PERMIT 107517

ENVIRONMENTAL MONITORING COMMITTEE

2017 Public Report

Feedback Form

Contact the independent facilitator for the Environmental Monitoring Committee (EMC) if you have questions about the Committee , the science-based advice or input it provides, or responses from Teck to the EMC's science-based advice. The EMC's annual public reports are available at **www.teck.com/elkvalley**

Environmental Monitoring Committee
Independent Facilitator
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250-352-6881

- ☐ Notify me about the EMC's annual public meetings and reports.

I would like to request the EMC's advice or input, plus feedback from Teck on the following:

- ☐ Introducing the Elk Valley
- ☐ Managing Water Quality in the Elk Valley
- ☐ Environmental Monitoring Committee Activities 2016-2017
- ☐ Adaptive Management Plan
- ☐ Water Quality
  - ☐ Surface Water Quality
  - ☐ Acute Toxicity Testing
  - ☐ Chronic Toxicity Testing
  - ☐ Nitrate and Sulphate Toxicity Study
  - ☐ Elk Valley Groundwater Monitoring
- ☐ Aquatic Ecosystem Health
  - ☐ Aquatic Effects Monitoring
  - ☐ Koocanusa Reservoir Monitoring
  - ☐ Tributary Evaluation and Management
- ☐ Calcite
  - ☐ Annual Calcite Monitoring
  - ☐ Seasonal Calcite Monitoring
  - ☐ Calcite Biological Effects Evaluation
- ☐ Human Health Risk Assessment
- ☐ Third Party Audit

Name: ____________________

Affiliation (if any): ____________________

Email: ____________________ Phone: ____________________

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About this Public Report

This is the third annual public report released by the Environmental Monitoring Committee (EMC). The 2015 and 2016 EMC Public Reports may be accessed at www.teck.com/elkvalley .

The EMC was formed as a condition of Environment Management Act Permit 107517 (the Permit) issued by the British Columbia Ministry of Environment and Climate Change Strategy (formerly the BC Ministry of Environment) authorizing effluent discharges from Teck's five coal mines in the Elk Valley. The EMC is primarily a forum to share science-based information and Traditional Knowledge related to the environmental monitoring, adaptive management, and reporting activities prescribed by the Permit. The purpose of the EMC is to strengthen the design of monitoring programs and ultimately support the achievement of the Elk Valley Water Quality Plan's four over-arching environmental management objectives. Further information on the purpose and scope of the EMC's work is provided on page 24.

The EMC's Terms of Reference provide that an annual plain language report approved by the EMC will be presented to the general public in the Elk Valley. This annual plain language report provides results of the monitoring undertaken as per the Permit, as well as the status of implementation of activities and commitments as per the Elk Valley Water Quality Plan.

This EMC public report presents results from Permit-related monitoring completed from January to December 2016, and provides details about EMC activities for the period since the last public meeting was held on October 19, 2016. Where results are not yet available, a summary of activity to-date has been provided.

Acknowledgments

This report was prepared by Teck and the consultant writer (Lindsay McIvor, Compass Sustainability Services), with direction and input from the following members of the Environmental Monitoring Committee:

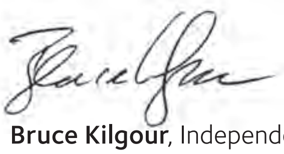
Carla Fraser and Mark Digel (Teck), Lana Miller and Jillian Tamblyn (B.C. Ministry of Environment and Climate Change Strategy), Bruce Kilgour (Independent Scientist), Heather McMahon, Don MacDonald, and Lillian Rose (Ktunaxa Nation Council).

The following member organizations of the Environmental Monitoring Committee have reviewed this public report and endorse its contents:

Lana Miller on behalf of B.C. Ministry of Environment and Climate Change Strategy

Carla Fraser on behalf of Teck

Heather McMahon on behalf of Ktunaxa Nation Council



Bruce Kilgour, Independent Scientist

The Ministry of Energy, Mines and Petroleum Resources (EMPR) supports the endorsement of this report provided by the Ministry of Environment and Climate Change Strategy (ENV). The Interior Health Authority (IHA) participates on the EMC.

Glossary

Active water treatment
A method of removing constituents of concern from water that requires regular and/or frequent human intervention and management.

Acute toxicity
The adverse effects of a substance on an organism that result either from a single exposure to a toxicant or from multiple exposures in a short period of time.

Adaptive Management
A systematic process for learning from management actions to confirm that a plan's objectives are being met and to adjust and improve management actions.

Alkalinity
A way to measure the ability of water to neutralize acid.

Aquatic Organisms
Animals and plants that live in the aquatic environment.

Aquitard
A zone within the earth that lies adjacent to an aquifer and restricts the flow of groundwater, allowing only a small of water to pass. Aquitards are comprised of layers of either clay or non-porous rock with low hydraulic conductivity.

Area Based Management Plan
An environmental management plan for a designated area under the Environmental Management Act. The Elk Valley Water Quality Plan is an approved area based management plan for managing water quality effects in the Elk Valley.

Average monthly maximum
The average of all samples collected in a calendar month at a sample location (from Permit 107517).

Baseline
Current or existing conditions (or a temporal period specifically defined to represent baseline [e.g., the year 2010]) and serves as a reference point to which future conditions can be compared. Unless otherwise noted, baseline refers to a surveyed or measured condition, rather than one predicted through the use of models.

Benchmarks/Screening Benchmarks
A standard or point of reference against which things may be compared or assessed.

Benthic invertebrates
Organisms lacking backbones and that live in or on the bottom of sediments of rivers, streams, and lakes. They include the larvae of aquatic insects, as well as clams, snails, mussels, crayfish, and various other kinds of aquatic worms.

Bioaccumulation
The buildup of substances, including both toxic and benign substances, within the tissues of an organism.

Biological treatment
A method of treating water through the use of organisms such as bacteria and other microfauna.

Biodiversity
An abbreviation for "biological diversity", biodiversity refers to the variety of life on earth: the different animals, plants and micro-organisms, and the ecosystems of which they are a part.

Biota
The living organisms in an ecosystem.

Bryophytes
Seedless plants that include mosses and liverworts and play a vital role in regulating ecosystems.

Calcite index
A numeric expression of the extent and degree of calcite formation; typically given as a range from 0 to 3.0.

Calcite
A mineral made up of calcium, carbon and oxygen. Calcite is collecting and cementing gravels and cobbles in some stream beds downstream of some waste rock piles in the Elk Valley study area.

Chronic toxicity
Adverse effects on an organism as a result of long-term exposure to a toxicant or other stressor.

Compliance Point
An effluent monitoring location specified in the Environmental Management Act Permit at which discharge limits apply.

Constituents of interest
An element or ionic compound that may pose a threat to ecological or human health when present at sufficient concentrations.

Control water
Water used in a toxicity test that has not been modified or impacted by mining.

Cumulative effects
The environmental changes that occur from a project or activity combined with natural factors and effects from other past, present, and future human activities.

Daily maximum limit
The maximum measurement in a 24-hour period of a constituent (Permit 107517 has daily maximums, not average daily maximums).

Designated area
A portion of southeastern British Columbia that contains the Elk Valley and is geographically defined by the Order.

Director
As defined by the Environmental Management Act: a person employed by the government, and designated in writing by the minister as a director of waste management, or as an acting deputy or assistant director of waste management.

Discharge
The volume of water or effluent flowing past a point expressed as litres per second (L/s) or cubic metres per second (cms, or m^3/s).

Effect benchmark
A concentration of a constituent in tissue that has been shown to produce effects on an organism.

Effluent
As defined by the Environmental Management Act: a substance that is introduced into water or onto land and that (a) injures or is capable of injuring the health or safety of a person, (b) injures or is capable of injuring property or any life form, (c) interferes with or is capable of interfering with visibility, (d) interferes with or is capable of interfering with the normal conduct of business, (e) causes or is capable of causing material physical discomfort to a person, or (f) damages or is capable of damaging the environment;

Elk River watershed
The area that includes the Elk River and all of its tributaries.

Environmental Management Act
The BC Law that regulates waste disposal to water, land, and air.

Exposed site/area/stream areas
Sites/areas/streams that are downstream of mining activities.

Exposure pathway
The physical mechanism whereby a constituent of interest comes into contact with an organism; typically includes ingestion and direct contact.

Food chain
A model that describes how nutrients, energy, and contaminants are passed from organism to organism.

Freshet
The increase in river and stream flows due to snow melt.

Gamete
Fish eggs that will be fertilized and raised.

Groundwater
That part of the subsurface water that occurs beneath the water table, in soils and geologic formations.

Hardness
Hard water has a high content of calcium and magnesium or other dissolved metals. It can form deposits similar to scale that forms on the bottom of kettle. Calculated mainly from the calcium and magnesium concentrations in water, it originally developed as a measure of the capacity of water to precipitate soap. The hardness of water is environmentally important since it is inversely related to the toxicity of some metals (e.g., copper, nickel, lead, cadmium, chromium, silver and zinc).

Human health risk assessment
A determination of probable impacts to human health from contaminants that considers both exposure to and toxicity of a contaminant.

Local aquatic effects monitoring program
In the Elk Valley, these are programs designed to evaluate the environmental response to specific management actions or to address specific knowledge gaps.

Larval life stage
Newly hatched and not fully developed stage of invertebrate animals. Normally there is a fundamental change in form that is required to get from a larval form to an adult form. Mayflies, stoneflies and caddisflies, among many aquatic insects have larval forms that live in the water, while the adult and flying stages are more terrestrial (land based).

Management Unit
A portion of the Designated Area specified for water quality management purposes.

Market foods
Food purchased from a commercial setting.

Non-point source
A source of pollution that enters the environment at multiple locations (e.g. agricultural runoff from fields).

Opportunistic sampling
Collection of a sample at irregular intervals. For fish, this means a sample will be collected if they are caught in the course of other work.

Order (the)
A directive issued by the BC Minister of Environment in April 2013 requiring Teck to develop an area based management plan (also known as the Elk Valley Water Quality Plan).

Order station
A monitoring location specified by the Order to monitor water quality in the Designated Area.

Periphyton
Algae, bacteria, and other associated microorganisms attached to a submerged surface.

Phytoplankton
Microscopic algae that live in the water column and are food for zooplankton and fish.

Point source
A source of pollution that enters the environment at only one place (e.g. the end of a pipe).

Potable water
Water that is safe to drink.

Primary productivity
Growth of algae and other aquatic plants.

Productivity
A technical term for the amount of plant or animal matter that grows in a year on a per unit area (i.e., a square meter) basis.

Reach
A section of stream that is typically a minimum of 100 metres in length.

Receiving environment
Bodies of water that receive runoff/effluent of wastewater discharges, such as streams, rivers, ponds, lakes, etc.

Reclamation
The restoration of a site after mining or exploration activity is completed. Reclamation initiatives are used to create diverse environments that are similar to the pre-mining landscape. These landscapes are meant to attract a variety of wildlife species and to function in ways that will sustain biodiversity over time.

Reference stream
A watercourse that is not affected by point sources of contamination; used to compare the effects of mining activity on constituents of interest and calcite formation.

Regional Aquatic Effects Monitoring Program
A long-term monitoring program to assess potential regional-scale effects in the aquatic environment downstream of mining operations within the Elk River watershed.

Rehabilitation
Improving habitat for aquatic organisms.

Restoration
improving habitat for aquatic organisms so it has been returned to un-impacted state.

Site Performance Objective
An authorization limit or standard applicable to the receiving environment and imposed by the statutory decision maker (e.g., Ministry of Environment and Climate Change Strategy Director) that may be an adopted guideline or site specific water quality objective, or another limit set by the statutory decision maker after weighing multiple factors.

Trend analysis
An analysis of data that determines if variations in monitored endpoints (concentrations of chemicals for instance) are increasing or decreasing over time.

Variance analysis
An analysis of data that determines if variations in monitored endpoints (e.g., concentrations of chemicals for instance) are likely to be meaningful, or are otherwise related to various other factors (e.g., mine operations, land cover).

Water quality guideline
The concentration of a constituent of concern developed to protect ecological or human health; may be federal or provincial.

Water quality limit
A water quality concentration specified by Environmental Management Act Permit 107517 that the BC Ministry of Environment and Climate Change Strategy requires Teck to meet. Includes both Site Performance Objectives and Compliance Limits.

Wild Foods
Food that may be produced in an agricultural (not for commercial sale), backyard setting and/or harvested through hunting, gathering, and/or fishing activities. Also referred to as Country Foods.

Zooplankton
Small invertebrates that live in the water column and are a food source for many fish species.

1 Introducing the Elk Valley

In this chapter, the reader will be introduced to some of the geographical, social, and economic characteristics of the Elk Valley.

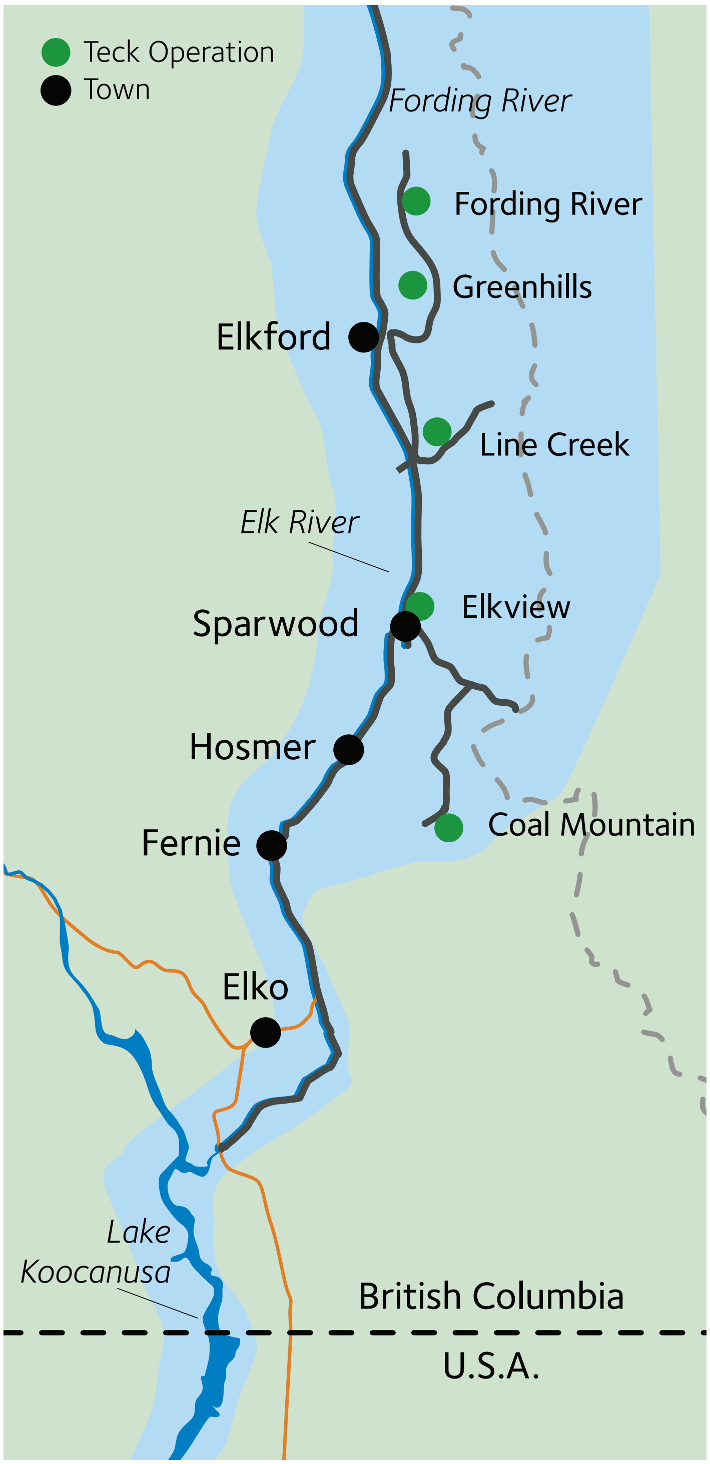


Figure 1. Primary Communities and Teck's Operations in the Elk Valley Watershed

The Elk Valley is located in the southeast corner of British Columbia and contains the main stem Elk River and many tributaries, including the Fording River. Archaeological evidence indicates that for more than 10,000 years the Ktunaxa (pronounced 'k-too-nah-ha') people have occupied the lands adjacent to the Kootenay and Columbia Rivers and the Arrow Lakes of British Columbia. The Ktunaxa Territory is divided into Land Districts, and the Elk Valley falls within one of these districts, called **Qukin ʔamakʔis**, or Raven's Land. The Ktunaxa people have continuously used and occupied the Elk Valley area within **Qukin ʔamakʔis**, and the formation of the geography of the Elk Valley is described in the final events of the Ktunaxa Creation story. Because of their deep connection to the Elk Valley, the Ktunaxa Nation Council (KNC) retains 3 seats on the EMC—two scientific seats and one Traditional Knowledge seat. Information on the Ktunaxa Nation, the Ktunaxa Creation story, and Ktunaxa law has been provided by KNC and can be accessed in Appendix A of this report.

The Elk Valley has a long history of mining activity and the regional economy is heavily dependent on steelmaking coal mining and related activities. Evidence demonstrates that the Ktunaxa were the first to mine the earth in the Elk Valley, and the Ktunaxa word for Raven's rock (coal) is **qukin nuʔkiy**. With the arrival of the southern branch of the Canadian Pacific Railway at the end of the 19th century, larger scale industrial mining began and brought families from across Canada, America and Europe to settle in the Elk Valley.

In 2003, Teck and Fording Coal combined five coal mines into Elk Valley Coal Partnership, which was operated by Teck, and in 2008, Teck acquired 100% of Fording Coal. In 2016, the Ktunaxa Nation and Teck signed an Impact Management and Benefits Agreement (IMBA)—a comprehensive agreement that sets out commitments and obligations for both parties that supports sustainable mining in the Elk Valley.

2 Monitoring Water Quality in the Elk Valley

In this chapter, the reader will find necessary background information about the mining-related environmental impacts that catalyzed the issuing of the Ministerial Order requiring the establishment of the Elk Valley Water Quality Plan; the issuing of Environment Management Act Permit 107517 (the Permit) to Teck; and the work of the Environmental Monitoring Committee.

Background: Mining and Water Quality in the Elk Valley

Teck operates five steelmaking coal mines in the Elk Valley. Steelmaking coal is different from thermal coal because it is used to produce steel, rather than burned to produce energy.

Steelmaking coal occurs as layers within rock. To access the coal, large quantities of this rock (referred to as waste rock) are mined and placed in piles within the mining pits or in nearby valleys, creating "valley-fill waste rock piles". As this rock is mined and broken up, significantly greater surface area of the rock is exposed to air and water (Step 1 in Figure 2).

The rock found in the Elk Valley is high in selenium and sulphate. Mining can speed up the release of these substances, as well as cadmium. Nitrate from blasting residue is being released into the environment. (Step 2).

Water from rain and melting snow flows through these waste rock piles taking selenium, cadmium, nitrate, sulphate, and other minerals, such as calcium, into nearby rivers and tributaries (Step 3), which flow downstream into the Elk River. As the Elk River flows into the Koocanusa Reservoir, upstream mining activities can influence water quality conditions in the Elk Valley and in the reservoir.

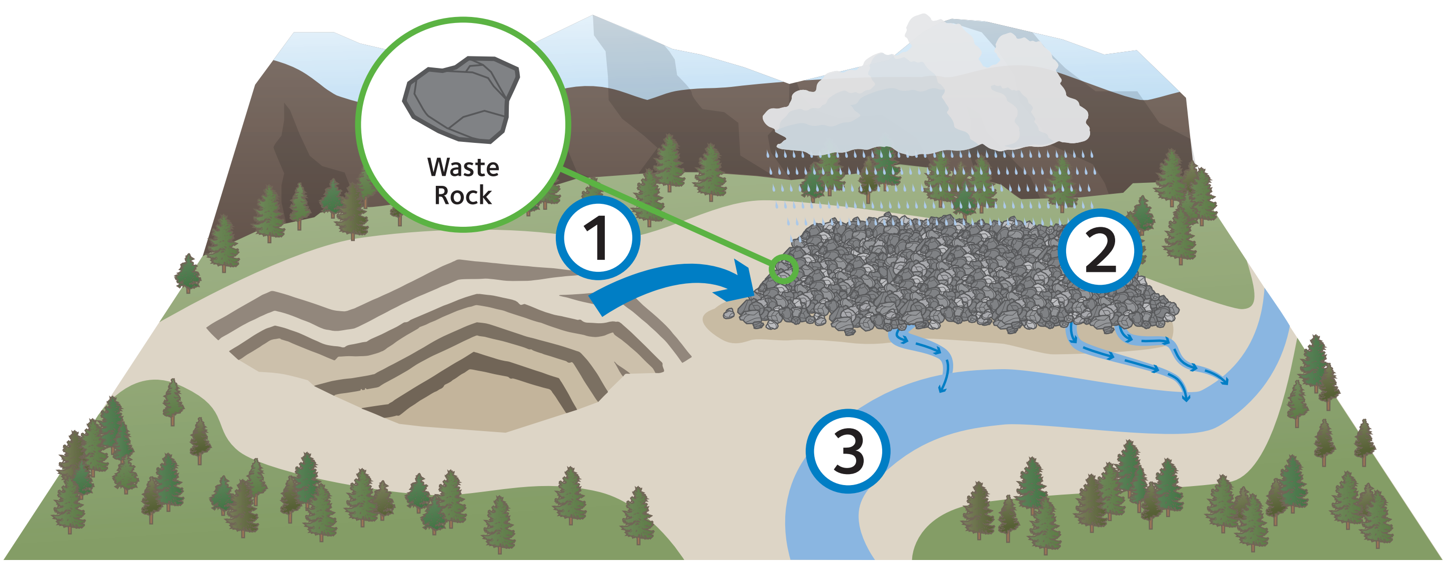


Figure 2: Simplified Relationship between Coal Mining and Water Quality in the Elk Valley

Initiating Efforts to Address Increasing Constituents

In response to evidence of increasing concentrations of selenium, cadmium, nitrate, and sulphate in watercourses in the Elk Valley, as well as evidence of calcite formation in some of these watercourses, the BC Ministry of Environment issued Ministerial Order No. M113 (the Order) to Teck in 2013. This Ministerial Order required that the company prepare an area based management plan for the Elk River watershed and Canadian portion of the Koocanusa Reservoir, to remediate water quality effects of past and current coal-mining activities, and to guide future development of mining operations.

The Order required Teck to assess water quality and to develop a water quality plan with the purpose of stabilizing and reducing these constituents. Teck developed an area based management plan called the Elk Valley Water Quality Plan (the Plan) with the advice from a technical advisory committee. This plan was subsequently approved by the BC Ministry of Environment in 2014 and Environment Management Act Permit 107517 (the Permit) was issued. This Permit authorizes effluent discharges from Teck's mining operations and required the establishment of the Environmental Monitoring Committee.

The overarching environmental management objectives of the Elk Valley Water Quality Plan are:

- Protection of groundwater;
- Protection of aquatic ecosystems;
- Protection of human health; and
- Management of bioaccumulation.

Figure 3: Background of the Environmental Monitoring Committee

The Elk Valley Water Quality Model

During preparation of the Elk Valley Water Quality Plan, Teck developed the Elk Valley Water Quality Model (the water quality model or the model). The water quality model provides a tool for predicting how historical, current, and future mining activities will affect the concentrations of selenium, nitrate, and sulphate in the Fording River, Elk River, main tributaries, and Koocanusa Reservoir. The water quality model is used to estimate future water quality conditions throughout the Elk Valley for a 20-year planning period, and uses more than two decades of historical data to estimate how coal mining and associated waste rock influences water quality.

The water quality model was used during the preparation of the Elk Valley Water Quality Plan to develop a phased implementation plan for water treatment, in order to meet Site Performance Objectives and Compliance Limits defined in the Permit. As the Elk Valley Water Quality Plan is implemented, the water quality model will be used in the Adaptive Management Plan as an assessment and planning tool for adaptively managing the planned water quality mitigation measures. See page 50 in the Water Quality chapter for further information about the water quality model.

The process of developing the Elk Valley Water Quality Plan involved characterizing baseline water quality, sediment and biological conditions, assessing current water quality conditions, projecting future of water quality, assessing potential effects to aquatic ecosystem health, and assessing the potential for human health effects through comparisons of concentrations of constituents in surface water, sediment, fish tissue and groundwater against provincial guidelines and health-protective benchmarks. The water quality assessment identified that selenium and nitrate concentrations in the Fording and Elk rivers were routinely elevated above water quality guidelines, and were generally increasing in many areas. There was evidence of selenium bioaccumulation in fish and other biota, and while no regional effects were found, localized effects were observed close to mine sources. Results from Teck's research and technology development program determined that active water treatment and clean-water diversions were the most effective options for stabilizing selenium and nitrate in the near-term.

A primary outcome of the Plan was to establish short-, medium- and long-term water quality targets at locations in the Elk Valley. The long-term targets are set at levels that will ensure continued human and aquatic health. Short-term targets are set with the goal of stabilizing levels of substances at locations where concentrations are expected to exceed long-term targets without mitigation. Medium-term targets are intended to ensure the implementation plan is on track to meet the long-term targets. The targets are a key measure for the successful implementation of the Plan, and contribute to determining what water quality mitigation measures may be necessary. Further details are provided in the Water Quality chapter (section five; page 38).

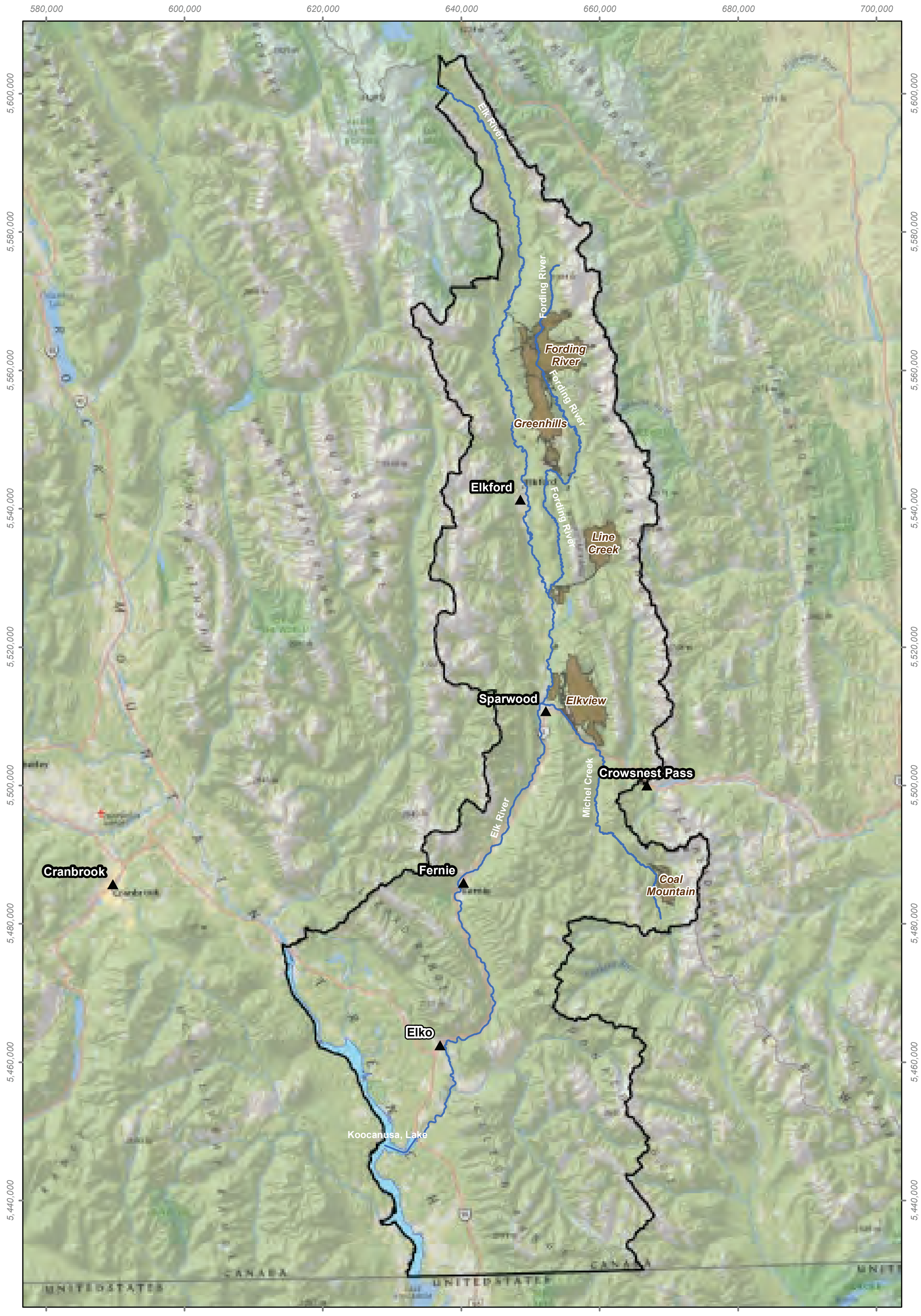
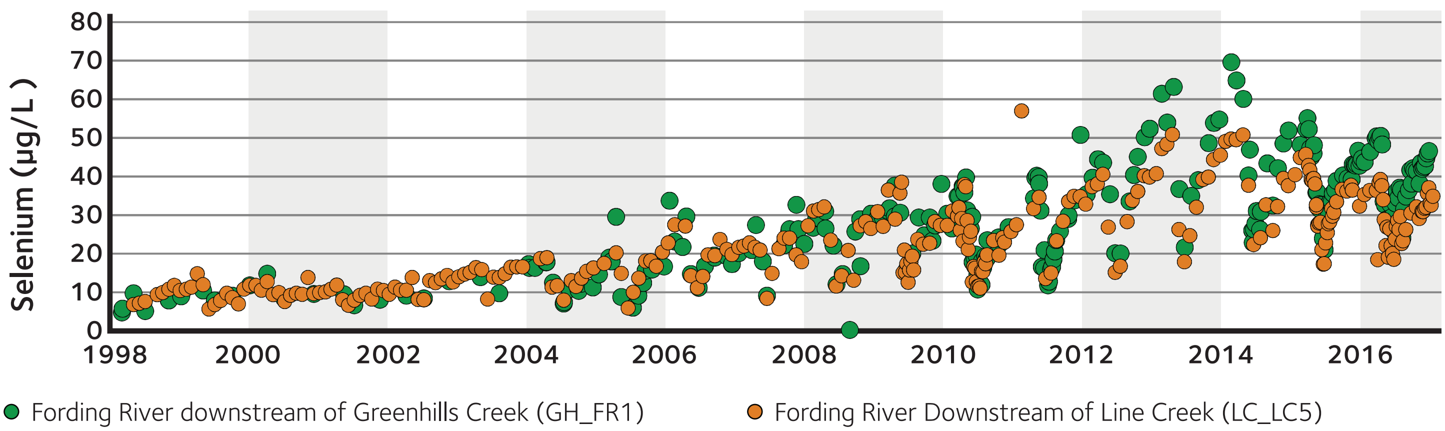


Figure 4: The EVWQP Boundary

Order Constituents

Selenium, cadmium, nitrate, sulphate, and calcite are specifically named in the Order. Collectively, these five constituents of interest are referred to as Order Constituents and are the focus of much of this public report. The primary source of these constituents is waste rock piles at Teck's five steelmaking coal mines in the Elk Valley. Studies show that waste rock piles placed decades ago continue to release these elements and are expected to do so for many decades more.



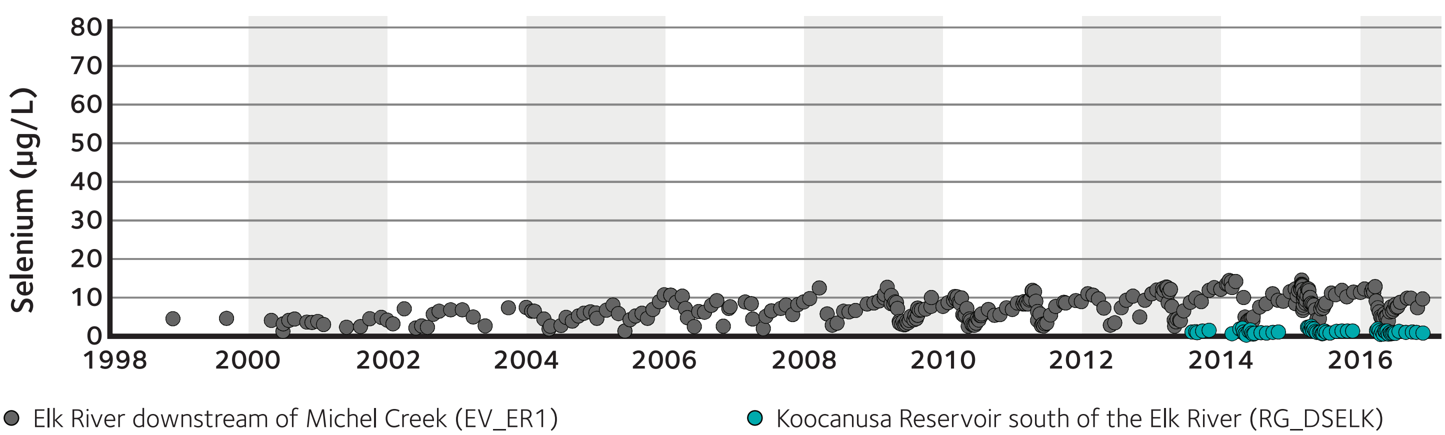
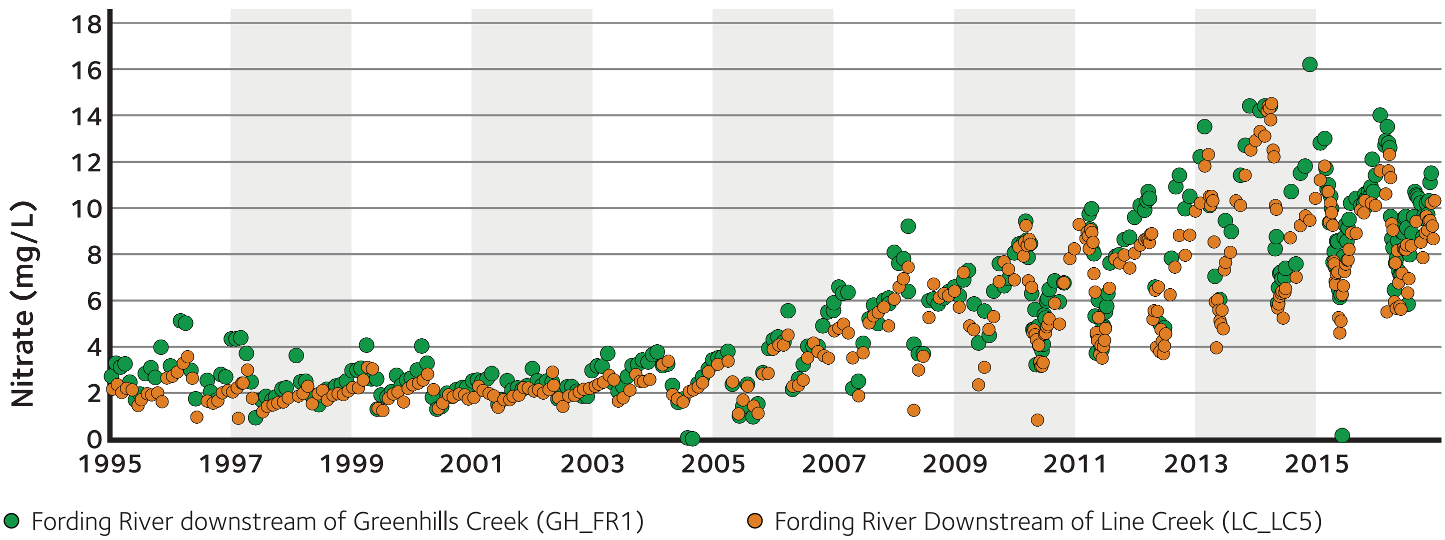


Figure 5: Historical Selenium Concentrations (1998-2016)

Selenium is a common element found naturally in rock and is an essential nutrient for living things. In water, such as tributaries and rivers, selenium can be taken up by algae and other microorganisms and transferred through the food web to aquatic invertebrates, fish, birds, and other vertebrates. When selenium occurs at higher concentrations it can interfere with reproduction, especially in animals that lay eggs such as fish, birds, amphibians, and reptiles.

Total selenium concentrations within the Elk Valley have been increasing since the 1990's, and based on data collected by Environment Canada at the long-term water quality monitoring station in the Elk River (at Highway 93 bridge South of Elko, BC), concentrations have been observed to exceed the British Columbia Freshwater Aquatic Life Water Quality Guideline (2 μg/L) since around 1993. Selenium concentrations at this monitoring station steadily increased and reached a peak concentration (~8.2 μg/L) in approximately late-2013/early-2014. Similar patterns can be seen at other monitoring stations in the area.

Refer to Figure 5 for a graphical illustration of recorded selenium concentrations at a selection of key water sampling locations from 1998 to 2016. Sampling for selenium concentrations was not conducted prior to 1998 at these locations.



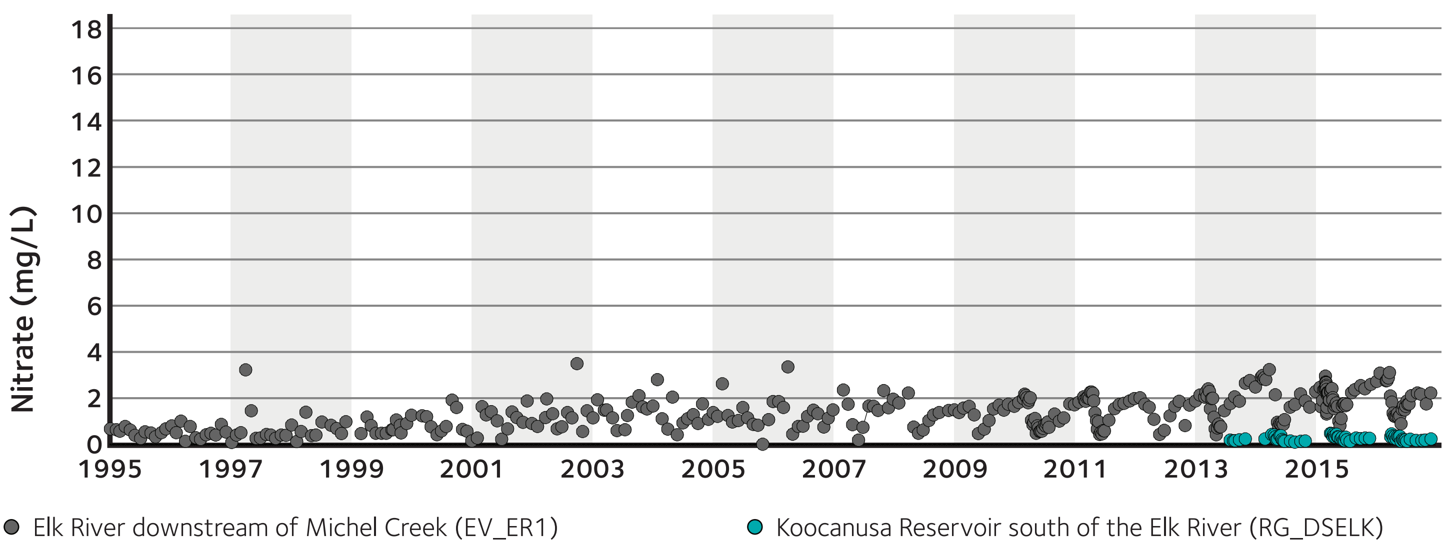
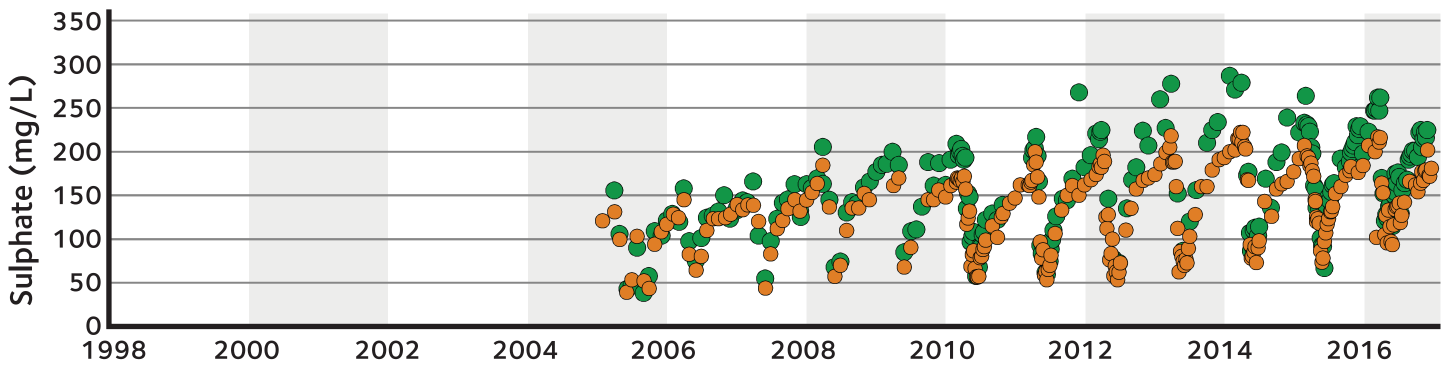


Figure 6: Historical Nitrate Concentrations (1995-2016)

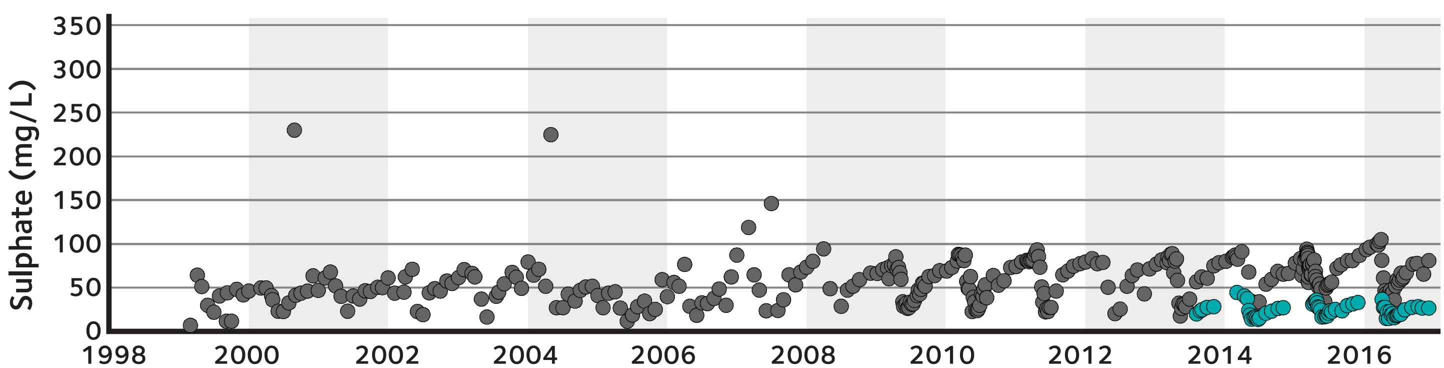
Nitrate is an inorganic substance that contains nitrogen and oxygen. It is carried by water from waste rock piles containing blasting material used for mining. At elevated concentrations, nitrate can be toxic to fish and other aquatic organisms. It disrupts their ability to use oxygen, which harms growth and development, particularly in the early life stages (e.g., larval stage) of fish. High levels of nitrate can also contribute to eutrophication, which is when excess nutrients in the water stimulate excessive plant growth.

