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Technical Report Overview

Report: Elk Valley Selenium Speciation Monitoring Program 2021 Annual Report

Overview: This report summarizes the findings of the 2021 selenium speciation monitoring program. This monitoring program was designed to identify areas with atypical selenium speciation and increase understanding of the potential mechanisms driving generation of organic and reduced forms of selenium.

This report was prepared for Teck by Adept Environmental Inc.

For More Information
If you have questions regarding this report, please:
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Future studies will be made available at **teck.com/elkvalley.**

ADEPT
Environmental
Sciences Ltd.

Elk Valley Selenium Speciation Monitoring Program

2021 Annual Report

Submitted to:

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GLOSSARY

µg/L	micrograms/Liter
AFDM	Ash Free Dry Mass
AIC	Akaike Information Criterion
BI [Se]	Benthic Invertebrate Tissue Selenium Concentration
Schwarz's BIC	Schwarz's Bayesian Information Criterion
CABIN	Canadian Aquatic Biomonitoring Network
CALA	Canadian Association for Laboratory Accreditation
CMm	Coal Mountain Mine
DMDSe	Dimethyldiselenide
DMSe	Dimethylselenide
DMSeO	Dimethylselenoxide
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DS	Downstream
EMC	Environmental Monitoring Committee
EVO	Elkview Operations
EVO SRF	Elkview Saturated Rock Fill
FRO	Fording River Operations
GHO	Greenhills Operations
GPS	Global Positioning System
GLM	General Linear Model
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
km	kilometer
LAEMP	Local Aquatic Effects Monitoring Program
LCO	Line Creek Operations
MeSe(IV)	Methylseleninic acid
MeSe(VI)	Methaneselenonic acid
mg/kg dw	milligrams/kilogram dry weight
mL	milliliter
m/s	meters/second
ORP	Oxidation Reduction Potential
PCA	Principal Component Analysis
r^2	model coefficient of determination
RAEMP	Regional Aquatic Effects Monitoring Program
SeCN	Selenocyanate
SeMet	Selenomethionine
SeSMP	Elk Valley Selenium Speciation Monitoring Program
Se(VI)	Selenate
Se(IV)	Selenite
$SeSO_3$	Selenosulphate
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
US	Upstream
WLC AWTF	West Line Creek Active Water Treatment Facility

1.0 INTRODUCTION

ADEPT Environmental Sciences Ltd. (ADEPT) is pleased to provide Teck Coal Limited (Teck) with the following 2021 Annual Report on the Elk Valley Selenium Speciation Monitoring Program (SeSMP). The study design for the 2021 SeSMP was developed with advice and input from the Elk Valley Environmental Monitoring Committee (EMC). The study design, as well as the data analysis and interpretation presented herein, also received input from Dr. Jen Ings and Dr. Robin Valleau (Minnow), Dr. Kevin Brix (EcoTox LLC), Dr. Sam Luoma (Samuel N Luoma PhD LLC), and Dr. Peter Campbell (Institut National de la Recherche Scientifique). Field data presented in this report were collected by Minnow Environmental Inc. (Minnow) and Teck.

In combination with the State of the Science Report (Golder 2021a) and the 2021 SeSMP Study Design (Golder 2021b), this Annual Report addresses requirements for selenium speciation monitoring in Sections 8.6 and 9.11 of *Environmental Management Act* Amended Permit 107517 (11 March 2021).

2.0 BACKGROUND

2.1 Scope, Objectives, and Study Questions

The scope of the SeSMP was specified in Section 8.6 of Amended Permit 107517, which states:

> *The permittee must develop and implement a Selenium Speciation Monitoring Program. The Selenium Speciation Monitoring Program is intended to:*
>
> - *Identify sites in the Designated Area, affected or potentially influenced by the permittee's current operations, where organic and reduced forms of selenium are occurring or are likely to occur;*
> - *Investigate the physical and/or biogeochemical mechanisms driving selenium speciation and the generation of organic and reduced forms of selenium species; and*
> - *Assess the site-specific bioaccumulation of selenium in biological resources.*
>
> *The Selenium Speciation Monitoring Program must include the following elements:*
>
> *i. Assessment of water quality and selenium tissue concentrations in benthic invertebrates; and*
>
> *ii. Characterization of factors that lead to enhanced selenium bioaccumulation in the receiving environment, as applicable.*

In developing the study design for the SeSMP (Golder 2021b), an overarching goal was established that links the specific requirements in Section 8.6 to the broader environmental management objectives outlined for Teck in Permit 107517. Objectives in support of the goal were adopted directly from the intended outcomes of the SeSMP, as summarized above. Study questions were then developed to address each of the objectives.

A detailed rationale for the scope of the study questions, and how these questions address the objectives, is provided in Golder (2021b). In brief, the analysis in Golder (2021a) highlighted the greater importance of organoselenium species over the inorganic species selenate and selenite, both in terms of exhibiting larger changes in mine sedimentation ponds (making organoselenium an appropriate focus for studying mechanisms of change and spatial and temporal patterns of speciation) and in terms of having a larger influence on bioaccumulation (making organoselenium an appropriate focus for studying effects on bioaccumulation). Accordingly, the SeSMP study questions laid out in the study design focus on characterizing spatial and temporal patterns of organoselenium, investigating mechanisms of organoselenium production, and testing the existing bioaccumulation tool that predicts how organoselenium species (in combination with other selenium species) affect bioaccumulation. The goal, objectives, and study questions for the SeSMP are provided in Box 1.

