Elk Valley Water Quality Plan

Annex D.2

Water Quality Modelling for the Initial Implementation Plan

Teck

ELK VALLEY WATER QUALITY PLAN

WATER QUALITY MODELLING FOR THE INITIAL IMPLEMENTATION PLAN

July 2014

Teck

This report has been prepared by:

GOLDER ASSOCIATES LTD.

Amanda Snow, M.A.Sc., EIT
Water Quality Specialist

Dicksen Tanzil, Ph.D.
Senior Engineer

This report has been reviewed by:

Andrew Forbes, M.Sc., P.Geo.
Associate, Senior Geoscientist

Summary

To support the Elk Valley Water Quality Plan (the Plan), Teck has developed the Elk Valley Water Quality Planning Model (the model), which is a regional, forward-looking planning model that predicts how application of candidate mitigation measures will likely affect water quality in the Elk Valley. The model reflects the current understanding of regional hydrology and release rates of selenium, sulphate and nitrate from waste rock, and it has been calibrated and refined using historical information. The model was used to evaluate water quality management scenarios to support the development of the initial implementation plan, which in turn defines the specific management measures and timeframe required to meet the identified water quality targets.

The purposes of this report are to:

- describe the assessment of representative water quality management scenarios for the Plan
- describe the water quality modelling work performed to support the development of the initial implementation plan
- present predicted water quality conditions at Order stations and at the Upper Fording River and Michel Creek, based on the initial implementation plan.

Early in the planning process, three initial representative scenarios involving different combinations of water quality management options were identified: active water treatment, active water treatment with clean-water diversions, and active water treatment with clean water diversions and covers. Management options that included active water treatment, clean-water diversion and covers were identified for each mine operation and incorporated into the model. The model estimated in-stream concentrations of selenium, nitrate and sulphate under the representative scenarios over the planning timeframe of 20 years (i.e., up to 2034). The patterns identified from the assessment of representative scenarios were used to guide subsequent iterations in the selection of management options for the initial implementation plan.

Assisted by the patterns identified for the representative scenarios, it was concluded that active water treatment with biological technology and clean-water diversions were to be carried forward as part of the planning basis for the initial implementation plan. Covers were not carried forward for the initial implementation plan. Instead, along with other options with higher uncertainty and based on emerging technologies and management approaches, covers will continue to be evaluated for possible incorporation through an adaptive management process.

This report presents supporting technical information on the development process for the Plan, including:

- the relationship between total treatment capacity and in-stream concentrations
- flows available for treatment
- the relationship between treatment capacity and selenium load removed.

A summary of the initial implementation plan as incorporated in the model is provided in Table S-1.

Table S-1 Initial Implementation Plan

Sources Targeted for Treatment	Year	Total Water Volume Treated[a]	Associated Diversions[a]	Associated Conveyance of Mine-Influenced Water[a]
LCO West Line	Q2 2014	7,500	–	• Convey Line Creek to AWTF • Discharge to Line Creek
GHO Swift, Cataract and FRO Kilmarnock	2018	20,000	Diversion of Upper Kilmarnock watershed (estimated at 45,000 m^3/d capacity) and Upper Brownie watershed (estimated at 14,000 m^3/d)	• Convey Swift and Cataract and the mine-influenced portion of Kilmarnock to the AWTF • Discharge to the Fording River
EVO Bodie, Gate, Erickson	2020	30,000	Diversion of Upper Erickson watershed (estimated 14,000 m^3/day) and South Gate Creek (estimated 3,500 m^3/d)	• Convey mine-influenced water from Erickson to the AWTF • Discharge to Erickson Creek
FRO Clode, North Spoil, Swift Pit	2022	15,000	–	• Convey mine-influenced water to the AWTF • Discharge to the Fording River
EVO Erickson	2024	20,000	–	• Convey mine-influenced water to the AWTF • Discharge to Erickson Creek
GHO West Spoil and Greenhills Creek	2026	7,500	–	• Convey mine-influenced water to the AWTF • Discharge to Thompson Creek
LCO Dry Creek	2028	7,500	–	• Convey mine-influenced water to the AWTF • Discharge to the Fording River
FRO Swift Pit	2030	15,000	–	• Convey mine-influenced water to the AWTF • Discharge to the Fording River
LCO Line Creek	2032	7,500	Diversion of Upper Line Creek (estimated 35,000 m^3/d)	• Convey mine-influenced water to the AWTF • Discharge to line Creek

[a] Associated Diversions and Associated Conveyance of Mine-Influenced Water are identified for planning purposes, to be evaluated during detailed design. Total Water Volume Treated and diversion sizes will be refined based on site-specific information developed during detailed design.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

Acronym	Definition
AWTF	active water treatment facility
BC	British Columbia
BC MOE	British Columbia Ministry of Environment
BGM	bituminous geomembrane
CMO	Coal Mountain Operations
CWD	clean-water diversion
EAC	Environmental Assessment Certificate
EMS	environment monitoring station
EVO	Elkview Operations
FRO	Fording River Operations
FRO N	Fording River Operations North
FRO S	Fording River Operations South
GHO	Greenhills Operations
ID	identification
LCO	Line Creek Operations
LCO I	Line Creek Operations Phase I
LCO II	Line Creek Operations Phase II
the model	Elk Valley Water Quality Planning Model
the Plan	Elk Valley Water Quality Plan
WLC	West Line Creek

UNITS

%	percent
>	greater than
µg/L	micrograms per litre
ha	hectare
km^2	square kilometre
m^3/d	cubic metres per day
mg/L	milligrams per litre

1 Introduction

1.1 Background

Teck Coal Limited (Teck) operates five open-pit steelmaking coal mines in the Elk Valley in southeastern British Columbia (Figure 1-1):

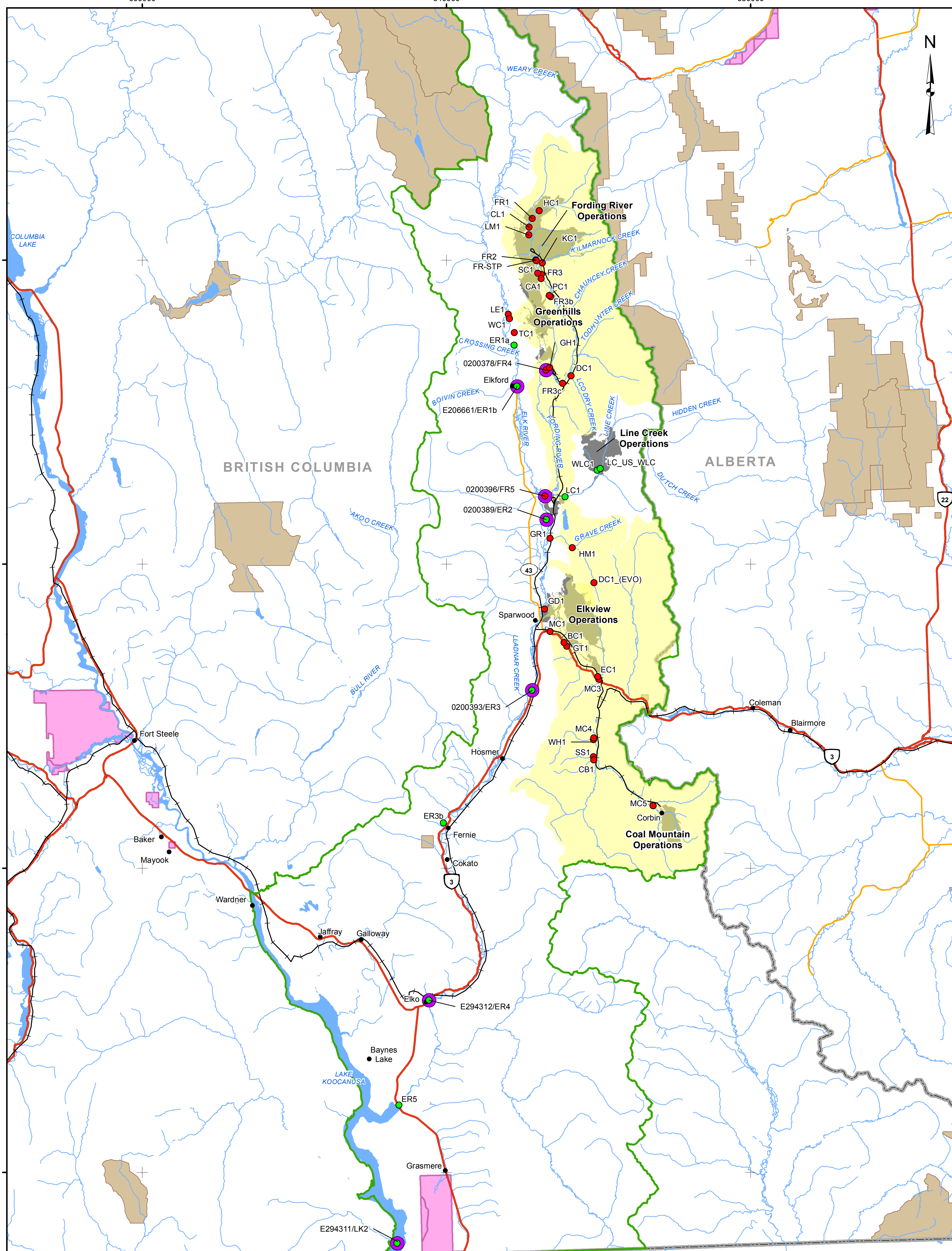
- Fording River Operations (FRO)
- Greenhills Operations (GHO)
- Line Creek Operations (LCO)
- Elkview Operations (EVO)
- Coal Mountain Operations (CMO).

On April 15, 2013, Ministerial Order No. M113 (the Order) was issued by the BC Minister of the Environment. The Order requires Teck to develop an area based management plan for the Elk Valley, for the purpose of managing concentrations of selenium, cadmium, nitrate and sulphate and the rate of calcite formation in water in the Elk River watershed. Teck refers to this area-based management plan as the Elk Valley Water Quality Plan (the Plan). As part of the Plan, Teck must develop targets for water quality at specified locations in the Fording River, Elk River and Lake Koocanusa. The Order also requires Teck to develop a detailed implementation plan to demonstrate how water quality concentrations targets will be met at the Order Stations.

To support the planning process, Teck developed the Elk Valley Water Quality Planning Model (the model), which is a regional, forward-looking planning model that predicts how the application of candidate mitigation measures will likely affect water quality in the Elk Valley. The model reflects the current understanding of regional hydrology and release rates of selenium, sulphate and nitrate from waste rock, and it has been calibrated and refined using historical information (see the technical report *Water Quality Modelling Methods*). The model has been used to evaluate water quality management scenarios to support the development of the initial implementation plan, which in turn defines the specific management measures and timeframe required to meet the identified water quality targets.

This report is part of a series of supporting documents that provide additional information on the development of the Plan, including:

- *Site Conditions* (Teck 2014a), which describes site conditions at the Elk Valley mine operations, including historical operational data and mine plans that were incorporated into the model
- *Water Quality Modelling Methods* (Teck 2014b), which describes the setup and configuration of the model and the results of the model
- *Hydrology* (Teck 2014c), which describes the hydrology inputs to the model
- *Consolidation of Geochemical Source Term Inputs and Methods for Elk Valley Water Quality Modelling* (SRK 2014), which describes the geochemical inputs to the model.



LEGEND

- CITY / TOWN / COMMUNITY
- FLOWS AT MODELLING NODE SIMULATED USING REPRESENTATIVE HYDROGRAPH METHOD
- MODELLING NODE
- ORDER STATION
- CANADIAN PACIFIC RAILWAY
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- WATERCOURSE
- BRITISH COLUMBIA - ALBERTA BORDER
- COAL MINING OPERATION
- DESIGNATED AREA
- FIRST NATIONS RESERVE
- PROVINCIAL PARK
- WATERBODY
- WATERSHED FLOWS SIMULATED USING REPRESENTATIVE HYDROGRAPH METHOD

15 0 15

SCALE 1:500,000 KILOMETRES

REFERENCE

Communities obtained from The Atlas of Canada, Natural Resources Canada. Roads obtained from Geobase. Parks/ protected areas, First Nations and railroad data obtained from Geogratis. Provincial boundary and hydrography data obtained from IHS Energy Inc. USA data obtained from ESRI. Projection: UTM Zone 11 Datum: NAD 83

PROJECT

TECK COAL ELK VALLEY WATER QUALITY PLAN

TITLE

DESIGNATED AREA, ORDER STATIONS AND MODELLING NODES

Teck

PROJECT No. 13-1349-0006			SCALE AS SHOWN	REV. 0
DESIGN	AC	27 Feb. 2013		
GIS	DR	27 Jun. 2014		
CHECK	JC	27 Jun. 2014		
REVIEW	AC	27 Jun. 2014		

FIGURE 1-1

1.2 Purpose and Scope

This report provides a summary of the water quality modelling that was completed to support the development of the Plan. A detailed outline of the Plan, described herein as the Plan Document, is provided in the main report.

The purposes of this technical report are to:

- describe the assessment of representative water quality management scenarios for the Plan
- describe the water quality modelling work performed to support the development of the initial implementation plan
- present predicted water quality conditions at Order stations and the Upper Fording River and Michel Creek, based on the initial implementation plan.

This technical report should be read within the context of the Plan.

1.3 Overall Approach

The Plan is an example of a solution to a complex planning problem. The complexity arises partly from the scale of the affected area, the multiple mine sites and the many receiving streams. The planning process also involves many possible combinations of management actions that could be considered, such as various combinations of treatments and clean-water diversions, while recognizing that actions taken at one mine site potentially benefit all downstream locations. Furthermore, each combination of management actions can actually involve many sub-options; for example, a plan to treat water at any mine site requires the selection of treatment technologies, design flow rates, and intake locations. For these reasons, the selection of water quality management actions and options for the initial implementation of the Plan is a semi-structured decision process. It is most efficient to take educated guesses at reasonable scenarios, analyze those scenarios for patterns, and then iterate towards a preferred plan.

To develop the representative scenarios, the first step was to identify potential management options that could be implemented with consideration of site-specific conditions. The identified management options are outlined in Section 2. The combinations of management options were then grouped into representative scenarios, which were assessed in Section 3, based on their relative effectiveness. The purpose of the assessment of representative scenarios was to identify patterns related to the management options to assist in determining which options would be considered for the initial implementation plan.

As a final step, the preferred scenario identified in Section 3 was refined to arrive at a set of management options that are expected to meet all long-term water quality targets in an efficient manner; supporting information is presented in Section 4. The plan described herein is referred to as the "initial implementation plan" because it will be refined through future iterations of the Plan as mine plans and mitigation technologies evolve. Predicted selenium, sulphate and nitrate concentrations in the Elk Valley that result from the initial implementation plan are presented in Section 5.

2 Management Options

For the purposes of Plan development, a range of water quality management options were reviewed. The two options identified as being currently reliable to reduce concentrations/loadings of selenium and nitrate are:

- Active water treatment, which reduces the concentrations of selenium and nitrate in the water directed for treatment. At each operation, factors were considered to select sources to evaluate for treatment. These factors were:
  - a focus on sources with large amounts of waste rock
  - grouping sources together to improve the efficiency of the treatment plant by keeping the treatment plant closer to full capacity during flow fluctuations
  - whether treating the source had an influence on regional concentrations, and whether the source was the most efficient place to remove selenium.
- Clean-water diversion, which routes clean (i.e., non mine-influenced) water around waste-rock spoils or other mining activities. At each operation, factors when selecting sub-watersheds to consider for a diversion were examined at each operation. These factors were:
  - an unaffected upstream watershed that collects at a single point (rather than side hill collection, where streamflow along a steep side hill is diffuse, often subsurface, and often has avalanche and construction constraints)
  - an available diversion route
  - source that is a candidate for treatment.

Waste-rock covers, which can potentially reduce the infiltration of water through waste-rock spoils, were considered for reducing the need for active water treatment in the longer term. Factors that indicated whether a watershed was a candidate for a waste rock cover were:

- ex-pit spoils available for reclamation in the planning period
- that the spoil can be resloped, with enough material and space
- that the cover could remove a source from needing treatment.

Covers and other options, such as saturated fills, that have higher uncertainty are being evaluated through research and development, with the intention that the Plan could be updated as required when these options are sufficiently understood. These would be considered for incorporation as described in the Adaptive Management plan.

All management options, inclusive of active water treatment, clean-water diversion and covers were identified for each mine operation. These considerations are discussed in Sections 2.1 through 2.5. The selected management options were then incorporated into the model, as described in Section 2.6. Each of the following sections refer to specific waste-rock sources, which are characterized in the site conditions report (Teck 2014a).

2.1 Fording River Operations

FRO accounts for 52% of waste rock placed in the Elk Valley as of 2012. Based on current long-range mine planning, these options are expected to account for 43% of waste rock in the Elk Valley by 2034. The placement of waste rock by watershed is described in Teck 2014a. Waste rock from GHO that was placed in the Swift, Cataract and Porter watersheds is counted as part of FRO waste rock, for the purpose of the Plan because those sources report to the Fording River, near other sources at FRO.

2.1.1 Sources Targeted for Active Water Treatment

Watersheds containing most of the waste rock at FRO were selected for evaluation for active water treatment, namely:

- North (Turnbull) Spoil and Lake Mountain Creek
- Lower Fording 2 and Swift Pit
- Swift and Cataract Creeks
- Clode Creek, including Eagle Six Pit
- Kilmarnock Creek.

These watersheds contained 87% and will contain 92% of waste rock at FRO as of 2012 and 2034, respectively. The assumptions that were made to model treatment of these sources are discussed in Section 2.6.1.

Watersheds not targeted for treatment are;

- Henretta Creek
- Lower Fording 1 (including South Tailing Pond and Eagle Pond)
- Porter Creek.

These watersheds contain 7% in 2012 and will contain 3% in 2034. Waste rock volumes at FRO are summarized in Table 2-1.

Table 2-1 Waste Rock Volumes at FRO

Watershed	2012			2034		
	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total
North (Turnbull) Spoil	55	2	1	863	17	7
Lake Mountain Creek	30	1	1			
Lower Fording 2/Swift Pit	152	6	3	242	5	2
Swift Creek	219	8	4	1,020	20	9
Cataract Creek	432	16	8			
Clode Creek	289	11	6	816	16	7
Kilmarnock and Brownie Creeks	1,146	43	22	1,706	34	15
Henretta Creek	159	6	3	159	3	1
Lower Fording 1	96	4	2	96	2	1
Porter Creek	81	3	2	102	2	1

2.1.2 Areas for Potential Clean-Water Diversions

Each of the watersheds containing waste rock at FRO was screened for potential clean-water diversion, as shown in Table 2-2. Three potential clean-water diversions were carried forward for further evaluation in the model, namely:

- North (Turnbull) Spoil and Lake Mountain Creek (referred to as the North Spoil diversion)
- Lower Fording 2 and Swift Pit (referred to as the Upper Swift Creek diversion)
- Kilmarnock Creek (referred to as the Kilmarnock and Brownie diversion).

The assumptions used to model these potential clean-water diversions are discussed in Section 2.6.2.

Table 2-2 Identification of Potential Clean-Water Diversions at FRO

Watershed	Total Watershed Area (km^2)	Area Available for Collection and Diversion (km^2)	Carried Forward for Evaluation?	Rationale
North (Turnbull) Spoil and Lake Mountain Creek	15	3	Yes (during operation)	Existing clean-water diversion, which will be extended as the spoil expands. However, in 2034 the spoil will be complete and the area available for diversion would not be contiguous and small in area.
Lower Fording 2[(a)]/Swift Pit	16	5	Yes (during operation)	Existing clean water diversion, which will be extended as the spoil expands as part of the Swift Project.
Kilmarnock and Brownie Creek	40	19	Yes	Large catchment area upstream of the Kilmarnock spoil, which has the potential to greatly reduce water flows through the spoil and the volume of mine-influenced water requiring management. The diversion incorporated is extended to include the catchment area upstream of Brownie spoil.
Swift Creek and Cataract Creek	7	Negligible	No	Available natural catchment is small.
Clode Creek	13	2	No	Available natural catchment is small and diverting this catchment would require a side hill diversion in very steep terrain.
Henretta Creek	50	35	No	Not planned for treatment.
Lower Fording 1[(b)]	3	Negligible	No	Not planned for treatment. Available natural catchment is small, and not feasible with site infrastructure.
Porter Creek	2	Negligible upstream of the waste-rock spoil	No	Available natural catchment upstream of the spoil is small and the source is not being treated.

(a) Lower Fording 2 (see Figure 3-1 in the technical report on site conditions [Teck 2014a]) is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility.

(b) Lower Fording 1 (see Figure 3-1 in the technical report on site conditions [Teck 2014a]) is a predominately mine disturbed area on the east side of Fording River that includes Eagle Pond and the South Tailings Facility.

2.1.3 Spoils for Potential Waste-Rock Covers

Each of the watersheds containing waste rock at FRO was screened for potential waste-rock covers, as shown in Appendix A. Two areas of large ex-pit waste rock spoils were carried forward for further evaluation. These areas were incorporated in the model as the North Spoil, found in the combined North Spoil and Lake Mountain Creek watershed and the South Spoil, found in the combined Swift/Cataract watershed. The assumptions used to model the waste-rock covers are discussed in Section 2.6.3.

2.2 Greenhills Operations

GHO (excluding Swift and Cataract) accounts for ~6% of waste rock placed in the Elk Valley as of 2012, and is expected to account for 12% of waste rock by 2034. The placement of waste rock by watershed is described in Teck 2014a. As discussed in Section 2.1, waste rock from GHO that was placed in the Swift, Cataract and Porter watersheds is included as part of FRO waste rock for the purpose of the Plan. Waste rock volumes at GHO are summarized in Table 2-3 below.

Table 2-3 Waste Rock Volumes at GHO

Watershed	2012			2034		
	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total
Leask Creek	12	5	<1	804	57	7
Wolfram Creek	28	11	1	258	18	2
Thompson Creek	94	37	2	130	9	1
Greenhills Creek	121	47	2	214	15	2

2.2.1 Sources Targeted for Active Water Treatment

All watersheds containing waste rock at GHO were selected for active water treatment, namely:

- Leask Creek
- Wolfram Creek
- Thompson Creek
- Greenhills Creek.

The assumptions made to model treatment of these sources are discussed in Section 2.6.1.

2.2.2 Areas for Potential Clean Water Diversions

Each of the watersheds containing waste rock at GHO was screened for potential clean-water diversion, as shown in Table 2-4. As indicated in the table, no watersheds were carried forward for further evaluation in the model.

Table 2-4 Identification of Potential Clean-Water Diversions at GHO

Watershed	Total Watershed Area (km^2)	Area Available for Collection and Diversion (km^2)	Carried Forward for Evaluation?	Rationale
Leask Creek	10	Negligible	No	No clean-water diversion was considered; however, mine-influenced water will be collected downstream of the West Spoil and conveyed to the GHO AWTF. After accounting for site topography and safety considerations, water will captured close to the toe of the spoil to avoid mixing with clean water downstream.
Wolfram Creek	4	1	No	
Thompson Creek	9	6	No	
Greenhills Creek	15	Negligible	No	No clean-water diversion was considered because the only area available was small and would require side hill collection. Mine-influenced water will be collected downstream of the Greenhills spoil and conveyed to the GHO AWTF. After accounting for site topography and safety considerations, water will captured close to the toe of the spoil to avoid mixing with clean water downstream.

2.2.3 Spoils for Potential Waste-Rock Covers

Each of the watersheds containing waste rock at GHO was screened for potential waste-rock covers, as shown in Appendix A. Two areas of large ex-pit, waste-rock spoils were carried forward for further evaluation. These were incorporated in the model as the West Spoil and East Spoil. The assumptions made to model these potential waste-rock covers are discussed in Section 2.6.3.

2.3 Line Creek Operations

LCO accounts for 11% of waste rock placed in the Elk Valley as of 2012, and it is expected to account for 13% of waste rock in the Elk Valley by 2034. The placement of waste rock by watershed is described in Teck 2014a.

2.3.1 Sources Targeted for Active Water Treatment

All watersheds containing waste rock at LCO were selected for evaluation for active water treatment, namely:

- West Line Creek
- Line Creek upstream of West Line Creek
- LCO Dry Creek.

Line Creek upstream of West Line Creek includes the following sub-watersheds: Centre Line Creek, No Name Creek, Horseshoe Creek, and Upper Line Creek. The watersheds for Centre Line, No Name and Horseshoe creeks are mine-influenced and contain most of the Phase I waste rock and pits. In contrast, the watershed of Upper Line Creek is predominantly natural. The assumptions made to model treatment of these sources are discussed in Section 2.6.1. Waste rock volumes at LCO are summarized in Table 2-5 below.

Table 2-5 Waste Rock Volumes at LCO

Watershed	2012			2034		
	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total
West Line Creek	210	37	4	210	15	2
Upstream of West Line Creek (Centre Line Creek, No Name Creek, Horseshoe Creek)	362	63	7	531	38	5
LCO Dry Creek	0	0	0	650	47	6

2.3.2 Areas for Potential Clean-Water Diversions

Each of the watersheds containing waste rock at LCO was screened for potential clean-water diversion, as shown in Table 2-6. Potential clean-water diversions at Line Creek upstream of West Line Creek were carried forward for further evaluation in the model. As discussed in Section 2.2.2, this includes the upper Line Creek diversion according to the commitment made in the LCO Phase II Environmental Assessment Certificate Application, potential extension of the diversion to the Horseshoe Creek watershed, and potential extension of the existing operational pit water diversion at the No Name Creek watershed. The assumptions made to model these potential clean water diversions are discussed in Section 2.6.2.

Table 2-6 Identification of Potential Clean-Water Diversions at LCO

Watershed	Total Watershed Area (km^2)	Area Available for Collection and Diversion (km^2)	Carried Forward for Evaluation?	Rationale
Line Creek upstream of West Line Creek	61	39	Yes	This large catchment area upstream of mining areas in the upper Line Creek watershed will be diverted according to the commitments made in the LCO Phase II Environmental Assessment Certificate Application. The clean water diversion could be extended to the upper Horseshoe Creek watershed that would join the upper Line Creek diversion and convey clean water to the mouth of Line Creek. Existing operational pit water management that collects clean water in the No Name Creek drainage and diverts it around Burnt Ridge South and the North Line Creek Extension highwall can be extended downstream of the spoil to minimize mine-influenced water requiring management. The diversion will prevent dilution of mine-influenced water from the lower Line Creek watershed, potentially improving the efficiency of the West Line Creek AWTF.
West Line Creek	10	7	No	Side hill diversion of talus filled slopes which would be very challenging to collect water from; the entire catchment area is treated by the current West Line Creek AWTF.
LCO Dry Creek	27	Negligible upstream of the waste-rock spoil	No	No clean-water diversion was considered; however, mine-influenced water will be collected downstream of the LCO Dry Creek spoil and conveyed to the Dry Creek AWTF. After accounting for site topography and safety considerations, water will be captured close to the toe of the spoil, to avoid mixing with clean water downstream.

2.3.3 Spoils for Potential Waste-Rock Covers

Each of the watersheds containing waste rock at LCO was screened for potential waste-rock covers, as shown in Appendix A. Three areas of large ex-pit, waste-rock spoils, including West Line Creek, Line Creek upstream of West Line Creek and LCO Dry Creek, were carried forward for further evaluation. The assumptions made to model these potential waste rock covers are discussed in Section 2.6.3.

2.4 Elkview Operations

EVO accounts for 27% of waste rock placed in the Elk Valley as of 2012, and it is expected to account for 25% of waste rock in the Elk Valley by 2034. The placement of waste rock by watershed is described in Teck 2014a.

2.4.1 Sources Targeted for Active Water Treatment

Watersheds containing most of the waste rock at EVO were selected for evaluation for active water treatment, namely:

- Erickson Creek
- Bodie Creek, including the influences of Cedar Pit, Natal Pit and Baldy Ridge Pit
- EVO Dry Creek
- Gate Creek.

These watersheds contained 87% as of 2012 and will contain 94% of waste rock at EVO in 2034. The assumptions that were made to model treatment of these sources are discussed in Section 2.6.1.

Watersheds not evaluated for treatment include South Pit, Milligan, Thresher, Harmer, Six Mile and Goddard creeks. These watersheds contained 5% of valley waste rock as of 2012 and will contain 1% in 2034.

EVO Dry Creek (8% and 7% of valley waste rock in 2012 and 2034) was evaluated to determine the regional influence of treating that source. For the evaluation, the plant was sized for the modelled mean winter flow under average flow conditions (10 000 m^3/day). Selenium concentrations in the Elk River downstream of Grave Creek (where EVO Dry Creek reports) decreased by less than 1 µg/L. Based on this evaluation and results of the integrated effects assessment on MU4, treatment at EVO Dry Creek was not included in the initial implementation plan. Waste rock volumes at EVO are summarized in Table 2-7 below.

Table 2-7 Waste Rock Volumes at EVO

Watershed	2012			2034		
	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total
Erickson Creek	472	34	9	1,068	38	9
Bodie Creek	266	19	5	780	27	7
EVO Dry Creek	417	30	8	771	27	7
Harmer Creek	142	10	3	142	5	1
Gate Creek	50	4	1	50	2	<1
South Pit, Milligan and Thresher Creek	28	2	1	28	1	<1
Six Mile Creek	7	1	<1	7	<1	<1
Goddard Creek	1	<1	<1	1	<1	<1

2.4.2 Areas for Potential Clean-Water Diversions

Each of the watersheds containing waste rock at EVO was screened for potential clean-water diversion, as shown in Table 2-8. Potential clean-water diversions at Erickson Creek and Gate Creek were carried forward for further evaluation in the model, as indicated in the table. Assumptions made to model these potential clean-water diversions are discussed in Section 2.6.2.

Table 2-8 Identification of Potential Clean-Water Diversions at EVO

Watershed	Total Watershed Area (km^2)	Area Available for Collection and Diversion (km^2)	Carried Forward for Evaluation?	Rationale
Erickson Creek	31	4	Yes	Water from the small catchment area upstream of the Erickson spoils can be collected to minimize the volume of mine-influenced water requiring management. Mine-influenced water will be collected downstream of the Erickson spoils and conveyed to the EVO AWTF. After accounting for site topography and safety considerations, water will be captured as close to the toe of the spoil as practical to avoid mixing with clean water downstream, and with consideration of local groundwater conditions.
Gate Creek	8	1	Yes	The existing South Gate diversion channel can be extended to prevent mixing with mine-influenced water and discharge into Michel Creek.
Bodie Creek	9	Negligible	No	The majority of the watershed is mine-influenced. There are no natural areas to divert.
EVO Dry Creek	12	Negligible	No	The majority of the catchment is mine-influenced; the remaining areas are not contiguous.
South Pit, Milligan and Thresher Creeks	6	Negligible	No	Not evaluated for treatment. Available natural catchment is small.
Six Mile Creek	4	Negligible	No	Not evaluated for treatment. Available natural catchment is small.
Goddard Creek	2	Negligible	No	Not evaluated for treatment. Available natural catchment is small.

2.4.3 Spoils for Potential Waste-Rock Covers

Each of the watersheds containing waste rock at EVO was screened for potential waste rock covers, as shown in Appendix A. Among these watersheds, the EVO Dry Creek spoil was selected for further evaluation in the water quality model, as indicated in the table. The assumptions made to model these potential waste rock covers are discussed in Section 2.6.3.

2.5 Coal Mountain Operations

The CMO Phase 1 operating area is a minor contributor to selenium loading, because its geochemical characteristics produce less selenium per unit of waste rock than other operations. The area has 5% of the waste rock in the valley in 2012, and will have 3% by 2034. As selenium is the limiting constituent of interest in meeting long-term targets in the Plan, the CMO Phase 1 operating area was not considered in the planning process. However, the proposed CMO Phase 2 project was considered, because its geochemical characteristics are expected to be similar to the other operations.

The CMO Phase 2 project is not currently in place, but it is expected to account for 5% of waste rock in the Elk Valley by 2034. As described in Teck 2014a, the mine plan for the current CMO Phase 2 project design calls for all waste rock to be placed in the Wheeler Creek watershed. Waste rock volumes at CMO are summarized in Table 2-9.

Table 2-9 Waste Rock Volumes at CMO

Watershed	2012			2034		
	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total	Waste Rock (M BCM)	Percent of Site Total	Percent of Elk Valley Total
CMO Phase 2 - Wheeler Creeks and Martin Ridge Pit	0	0	0	583	65	5
Coal Mountain Operations (Phase 1)	257	100	5	310	35	3

2.5.1 Sources Targeted for Active Water Treatment

Wheeler Creek is the only watershed at CMO Phase 2 that is expected to contain waste rock (based on the August 2013 mine plan). As such, this watershed was evaluated as a source for active water treatment.

2.5.2 Areas for Potential Clean-Water Diversions

The Wheeler Creek and Marten Ridge Pit watersheds were screened for potential clean-water diversion, as shown in Table 2-10. The Marten Ridge Pit diversion was carried forward for further evaluation in the model, as indicated in the table. The assumptions made to model these potential clean water diversions are discussed in Section 2.6.2.

Table 2-10 Identification of Potential Clean-Water Diversions at the CMO Phase 2

Watershed	Total Watershed Area (km^2)	Area Available for Collection and Diversion (km^2)	Carried Forward for Evaluation?	Rationale
Marten Ridge Pit	1	1	Yes	Avoid discharging water collected in the Marten Ridge Pit to the Wheeler drainage, where it would mix with mine-influenced water.
Wheeler Creek	30	Negligible upstream of operation	No	The spoil design is an upper valley fill, and, once the spoil is built to completion, the remaining catchment area for diverting clean water will be very small.

2.5.3 Spoils for Potential Waste-Rock Covers

Spoils in the Wheeler Creek watershed were screened for potential waste-rock covers, as shown in Appendix A. The Little Wheeler and Main Wheeler spoils were carried forward for further evaluation, as indicated in the table. Assumptions made to model these potential waste-rock covers are discussed in Section 2.6.3.

2.6 Incorporation of Management Options into the Model

The management options identified in Sections 2.1 through 2.5 were incorporated into the model. These considerations are described in detail in the following sub-sections.

2.6.1 Active Water Treatment

Sites where potential active water treatment facilities were incorporated into the model are shown in Table 2-11. Sources identified and evaluated above were grouped geographically such that multiple sources could report to a single facility. This allows the plants to have more water during more of the year. At a high level, the plants are located close to the sources, where there is space required (considering other infrastructure, slope and site constraints). As discussed in the technical report on water quality modelling methods (Teck 2014b), when multiple treatment sources were identified, the model simulation was performed such that the treatment facility would draw sequentially from the source with the highest selenium concentration to the source with the lowest concentration, until either the treatment capacity was reached or all available intake sources were treated. This approach reflects the understanding that elevated selenium is the most pressing water quality issue in the Elk Valley. If the capacity were reached before all available intake sources were treated, remaining water was bypassed and modelled as being released into local watercourses. The order of priority for the treatment sources, as well as the modelled discharge locations for the treated water, are shown in Table 2-11.

Planning-level assumptions were made for the destinations of AWTF discharge. Generally, discharge was returned to the location nearest to the planned treatment facility, or to a fish-bearing stream to maintain flows. More refined water management plans will be developed during implementation.

Table 2-11 Active Water Treatment Facilities Modelled

Operation	Name	Treatment Sources (in order of priority)	Treated Water Discharge Location
Fording River	FRO South	• Swift &Cataract creeks • Kilmarnock Creek	Fording River between Swift and Cataract creeks
	FRO North	• North Spoil • Clode Creek • Swift Pit	Fording River downstream of Henretta Creek
Greenhills	GHO	• West Spoil (mixed flow from Leask, Thompson and Wolfram creeks) • Upper Greenhills Creek	Thompson Creek
Line Creek	West Line Creek	• West Line Creek • Line Creek	Line Creek
	LCO Dry Creek	• LCO Dry Creek	Fording River downstream of Dry Creek
Elkview	EVO AWTF	• Bodie Creek • Gate Creek • Erickson Creek	Erickson Creek
Coal Mountain	Marten Wheeler	• Wheeler Creek • Little Wheeler Creek	Wheeler Creek

The modelled active water treatment facilities require water management systems, involving collection of mine-influenced water downstream of spoils and conveyance to an AWTF. After accounting for site topography and safety considerations, water is captured close to the toe of the spoil to avoid mixing with clean water downstream.

In the model, collection efficiency accounts for leakage and losses from the water management systems. As shown in Table 2-12, model collection efficiencies were evaluated using available information on local factors, such as geology and hydrology, to provide an estimated collection efficiency for each of the waste rock sources considered for treatment. Site-specific investigations will be undertaken during design and permitting of active water treatment facilities (as part of Plan implementation) to refine estimates of intake efficiency for waste rock source areas.

Table 2-12 Modelled Collection Efficiencies for the Potential Active Water Treatment Facilities

Modelled AWTFs	Treatment Sources	Modelled Collection Efficiency	Rationale
FRO North	North Spoil	70%	Water reporting to a ditch along the highwall; challenges with collecting water in floodplain
	Clode Creek	80%	Water reporting to gauge is less than expected, so could be subsurface and less likely to be all captured
	Swift Pit	95%	Pit dewatering expected to be efficient
FRO South	Swift & Cataract	80%	Valley-bottom intake for Swift watershed presents challenges for collection efficiency
	Kilmarnock Creek	70%	Deep valley-bottom sediments present challenges for collection efficiency
GHO	West Spoil (Leask)	95%	Shallow depth of groundwater
	West Spoil (Wolfram)	95%	Shallow depth of groundwater
	West Spoil (Thompson)	95%	Shallow depth of groundwater
	Greenhills Creek	70%	Possible subsurface gravel and unfavourable groundwater conditions
LCO WLC	West Line Creek	95%	LCO Phase II EAC and confirmed with flow measurements
	Line Creek	95%	LCO Phase II EAC and won't influence facility sizing
LCO Dry	LCO Dry Creek	>95%	LCO Phase II EAC
EVO	Pit water	95%	Pit dewatering expected to be efficient
	Bodie Creek	95%	Collect upslope of floodplain, expect shallow depth of groundwater
	Gate Creek	95%	Collect upslope of floodplain, expect shallow depth of groundwater
	Erickson Creek	90%	Expect to construct intake at a location where mine-influenced groundwater recharges to surface

Site-specific detailed design of the AWTFs and associated water management measures will be completed during implementation and may result in changes to the collection efficiencies used in the model.

2.6.2 Clean-Water Diversion

The potential clean-water diversions incorporated in the model are described in Table 2-13. The set-up for the incorporation of clean-water diversion in the model is described in Teck 2014b.

Table 2-13 Modelled Clean-Water Diversions

Operation	Modelled Clean Water Diversion	Description	Area of Watershed Targeted for Diversion [km^2]	Modelled Percent of Natural Flow Diverted (Before Leakage)[a]	Modelled Discharge Location
Fording River [b]	Kilmarnock Creek	Collect clean water upstream of the Kilmarnock spoil and pump around the downstream side of the spoil.	15	100%	Kilmarnock Creek at the mouth
	Brownie Creek	Collect and pump clean water upstream of Brownie spoil to the downstream side into Kilmarnock watershed, which would subsequently be pumped to the downstream side of the Kilmarnock spoil.	4	100%	Kilmarnock Creek at the mouth
	Upper Swift Creek	Extend the existing clean water diversion north as part of the Swift Project.	3 to 5[c]	100%	Fording River between Swift and Cataract creeks
Line Creek	No-Name Creek	Collect clean water in the No Name Creek drainage and discharge downstream of the Line Creek spoils and mine-influenced water intake system.	2	88.4%	Line Creek at the mouth
	Upper Line Creek	Collect and pump clean water in the upper Line Creek watershed and discharge into Line Creek, according to the commitments made in the LCO Phase II Environmental Assessment Certificate Application.	28	100% up to maximum of 35,000 m^3/d	Line Creek at the mouth
	Upper Horseshoe Creek	Extend Upper Line Creek diversion to the upper Horseshoe Creek watershed.	9	100% up to maximum of 35,000 m^3/d combined with Upper Line Creek diversion	Line Creek at the mouth
Elkview	Upper Erickson Creek	Collect and pump clean water upstream of the spoil and discharge downstream of the mine-influenced water intake system.	4	27 to 33%[c]	Erickson Creek at the mouth
	South Gate	Divert clean water in the existing South Gate Diversion channel to Gate Creek at the mouth.	1[c]	72 to 76%[c]	Gate Creek at the mouth.
Coal Mountain	Marten Ridge Pit	Pump clean water from the Marten Ridge Pit and discharge downstream of the mine-influenced water intake system.	1	100% of mined and natural flow	Upper Carbon Creek

(a) Modelled percentages of natural flow diverted before leakage are based on initial estimates (for planning purposes) of drainage areas that could be practically diverted with consideration for topography and potential locations of the collection systems.

(b) North Spoil diversion is not modelled separately because it is included in the overall analysis of the watershed.

(c) Changes in percent of natural flow diverted with time due to changes in the spoil or pit footprint are incorporated into the model.

The efficiency of each clean-water diversion will be influenced by local factors, such as geology and hydrogeology. Site-specific investigations will be required to support detailed design and the estimation of capture efficiency at the local scale (Teck 2013d). The efficiency of the diversion systems has been set at 95%, such that 95% of the water will be collected and 5% will be lost through leakage in the collection and conveyance system.

In the final simulations, the diversions in most areas were set to convey up to the average May monthly flow . In general, May is the second highest flow month after June, with flow volumes in May typically being half of the flow volumes in June. The purpose of the planning level evaluation was to identify which diversions are most likely to have a regional influence. Sizing the diversions for May flow would include any diversion that could potentially have a regional influence (and may include those with no or limited regional influence). The exception was in Upper Line Creek where the diversion was sized at 35,000 m^3/d (corresponding to winter flows in an average year) according to the LCO Phase II Environmental Assessment Certification (EAC) Application. This is appropriate for Upper Line Creek because it has an influence on treatment only during low flow months.

2.6.3 Waste-Rock Covers

The waste-rock covers incorporated in the model are described in Table 2-14. The setup for the incorporation of waste-rock covers in the model is described in Teck 2014b.

Table 2-3 shows the modelled start date and height of each spoil considered for cover. Furthermore, the effects of 3H:1V resloping required for geomembrane covers are also shown. The resloping would increase flow through the waste rock and decrease natural flow in the watershed due to an increase in the spoil's footprint. A portion of the natural flow may bypass the spoil and be released to the environment as clean water. However, some of the natural runoff would mix with mine-influenced water and be directed for treatment.

Table 2-14 Waste-Rock Covers Modelled

Operation	Spoil Evaluated for Potential Waste Rock Covers	Modelled Cover Start Date[(a)] (Beginning of Year)	Average Spoil Height (m)	Surface Area with 3H:1V Resloping (ha)	Estimated Year Achieving 75% Performance
Fording River	North Spoil	2037	200	1,069	2054
	South Spoil	2031	250	397	2057
Greenhills	East Spoil	2031	225	211	2048
	West Spoil	2047	125	536	2056
Line Creek	West Line Creek	2016	190	292	2033
	North Horseshoe	2023	90	179	2032
	No Name Creek	2023	75	239	2032
	LCO Dry Creek	2035	120	439	2044
Elkview	EVO Dry Creek / Adit North	2046	150	515	2063
Coal Mountain	Little Wheeler	2023	200	872	2040
	Main Wheeler	2037	100	1,069	2046

(a) Assumes start date on January 1st following the year that the spoil is available for cover (as defined in Sections 2.1 through 2.5). Dates after 2034 are modelled start dates estimated from current mine plans. Spoils available for covers after 2034 would not affect the current planning period. However, they were included in the model to gauge whether they may offer a longer term management option.

(b) Assumes that the Horseshoe clean water diversion is in place.

(c) Assumes that the Horseshoe clean water diversion is not in place.

3 Assessment of Representative Scenarios

3.1 Representative Scenarios

The choice of initial scenarios determines how many subsequent iterations will be required. The representative scenarios approach selects initial scenarios that:

- Make use of available information to identify a range of reasonable options
- Attempt to include the range of reasonable options by selecting options that represent different approaches
- Bundle options into complete scenarios that can be subjected to a full analysis and be compared to all factors evaluated.

Three initial representative scenarios, involving different combinations of water quality management options were included:

- Scenario 1: Active water treatment
- Scenario 2: Active water treatment with clean-water diversions
- Scenario 3: Active water treatment with clean-water diversions and waste-rock covers.

Descriptions of the water quality management options included in these representative scenarios are provided in Section 2.

3.2 Patterns Identified

Early in the planning process, the model was used to assess how different management options may influence water quality conditions in the Elk Valley. The model estimated in-stream concentrations of selenium, nitrate and sulphate under the representative scenarios over the planning timeframe of 20-years, i.e., up to 2034.

This section describes patterns identified from the assessment of the representative scenarios. These patterns were used to guide subsequent iterations in selection of management options for the initial implementation plan as described in Section 4. The assessment focused on identifying patterns of in-stream concentrations and the level of treatment associated with management options; without consideration of timing and sequencing of treatment. The results are as general patterns in relation to the effects of the different management options, including:

- Influence of active water treatment on seasonal concentration patterns
- Influence of different treated effluent concentrations (i.e., different active water treatment technologies) on regional in-stream concentrations
- Influence of clean water diversions on required treatment capacity
- Influence of clean water diversions on achievable regional in-stream concentrations
- Influence of waste rock covers

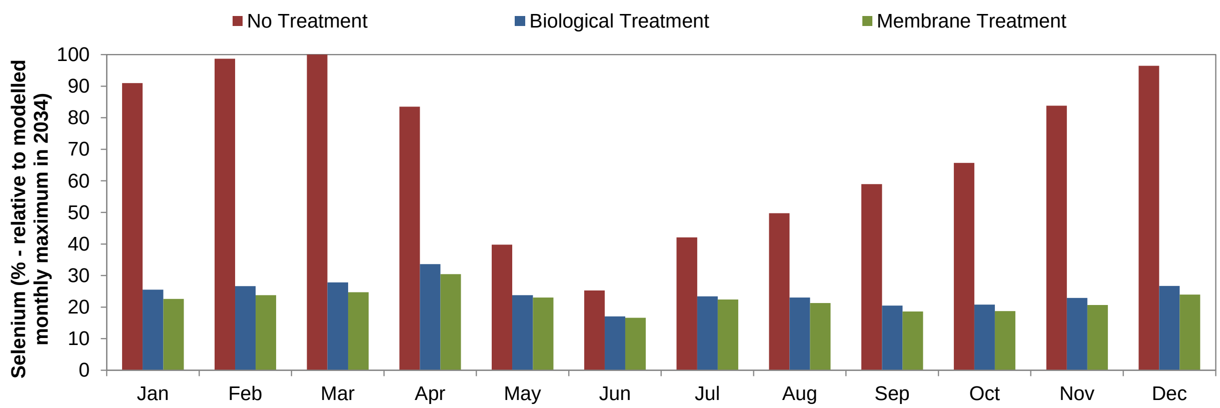
3.2.1 Influence of Active Water Treatment on Seasonal Concentration Patterns

Active water treatment is expected to reduce in-stream concentrations and seasonal variability. Greater reductions of in-stream concentrations occur when a larger portion of the mine-influenced water is treated (i.e., in winter, when flows are the lowest). In the absence of treatment, the highest concentrations of constituents of interest tend to occur in winter; however, with active water treatment, reductions in constituents of interest are highest in winter. During freshet and with active water treatment, flow volumes of mine-influenced water are likely to exceed treatment facility capacities, resulting in water bypassing active water treatment, with less reduction of in-stream concentrations compared to the winter period. Thus, with active water treatment, seasonal variability is reduced. These effects on seasonal concentration patterns are expected in the Fording River (Figure 3-1) and parts of the Elk River (Figure 3-2).

In addition to treated effluent and waters that bypass active water treatment facilities during high flow periods, in-stream concentrations will be influenced by several other factors, including drainage released from mine areas not targeted for management and leakage from contact water handling systems. All of these factors in combination will influence what can be achieved, in terms of in-stream concentrations, with active treatment and other management measures.

Figure 3-1 Modelled Effects of Active Water Treatment on In-stream Concentrations at the Mouth of the Fording River (FR5)

(a) Selenium



(b) Nitrate

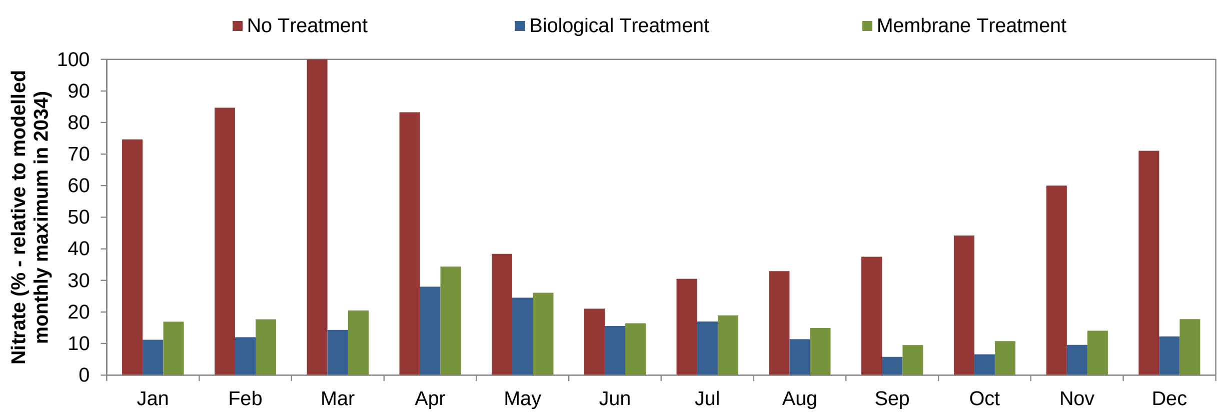
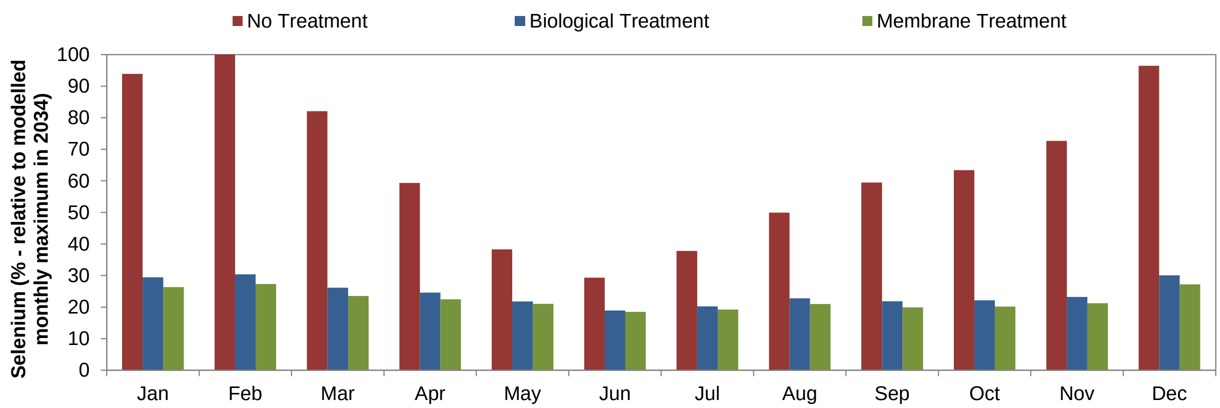
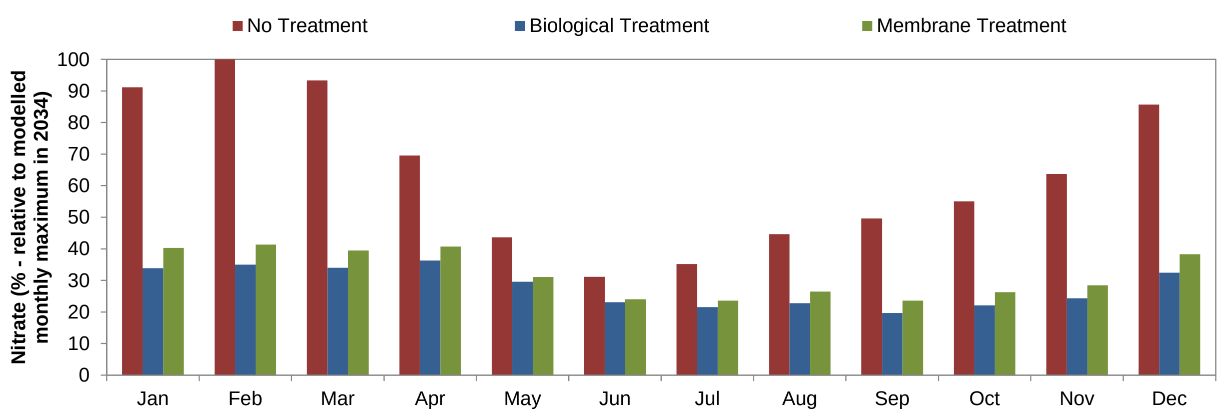


Figure 3-2 Modelled Effects of Active Water Treatment on In-stream Concentrations in the Elk River Downstream of Michel Creek (ER3)

(a) Selenium



(b) Nitrate



3.2.2 Influence of Treated Effluent Concentrations

As shown in Figures 3-1 and 3-2, active water treatment is expected to reduce in-stream selenium concentrations. Use of membrane technology may result in lower winter in-stream selenium concentrations than can be produced using biological technology because membrane technology can achieve a lower end-of-pipe concentration. Limitations associated with membrane technology are discussed in Chapter 4 of the Plan. In contrast, in-stream nitrate concentrations may be lower when biological treatment technology is used, because biological treatment produces lower end-of-pipe concentrations. The influence of treatment technology on maximum monthly concentrations of selenium and nitrate tend to be limited because maximum concentrations tend to occur during high-flow months and are driven largely by water bypassing the treatment facility.

3.2.3 Influence of Clean-Water Diversions on Treatment Volumes

Potential benefits associated with clean-water diversions were evaluated by comparing model simulations of Scenario 1 (active water treatment) and Scenario 2 (active water treatment with clean-water diversions); with a specific focus on treatment facility capacities that produce the same in-stream concentrations.

As shown in Table 3-1, results of this analysis suggest that clean water diversions can be an effective means to reduce treatment capacity, especially when focused on large, upstream undisturbed watersheds, such as upper Kilmarnock Creek. Clean-water diversion of upper Kilmarnock Creek resulted in a reduction of 10 to 15% of the valley-wide total treatment capacity (Table 3-1). Some reduction in total treatment capacity could also be achieved with the Marten Ridge Pit diversion at CMO. Other potential diversions were predicted to have little or no effect on total treatment capacity. All diversions were carried forward in recognition that these will be evaluated in more detail at a local scale during the implementation phase.