Similar to selenium, nitrate concentrations have increased within the Elk Valley over time. Based on data collected by Environment Canada at the same long-term water quality monitoring station in the Elk River (at Highway 93 bridge South of Elko, BC), nitrate concentrations follow a similar pattern observed for selenium at this station. Based on data collected to date, the highest nitrate concentrations were measured in 2014.

Refer to Figure 6 for a graphical illustration of recorded nitrate concentrations at a selection of key water sampling locations from 1995 to 2016.



● Fording River downstream of Greenhills Creek (GH_FR1) ● Fording River Downstream of Line Creek (LC_LC5)



● Elk River downstream of Michel Creek (EV_ER1) ● Koocanusa Reservoir south of the Elk River (RG_DSELK)

Figure 7: Historical Concentrations of Sulphate (1998-2016)

Sulphate is a naturally occurring substance that contains sulphur and oxygen. It is released from waste rock through the oxidation of minerals containing sulphide. Exposure to sulphate in water can interfere with the ability of many aquatic invertebrates to regulate bodily fluids. At elevated levels, sulphate is toxic to fish and other aquatic organisms.

Some patterns of sulphate concentrations mirror those of selenium concentrations, and elevated concentrations are understood to be associated with waste rock piles. Similar to the other Order Constituents, sulphate concentrations recorded at certain stations show an increasing trend peaking in 2013–2014.

Refer to Figure 7 for a graphical illustration of recorded sulphate concentrations at a selection of key water sampling locations from 1998 to 2016.

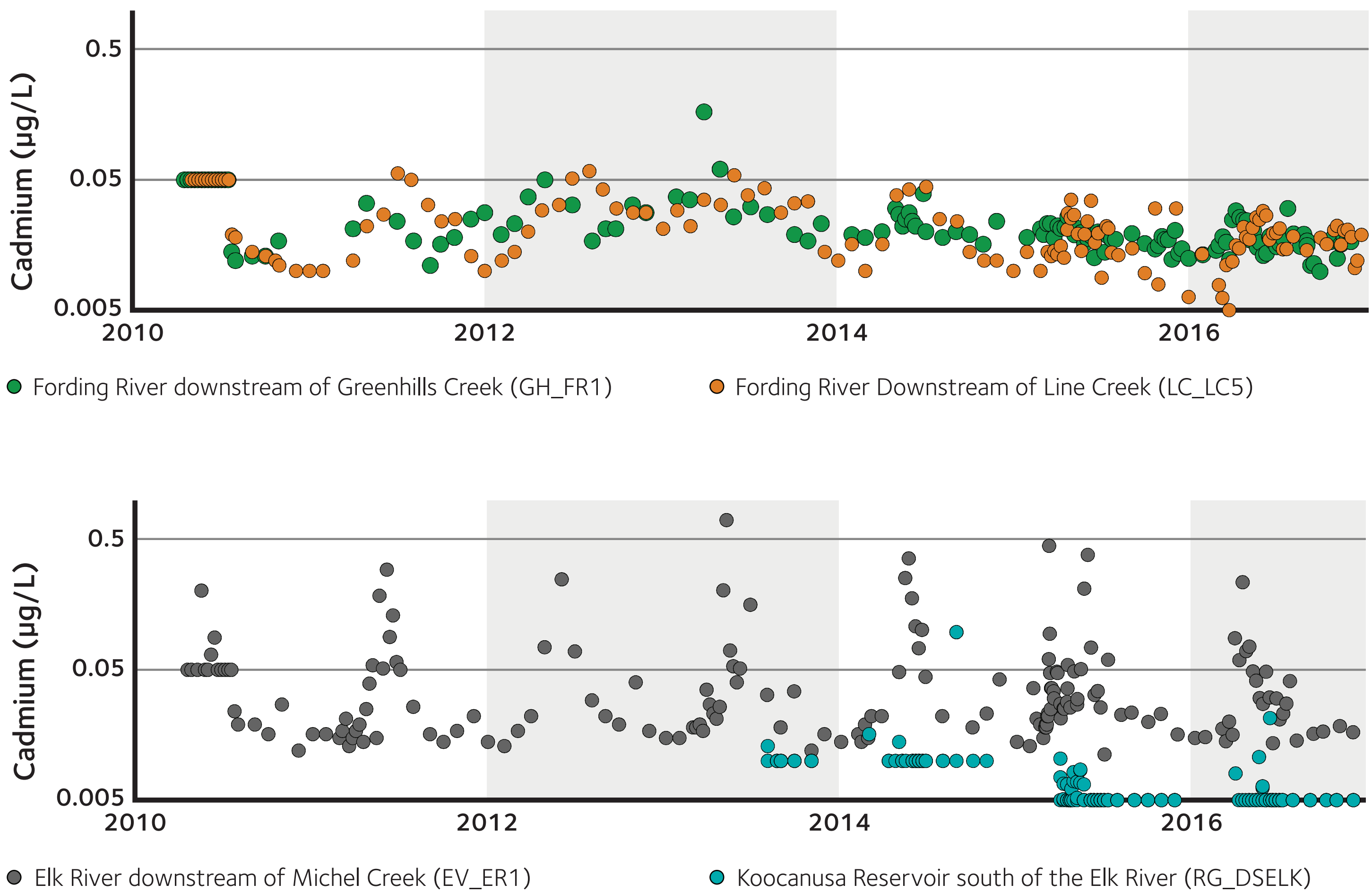


Figure 8: Historical Concentrations of Cadmium (2010-2016)

Elevated cadmium concentrations have been observed locally in some tributaries in the Elk Valley. Cadmium concentrations at monitoring stations appear to be driven by background conditions and seem to be less associated with waste rock piles. Continued surface water monitoring for cadmium will help improve understanding of relationships, patterns, and effects.

Refer to Figure 8 for a graphical illustration of recorded cadmium concentrations at a selection of key water sampling locations from 1995 to 2016. Sampling for cadmium concentrations was not conducted prior to 2010 at these locations.

Calcite is a white or colourless mineral consisting of calcium carbonate. As water travels through the ground, or through mining waste rock, calcium carbonate is dissolved and carried downstream where it may precipitate (i.e. separate from the water) and form a calcite crust on stream beds. This is similar to what happens when calcium builds up on the bottom of your kettle. When calcite builds up in a stream, it can change the characteristic of the stream by cementing rocks together, potentially making it difficult for some species of fish to use the streambed for reproductive nesting habitats.

Calcite formation has been observed in the Elk Valley watershed downstream of mining activities and, to a lesser extent, in streams unaffected by mining. There are wide ranges in the extent of calcite cover and Teck is committed to continuing a program of monitoring and management for calcite.

Refer to the Calcite chapter on page 108 for further information on calcite measurement and planned management approaches.

Background: Environmental Monitoring Committee

The Environmental Monitoring Committee (EMC) was formed in 2015 as a condition of Environment Management Act Permit 107517 (the Permit) issued to Teck by the BC Ministry of Environment. The Permit followed the BC Ministry of Environment's approval of the Elk Valley Water Quality Plan (discussed above).

Quick Facts—the Environmental Monitoring Committee

- Reviews monitoring submissions required under the Permit and provides science-based and Traditional Knowledge advice;
- Has its membership defined by the Permit;
- Is a non-regulatory body that will be active throughout Teck's mine operations in the Elk Valley;
- Prepares and releases a plain-language public report annually (i.e. this report);
- Hosts an annual public open house where members of the EMC and Teck representatives discuss information reviewed by the EMC, present results of the third-party audit activities, and answer questions.

Membership

The EMC consists of representatives from the following organizations, plus an independent scientist:

- British Columbia Ministry of Environment and Climate Change Strategy (ENV)[1]
- British Columbia Ministry of Energy, Mines and Petroleum Resources (EMPR)
- Ktunaxa Nation Council (KNC)
- Interior Health Authority (IHA)
- Teck Coal Limited (Teck)
- Independent Scientist

Environment and Climate Change Canada (i.e. at the federal level of government) has agreed to provide its perspectives on matters related to the Permit and the EMC's activities on a case-by-case basis when requested by the EMC. To-date, the EMC has not called on Environment and Climate Change Canada to participate.

[1] In August 2017, the BC Ministry of Environment was re-named the BC Ministry of Environment and Climate Change Strategy. However, where the ministry is referenced before this date, the BC Ministry of Environment name was used.

Figure 9: Timeline of Events

2013

April 2013
The British Columbia Ministry of Environment (MoE), under Section 89 of the Environmental Management Act (EMA) of British Columbia, issued Ministerial Order No. M113 (the Order) to Teck requiring that the company prepare an area based management plan (ABMP) for the Elk Valley to remediate water quality effects of past coal-mining activities and to guide future development.

2014

July 2014
Teck submitted its area based management plan—known as the Elk Valley Water Quality Plan—to the Ministry of Environment as required by the Order.

November 2014
The Ministry of Environment approved the Elk Valley Water Quality Plan and issued Environmental Management Act permit (Permit 107517), authorizing effluent discharges from Teck's steelmaking coal operations in the Elk Valley (Figure 3) and requiring the establishment of the EMC.

2015

March 10, 2015
The first EMC meeting was held.

2015
Four in-person EMC meetings held

October 27, 2015
The first EMC public meeting was held in Fernie concurrent with the third in-person meeting of the EMC.

2016

January 26–29, 2016
EMC meeting in Vancouver

April 26–28, 2016
EMC meeting in Cranbrook

June 20–24, 2016
EMC meeting in Fernie

October 18–21, 2016
EMC meeting in Fernie

October 19, 2016
The second EMC public meeting was held in Fernie

Role of the Environmental Monitoring Committee

As defined by the Permit, the EMC provides input on the design of environmental monitoring studies (i.e., what is monitored, when, and where), and reviews the results of those environmental monitoring studies. The EMC may recommend changes to monitoring plans or request new supporting studies to help answer new questions. The EMC is focused solely on its obligations specified in the Permit.

Under the Permit, the EMC reviews submissions (i.e. documentation that will be submitted to the BC Ministry of Environment and Climate Change Strategy) and provides science-based advice to Teck and to the Ministry of Environment and Climate Change Strategy. EMC advice is focused on providing input to the design of monitoring studies and to Teck reports which detail the results and interpretation of results, both of which are submitted to the BC Ministry of Environment and Climate Change Strategy. The EMC may also review other monitoring data relevant to water quality and aquatic life in the Fording and Elk rivers, as well as in the Koocanusa Reservoir, and provide input into the associated annual reports that are submitted to the regulator. Teck provides written responses to the EMC about how its advice and input has been considered in alignment with the current advice and input protocol developed by the EMC. This public report is largely focused on discussing the above activities.

The EMC does not replace the regulatory responsibilities of government agencies, direct government-to-government agreements or discussions, or direct Teck-to-Ktunaxa Nation agreements or discussions.

The EMC is required by the Permit to host an annual public meeting to communicate monitoring results. Additionally, the EMC Terms of Reference* state that the EMC is committed to hold a minimum of four face-to-face meetings per year.

Studies and Reports the EMC Provides Input On

In accordance with the Permit, the EMC reviews submissions and provides science-based advice to Teck and to the BC Ministry of Environment and Climate Change Strategy regarding the monitoring study designs and monitoring reports shown in Figure 10 below. The reader will notice that many of the topics listed are also the topics discussed in this public report.

Study Design Topics	Monitoring Report Topics
Adaptive Management	Adaptive Management
Chronic Toxicity Testing Program	Tributary Evaluation and Management
Groundwater Monitoring Program	Groundwater
Local Aquatic Effects Monitoring Programs	Local Aquatic Effects Monitoring Programs
Regional Aquatic Effects Monitoring Program (RAEMP)	Regional Aquatic Effects Monitoring Program
Calcite Monitoring	Calcite
Human Health Risk Assessment	2015 Koocanusa Reservoir Burbot Baseline Study
Third-Party Audit	Third-Party Audit
	Re-evaluation of Limits
	Annual Reporting (Discharge and Receiving Environment Monitoring Data)
	Koocanusa Reservoir
	Water Quality Modelling

Figure 10: Studies and Reports the EMC Provides Input On

Summary—Role of the Environmental Monitoring Committee

As outlined in its Terms of Reference, the role of the EMC is to:

- Provide science-based and/or Traditional Knowledge-based advice to Teck, the Ktunaxa Nation Council, and the Ministry of Environment
- Support communicationg of environmental monitoring results collected under the Elk Valley Water Quality Plan and the Permit to Ktunaxa Nation members
- Provide advice to support continual improvement in monitoring activities conducted under the Elk Valley Water Quality Plan and the Permit

*The EMC Terms of Reference can be accessed at www.teck.com/elkvalley

Traditional Knowledge

Including Traditional Knowledge in the EMC's work is described in the EMC Terms of Reference and is an aspect the EMC continues to develop.

Environmental Monitoring Committee Advice and Input Protocol

The EMC receives monitoring submissions and reports for review as prescribed by the Permit. Teck is required to provide the EMC with:

- Draft study designs for specific monitoring activities, and
- Reports detailing results of monitoring activities.

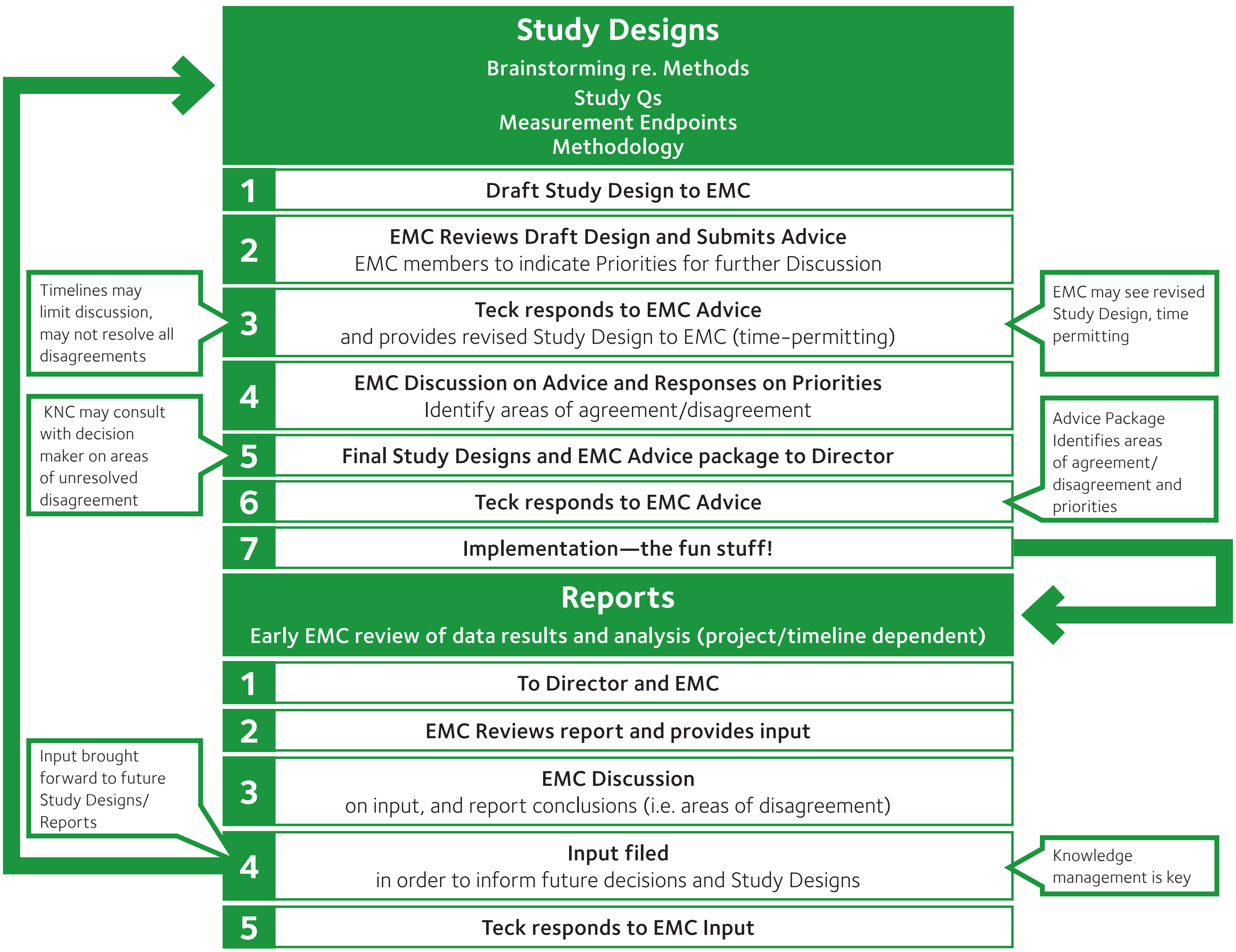


Figure 11: Overview of EMC Engagement with regards to Monitoring Activities under the Permit

In order to obtain input on the data and approaches to analyzing and interpreting the data, Teck presents the monitoring data to the EMC prior to issuing final reports. Presentations to the EMC are made via conference call or in-person meetings. Each EMC member organization conducts an independent review and provides written comments using a common template. All EMC comments are consolidated into a single document and shared with all EMC members, including Teck. Teck subsequently responds to EMC comments within submissions or directly to the EMC after a submission has been made. Teck submits their final reports and study designs to the Ministry of Environment and Climate Change Strategy and also provides them to the EMC.

EMC input on final monitoring reports may be used by Teck to inform the design of subsequent monitoring activities. The study designs and reports are often complex, detailed, and require specialized knowledge and expertise to review in order to provide meaningful comments to Teck. Members of the EMC may call upon others within their member organization, or external consultants, to support their review.

Science-based advice and input provided by EMC members has the potential to change over time, as new information becomes available and study designs evolve. Conference calls and in-person meetings are used to discuss and understand perspectives of individual EMC members.

Priority Advice

In spring 2016, the EMC took steps to identify priority advice in order to focus on the comments of the greatest importance to the EMC and identify areas where EMC member organizations are not in agreement. The EMC continues to discuss and to evolve the advice and input protocol with the goal of developing consensus on input and advice.

Working with Other Committees

The EMC may serve a role in sharing information with other committees, as outlined in the EMC Terms of Reference. In 2015, the EMC identified other committees and groups with objectives that align with the EMC's—particularly those groups working on aquatic issues—as candidates for the EMC to communicate with, if and when desirable to do so.

In 2015, the EMC began working with members of the Elk Valley Fish and Fish Habitat Committee on the Tributary Evaluation Program. By inviting fish committee members to participate in EMC discussions related to tributaries, the EMC benefits from the fish committee's extensive knowledge and experience.

Some members of the EMC also hold membership on the Koocanusa Reservoir Monitoring and Research Working Group (KRMRWG)[2], allowing these EMC members to bring information from the KRMRWG to the EMC table. As a requirement of the Permit, Teck participates fully in the KRMRWG and annually provides the KRMRWG with a report summarizing Teck's activities and monitoring results that take place in the Canadian portion of the reservoir.

[2]The KRMRWG is also known as the Lake Koocanusa Monitoring and Research Group.

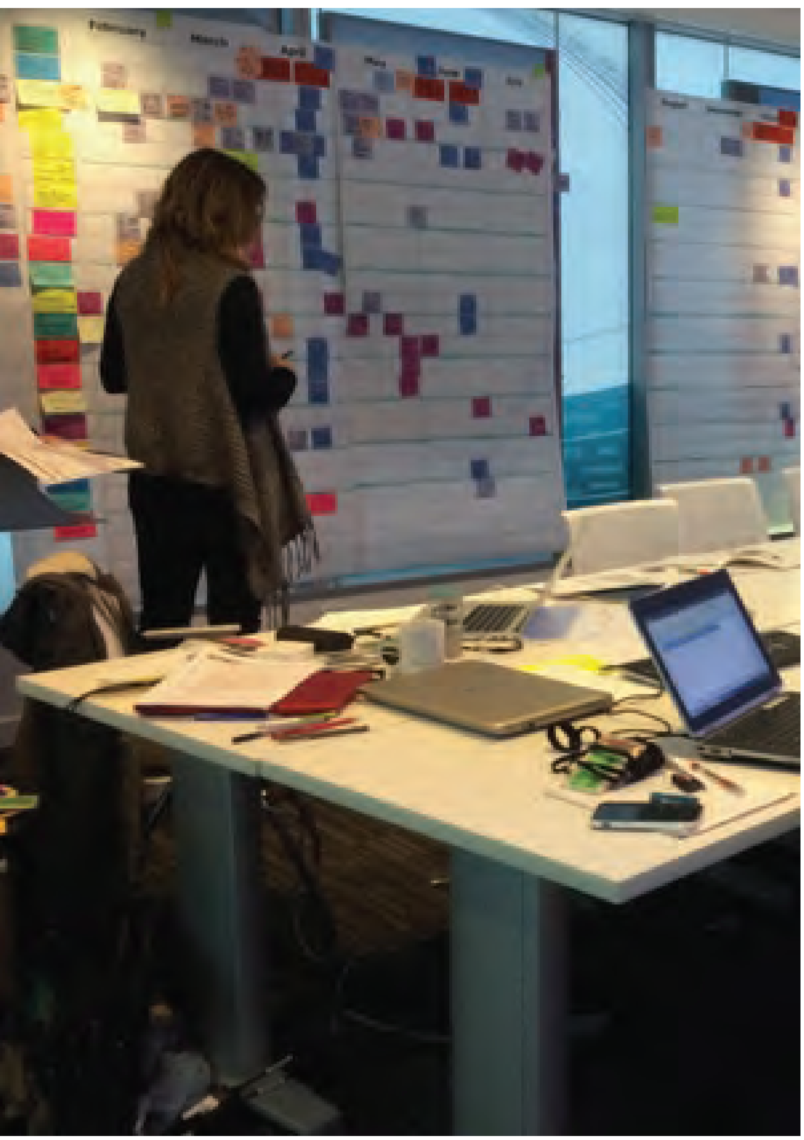
3 Environmental Monitoring Committee Activities in 2016–2017

In this chapter, the reader will find an overview of the activities carried out by the Environmental Monitoring Committee since the last public report was issued at last year's public meeting.

Submissions Reviewed

Since the last public meeting held on October 19, 2016, the Environmental Monitoring Committee (EMC) has reviewed and provided science-based advice and input on 32 submissions and reports (i.e., draft designs for monitoring tests and studies, annual reports, etc.) from Teck (Table 1). In addition to verbal feedback EMC members provide during meetings and conference calls, EMC members provided 1,113 pieces of written advice and input. Teck considers all feedback from the EMC and provides written responses to each piece of written advice and input.

In addition to reviewing submissions from Teck and providing advice or input, the EMC met in-person four times and held 26 conference calls to discuss monitoring activities in 2017.



Meetings

2017 Face-to-Face Meetings:

Jan 31-Feb 3	Vancouver
Apr 24-28	Cranbrook
Jun 19-23	Fernie
Oct 24-27	Fernie

2016/2017 Conference Calls:

Nov 21	Third-Party Audit
Nov 24	Regional Aquatic Effects Monitoring Program
Nov 30	Chronic Toxicity Testing
Dec 8	Regional Aquatic Effects Monitoring Program
Dec 20	Tributary Evaluation and Management
Feb 14	Chronic Toxicity Testing
Feb 15	Annual Water Quality Report
Mar 3	Seasonal Calcite and Biological Effects of Calcite
Apr 11	Pre-Meeting
Apr 13	Groundwater Monitoring Program
May 15	LCO LAEMP
May 16	Koocanusa Monitoring
Jun 7	EMC Meeting #13 Planning
Aug 21	Public Report
Aug 22	Public Report
Aug 31	Public Meeting
Sep 19	Tributary Management Plan
Sep 25	Public Report
Sep 26	Public Meeting
Oct 3	EMC Meeting #14 Planning
Oct 5	Public Meeting
Oct 10	Public Meeting

TECK SUBMISSIONS REVIEWED BY THE EMC	FIND MORE INFORMATION
NOVEMBER 2016	
Tributaries Analysis and Interpretation Report	Page 100
DECEMBER 2016	
Third-Party Audit Scope	Page 124
FEBRUARY 2017	
Regional Aquatic Effects Monitoring Program Data	Page 81
Interim Tributary Management Plan	Page 100
MARCH 2017	
Seasonal Calcite Supporting Study Data	Page 113
Seasonal Calcite Supporting Study Final Report	Page 113
Elk Valley Annual Water Quality Report for 2016	Page 38
Chronic Toxicity Testing Program and Interpretive Report for 2016	Page 52
Tributaries Analysis and Interpretation Report Revised	Page 100
Tributary Management Plan Draft	Page 100
MAY 2017	
Line Creek Operations Local Aquatic Effects Monitoring Program Data	Page 90
Regional Groundwater Monitoring Program Report for 2016	Page 56
Calcite Effects on Fish Spawning and Incubation Success Report for 2016	Page 115
Line Creek Operations Local Aquatic Effects Monitoring Program 2017 Study Design	Page 90
Line Creek Operations Local Aquatic Effects Monitoring Program Report for 2016	Page 90
Fording River Operations Local Aquatic Effects Monitoring Program Report for 2016	Page 84
Calcite Monitoring Program Report for 2016	Page 110
JUNE 2017	
Greenhills Operations Local Aquatic Effects Monitoring Program Study Design for 2017–2020	Page 94
Calcite Effects on Fish Spawning and Incubation Success Draft Study Design	Page 115
Koocanusa Monitoring	Page 94
JULY 2017	
Adaptive Management Plan Annual Report	Page 36
Interim Tributary Management Plan	Page 100
SEPTEMBER 2017	
Regional Aquatic Effects Monitoring Program Three-Year Report	Page 81
Regional Groundwater Monitoring Program Update	Page 56
OCTOBER 2017	
Third-Party Audit Report	Page 124
NOVEMBER 2017	
Tributary Management Plan—Revised	Page 100
DECEMBER 2017	
Regional Aquatic Effects Monitoring Program Three-Year Report—Final	Page 81
Regional Aquatic Effects Monitoring Program Three-Year Study Design	Page 81
Sulphate Toxicity at High Hardness Concentrations Report	Page 53
Integrated NO3-SO4 Toxicity Study Report	Page 55

Table 1. Submissions Reviewed by the EMC

What's Next?

The EMC will continue to meet in-person and via conference calls to review monitoring submissions and reports, and provide science-based advice or input as required by the permit.

4 Adaptive Management Plan

In this chapter, the reader will find an introduction to the concept of adaptive management and information on how the Adaptive Management Plan will be used to achieve the objectives of the Elk Valley Water Quality Plan. The Adaptive Management Plan is intended to support the implementation of the Elk Valley Water Quality Plan by addressing key uncertainties associated with water quality and calcite management. The information generated through the various monitoring programs discussed in the remainder of this report feeds into the Adaptive Management Plan, in order to improve the approach to understanding and mitigating environmental impacts associated with Teck's five steelmaking coal mines in the Elk Valley.

Context

Under the Permit, Teck is required to develop and implement an Adaptive Management Plan to support implementation of the Elk Valley Water Quality Plan. The Adaptive Management Plan combines all necessary management activities into a comprehensive environmental management framework, which works towards achieving the objectives of the Elk Valley Water Quality Plan (discussed on page 15). The Adaptive Management Plan is based on the adaptive management cycle (see Figure 12), and the Permit specifies actions to be undertaken during each of the six stages of the adaptive management cycle.

Introduction to Adaptive Management

To achieve environmental management objectives, the adaptive management cycle provides opportunities for adjustments to management actions, monitoring programs, and evaluation processes where areas for improvement are identified. Adaptive management aims to maximize learning about uncertainties in management approaches and performance. This facilitates Teck to adapt management actions based on what is learned, in order to achieve environmental management objectives. It is an explicit focus on identifying and reducing key uncertainties that can affect management decisions.

Adaptive management follows a six-stage cycle where:

1. A management problem is assessed (Assess);

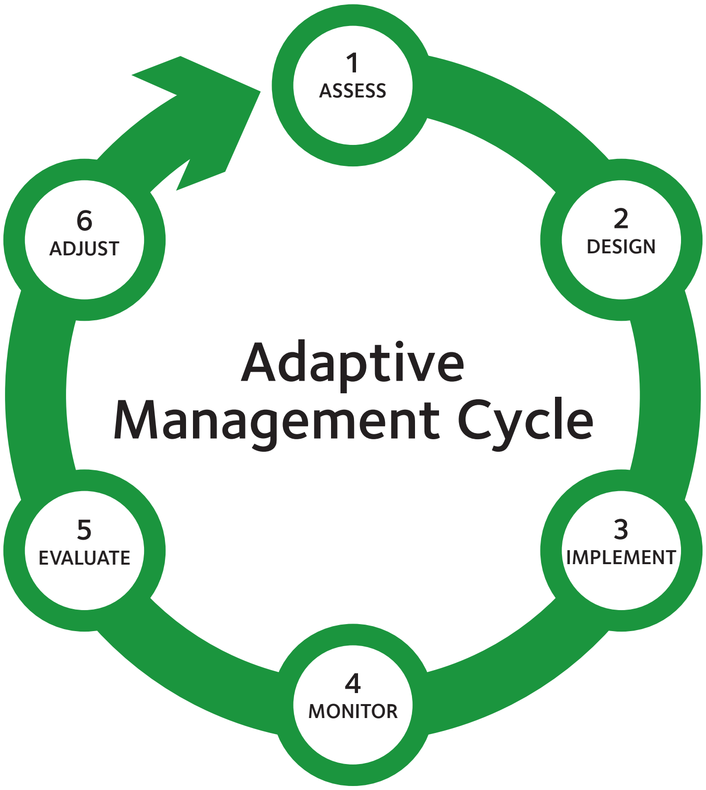
2. A solution is identified and developed (Design);

3. The solution is implemented (Implement);

4. The success of the solution and its implementation are monitored (Monitor);

5. The solution is re-evaluated for its ability to achieve intended objectives (Evaluate); and

6. Adjustments are made where required (Adjust).



1. Assess

Define the management problem

Identify measurable objectives—what are you trying to achieve?

Identify key uncertainties—what do you need to learn to be more confident about achieving the objectives? What hypotheses could be tested to learn it? What could you change if you learned it?

2. Design

Design plans for Stages 3–5 to solve the management problem, and to reduce the key uncertainties

Predict expected outcomes from current knowledge

3. Implement

Implement the management actions, and alternatives if feasible; document deviations

4. Monitor

Implementation monitoring (was implementation done as expected?)

Effectiveness monitoring (what were the results, e.g. was there an improvement in water quality?)

Validation monitoring (e.g. is there an improvement in aquatic ecosystem health?)

5. Evaluate

Evaluate monitoring results against expectations (e.g. model predictions) and quantitative objectives

Follow-up in response to unexpected outcomes

What conclusions can you draw—what did you learn?

6. Adjust

Modify management actions as appropriate

Modify monitoring and evaluation if needed

Figure 12: The Adaptive Management Cycle

Developing the Adaptive Management Plan

The Permit requires that the Adaptive Management Plan receives approval by the BC Ministry of Environment and Climate Change Strategy, and the proposed Adaptive Management Plan is currently under review.

To organize the currently proposed Adaptive Management Plan, six overarching environmental management questions were formulated, which are referred to as "big questions":

1. Will Compliance Limits and Site Performance Objectives be met for selenium, nitrate, sulphate, and cadmium?

2. Will aquatic ecosystem health be protected by meeting the long-term Site Performance Objectives?

3. Are the combinations of methods for controlling selenium, nitrate, sulphate, and cadmium included in the implementation plan the most effective for meeting Compliance Limits and Site Performance Objectives?

4. Is calcite being managed effectively to meet Site Performance Objectives and protect aquatic ecosystem health?

5. Does monitoring for mine-related effects indicate that the aquatic ecosystem is healthy?

6. Is water quality being managed to be protective of human health?

The proposed Adaptive Management Plan outlines activities that will be undertaken to evaluate and answer these six big questions. Key management uncertainties are also identified under each big question, along with designs of monitoring studies that will be used to evaluate and reduce the uncertainties. Learnings from key uncertainty evaluations are intended to contribute to improvements to different stages of the adaptive management cycle. Two key uncertainties that will be a focus for Teck and the EMC in the near-term are:

- The development of water quality based early warning triggers; and
- The evaluation of aquatic effects monitoring data to identify meaningful biological endpoints (to properly detect changes in aquatic organisms, populations, and/or ecosystems).

How does the Adaptive Management Plan relate to the environmental monitoring discussed in the rest of this public report?

Under the Permit, Teck must develop and implement a variety of environmental monitoring programs that ultimately work together to increase understanding of the environmental impacts of coal mining in the Elk Valley. The chapters in the remainder of this public report are focused on discussing these various environmental monitoring programs. The data that is generated under the various environmental programs is being used to better understand environmental impacts and identify where further investigation is required through environmental monitoring. This knowledge will inform approaches to monitoring and impact mitigation activities, in order to ensure that the goals of the Elk Valley Water Quality Plan are met over time. The Adaptive Management Plan will serve as the framework which facilitates the above process of learning to inform monitoring and management actions, and it will do so on a continuous basis (i.e. the process repeats continuously to refine knowledge and actions).

Status

Adaptive Management Plan Submission

The Adaptive Management Plan was submitted to the BC Ministry of Environment and Climate Change Strategy on February 29, 2016, as required by the Permit. Following this, the EMC reviewed the Adaptive Management Plan and provided substantial technical advice. Teck considered this advice and submitted a revised Adaptive Management Plan to the Director and the EMC on July 31, 2016. The EMC reviewed the revised submission and provided additional technical advice, concluding in September 2016. In October 2016, KNC wrote a letter that outlined their key concerns with the submission. The KNC, Teck, and BC Ministry of Environment and Climate Change Strategy continue to work towards addressing the concerns about the Adaptive Management Plan identified by the KNC.

Work to Address Key Uncertainties

In consultation with the EMC, Teck has been advancing work towards resolving two key uncertainties (as introduced above):

- The development of water quality based early warning triggers; and
- The evaluation of aquatic effects monitoring data to identify meaningful biological endpoints (to properly detect changes in aquatic organisms, populations, and/or ecosystems).

The water quality early warning triggers, once finalized, will become part of the Adaptive Management Plan and resolve a key uncertainty under big question 1—"what are effective water quality early warning triggers?".

Evaluation of aquatic effects monitoring data, and consideration of how this data is used to identify meaningful biological endpoints (i.e. growth, reproduction, survival, etc.), will be undertaken in consultation with the EMC. The development of a framework used to review and evaluate data that is generated under the Regional Aquatic Effects Monitoring Program is ongoing (see page 81 for further information on this program), and the EMC is providing input to the development of this framework. Once this framework is developed, biological monitoring triggers will be developed, and will become part of the Adaptive Management Plan.

Annual Report

The Permit requires that an annual report documenting the activities undertaken in each stage of the Adaptive Management Plan be submitted to the BC Ministry of Environment and Climate Change Strategy by July 31st each year. The Permit also requires that the Adaptive Management Plan is updated every three years. The EMC provides technical advice related to the Adaptive Management Plan, and provides input on the Adaptive Management Plan annual reports.

Given the work underway to resolve KNC's concerns with the submitted Adaptive Management Plan, the BC Ministry of Environment and Climate Change Strategy required Teck to develop an Adaptive Management Plan status report, rather than an Adaptive Management Plan annual report in 2017. The BC Ministry of Environment and Climate Change Strategy stated that the status report must include how Teck is addressing KNC's concerns, progress on development of early warning triggers, and examples of adaptive decision-making to date. As well, the status report was required to include details on how the Adaptive Management Plan will make connections across programs that are necessary to inform decision-making at Teck's operations. The Adaptive Management Plan status report was submitted to the BC Ministry of Environment and Climate Change Strategy and KNC on July 27, 2017.

What's Next

Teck will continue to work actively with the BC Ministry of Environment and Climate Change Strategy and KNC to advance the Adaptive Management Plan to a point of acceptance by the BC Ministry of Environment and Climate Change Strategy. In parallel, monitoring programs and supporting studies to reduce identified key uncertainties will continue to be advanced, as outlined in the submitted version of the Adaptive Management Plan. These monitoring plans and supporting studies will continue to be discussed at the EMC table in alignment with the Permit requirements.

5 Water Quality

In this chapter, the reader will find information about four main topics, including:

- Surface water quality monitoring and results from locations throughout the Elk Valley and downstream in the Koocanusa Reservoir (focused on discussing the concentrations of various constituents in surface water);
- Toxicity testing information and results (examines potential effects of mine-influenced waters on aquatic organisms);
- Groundwater quality monitoring and results (examines the quality of groundwater by comparing results to water quality guidelines for drinking water, irrigation and livestock watering, and aquatic life); and
- Updates to the Elk Valley Water Quality Model.

Surface Water Quality

Context

Monitoring Surface Water Quality

In accordance with the requirements of the Permit, Teck operates an extensive surface water monitoring program in the Elk Valley. The program measures water quality parameters such as metals, nutrients (such as ammonia and phosphorus), ions in the water (such as sulphate), dissolved oxygen, and water temperature. The water quality monitoring program required by the Permit includes monitoring at:

- Eight authorized discharge Compliance Points;
- Seven Order Stations; and
- 88 authorized discharge, receiving environment, and other sampling sites.

Water quality data for these sampling locations are used to evaluate compliance with Permit requirements and the overall effectiveness of the Elk Valley Water Quality Plan.

The Permit requires that an annual water quality report summarizing monitoring results and non-compliance with Permit requirements is submitted to the BC Ministry of Environment and Climate Change Strategy. The 2016 Water Quality Annual Report was submitted for review to the Environmental Monitoring Committee (EMC) on March 31, 2017 and provides an overview of 2016 water quality data. The EMC reviewed the 2016 Water Quality Annual Report and provided input on the report. The content focuses on providing an overview of the 2016 Water Quality Annual Report.

Water Quality at Compliance Points and Order Stations

Two types of surface water quality monitoring locations defined in the Permit include: Compliance Points and Order Stations.

Compliance Points

Eight authorized Compliance Points are located downstream of the various mining operations. Compliance Points are meant to be effluent monitoring stations that capture and reflect all or most direct and indirect discharges from a mine site, and as such, reflect a total discharge from the operation to the receiving environment. This means that the accumulated discharge (i.e mine-influenced water) from each mining operation is evaluated at these Compliance Points. The locations of the eight Compliance Points can be found in Figure 13.

What is the difference between direct and indirect mine discharges?

Direct mine discharges are those discharges that often occur at a single, identifiable point, such as through a pipe. These discharges will include water from pit pumping, process plants, and/or tailings impoundments. Indirect mine discharges include any water that comes into contact with the landscape that has been altered for mining-related activities, and generally result from land runoff, precipitation, drainage, seepage, or hydrologic modification (i.e. altering of watercourses).

Compliance Limits are set at Compliance Points. Selenium and nitrate are regulated at all eight Compliance Points. Sulphate is also regulated at all Compliance Points except the active water treatment facility Compliance Point in Line Creek. Compliance Limits are set for different time periods and are designed to facilitate continuous improvement of water quality in the Elk Valley (i.e the allowable limits for concentrations of constituents in the water are generally more stringent as the years pass by). For your information, the monthly average Compliance Limits can be found in Appendix C.

Harmer Creek Compliance Point

The Harmer Compliance Point is one of eight Compliance Points in the Elk Valley. This Compliance Point is located on Harmer Creek at the edge of current mine activity. Future mining development is expected upstream of this Compliance Point and this is projected to increase selenium levels at this monitoring location. An interim selenium limit for this location has been established, and a long-term Compliance Limit is currently being developed. An update on this topic will be provided in the 2018 EMC Public Report.

Order Stations

Teck also collects water samples at seven water quality monitoring stations that have been specifically set up under the Order, called Order Stations. The seven Order Stations are located farther away from the mining operations than the Compliance Points, and are used to monitor water quality in the Elk Valley more generally and provide information on the implementation success of the Elk Valley Water Quality Plan. The locations of the seven Order Stations can be found in Figure 13.

Site Performance Objectives have been set at Order Stations for four of the five Order constituents (i.e. selenium, cadmium, nitrate, and sulphate, excluding calcite). Site Performance Objectives are set to reflect the unique environmental characteristics found at the different Order Stations and are designed to protect aquatic life in the long term. Site Performance Objectives have also been set for different time periods to facilitate the improvement of water quality in the Elk Valley over the coming years (i.e the allowable limits for concentrations of constituents in the water are generally more stringent as the years pass by). Concentrations of the Order constituents in water must remain below the Site Performance Objectives established at these Order Stations. For your information, please see Appendix B for the Site Performance Objectives set for each Order station.

Compliance Limits and Site Performance Objectives are defined as monthly average limits of the four Order constituents (excluding calcite). Additionally, daily maximum limits exist at four of the eight Compliance Points. Teck is required to comply with established Compliance Limits and Site Performance Objectives.

