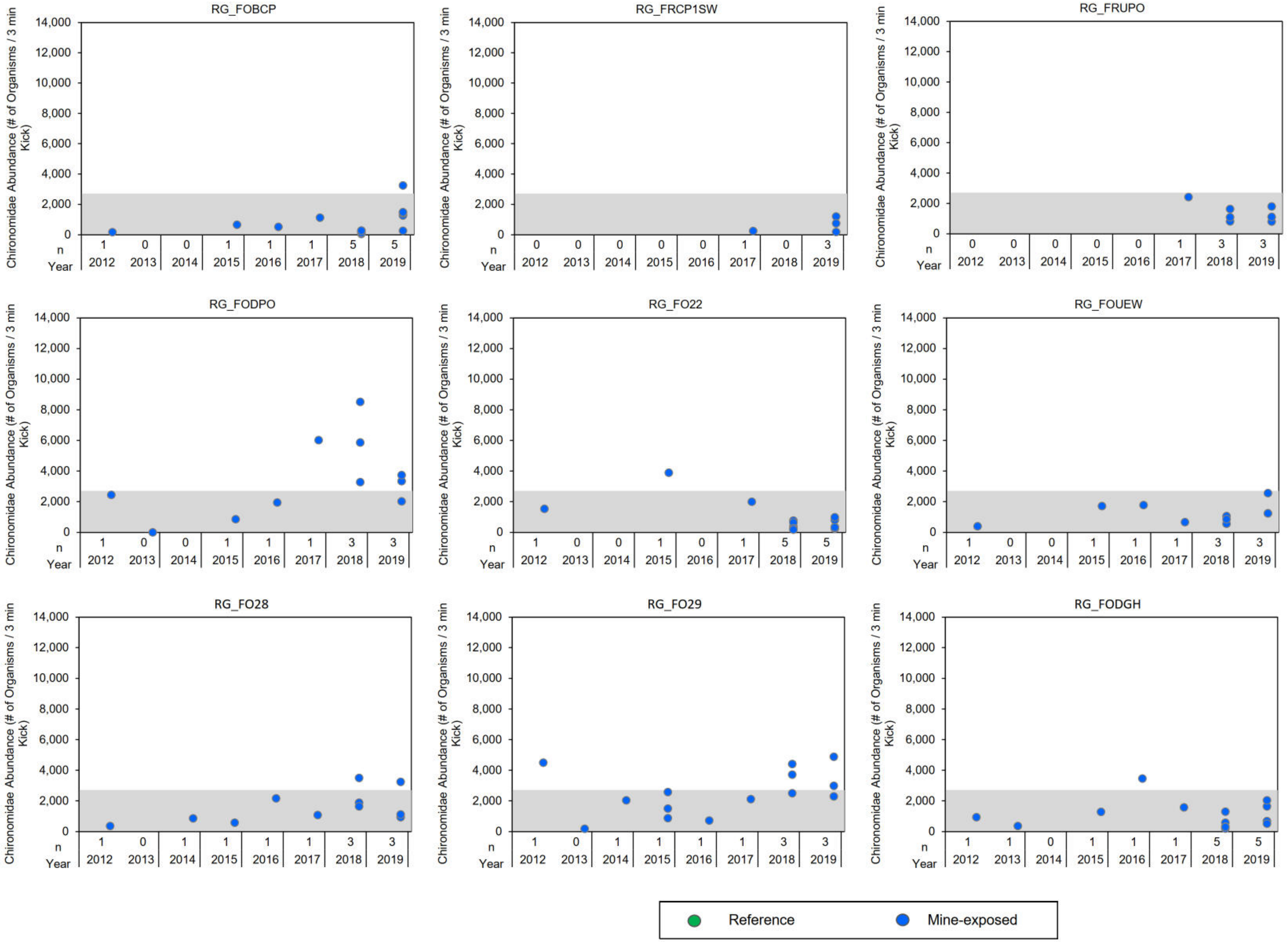
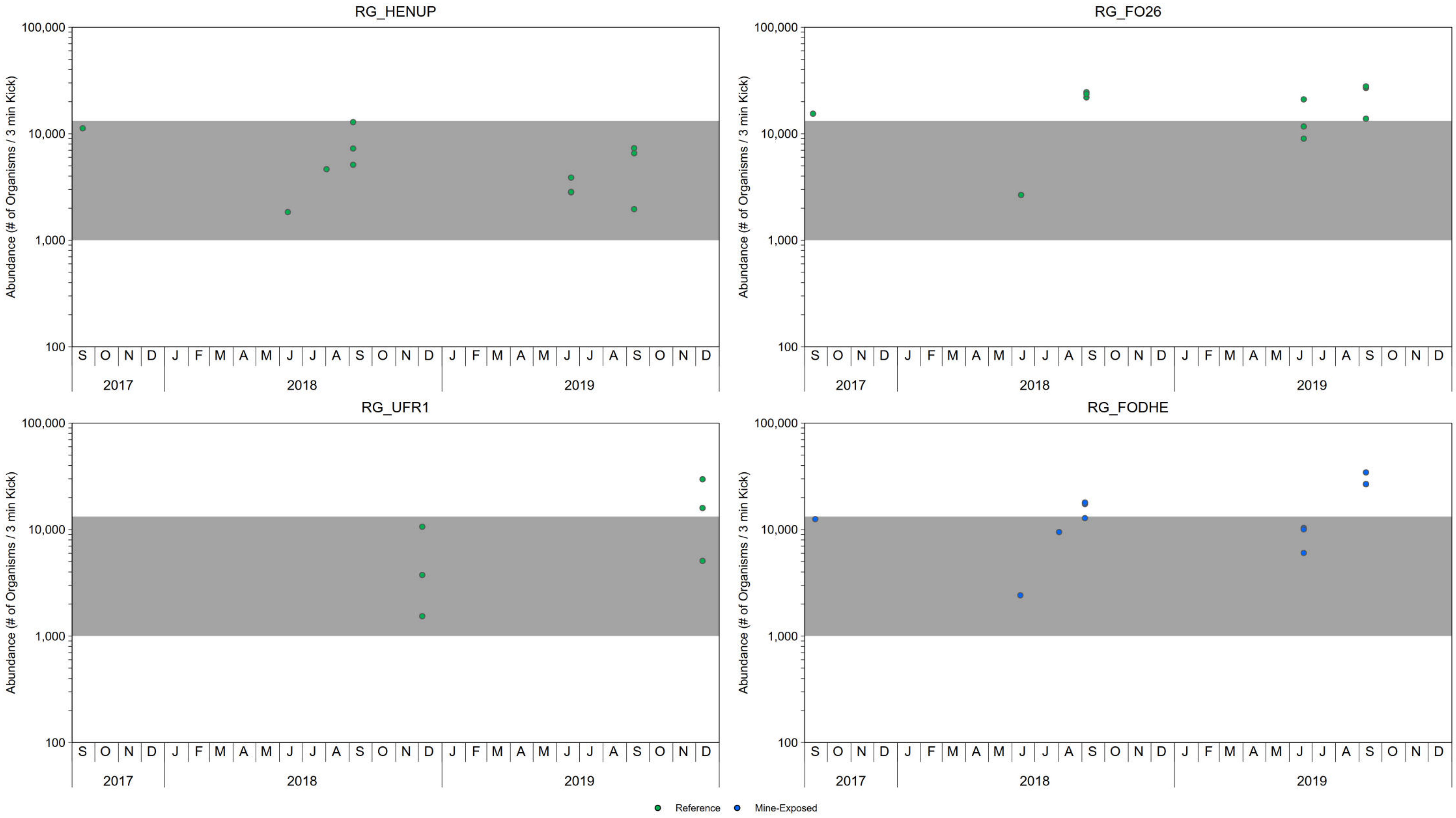


Figure A.9: **Benthic Invertebrate Community Chironomidae Abundance in Upper Fording River September 2012 to 2019**

Notes: Grey shading represents the normal range defined as the 2.5th and 97.5th percentiles of the 2012 and 2015 reference area data from the Regional Aquatic Environmental Monitoring Program (RAEMP). RG_FOUCL and RG_SCOUTDS are not shown because they were only sampled in 2019. n = the sample size for a given year.


RG_HENUP

RG_FO26

RG_UFR1

RG_FODHE

Figure A.10: Seasonal Benthic Invertebrate Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

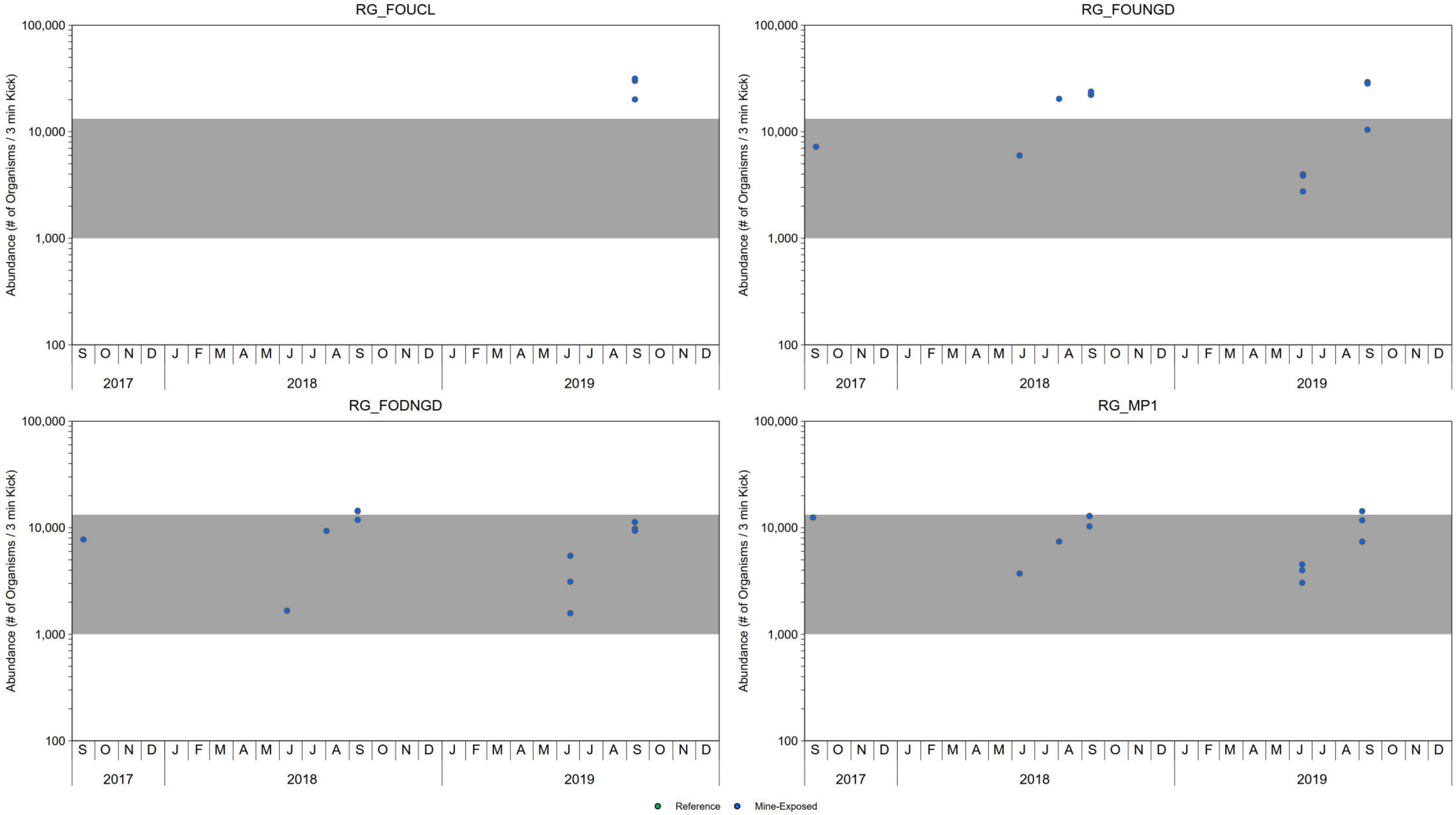


Figure A.10: **Seasonal Benthic Invertebrate Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

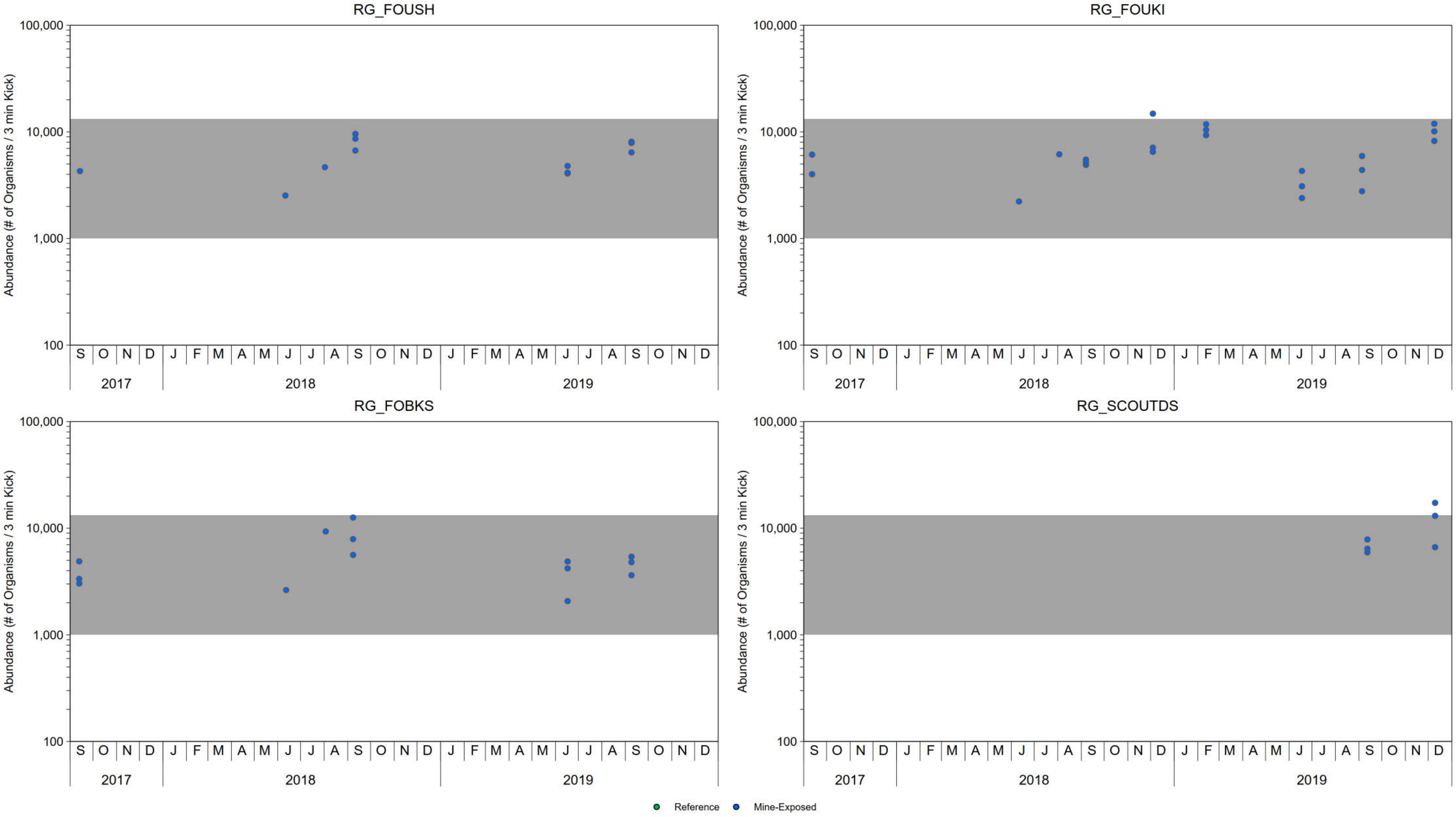


Figure A.10: Seasonal Benthic Invertebrate Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

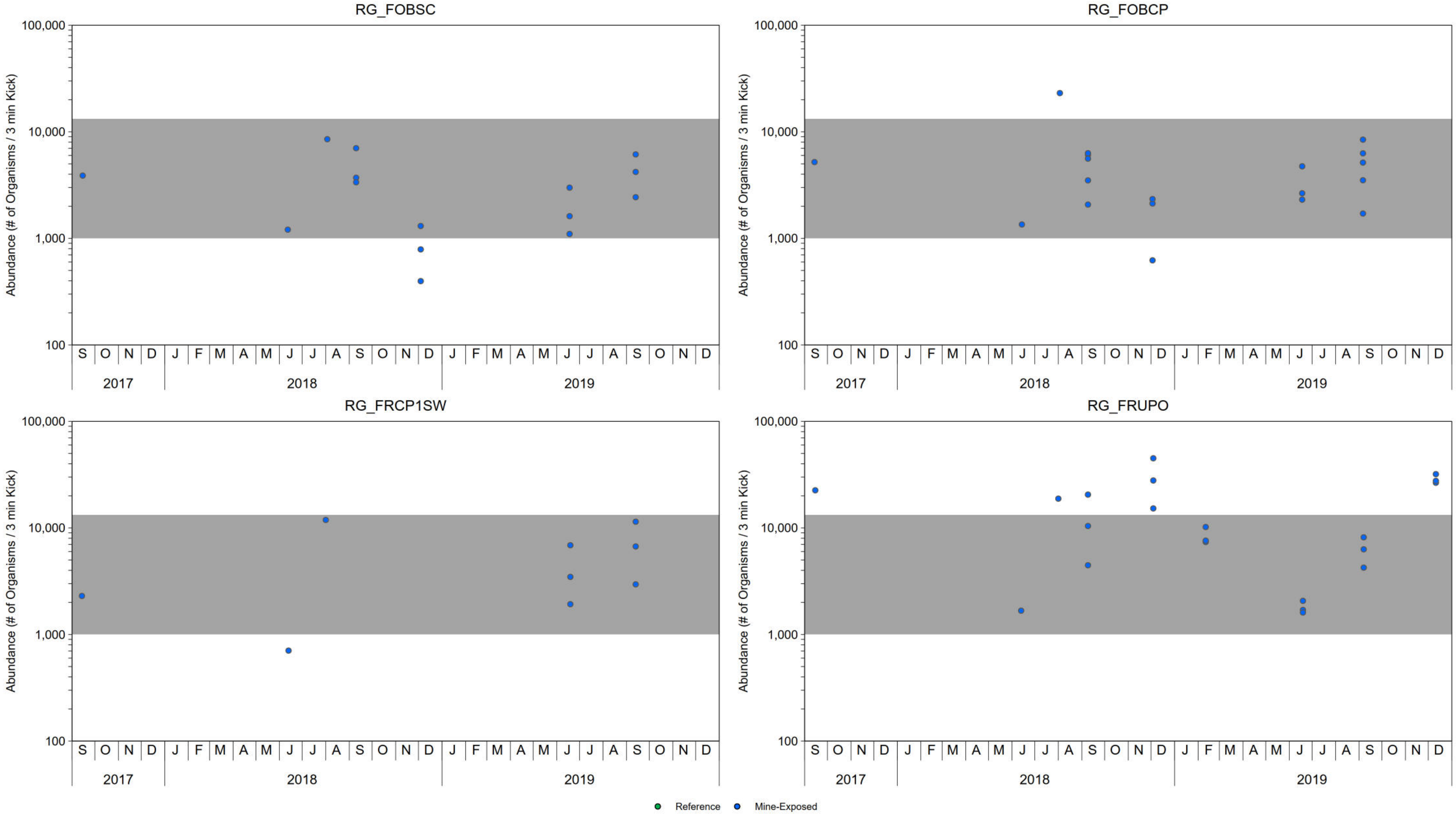


Figure A.10: **Seasonal Benthic Invertebrate Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

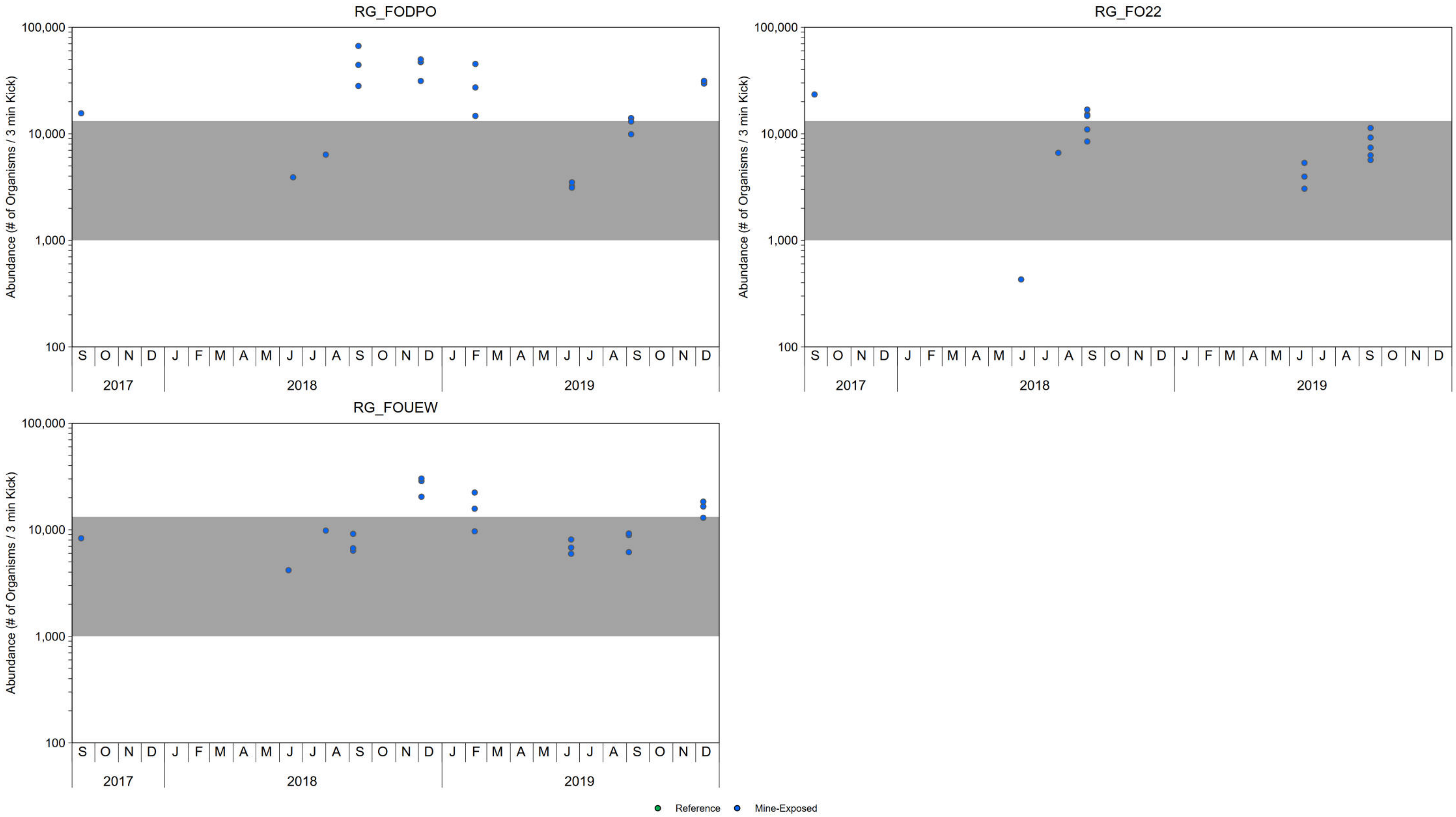


Figure A.10: Seasonal Benthic Invertebrate Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

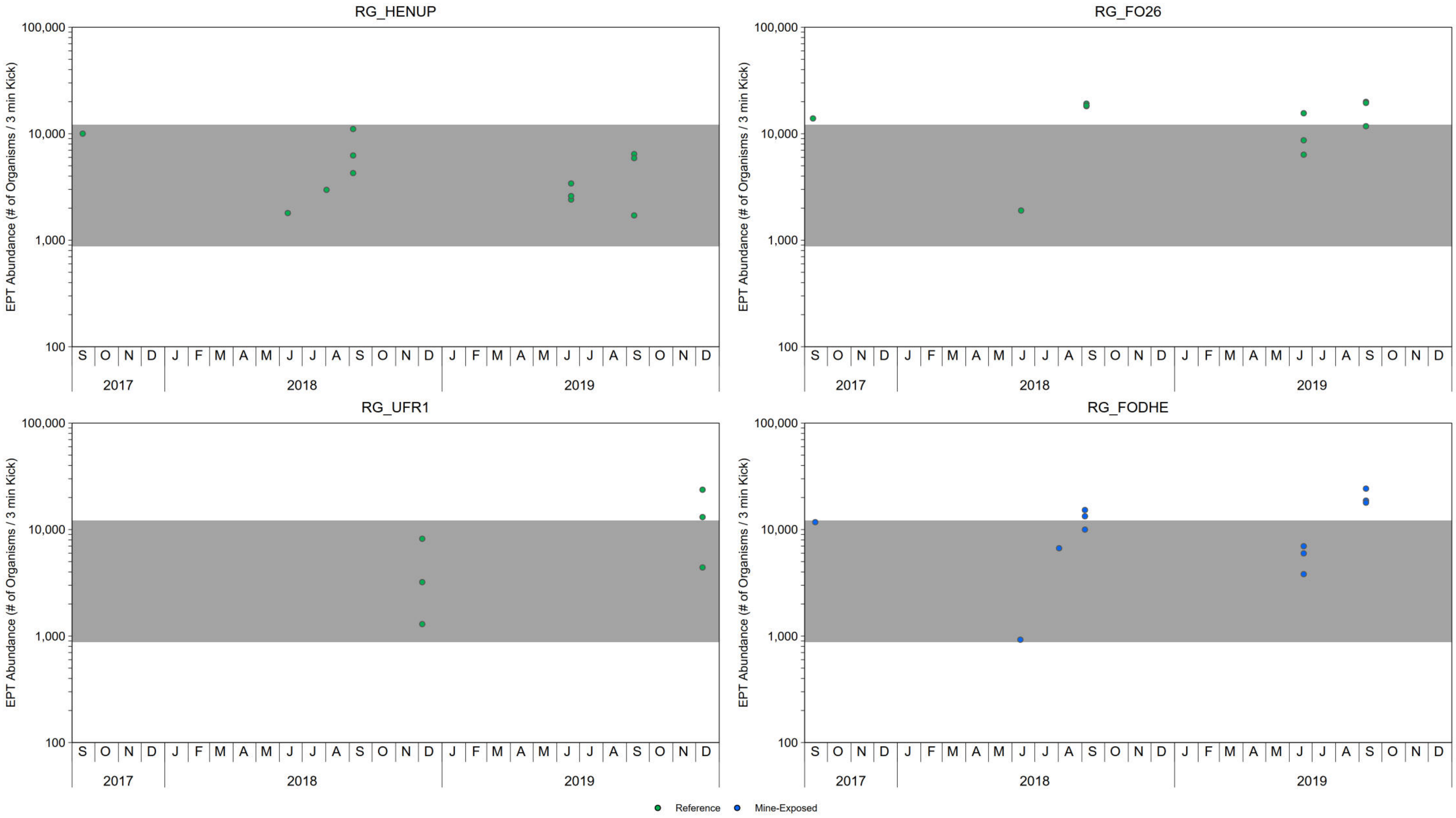


Figure A.11: Seasonal Benthic Invertebrate EPT Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

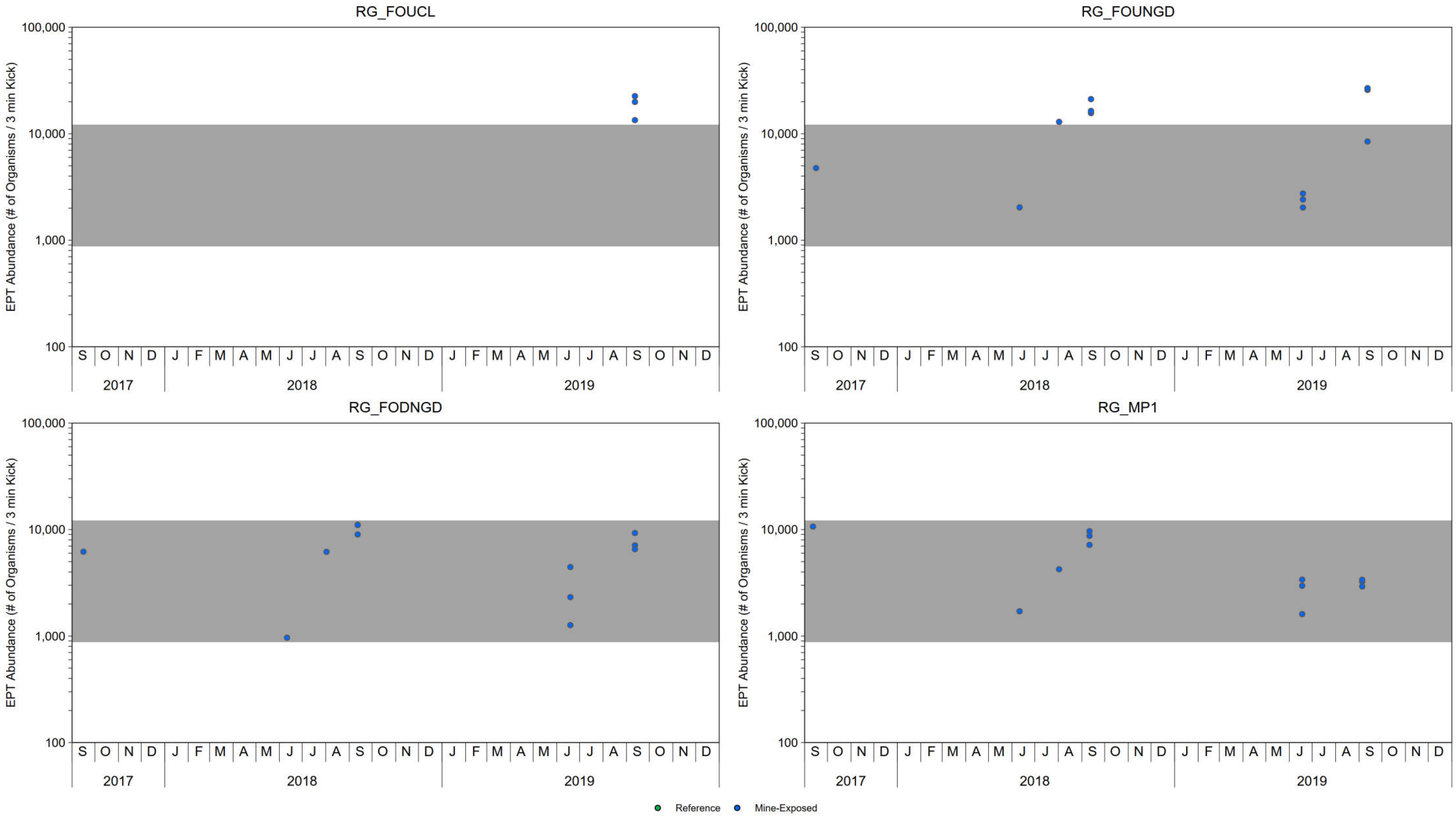


Figure A.11: Seasonal Benthic Invertebrate EPT Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

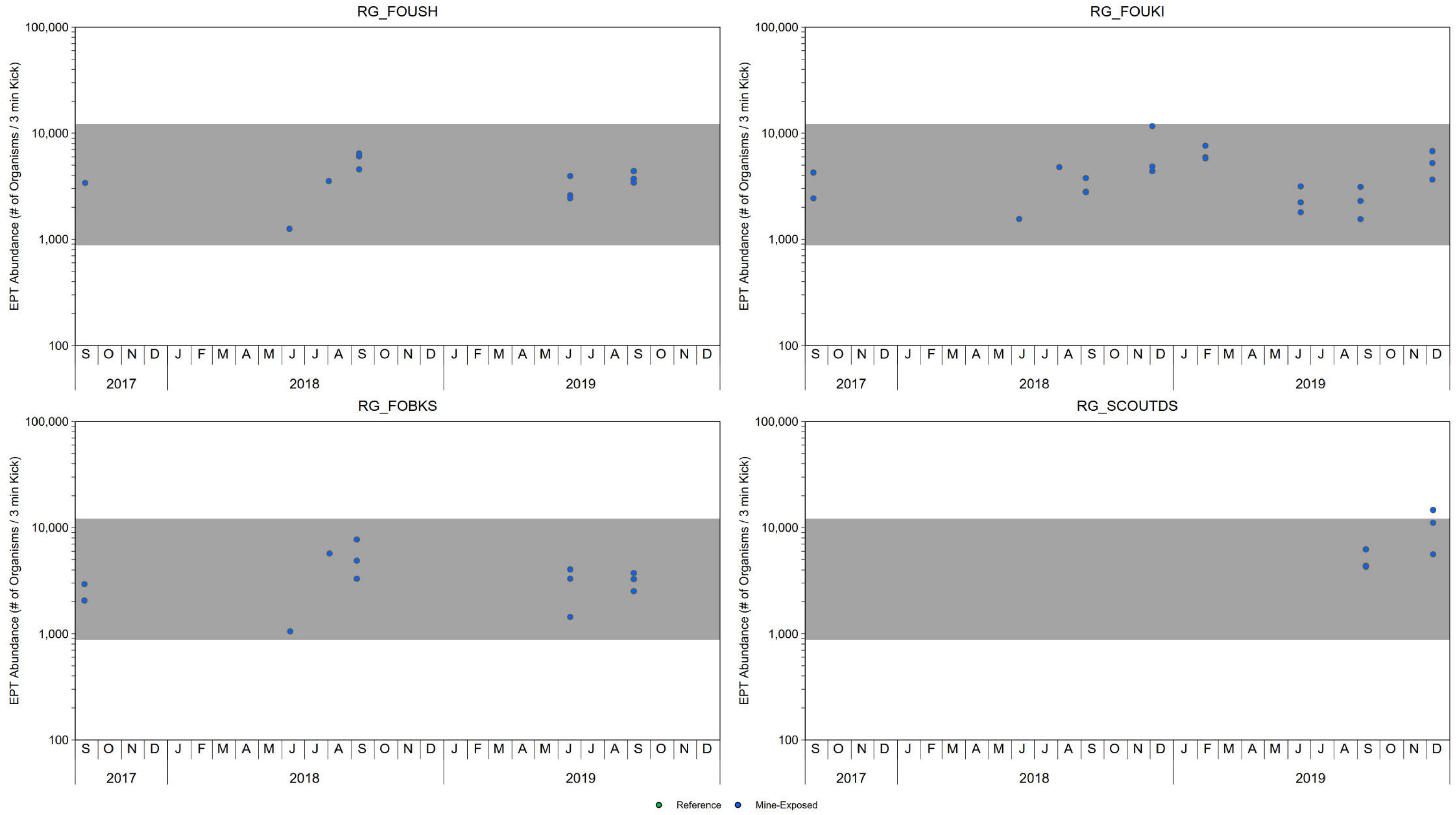


Figure A.11: Seasonal Benthic Invertebrate EPT Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