Box 1. Goal, objectives, and study questions for the SeSMP

Goal	To better understand areas with atypical selenium speciation conditions and how these conditions affect site-specific selenium bioaccumulation. This understanding will support Teck's adaptive management planning to attain area-based environmental management objectives of protection of aquatic ecosystem health and management of bioaccumulation of selenium in the receiving environment.
Objectives	Identify sites in the Designated Area, affected or potentially influenced by Teck's current operations, where organic and reduced forms of selenium are occurring or are likely to occur. Investigate the physical and/or biogeochemical mechanisms driving selenium speciation and the generation of organic and reduced forms of selenium species. Assess the site-specific bioaccumulation of selenium in biological resources.
Study Questions	Study Question 1: What is the spatial extent of detectable organoselenium? Study Question 2: Are there temporal trends in organoselenium concentrations? Study Question 3: What are the mechanisms of organoselenium production? Study Question 4: Do new data support refinement of the speciation bioaccumulation tool?

The annual reporting requirement for the SeSMP is specified in Section 9.11 of Amended Permit 107517:

> *The permittee must prepare an annual report documenting the activities and results of monitoring undertaken for each element of the Selenium Speciation Monitoring Program, as per Section 8.6. The report must be submitted to the director and the EMC by April 15th of each year.*

Per this requirement, the remainder of this report documents the approach (Sections 2.2 and 2.3), specific methods (Section 3), and results (Section 4) of the 2021 SeSMP. An interpretation of results to date to answer the study questions is provided in Section 5. Recommendations for the 2022 SeSMP are provided in Section 6.

2.2 Overview of 2021 SeSMP Study Design

The overall approach to answering the SeSMP study questions is discussed in detail in Golder (2021b) and outlined in Table 1. This approach has two parts:

The first part (Section 4 of the Golder 2021b study design) is an extensive (studying many locations) and intensive (measuring many things) investigation, to be conducted in the first three-year cycle of the SeSMP (2021 – 2023), intended to characterize spatial patterns and seasonal trends in organoselenium, provide insight into the conditions that facilitate organoselenium production, and test the ability of the speciation bioaccumulation tool to predict the effect of measured organoselenium concentrations on selenium concentrations in biota. It is anticipated that the investigation component of the SeSMP and associated objectives and study questions will be refined with each three-year cycle to build on the findings of previous cycles and refocus on key residual uncertainties.

The second part (Section 5 of the Golder 2021b study design) is an ongoing monitoring program aimed specifically at the interannual element of Study Question 2: *Are there temporal trends in organoselenium concentrations?* It is anticipated that the study design for ongoing monitoring will be re-evaluated and updated upon completion of the investigation studies to confirm that monitoring locations, timing, and parameters are appropriate to the objectives of ongoing monitoring.

Table 1. Outline of how 2021 SeSMP study components address the study questions

Study Question	Study Component	Overview of Study Design
Study Question 1 (Spatial Extent)	Regional survey	Regional sampling of speciation, water quality, and tissue selenium concentrations. Includes sampling at compliance and Order stations on the Elk River, Fording River, Line Creek, and Michel Creek, at the outflow of all sedimentation ponds with a permitted discharge, and upstream and downstream of a set of sedimentation ponds selected to help answer Study Questions 2, 3, and 4. Reporting on this component herein includes data tables, maps, and an interpretation of regional spatial patterns of speciation, focusing on peak organoselenium concentrations at each location.
	Longitudinal patterns	Local sampling of speciation, water quality, and tissue selenium concentrations along a longitudinal spatial gradient downstream of selected sedimentation ponds. Reporting on this component herein includes data tables, plots, and an interpretation of local spatial gradients of speciation at the three study sedimentation ponds.
Study Question 2 (Temporal Trends)	Seasonality	Monthly sampling of speciation, water quality, and tissue selenium concentrations upstream and downstream of selected sedimentation ponds. Reporting on this component herein includes data tables and plots of the partial seasonal data collected to date at the three study sedimentation ponds. A detailed analysis of seasonality will be provided in the 2022 SeSMP when a full annual cycle of data is available.
	Long-term trends	Ongoing monitoring of speciation at compliance and Order stations (quarterly) and permitted sedimentation pond discharges (annually) in each management unit. Weekly to monthly local monitoring at sites with identified uncertainty in projected speciation, to be reviewed as uncertainty is reduced. Reporting on this component herein includes tables of speciation data collected in 2021. An evaluation of interannual trends will be provided in the 2022 SeSMP.
Study Question 3	Mechanisms	Correlation- and ordination-type analyses to relate differences in speciation among ponds (regional survey) and over time within ponds (seasonality) to pond characteristics and conditions. Reporting on this component herein includes data tables, statistical analyses, and interpretation of evidence for factors contributing to changes in selenium speciation at the study sedimentation ponds.
Study Question 4	Bioaccumulation	Use of paired speciation and tissue selenium data collected for Study Questions 1 and 2 to test and, if warranted, update the speciation bioaccumulation tool. Reporting on this component herein includes data tables, plots, and an interpretation of how well (and why) data collected in 2021 do or do not conform to the bioaccumulation tool.