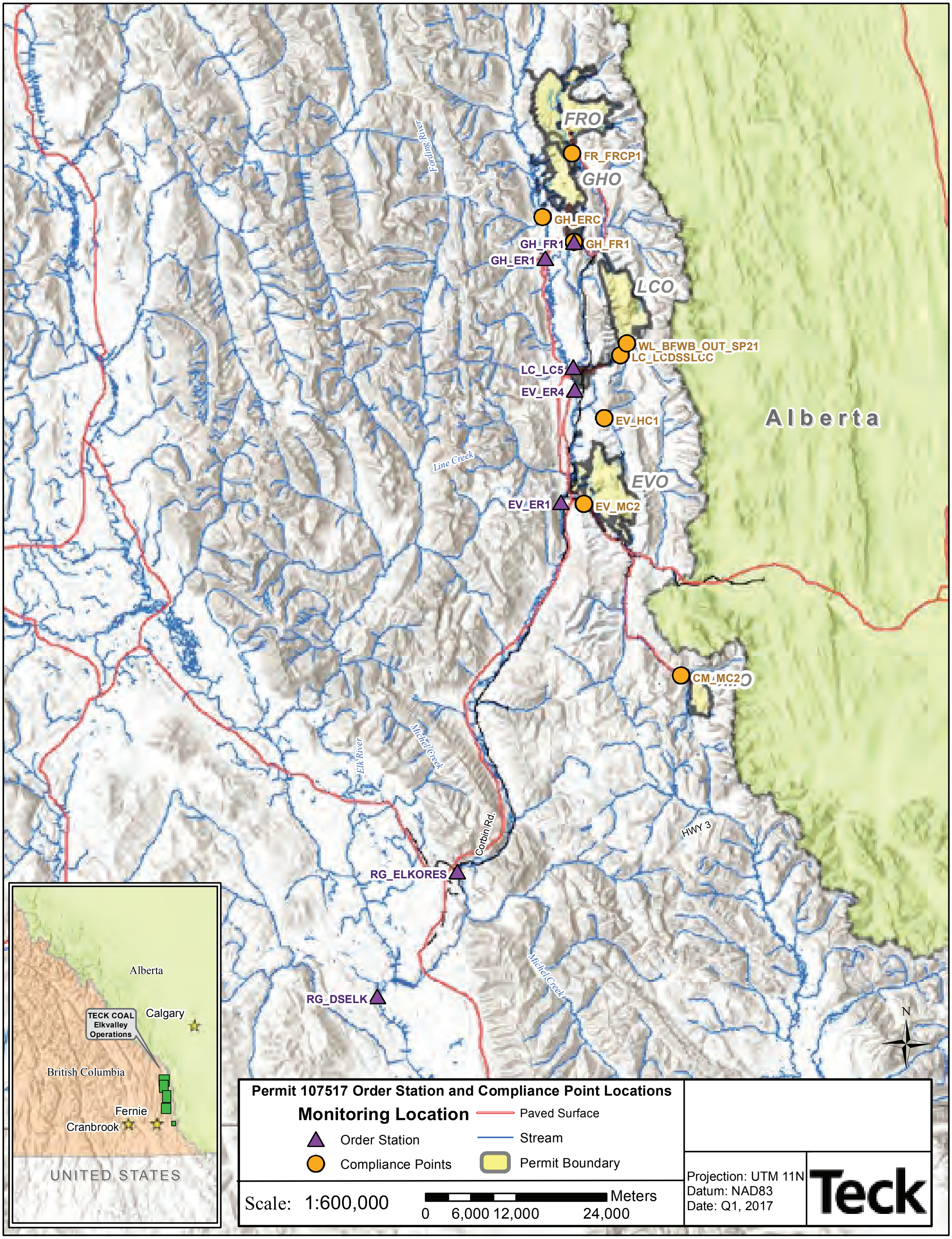


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Figure 13: Order Station and Compliance Point Locations

Authorized Discharge and Receiving Environment Water Sampling Sites

In addition to the Compliance Points and Order Stations, water is sampled at 88 discharge and receiving environment sites at or downstream of Teck's operations in the Elk Valley (see Figure 14). The distribution of water sampling sites by mining operation is as follows:

- Fording River Operations collects samples from 24 water sampling sites;
- Greenhills Operations collects samples from 19 water sampling sites;
- Line Creek Operations collects samples from 13 water sampling sites;
- West Line Creek Active Water Treatment Facility collects samples from two water sampling sites;
- Elkview Operations collects samples from 20 water sampling sites;
- Coal Mountain Operations collects samples from 6 water sampling sites; and,
- There are also four water sampling sites located within the Koocanusa Reservoir.

Water sampling at these sites provides additional information that helps improve the understanding of water quality conditions throughout the Elk Valley. Unlike the Compliance Points and Order Stations, the Permit does not define any water quality limits for these monitoring sites. Water quality at these sites is evaluated against the BC Water Quality Guidelines for the Protection of Aquatic Life.

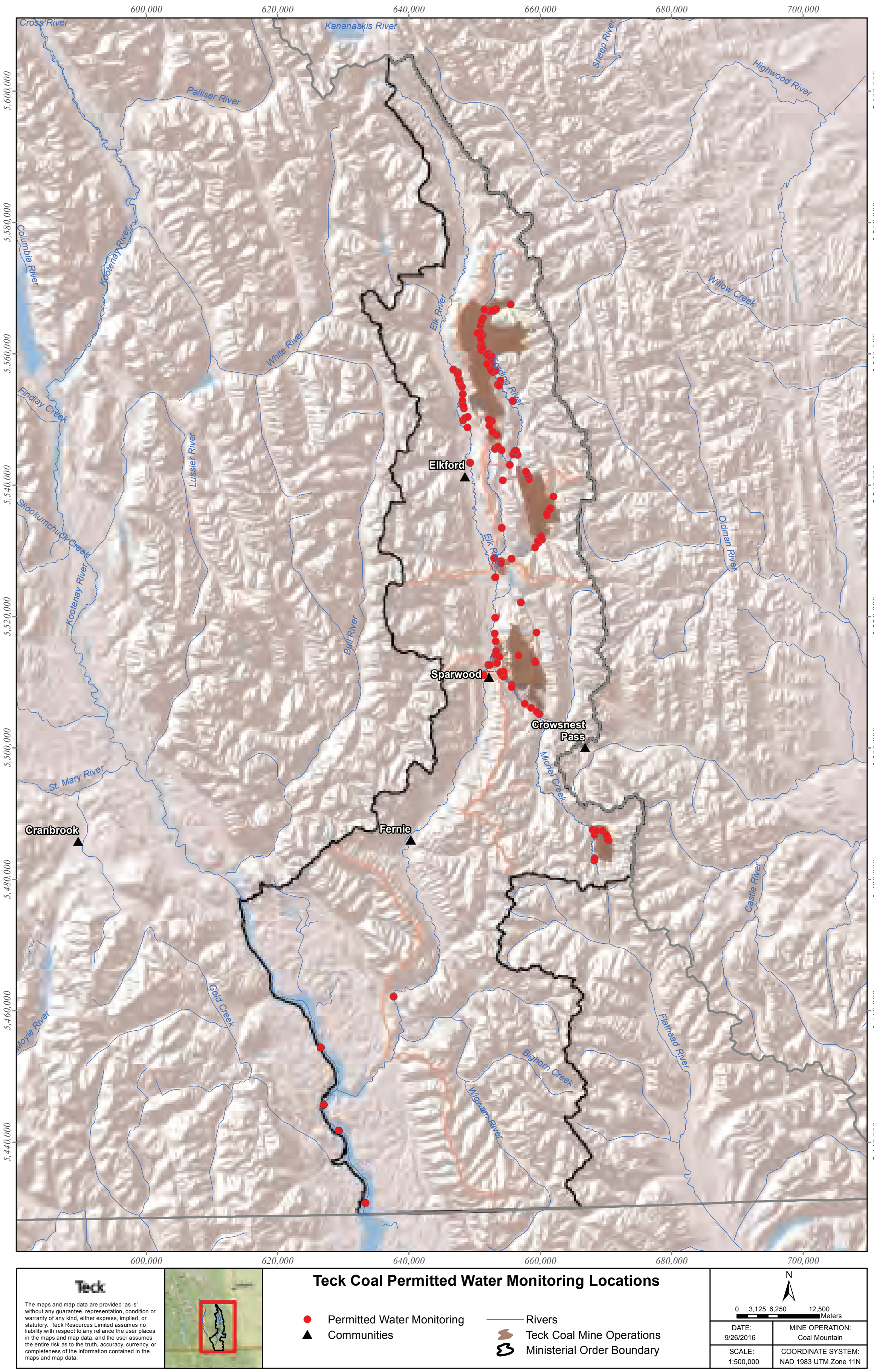


Figure 14: Water Sampling Sites within the Permit Boundary

Results

The results of the 2016 Annual Water Quality Report, which was submitted to the BC Ministry of Environment and Climate Change to satisfy permit requirements, are summarized in this section. As specified by the Permit, the 2016 Annual Water Quality Report uses the 2016 water quality limits for determining if Site Performance Objectives have been achieved at Order Stations and for determining compliance with Permit requirements. Non-compliances can be grouped into one of five categories: 1) exceedances of water quality Compliance Limits (at Compliance Points), 2) acute toxicity failures, 3) missed sample collection, 4) administrative non-compliances (i.e. late reporting), and 5) holding time exceedances (i.e., some samples must be analyzed within a certain number of days or the results are not considered to be valid).

Water Quality at Order Stations

In 2016, all Site Performance Objectives were achieved for selenium, cadmium, nitrate, and sulphate at the seven Order stations in the Elk River, Fording River, and Koocanusa Reservoir. Refer to Appendix B if you would like to see details on these Site Performance Objectives.

2016 Results Overview

Order Stations
Site Performance Objectives for selenium, cadmium, nitrate, and sulphate were met at the seven Order stations in 100% of the water samples collected.

Compliance Points
97.5% of water quality samples collected at the eight Compliance Points were below compliance limits for selenium, nitrate and sulphate.

Other Surface Water Sampling Sites
Excluding the four order constituents, 0.2% of analyses on surface water samples from tributary and mainstem Elk and Fording River exceeded BC's Water Quality Guidelines for the Protection of Aquatic Life.

Figure 15: 2016 Water Quality Results Overview

Compliance

Exceedances of Compliance Limits at Compliance Points (Category 1)

In 2016, a total of 44 exceedances of Compliance Limits were recorded (i.e., 44 water samples had concentrations of one or more constituent in excess of the Compliance Limits), representing 2.5% of the water samples collected at all the Compliance Points. This represents 4.8% of the monthly averages calculated.[3]

Exceedances of Compliance Limits at Line Creek Operations

The majority of the exceedances of Compliance Limits in 2016 were associated with Line Creek Operations Compliance Point (LC_LCDSSLCC). The daily nitrate maximum limit was exceeded in 52% of samples (24 of 46 samples) and the monthly average limit was exceeded in nine of 12 months. All other Order constituents were within Compliance Limits at this Compliance Point. See Figures 16 and 17 for graphical illustrations of this information.

The Line Creek Operations Compliance Limits for nitrate were reduced from 14 mg/L monthly average and 20 mg/L daily maximum, to 7 mg/L monthly average and 9 mg/L daily maximum in December 2015. This limit reduction is a permit requirement and is consistent with the intention of continuous improvement in water quality concentrations. It was thought to be appropriate and achievable based on modelling of the available data at the time, and the planned commissioning schedule for the West Line Creek Active Water Treatment Facility. It has become apparent that the model which informed this limit reduction underestimated the nitrate loadings in Line Creek, and although the treatment facility is operating as designed in terms of removal of nitrate, the nitrate levels are still above the new Compliance Limits established at the Line Creek Operations Compliance Point.

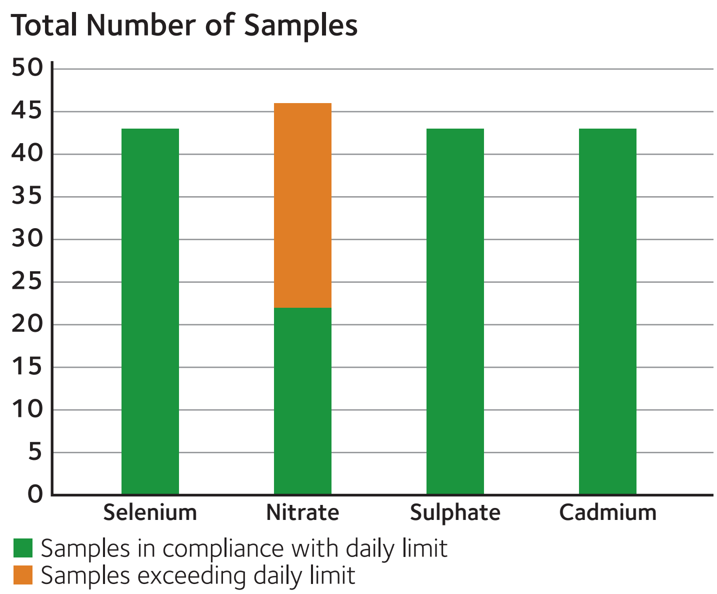


Figure 16: Daily Limit Compliance Performance at Line Creek Operations Compliance Point LC_LCDSSLCC

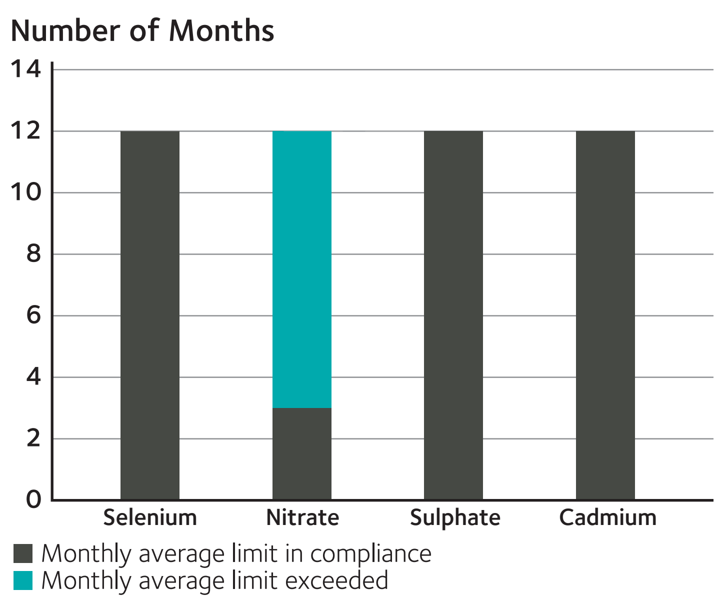


Figure 17: Monthly Average Compliance Performance at Line Creek Operations Compliance Point LC_LCDSSLCC

[3]Monthly averages are calculated each month at the seven compliance points, for each of the four Order constituents. In total, there were 336 monthly averages calculated (i.e. 12 months * seven compliance points * 4 Order constituents = 336), of which there were 16 monthly average non-compliances.

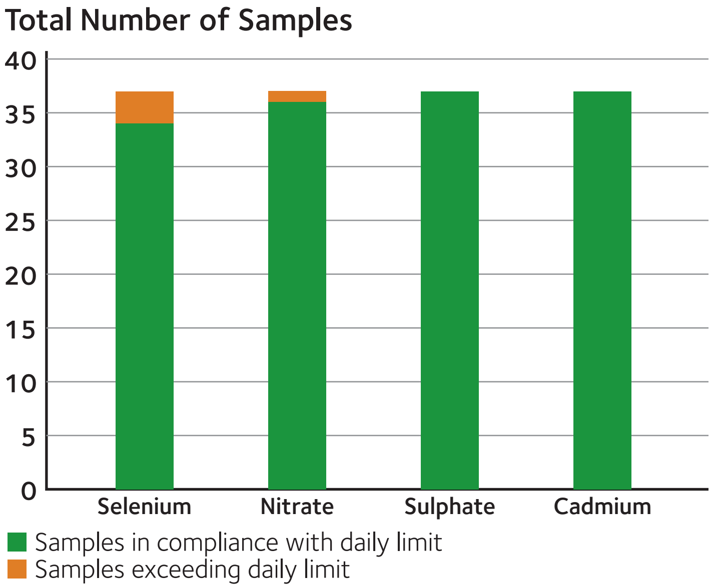


Figure 18: Daily Limit Compliance Performance at Fording River Operations Compliance Point FR_FRCP1

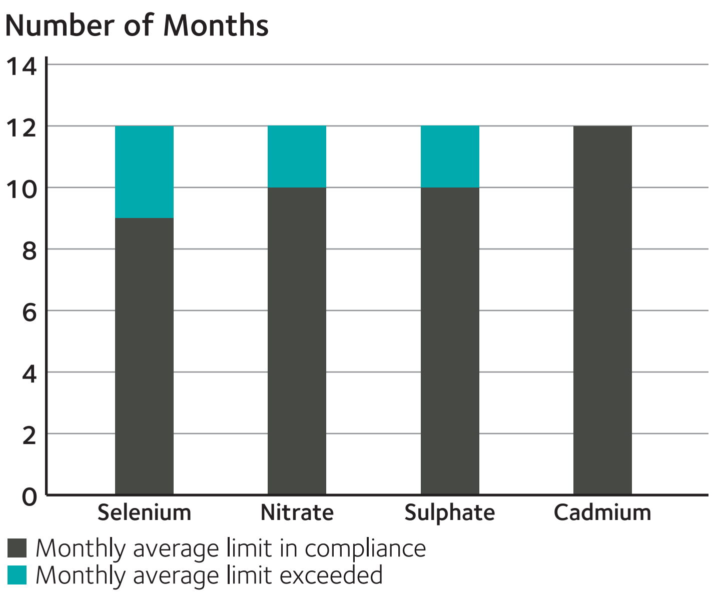


Figure 19: Monthly Average Compliance Performance at Fording River Operations Compliance Point FR_FRCP1

Actions:

Actions taken by Teck are outside the scope of the EMC, but have been included here for the reader's reference. Teck is currently preparing a Compliance Action Plan that outlines a path forward and the timing of activities that will support bringing Line Creek Operations back into compliance with the Compliance Limits for nitrate. Mitigation measures initiated by Teck to date include:

- A review of blasting products and practices;
- Water management to minimize water accumulation in pits and blasting areas;
- Updating the regional water quality model to improve representation of nitrate loadings, in order to better plan management activities; and
- Optimizing the West Line Creek Active Water Treatment Facility and accelerating development of treatment alternatives.

Teck's mitigation activities fall outside the scope of the EMC and readers can refer to teck.com/elkvalley for further details.

Exceedances of Compliance Limits at Fording River Operations

At Fording River Operations Compliance Point (FR_FRCP1), Compliance Limits were exceeded a total of eleven times in 2016, with these exceedances all occurring during the winter months of January, February and March. Exceedances included:

- The daily limit for selenium was exceeded in 3 of 34 samples (8.8%) and the monthly average limit was exceeded in three of 12 months.
- The daily limit for nitrate was exceeded in one of 36 samples (2.8%) and the monthly average limit was exceeded in two of 12 months.
- The monthly average limit for sulphate was also exceeded in two of 12 months.

Refer to Figures 18 and 19 for illustrations of these exceedances.

Implications of Fording River Operations non-compliances:

Compliance Points are intended to monitor fully mixed conditions in the receiving environment (i.e., main stem river) of all or most of the direct or indirect discharges from one mine operation. Water quality and quantity monitoring data have indicated that surface water flow at FR_FRCP1 is predominantly discharge water from the mine-impacted Cataract Creek during winter low flow months. This information may assist in explaining water quality data and chronic toxicity results (see page 48) obtained at FR_FRCP1 during low flow periods (during winter months) in 2016.

Actions:
Teck will be requesting an amendment to the Permit that proposes an alternative location to this Compliance Point.

Acute Toxicity Failures (Category 2)

Seven of the 451 acute toxicity tests with Daphnia magna failed (i.e., in 7 of 451 tests, more than 50% of the test organisms died during the 48-hour exposure period. However, none of the acute toxicity tests with rainbow trout failed. These results are discussed further in the Acute Toxicity section of this report, found on page 52.

Missed Samples (Category 3)

Missed sample non-compliances were the result of either failed field equipment, scheduling errors and/ or lab error. Missed sample data represents 178 out of 182,774, or 0.1 %, of surface water data points collected at Permit locations in 2016 and is not expected to affect the integrity of data analysis.

Actions:
To reduce the potential for lab errors, Teck worked with the relevant laboratories to ensure that similar instances are not repeated in the future. To reduce the occurrences of missed field samples, Teck is ensuring back-ups of critical field equipment are available. To reduce the likelihood of missing the collection of water samples, Teck has implemented changes to sample schedules to reduce the risk of scheduling errors happening in the future.

Administrative Non-compliances (Category 4)

Two non-compliances resulting from late reporting were identified in 2016.

Actions:
To ensure appropriate reporting obligations are met, automatic notifications of exceedances will be sent to multiple staff via email. Teck will also be implementing an automated completeness report that will warn relevant personnel of missing data.

Hold Time Exceedances (Category 5)

Parameter hold times were exceeded on 884 samples in 2016. These were generally related to time-sensitive water quality parameters such as nitrate, nitrite, turbidity, and phosphorus. Exceeding hold times may affect the reliability of the sample result in different ways depending on environmental conditions and contents of the sample.

Actions:
Teck continues to work on shipping options and available shipping contractors to reduce the number of hold time exceedances. Progress to date includes sampling schedule adjustment to obtain same day or next day delivery of samples to the lab, shipping via airplane freight delivery services, and working with the lab to expedite sample analysis once a sample is received. Teck is also evaluating other ways to reduce shipment and analysis delays for samples and will continue to stay focused on identifying QA/QC issues and implementing corrective actions to improve data integrity.

Authorized Discharge and Receiving Environment Monitoring Sites

Waste rock piles are the major source of constituents of interest in the Elk and Fording rivers. As such, monitoring the quality of water that flows from these waste rock piles is part of the authorized Discharge and Receiving Environment Monitoring Program.

Surface water sampling activities are carried out weekly, monthly, and quarterly throughout the calendar year, with samples analyzed for a number of water quality parameters. Water sampling results are used to evaluate water quality relative to BC's Water Quality Guidelines for the Protection of Aquatic Life (BCWQG or the Guidelines). These data are also used to evaluate the overall effectiveness of the Elk Valley Water Quality Plan and contribute to Adaptive Management of water quality in the Elk Valley.

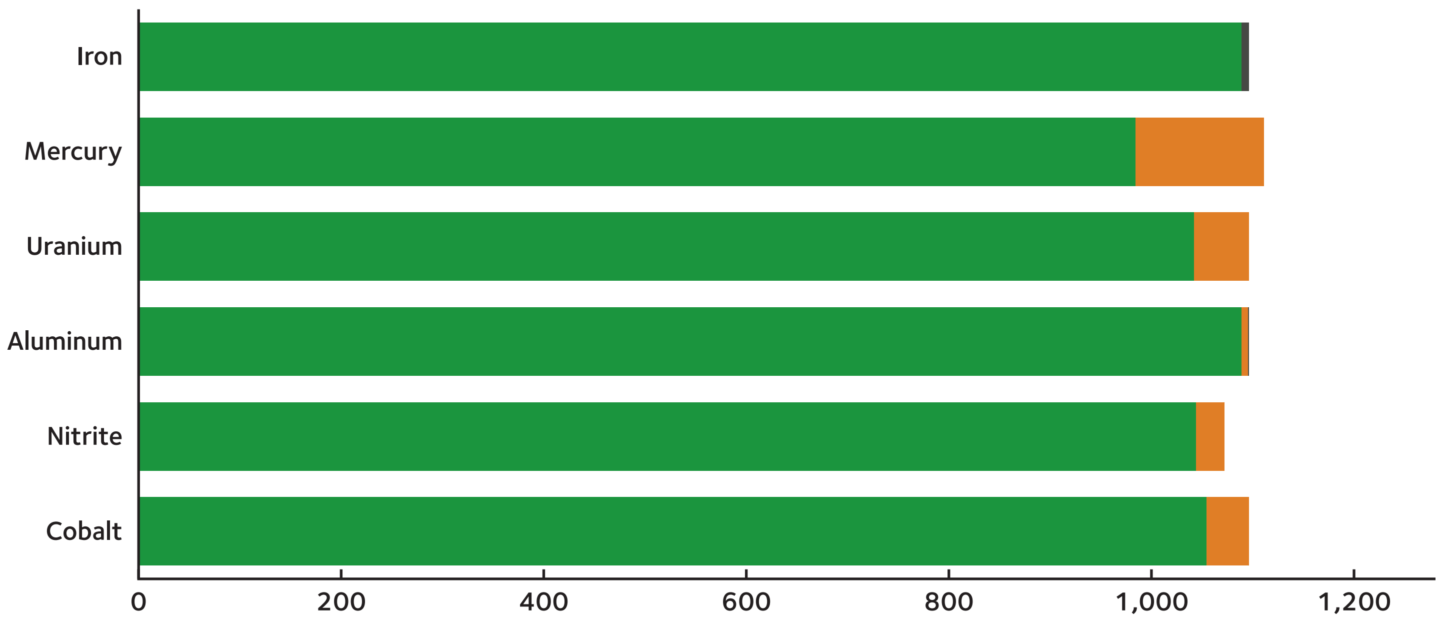
In 2016, 129,388 separate analyses were run on non-Order constituents in surface water samples from tributary and main stem Elk and Fording River locations. Results indicated that concentrations of iron, mercury, uranium, aluminum, nitrite, and cobalt periodically exceeded the BCWQG at various locations. See Figure 20 for a graphical illustration of 2016 results, and Figure 21 for a comparison of 2015 and 2016 results. Further discussion about BCWQG exceedances is provided.

Discussion of Results

Mercury

Mercury concentrations in water present negligible risks to aquatic organisms. Sampling of mercury in water initially involved measurement of total mercury, which includes organic and inorganic mercury, whereas the organic methyl mercury component is what poses bioaccumulation and biomagnification risks to organisms. Concentrations of total mercury exceeded the most conservative guidelines for mercury (which assumed a high concentration of methyl mercury) with the frequency illustrated in the figure below. In response, Teck started sampling for methyl mercury in 2016 to measure organic methyl mercury. The results of all 48 of the 2016 methyl mercury samples were below the minimum detection limit (<0.000050 µg/L) and the total mercury was below the WQG in all these cases. The concentrations of methyl mercury have thus far been non-detectable, indicating negligible risks of harm to aquatic organisms related to mercury exposure.

Actions:
Sampling for methyl mercury will continue for 2017.



	Iron	Mercury	Uranium	Aluminum	Nitrite	Cobalt
Number of Samples <BCWQG	1089	984	1042	1089	1044	1054
Number of Samples > Monthly Average BCWQG	0	127	54	6	28	42
Number of samples > Daily Maximum BCWQG	7	0	0	1	0	0

Figure 20: 2016 Surface Water Sampling Results against the BCWQG[1]

[1] "NG" means no guideline exists.

Uranium

Uranium was measured above the long-term BCWQG in 54 samples out of 1,096 samples taken. Of the 54 samples that exceeded the BCWQG, 93% were collected at a Line Creek sampling site (LC_WLC), with the remaining 7% collected at the Fording River Compliance Point (FR_FRCP1).

Actions:
Teck is in the initial investigation phase with uranium and does not yet understand what's driving BCWQG exceedances. The effect of uranium concentrations and other water quality constituents on aquatic life in the Fording River will be evaluated in the Regional Aquatic Effects Monitoring Program (RAEMP; see section 6). Teck also has an ongoing chronic toxicity program in the Fording River, which will provide an indication of potential effects of various water quality constituents on aquatic life.

Cobalt

Elevated cobalt levels were observed in 42 of 1,096 samples collected. Six of the samples with elevated cobalt levels were taken at the Coal Mountain Operations Compliance Point and 36 samples were collected at Corbin Creek (CM_CC1). Cobalt concentrations were occasionally elevated above the 30-day average guideline at these monitoring locations; the maximum daily guideline was not exceeded at any site.

Actions:
See actions on cobalt management below, as part of the nitrite actions.

Nitrite

Elevated nitrite concentrations were observed in 28 samples out of 1,082 samples collected. Five of these samples were collected at the Coal Mountain Operations Compliance Point, 22 samples were collected at Corbin Creek (CM_CC1), and one sample was collected at Line Creek, above West Line Creek (LC_LCUSWLC).

Actions:
In consideration of nitrite and cobalt exceedances at the Coal Mountain Operations Compliance Point, Teck is in the process of developing a Water Management Plan for Coal Mountain Operations. This will inform water management decisions required to achieve both short- and long-term water quality objectives as Coal Mountain Operations moves into care and maintenance and closure. The Water Management Plan will outline additional water management and mitigation activities to address water-related risks, meet permit limits, and reduce sediment and mine-related constituent loads.

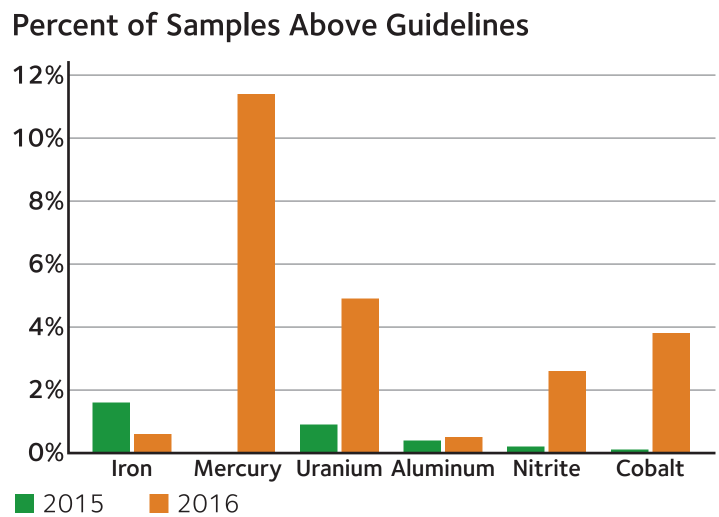


Figure 21: Year over Year Comparison of Surface Water BCWQG Exceedances (2015–2016)

*Mercury results for 2015 are not included as they are not comparable to 2016 data. The detection limit was unsuitable in 2015 and was adjusted for the 2016 sampling program.

All Water Quality Parameters

Teck will continue to monitor all water quality parameters as required by the Permit, will evaluate trends, and assess impacts to aquatic life. The EMC will continue to review this information annually.

What's Next?

Regularly scheduled sampling and analysis at the Compliance Points, Order stations, and other authorized monitoring sites across the Elk Valley will continue in 2017. No new additional monitoring is anticipated at this time. The 2017 Annual Water Quality Monitoring Report will be provided to the EMC for review in 2018, and results will be summarized in the EMC's 2018 Public Report.

Updating the Elk Valley Water Quality Model

The Permit requires Teck to update the Elk Valley Water Quality Model (introduced on page 16 above) and complete a water quality prediction report for each of Teck's five mines in the Elk Valley by October 31, 2017, and then again every three years. The model update must occur more frequently if:

- Mine plans change;
- If concentration levels vary significantly from the water quality model's predicted concentration levels; or
- If directed to do so by the BC Ministry of Environment and Climate Change Strategy.

Differentiating the Computer Models Used to Understand Water in the Elk Valley

On this page, the Elk Valley Water Quality Model is discussed. In the groundwater section later in this report, the Groundwater Regional Conceptual Model is discussed. These two models are different and are used for different purposes. Using existing data, the Elk Valley Water Quality Model provides a tool for predicting how historical, current, and future mining activities will affect the concentrations of selenium, nitrate, and sulphate in the Fording River, Elk River, main tributaries, and Koocanusa Reservoir. Whereas the Groundwater Regional Conceptual Model is used to improve understanding of how groundwater flows and is being influenced by mining activities in the Elk Valley.

Water quality model update work was initiated in 2016 and will continue into 2017. The three-year water quality model update allows for continuous improvement of the model. Continual improvement of the model will strengthen its ability to reliably project future water quality conditions throughout the Elk Valley. The focus of the update to the model has been informed by feedback received since the Elk Valley Water Quality Plan submission (in 2014) and relates to improved accuracy of water quality projections and flow estimates in tributaries, and specifically the accuracy of projected nitrate concentrations. In 2016, flow estimates in tributaries were refined through additional detail added to the model and nitrate release mechanisms were investigated for further refinement.

The results of model update work will be incorporated into the October 31, 2017 water quality model update. The EMC will be involved in discussions leading up to the update of the water quality model. The EMC's 2018 Public Report will provide an update on the water quality model.

Evaluation of Waste Rock Piles as Direct Sources of Order Constituents

To improve understanding of the relationship between waste rock piles and downstream water quality, water flowing from waste rock piles continues to be monitored. This knowledge is used to continuously improve the accuracy of predictions developed using the Elk Valley Water Quality Model.

The four Order-constituents are monitored at important source sites (i.e., waste rock piles) and receiving environment sampling sites (i.e. Order stations), and results are compared to characterize relationships. As part of this evaluation, efforts are made to understand if active and dormant waste rock piles are exhibiting different patterns of release of the Order constituents (i.e. does a dormant waste rock pile release constituents at lower levels than an active one?). A dormant waste rock pile is defined as not having any new waste deposited for at least 1 year; while an active waste rock dump is defined as having received waste rock within the past year.

Findings:

- 2016 data continued to confirm waste rock piles as the main source of selenium, nitrate and sulphate. Trends in cadmium data are less apparent.
- Based on data collected to date, it does not appear that waste rock pile status (active vs. dormant) directly influences surface water selenium and sulphate concentrations. Nitrate concentrations associated with some dormant waste rock piles appear to have a decreasing trend, or have remained fairly constant. This is consistent with the conceptual model for nitrate release, which predicts that elevated nitrate concentrations in watercourses downstream of Teck's waste rock piles are due to residual nitrogen compounds from explosives used during mining. These concentrations are expected to naturally decrease over time, as nitrates are rinsed off the waste rock by water that flows through the piles.

Toxicity Testing

Context

Toxicity tests are conducted to determine how organisms respond to short-term and long-term exposure to mine-influenced waters, including effluent and receiving waters. Such toxicity tests measure the health (i.e., survival, growth, development, or reproduction) of various test organisms. The tests are done in a laboratory using plants, invertebrates, and fish species representative of sensitive aquatic organisms in the Elk Valley. Water is collected from specific sites in the Elk Valley and shipped to laboratories where the toxicity tests are performed in accordance with standardized methods and procedures. The results of these toxicity tests help inform if changes to mine operations and/or water quality management may be necessary to protect aquatic ecosystems.

As per the Permit, Teck carries out a series of toxicity tests to assess the short-term (i.e. acute) and long-term (i.e. chronic) effects on select organisms. Acute toxicity tests are conducted on organisms using water discharged directly from mining operations (i.e., effluent collected at the Compliance Points); whereas chronic toxicity testing is done on organisms using water downstream in the receiving environment (i.e., using water collected from the streams and rivers that receive the effluent).

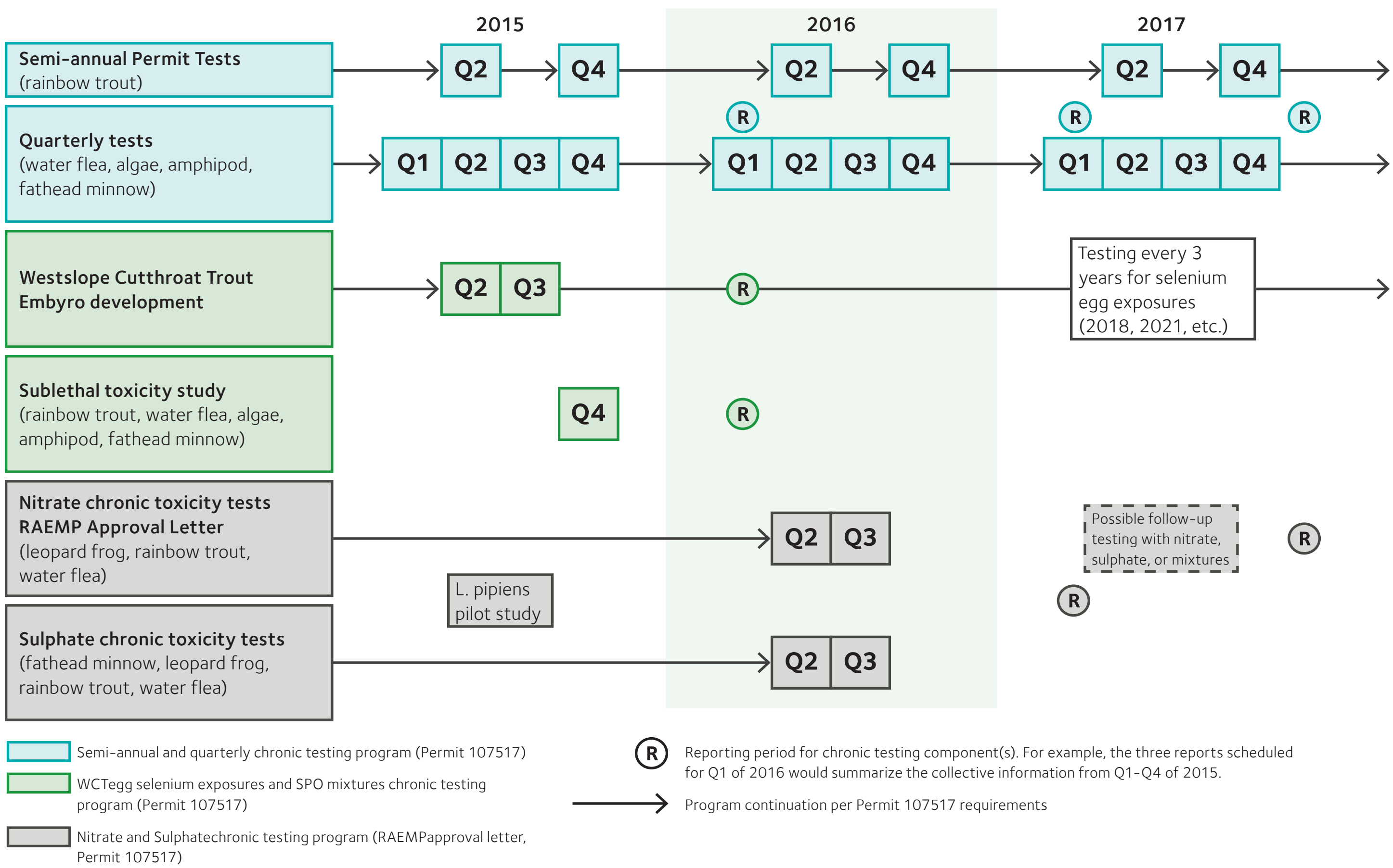


Figure 22. Elk Valley Chronic Toxicity Testing Program Overview

Acute Toxicity Testing

Context

The Permit requires Teck to conduct acute toxicity tests on fish (rainbow trout) and water flea (Daphnia magna). Acute toxicity tests are short term tests (2–4 days) that are typically done using undiluted effluent discharged from a mining operation.

Acute toxicity tests are done at least four times per year using Teck's mine effluent (i.e., the water that is collected before leaving the mine site). Acute toxicity test results for each species are interpreted as either a pass (50% or more of exposed individuals in the test survive) or a fail (more than 50% of exposed individuals die).

Results

Four hundred and fifty-one (451) acute toxicity tests were completed in 2016.

- All rainbow trout tests passed.
- 98.5% of tests on water flea (Daphnia magna) passed in 2016 testing. Seven tests had greater than 50% mortality to water flea and as such, are considered failed test results.

Discussion of Results

Follow-up investigations and visual observations indicate that the cause for the reduced survival in the water flea tests is precipitate formation on the organism during lab testing. Two of the seven failed tests occurred in the West Line Creek Active Water Treatment Facility Outfall; three of the seven occurred in Cataract Creek; one occurred at the Elkview Operations Dry Creek Sediment Pond (EV_DC1); and the other failure occurred at the Fording River Operations Smith Ponds (FR_SP1).

Actions:

Teck is required to address the issue of precipitate/calcite management in the valley, as per Section 6 in the Permit. See section 7 for further information about calcite and calcite management.

What's Next?

Acute toxicity testing required under the Permit will continue as scheduled. Results from 2017 acute toxicity testing will be provided to the EMC for review in March 2018. The EMC will report on those results in the 2018 EMC Public Report

Chronic Toxicity Testing

Context

Chronic toxicity tests determine the effects on selected organisms associated with longer-term exposure to mine-influenced water from streams and rivers (i.e., the receiving environment). In addition to measuring survival, these tests can also measure the growth, development, and reproduction of toxicity test organisms exposed to surface water obtained from various locations in the Elk Valley. Chronic toxicity tests are being used to fill information or knowledge gaps, and confirm if water quality targets in the Permit are protective of aquatic health.

Using water collected from the Elk Valley, chronic toxicity tests are performed by toxicity testing laboratories. Chronic toxicity tests are typically conducted using a wider variety of species (as compared to acute toxicity testing), take longer to complete (three to 30 days), and use more water from the Elk Valley than do the acute toxicity tests.

There are three main elements of the chronic toxicity testing program, including:

1. Ongoing scheduled chronic toxicity testing;

2. Nitrate and Sulphate Toxicity Study; and

3. Westslope Cutthroat Trout Egg Study.

As the results of the Westslope Cutthroat Trout Study were reported in the 2016 EMC Public Report, only the first two elements of the program are discussed in this report.

Westslope Cutthroat Trout Egg Study

Every three years, the Permit requires Teck to conduct a study to evaluate the survival and development of Westslope Cutthroat Trout eggs collected from fish in the Fording River. In 2015, this study was conducted and details can be found in the 2016 EMC Public Report. The next study will occur in 2018 and results will be discussed in the 2019 EMC Public Report.

Ongoing Scheduled Chronic Toxicity Testing

Context

The locations, frequencies, and organisms used in the ongoing scheduled chronic toxicity tests are prescribed by the Permit. These scheduled tests are conducted at Compliance Points quarterly, or in some cases, semi-annually. Tests are also conducted at sites not influenced by mining activities to provide a measure of background (i.e. natural) toxicity and allow for comparison of results. Species used in the chronic toxicity tests are representative to those found in the Elk Valley and include fish, amphipods, water fleas, and algae, and represent different parts of the food web.

Elk Valley Aquatic Organisms Simplified Food Web

The food web figure below (Figure 23) shows simplified relationships among the basic kinds of aquatic organisms in Elk Valley waters. Algae and bacteria are the base of the food chain. Invertebrates like clams, snails, and the larvae of various insects largely depend on algae and bacteria as a food base. Invertebrates are in the middle of the food chain and are food for fish. All levels in the food chain need to be healthy to ensure a fully functioning aquatic ecosystem.

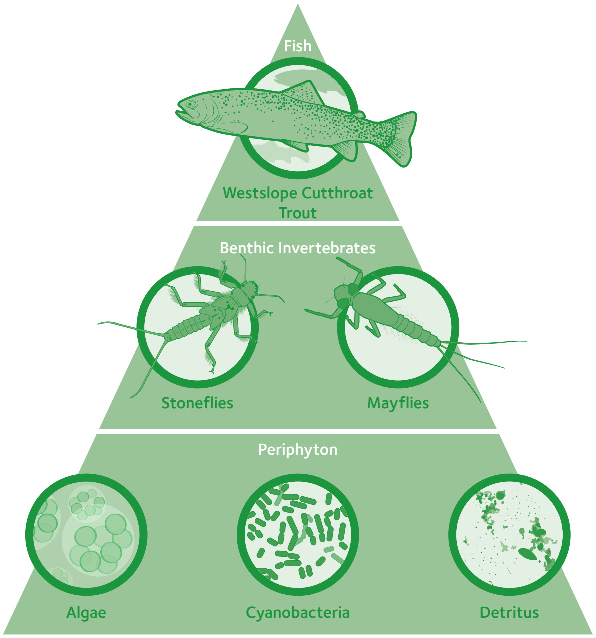


Figure 23: Aquatic Relationships in the Watershed

Results

Chronic toxicity testing was completed on algae, amphipods, water fleas, fathead minnows, and rainbow trout, with each representing different components of the food web. In testing on algae and fathead minnows, the majority of tests on organisms with water collected downstream of mining activities were similar to the results of the same organism in water collected upstream of mining activities. Conversely, the majority of tests on water fleas, amphipods, and rainbow trout identified lower survival, growth, development or reproduction in organisms exposed to mine-influenced waters, compared to the results of the same organism in water collected upstream of mining activities.

Test results are summarized on the following page. The EMC will continue to discuss the implications of these results.

What are reference and mine-influenced water?

Reference water is water that has not been influenced by mining because it is upstream of mining activities. Mine-influenced water is water that is found downstream of mining activities and has been impacted by direct and indirect discharges from mining operations.