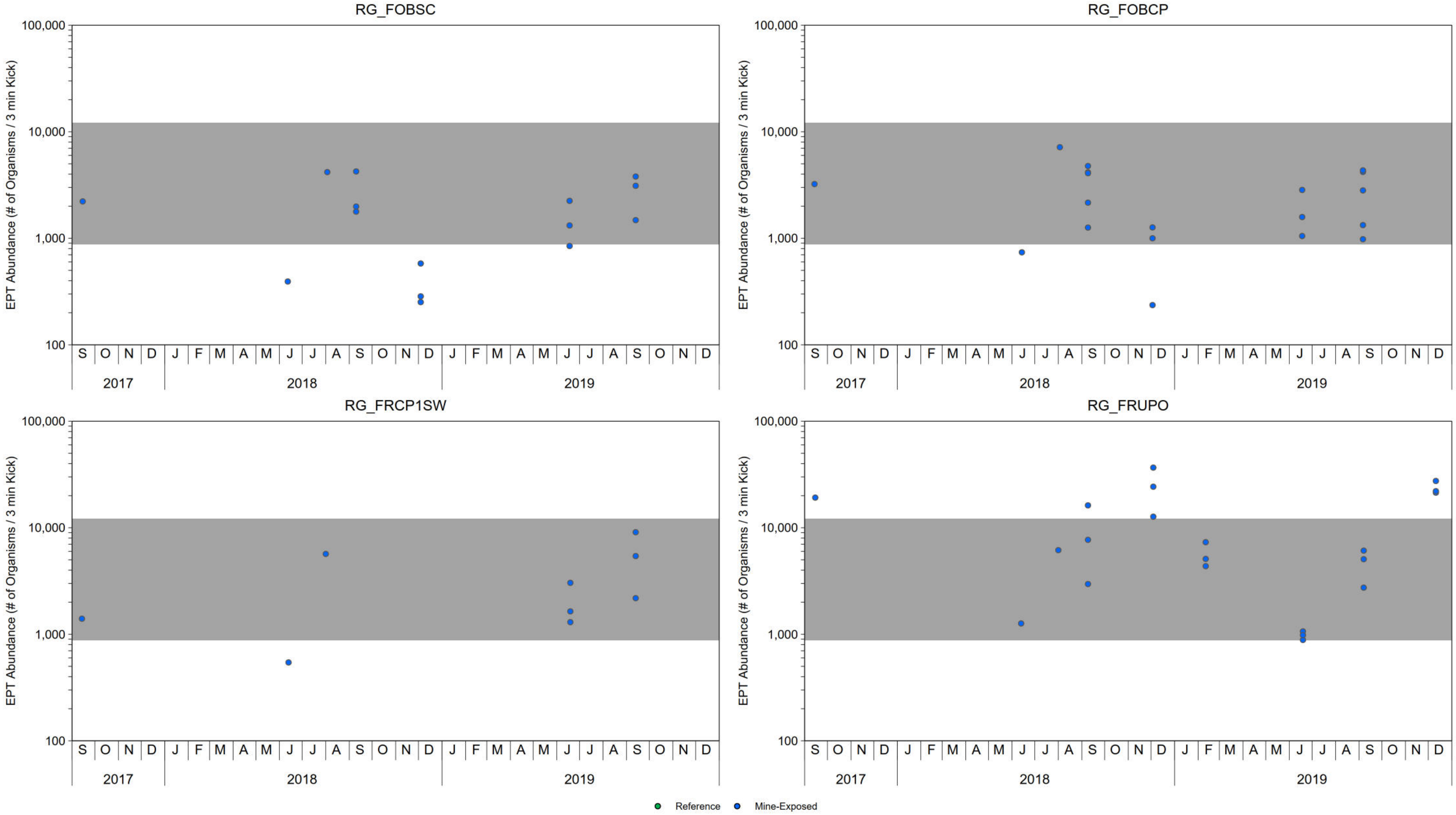


Figure A.11: **Seasonal Benthic Invertebrate EPT Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

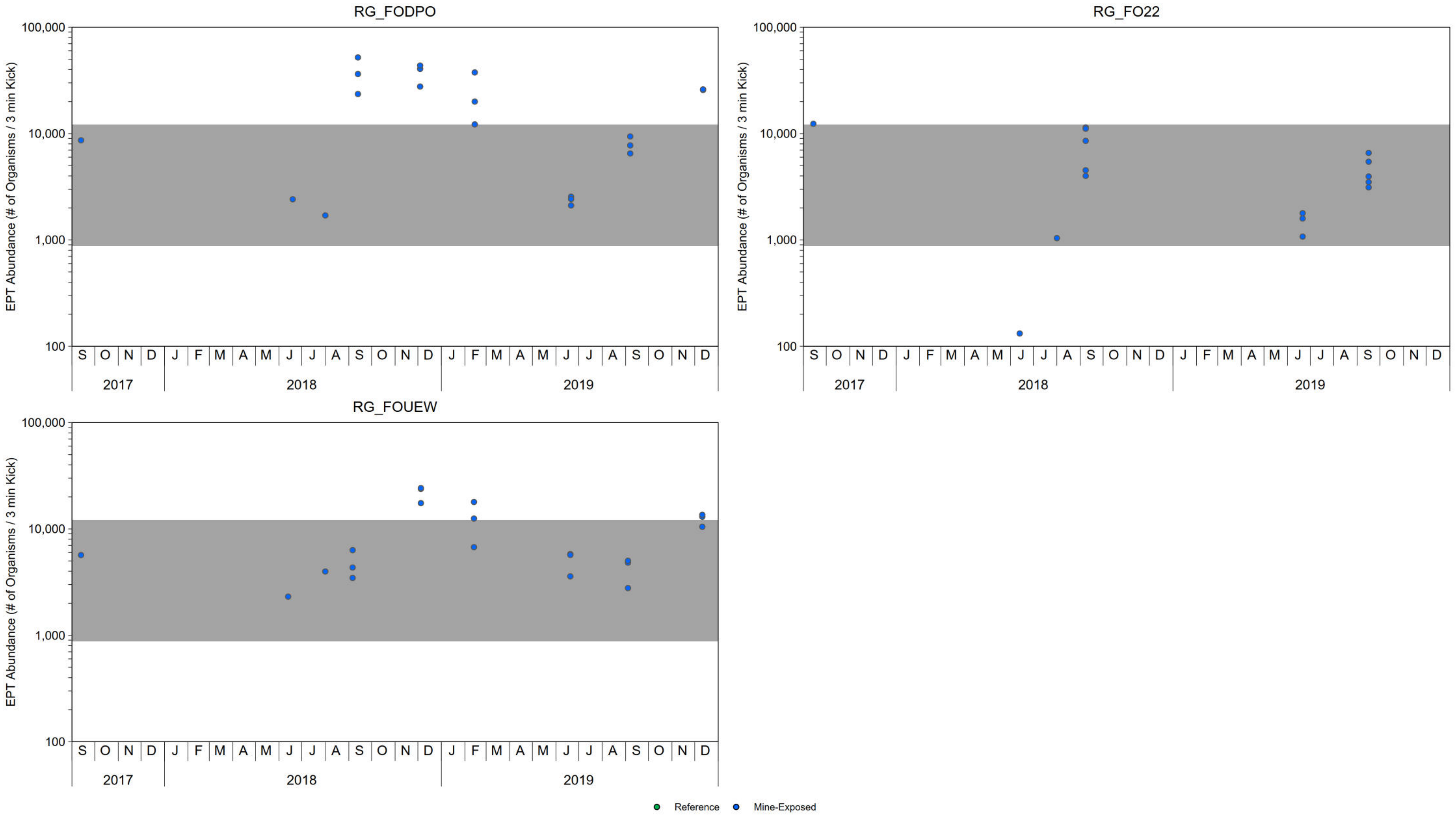


Figure A.11: **Seasonal Benthic Invertebrate EPT Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

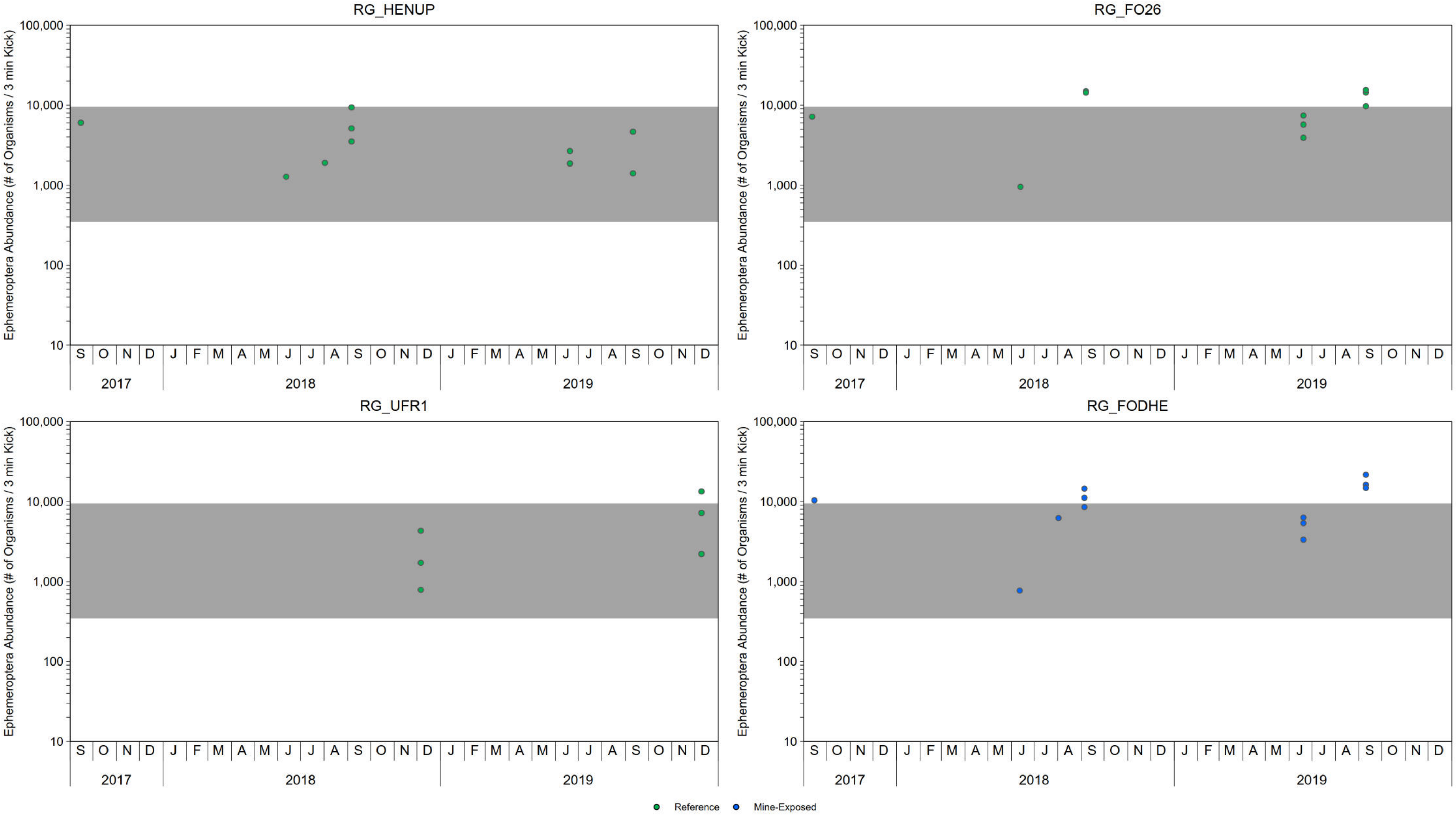


Figure A.12: **Seasonal Benthic Invertebrate Ephemeroptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

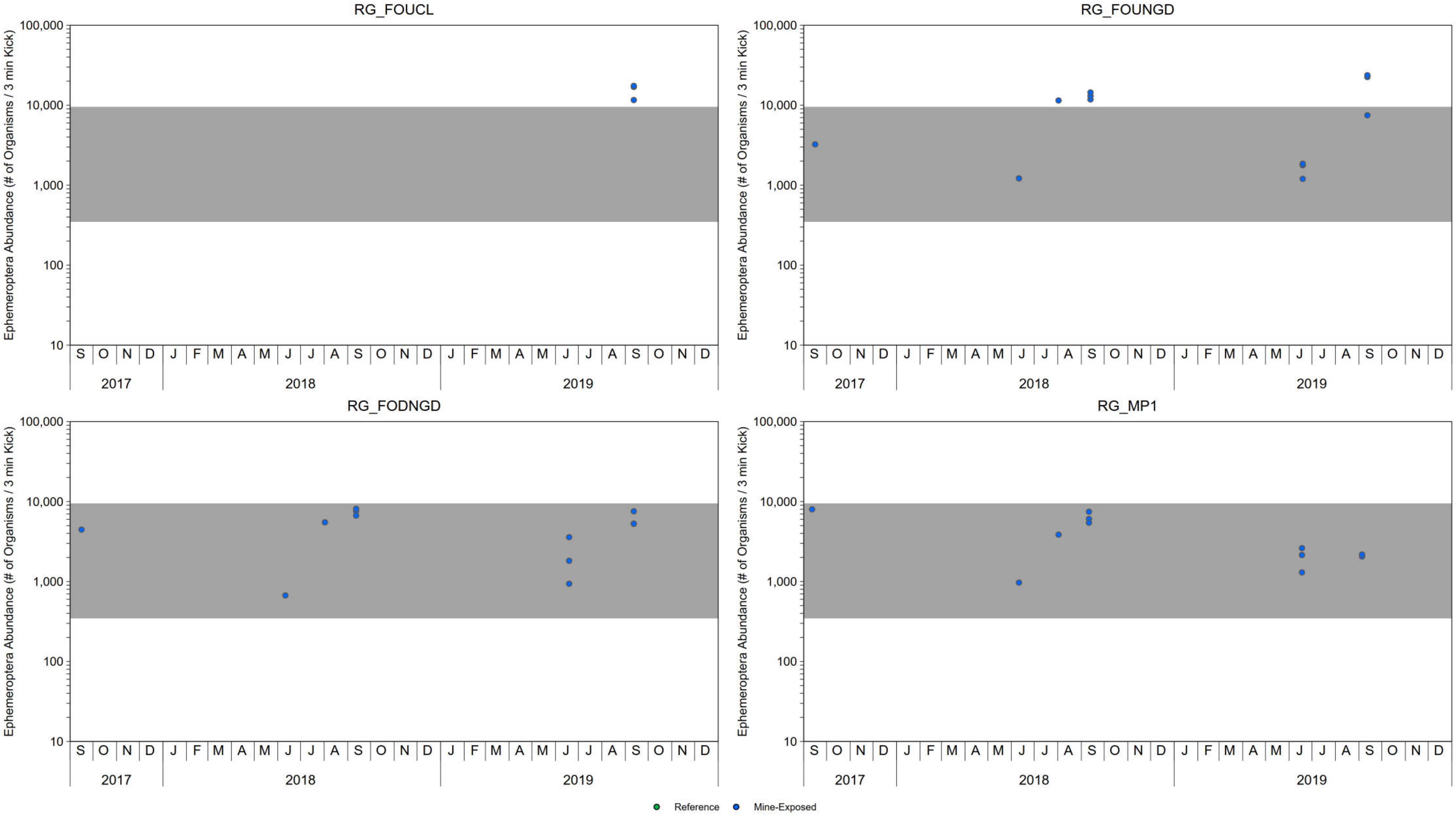


Figure A.12: **Seasonal Benthic Invertebrate Ephemeroptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

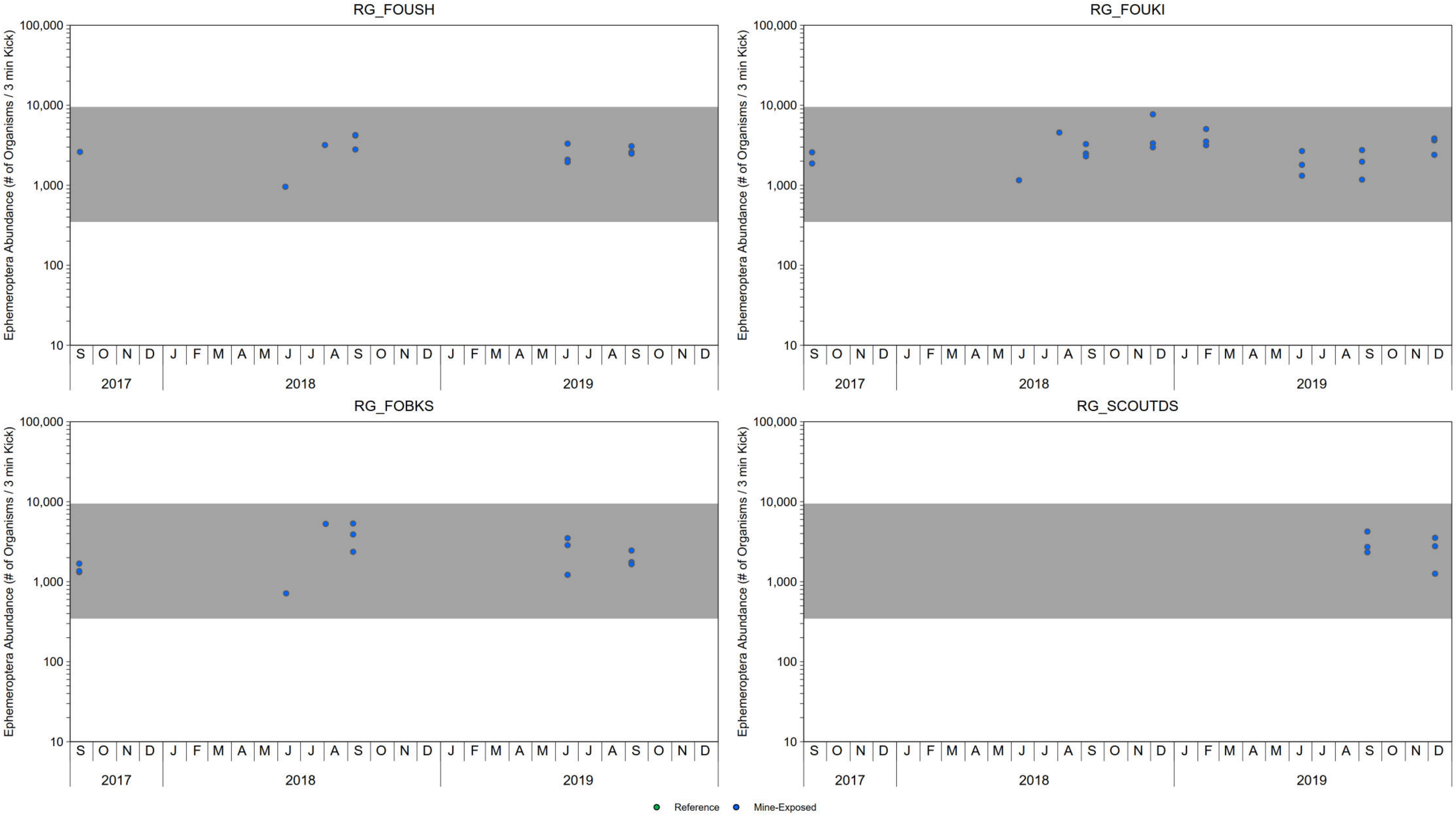


Figure A.12: **Seasonal Benthic Invertebrate Ephemeroptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

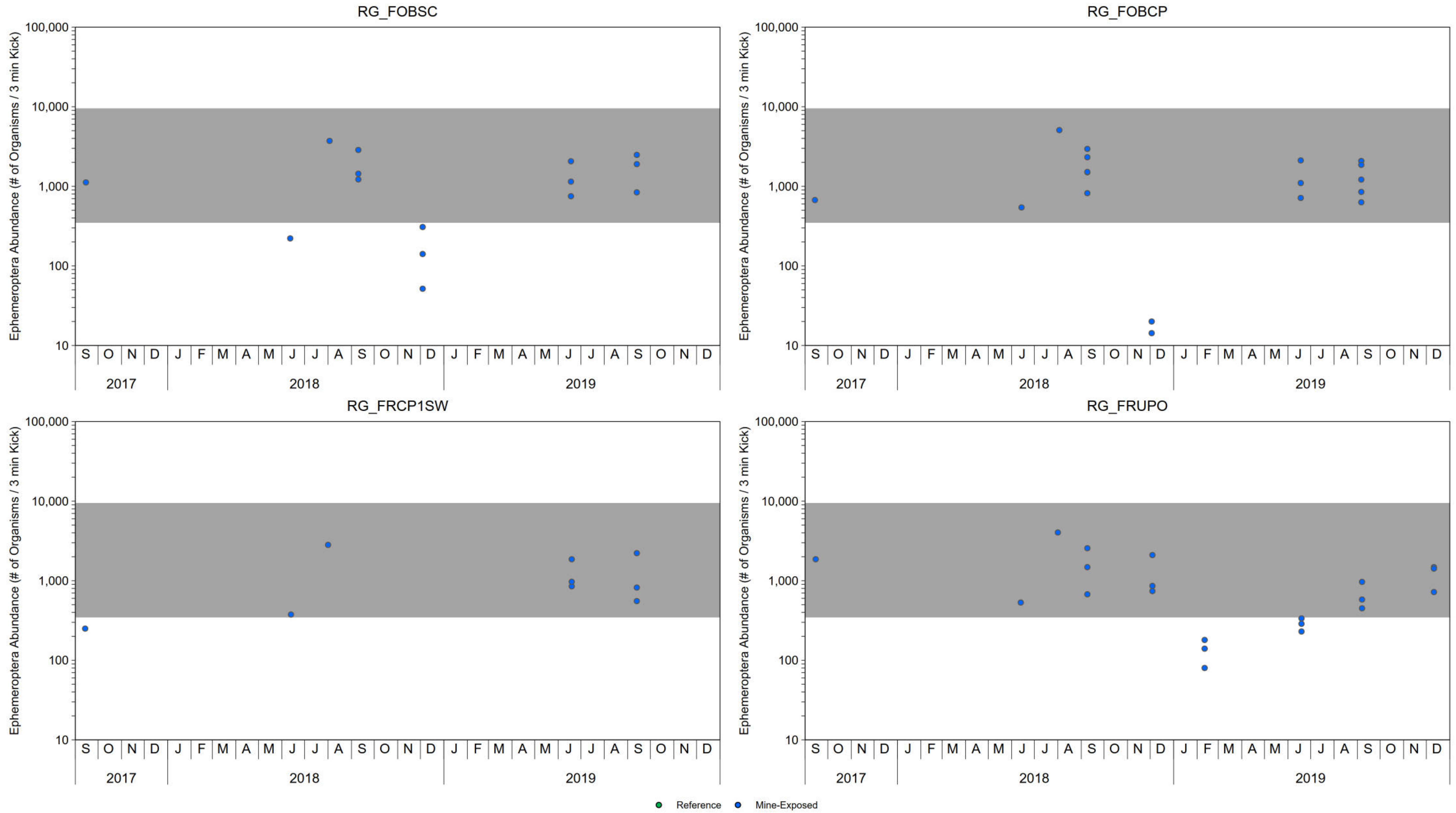


Figure A.12: **Seasonal Benthic Invertebrate Ephemeroptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

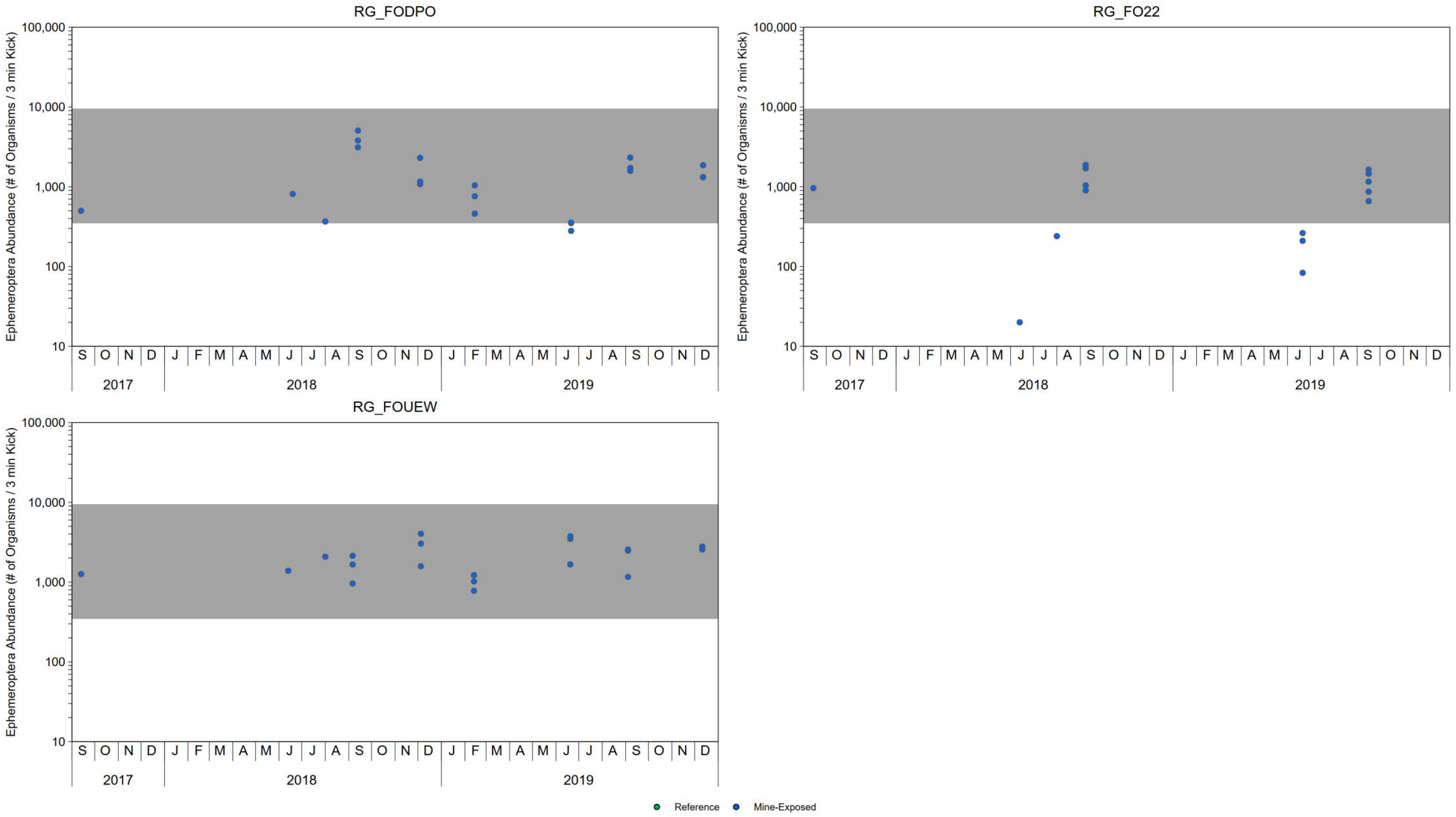


Figure A.12: **Seasonal Benthic Invertebrate Ephemeroptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

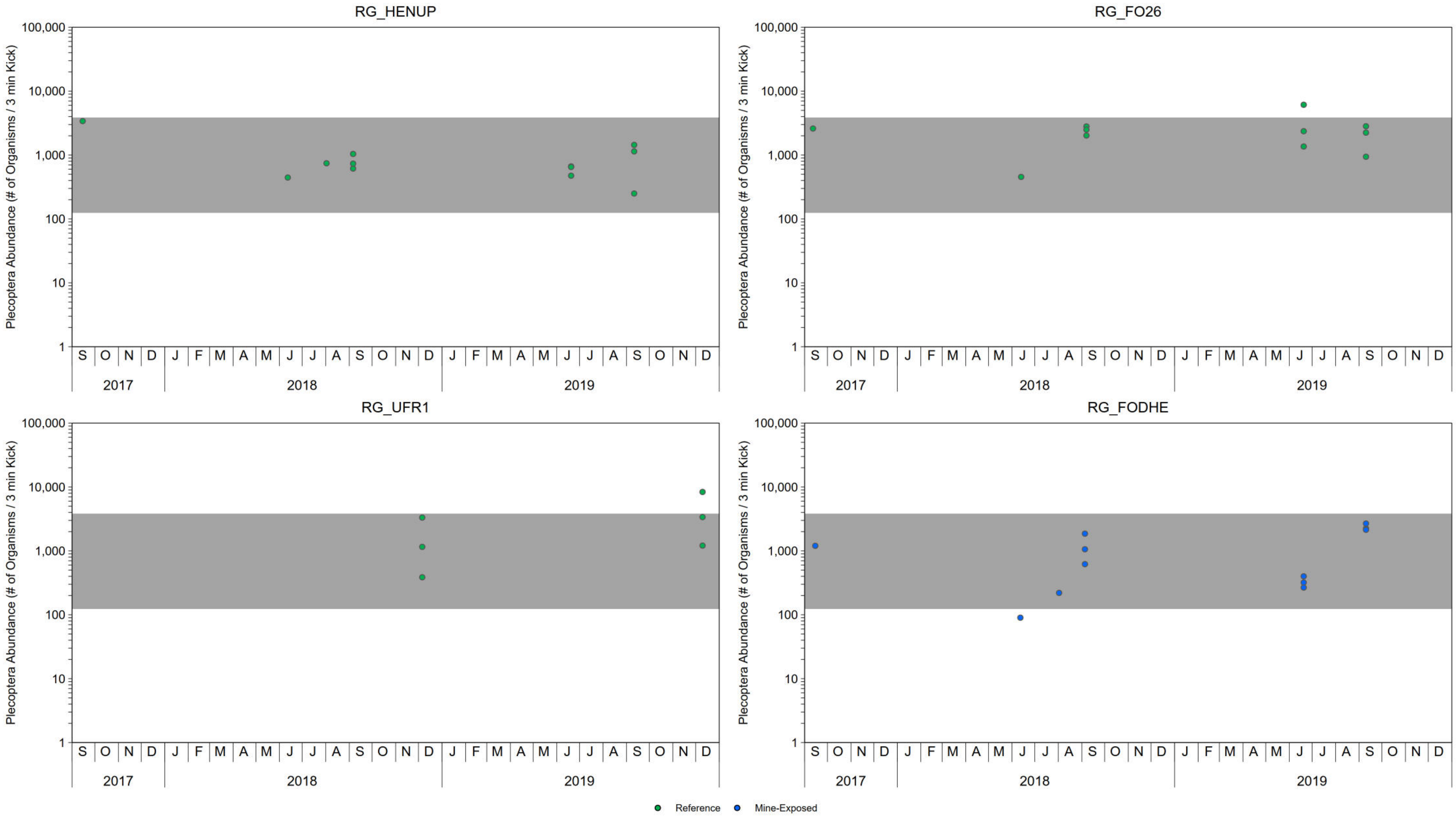


Figure A.13: **Seasonal Benthic Invertebrate Plecoptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