2.3 Conceptual Model for Selenium Speciation

Selenium speciation can vary greatly across different kinds of aquatic environments, affecting its fate (Milne 1998; Maher et al. 2010), bioaccumulative potential (Reidel et al. 1996; Simmons and Wallschläger 2005; Stewart et al. 2010), and resulting toxicity (Besser et al. 1993; Janz et al. 2010). Selenium can occur in natural waters as the oxyanions selenate (SeO_4^{2-}, oxidation state VI) and selenite (SeO_3^{2-}, oxidation state IV), as organic or inorganic selenides (oxidation state -II), and as elemental selenium (oxidation state 0).

Selenate and selenite are thermodynamically stable and highly soluble in natural waters (Milne 1998), although selenite is more reactive and has a relatively strong tendency to adsorb to organic and mineral solid phases (Faust 1981; Maher et al. 2010). In contrast, elemental selenium is insoluble and generally occurs where microbial activity has resulted in the deposition of selenium in the solid phase in sedimentations (Faust 1981; Dungan and Frankenberger 1999; Maher et al. 2010). Selenides have variable properties: some are soluble (e.g., seleninic acids), some are insoluble (e.g., metal selenides), and some are volatile (e.g., dimethylselenide). The amino acids selenomethionine and selenocysteine are organoselenides that are ubiquitous in living systems but rarely detected in surface waters (LeBlanc and Wallschläger 2016). Many organoselenides are highly labile and are not expected to persist in natural waters (LeBlanc and Wallschläger 2016; Jain 2017).

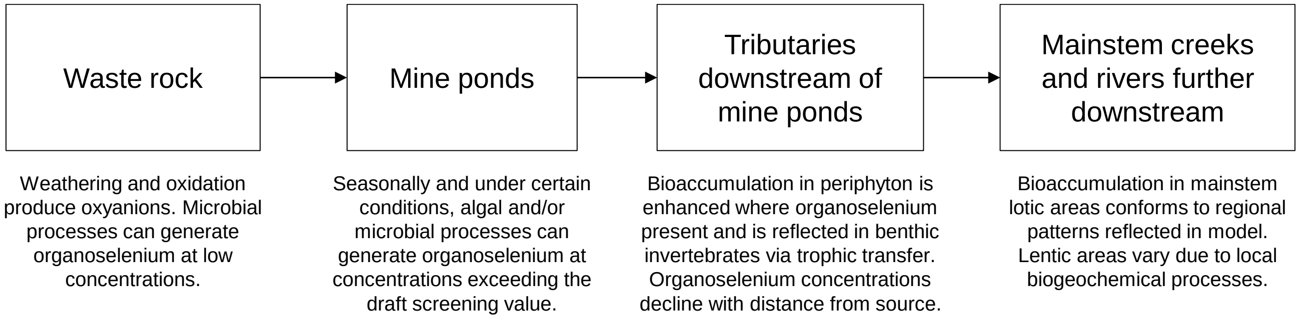
The biotic and abiotic processes that transform selenium from one species to another are extremely complex. Detailed overviews of these processes are available elsewhere (e.g., Maher et al. 2010; Eswayah et al. 2016; Ponton et al. 2020). Selenium speciation data collected by Teck in focused investigations and in local and regional monitoring were summarized and analyzed in Golder (2021a), with the following key findings:

- Selenium species that are most often detected in the Elk Valley are selenate, selenite, dimethylselenoxide (DMSeO), and methylseleninic acid (MeSe(IV)). Methaneselenonic acid (MeSe(VI)), selenosulphate ($SeSO_3$), and selenocyanate (SeCN) have also been reported in some analyses but are localized and/or infrequently detected (<0.01 µg/L). Selenate is ubiquitous and predominates in Elk Valley waters. Selenite is detected in both reference and mine-affected waters but is generally present in higher concentrations at locations closer to mining. DMSeO and MeSe(IV) occur primarily in some mine sedimentation ponds and buffer ponds and in portions of tributaries immediately downstream of these ponds. Some pit waters contain relatively high concentrations of selenite but rarely have detectable organoselenium. Seeps rarely contain any detectable organoselenium and have consistently low concentrations of selenite. Organoselenium has been detected only rarely in Michel Creek or the Elk River but is occasionally detected in the Fording River.
- The most important species affecting selenium bioaccumulation in the Elk Valley are selenate, selenite, DMSeO, and MeSe(IV). An analysis of speciation and bioaccumulation data from the Elk Valley (de Bruyn and Luoma 2021) did not detect a contribution to bioaccumulation from any other species, although most other species were not detected in that dataset with sufficient frequency to provide a rigorous evaluation. Selenate and selenite alone can account for selenium bioaccumulation in most lotic areas in the Elk Valley, resulting in a consistent “typical” pattern of bioaccumulation relative to aqueous total selenium as described by the updated lotic bioaccumulation models (Golder 2020). Higher bioaccumulation in some areas is associated with DMSeO and MeSe(IV). The analysis of de Bruyn and Luoma (2021) indicates that the bioaccumulative potential of DMSeO and MeSe(IV) is on the order of 10× higher than selenate or selenite.
- Patterns of bioaccumulation support a draft screening value of 0.025 µg/L (expressed as the sum of DMSeO and MeSe(IV)) to indicate conditions that might cause an incremental increase in bioaccumulation relative to the normal range of variation in monitoring data. Organoselenium concentrations greater than 0.05 µg/L were more consistently associated with measured and modelled benthic invertebrate selenium concentrations outside the normal range of variability.
- The processes by which DMSeO and MeSe(IV) are generated have been linked to algal productivity and/or microbial activity in sedimentation ponds, consistent with published literature on biological reduction of selenium (e.g., Eswayah et al. 2016; Ponton et al. 2020). The inferred mechanism is assimilatory reduction of inorganic selenium to organoselenides, followed by enzymatic degradation and oxidation to form methylated selenium metabolites. The specific characteristics of sedimentation ponds that promote these processes appear to include nutrient availability and likely other factors that are not yet well understood (Lorax 2020).