Table 3-1 Changes to Total Potential Active Water Treatment Capacities with the Addition of Clean-Water Diversions

Operation	Potential Clean-Water Diversion [(a)] (and Diverted Watershed Area)	Estimated Changes in Total Active Water Treatment Capacity (Scenario 2 Compared to Scenario 1)	
		Biological Treatment	Membrane Treatment
Fording River	Kilmarnock Creek (15 km^2) Brownie Creek (4 km^2)	−15%	−10%
Greenhills	None	n/a	n/a
Line Creek	No Name Creek (2 km^2) Horseshoe Creek (9 km^2)	< 1%	< 1%
Elkview	Erickson Creek (4 km^2) South Gate (1 km^2)	< 1%	< 1%
Coal Mountain (Phase 2)	Marten Ridge Pit (1 km^2)	−3%	−3%

(a) FRO Upper Swift Creek and LCO Upper Line Creek diversions were included in both Scenario 1 and Scenario 2; therefore, their effect on treatment facility capacity was not evaluated.

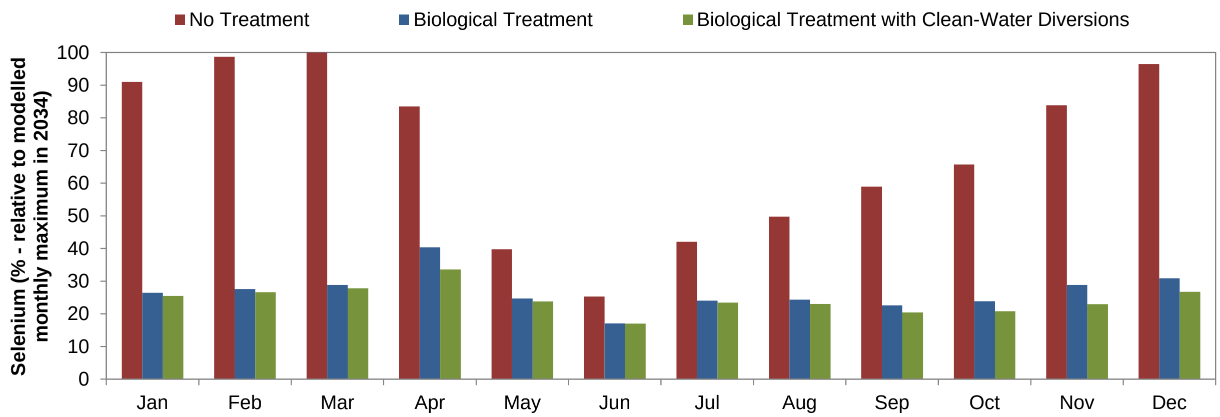
3.2.4 Influence of Clean-Water Diversions on Achievable In-stream Concentrations

The effects of clean-water diversions on achievable in-stream concentrations were evaluated by comparing Scenario 1 (active water treatment) and Scenario 2 (active water treatment with clean-water diversions) using the same active water treatment facility capacities in both scenarios.

As shown in Figures 3-3 and 3-4, the addition of clean-water diversions is predicted to result in a reduction of in-stream concentrations of selenium, sulphate and nitrate. Based on the conditions simulated by the model, the differences were on the order of 10% or less for selenium and 15% for nitrate.

Figure 3-3 Modelled Effects of Clean-Water Diversions on In-stream Concentrations at the Mouth of the Fording River

(a) Selenium



(b) Nitrate

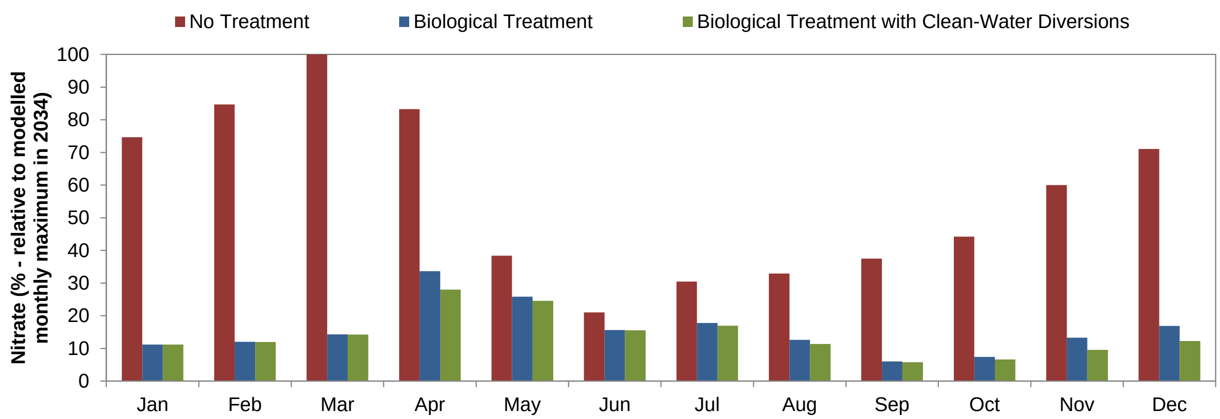
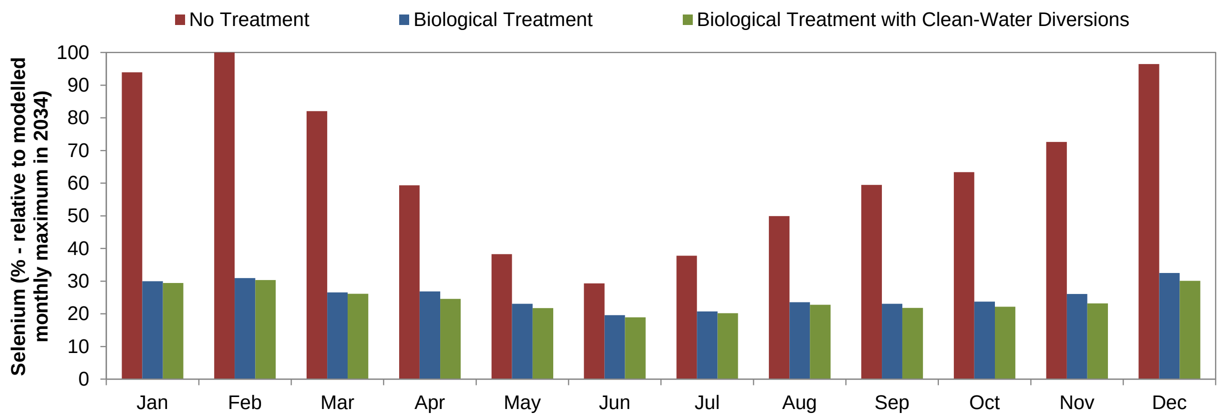
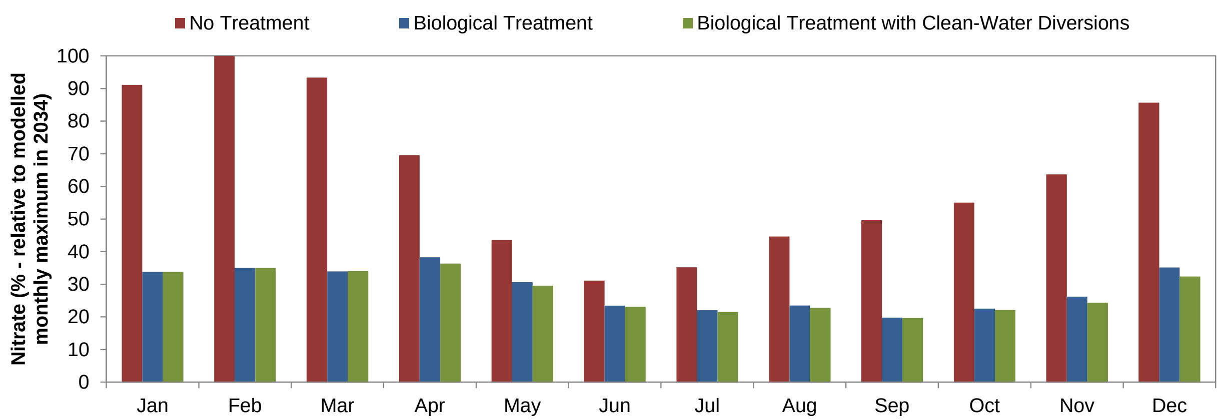


Figure 3-4 Effects of Clean-Water Diversions on In-stream Concentrations in the Elk River Downstream of Michel Creek

(a) Selenium



(b) Nitrate



3.2.5 Influence of Waste Rock Covers

Covers were not included in the initial implementation plan because they have not been proven effective or economic. The current estimated performance was incorporated in the model and the results were used to gauge whether they may offer a longer term management option.

The effects of waste-rock covers were evaluated by comparing model simulations of Scenario 2 (active water treatment with clean-water diversions) and Scenario 3 (active water treatment with clean-water diversions and covers). Waste-rock covers were modelled based on anticipated performance of bituminous geomembrane (BGM) cover systems described in Teck 2014b, including the estimated transition time for a cover to reach its full performance. Potential limitations of the cover system, such as construction practicality and availability of cover materials, were not considered in the model.

Due to the timing of waste-rock spoils' availability for reclamation and the transition time for a cover system to reach its full performance (see Teck 2014b), covers are expected to have limited effect within the period being considered for the Plan (i.e., until 2034). Modelling of representative scenarios showed that BGM cover systems did not result in a reduction in the treatment facility capacity required to meet a given in-stream concentration over the next 20 years, nor did they achieve lower in-stream selenium concentrations in that time period.

Current conceptual understanding of cover performance indicates that unless a cover is very effective, resulting in very little infiltration, it would only reduce the amount of water needing active water treatment, with no benefits to water quality in the receiving streams. A similar pattern would hold for partial covers, i.e. that they might reduce the amount of water needing treatment but would not improve water quality in the receiving streams. As a result, partial covers were not considered for the initial implementation plan, but they will be kept in consideration for technology development and future iterations of the Plan.

While not effective for the current planning period, covers may offer a longer-term management option. Preliminary modelling suggests that BGM cover systems may reduce the active water treatment capacities needed to achieve a given in-stream concentration beyond the 20-year planning timeframe. Analyses to date have not shown covers to have significant additional effects on in-stream water quality, once water treatment plants are assumed to be in place. This largely reflects the current assumptions that covers do not have direct geochemical effects, but rather only reduce the amount of water that contacts the waste and later reports to treatment plants. These assumptions have a degree of uncertainty that the R&D program will work to resolve.

3.3 Selected Management Options

An iterative process was used to assess and select water quality management options best-suited for the initial implementation plan. By examining patterns identified from the assessment of the representative scenarios, ways to improve each scenario were identified which were also analysed and considered.

In February 2014, a Teck group was assembled to participate in two workshops, to review initial water-quality predictions, and to select a preferred combination of management options. The workshops included discussion of confidential cost and technical information, so it was not possible to involve external stakeholders, but participants were asked to consider all of Teck's responsibilities to its stakeholders, as well as personal perspectives as members of local communities.

In the first workshop, participants examined the available information and recommended that two additional scenarios be assessed. The first was an improved combination of active water treatment and clean-water diversion. The second was a new “minimum treatment scenario” that incorporated methods still being investigated in the source-control R&D program, such as treatment in saturated fills and the use of waste rock covers.

The two new scenarios were further developed for review by participants in the second workshop. Although additional improvements to both scenarios were identified, the implications for the Plan were clear. Specifically, participants in the second workshop agreed that active water treatment, supplemented by clean-water diversion, should be the primary management method proposed by Teck in the Plan. However, they also agreed that methods with the potential to reduce long-term reliance on active water treatment could be very attractive to Teck and external stakeholders, and therefore should be considered for future plans.

A summary of the workshop outcomes is as follows:

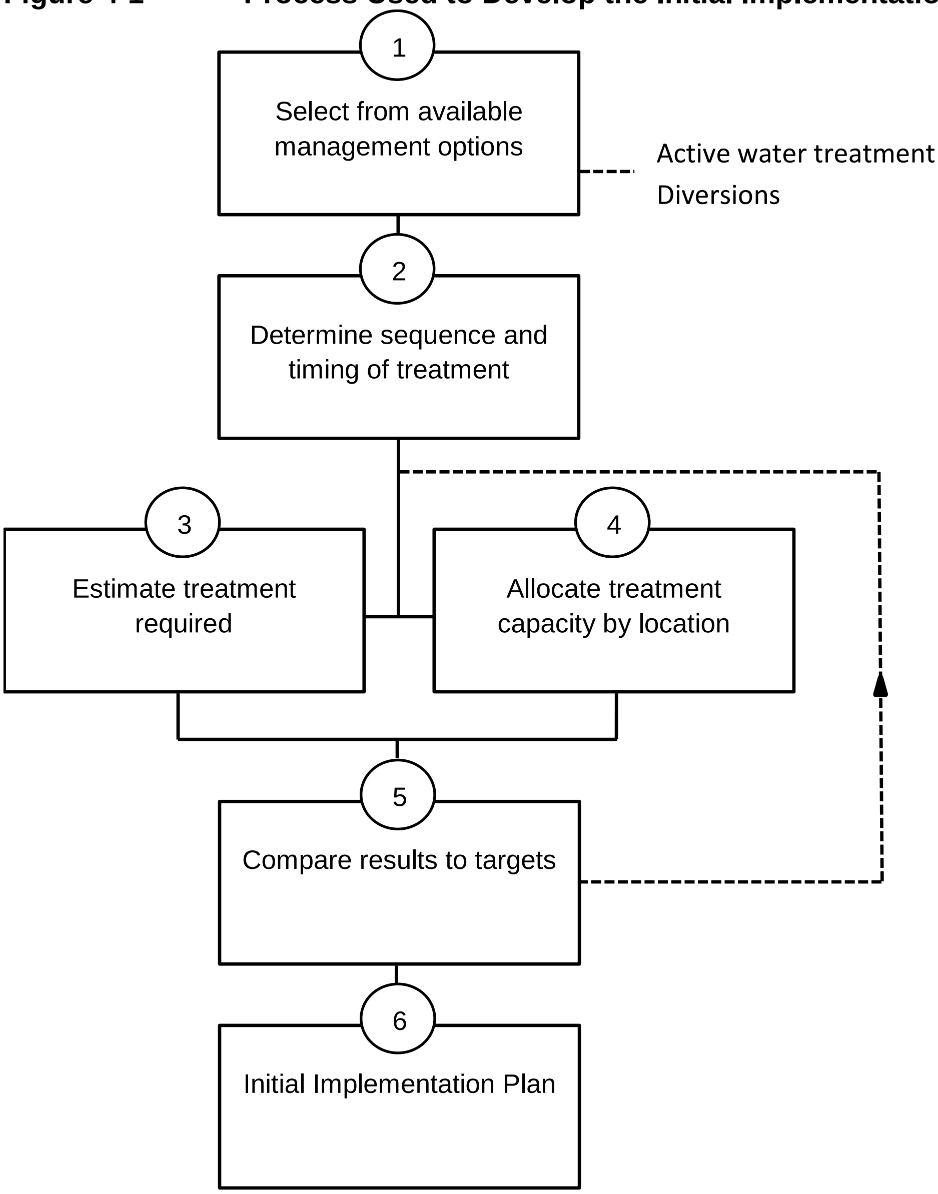
- Active water treatment and clean-water diversion are the only methods that are sufficiently proven to meet the Order requirement to start stabilizing contaminant concentrations.
- Depending on R&D progress, alternative technologies could supplement or replace active treatment in later stages of the Plan, and reduce the long-term need for active water treatment.
- The primary benefits of the alternative methods is that they reduce long-term commitments for Teck, and post-closure concerns for external stakeholders. Some alternative methods could also provide additional “non-water” benefits such as improved reclamation, biodiversity and land use.

As a result of the workshop two options, active water treatment and clean-water diversion, were identified as the options carried forward for the initial implementation plan. Through this process Teck also identified two options, covers and treatment through saturated fills, that are currently in R&D but that are believed to be good candidates for later stages of the Plan.

4 Development of the Initial Implementation Plan

The process for developing the initial implementation plan is described in Section 8.3 of the Plan and depicted in Figure 4-1. This section presents supporting technical information on the development process as described in the Plan. The planning basis associated with the selected management options (Step 1 in Figure 4-1) is discussed in Section 4.1, followed by a discussion on the sequence and timing of treatment (Step 2) in Section 4.2. Water-quality modelling work related to estimation of treatment capacities required at each mine site (Steps 3 and 4) is discussed in Section 4.3. The resulting initial implementation plan is presented in Section 5.

Figure 4-1 Process Used to Develop the Initial Implementation Plan



4.1 Planning Basis for the Selected Management Options

Assisted by the patterns identified for the representative scenarios, it was concluded that active water treatment with biological technology and clean-water diversions were to be carried forward as part of the planning basis for the initial implementation plan.

As described in Section 2, each potential AWTF is supported by water handling systems to direct mine-influenced water to and from the facility and to direct excess water around the treatment facility during high-flow months. The planning basis for the water handling systems, including intake and outflow locations, sizing and collection efficiencies, was developed based on current understanding of site conditions and is summarized in Section 2.

As discussed in Sections 3.2.3 and 3.2.4, clean-water diversions have the potential to reduce treatment capacities and to reduce in-stream concentration when treatment facility capacities are left unchanged, particularly when focused on large, upstream, undisturbed watersheds. However, all diversions were carried forward as part of the planning basis for the initial implementation plan. Marten Ridge Pit diversion at the Coal Mountain Phase 2 project was eventually dropped from the plan as subsequent iterations found treatment at CMO to be less effective than additional treatment at EVO.

4.2 Sequence and Timing for Treatment

The sequence of treatment was determined by considering the environmental benefit and the volume and timing of waste-rock placement in watersheds evaluated for treatment. The LCO West Line Creek facility is currently built and will be commissioned in 2014. The upper Fording River (i.e., FRO) was selected as the site for the next treatment facility, given that this is where the highest concentrations of selenium and nitrate occur relative to long-term targets and the treatment in the upper Fording River will benefit all areas downstream. Sources with higher existing waste-rock volumes were timed for earlier commissioning, recognizing the correlation between waste-rock volume and water quality constituent release.

The planning basis for the timing of active water treatment facilities in the initial implementation plan, is for the first active water treatment facility in the upper Fording River to be commissioned in 2018 and subsequent facilities to be commissioned two years apart thereafter. Phasing of an active water treatment facility was introduced if the required treatment capacity was greater than or equal to 30,000 m^3/d and the waste rock was not all in place by commissioning of the first phase.

4.3 Water Quality Modelling to Estimate Treatment Capacities for the Initial Implementation Plan

More than 700 model runs were completed to evaluate how different treatment capacities may influence in-stream concentrations in the Elk Valley. No treatment (zero total treatment capacity) was used as a lower bounding case. Treatment of all water in the targeted watersheds during 1-in-10-year high flows was used to define an upper bounding case. Treatment at all sources described in section 2 is included in various runs, at capacities ranging from no treatment to treating high flows.

The process for estimating treatment capacities for the initial implementation plan is presented in Chapter 8 of the Plan. The process considers the relationship between total treatment capacity and in-stream concentrations, the monthly hydrographs of flows available for treatment, and the efficiency of the treatment facilities in removing the selenium and nitrate load. The modelling results related to these considerations are presented below.

4.3.1 Relationship Between Total Treatment Capacity and In-stream Concentrations

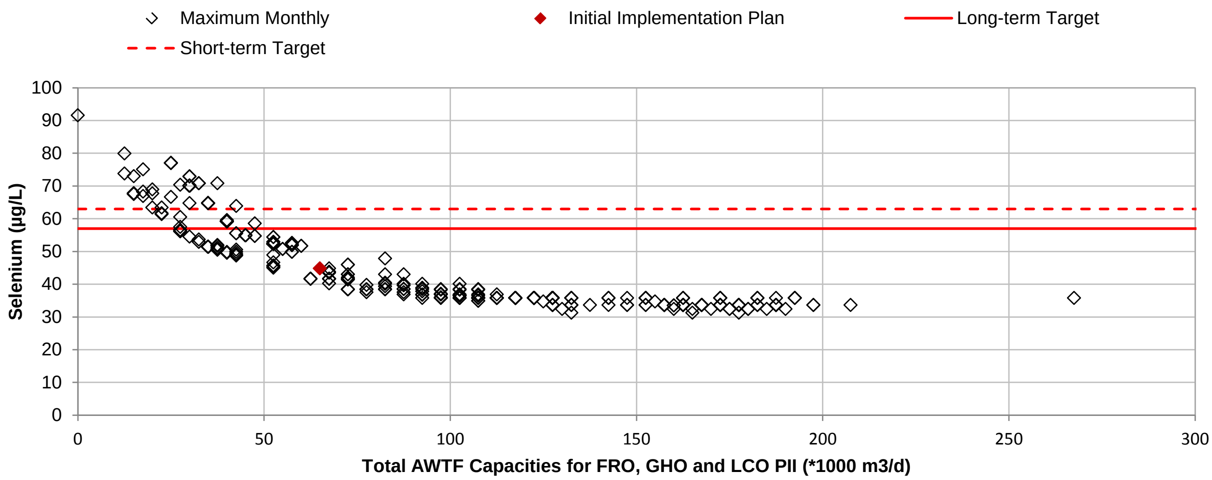
The relationship between maximum monthly selenium concentrations and total treatment capacity in the Fording and Elk rivers, Michel Creek and Lake Koocanusa is shown in Figure 4-2. The horizontal axis shows the total treatment capacity upstream of each location. For reference, relevant plots also the short and long term targets . This relationship was used as an initial estimate of treatment capacities required to meet an in-stream concentration during the development of the initial implementation plan.

The modelled maximum monthly selenium concentrations at all locations show similar patterns. As expected, the results demonstrate lower in-stream selenium concentrations with increasing total treatment capacity. However, the results also show diminishing influence on in-stream concentrations as total treatment capacity increases. That is, at some point, a marginal increase in treatment capacity would yield less marginal decrease of in-stream concentrations than had previously been the case for an increase in capacity, until the concentration-versus-capacity curve eventually reaches an asymptote. The locations of the point of diminishing returns and the asymptote are influenced by the treated effluent concentration (i.e., choice of treatment technology), as well as by the volume and selenium concentrations in the water not directed to treatment or that escapes from contact water collection systems.

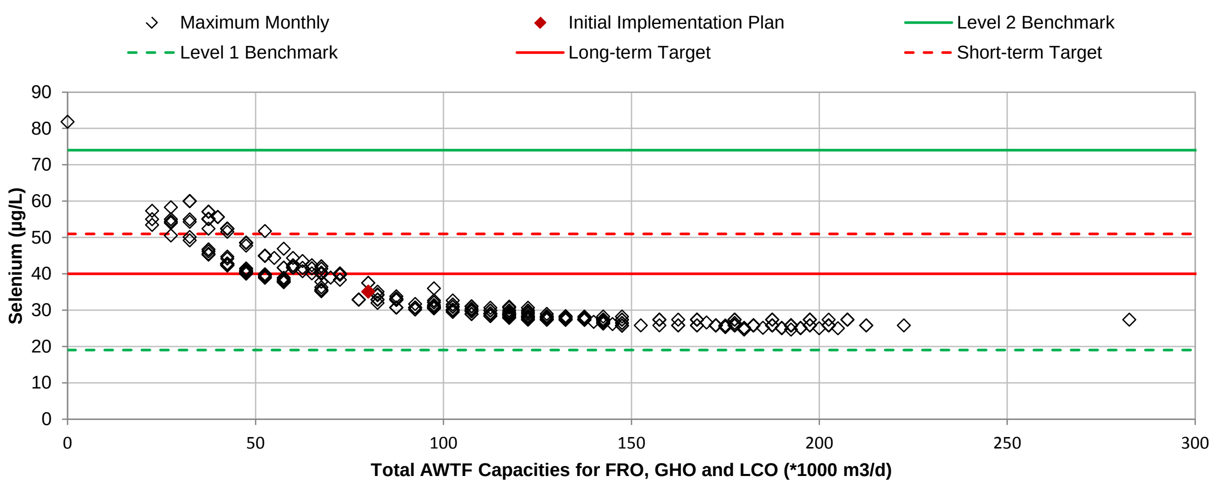
This relationship was used as an initial estimate of the total treatment capacity required upstream of a modelled location. While some runs at individual stations appear to achieve lower concentrations with the same total treatment volume, the initial implementation plan was selected to meet targets throughout the system. For example, the runs on the plots at Elk River nodes that have lower treatment volume than the initial implementation plan generally have higher concentrations in the Fording River. The runs on the plots at Fording River nodes that appear more efficient are influenced by the fact that the GHO facility only treats Greenhills Creek at high facility capacities.

Figure 4-2 Maximum Monthly Selenium Concentrations Based on Varying Active Water Treatment Capacities

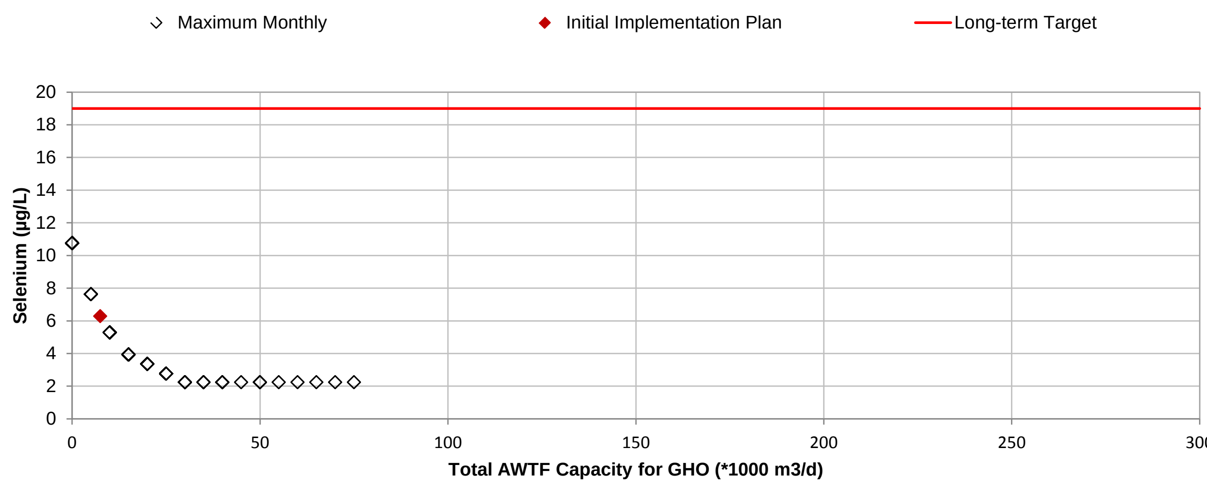
(a) Fording River Downstream of Greenhills Creek (FR4, EMS 0200378)



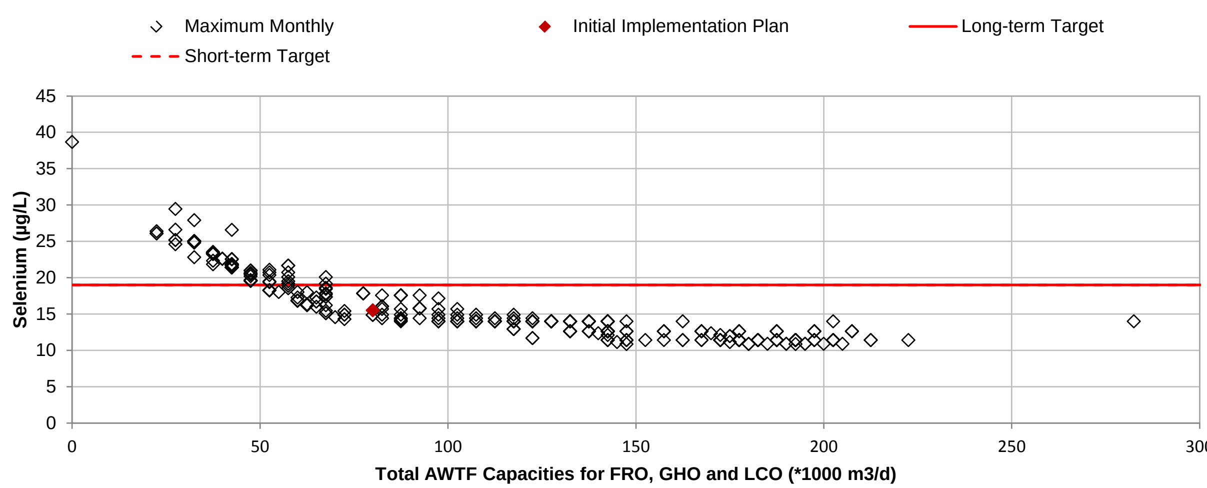
(b) Fording River at the Mouth (FR5, EMS 0200396)



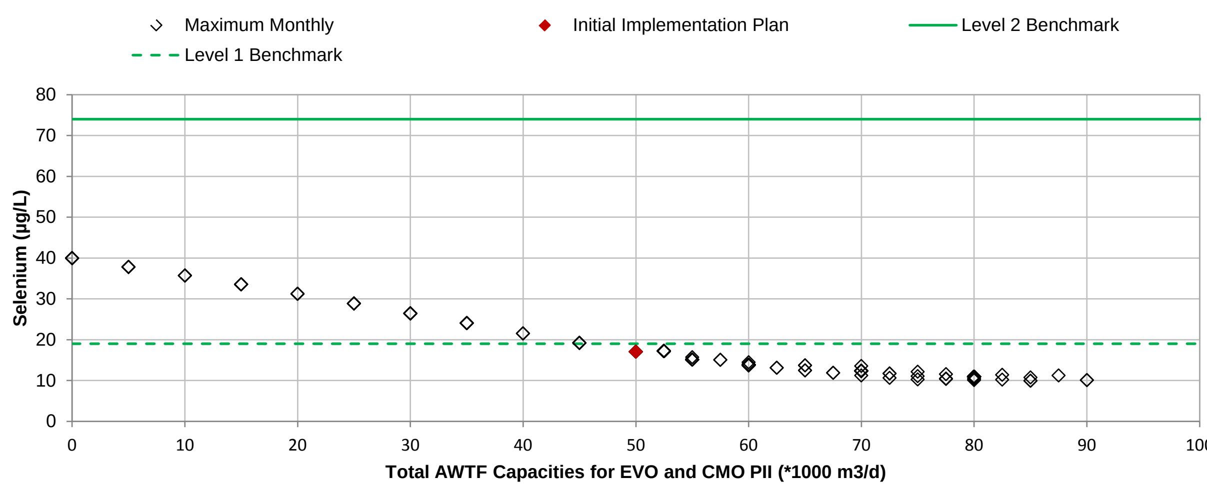
(c) Elk River Downstream of Greenhills Operations (ER1, EMS E206661)



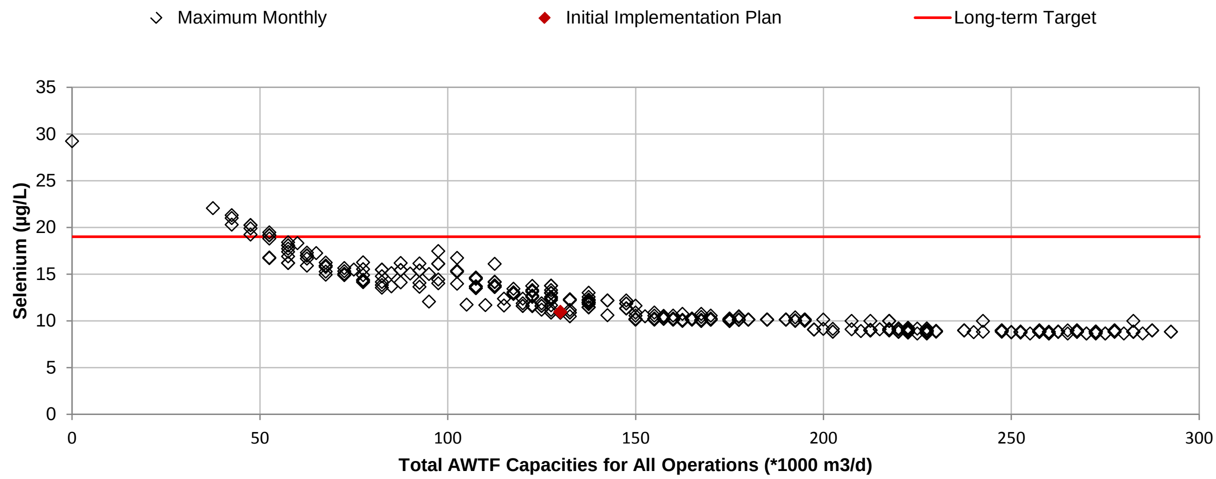
(d) Elk River Downstream of Fording River (ER2, EMS 0200389)



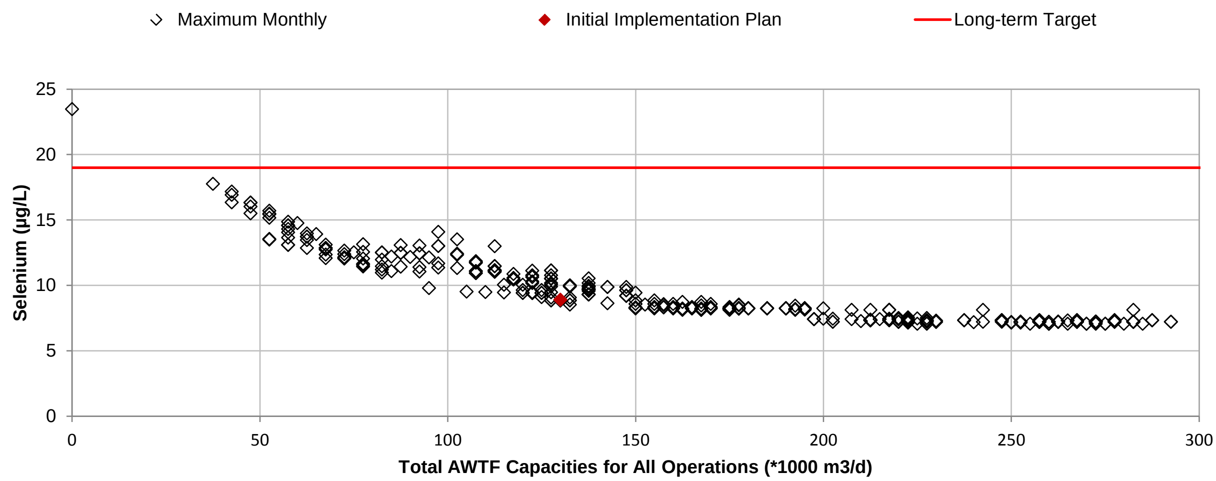
(e) Michel Creek at the Mouth (MC1)



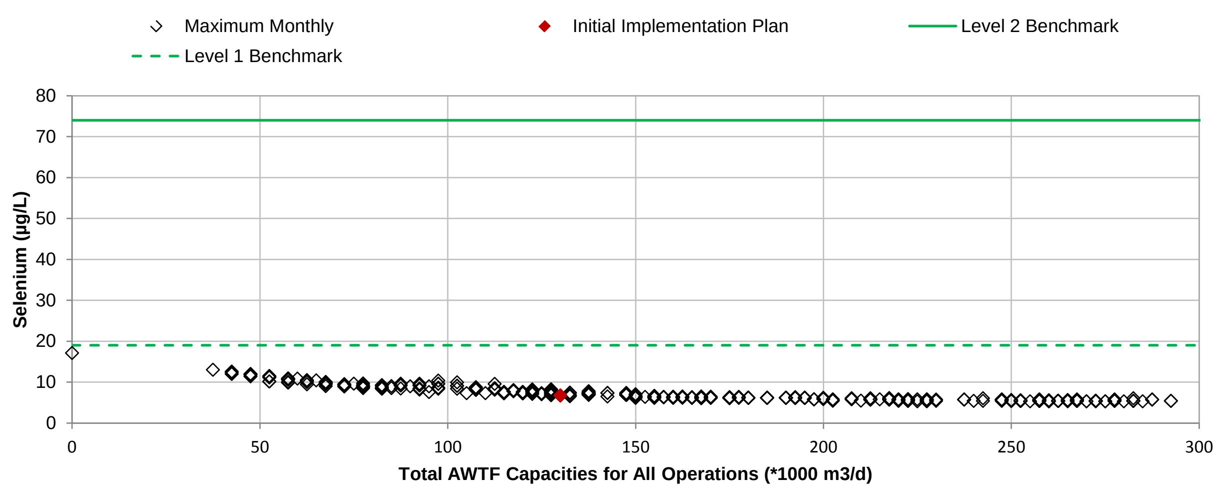
(f) Elk River Downstream of Michel Creek (ER3, EMS 0200393)



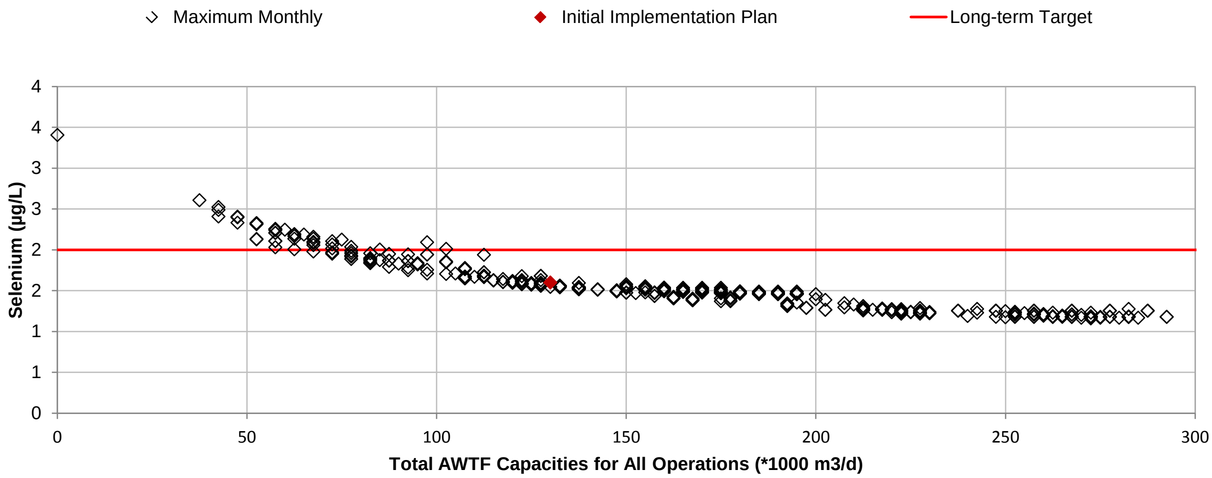
(g) Elko Reservoir (ER4, EMS E294312)



(h) Elk River at the Mouth (ER5)



(i) Lake Koocanusa (LK2, EMS E294311)



Notes: Maximum monthly concentrations shown for the period from the installation of all water management options to the end of the planning period (2034). Results were produced under high-flow conditions using (P50) geochemical release rates. Variability along the y-axis for a given treatment capacity reflects the influence of how the total treatment capacity is divided among the individual AWTF residing upstream of the order station in question. Maximum monthly concentrations at Lake Koocanusa have been corrected to account for model bias.

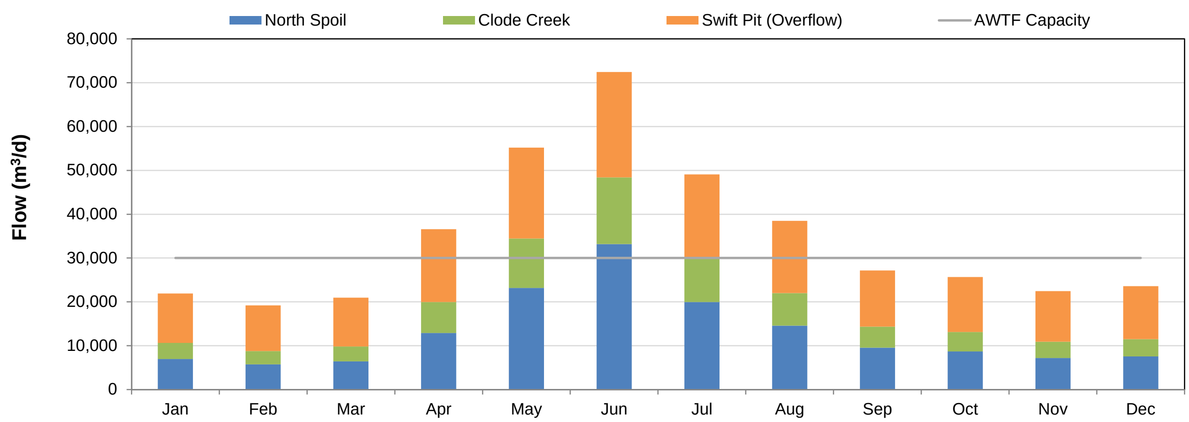
4.3.2 Flows Available for Treatment

The decreasing efficiency of an AWTF in removing selenium and nitrate is influenced by the monthly hydrographs of the flows available for treatment. The monthly hydrographs under average flows are presented in Figure 4-3 and consider the active water treatment facilities and clean-water diversions incorporated in the model. The associated monthly hydrographs under low and high flows are presented in Appendix B.

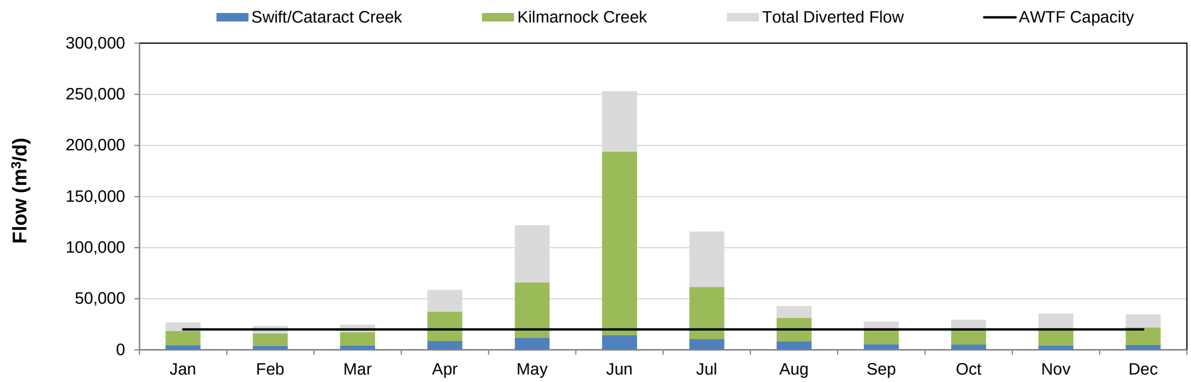
For reference, the hydrographs are plotted along with the treatment capacities selected for the initial implementation plan. An AWTF would be operating under capacity when available flows are less than the treatment capacity. The AWTFs would operate under capacity more often during a low flow year.

Figure 4-3 Monthly Hydrographs of Flows Available for Active Water Treatment under Average Flows

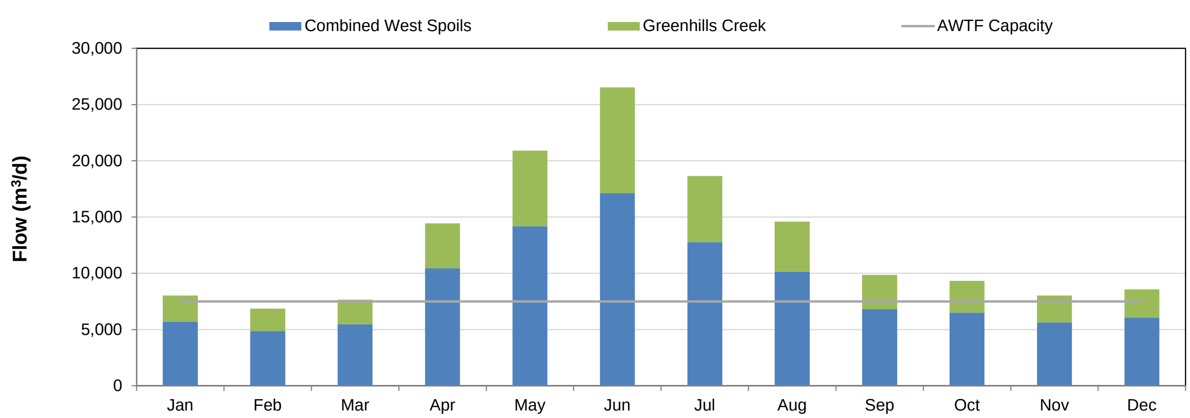
(a) Fording River Operations North



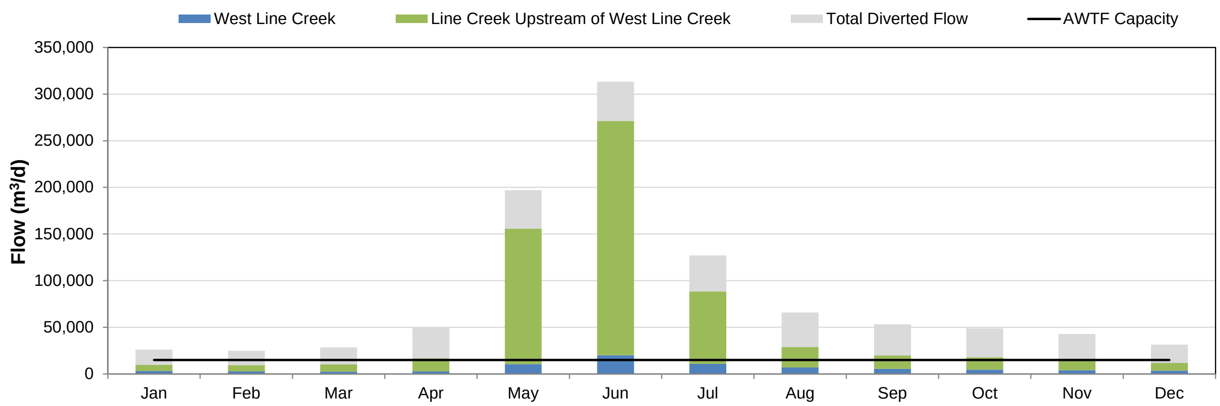
(b) Fording River Operations South



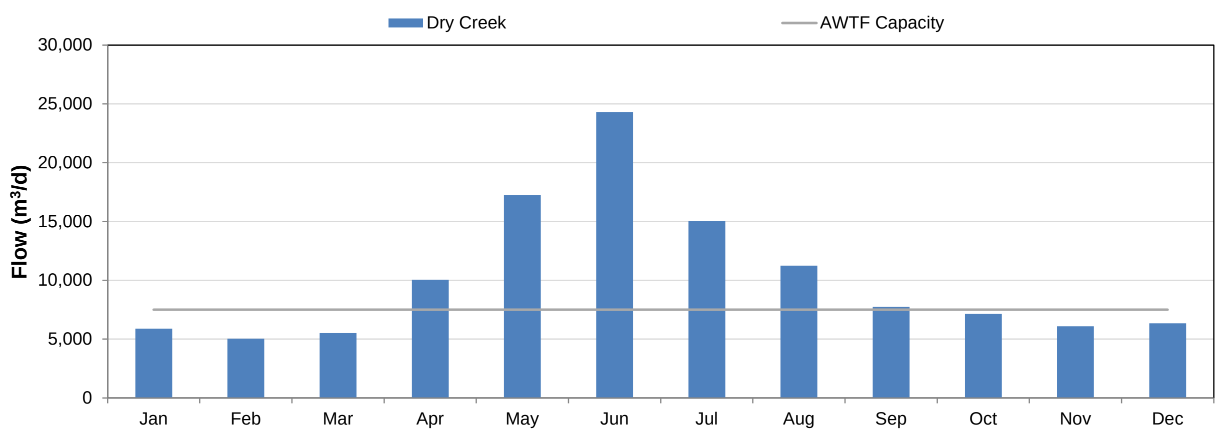
(c) Greenhills Operations



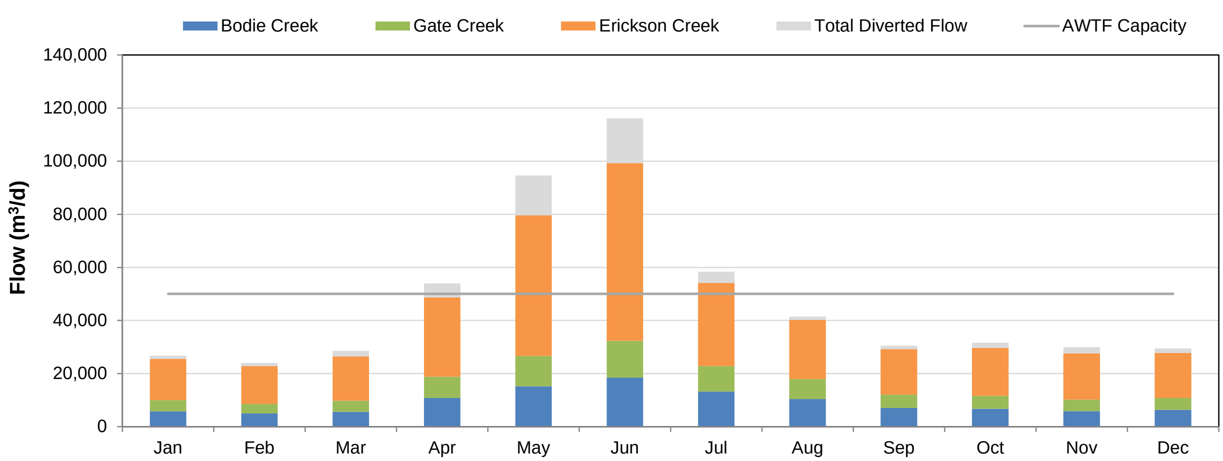
(d) Line Creek Operations West Line Creek



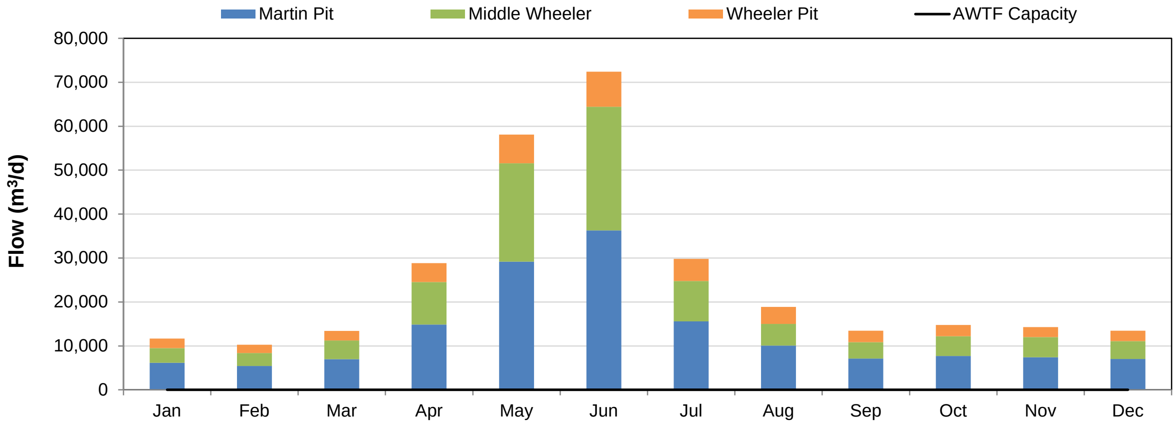
(e) Line Creek Operations Dry Creek



(f) Elkview Operations



(g) Coal Mountain Operations Phase 2



Notes: The monthly hydrographs are shown for year 2034 under average flows based on flow information provided in the technical report on *Hydrology*. The hydrographs do not account for capture efficiencies in the water management systems.

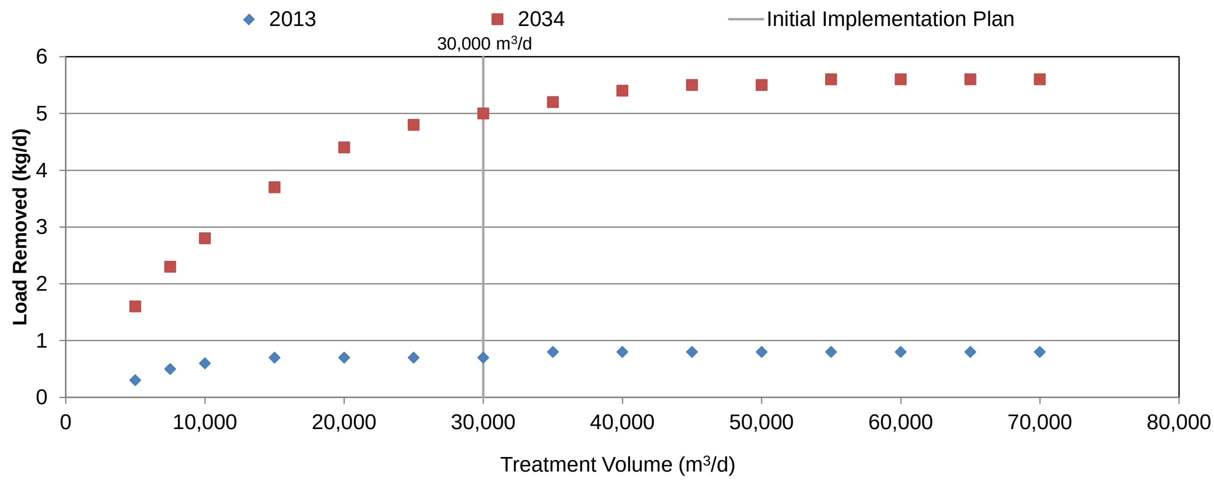
4.3.3 Relationship Between Active Water Treatment Capacity and Load Removed

The relationship between treatment capacity and selenium removal for each treatment facility is shown in Figure 4-4. These relationships are primarily driven by waste-rock volume and the hydrographs presented in Section 4.3.2. As selenium is the limiting constituent in the development process, inspecting the relationship between treatment capacity and selenium removal at each treatment facility would allow capacity to be allocated to the location where it has the most effect. For reference, the treatment capacities selected for the initial implementation plan are plotted on the figures.