Chronic Toxicity Testing Results

- **Algae:** Algae toxicity tests were done using a total of 34 samples in 2016, including six tests with reference waters and 28 tests with mine-influenced waters. In 2016, 10 of the 28 tests (i.e. 35%, as compared to 43% in 2015) indicated that growth of algae was decreased in the mining-influenced waters.
- **Amphipod:** Amphipod toxicity tests were conducted using a total of 16 water samples in 2016, including four tests with reference waters and 12 tests with mine-influenced waters. In 1 of the 12 tests (i.e. 8%, as compared to 8% in 2015), there was evidence of adverse effects on survival. Decreased growth was observed in eight of the 12 tests (i.e. 67%; as compared to 17% in 2015).
- **Water flea:** Water flea toxicity tests were conducted using a total of 34 water samples in 2016, including six tests with reference waters and 28 tests with mine-influenced water. Based on the current test methodology, the results of the test indicated no reduction of survival of water fleas using mine-influenced water. Further discussions with the EMC on changes to the test design regarding the detection of survival are ongoing. Reproduction was reduced in mine-influenced waters relative to reference water in 14 of 28 tests (i.e. 50%; as compared to 18% in 2015 testing).
- **Fathead Minnows:** Fathead minnows toxicity tests were done using a total of 16 water samples in 2016, including four tests with reference water and 12 with mine-influenced waters. There was no evidence of adverse effects on hatching success, survival, biomass, length or development, except for one test in which hatch and survival rates were lower. For comparison, in 2015, survival was reduced in three of the 12 tests (i.e. 25%), and biomass was reduced in two of the 12 tests (i.e. 17%).
- **Rainbow Trout:** Rainbow trout toxicity tests were conducted using a total of 18 water samples in 2015, including four tests with reference waters and 14 tests with mine-influenced waters. There were no adverse effects on Rainbow Trout weight in any test in 2016 (lower weights were observed in 14% of tests in 2015). Survival was significantly reduced in 11 of 14 tests (i.e. 79%, as compared to 36% in 2015). Hatching success was significantly reduced in 12 of 14 tests (i.e. 86%, as compared to 36% in 2015). Length was significantly reduced in 2 of 14 tests (i.e. 14%, as compared to 21% in 2015).

Discussion of Results

In 2016, there were no adverse effects in the majority of tests conducted on minnows and algae using mine-influenced waters; however, adverse effects were observed in half of the tests conducted with water fleas and the majority of tests conducted with amphipods and rainbow trout. For comparison, in 2015, there were no adverse effects on any of the above organisms in the majority of toxicity tests conducted using mine-influenced water.

In the majority of tests in 2015 and 2016 where lower survival, growth, development, or reproduction were observed, the potential cause of the effects was not identified. Nitrate has been identified as a likely causal factor for significant effects observed in tests using mine-influenced water samples from one of the Fording River (FR_FRCP1) test sites in both Q1 2015 (adverse effects observed in water flea and algae tests) and Q1 2016 (adverse effects observed in water flea, algae, and amphipod tests).

It should be noted that water quality at FR_FRCP1 under winter low-flow conditions may not be representative of the Fording River as a whole (see page 47 above for further information).

What's Next

The 2016 chronic toxicity testing results were reviewed by the EMC. The EMC also reviewed the full suite of tests associated with the toxicity testing program. The KNC expressed concerns about how the toxicity data were analyzed and interpreted, and indicated that cause analyses (i.e. investigations into what was causing the effects) were not well designed. Teck will continue to work with the EMC on the collection and interpretation of data for the chronic toxicity testing done under the program. In 2017, additional reference testing upstream of Coal Mountain Operations in Michel Creek and additional exploratory testing to investigate potential microbial effects on rainbow trout is planned.

Scheduled chronic toxicity testing is part of Teck's ongoing permit monitoring. Tests will continue to be completed and results shared with the EMC. Results from 2017 chronic toxicity testing will be provided to the EMC for review in April 2018. The EMC will report on those results in the 2018 EMC Public Report.

Please see the next section for further information about the in-progress nitrate and sulphate toxicity study.

Nitrate and Sulphate Toxicity Study

Context

The Permit requires Teck to develop a chronic toxicity study to increase understanding about the toxicity of nitrate and sulphate in the aquatic environment. It is expected that results of these studies will provide a basis for confirming if the Site Performance Objectives for nitrate and sulphate set at the Order Stations will be protective of aquatic life as predicted.

Status

In 2015, a draft study design for this program was developed and reviewed by the EMC. The final study design has been submitted and was reviewed by the EMC in 2016. Testing associated with this program is now underway and the results of this program are scheduled to be available by the end of 2017.

What's Next?

Testing of nitrate and sulphate with amphibians, fish, and aquatic invertebrates is in-progress in 2017. Results will be reviewed by the EMC and shared in the 2018 EMC Public Report.

Elk Valley Groundwater Monitoring

Context

By the Permit, Teck is required to develop and implement a comprehensive Regional Groundwater Monitoring Program with EMC advice and input. A regional hydrological conceptual model (herein referred to as the groundwater conceptual model) has been developed to illustrate groundwater flow patterns and behaviours. Teck presented this groundwater conceptual model to the BC Ministry of Environment and the EMC in a synthesis report in April 2015. Based on EMC input, the synthesis report was updated and re-submitted in November 2015. The EMC provided advice associated with the synthesis report, which was considered in the development of the 2016 Regional Groundwater Monitoring Program that was used to guide monitoring activities in 2016. Along with the necessary background information, this section summarizes the activities and results presented in the 2016 Regional Groundwater Monitoring Program Annual Report, which was submitted to the BC Ministry of Environment on May 16, 2017.

The Regional Groundwater Monitoring Program is focused on 12 Key Areas where groundwater transport of mining-related constituents to the valley-bottom of the main river systems may be occurring. This allows for a focused assessment of groundwater while maintaining a regional scale perspective.

The objective of the Regional Groundwater Monitoring Program is to assess at a regional scale the potential effects on groundwater related to Teck's mining operations. By the Permit, this monitoring program focuses on specific areas: Management Units 1, 2, 3, and 4 (see the Figure 24 map for a visual of where these Management Units are located). Within each of these four Management Units, Key Areas have been identified as the focus of groundwater monitoring activities (see page 58 for further information on how and why Key Areas were identified). Site-specific groundwater monitoring programs at each mine operation are also required by the Permit and will be aligned with the Regional Groundwater Monitoring Program.

The Regional Groundwater Conceptual Model

Mining involves the excavation of material and changes the topography of the landscape and local watersheds, and it can impact the flow of groundwater in the Elk Valley. In order to gain a better understanding of how groundwater is being influenced in the Elk Valley, a groundwater conceptual model was developed in 2015 (see Figure 25 for an illustration of the concepts that inform the conceptual model).

The groundwater conceptual model provides a general description of the main pathways for constituents to travel in groundwater, from sources (i.e. mining operations) to receptors (e.g. people, livestock, aquatic organisms). Further, the groundwater conceptual model illustrates potential groundwater flow patterns and provides information on how mining-related constituents (including the Order constituents) are entering and being carried through groundwater systems in the Elk Valley. The main sources of Order and other constituents to groundwater include: percolation from mining waste rock, infiltration from settling ponds and process plants, and surface water interactions.

The groundwater conceptual model is used as a tool for interpreting data generated under the Regional Groundwater Monitoring Program. There are areas (especially in the Fording river) that do not behave the way the groundwater conceptual model suggests. Newly acquired monitoring data is used to confirm and update the conceptual model to re-evaluate if the right things are being looked for in the right places, and this information informs each successive annual Regional Groundwater Monitoring Program.

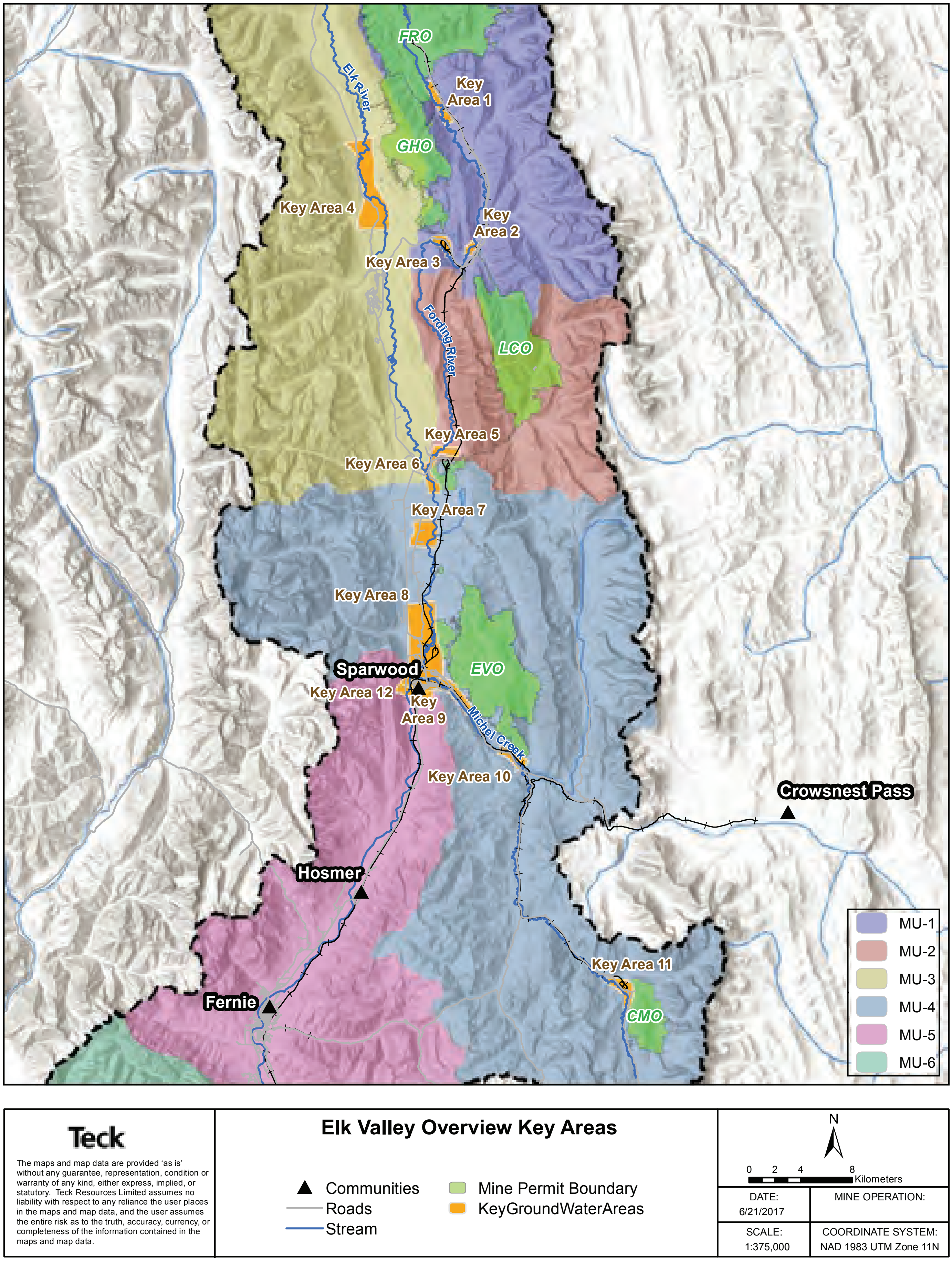


Figure 24: Map of Management Units and twelve Key Areas of the Groundwater Monitoring Program

The groundwater conceptual model has broadly defined two groundwater systems:

1. Upland Setting: Groundwater in the upland area typically occurs as thin layers of saturated earth near the ground surface. Upland groundwater eventually flows into valley-bottom sediments, transporting mine-related constituents into the valley-bottom groundwater system.

2. Valley-Bottom Setting: Valley bottom groundwater is the primary pathway for transporting mining-related constituents into the main river systems. Valley-bottom groundwater is assumed to have a high degree of interaction with surface water, meaning that some surface water enters the groundwater system and conversely, some groundwater supplies river systems. As such, the quality of surface water has the potential to influence groundwater quality and vice versa.

Key Areas

During the development of the approved Regional Groundwater Monitoring Program, twelve Key Areas were defined where groundwater transport of mining-related constituents to the valley-bottom of the main river systems may be occurring. Furthermore, groundwater monitoring in these Key Areas provides information on how Order constituents interact with groundwater flows, particularly in valleys of the main river systems.

Regional Groundwater Monitoring Program Overview

- 37 monitoring wells within the 12 Key Areas;
- Quarterly sampling;
- Results are compared to applicable guidelines and standards for the protection of human health, irrigation, livestock and wildlife, and aquatic life.

An annual Regional Groundwater Monitoring Program report is required by the Permit and the EMC provides input on this report.

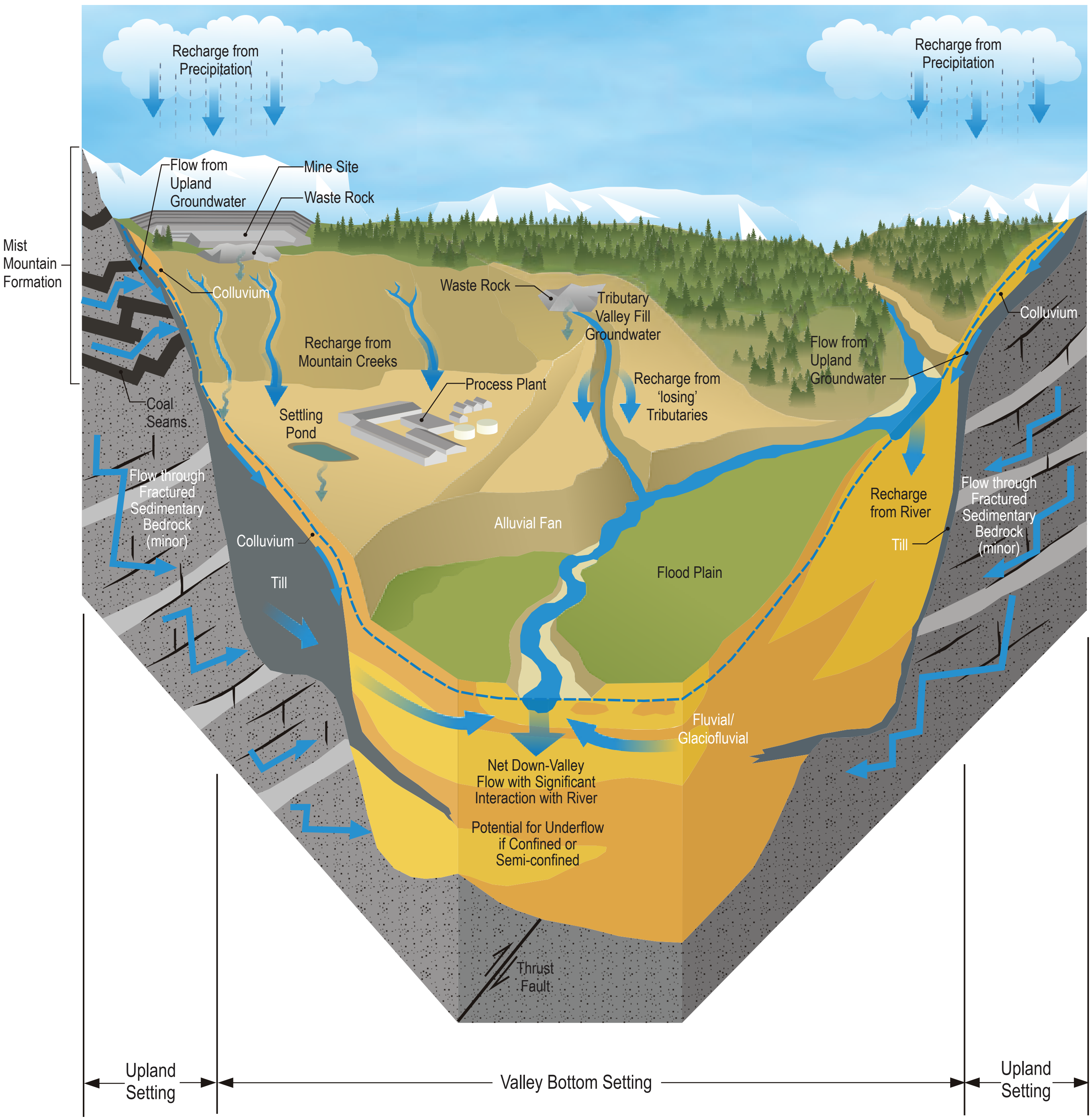


Figure 25: Regional Groundwater Conceptual ModelProgram

Key Area	Description	Management Unit(s)
1	Fording River Valley Bottom Downgradient (i.e. downstream) of Fording River Operations (FRO), Cataract and Porter Creeks: This area is the focal point for the majority of upland and tributary flow to the Fording River valley bottom near FRO and Greenhills Operations (GHO) property boundaries, and the primary off-site groundwater migration pathway from FRO.	1
2	Fording River Valley Bottom Downgradient of Line Creek Operations (LCO) Dry Creek: This area receives drainage from the LCO Phase II development as well as upgradient Fording River valley-bottom groundwater from FRO and GHO.	1
3	Fording River Valley Bottom Downgradient of GHO Rail Loop and Greenhills Creek: This area receives upland groundwater from GHO.	1
4	Elk River Valley Bottom Downgradient of Leask, Wolfram and Thompson Creeks: This area receives groundwater recharge from upgradient mining activities along the western slope of GHO, and is a potential offsite migration pathway.	3
5	Fording River Valley Bottom Downgradient of Line Creek: The valley bottom in this area receives inputs from Line Creek, the Fording River and the LCO Process Plant.	2 and 4
6	Elk River Valley Bottom Downgradient of Convergence with Fording River: This area receives input from the Fording River valley-bottom, the Elk River valley-bottom, and the Line Creek Process Plant site.	4
7	Elk River Valley Bottom Downgradient of Grave Creek: This area receives input from drainages flowing from the northwest slope of Elkview Operations (EVO), as well as upgradient from the Elk River and Key Area 6.	4
8	Elk River Valley Bottom Downgradient of Balmer, Lindsay, Goddard, Otto and Marsh Creeks: Upland groundwater flows into the Elk River valley bottom from potential sources along the western slope of EVO.	4
9	Michel Creek Valley Bottom Downgradient of Bodie Creek: Upland groundwater flows into Michel Creek valley bottom from potential sources along the western slope of EVO.	4
10	Michel Creek Valley Bottom Downgradient of Erickson Creek: Mining activities on the southwest slope of EVO around Erickson Creek are a potential source of mining-related constituents to valley-bottom groundwater into the Michel Creek valley bottom.	4
11	Michel Creek Valley Bottom Downgradient of Coal Mountain Operations (CMO): The Michel Creek valley bottom receives input from CMO immediately downgradient of the confluence of Michel and Corbin Creeks. Valley-bottom deposits in this area are the primary off-site migration pathway from CMO.	4
12	Elk River Valley Bottom at Study Area Boundary: This area is at the boundary of MU4 and the Study Area. Coarse sediments in this area have been identified as a potential migration pathway, and previous studies have inferred that surface water recharge from the Elk River occurs in this area.	4

Table 2: Description of Key Areas in the Groundwater Monitoring Program

Overview of Monitoring Wells used in the Regional Groundwater Monitoring Program

The wells selected for the Regional Groundwater Monitoring Program are a subset of wells from:

- Site-specific (i.e. operation-specific) groundwater monitoring programs;
- The Regional Drinking Water Sampling Program; and
- Other ongoing sampling programs, such as the operational water supply sampling programs.

Locations selected for the Regional Groundwater Monitoring Program and the supporting rationale will be reviewed by the EMC as part of the Regional Groundwater Monitoring Program update that will be submitted to the BC Ministry of Environment and Climate Change Strategy September 30, 2017.

The types of monitoring wells used in the Regional Groundwater Monitoring Program include:

- **Dedicated monitoring wells**, which are specialised wells developed specifically for the purpose of monitoring groundwater. They are included in the Regional Groundwater Monitoring Program because they provide a discrete, representative sample of groundwater and water level from the targeted. Where available, nested wells drilled at two or more different depths were chosen to monitor the variation of water constituents with depth. Multi-level wells may also be used to assess the vertical hydraulic gradient and inform groundwater and surface water interactions.
- **Supply wells**, which are groundwater extraction wells developed for the purpose of supplying water to multiple water users (e.g. a municipality). Supply wells can provide representative average groundwater quality over a much larger region compared to dedicated monitoring wells, and are included in the Regional Groundwater Monitoring Program in areas where dedicated monitoring wells do not exist. Water supply wells are not ideal for discrete sampling of groundwater due to longer well screens and mixing effects in the well that is caused by pumping.
- **Domestic wells**, which are groundwater extraction wells developed for the purpose of supplying water to a private domestic water user (e.g. a household). Domestic wells selected in the Regional Groundwater Monitoring Program are near operations and provide a representative indication of groundwater quality in areas that recharge from surface waters (i.e. such as the Elk and Fording Rivers). Similar to supply wells, domestic wells are not ideal for discrete sampling of groundwater due to longer well screens and mixing effects within the well's capture zone caused by pumping. Domestic wells are included in the Regional Groundwater Monitoring Program in areas where dedicated monitoring wells or supply wells are not available. Independently from the Regional Groundwater Monitoring Program, Teck supplies drinking water to domestic well owners wherever desired.

Groundwater Quality Screening Criteria

Under the Regional Groundwater Monitoring Program, groundwater quality is screened against:

- Standards set in provincial water quality criteria and guidance (i.e. primary screening criteria); as well as,
- Site Performance Objectives and Compliance Limits defined by the Permit (i.e. secondary screening criteria).

Each constituent (eg. nitrate, selenium, etc.) has a set of specific concentrations that are considered acceptable in groundwater, depending on the receptors (i.e. people, livestock, aquatic organisms). As an example, acceptable concentrations of constituents in water will generally be lower for drinking water than irrigation and livestock.

Using the standards set in provincial water quality criteria and guidance, and Site Performance Objectives and Compliance Limits defined in the Permit, primary and secondary screening criteria were developed for each receptor and are used as a basis for evaluating the acceptability of constituent concentrations in groundwater.

What are Primary and Secondary Screening Criteria Based On?

Primary screening criteria developed for the Regional Groundwater Monitoring Program is consistent with regulatory guidance, which has been set to achieve the overarching objective that resource development is protective of all existing or reasonably expected future uses of groundwater. The following standards and guidelines were used to formulate primary screening criteria for the following main receptors:

- Human Health—Primary screening of groundwater data for protection of drinking water (DW) was conducted against the applicable Contaminated Sites Regulation Drinking Water standard;
- Freshwater Aquatic Life—Primary screening of groundwater data for protection of aquatic life (AW) was conducted against Contaminated Sites Regulation Aquatic Life standards. The exception to this was for wells located within 10 m from a receiving surface water body where the concentrations were screened against the British Columbia Water Quality Guidelines, which is a practice consistent with BC Ministry of Environment and Climate Change Strategy Technical Guidance; and
- Irrigation and Livestock Watering—Primary screening of groundwater data protection of irrigation (IW) and livestock (LW) watering was conducted against applicable Contaminated Sites Regulation Irrigation and Livestock standards.

Generally speaking, acceptable concentrations of constituents in water are lower for drinking water and aquatic life, with livestock then irrigation watering allowing higher concentrations of most constituents.

Secondary screening criteria are used when concentrations of constituents are above primary screening criteria. Secondary screening criteria are based on surface water quality limits related to Compliance Limits (CP) and Site Performance Objectives (SPO), as well as Health Canada's Guidelines for Canadian Drinking Water Quality (DW) for selenium. The intention of evaluating groundwater quality using the surface water limits (Compliance Limits and Site Performance Objectives) is to understand if groundwater is protective of aquatic life in the Elk Valley. This is being done because of the high degree of interaction between surface water and groundwater.

Status

The first annual Regional Groundwater Monitoring Report was submitted to the BC Ministry of Environment on March 31, 2016, and included monitoring activities and results for 2015. As per the Permit, the EMC will continue to provide technical advice on monitoring submissions related to the Regional Groundwater Monitoring Program. In addition, in the fall of 2016, technical groundwater representatives from the KNC, BC Ministry of Environment, and Teck formed the Groundwater Working Group to provide input on specific aspects of Teck's groundwater monitoring programs. The Groundwater Working Group meets as needed to provide input on groundwater related subjects. Outcomes and updates from the Groundwater Working Group meetings are shared with the EMC periodically.

The 2016 Annual Regional Groundwater Monitoring Program Report (of which the rest of this section is focused on discussing) incorporated EMC and Groundwater Working Group feedback where appropriate.

Results

The monitoring activities and associated results of the 2016 Regional Groundwater Monitoring Program are presented in this section. Results are presented for each of the twelve Key Areas, with tables summarizing results that were above the screening criteria.

A total of 37 monitoring, supply and/or domestic wells were included in the Regional Groundwater Monitoring Program, and these wells provide information on regional groundwater conditions. The wells were selected because they were pre-existing and are thought to best characterize groundwater conditions and potential transport of Order constituents to the valley bottom in the Key Areas. The table in Appendix E provides the full list of monitoring wells associated with each Key Area, and includes information on the type of well (i.e. domestic, monitoring or supply), the operation the well is associated with, and location coordinates.

Groundwater Quality Monitoring Results—Overview

In general, groundwater conditions in 2016 were similar to those outlined in the synthesis report (introduced on page 56) and in the 2015 Regional Groundwater Monitoring Program Annual Report. Patterns of concentrations of Order constituents above primary and secondary screening criteria were generally consistent with previous observations.

Some non-Order constituents exceeded primary screening criteria at specific wells in various Key Areas, including:

- Barium (Key Areas 2, 6, and 11);
- Boron (Key Area 4);
- Cloride (Key Area 11);
- Copper (Key Area 9);
- Fluoride (Key Areas 6 and 8);
- Iron (Key Area 9);
- Magnesium (Key Area 9);
- Manganese (Key Areas 3, 4, 6, 8, and 11);
- Molybdenum (Key Areas 2, 3, 4, 5, 6, 8, 9, 10, and 11); and
- Sodium (Key Area 11).

In the majority of cases, these exceedances had no identified receptor for a specific pathway and/or the results were only marginally above primary screening criteria. Where non-Order constituent concentrations were more than marginally higher than primary screening criteria, results were not consistent (i.e. with copper) or appear to be a result of naturally occurring conditions (i.e. fluoride, iron and manganese). The source of these constituents is currently unknown. The monitoring, evaluation and reporting of all non-Order constituents will continue under the Regional Groundwater Monitoring Program.

Understanding groundwater and surface water interactions is a major focus of the interpretation of the results generated through the Regional Groundwater Monitoring Program. This is of particular interest because the release of Order and other constituents through mining-related activities occurs on the surface of the earth, and it is important to understand where the constituents go after they are released, including where they may be entering into and flowing through groundwater systems.

Information on Natural, Background Conditions of Groundwater

A background well has been installed to provide a reference for naturally occurring groundwater conditions. To ensure the well is representative of natural conditions, the well has been installed upstream of the Fording River Operations mining footprint. This well is located in the Henretta Creek valley-bottom, which is a tributary of the upper watershed of the Fording River. Concentrations of all constituents were below primary screening criteria at this well during monitoring in 2016, so it was considered an appropriate reference well.

Key Area	Total Number of Wells Monitored in Regional Program	Number of Wells with Concentrations of Order Constituents above Groundwater Primary and/or Secondary Screening Criteria			
		Selenium	Nitrate	Sulphate	Cadmium
1	3	3	3	0	0
2	2	0	0	0	0
3	4	1	0	1	0
4	7	2	0	2	0
5	0	–	–	–	–
6	1	0	0	0	0
7	2	1	0	0	0
8	2	0	0	0	0
9	7	4	3	1	0
10	1	0	0	0	0
11	4	0	0	1	0
12	3	2	0	0	0
Total[4]	**36**	**13**	**6**	**5**	**0**

Table 3: Overview of 2016 Regional Groundwater Monitoring Program Results

[4] The thirty-seventh monitoring well in the Regional Groundwater Monitoring Program is the background well and as such, monitoring results associated with that well are not presented in this table.

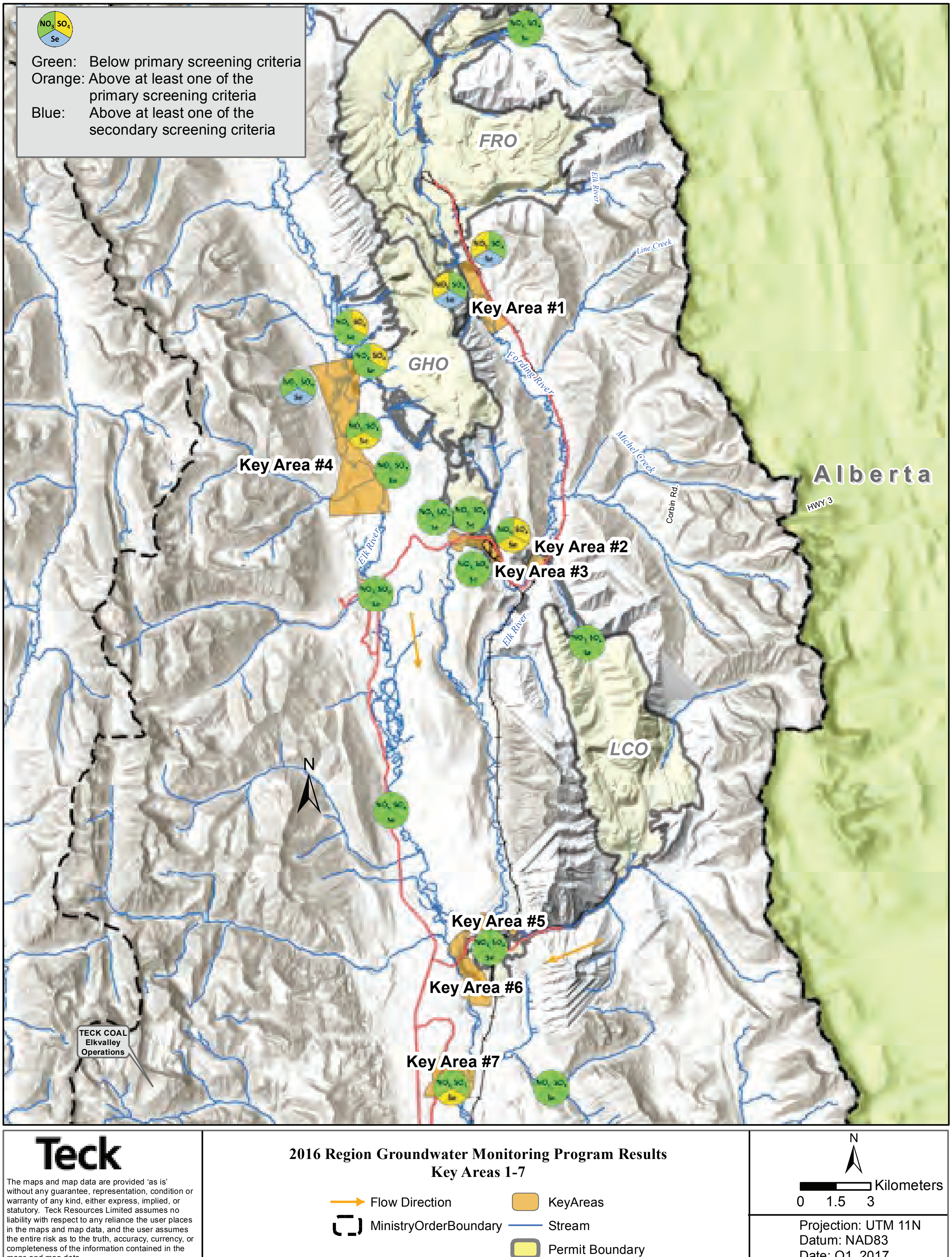


Figure 26: 2016 Regional Groundwater Monitoring Program Results Key Areas 1–7

Figure 27: 2016 Regional Groundwater Monitoring Program Results Key Areas 8–12

Groundwater Quality Monitoring Results —by Key Area

Key Area 1—Fording River Valley-bottom, Downgradient from Fording River Operations, Cataract and Porter Creeks

Description

This Key Area was identified because it receives significant groundwater flows from areas that may be influenced by the Fording River Operations and Greenhills Operations.

The groundwater in this area receives recharge from the Fording River, as well as infiltration from the South Tailings Pond, and South Kilmarnock Phase 1 and 2 settling ponds. This area may be receiving mine-influenced constituents (i.e. nitrate and selenium) from waste rock dumps in the Kilmarnock, Swift, Cataract and Porter Creek watersheds, as well as from surface water recharge from the Fording River and other tributaries.

Three wells were selected to monitor groundwater near the southern boundary of Fording River Operations (refer to Figures 26 and 27 on page 64 for a visual of where these wells are located):

- Two dedicated monitoring wells FR_09-01-A and FR_09-01-B; and
- One water supply well FR_GHHW.

Results

Primary screening criteria was exceeded in sampling at all three wells in Key Area 1, in all four quarters of 2016.

Secondary screening was completed where sample concentrations exceeded primary screening criteria. Most selenium samples were above secondary Site Performance Objective and drinking water criteria, and a few samples were also above the Compliance Point criteria.

Discussion of Results

The furthest downgradient (i.e. downstream) monitoring point, FR_GHHW, had selenium and nitrate above primary screening criteria. Selenium concentrations at FR_GHHW were also above secondary screening criteria for some sampling events. Analyses suggest that the variability in selenium and nitrate concentrations at this location may be related to seasonal effects from upstream surface water in Kilmarnock Creek. FR_GHHW is also intermittently pumped at low volumes and, as such, concentrations from FR_GHHW may be considered average groundwater concentrations in the valley-bottom aquifer.

Understanding of localized groundwater quality, as well as an understanding of groundwater flow paths, is still being developed and knowledge gaps will be filled as the RGMP continues. Additional groundwater studies have been initiated at Fording River Operations to further assess groundwater influence from Kilmarnock Creek, Swift Creek and Cataract Creek, and the adequacy of existing monitoring wells for use in the Regional Groundwater Monitoring Program.

Parameter[1]	FR_09-01-A				FR_09-01-B				FR_GHHW[2]			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Nitrate	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW	DW
Selenium	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW

Table 4: Summary of Results Above Primary Screening Criteria for Key Area 1

1.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW);
2.) Q4 sample from FR_GHHW was collected from FR_GH_WELL2.

Parameter[1, 2]	FR_09-01-A				FR_09-01-B				FR_GHHW			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Selenium	SPO DW	SPO DW	SPO DW	CP SPO DW	—	SPO DW	SPO DW	SPO DW	CP SPO DW	CP SPO DW	SPO DW	SPO DW

Table 5: Summary of Results above Secondary Screening Criteria for Key Area 1

1.) '—' denotes result below secondary screening criteria; and
2.) Secondary screening criteria are Site Performance Objective (SPO), Compliance Point (CP) and Health Canada's Guidelines for Drinking Water Quality (DW).

Key Area 2—Fording River Valley-bottom, Downgradient from Line Creek Operations Dry Creek

Description

This area was identified because it receives drainage from the Line Creek Operations Phase II development in the Line Creek Operations' Dry Creek watershed, which is a tributary to the Fording River.

Two dedicated monitoring wells (LC_PIZDC1308 and LC_PIZDC1307) were selected to monitor groundwater at locations that are downgradient of mine influence and are expected to identify any potential mine-related impacts to groundwater. These wells are a nested pair - meaning that they are drilled side by side, but at different depths - to obtain a better understanding of how groundwater moves vertically in order to better characterize the aquifer. Refer to Figures 26 and 27 on page 64 for a visual of where these wells are located.

Results

Concentrations of Order constituents were below the primary screening criteria in groundwater samples collected at both monitoring locations; therefore, no secondary screening was performed.

Discussion of Results

Concentrations of Order constituents in groundwater samples from LC_PIZDC1308 and LC_PIZDC1307 have consistently been below all primary screening criteria, and results from 2015 and 2016 are consistent with historical results. Based on monitoring results at these two wells, a significant pathway for groundwater transport of Order constituents to Key Area 2 does not appear to exist. The most substantial pathway for constituents in mine-influenced water to reach the valley-bottom appears to be Line Creek Operations' Dry Creek surface water.

Key Area 3—Fording River Valley-bottom, Downgradient from Greenhills Operations Rail Loop and Greenhills Creek

Description

This Key Area was identified because groundwater in the Fording River valley-bottom may be influenced by upland groundwater that is influenced by Greenhills Operations (GHO). Potential sources of groundwater recharge to the valley-bottom groundwater in this area include surface water and upland groundwater from Greenhills Creek and the Fording River.

Four water supply wells were used to obtain data on groundwater in Key Area 3, with the following identification names: GH_POTW09, GH_POTW10, GH_POTW15, and GH_POTW17. Refer to Figures 26 and 27 on page 64 for a visual of where these wells are located.

Results

None of the samples taken from GH_POTW09, GH_POTW10, and GH_POTW15 found concentrations of Order constituents in groundwater higher than the primary screening criteria.

Samples collected at GH_POTW17 found selenium and sulphate concentrations exceeded primary screening criteria for aquatic life during all four quarterly sampling events. Q2 samples collected at GH_POTW17 also found that sulphate concentrations exceeded primary screening criteria for drinking water.

Secondary screening for selenium at GW_POTW17 was completed, and all samples were below secondary screening criteria.

Discussion

Concentrations of total selenium and sulphate in GH_POTW09, GH_POTW10 and GH_POTW15 were relatively consistent throughout the year, suggesting little seasonal influence and therefore not a direct connection with Fording River surface water. This is consistent with the interpretation that relatively continuous aquitards exist in the valley bottom in Key Area 3. The higher sulphate concentrations at GH_POTW17 suggest influence from Greenhill Creek surface water at this location. The highest concentration of sulphate at GH_POTW17 was measured in June of 2016 and was slightly above the primary screening criteria for drinking water.

Parameter[1, 2]	GH_POTW09				GH_POTW10	GH_POTW15	GH_POTW17			
	Q1	Q2	Q3	Q4	Q1 to Q4	Q1 to Q4	Q1	Q2	Q3	Q4
Selenium	—	—	—	—	—	—	AW	AW	AW	AW
Sulphate	—	—	—	—	—	—	AW	AW DW	AW	AW

Table 6: Summary of Results Above Primary Screening Criteria for Key Area 3

1.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW) with the exception of GW_POT17 which was compared to BCWQG (AW);
2.) ‘ —‘ denotes result below primary screening criteria for given constituents.

Key Area 4—Elk River Valley-bottom, Downgradient from Leask, Wolfram and Thompson Creeks

Description

Key Area 4 was identified for inclusion in the Regional Groundwater Monitoring Program because surface water and upland groundwater from Mickelson, Leask, Wolfram and Thompson Creek drainages are potential sources of Order constituents. Surface water from these creeks is diverted to settling ponds located near the valley-bottom. Groundwater in upland areas is thought to flow toward the Elk River valley-bottom.

Seven monitoring locations were selected for Key Area 4:

- Five dedicated monitoring wells (GH_GA-MW-1, GH_GA-MW-2, GH_GA-MW-3, GH_GA-MW-4, and GH_MW-ERSC-1);
- One water supply well (RG_DW-01-03); and
- One domestic well (RG_DW-01-07).

Refer to Figures 26 and 27 on page 64 for a visual of where these wells are located.

Results

Out of the four Order constituents, selenium and sulphate concentrations were measured above primary screening criteria in Key Area 4 at some point in 2016.

Secondary screening for selenium was completed where sample concentrations were above primary screening criteria. The only result above secondary screening criteria was a Q4 sample from GH_GA_MW-2.

Discussion

Groundwater selenium concentrations in Key Area 4 have shown considerable variability in select wells. Interaction between surface water and groundwater is not clear based on available data, but it is suspected that variable groundwater concentrations are due to periods of elevated selenium concentrations in surface water.

Groundwater quality in the Elk River valley-bottom appears to improve as it moves down-valley (i.e downstream). Selenium concentrations in the valley-bottom groundwater were below all screening criteria at the water supply well RG_DW-01-03, with concentrations decreasing further down-valley of Elkford at domestic well location RG_DW-01-07, suggesting dilution is occurring along the valley-bottom groundwater flow path due to mixing with surface water and additional fresh water inputs.

Parameter[1, 2]	GH_GA-MW-1				GH_GA-MW-2				GH_GA-MW-3				GH_GA-MW-4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sulphate	—	DW	—	DW	—	—	—	—	—	—	—	—	DW	—	—	—
Selenium	—	—	—	—	AW DW	—	AW DW	AW DW	AW DW	—	—	—	—	—	—	—

Table 7: Summary of Results Above Primary Screening Criteria for Key Area 4

1.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW);
2.) '—' denotes result below primary screening criteria for given constituents.

Key Areas 5 and 6—Fording River Valley-bottom Downgradient of Line Creek, and Elk River Valley-bottom Downgradient of Convergence with Fording River

Description

Key Areas 5 and 6 were selected because the Regional Drinking Water Sampling Program identified elevated selenium in groundwater downgradient of the convergence with Fording River. These Key Areas receive inputs from Line Creek, the Fording River and the Line Creek Operations Process Plant.

There is no monitoring well within Key Area 5 and there is one dedicated monitoring well located in Key Area 6, with the identification name: LC_PIZP1101. Refer to Figure 26 on page 64 for a visual of where this well is located.

Results

Concentrations of Order constituents in samples from LC_PIZP1101 were below the primary screening criteria; therefore, no secondary screening was performed.

Discussion

Groundwater from the Line Creek Operations Process Plant Site has been shown to flow towards Key Area 6; however, relatively low concentrations of Order constituents (i.e. below primary screening criteria) were measured in groundwater collected from LC_PIZP1101 during the 2015 and 2016 groundwater monitoring program.

Based on a comparison of groundwater concentrations at this location and surface water concentrations in Line Creek, the most significant pathway of mine-influenced water to the valley-bottom appears to be through surface water from Line Creek.

Key Area 7—Elk River Valley-bottom, Downgradient of Grave Creek

Description

This area was selected because Harmer Creek flows from Elkview Operations (EVO) into the Grave Creek drainage, and Grave Creek is a tributary to the Elk River. Additionally, samples from the Regional Drinking Water Sampling Program in this area exceeded selenium primary screening criteria for aquatic life and drinking water.

Two wells were selected for use in the 2016 RGMP in Key Area 7:

- One dedicated monitoring well, EV_GV3gw; and
- One domestic well, RG_DW-02-20.

Refer to Figures 26 and 27 on page 64 for a visual of where these wells are located.

Results

At RG_DW-02-20, groundwater concentrations of selenium were above drinking water and aquatic life primary screening criteria during two sampling events in June 2016

Secondary screening was performed for selenium concentrations in well RG_DW-02-20 and all results were below the secondary screening criteria.

Discussion

To assess groundwater and surface water interactions, selenium concentrations measured in groundwater at EV_GV3gw and RG_DW-02-20 were compared to concentrations in surface water in Harmer Creek (EV_HC1) and in the Elk River upstream from the confluence with Grave Creek (EV_ER4), respectively.