- Concentrations of DMSeO and MeSe(IV) decline with distance downstream of where they are generated, and these rates of loss are faster than can be accounted for by dilution. This loss of organoselenium species from the aqueous phase is hypothesized to reflect some combination of chemical decomposition (LeBlanc and Wallschläger 2016; Jain 2017) and uptake by periphyton (de Bruyn and Luoma 2021).

The general and site-specific information summarized in Golder (2021a) was used to develop the conceptual model for organoselenium sources and fate at Teck's operations in the Elk Valley depicted in Figure 1. This conceptual model highlights the production of organoselenium in sedimentation ponds as the primary mechanism by which mine-related changes to speciation affect patterns of bioaccumulation in the Elk Valley.

Figure 1. Conceptual model for changes to selenium speciation at Teck's Elk Valley operations



Weathering and oxidation produce oxyanions. Microbial processes can generate organoselenium at low concentrations.

Seasonally and under certain conditions, algal and/or microbial processes can generate organoselenium at concentrations exceeding the draft screening value.

Bioaccumulation in periphyton is enhanced where organoselenium present and is reflected in benthic invertebrates via trophic transfer. Organoselenium concentrations decline with distance from source.

Bioaccumulation in mainstem lotic areas conforms to regional patterns reflected in model. Lentic areas vary due to local biogeochemical processes.

3.0 METHODS

The following subsections describe the specific field, laboratory, and data analysis methods used to implement the study components outlined in Table 1. Each component followed the design outlined in Golder (2021b) with modifications as noted herein to adapt to field conditions and characteristics of the data collected.

All field sampling followed approved methods of the Elk Valley Regional Aquatic Effects Monitoring Program (RAEMP; Minnow 2020). Unless otherwise specified, all aqueous selenium speciation sampling, sample handling, and chemical analysis was conducted following standard methods provided by the analytical laboratory and adopted for Teck's regional water quality monitoring program. Speciation samples were submitted to Brooks Applied Labs (Brooks, Bothell, Washington) for analysis of selenate, selenite, DMSeO, MeSe(IV), MeSe(VI), SeCN, $SeSO_3$, and SeMet. Where noted, additional samples were collected and submitted for analysis of the volatile selenium species dimethylselenide (DMSe) and dimethyldiselenide (DMDSe).

3.1 Regional Survey

This study component focused on regional spatial patterns of selenium speciation in mainstem rivers and in relation to known or suspected sources of organoselenium, with a focus on sedimentation ponds per the conceptual model outlined in Section 2.3 (see analysis in Golder 2021a for further discussion). Speciation monitoring was conducted in 2021 at compliance and Order stations on the Elk River, Fording River, Line Creek, and Michel Creek, at most permitted sedimentation pond discharges, and in several local and regional monitoring programs in all major mine-affected drainages of the Elk Valley. All available data from these monitoring programs were retreived from Teck's water quality database and compiled to support the analyses below.

In addition to compiling data from ongoing and existing monitoring, a set of sedimentation ponds was selected for more intensive sampling in 2021 as described below. This intensive sampling program was intended to expand the spatial dataset to previously unsampled sedimentation ponds and supplement existing data for previously sampled ponds. The focus of this intensive sampling was on sedimentation ponds with a surface discharge to downstream aquatic habitat, so that sampling could be paired with benthic invertebrate tissue selenium concentrations.

Sampling and Analysis – Local and Regional Monitoring

Monitoring of selenium speciation at compliance and Order stations (Table 2)[1] and permitted sedimentation pond discharges (Table 3) was conducted by Teck staff at Fording River Operations (FRO), Greenhills Operations (GHO), Line Creek Operations (LCO), Elkview Operations (EVO), and Coal Mountain Mine (CMM). Sedimentation Ponds shown in bold font in Table 3 were also included in the 2021 sedimentation pond study, discussed further below. Speciation monitoring under other local and regional programs (Table 4) was conducted by staff from Teck and Minnow. Monitoring locations sampled under the programs summarized in Tables 2 – 4 are shown on regional maps for each mine operation in Attachment A.

For all programs summarized below, water samples were taken in accordance with the procedures described in the most recent edition of the *British Columbia Field Sampling Manual for Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sedimentation, and Biological Samples* (BC MOE 2003) or by suitable alternative procedures as authorized by the Director. Speciation samples were submitted to Brooks for analysis.