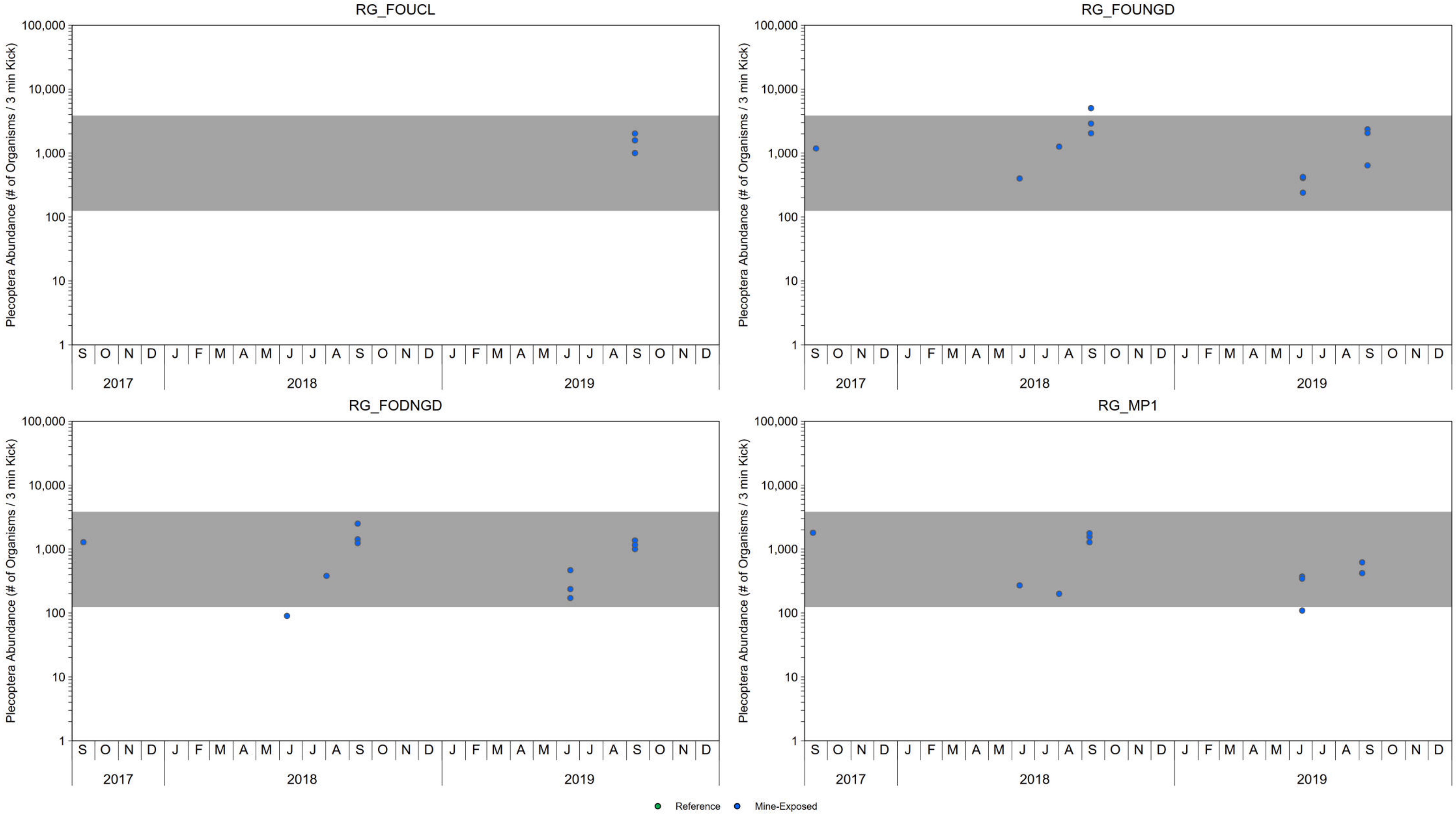


Figure A.13: Seasonal Benthic Invertebrate Plecoptera Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

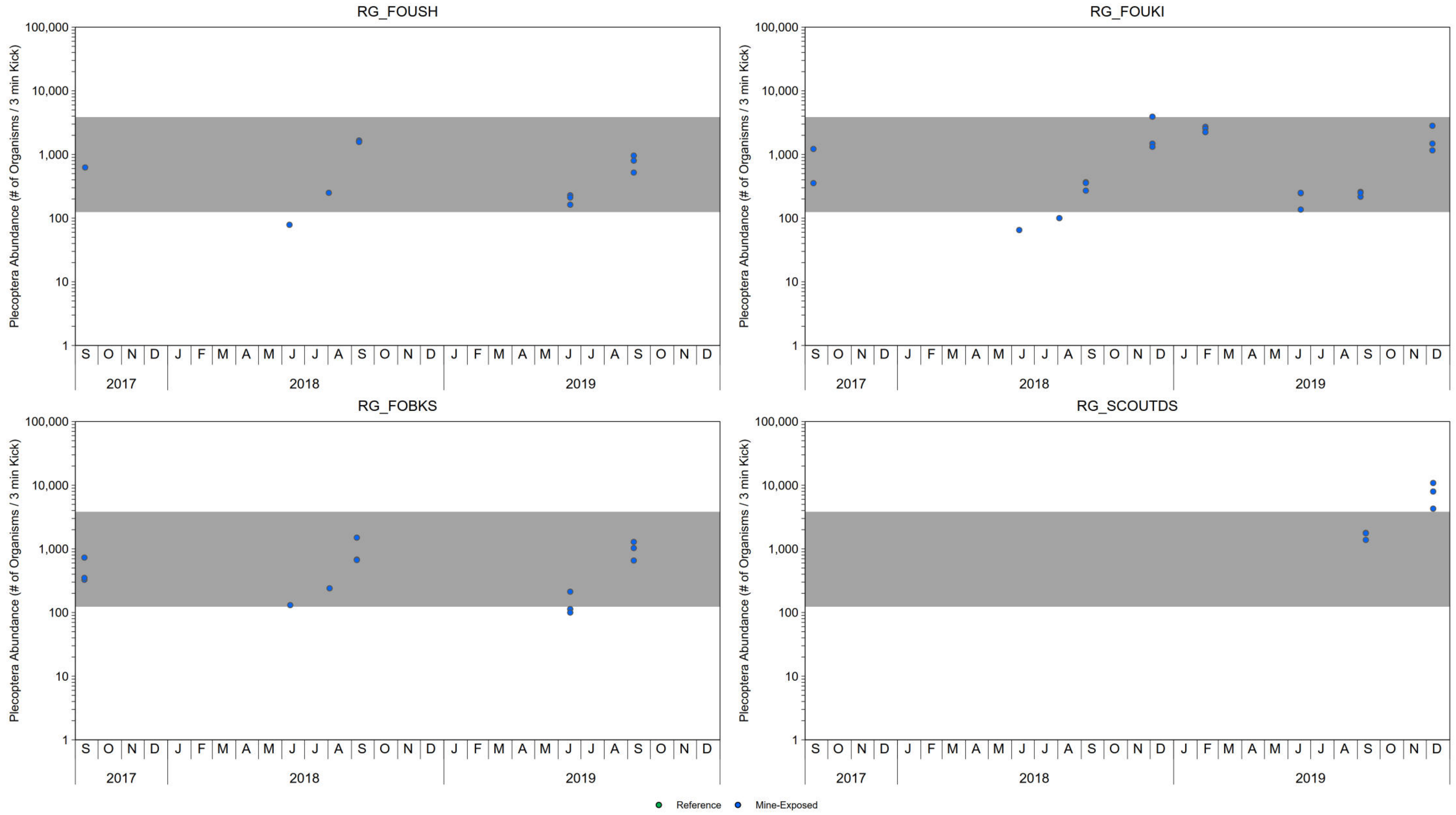


Figure A.13: Seasonal Benthic Invertebrate Plecoptera Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

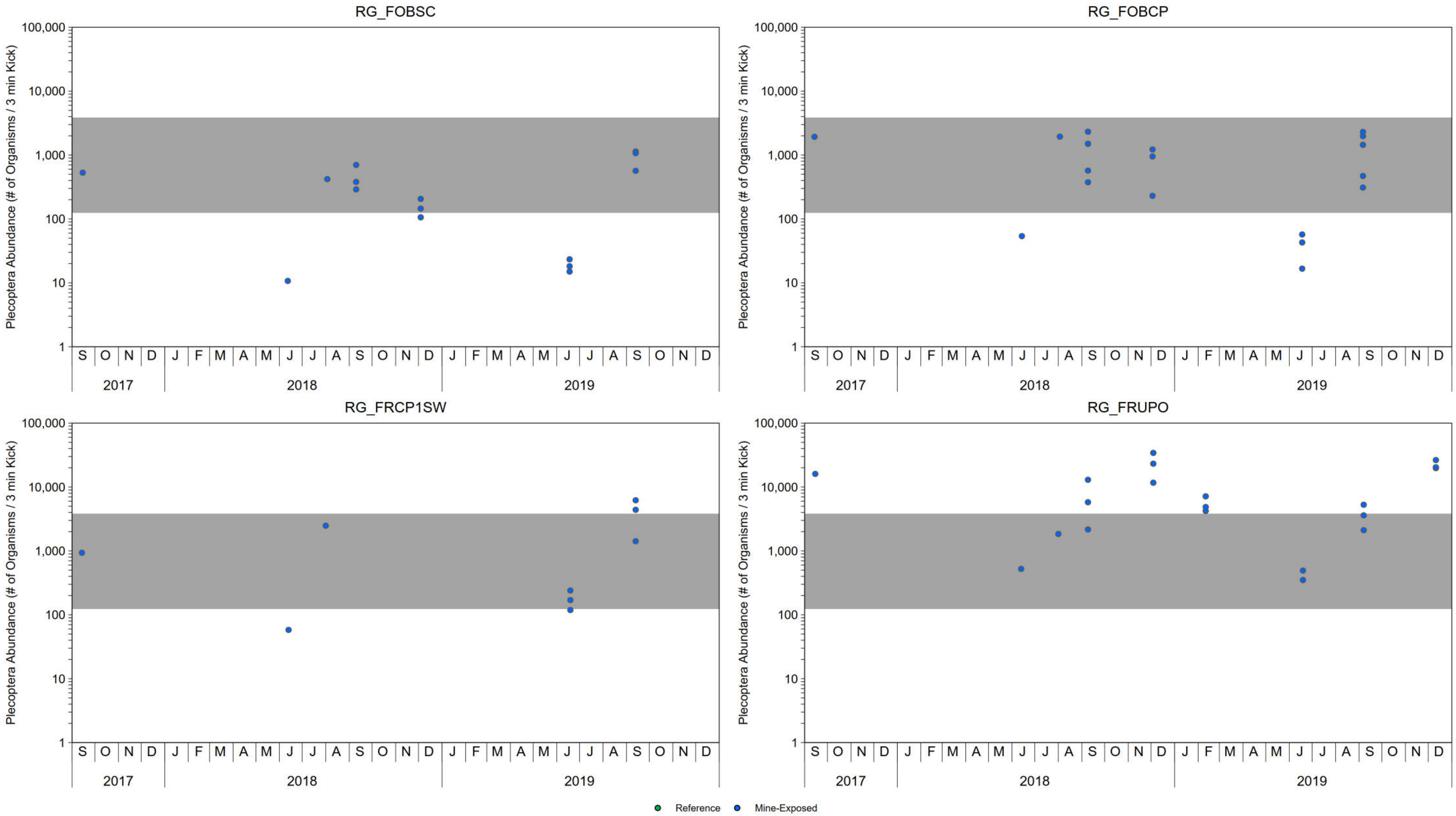


Figure A.13: **Seasonal Benthic Invertebrate Plecoptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

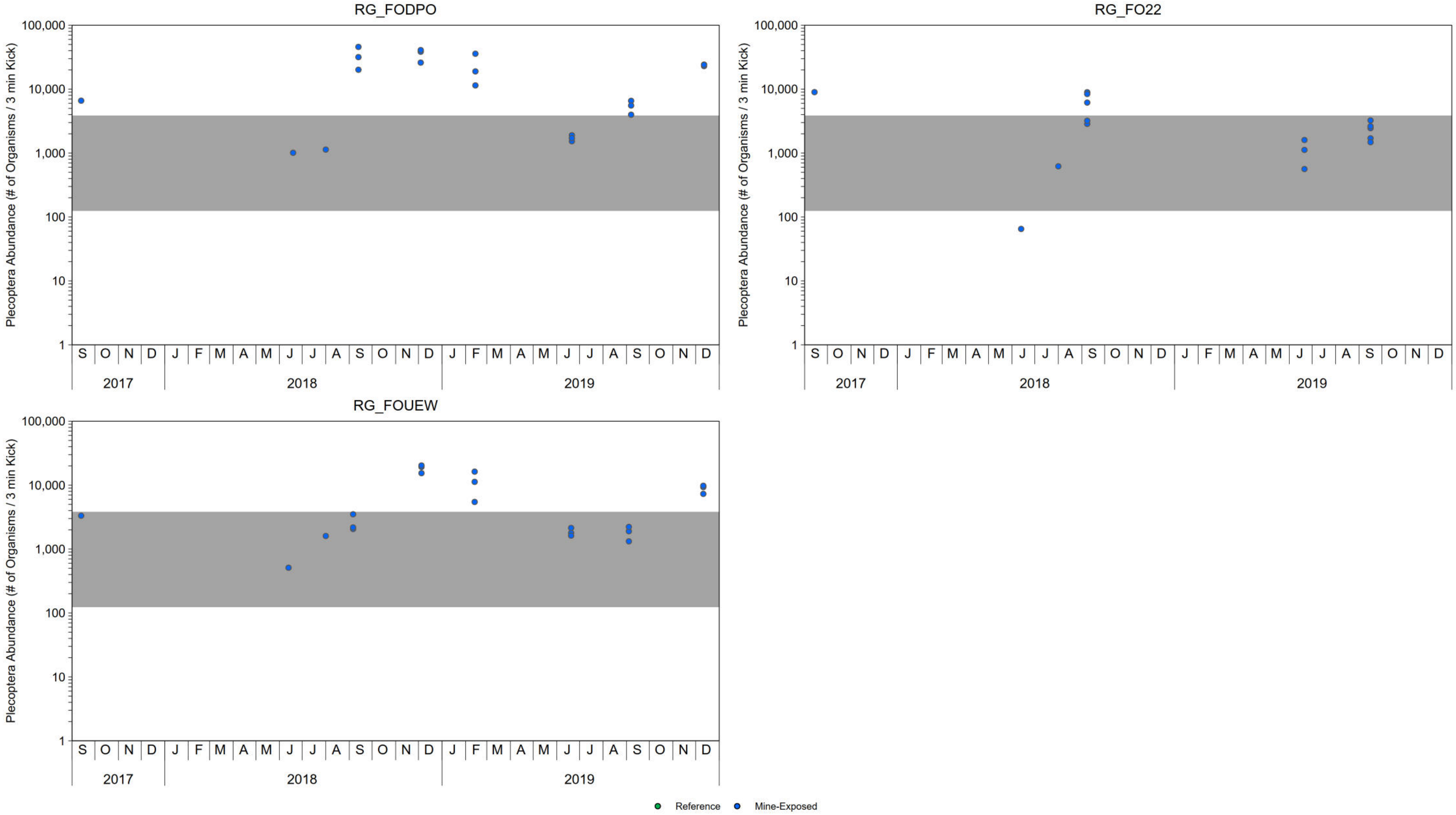


Figure A.13: Seasonal Benthic Invertebrate Plecoptera Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

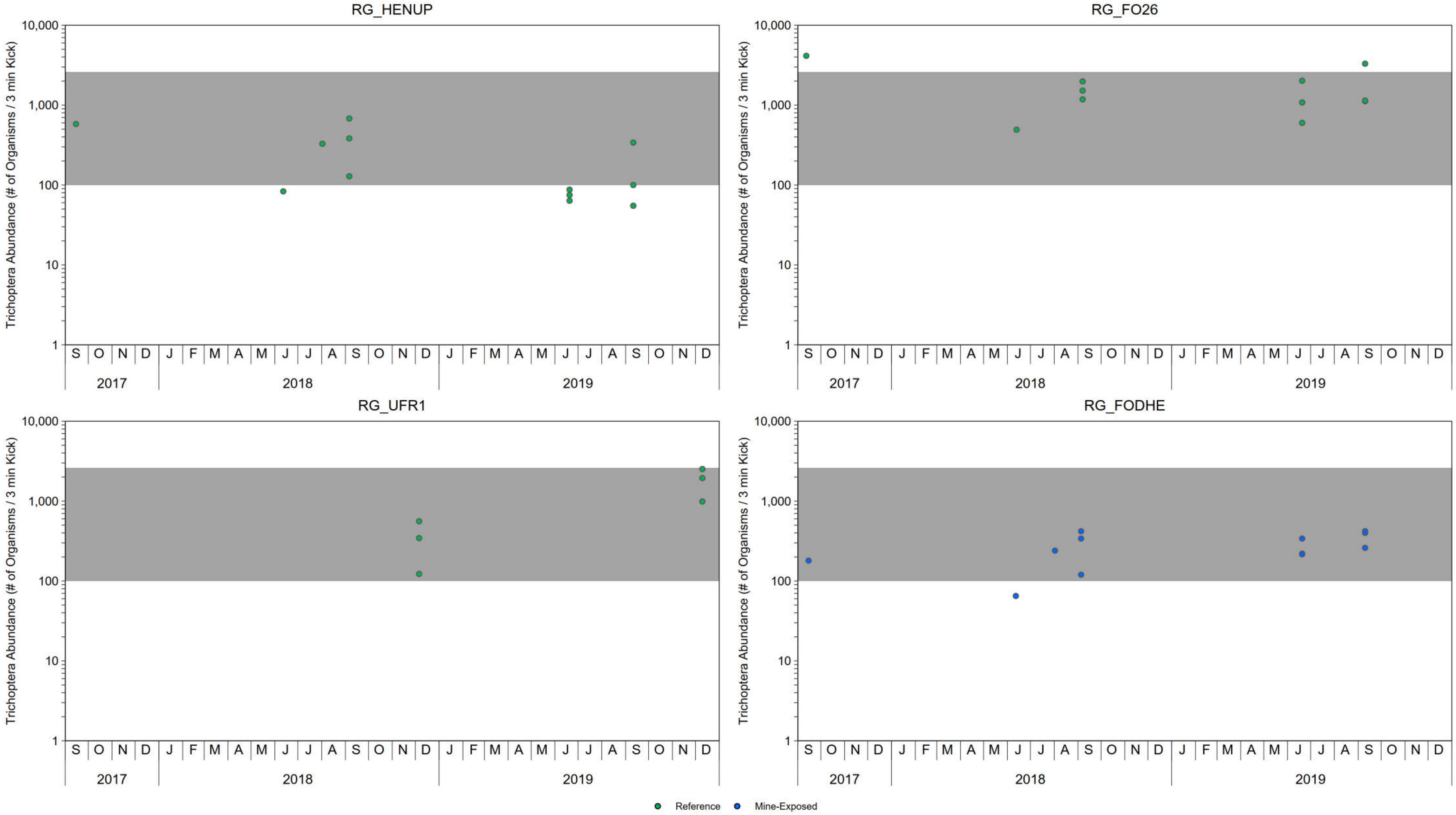


Figure A.14: Seasonal Benthic Invertebrate Trichoptera Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

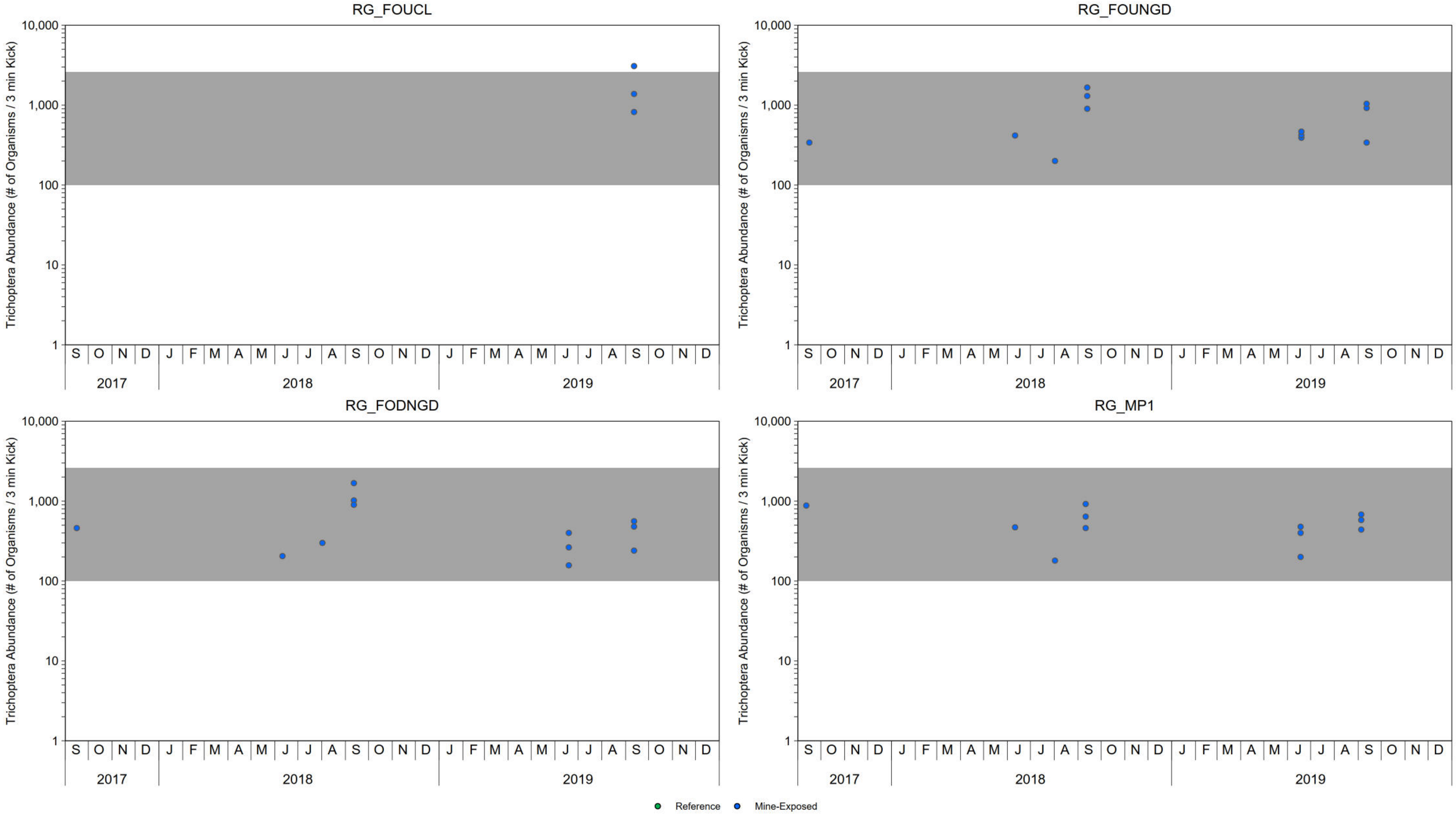


Figure A.14: **Seasonal Benthic Invertebrate Trichoptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

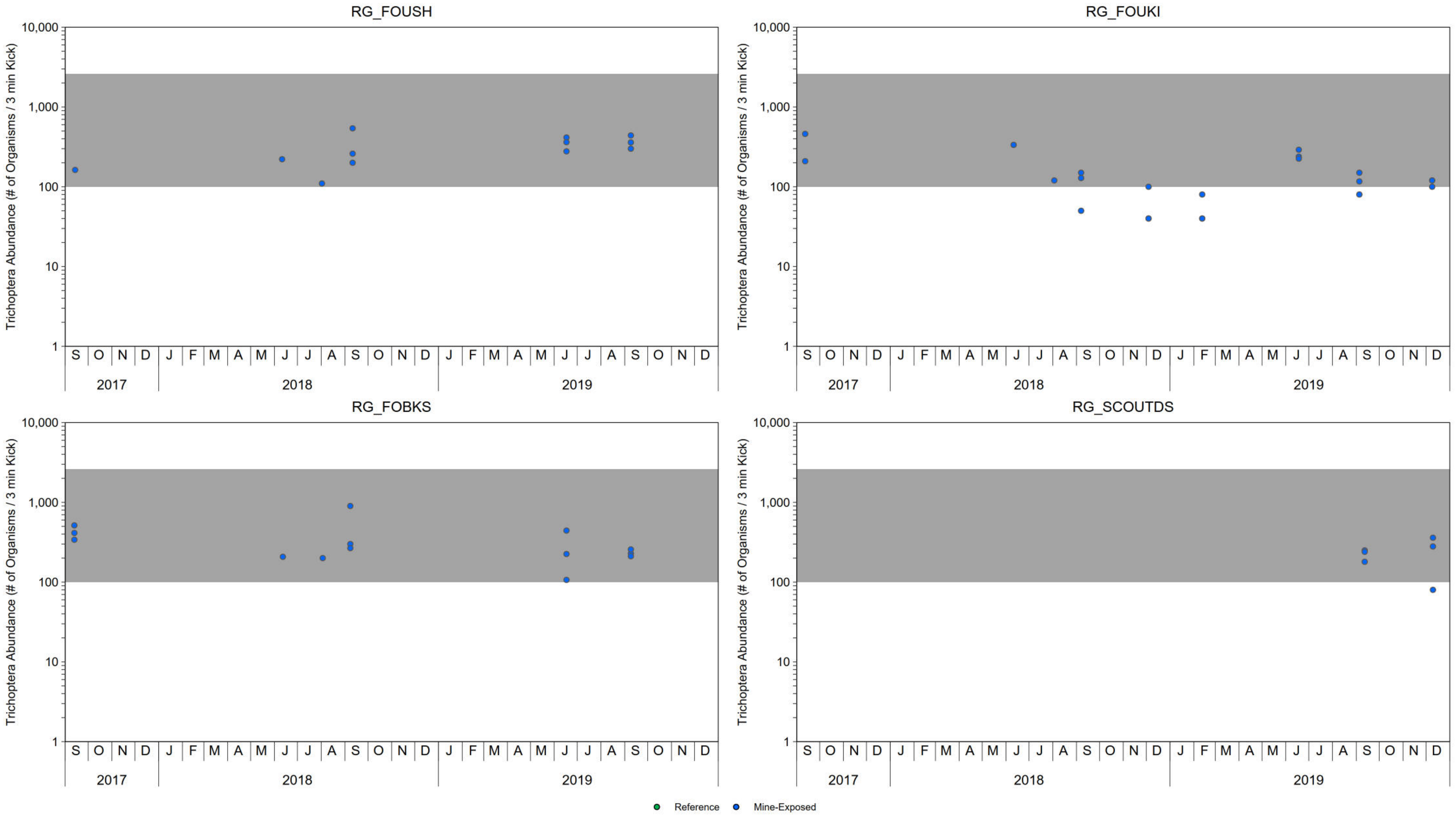


Figure A.14: **Seasonal Benthic Invertebrate Trichoptera Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

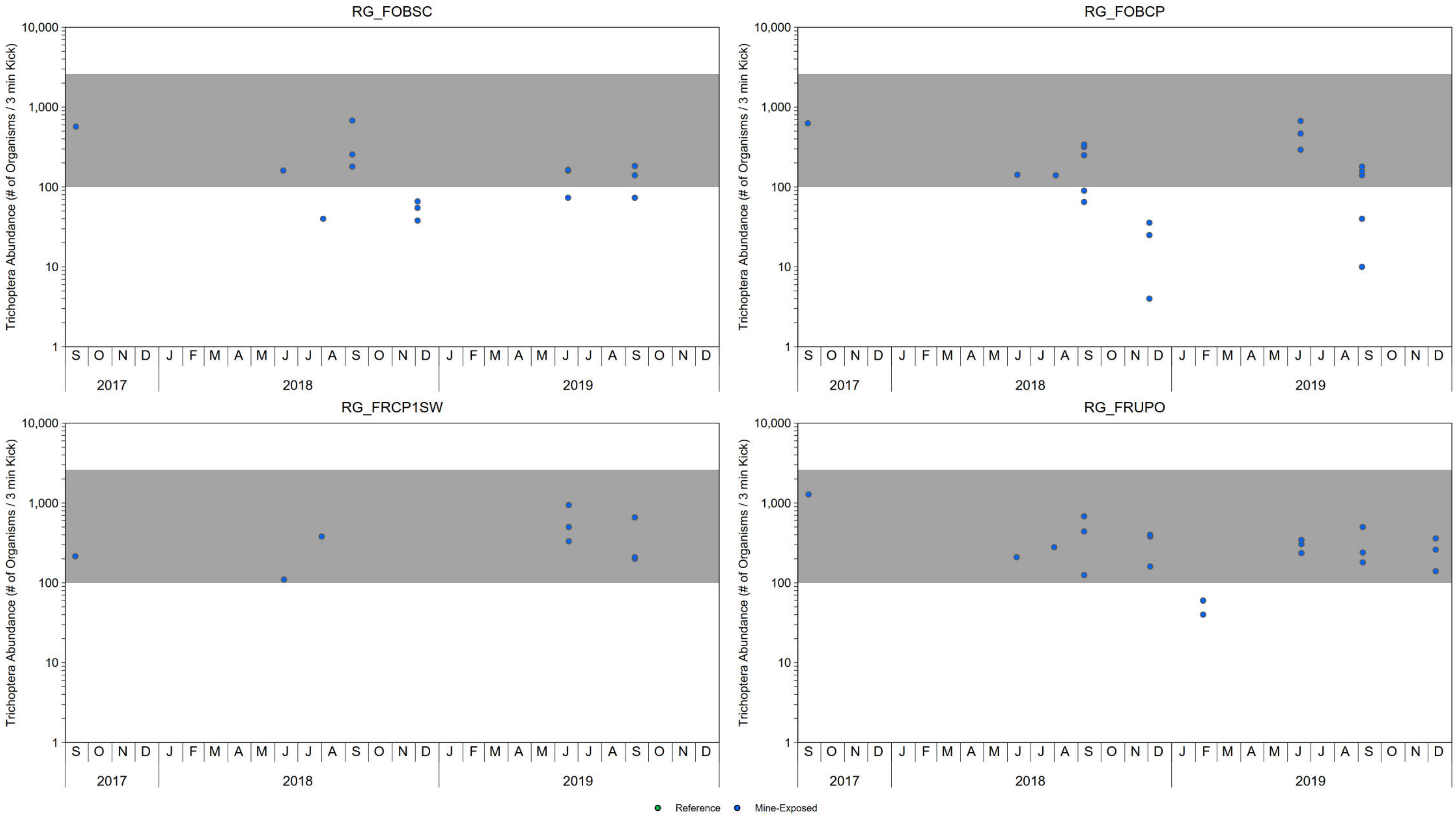


Figure A.14: Seasonal Benthic Invertebrate Trichoptera Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

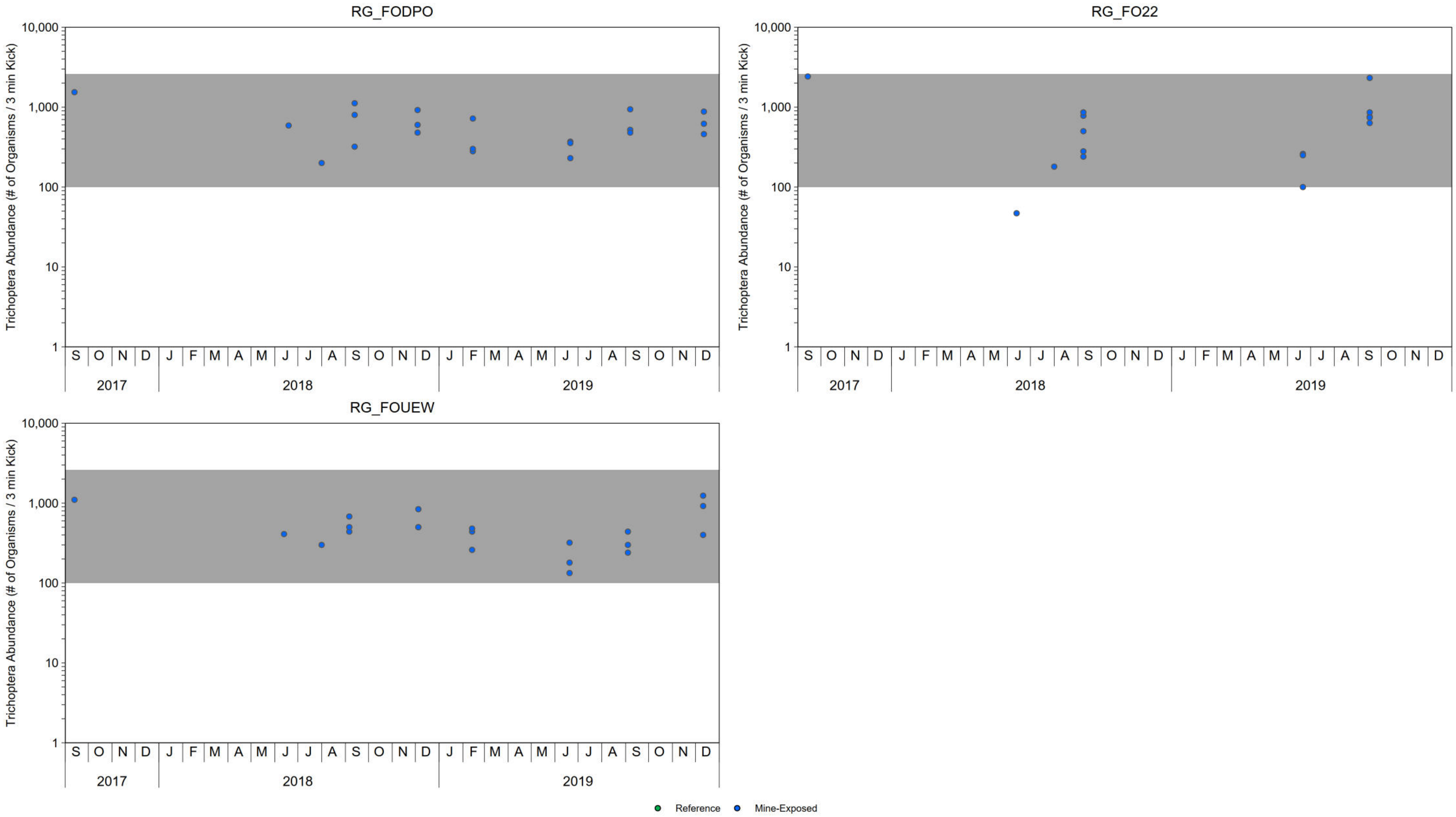


Figure A.14: Seasonal Benthic Invertebrate Trichoptera Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