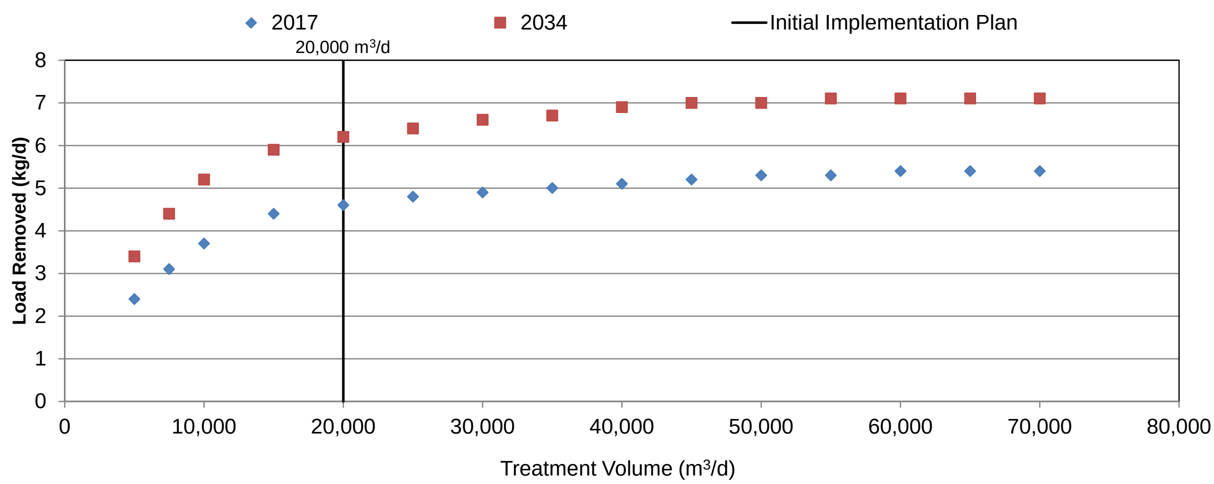
The approach used in developing the initial implementation plan was to manage water quality at the order stations to meet targets in the most efficient manner from a regional perspective. With respect to managing water quality from the Michel Creek watershed, both EVO and CMO Phase 2 sources were evaluated. It was determined that additional capacity at EVO was more efficient than treatment at CMO Phase 2. Lower selenium concentrations are expected in CMO Phase 2 compared to those at EVO, and release rates at EVO are higher than average and higher than currently expected at CMO Phase 2. As additional knowledge is gained with respect to the mine plan and geochemical characteristics of CMO Phase 2, treatment distribution between CMO2 and EVO will continue to be evaluated. The size of the first phase of the EVO facility (nominally in 2020) would be determined based on management of the sources at EVO, although the total size of the facility would inform some infrastructure considerations (e.g., intake sizes, conveyance). The optimization between CMO and EVO would be used to assist in planning the second phase at EVO, if required.

Figure 4-4 Relationship Between Active Water Treatment Capacity and Selenium Load Removed

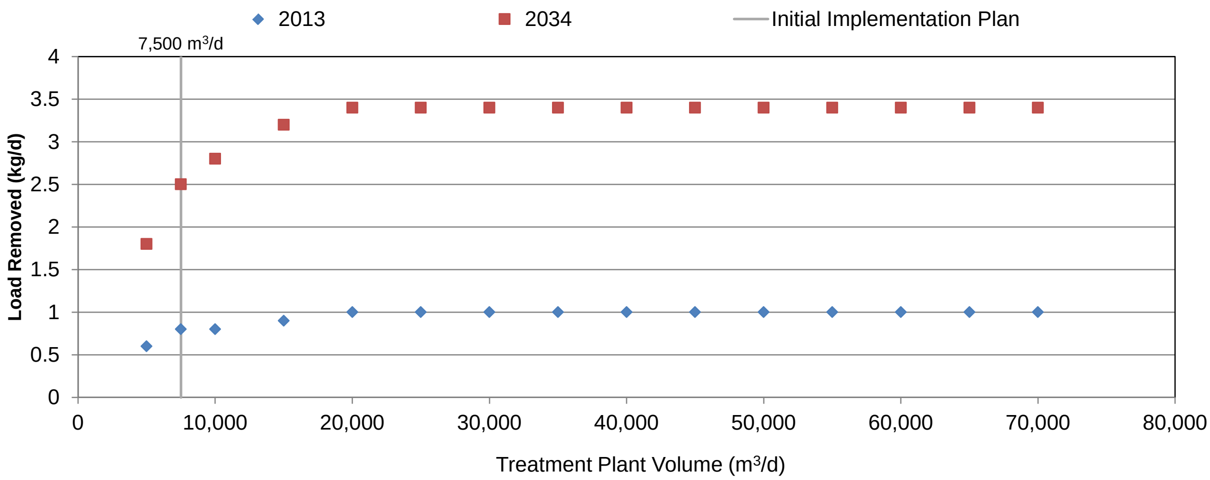
(a) Fording River Operations North



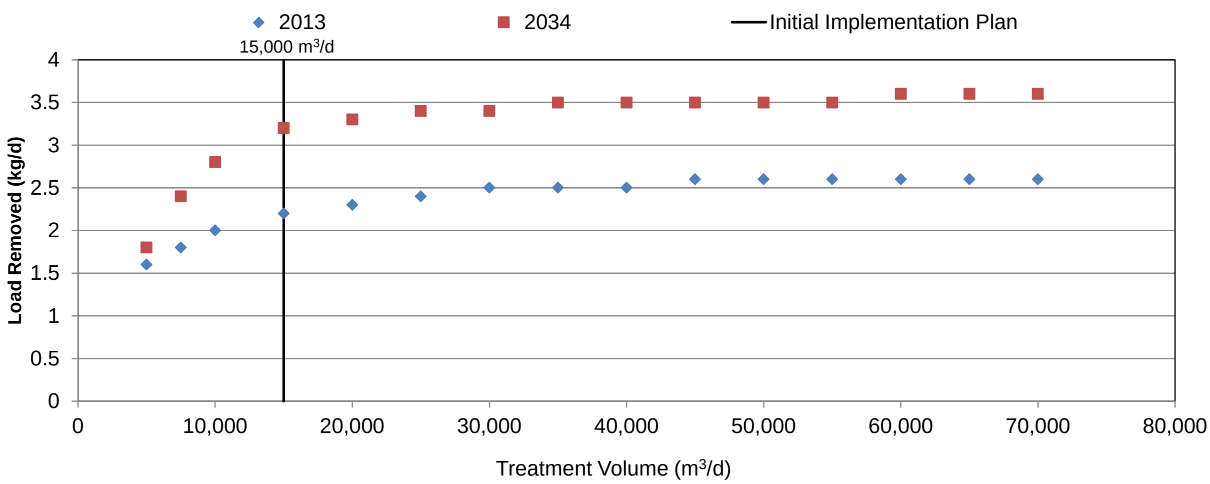
(b) Fording River Operations South



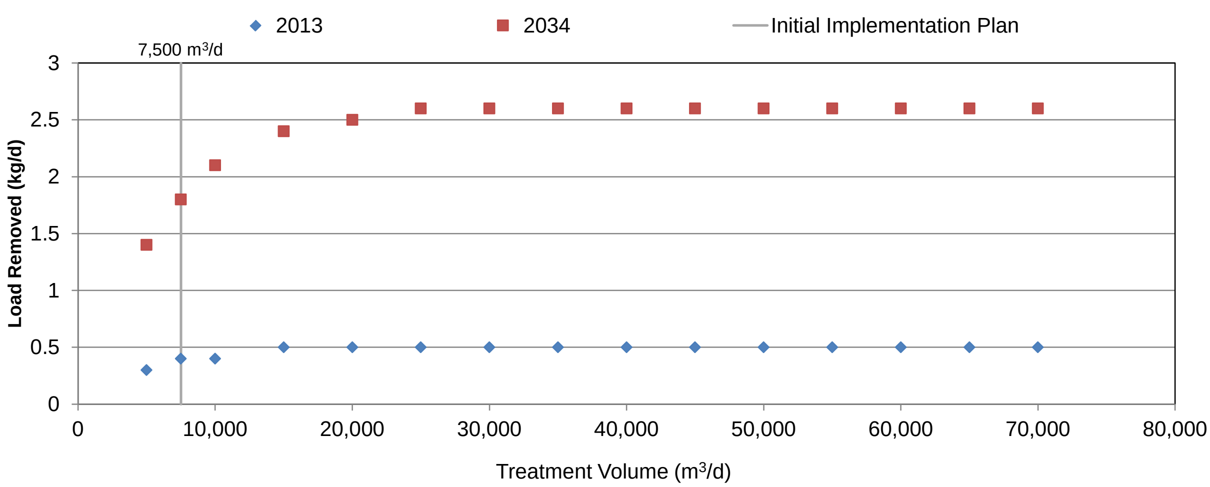
(c) Greenhills Operations



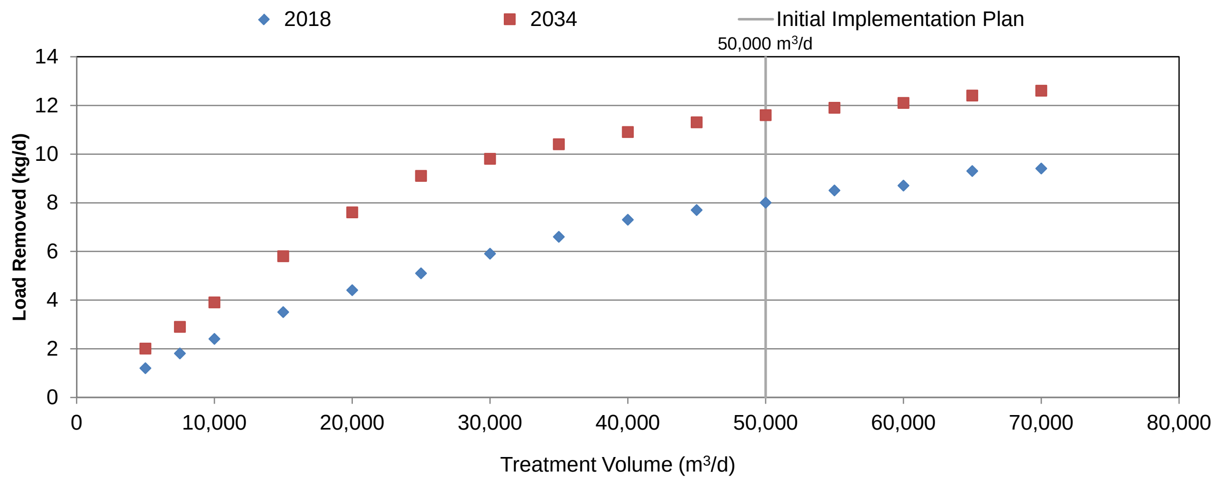
(d) Line Creek Operations West Line Creek



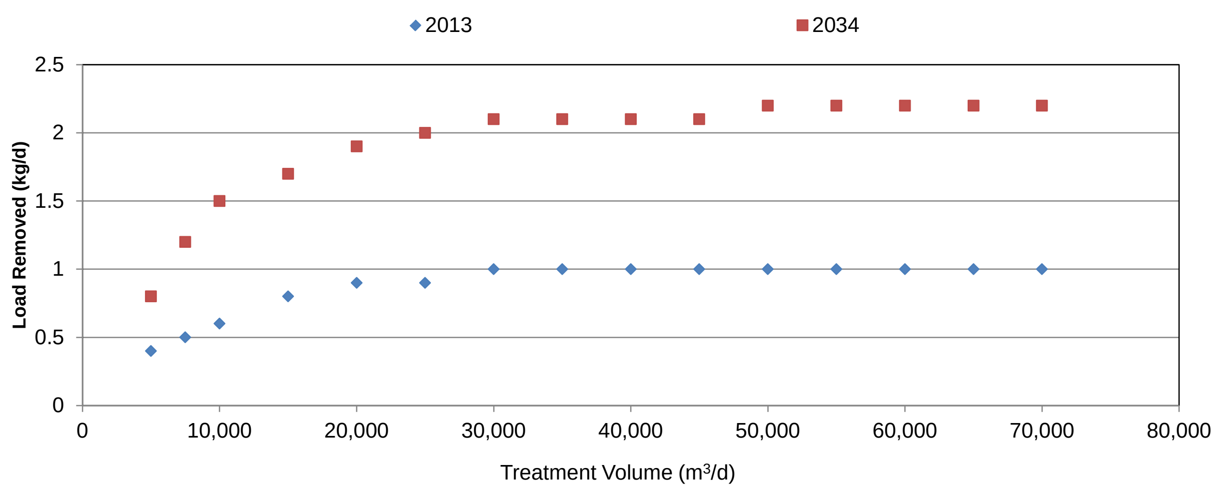
(e) Line Creek Operations Dry Creek



(f) Elkview Operations



(g) Coal Mountain Phase 2



Note: Selenium load removed was calculated based on the reasonable, worst-case (P95) geochemical release rate under average flows.

5 Water Quality Model Predictions for the Initial Implementation Plan

5.1 Summary of the Initial Implementation Plan

A summary of the initial implementation plan as incorporated in the model is provided in Table 5-1. No treatment is needed at CMO to meet the long-term water quality targets according to the water quality model. Water quality modelling results for the initial implementation plan are provided in Sections 5.2 through 5.4.

Table 5-1 Initial Implementation Plan as Incorporated in the Model

Modelled Active Water Treatment Facility[(a)]	Sources Targeted for Treatment	Year[(b)]	Total Water Volume Treated[(a)]	Associated Diversions[(a)]	Associated Conveyance of Mine-Influenced Water[(a)]
West Line Creek (Phase I)	LCO West Line	Q2 2014[(c)]	7,500	–	• Convey Line Creek to AWTF • Discharge to Line Creek
FRO South	GHO Swift, Cataract and FRO Kilmarnock	2018	20,000	Diversion of Upper Kilmarnock watershed (estimated at 45,000 m^3/d capacity) and Upper Brownie watershed (estimated at 14,000 m^3/d)	• Convey Swift and Cataract and the mine-influenced portion of Kilmarnock to the AWTF • Discharge to the Fording River
EVO (Phase I)	EVO Bodie, Gate, Erickson	2020	30,000	Diversion of Upper Erickson watershed (estimated 14,000 m^3/d) and South Gate Creek (estimated 3,500 m^3/d)	• Convey mine-influenced water from Erickson to the AWTF • Discharge to Erickson Creek
FRO North (Phase I)	FRO Clode, North Spoil, Swift Pit	2022	15,000	–	• Convey mine-influenced water to the AWTF • Discharge to the Fording River
EVO (Phase II)	EVO Erickson	2024	20,000	–	• Convey mine-influenced water to the AWTF • Discharge to Erickson Creek
GHO	GHO West Spoil and Greenhills Creek	2026	7,500	–	• Convey mine-influenced water to the AWTF • Discharge to Thompson Creek
LCO Dry Creek	LCO Dry Creek	2028	7,500	–	• Convey mine-influenced water to the AWTF • Discharge to the Fording River
FRO North (Phase II)	FRO Swift Pit	2030	15,000	–	• Convey mine-influenced water to the AWTF • Discharge to the Fording River
West Line Creek (Phase II)	LCO Line Creek	2032	7,500	Diversion of Upper Line Creek (estimated 35,000 m^3/d)	• Convey mine-influenced water to the AWTF • Discharge to line Creek

(a) Modelled Active Water Treatment Facility (AWTF), Associated Diversions and Associated Conveyance of Mine-Influenced Water are identified for planning purposes, to be evaluated during detailed design. Total Water Volume Treated and diversion sizes will be refined based on site-specific information developed during detailed design.

(b) Commissioning dates modelled as January 1st of the year, unless otherwise specified.

(c) In the model, the LCO West Line Creek facility is commissioned in January 1st, 2014. The difference between this date and the actual commissioning date in Q2 2014 will have negligible effects on predicted water quality conditions for the planning period.

5.2 In-stream Concentrations

5.2.1 Regional Locations

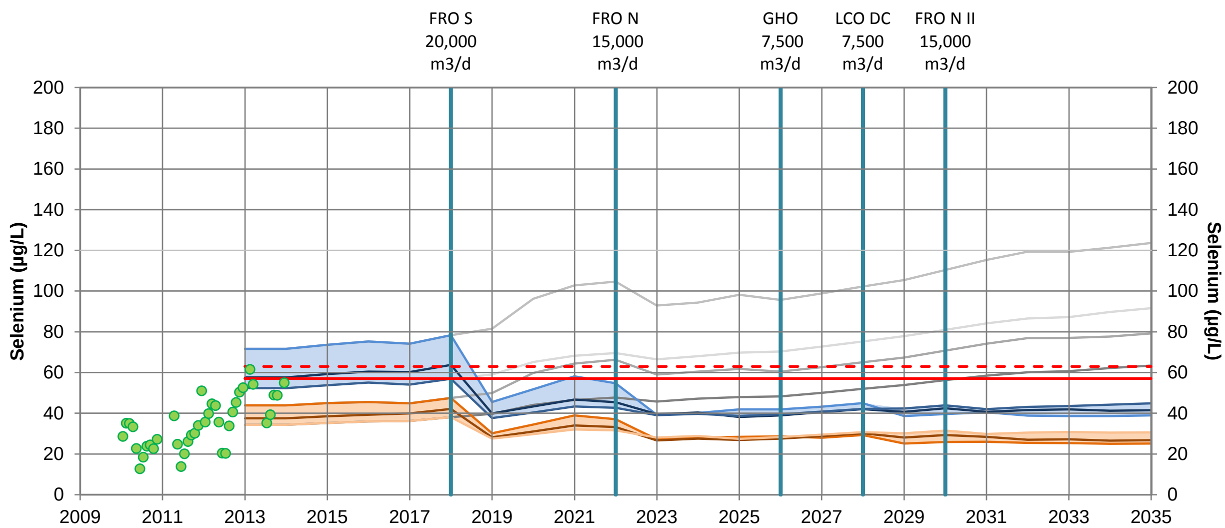
Predicted selenium, nitrate and sulphate concentrations in the Fording and Elk rivers and Michel Creek under low, average and high flows are shown in Figures 5-1 to 5-6. The predictions are presented as time series plots and, for context, include historical observations (green points) and commissioning dates (vertical lines) for the active water treatment facilities according to the initial implementation plan. Long term and short term targets, or level 1 and level 2 benchmarks as appropriate, are included for reference. The blue band indicates the predicted envelope of maximum monthly average concentrations under low, average or high flows. The orange band indicates the predicted envelope of annual average concentrations under the same range of flows. Grey lines are the predictions without mitigation. Predicted hardness concentrations under low, average and high flows are presented in Appendix C.

Explanations of the patterns in predicted selenium and nitrate concentrations are presented in Appendices D and E.

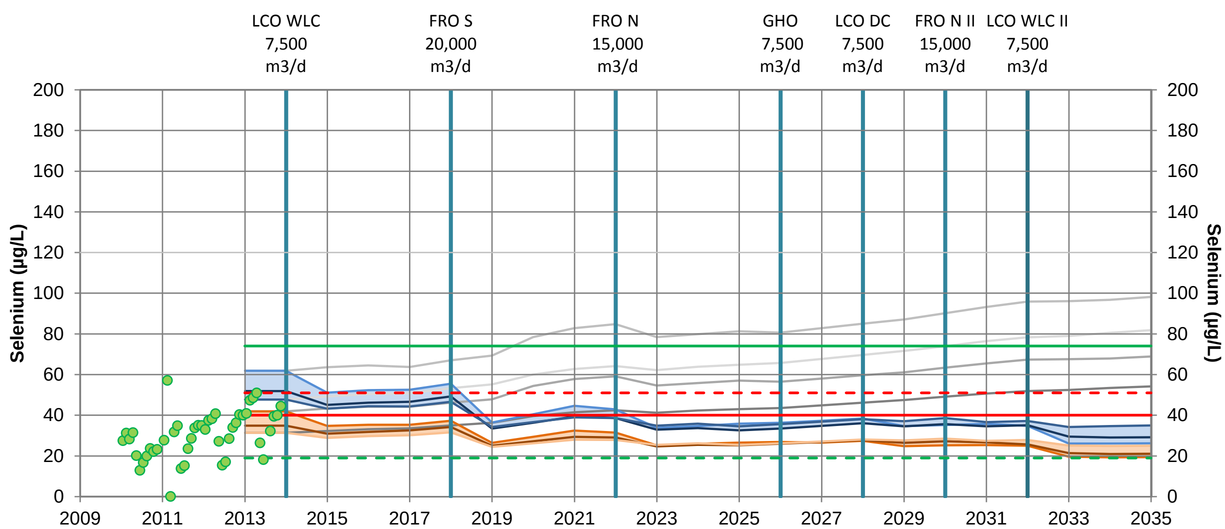
As with any model, input assumptions and predictions of future conditions involve uncertainty. A detailed list of model assumptions is provided in Teck 2014b. The uncertainty in the model is considered by the model error and bias calculated for the calibration period, which is also described in Teck 2014b.

Figure 5-1 Predicted Selenium Concentrations at Order Stations in the Fording and Elk Rivers

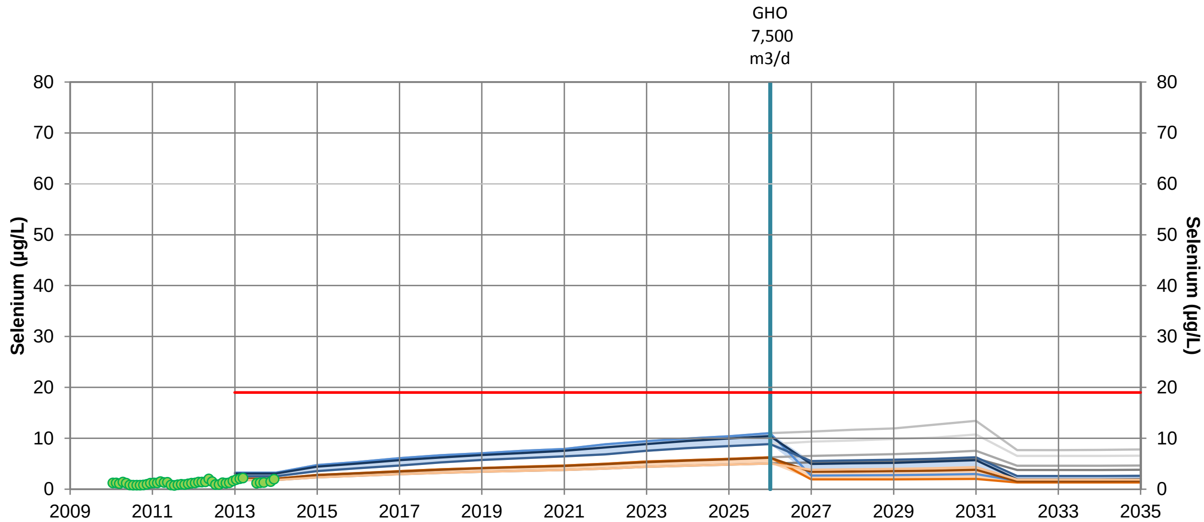
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



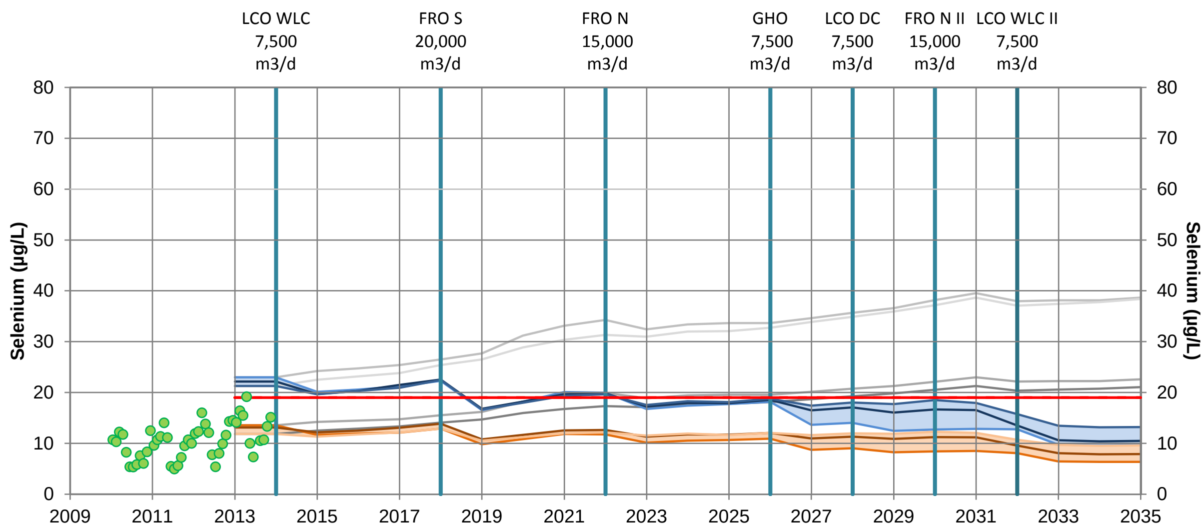
(b) Fording River at the mouth, FR5 (EMS 0200396)



(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



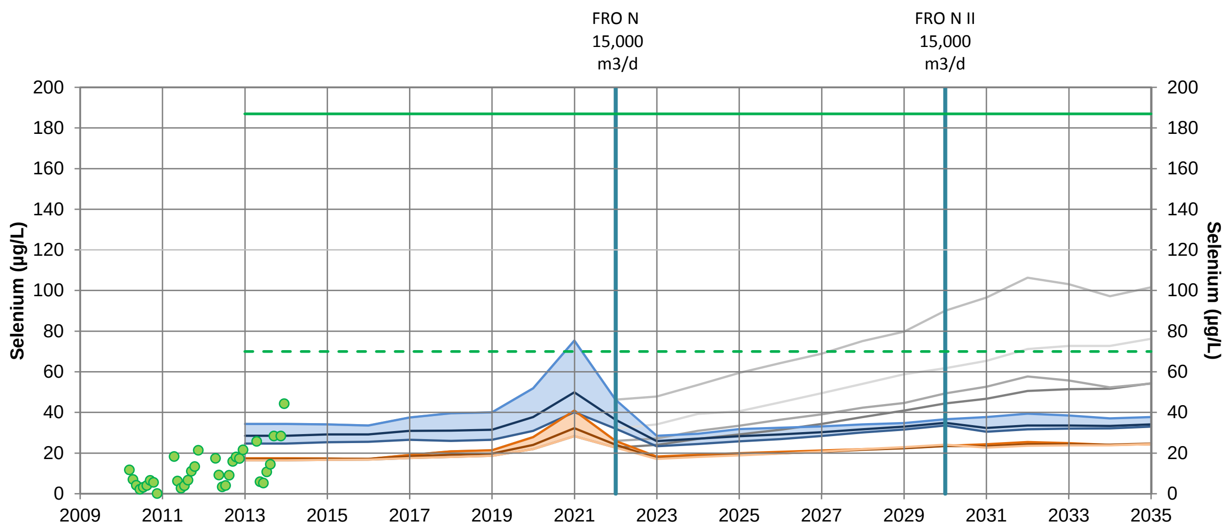
(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)

Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

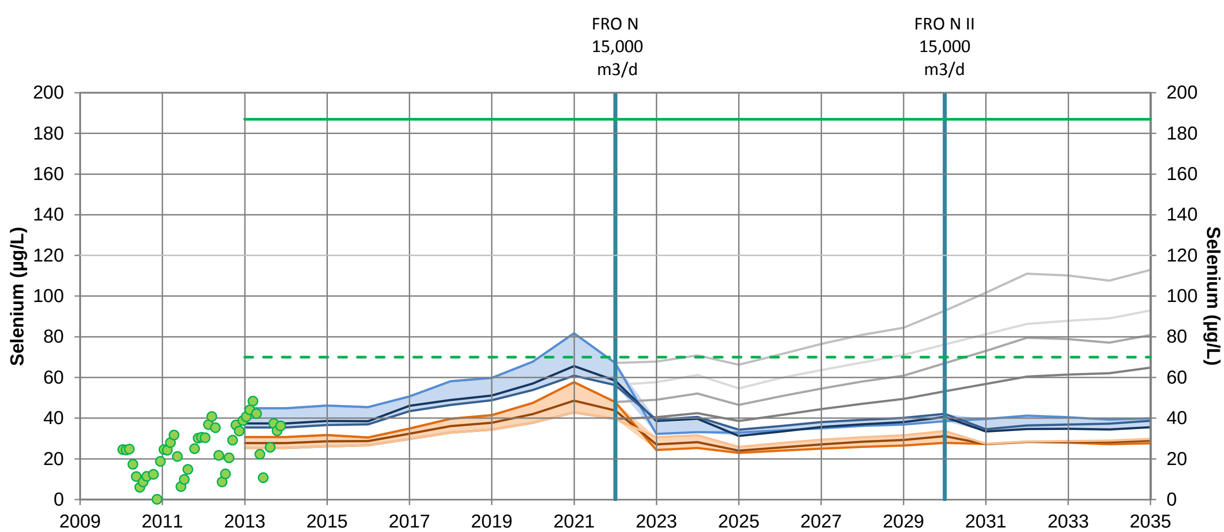
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-2 Predicted Selenium Concentrations at Other Nodes in the Fording and Elk Rivers and Michel Creek

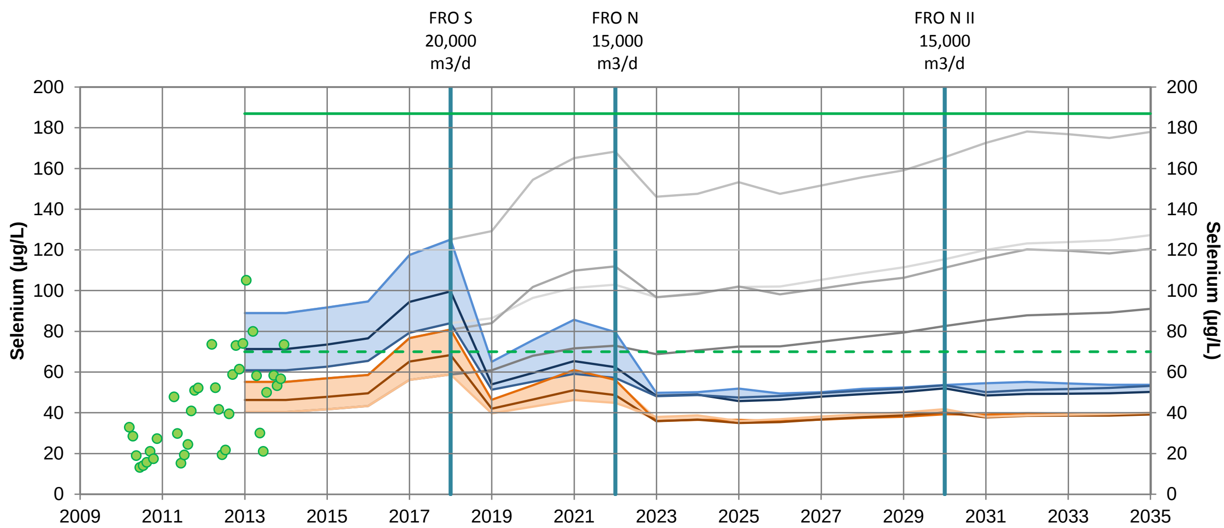
(a) Fording River Downstream of Henretta Creek (FR1)



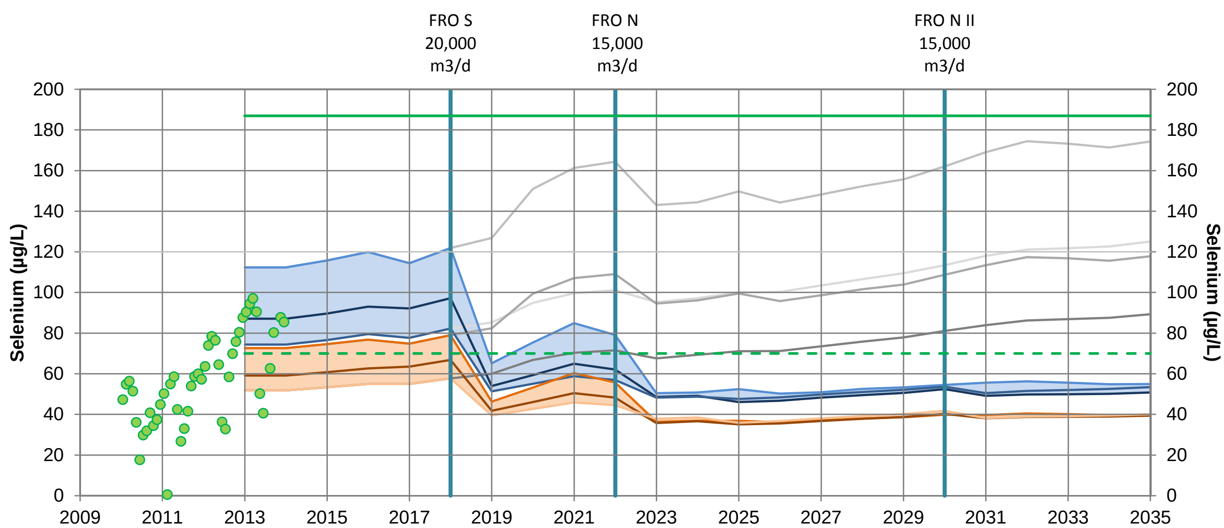
(b) Fording River Downstream of Clode Creek (FR2)



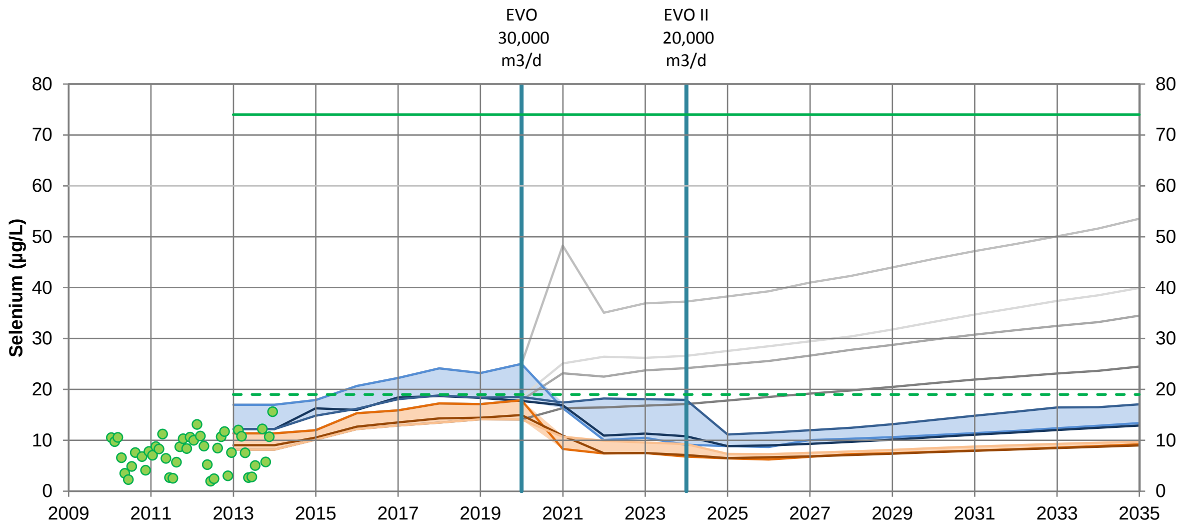
(c) Fording River Between Swift and Cataract Creeks (FR3)



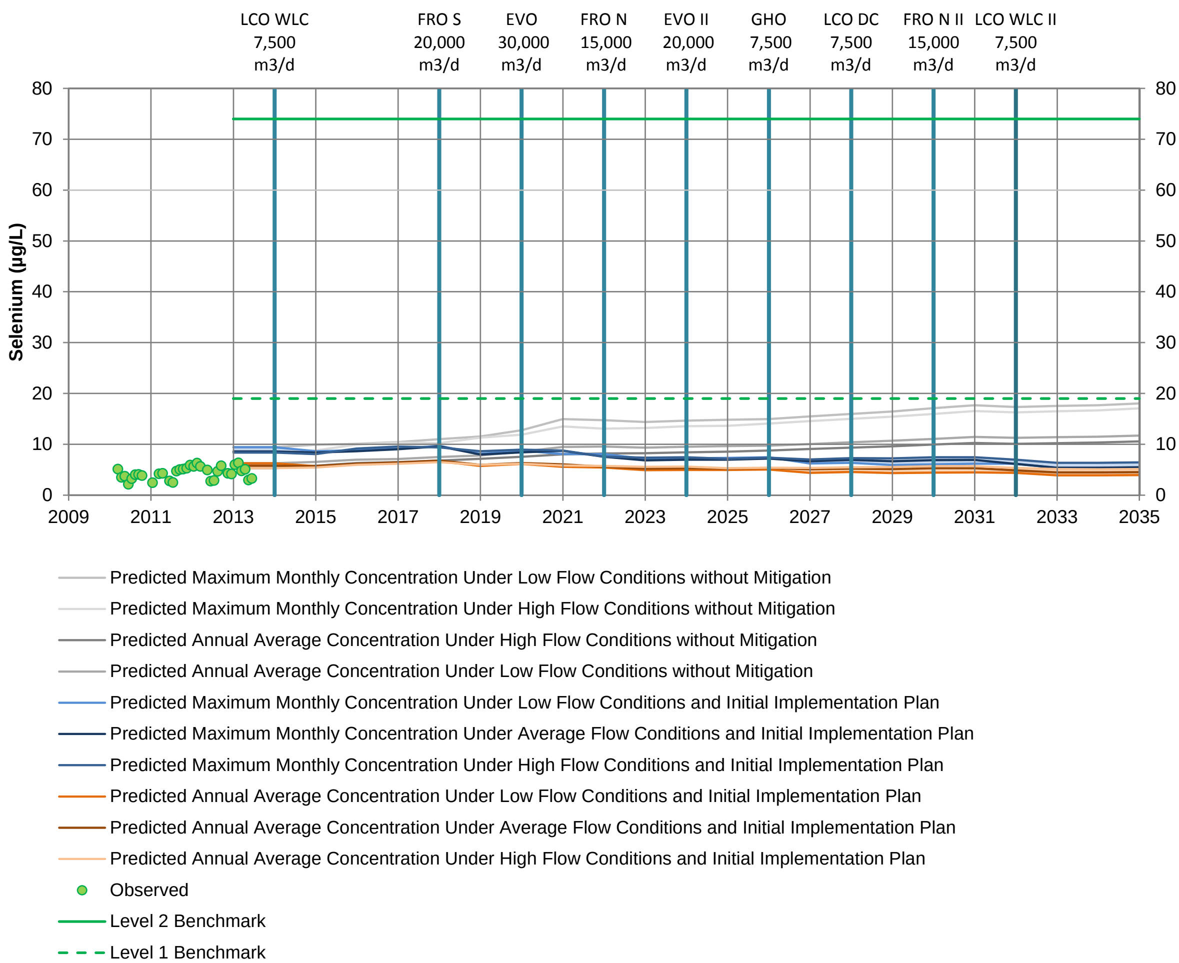
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)

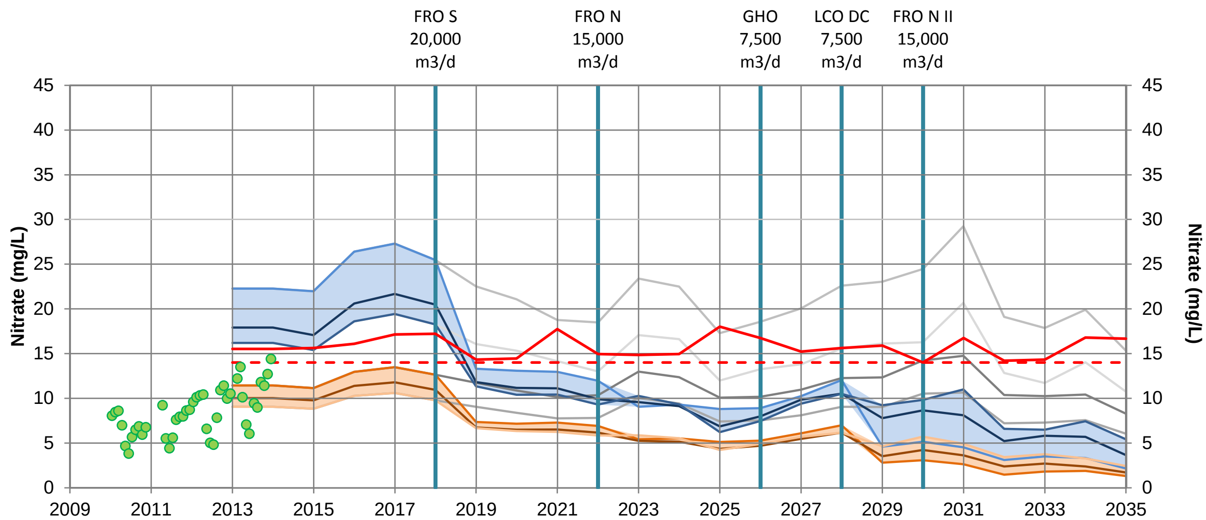


Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

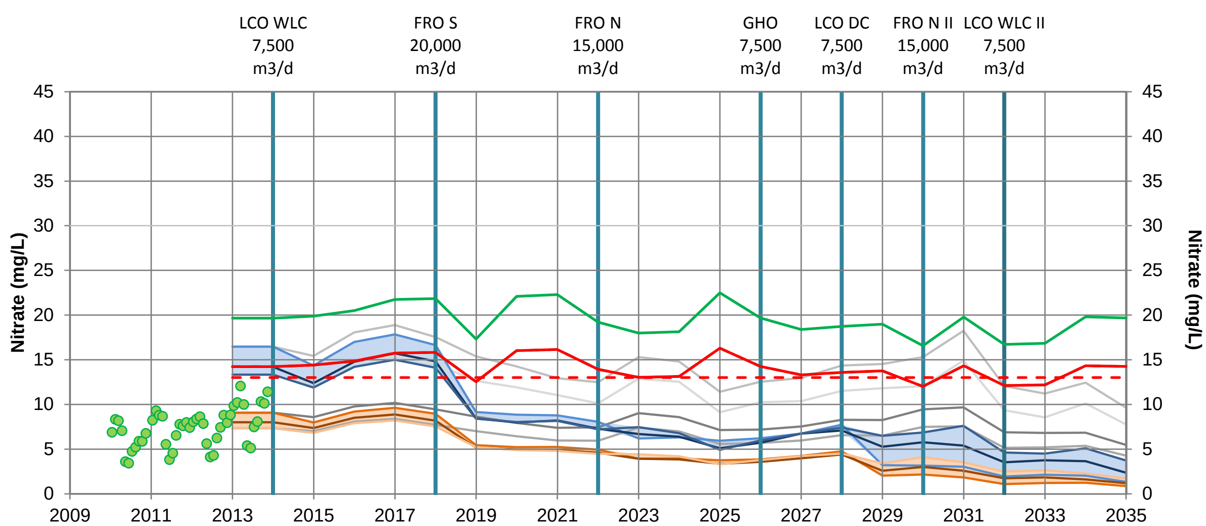
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-3 Predicted Nitrate Concentrations at Order Stations in the Fording and Elk Rivers

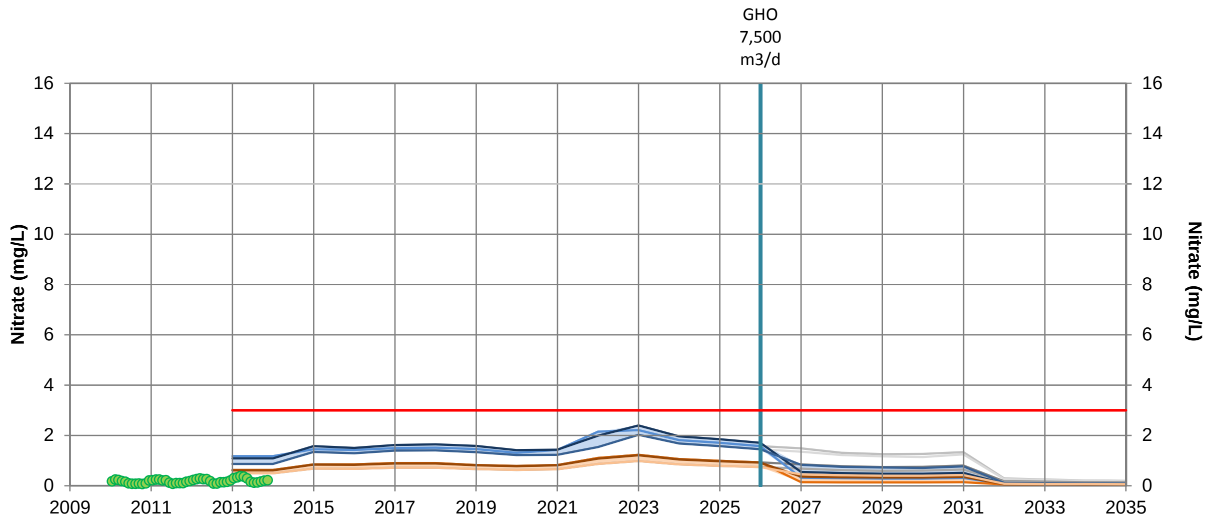
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



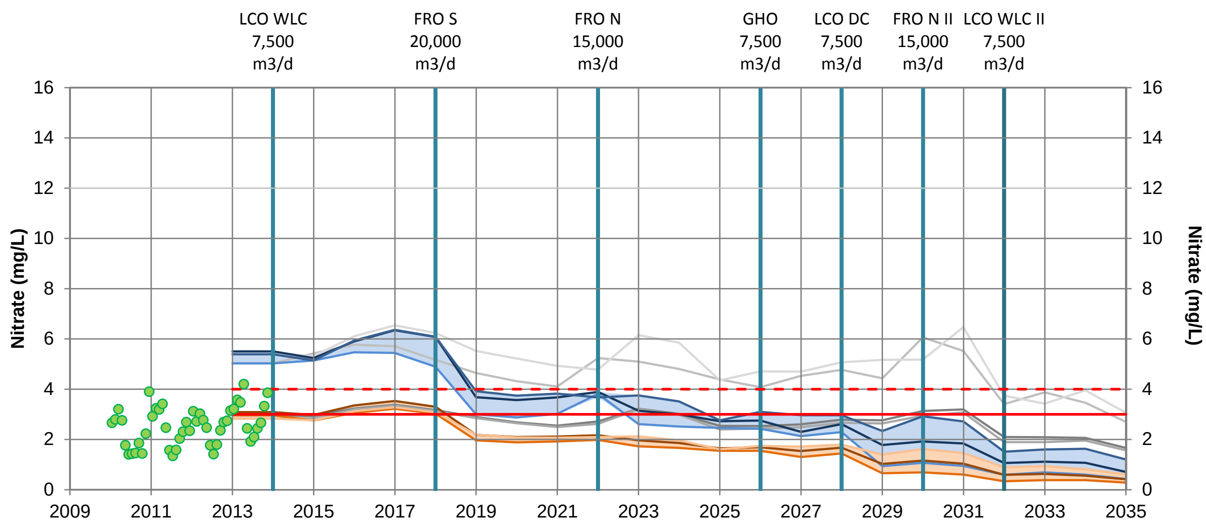
(b) Fording River at the Mouth, FR5 (EMS 0200396)



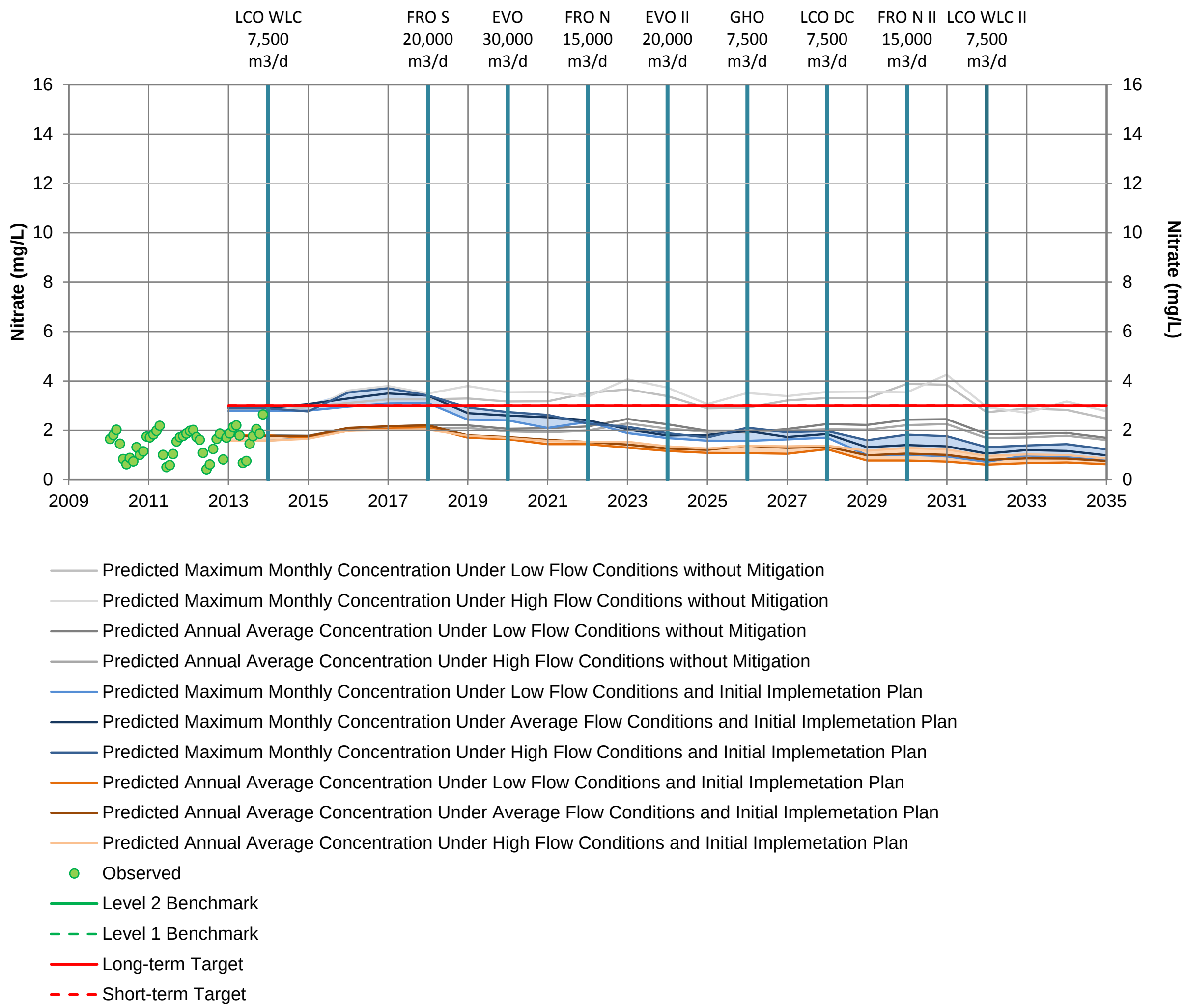
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)



Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

In the Fording River, the Level 1 and Level 2 benchmarks, as well as the long-term target, were adjusted for hardness using the following equations:

$$Level\ 1\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.52}$$

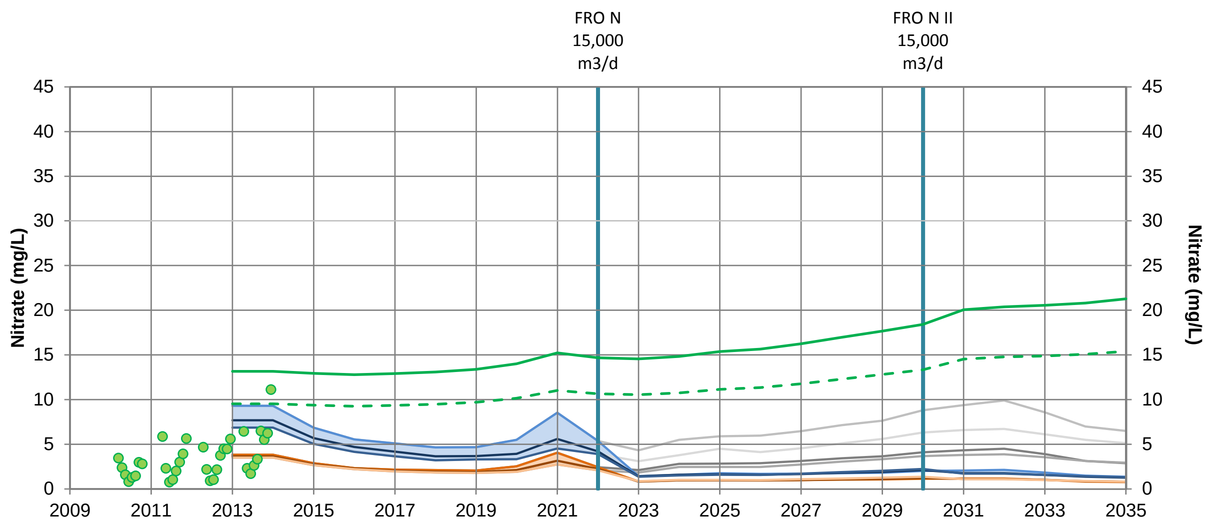
$$Level\ 2\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.38}$$

The long-term target was adjusted using the equation for the Level 1 benchmark.