Table 2. Compliance and Order stations monitored for selenium speciation

Watercourse	Monitoring Location	EMS
Compliance Points specified in Section 2 of Permit 107517		
Fording River	FR_FRABCH	E223753
Fording River	GH_FR1	0200378
Elk River	GH_ERC	0300090
Line Creek	LC_LCDSSLCC	E297110
Harmer Creek	EV_HC1	E102682
Michel Creek	EV_MC2	E300091
Michel Creek	CM_MC2	E258937
Order Stations specified in Section 3 of Permit 107517		
Fording River	FR4/GH_FR1	0200378
Fording River	FR5/LC_LC5	0200028
Elk River	ER1/GH_ER1	0206661
Elk River	ER2/EV_ER4	0200027
Elk River	ER3/EV_ER1	0200393
Elk River	ER4/RG_ELKORES	E294312
Koocanusa Reservoir	LK2/RG_DSELK	E300230

Notes: EMS = Environmental Monitoring System

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[1] Water quality monitoring at the compliance and Order stations summarized in Table 2 is conducted in accordance with requirements in Sections 2 and 3 of Permit 107517. These monitoring points are intended to capture the combined effects of all upstream mining at representative locations along the major mine-affected watercourses in the Elk Valley. Accordingly, these locations are also being used by Teck to monitor regional patterns of selenium speciation in relation to mining.

Table 3. Summary of speciation monitoring in 2021 at permitted sedimentation pond discharges

Sedimentation Pond	EMS	Monitoring Location	Notes
FRO Discharge Monitoring Program (Table 13 in Permit 107517)			
North Loop Pond	E102476	FR_NL1H	(a,b)
Maintenance and Services Sed. Pond	E102478	FR_MS1	(a)
Eagle Pond Decant	E102480	FR_EC1	(a)
Clode Pond	E102481	FR_CC1	●
South Kilmarnock Sed. Pond – Phase I	E208394	FR_SKP1	(a)
South Kilmarnock Sed. Pond – Phase II	E208395	FR_SKP2	(a,c)
Smith Ponds	E261897	FR_SP1	●
Swift-Cataract Sed. Pond to Fording River	E320694	FR_SCCAT	●
Liverpool Sed. Ponds to Fording River	E304835	FR_LP1	(e)
Post Sed. Ponds to Fording River	E304750	FR_PP1	●
Lake Mountain Sed. Ponds to Lake Mountain Creek	E306924	FR_LMP1	(e)
Floodplain Widening Sed. Pond Decant	E325311		(d)
GHO Discharge Monitoring Program (Table 15 In Permit 107517)			
Greenhills Creek Sed. Pond Decant	E102709	GH_GH1	●
Thompson Creek Sed. Pond Decant	E207436	GH_TC1	●
Porter Creek Sed. Pond Decant	0200385	GH_PC1	●
Wolfram Creek Sed. Pond Decant	E257795	GH_WC1	●
Leask Creek Sed. Pond Decant	E257796	GH_LC1	● (c)
Rail Loop Sed. Pond Decant	E207437	GH_RLP	● (c)
Mickelson Creek at LRP Road	0200388	GH_MC2	(c)
Wade Creek at LRP Road	E287433	GH_WADE	● (a)
Wolf Creek Sed. Pond Decant	E305855	GH_WOLF_SP1	(c)
Willow Creek Sed. Pond Decant	E305854	GH_WILLOW_SP1	(a)
LCO Phase I Discharge Monitoring Program (Table 17 In Permit 107517)			
No Name Creek Pond Effluent to Line Creek	E221268	LC_LC9	(b)
MSA North Ponds Effluent to Line Creek	E216144	LC_LC7	●
Contingency Treatment System Effluent To Line Creek	E219411	LC_LC8P1	(a)
LCO Phase II Discharge Monitoring Program (Table 18 In Permit 107517)			
LCO Dry Creek Sed. Ponds Effluent to Dry Creek via Return Channel	E295211	LC_SPDC	●
Diversion Structure Spillway (When In Use)	E295313	LC_DSSW	(d)
Sed. Pond 1 Spillway (When In Use)	E295314	LC_SP1D	(d)
Sed. Pond 2 Spillway (When In Use)	E295315	LC_SP2D	(d)
EVO Discharge Monitoring Program (Tables 21 And 22 In Permit 107517)			
South Pit Creek Sed. Pond Discharge to Michel Creek	E296311	EV_SP1	●
Milligan Creek Sed. Pond Discharge to Michel Creek	E208057	EV_MG1	●
Gate Creek Sed. Pond Discharge to Michel Creek	E206231	EV_GT1	●
Bodie Creek Sed. Pond Discharge to Michel Creek	E102685	EV_BC1	●
Aqueduct Creek Control Structure to Aqueduct Creek	E302170	EV_AQ6	●
Otto Creek at Mouth Discharge to Elk River	E102679	EV_OC1	(e)
Goddard Creek Sed. Pond Discharge via Goddard Marsh to Elk River	E208043	EV_GC2	(e)
Lindsay Creek Infiltration Basin Discharge to Ground	E258135	EV_LC1	● (c)

Sedimentation Pond	EMS	Monitoring Location	Notes
Dry Creek Sed. Pond Decant to Harmer Creek	E298590	EV_DC1	●
6 Mile Creek Sed. Pond Decant Discharge to Elk River	E102681	EV_SM1	(e)
CMO Discharge Monitoring Program (Table 24 In Permit 107517)			
Decant Discharge from Main Interceptor Sed. Ponds	E102488	CM_SPD	●
Decant Discharge from Corbin Sed. Pond	E206438	CM_CCPD	●
Other Permitted Discharges			
Harmer Creek Sed. Pond	E102682	EV_HC1	●
West Line Creek AWTF Buffer Pond	E291569	WL_BFWB_OUT_SP21	●