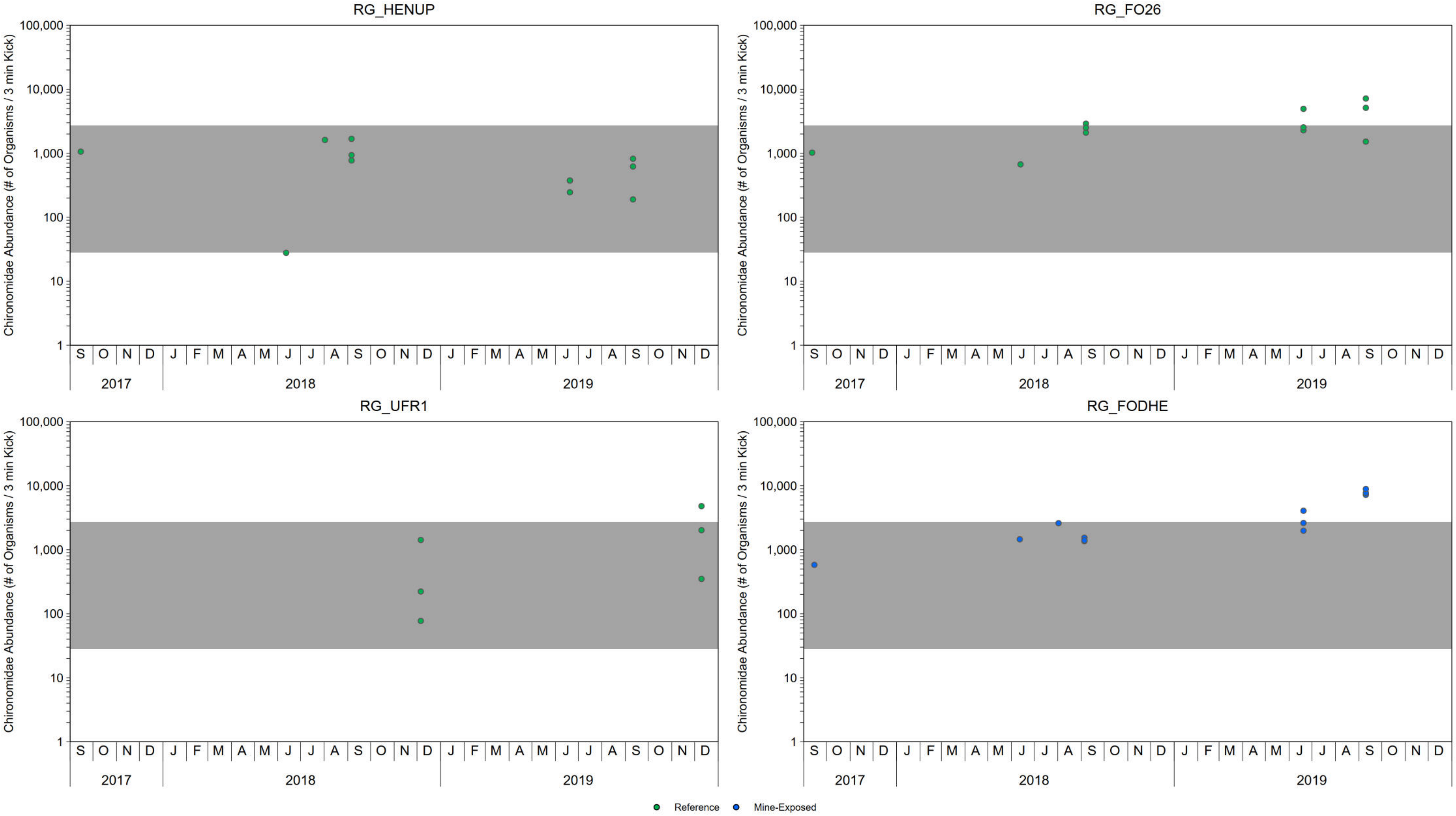


Figure A.15: **Seasonal Benthic Invertebrate Chironomidae Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

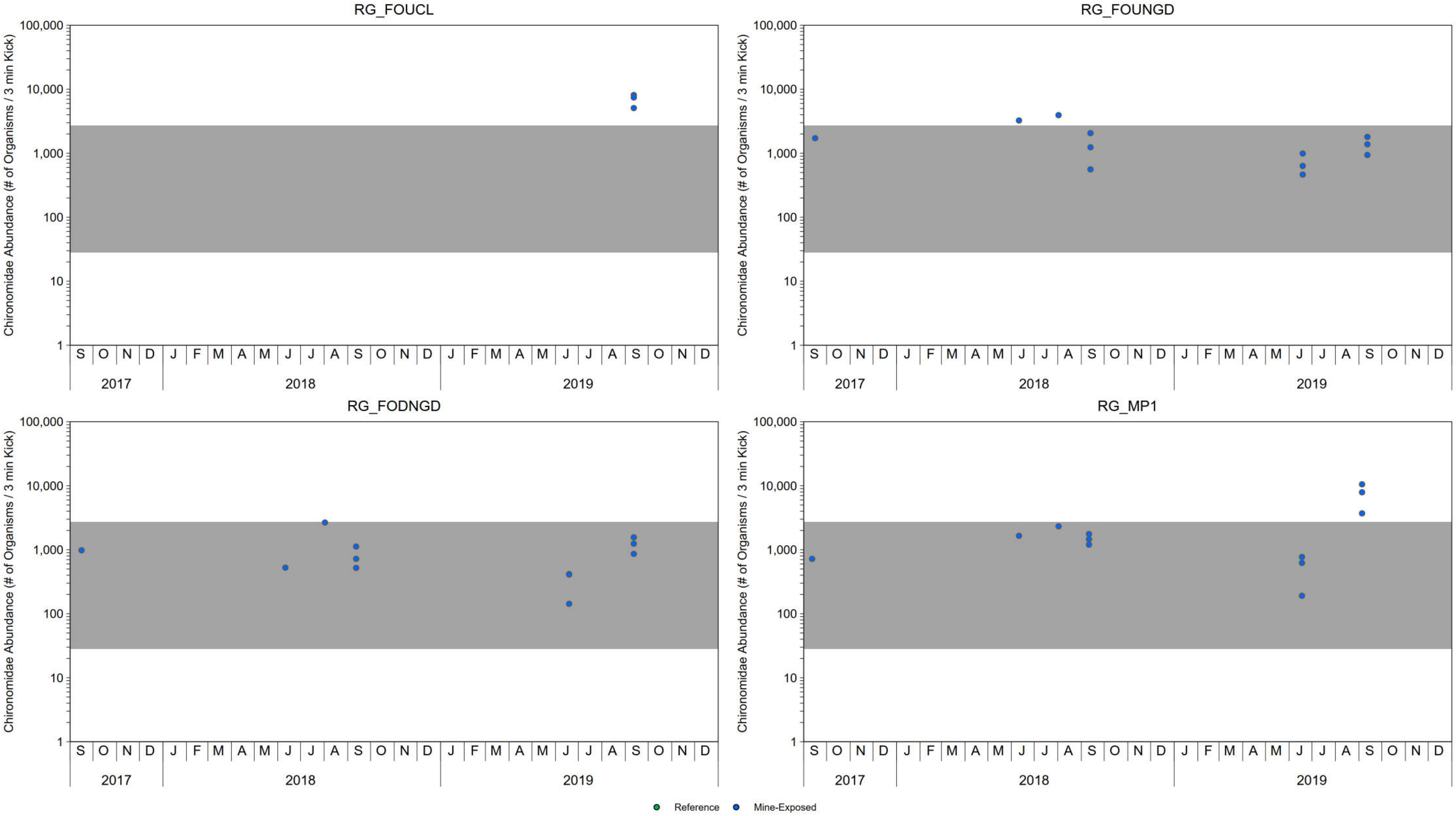


Figure A.15: **Seasonal Benthic Invertebrate Chironomidae Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

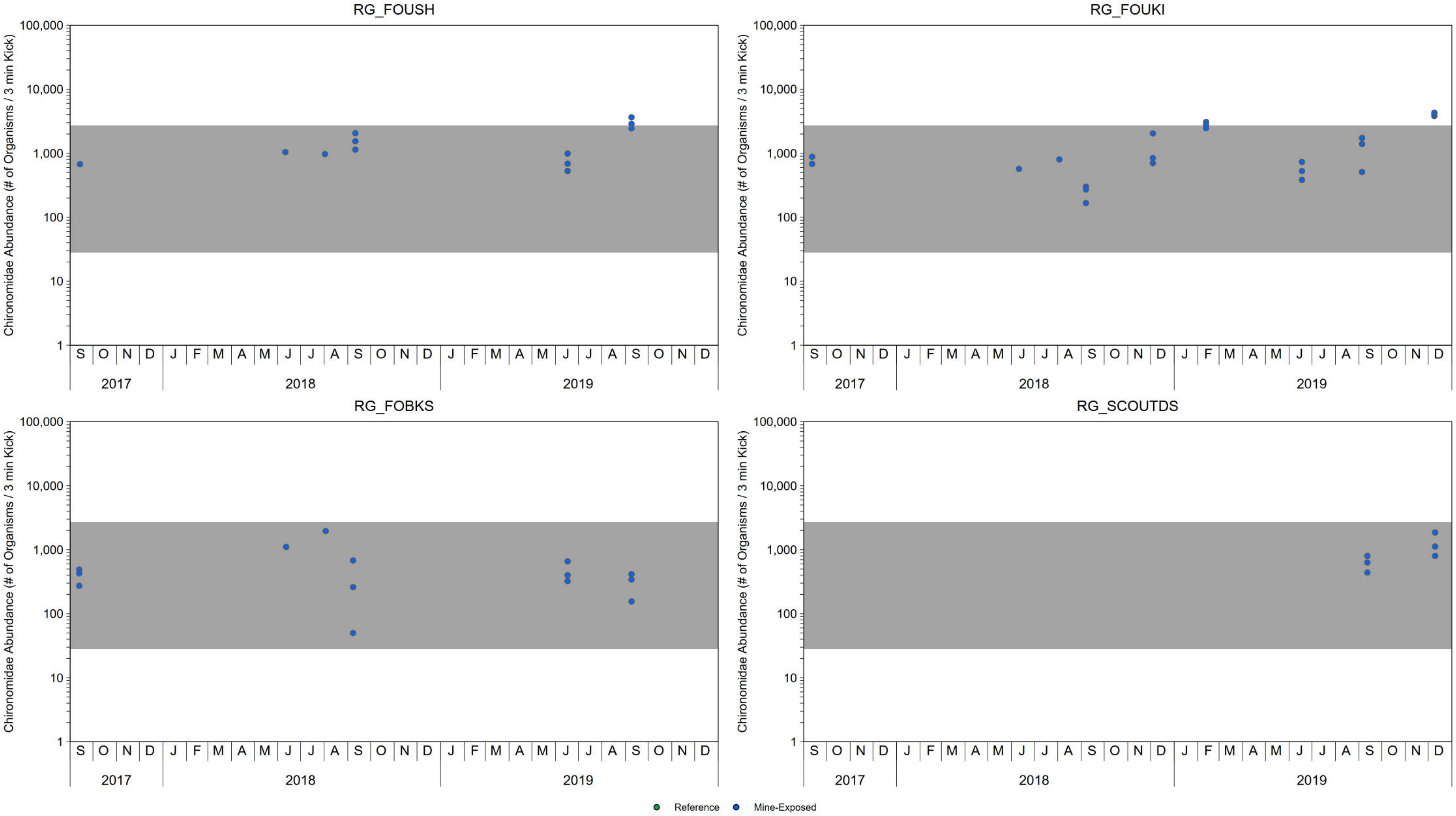


Figure A.15: **Seasonal Benthic Invertebrate Chironomidae Abundance FRO LAEMP, September 2017 - December 2019**

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

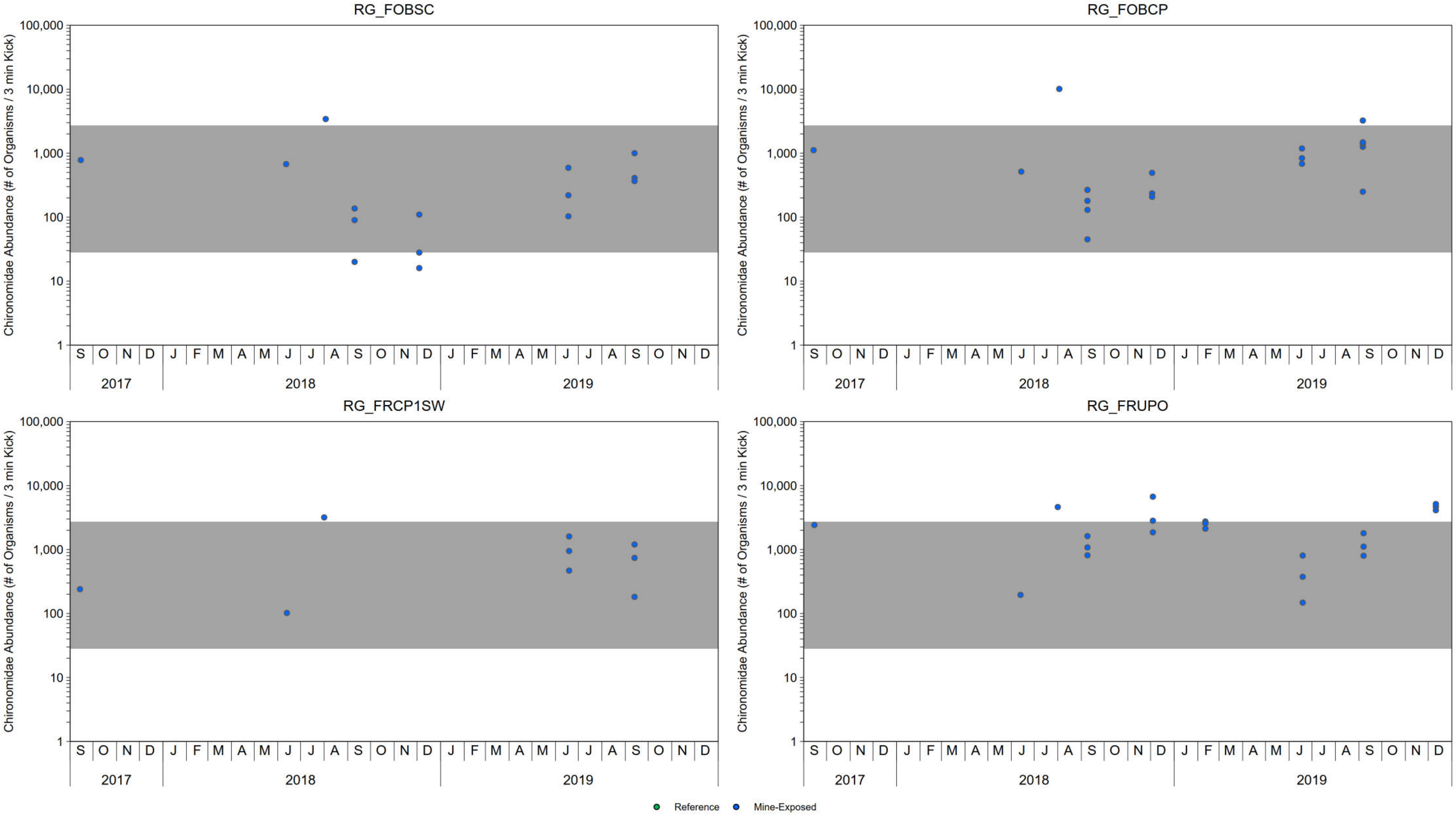


Figure A.15: Seasonal Benthic Invertebrate Chironomidae Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).

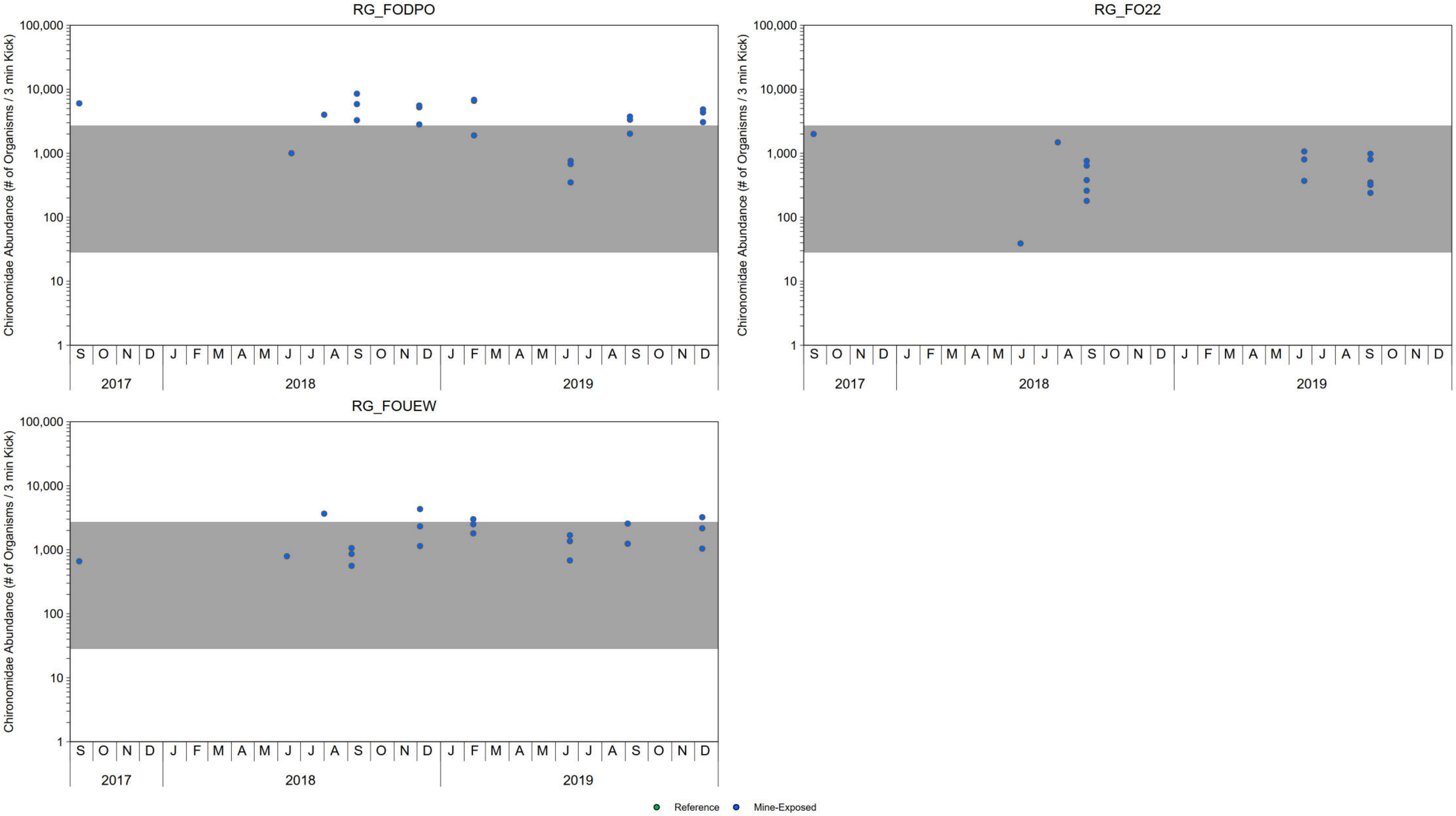
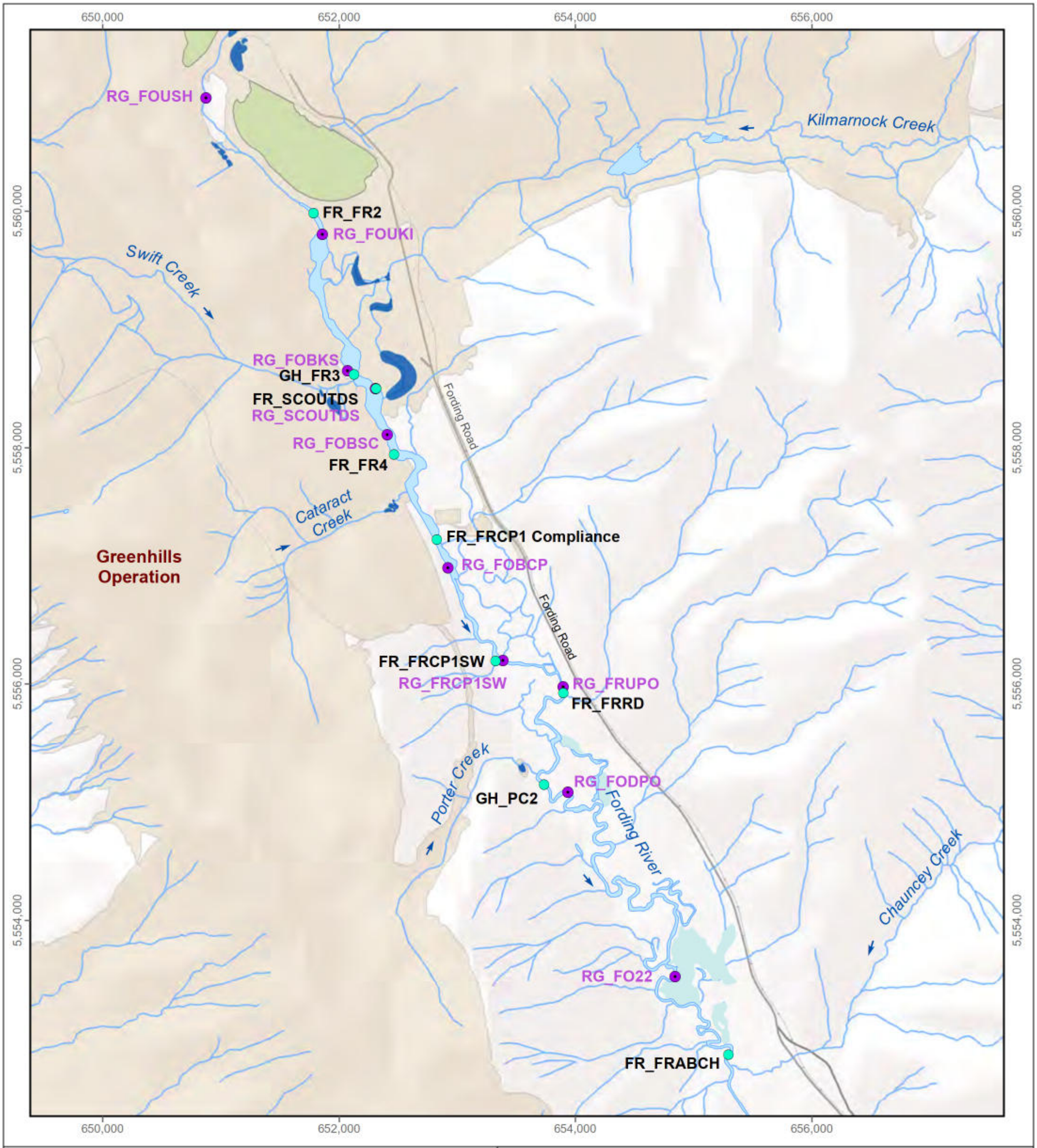


Figure A.15: Seasonal Benthic Invertebrate Chironomidae Abundance FRO LAEMP, September 2017 - December 2019

Notes: Grey shading represents the reference area normal range in September (2.5th and 97.5th percentiles of the data from ~40 reference areas sampled September 2012 and September 2015 in the RAEMP).



LEGEND

Water Monitoring Station
- ● Mine-exposed

Biological Sampling Area
- ● Mine-exposed

- ▨ Settling Pond
- ▨ Tailings Pond
- ▨ Teck Coal Mine Operation

Drying Surveys in the South Section of the Upper Fording River, October and November, 2017

0 0.5 1 2 km

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Date: November 2020
Project 197202.0071

Figure A.16

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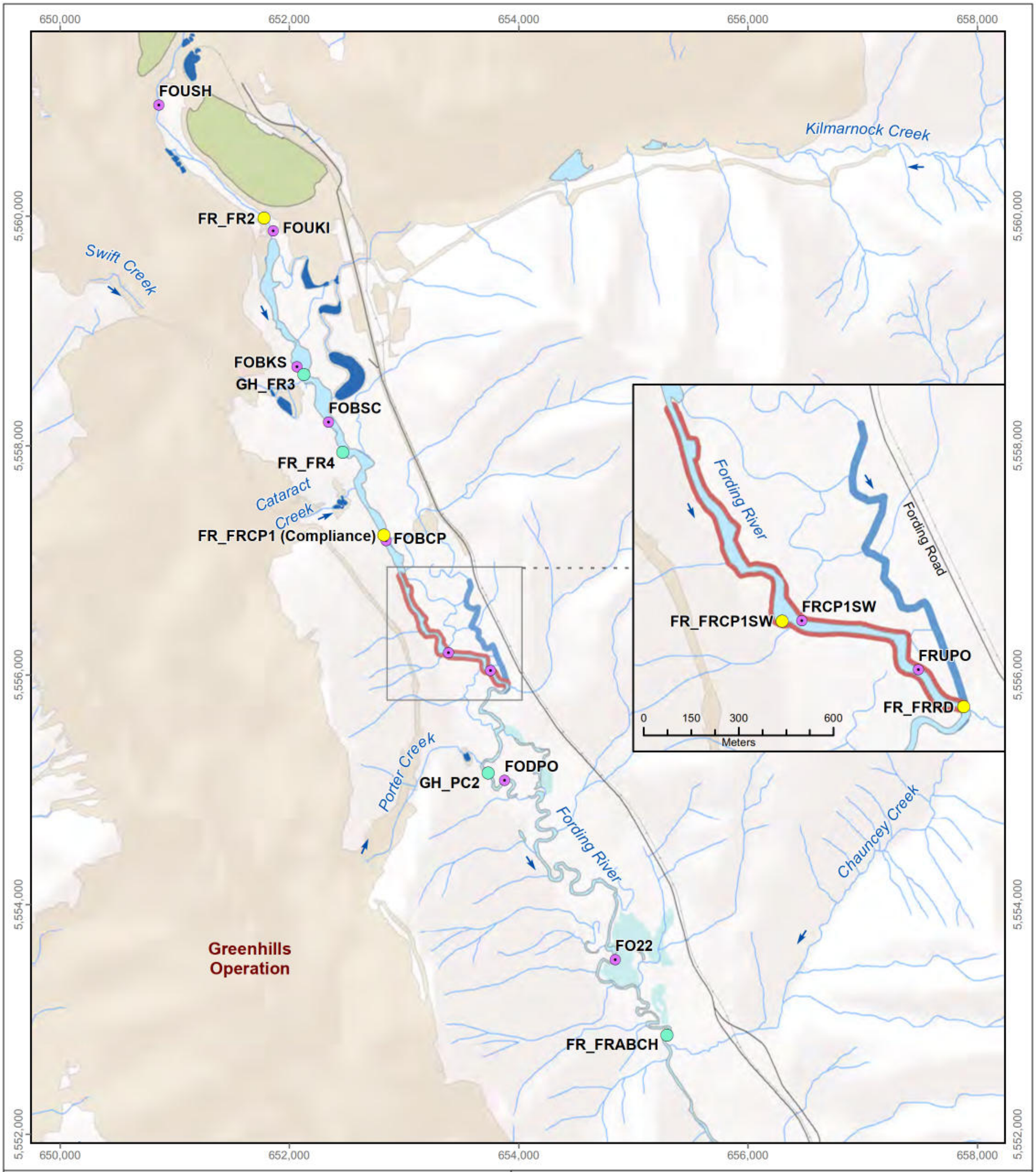

LEGEND

- ● Water Monitoring Station (Non-permit)
- ● Water Monitoring Station (Permit)
- ⊙ Mine-exposed
- ⊙ Reference
- ☒ Hydrometric Station
- ━ Greenhouse Groundwater Channel
- ━ Dry Section
- ■ Settling Pond
- ■ Tailings Pond
- ■ Teck Coal Mine Operation

"*drying began at FRCP1SW on 14 December 2017

Drying Surveys in the South Section of the Upper Fording River, January* through March, 2018

0 0.75 1.5 3 km

Datum: NAD 83 Map Projection: UTM Zone 11N
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Figure A.17

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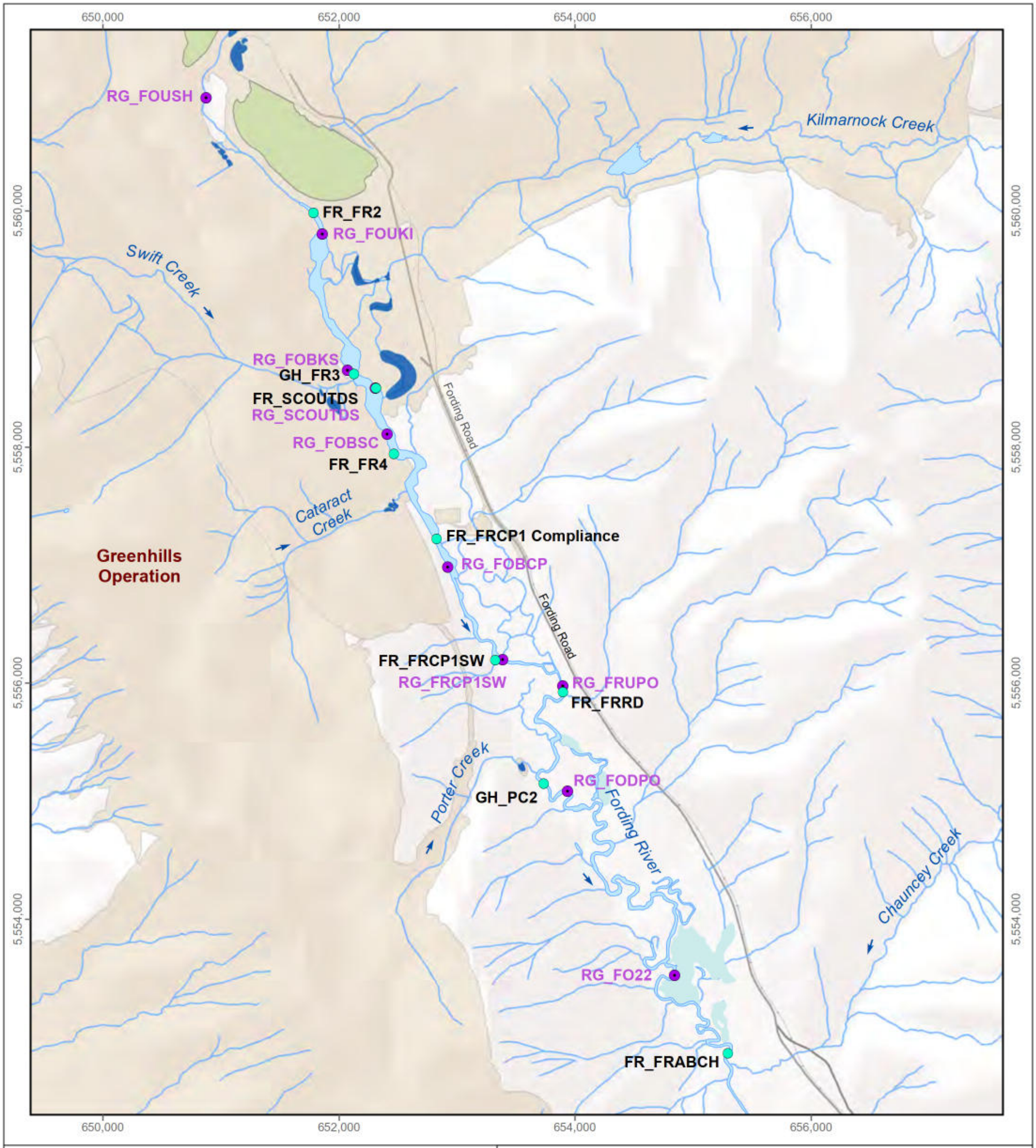

LEGEND

Water Monitoring Station

● Mine-exposed

Biological Sampling Area

● Mine-exposed

🟦 Settling Pond

🟩 Tailings Pond

▨ Teck Coal Mine Operation

Drying Surveys in the South Section of the Upper Fording River, April through August, 2018

0 0.5 1 2 km

N E S W

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Figure A.18

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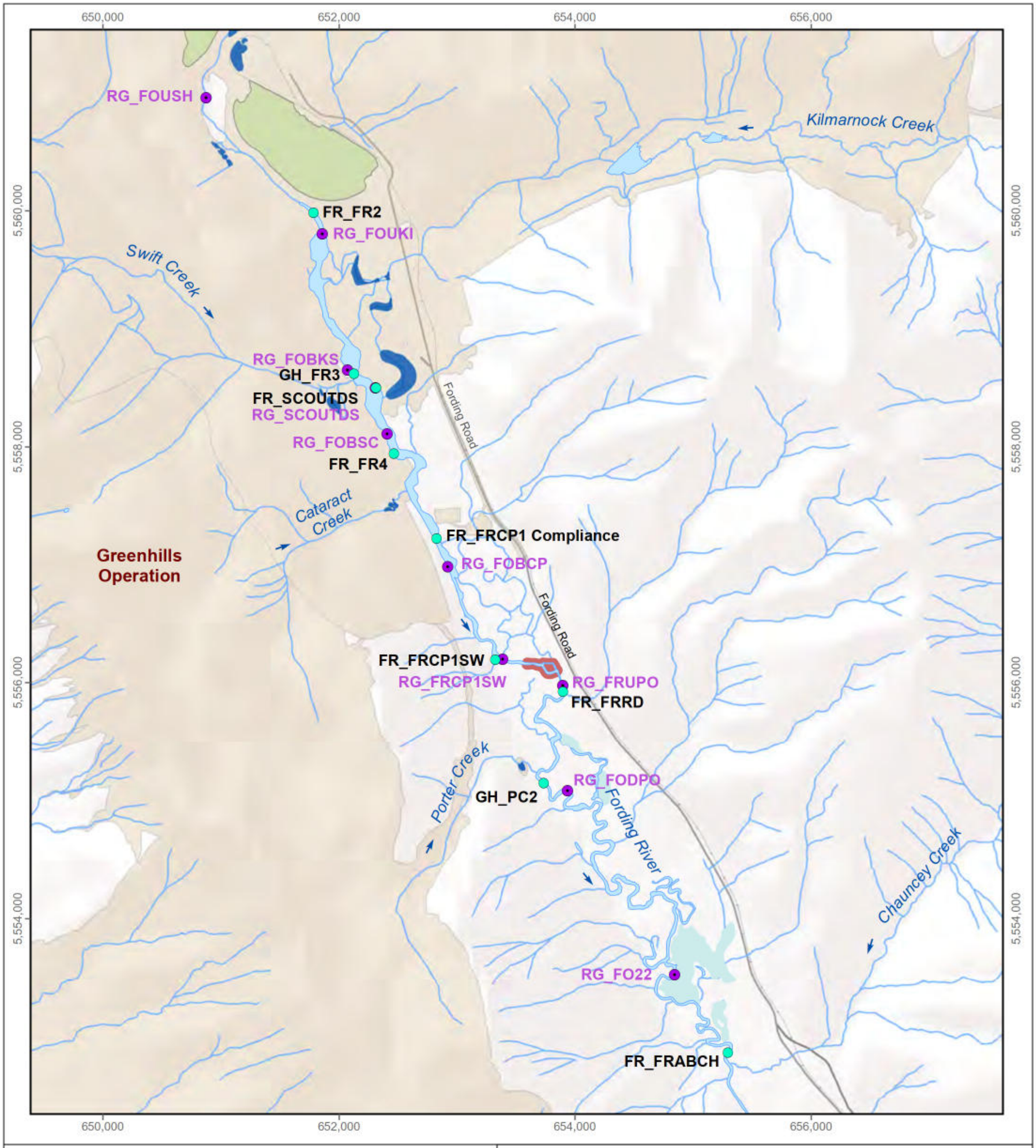