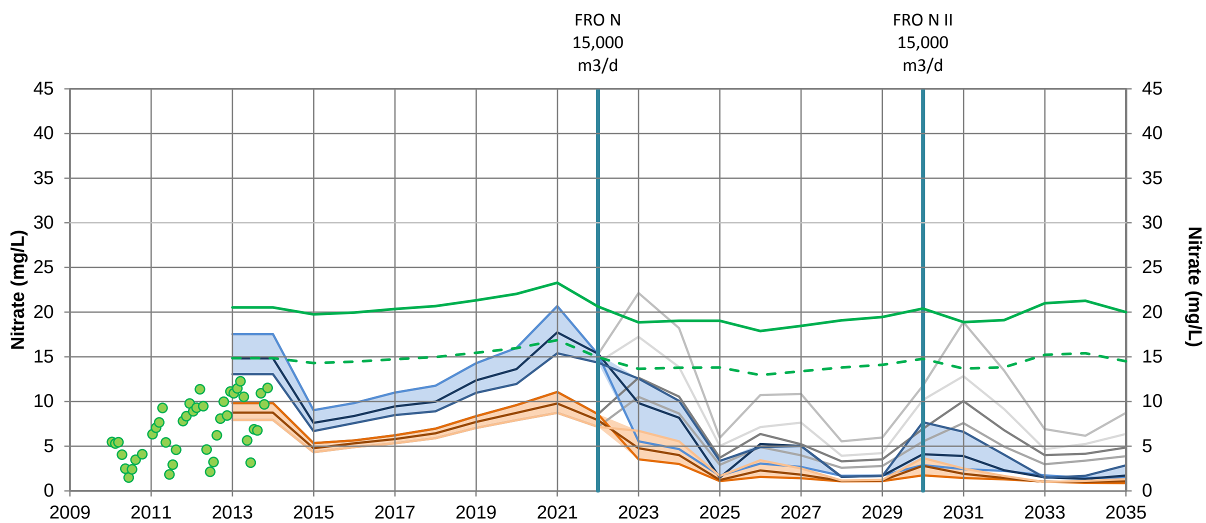
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-4 Predicted Nitrate Concentrations at Other Nodes in the Fording and Elk Rivers and Michel Creek

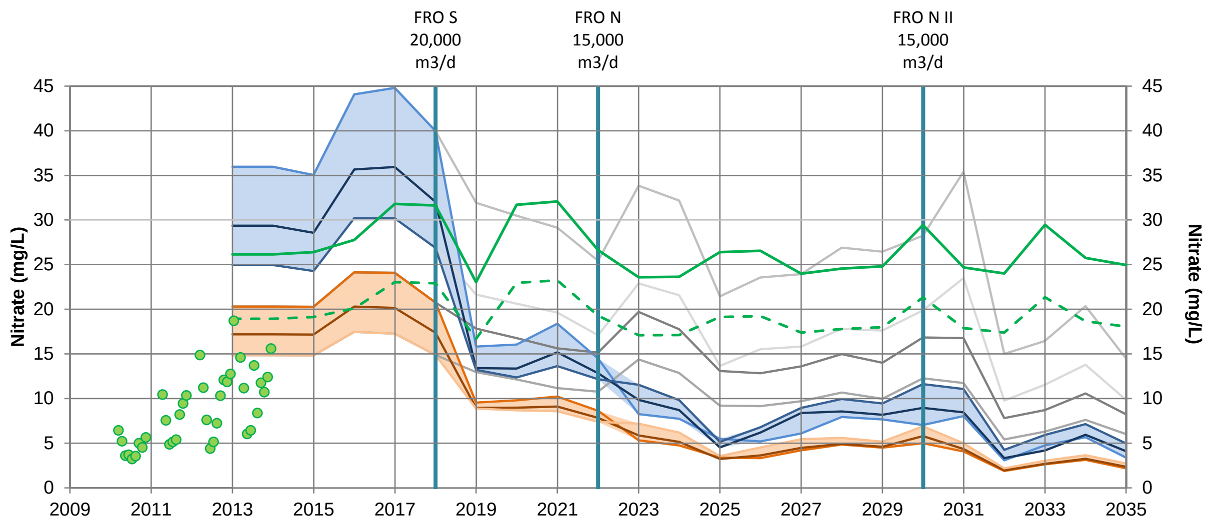
(a) Fording River Downstream of Henretta Creek (FR1)



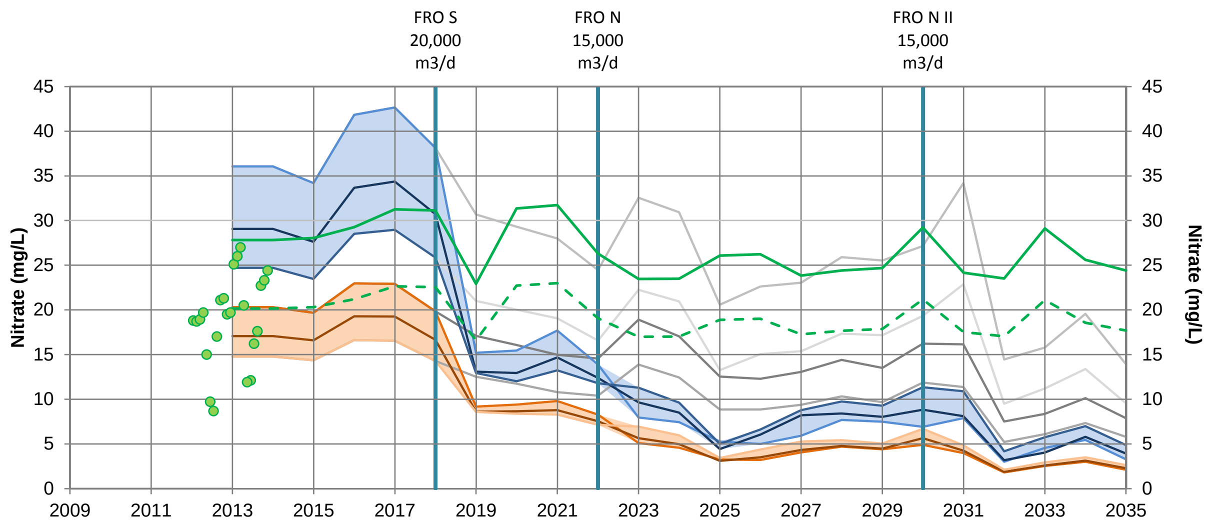
(b) Fording River Downstream of Clode Creek (FR2)



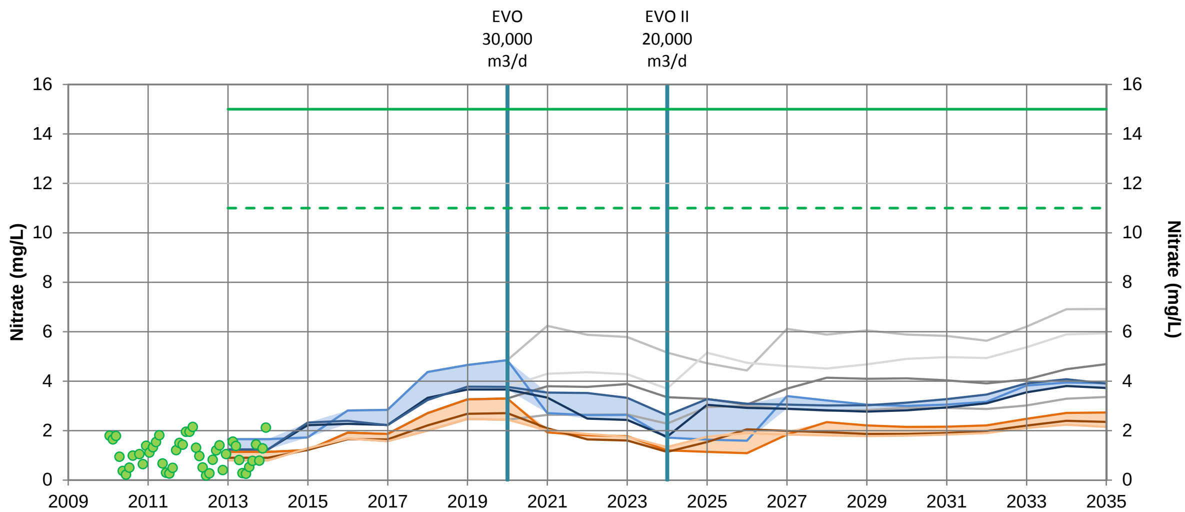
(c) Fording River Between Swift and Cataract Creeks (FR3)



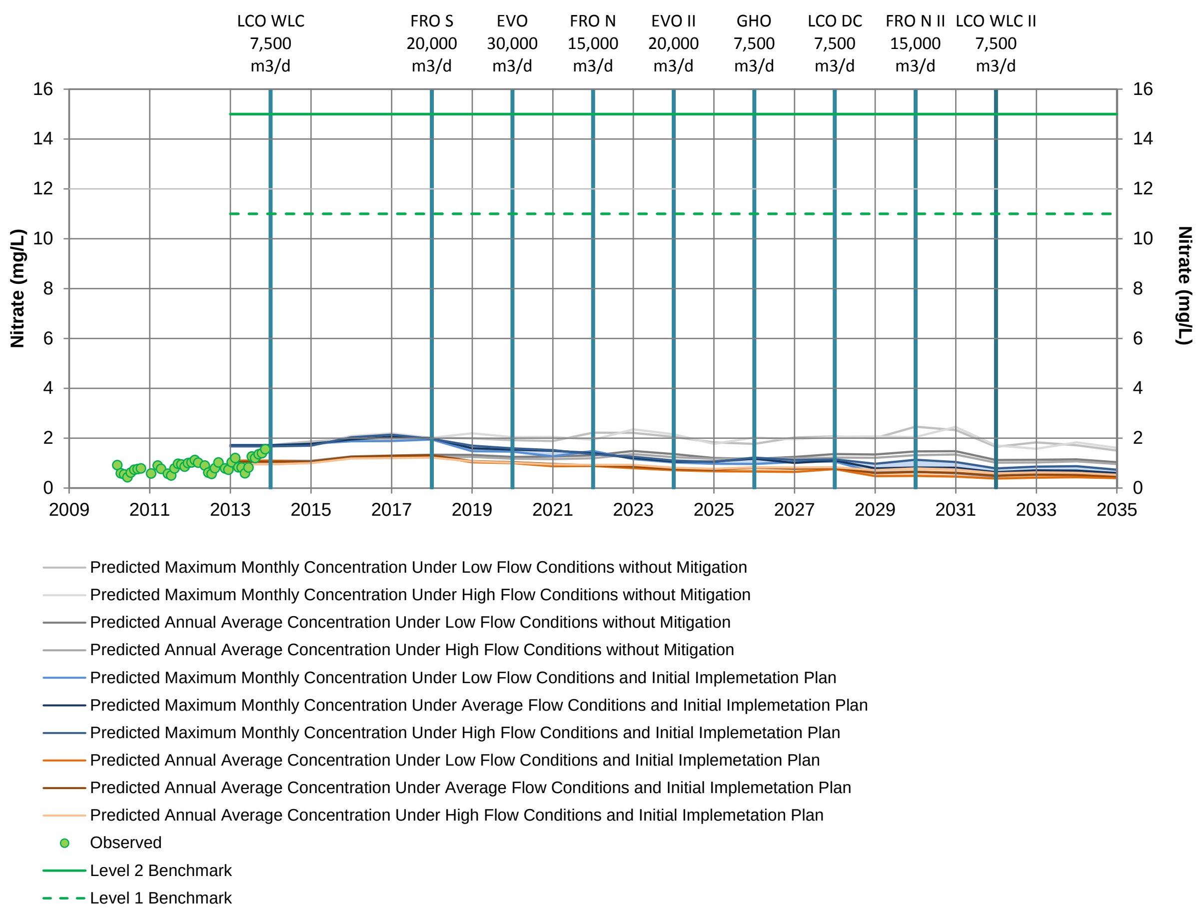
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)



Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

In the Fording River, the Level 1 and Level 2 benchmarks were adjusted for hardness using the following equations:

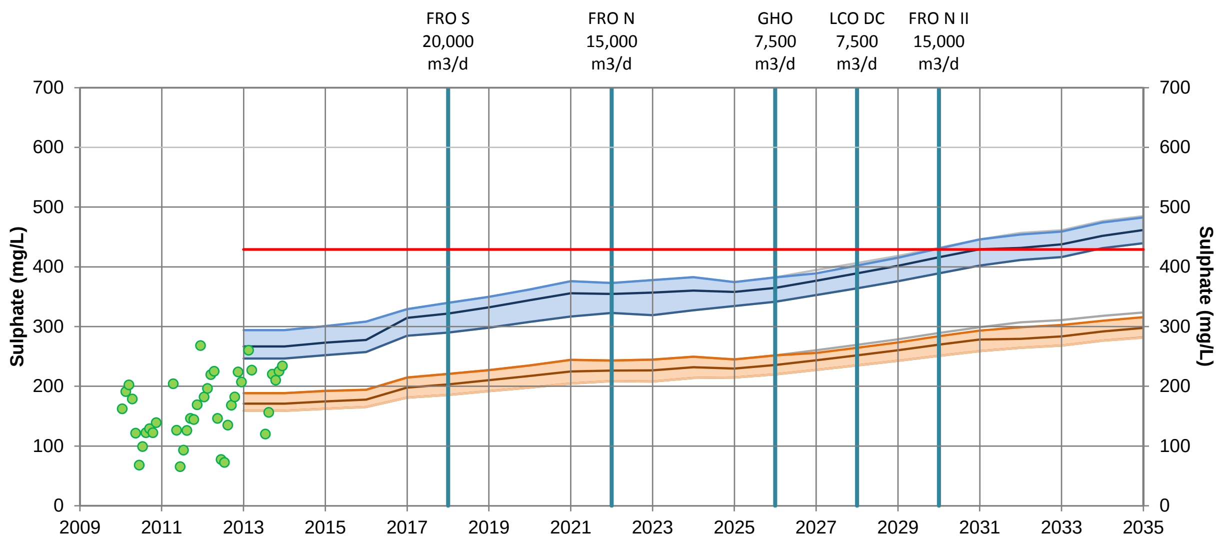
$$Level\ 1\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log10(hardness)-1.52}$$

$$Level\ 2\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log10(hardness)-1.38}$$

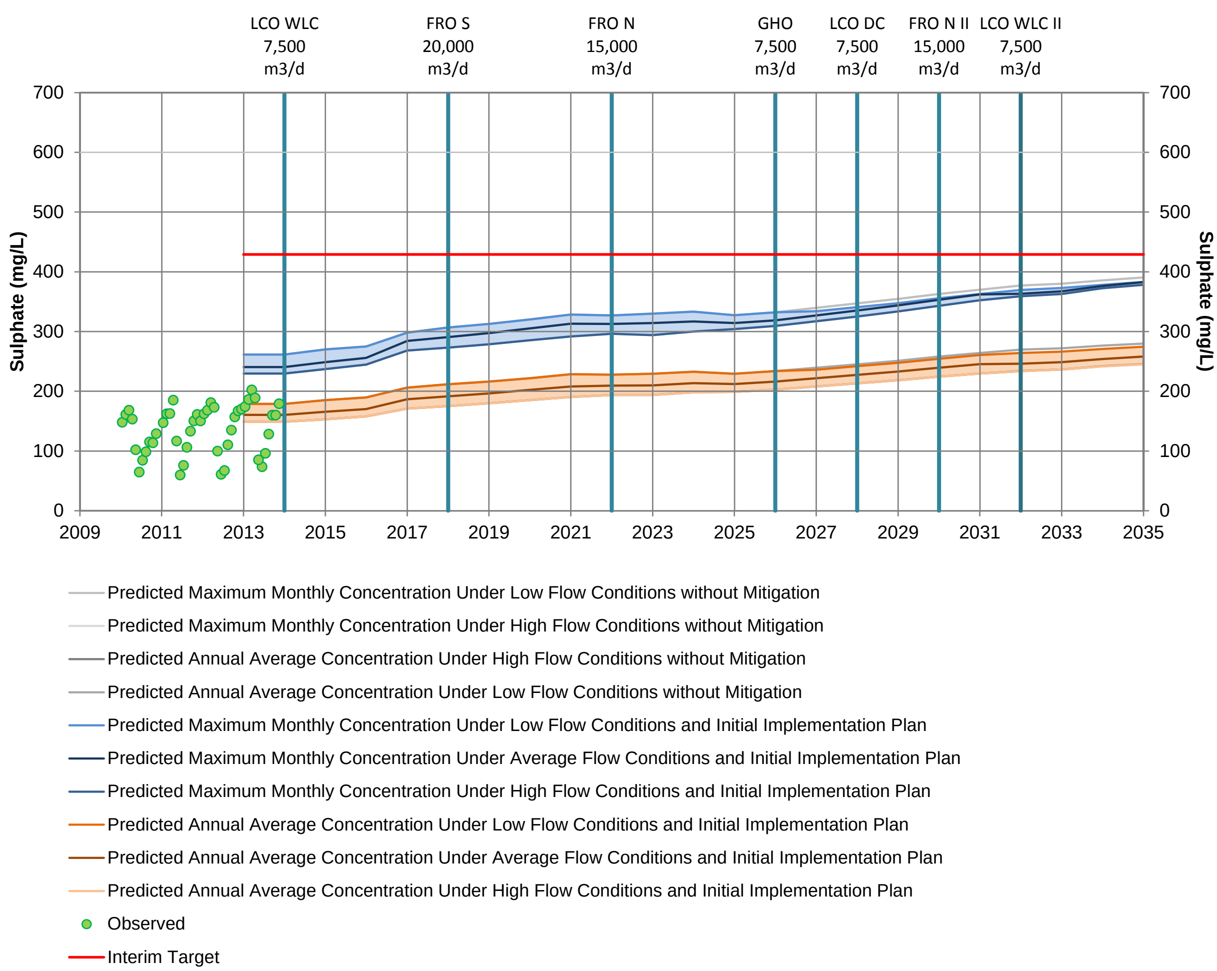
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-5 Predicted Sulphate Concentrations at Order Stations in the Fording and Elk Rivers

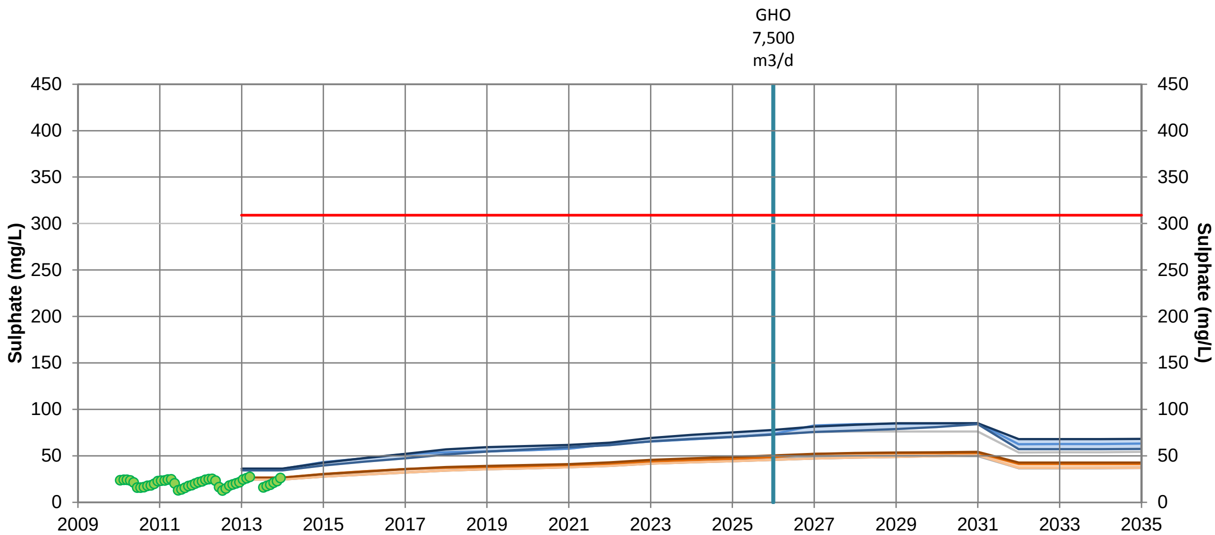
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



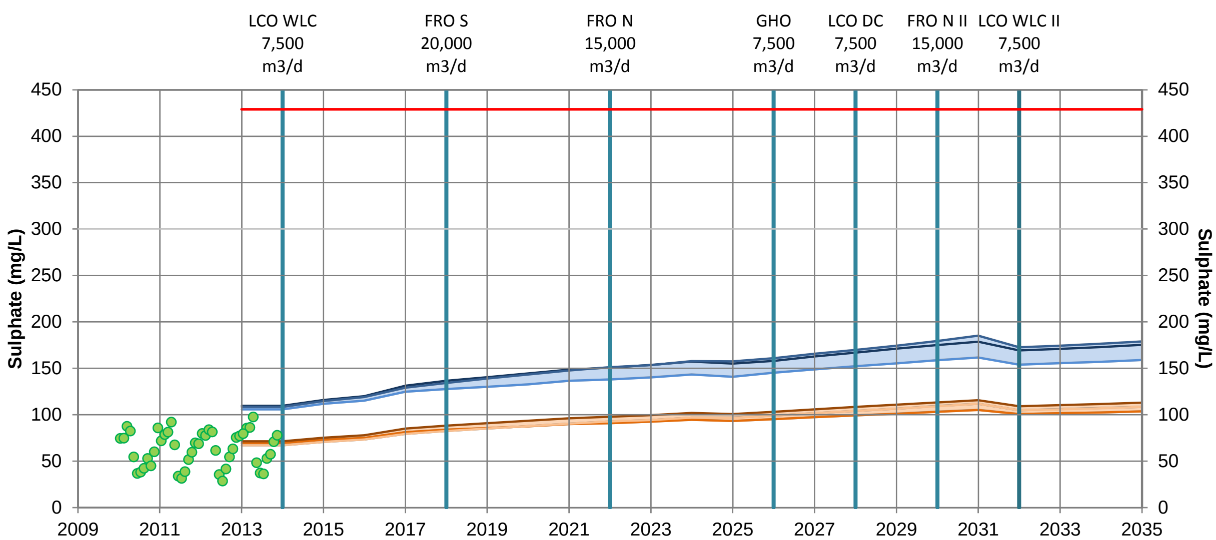
(b) Fording River at the Mouth, FR5 (EMS 0200396)



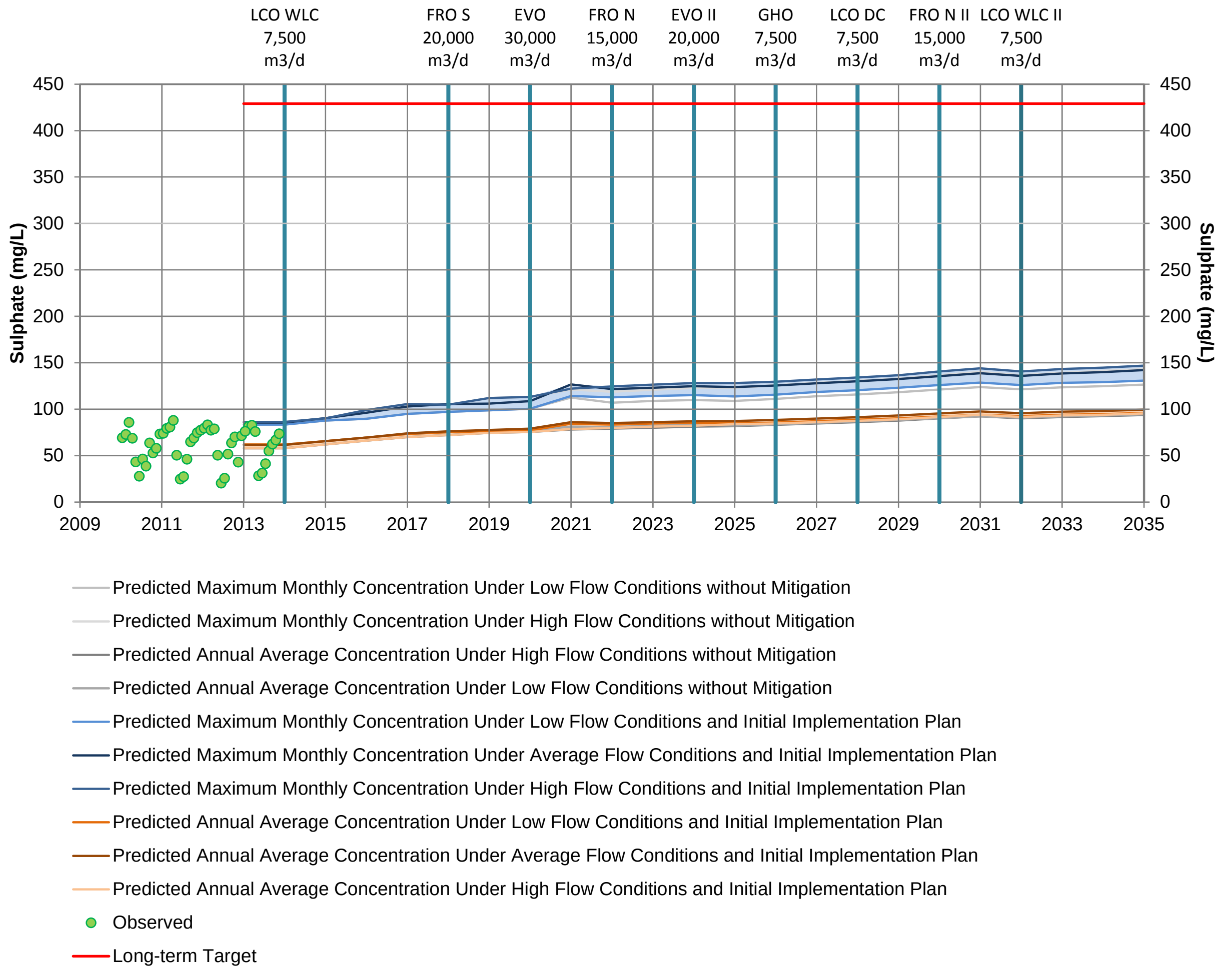
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)

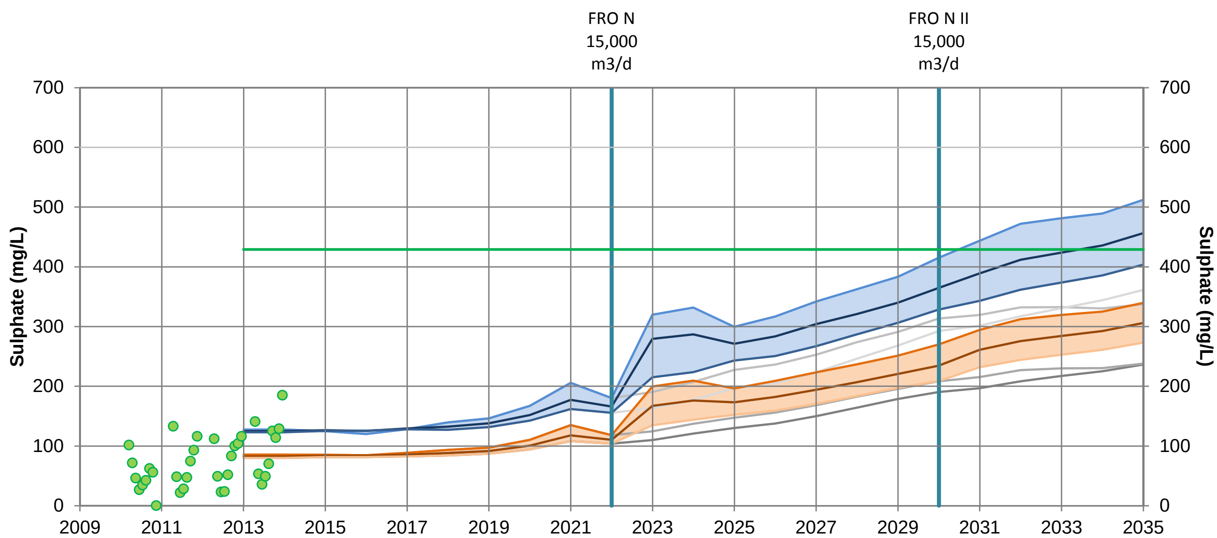


Notes: The model was run with the average (P50) geochemical release rate under average flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

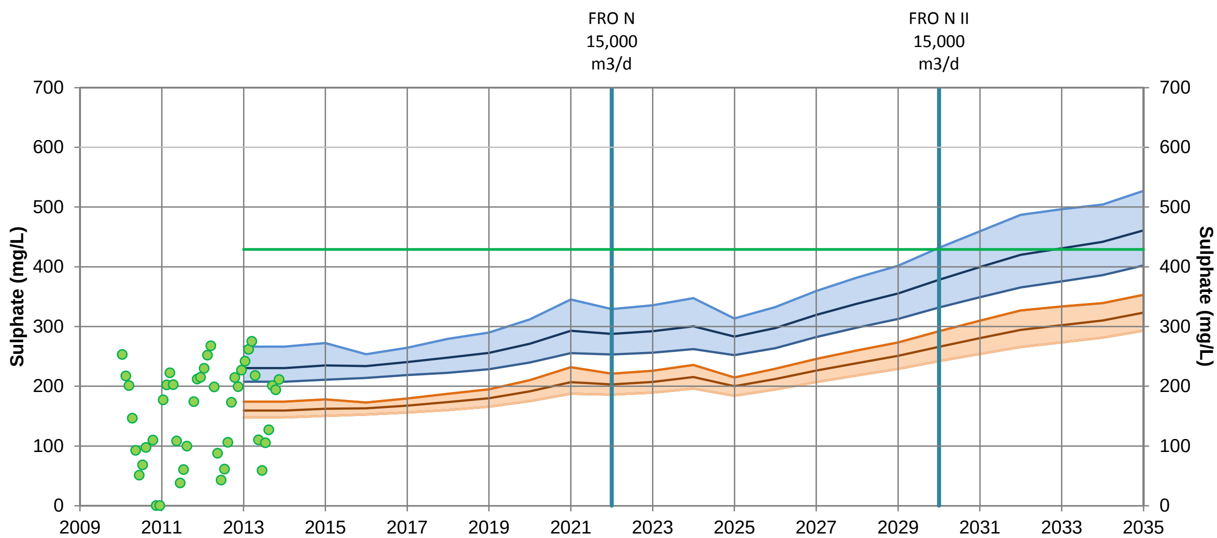
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-6 Predicted Sulphate Concentrations at Other Nodes in the Fording and Elk Rivers and Michel Creek

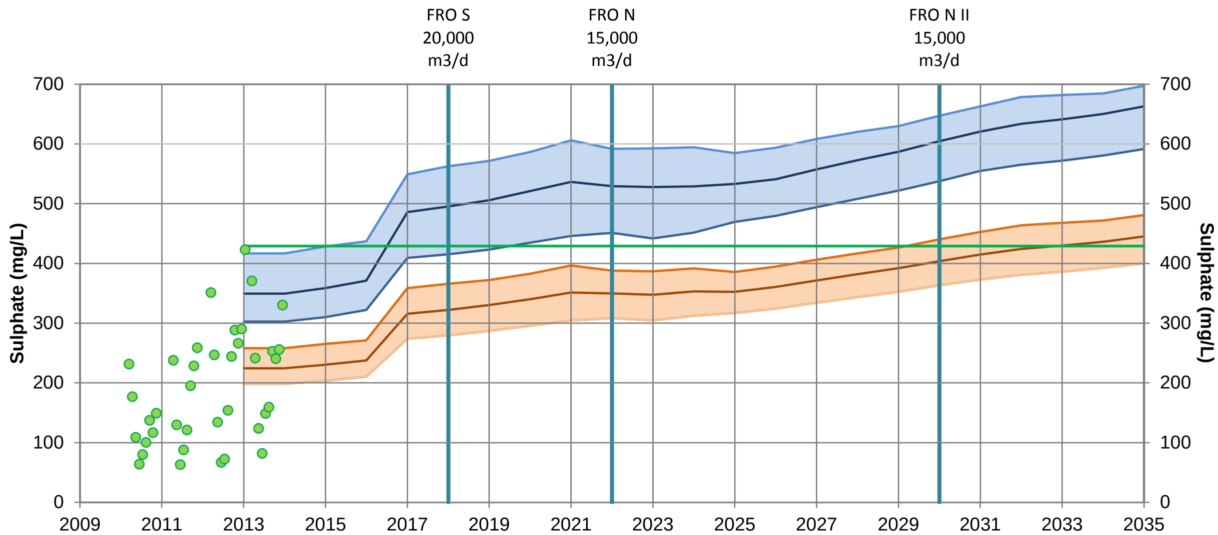
(a) Fording River Downstream of Henretta Creek (FR1)



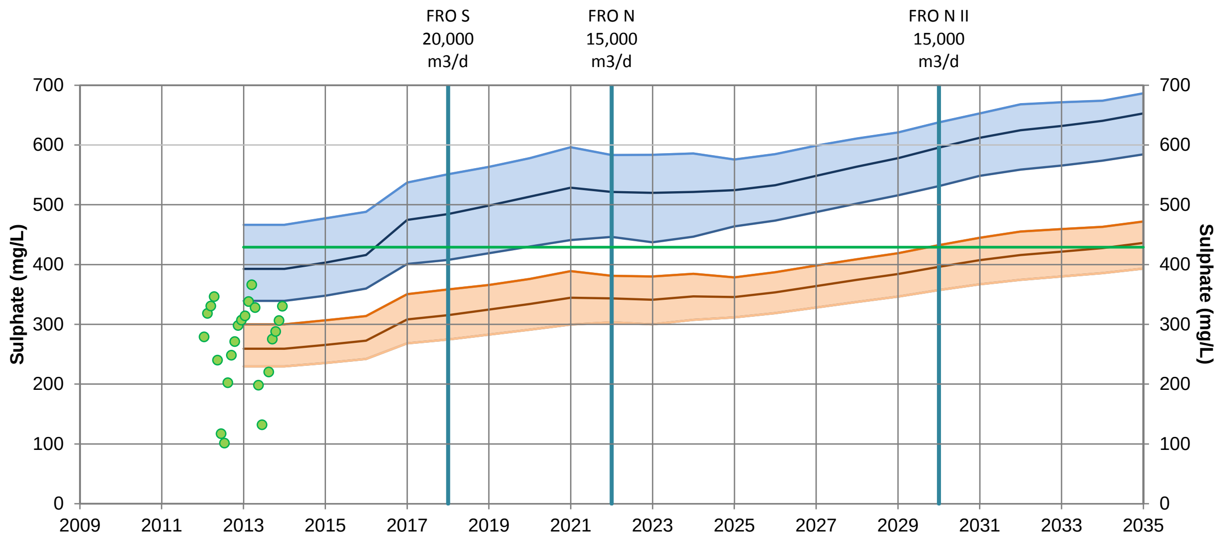
(b) Fording River Downstream of Clode Creek (FR2)



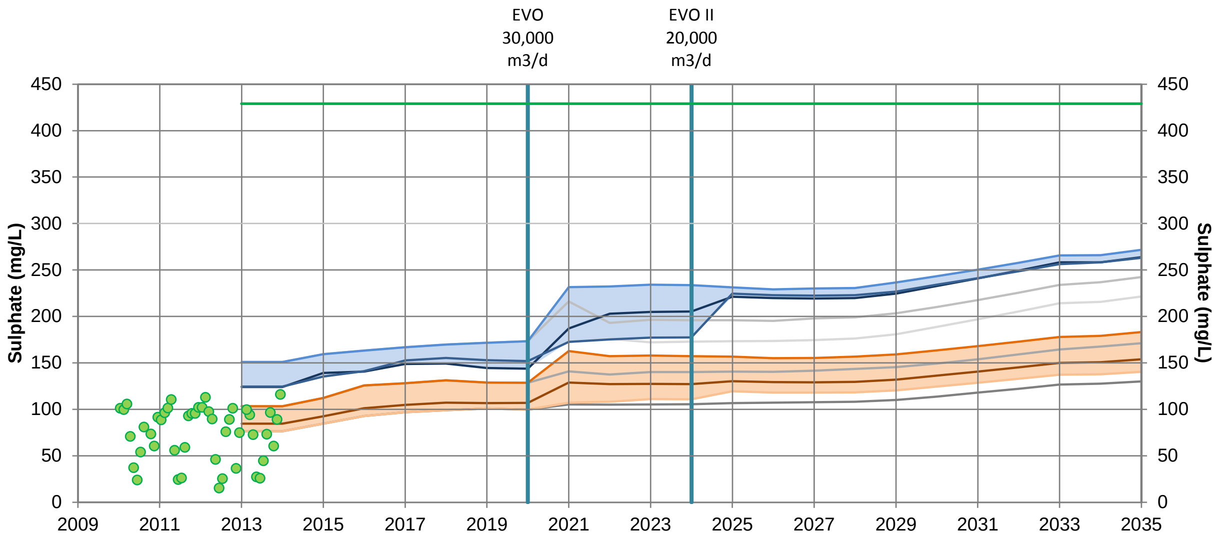
(c) Fording River Between Swift and Cataract Creeks (FR3)



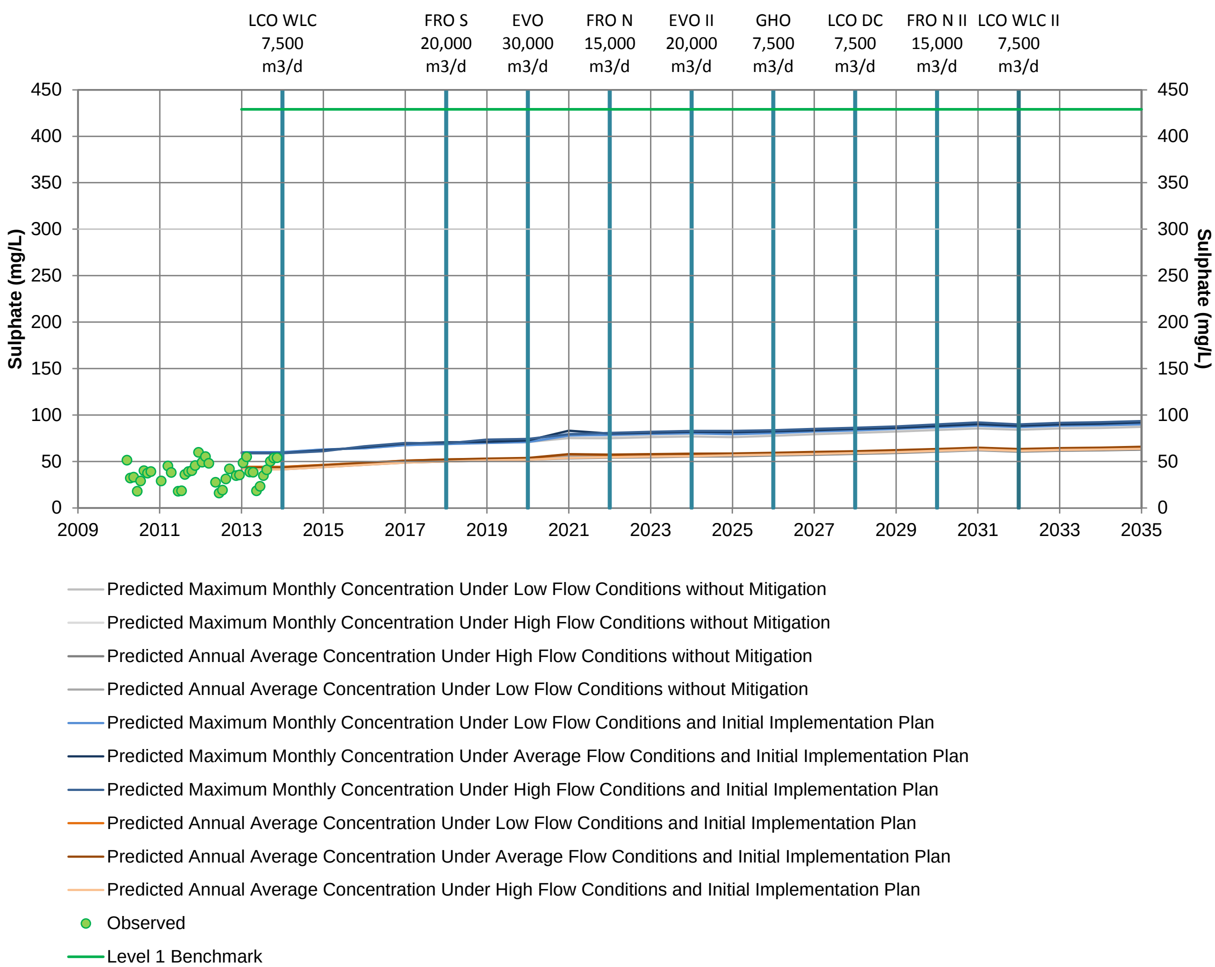
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)



Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

5.2.2 Tributaries

As discussed in Teck 2014b, the model reasonably reproduced observed concentrations in the Fording and Elk rivers, with less agreement in the individual tributaries. Therefore, the following equation was used to estimate selenium, nitrate and sulphate concentrations in tributaries:

(Equation 1)

$$\text{Estimated concentration}_{Year\ x} = \text{Observed concentration}_{2013} \times \frac{\text{Modelled concentration}_{Year\ x}}{\text{Modelled concentration}_{2013}}$$

The estimated selenium, nitrate and sulphate concentrations under average flows are provided in Tables 5-2, 5-3 and 5-4, respectively. Estimated concentrations under low and high flows are presented in Appendix C.

Table 5-2 Estimated Total Selenium Concentrations (µg/L) in Tributaries of the Fording and Elk Rivers and Michel Creek under Average Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 - 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	30	44	29	44	29	44	44
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	77	103	-[c]	-[c]	226[d]
CC1	Clode Creek at the mouth	106	162	141	219	273	413	418
SP1[a]	Swift Pit	-[b]	-[b]	146	190	-[c]	-[c]	194[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	10	13	9	11	56
SC_CA[f]	Swift/Cataract watershed	587	730	493	608	-[c]	-[c]	608[d]
KC1	Kilmarnock Creek at the mouth	177	280	214	340	157	225	340
PC1	Porter Creek at the mouth	73	84	92	129	154	175	175
LE1	Leask Creek at the mouth	60	86	264	362	-[c]	-[c]	-[c]
WC1	Wolfram Creek at the mouth	48	113	80	174	-[c]	-[c]	-[c]
TC1	Thompson Creek at the mouth	115	163	162	225	31	36	225
GH1	Greenhills Creek at the mouth	122	178	126	183	124	227	294
WLC1	West Line Creek at the mouth	458	603	458	603	-[c]	-[c]	-[c]
LC1	Line Creek at the mouth	41	57	25	31	13.3	19	57
DC1	Dry Creek at the mouth	1.6	1.8	2	3	5	8	8
BC1	Bodie Creek at the mouth	385	443	140	136	-[c]	-[c]	-[c]
GT1	Gate Creek at the mouth	171	298	177	305	-[c]	-[c]	-[c]
EC1	Erickson Creek at the mouth	110	121	145	158	46	83	182
DC1_EVO	Dry Creek (EVO) at the mouth	118	164	141	210	217	307	308
HM1	Harmer Creek at the mouth	32	40	37	47	56	67	67
GR1[g, h]	Grave Creek at the mouth	-	-	22	29	33	43	43
WH1	Wheeler Creek at the mouth	0.8	1.1	3	8	50	85	85
SS1	Snowslide Creek at the mouth	0.8	1.1	1	1	1	1	1
CB1	Carbon Creek at the mouth	0.6	0.8	1	1	1	1	1

Notes: Refer to Page 65 (that follows Table 5-4) for details.

Table 5-3 Estimated Nitrate Concentrations (mg/L as N) in Tributaries of the Fording and Elk Rivers and Michel Creek under Average Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 - 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	7	11	3	4	0.4	1	11
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	8.4	12	-[c]	-[c]	33[d]
CC1	Clode Creek at the mouth	32	36	26	30	1	2	65
SP1[a]	Swift Pit	-[b]	-[b]	0.8	1.0	-[c]	-[c]	1.0[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	0.2	0.2	0.07	0.08	1.5
SC_CA[f]	Swift/Cataract watershed	36	49	18	23	-[c]	-[c]	24[d]
KC1	Kilmarnock Creek at the mouth	81	122	95	166	18	24	191
PC1	Porter Creek at the mouth	2	3	1	1	1	1	16
LE1	Leask Creek at the mouth	42	59	114	159	-[c]	-[c]	-[c]
WC1	Wolfram Creek at the mouth	21	33	14	19	-[c]	-[c]	-[c]
TC1	Thompson Creek at the mouth	14	18	15	20	0.2	0.2	27
GH1	Greenhills Creek at the mouth	4	6	2	2	1	1	22
WLC1	West Line Creek at the mouth	26	39	9	11	-[c]	-[c]	-[c]
LC1	Line Creek at the mouth	8	12	5	7	0.2	0.4	12
DC1	Dry Creek at the mouth	0.1	0.2	1	4	2	10	44
BC1	Bodie Creek at the mouth	69	85	42	40	-[c]	-[c]	-[c]
GT1	Gate Creek at the mouth	19	30	9	15	-[c]	-[c]	-[c]
EC1	Erickson Creek at the mouth	11	12	17	19	1	3	23
DC1_EVO	Dry Creek (EVO) at the mouth	4	6	20	41	2	3	42
HM1	Harmer Creek at the mouth	1	2	5	9	1	1	10
GR1[g,h]	Grave Creek at the mouth	-	-	3	5	0.3	0.5	6
WH1	Wheeler Creek at the mouth	0.02	0.1	5	35	17	60	62
SS1	Snowslide Creek at the mouth	0.02	0.1	0.02	0.1	0.0	0.1	0.1
CB1	Carbon Creek at the mouth	0.01	0.1	0.01	0.1	0.0	0.1	0.1

Notes: Refer to Page 65 (that follows Table 5-4) for details.

Table 5-4 Estimated Sulphate Concentrations (mg/L) in Tributaries of the Fording and Elk Rivers and Michel Creek under Average Flows

Node ID	Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 -2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	137	197	136	196	136	196	197
TS1[(a)]	North (Turnbull) Spoil	-[(b)]	-[(b)]	293	381	-[(c)]	-[(c)]	775[(d)]
CC1	Clode Creek at the mouth	289	381	374	497	725	997	1009
SP1[(a)]	Swift Pit	-[(b)]	-[(b)]	641	787	-[(c)]	-[(c)]	787[(d)]
LF2[(a, e)]	Lower Fording 2	-[(b)]	-[(b)]	333	363	324	351	602
SC_CA[(f)]	Swift/Cataract watershed	1508	1789	2122	2190	-[(c)]	-[(c)]	2190[(d)]
KC1	Kilmarnock Creek at the mouth	442	664	530	800	393	534	800
PC1	Porter Creek at the mouth	405	464	503	653	841	1070	1070
LE1	Leask Creek at the mouth	290	378	1792	2371	-[(c)]	-[(c)]	-[(c)]
WC1	Wolfram Creek at the mouth	414	621	521	727	-[(c)]	-[(c)]	-[(c)]
TC1	Thompson Creek at the mouth	573	735	840	1101	1700	2061	2061
GH1	Greenhills Creek at the mouth	554	799	564	816	577	908	1130
WLC1	West Line Creek at the mouth	960	1260	960	1260	-[(c)]	-[(c)]	-[(c)]
LC1	Line Creek at the mouth	155	216	186	259	196	258	259
DC1	Dry Creek at the mouth	8	9	8	9	11	16	17
BC1	Bodie Creek at the mouth	960	1020	375	369	-[(c)]	-[(c)]	-[(c)]
GT1	Gate Creek at the mouth	770	1190	795	1217	-[(c)]	-[(c)]	-[(c)]
EC1	Erickson Creek at the mouth	611	673	742	826	950	1109	1109
DC1_EVO	Dry Creek (EVO) at the mouth	597	880	656	966	1050	1518	1518
HM1	Harmer Creek at the mouth	169	215	184	234	290	358	358
GR1[(g, h)]	Grave Creek at the mouth	-	-	116	159	179	243	243
WH1	Wheeler Creek at the mouth	4	6	7	14	66	115	115
SS1	Snowslide Creek at the mouth	5	6	5	6	5	6	6
CB1	Carbon Creek at the mouth	4	5	4	5	4	6	6

Notes: Refer to Page 65 for details.

Notes for Tables 5-2 through 5-4:

[a] Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

[b] No monitoring data available.

[c] Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

[d] Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

[e] Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

[f] For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

[g] No observed data available for Grave Creek at the mouth.

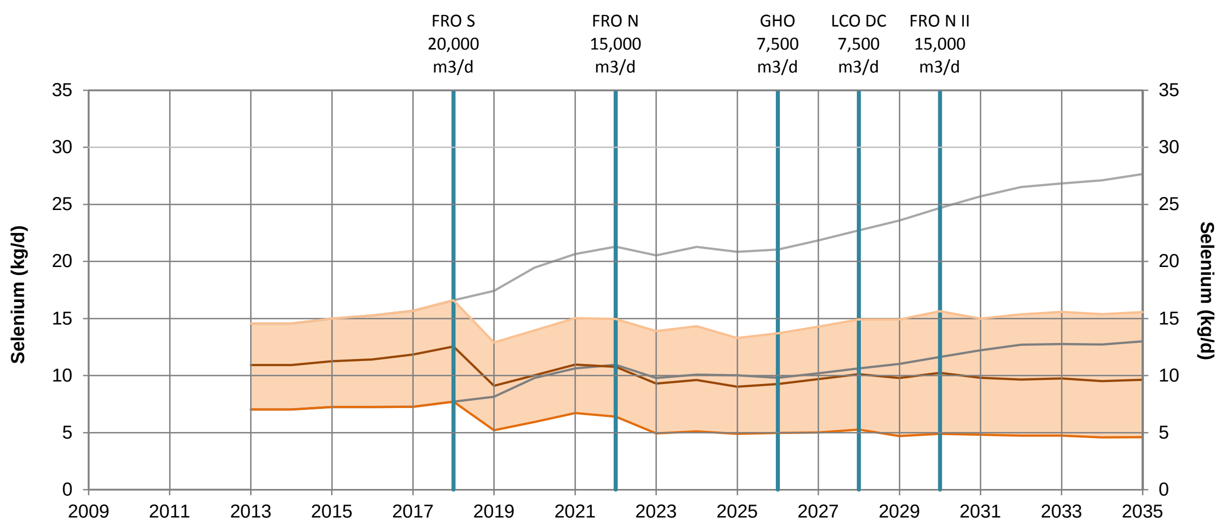
[h] For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

5.3 Predicted Loads

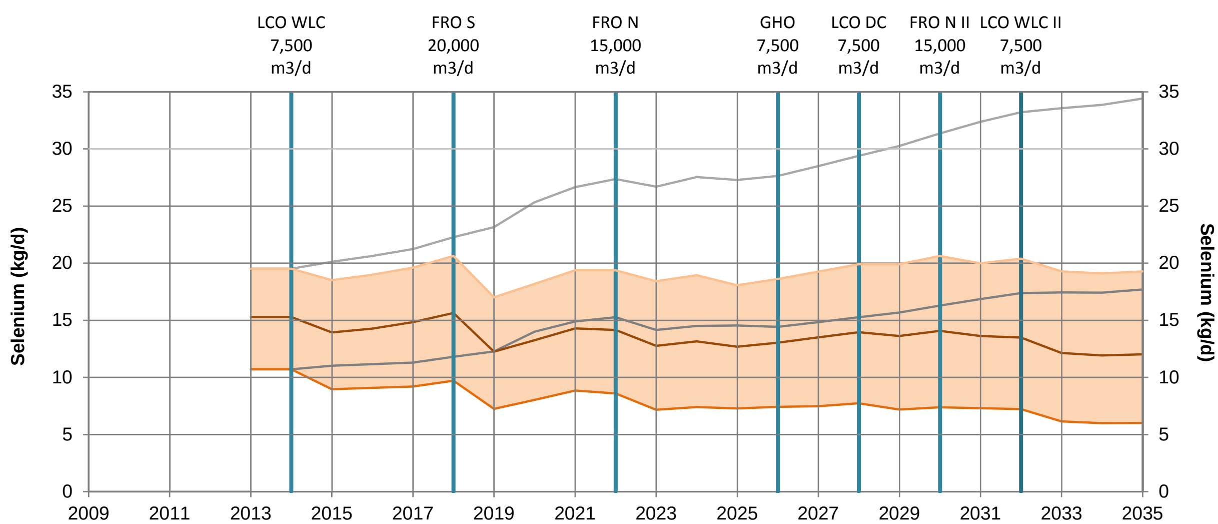
Predicted selenium, nitrate and sulphate loads in the Fording and Elk rivers and Michel Creek under low, average and high flows are shown in Figures 5-7 to 5-12. The predictions are shown as time series plots and, for context, include commissioning dates for the AWTFs according to the initial implementation plan.