Notes: EMS = Environmental Monitoring System; Sed. = Sedimentation; ponds in **bold** were included in the 2021 SeSMP study (sampled upstream, downstream, and in-pond where possible); ● = sampled for selenium speciation in 2021; (a) = rarely discharges and/or was not discharging at time of sampling; (b) = flows to mine works; (c) = discharges to ground; (d) = not in use in 2021; (e) = not sampled in 2021, prioritized for sampling in 2022

Table 4. Summary of local and regional monitoring programs that measured selenium speciation in 2021

Monitoring Program	Speciation Monitoring Locations in 2021
Corbin Sedimentation Pond	CM_CCPD, CM_CCRD, CM_CCOFF, CM_CCSC, CM_MC2, CM_14PIT-PIPE, CM_34PIPEDIS, CM_6PITDW, CM_CC1, CM_ND2, CM_SPD
LCO Dry Creek Water Management System / LCO Dry Creek LAEMP	LC_DC3, LC_DCEF, LC_SPDC, LC_DCDS, LC_DC1, LC_DC4, LC_FRUS, LC_FRB, LC_GRCK
LCO LAEMP	RG_SLINE/LC_SLC, RG_LI24/LC_LC1, RG_LCUT/LC_WLC, RG_LILC3/LC_LC3, RG_LISP24 /WL_DCP_SP24, RG_LIDSL/LC_LCDSSLCC, RG_LIDCOM/LC_LCC, RG_LI8/LC_LC4, RG_FRUL/LC_LC6, RG_FO23
Greenhills Creek and Gardine Creek	RG_GHUT, RG_GHNF, RG_GHBP, RG_GHFF / RG_GHFFA, RG_GAUT, RG_GANF, RG_GHP/GHPS
Fording River LAEMP	RG_UFR1/FR_UFR1, RG_HENUP/FR_HC3, RG_FRSCH2, RG_FRGHSC, RG_FOUCL/FR_FOUCL, RG_FOUNGD, RG_FODHE/FR_FR1, RG_FOUSH, RG_FRCP1SW, RG_MP1/FR_MULTIPLATE, RG_FOUKI/FR_FR2, RG_FOBKS/FR_FR3, RG_SCOUTDS/FR_SCOUTDS, RG_FOBSC/FR_FR4, RG_FRUPO/FR_FRRD, RG_FOBCP/FR_FRCP1, RG_FODPO/GH_PC2, RG_FOUEW/FR_FR5, RG_FO22/FR_FRABCH
West Line Creek AWTF	WL_BFWB_OUT_SP21, WL_LCI_SP02, WL_WLCI_SP01
EVO LAEMP	RG_ALUSM/EV_AC2, RG_MI25/CM_MC1, RG_ERCKUT, RG_ERCKDT/EV_ECOUT, RG_ERCK/EV_EC1, RG_GATE, RG_GATEDP, RG_BOCK, RG_MI3, RG_MIDER, RG_MIDBO, RG_MICOMP/EV_MC2
EVO SRF	F2_NWPI, F2_BPO, EV_MC2, EV_MC2a, EV_MC3, EV_EC1, EV_ECOUT, EV_BRD_LOT3, EV_BC1, EV_GT1, EV_ER1
EVO Dry Creek Water Treatment Project / Harmer Dam Removal Project	EV_HC1, EV_HC1a, EV_HCDSDAM, EV_DC2a, EV_DCOUT
RAEMP (not including LAEMP sites)	RG_CLODE, RG_KICKRG_GHCKD, RG_FODGH, RG_ALUSM, RG_HACKDS, RG_GRDS, RG_BACK, RG_ELELKO, RG_ELH93

Notes: FRO = Fording River Operations; LCO = Line Creek Operations; EVO = Elkview Operations; LAEMP = Local Aquatic Effects Monitoring Program; AWTF = Active Water Treatment Facility; SRF = Saturated Rock Fill; RAEMP = Regional Aquatic Effects Monitoring Program

Sampling and Analysis – 2021 Sedimentation Pond Study

A set of sedimentation ponds was selected for intensive sampling as described in Golder (2021b). Candidate ponds were required to have both safe access and a surface discharge to downstream aquatic habitat, to focus effort on sites with the greatest relevance to potential environmental effects, and so that benthic invertebrate tissue could be collected for selenium analysis. Ponds were prioritized for sampling if they had no existing aqueous speciation and/or benthic invertebrate tissue selenium data, or if existing data indicated that the pond would help establish a range of low to high organoselenium concentrations. Of the 30 candidate ponds identified in Golder (2021b), 24 were prioritized for sampling following these criteria. Four of these (Willow Creek Secondary, Kilmarnock Creek Secondary, and LCO Dry Creek 1 and 2) had no inflow or outflow at the time of sampling. The remaining 20 ponds (those indicated in bold in Table 3) were sampled between 24 August and 3 September 2021.

At each sampled pond, locations were selected upstream of the pond inflow and downstream of the pond outflow. Locations were selected to be as close to the pond inflow and outflow as safely accessible and, where possible, suitable for collection of periphyton and benthic invertebrates. Sampling location maps for the 2021 regional survey of sedimentation ponds are provided in Attachment A.