LEGEND

Water Monitoring Station

- ● Mine-exposed

Biological Sampling Area

- ● Mine-exposed

▭ Dry Section

🟦 Settling Pond

🟩 Tailings Pond

▭ Teck Coal Mine Operation

*drying was intermittent in September 2018

Drying Surveys in Upper Fording River, FRO LAEMP, September* and October 2018

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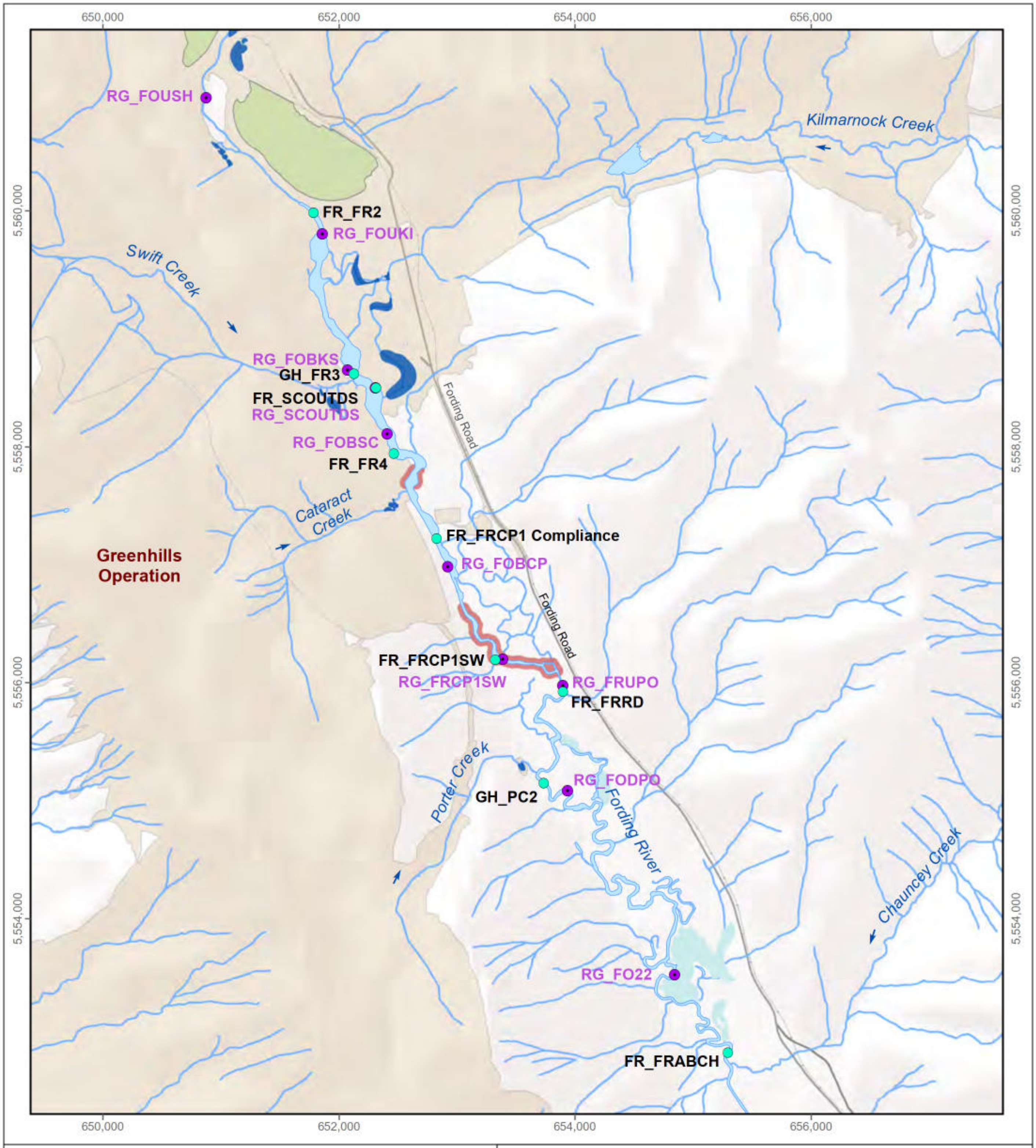
Figure A.19



LEGEND

Water Monitoring Station

● Mine-exposed

Biological Sampling Area

● Mine-exposed

▭ Dry Section

■ Settling Pond

🟩 Tailings Pond

▢ Teck Coal Mine Operation

Drying Surveys in Upper Fording River, FRO LAEMP, November 2018

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Figure A.20

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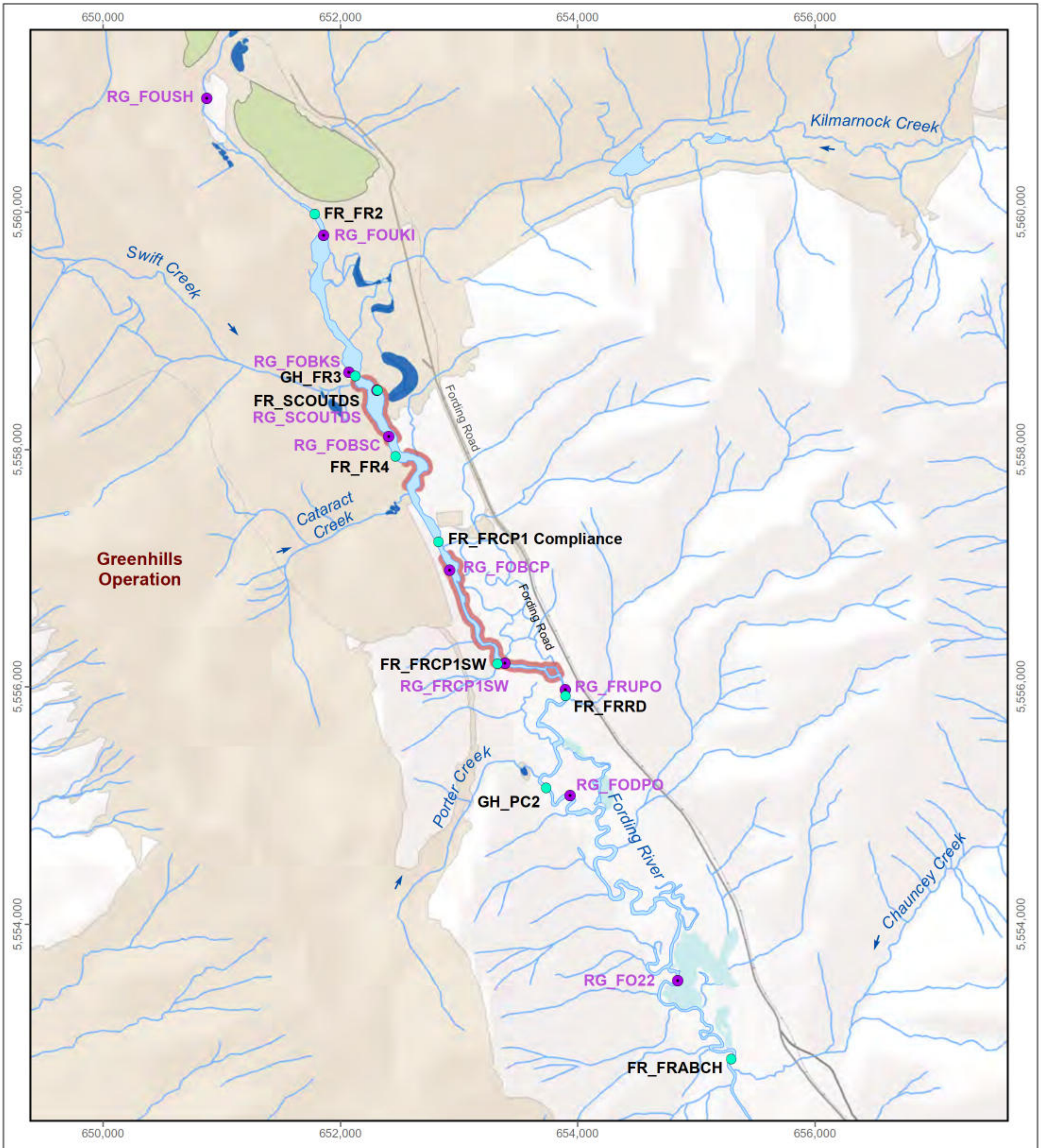

LEGEND

Water Monitoring Station

● Mine-exposed

Biological Sampling Area

● Mine-exposed

▭ Dry Section

▨ Settling Pond

🟩 Tailings Pond

▭ Teck Coal Mine Operation

Drying Surveys in Upper Fording River, FRO LAEMP, December 2018

0 0.5 1 2 km

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Figure A.21

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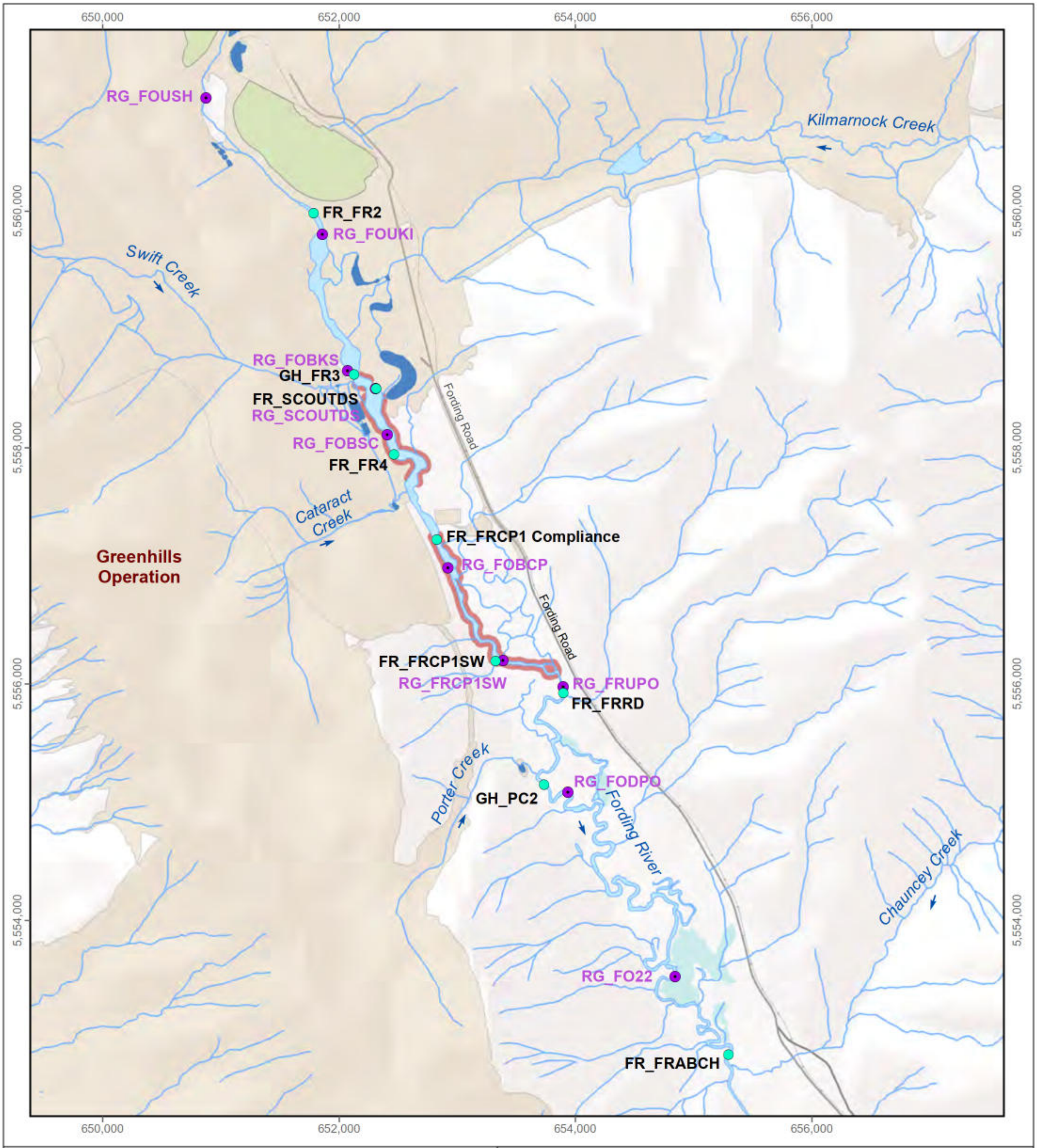

LEGEND

Water Monitoring Station

● Mine-exposed

Biological Sampling Area

● Mine-exposed

▭ Dry Section

■ Settling Pond

■ Tailings Pond

■ Teck Coal Mine Operation

Drying Surveys in South Section of Fording LAEMP, January 2019

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Figure A.22

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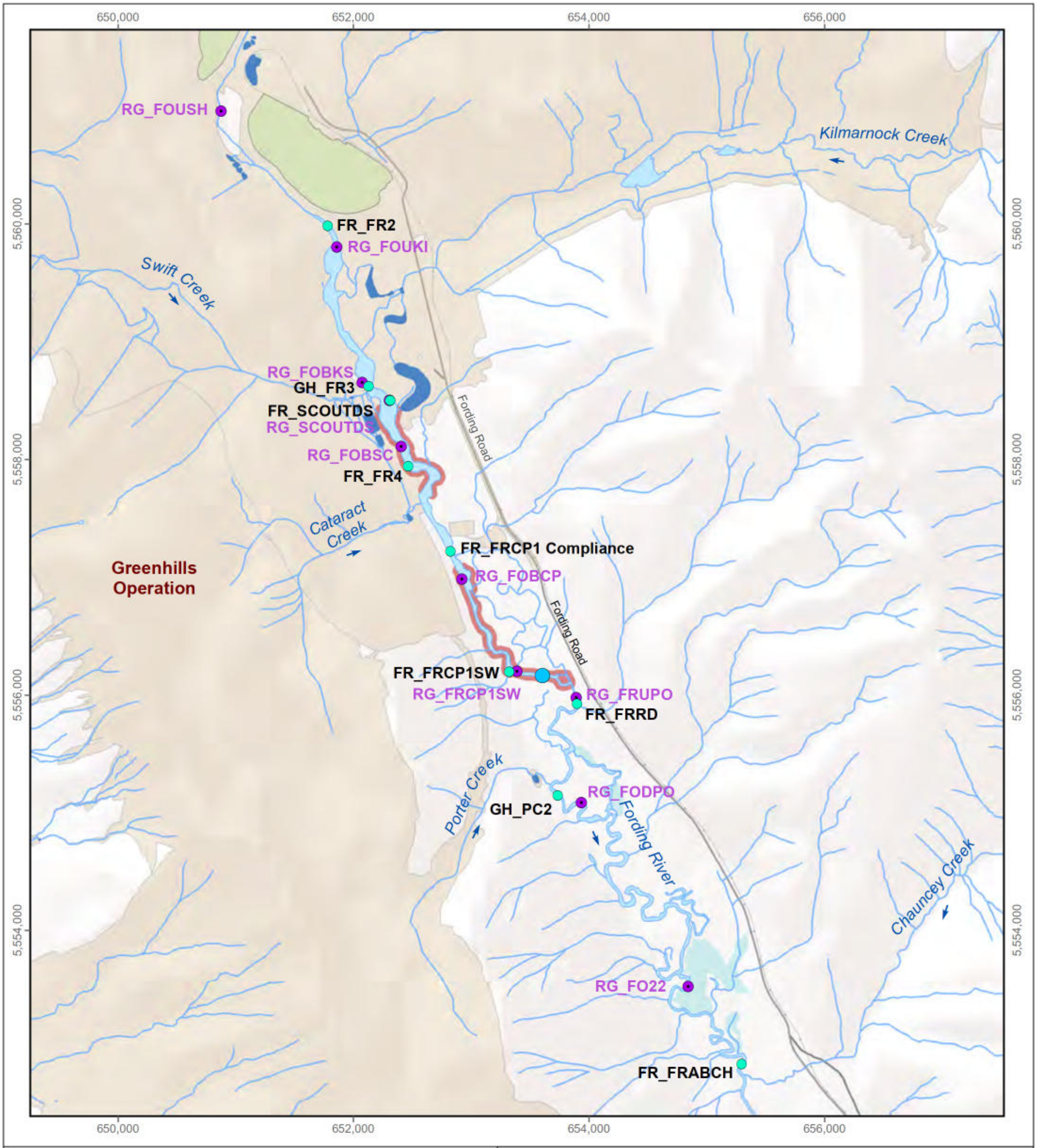

LEGEND

Water Monitoring Station

● Mine-exposed

Biological Sampling Area

● Mine-exposed

● Pool

▬ Settling Pond

▬ Tailings Pond

▭ Dry Section

▭ Teck Coal Mine Operation

Note: Pool present in February only.

Drying Surveys in South Section of the Fording LAEMP, February and March, 2019

0 0.5 1 2 km

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Figure A.23

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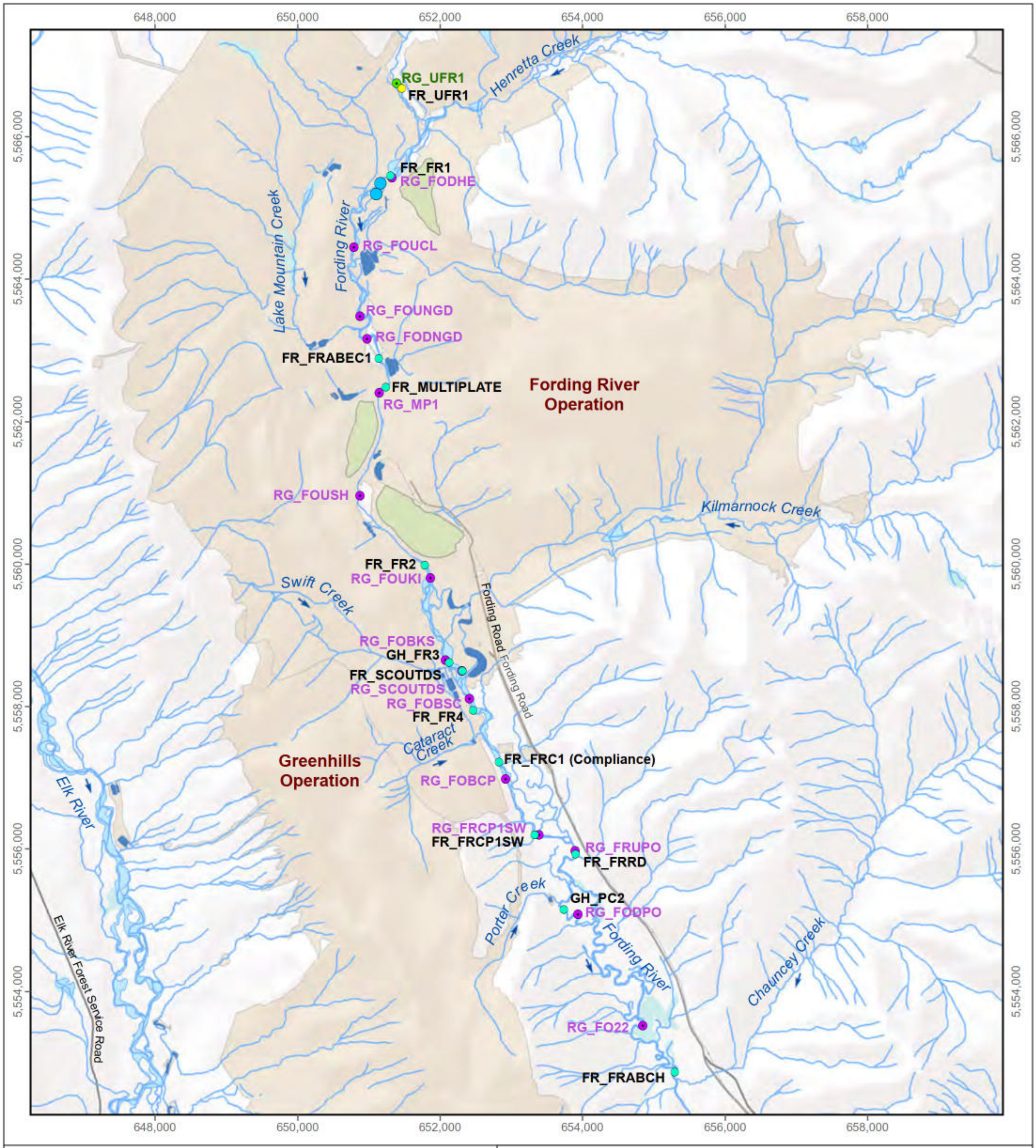

LEGEND

Water Monitoring Station

- ● Mine-exposed
- ● Reference

Biological Sampling Area

- ● Mine-exposed
- ● Reference

- ● Pool
- ▨ Settling Pond
- ▨ Tailings Pond
- ▨ Teck Coal Mine Operation

Drying Surveys in Southern and Northern Section of Fording LAEMP, April through October 2019

0 1 2 4 km

N W E S

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Figure A.24

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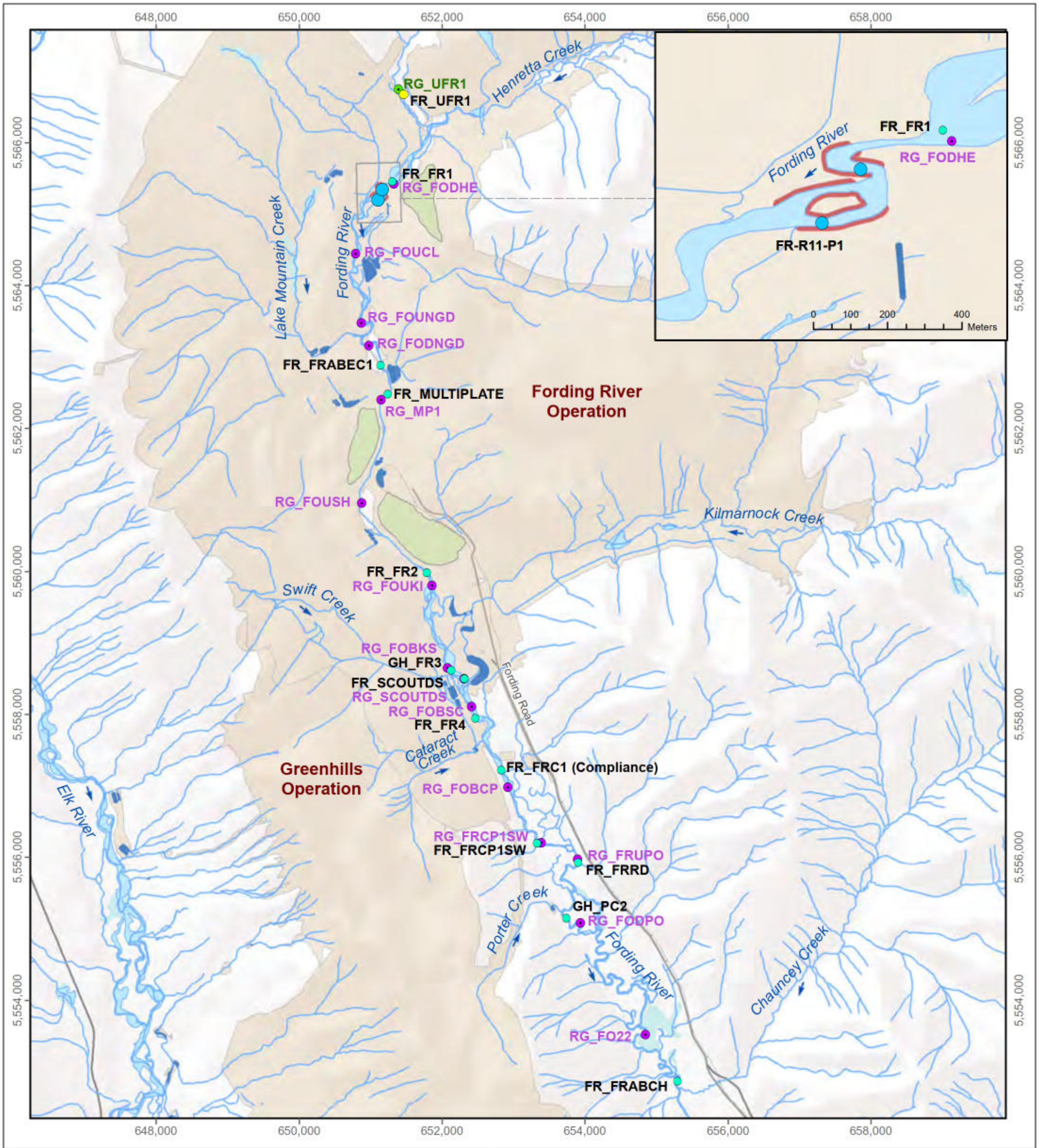

LEGEND

Water Monitoring Station

● Mine-exposed

● Reference

Biological Sampling Area

● Mine-exposed

● Reference

● Pool

▬ Settling Pond

▬ Tailings Pond

▭ Dry Section

▭ Teck Coal Mine Operation

Drying Surveys in Southern and Northern Sections of Fording LAEMP, November 2019

0 1 2 4 km

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Figure A.25

Document Path: C:\Users\MLaPalme\Trinity Consultants, Inc\Teck - 197202.0071 - FRO WCT Counts\4 - GIS\Report\19-71 Figure A.25 FRO Drying - NOV 2019.mxd

TABLES

Table A.1: Temporal Changes in Benthic Invertebrate Abundance for Reference and Mine-exposed Areas in the FRO LAEMP, September 2012 to 2019

Status	Area	Year P-value[a]	Q1. Is there a positive or negative change since the base year (b) of monitoring?								Temporal Contrasts								Q2. Is the 2018 mean different than historical means (2012 - 2017) and the previous year (2017)?c		Q3. Is the 2019 mean different than historical means (2012 - 2018) and the previous year (2018)?c	
			Magnitude of Difference (MOD)[b] and Significance (bolded) from Base Year (b)[c]																			
			2012	2013	2014	2015	2016	2017	2018	2019	2012	2013	2014	2015	2016	2017	2018	2019	2012-2017	2017	2012-2018	2018
Reference	RG_HENUP	0.288	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FO26	0.002	b	-2.3	-	-0.42	1.4	1.0	2.4	2.2	AB	B	-	AB	AB	AB	A	A	ns	ns	ns	ns
Mine-exposed	RG_FODHE	0.048	b	-	-	0.24	-1.4	-0.71	0.019	2.1	AB	-	-	AB	B	AB	AB	A	ns	ns	ns	ns
	RG_FOUNGD	0.052	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODNGD	0.821	-	-	-	ns	-	ns	ns	ns	-	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_MP1	0.153	ns	ns	-	ns	-	ns	ns	ns	ns	ns	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUSH	0.229	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUKI	0.017	b	-	-	-3.1	**-4.8**	-2.3	-2.2	-2.7	A	-	-	AB	B	AB	AB	AB	ns	ns	ns	ns
	RG_FOBKS	0.198	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBSC	0.580	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBCP	0.479	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FRCP1SW	0.455	-	-	-	-	-	ns	-	ns	-	-	-	-	-	ns	-	ns	ns	ns	ns	ns
	RG_FRUPO	0.021	-	-	-	-	-	b	-2.4	**-3.9**	-	-	-	-	-	A	AB	B	ns	ns	ns	ns
	RG_FODPO	<0.001	b	1.3	-	-1.3	-0.94	-0.044	**3.7**	-0.79	B	AB	-	B	B	B	A	B	ns	↑	ns	↓
	RG_FO22	0.046	b	-	-	3.5	-	3.8	1.9	0.45	AB	-	-	AB	-	A	AB	B	ns	ns	ns	ns
	RG_FOUEW	0.986	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns

▨ P-value < 0.05

🟩 > 2 SD Increase

🟩 > 3 SD Increase

🟩 > 4 SD Increase

🟩 > 5 SD Increase

🟦 > 2 SD Decrease

🟦 > 3 SD Decrease

🟦 > 4 SD Decrease

🟦 > 5 SD Decrease

bold Significant increase or decrease from base year (b)

🟩 Significantly > than all historical years (or 2017 or 2018)

🟦 Significantly < than all historical years (or 2017 or 2018)

Notes: "ns" = not significant; "-" insufficient data for comparison.

[a] *Year* p-value from an ANOVA with factors *Year* and *Month*.

[b] Magnitude of Difference (MOD) = $[\text{Mean}_{\text{given year}} - \text{Mean}_{\text{year b}}] / \text{SD}_{\text{year b}}$

[c] Significance among year determined using all pairwise comparisons using Tukey's honestly significant differences method. Years that share a letter are not significantly different. Letters assigned such that the mean with the highest magnitude is assigned "A".

Table A.2: Temporal Changes in Benthic Invertebrate EPT Abundance for Reference and Mine-exposed Areas in the FRO LAEMP, September 2012 to 2019

Status	Area	Year P-value[a]	Q1. Is there a positive or negative change since the base year (b) of monitoring?								Temporal Contrasts								Q2. Is the 2018 mean different than historical means (2012 - 2017) and the previous year (2017)?c		Q3. Is the 2019 mean different than historical means (2012 - 2018) and the previous year (2018)?c	
			Magnitude of Difference (MOD)[b] and Significance (bolded) from Base Year (b)[c]																			
			2012	2013	2014	2015	2016	2017	2018	2019	2012	2013	2014	2015	2016	2017	2018	2019	2012-2017	2017	2012-2018	2018
Reference	RG_HENUP	0.351	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FO26	0.010	b	-1.8	-	-0.098	1.4	1.5	2.4	2.0	AB	B	-	AB	AB	AB	A	A	ns	ns	ns	ns
Mine-exposed																						
	RG_FOUNGD	0.025	b	-	-	-1.3	-	-2.1	1.5	1.7	AB	-	-	AB	-	B	A	A	ns	↑	ns	ns
	RG_FODNGD	0.901	-	-	-	ns	-	ns	ns	ns	-	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_MP1	0.076	ns	ns	-	ns	-	ns	ns	ns	ns	ns	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUSH	0.168	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUKI	0.006	b	-	-	-3.2	**-5.3**	-2.7	-2.8	-3.5	A	-	-	AB	B	AB	AB	AB	ns	ns	ns	ns
	RG_FOBKS	0.389	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBSC	0.528	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBCP	0.357	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FRCP1SW	0.304	-	-	-	-	-	ns	-	ns	-	-	-	-	-	ns	-	ns	ns	ns	ns	ns
	RG_FRUPO	0.014	-	-	-	-	-	b	-2.7	**-4.0**	-	-	-	-	-	A	AB	B	ns	ns	ns	ns
	RG_FODPO	<0.001	b	2.2	-	-0.60	-0.72	-0.79	**3.8**	-1.1	B	AB	-	B	B	B	A	B	ns	↑	ns	↓
	RG_FO22	0.095	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns

▨	P-value < 0.05
🟩	> 2 SD Increase
🟩	> 3 SD Increase
🟩	> 4 SD Increase
🟩	> 5 SD Increase
🟦	> 2 SD Decrease
🟦	> 3 SD Decrease
🟦	> 4 SD Decrease
🟦	> 5 SD Decrease
bold	Significant increase or decrease from base year (b)
🟩	Significantly > than all historical years (or 2017 or 2018)
🟦	Significantly < than all historical years (or 2017 or 2018)

Notes: "ns" = not significant; "-" insufficient data for comparison.

[a] *Year* p-value from an ANOVA with factors *Year* and *Month*.

[b] Magnitude of Difference (MOD) = $[\text{Mean}_{\text{given year}} - \text{Mean}_{\text{year b}}] / \text{SD}_{\text{year b}}$

[c] Significance among year determined using all pairwise comparisons using Tukey's honestly significant differences method. Years that share a letter are not significantly different. Letters assigned such that the mean with the highest magnitude is assigned "A".