Groundwater transport of Order constituents from the Harmer Creek drainage to the Elk River valley bottom is thought to be minimal based on relatively low groundwater concentrations measured in Harmer Creek drainage at EV_GV3gw compared to surface water.

Parameter[1, 2]	EV_GV3gw				RG_DW-02-20[4]			
	Q1	Q2	Q3	Q4	Q1	Q2[4]	Q3	Q4
Selenium	—	—	—	—	AW, DW	AW, DW	—	—

Table 8: Summary of Results Above Primary Screening Criteria for Key Area 7

1.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW);
2.) '—' denotes result below primary screening criteria;
4.) No sample collected in Q1, 2 samples collected in Q2.

Key Area 8—Elk River Valley-bottom, Downgradient of Balmer, Lindsay, and Otto/Cossarini Creeks

Description

Key Area 8 was included in the Regional Groundwater Monitoring Program because surface water and upland groundwater from the Lindsay and Otto/Cossarini drainages, as well as Goddard Marsh, flow into the Elk River valley-bottom. These drainages may transport Order constituents to the Elk River valley-bottom. Potential sources of groundwater recharge in this Key Area includes rainwater, surface water, and recharge from tailings ponds such as Lagoons C and D. Groundwater in Key Area 8 eventually discharges to the Elk River or flows towards the valley-bottom setting in Key Area 12.

Two wells were selected for the 2016 RGMP in Key Area 8:

- Two dedicated monitoring wells, EV_LSgw and EV_OCgw.

Refer to Figures 26 and 27 on page 65 for a visual of where these wells are located.

Results

Groundwater quality in samples collected from EV_LSgw and EV_OCgw was below the primary screening criteria concentrations for all the Order constituents. As such, no secondary screening on these constituents was completed.

Discussion

Concentrations of Order constituents have not been above primary screening criteria in recent groundwater sampling at the wells in Key Area 8. Higher concentrations of dissolved selenium and sulphate measured at EV_LSgw and EV_OCgw in 2013 and 2014 appear to be isolated events, and concentrations since then have been stable and significantly lower than the primary screening criteria for both parameters. Sampling techniques employed in 2014 and 2015 might have explained the high concentrations obtained from those isolated sampling events.

Key Area 9—Michel Creek Valley-bottom, Downgradient of Bodie Creek

Description

This area was selected because the upland Bodie Creek area was identified as a potential source of Order constituents to the Michel Creek valley-bottom. Groundwater recharge in this Key Area may occur in the form of infiltration of surface water from Bodie Creek, surface water from Michel Creek, or as a result of upgradient groundwater flowing down to the valley-bottom.

Seven wells were selected for monitoring in Key Area 9, with the following identification names:

- Three water supply wells (EV_RCgw, EV_WH50gw, and EV_BRgw);
- Three dedicated monitoring wells (EV_BCgw, EV_MCgwS and EV_MCgwD); and
- One domestic well (RG_DW-03-01).

Refer to Figure 27 on page 65 for a visual of where these wells are located.

Results

Groundwater quality in EV_MCgwS, EV_MCgwD and RG_DW-03-01 were below the primary screening criteria concentrations for all the Order constituents in 2016, while exceedances of the primary screening criteria was observed at the other wells. Refer to the two tables for further details on results.

Secondary screening for selenium was completed where sample concentrations were above primary screening criteria. EV_BCgw, EV_BRgw, and EV_RCgw concentrations were above Site Performance Objective secondary screening criteria for selenium in all sampling events. Selenium concentrations were also above Michel Creek Compliance Point concentrations for most sampling events. The Canadian Drinking Water Guideline (CDWG) of 50 mg/L for selenium was exceeded in all four sampling events at EV_RCgw and in Q1 at EV_BCgw.

Parameter[1, 2]	EV_BCgw				EV_MCgwS				EV_MCgwD			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Nitrate Nitrogen	AW DW	AW DW	AW	AW	—	—	—	—	—	—	—	—
Selenium	AW IW LW DW	AW IW DW	AW IW DW	AW IW DW	—	—	—	—	—	—	—	—

Table 9: Summary of Results Above Primary Screening Criteria for Key Area 9

1.) CSR standards for Drinking Water (DW), Livestock (LW) and Irrigation (IW). All wells in Key Area 9 are located within 10 m of surface water, so primary screening criteria for aquatic life are BCWQG for Aquatic Life (AW) and;
2.) '—' denotes result below primary screening criteria for given constituents.

Discussion

Groundwater concentrations of selenium, nitrate and sulphate exceeded the primary and secondary screening criteria in several wells in this Key Area. Groundwater concentration trends were compared to surface water concentration trends in Key Area 9, particularly selenium, nitrate and sulphate measured in nearby surface water at Bodie Creek, Gate Creek and further downstream at Michel Creek.

The highest concentrations of selenium, nitrate and sulphate have been measured in water supply well EV_RCgw, with levels consistently higher than concentrations measured in the Bodie and Gate creeks surface water stations since 2015. The source and extent of high concentrations measured at EV_RCgw are not well understood at this time.

Based on monitoring results, decreasing concentrations of selenium, nitrate and sulphate appears to be occurring in the Michel Creek valley-bottom, suggesting dilution along the flow path and/or groundwater recharge at the local scale.

Uncertainty exists in the extent of groundwater influences in Key Area 9. A Groundwater Supporting Study has been initiated in the Sparwood Area to further assess groundwater conditions and potential influences from mine-related activities. See page 121 for further information about this supporting study.

Parameter[1, 2, 3]	EV_BRgw				EV_WH50gw				EV_RCgw				RG_DW-03-01[4]		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q2	Q3	Q4
Nitrate Nitrogen	—	DW	DW	—	—	—	—	—	DW	DW	DW	DW	—	—	—
Sulphate	—	—	—	—	—	—	—	—	AW IW DW	AW IW DW	AW IW DW	AW IW DW	—	—	—
Selenium	AW IW DW	AW IW DW	AW IW DW	AW IW DW	AW DW	—	AW DW	—	AW IW LW DW	AW IW LW DW	AW IW LW DW	AW IW LW DW	—	—	—

Table 10: Summary of Results Above Primary Screening Criteria for Key Area 9—Continued

1.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW);
2.) '—' denotes result below primary screening criteria for given constituents; and
3.) na indicates the well was not sampled for specific parameter; and
4.) No sample collected in Q1 and 2 samples collected in Q2.

Parameter[1, 2]	EV_BCgw				EV_BRgw				EV_WH50gw				EV_RCgw			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Selenium	SPO CP DW	SPO CP	SPO CP	SPO	SPO CP	SPO CP	SPO CP	SPO CP	—	—	—	—	SPO CP DW	SPO CP DW	SPO CP DW	SPO CP DW

Table 11: Summary of Results Above Secondary Screening Criteria for Key Area 9

1) Secondary screening criteria are Site Performance Objective (SPO), Compliance Point (CP) and Health Canada's Guidelines for Drinking Water Quality (DW); and 2.) '—' denotes result below secondary screening criteria.

Key Area 10—Michel Creek Valley-bottom, Downgradient of Erickson Creek

Description

Key Area 10 consists of the Michel Creek valley bottom located downgradient from Erickson Creek. Mining activities on the southeast slope of Elkview Operations around Erickson Creek are a potential source of mining-related constituents to groundwater in the Michel Creek valley bottom, with transport from the Erickson Creek valley-bottom.

One well was selected for monitoring groundwater in Key Area 10, with the identification name EV_ECgw. Refer to Figure 27 on page 65 for a visual of where this well is located.

Results

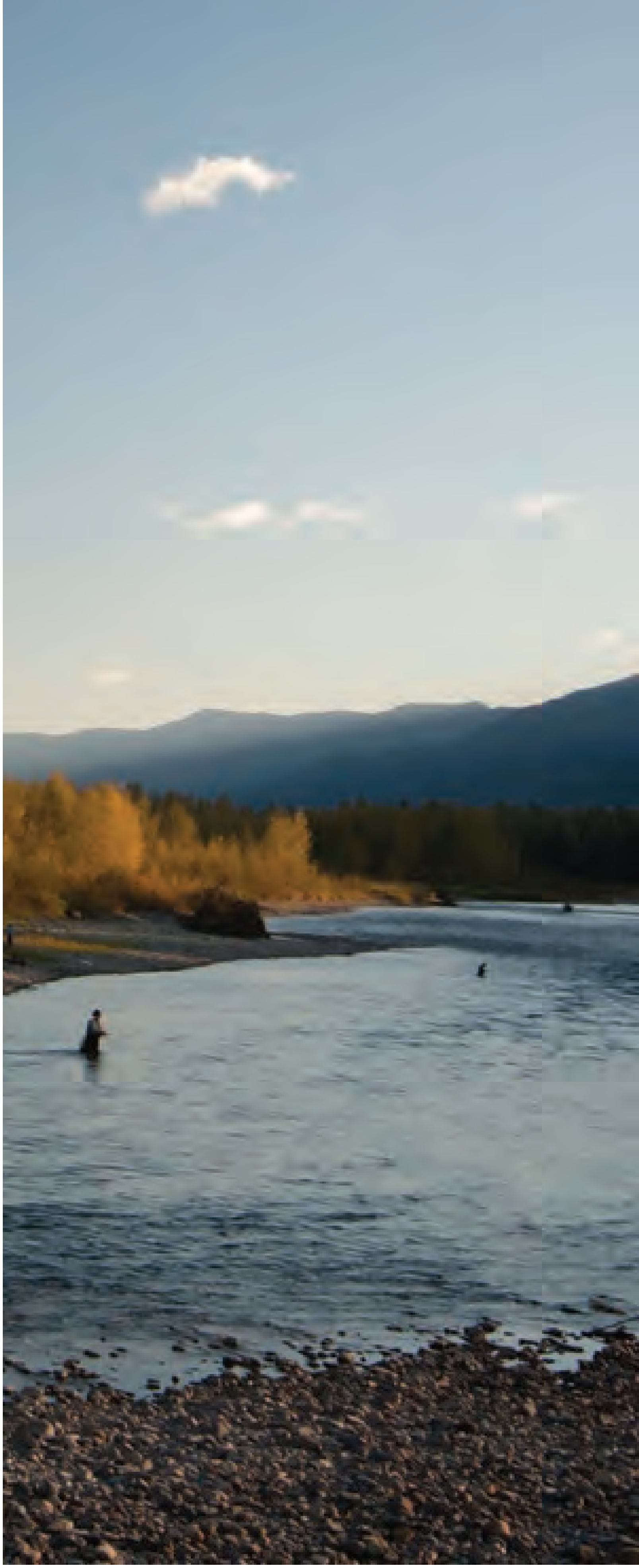
Groundwater concentrations for all Order constituents were below the primary screening criteria in all sampling events at EV_ECgw.

Discussion

Key Area 10 has been identified as an area where transport of Order constituents to the Michel valley-bottom may be occurring due to spoils in Erickson Creek. There are no groundwater wells in the valley-bottom aquifer; however, groundwater monitoring of EV_ECgw, located upgradient in the tributary, is considered adequate to assess potential groundwater transport of Order constituents to Key Area 10.

In the absence of a monitoring well, groundwater quality is unknown in the Michel valley-bottom aquifer, immediately downgradient of Erickson Creek. If there are any mine-related influences on groundwater, these would likely be the result of infiltration of impacted surface water, rather than from tributary groundwater.

Groundwater quality in EV_ECgw was below all primary screening criteria for the Order constituents in 2016; as such, groundwater transport of Order constituents in the Erickson drainage appears to be relatively insignificant, as compared to surface water transport. These 2016 results are consistent with historical results available at this location since the end of November 2013.



Key Area 11—Michel Creek Valley-bottom, Downgradient of Coal Mountain Operations

Description

Key Area 11 consists of Michel Creek valley bottom groundwater located downgradient of Coal Mountain Operations. The Michel Creek valley bottom receives water from Coal Mountain Operations immediately downgradient of the convergence of Michel and Corbin Creeks. In the conceptual model, water flowing outside mine-permitted areas of Coal Mountain Operations primarily flows towards the valley-bottom groundwater in this area.

The groundwater monitoring locations in Key Area 11 included:

- One domestic well near Corbin Creek, RG_DW-07-01, located just west of the Main Settling Pond; and
- The nested dedicated monitoring wells, CM_MW1-OB, CM_MW1-SH, CM_MW1-DP, installed immediately downgradient of Coal Mountain Operations at the convergence of Michel Creek and Corbin Creek.

Nested monitoring wells are drilled side by side, but at different depths, to obtain a better understanding of how groundwater moves vertically, in order to better characterize the aquifer. The nested monitoring wells were installed in 2015 to provide additional monitoring locations in the Michel Creek valley-bottom deposits.

Refer to Figures 26 and 27 on page 65 for a visual of where these wells are located..

Results

The only results above primary screening criteria for the Order constituents in Key Area 11 were the concentrations of sulphate that were marginally above the primary screening criteria for drinking water in domestic well RG_DW-07-01 in two samples. Groundwater concentrations for other Order constituents in Key Area 11 were below the primary screening criteria.

Discussion

At domestic well RG_DW-07-01, sulphate concentrations were slightly above the applicable drinking water standard of 500 mg/L in some of the samples during the monitoring period[5]. Selenium concentrations were below applicable standards in 2015-2016 and only above aquatic life and drinking water standards in March 2014. Upon comparing groundwater monitoring trends against surface water concentrations of Order constituents, it appears that groundwater sampled from RG_DW-07-01 is connected to surface water.

The nested monitoring well (CM_MW1) was added to the RGMP in 2015 to provide an additional monitoring point in the Michel Creek valley-bottom deposits. No results above primary screening criteria were noted in CM_MW1-OB, which is installed in valley-bottom deposits furthest downgradient from Coal Mountain Operations; therefore, dilution of sulphate and dissolved selenium appears to be occurring in the Michel Creek valley-bottom further downgradient of the convergence of Corbin Creek and Michel Creek. This observation is consistent with the groundwater conceptual model.

Parameter[1, 2]	CM_MW-1-OB				CM_MW-1-SH				CM_MW-1-DP				RG_DW-07-01[3]			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Sulphate	—	—	—	—	—	—	—	—	—	—	—	—	—	DW	DW	—

Table 12: Summary of Results Above Primary Screening Criteria for Key Area 11

1.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW);
2.) '—' denotes result below primary screening criteria for given constituents;
3.) No sample collected in Q1 and 2 samples collected in Q2.

[5] This standard is focused on aesthetic considerations, such as taste, colour, and/or odour.

Key Area 12—Elk River Valley-bottom at Study Boundary

Description

Key Area 12 is the furthest downstream Key Area from mining operations and was selected because it is at the boundary of the study area for the Regional Groundwater Monitoring Program. This Key Area receives water flow from valley-bottom groundwater in Key Areas 8 (Elk River) and 9 (Michel Creek), and groundwater is recharged here from Elk River and/or Michel Creek surface water, as well as local precipitation. Monitoring in Key Area 12 provides insight into the quality of groundwater as it leaves Management Unit 4 (which is the boundary of the Regional Groundwater Monitoring Program study area).

Three wells were selected for monitoring in the 2016 RGMP:

- Two dedicated monitoring wells, EV_ER1gwS and EV_ER1gwD; and
- One water supply well, RG_DW-03-04 (i.e. the Sparwood Municipal Well 3).

Refer to Figures 26 and 27 on page 65 for a visual of where these wells are located.

Results

Selenium is the only Order constituent with concentrations above primary screening criteria in Key Area 12.

Secondary screening was performed on samples where selenium concentrations were above primary criteria, and all were below secondary screening criteria.

Discussion

Groundwater quality in Key Area 12 appears to reflect and be influenced by Elk River and Michel Creek surface water quality. Surface water infiltration (i.e. aquifer recharge), rather than a valley-bottom groundwater flow pathway, appears to be the cause of concentrations above screening criteria measured at this location. A Groundwater Supporting Study has been initiated in the Sparwood Area to further assess groundwater conditions and potential impacts from mine-related activities. Please see page 121 in the Human Health Risk Assessment chapter for further information on this work.

Parameter[1, 2, 3, 4]	EV_ER1gwS				EV_ER1gwD				RG_DW-03-04			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Dissolved Selenium	AW DW	—	—	—	—	—	—	—	na	na	na	na
Total Selenium	—	—	—	—	—	—	—	—	AW DW	AW DW	—	AW DW

Table 13: Summary of Results Above Primary Screening Criteria for Key Area 12

1.) Dissolved parameter unless otherwise indicated;
2.) Primary screening criteria applied are CSR standards for Aquatic Life (AW), Drinking Water (DW), Livestock (LW) and Irrigation (IW);
3.) '—' denotes result below primary screening criteria for given constituent; and
4.) na indicates the well was not sampled for specific parameter.

What's Next?

The 2016 Regional Groundwater Monitoring Program report supports the periodic re-evaluation of Big Question six, "Is water quality being managed to be protective of human health?", by identifying uncertainty in the regional water quality monitoring and bringing this forward for consideration in the 2017 Regional Groundwater Monitoring Program update, which is due to be submitted to the BC Ministry of Environment and Climate Change Strategy by September 30, 2017. The 2017 Regional Groundwater Monitoring Program will contain a framework for developing groundwater triggers that integrate with the Adaptive Management Plan and will be discussed with the Groundwater Working Group and the EMC.

The 2018 EMC Annual Public Report will describe any changes to the Regional Groundwater Monitoring Program framework, as well as results from sampling in 2017.

6 Aquatic Ecosystem Health

While the Water Quality chapter above is focused on discussing the concentrations of constituents in surface and groundwater in the Elk Valley watershed, in this chapter, the reader will learn about monitoring studies that are being done to understand the potential impacts of altered water quality on aquatic organisms in this area. Protection of aquatic ecosystem health and management of bioaccumulation of constituents in aquatic organisms and ecosystems are two of the environmental management objectives for the Elk Valley Water Quality Plan. This section provides an update on monitoring activities required by the Permit related to these objectives.

Regional Aquatic Effects Monitoring

Context

Teck's Regional Aquatic Effects Monitoring Program is a requirement under the Permit, and it provides comprehensive routine monitoring and assessment of potential mine-related effects on the aquatic environment downstream from Teck's coal mines in the Elk Valley. Under this program, data collection, analysis, and supporting studies are the basis for a long-term program to monitor and assess the regional aquatic effects. Information collected in the region about the aquatic environment will influence decision-making related to mine operations and the management of the chemical, physical, and biological changes in the aquatic environment through the Adaptive Management Plan (discussed on page 34 above).

What will we learn from regional aquatic effects monitoring?

The Regional Aquatic Effects Monitoring Program has six main questions guiding monitoring of the aquatic environment and mining-related impacts:

1. What are the mine-related chemical and physical changes to aquatic ecosystems, and where do they occur?

2. Are mine-related chemical and physical changes to the aquatic environment resulting in unacceptable biological effects, and where do they occur?

3. What are the specific mine-related sources of any unacceptable changes to chemical, physical, or biological conditions?

4. How are chemical, physical, and biological conditions changing over time?

5. What are the consequences of observed biological effects to the aquatic ecosystem?

6. Are the mine-related chemical and physical changes, and/or biological effects, impacting water and aquatic ecosystem uses?

Status/Results

By the Permit, Teck is required to collect and analyze data related to water quality and its effect on the aquatic environment and select species that live in the water. The 2016 monitoring activities are summarized in table 14.

What about effects to localized aquatic environments?

In addition to regional monitoring, Teck is required to study aquatic effects of mining effluent discharges at a more localized level. These monitoring programs are known as local aquatic effects monitoring programs. To-date, the Permit requires local aquatic effects monitoring programs be implemented for the Fording River, Line Creek, and Greenhills mining operations:

- The Fording River Local Aquatic Effects Monitoring Program has been implemented to take a closer look at nitrate concentrations and potential associated effects at a localized level, in order to better understand conditions prior to the establishment of the Fording River Active Water Treatment Facility;
- The Line Creek Local Aquatic Effects Monitoring Program has been pursued to monitor the effects of active water treatment in the area surrounding the West Line Creek Active Water Treatment Facility; and
- The Greenhills Local Aquatic Effects Monitoring Program will occur in the years 2018-2020 and has been designed to address concerns about potential localized aquatic effects associated with the west spoil development at Greenhills Operations.

See the Local Aquatic Effects Monitoring Programs section on page 84 below for more information on these local programs.

Subject	2016 Activity	Status
Sediment Chemistry	No additional sampling was conducted in 2016.	Data from samples collected in 2013 and 2015 at 10 reference areas and 19 mine-exposed areas were discussed with the Environmental Monitoring Committee (EMC) as input to the Regional Aquatic Effects Monitoring (RAEMP) report due in September 2017.
Sediment Toxicity	No additional sampling was conducted in 2016.	A report was completed in May 2016 that summarized toxicity test results for sediment collected in September 2015 from five mine-exposed and three reference areas. The test species were: (1) the mayfly; (2) the amphipod; and (3) larvae of the midge, all of which are conventional test species. The goal of the study was to determine which species and which test endpoints were the most sensitive to mine-related contaminants. The study results were presented to and discussed with the EMC
Algae	As part of the annual RAEMP sampling program, samples were collected from 6 reference and 14 mine-exposed areas in 2016 for analysis of productivity.	Data from these samples were discussed with the EMC as input to the RAEMP report due in September 2017.
Benthic Invertebrates	As part of the annual RAEMP sampling program, samples were collected at 5 reference and 20 mine-exposed areas for analysis of tissue selenium concentrations.	Data from benthic invertebrate community samples collected at 40 reference and 60 mine-exposed areas in 2015 were analyzed and discussed with the EMC as input to the RAEMP report due in September 2017. Data analyses included evaluation of potential effects of mining on benthic invertebrate community characteristics and tissue selenium concentrations.
Fish	No additional sampling was conducted in 2016.	Monitoring data collected in 2015 were analyzed and discussed with the EMC, including the study of the Westslope Cutthroat Trout population study upstream of Josephine Falls, evaluation of longnose sucker population characteristics at seven mine-exposed and two reference areas sampled in 2015, and tissue selenium concentrations observed in Westslope Cutthroat Trout, longnose sucker, and mountain whitefish in 2015. The results will be presented in the RAEMP report due September 2017.
Amphibians and Birds	There was no monitoring of bird populations in 2016. There was no monitoring of wild amphibian populations in 2016. A laboratory-based amphibian toxicity test was developed by Teck, with input from the Environmental Monitoring Committee in 2016 to assess sensitivity of amphibians to water quality in the Elk Valley.	A report was completed in February 2016 that conducted an analysis of selenium concentrations in Spotted Sandpiper eggs as supporting information. This study was based on sampling and surveys conducted in 2013 and 2014. The main objectives of the spotted sandpiper study was to: (1) Determine if there is an association between sandpiper egg hatchability and selenium concentrations; (2) Define the egg selenium concentration that causes a 10% reduction in hatching success of spotted sandpiper eggs, if possible (i.e., an EC10); and (3) Assess the degree to which disturbances or other factors may affect sandpiper egg hatchability. The study results were presented to and discussed with the EMC. Two rounds of the laboratory-based amphibian toxicity testing were conducted in 2016. Both test were terminated after quality control specimens grown in lab waters failed laboratory control criteria. The failures were theorized by the lab to be related to specimen batch health, and may have been related to a viral or bacterial infection within the supplied egg masses.

Table 14: Summary of the 2016 RAEMP Monitoring Activities

What's Next

The Regional Aquatic Effects Monitoring Program requires ongoing monitoring of the aquatic environment across the watershed on a three-year cycle to fill information gaps and help manage mine-related impacts to water quality and aquatic organisms.

The first three-year cycle of the Regional Aquatic Effects Monitoring Program will be completed in 2017. Data collected throughout 2015 and 2016 has been discussed with the EMC and their input will be reflected in the Regional Aquatic Effects Monitoring Program report due in September 2017. Based on the 2017 report, the EMC may recommend changes to the Regional Aquatic Effects Monitoring Program (i.e. what is monitored, when, and where) or recommend new supporting studies moving forward. An updated study design for the next three-year cycle of monitoring will be discussed with the EMC and must be submitted to the BC Ministry of Environment and Climate Change Strategy by December 15, 2017.

Local Aquatic Effects Monitoring Programs

Fording River Operations Local Aquatic Effects Monitoring Program

Context

By the Permit, Teck was required to develop a local aquatic effects monitoring program focusing on the Upper Fording River from 2016 to 2018 related to the continued development of Fording River Operations and the future commissioning of an active water treatment facility that will be treating waters from Cataract, Swift and Kilmarnock creeks at Fording River Operations.

The goal of the Fording River Operations Local Aquatic Effects Monitoring Program is to assess site-specific issues (e.g., potential aquatic effects in the Fording River in advance of and after implementation of active water treatment) on a more frequent and localized basis, as required until sufficient data has been collected to resolve the concerns of the BC Ministry of Environment and Climate Change Strategy statutory decision maker.

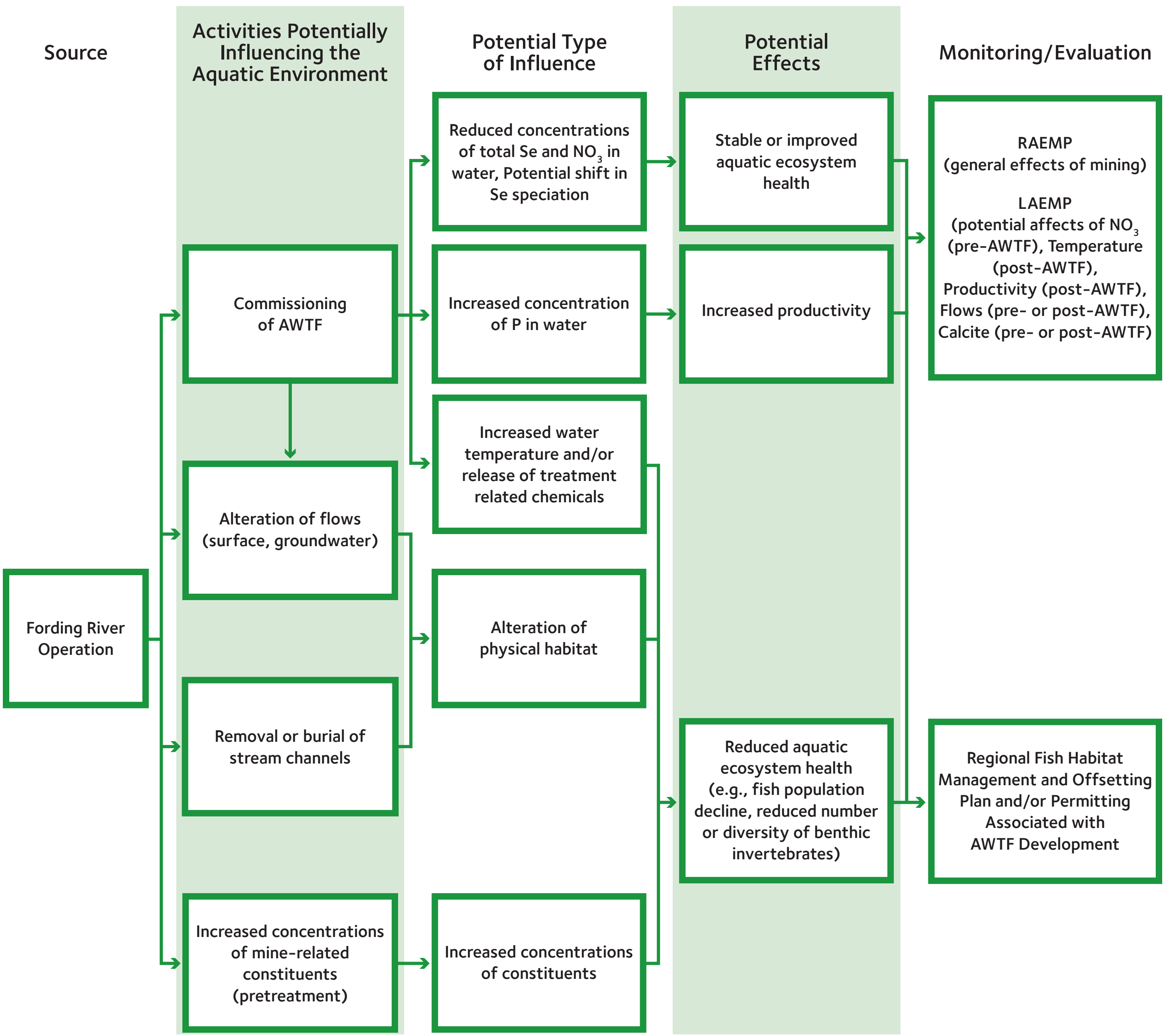


Figure 28: Fording River Operations Local Aquatic Effects Monitoring Program Conceptual Site Model

In consideration of potential existing and future mine-related influences at Fording River Operations, the following key questions were developed in consultation with the EMC to guide the development of the Fording River Operations Local Aquatic Effects Monitoring Program:

1. Are nitrate concentrations increasing, and if so, are they adversely affecting biota?

2. Is active water treatment affecting biological productivity downstream in the Fording River?

3. Are tissue selenium concentrations reduced downstream from the active water treatment facility?

4. Is active water treatment facility operation affecting aquatic biota through thermal effects or concentrations of treatment-related constituents other than nutrients or selenium?

5. Is re-direction of water potentially affecting biota in the Fording River?

The first key question will be addressed through monitoring of benthic invertebrate community structure as part of annual sampling in the Fording River Operations Local Aquatic Effects Monitoring Program, supported by benthic invertebrate data from the Regional Aquatic Effects Monitoring Program, as well as through Teck's water quality monitoring along the upper Fording River and in its tributaries.

The last four key questions relate specifically to active water treatment, which is not required to be operational until December 31, 2018. As such, the initial years of the Local Aquatic Effects Monitoring Program will include collection of baseline information, which will be used to better understand potential changes in aquatic conditions after water treatment commences.

The Fording River Operations Local Aquatic Effects Monitoring Program was also developed in response to concerns of projected increases in nitrate concentrations—and potential effects to the aquatic environment—in the Fording River prior to initiation of water treatment.

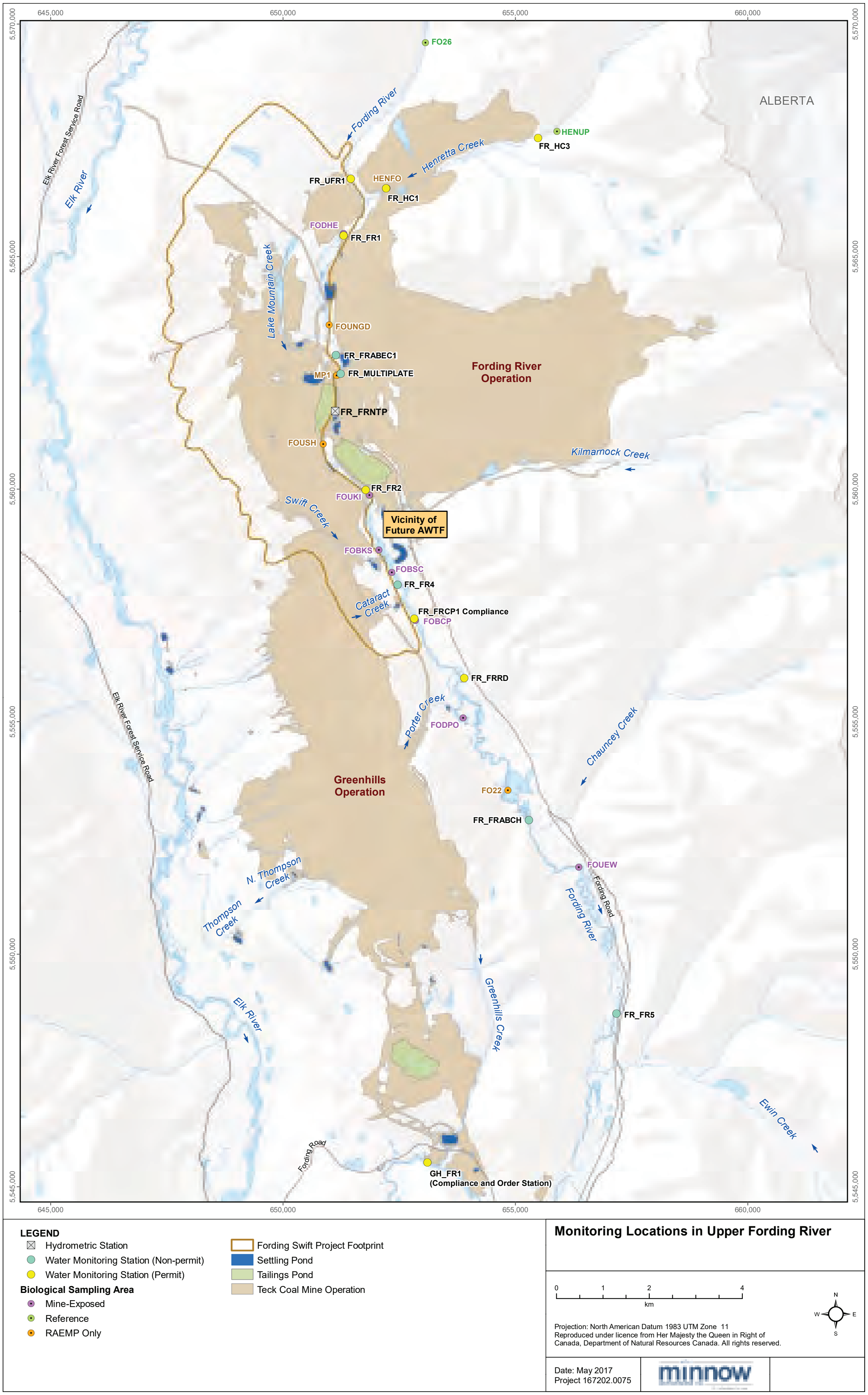


Figure 29: Local Aquatic Effects Monitoring Program Monitoring Locations in the Upper Fording River

Status

The first cycle of the Fording River Operations Local Aquatic Effects Monitoring Program—encompassing the 2016 to 2018 period—represents a period of baseline monitoring. A study design for the Fording River Operations Local Aquatic Effects Monitoring Program was submitted in accordance with the permit requirements June 1, 2016, and subsequently approved by the BC Ministry of Environment on October 24, 2016. Biological samples were collected in September 2016 and results are reported below.

Results

Key Question #1: Are nitrate concentrations increasing, and if so, are they adversely affecting biota?

In the Fording River in 2016, nitrate concentrations were compared upstream to downstream of mining operations and were looked at over a four-year time-period (2012 to 2016), to determine if nitrate concentrations are:

a) increasing over time in a manner consistent with Elk Valley Water Quality Plan projections; and

b) currently above levels that may potentially affect aquatic biota in areas of the Fording River, and, if so, is there evidence of biological effects?

Discussion of Results: Water Quality Trends (part A of Key Question #1)

Seasonal trends are visible throughout all monitoring locations in the upper Fording River, with higher concentrations of nitrate during low flow (i.e. during the winter) and lower concentrations during high flow (i.e. during the spring, when freshet occurs).

Nitrate concentrations for monitoring stations in the upper Fording River reflected varying trends over the period 2012 to 2016, with small increasing trends observed at the upstream reference stations (FR_UFR1 – 0.013 mg/l per year, FR_HC3 – 0.022 mg/l per year); a decreasing trend at mine-influenced FR_FR1 (- 0.20 mg/l per year); and a greater increasing trend at mine-influenced FR_FR2 (0.84 mg/l per year). At stations farther downstream, no long term trend was indicated, although data were limited for some stations (FR_FRCP1, FR_FRRD, and FR_FRABCH) where monitoring began only in the last 2–3 years.

Nitrate concentrations remained below the BC Water Quality Guideline of 3 mg/l at the upstream reference stations, but exceeded the Elk Valley Water Quality Plan Level 1 and 2 benchmarks in at least one sample at most sampling areas in the Fording River downstream from mining activities, particularly at the areas downstream from Cataract Creek. Refer to Figures 30–39 below for a graphical illustration of nitrate trends at monitoring locations in the upper Fording River.

The 2016 annual medians of monthly average nitrate concentrations increase moving downstream from the reference stations through the mine affected areas, and begin decreasing upstream of Ewin Creek (FR_FR5; Figure 40).

What are Elk Valley Water Quality Plan Level 1 and 2 benchmarks?

Water-quality benchmarks were defined for Order constituents for the protection of aquatic life in the Elk Valley. Water-quality benchmarks were derived from toxicity test results relevant to the Elk Valley, with a focus on biological endpoints such as growth or reproduction for the most sensitive aquatic species. Work to develop the benchmarks identified sensitive aquatic species and determined concentrations that result in critical-effect sizes of ~10% (Level 1) and 20% (Level 2) to sensitive life-history endpoints. Further, critical-effect sizes are typically expressed as a percentage effect for a life-history endpoint, such as a 10% effect on growth or reproduction.

The benchmarks are specific points along a dose-response curve that defines the relationship between tissue concentration and the percentage effect of the response in an aquatic organism (i.e. as concentrations of a constituent increase, greater effects are anticipated, and vice versa). Two levels of water-quality benchmarks are defined for selenium, nitrate and sulphate in the Elk Valley watershed: Level 1 benchmarks for a 10% effect size, and Level 2 benchmarks for a 20% effect size. Cadmium concentrations in the Elk and Fording rivers are below the Level 1 benchmark; therefore, no Level 2 benchmark was developed.

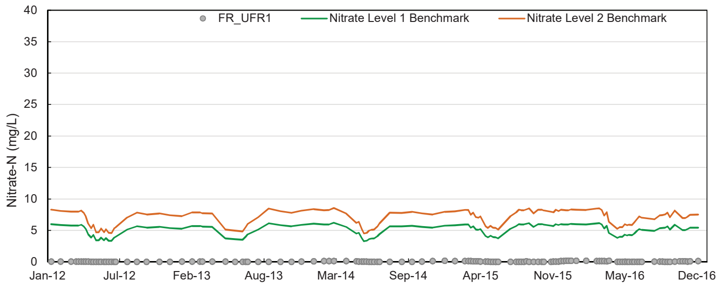


Figure 30: Nitrate benchmarks and concentrations at the FR_UFR1 monitoring location (Fording River upstream of Henretta Creek) from 2012 to 2016.

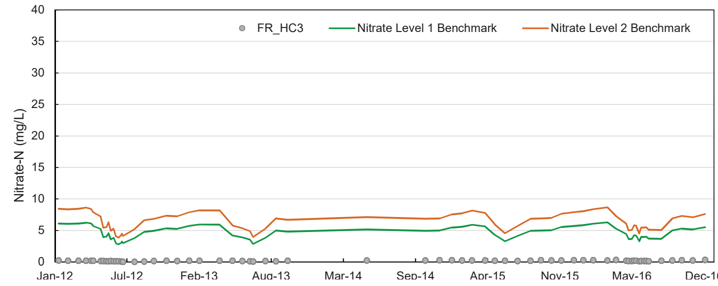


Figure 31: Nitrate benchmarks and concentrations at the FR_HC3 monitoring location (Henretta Creek upstream of McQuarrie Creek) from 2012 to 2016.

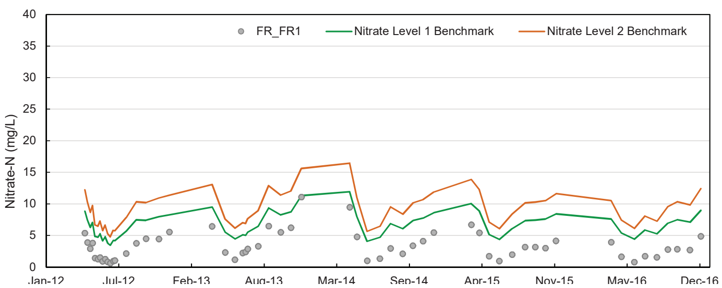


Figure 32: Nitrate benchmarks and concentrations at the FR_FR1 monitoring location (Fording River downstream of Henretta Creek) from 2012 to 2016.

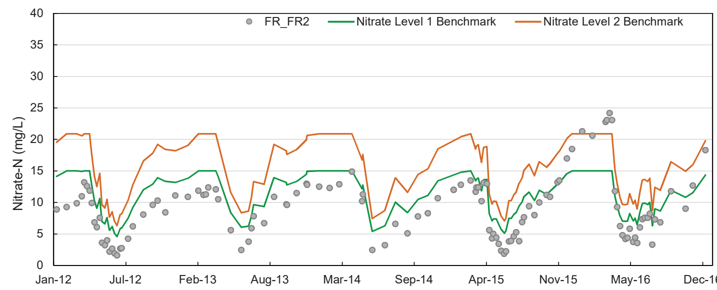


Figure 33: Nitrate benchmarks and concentrations at the FR_FR2 monitoring location (Fording River upstream of Kilmarnock Creek) from 2012 to 2016.

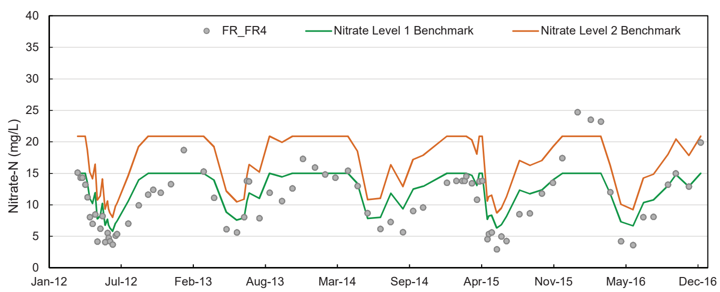


Figure 34: Nitrate benchmarks and concentrations at the FR_FR4 monitoring location (Fording River downstream of Swift Creek and upstream of Cataract Creek) from 2012 to 2016.

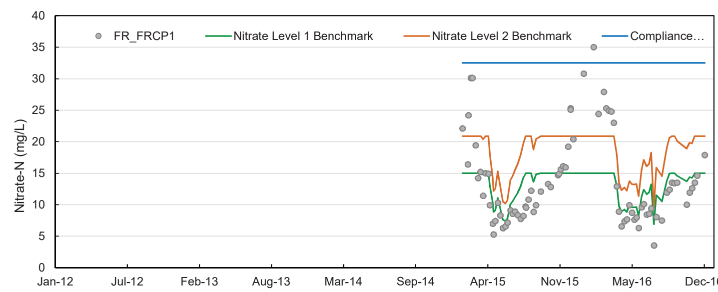


Figure 35: Nitrate benchmarks and concentrations at the FR_FRCP1 monitoring location (Fording River downstream of Cataract Creek) from 2012 to 2016.