Figure 5-7 Average Selenium Loads at Order Stations in the Fording and Elk Rivers

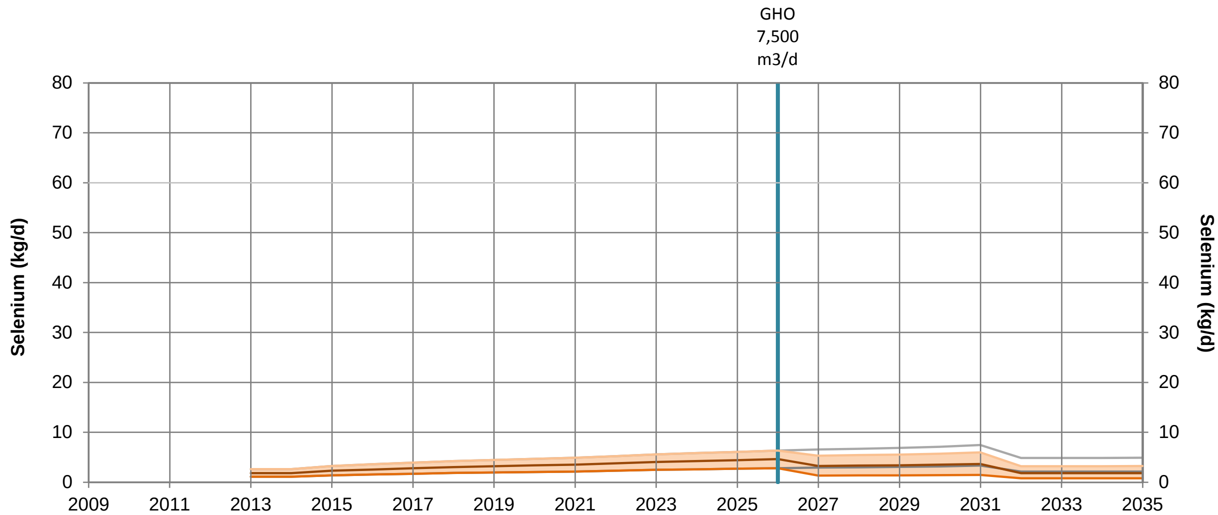
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



(b) Fording River at the Mouth, FR5 (EMS 0200396)



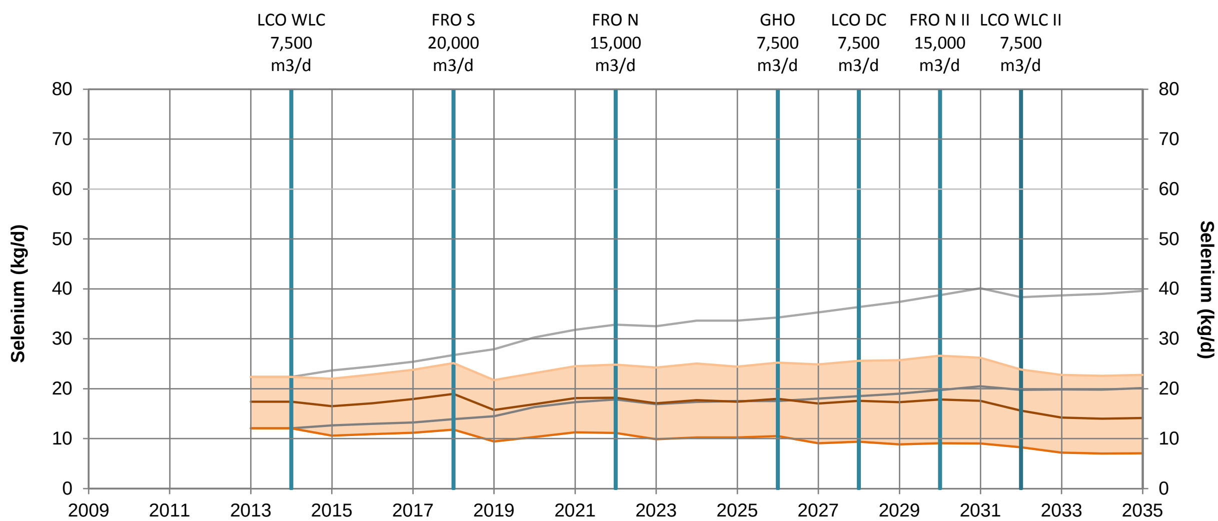
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



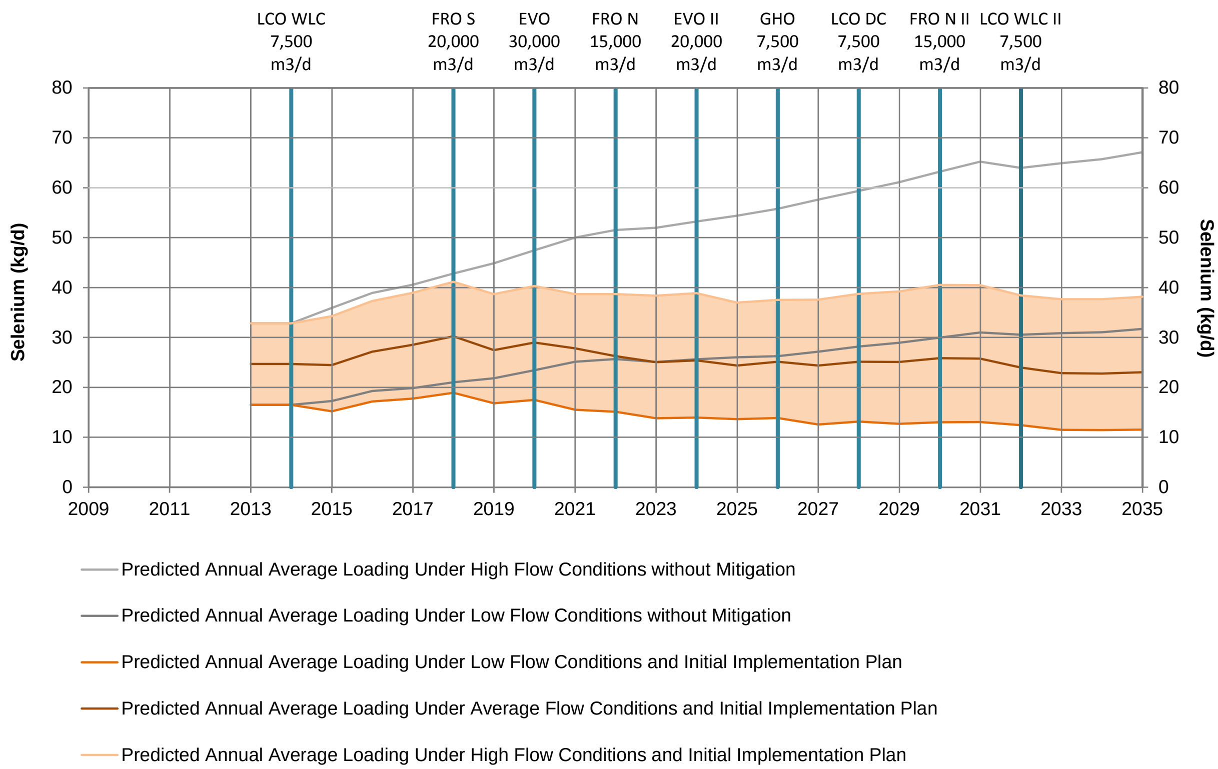
Note:

Loads are predicted to decrease in 2031 due to filling of Cougar Pit at GHO.

(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)

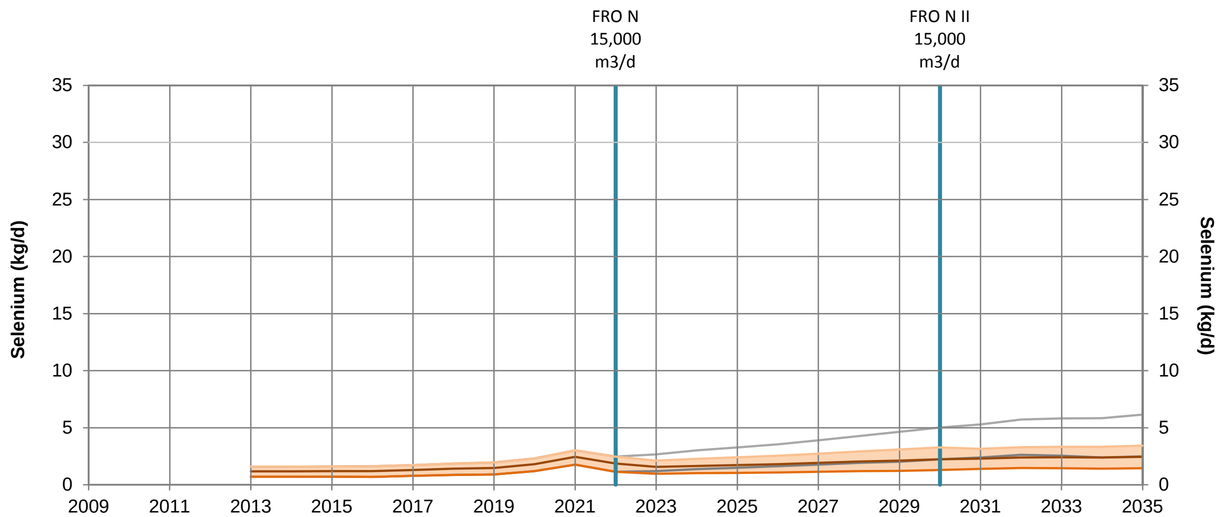


Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted load for a given year is plotted at the end of the year.

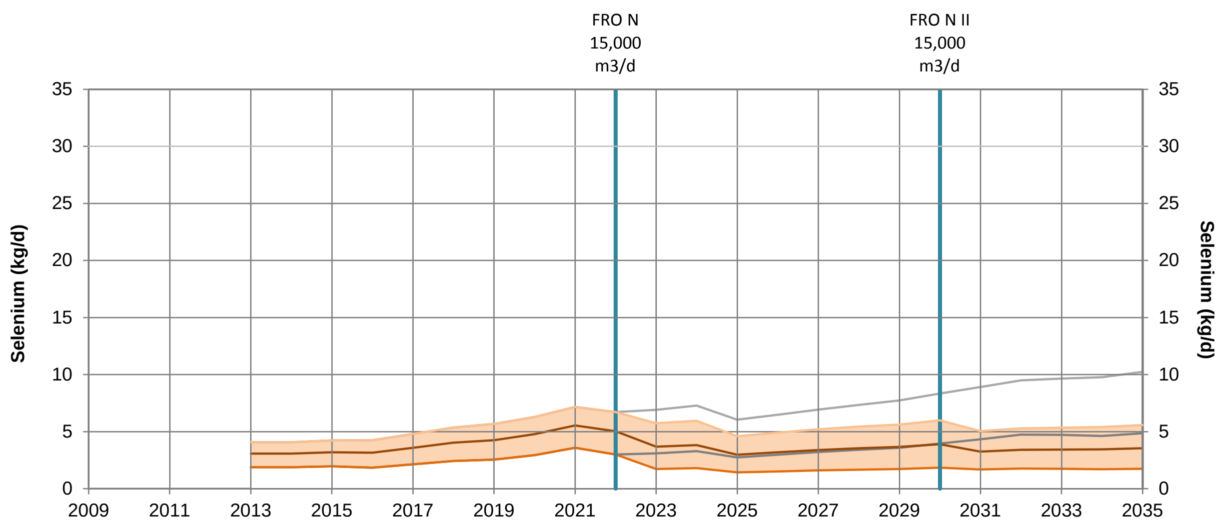
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-8 Average Selenium Loads at Other Nodes in the Fording and Elk Rivers and Michel Creek

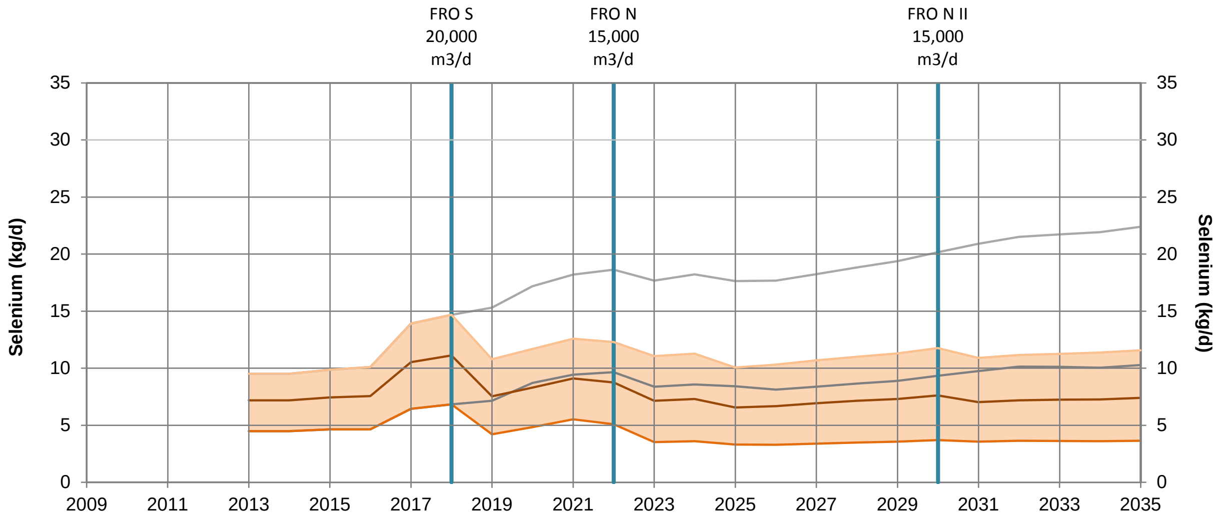
(a) Fording River Downstream of Henretta Creek (FR1)



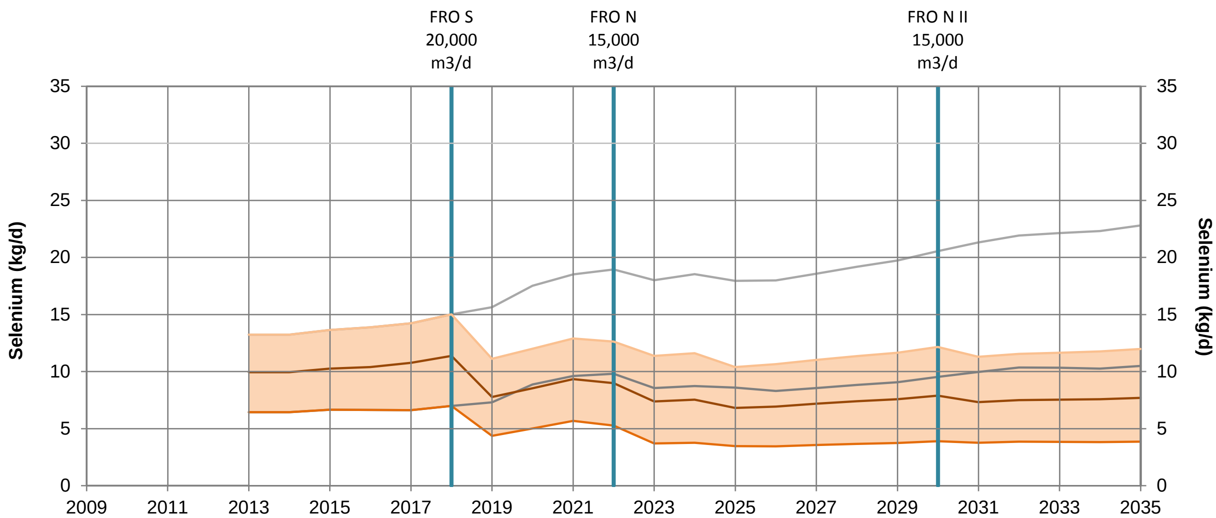
(b) Fording River Downstream of Clode Creek (FR2)



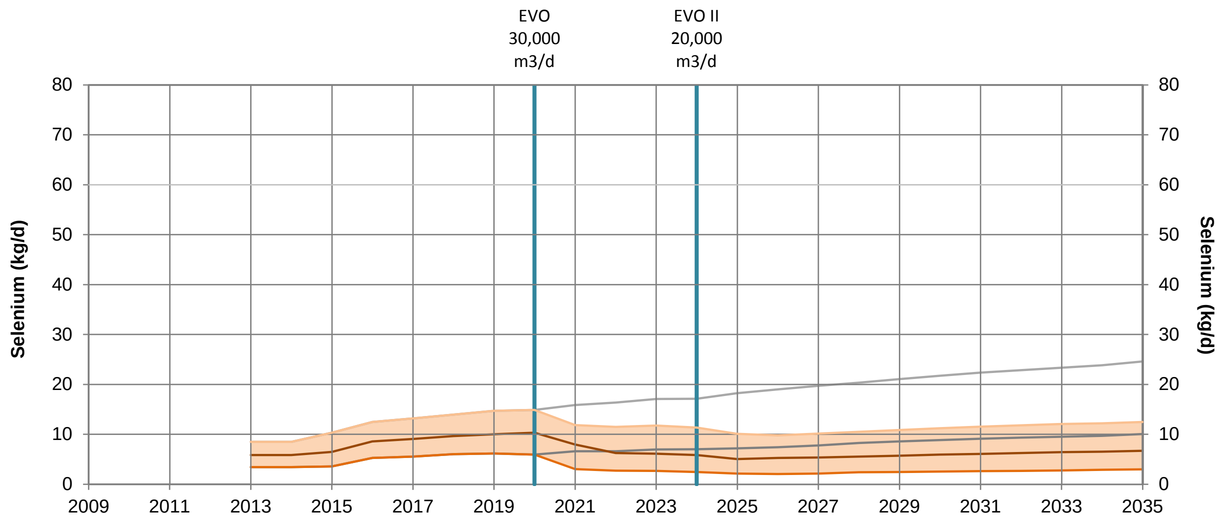
(c) Fording River Between Swift and Cataract Creeks (FR3)



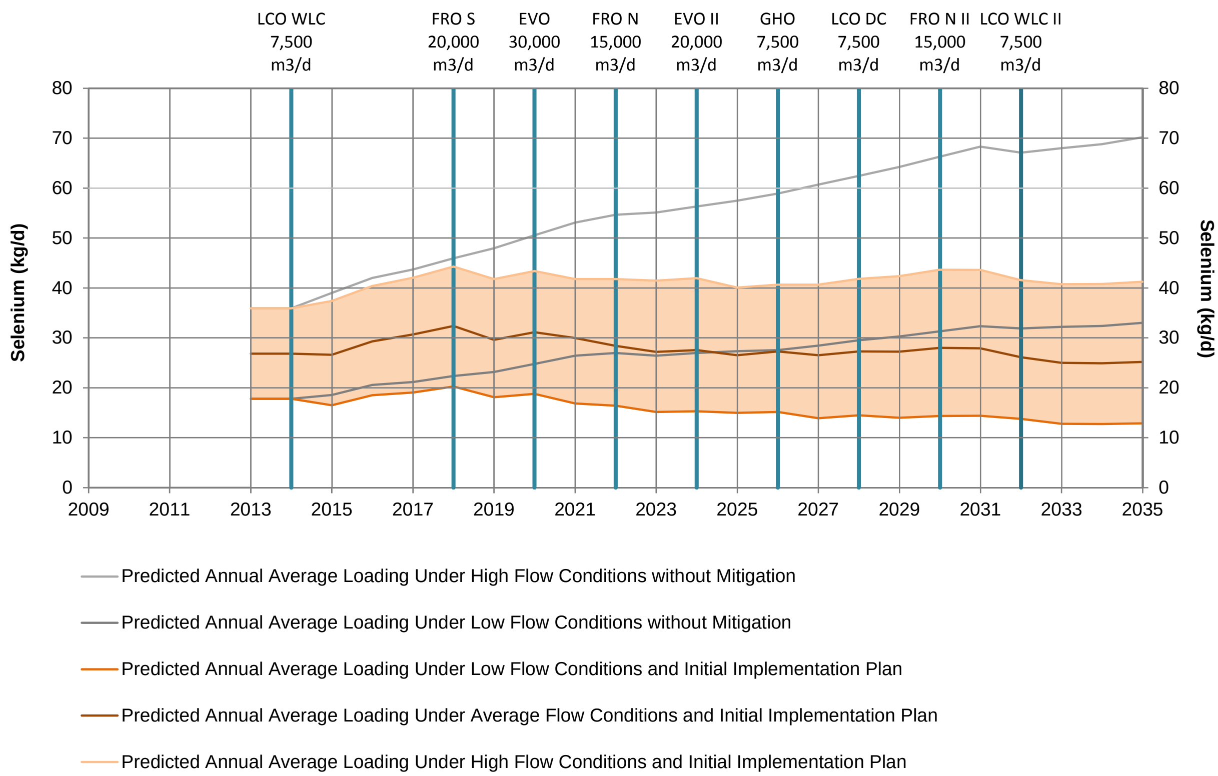
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)

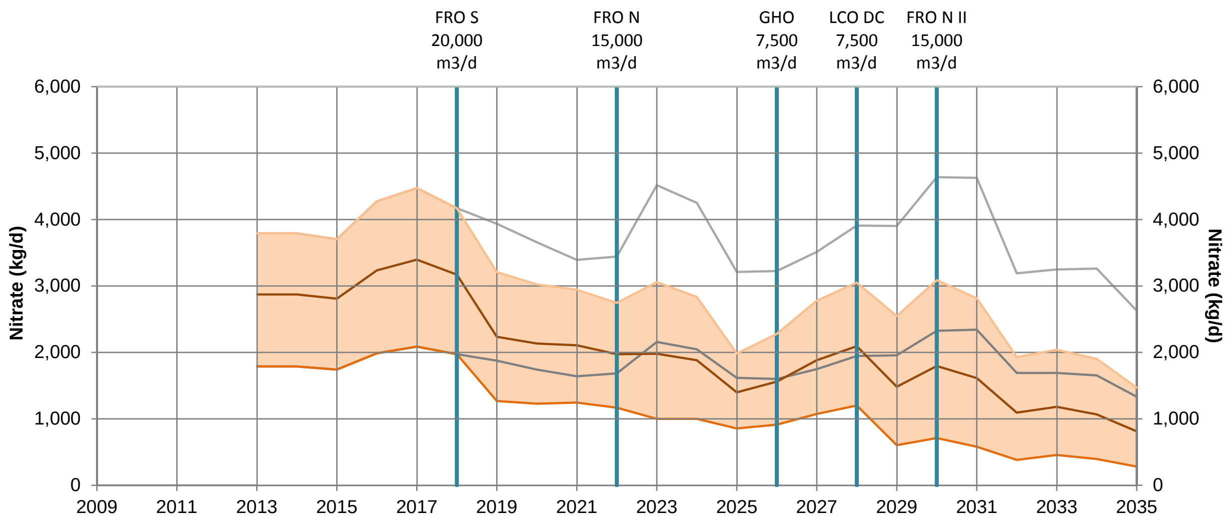


Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted load for a given year is plotted at the end of the year.

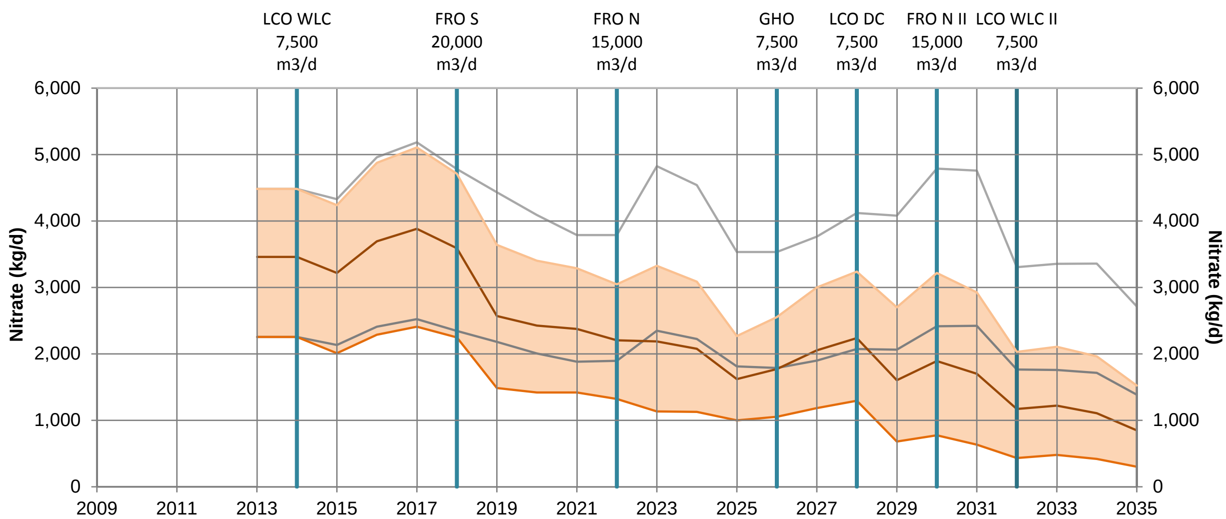
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-9 Average Nitrate Loads at Order Stations in the Fording and Elk Rivers

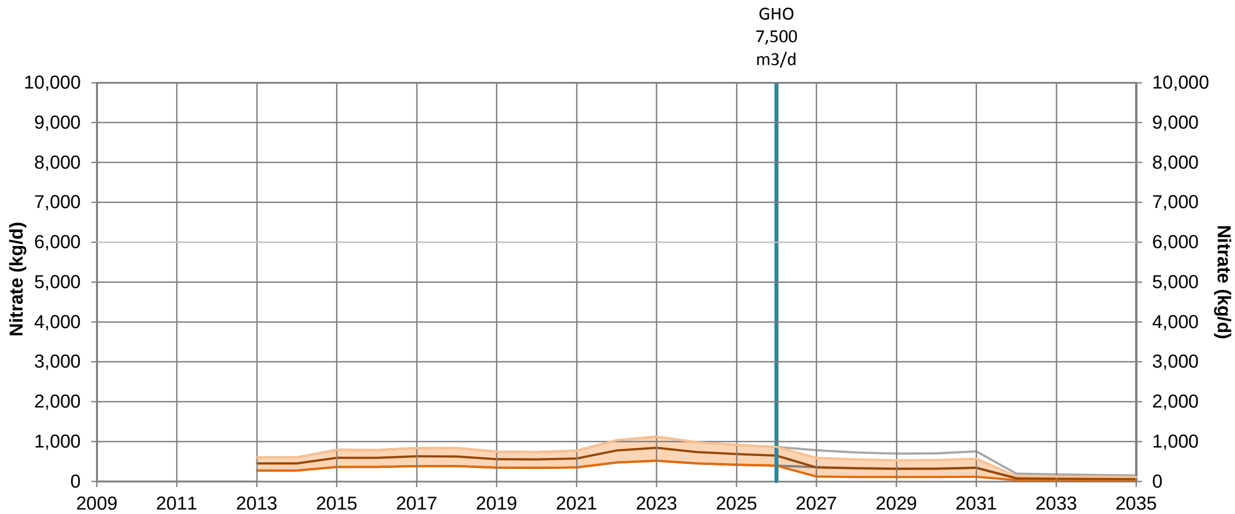
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



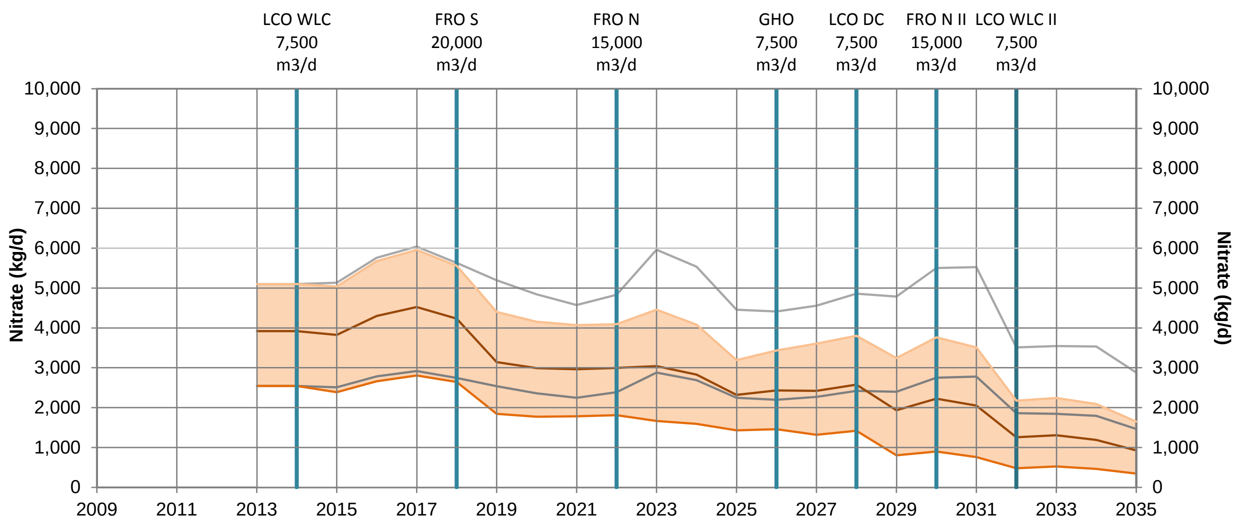
(b) Fording River at the Mouth, FR5 (EMS 0200396)



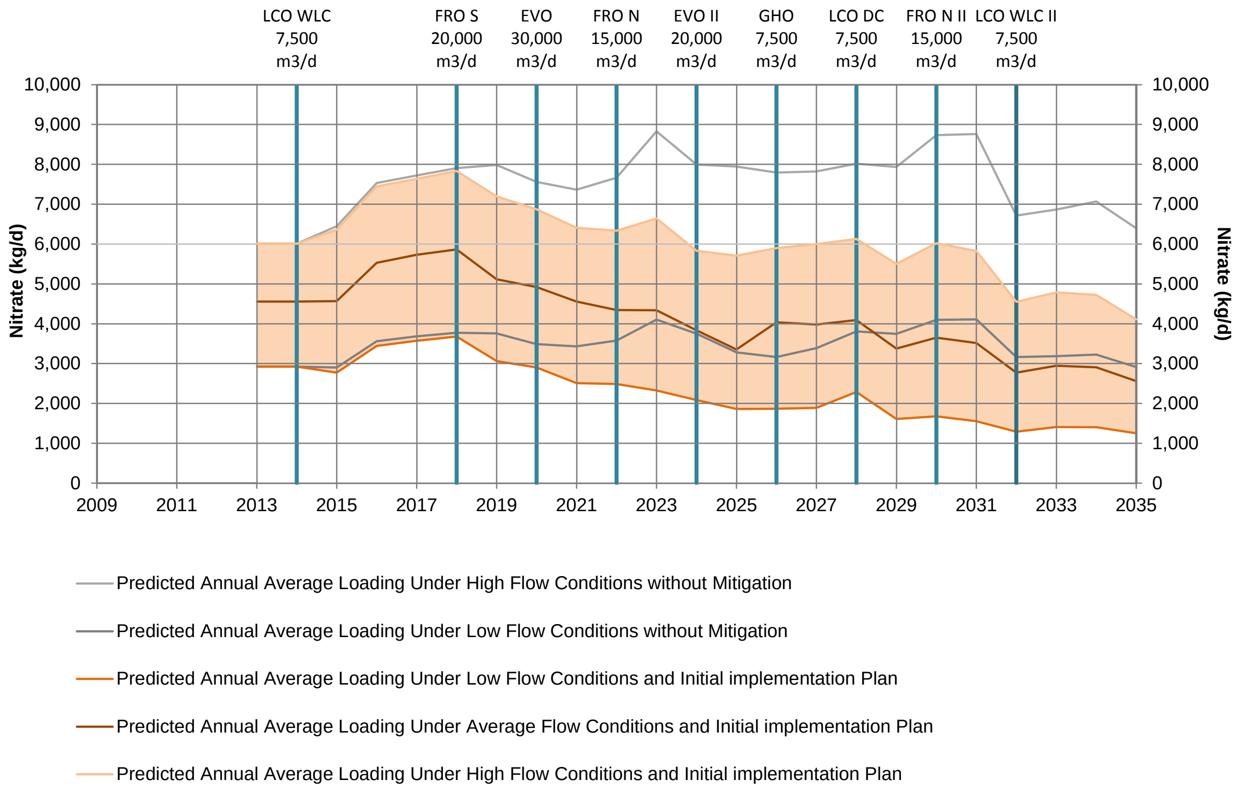
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)

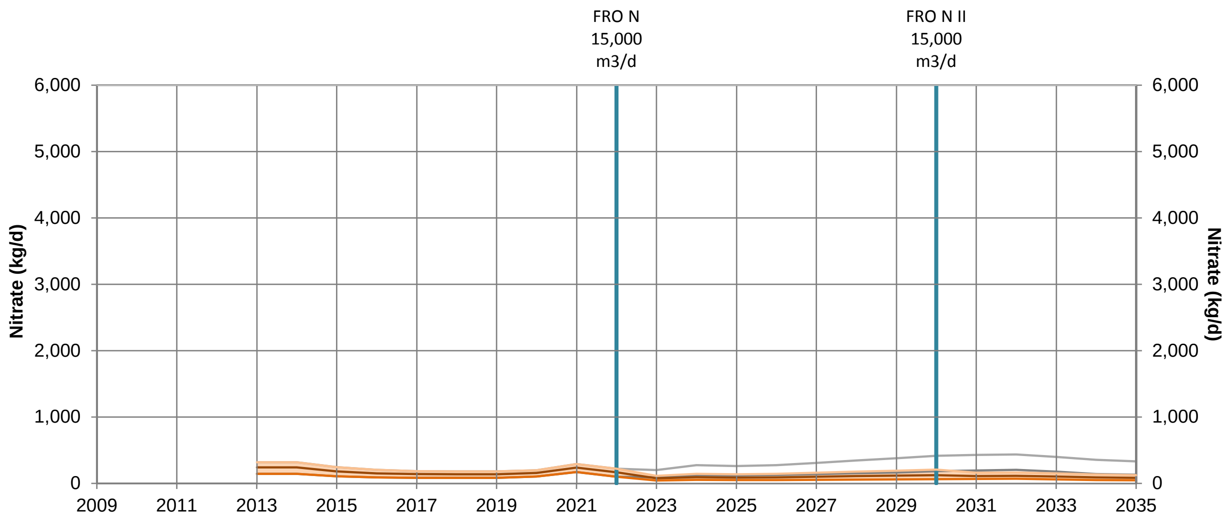


Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted load for a given year is plotted at the end of the year.

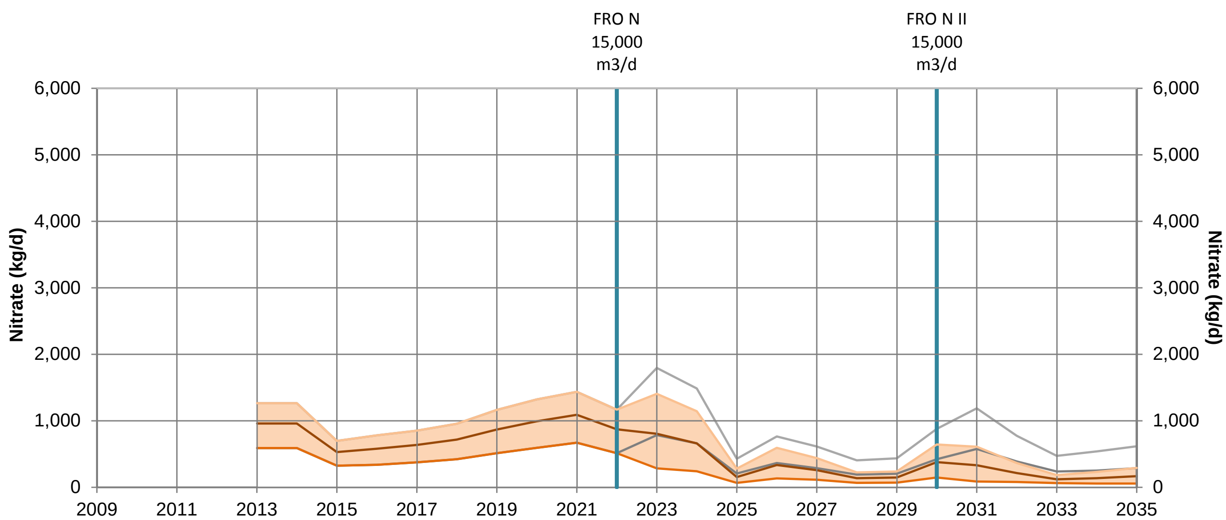
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-10 Average Nitrate Loads at Other Nodes in the Fording and Elk Rivers and Michel Creek

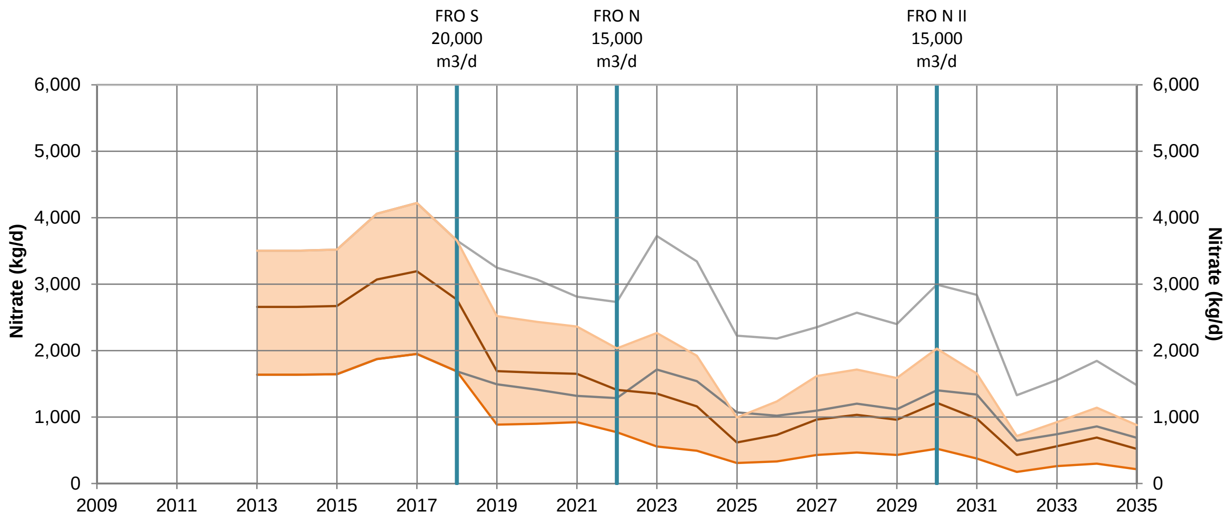
(a) Fording River Downstream of Henretta Creek (FR1)



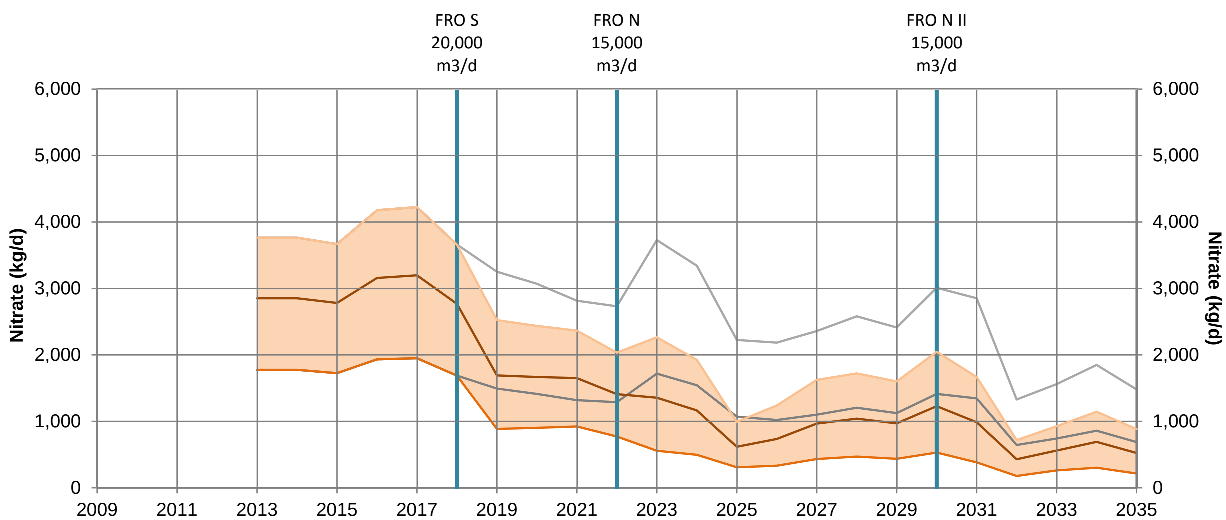
(b) Fording River Downstream of Clode Creek (FR2)



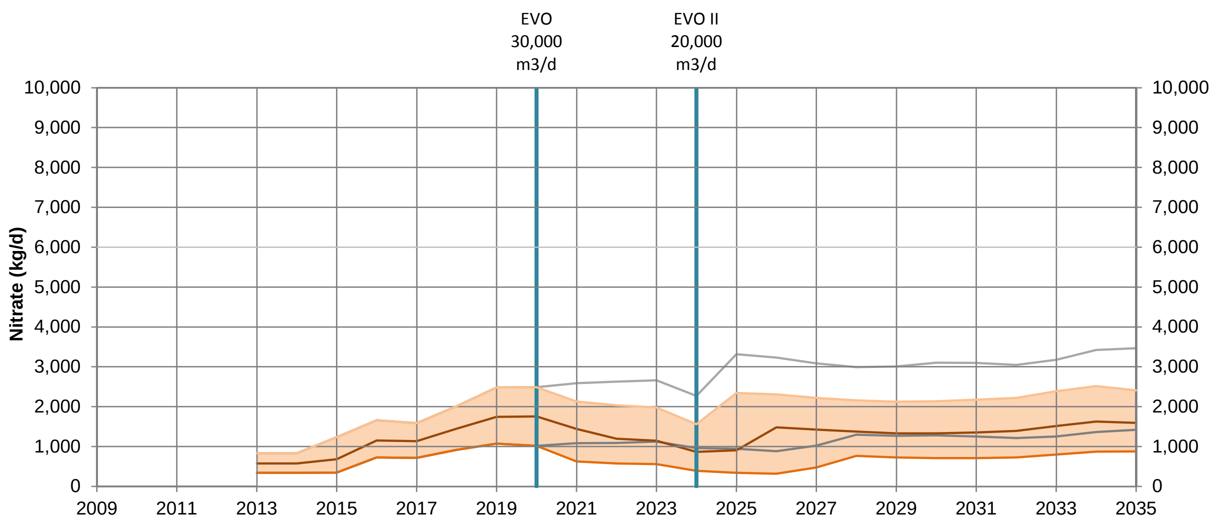
(c) Fording River Between Swift and Cataract Creeks (FR3)



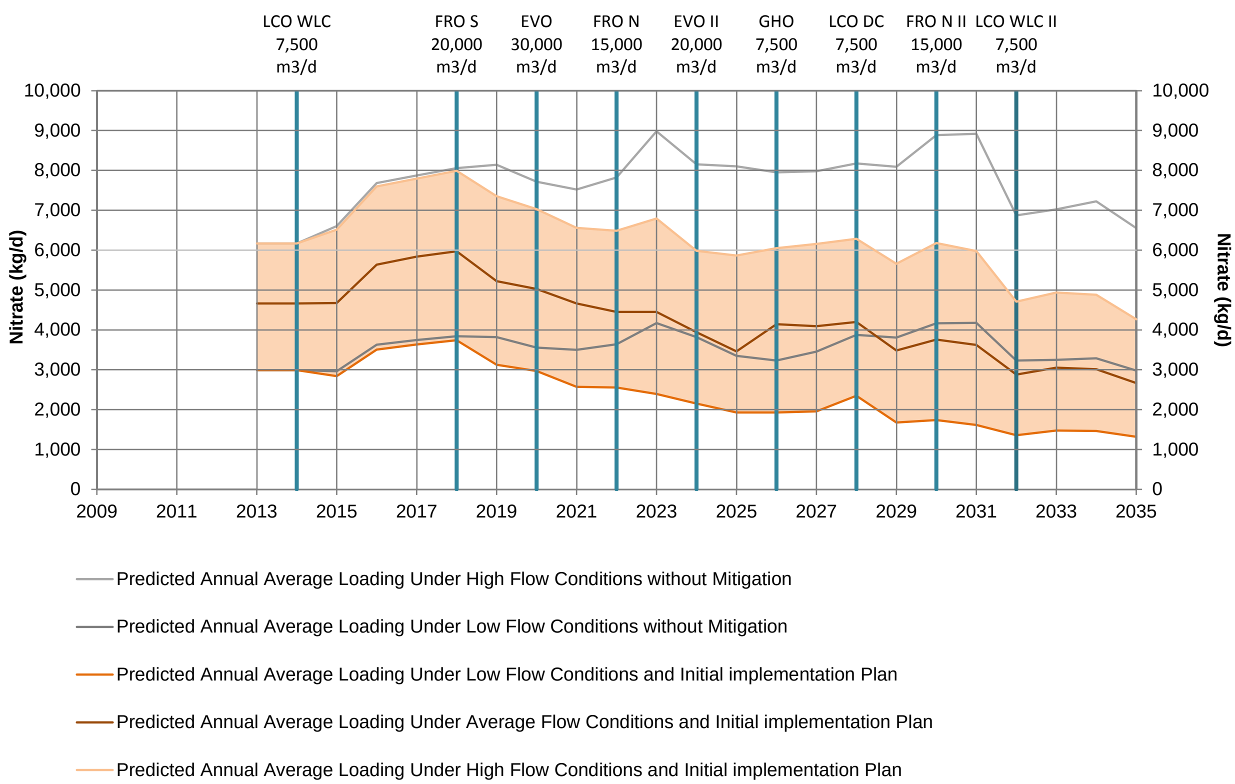
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)

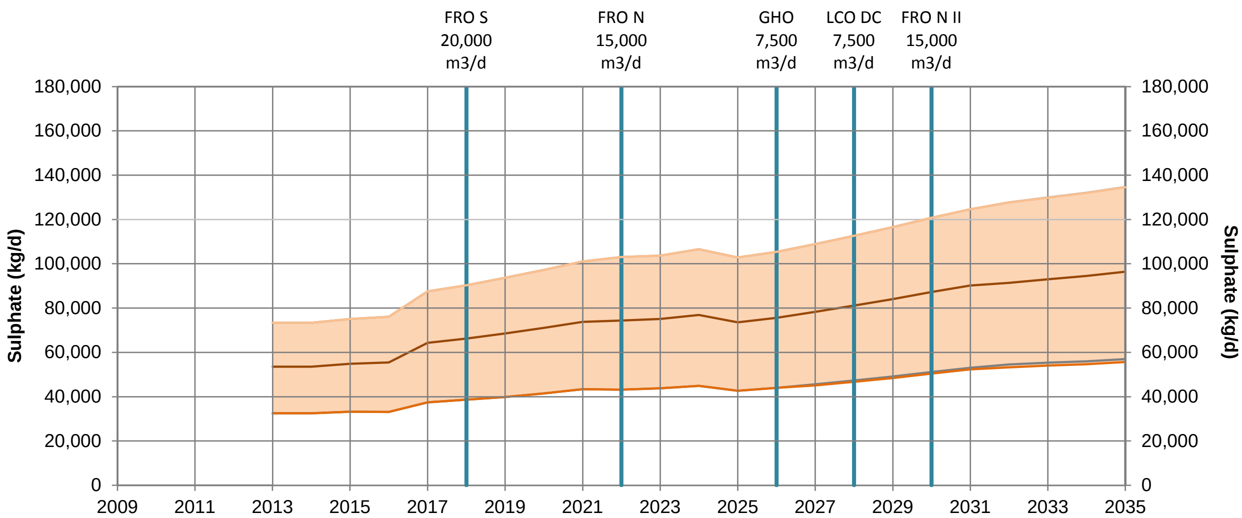


Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted load for a given year is plotted at the end of the year.

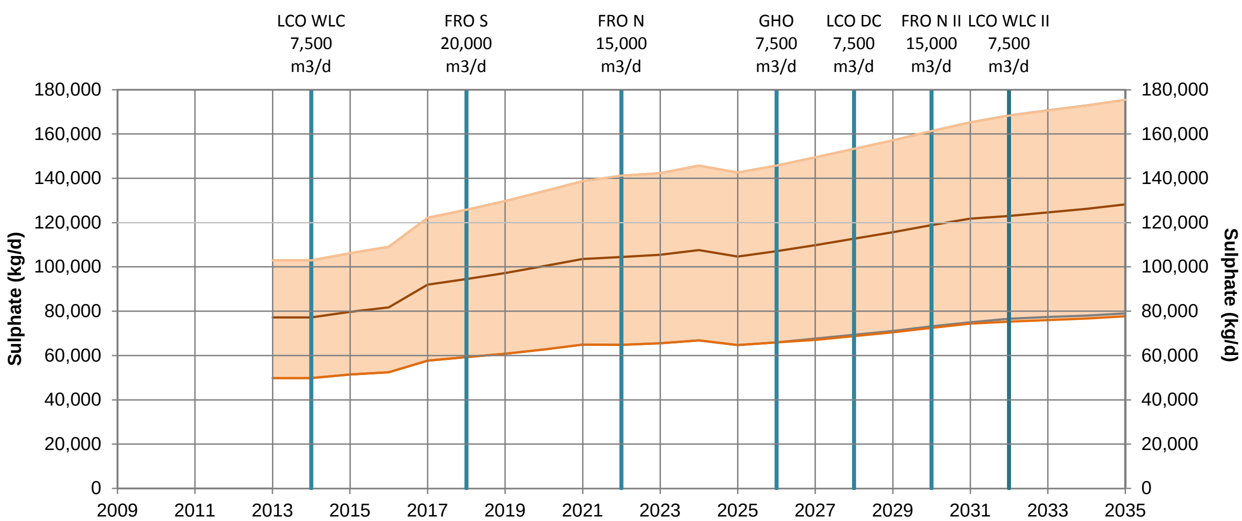
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-11 Average Sulphate Loads at Order Stations in the Fording and Elk Rivers

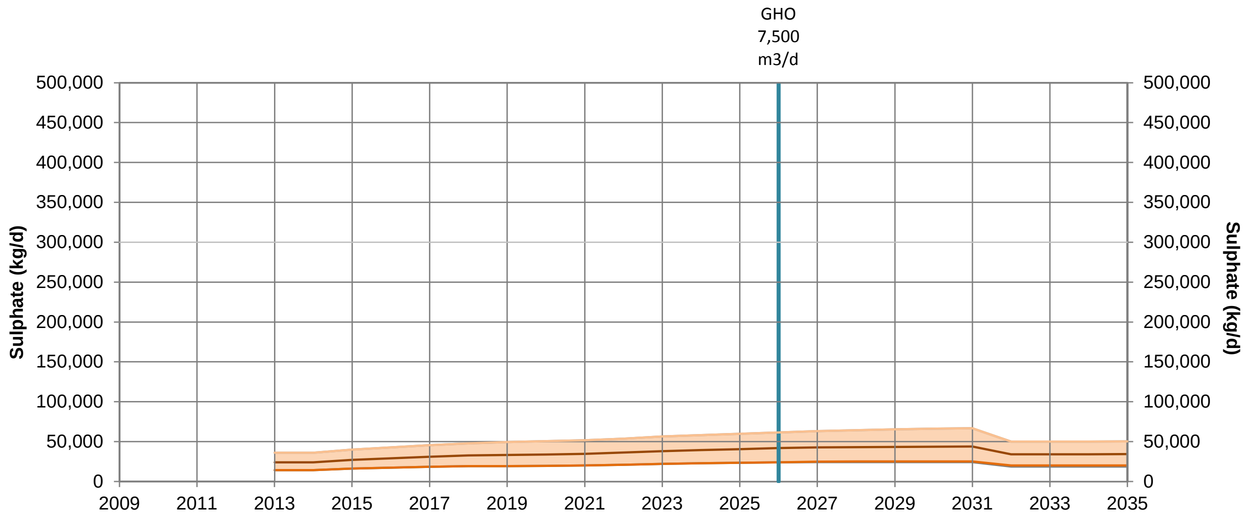
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



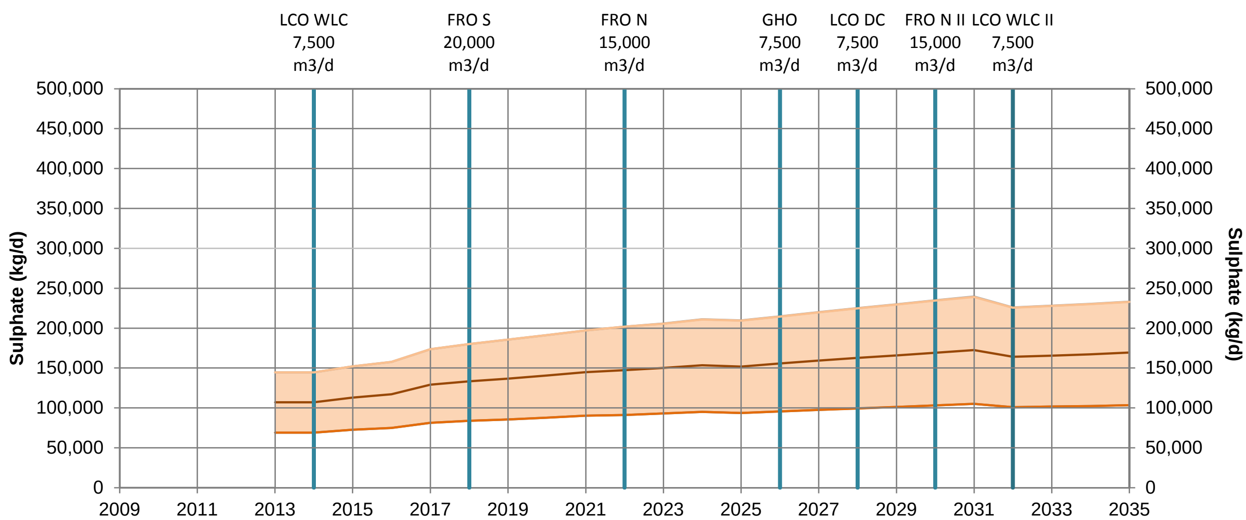
(b) Fording River at the Mouth, FR5 (EMS 0200396)



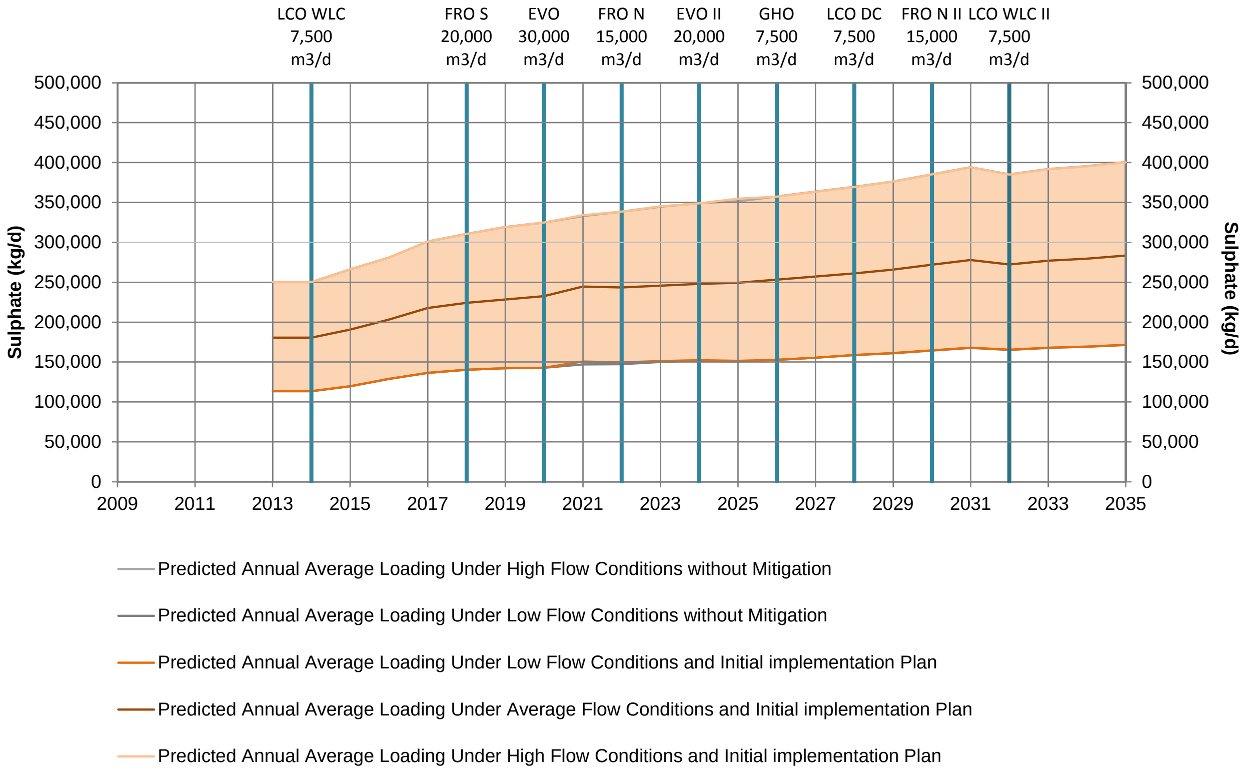
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)

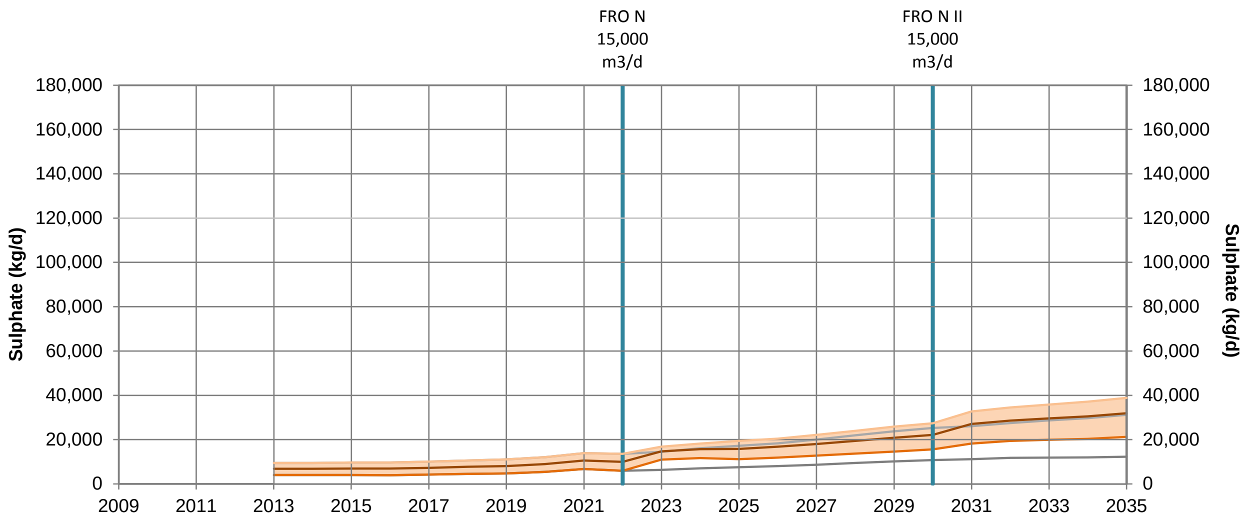


Note: The model was run with the average (P50) geochemical release rate under low, average and flows. The predicted load for a given year is plotted at the end of the year.