Table A.3: Temporal Changes in Benthic Invertebrate Ephemeroptera Abundance for Reference and Mine-exposed Areas in the FRO LAEMP, September 2012 to 2019

Status	Area	Year P-value[a]	Q1. Is there a positive or negative change since the base year (b) of monitoring? Magnitude of Difference (MOD)[b] and Significance (bolded) from Base Year (b)[c]								Temporal Contrasts								Q2. Is the 2018 mean different than historical means (2012 - 2017) and the previous year (2017)?c		Q3. Is the 2019 mean different than historical means (2012 - 2018) and the previous year (2018)?c	
			2012	2013	2014	2015	2016	2017	2018	2019	2012	2013	2014	2015	2016	2017	2018	2019	2012-2017	2017	2012-2018	2018
Reference	RG_HENUP	0.385	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FO26	<0.001	b	-1.5	-	0.98	2.4	1.4	**4.0**	**3.5**	B	B	-	AB	AB	AB	A	A	ns	ns	ns	ns
Mine-exposed	RG_FODHE	0.107	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOUNGD	<0.001	b	-	-	-1.4	-	-2.9	1.7	2.6	ABC	-	-	BC	-	C	AB	A	ns	↑	ns	ns
	RG_FODNGD	0.800	-	-	-	ns	-	ns	ns	ns	-	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_MP1	0.002	b	**-5.2**	-	-3.9	-	-0.79	-1.6	**-4.6**	A	B	-	AB	-	A	A	B	ns	ns	ns	↓
	RG_FOUSH	0.004	b	-	-	-1.2	-	-3.3	-2.3	**-3.2**	A	-	-	AB	-	AB	AB	B	ns	ns	ns	ns
	RG_FOUKI	<0.001	b	-	-	-4.0	**-7.2**	**-4.1**	**-3.6**	**-4.5**	A	-	-	ABC	C	BC	B	BC	ns	ns	ns	ns
	RG_FOBKS	0.068	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBSC	0.064	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBCP	0.002	b	-	-	**-5.0**	**-5.8**	**-5.0**	-3.1	**-3.8**	A	-	-	B	B	B	AB	B	ns	ns	ns	ns
	RG_FRCP1SW	0.336	-	-	-	-	-	ns	-	ns	-	-	-	-	-	ns	-	ns	ns	ns	ns	ns
	RG_FRUPO	0.445	-	-	-	-	-	ns	ns	ns	-	-	-	-	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODPO	0.003	b	-0.63	-	**-4.7**	-3.2	**-5.6**	-0.96	-2.9	A	AB	-	BC	ABC	C	A	ABC	ns	↑	ns	ns
	RG_FO22	0.435	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns

▨ P-value < 0.05

▨ > 2 SD Increase

▨ > 3 SD Increase

▨ > 4 SD Increase

▨ > 5 SD Increase

▨ > 2 SD Decrease

▨ > 3 SD Decrease

▨ > 4 SD Decrease

▨ > 5 SD Decrease

bold Significant increase or decrease from base year (b)

🟩 Significantly > than all historical years (or 2017 or 2018)

🟦 Significantly < than all historical years (or 2017 or 2018)

Notes: "ns" = not significant; "-" insufficient data for comparison.

[a] *Year* p-value from an ANOVA with factors *Year* and *Month*.

[b] Magnitude of Difference (MOD) = [$\text{Mean}_{\text{given year}}$ − $\text{Mean}_{\text{year b}}$] /$\text{SD}_{\text{year b}}$

[c] Significance among year determined using all pairwise comparisons using Tukey's honestly significant differences method. Years that share a letter are not significantly different. Letters assigned such that the mean with the highest magnitude is assigned "A".

Table A.4: **Temporal Changes in Benthic Invertebrate Plecoptera Abundance for Reference and Mine-exposed Areas in the FRO LAEMP, September 2012 to 2019**

Status	Area	Year P-value[a]	Q1. Is there a positive or negative change since the base year (b) of monitoring?								Temporal Contrasts								Q2. Is the 2018 mean different than historical means (2012 - 2017) and the previous year (2017)?c		Q3. Is the 2019 mean different than historical means (2012 - 2018) and the previous year (2018)?c	
			Magnitude of Difference (MOD)[b] and Significance (bolded) from Base Year (b)[c]																			
			2012	2013	2014	2015	2016	2017	2018	2019	2012	2013	2014	2015	2016	2017	2018	2019	2012-2017	2017	2012-2018	2018
Reference	RG_HENUP	0.044	b	-1.5	-	1.8	-0.85	2.8	-0.094	-0.18	AB	B	-	AB	AB	A	AB	AB	ns	ns	ns	ns
	RG_FO26	0.797	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mine-exposed																						
	RG_FOUNGD	0.537	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODNGD	0.963	-	-	-	ns	-	ns	ns	ns	-	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_MP1	0.089	ns	ns	-	ns	-	ns	ns	ns	ns	ns	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUSH	0.452	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUKI	0.192	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBKS	0.244	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBSC	0.575	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBCP	0.559	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FRCP1SW	0.307	-	-	-	-	-	ns	-	ns	-	-	-	-	-	ns	-	ns	ns	ns	ns	ns
	RG_FRUPO	0.128	-	-	-	-	-	ns	ns	ns	-	-	-	-	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODPO	0.001	b	2.3	-	0.36	-0.32	0.30	3.3	-0.16	AB	AB	-	AB	B	AB	A	B	ns	ns	ns	↓
	RG_FO22	0.101	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns

⬜	P-value < 0.05
🟩	> 2 SD Increase
🟩	> 3 SD Increase
🟩	> 4 SD Increase
🟩	> 5 SD Increase
🟦	> 2 SD Decrease
🟦	> 3 SD Decrease
🟦	> 4 SD Decrease
🟦	> 5 SD Decrease
bold	Significant increase or decrease from base year (b)
🟩	Significantly > than all historical years (or 2017 or 2018)
🟦	Significantly < than all historical years (or 2017 or 2018)

Notes: "ns" = not significant; "-" insufficient data for comparison.

[a] *Year* p-value from an ANOVA with factors *Year* and *Month.*

[b] Magnitude of Difference (MOD) = $[\text{Mean}_{\text{given year}} - \text{Mean}_{\text{year b}}] / \text{SD}_{\text{year b}}$

[c] Significance among year determined using all pairwise comparisons using Tukey's honestly significant differences method. Years that share a letter are not significantly different. Letters assigned such that the mean with the highest magnitude is assigned "A".

Table A.5: Temporal Changes in Benthic Invertebrate Trichoptera Abundance for Reference and Mine-exposed Areas in the FRO LAEMP, September 2012 to 2019

Status	Area	Year P-value[a]	Q1. Is there a positive or negative change since the base year (b) of monitoring? Magnitude of Difference (MOD)[b] and Significance (bolded) from Base Year (b)[c]								Temporal Contrasts								Q2. Is the 2018 mean different than historical means (2012 - 2017) and the previous year (2017)?c		Q3. Is the 2019 mean different than historical means (2012 - 2018) and the previous year (2018)?c	
			2012	2013	2014	2015	2016	2017	2018	2019	2012	2013	2014	2015	2016	2017	2018	2019	2012-2017	2017	2012-2018	2018
Reference	RG_HENUP	0.280	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FO26	<0.001	b	-3.4	-	-3.1	-0.043	3.7	0.81	1.0	AB	B	-	B	AB	A	A	A	ns	ns	ns	ns
Mine-exposed	RG_FODHE	0.016	b	-	-	-3.4	**-4.9**	-2.3	-1.7	-1.2	A	-	-	AB	B	AB	AB	A	ns	ns	ns	ns
	RG_FOUNGD	0.043	b	-	-	-2.5	-	-1.7	1.0	-0.26	AB	-	-	B	-	AB	A	AB	ns	ns	ns	ns
	RG_FODNGD	0.117	-	-	-	ns	-	ns	ns	ns	-	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_MP1	0.219	ns	ns	-	ns	-	ns	ns	ns	ns	ns	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUSH	0.849	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUKI	0.462	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBKS	0.595	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBSC	0.329	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FOBCP	0.055	ns	-	-	ns	ns	ns	ns	ns	ns	-	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FRCP1SW	0.998	-	-	-	-	-	ns	-	ns	-	-	-	-	-	ns	-	ns	ns	ns	ns	ns
	RG_FRUPO	0.131	-	-	-	-	-	ns	ns	ns	-	-	-	-	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODPO	0.054	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FO22	0.005	b	-	-	**4.3**	-	**5.4**	1.7	3.1	C	-	-	AB	-	A	BC	ABC	ns	↓	ns	ns

▨ P-value < 0.05

🟩 > 2 SD Increase

🟩 > 3 SD Increase

🟩 > 4 SD Increase

🟩 > 5 SD Increase

🟦 > 2 SD Decrease

🟦 > 3 SD Decrease

🟦 > 4 SD Decrease

🟦 > 5 SD Decrease

bold Significant increase or decrease from base year (b)

🟩 Significantly > than all historical years (or 2017 or 2018)

🟦 Significantly < than all historical years (or 2017 or 2018)

Notes: "ns" = not significant; "-" insufficient data for comparison.

[a] *Year* p-value from an ANOVA with factors *Year* and *Month*.

[b] Magnitude of Difference (MOD) = $[\text{Mean}_{\text{given year}} - \text{Mean}_{\text{year b}}] / \text{SD}_{\text{year b}}$

[c] Significance among year determined using all pairwise comparisons using Tukey's honestly significant differences method. Years that share a letter are not significantly different. Letters assigned such that the mean with the highest magnitude is assigned "A".

Table A.6: Temporal Changes in Benthic Invertebrate Chironomid Abundance for Reference and Mine-exposed Areas in the FRO LAEMP, September 2012 to 2019

Status	Area	Year P-value[a]	Q1. Is there a positive or negative change since the base year (b) of monitoring?								Temporal Contrasts								Q2. Is the 2018 mean different than historical means (2012 - 2017) and the previous year (2017)?c		Q3. Is the 2019 mean different than historical means (2012 - 2018) and the previous year (2018)?c	
			Magnitude of Difference (MOD)[b] and Significance (bolded) from Base Year (b)[c]																			
			2012	2013	2014	2015	2016	2017	2018	2019	2012	2013	2014	2015	2016	2017	2018	2019	2012-2017	2017	2012-2018	2018
Reference	RG_HENUP	0.094	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	-	ns	ns	ns	ns	ns	ns	ns	ns	ns
	RG_FO26	<0.001	b	-3.1	-	-0.74	1.5	-0.95	0.94	2.2	AB	B	-	AB	A	AB	A	A	ns	ns	ns	ns
Mine-exposed	RG_FODHE	<0.001	b	-	-	**4.9**	1.6	1.0	2.7	**7.1**	C	-	-	AB	BC	BC	BC	A	ns	ns	ns	↑
	RG_FOUNGD	0.268	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODNGD	0.112	-	-	-	ns	-	ns	ns	ns	-	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_MP1	<0.001	b	-2.3	-	-2.7	-	-3.8	-2.4	1.5	AB	B	-	B	-	B	B	A	ns	ns	ns	↑
	RG_FOUSH	0.051	ns	-	-	ns	-	ns	ns	ns	ns	-	-	ns	-	ns	ns	ns	ns	ns	ns	ns
	RG_FOUKI	0.014	b	-	-	1.3	2.5	3.3	1.5	**4.0**	B	-	-	AB	AB	AB	AB	A	ns	ns	ns	ns
	RG_FOBKS	0.037	b	-	-	2.1	**4.4**	3.0	2.3	2.6	B	-	-	AB	A	AB	AB	AB	ns	ns	ns	ns
	RG_FOBSC	0.030	b	-	-	-0.10	2.1	2.7	-0.58	2.0	AB	-	-	AB	AB	AB	B	A	ns	ns	ns	↑
	RG_FOBCP	<0.001	b	-	-	2.0	1.6	3.0	-0.018	3.2	AB	-	-	AB	AB	AB	B	A	ns	ns	ns	↑
	RG_FRCP1SW	0.910	-	-	-	-	-	ns	-	ns	-	-	-	-	-	ns	-	ns	ns	ns	ns	-
	RG_FRUPO	0.796	-	-	-	-	-	ns	ns	ns	-	-	-	-	-	ns	ns	ns	ns	ns	ns	ns
	RG_FODPO	<0.001	b	**-8.1**	-	-2.2	-0.53	2.4	2.2	0.47	AB	C	-	B	AB	A	A	AB	ns	ns	ns	ns
	RG_FO22	0.001	b	-	-	2.2	-	0.57	-2.4	-2.1	AB	-	-	A	-	AB	B	B	ns	ns	ns	ns

▨	P-value < 0.05
🟩	> 2 SD Increase
🟩	> 3 SD Increase
🟩	> 4 SD Increase
🟩	> 5 SD Increase
🟦	> 2 SD Decrease
🟦	> 3 SD Decrease
🟦	> 4 SD Decrease
🟦	> 5 SD Decrease
bold	Significant increase or decrease from base year (b)
🟩	Significantly > than all historical years (or 2017 or 2018)
🟦	Significantly < than all historical years (or 2017 or 2018)

Notes: "ns" = not significant; "-" insufficient data for comparison.

[a] *Year* p-value from an ANOVA with factors *Year* and *Month*.

[b] Magnitude of Difference (MOD) = [Mean$_{\text{given year}}$ − Mean$_{\text{year b}}$] /SD$_{\text{year b}}$

[c] Significance among year determined using all pairwise comparisons using Tukey's honestly significant differences method. Years that share a letter are not significantly different. Letters assigned such that the mean with the highest magnitude is assigned "A".

Table A.7: Benthic Invertebrate Total and EPT Abundances at Mine-Exposed Compared to Reference Areas within Seasons Sampled in 2018 and 2019

Endpoint	ANOVA		Post-Hoc Contrasts														
	Term	P-value	Mine-Exposed Station	Reference	2018						2019					
					June		September		December		June		September		December	
					P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)
Abundance (# organisms)	Year	0.376	RG_FODHE	RG_HENUP	0.636	0.315	**0.0349**	0.817	-	-	**0.00306**	1.16	**<0.0001**	2.14	-	-
	Station	<0.001		RG_FO26	0.866	-0.112	0.247	-0.445	-	-	0.208	-0.485	0.388	0.332	-	-
	Month	<0.001		RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
	Year x Station	<0.001	RG_FOUCL	RG_HENUP	-	-	-	-	-	-	-	-	**<0.0001**	2.04	-	-
	Station x Month	<0.001		RG_FO26	-	-	-	-	-	-	-	-	0.543	0.234	-	-
	Year x Month	<0.001		RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
	Year x Station x Month	0.0544	RG_FOUNGD	RG_HENUP	**0.0422**	1.36	**0.00154**	1.24	-	-	0.755	0.120	**<0.0001**	1.74	-	-
	-			RG_FO26	0.161	0.935	0.953	-0.0229	-	-	**0.000117**	-1.52	0.857	-0.0690	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FODNGD	RG_HENUP	0.863	-0.115	0.104	0.628	-	-	0.882	-0.0569	**0.0174**	0.923	-	-
				RG_FO26	0.416	-0.541	0.100	-0.634	-	-	**<0.0001**	-1.70	**0.0223**	-0.886	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_MP1	RG_HENUP	0.223	0.813	0.203	0.490	-	-	0.567	0.220	**0.0107**	0.993	-	-
				RG_FO26	0.561	0.386	**0.0460**	-0.772	-	-	**0.000305**	-1.42	**0.0350**	-0.816	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FOUSH	RG_HENUP	0.581	0.368	0.887	0.0544	-	-	0.339	0.368	0.143	0.565	-	-
				RG_FO26	0.929	-0.0592	**0.00201**	-1.21	-	-	**0.00115**	-1.27	**0.00148**	-1.24	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FOUKI	RG_HENUP	0.741	0.220	0.219	-0.473	-	-	0.981	0.00905	0.791	-0.102	-	-
				RG_FO26	0.756	-0.207	**<0.0001**	-1.74	-	-	**<0.0001**	-1.63	**<0.0001**	-1.91	-	-
				RG_UFR1	-	-	-	-	**0.0166**							
			RG_FOBKS	RG_HENUP	0.535	0.413	0.876	0.0597	-	-	0.755	0.120	0.998	-0.000940	-	-
				RG_FO26	0.984	-0.0134	**0.00210**	-1.20	-	-	**0.000117**	-1.52	**<0.0001**	-1.81	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_SCOUTDS	RG_HENUP	-	-	-	-	-	-	-	-	0.248	0.444	-	-
				RG_FO26	-	-	-	-	-	-	-	-	**0.000513**	-1.36	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	0.636	-0.182
			RG_FOBSC	RG_HENUP	0.466	-0.486	0.0904	-0.654	-	-	0.0786	-0.679	0.684	-0.156	-	-
				RG_FO26	0.172	-0.913	**<0.0001**	-1.92	-	-	**<0.0001**	-2.32	**<0.0001**	-1.97	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	-1.93	-	-	-	-	-	-
			RG_FOBCP	RG_HENUP	0.592	-0.357	0.0503	-0.677	-	-	0.945	-0.0264	0.907	-0.0402	-	-
				RG_FO26	0.240	-0.783	**<0.0001**	-1.94	-	-	**<0.0001**	-1.67	**<0.0001**	-1.85	-	-
				RG_UFR1	-	-	-	-	**0.00324**	-1.15	-	-	-	-	-	-
			RG_FRCP1SW	RG_HENUP	0.0984	-1.10	-	-	-	-	0.695	0.151	0.380	0.338	-	-
				RG_FO26	**0.0226**	-1.53	-	-	-	-	**0.000158**	-1.49	**0.000191**	-1.47	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FRUPO	RG_HENUP	0.869	-0.109	0.488	0.266	-	-	0.0896	-0.655	0.401	0.323	-	-
				RG_FO26	0.421	-0.536	**0.0104**	-0.996	-	-	**<0.0001**	-2.30	**0.000166**	-1.49	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	2.21	-	-	-	-	**0.0238**	0.876
			RG_FODPO	RG_HENUP	0.193	0.868	**<0.0001**	1.98	-	-	0.901	0.0478	**0.00354**	1.14	-	-
				RG_FO26	0.508	0.441	0.0616	0.723	-	-	**<0.0001**	-1.59	0.0822	-0.671	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	2.73	-	-	-	-	**0.0140**	0.954
			RG_FO22	RG_HENUP	**0.0126**	-1.68	0.0974	0.572	-	-	0.465	0.281	0.0764	0.612	-	-
				RG_FO26	**0.00187**	-2.11	**0.0461**	-0.690	-	-	**0.000534**	-1.36	**0.000652**	-1.20	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FOUEW	RG_HENUP	0.157	0.945	0.839	-0.0779	-	-	**0.0195**	0.907	0.0939	0.647	-	-
				RG_FO26	0.436	0.518	**0.000641**	-1.34	-	-	0.0573	-0.735	**0.00291**	-1.16	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	2.18	-	-	-	-	0.622	0.189

Table A.7: Benthic Invertebrate Total and EPT Abundances at Mine-Exposed Compared to Reference Areas within Seasons Sampled in 2018 and 2019

Endpoint	ANOVA		Post-Hoc Contrasts														
	Term	P-value	Mine-Exposed Station	Reference	2018						2019					
					June		September		December		June		September		December	
					P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)	P-value	MOD (SD)
EPT Abundance (# organisms)	Year	0.593	RG_FODHE	RG_HENUP	0.280	-0.488	0.0716	0.471	-	-	0.0608	0.491	**<0.0001**	1.18	-	-
	Station	<0.001		RG_FO26	0.243	-0.528	0.283	-0.280	-	-	0.115	-0.412	0.589	0.141	-	-
	Month	<0.001		RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
	Year x Station	<0.001	RG_FOUCL	RG_HENUP	-	-	-	-	-	-	-	-	**<0.0001**	1.11	-	-
	Station x Month	<0.001		RG_FO26	-	-	-	-	-	-	-	-	0.795	0.0677	-	-
	Year x Month	<0.001		RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
	Year x Station x Month	0.1862	RG_FOUNGD	RG_HENUP	0.843	0.0893	**0.00707**	0.710	-	-	0.662	-0.114	**<0.0001**	1.10	-	-
	-			RG_FO26	0.912	0.0497	0.875	-0.0409	-	-	**0.000143**	-1.02	0.816	0.0607	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FODNGD	RG_HENUP	0.311	-0.457	0.218	0.322	-	-	0.644	-0.120	0.0772	0.462	-	-
				RG_FO26	0.271	-0.497	0.100	-0.429	-	-	**0.000130**	-1.02	**0.0280**	-0.577	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_MP1	RG_HENUP	0.933	-0.0376	0.500	0.175	-	-	0.793	-0.0682	0.506	-0.173	-	-
				RG_FO26	0.864	-0.0772	**0.0282**	-0.576	-	-	**0.000271**	-0.971	**<0.0001**	-1.21	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FOUSH	RG_HENUP	0.559	-0.263	0.635	-0.124	-	-	0.878	0.0399	0.889	-0.0364	-	-
				RG_FO26	0.502	-0.303	**0.000985**	-0.875	-	-	**0.00114**	-0.863	**<0.0001**	-1.08	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FOUKI	RG_HENUP	0.812	-0.107	**0.0320**	-0.562	-	-	0.621	-0.128	0.0987	-0.431	-	-
				RG_FO26	0.744	-0.147	**<0.0001**	-1.31	-	-	**0.000116**	-1.03	**<0.0001**	-1.47	-	-
				RG_UFR1	-	-	-	-	0.0633	0.486	-	-	-	-	**0.0284**	-0.575
			RG_FOBKS	RG_HENUP	0.384	-0.392	0.417	-0.211	-	-	0.920	-0.0260	0.485	-0.182	-	-
				RG_FO26	0.338	-0.432	**0.000307**	-0.962	-	-	**0.000483**	-0.929	**<0.0001**	-1.22	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_SCOUTDS	RG_HENUP	-	-	-	-	-	-	-	-	0.583	0.143	-	-
				RG_FO26	-	-	-	-	-	-	-	-	**0.000747**	-0.896	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	0.705	-0.0984
			RG_FOBSC	RG_HENUP	**0.0143**	-1.12	**0.00573**	-0.729	-	-	**0.0458**	-0.523	0.219	-0.321	-	-
				RG_FO26	**0.0113**	-1.16	**<0.0001**	-1.48	-	-	**<0.0001**	-1.43	**<0.0001**	-1.36	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	-1.64	-	-	-	-	-	-
			RG_FOBCP	RG_HENUP	0.149	-0.653	**0.0109**	-0.599	-	-	0.158	-0.369	0.0843	-0.404	-	-
				RG_FO26	0.126	-0.693	**<0.0001**	-1.35	-	-	**<0.0001**	-1.27	**<0.0001**	-1.44	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	-1.16	-	-	-	-	-	-
			RG_FRCP1SW	RG_HENUP	0.0531	-0.877	-	-	-	-	0.263	-0.291	0.637	0.123	-	-
				RG_FO26	**0.0434**	-0.917	-	-	-	-	**<0.0001**	-1.19	**0.000572**	-0.916	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FRUPO	RG_HENUP	0.565	-0.259	0.833	0.0547	-	-	**0.00368**	-0.767	0.803	0.0647	-	-
				RG_FO26	0.507	-0.299	**0.00823**	-0.696	-	-	**<0.0001**	-1.67	**0.000260**	-0.974	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	1.42	-	-	-	-	**0.0363**	0.549
			RG_FODPO	RG_HENUP	0.634	0.214	**<0.0001**	1.22	-	-	0.642	-0.121	0.0639	0.485	-	-
				RG_FO26	0.698	0.175	0.0703	0.474	-	-	**0.000129**	-1.02	**0.0347**	-0.554	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	1.78	-	-	-	-	**0.0182**	0.621
			RG_FO22	RG_HENUP	**<0.0001**	-1.92	0.801	0.0588	-	-	0.0690	-0.476	0.808	0.0565	-	-
				RG_FO26	**<0.0001**	-1.95	**0.00341**	-0.692	-	-	**<0.0001**	-1.38	**<0.0001**	-0.982	-	-
				RG_UFR1	-	-	-	-	-	-	-	-	-	-	-	-
			RG_FOUEW	RG_HENUP	0.685	0.183	0.286	-0.278	-	-	0.109	0.418	0.974	0.00847	-	-
				RG_FO26	0.751	0.143	**0.000120**	-1.03	-	-	0.0642	-0.484	**0.000117**	-1.03	-	-
				RG_UFR1	-	-	-	-	**<0.0001**	1.39	-	-	-	-	0.776	0.0741

▨ P-value <0.05 (ANOVA P-Value) and P-value <0.05/ number of comparisons (for post-hoc tests)
0.05 Post-hoc P-value <0.05
🟦 MOD < -2
🟩 MOD > 2

Notes: '-' = no data, MOD = Magnitude of Difference = (MCT_{EXP} - MCT_{REF})/SD_{pooled}, where MCT_{EXP} and MCT_{REF} is the measure of central tendency for the exposed and reference site separately, and SD_{pooled} is the residual standard deviation of the full ANOVA model.

APPENDIX B

WESTSLOPE CUTTHROAT TROUT SAMPLING, FEBRUARY - MARCH 2019

Teck Coal Limited

Upper Fording River Aquatic Effects Monitoring of Westslope Cutthroat Trout Over-wintering Habitats

FISH SAMPLING REPORT

Study Period: February and March 2019

Scott Cope, M.Sc., R.P.Bio.
Westslope Fisheries Ltd.

V1 May 2019

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1. Introduction

Westslope Cutthroat Trout are a key fisheries resource in the Fording River watershed. It is the only species known to occur in the upper Fording River, and its tributaries, upstream of Josephine Falls. Coal mining accelerates the natural release of selenium (Se) and the Elk Valley and the upper Fording River lie within the Kootenay geological formation, an area of naturally seleniferous soils (Orr et al. 2006). This has resulted in concern that selenium concentrations may be approaching or could approach levels that have the ability to manifest themselves as population level effects for the upper Fording River Westslope Cutthroat Trout (Minnow Environmental Inc. 2018, Orr et al. 2012, Elphick et al. 2009).

The majority of Fording River selenium loading originates from Henretta, Clode, Swift, Kilmarnock, Cataract and Greenhills Creeks. These sources result in high selenium loads within river sections containing notable over-wintering aggregations of Westslope Cutthroat Trout. Westslope Cutthroat Trout captured during spawning season within the Fording Oxbow area (i.e., Population Segment S6) and Henretta Pit Lake are known to contain elevated selenium within fish tissue samples (McDonald 2013, Minnow et al. 2012).

Recent study has identified four (4) critical over-wintering habitats that represent 20% of available habitat but supports 90% of the over-wintering population (Cope *et al.* 2016). These locations are; 1) Henretta Pit Lake (in lower Henretta Creek), 2) Clode Flats (in Fording River Segments S8 and S9 in vicinity of Fish Pond Creek and Clode Creek settling ponds), 3) the Fording Oxbow area (in Fording River Segment S6 downstream of Fording River Operations), and 4) the Greenhills pools (in Fording River Segment S2 adjacent to Greenhills Creek). Westslope Cutthroat Trout typically reside within these over-wintering areas from October through March.

The proposed fish sampling is primarily in support of substantive on-going work on ecosystem health, namely the Elk Valley Water Quality Plan (EVWQP) and the Regional Aquatic Effects Monitoring Program (RAEMP). The goal of the EVWQP (2014) is to stabilize and reverse the increasing trend of selenium, cadmium, nitrate, sulphate and calcite to ensure the ongoing health of the watershed, while at the same time allowing for continued sustainable mining. The goal of the RAEMP, a comprehensive monitoring program, is to assess potential effects in the aquatic environment throughout the Elk River watershed and Koocanusa Reservoir (Minnow Environmental Inc. 2018, Windward et al. 2014).

1.1 Project Goal and Key Study Questions

The goal of the Upper Fording River Aquatic Effects Monitoring of Westslope Cutthroat Trout Over-wintering Habitats is to gather additional fish tissue data during the over-wintering period for local effects monitoring within these habitats or river segments that have been identified as important over-wintering habitats and are known to have elevated aqueous selenium. Additional biological sampling within these same over-wintering sites will be completed at the same time to evaluate selenium concentrations within stream sediments and benthic invertebrate tissue These activities are covered under a separate study design to be completed by the RAEMP consultant (Minnow Environmental Ltd.). This temporal local effects monitoring may provide additional information about selenium source-exposure relationships.

This study design is specific to the non-lethal capture of Westslope Cutthroat Trout and the collection of selenium tissue samples within the four notable over-wintering areas identified above. Fish sampling will occur within these four sites during the late over-wintering period (Feb – March) before these Westslope Cutthroat Trout initiate feeding movements (April) and spawning migrations (May). Previous sampling in these locations has been completed during spawning or summer rearing periods without prior knowledge of residence time within these habitats (note that fish from other river reaches also migrate into these areas to spawn and rear during the summer season, Cope et al. 2016).

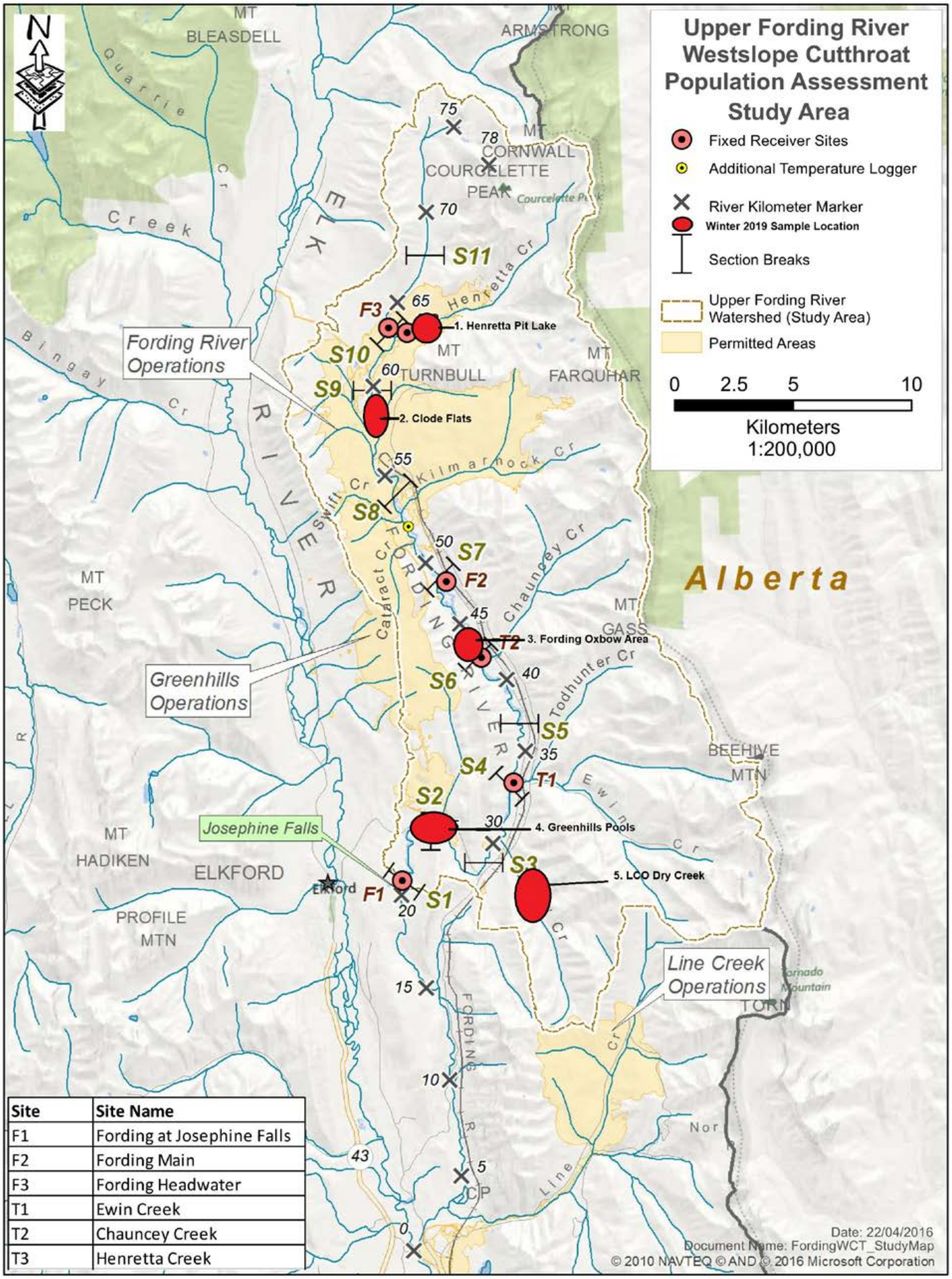
1.2 Study Area

This local effects sampling will be restricted to the four notable over-wintering aggregations located at; 1) Henretta Pit Lake (in lower Henretta Creek), 2) Clode Flats (in Fording River Segments S8 and S9 around Clode Creek settling ponds), 3) the Fording Oxbow area (in Fording River Segment S6 downstream of Swift, Kilmarnock and Cataract Creeks), and 4) the Greenhills pools (in Fording River Segment S2 adjacent to Greenhills Creek) (Figure 1).

LCO Dry Creek at Site Code LC_SPDC (outlet of settling ponds) was added in March to investigate angling capture opportunities for capture and sampling (Figure 1).

1.3 Schedule

The Westslope Cutthroat Trout over-wintering sampling will initially be completed over 5 days during an appropriate weather window during February 11 – 16. Catches will likely depend on weather and ice conditions. If necessary, a second 5 day sample period would be completed in March 2019.



Site	Site Name
F1	Fording at Josephine Falls
F2	Fording Main
F3	Fording Headwater
T1	Ewin Creek
T2	Chauncey Creek
T3	Henretta Creek

Figure 1. Upper Fording River study area illustrating the five over-wintering sample sites.

1.4 Sample Sensitivities

These two sample periods should be sufficient to capture the sample target of 8 Westslope Cutthroat Trout within each of the 4 notable over-wintering aggregations for a maximum total sample size of 32 Westslope Cutthroat Trout. The latest population estimate for these aggregations is 3,305 mature fish (i.e. 3, 672 mature fish x 0.90; Cope et al. 2017). As such, the sample size represents < 1% of the population within these habitats.

Westslope Cutthroat Trout may exhibit some sensitivity to capture, handling and sampling during the over-wintering period and special capture and handling procedures are outlined in the following methods section. The capture and sampling personnel have sampled in winter shoulder seasons under similar conditions and will use recovery fish sleeves to monitor *in situ* fish recovery for a minimum of 30 minutes before release. Any sign of trauma, or mortality will result in the cancellation of any further sampling and the Elk Valley Fish and Fish Habitat Committee will be consulted immediately.