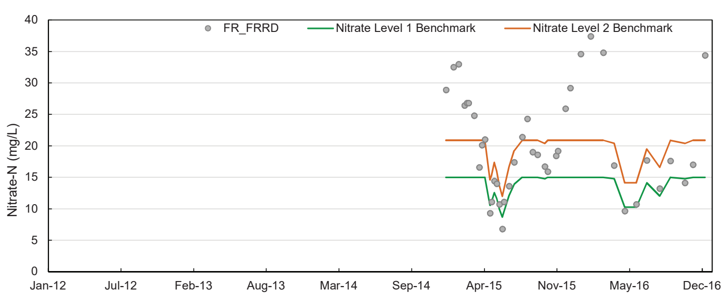


Figure 36: Nitrate benchmarks and concentrations at the FR_FRRD monitoring location (Fording River near Fording River Road) from 2012 to 2016.

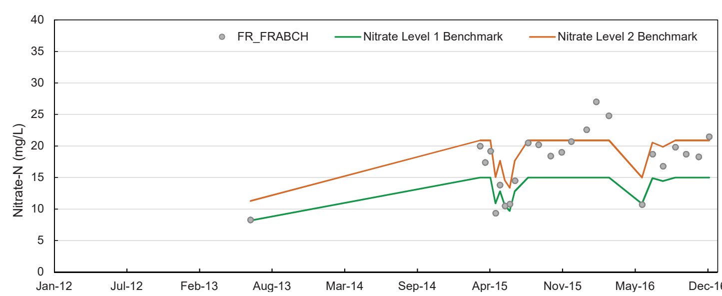


Figure 37: Nitrate benchmarks and concentrations at the FR_FRABCH monitoring location (Fording River upstream of Chauncey Creek) from 2012 to 2016.

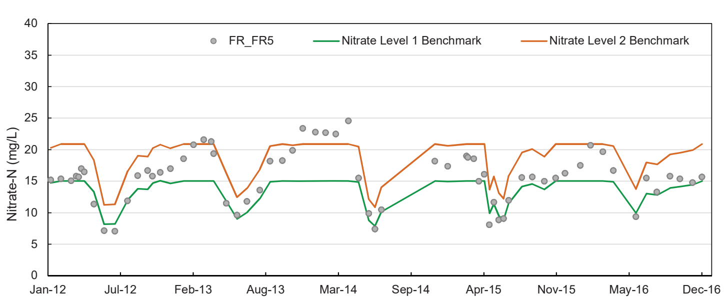


Figure 38: Nitrate benchmarks and concentrations at the FR_FR5 monitoring location (Fording River downstream of Chauncey Creek) from 2012 to 2016.

Discussion of Results: Effects to Biota (part B of Key Question #1)

Chronic toxicity tests using the water sampled quarterly from the Fording River Compliance Point (FR_FRCP1) have shown evidence of adverse effects to invertebrates. Compliance Points are intended to monitor fully mixed conditions in the receiving environment (i.e., main stem river) of all or most of the direct or indirect discharges from one mine operation. Water quality and quantity monitoring data have indicated that surface water flow at FR_FRCP1 is predominantly discharge water from mine-impacted Cataract Creek during winter low flow months. This information may assist in explaining water quality data and chronic toxicity results obtained at FR_FRCP1 during low flow periods (Q1 and Q4) in 2016 (see page 52 for further discussion of these chronic toxicity results).

At GH_FR1 (18.5 km farther downstream), where nitrate concentrations have been less than modeled projections in the Elk Valley Water Quality Plan, adverse effects to invertebrates were evident in tests in the second quarter of 2016 only, and no specific water quality parameter was conclusively identified as the cause (see page 52 for further discussion of these chronic toxicity results).

Overall, the evaluation of data related to Key Question #1 (Are nitrate concentrations increasing, and if so, are they adversely affecting biota?) indicated that:

1. The abundance and richness of the benthic invertebrate community in the Fording River are within normal ranges of communities found in local and regional reference areas.

2. Community structure identified a reduction in the percentage of mayflies from upstream Kilmarnock Creek (FOUKI) to downstream of Chauncey Creek (FOUEW). In 2016, all locations moving downstream from FOUKI were outside the local reference range for % Ephemeroptera (based on FO26 and HENUP), while downstream of Cataract Creek (FRCP1) to downstream of Chauncey were outside the regional reference range.

Nitrate concentrations may contribute to the spatial pattern of decreasing percentages of mayflies (i.e. Ephemeroptera) with distance downstream, but do not explain the apparent change in benthic invertebrate community structure over time. Other factors, in addition to nitrate concentrations, that may be impacting the benthic communities and are being investigated further include:

- Temperature trends (and/or associated annual variation in flows);
- Annual variation in flow and sections that naturally dewater during low winter flow conditions; and
- Calcite deposition.

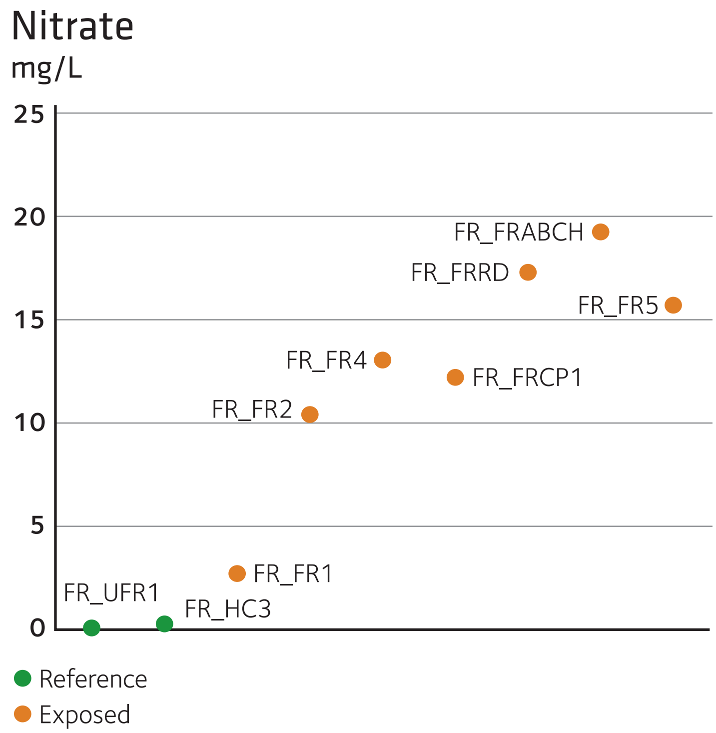


Figure 40: Annual Medians of Monthly Averages of Nitrate at Fording River Monitoring Stations

Key Question #2–"Is active water treatment affecting biological productivity downstream in the Fording River?"

Data currently being collected represent baseline water concentrations prior to active water treatment facility operation. Key Question #2 will be addressed after the active water treatment facility is commissioned. In the meantime, the EMC will provide advice on how the data is analyzed.

Key Question #3–"Are tissue selenium concentrations reduced downstream from the active water treatment facility?"

Selenium concentrations in composite taxa (2006 to 2016) and individual taxa (beginning in 2016) were monitored as part of the Fording River Operations Local Aquatic Effects Monitoring Program and other historical studies. Tissue selenium concentrations in benthic invertebrates and fish are currently within the ranges predicted in the Elk Valley Water Quality Plan. These data, combined with data collected during the 2017 Local Aquatic Effects Monitoring Program study, will characterize conditions prior to active water treatment facility operation. In the meantime, the EMC will provide advice on how the data is analyzed.

Key Question #4—"Is active water treatment facility operation affecting aquatic biota through thermal effects or concentrations of treatment-related constituents other than nutrients or selenium?"

Water temperature trends in the Fording River were identified as a factor potentially contributing to changes in benthic invertebrate communities during the current baseline period preceding active water treatment facility operation. Water temperatures will continue to be monitored throughout the Local Aquatic Effects Monitoring Program.

Once in operation, effluent acute toxicity testing (on rainbow trout and Daphnia magna) will be required as a condition of the Permit. Effluent acute toxicity data, as well as data collected as part of the Compliance Point chronic toxicity program (see section 52 for further information), will be used to evaluate potential effects associated with treatment-related constituents.

Key Question #5—"Is re-direction of water potentially affecting biota in the Fording River?"

Water flow characteristics in the Fording River were identified as a factor potentially contributing to changes in benthic invertebrate communities during the current baseline period preceding active water treatment facility operation. Water flows will continue to be routinely measured to further characterize baseline conditions prior to commissioning of the active water treatment facility. Key Question #5 will be addressed after the active water treatment facility is commissioned. In the meantime, the data analysis approach for addressing this question will be developed in consultation with the EMC.

What's Next?

In consideration of the decreasing percentage of mayflies, Teck will be submitting an amendment to the Fording River Operations Local Aquatic Effects Monitoring Program in 2017 and is currently working on the finalization of that amendment. It is anticipated that the Fording River Operations Local Aquatic Effects Monitoring Program design will be amended to allow for further investigation of the Fording River benthic invertebrate communities. This will occur in consultation with the EMC prior to implementation of field sampling in September, 2017. Results from the 2017 monitoring will be discussed with the EMC and will be reported on in the 2018 EMC Public Report.

Line Creek Local Aquatic Effects Monitoring Program

Context

As per the Permit, Teck was required to develop a local aquatic effects monitoring program related to commissioning of the West Line Creek Active Water Treatment Facility, which became fully operational in February 2016. The goal of the Line Creek Local Aquatic Effects Monitoring Program is to assess site-specific issues (e.g., potential effects of active water treatment) on a more frequent and localized basis, as required until sufficient data has been collected to resolve the concerns of the BC Ministry of Environment and Climate Change Strategy statutory decision maker.

The technology used at the West Line Creek Active Water Treatment Facility for selenium and nitrate removal requires the addition of phosphorus to the treatment process. Although the West Line Creek Active Water Treatment Facility has managed to minimize the amount of residual phosphorus in treated effluent, there is potential for phosphorus concentrations to increase and potentially cause increased algal growth, changing the trophic status and biotic community structure in Line Creek downstream from the treatment facility discharge. Consequently, as part of the approval for operation of the treatment facility at Line Creek Operations, the BC Ministry of Environment and Climate Change Strategy specified Site Performance Objectives for a new monitoring station in Line Creek, situated downstream from the West Line Creek Active Water Treatment Facility discharge.

Selenate has been the dominant form of selenium in surface waters downstream from Teck's coal mines. At the West Line Creek Active Water Treatment Facility, selenium is removed via uptake into microorganisms within the treatment system. One outcome from treatment is that some of the selenium in the treated water is being transformed into different forms of selenium (see Figure 42) that can be accumulated into the base of the food web more readily than selenate. As a result, although the West Line Creek Active Water Treatment Facility is designed to reduce total selenium loads to Line Creek, there is potential that selenium concentrations in tissues of biota may not show a similar reduction. Research is underway to address and mitigate selenium transformation.

[6] Ammonia, nitrate, nitrite, total Kjeldahl nitrogen, orthophosphate, total phosphorous.

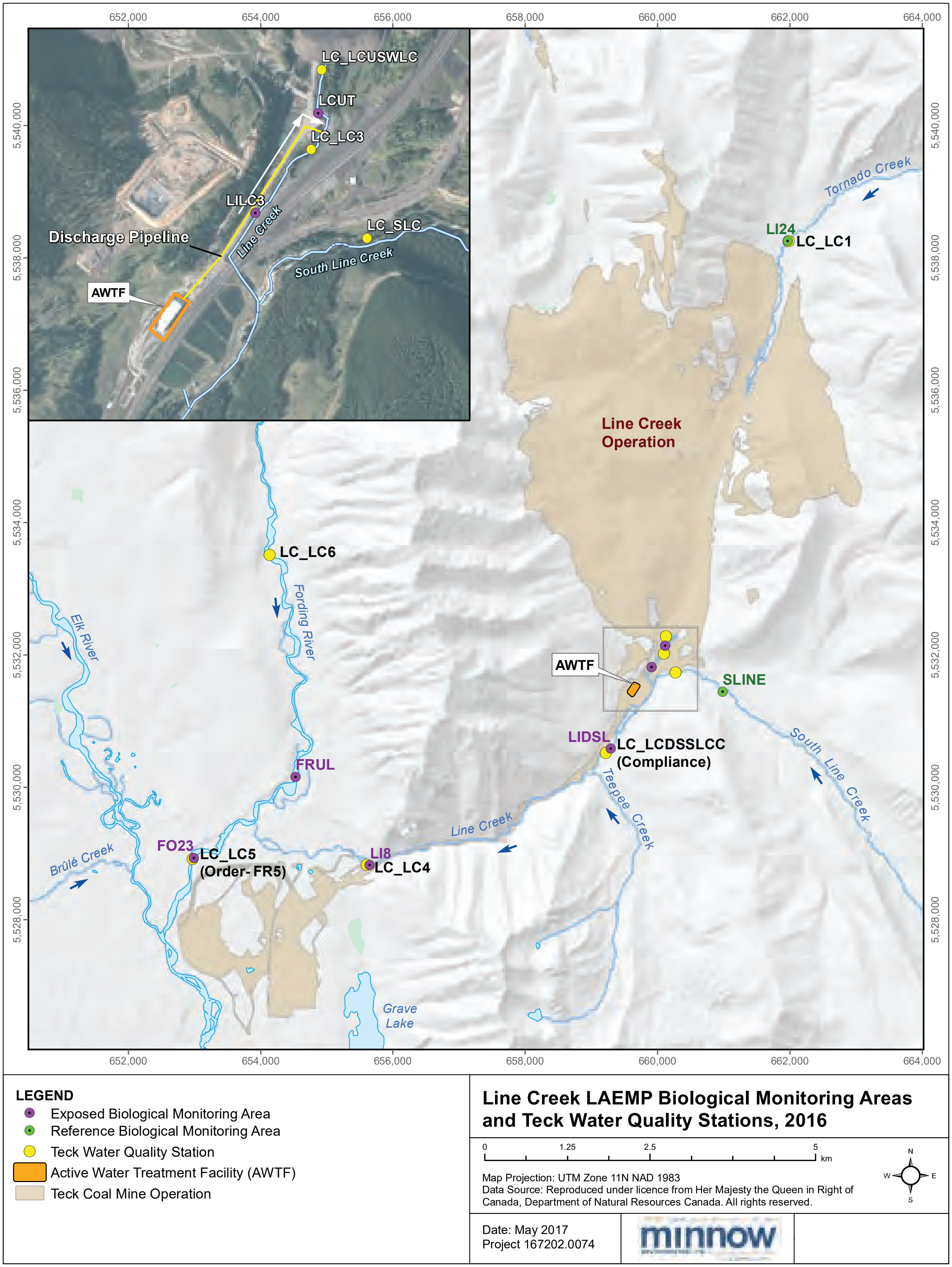


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Figure 41: Line Creek Local Aquatic Effects Monitoring Program Monitoring Areas and Teck Water Quality Stations, 2016

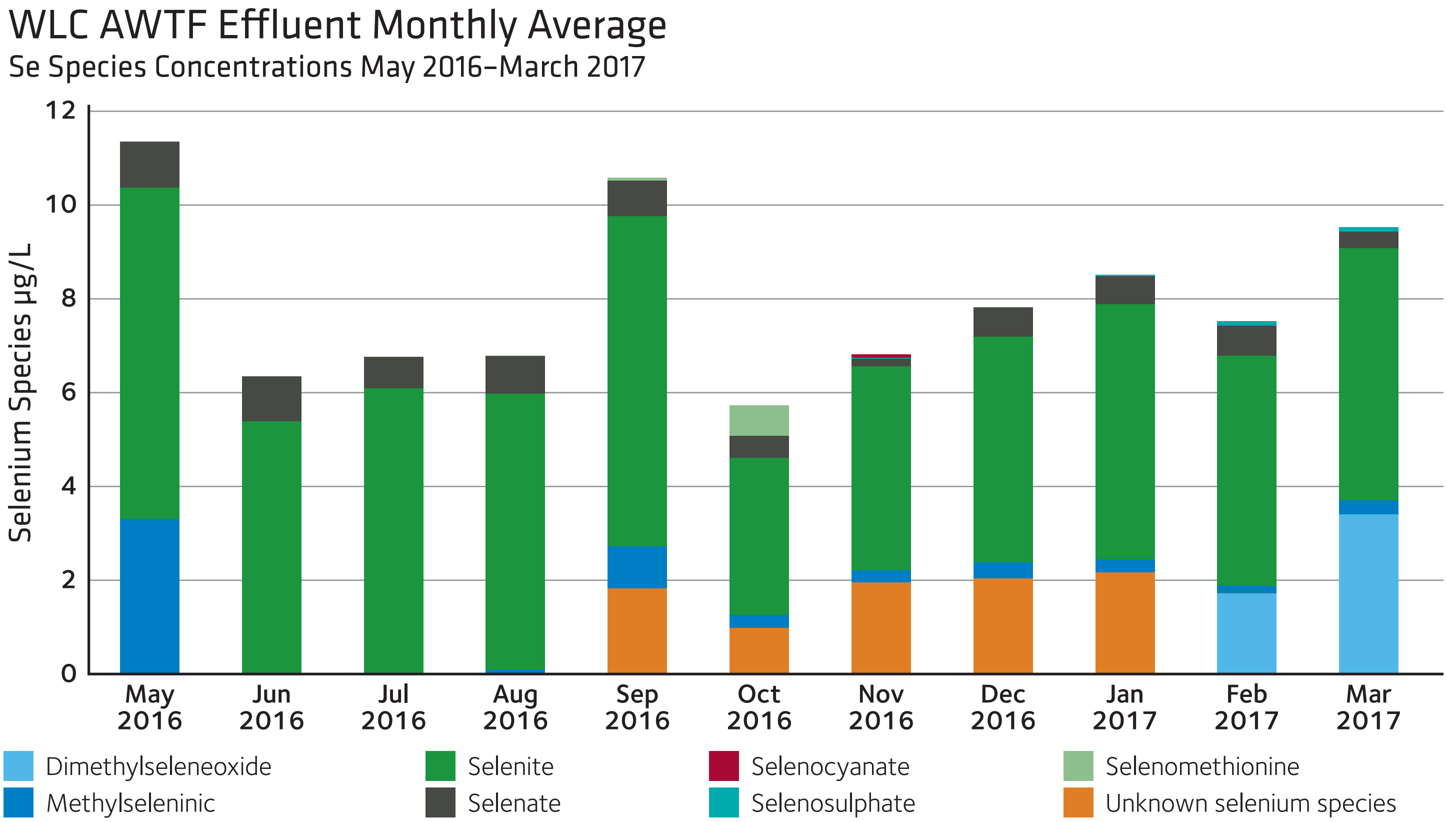

Figure 42: Selenium Species in West Line Creek Active Water Treatment Facility Effluent

Activities and advancement related to addressing the selenium speciation (i.e. transformation) issue include:

- Collecting selenium speciation samples within the plant process;
- Maintaining plant stability and establishing a baseline of selenium speciation;
- Analyzing plant data to determine how operational changes correlate with a change in selenium speciation in the West Line Creek Active Water Treatment Facility;
- Identifying a number of potential pilot scale options;
- Began pilot-scale testing in summer 2017 on prioritized options (Advanced Oxidation Process);
- Assessing the implications for the design and flowsheet for the planned Fording River Operations Active Water Treatment Facility, so the regulatory application for the Fording River Operations Active Water Treatment Facility can be submitted;
- Continuing research and development of alternative treatment methods such as the Saturated Rock Fill full scale trial project at Elkview Operations.

Information from the Line Creek Local Aquatic Effects Monitoring Program will continue to evaluate biological productivity and tissue selenium accumulation downstream from the treatment facility discharge. Other variables in relation to the active water treatment facility that were examined under the Line Creek Local Aquatic Effects Monitoring Program included data on instream temperature, dissolved oxygen, other constituents, and nutrients.

Status

Based on the information described above and consultations with the EMC, the objectives for the Line Creek Local Aquatic Effects Monitoring Program were updated and re-stated as Key Questions in 2016:

1. Is active water treatment affecting biological productivity downstream in Line Creek?

2. Are tissue selenium concentrations reduced downstream from the West Line Creek Active Water Treatment Facility?

3. Is West Line Creek Active Water Treatment Facility operation affecting aquatic biota through thermal effects, effects on dissolved oxygen concentrations, or concentrations of treatment-related constituents other than nutrients or selenium?

The following section presents results related to the third year of data collection (2016) for the Line Creek Local Aquatic Effects Monitoring Program, and the first year reflecting full operation of the West Line Creek Active Water Treatment Facility.

Results

Key Question #1: Is active water treatment affecting biological productivity downstream in Line Creek?

Periphyton chlorophyll-a concentrations at the West Line Creek Active Water Treatment Facility Compliance Point varied over the 2016 growing season, and were generally higher than concentrations observed in 2015. Visual scores of periphyton coverage were similar among reference and mine-exposed areas, with all receiving scores of 2 or 3 (of a maximum of 5).

Total phosphorus concentrations in West Line Creek Active Water Treatment Facility effluent averaged 0.04 mg/L in 2016 compared to the average of 0.3 mg/L projected prior to West Line Creek Active Water Treatment Facility operation. Consequently, concentrations of total phosphorus in Line Creek at the Compliance Point (LC_LCDSSLCC) have usually been below the projected range, and always below the Site Performance Objective of 0.02 mg/L, since the West Line Creek Active Water Treatment Facility began operating.

In 2016, benthic invertebrate biomass and density followed a similar pattern to previous years. Overall, West Line Creek Active Water Treatment Facility operation does not appear to have adversely affected benthic invertebrate communities downstream, other than a potential reduction in family richness, which will be evaluated again in the 2017 cycle of the Line Creek LAEMP.

Key Question #2: Are tissue selenium concentrations reduced downstream from the West Line Creek Active Water Treatment Facility?

Compared to historical and upstream levels, tissue selenium concentrations in periphyton and benthic invertebrates were increased immediately downstream from the West Line Creek Active Water Treatment Facility outfall during the 2016 sampling.

The West Line Creek Active Water Treatment Facility has successfully reduced total selenium loads to the receiving environment. However, tissue selenium data collected in 2016 and early 2017 indicate that some of the selenium remaining in treated effluent has shifted from being in the form of selenate—which has relatively low bioavailability—to other selenium forms that may be more bioavailable. Additional monitoring is required to fully understand these results.

Key Question #3: Is West Line Creek Active Water Treatment Facility operation affecting aquatic biota through thermal effects, effects on dissolved oxygen concentrations, or concentrations of treatment-related constituents other than nutrients or selenium?

There does not appear to be other potential influences associated with West Line Creek Active Water Treatment Facility operation (i.e. temperature, dissolved oxygen, or precipitation of calcite) that are not already being addressed through monitoring related to Key Questions #1 (productivity) and #2 (tissue selenium accumulation).

What's Next?

In order to monitor potential changes in the receiving environment, the Line Creek Local Aquatic Effects Monitoring Program will be repeated annually for at least two more years, to allow for three years of sampling during full operation of the West Line Creek Active Water Treatment Facility.

By the Permit, Teck is required to submit to the BC Ministry of Environment and Climate Change Strategy an annual study design by May 31 of each year. The 2017 Line Creek Local Aquatic Effects Monitoring Program was submitted on May 31, 2017 and was adjusted to allow greater resolution of spatial differences along Line Creek (i.e., by adding additional sampling areas) and measurement of within-area variability in biological endpoints, to improve understanding of the local aquatic effects on Line Creek associated with West Line Creek Active Water Treatment Facility operation. Results from the 2017 monitoring will be discussed with the EMC and included in the 2018 EMC Public Report.

Teck is continuing to advance work to address the West Line Creek Active Water Treatment Facility performance challenge related to selenium speciation. It has been determined that timely and successful testing and implementation of a solution to this challenge requires continued operation of the facility. On-going operation will also have the benefit of continued removal of 99% of the nitrate from mine-affected water (i.e., 3,500 kg of nitrates that are not being released to the receiving environment each month), as well as an average of 47 kg of selenium per month.

The EMC is providing input and advice to the study designs and monitoring related to addressing the selenium speciation issue. Teck will consider what has been learned at the West Line Creek Active Water Treatment Facility when designing future water treatment facilities.

Koocanusa Reservoir Monitoring

Context

The Koocanusa Reservoir straddles the border between Canada and the United States, and lies within the traditional territory of the Ktunaxa First Nation. When the reservoir is at its fullest, about 68 km of the total 155 km length of the reservoir is in BC. Three Canadian rivers supply most of the reservoir's inflow: the Kootenay (62% of mean annual inflow), the Elk (26%), and the Bull (11%).

As per the Permit requirements, Teck implemented a three-year study from 2014 to 2016 to characterize and compare environmental conditions in the Canadian portion of the reservoir. The water in the reservoir flows from north to south (see Figure 43 for a map of the area). In order to identify environmental differences that may be attributable to influences from the Elk River, the overall objective of the Koocanusa Reservoir monitoring program was to characterize conditions in the reservoir both upstream and downstream from where the Elk River flows into the reservoir.

The sampling locations for Koocanusa Reservoir Monitoring Program extend from the Kootenay River at the Wardner Bridge (RG_WARDB) to the Kootenay Reservoir near the USA Border (RG_BORDER) (see Figure 44).

Study Design for the Greenhills Operations Local Aquatic Effects Monitoring Program (2018 to 2020)

By Permit requirement, and after consultation with the EMC, Teck submitted to the BC Ministry of Environment and Climate Change Strategy a study design for the 2018-2020 Greenhills Operations Local Aquatic Effects Monitoring Program on June 1, 2017. The Greenhills Operations Local Aquatic Effects Monitoring Program focuses on the Upper Elk River and the Elk River side channel and tributaries located on the west side of Greenhills Operations. It has been designed to address localized concerns about potential aquatic effects associated with the west spoil development at Greenhills Operations and to inform an updated study design that will guide the 2018-2020 Local Aquatic Effects Monitoring Program. A side channel of the Elk River and its adjacent floodplain have been identified as key areas of potential localized concern because they receive flows, either via surface water or ground water, from mine-influenced tributaries (e.g., Thompson Creek, Wolfram Creek, Leask Creek, and likely also Michelson Creek).

Further information on the Greenhills Operations Local Aquatic Effects Monitoring Program will be included in the 2018 EMC Public Report.

Koocanusa Reservoir Monitoring and Research Working Group

Teck is required to participate in, and contribute to the costs of, the Koocanusa Reservoir Monitoring and Research Working Group. This group is co-chaired by the BC Ministry of Environment and Climate Change Strategy and the Montana Department of Environmental Quality. Participants include government, First Nations, industry and other stakeholder groups from both Canada and the United States. After obtaining EMC review and input, Teck is required to provide a report summarizing monitoring activities and results on an annual basis, and monitoring completed to date is used to inform future monitoring programs within the reservoir.

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Figure 43: Map of Koocanusa Reservoir area

Status

2016 was the third year of a three-year monitoring program to assess water quality, sediment, and the biological conditions in the reservoir, including algae, invertebrates, and fish. Data for the 2014-2016 monitoring activities were reviewed by the EMC and results are summarized in the next section.

Results

This section summarizes the combined results and analysis of the 2014 to 2016 studies.

2014–2016 Water Quality Results

The quality of water in the reservoir generally met water quality objectives over the study period. There were a few exceptions, and they included the following:

- One sample in 2015 exceeded BC Water Quality Guidelines for aluminum
- One sample in 2015 and one sample in 2016 exceeded BC Water Quality Guidelines for iron; and
- Five samples in 2016 exceeded BC Water Quality Guidelines for mercury.

Site Performance Objectives for nitrate, selenium, sulphate, and dissolved cadmium were consistently met at the Order station located in the reservoir downstream from the Elk River junction with the Koocanusa Reservoir.

2014–2016 Algal (Phytoplankton) Results

There were no significant differences between downstream and upstream areas in overall phytoplankton density, biomass, or richness over the three years. Community structure was similar between upstream and downstream areas, except for greater Cyanophyte (blue-green algae) biomass at the downstream area, which was considered to have low ecological significance because this group represented less than 1% of the community.

Explaining community density, biomass, richness, and structure in ecological terms

The following concepts are used to characterize an ecological community and monitoring of these biological markers can provide clues of potential ecological change:

- Density is a measure of the number of organisms that make up a population in a defined area.
- Biomass is the mass of living material in a specific area, habitat, or region.
- Species richness is the number of different species represented in an ecological community, landscape or region. Species richness is simply a count of the different species present in a particular area.
- Community structure combines some of the above concepts. It is the composition of an ecological community, including the number of species present (richness), but also the relative numbers of the populations of the species and the evenness of these numbers. Community structure may be interpreted to include the patterns of interaction between different species as well.

2014-2016 Invertebrates from the Water Column (Zooplankton) Results

Over the three-year study, no consistent differences were observed between downstream and upstream areas in overall zooplankton density, biomass, or richness, or in absolute or relative density or biomass of two types of zooplankton. Additionally, overall community structure indicated no consistent differences in the reservoir downstream compared to upstream from the Elk River over the three years. Selenium concentrations in zooplankton were also similar between downstream and upstream areas in all three years.

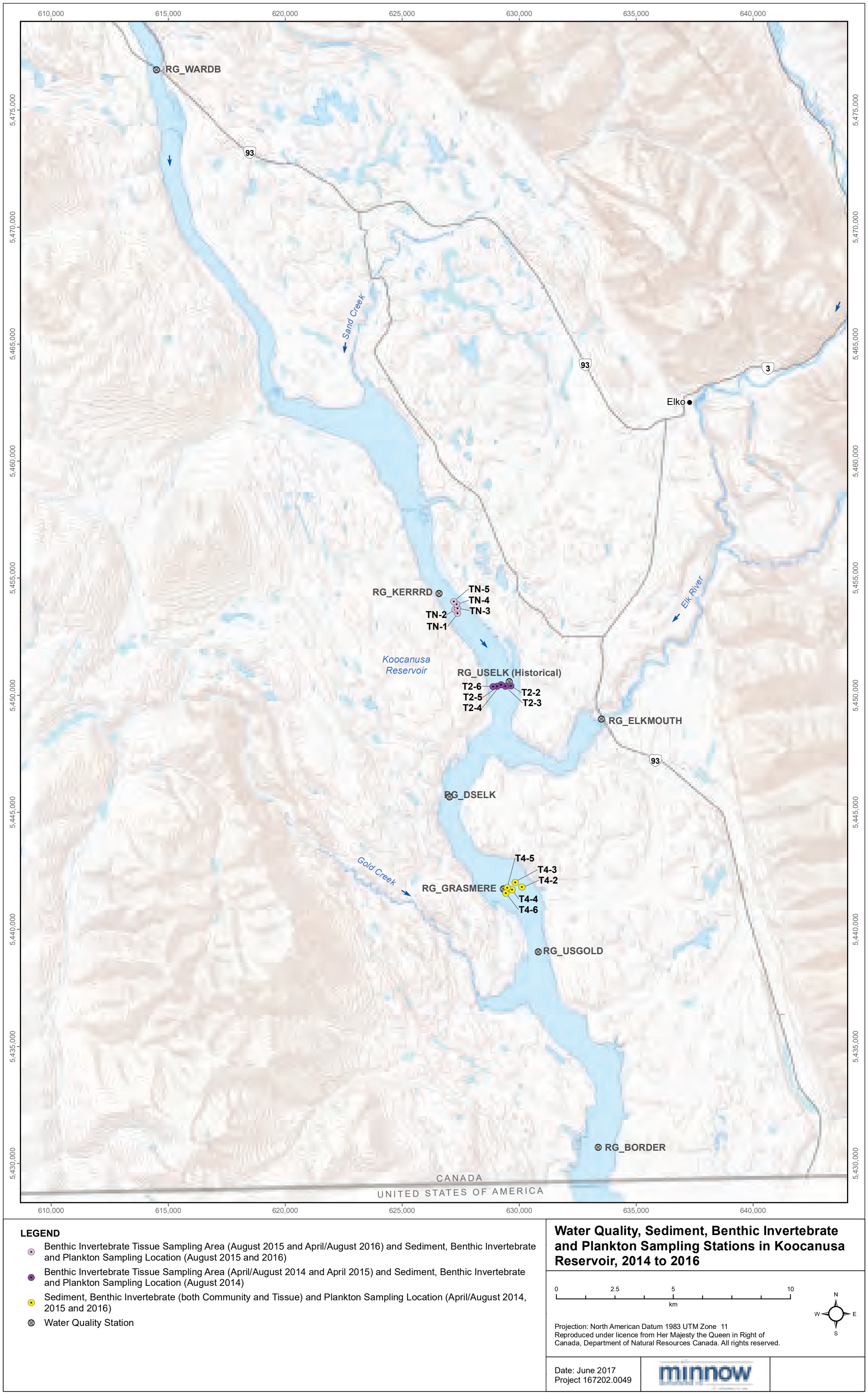

Figure 44: Sampling Stations in Koocanusa Reservoir, 2014–2016

2014–2016 Benthic Invertebrate Results

Clams, insect larvae, worms, seed shrimp, and mites are among the organisms found in reservoir sediments. These types of species are typical of reservoir habitat (deep and slow moving).

Community density and richness did not differ significantly between upstream and downstream areas in any of the three study years. However, community structure differed between areas, particularly with respect to seed shrimp, which had higher average density at the downstream area compared to the upstream area over the three years of study. Densities of worms were also significantly higher at the downstream area compared to the upstream area. Greater abundance of these organisms downstream from the Elk River compared to upstream may be associated with preference for greater depths and finer sediment texture, and/or avoidance of coarser, compacted sediments in the upstream area that dry out during low pool.

Mean benthic invertebrate tissue selenium concentrations were significantly higher at the downstream area (6.9 µg/g dry weight (dw)) than the upstream area (5.0 µg/g dw), and were higher than the interim chronic dietary guideline of 4 µg/g dw set by the BC Ministry of Environment and Climate Change Strategy for fish diet at both locations.

2014–2016 Fish Health Results

Sampling of peamouth chub, northern pikeminnow, largescale sucker, redside shiner and yellow perch provide important information about fish age, condition (weight and length), liver size, gonad size, and growth. Refer to Figure 44 on page 97 for a visual of the sampling locations referenced.

Comparing fish muscle selenium concentrations to guidelines:

Fish muscle selenium concentrations were below the 2016 US Environmental Protection Agency guideline criteria of 11.3 µg/g dw at all study areas, with the exception of one yellow perch with a muscle selenium concentration of 15.0 µg/g dw collected at the Elk River downstream study area in April 2015. Four of the ten species sampled (largescale sucker, mountain whitefish, peamouth chub, and yellow perch) had mean muscle selenium concentrations greater than the BC Ministry of Environment and Climate Change Strategy guideline (4 µg/g dw) at the downstream Elk River area. The mean selenium concentration in mountain whitefish muscle was also above the BC guideline at the upstream Sand Creek area. The mean selenium concentration in burbot was below the BC guideline throughout the reservoir.

Comparing fish muscle selenium concentrations, upstream to downstream:

Muscle selenium concentrations in largescale sucker, peamouth chub, yellow perch, and redside shiner from the Elk River downstream area were consistently greater than those in fish from the upstream Sand Creek area. Selenium concentrations in northern pikeminnow muscle were also greater at the downstream Elk River area compared to the upstream Sand Creek area in 2014 and 2015, but were lower at the upstream Sand Creek area in 2016.

Comparing fish whole body selenium concentrations to guidelines and upstream to downstream:

All whole body selenium concentrations for peamouth chub and redside shiner were less than the 2016 US Environmental Protection Agency guideline criteria of 8.5 µg/g dw and mean values were at or below the BC Ministry of Environment and Climate Change Strategy guideline of 4 µg/g dw in all study areas in all three years. No differences were found between whole body peamouth chub selenium concentrations from the downstream areas (Elk River and Gold Creek) relative to the upstream area (Sand Creek area).

Comparing selenium concentrations in fish ovaries to guidelines:

Ovary selenium concentrations were frequently greater than the BC chronic guideline of 11 µg/g dw (particularly in peamouth chub, redside shiner, and northern pikeminnow). All species except redside shiner and northern pikeminnow had mean ovary selenium concentrations less than the Elk Valley Water Quality Plan Level 1 benchmark for reproductive effects to fish (18 mg/kg dw), and the 2016 US Environmental Protection Agency guideline of 15.1 µg/g dw. Northern pikeminnow had mean ovary selenium concentrations above the Level 1 benchmark at the Elk River area in only one of the three years they were sampled (2014), when ovaries were relatively undeveloped. Mean redside shiner ovary concentrations were above the Level 1 benchmark at both the downstream and the upstream areas in both years sampled.

Comparing selenium concentration in fish ovaries, upstream to downstream:

Yellow perch was the only fish species that had higher ovary selenium concentrations at the downstream Elk River study area compared to the upstream area. Selenium concentrations in the ovaries of northern pikeminnow and redside shiners were significantly lower at the downstream Gold Creek area than at the upstream Sand Creek area, and no differences were observed for either of these species between the downstream Elk River and upstream Sand Creek areas.

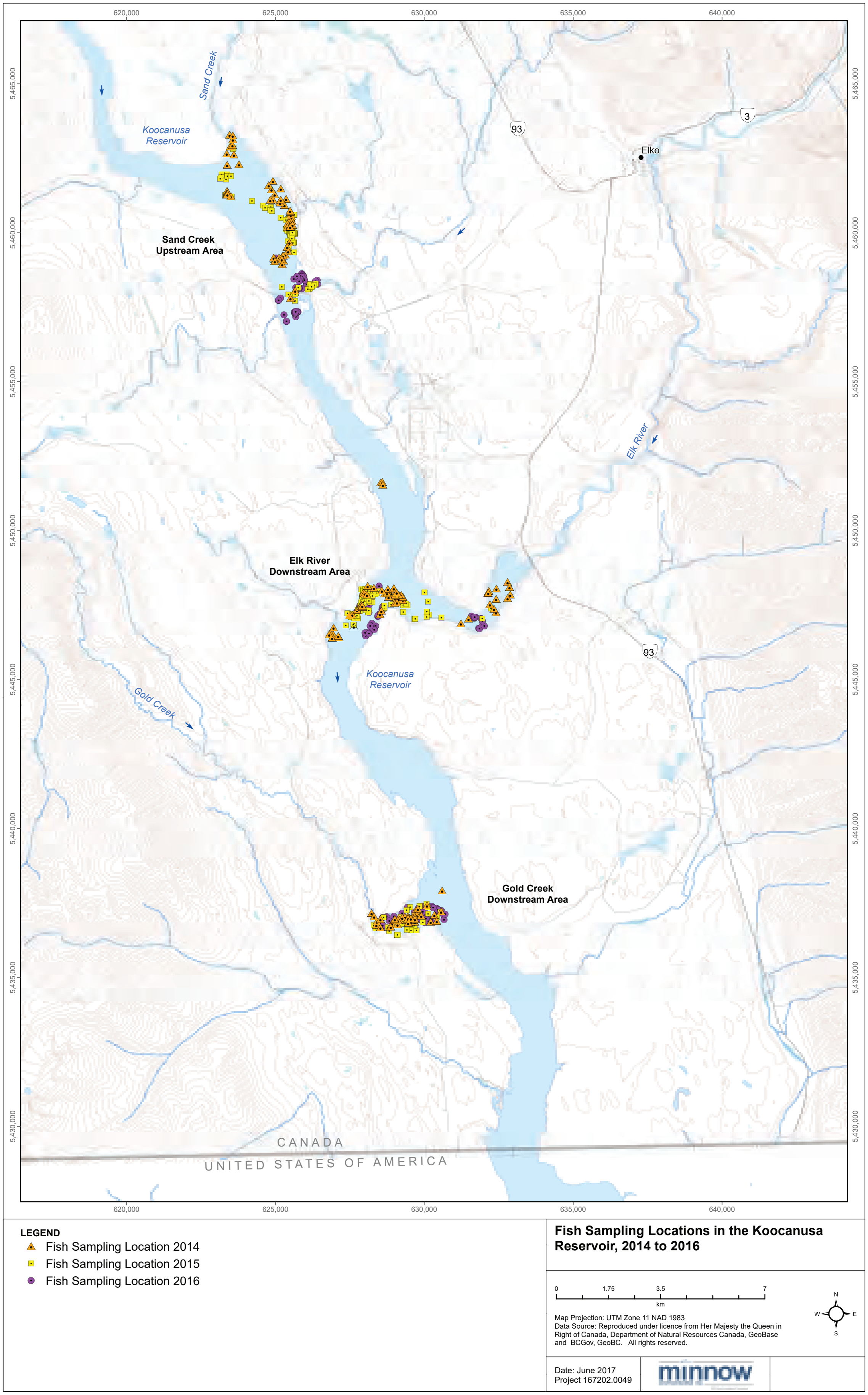

Figure 45: Fish Sampling Locations in Koocanusa Reservoir, 2014-2016

Monitoring Burbot Tissue Selenium Concentrations

Based on concerns about burbot abundance, and the cultural importance of this fish species to the Ktunaxa First Nation, a study of burbot tissue selenium concentrations was undertaken in 2014 and 2015. The objective was to measure tissue selenium concentrations in pre-spawning females, if possible. Although burbot were not targeted in 2016, any individuals caught opportunistically were also sampled non-lethally for tissue selenium analysis in 2016.

This species, which spawns in deep water during winter, has proven difficult to catch in Koocanusa Reservoir. In total, 43 burbot were captured among the three study areas in Koocanusa Reservoir from 2014 to 2016. On average, the burbot that were captured from 2014 to 2016 had tissue selenium concentrations below the BC Ministry of Environment and Climate Change Strategy guideline (4 µg/g dw) for the protection of fish species.

Mercury concentrations in fish muscle:

Elevated mercury concentrations may be observed in fish species due to naturally high mercury levels, atmospheric deposition of mercury, and conditions that favour mercury methylation (transformation of mercury into a form that may bioaccumulate). Methylated mercury may bioaccumulate and biomagnify through the food chain resulting in elevated concentrations in larger, older, and more predatory fish such as burbot and bull trout. Consistent with what is normally found in rivers, lakes and reservoirs, concentrations in the muscle of fish from Koocanusa Reservoir were typically higher in larger fish. Muscle mercury concentrations were consistently higher than the BC Ministry of Environment and Climate Change Strategy guideline for the protection of wildlife, assuming all mercury is present as methyl mercury. The only exception was mountain whitefish. Concentrations in most individuals were below the guideline. The metallurgical coal mines in the Elk River watershed are not considered to be a source of mercury.

What's Next?

The EMC has reviewed the first three-year report on the conditions in the Canadian portion of the Koocanusa Reservoir. Monitoring will continue, with changes to the study design as per EMC recommendations and discussion.

Tributary Evaluation and Management

Context

In consultation with the EMC, Teck was required to develop and implement a phased study design for a Tributary Evaluation Program in 2016, in order to develop the Tributary Management Plan in 2017. Both the program and plan must consider current and future mining plans. As outlined in the Permit, the purpose of the Tributary Evaluation Program and Tributary Management Plan is to support the overarching goal to:

Protect and rehabilitate high ecological value tributaries of the Elk River watershed on a priority and feasibility basis to benefit fish, aquatic-dependent wildlife, and vegetation, recognizing biological, social, economic, and cultural values.

Tributary Evaluation Program

The Tributary Evaluation Program will evaluate the ecological value of tributaries in the Elk and Fording rivers. In consultation with the Elk Valley Fish and Fish Habitat Committee, the evaluation will identify those tributaries that play a significant role in supporting the Elk Valley watershed ecosystem as a whole. The purpose of the evaluation is to provide the context for phased management of the tributaries within the Elk Valley.