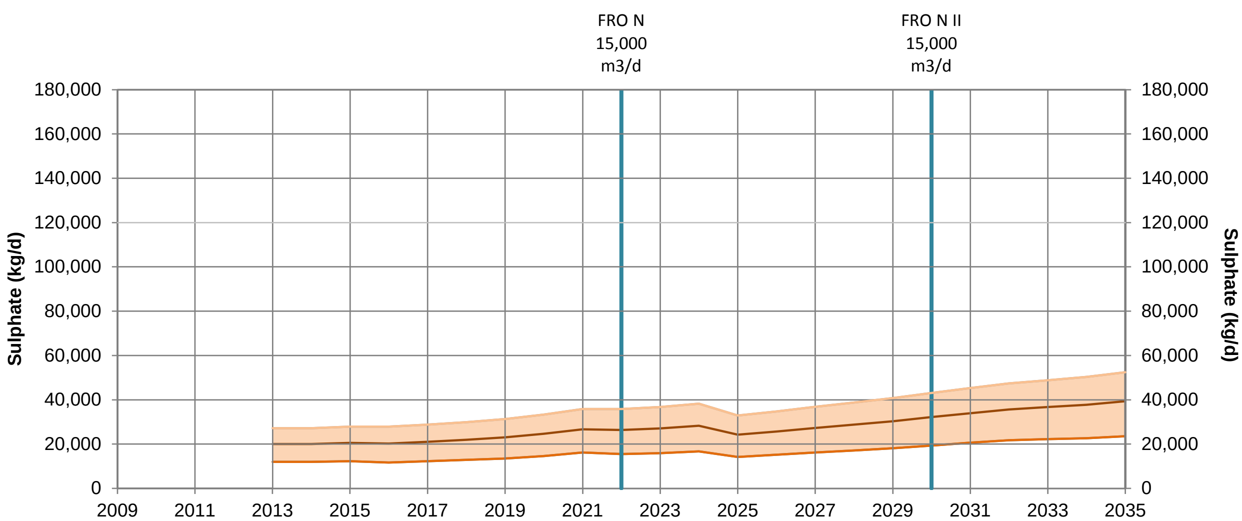
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-12 Average Sulphate Loads at Other Nodes in the Fording and Elk Rivers and Michel Creek

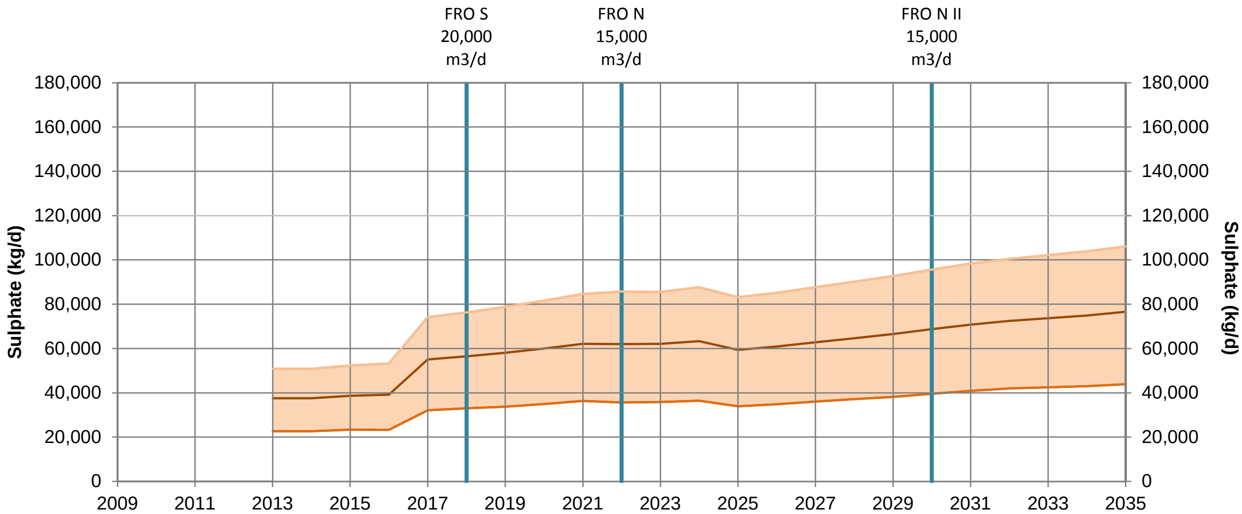
(a) Fording River Downstream of Henretta Creek (FR1)



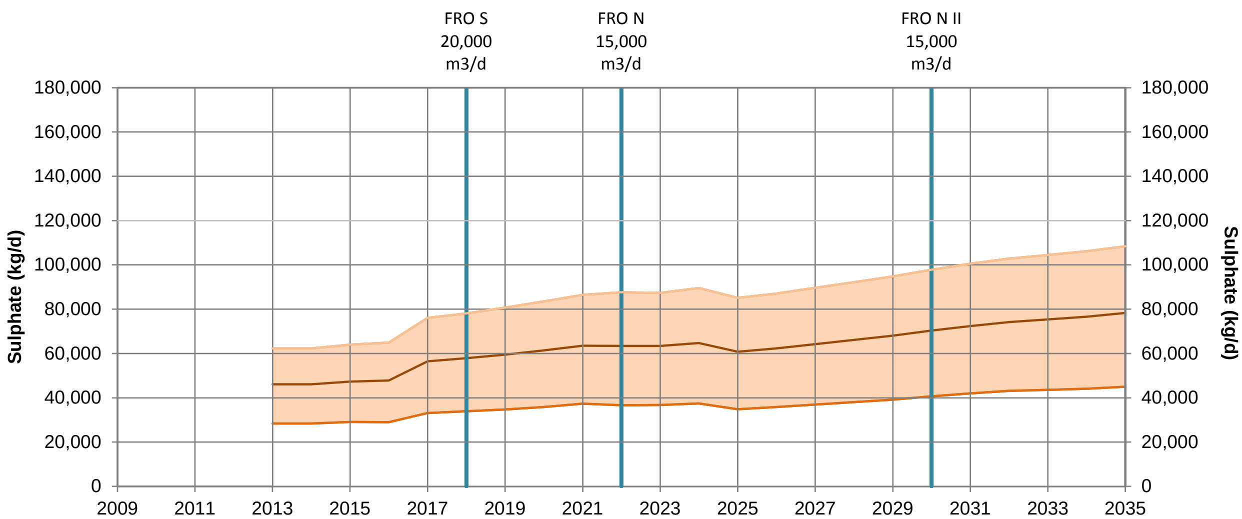
(b) Fording River Downstream of Clode Creek (FR2)



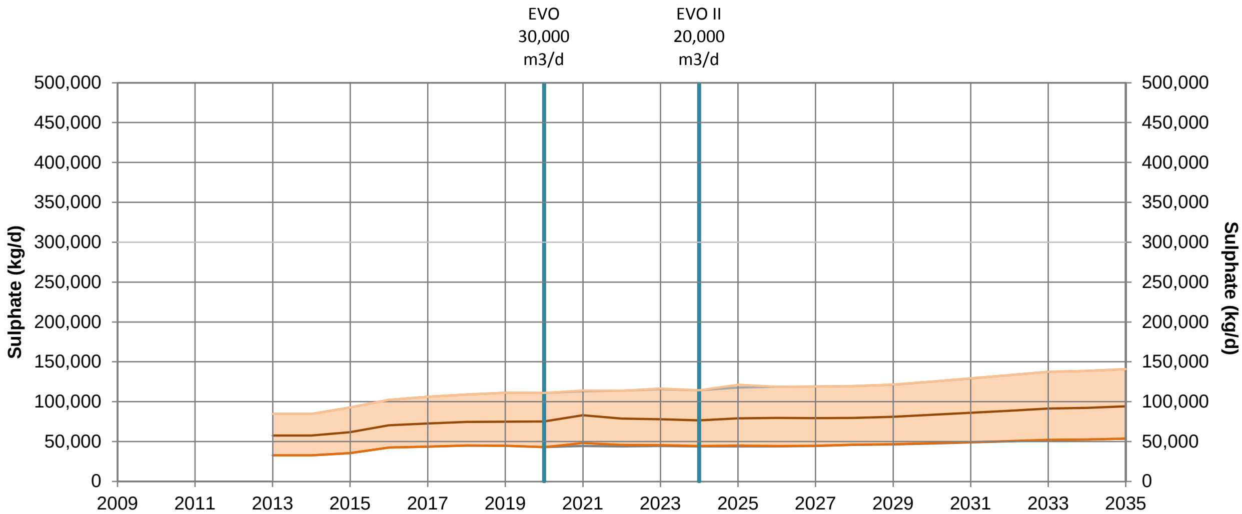
(c) Fording River Between Swift and Cataract Creeks (FR3)



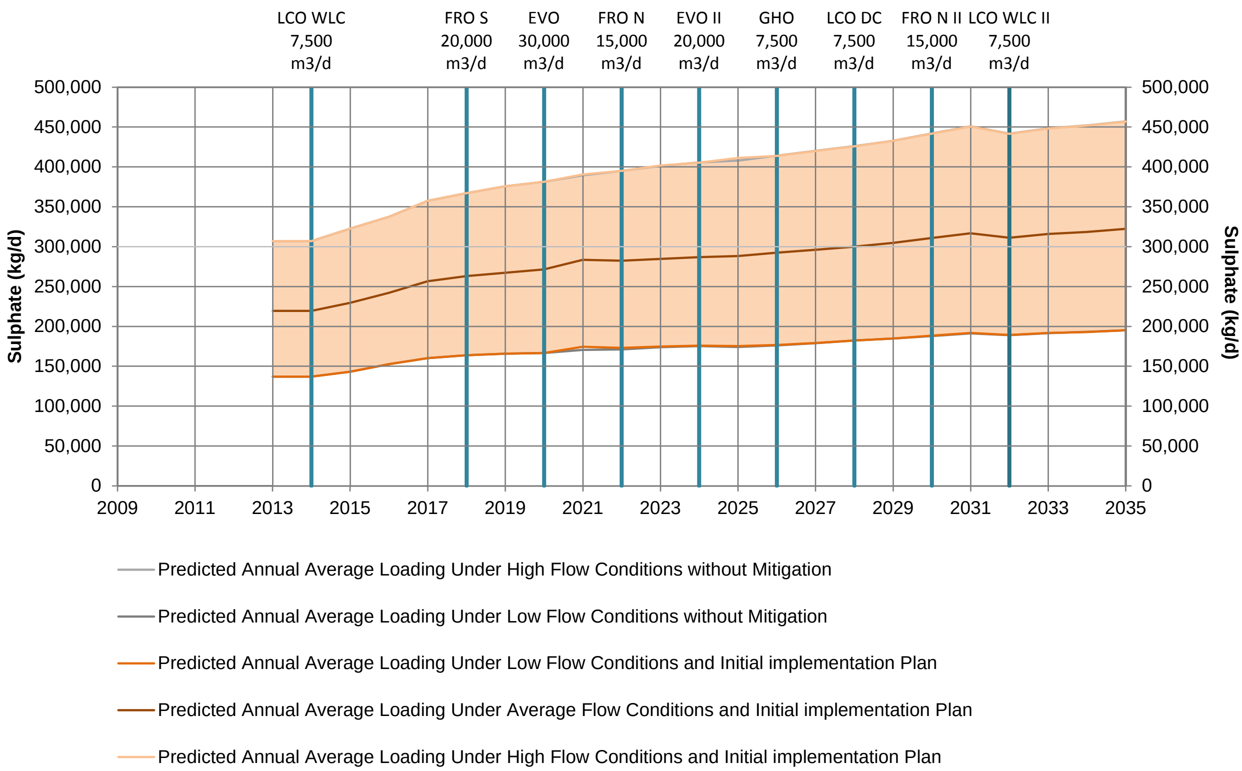
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)



Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted load for a given year is plotted at the end of the year.

LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

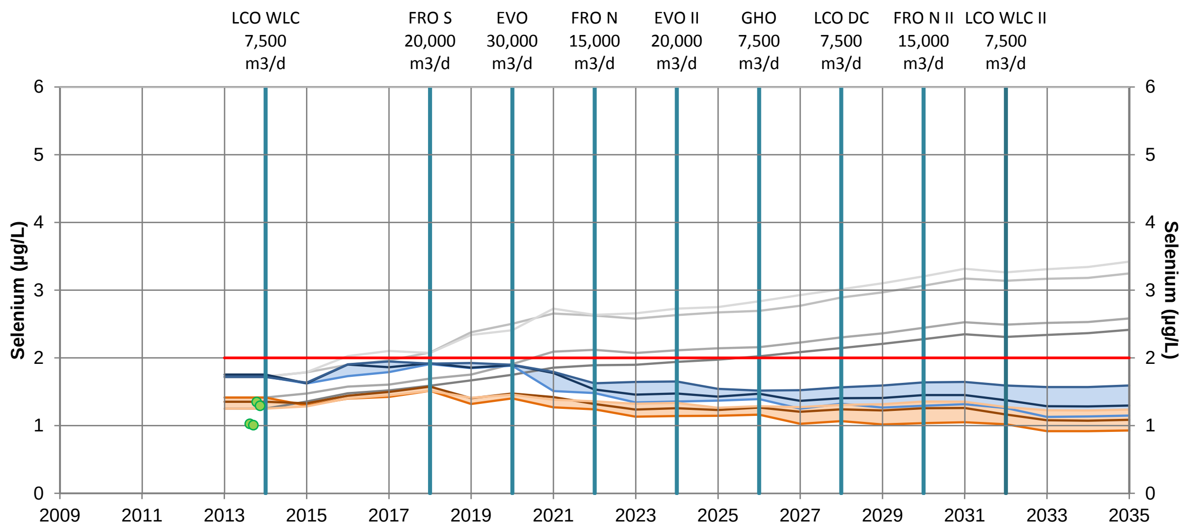
5.4 Lake Koocanusa

As discussed in Teck 2014b, the model tends to over-predict in-stream concentrations (i.e., relative bias > 1). From a planning perspective, this bias was deemed problematic only for predicted selenium concentrations in Lake Koocanusa (LK2). Because there are limited data at LK2 to correct for bias, the station immediately upstream (ER5) was used. The average over-prediction at ER5 is 1 µg/L, which if not corrected would falsely generate long-term concentrations above the long-term target. To correct for bias, loads at ER5 were reduced by the amount of bias in each month before the mass balance is calculated in the lake. Bias correction at LK2 allows the model to more accurately reflect expected concentrations. Bias was not corrected at other Order stations.

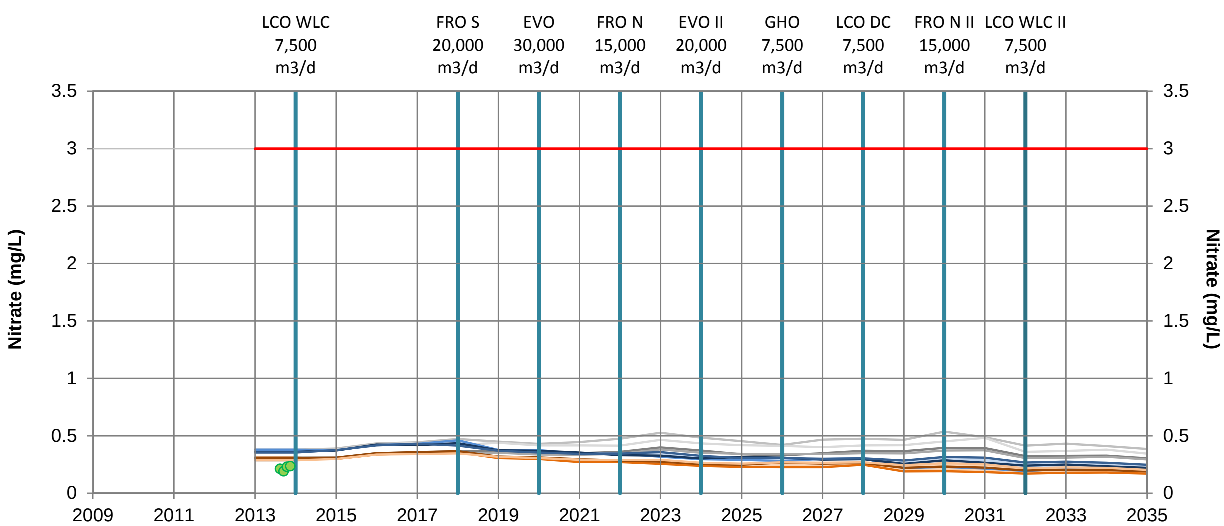
Bias-corrected selenium, nitrate and sulphate concentrations and loadings in LK2 are presented in Figures 5-13 and 5-14.

Figure 5-13 Predicted Selenium, Nitrate and Sulphate Concentrations in Lake Koocanusa

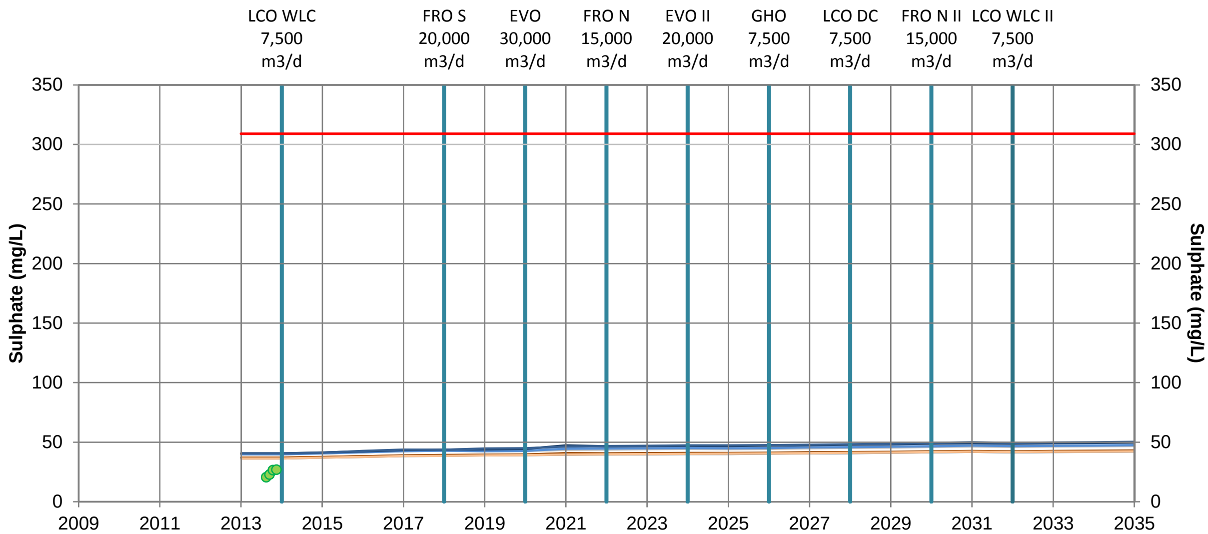
a. Selenium



b. Nitrate



c. Sulphate



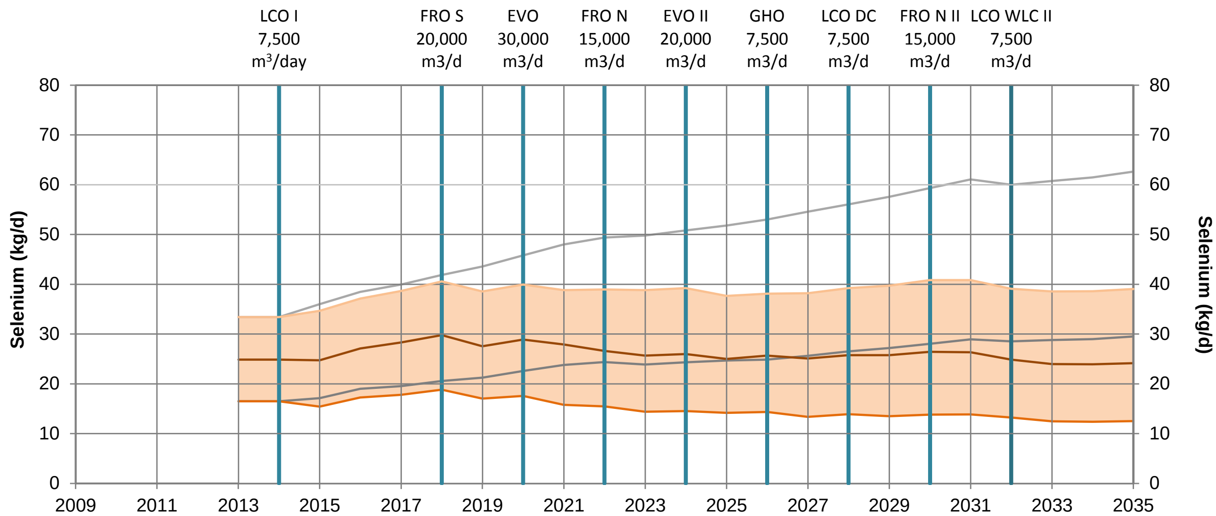
- Predicted Maximum Monthly Concentration Under Low Flow Conditions without Mitigation
- Predicted Maximum Monthly Concentration Under High Flow Conditions without Mitigation
- Predicted Annual Average Concentration Under High Flow Conditions without Mitigation
- Predicted Annual Average Concentration Under Low Flow Conditions without Mitigation
- Predicted Maximum Monthly Concentration Under Low Flow Conditions and Initial Implementation Plan
- Predicted Maximum Monthly Concentration Under Average Flow Conditions and Initial Implementation Plan
- Predicted Maximum Monthly Concentration Under High Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under Low Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under Average Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under High Flow Conditions and Initial Implementation Plan
- Observed
- Long-term Target

Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year. Concentrations have been modified to account for model bias.

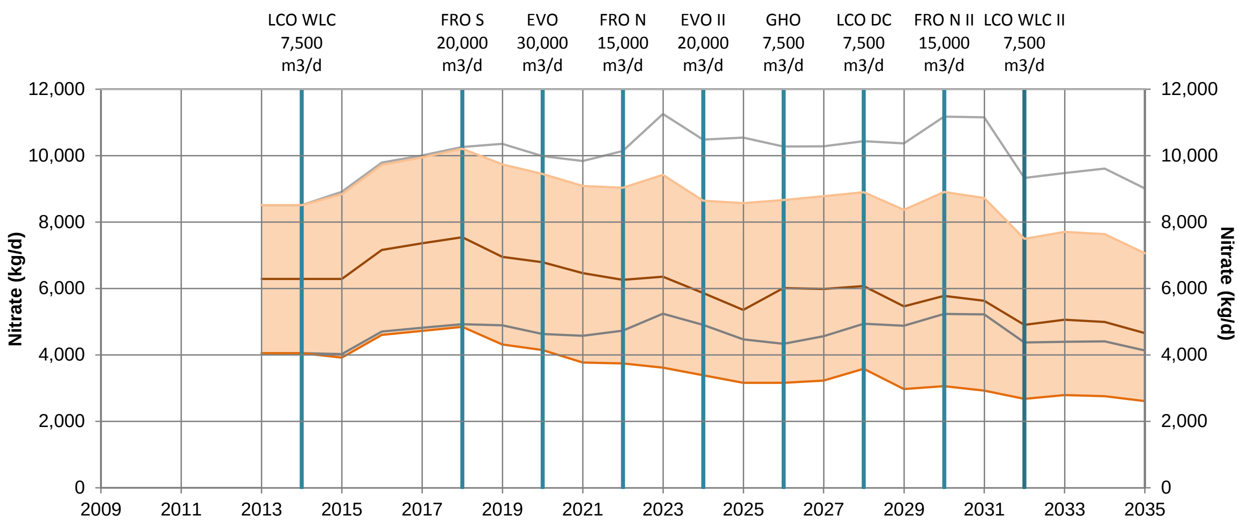
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure 5-14 Predicted Selenium, Nitrate and Sulphate Loads in Lake Koocanusa

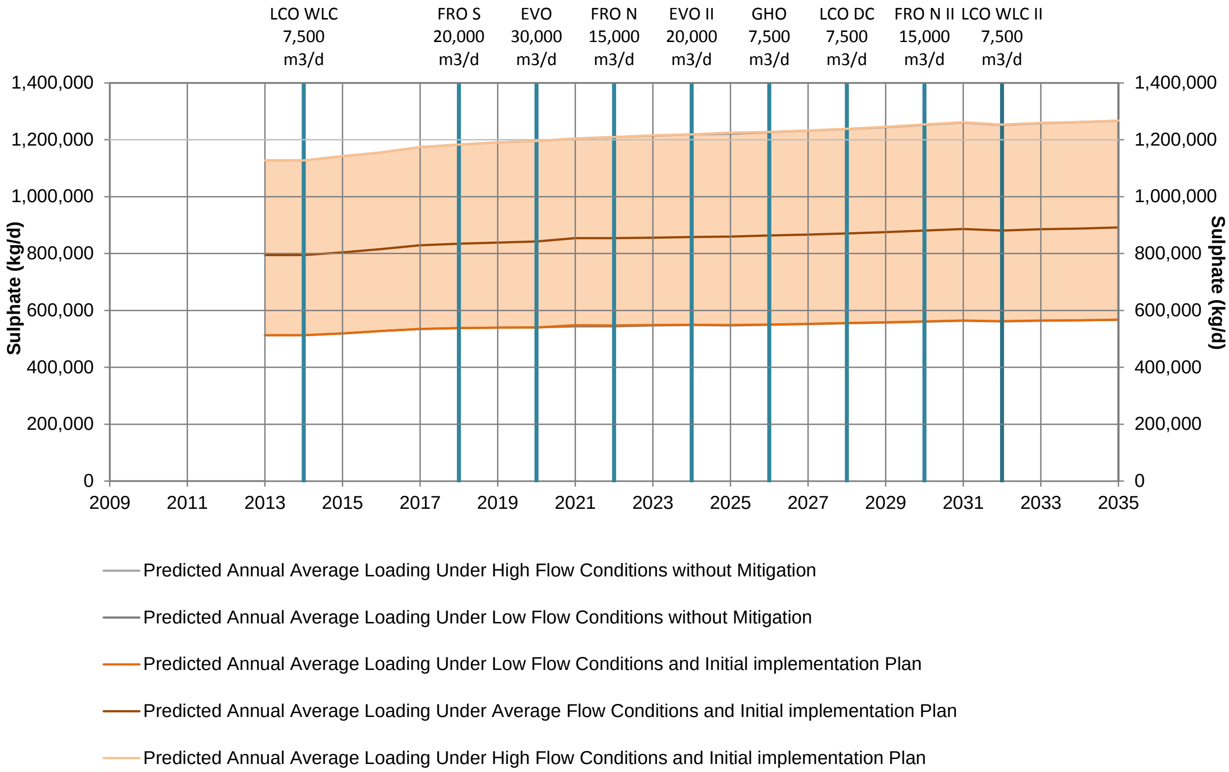
a. Selenium



b. Nitrate



c. Sulphate



Note: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted load for a given year is plotted at the end of the year. Loads have been modified to account for model bias.

LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

6 References

SRK Consulting (Canada) Inc. 2014. Consolidation of Geochemical Source Term Inputs and Methods for Elk Valley Water Quality Modelling. Prepared for Teck Coal Limited, June 2014.

Teck Coal Limited (Teck) 2014a. Elk Valley Water Quality Plan - Site Conditions Report. Prepared for Teck Coal by Golder Associates Ltd, July 2014.

Teck 2014b. Elk Valley Water Quality Plan – Water Quality Modelling Methods Report. Prepared for Teck Coal by Golder Associates Ltd, July 2014.

Appendix A

Potential Waste-Rock Covers

July 2014

This appendix presents information on waste-rock spoils that were screened for potential waste-rock covers at Teck's operations in the Elk Valley.

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LIST OF TABLES

Table A-1 Identification of Potential Waste-Rock Covers at Fording River Operations

Watershed	Percent Waste Rock in 2034 as part of Elk Valley Total	Waste-Rock Location	Year Available for Cover	Surface Area of Spoil at 3H:1V (ha)	Carried Forward for Evaluation?	Rationale
North (Turnbull) Spoil and Lake Mountain Creek	7%	Ex-pit	After 2034[a]	1,069	Yes	Relatively large ex-pit spoil (North Spoil)
Swift Creek and Cataract Creek	9%	Ex-pit	2030	397	Yes	Relatively large ex-pit spoil (South Spoil)
Lower Fording 2[b]/Swift Pit	2%	In-pit	After 2034[a]	n/a[c]	No	In-pit waste rock
Clode Creek	7%	Ex-pit and in-pit	2024	n/a[c]	No	Most waste rock located in-pit, relatively small amount of waste rock in the ex-pit spoil
Kilmarnock and Brownie Creek	15%	Ex-pit	2020	n/a[c]	No	Only feasible to cover part of the spoil, which would not replace treatment
Henretta Creek	1%	Ex-pit	Currently available	n/a[c]	No	Relatively small amount of waste rock
Lower Fording 1[d]	1%	Ex-pit	After 2034[a]	n/a[c]	No	Relatively small amount of waste rock
Porter Creek	1%	Ex-pit	2030	n/a[c]	No	Relatively small amount of waste rock

[a] Spoils that are available for covers after 2034 would not affect the current planning period. However, some were included in the model to gauge whether they may offer a longer term management option.

[b] Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds and that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility.

[c] Surface area of spoils was not calculated if the potential cover was not carried forward.

[d] Lower Fording 1 is a predominately mine disturbed area on the east side of Fording River that includes Eagle Pond and the South Tailings Facility.

Table A-2 Identification of Potential Waste-Rock Covers at Greenhills Operations

Watershed	Percent Waste Rock in 2034 as part of Elk Valley Total	Waste- Rock Location	Year Available for Cover	Surface Area of Spoil at 3H:1V (ha)	Carried Forward for Evaluation?	Rationale
Leask Creek	7%	Ex-pit and in-pit	After 2034[a]	536	Yes	Relatively large ex-pit spoil (West Spoil)
Wolfram Creek	2%	Ex-pit				
Thompson Creek	1%	Ex-pit				
Greenhills Creek	2%	Ex-pit and in-pit	2030	211	Yes	Relatively large ex-pit spoil (East Spoil)

[a] Spoils that are available for covers after 2034 would not affect the current planning period. However, some were included in the model to gauge whether they may offer a longer term management option.

Table A-3 Identification of Potential Waste-rock Covers at Line Creek Operations

Watershed	Percent Waste Rock in 2034 as part of Elk Valley Total	Waste Rock Location	Year Available for Cover	Surface Area of Spoil at 3H:1V (ha)	Carried Forward for Evaluation?	Rationale
West Line Creek	2%	Ex-pit	2015	292	Yes	Relatively large ex-pit spoil
Line Creek upstream of West Line Creek	5%	Ex-pit and in-pit	Horseshoe spoils currently available, No Name Creek spoils available in 2022	179	Yes	Relatively large ex-pit spoil
LCO Dry Creek	6%	Ex-pit and in-pit	2034	439	Yes	Relatively large ex-pit spoil

Table A-4 Identification of Potential Waste-rock Covers at Elkview Operations

Watershed	Percent Waste Rock in 2034 as part of Elk Valley Total	Waste Rock Location	Year Available for Cover	Surface Area of Spoil at 3H:1V (ha)	Carried Forward for Evaluation?	Rationale
EVO Dry Creek	7%	Ex-pit	After 2034[(a)]	515	Yes	Relatively large ex-pit spoil
Erickson Creek	9%	Ex-pit	After 2034[(a)]	Not applicable – the spoil cannot be geometrically sloped to 3H:1V due to height and volume constraints	No	Cannot be resloped for geomembrane cover application
Bodie Creek	7%	Ex-pit and in-pit	After 2034[(a)]	n/a[(b)]	No	Predominantly in-pit sources
Harmer Creek	1%	Ex-pit	Currently available	n/a[(b)]	No	Relatively small amount of waste rock
Gate Creek	0.4%	Ex-pit	Currently available	n/a[(b)]	No	Relatively small amount of waste rock
South Pit, Milligan and Thresher Creeks	0.2%	Ex-pit	Currently available	n/a[(b)]	No	Relatively small amount of waste rock
Six Mile Creek	0.1%	Ex-pit	Currently available	n/a[(b)]	No	Insufficient waste rock volume - it cannot be resloped for geomembrane cover
Goddard Creek	0.01%	Ex-pit	Currently available	n/a[(b)]	No	Insufficient waste rock volume it cannot be resloped for geomembrane cover

(a) Spoils that are available for covers after 2034 would not affect the current planning period. However, some were included in the model to gauge whether they may offer a longer term management option.
(b) Surface area of spoils was not calculated if a potential cover was not carried forward.

Table A-5 Identification of Potential Waste-Rock Spoils at Coal Mountain Phase 2 Project

Watershed	Percent Waste Rock in 2034 as part of Elk Valley Total	Waste Rock Location	Year Available for Cover	Surface Area of Spoil at 3H:1V (ha)	Carried Forward for Evaluation?	Rationale
Wheeler Creek	5%	Ex-pit and in-pit	Little Wheeler spoil – 2026 Main Wheeler spoil – 2033	872	Yes	Relatively large ex-pit spoils

Appendix B

Monthly Hydrographs for Active Water Treatment under Low and High Flows

July 2014

This appendix presents monthly hydrographs of the flows available for treatment at each active water treatment facility under consideration in the Plan. For reference, the hydrographs are plotted along with the treatment capacities identified for the initial implementation plan.

The monthly hydrographs are shown for year 2034 under high and low flows based on flow information provided in the *Hydrology Report*. The hydrographs assume the implementation of clean-water diversions, but do not account for capture efficiencies in the water management system as discussed in the *Site Conditions Report*.

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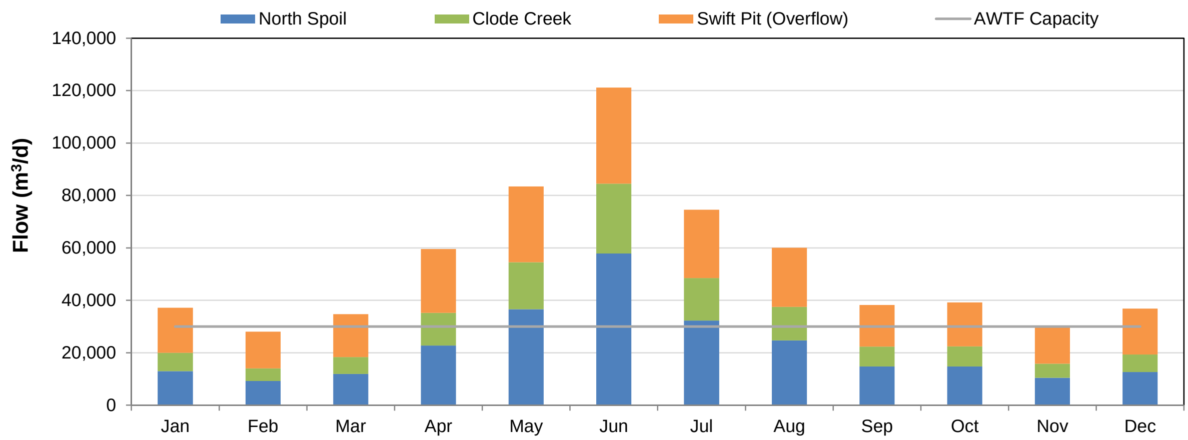
List of Figures

Figure B-1 Monthly Hydrographs of Flows Available for Treatment at Fording River Operations North Active Water Treatment Facility

(a) High Flows



(b) Low Flows

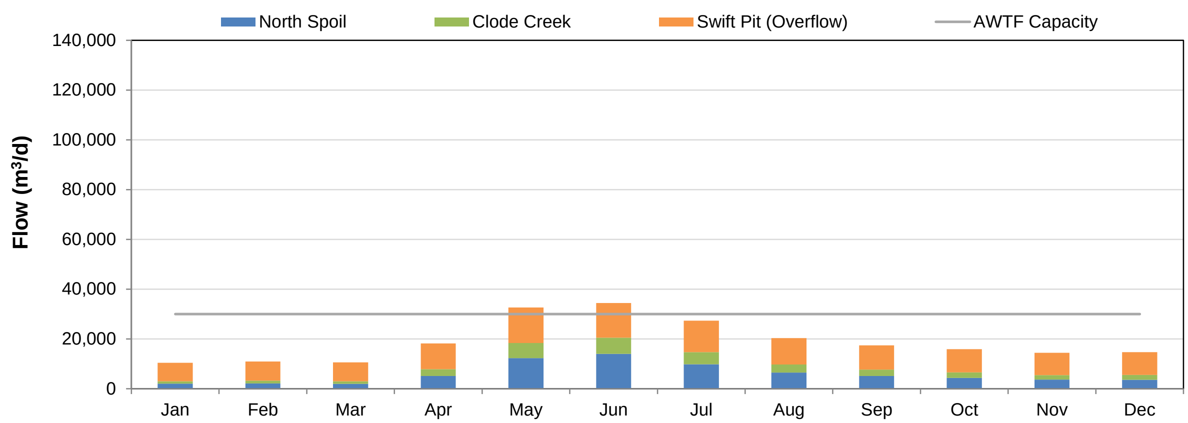
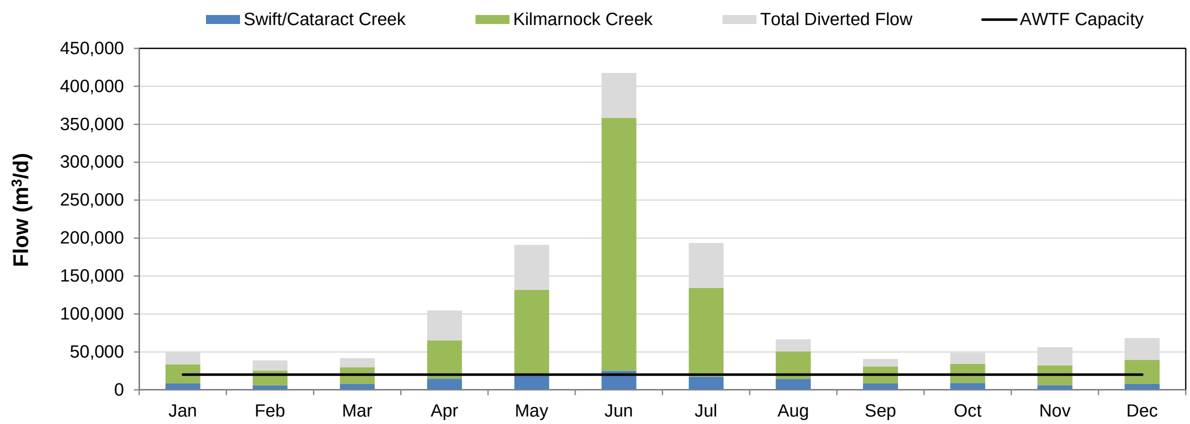


Figure B-2 Monthly Hydrographs of Flows Available for Treatment at Fording River Operations South Active Water Treatment Facility

(a) High Flows



(b) Low Flows

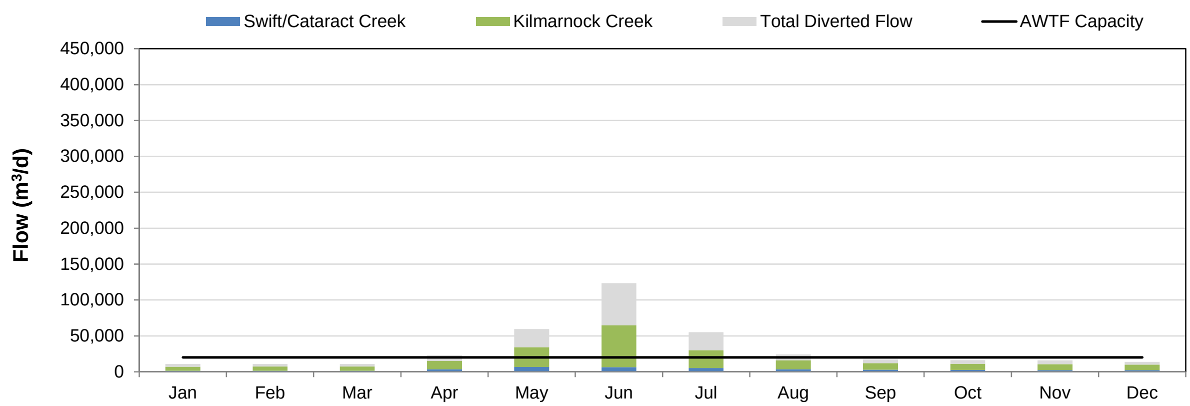
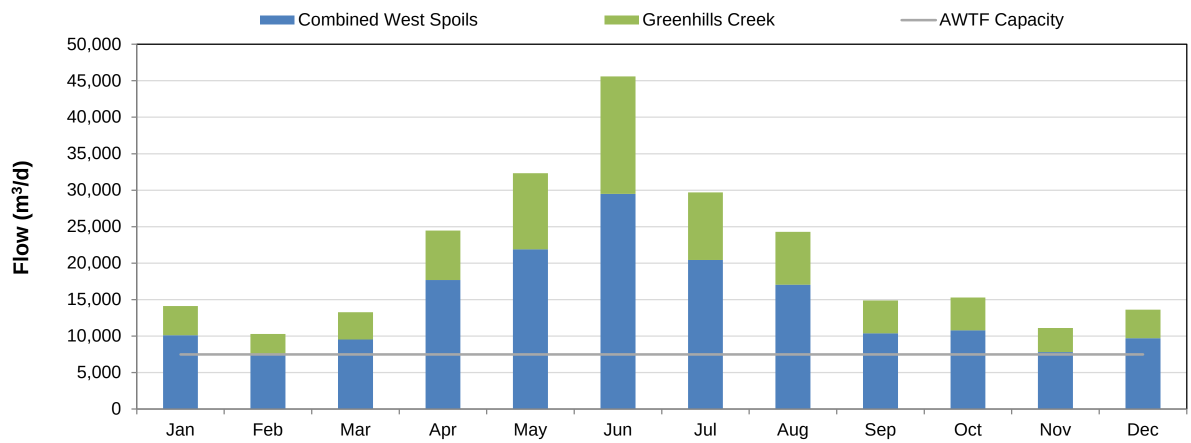


Figure B-3 Monthly Hydrographs of Flows Available for Treatment at Greenhills Operations Active Water Treatment Facility

(a) High Flows



(b) Low Flows

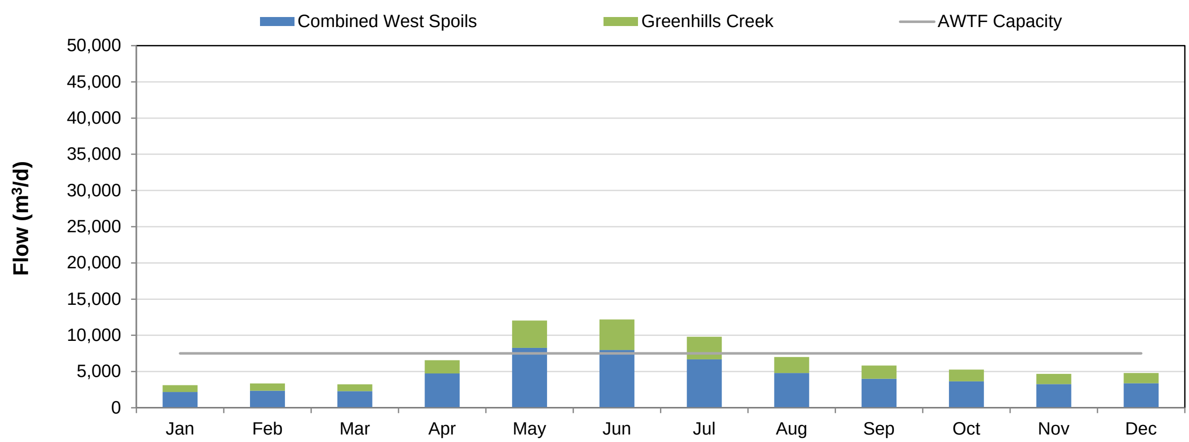
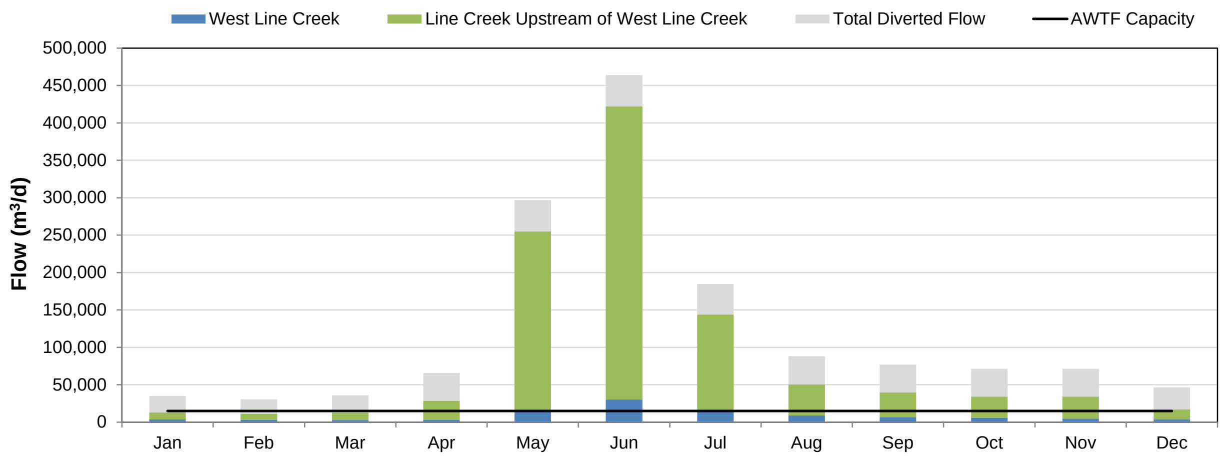


Figure B-4 Monthly Hydrographs of Flows Available for Treatment at Line Creek Operations West Line Creek Active Water Treatment Facility

(a) High Flows



(b) Low Flows

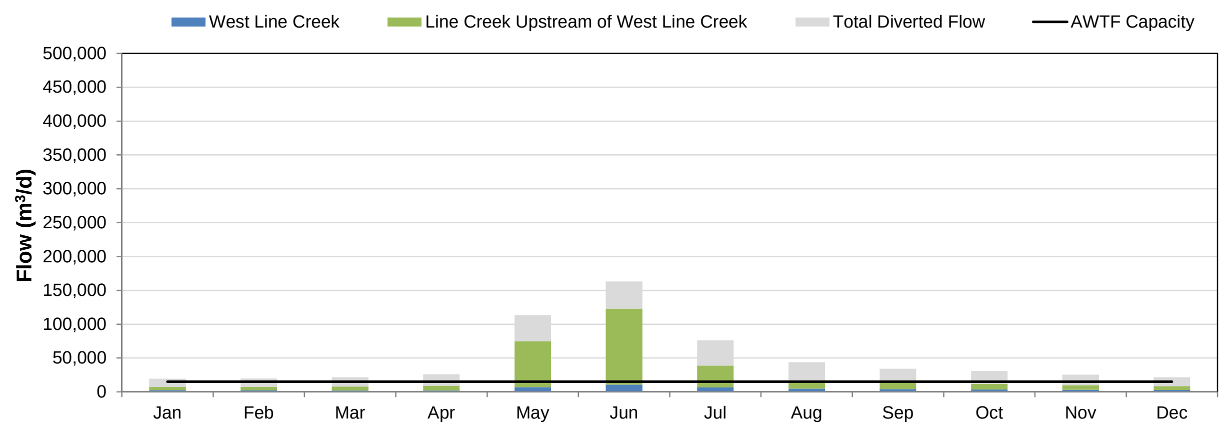
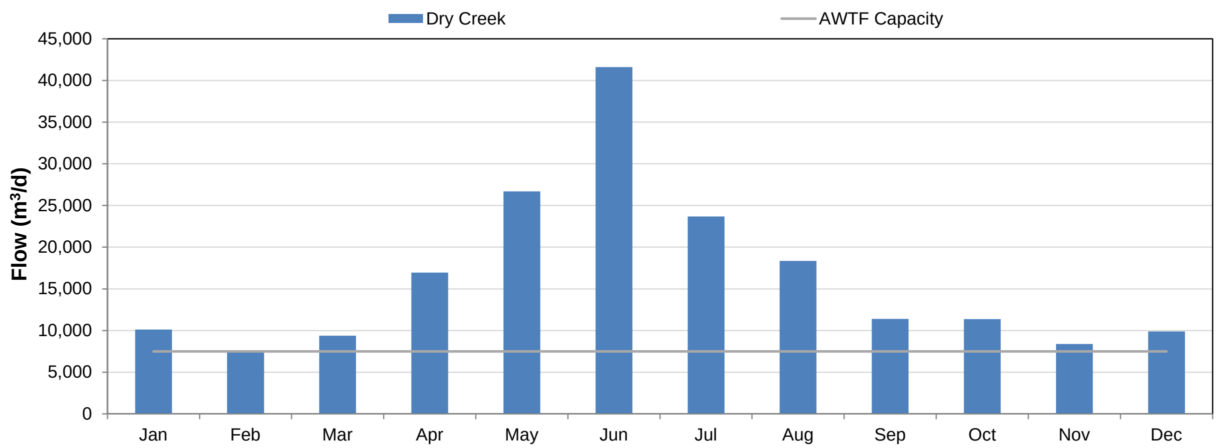


Figure B-5 Monthly Hydrographs of Flows Available for Treatment at Line Creek Operations Dry Creek Active Water Treatment Facility

(a) High Flows



(b) Low Flows

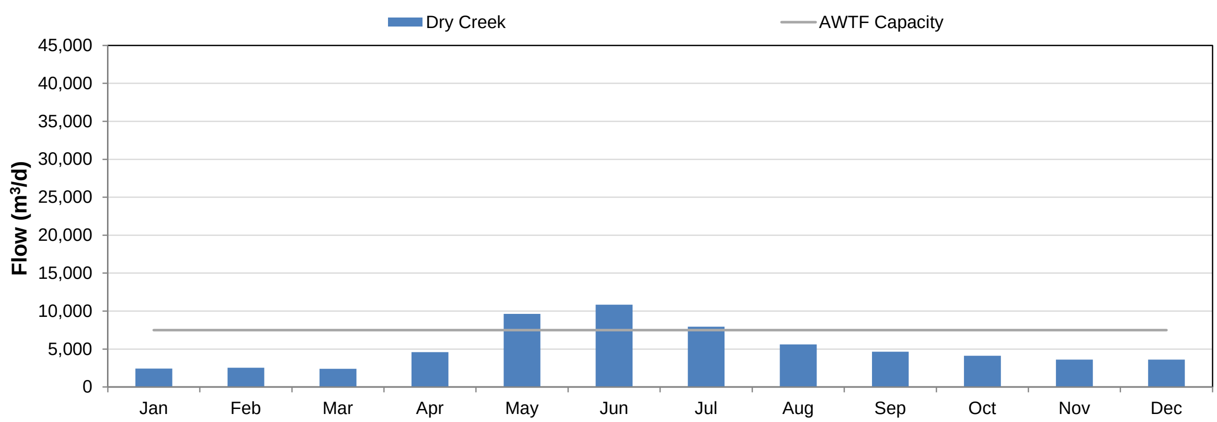
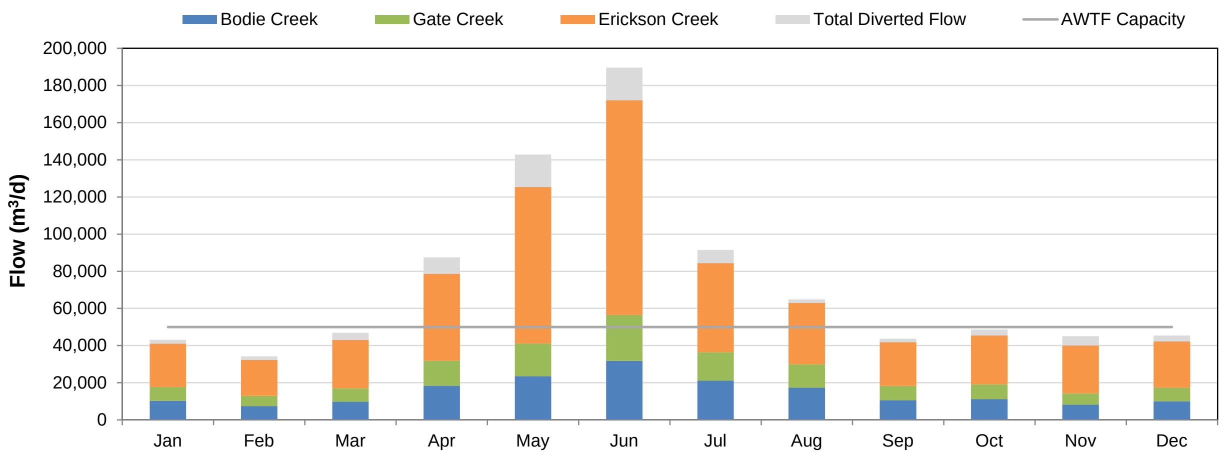
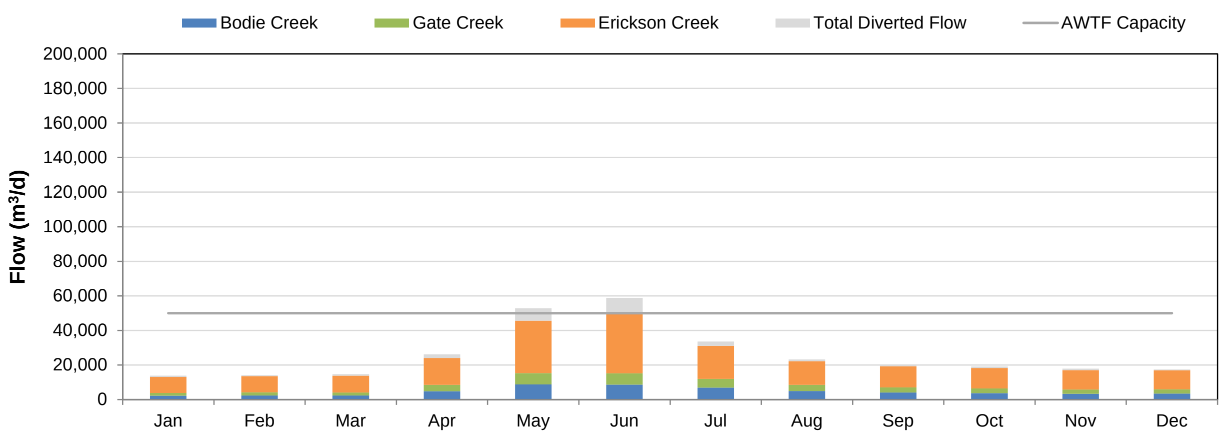


Figure B-6 Monthly Hydrographs of Flows Available for Treatment at Elkview Operations Active Water Treatment Facility

(a) High Flows



(b) Low Flows



Appendix C

Predicted Hardness Concentrations in the Fording and Elk Rivers and Michel Creek

July 2014

Appendix C contains predicted hardness concentrations in the Fording and Elk rivers and Michel Creek. The model was run with the average (P50) geochemical release rate under low, average and high flows. The predictions are presented as time series plots and, for context, include historical observations (green points) and commissioning dates (vertical lines) for the active water treatment facilities according to the initial implementation plan. The blue band indicates the predicted envelope of maximum monthly average concentrations under low, average or high flows. The orange band indicates the predicted envelope of annual average concentrations under the same range of flows. Grey lines are the predictions without mitigation.