The proposed study team all represent senior biologists and capture specialists that have worked together to Floy, PIT and Radio tag 3,850 Westslope Cutthroat Trout in the East Kootenay between 2000-2018.

There are logistical and safety considerations to working within these areas during the winter season. The proposed crew has traversed and worked in these exact locations every month of the year from May 2012 through October 2015 and have the relevant site specific skills and knowledge to operate safely during the proposed timeline.

2. Methods

Eight (8) Westslope Cutthroat Trout within each of the four notable over-wintering aggregations will be collected for selenium tissue samples; for a maximum total sample size of 32 Westslope Cutthroat Trout. The non-lethal tissue sample methodology for this project represents procedures developed for the ongoing RAEMP (Minnow Environmental Inc. 2018).

Fish will be captured using anglers experienced with safe fish handling, with artificial flies (preferred) and bait (if necessary). Baited fyke traps have been employed with some success previously (L. Amos, Teck Coal Ltd., *pers. comm.*) and burbot cod traps may be employed as a second passive trapping method for inclusion in the capture program; depending on initial angling results.

Captured fish are allowed to recover their oxygen deficit (created during capture) in an instream fish sleeve for 30 minutes prior to being anaesthetized and processed. Since sampling is being conducted during winter, all efforts will be made to ensure fish remain in water during sampling using a V-shaped surgical table that is partially submerged in a water bath to ensure the head and gills are in contact with oxygenated water. Nitrile gloves are used for all sampling and handling of fish.

Fish are anaesthetized in a 40 L bath of river water containing 2.0 ml clove oil yielding bath concentrations of 50 mg/l. Clove oil is a safe, inexpensive, and effective anaesthetic suitable for invasive procedures in the field (Prince and Powell 2000, Peake 1998, Anderson *et al.* 1997). The lowest effective dose of clove oil is recommended as time to recovery of equilibrium and fear response in salmonids has been shown to increase exponentially with exposure time (Keene *et al.* 1998). As such, fish will only be anaesthetized to level two (total loss of equilibrium with normal swimming motion) or level three (partial loss of swimming motion) to facilitate rapid recovery (Yoshikawa *et al.* 1988).

Once anaesthetized, each captured Westslope Cutthroat Trout is assigned a unique identification code. Body weight is measured using an appropriately-sized spring scale (e.g., 100 g, 500 g, 1,000 g). Total and fork length are determined using a measuring board (± 1 mm). External fish condition, including the presence of any deformities, lesions, or parasites, is documented. A biopsy punch (4 mm acu-punch) is inserted into the dorsal musculature, ensuring the penetration is perpendicular to the fish skin surface. Light pressure is applied while turning (twisting) the punch into the dorsal musculature (about 5 to 7 mm). The punch is then angled slightly and removed, while still turning, to separate the sample from the surrounding musculature. Some veterinary-grade tissue adhesive 3MVetbond™ is applied to the plug location and allowed to dry for approximately 30 seconds to prevent infection and promote healing. Skin is removed from the sample with a scalpel and the remaining muscle sample is placed into a sterile micro-centrifuge tube. Following sampling, the fish is returned to the instream fish sleeve for 30 minutes to recover before being released back into the water body where it was captured.

Samples are stored on ice until transfer to a freezer later in the day. At the completion of each sample session all samples are shipped with ice to Saskatchewan Research Council Research laboratory consistent with other regional tissue samples for selenium analyses (Minnow Environmental Inc. 2018).

2.1 Reporting

This data report summarizes the fish sampling activities and provides copies of the Fish Data Submission (FDS) summarizing fish sample activities and catch as well as the Minnow Environmental Inc. field data sheets.

Results will be evaluated as part of the RAEMP. At the time of shipping samples to the RAEMP laboratory provider the chain of custody will specify the selenium analyses data will be submitted to the project manager, Regional Aquatic Effects Monitoring Program (RAEMP) and the consultant charged with reporting the 2018-19 field sample results (Minnow Environmental Ltd., *in prep.*). The field collection manager (Westslope Fisheries Ltd.) will submit the fish collection permit Fish Data Submission (FDS) summarizing sample activities and catch.

3. Results

3.1 February 2019

During February 11 -14, 2019 Henretta Pit Lake (Site Code RG_HE27), Clode Flats (Site Code RG_MP1), Fording Oxbow Area (Site Code RG_FRABC_HF1) and the recently constructed Fish Pond Creek over-wintering pools were also angled. Various angling strategies were used at all four locations above (e.g., bait fishing and fly fishing).

This angling session coincided with two weeks of cold weather. Elkford daily maximum air temperatures ranged between -4.3 ^{0}C and -12.1 ^{0}C and daily minimum temperatures ranged between -16.6 ^{o}C and -23.8 ^{0}C. The previous week was just as cold. As a result, the primary oxbow pool area identified between Chauncey Creek (42.0 rkm) and river kilometer 43.66 was ice covered. Ice thickness and water depths represented safety concerns and sampling had to be relocated upstream several kilometers (44.5 to 46.0 rkm) to similar pool habitat closer to the groundwater influence and open water.

Greenhills area pools (Site Code RG_FODGH) were ice covered and unsafe and sampling was redirected to resampling Henretta Pit Lake and the Fish Pond Creek ponds a second time during a slightly warmer day. The ice thickness at these lentic locations was safe and inlet flows provided open water fishing opportunities.

One WCT trout was captured in Henretta Pit Lake on the second attempt (February 14). This fish was 445 mm fork length and weighed 1,240 g. This fish was previously PIT tagged (# 90011800158149).

Photo 1 illustrates the environmental conditions. Minnow Environmental Staff collected a benthic invertebrate sample from the inflow channel at the capture location.

3.2 March 2019

March 25-29, 2019 Henretta Pit Lake (Site Code RG_HE27), Clode Flats (Site Code RG_MP1), Fording Oxbow Area (Site Code RG_FRABC_HF1) and Greenhills Pools (Site Code RG_FODGH) were angled. The recently constructed Fish Pond Creek over-wintering pools were also angled. Angling opportunities were investigated for LCO Dry Creek at several locations including Site Codes LC_DC1, LC_DCDS, LC_SPDC and a lower reach 3 forested site. Various angling strategies were used at all five locations above (e.g., bait fishing and fly fishing). Baited burbot traps (n=3) were deployed in an overnight set in the oxbow pools (Photo 9).

Eight WCT were captured in Henretta Pit Lake (March 25) ranging in fork length from 392 to 467 mm and 680 to 1,340 g. Muscle tissue plugs were collected from all 8 fish (Sample ID RG_HE27_WCT_01_M20190325; 01_M to 08_M samples). Four of the eight fish were captures (Floy Tag 793 Green; Floy Tag 610 Blue; PIT Tags 900118001580512 and 985121021328816). These fish have been added to the upper Fording River recapture database and are discussed later. A benthic invertebrate sample (Sample ID RGHE27_BI_20190325) and a water sample (Sample ID RGHE27_WS_20190325) were collected at the Henretta PIT Lake capture site. Photo 2 illustrates the environmental conditions.

No other fish were captured at Clode Flats (including the multi-plate culvert pool and Fish Pond Creek, Photo 6 and 7), the Segment S6 Oxbow Area at 2 locations (the lower site from Chauncey Creek upstream 1.5 km and the upper 1.5 km site fished in February, Photo 8) or the Greenhills pools.

LCO Dry Creek was fished with no catch at the LC_SPDC site (outlet of settling ponds), however; the angling opportunities were limited by the habitat conditions (Photo 3). All other LCO Dry Creek sites were either too shallow or frozen (Photos 4 and 5). Winter angling in small stream habitat (i.e., small body form WCT) within a low density population is unlikely to meet capture objectives without an extraordinary amount of effort. Alternative sample methods or seasons should be explored.

3.3 Fish Capture Data

The location, effort and fish capture data are attached at the end of this report (Section 6 Fish Data Submission). There were five recaptures of previously tagged fish and the previous location data are provided below for the two fish records relocated so far.

Floy Tag 793 Lime was radio tagged in the Turnbull area of FRO in August 2014 and has a seven (7) year history of capture - recapture locations (June 2012 to March 2019). This fish is a Fording River Operations (FRO) resident male with a home range of 4.3 km over these 7 years. The location history illustrated in Figure 2 below identifies the home range and life history habits of this fish; centered around Henretta Pit Lake (over-wintering habitat) and the Clode Flats (spawning and summer rearing habitat); including the Fish Pond Creek tributary habitat within Clode Flats. The Figure below is river kilometers on the Y axis with landmarks and fork length inserted in text boxes for reference.

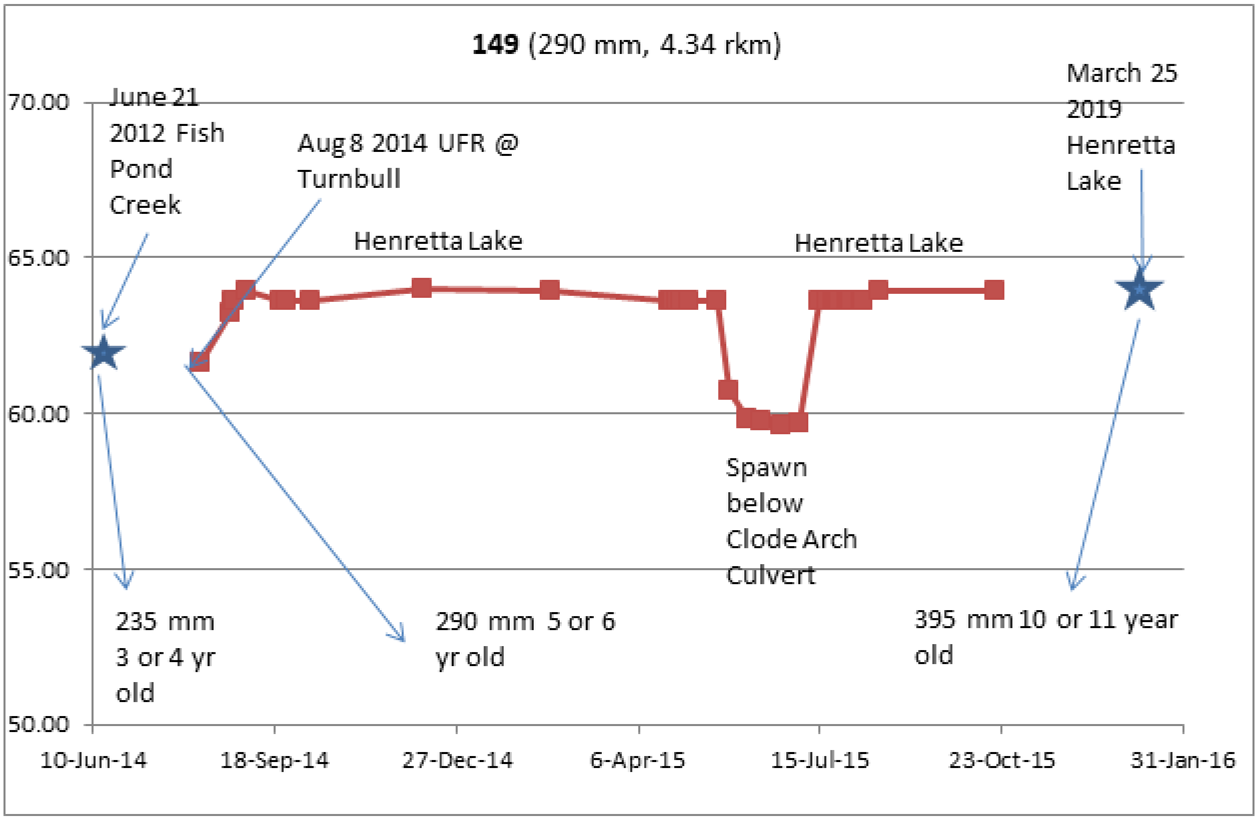


Figure 2. Capture – recapture history illustrating a representative Fording River Operations resident life history strategy over a 7 year period.

This male Westslope Cutthroat Trout illustrated in Figure 2 grew 160 mm and 579 g in just under 7 yrs. This equals 22.85 mm/yr which is consistent with the growth rates estimated from recaptures in the assessment report (Cope et al. 2016). These data points provide quantitative validation of WCT growth rates and ages in the assessment report. This fish at 235 mm was estimated to be 3 or 4 years old based on juvenile and sub-adult growth rates. We have good separation of age classes at these ages (i.e., we have confidence in our age estimates). This fish at 290 mm was estimated to be 5 or 6 years old based on time at large and consistency with the growth model. Currently, at 395 mm this fish is estimated to be 10 or 11 years old after 7 years at large (Figure 2).

Floy Tag 610 Blue was originally 321 mm fork length and weighed 380 g and was captured within Clode Flats during August 2013. This fish was recaptured March 25 2019 in Henretta Pit Lake and was 439 mm and weighed 1,070 g. The Westslope Cutthroat Trout grew 20.5 mm per year over the 5.75 years at large which is consistent with the growth rates estimated from recaptures in the assessment report (Cope et al. 2016). At 321 mm this fish was estimated to be 7 years old and after 5.75 years at large was estimated to be almost 13 years old. These data points provide quantitative validation of WCT growth rates and ages in the assessment report.

There were three PIT tags recaptured. These PIT tags are currently being searched for original capture data from other FRO programs and will be added to the database once confirmed (PIT Tag 90011800158149, PIT Tag 900118001580512, PIT Tag 985121021328816).

4. References

Anderson, W.G., McKinley, R.S. and M. Colavecchia, 1997. The use of clove oil as an anesthetic for rainbow trout and its effects on swimming performance. North American Journal of Fisheries Management 17:301-307.

Cope, S., C.J. Schwarz, and A. Prince. 2017. Upper Fording River Westslope Cutthroat Trout Population Monitoring Project: 2017. Report Prepared for Teck Coal Limited, Sparwood, BC. Report Prepared by Westslope Fisheries Ltd., Cranbrook, BC. 40 p + 1 app.

Cope, S., C.J. Schwarz, A. Prince and J. Bisset. 2016. Upper Fording River Westslope Cutthroat Trout Population Assessment and Telemetry Project: Final Report. Report Prepared for Teck Coal Limited, Sparwood, BC. Report Prepared by Westslope Fisheries Ltd., Cranbrook, BC. 259 p.

Elphick, J.R., H.C. Bailey, B.K. Lo, J. Berdusco and G. Sword. 2009. Effect of Selenium on Early Life-stage Development of Westslope Cutthroat Trout. Report prepared for the Elk Valley Selenium Task Force. Prepared by Nautilus Environmental, Burnaby, British Columbia. -66 pp.

Keene, J.L., Noakes, D.L.G., Moccia, R.D., and C.G. Soto, 1998. The efficacy of clove as an anesthetic for rainbow trout, *Oncorhynchus mykiss* (Walbaum). Aquaculture Research 29:89-101.

McDonald, L.E. 2013. Selenium bioaccumulation in fish from the Elk River, British Columbia, a review of data collected from 1996 to 2010. Report prepared by Spirogyra Scientific Consulting, Cranbrook, B.C. Prepared for British Columbia Ministry of Environment, Cranbrook, B.C. 39 p. + app.

Minnow Environmental Inc. 2018. Elk River Watershed Regional Aquatic Effects Monitoring Program (RAEMP) Report, 2015-2016. Report prepared for Teck Coal Ltd, Sparwood, B.C.

Minnow Environmental Inc. and Paine, Ledge and Associates (PLA). 2012. Surface water quality evaluation for Teck's Coal mining operations in the Elk River Valley, B.C. Report prepared for Teck Coal Limited, Sparwood, B.C. Prepared by Minnow Environmental Inc., Georgetown, ON. and Paine, Ledge and Associates, North Vancouver, B.C. 64 p. + app.

Orr, P.L. and C.I.E. Wiramanaden, M.D. Paine, W. Franklin and C. Fraser. 2012. Food chain model based on field data to predict Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) ovary selenium concentrations from water selenium concentrations in the elk valley, British Columbia. Environmental Toxicology and Chemistry, Vol. 31, No. 3, pp. 672–680, 2012.

Orr, P.L., Guiguer, K.R. and C.K. Russel. 2006. Food chain transfer of selenium in lentic and lotic habitats of a western Canadian watershed. Ecotoxicology and Environmental Safety 63: 175-188.

Peake, S.1998. Sodium bicarbonate and clove oil as potential anesthetics for nonsalmonid fishes. North American Journal of Fisheries Management 18:919-924.

Prince, A., and C. Powell, 2000. Clove oil as an anesthetic for invasive field procedures on adult rainbow trout. North American Journal of Fisheries Management 20:1029-1032.

Windward Environmental, Minnow Environmental Inc. and CH2M Hill Limited. 2014. Elk River watershed and Lake Koocanusa, British Columbia Aquatic environment synthesis report 2014. Report Prepared for Teck Coal Limited, Sparwood, B.C. 223 p. including 5 app.

Yoshikawa, H., Y. Ishida, S. Ueno, and H. Mitsuda. 1988. Changes in depth of anesthesia of the carp anesthetized with a constant level of carbon dioxide. Bulletin of the Japanese Society of Scientific Fisheries 54: 457-462.

5. Photographs

Photo 1. Henretta Pit Lake February 14, 2019. Note ice fishing in background.

Photo 2. Henretta Pit lake March 25, 2019.

Photo 3 .

Photo 4. LCO Dry Creek reach 3 open water site March 28, 2019.

Photo 5. LCO Dry Creek at

Photo 7. Fording River Clode Flats area sampling February 12, 2019.

Photo 8. Fording River Oxbow area sampling March 27, 2019.

Photo 9. Baited burbot trap used to sample oxbow pools March 27-28, 2019.

6. Fish Data Submission

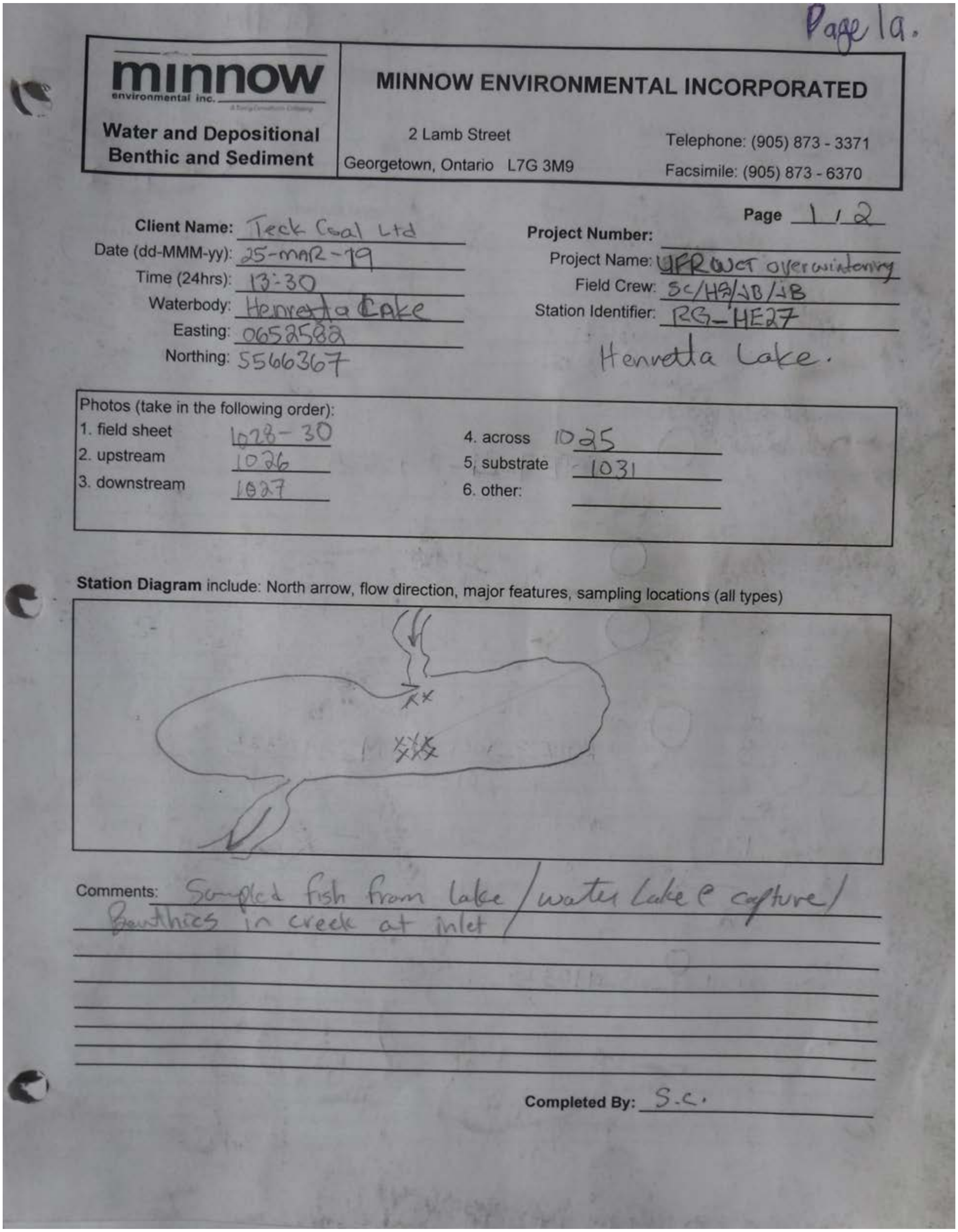
Fish Data Submission.

	Locational Information													Channel Status	
	IMPORTANT!: 1. Only use one unique reference # for each sampling event. 2. Enter the Reference Numbers from this worksheet to the corresponding lines of the other worksheets that you work on.		Drop Down List							Drop Down List	Drop Down List			Drop Down List	Drop Down List
REFERENCE NUMBER	Gazetted Name	Alias (Local Name)	Waterbody Type	Waterbody (ID) Identifier	Watershed Code (45 Digit)	TWC#	Reach #	Site #	Survey Date	UTM Method	UTM Zone	UTM Easting	UTM Northing	No Visible Channel	Dewatered-Dry/Int Channel
1	Henretta Creek	Henretta Lake	stream	00000ELKR	349-248100-48300-81900		2.0	1	2019-02-11	GPS general	11	652544	5566386	visible channel	
2	Fording River	Clode Flats	stream	00000ELKR	349-248100-48300		9.0	1	2019-02-12	GPS general	11	651036	5564814	visible channel	
3	Fording River	Oxbow Pools	stream	00000ELKR	349-248100-48300		6.0	1	2019-02-13	GPS general	11	655307	5552944	visible channel	
4	Henretta Creek	Henretta lake	stream	00000ELKR	349-248100-48300-81900		2.0	1	2019-03-25	GPS general	11	652582	5566367	visible channel	
5	Fording River	Clode Flats	stream	00000ELKR	349-248100-48300		9.0	1	2019-03-26	GPS general	11	651303	5562491	visible channel	
6	Fording River	Oxbow Pools	stream	00000ELKR	349-248100-48300		6.0	1	2019-03-27	GPS general	11	655307	5552944	visible channel	
7	Dry Creek		stream	00000ELKR	349-248100-48300-39300		3.0	1	2019-03-28	GPS general	11	656309	5544996	visible channel	
8	Fording River	Greenhills Pools	stream	00000ELKR	349-248100-48300		2.0	1	2019-03-29	GPS general	11	653027	5545536	visible channel	

	Locational Info (This information fills in automatically)					Stream Condition			Site Effort			Electrofisher Specifications									Net/Trap Specifications											Fish Summary							
										Preferred Information	Preferred Information	EF Effort														Net/Trap Effort Preferred Information Use Date/Time Selector? ● es ● No													
REFERENCE NUMBER	Gazetted Name	Local Name	Waterbody ID	Reach #	Site #	Temperature (°C)	Conductivity (µS/cm)	Turbidity	Sampling Method	Method Number	Haul # /Pass #	EF Seconds	EF Length (m)	EF Width (m)	Enclosure	Voltage	Frequency	Pulse	Make	Model	Gill Net type	Length (m)	Depth (m)	Mesh Size	Set	Date In	Time In	Date Out	Time Out	Soak Time	Habitat	Species	Stage	Age	Total Number	Min. Length (mm)	Max. Length (mm)	Fish Activity	Comments
1	Henretta Creek	Henretta Lake	00000ELKR	2	1	0.2	699	clear	angling	4	1															2019-02-11	11:00:00	2019-02-11	15:30:00	4.50		No Fish Caught							
1	Henretta Creek	Henretta Lake	00000ELKR	2	1	0.2	699	clear	angling	4	2															2019-02-14	09:30:00	2019-02-14	15:45:00	6.25		Westslope Cutthroat Trout	adult		1	445	445	rearing	
2	Fording River	Clode Flats	00000ELKR	9	1	0.0		clear	angling	4	1															2019-02-12	09:30:00	2019-02-12	15:30:00	6.00		No Fish Caught							
3	Fording River	Oxbow Pools	00000ELKR	6	1				angling	2	1															2019-02-13	11:00:00	2019-02-13	16:30:00	5.50		No Fish Caught							
4	Henretta Creek	Henretta lake	00000ELKR	2	1	1.7	502	moderately turbid	angling	2	3															2019-03-25	11:30:00	2019-03-25	16:30:00	5.00		Westslope Cutthroat Trout	adult		8	392	467	rearing	
5	Fording River	Clode Flats	00000ELKR	9	1	1.7	521	turbid	angling	2	2															2019-03-26	11:00:00	2019-03-26	18:00:00	7.00		No Fish Caught							
6	Fording River	Oxbow Pools	00000ELKR	6	1	3.3	837	moderately turbid	angling	2	2															2019-03-27	10:30:00	2019-03-27	18:00:00	7.50		No Fish Caught							
6	Fording River	Oxbow Pools	00000ELKR	6	1	3.3	837	moderately turbid	trap net	3	1															2019-03-27	15:00:00	2019-03-28	13:30:00	22.50		No Fish Caught							
6	Fording River	Oxbow Pools	00000ELKR	6	1	3.3	837	moderately turbid	angling	2	3															2019-03-28	13:30:00	2019-03-28	18:00:00	4.50		No Fish Caught							
7	Dry Creek	0	00000ELKR	3	1				angling	2	1															2019-03-28	09:30:00	2019-03-28	13:00:00	3.50		No Fish Caught							
8	Fording River	Greenhills Pools	00000ELKR	2	1	1.6	680	clear	angling	3	1															2019-03-29	10:30:00	2019-03-29	13:30:00	3.00		No Fish Caught							

REFERENCE NUMBER	Gazetted Names	Local Name	Waterbody ID	Reach #	Site #	Sampling Method	Method Number	Haul#/Pass#	Species	Length (mm)	Weight (g)	Sex	Maturity	Age Structure	Age Sample #	Age	Genetic Structure	Genetic Sample #	Comments
1	Henretta Creek	Henretta Lake	00000ELKR	2	1	angling	4	2	Westslope Cutthroat Trout	445	1240.0	male	Mature						PIT Tag RECAP 90011800158149 Muscle Plug taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	393	680.0		Mature						Muscle Plug Taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	392	740.0		Mature						Muscle Plug Taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	395	710.0	male	Mature			11+			Age known from recapture history dating to June 2012; Muscle Plug taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	439	1070.0		Mature						Muscle Plug Taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	412	880.0	male	Mature						Muscle Plug Taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	424	960.0		Mature						Muscle Plug Taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	467	1340.0	male	Mature						Muscle Plug Taken
4	Henretta Creek	Henretta lake	00000ELKR	2	1	angling	2	3	Westslope Cutthroat Trout	428	1020.0		Mature						Muscle Plug Taken

7. Minnow Environmental Inc. Field Data Sheets



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Water and Depositional Benthic and Sediment

MINNOW ENVIRONMENTAL INCORPORATED

2 Lamb Street
Georgetown, Ontario L7G 3M9

Telephone: (905) 873 - 3371
Facsimile: (905) 873 - 6370

Page 1 / 2

Client Name: Teck Coal Ltd
Date (dd-MMM-yy): 25-MAR-19
Time (24hrs): 13:30
Waterbody: Henretta Lake
Easting: 0652582
Northing: 5566367

Project Number:
Project Name: UFR WCT overwintering
Field Crew: SC/HS/JB/JB
Station Identifier: RG_HE27

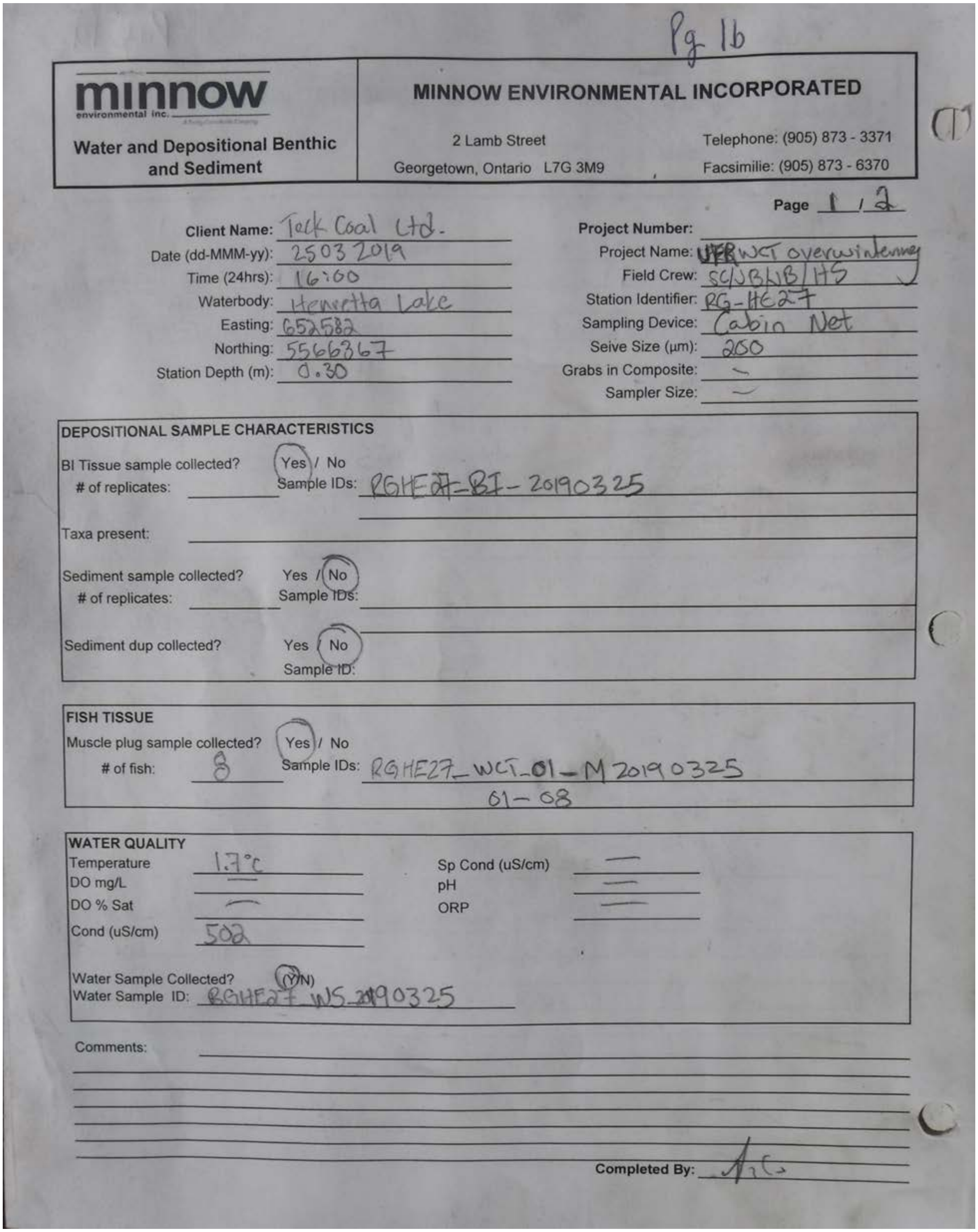
Henretta Lake.

Photos (take in the following order):
1. field sheet 1028-30
2. upstream 1026
3. downstream 1027
4. across 1025
5. substrate 1031
6. other:

Station Diagram include: North arrow, flow direction, major features, sampling locations (all types)

Comments: Sampled fish from lake / water Lake @ capture / Benthics in creek at inlet /

Completed By: S.C.