Water quality samples and in situ water quality measurements (temperature, dissolved oxygen, pH, conductivity, specific conductance, oxidation-reduction potential, chlorophyll-a and phycocyanin) were collected from all upstream and downstream locations. Sampling was conducted as follows:

- Water samples were collected by wading into a mid-channel area (unless it was not practical or safe to do so), moving from downstream to upstream, so as not to collect water downstream of disturbed substrates. Samples were collected from mid-depth by inverting sample bottles below the surface of the water. Samples were taken to shore prior to adding applicable preservatives. Water samples being analyzed for dissolved parameters were filtered in the field using a clean syringe affixed with a 0.45-µm membrane. Once filtered, the sample was preserved immediately in the manner specified by the analytical laboratory. Global Positioning System (GPS) coordinates and sample date, time, and identifier were recorded on field sheets. Samples were kept cold until analysis. Samples were shipped to the analytical laboratory daily or every other day to achieve compliance with recommended analytical hold times.
- Water quality samples were analyzed by Canadian Association for Laboratory Accreditation Inc. (CALA)-certified laboratories. Water samples were analyzed by ALS Environmental for the same suite of parameters as monthly samples collected by Teck, including total and dissolved metals, nutrients, major ions, and other conventional parameters such as total suspended and dissolved solids (TSS and TDS) and total and dissolved organic carbon (TOC and DOC). Speciation samples were analyzed by Brooks.
- Benthic invertebrate tissue chemistry samples were collected in triplicate at the nearest downstream or upstream riffle to the pond. Benthic invertebrate tissue chemistry samples were collected according to the Canadian Aquatic Biomonitoring Network (CABIN) protocol (Environment Canada 2012), using a net with a triangular aperture measuring 36 cm per side and a 400-µm mesh. During sampling, the technician moved across the stream channel from bank to bank in an upstream direction. The net was held immediately downstream of the technician’s feet, so the detritus and invertebrates disturbed from the substrate were passively collected into the kick-net by the stream current. Upon collection of the sample using the kick and sweep sampling method, organisms in the sample were carefully removed from sample debris using tweezers until a minimum of approximately 0.5 g of wet tissue was obtained. Invertebrate tissue samples were then photographed to document taxa composition, placed into labelled, sterile, 20 mL scintillation vials, stored in a cooler with ice packs, and transferred to a freezer later in the day.
- Frozen samples were shipped by courier in coolers with ice packs to TrichAnalytics Inc. (Saanichton, BC). Samples were dehydrated upon receipt and were analyzed using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Results were reported on a dry weight basis.

- Triplicate composite samples of periphyton were collected for measurement of ash free dry mass (AFDM) and chlorophyll-*a*. Chlorophyll-*a* data provide an indication of the abundance of chlorophyll-producing algae within the periphyton community. AFDM data provide an indication of the total dried biomass of organisms comprising the periphyton community (e.g., algae, fungi, bacteria, protozoa). Composite samples were collected a minimum of 5 m apart.

- Periphyton samples were collected from riffle habitat with water depth of at least 5 cm and uniform substrate characteristics, including relatively flat rocks with a diameter of at least 12 cm. Five rocks were selected, excluding those that are too small, highly angular, or uncharacteristic in surface texture, and taken to shore. A thin rubber or acetate template with a 4 cm^2 opening in the middle was then placed firmly on each rock so that the periphyton could be scraped from the opening using a scalpel. Scrapings from each of the five rocks were placed on a wetted Whatman GF/F glass fiber filter (90 mm diameter, 0.7 µm pore size) to provide a single composite sample per station for chlorophyll-*a* analysis. The filter paper containing the composite sample was folded in half twice and then tightly wrapped with aluminum foil. The foil-wrapped sample was placed in a labelled Whirl-Pak® bag and stored in a cooler with freezer packs in the field until transfer later in the day to a freezer for storage. Samples can be stored frozen for up to 30 days as long as they are not exposed to light (APHA et al. 1998). The same five rocks sampled for chlorophyll-*a* were used to collect separate scrapings for analysis of AFDM. The material on the scalpel from each scraping was rinsed into a small prelabelled plastic jar with additional water added as necessary to cover the tissue. Each composite sample for AFDM analysis was then placed in a cooler until transfer to a freezer later in the day.

The following characteristics were recorded for each sedimentation pond:

- Aquatic vegetation was recorded as absent, sparse, common, or abundant. Recorded vegetation categories were cattails (*Typha* spp.), *Chara* spp., Bur-reed (*Sparganium* spp.), duckweed (*Lemna* spp.), blue-green algae, grasses, mare's tail (*Hippuris* spp.), water lily (Nymphaeaceae), rushes, sedges, water milfoil (*Myriophyllum* spp.), and 'other'.

- A description was recorded of features shading the pond.

Where possible, the following samples were collected within each sedimentation pond:

- Sedimentation samples were collected for grain size and TOC analysis from unlined ponds with accessible sedimentation. Sedimentation samples could not be collected from ponds that were lined (Corbin Reservoir, WLC AWTF Buffer Pond), could not be safely accessed (Wade Creek), or had vegetation that precluded access to sediment (Bodie North, Gate Creek, Milligan Creek, MSAN).

- In situ measurements of Secchi depth, water temp, DO, DO%, pH, conductivity and specific conductance, ORP, chlorophyll-*a*, and phycocyanin were collected from 3 locations at each pond. Depth profiles were collected at those locations if depth was >1 m.

Data Analysis

Speciation data from regional and local monitoring and the 2021 sedimentation pond study were compiled and summarized to provide a regional overview and visualization of patterns of selenium speciation across the Elk Valley. Concentration data were presented in tables, plotted to illustrate ranges at different types of sites, and used to generate maps to visually depict the spatial distribution of organoselenium concentrations across the major mine-affected drainages of the Elk Valley.