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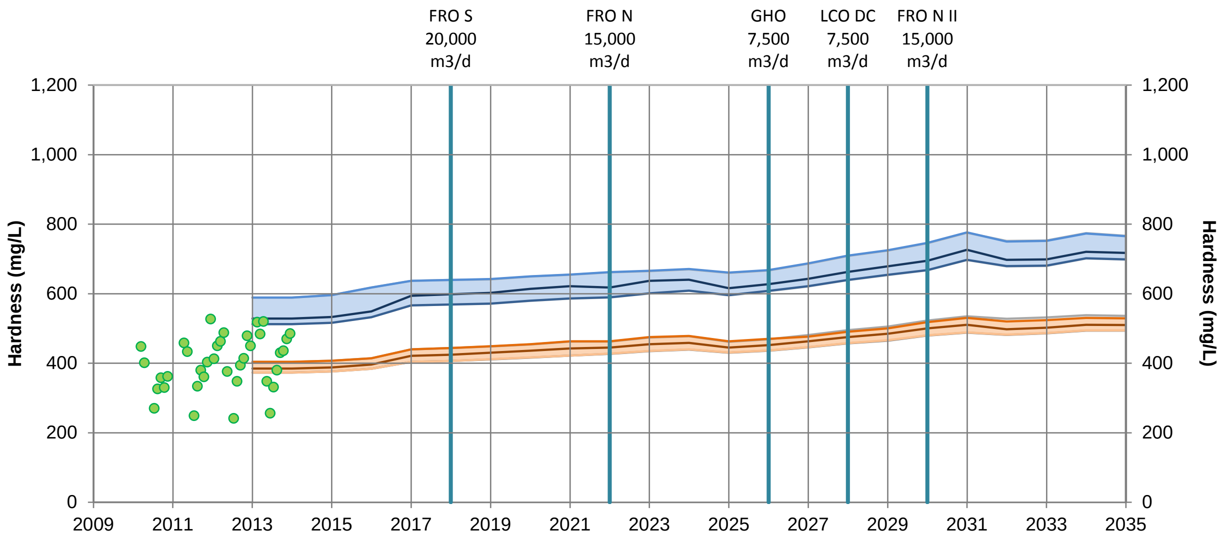
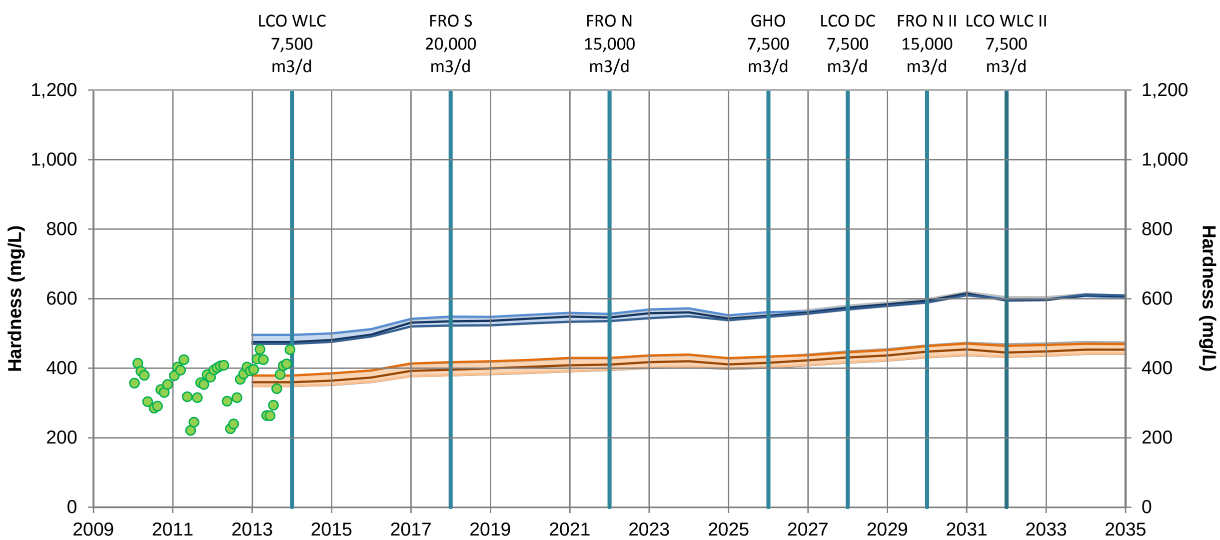
List of Figures

Figure C-1 Predicted Hardness Concentrations at Order Stations in the Fording and Elk Rivers

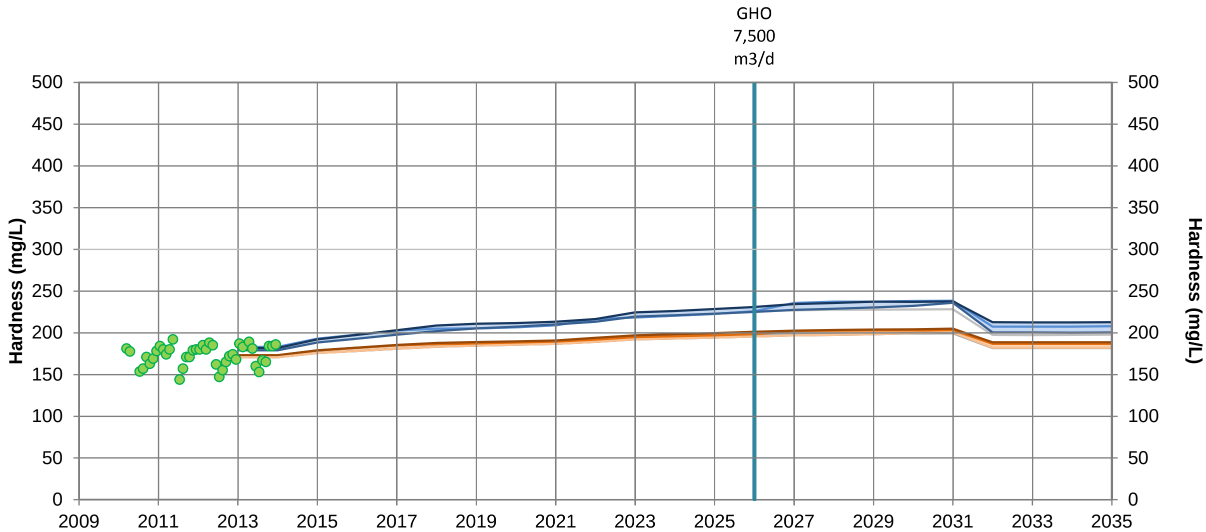
(a) Fording River downstream of Greenhills Creek, FR4 (EMS 0200378)



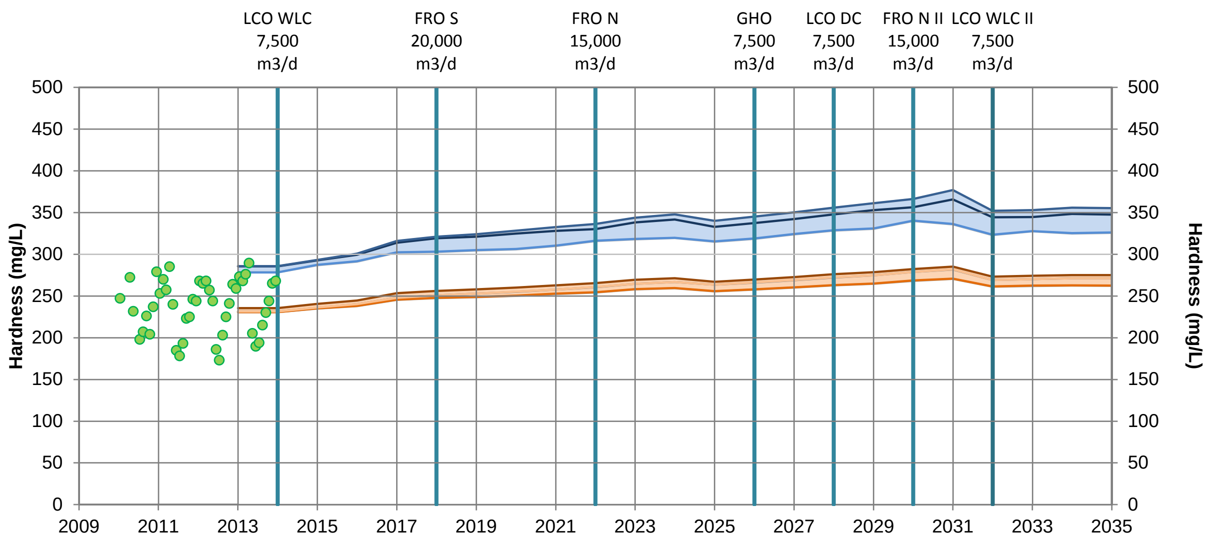
(b) Fording River at the mouth, FR5 (EMS 0200396)



(c) Elk River downstream of GHO and upstream of FRO, ER1 (EMS E206661)



(d) Elk River downstream of Fording River, ER2 (EMS 0200389)



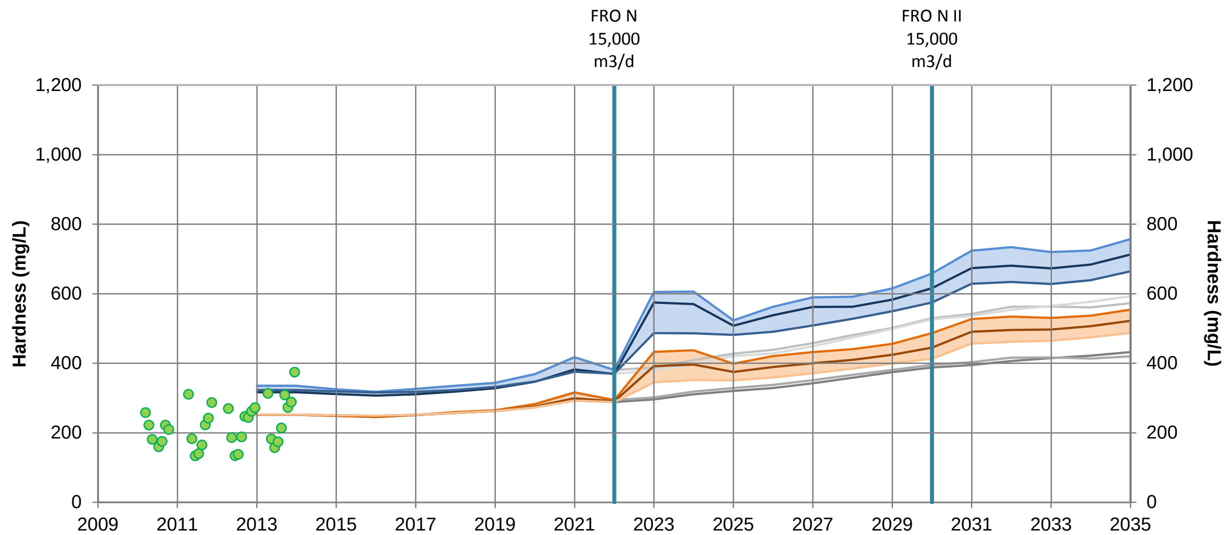
(e) Elk River downstream of Michel Creek, ER3 (EMS 0200393)

Notes: The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

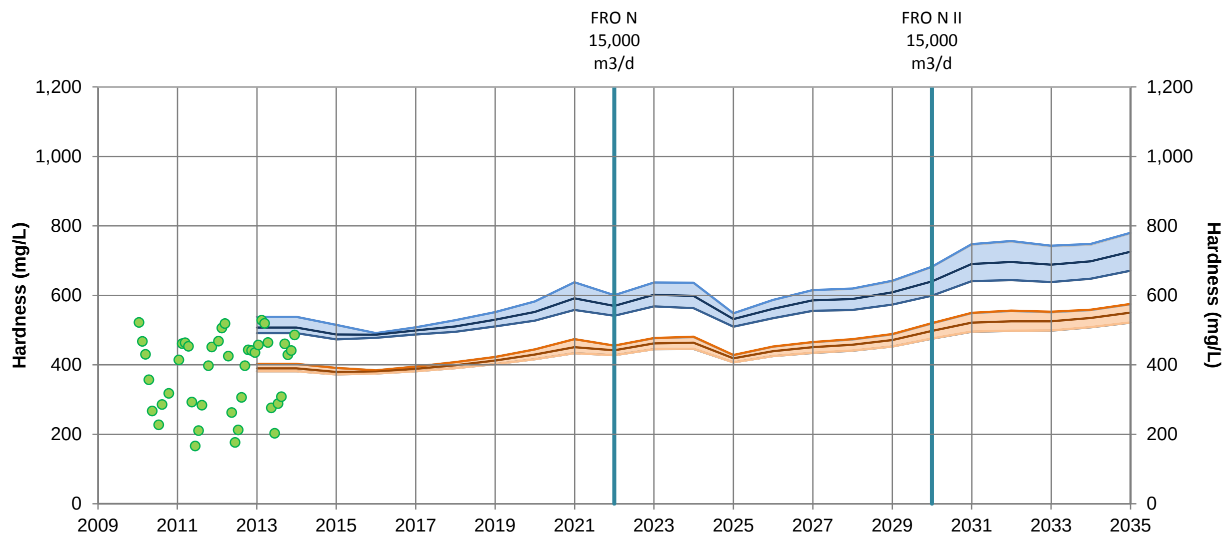
LCO WLC = Line Creek Operations West Line Creek; FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North; GHO = Greenhills Operations; LCO DC = Line Creek Operations Dry Creek.

Figure C-2 Predicted Hardness Concentrations at Other Nodes in the Fording and Elk Rivers and Michel Creek

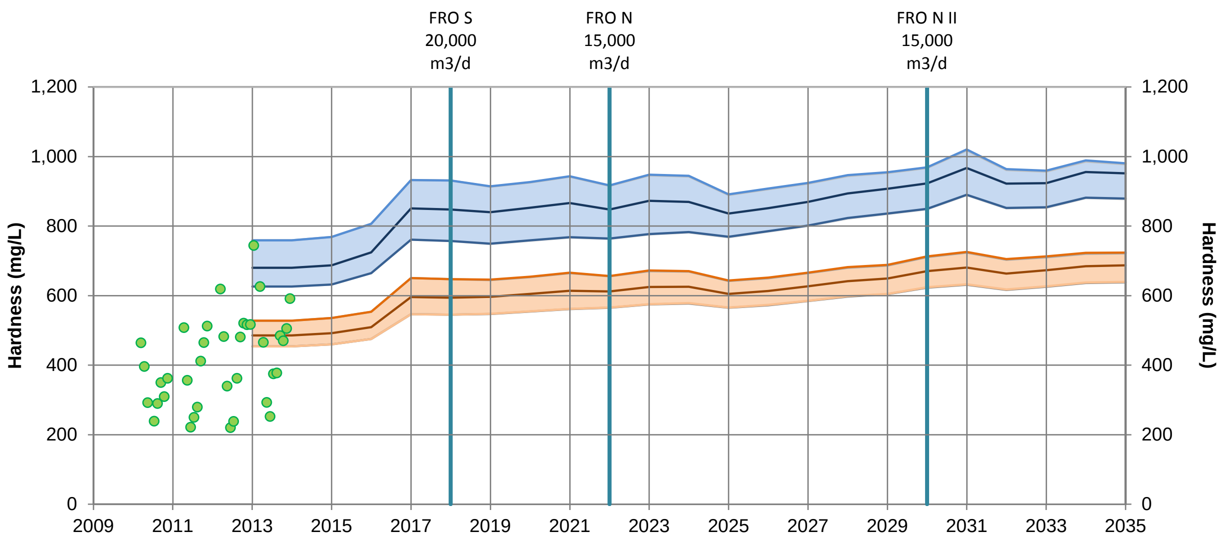
(a) Fording River downstream of Henretta Creek, FR1



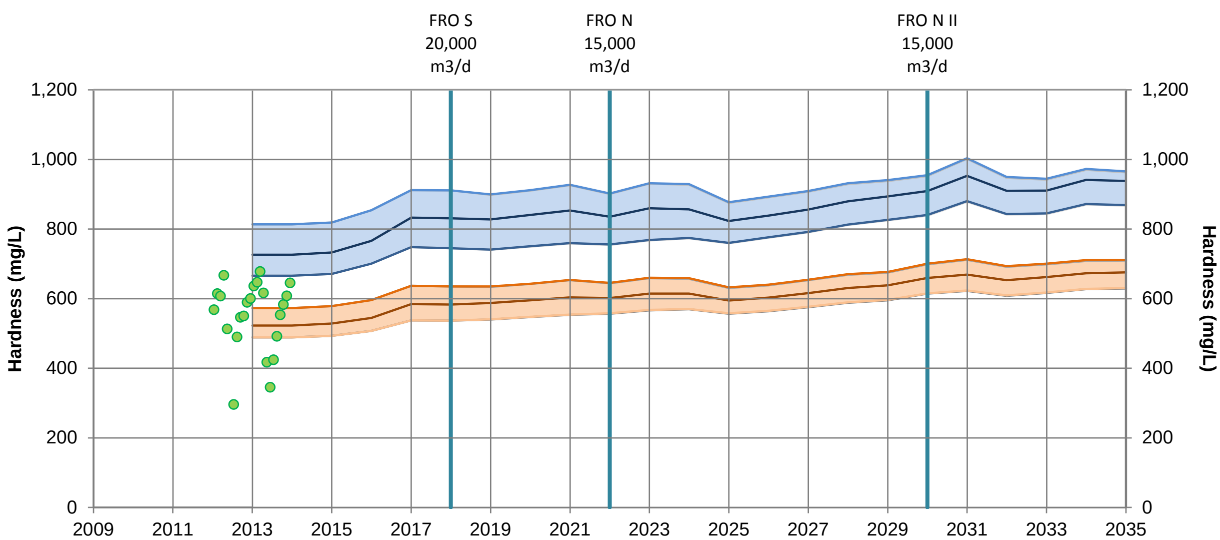
(b) Fording River downstream of Clode Creek, FR2



(c) Fording River between Swift and Cataract Creeks, FR3



(d) Fording River downstream of Porter Creek, FR3b



(e) Michel Creek at the mouth, MC1

Notes: The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

FRO S = Fording River Operations South; EVO = Elkview Operations; FRO N = Fording River Operations North.

Appendix D

Initial Implementation: Predicted Selenium Concentrations in the Fording and Elk Rivers under Average Flows

July 2014

Teck

TECHNICAL MEMORANDUM

DATE July 16, 2014 **REFERENCE No.** 1313490006/M25

TO Kirsten Gillespie
Teck Coal Limited

CC JP Bechtold, Dennis Kramer, Andrew Forbes

FROM Amanda Snow **EMAIL** amanda_snow@golder.com

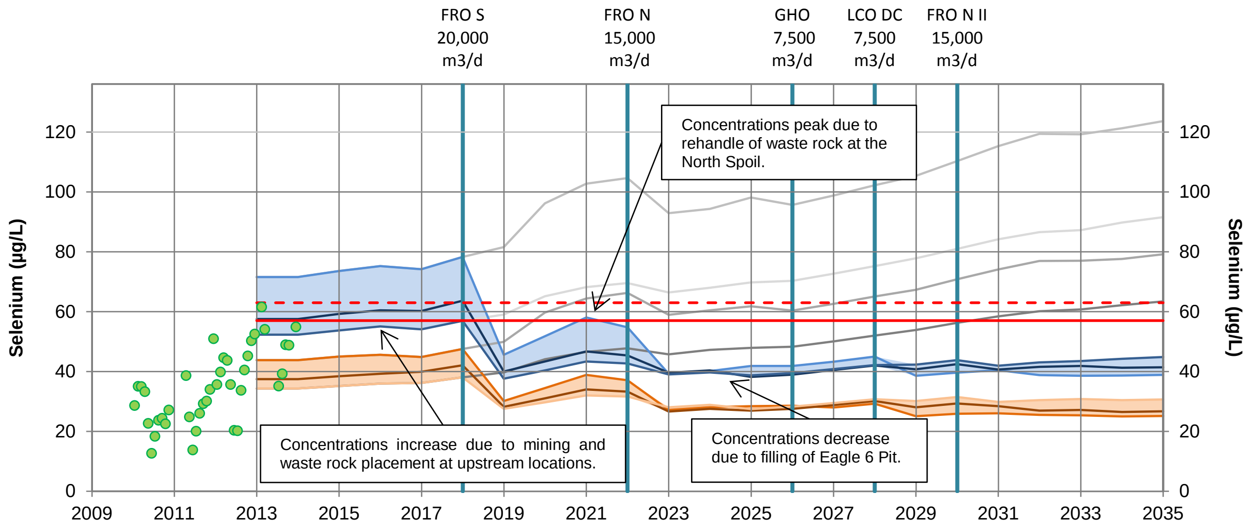
ELK VALLEY WATER QUALITY PLAN – INITIAL IMPLEMENTATION: PREDICTED SELENIUM CONCENTRATIONS IN THE FORDING AND ELK RIVERS UNDER AVERAGE FLOWS

To support the Elk Valley Water Quality Plan, Teck Coal Ltd. retained Golder Associates Ltd. to develop a regional water quality model (the model) that can be used to evaluate how different water quality management strategies can be used to influence constituent concentrations in the Elk Valley. As part of the planning process, the model was used to simulate selenium concentrations under low, average and high flows with the average geochemical source terms for a range of water quality management strategies.

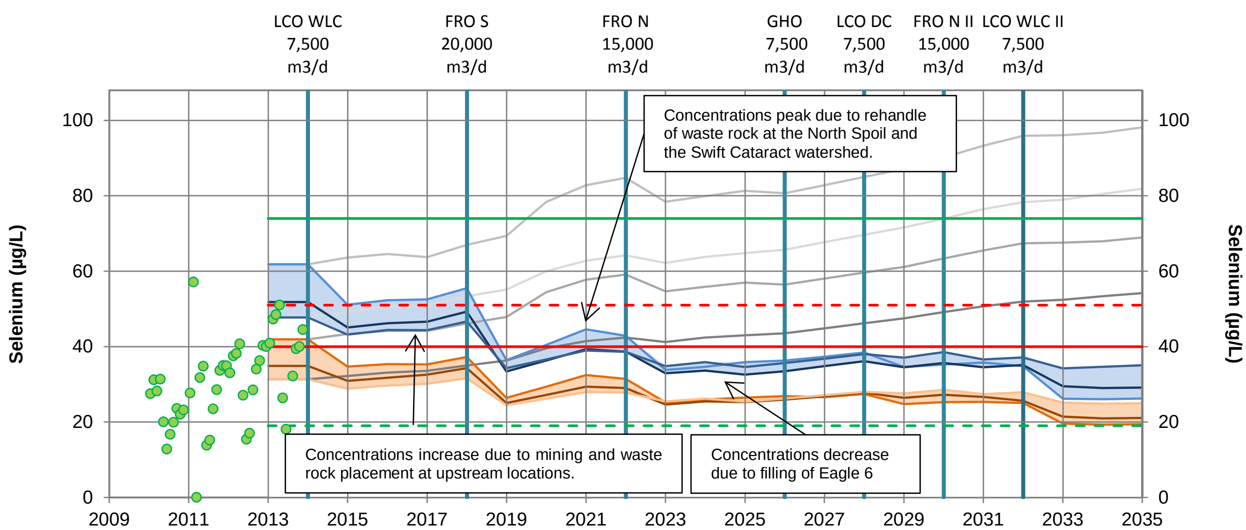
The figures presented in this document provide explanations for the patterns in predicted selenium concentrations at the river nodes from 2013 and 2034 under the initial implementation plan. The model was run under low, average, and high flow conditions with no correction for model bias. The predictions are presented as time series plots and, for context, include historical observations (green points) and commissioning dates (vertical lines) for the active water treatment facilities according to the initial implementation plan. Long term and short term targets, or level 1 and level 2 benchmarks as appropriate, are included for reference. The blue band indicates the predicted envelope of maximum monthly average concentrations under low, average or high flows. The orange band indicates the predicted envelope of annual average concentrations under the same range of flows. Grey lines are the predictions without mitigation.

Figure 1: Predicted Selenium Concentrations at Order Stations in the Fording and Elk Rivers

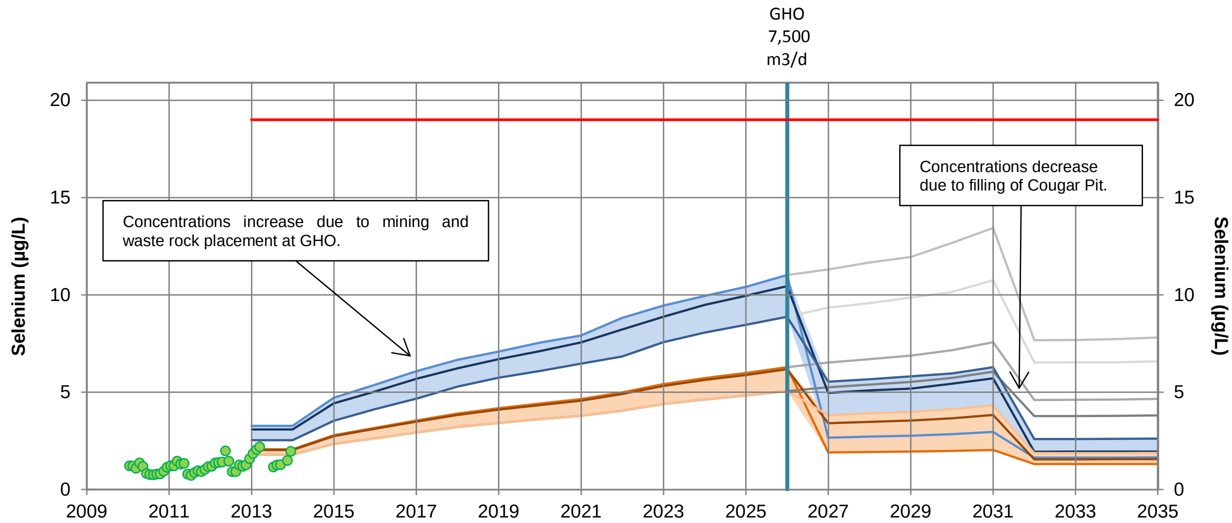
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



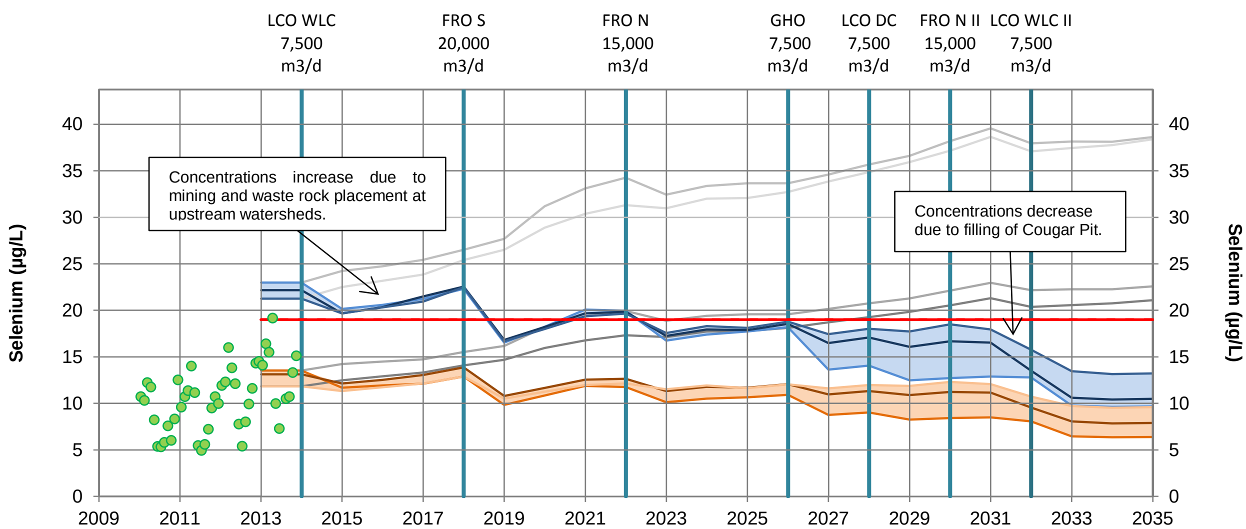
(b) Fording River at the mouth, FR5 (EMS 0200396)



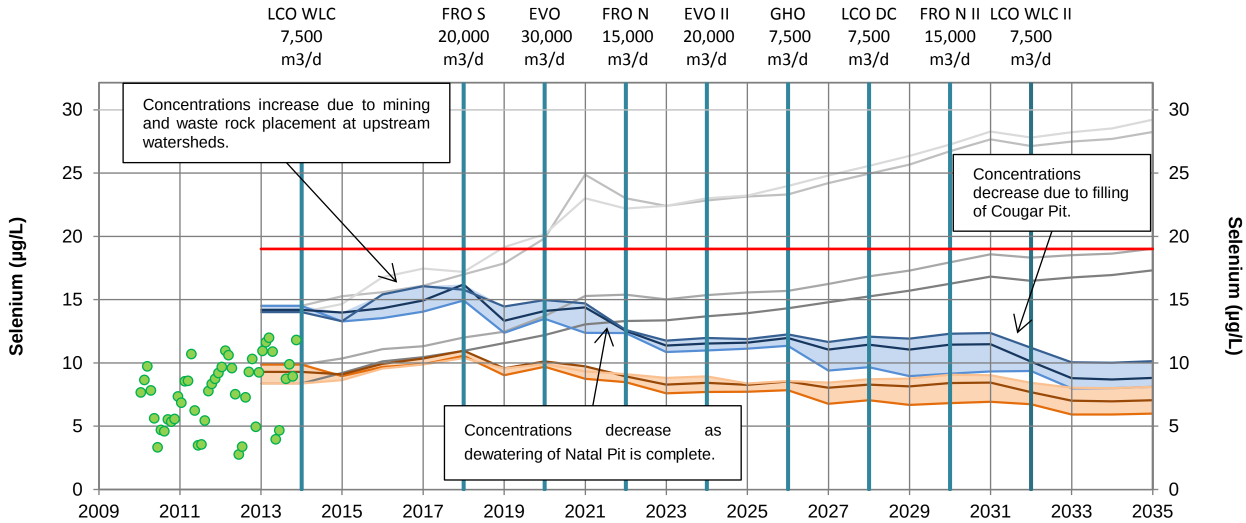
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)



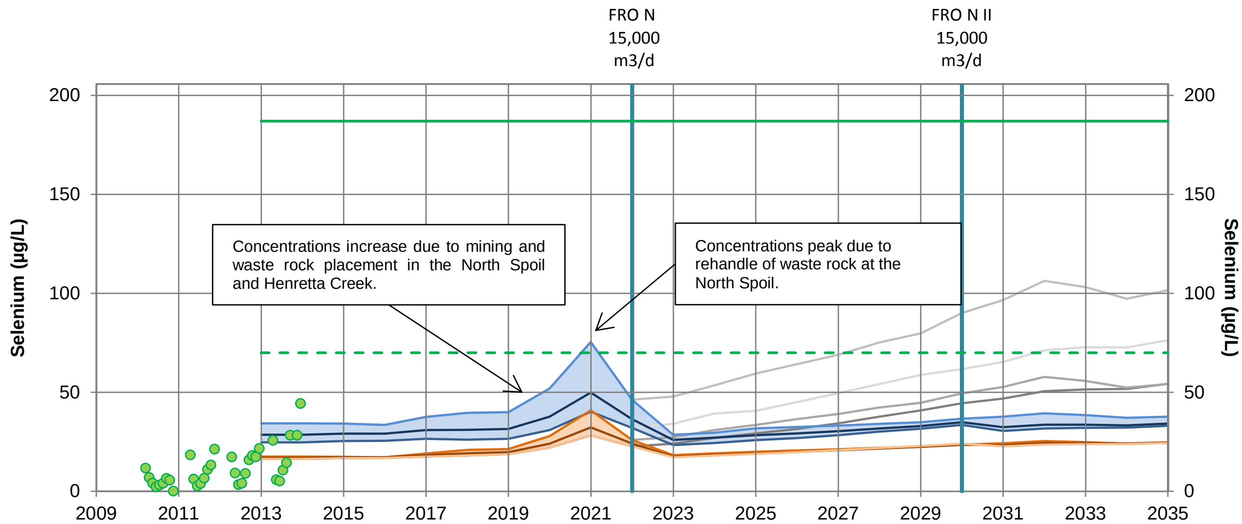
- Predicted Maximum Monthly Concentration Under Low Flow Conditions without Mitigation
- Predicted Maximum Monthly Concentration Under High Flow Conditions without Mitigation
- Predicted Annual Average Concentration Under High Flow Conditions without Mitigation
- Predicted Annual Average Concentration Under Low Flow Conditions without Mitigation
- Predicted Maximum Monthly Concentration Under Low Flow Conditions and Initial Implementation Plan
- Predicted Maximum Monthly Concentration Under Average Flow Conditions and Initial Implementation Plan
- Predicted Maximum Monthly Concentration Under High Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under Low Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under Average Flow Conditions and Initial Implementation Plan
- Predicted Annual Average Concentration Under High Flow Conditions and Initial Implementation Plan
- Observed
- Level 2 Benchmark
- Level 1 Benchmark
- Long-term Target
- Short-term Target

Notes: Concentrations were simulated using the average geochemical release rate under low, average and high flows and have not been corrected for model bias.

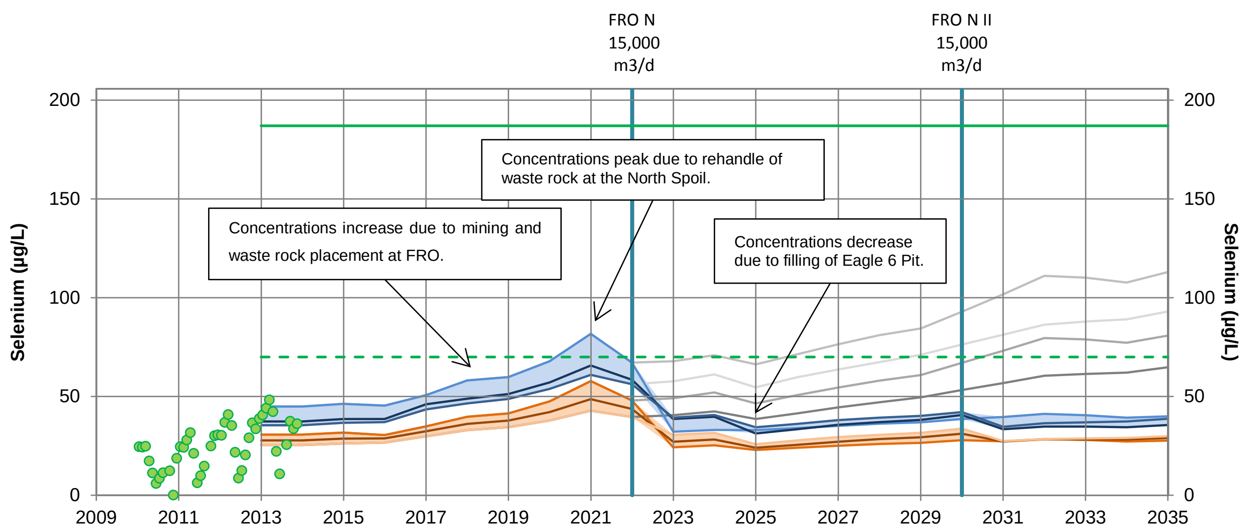
Selenium concentrations decrease after commissioning of Phase I and Phase II of the LCO I AWTF in 2014 and 2032, FRO South AWTF in 2018, Phase I and Phase II of the EVO AWTF in 2020 and 2024, Phase I and Phase II of the FRO North AWTF in 2022 and 2030, GHO AWTF in 2026, and LCO II AWTF in 2028.

Figure 2: Predicted Selenium Concentrations at Other Nodes in the Fording and Elk Rivers and Michel Creek

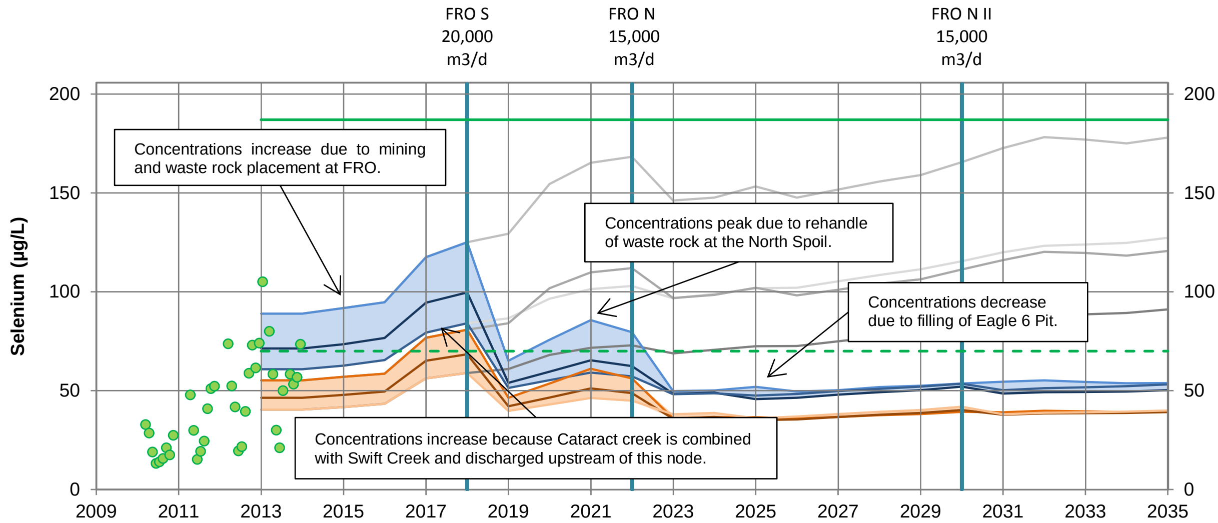
(a) Fording River Downstream of Henretta Creek (FR1)



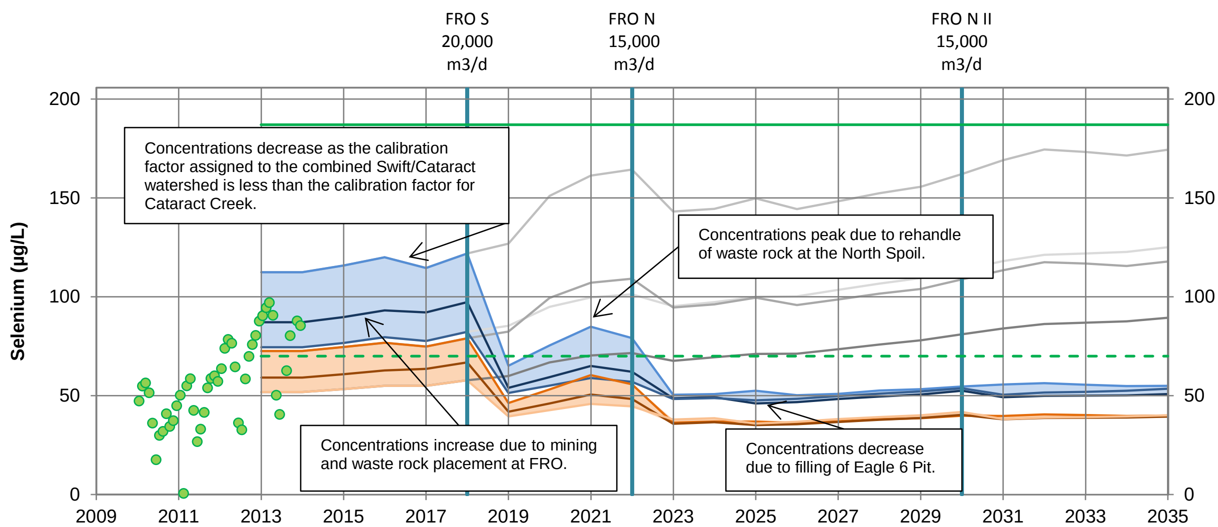
(b) Fording River Downstream of Clode Creek (FR2)



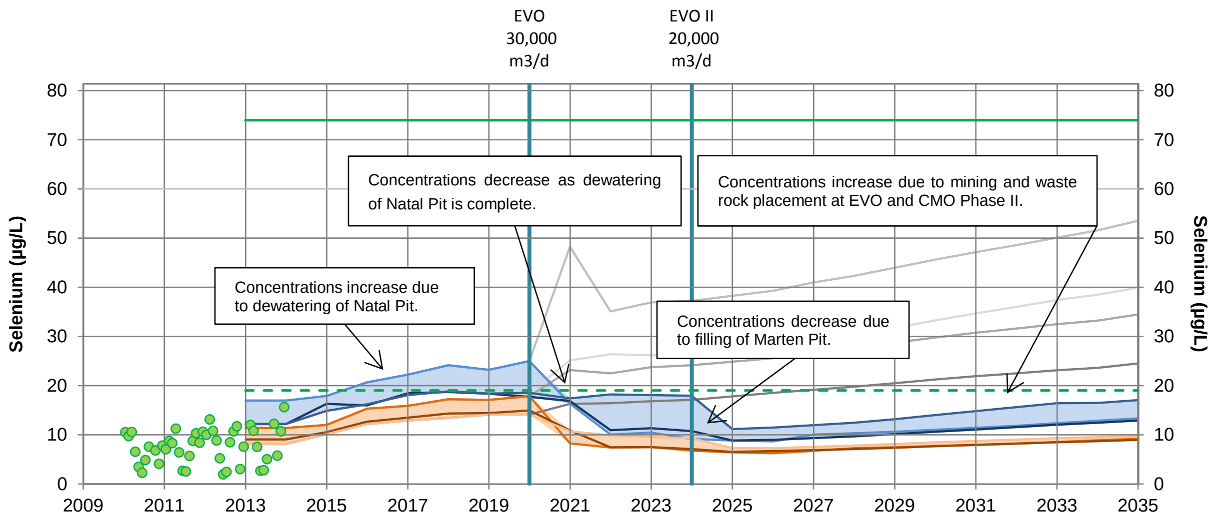
(c) Fording River Between Swift and Cataract Creeks (FR3)



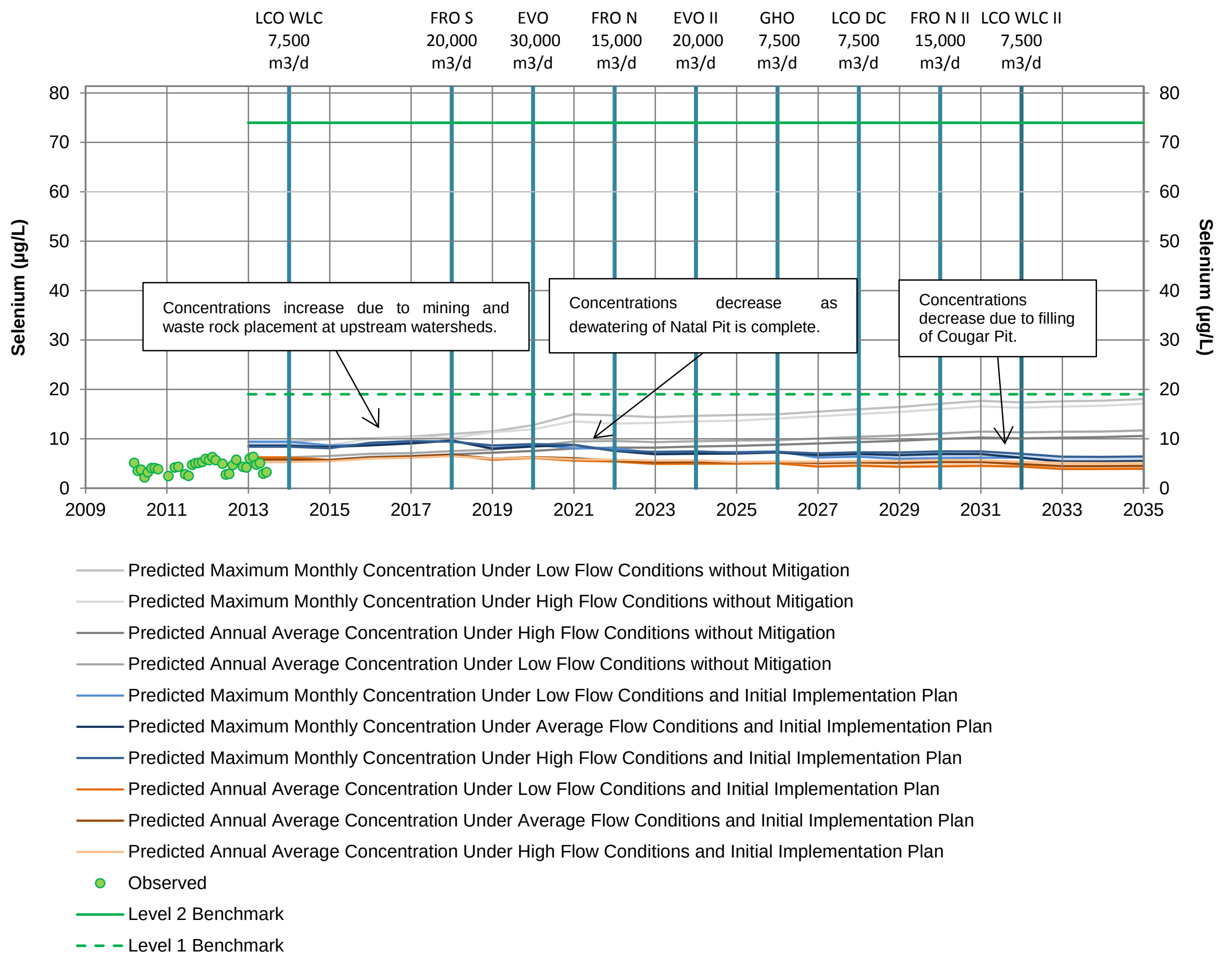
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)



Notes: Concentrations were simulated using the average geochemical release rate under average flow conditions and have not been corrected for Model bias.

Selenium concentrations decrease after commissioning of Phase I and Phase II of the LCO I AWTF in 2014 and 2032, FRO South AWTF in 2018, Phase I and Phase II of the EVO AWTF in 2020 and 2024, Phase I and Phase II of the FRO North AWTF in 2022 and 2030, GHO AWTF in 2026, and LCO II AWTF in 2028.

Closure

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Amanda Snow, M.A.Sc., EIT
Water Quality Specialist

Dennis Kramer, M.Sc.
Scientist

AS/DK/cd

https://capws.golder.com/sites/p313490006elkvalleyareabasedplan/advicetracker_formalresponses/water_quality/wq_results/g0314_wq_model_results_appendix_d_m25.docx

Appendix E

Initial Implementation: Predicted Nitrate Concentrations in the Fording and Elk Rivers under Average Flows

July 2014

Teck

TECHNICAL MEMORANDUM

DATE July 16, 2014 **PROJECT No.** 1313490006/M26

TO Kirsten Gillespie
Teck Coal Limited

CC JP Bechtold, Andrew Forbes

FROM Amanda Snow and Dennis Kramer **EMAIL** amanda_snow@golder.com

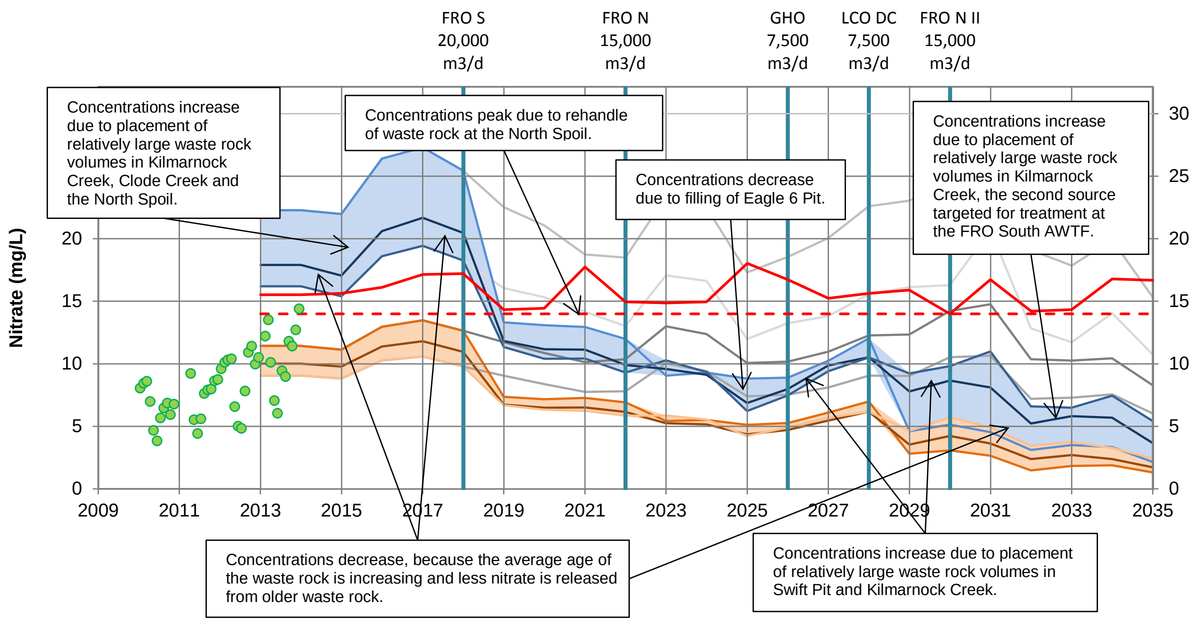
ELK VALLEY WATER QUALITY PLAN – INITIAL IMPLEMENTATION: PREDICTED NITRATE CONCENTRATIONS IN THE FORDING AND ELK RIVERS UNDER AVERAGE FLOWS

To support the Elk Valley Water Quality Plan, Teck Coal Ltd. retained Golder Associates Ltd. to develop a regional water quality model (the model) that can be used to evaluate how different water quality management strategies could influence constituent concentrations in the Elk Valley. As part of the planning process, the model was used to simulate nitrate concentrations under low, average and high flows with the average (P50) geochemical source terms for a range of water quality management strategies.

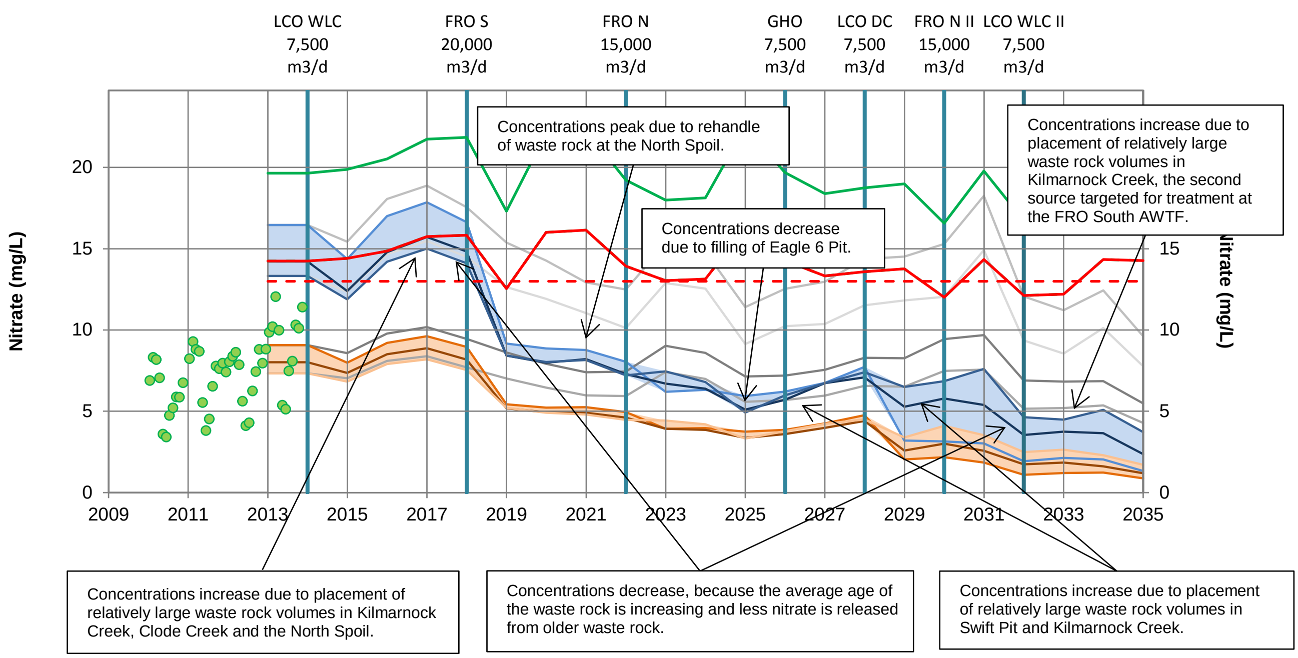
The figures presented in this document provide explanations for the patterns in predicted nitrate concentrations at the river nodes from 2013 and 2034 under the initial implementation plan. The model was run under low, average, and high flow conditions with no correction for model bias. The predictions are presented as time series plots and, for context, include historical observations (green points) and commissioning dates (vertical lines) for the active water treatment facilities according to the initial implementation plan. Long term and short term targets, or level 1 and level 2 benchmarks as appropriate, are included for reference. The blue band indicates the predicted envelope of maximum monthly average concentrations under low, average or high flows. The orange band indicates the predicted envelope of annual average concentrations under the same range of flows. Grey lines are the predictions without mitigation.