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Water and Depositional Benthic and Sediment

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Page 1 / 2

Client Name: Teck Coal Ltd.
Date (dd-MMM-yy): 25032019
Time (24hrs): 16:00
Waterbody: Henretta Lake
Easting: 652582
Northing: 5566367
Station Depth (m): 0.30

Project Number:
Project Name: ~~UFR~~ WCT overwintering
Field Crew: SC/JB/LB/HS
Station Identifier: RG-HE27
Sampling Device: Cabin Net
Seive Size (µm): 200
Grabs in Composite: –
Sampler Size: –

DEPOSITIONAL SAMPLE CHARACTERISTICS

BI Tissue sample collected? [✓ Yes] / No
\# of replicates:
Sample IDs: RGHE27-BI-20190325

Taxa present:

Sediment sample collected? Yes / [✓ No]
\# of replicates:
Sample IDs:

Sediment dup collected? Yes / [✓ No]
Sample ID:

FISH TISSUE

Muscle plug sample collected? [✓ Yes] / No
\# of fish: 8
Sample IDs: RGHE27_WCT_01_M 20190325
01–08

WATER QUALITY

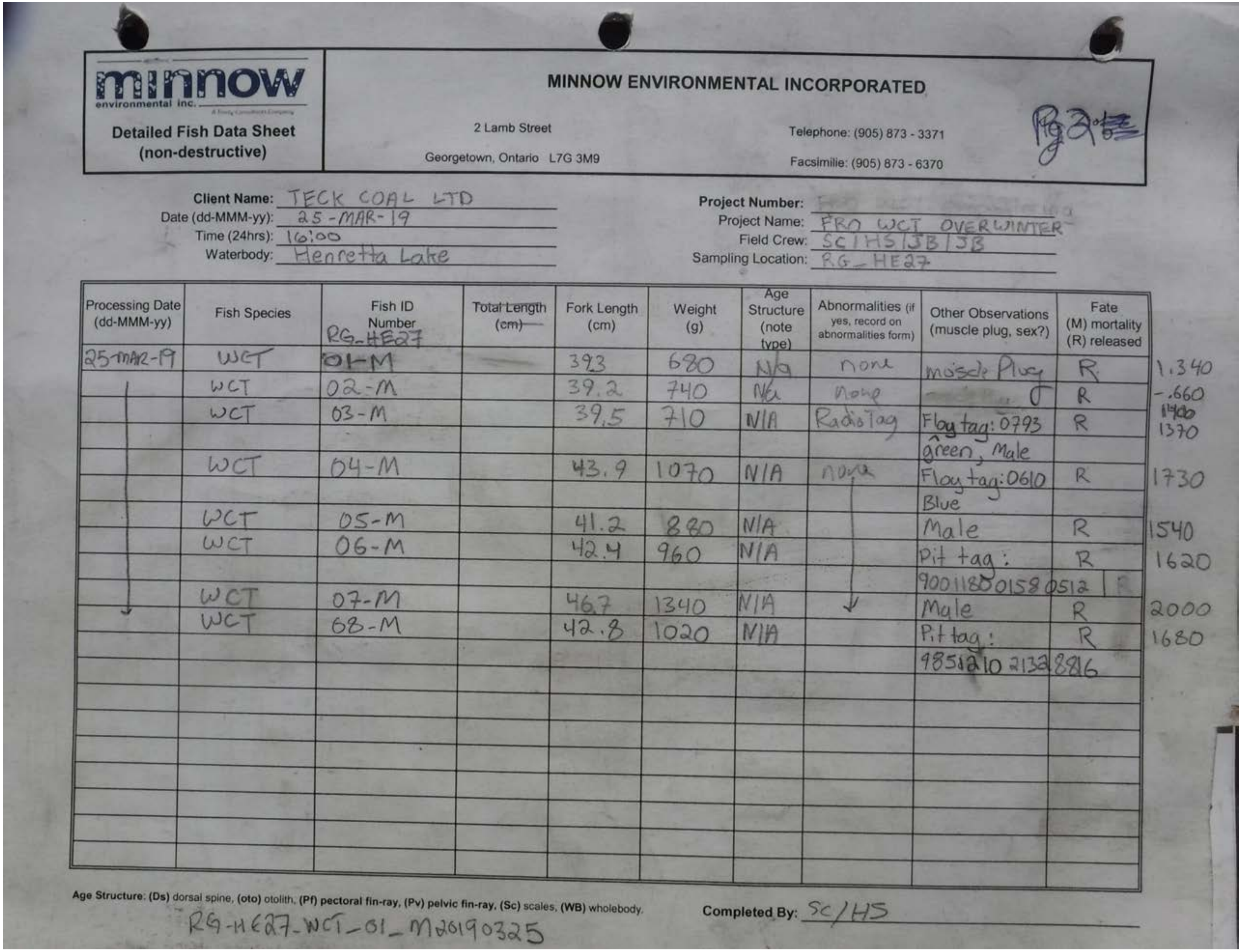
Temperature 1.7°C
DO mg/L —
DO % Sat —
Cond (uS/cm) 502

Sp Cond (uS/cm) —
pH —
ORP —

Water Sample Collected? ([✓ Y]/N)
Water Sample ID: RGHE27 WS 20190325

Comments:

Completed By:



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Detailed Fish Data Sheet (non-destructive)

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Pg 2 of 2

Client Name: TECK COAL LTD
Date (dd-MMM-yy): 25-MAR-19
Time (24hrs): 16:00
Waterbody: Henretta Lake

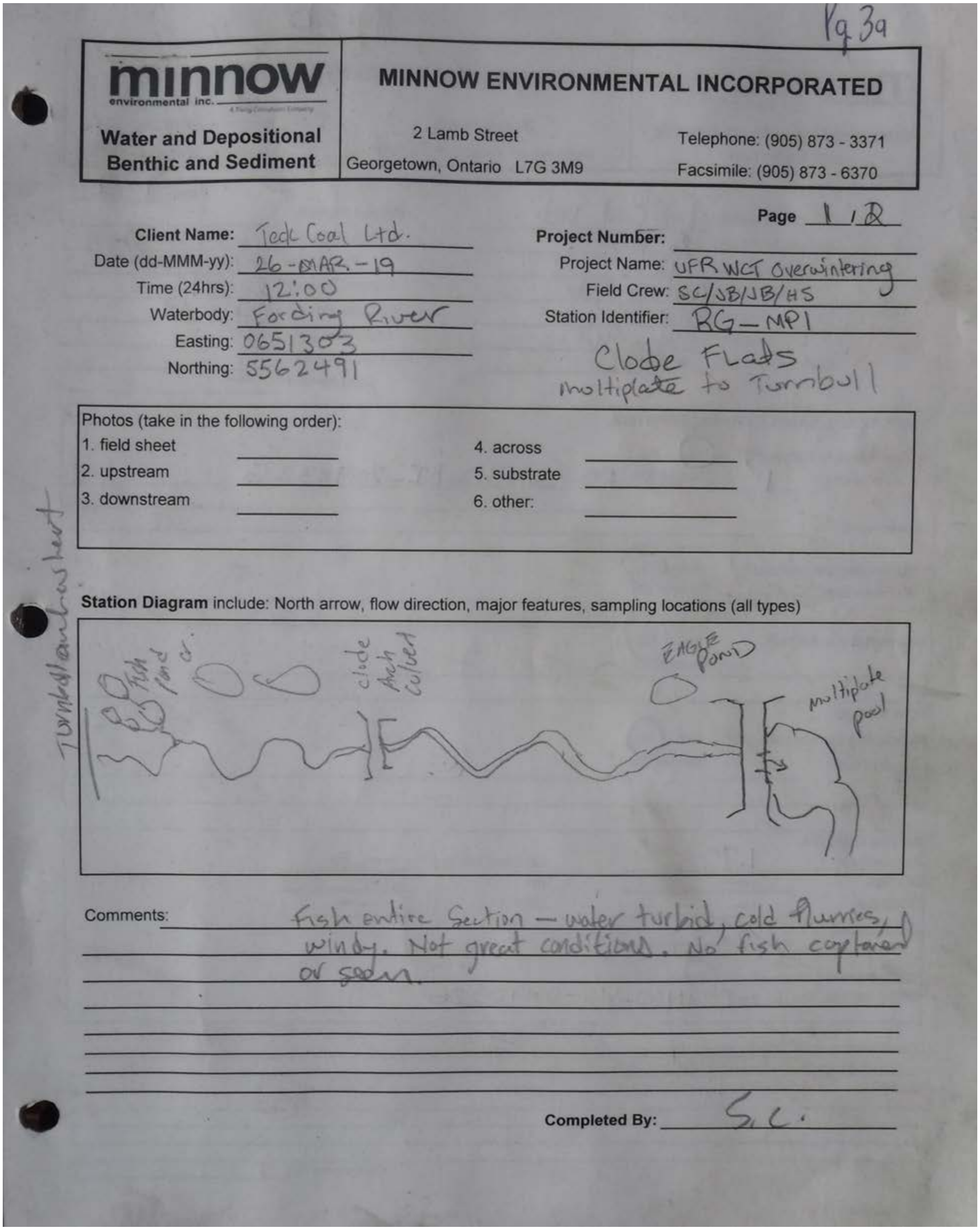
Project Number:
Project Name: FRO WCT OVERWINTER
Field Crew: SC/HS/JB/JB
Sampling Location: RG_HE27

Processing Date (dd-MMM-yy)	Fish Species	Fish ID Number RG_HE27	~~Total Length (cm)~~	Fork Length (cm)	Weight (g)	Age Structure (note type)	Abnormalities (if yes, record on abnormalities form)	Other Observations (muscle plug, sex?)	Fate (M) mortality (R) released	
25-MAR-19	WCT	01-M	—	393	680	N/a	none	muscle Plug	R	1.340
↓	WCT	02-M		39.2	740	N/a	none	♂	R	-.660
	WCT	03-M		39.5	710	N/A	Radio Tag	Floy tag: 0793	R	1400
								green, Male		1370
	WCT	04-M		43.9	1070	N/A	none	Floy tag: 0610	R	1730
							↓	Blue		
	WCT	05-M		41.2	880	N/A		Male	R	1540
	WCT	06-M		42.4	960	N/A		Pit tag:	R	1620
								900118001580512		
	WCT	07-M		46.7	1340	N/A		Male	R	2000
	WCT	08-M		42.8	1020	N/A		Pit tag:	R	1680
								985121021328816		

Age Structure: (Ds) dorsal spine, (oto) otolith, (Pf) pectoral fin-ray, (Pv) pelvic fin-ray, (Sc) scales, (WB) wholebody.

Completed By: SC/HS

RG-HE27-WCT-01-M20190325



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Page 1 / 2

Client Name: Teck Coal Ltd.
Date (dd-MMM-yy): 26-MAR-19
Time (24hrs): 12:00
Waterbody: Fording River
Easting: 0651303
Northing: 5562491

Project Number:
Project Name: UFR WCT Overwintering
Field Crew: SC/JB/JB/HS
Station Identifier: RG-MP1

Clode Flats
multiplate to Turnbull

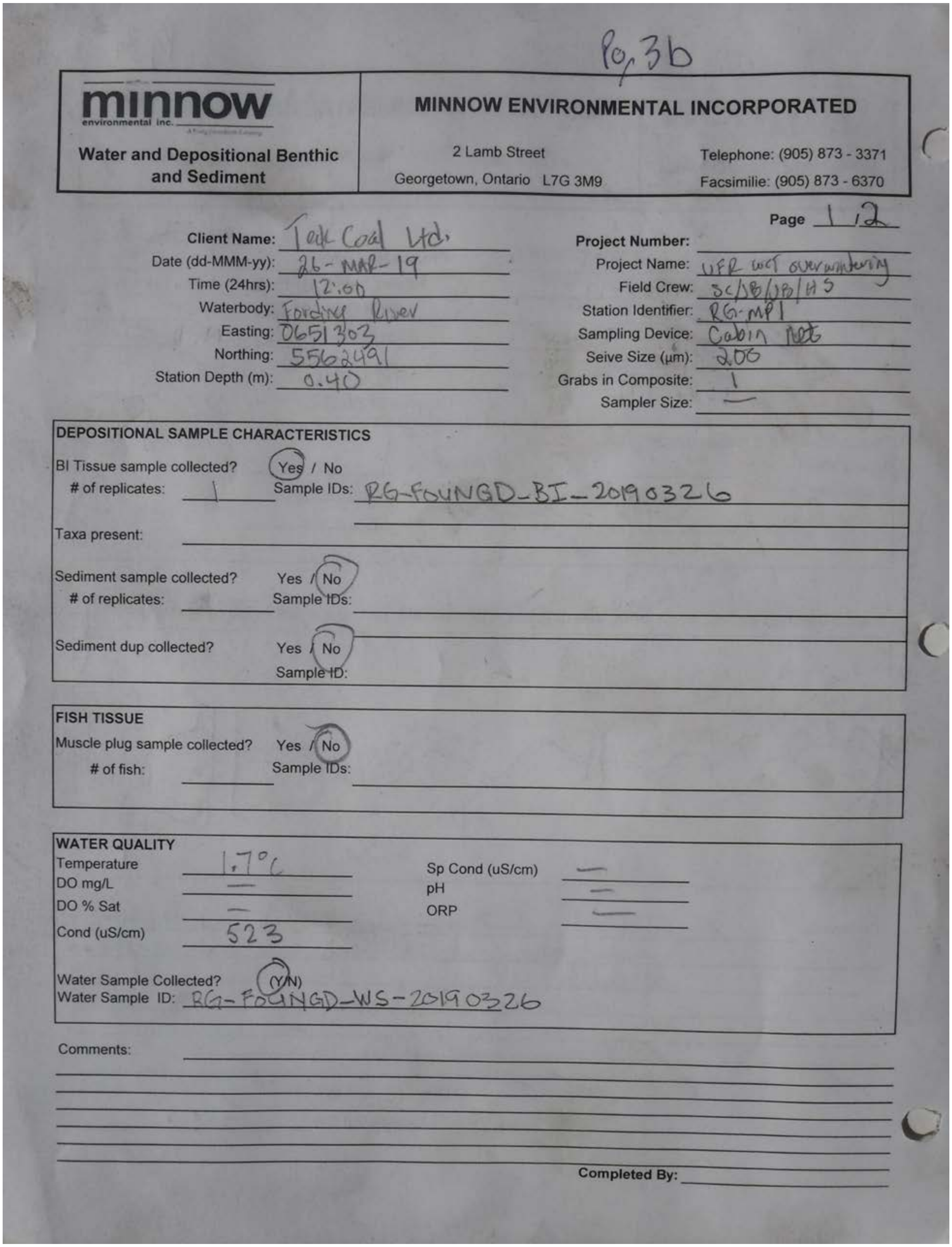
Photos (take in the following order):
1. field sheet
2. upstream
3. downstream
4. across
5. substrate
6. other:

Turnbull on this sheet

Station Diagram include: North arrow, flow direction, major features, sampling locations (all types)

Comments: Fish entire Section – water turbid, cold flurries, windy. Not great conditions. No fish captured or seen.

Completed By: S.C.



Po,3b

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Water and Depositional Benthic and Sediment

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Page 1/2

Client Name: Teck Coal Ltd.
Date (dd-MMM-yy): 26-MAR-19
Time (24hrs): 12:00
Waterbody: Fording River
Easting: 0651303
Northing: 5562491
Station Depth (m): 0.40

Project Number:
Project Name: UFR WCT overwintering
Field Crew: SC/JB/JB/HS
Station Identifier: RG-MP1
Sampling Device: Cabin Net
Seive Size (µm): 200
Grabs in Composite: 1
Sampler Size: —

DEPOSITIONAL SAMPLE CHARACTERISTICS

BI Tissue sample collected? [✓ Yes] / No
\# of replicates: 1 Sample IDs: RG-FOUNGD-BI-20190326

Taxa present:

Sediment sample collected? Yes / [✓ No]
\# of replicates: Sample IDs:

Sediment dup collected? Yes / [✓ No]
Sample ID:

FISH TISSUE

Muscle plug sample collected? Yes / [✓ No]
\# of fish: Sample IDs:

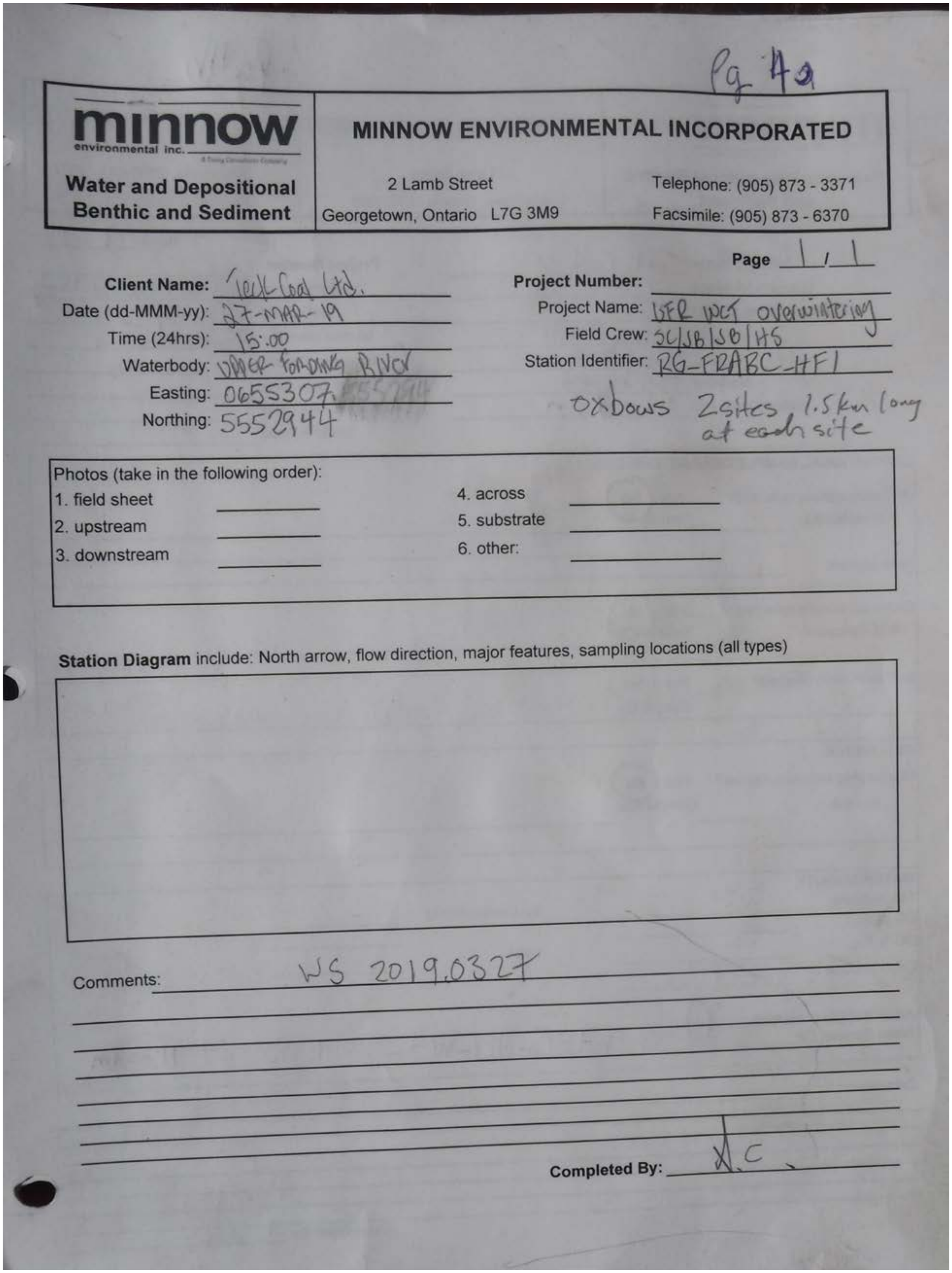
WATER QUALITY

Temperature: 1.7°C
DO mg/L: —
DO % Sat: —
Cond (uS/cm): 523
Sp Cond (uS/cm): —
pH: —
ORP: —

Water Sample Collected? ([✓ Y]/N)
Water Sample ID: RG-FOUNGD-WS-20190326

Comments:

Completed By:



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Page 1 / 1

Client Name: Teck Coal Ltd.
Date (dd-MMM-yy): 27-MAR-19
Time (24hrs): 15:00
Waterbody: Upper Fording River
Easting: 0655307.
Northing: 5552944

Project Number:
Project Name: UFR WCT overwintering
Field Crew: SC/JB/SB/HS
Station Identifier: RG-FRABC-HF1

oxbows 2 sites, 1.5 km long at each site

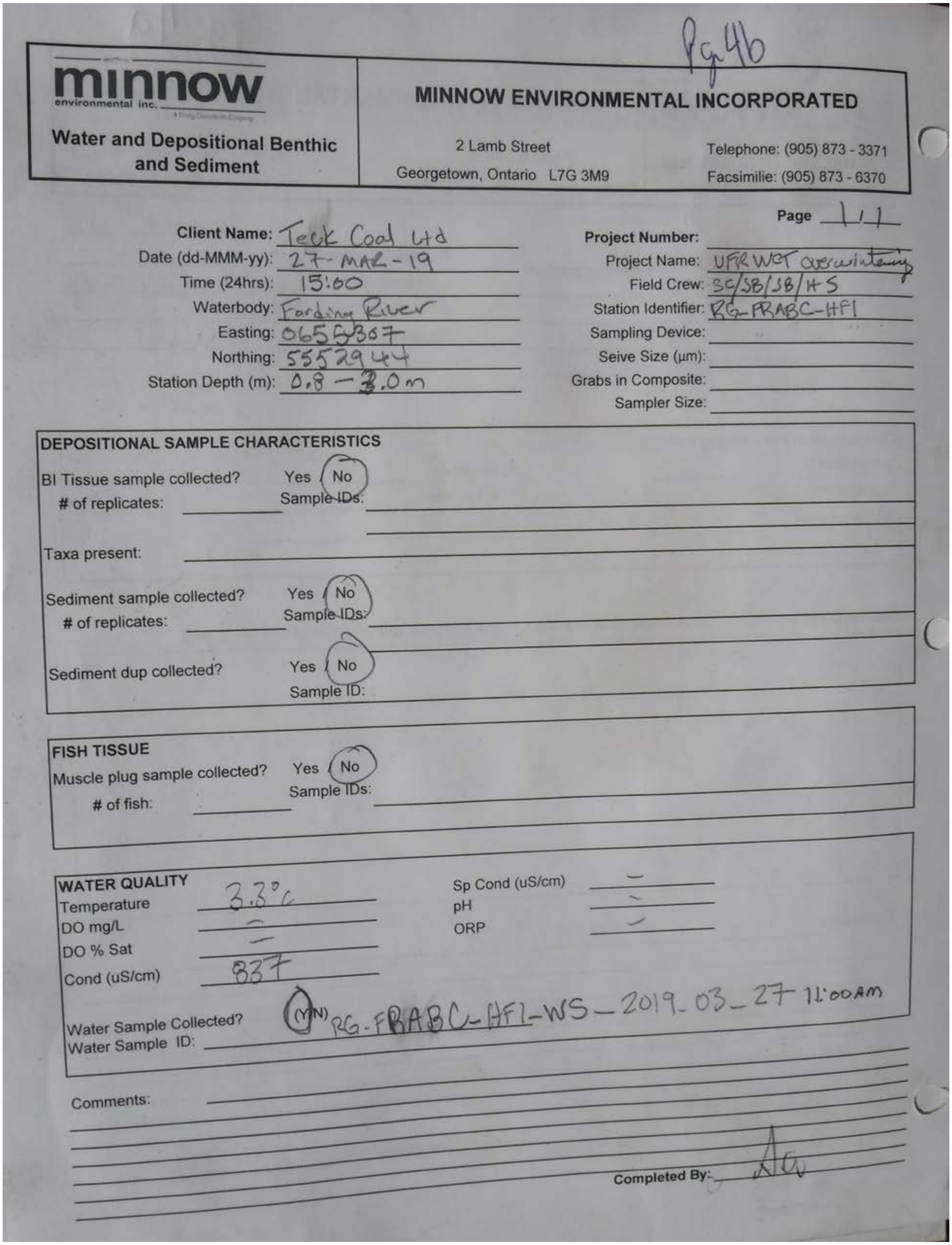
Photos (take in the following order):

1. field sheet ______
2. upstream ______
3. downstream ______
4. across ______
5. substrate ______
6. other: ______

Station Diagram include: North arrow, flow direction, major features, sampling locations (all types)

Comments: WS 2019.0327

Completed By: S.C.



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Water and Depositional Benthic and Sediment

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Page 1/1

Client Name: Teck Coal Ltd
Date (dd-MMM-yy): 27-MAR-19
Time (24hrs): 15:00
Waterbody: Fording River
Easting: 0655307
Northing: 5552944
Station Depth (m): 0.8 – 3.0 m

Project Number:
Project Name: UFR WCT overwintering
Field Crew: SC/SB/JB/HS
Station Identifier: RG-FRABC-HF1
Sampling Device:
Seive Size (µm):
Grabs in Composite:
Sampler Size:

DEPOSITIONAL SAMPLE CHARACTERISTICS

BI Tissue sample collected? Yes / [✓ No]
# of replicates: Sample IDs:

Taxa present:

Sediment sample collected? Yes / [✓ No]
# of replicates: Sample IDs:

Sediment dup collected? Yes / [✓ No]
Sample ID:

FISH TISSUE

Muscle plug sample collected? Yes / [✓ No]
# of fish: Sample IDs:

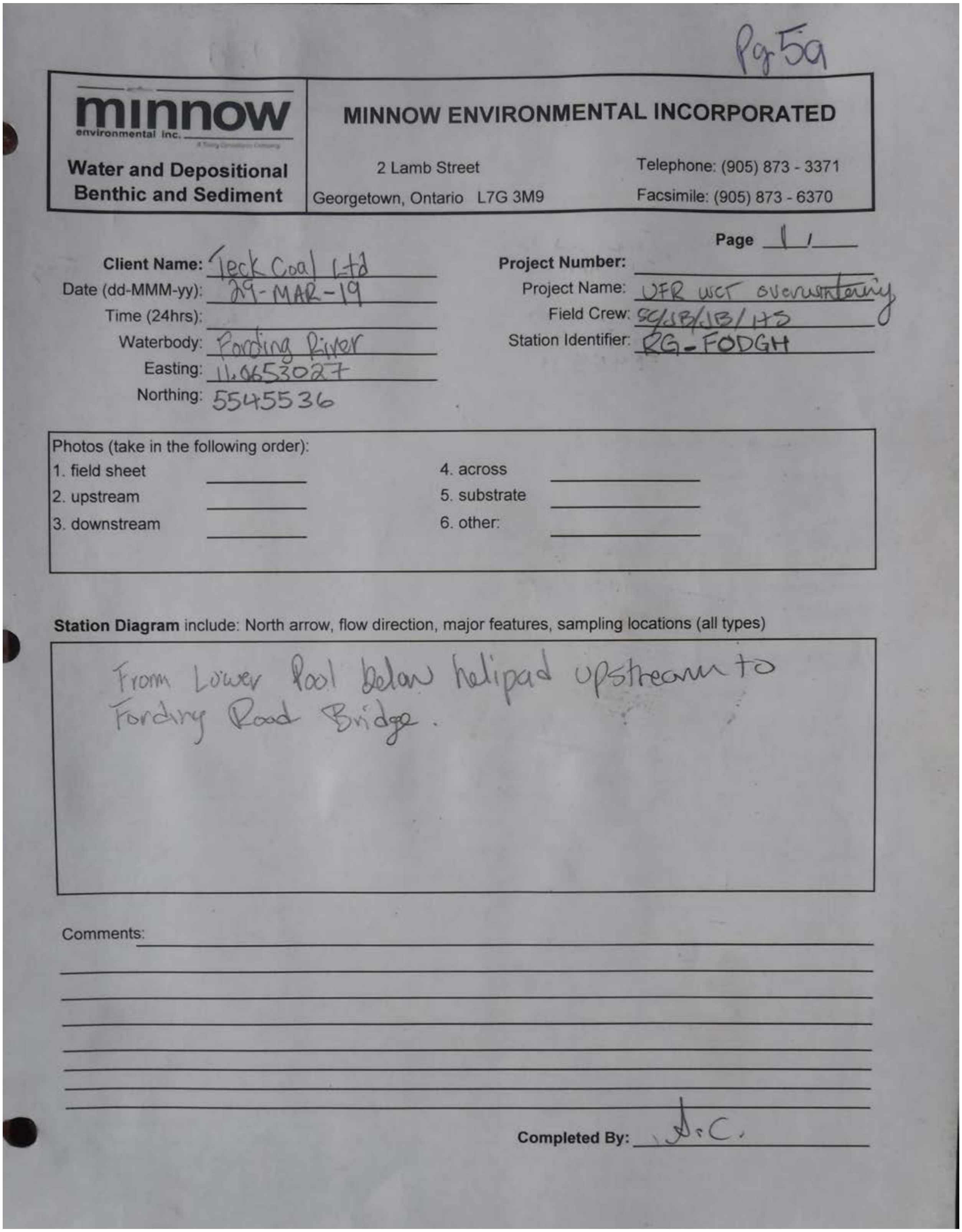
WATER QUALITY

Temperature 3.3°c
DO mg/L –
DO % Sat –
Cond (uS/cm) 837
Sp Cond (uS/cm) –
pH –
ORP –

Water Sample Collected? ([✓ Y]/N) RG-FRABC-HF1-WS_2019_03_27 11:00AM
Water Sample ID:

Comments:

Completed By:



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Water and Depositional
Benthic and Sediment

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Page 1 /

Client Name: Teck Coal Ltd
Date (dd-MMM-yy): 29-MAR-19
Time (24hrs):
Waterbody: Fording River
Easting: 11.0653027
Northing: 5545536

Project Number:
Project Name: UFR WCT overwintering
Field Crew: SG/SB/JB/HS
Station Identifier: RG-FODGH

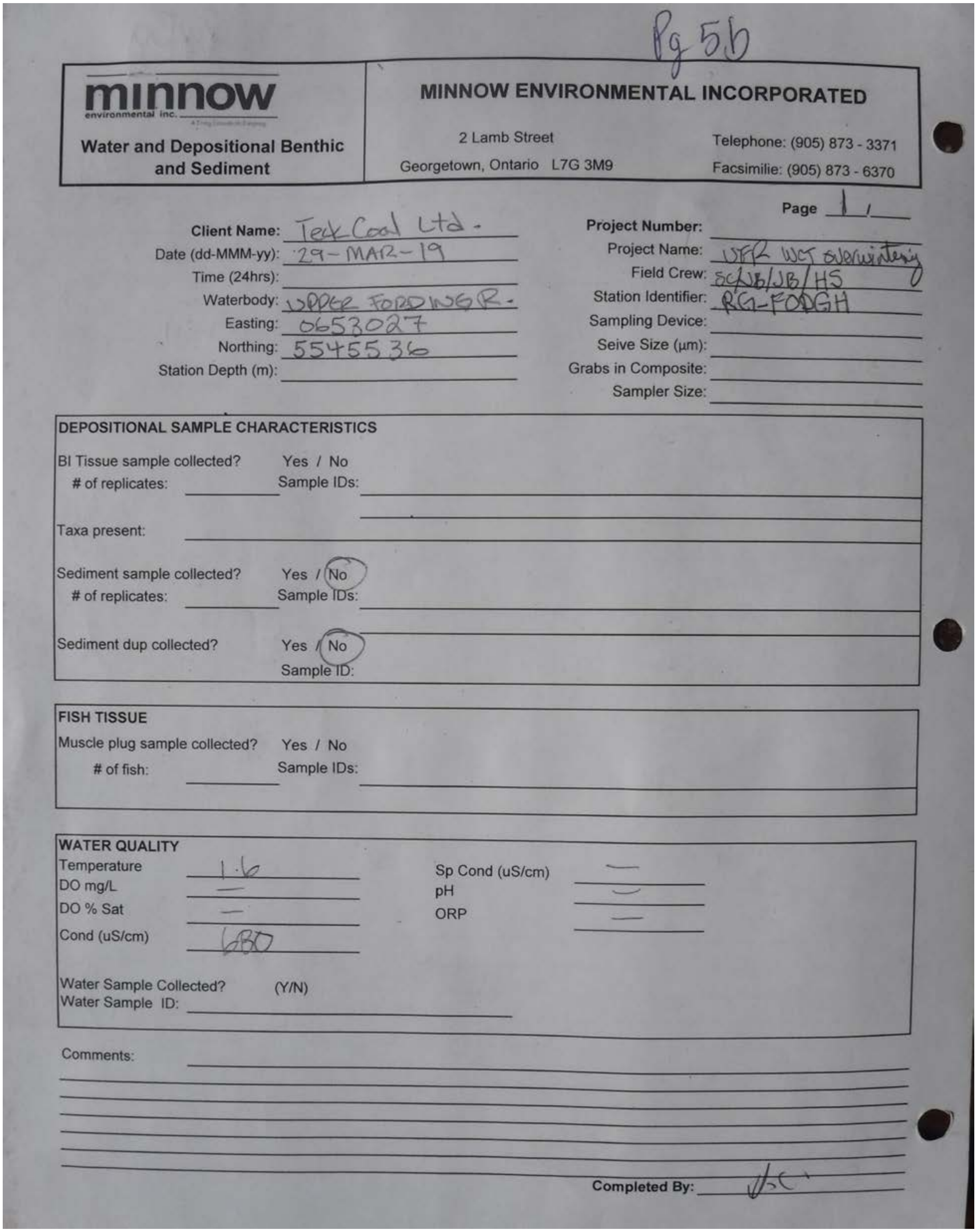
Photos (take in the following order):
1. field sheet
2. upstream
3. downstream
4. across
5. substrate
6. other:

Station Diagram include: North arrow, flow direction, major features, sampling locations (all types)

From Lower Pool below helipad upstream to Fording Road Bridge.

Comments:

Completed By: A.C.



Pg 5b

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Water and Depositional Benthic and Sediment

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Page 1 / ___

Client Name: Teck Coal Ltd.
Date (dd-MMM-yy): 29-MAR-19
Time (24hrs): ___
Waterbody: UPPER FORDING R.
Easting: 0653027
Northing: 5545536
Station Depth (m): ___

Project Number: ___
Project Name: UFR WCT overwintering
Field Crew: SC/JB/JB/HS
Station Identifier: RG-FODGH
Sampling Device: ___
Seive Size (µm): ___
Grabs in Composite: ___
Sampler Size: ___

DEPOSITIONAL SAMPLE CHARACTERISTICS

BI Tissue sample collected? Yes / No
\# of replicates: ___ Sample IDs: ___

Taxa present: ___

Sediment sample collected? Yes / [✓ No]
\# of replicates: ___ Sample IDs: ___

Sediment dup collected? Yes / [✓ No]
Sample ID:

FISH TISSUE

Muscle plug sample collected? Yes / No
\# of fish: ___ Sample IDs: ___

WATER QUALITY

Temperature	1.6	Sp Cond (uS/cm)	—
DO mg/L	—	pH	—
DO % Sat	—	ORP	—
Cond (uS/cm)	680		

Water Sample Collected? (Y/N)
Water Sample ID: ___

Comments: ___

Completed By: ___