The EMC has been working collaboratively with the Elk Valley Fish and Fish Habitat Committee and the study team to evaluate tributaries that play a significant role in supporting the ecosystem as a whole, and to ensure that the evaluation results are verified by local knowledge. These results will be used to help prioritize the Tributary Evaluation Program.

Tributary Management Plan

In consideration of Teck's current and future mining plans, the Tributary Management Plan is intended to incorporate protection and rehabilitation goals for tributaries that will support achieving the objective of protecting aquatic ecosystem health in the Elk Valley watershed. Using the results from the Tributary Evaluation Program and a tributaries management tool, as well as the input received from the EMC, tributaries will be prioritized for protection, rehabilitation, or a combination of both. The Tributary Management Plan will define a process for monitoring, implementing, and reviewing the management plan, which includes annual updates to the management plan.

During development of the Tributary Management Plan, those tributaries that are unimpacted by mining activities, that provide relatively high habitat value, and/or support ongoing habitat use by fish and sensitive aquatic dependent wildlife (i.e. directly or indirectly through food production), will be identified as the highest priority tributaries for permanent protection. Those tributaries that have been impacted by mining, provide or have the potential to provide relatively high habitat value, and/or support (or could support) habitat use by fish and sensitive aquatic dependent wildlife, will be identified as the highest priority tributaries for restoration/rehabilitation.

The scope of the Tributary Management Plan excludes tributaries that have been permanently removed or severely altered (e.g., covered by waste spoils or other mine infrastructure or dewatered) by mining activities within Teck's current mine permit boundaries. Loss of habitat for such tributaries is governed by requirements under the Federal Fisheries Act and the provincial mitigation policy.

The maps in Figures 46–50 provide the reader with a visual of the tributaries being considered as part of the Tributary Evaluation Program and Tributary Management Plan

To support the overarching goal of protecting and rehabilitating high ecological value tributaries of the Elk River watershed, five objectives were identified and are consistent with the objectives and sub-objectives listed in the Regional Fish Habitat Management Plan and the Permit wording. The five objectives are as follows (brackets indicate where the objective is considered in):

1. Biological: Maintain or enhance the viability of fish and aquatic-dependent wildlife in the Elk River watershed; (Tributary Evaluation Program and Tributary Management Plan)

2. Social: Maintain or enhance tributary conditions and opportunities for social and cultural uses and cultural values of the Elk River watershed; (Tributary Management Plan)

3. Feasibility: Maximize the feasibility of the actions needed to protect and/or rehabilitate tributaries; (Tributary Management Plan)

4. Safety: Identify protection and rehabilitation options that will be safe to implement and maintain, and do not create a public hazard; (Tributary Management Plan) and

5. Financial: Minimize financial cost of implemented actions and potential loss to mining opportunities in the Elk River watershed. (Tributary Management Plan)

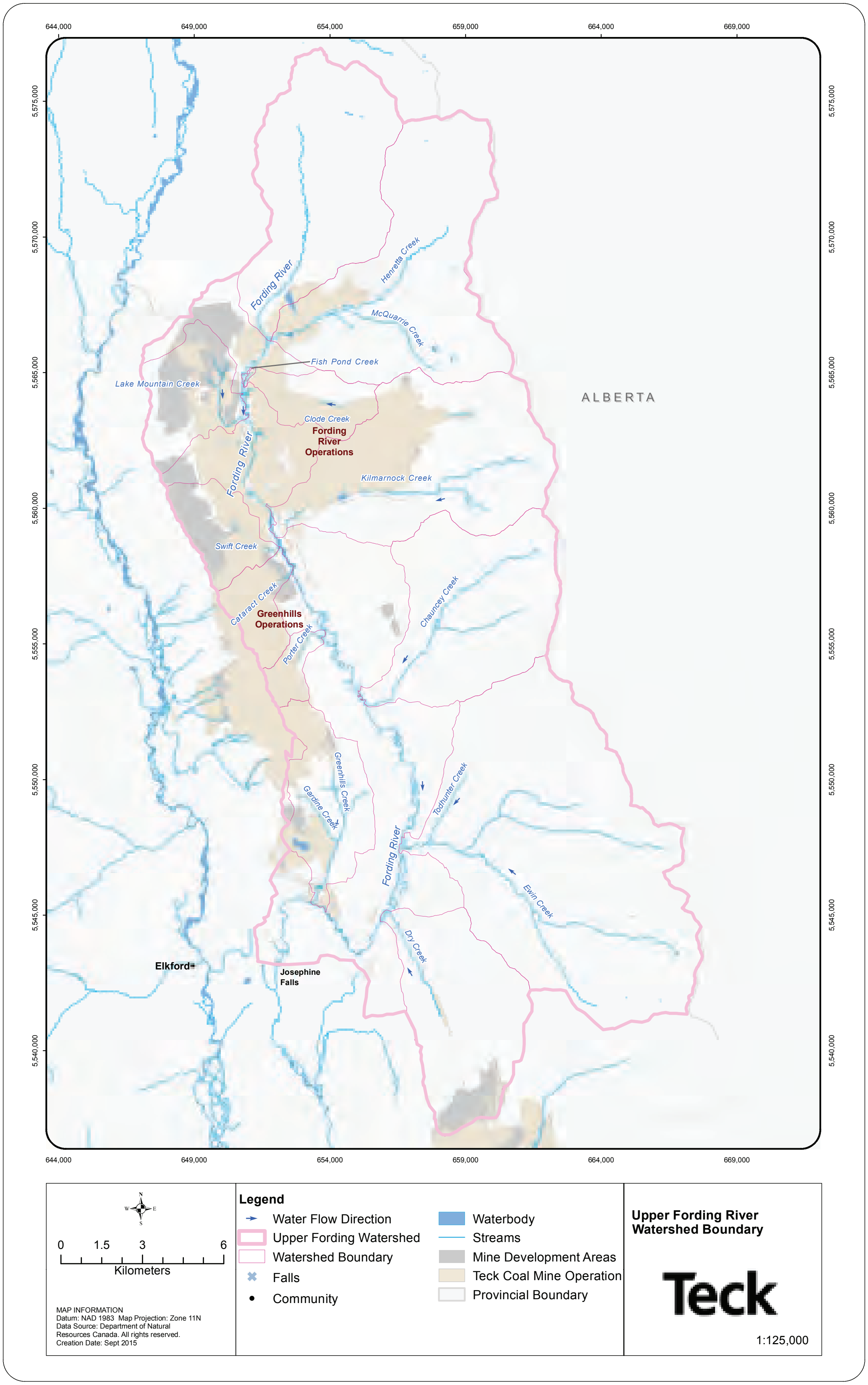

Figure 46: Upper Fording River Watershed Boundary

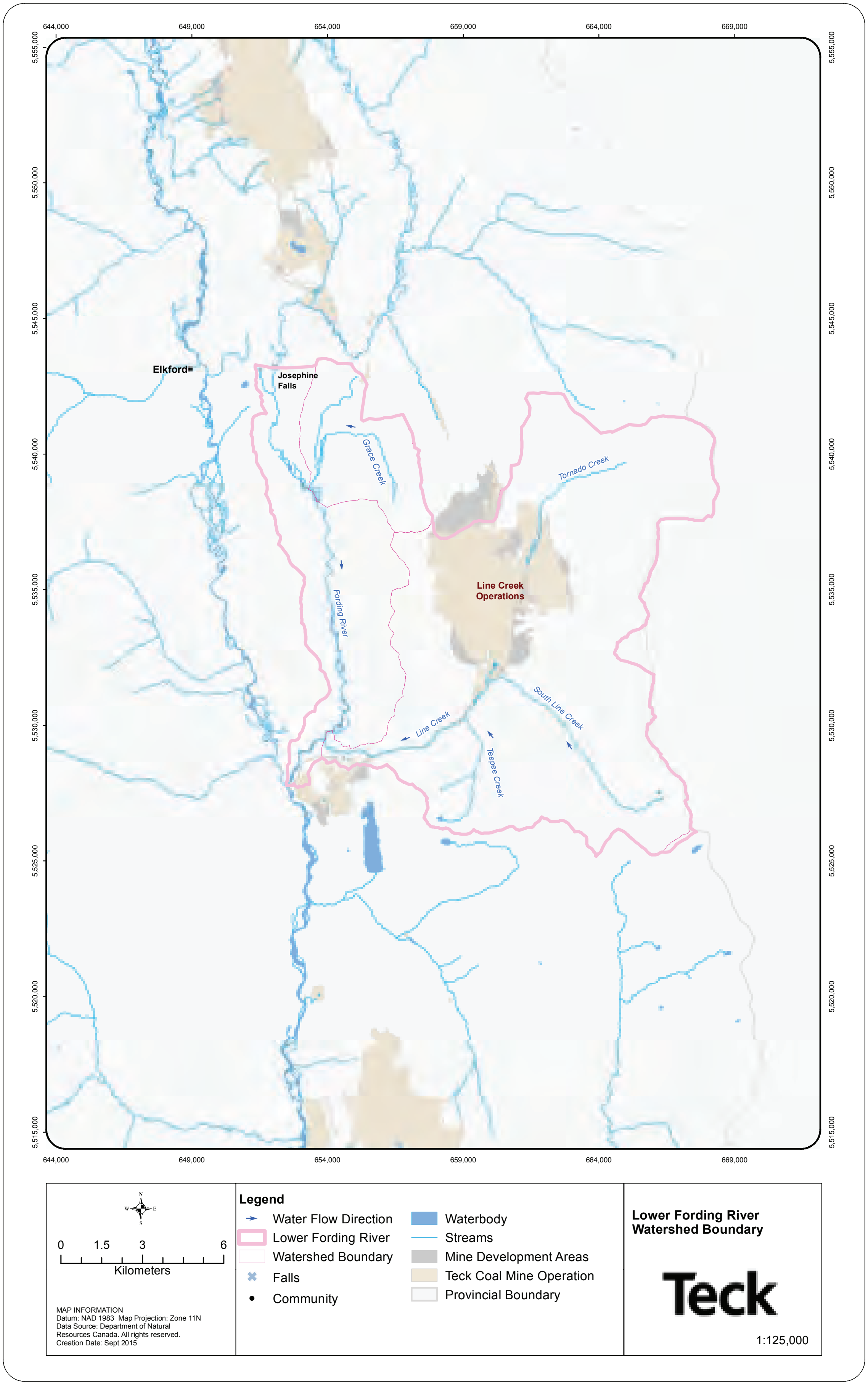

Figure 47: Lower Fording River Watershed Boundary

Figure 48: Upper Elk River Watershed Boundary

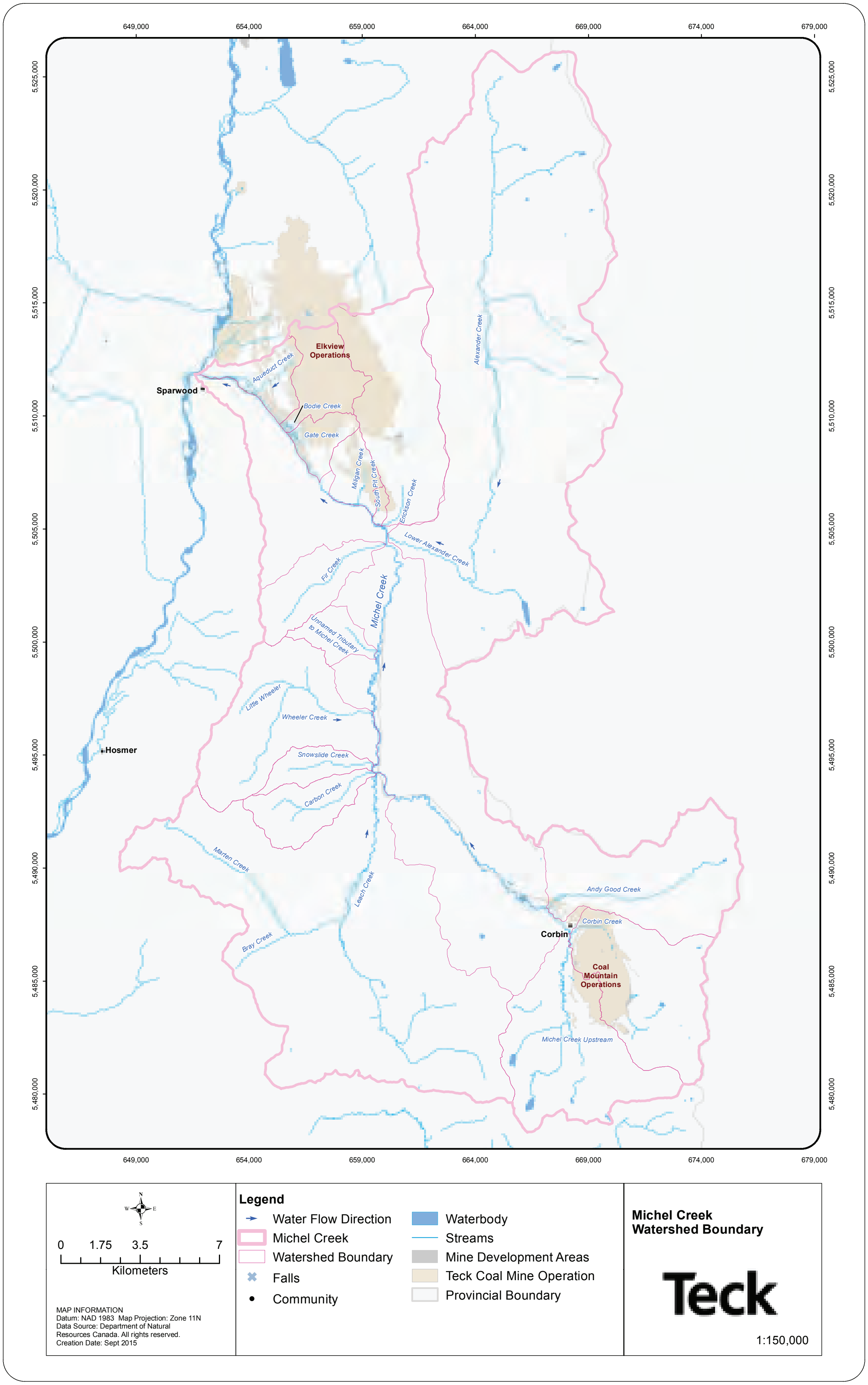

Figure 49: Michel Creek Watershed Boundary

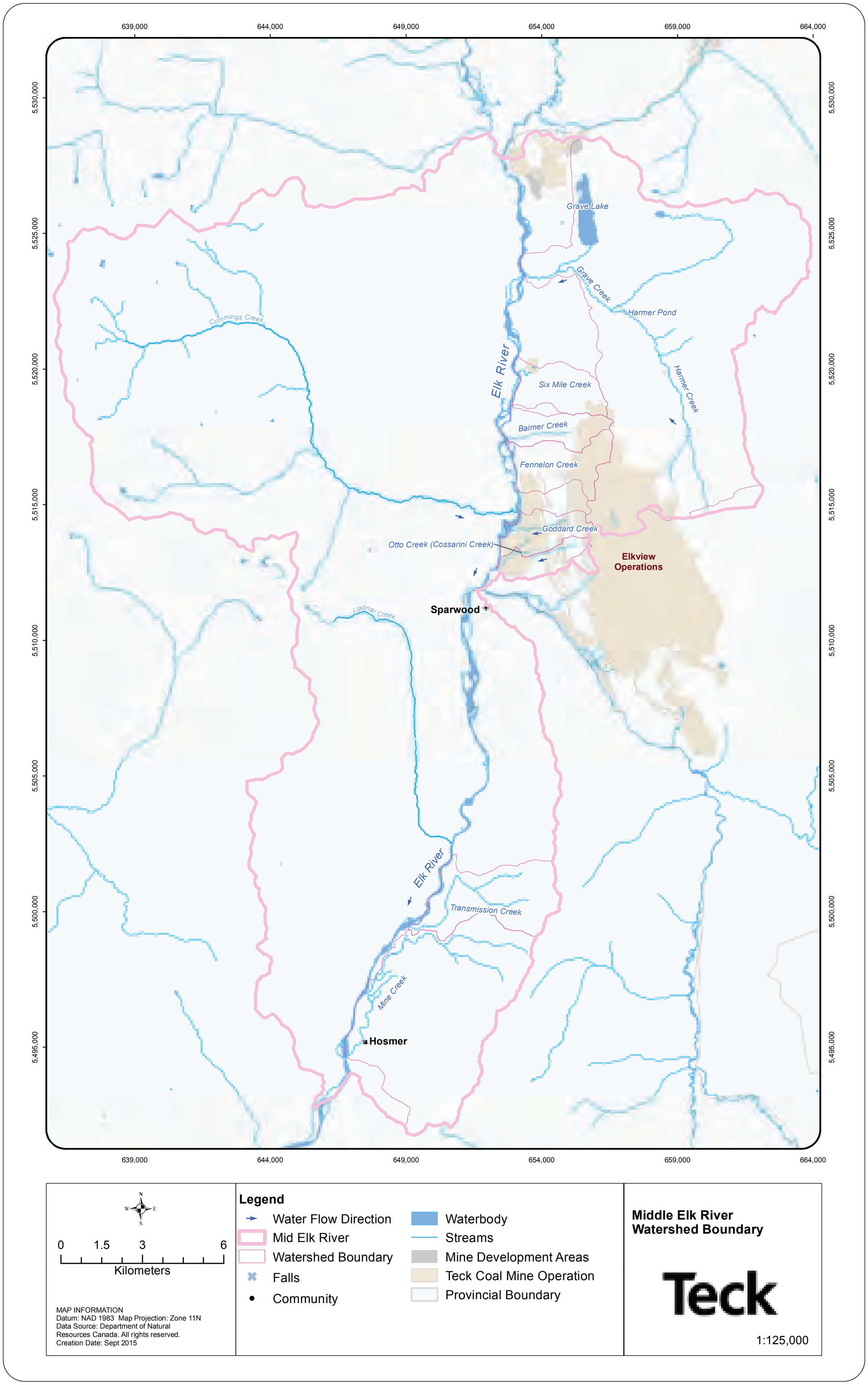

Figure 50: Middle Elk River Watershed Boundary

Status

The following Permit requirements have directed efforts related to the Tributary Evaluation Program thus far:

- Completion of a draft phased study design by May 1, 2015 (completed)
- Completion of a phased study design by May 31, 2015 (completed)
- Submission of a Tributary Evaluation Program Data Report to the EMC by March 31, 2016 (submitted)
- Analysis and interpretation of Tributary Evaluation Program data, assessment of potential for rehabilitation and/or mitigation, and prioritization of tributaries compiled into a written interim report and submitted to the BC Ministry of Environment statutory decision maker by November 30, 2016 (submitted). A revised interim version of the report was submitted in March 2017 which considered EMC input received in December 2016 and February 2017.

Focus of 2016 Activities

As part of the Tributary Evaluation Program, a prioritization exercise was undertaken in 2016 to assess the ecological values of tributaries to the Elk and Fording Rivers. The prioritization approach was developed with considerable input and guidance from the EMC, resulting in the creation of a prioritization tool. This work will be used to develop the Tributary Management Plan.

Using this prioritization tool, generic management options were evaluated for each tributary using a range of biological metrics. The four categories of biological metrics included:

1. Habitat quantity;

2. Habitat quality—water chemistry;

3. Habitat quality—physical; and

4. Habitat type.

Within each of the above biological metric categories, sub-metrics provided scores or flags to aid in the evaluation of ecological value (e.g. habitat quantity includes stream length, riparian area, fish habitat connected to mainstem, wetland presence). Preliminary lists of prioritized tributaries were generated.

The generalized management options for the prioritized tributaries fell into three categories:

1. Protection of current conditions;

2. Water quality rehabilitation (i.e., improve water quality in tributary); and/or

3. Connectivity rehabilitation (i.e., removal of an anthropogenic movement barrier to increase habitat availability in the tributary).

This prioritization exercise has provided a framework that can be used to support management decisions regarding which tributaries should receive focus for potential protection actions. Management approaches may consider combinations of the three management options. For example, ongoing protection may be required to maintain ecological improvements following rehabilitation. These combinations of options will be explored further in the Tributary Management Program.

What’s Next

Going forward, activities will be focused on developing the Interim Tributary Management Plan, based on:

- The Tributary Evaluation Program Data and Analysis reports;
- The Tributary Management Plan Terms of Reference; and
- EMC input received to date.

An Interim Tributary Management Plan must be submitted to the EMC by July 31, 2017 and an update will be provided in the 2018 EMC Public Report.

7 Calcite

In this chapter, the reader will find information about the formation and removal of calcite on streambeds in the Elk Valley, and the factors that may be influencing calcite build-up in some mining-influenced streams. There are three main sections to the Calcite chapter, including:

- Annual calcite monitoring, where readers will find information about the on-going annual monitoring of calcite characteristics in the Elk Valley watershed;
- Seasonal calcite monitoring, where readers will find information about the seasonal calcite monitoring study that was completed to support understanding of any seasonal characteristics of calcite formation in the Elk Valley; and
- Calcite biological effects monitoring, where readers will find information about monitoring being done to understand if and how calcite formation may impact stream bed conditions, to better understand if and how aquatic organisms may be affected by a calcite-affected habitat.

Context

As water flows through waste rock piles at Teck's coal mining operations in the Elk Valley, calcium carbonate is dissolved and carried downstream. Under certain conditions (e.g., water temperature and other factors), calcite, which is a solid form of calcium carbonate, can form on the bottom of streams. It can occur naturally, but excessive calcite build-up can change streambeds by cementing rocks together and potentially reducing the quality of the habitat for aquatic organisms.

Calcite formation has been observed in the Elk Valley watershed downstream of mining activities, and to a lesser extent, in streams unaffected by mining. There are wide ranges in the extent of calcite cover. In limited sections of certain streams, calcite completely covers portions of the stream bed, making stream gravels largely immovable (see photograph for an example of this in Figure 53).

Under the Elk Valley Water Quality Plan and the Permit, Teck is required to monitor and manage calcite levels in mining-influenced streams, with the objective of ensuring that aquatic habitats support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish (i.e., comparable to those in reference areas). Annual and seasonal monitoring of calcite formation in the Elk Valley is performed by Teck.

How is calcite measured? Explaining the calcite index

The calcite index is a way to quantify the calcite formation in a stream. By collecting, examining, and assessing calcite formation at a monitoring site, a calcite index score is determined based on the number of pebbles (out of 100) that show calcite is present, and how concreted (stuck together) the pebbles in a stream bed are as a result of calcite formation. The calcite index is the combined score for both the presence of calcite on rocks and the level of calcite concreted on the streambed.

A calcite index score of 0.0 indicates that no calcite was observed at a site. A score of 3.0 on the calcite index indicates the streambed surface is fully concreted. Reference streams in the Elk Valley typically have a calcite index score that is at or near zero, but it could be as high as 0.50. The calcite index is used to interpret the results of Teck's annual and seasonal monitoring of calcite formation.

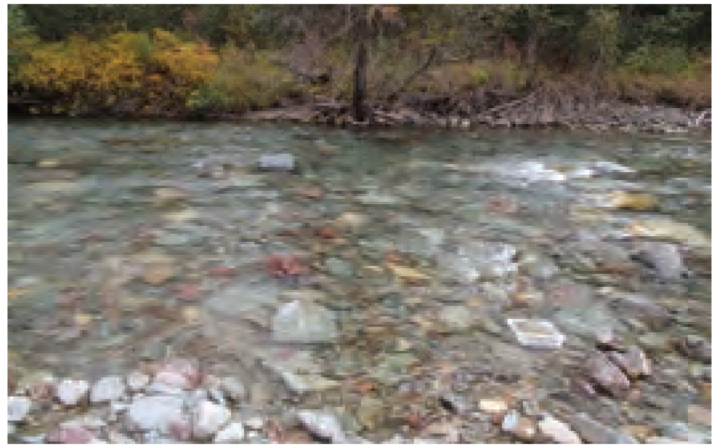

Figure 51: Substrate with no calcite (Calcite Index score = 0).

Figure 52: Substrate covered in calcite but no concretion (Calcite Index score = 1). Note uniform colour of substrate.

Figure 53: Substrate covered in concreted calcite (Calcite Index score = 3).

Site Performance Objectives (and their respective target dates) for calcite management in streams that are fish bearing, provide fish habitat, or flow directly into fish bearing streams, are as follows:

- By December 31, 2024, the Permit requires Teck to achieve a medium-term target Site Performance Objective for calcite concretion of less than 0.50 (i.e., $CI_{Conc} \leq 0.50$).
- By December 31, 2029, the Permit requires Teck to achieve a long-term target Site Performance Objective for total calcite index of less than 0.50 (i.e., $CI_{total} \leq 0.50$). This is a level of calcite that is found naturally in streams unaffected by mining.

Calcite Treatment Starts in 2017

As reported in the 2016 EMC Public Report, after considering the calcite monitoring data, Teck selected Greenhills Creek as the first Elk Valley stream for calcite management in 2017. Progress on calcite treatment will be reported in the 2018 EMC Public Report.

Annual Calcite Monitoring

Context

Under the Permit, Teck is required to monitor calcite formation in the Elk and Fording rivers and tributaries. The objectives of calcite monitoring are to:

1. Document the extent and degree of calcite deposition in streams downstream of Teck's coal operations (e.g., streams influenced by mining, calcite treatment, water treatment and in reference streams);

2. Satisfy the requirements for annual calcite monitoring in the Permit; and,

3. Provide data to support calcite management within the Adaptive Management Plan (AMP).

Teck was required to monitor calcite formation each year for three years (2013 to 2015), and then assess next steps. After a detailed review of the data collected and collection methods of the annual Calcite Monitoring Program from 2013 to 2015, Teck proposed to adjust calcite monitoring to a three-year cycle, starting in 2016. In years one (2016) and two (2017), all 59 streams will be monitored, but the number of sites sampled per stream will be based on the levels of calcite observed in previous years. In some cases, more sites will be sampled per reach than previously (e.g. where calcite conditions appear to be increasing), but for the most part, data will be collected from fewer sites per stream. In year three (2018), all streams and sites (consistent with the 2013-2015 monitoring) would again be assessed.

Historical Calcite Monitoring Results (2013–2015)

Between 2013 and 2015, calcite index values at over 95% of monitored reaches did not change and the calcite index increased in value at only one of the mine-influenced stream reaches.

Status

An updated program for 2016 to 2018 was submitted to the EMC for review, and was subsequently approved by the BC Ministry of Environment and Climate Change Strategy. This program and the associated approval conditions guided the monitoring that was undertaken in 2016.

As introduced above, the updated calcite monitoring program was designed to improve monitoring efficiency in the field. The main changes incorporated into the 2016 program were related to increasing focus on areas where calcite index variability has been high. This was done by:

- Grouping sections of streams with similar calcite indexes into stream segments;
- Reducing the number of survey sites in segments with low variability of calcite deposition; and
- Increasing the number of survey sites at segments with high variability of calcite deposition.

By increasing the number of survey sites at locations with high variability, the study team was able to detect changes in the calcite index with more confidence.

Monitoring of segments of a stream was done at an indicator reach, and results collected from the indicator reach were used as an indicator of change of the entire segment. The indicator reach for a segment was selected because it was representative of the entire segment.

Sampling sites were also added to the 2016 monitoring program to support understanding of calcite treatment (to be conducted in Greenhills Creek) and to provide more detailed monitoring data downstream of new mining activity at Line Creek Operations in Dry Creek.

Results

The field component of the 2016 calcite monitoring program was conducted from September 22 – November 10, 2016, and:

- A total of 85 indicator reaches and 232 sites were surveyed in 2016 (compared to 124 stream reaches and 348 sites that were surveyed in 2015).
- A total of 372 km of stream were assessed and mapped in 2016 (compared to a total of 374 km in 2015 monitoring).

In 2016 monitoring, all reference stream segments (i.e. streams not influenced by mining) had calcite values of between 0 and 0.5, similar to previous years.

Calcite distribution observed in mine-influenced streams in 2016 was consistent with previous observations, with 74% having calcite values of between 0 and 0.5 (i.e. same as reference streams). As a comparison, 84% of the stream kilometres surveyed downstream of mining had levels of calcite deposition similar to reference streams in 2015.

See Figures XX for graphical illustrations of calcite results, along with additional information about monitoring results.

At the request of the EMC, calcite data were divided into four groups (reference, historical exposure, recent exposure and treated) and changes over time were assessed for each of these groups. 2013 to 2016 data have been used to assess if any changes within each of the reference, historical exposure, recent exposure and treated groups were occurring over time. The analysis failed to detect a trend of calcite deposition (i.e. addition of calcite to stream beds) in any group. This suggests that where trends are occurring, it is likely to be reach specific and is not occurring over larger blocks of streams types. This assessment could be repeated in future years once data have been collected over a longer period of time.

Discussion of Results

The increase in the levels of calcite deposition seen in these results may be related to the new sampling protocols used in 2016 monitoring. The 2016 sampling protocols will be used again in 2017, which will provide greater insight into the efficacy of the sampling protocols, and then will be re-assessed in 2018.

It is also possible that some of the increases in calcite deposition may be explained by water management activities at the mine sites (i.e. pit pumping), which may have affected the following tributaries: Mickelson Creek, Wolfram Creek, Bodie Creek, and Gate Creek.

2016 Calcite Index Range

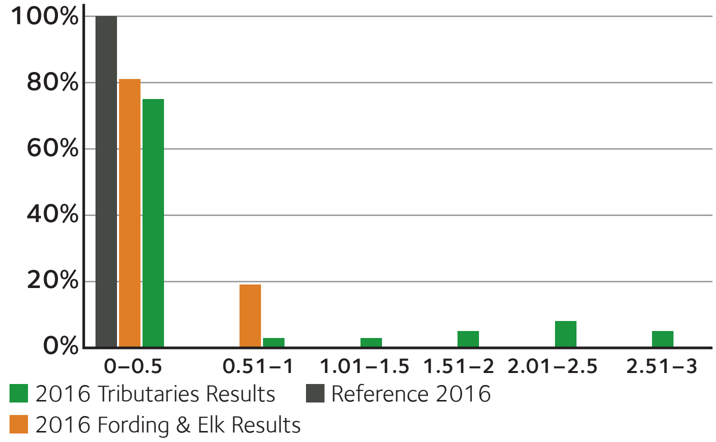

Table 15: Summary of Results of the Calcite Index in Mine-Influenced Streams (2016)

2015 Calcite Index Range

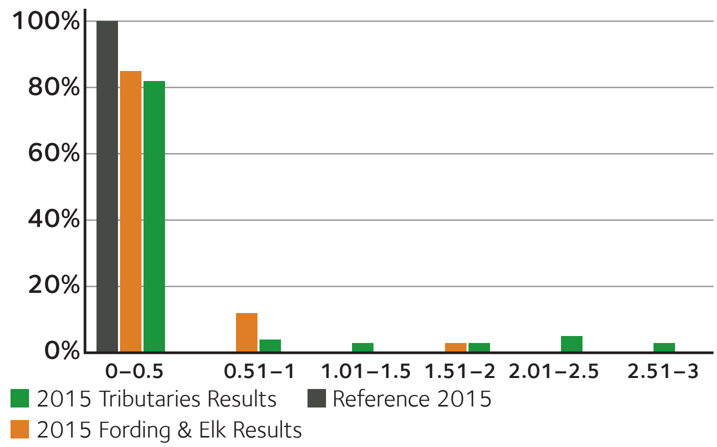

Table 16: Summary of Results of the Calcite Index in Mine-Influenced Streams (2015)

What's Next?

The recommended 2017 calcite monitoring program will be returning to the sampling sites visited in 2016. The number of sites to be sampled will follow the protocol used in 2016, where the most recent calcite index will be used to determine the amount of effort (sites per indicator reach) required. The current sampling protocol will be assessed in 2018, with input from the EMC. Results from the 2017 calcite monitoring program will be summarized in the 2018 EMC Public Report.

Seasonal Calcite Supporting Study

Context

As per the Permit, Teck has collected two years of data (2015 and 2016) on seasonal variation in calcite formation. Understanding seasonal changes in calcite deposition and removal will help Teck plan calcite management activities in the Elk Valley.

During this study, sample rocks are tethered in streams and left for about one month, at which point they are removed and replaced with new sample rocks. The removed sample rocks are analyzed to see if calcite has been added to or removed from the rocks.

Season	Description
Winter (end)	The time between the melting of ice cover and freshet. Pebble counts for the calcite index can be done because rock samples can be placed; stream flows are still low.
Freshet	High flows in the spring as a result of snow melt at higher elevations. High flows provide turbulence to the stream, potentially breaking up existing calcite. Due to high contributions of surface water, the saturation index is reduced.
Summer/Fall	The time between freshet and start of winter. During this time, there is a seasonal increase in the saturation index.
Winter (start)	The time when ice generally covers streams. At some locations there is open water where rock samples can be placed, but the calcite index cannot be measured.

Figure 55: Description of Generalized Seasons

Figure 54: EMC members Inspecting the Calcite Rock Sampling Method

Status

Methods for the seasonal calcite monitoring were approved by the BC Ministry of Environment and Climate Change Strategy in May 2015. Monitoring commenced soon afterwards and results were submitted in March 2017.

Seasonal Monitoring sites were chosen to reflect a range of chemical and calcification conditions within the Elk Valley (see Figure 57 map). Additionally, streams identified as priority streams for calcite management in the Elk Valley Water Quality Plan were included in the study where practical. To gather data across a variety of conditions, nine sites were selected for the seasonal calcite study which cover a range of conditions.

The results and interpretation presented covers monitoring that was conducted from January 2015 to December 2016.

Site	Description	Rationale for Selection
Kilmarnock (FR_KC1)	Below South Spoil	Selected because of a change in calcite index greater than |0.50| over one year and demonstrates a seasonal pattern in water chemistry with calcite index levels >1.00
Greenhills (GH_GH1)	Proposed stream for active calcite management	Selected due to being identified as a priority stream and demonstrates a seasonal pattern in water chemistry with calcite index levels >1.00
Mickelson (GH_MC1)	Below Greenhills West Spoil; receives pit dewatering	Selected due to showing a seasonal pattern in water chemistry, but has low levels of calcite
Wolfram (GH_WC2)	Below Greenhills West Spoil; receives pit dewatering	Selected because of a change in calcite index greater than |0.50| over one year
Thompson (GH_TC1)	Greenhills West Side	Selected due to showing a seasonal pattern in water chemistry, but has low levels of calcite
Corbin (CM_CC1)	Coal Mountain Operation	Selected due to being identified as a priority stream
Bodie (EV_BC1)	Receives pit dewatering, water redirected late 2016[7]	Selected because of a change in calcite index greater than |0.50| over one year
Dry (EV_DC1)	Elkview Dry Creek[8]	Selected due to being identified as a priority stream
Line Creek (LC_LC8)	Contingency ponds outlet—water redirected 2015[9]	Selected because it has consistent levels of calcite and consistent water chemistry across seasons

Figure 56: Seasonal Monitoring Sites

Results

The mean calcite index was calculated for each study site in each season. No consistent seasonal changes in the calcite index were observed; however field observations of the study team noted some potential patterns.

Data indicate that there are seasonal differences to the rates of calcite precipitation or removal at some study sites; however, there was no consistent pattern across the range of conditions tested. Some study sites (e.g. Dry Creek) indicated that calcite removal tends to occur during spring (i.e. when freshet occurs), when the greatest amount of water is running in the stream. Freshet conditions during spring were also linked to negligible calcite precipitation (i.e. addition) at multiple study sites (e.g. Corbin, Dry, Kilmarnock, Greenhills, Thompson, and Line Creeks).

Only Kilmarnock Creek demonstrated a significant correlation between rates of calcite precipitation and the water chemistry (i.e. the saturation index). The seasonal calcite supporting study has provided information as to the seasonal aspects of water chemistry and calcite formation, but it has not defined a consistent relationship between calcite formation and water chemistry or any other factor.

What is the saturation index?

The Saturation Index (SI) is a method to determine whether calcite is likely to precipitate or dissolve. Waters tend to precipitate calcite (meaning that calcite will be added to river beds) when oversaturated with respect to calcite constituents, and tend to dissolve calcite (calcite will be removed from riverbeds) if under saturated with respect to calcite constituents.

[7]As a result of water management decisions taken at the Elkview Operations mine site, water was directed away from this stream in late 2016. The 2016 study includes data up to that time only.

[8]Teck has two streams named Dry Creek (at separate mine sites), one of which is at Elkview, which was selected for this study. The site is referred to as Dry Creek throughout this section of the report.

[9]As a consequence of water management decisions taken at the Line Creek Operations mine site, water was directed away from these ponds in 2015, and the ponds have not been used since. Very little data was collected from this site; data will be reported where available in this report, but no regression analysis was done.

Flow rate (i.e. the speed that water is flowing in the stream) influences calcite precipitation in two distinct way. Under low flow conditions (e.g. during winter), more of the dissolved calcite constituents are delivered to the rocks as the flow rate increases, which allows increased rates of calcite precipitation. Under high flow conditions (i.e. during freshet), the stream becomes much more turbulent and there are higher levels of suspended solids in the water, which work to break up and remove calcite through erosion, abrasion, and bed-load movement.

Discussion of Results

The study was not able to determine a general value for the critical saturation index, above which calcite precipitation takes place, and below which calcite removal happens.

At three of the study streams (Bodie, Mickelson, and Wolfram), the data showed increasing trends in the calcite index over time. Thompson Creek also showed increasing calcite over the study period. Bodie, Mickelson, and Wolfram streams received mine-impacted water from pit pumping in 2016. All four streams are characterized as having low-flows. Other streams, including other low flow streams, did not demonstrate a trend in the calcite index.

At certain sites (Bodie and Mickelson), the concretion index (CIconc) increased to a level above the December 31, 2024 Site Performance Objective of 0.50 established in the Elk Valley Water Quality Plan and the Permit. Further analysis of data from these sites may help inform water management for mine operations (i.e. pit pumping), as well as provide an opportunity to understand whether early warning triggers can be established to support calcite management.

What's Next

The seasonal calcite study required by the Permit is now complete. Monitoring of overall calcite formation will continue under the annual calcite monitoring program.

Calcite Biological Effects Evaluation

Context

As presented in the previous section, calcite formation has been documented in the Elk Valley watershed downstream of mining activities and, to a lesser extent, in streams unaffected by mining. Teck is required to continue a program of monitoring and management for calcite, with the objective of understanding and managing mine-related calcite formation such that stream-beds in the Elk and Fording rivers and their tributaries can support abundant and diverse communities of aquatic plants, benthic invertebrates, and fish comparable to those in reference areas.

The presence of calcite and its potential to concrete substrates have raised questions about the effect of calcite on fish spawning success, as high levels of calcite in tributaries may impact spawning habitat by: reducing usable spawning gravels and food, by impacting egg incubation conditions, and by decreasing juvenile habitat.

Surface water and near-surface groundwater exchange in a porous area beside and under the streambed called the hyporheic zone. Functions of this zone include providing invertebrates refuge and places of storage, facilitating the supply of organic matter and nutrients to the streambed, and allowing surface water and groundwater exchange. As a streambed experiences greater amounts of concretion (due to accumulated calcite), the quality and function of the hyporheic zone may deteriorate. Calcite accumulations have been hypothesized to reduce water flow and dissolved oxygen in spawning gravel by interfering with exchange of surface water and near-surface groundwater in the hyporheic zone.

Status

The EMC has worked with Teck to develop a phased study to assess the biological effects of calcite. Phase 1 examined relationships between calcite and effects on benthic invertebrates, algae, and fish (2014-2015); Phase 2 examined calcite effects on fish spawning and incubation success (2016-2017). Phase 1 results can be found in the 2016 EMC Public Report, available at teck.com/elkvalley. The rest of this section discusses the results of Phase 2 evaluations.

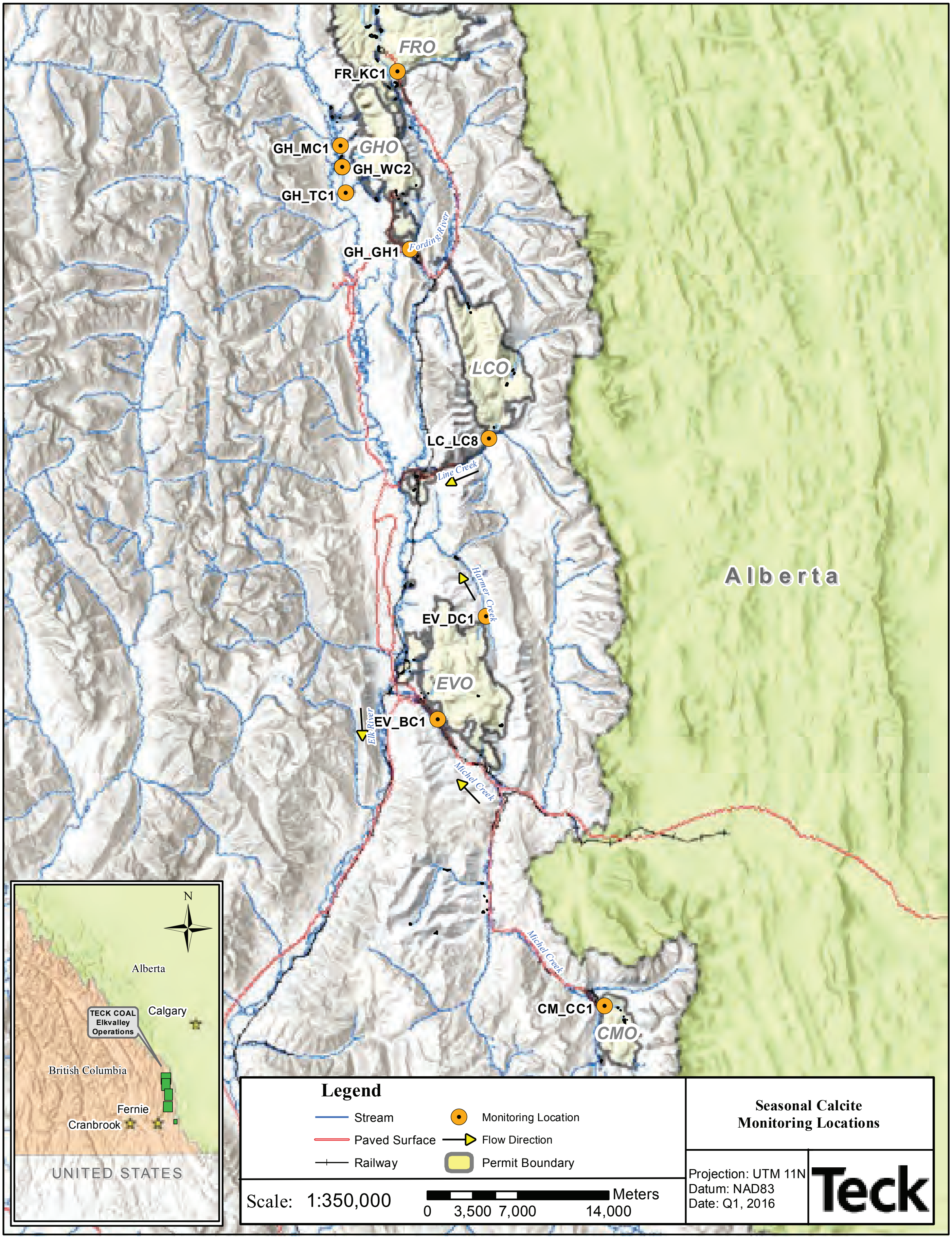

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Figure 57: Seasonal Calcite Study Sites

Results

The purpose of the Phase 2 study was to assess the extent to which hyporheic water flow and dissolved oxygen are influenced by calcite in the Elk River watershed. As discussed above, hyporheic water flow and dissolved oxygen are of interest due to their influence on incubation success of Westslope Cutthroat Trout eggs buried in stream gravels.