Figure 1: Predicted Nitrate Concentrations at Order Stations in the Fording and Elk Rivers

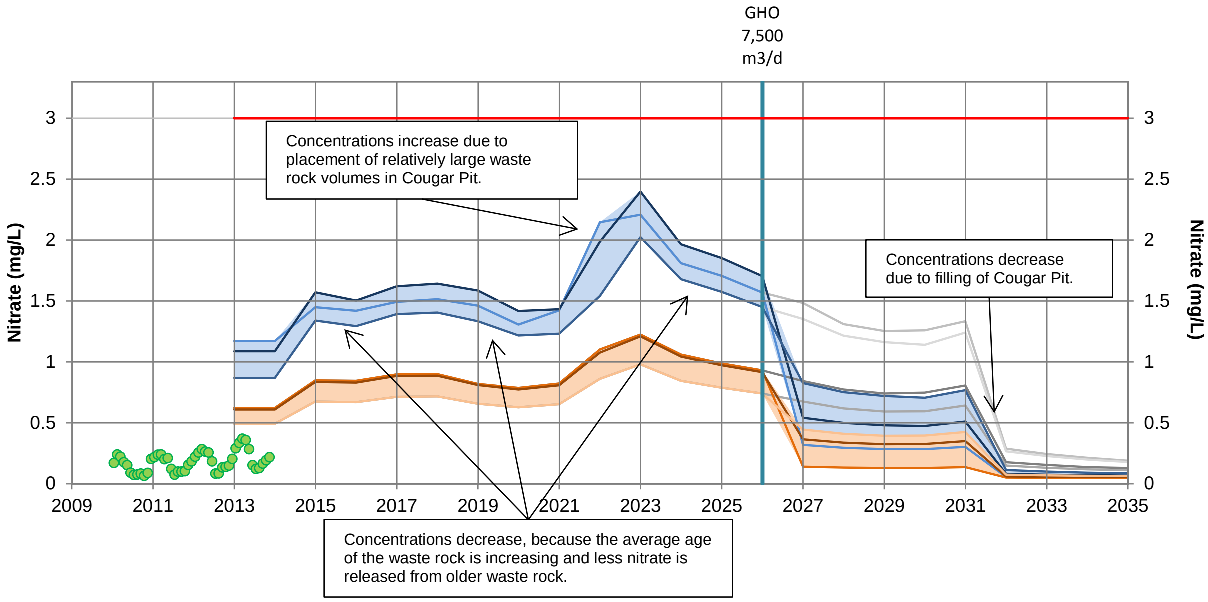
(a) Fording River Downstream of Greenhills Creek, FR4 (EMS 0200378)



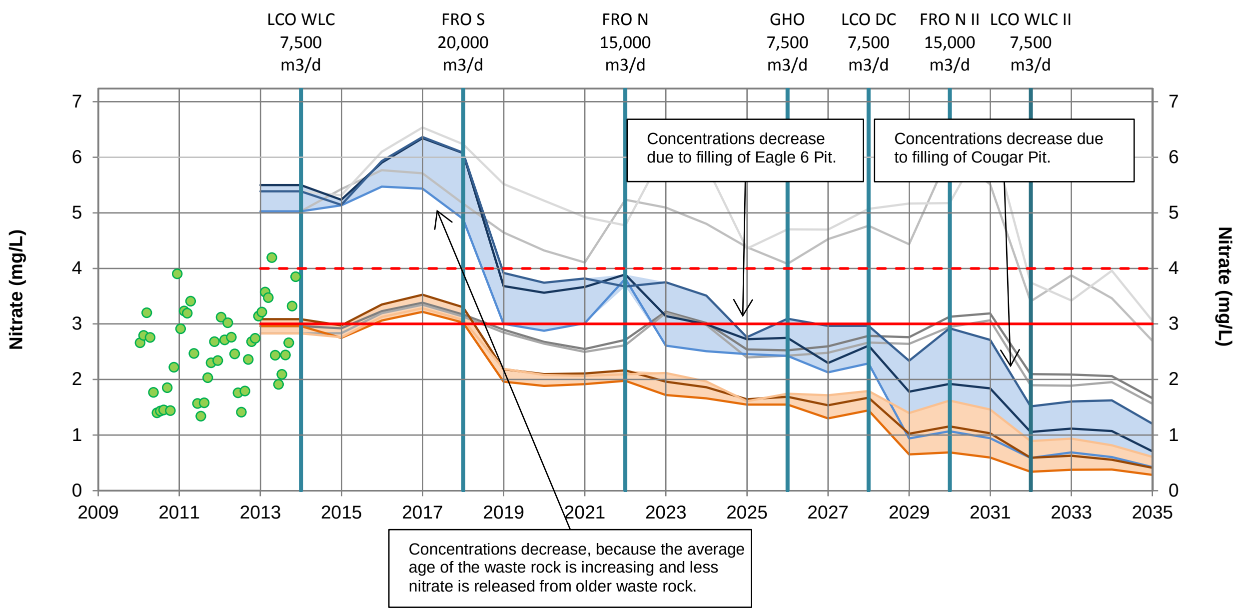
(b) Fording River at the Mouth, FR5 (EMS 0200396)



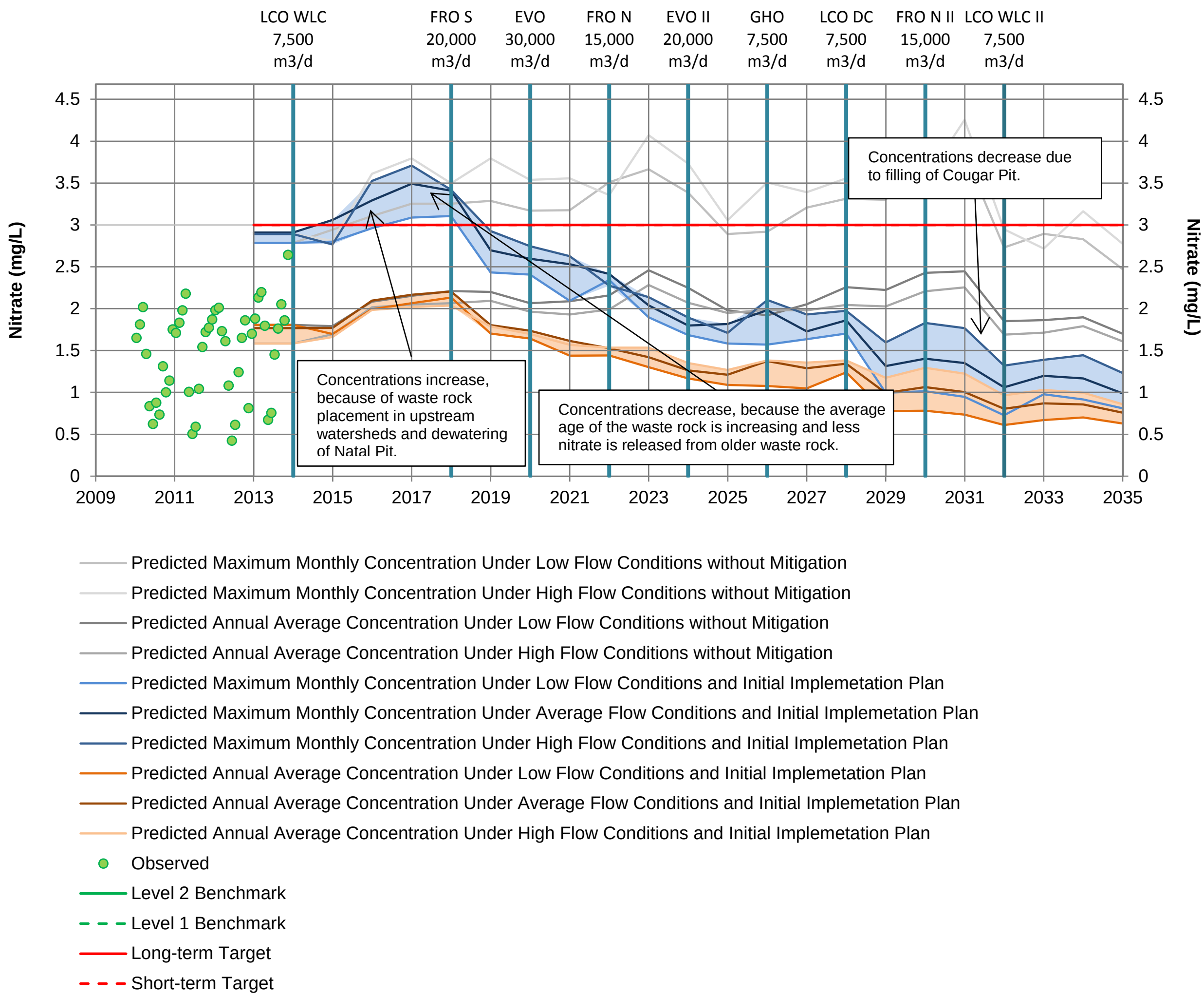
(c) Elk River Downstream of GHO and Upstream of FRO, ER1 (EMS E206661)



(d) Elk River Downstream of Fording River, ER2 (EMS 0200389)



(e) Elk River Downstream of Michel Creek, ER3 (EMS 0200393)



Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.
In the Fording River, the Level 1 and Level 2 benchmarks, as well as the long-term target, were adjusted for hardness using the following equations:

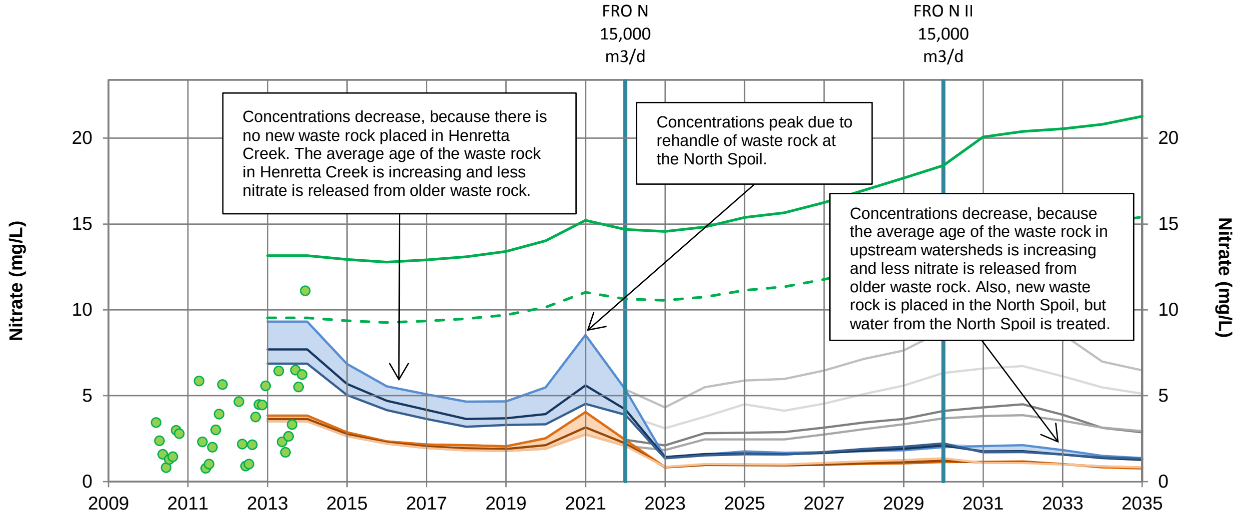
$$Level\ 1\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.52}$$

$$Level\ 2\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.38}$$

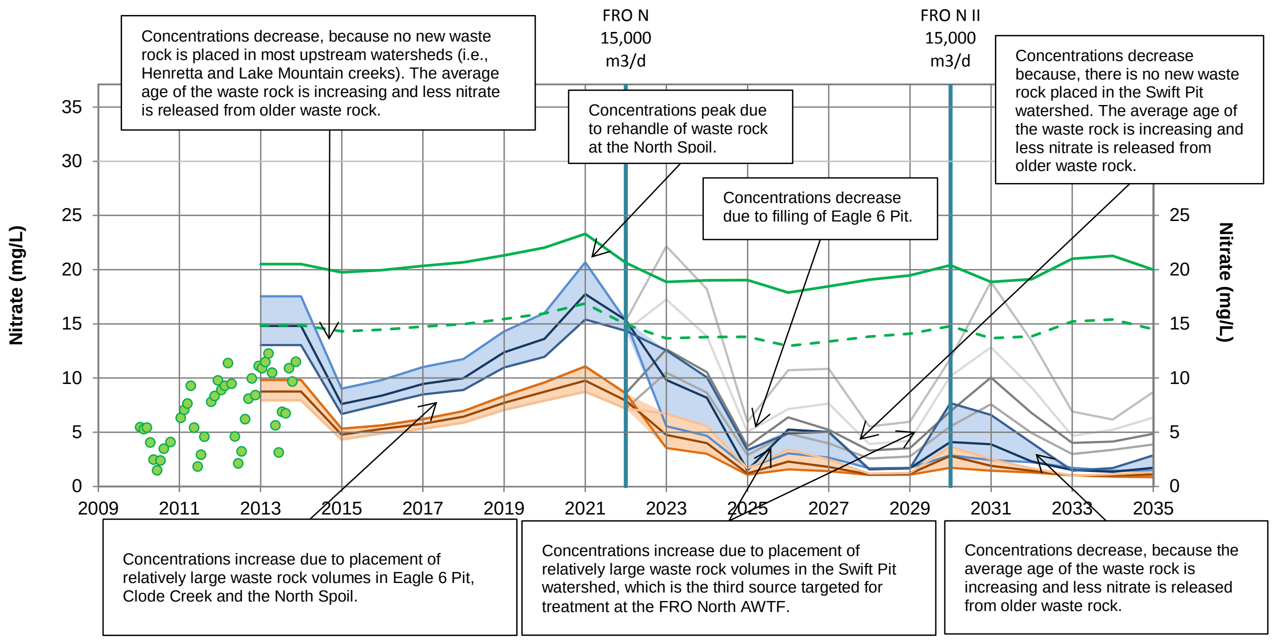
The long-term target was adjusted using the equation for the Level 1 benchmark.
Concentrations decrease after commissioning of Phase I and Phase II of the West Line Creek AWTF in 2014 and 2032, FRO South AWTF in 2018, Phase I and Phase II of the EVO AWTF in 2020 and 2024, Phase I and Phase II of the FRO North AWTF in 2022 and 2030, GHO AWTF in 2026, and the Dry Creek AWTF in 2028.

Figure 2: Predicted Nitrate Concentrations at Other Nodes in the Fording and Elk Rivers and Michel Creek

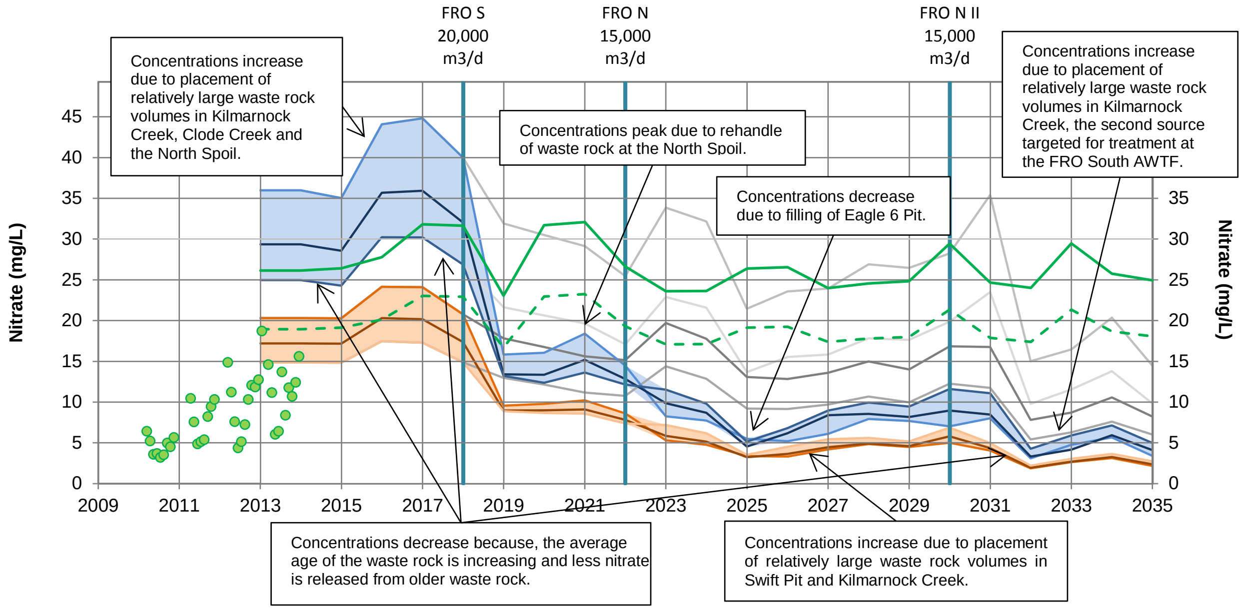
(a) Fording River Downstream of Henretta Creek (FR1)



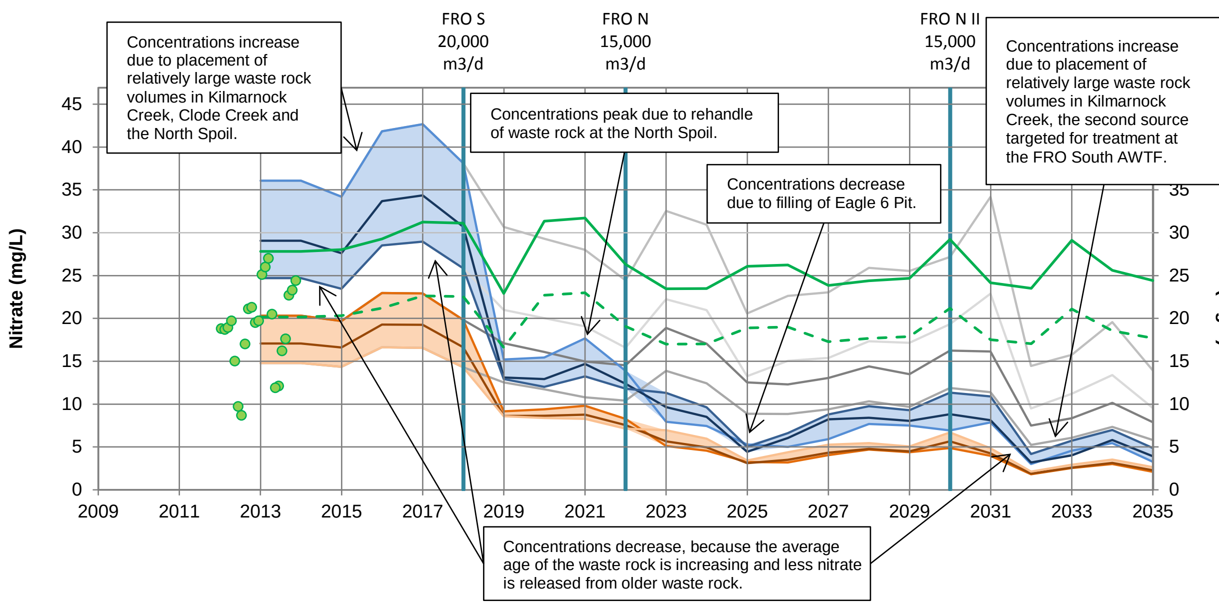
(b) Fording River Downstream of Clode Creek (FR2)



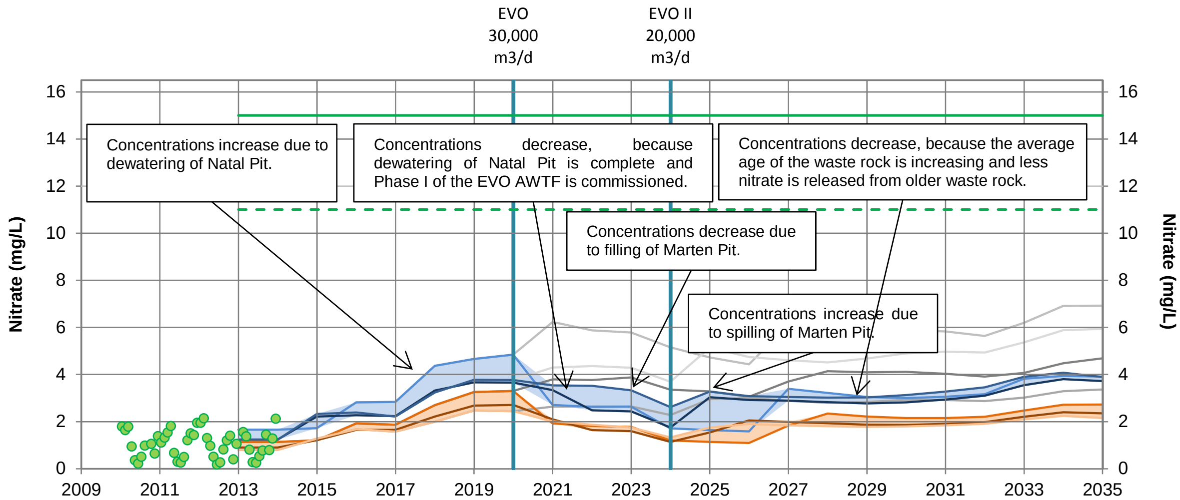
(c) Fording River Between Swift and Cataract Creeks (FR3)



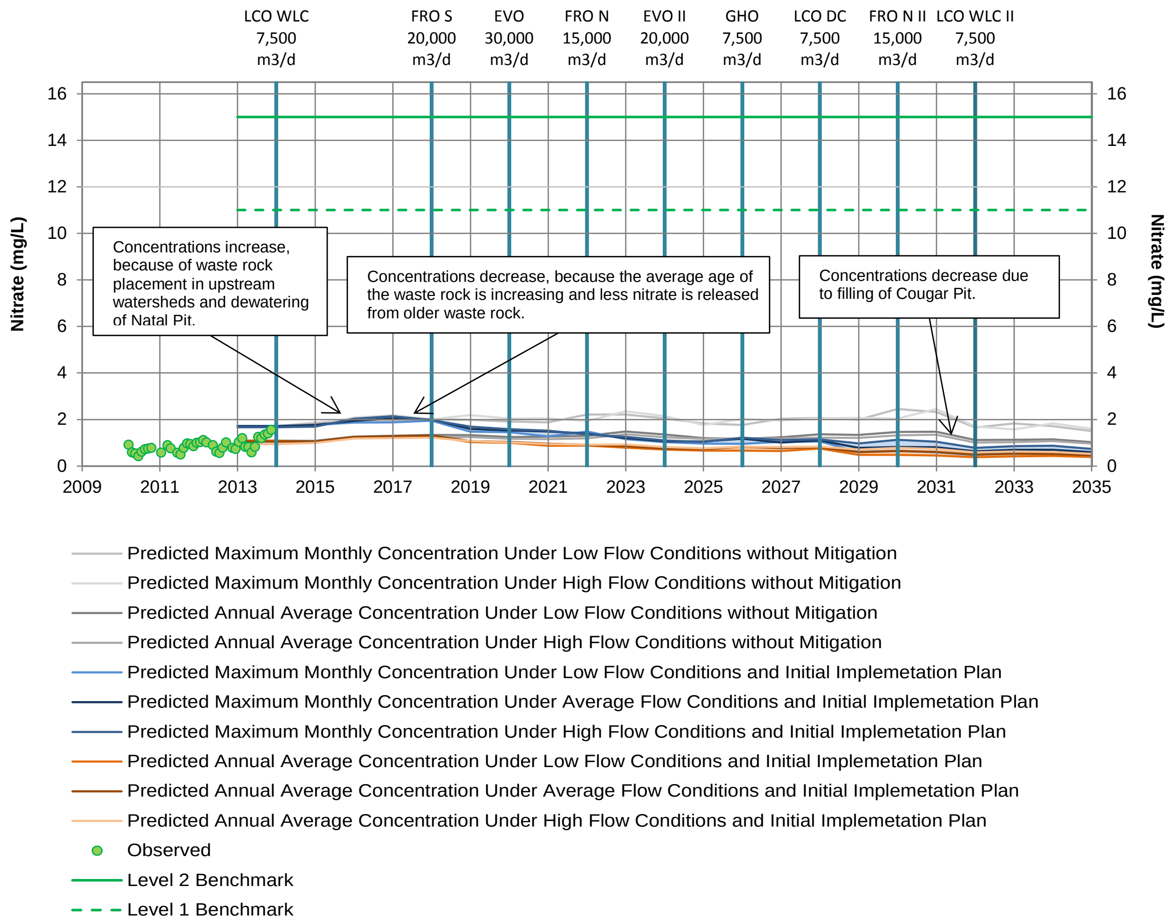
(d) Fording River Downstream of Porter Creek (FR3b)



(e) Michel Creek at the Mouth (MC1)



(f) Elk River at the Mouth (ER5)



Notes: The model was run with the average (P50) geochemical release rate under low, average and high flows. The predicted concentrations (the annual average and maximum) for a given year are plotted at the end of the year.

In the Fording River, the Level 1 and Level 2 benchmarks, as well as the long-term target, were adjusted for hardness using the following equations:

$$Level\ 1\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.52}$$

$$Level\ 2\ Benchmark\ for\ the\ Fording\ River\ (mg\ as\ N/L) = 10^{1.0003*\log 10(hardness)-1.38}$$

The long-term target was adjusted using the equation for the Level 1 benchmark.
Concentrations decrease after commissioning of Phase I and Phase II of the West Line Creek AWTF in 2014 and 2032, FRO South AWTF in 2018, Phase I and Phase II of the EVO AWTF in 2020 and 2024, Phase I and Phase II of the FRO North AWTF in 2022 and 2030, GHO AWTF in 2026, and the Dry Creek AWTF in 2028.

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Amanda Snow, M.A.Sc., EIT
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Dennis Kramer, M.Sc.
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https://capws.golder.com/sites/p313490006elkvalleyareabasedplan/advicetracker_formalresponses/water_quality/wq_results/g0314_wq_model_results_appendix_e_m26.docx

Appendix F

Predicted Concentrations in Tributaries to the Fording and Elk Rivers and Michel Creek and Predicted Concentrations in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa

This appendix contains tables showing estimated selenium, nitrate and sulphate concentrations in tributaries to the Fording and Elk rivers and Michel Creek under low and high flows.

It also contains tables showing predicted selenium, nitrate and sulphate concentrations in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under low, average and high flows.

List of Tables

Table F-1 Estimated Total Selenium Concentrations (µg/L) in Tributaries to the Fording and Elk Rivers and Michel Creek under Low Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	30	44	29	44	29	44	44
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	99	133	-[c]	-[c]	333[d]
CC1	Clode Creek at the mouth	106	162	143	217	279	436	442
SP1[a]	Swift Pit	-[b]	-[b]	178	230	-[c]	-[c]	230[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	12	15	11	13	66
SC_CA[f]	Swift/Cataract watershed	601	748	457	522	-[c]	-[c]	522[d]
KC1	Kilmarnock Creek at the mouth	177	280	214	341	143	218	341
PC1	Porter Creek at the mouth	73	84	90	120	150	182	182
LE1	Leask Creek at the mouth	60	86	278	375	-[c]	-[c]	-[c]
WC1	Wolfram Creek at the mouth	48	113	82	176	-[c]	-[c]	-[c]
TC1	Thompson Creek at the mouth	115	163	162	232	28	38	232
GH1	Greenhills Creek at the mouth	122	178	126	183	94	118	234
WLC1	West Line Creek at the mouth	458	603	458	603	-[c]	-[c]	-[c]
LC1	Line Creek at the mouth	41	57	20	27	10	17	57
DC1	LCO Dry Creek at the mouth	2	2	2	3	5	11	11
BC1	Bodie Creek at the mouth	385	443	242	447	-[c]	-[c]	-[c]
GT1	Gate Creek at the mouth	171	298	177	307	-[c]	-[c]	-[c]
EC1	Erickson Creek at the mouth	110	121	141	156	30	40	180
DC1_EVO	Dry Creek (EVO) at the mouth	118	164	136	180	212	289	289
HM1	Harmer Creek at the mouth	32	40	37	48	56	67	67
GR1[g, h]	Grave Creek at the mouth	-	-	22	30	34	44	44
WH1	Wheeler Creek at the mouth	1	1	4	14	57	100	100
SS1	Snowslide Creek at the mouth	1	1	1	1	1	1	1
CB1	Carbon Creek at the mouth	1	1	1	1	1	1	1

[a] Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

[b] No monitoring data available.

[c] Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

[d] Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

[e] Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

[f] For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

[g] No observed data available for Grave Creek at the mouth.

[h] For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

Table F-2 Estimated Total Selenium Concentrations (µg/L) in Tributaries to the Fording and Elk Rivers and Michel Creek under High Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	30	44	29	44	29	44	44
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	64	96	-[c]	-[c]	192[d]
CC1	Clode Creek at the mouth	106	162	140	217	269	408	414
SP1[a]	Swift Pit	-[b]	-[b]	121	179	-[c]	-[c]	185[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	9	12	8	11	53
SC_CA[f]	Swift/Cataract watershed	581	721	467	580	-[c]	-[c]	580[d]
KC1	Kilmarnock Creek at the mouth	177	280	214	340	191	263	340
PC1	Porter Creek at the mouth	73	84	93	126	158	177	177
LE1	Leask Creek at the mouth	60	86	252	355	-[c]	-[c]	-[b]
WC1	Wolfram Creek at the mouth	48	113	79	173	-[c]	-[c]	-[b]
TC1	Thompson Creek at the mouth	115	163	162	225	34	37	225
GH1	Greenhills Creek at the mouth	122	178	126	183	195	288	292
WLC1	West Line Creek at the mouth	458	603	458	603	-[c]	-[c]	-[b]
LC1	Line Creek at the mouth	41	57	29	33	20	24	57
DC1	LCO Dry Creek at the mouth	2	2	2	2	4	7	7
BC1	Bodie Creek at the mouth	385	443	142	152	-[c]	-[c]	-[b]
GT1	Gate Creek at the mouth	171	298	177	305	-[c]	-[c]	-[b]
EC1	Erickson Creek at the mouth	110	121	146	158	69	113	182
DC1_EVO	Dry Creek (EVO) at the mouth	118	164	144	222	222	333	333
HM1	Harmer Creek at the mouth	32	40	38	48	55	67	67
GR1[g, h]	Grave Creek at the mouth	-	-	23	30	33	43	43
WH1	Wheeler Creek at the mouth	1	1	3	8	45	78	78
SS1	Snowslide Creek at the mouth	1	1	1	1	1	1	1
CB1	Carbon Creek at the mouth	1	1	1	1	1	1	1

[a] Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

[b] No monitoring data available.

[c] Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

[d] Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

[e] Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

[f] For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

[g] No observed data available for Grave Creek at the mouth.

[h] For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

Table F-3 Estimated Nitrate Concentrations (mg/L as N) in Tributaries to the Fording and Elk Rivers and Michel Creek under Low Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	7.1	10.9	3.0	4.5	0.4	0.5	11
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	11	17	-[c]	-[c]	45[d]
CC1	Clode Creek at the mouth	32	36	27	31	1.5	1.8	71
SP1[a]	Swift Pit	-[b]	-[b]	0.96	1.4	-[c]	-[c]	1.4[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	0.23	0.33	0.081	0.11	2.2
SC_CA[f]	Swift/Cataract watershed	37	50	16	20	-[c]	-[c]	23[d]
KC1	Kilmarnock Creek at the mouth	81	122	95	159	16	25	181
PC1	Porter Creek at the mouth	2.2	2.8	1.2	1.2	0.7	0.8	-[c]
LE1	Leask Creek at the mouth	42	59	122	174	-[c]	-[c]	-[c]
WC1	Wolfram Creek at the mouth	21	33	14	23	-[c]	-[c]	-[c]
TC1	Thompson Creek at the mouth	14	18	15	20	0.2	0.2	27
GH1	Greenhills Creek at the mouth	4.2	6.0	2.2	2.4	0.8	0.8	16
WLC1	West Line Creek at the mouth	26	39	9.2	11	-[c]	-[c]	-[c]
LC1	Line Creek at the mouth	8.1	12	4.3	5.3	0.2	0.3	12
DC1	LCO Dry Creek at the mouth	0.1	0.2	0.8	5.5	1.8	14	52
BC1	Bodie Creek at the mouth	69	85	38	34	-[c]	-[c]	-[c]
GT1	Gate Creek at the mouth	19	30	9.4	15	-[c]	-[c]	-[c]
EC1	Erickson Creek at the mouth	11	12	16	19	0.8	1.5	23
DC1_EVO	Dry Creek (EVO) at the mouth	4.3	6.4	19	35	2.1	3.6	42
HM1	Harmer Creek at the mouth	1.1	1.5	5.1	10	0.6	0.9	10
GR1[g, h]	Grave Creek at the mouth	-	-	3.0	6.4	0.4	0.5	6.4
WH1	Wheeler Creek at the mouth	0.02	0.1	6.7	60	19	70	71
SS1	Snowslide Creek at the mouth	0.02	0.1	0.02	0.1	0.02	0.1	0.1
CB1	Carbon Creek at the mouth	0.01	0.1	0.01	0.1	0.01	0.1	0.1

(a) Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

(b) No monitoring data available.

(c) Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

(d) Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

(e) Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

(f) For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

(g) No observed data available for Grave Creek at the mouth.

(h) For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

Table F-4 Estimated Nitrate Concentrations (mg/L as N) in Tributaries to the Fording and Elk Rivers and Michel Creek under High Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	7.1	11	3.0	4.5	0.4	0.5	11
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	7.1	11	-[c]	-[c]	28[d]
CC1	Clode Creek at the mouth	32	36	26	33	1.4	1.6	61
SP1[a]	Swift Pit	-[b]	-[b]	0.6	0.9	-[c]	-[c]	0.9[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	0.2	0.2	0.06	0.07	1.3
SC_CA[f]	Swift/Cataract watershed[c]	36	48	17	24	-[c]	-[c]	24[d]
KC1	Kilmarnock Creek at the mouth	81	122	95	166	22	28	191
PC1	Porter Creek at the mouth	2.2	2.8	1.3	1.5	0.7	0.8	17
LE1	Leask Creek at the mouth	42	59	109	167	-[c]	-[c]	-[c]
WC1	Wolfram Creek at the mouth	21	33	14	19	-[c]	-[c]	-[c]
TC1	Thompson Creek at the mouth	14	18	15	21	0.2	0.3	27
GH1	Greenhills Creek at the mouth	4.2	6.0	2.2	2.6	1.7	2.0	24
WLC1	West Line Creek at the mouth	26	39	9.0	11	-[c]	-[c]	-[c]
LC1	Line Creek at the mouth	8.1	12	5.8	7.8	0.4	0.4	12
DC1	LCO Dry Creek at the mouth	0.1	0.2	0.6	3.4	1.4	8.2	42
BC1	Bodie Creek at the mouth	69	85	39	36	-[c]	-[c]	-[c]
GT1	Gate Creek at the mouth	19	30	9.4	15	-[c]	-[c]	-[c]
EC1	Erickson Creek at the mouth	11	12	17	19	2.2	4.7	23
DC1_EVO	Dry Creek (EVO) at the mouth	4.3	6.4	21	42	1.8	3.0	43
HM1	Harmer Creek at the mouth	1.1	1.5	5.3	8.8	0.5	0.8	10
GR1[g, h]	Grave Creek at the mouth	-	-	3.1	5.5	0.3	0.5	6
WH1	Wheeler Creek at the mouth	0.02	0.1	4.5	33	14	54	57
SS1	Snowslide Creek at the mouth	0.02	0.1	0.02	0.1	0.02	0.1	0.1
CB1	Carbon Creek at the mouth	0.01	0.1	0.01	0.1	0.01	0.1	0.1

[a] Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

[b] No monitoring data available.

[c] Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

[d] Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

[e] Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

[f] For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

[g] No observed data available for Grave Creek at the mouth.

[h] For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

Table F-5 Estimated Sulphate Concentrations (mg/L) in Tributaries to the Fording and Elk Rivers and Michel Creek under Low Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration[a]		2017 Estimated Concentration[b]		2034 Estimated Concentration[b]		Estimated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	137	197	136	196	136	196	197
TS1[a]	North (Turnbull) Spoil	-[b]	-[b]	355	516	-[c]	-[c]	956[d]
CC1	Clode Creek at the mouth	289	381	374	479	730	956	968
SP1[a]	Swift Pit	-[b]	-[b]	781	1058	-[c]	-[c]	1058[d]
LF2[a, e]	Lower Fording 2	-[b]	-[b]	352	400	341	383	784
SC_CA[f]	Swift/Cataract watershed[c]	1548	1835	1991	2098	-[c]	-[c]	2098[d]
KC1	Kilmarnock Creek at the mouth	442	664	531	804	346	518	804
PC1	Porter Creek at the mouth	405	464	492	503	795	908	908
LE1	Leask Creek at the mouth	290	378	1896	2491	-[c]	-[c]	-[c]
WC1	Wolfram Creek at the mouth	414	621	484	637	-[c]	-[c]	-[c]
TC1	Thompson Creek at the mouth	573	735	841	1099	1661	1730	1730
GH1	Greenhills Creek at the mouth	554	799	565	817	491	642	983
WLC1	West Line Creek at the mouth	960	1260	960	1260	-[c]	-[c]	-[c]
LC1	Line Creek at the mouth	155	216	187	246	193	246	247
DC1	LCO Dry Creek at the mouth	8	9	8	10	11	19	20
BC1	Bodie Creek at the mouth	960	1020	591	1019	-[c]	-[c]	-[c]
GT1	Gate Creek at the mouth	770	1190	794	1231	-[c]	-[c]	-[c]
EC1	Erickson Creek at the mouth	611	673	753	806	942	1028	1028
DC1_EVO	Dry Creek (EVO) at the mouth	597	880	641	923	1032	1523	1523
HM1	Harmer Creek at the mouth	169	215	182	238	293	362	362
GR1[g, h]	Grave Creek at the mouth	-	-	112	156	179	238	239
WH1	Wheeler Creek at the mouth	4	6	7	18	75	123	123
SS1	Snowslide Creek at the mouth	5	6	5	6	5	6	6
CB1	Carbon Creek at the mouth	4	5	4	5	4	6	6

[a] Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

[b] No monitoring data available.

[c] Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

[d] Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

[e] Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

[f] For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

[g] No observed data available for Grave Creek at the mouth.

[h] For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

Table F-6 Estimated Sulphate Concentrations (mg/L) in Tributaries to the Fording and Elk Rivers and Michel Creek under High Flows

Modelling Node ID	Modelling Node Description	2013 Observed Concentration		2017 Estimated Concentration		2034 Estimated Concentration		Estimated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
HC1	Henretta Creek at the mouth	137	197	136	196	136	196	197
TS1[(a)]	North (Turnbull) Spoil	-[(b)]	-[(b)]	251	323	-[(c)]	-[(c)]	660[(d)]
CC1	Clode Creek at the mouth	289	381	373	500	719	939	952
SP1[(a)]	Swift Pit	-[(b)]	-[(b)]	530	665	-[(c)]	-[(c)]	671[(d)]
LF2[(a, e)]	Lower Fording 2	-[(b)]	-[(b)]	318	339	310	329	503
SC_CA[(f)]	Swift/Cataract watershed[(c)]	1500	1774	2002	1978	-[(c)]	-[(c)]	1798[(d)]
KC1	Kilmarnock Creek at the mouth	442	664	529	798	471	620	798
PC1	Porter Creek at the mouth	405	464	511	701	864	992	992
LE1	Leask Creek at the mouth	290	378	1708	2074	-[(c)]	-[(c)]	-[(c)]
WC1	Wolfram Creek at the mouth	414	621	532	728	-[(c)]	-[(c)]	-[(c)]
TC1	Thompson Creek at the mouth	573	735	841	1061	1671	2219	2219
GH1	Greenhills Creek at the mouth	554	799	563	815	741	1128	1140
WLC1	West Line Creek at the mouth	960	1260	960	1260	-[(c)]	-[(c)]	-[(c)]
LC1	Line Creek at the mouth	155	216	185	260	200	259	260
DC1	LCO Dry Creek at the mouth	8	9	8	9	10	14	15
BC1	Bodie Creek at the mouth	960	1020	379	365	-[(c)]	-[(c)]	-[(c)]
GT1	Gate Creek at the mouth	770	1190	795	1217	-[(c)]	-[(c)]	-[(c)]
EC1	Erickson Creek at the mouth	611	673	759	835	970	1206	1206
DC1_EVO	Dry Creek (EVO) at the mouth	597	880	668	967	1063	1476	1479
HM1	Harmer Creek at the mouth	169	215	186	236	286	355	355
GR1[(g, h)]	Grave Creek at the mouth	-	-	119	166	180	249	249
WH1	Wheeler Creek at the mouth	4	6	6	14	60	108	108
SS1	Snowslide Creek at the mouth	5	6	5	6	5	6	6
CB1	Carbon Creek at the mouth	4	5	4	5	4	6	6

(a) Concentrations in this table were estimated using the approach outlined in Section 5.2. with the exception of the following discharge locations: the North (Turnbull) Spoil, Swift Pit and Lower Fording 2. For these locations, all concentrations presented in the table are predicted using the model, because there are no monitoring data at these locations.

(b) No monitoring data available.

(c) Physical or flow-related loss of habitat is anticipated in these tributaries, given that water is diverted to treatment.

(d) Concentrations presented are maximum values that are predicted to occur before active water treatment is implemented.

(e) Lower Fording 2 is a predominantly mine disturbed area on the west side of Fording River between Lake Mountain Creek and Swift Creek watersheds that discharges to Smith Pond. This area includes historical pits, waste rock and the North Tailings Facility. Concentrations are predicted to decrease, because the Lower Fording 2 watershed will decrease in area as the Swift Pit watershed increases.

(f) For the combined Swift/Cataract watershed, the 2013 observed concentrations were estimated based on the annual average flows and the observed concentrations in Swift and Cataract creeks (i.e., flow weighted average). The 2013 modelled concentrations were estimated using the 2013 modelled flows and loadings at Swift and Cataract creeks.

(g) No observed data available for Grave Creek at the mouth.

(h) For Grave Creek at the mouth (GR1), the 'scaled up' concentrations were estimated based on the 'scaled up' concentrations at Harmer Creek (HM1) and the ratio between the modelled concentrations at GR1 and HM1.

Table F-7 Simulated Total Selenium Concentrations (µg/L) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under Low Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	17	34	21	40	24	38	75
FR2	Fording River downstream of Clode Creek	31	45	40	58	28	40	82
FR3	Fording River between Swift and Cataract Creeks	55	89	81	125	39	54	125
FR3b	Fording River downstream of Porter Creek	73	112	79	122	40	55	122
FR4	Fording River downstream of Greenhills Creek	44	72	48	78	25	39	78
FR5	Fording River at the mouth	42	62	37	55	19	26	62
ER1	Elk River downstream of GHO and upstream of FRO	2	3	4	7	1	2	11
ER2	Elk River downstream of Fording River	14	23	13	22	6	10	23
MC1	Michel Creek at the mouth	11	17	17	24	9	13	25
ER3	Elk River downstream of Michel Creek	10	15	11	15	6	8	15
ER4	Elko Reservoir	8	12	9	12	5	7	12
ER5	Elk River at the mouth	6	9	7	10	4	5	10
LK2	Main Basin of Lake Koocanusa	1	2	2	2	1	1	2

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-8 Simulated Total Selenium Concentrations (µg/L) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under Average Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	17	29	19	31	25	34	50
FR2	Fording River downstream of Clode Creek	28	37	36	49	29	35	66
FR3	Fording River between Swift and Cataract Creeks	46	71	68	100	39	50	100
FR3b	Fording River downstream of Porter Creek	59	87	67	97	39	51	97
FR4	Fording River downstream of Greenhills Creek	37	58	42	64	27	41	64
FR5	Fording River at the mouth	35	52	34	49	21	29	52
ER1	Elk River downstream of GHO and upstream of FRO	2	3	4	6	2	2	10
ER2	Elk River downstream of Fording River	13	22	14	23	8	10	23
MC1	Michel Creek at the mouth	9	12	14	19	9	13	19
ER3	Elk River downstream of Michel Creek	9	14	11	16	7	9	16
ER4	Elko Reservoir	8	11	9	13	6	7	13
ER5	Elk River at the mouth	6	9	7	10	5	5	10
LK2	Main Basin of Lake Koocanusa	1	2	2	2	1	1	2

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-9 Simulated Total Selenium Concentrations (µg/L) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under High Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	16	25	18	26	24	33	40
FR2	Fording River downstream of Clode Creek	25	35	33	46	30	39	61
FR3	Fording River between Swift and Cataract Creeks	40	61	59	84	40	53	84
FR3b	Fording River downstream of Porter Creek	52	74	58	82	40	53	82
FR4	Fording River downstream of Greenhills Creek	34	52	38	57	31	45	57
FR5	Fording River at the mouth	31	48	32	47	25	35	48
ER1	Elk River downstream of GHO and upstream of FRO	2	3	3	5	2	3	9
ER2	Elk River downstream of Fording River	12	21	13	22	10	13	22
MC1	Michel Creek at the mouth	8	12	13	19	10	17	19
ER3	Elk River downstream of Michel Creek	8	14	10	16	8	10	16
ER4	Elko Reservoir	7	11	8	13	7	8	13
ER5	Elk River at the mouth	5	8	6	9	5	6	10
LK2	Main Basin of Lake Koocanusa	1	2	2	2	1	2	2

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-10 Simulated Nitrate Concentrations (mg/L as N) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under Low Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	3.8	9.3	2.1	4.7	0.8	1.4	9.3
FR2	Fording River downstream of Clode Creek	9.8	18	7.0	12	0.9	1.5	21
FR3	Fording River between Swift and Cataract Creeks	20	36	21	40	2.2	3.4	45
FR3b	Fording River downstream of Porter Creek	20	36	20	38	2.1	3.3	43
FR4	Fording River downstream of Greenhills Creek	11	22	13	25	1.3	2.2	27
FR5	Fording River at the mouth	9.1	16	9.0	17	0.9	1.3	18
ER1	Elk River downstream of GHO and upstream of FRO	0.6	1.2	0.9	1.5	0.0	0.1	2.2
ER2	Elk River downstream of Fording River	3.0	5.0	3.0	4.9	0.3	0.4	5.5
MC1	Michel Creek at the mouth	1.1	1.7	2.7	4.4	2.7	3.9	4.8
ER3	Elk River downstream of Michel Creek	1.8	2.8	2.1	3.1	0.6	0.8	3.1
ER4	Elko Reservoir	1.4	2.2	1.7	2.5	0.5	0.7	2.5
ER5	Elk River at the mouth	1.1	1.7	1.3	1.9	0.4	0.5	1.9
LK2	Main Basin of Lake Koocanusa	0.3	0.4	0.4	0.5	0.2	0.2	0.5

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-11 Simulated Nitrate Concentrations (mg/L as N) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under Average Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	3.6	7.7	1.9	3.6	0.8	1.3	7.7
FR2	Fording River downstream of Clode Creek	8.8	15	6.4	10.0	1.1	1.7	18
FR3	Fording River between Swift and Cataract Creeks	17	29	17	32	2.4	4.1	36
FR3b	Fording River downstream of Porter Creek	17	29	17	31	2.3	3.9	34
FR4	Fording River downstream of Greenhills Creek	10	18	11	20	1.7	3.7	22
FR5	Fording River at the mouth	8.0	14	8.2	15	1.2	2.4	16
ER1	Elk River downstream of GHO and upstream of FRO	0.6	1.1	0.9	1.6	0.1	0.1	2.4
ER2	Elk River downstream of Fording River	3.1	5.5	3.3	6.1	0.4	0.7	6.3
MC1	Michel Creek at the mouth	0.9	1.2	2.2	3.3	2.4	3.7	3.8
ER3	Elk River downstream of Michel Creek	1.8	2.9	2.2	3.4	0.8	1.0	3.5
ER4	Elko Reservoir	1.4	2.3	1.8	2.7	0.6	0.8	2.8
ER5	Elk River at the mouth	1.1	1.7	1.3	2.0	0.5	0.6	2.0
LK2	Main Basin of Lake Koocanusa	0.3	0.4	0.4	0.4	0.2	0.2	0.4

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-12 Simulated Nitrate Concentrations (mg/L as N) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under High Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	3.5	6.9	1.8	3.2	0.8	1.3	6.9
FR2	Fording River downstream of Clode Creek	7.9	13	5.9	8.9	1.3	2.9	15
FR3	Fording River between Swift and Cataract Creeks	15	25	15	27	2.7	5.0	30
FR3b	Fording River downstream of Porter Creek	15	25	14	26	2.6	4.9	29
FR4	Fording River downstream of Greenhills Creek	9.1	16	9.8	18	2.4	5.4	19
FR5	Fording River at the mouth	7.3	13	7.5	14	1.7	3.7	15
ER1	Elk River downstream of GHO and upstream of FRO	0.5	0.9	0.7	1.4	0.1	0.1	2.0
ER2	Elk River downstream of Fording River	2.8	5.4	3.1	6.1	0.6	1.2	6.4
MC1	Michel Creek at the mouth	0.8	1.2	2.0	3.2	2.2	3.9	4.1
ER3	Elk River downstream of Michel Creek	1.6	2.9	2.0	3.4	0.9	1.2	3.7
ER4	Elko Reservoir	1.3	2.3	1.6	2.7	0.7	1.0	3.0
ER5	Elk River at the mouth	0.9	1.7	1.2	2.0	0.5	0.7	2.1
LK2	Main Basin of Lake Koocanusa	0.3	0.4	0.3	0.4	0.2	0.2	0.4

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-13 Simulated Sulphate Concentrations (mg/L) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under Low Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	86	128	93	140	339	512	512
FR2	Fording River downstream of Clode Creek	174	266	188	279	353	527	527
FR3	Fording River between Swift and Cataract Creeks	258	417	366	563	481	697	697
FR3b	Fording River downstream of Porter Creek	300	467	358	551	472	686	686
FR4	Fording River downstream of Greenhills Creek	188	294	221	339	316	483	483
FR5	Fording River at the mouth	179	262	212	307	274	383	383
ER1	Elk River downstream of GHO and upstream of FRO	27	36	37	54	41	63	85
ER2	Elk River downstream of Fording River	69	106	84	128	104	159	162
MC1	Michel Creek at the mouth	103	151	131	170	183	272	272
ER3	Elk River downstream of Michel Creek	62	83	75	97	96	131	131
ER4	Elko Reservoir	53	71	64	82	80	109	109
ER5	Elk River at the mouth	44	60	52	69	65	90	90
LK2	Main Basin of Lake Koocanusa	37	40	39	43	42	47	47

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-14 Simulated Sulphate Concentrations (mg/L) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under Average Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	83	125	88	132	306	456	456
FR2	Fording River downstream of Clode Creek	159	230	173	248	323	461	461
FR3	Fording River between Swift and Cataract Creeks	224	349	322	495	445	663	663
FR3b	Fording River downstream of Porter Creek	259	393	315	484	436	653	653
FR4	Fording River downstream of Greenhills Creek	171	267	203	322	298	461	461
FR5	Fording River at the mouth	161	241	191	290	258	382	382
ER1	Elk River downstream of GHO and upstream of FRO	26	36	38	57	43	68	85
ER2	Elk River downstream of Fording River	71	110	88	136	113	175	179
MC1	Michel Creek at the mouth	85	124	107	149	154	264	264
ER3	Elk River downstream of Michel Creek	62	86	76	106	100	142	142
ER4	Elko Reservoir	53	73	64	89	83	118	118
ER5	Elk River at the mouth	44	59	52	71	66	92	92
LK2	Main Basin of Lake Koocanusa	37	41	39	44	43	50	50

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.

Table F-15 Simulated Sulphate Concentrations (mg/L) in the Fording and Elk Rivers, Michel Creek and Lake Koocanusa under High Flows

Modelling Node ID	Modelling Node Description	2013 Simulated Concentration		2017 Simulated Concentration		2034 Simulated Concentration		Simulated Maximum Concentration (2013 to 2034)
		Average	Maximum Monthly Average	Average	Maximum	Average	Maximum	Maximum
FR1	Fording River downstream of Henretta Creek	80	123	84	127	273	404	404
FR2	Fording River downstream of Clode Creek	148	208	160	223	293	402	402
FR3	Fording River between Swift and Cataract Creeks	198	302	279	415	400	591	591
FR3b	Fording River downstream of Porter Creek	230	339	274	408	393	584	584
FR4	Fording River downstream of Greenhills Creek	159	246	185	290	281	439	439
FR5	Fording River at the mouth	149	230	175	273	245	378	378
ER1	Elk River downstream of GHO and upstream of FRO	25	34	34	51	37	57	84
ER2	Elk River downstream of Fording River	67	108	82	134	108	179	185
MC1	Michel Creek at the mouth	76	125	99	155	140	263	263
ER3	Elk River downstream of Michel Creek	58	86	72	105	95	147	147
ER4	Elko Reservoir	50	73	61	88	80	122	122
ER5	Elk River at the mouth	42	59	50	70	64	94	94
LK2	Main Basin of Lake Koocanusa	36	41	39	44	42	50	50

Notes: Concentrations in Lake Koocanusa have been corrected for model bias. Concentrations are model predictions and do not involve the scaled-up approach that was used in the previous tables to estimate concentrations in tributaries.