As fish use within the Upper Fording River watershed is well known, study sites were selected to represent both mainstem and tributary spawning habitat used by Westslope Cutthroat Trout in the upper Fording River and to represent the full range of calcite conditions. Spawning was visually confirmed (i.e., redds, spawning fish) at the sites selected in the upper Fording River, Clode Creek Settling Pond System, and lower Greenhills Creek.

It was observed that dissolved oxygen tended to naturally decrease at greater depths in the streambed substrate (i.e. gravels). Study results also indicate that increasing amounts of accumulated calcite on a streambed decreases the amount of dissolved oxygen in the hyporheic zone. The average depth of spawning habitat for Westslope Cutthroat Trout is between 10 and 30 cm. Using a maximum egg deposition depth (i.e. 30cm), the study predicts that average dissolved oxygen concentrations during incubation will be above 6 mg/L (the minimum threshold for buried embryos/alevins from the BC Guidelines for Protection of Aquatic Life) for all levels of calcite in the watercourses studied. However, dissolved oxygen levels lower than the BC Guidelines are likely at some sites, particularly where fines (i.e. smaller gravels, sand) occur in conjunction with high levels of accumulated calcite.

Calcite index did not seem to be a predictor of hyporheic water flow (discussed above), with the caveat that the finding is constrained by sample size limitations and methods available for use in this study. Additional field study will be undertaken in 2017 to validate the methods used and this finding.

Overall, the study results indicate that sites with high levels of calcite are likely to experience some deterioration of incubation conditions for Westslope Cutthroat Trout. However, the negative effect of calcite on dissolved oxygen is most apparent at depths greater than the typical depth where Westslope

Cutthroat Trout eggs are deposited in the streambed.

What's Next

These results have been reviewed by Teck and the EMC, and follow-up studies are in the planning phase for 2017. Future monitoring within the Regional Aquatic Effects Monitoring Program will include continued evaluation on the relationships between calcite and biological effects.

8 Human Health Risk Assessment

In this chapter, readers will learn about work that has been done to better understand any potential human health effects associated with mining-related activities in the Elk Valley watershed.

> ### What's a Human Health Risk Assessment?
>
> Human Health Risk Assessment is a process to determine the potential risks to human health posed by the presence of contaminants at a site or in a region. The process considers humans' exposure to and the toxicity of the contaminants.

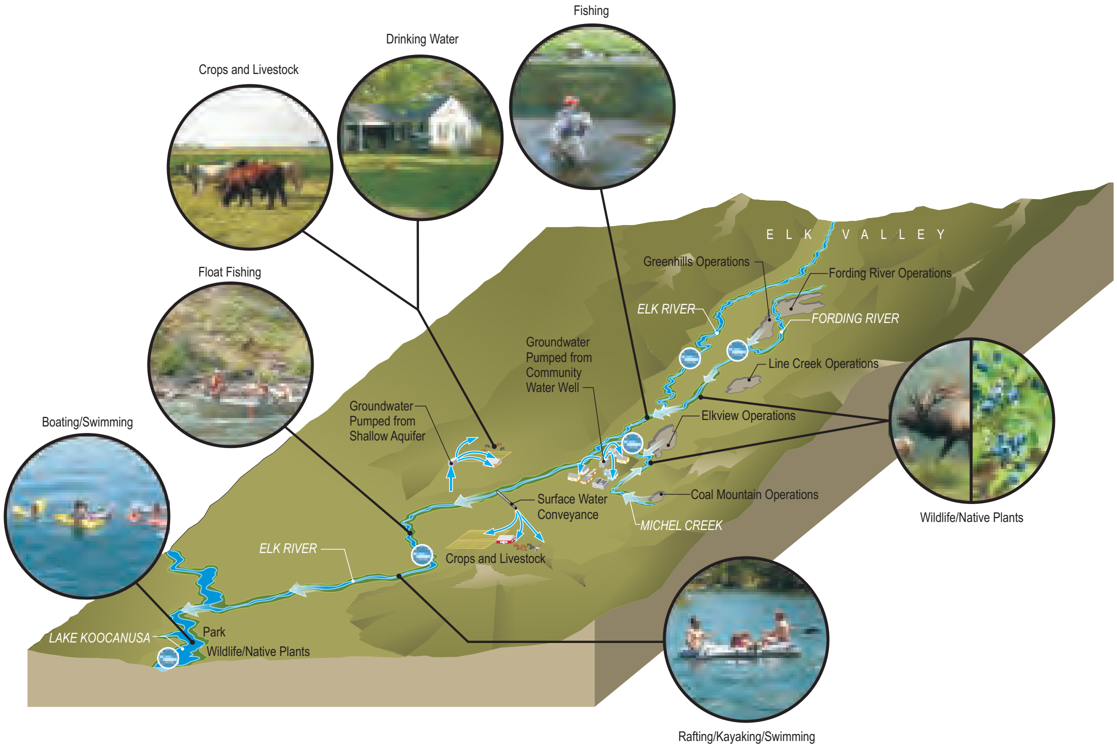

Figure 58: Conceptual Model of Exposure Pathways

Context

By the Permit, Teck, in consultation with the EMC, is required to conduct a Human Health Risk Assessment to examine the potential effects of mine-related constituents and other constituents of interest, including selenium, mercury, cadmium, chromium, copper, manganese, nitrate, nickel, vanadium, zinc, and others. This work must evaluate the human health risk associated with exposure to mine-related constituents from all exposure pathways (i.e., air, water, vegetation, sediment, fish, and wildlife; see Figure 58) in accordance with conditions outlined in the November 2016 BC Ministry of Environment and Climate Change Strategy letter approving the Human Health Risk Assessment work plan submitted by Teck.

Together, the Permit and BC Ministry of Environment and Climate Change Strategy approval letter define the scope of the Human Health Risk Assessment, which includes the following seven main requirements:

- Determine and assess how people may be exposed to selenium and other mine-related constituents that may be present in potable water sources, as well as in plants, fish, and game used for food or medicine.
- Follow approved methodologies and levels of acceptable risk for Human Health Risk Assessments provided in the British Columbia Contaminated Sites Regulation and consider Health Canada guidelines.
- Address First Nations consumption patterns and risk sensitivities.
- Incorporate information from many sources including, but not limited to, ongoing monitoring programs, traditional use studies, consultation records, wild foods consumption surveys, monitoring of mine-related substances, and environmental assessments completed for Teck's proposed expansions at the Elkview, Fording River, and Line Creek mining operations.
- Evaluate risks in the designated area for each management unit and the entire designated area as a whole (Figure 59).
- Identify links with the Adaptive Management Plan (see section 4) and outline how data gaps or potential impacts identified during the Human Health Risk Assessment will be addressed.
- Continue to provide opportunities to the EMC to provide advice on the Human Health Risk Assessment.

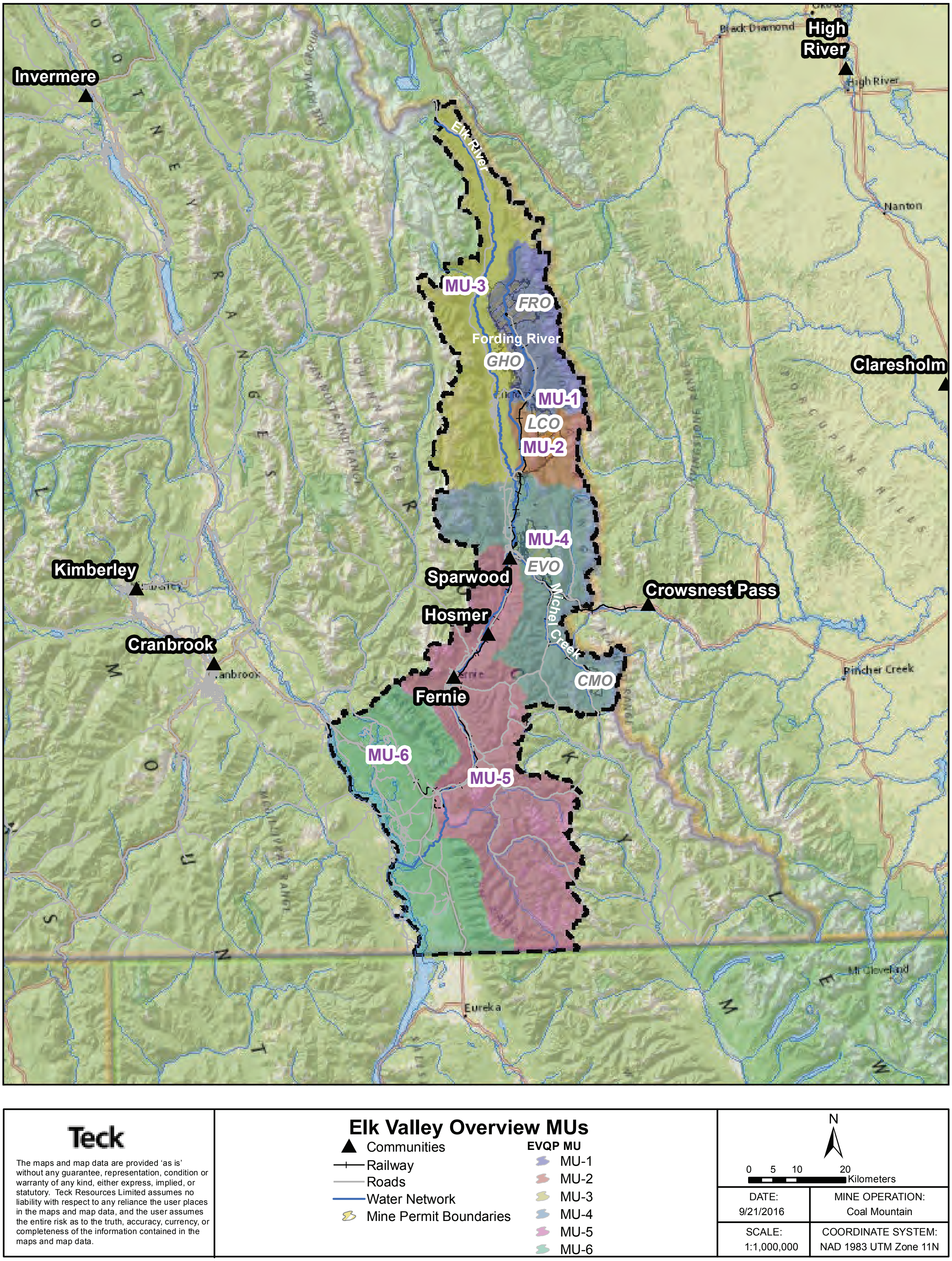

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Figure 59: Designated Area Management Units (MUs)

Status

As reported in the 2016 EMC Public Report, the Human Health Risk Assessment was submitted to the EMC and BC Ministry of Environment on March 31, 2016, as per Permit requirement. Subsequent to the submission, some EMC members requested further information to better understand the potential health risks to Ktunaxa Nation citizens from preferred consumption rates of wild foods. In response to this request, a technical memorandum was submitted by Teck to the EMC in mid-September 2016, as supporting information to the Human Health Risk Assessment. Some EMC members reviewed and provided input to the memo. Teck and KNC representatives are working in parallel to the EMC process to advance understanding and fill data gaps identified through the Human Health Risk Assessment and technical memorandum, and develop a path forward.

Results

Results from the March 31, 2016 Human Health Risk Assessment were reported in the last year's EMC Public Report and are repeated. The Human Health Risk Assessment report included results related to groundwater, surface water, sediment, wild foods, air and soil.

Groundwater

Shallow groundwater is the primary source of drinking water for communities in the Elk Valley.

- Groundwater currently used for drinking water does not present a risk to human health.

District of Sparwood Wells

The District of Sparwood operates three wells adjacent to the Elk River. Two wells (#1 and #2) are not presently influenced by surface water under current pumping conditions. Water quality data from the third well (Well #3) suggests that surface water is recharging the aquifer during low flow conditions, with the seasonal pattern of selenium concentrations in the wells matching seasonal patterns of concentrations in the Elk River and Michel Creek with some lag, and increasing selenium concentrations that at times exceed provincial water quality guidelines. To address any concern of elevated selenium concentrations, the District of Sparwood has been operationally managing municipal water needs by taking Well #3 offline during these periods of time. Teck and the District of Sparwood are currently working together to replace Well #3. Concurrently, the Sparwood Area Groundwater Supporting Study will be completed as a requirement under the Permit. The objective of the study is to evaluate the potential effects on groundwater in the Sparwood area from Teck's current and historical mining activities.

Surface Water

Elk Valley surface water is used primarily for recreation (e.g. boating, fishing, and occasional swimming) with some drinking (i.e. withdrawing water from a creek or river for drinking purposes), irrigation and industrial uses.

- Contact with surface water does not pose unacceptable risks to recreational activities.
- Use of surface water in MU-1 and MU-3 as primary sources of drinking water may pose a risk to infants due to the presence of nitrates. Surface water from these MU's are not currently known to be used as drinking water sources.
- In MU-1 through MU-4, use of surface water as primary sources of drinking water may pose a risk based on concentrations of selenium.

Sediment

People may contact sediment in rivers throughout the study area or in Koocanusa Reservoir while swimming or harvesting shoreline plants. All risks associated with sediment were well below the British Columbia Ministry of Environment risk management threshold. At this time, contact with sediment does not present a risk for people accessing these areas.

Wild Foods

Wild foods included in this assessment were fish, berries, and game. As requested by some EMC members, evaluation of the consumption of preferred amounts of wild foods in the Elk Valley was provided as supporting information to the Human Health Risk Assessment in mid-September 2016. The EMC recommended that more data is required to complete the evaluation of preferred wild food consumption. Refer to What's Next for more details of planned work.

Air and Soil

Based on current data, the exposure to mine-related contaminants and associated risks to human health resulting from soil contact and inhalation pathways are insignificant.

What's Next

The Human Health Risk Assessment is intended to inform the implementation of adaptive management actions required to address risks to human health from exposure to mine-related constituents. This is an ongoing process and data collected through the monitoring programs to address knowledge gaps will be used to update risk characterization as part of the Adaptive Management Plan.

Teck and KNC representatives are working together to address knowledge gaps related to wild foods, including consumption rates and concentrations of mine-related constituents in wild foods in mine-exposed and reference areas. Once this information is collected, it will be used to update the Human Health Risk Assessment Report to include a complete analysis of both current and preferred consumption rates. The updated report may be used by the KNC to inform their citizens of the health implications of eating wild foods from the Elk Valley.

The EMC will review the updated Human Health Risk Assessment Report and provide input in advance of its submission to the BC Ministry of Environment and Climate Change Strategy.

9 Third-Party Audit

In this chapter, the reader will find information about the activities carried out by an independent qualified professional to verify that environmental monitoring data required under the Permit is complete and accurately presented for analysis.

Context

The monitoring data and analysis required by the Permit, including the information that is presented in this public report, is subject to a third-party review and audit by a qualified professional. The audit may include a review of monitoring data and analysis for all monitoring reports required by the Permit for the previous two years. The first cycle of the audit covers the period from November 19, 2014 (the date of issuance of the Permit), to October 31, 2016, inclusive. The audit must consider at least one of the following topics:

- Data quality and completeness;
- Compliance with permit requirements;
- Protocols and procedures from the QA/QC plan for the monitoring program;
- Current water quality guidance documents established by the MoE; and/or
- Standard operating procedures and data-handling protocols in place for Teck.

The first third-party audit report will be submitted to the BC Ministry of Environment and Climate Change Strategy and the EMC by October 31, 2017, and then every two years following.

Status

At the EMC's June 2016 in-person meeting, members agreed to focus the first third-party audit on:

- Data quality and completeness; and
- Standard operating procedures and data-handling protocols in place for Teck.

The four monitoring subject areas selected by the EMC for this audit cycle are:

- Water quality
- Chronic toxicity
- Acute toxicity; and
- Benthic community structure (data only, as report is not yet complete)

The audit will review 10% of the content and data associated with each of these four monitoring subject areas. The EMC collaborated to define a breadth of questions provided to the auditor to assess for this audit cycle.

In March 2017, Matrix Solutions based out of Calgary, AB was selected by Teck to complete the audit and is conducting audit activities at the time of writing this report.

What's Next

The audit will be submitted to the EMC and BC Ministry of Environment and Climate Change Strategy by October 31, 2017. The EMC will provide an update as part of the 2018 EMC Public Report.

Appendix A:
The Ktunaxa Nation and the Elk Valley

The Ktunaxa Nation is made up of all Ktunaxa citizens residing both within and outside of **Ktunaxa ʔamakʔis**, including the member communities and their citizens. The northern portion of **Ktunaxa ʔamakʔis** has historically been claimed by Canada, while the southern half is claimed by the United States. In Canada, the member communities of the Ktunaxa Nation include, **ʔakink'umǂasnuqǂiʔit** (Tobacco Plains Band), **ʔaq̓am** (formerly known as St. Mary's Band), **yaqan nuʔkiy** (Lower Kootenay Band), and **ʔakisq'nuk** (Columbia Lake Band). The Ktunaxa Nation maintains unceded Aboriginal title in much of what is now considered the East and West Kootenays. Ktunaxa communities south of the Canada-USA border are located in what is now Idaho and Montana. The Elk Valley, which is wholly within the unceded and unsurrendered territory of the Ktunaxa has been occupied continuously by the Ktunaxa Nation since time immemorial, and is maintained as Aboriginal title by the Ktunaxa Nation. The British Columbia (BC) portion of the traditional territory is subject to ongoing treaty negotiations with the Province of BC and the Government of Canada.

The Elk Valley was traditionally used and occupied by the Ktunaxa Nation. Important Ktunaxa settlements were maintained in the Elk Valley well into the 20th century, and Ktunaxa citizens continue to reside throughout the lower Elk Valley, including in Sparwood, Fernie, and elsewhere. Ktunaxa oral histories, supported by historic archival and ethnographic data, suggest that Ktunaxa presence in the Elk Valley has long been centred on an important habitation area named **k̓ aqawakanmituk**, a Ktunaxa settlement at the confluence of Michel Creek and the Elk River near present-day Sparwood. This is a very important cultural area in the Elk Valley. It was occupied annually, and likely for a long period of time up to the late 1800's, by the Michel Prairie people, also referred to as the Fernie Band, or **k̓ aqawakanmituknik̓**. This was a historic Ktunaxa community with close ties to the current Ktunaxa community of Tobacco Plains whose annual round included hunting bison on the eastern slopes of the Rocky Mountains. As described further below, many Michel Prairie people died as a result of early smallpox epidemics, likely in the late 1700s.The settlement of **k̓ aqawakanmituk** at Michel Prairie included important tobacco cultivation areas, as well as habitation areas, processing areas, and other features including trails that connected the valley to mountain passes to the east. While there are no reserve lands in the Elk Valley, the Ktunaxa understand that reserve areas were promised in the area of Michel Flats and present day Sparwood, but were never formally allotted.

The Elk Valley itself falls within the Ktunaxa traditional land district of **qukinʔamakʔis**. **Qukin ʔamakʔis** is translated as Raven's Territory, Raven's Land or the Land of Raven. It is also sometimes used as a synonym for the Elk Valley because the valley and its surrounding mountains make up the majority of the lands associated with Raven. Today, the Elk Valley is known to Ktunaxa peoples not only for the richness of its fish and game but also for the presence of coal and extensive coal mining, and the associated restrictions on access to mining lands, many of which are private. For the Ktunaxa Nation, the history of coal mining in the Elk Valley, including recent history, has been a story of exclusion with more than a century of efforts by non-Ktunaxa individuals and companies to extract **qukin nuʔkiy** (Raven's Rock, or Coal) from **qukinʔamakʔis** (Raven's Land). Available information (archival and ethnographic), as well as oral histories and archaeology, supports an understanding that the Elk Valley in general, and specifically the upper Elk River, including areas around Michel Creek, Line Creek, Grave Creek, Round Prairie, and the Fording River, has been continuously used and occupied by Ktunaxa peoples, and specifically Upper Ktunaxa peoples, for hundreds of years prior to 1846.

Water is fundamental to the Ktunaxa creation story, and is understood by Ktunaxa knowledge holders to be the basis for all living things within **Ktunaxa ʔamakʔis**. Rivers, streams, lakes, and riparian areas provide essential habitat for the fish, and many of the animals and plants that Ktunaxa harvesters rely on, and responsible stewardship of water is a critical component of Ktunaxa responsibility. The Ktunaxa principle **ofʔa'kxam̓ is q̓** apiqapsin is translated to mean a responsibility for stewardship of all living things. Within the borders claimed by Canada and British Columbia, the **ʔamakʔis** of the Ktunaxa Nation covers approximately 70,000 km2 (27,000 square miles) of mountains, valleys, rivers and lakes in the Kootenay region. The region's landscape is alive with Ktunaxa culture and history. The Ktunaxa creation story relates the origins of the Ktunaxa people and describes the events and relationships that helped shape—and continue to shape—**Ktunaxa ʔamakʔis**. The geography of the Elk Valley is formed in the final events of the story, when the animal chief and creation hero, **Naɫmuqȼin**, collapses, forming the Rocky Mountains with his body.

Ktunaxa Creation Story

In ancestral times referred to by the Ktunaxa as the animal world, there were references made many times by the Creator to when there will be ʔaqⱡmaknik̓ (people).

At that time, there was some disturbance caused by a huge sea monster known as Yawuʔnik̓, who killed many of the animals. A council was called by the Chief animal, Naⱡmuqȼin. Naⱡmuqȼin was huge. He was so tall that he had to crawl on his hands and knees, for if he stood up his head would hit the ceiling of the sky.

It was decided that Yawuʔnik̓ had to be destroyed. A war party was formed. Yawuʔnik̓ plied the Kootenay and Columbia River System including Columbia Lake and Arrow Lakes.

Yawuʔnik̓ was sighted in the Columbia Lake near Yaqa·n Nuʔkiy and the chase was on. At that time, the Kootenay River and the Columbia Lake were joined. As the chase proceeded, Naⱡmuqȼin gave names to many locations along the Kootenay River, Kootenay Lake, Arrow Lakes and the Columbia River.

Yawuʔnik̓ was pursued down the Kootenay River past the Wasa sloughs, now called Wasa, BC. Skinkuȼ got into trouble here when he fell into the river and had to be rescued by Wasa, (horse-tail).

The chase went by where the St. Mary̓s River empties into the Kootenay River. ʔaq̓am, where the St. Mary̓s Reserve is now located, then on down river to Kank̓ak (spring) where Mayuk (weasel) joined the war party. There were animals on both sides of the river as the chase continued, and among the party was a parasite, ʔa·kukⱡakuwum, who had to be carried on the backs of other animals. His name was Ȼ̓umtus and he was mean and bossy. The other animals grew tired of his nagging and dumped him into the river at a place now known as Yaqakiⱡ wat̓mitquⱡiⱡki Ȼ̓umtus.

Leaving the land of the Eagle, ʔa·knuqⱡuⱡam̓ʔamak̓is and into the land of the woodtick, Ȼam̓na ʔAmakis, past Wasaʔki (Waldo) then on past the now 49th Parrallel and then past Kaxax (Turtle), now underwater, near Rexford, Montana. The chase went on by ʔa·kiʔyi (jennings) and on by ʔaqswaq (libby) then into Skinkuȼ ʔAmakis (the land of Coyote), past ʔaq̓anqmi (Bonners Ferry, Idaho) then northerly past the now international boundary into ʔaȼpu ʔamakis, the land of the Wolverine, past Yaqa·n Nuʔkiy (Creston, BC) then up the Kootenay Lake past ʔaq̓asqnuk, (Kuskannok, BC). The chase went on by ʔAkuqⱡi (Akokli Creek), past Ksanka Creek. The Yawuʔnik̓ chose to follow the Kootenay River past ʔaqyamⱡup (Nelson, BC). The chase was now in Miȼ̓qaqas ʔamakis (the land of Chickadee).

At Kik̓siⱡuk, (Castlegar, BC) Yawuʔnik̓ went north into the Arrow Lakes, past ʔakink̓aʔnuk (Arrow Rock) where arrows were shot into a crevice in the rock. If the arrow was true, the journey continued, if the mark was missed, beware, danger ahead. The arrow was true and the journey continued past Ȼaⱡnuʔnik̓ (Nakusp) then up past Ktunwakanmituk Miȼ̓qaqas (Revelstoke, BC) where the Columbia River flows into the Arrow Lakes, then up and around The Big Bend then down past ʔaknuqⱡuk (Golden, BC) past Yaknusuʔki (Briscoe, BC) then on past Yakyuȼki. The chase carries on through Kwataq̓nuk (Athalmere) then past Kananuk (Windermere, BC) past ʔakiskq̓nuk (Windermere Lakes), then back into the Columbia Lake, Yaqa·n Nukiy, (Canal Flats, BC). This completed the cycle of the chase.

Yawuʔnik̓ would once again escape into the Kootenay River and the chase would go on. The chase would go on and on. Every time the war party thought they had Yawuʔnik̓ cornered, Yawuʔnik̓ would escape again.

One day sitting on the river bank observing the chase was a wise old one named Kik̓um. Kik̓um told Naⱡmuqȼin, You are wasting your time and energy chasing the monster. Why not use your size and strength and with one sweep of your arm, block the river from flowing into the lake and the next time the monster enters the lake you will have him trapped. Naⱡmuqȼin took the advice of Kik̓um and did as he was told. The next time Yawunik̓ entered the lake, he was trapped.

Having successfully corralled Yawuʔnik̓, a decision had to be made as to whom the honor of killing Yawuʔnik̓ would be bestowed upon. The honor was awarded to Yamakpaⱡ (Red-headed Woodpecker).

When Yawuʔnik̓ was killed, he was taken ashore and butchered and distributed among the animals. There remained only the innards and bones. The ribs were scattered throughout the region and now form the Hoo Doos seen throughout the area.

Naɬlmuqȼin then took the white balloon-like organ, known as the swim bladder, and crumbled it into small pieces and scattered it in all directions saying, 'These will be the white race of people'. He then took the black ingredient from the inner side of the backbone, the kidney, and broke it into small pieces and scattered them in all directions declaring,'These will be the black race'. He then took the orange roe and threw the pieces in all directions saying,'These will be the yellow race of people'.

Naɬmuqȼin looked at his bloody hands and reached down for some grass to wipe his hands. He then let the blood fall to the ground saying, 'This will be the red people, they will remain here forever'.

Naɬmuqȼin, in all the excitement, rose to his feet and stood upright hitting his head on the ceiling of the sky. He knocked himself dead. His feet went northward and is today know as Ya·ɬiki, in the Yellowhead Pass vicinity. His head is near Yellowstone Park in the State of Montana. His body forms the Rocky Mountains.

The people were now keepers of the land. The spirit animals ascended above and are the guiding spirits of the people.

Ktunaxa Nation website: Ktunaxa.org

Ktunaxa Law

Ktunaxa law (**ʔaknumuȼtiⱡiⱡ**) and oral history (**ʔaqaⱡq'anuxwatiⱡ**) are both sacred and legal in nature. Ktunaxa land use rights are based on a sacred covenant with the Creator, whereby, in exchange for the land providing the Ktunaxa with the necessities of life, the Ktunaxa are responsible as stewards of the lands and resources in **Ktunaxa ʔamakʔis**. The Ktunaxa have terms that address the natural world and how people are a part of it. **ʔakuk'pukam** speaks to anything that gets life from the earth through roots. **ʔakuk'pukamnam** adds the human dimension, whereby the earth's life is translated into human life. That is, the Ktunaxa have roots that tie them to **Ktunaxa ʔamakʔis**, and they are of the earth. In other words, they believe that what they do to the earth, they do to themselves and to future generations. The Ktunaxa phrase that captures interconnectedness and the stewardship concepts applicable to land management is **YaqaⱡHankatiⱡiⱡkinaʔamak**. This phrase translates to "our people care for the land, the land cares for our people."

More information on the Ktunaxa laws and principles can be found in Section C for the Baldy Ridge Expansion project found on the Environmental Assessment Office website (**https://projects.eao.gov.bc.ca/p/baldy-ridge-extension/docs**).

Appendix B:
Site Performance Objectives at the Seven Order Stations under Permit 107517

ORDER STATION	DESCRIPTION	PARAMETER	UNIT	Immediately (Nov 2014)	By DEC 31, 2019	By DEC 31, 2023	By DEC 31,2025	By DEC 31, 2028
GH_FR1	Upper Fording River downstream of Greenhills Creek	Total Selenium	µg/L	—	63	57	57	57
		Nitrate as N	mg/L	20	14	11	11	11
		Sulphate	mg/L	429	429	429	429	429
		Dissolved Cadmium	µg/L	0.39	0.39	0.39	0.39	0.39
LC_LC5	Lower Fording River downstream of Line Creek	Total Selenium	µg/L	—	51	40	40	40
		Nitrate as N	mg/L	18	10	10	10	10
		Sulphate	mg/L	429	429	429	429	429
		Dissolved Cadmium	µg/L	0.39	0.39	0.39	0.39	0.39
GH_ER1	Elk River upstream of Boivin Creek	Total Selenium	µg/L	19	19	19	19	19
		Nitrate as N	mg/L	3	3	3	3	3
		Sulphate	mg/L	309	309	309	309	309
		Dissolved Cadmium	µg/L	0.24	0.24	0.24	0.24	0.24
EV_ER4	Elk River upstream of Grave Creek	Total Selenium	µg/L	23	23	19	19	19
		Nitrate as N	mg/L	-	4	4	3.5	3
		Sulphate	mg/L	429	429	429	429	429
		Dissolved Cadmium	µg/L	0.24	0.24	0.24	0.24	0.24
EV_ER1	Elk River downstream of Michel Creek	Total Selenium	µg/L	19	19	19	19	19
		Nitrate as N	mg/L	—	3	3	3	3
		Sulphate	mg/L	429	429	429	429	429
		Dissolved Cadmium	µg/L	0.24	0.24	0.24	0.24	0.24
RG_ELKORES	Elk River at Elko Reservoir	Total Selenium	µg/L	19	19	19	19	19
		Nitrate as N	mg/L	-	3	3	3	3
		Sulphate	mg/L	429	429	429	429	429
		Dissolved Cadmium	µg/L	0.24	0.24	0.24	0.24	0.24
RG_DSELK	Koocanusa Reservoir south of the Elk River	Total Selenium	µg/L	2	2	2	2	2
		Nitrate as N	mg/L	3	3	3	3	3
		Sulphate	mg/L	308	308	308	308	308
		Dissolved Cadmium	µg/L	0.19	0.19	0.19	0.19	0.19

Appendix C:
Compliance Limits (monthly averages), as set by Permit 107517

Station ID	Description	Parameter	Unit	Nov 2014	Dec 31, 2015	Dec 31, 2017	Dec 31, 2019	Dec 31, 2021	Dec 31, 2023	Dec 31, 2025	Dec 31, 2027	Dec 31, 2033
FR_FRCP1	Fording River, downstream of Cataract Creek	Selenium	µg/L	130	130	130	90	90	61	61	61	61
FR_FRCP1	Fording River, downstream of Cataract Creek	Nitrate	mg/L	27	27	27	19	19	13	13	13	13
FR_FRCP1	Fording River, downstream of Cataract Creek	Sulphate	mg/L	580	580	580	620	620	650	650	650	650
GH_FR1	Fording River, downstream of Greenhills Creek	Selenium	µg/L	80	80	80	63	63	51	51	51	51
GH_FR1	Fording River, downstream of Greenhills Creek	Nitrate	mg/L	24	24	24	14	14	11	11	11	11
GH_ERC	Elk River, downstream of Thompson Creek	Selenium	µg/L	15	15	15	15	15	15	15	8	8
GH_ERC	Elk River, downstream of Thompson Creek	Nitrate	mg/L	3	3	3	3	3	3	3	3	3
LC_LCDSSLCC	Line Creek, below water treatment facility	Selenium	µg/L	80	50	50	50	50	50	50	50	29
LC_LCDSSLCC	Line Creek, below water treatment facility	Nitrate	mg/L	14	7	7	7	7	7	7	7	3
EV_HC1	Harmer Creek, at the spillway*	Selenium	µg/L	45	45	57	57	TBD	TBD	TBD	TBD	TBD
EV_HC1	Harmer Creek, at the spillway	Nitrate	mg/L	4	4	16	16	8	8	8	8	8
EV_HC1	Harmer Creek, at the spillway	Sulphate	mg/L	300	300	380	380	450	450	450	450	450
EV_MC2	Michel Creek at Hwy 3 bridge	Selenium	µg/L	28	28	28	28	20	20	19	19	19
EV_MC2	Michel Creek at Hwy 3 bridge	Nitrate	mg/L	6	6	6	6	6	6	6	6	6
CM_MC2	Michel Creek, upstream of Andy Goode Creek	Selenium	µg/L	19	19	19	19	19	19	19	19	19
CM_MC2	Michel Creek, upstream of Andy Goode Creek	Nitrate	mg/L	5	5	5	5	5	5	5	5	5
CM_MC2	Michel Creek, upstream of Andy Goode Creek	Sulphate	mg/L	500	500	500	500	500	500	500	500	500

Appendix D:
BC Ministry of Environment and Climate Change Strategy Environmental Monitoring System (EMS) Web Reporting for Teck's Water Quality Monitoring Locations

Compliance Point Locations

EMS #[7]	TECK IDENTIFIER	SITE	SITE DESCRIPTION
E300071	FR_FRCP1	FRO	Fording River, approximately 525m downstream of Cataract Creek
0200378	GH_FR1	GHO	Fording River, approximately 205m downstream of Greenhills Creek
E300090	GH_ERC	GHO	Elk River, approximately 220m downstream of Thompson Creek
E297110	LC_LCDSSLCC	LCO	Line Creek immediately downstream of South Line Creek Confluence (approximately 1500m downstream of the WLC WTP outfall)
E102682	EV_HC1	EVO	Harmer Spillway
E300091	EV_MC2	EVO	Michel Creek at Highway 3 Bridge
E258937	CM_MC2	CMO	Michel Creek, approximately 50m upstream of Andy Goode Creek
E291569	WL_BFWB_OUT_SP21	LCO	WLC WTP Outfall (Effluent)

Order Station Locations

EMS #[8]	TECK IDENTIFIER	SITE DESCRIPTION
0200378	FR4 (GH_FR1)	Fording River Downstream of Greenhills Creek
0200028	FR5 (LC_LC5)	Fording River downstream of Line Creek
E206661	ER1 (GH_ER1)	Elk River upstream of Boivin Creek
0200027	ER2 (EV_ER4)	Elk River upstream of Grave Creek (from Fording River to Michel Creek)
0200393	ER3 (EV_ER1)	Elk River Downstream of Michel Creek
E294312	ER4 (RG_ELKORES)	Elk River at Elko Reservoir
E300230	LK2 (RG_DSELK)	Koocanusa Reservoir south of the Elk River

[10] http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/environmental-monitoring-databases
[11] http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/environmental-monitoring-databases

Appendix E:
2016 Regional Groundwater Monitoring Program Wells

Key Area	Well ID	Well Type	Management Unit (MU)	Operation	Setting	Location Description and Rationale
Background	FR_HMW5	Monitoring	1	FRO	Tributary valley-bottom	Background well upgradient of FRO in Henretta Creek Drainage. Selected to provide background regional groundwater conditions.
1	FR_09-01-A	Monitoring	1	FRO	Fording River valley-bottom	Downgradient of South Kilmarnock Phase 1 and 2 Settling Ponds, Swift Creek and Kilmarnock Creek, upgradient of Cataract Creek and Key Area 1. Completed in coarse sediments within the Fording River Valley. Selected to monitor groundwater near the Site boundary of FRO.
	FR_09-01-B	Monitoring	1	FRO		
	FR_GHHW1	Supply	1	FRO		Wells screened within coarse Fording River valley-bottom sediments at the southern border of FRO, downgradient of Swift, Porter and Cataract Creeks. Selected to monitor groundwater transport outside of mine-permitted areas in Key Area 1.
2	LC_PIZDC1308	Monitoring	1	LCO	Tributary valley-bottom	Multi-level overburden sentry well upgradient of Key Area 2 in the LCO Dry Creek valley bottom. Selected to monitor potential influence of planned upland and tributary valley-bottom development at LCO Phase II.
	LC_PIZDC1307	Monitoring	1	LCO		
3	GH_POTW09	Supply	1	GHO	Fording River valley-bottom	Located in the Fording River Valley Aquifer. Selected to monitor groundwater conditions in Key Area 3.
	GH_POTW10	Supply	1	GHO		
	GH_POTW15	Supply	1	GHO		
	GH_POTW17	Supply	1	GHO		
4	GH_MW-ERSC-1	Monitoring	3	GHO	Elk River valley-bottom	Located near the southern boundary of Key Area 4. Selected as a potential sentry well to monitor groundwater quality in Elk River valley-bottom sediments.
	GH_GA-MW-1	Monitoring	3	GHO		Upgradient area of Key Area 4. Selected to monitor groundwater conditions in Elk River valley-bottom groundwater conditions near GHO in the upgradient area of Key Area 4.
	GH_GA-MW-2	Monitoring	3	GHO		Located downgradient of Wolfram Creek Settling Ponds. Selected to monitor upland and tributary valley bottom influences from the west side of GHO and evolution of groundwater quality in within the Elk River valley bottom in Key Area 4.
	GH_GA-MW-3	Monitoring	3	GHO		Located downgradient of Thompson Creek Settling Ponds. Selected to monitor upland and tributary valley bottom influences from the west side of GHO and evolution of groundwater quality in within the Elk River valley bottom in Key Area 4.
	GH_GA-MW-4	Monitoring	3	GHO		Located downgradient of Leask Creek Settling Ponds. Selected to monitor upland and tributary valley bottom influences from the west side of GHO and evolution of groundwater quality in within the Elk River valley bottom in Key Area 4.
	RG_DW-01-03	Supply	3	RG		Located 5 km downgradient of Key Area 4. Selected as a potential sentry well to monitor groundwater within coarse Elk River valley bottom sediments downgradient of Key Area 4.
	RG_DW-01-07	Domestic	3	RDW		Located 15 km downgradient of Key Area 4. A sentry well to monitor groundwater within the Elk River valley bottom downgradient of Key Area 4.
5/6	LC_PIZP1101	Monitoring	4	LCO	Elk River valley-bottom	Southwest of the effluent ponds at the LCO Process Plant Site, upgradient of Key Area 6. Selected to monitor potential influence from the LCO Process Plant Site on the Elk River valley bottom in Key Area 6.

Key Area	Well ID	Well Type	Management Unit (MU)	Operation	Setting	Location Description and Rationale
7	EV_GV3gw	Monitoring	4	EVO	Tributary valley-bottom	Nearest upgradient well of Key Area 7, within the Grave Creek valley bottom. Selected to monitor upland and tributary valley-bottom input from drainages to the northeast of EVO.
	RG_DW-02-20	Domestic	4	RDW	Elk River valley-bottom	Located 4 km downgradient of Key Area 6. Selected to monitor groundwater in the Elk River valley bottom in Key Area 7.
8	EV_LSgw	Monitoring	4	EVO	Elk River valley-bottom	Located near the discharge of Lindsay Creek to the Elk River. Selected to monitor potential inputs to Key Area 8 from upland, tributary valley bottom, and Elk River valley bottom features along the western slope of EVO.
	EV_OCgw	Monitoring	4	EVO		Located immediately downgradient of Lagoon D and adjacent to Otto Creek. Selected to monitor potential inputs to Key Area 8 from upland, tributary valley bottom, and Elk River valley bottom features along the western slope of EVO.
9	EV_BCgw	Monitoring	4	EVO	Michel Creek valley-bottom	Downgradient of the confluence of Bodie Creek and Michel Creek. Selected to monitor spatial distribution of water quality within Michel Creek valley-bottom sediments in relation to potential inputs in Key Area 9.
	EV_MCgwS	Monitoring	4	EVO	Michel Creek valley-bottom	Located 1.8 km upgradient of the confluence of Michel Creek and the Elk River. Selected to monitor spatial distribution of water quality within Michel Creek valley-bottom sediments in relation to potential inputs in Key Area 9.
	EV_MCgwD	Monitoring	4	EVO		
	EV_BRgw	Supply	4	EVO		Michel Creek valley bottom upgradient and downgradient of Gate Creek and Bodie Creek confluence with Michel Creek. Selected to monitor spatial variation in groundwater quality within Michel Creek valley bottom in relation to Key Area 9.
	EV_RCgw	Supply	4	EVO		
	EV_WH50gw	Supply	4	EVO		
	RG_DW-03-01	Domestic	4	RDW		Located 1.2 km upgradient of the confluence of Michel Creek and the Elk River. Selected as a potential sentry well to monitor groundwater within coarse Elk River valley bottom sediments downgradient from Key Area 9.
10	EV_ECgw	Monitoring	4	EVO	Tributary valley-bottom	Nearest upgradient well of Key Area 10, within Erickson Creek valley bottom. Selected as a sentry well to monitor potential influence of upland and tributary valley-bottom groundwater from the southwest portion of EVO to Key Area 10.
11	CM_MW1-OB	Monitoring	4	CMO	Michel Creek valley-bottom	Multi-level sentry well immediately downgradient of CMO and the confluence of Michel Creek and Corbin Creek. Selected to monitor groundwater in the Michel Creek valley-bottom in Key Area 11.
	CM_MW1-SH	Monitoring	4	CMO		
	CM_MW1-DP	Monitoring	4	CMO		
	RG_DW-07-01	Domestic	4	RDW		Immediately downgradient of CMO at the confluence of Michel Creek and Corbin Creek. Selected as a sentry well to monitor groundwater conditions in the Michel Creek Valley bottom downgradient of CMO in Key Area 11.
12	EV_ER1gwS	Monitoring	4	EVO	Elk River valley-bottom	Adjacent to the Elk River, 1 km downgradient of the confluence with Michel Creek. Multi-level sentry well to monitor groundwater in Elk River valley-bottom sediments in Key Area 12.
	EV_ER1gwD	Monitoring	4	EVO		
	RG_DW-03-04	Supply	4	RG		Located near the border of MU4 and MU5 in the Elk River valley bottom. Selected as a sentry well to monitor deep overburden groundwater in the Elk River valley bottom at the southern extent of the Study Area in Key Area 12.