Heat maps were generated to show the maximum organoselenium concentration (as the sum of DMSeO and MeSe(IV)) measured at each location in 2021. These concentrations were colour-coded as in Golder (2021b) to show maximum measured concentrations relative to draft screening values, to support an interpretation of potential effects on bioaccumulation. Concentration ranges discussed in Golder (2021b) and the associated interpretation are:

- In lotic monitoring areas in the Elk Valley with no detectable organoselenium or detectable organoselenium <0.025 µg/L (shown as white symbols on the heat maps), selenium bioaccumulation is strongly inhibited by sulphate and organoselenium does not have a discernible effect on bioaccumulation.
- 0.025 to 0.05 µg/L organoselenium (shown as blue symbols) is sometimes associated with a discernible increment in bioaccumulation.
- 0.05 to 0.1 µg/L organoselenium (shown as yellow symbols) is often associated with a discernible increment in bioaccumulation.
- >0.1 µg/L organoselenium (shown as orange symbols) is consistently associated with a discernible increment in bioaccumulation.

3.2 Longitudinal Patterns

This study component was designed to repeat the longitudinal analysis in Golder (2021a) in three additional study reaches to test the consistency of selenium species loss rates across a range of creek conditions. Study reaches for longitudinal sampling were selected to meet the following criteria: 1) the source must have high enough concentrations and low enough dilution following discharge that organoselenium species should remain detectable at multiple downstream stations if they behave conservatively; 2) a downstream reach must be present with suitable habitat for benthic macroinvertebrates over several kilometres; and 3) the source and all downstream sites must be safely accessible for sampling anticipated peak organoselenium concentrations in late summer. Selected study reaches were lower Greenhills Creek downstream of Greenhills Main Sedimentation Pond, lower Harmer Creek downstream of Harmer Creek Sedimentation Pond, and upper Harmer Creek downstream of EVO Dry Creek Sedimentation Pond.

Sampling and Analysis

Multiple stations were sampled in each of the three study reaches to characterize longitudinal gradients in selenium species concentrations (Attachment A). Sample locations within each study reach were selected at the time of sampling based on considerations of safe access and available habitat, targeting locations near the source, 500 m to 1.5 km downstream of the source, 2 to 3 km downstream of the source, and 4 to 6 km downstream of the source. Speciation samples were also taken on Grave Creek upstream of Harmer Creek and on the Fording River upstream of Greenhills Creek. Four locations were sampled downstream of EVO Dry Creek and Harmer Creek sedimentation ponds. The planned location furthest downstream of Greenhills Creek Sedimentation Pond was not sampled because the Fording River flows through a steep canyon in this area and could not be safely accessed.

Field sampling methods were as described in Section 4.1. Water samples were taken for routine water chemistry and selenium speciation. In situ water quality parameters were recorded, triplicate composite benthic invertebrate tissue samples were collected for selenium analysis, and a periphyton sample was collected for measurement of AFDM and chlorophyll-a. Flow velocity was measured with a MF Pro velocity sensor at mid-depth at five points distributed across the channel.

Data Analysis

Data analysis followed the approach described in Golder (2021a) with modifications to accommodate differences between the sites analyzed therein and in the present study. Concentrations of each detected selenium species were adjusted for dilution using concurrent selenate concentrations, rather than sulphate as in the previous analysis. Golder (2021a) found that selenate exhibited no discernible loss after accounting for dilution (using sulphate) over 3.5 km in LCO Dry Creek or 6.1 km of Line Creek. Therefore, selenate provides an alternative conservative tracer of dilution that was more convenient for the present analysis for two reasons. First, the longitudinal gradients considered herein included stations above and below a confluence with a parent tributary. Use of selenate as a tracer simplified the calculation of dilution because upstream selenate concentrations were negligible (on Harmer Creek and Grave Creek) or well characterized (on the Fording River), whereas sulphate concentrations were non-negligible at all sites. Second, selenate concentrations were obtained from the same sample and analysis as the other species concentrations, and therefore were well matched and available for all calculations, whereas well-matched sulphate concentrations were not always available.

Where upstream selenate concentrations were negligible, selenium species concentrations were adjusted for dilution using the following equation:

$$[species]_{adj,a} = [species]_{raw,a} \times \frac{[Se(VI)]_{source}}{[Se(VI)]_a}$$

where *[species]* is the adjusted (*adj*) or unadjusted (*raw*) concentration of the species in question at site *a* and *[Se(IV)]* is the selenate concentration at the site nearest the sedimentation pond (*source*) or at site *a*. This calculation adjusts the measured concentration of a species to estimate what that concentration would have been if there had been no dilution, thereby permitting an unconfounded analysis of other factors that affect concentrations at successive sampling locations.

In the study reach downstream of Greenhills Main Sedimentation Pond, the concentration of selenate in the upstream Fording River ($[Se(VI)]_{upstream}$) was taken into account in this adjustment using the following equation:

$$[species]_{adj,a} = \frac{[species]_{raw,a}}{1-\left(\left([Se(VI)]_a-[Se(VI)]_{source}\right)/\left([Se(VI)]_{upstream}-[Se(VI)]_{source}\right)\right)}$$

This calculation adjusts the measured concentration of a species to estimate what that concentration would have been if there had been no mixing with Fording River water. This calculation can be applied to DMSeO and MeSe(IV) because there was no detectable organoselenium in upstream Fording River water, and therefore concentrations downstream of the confluence with Greenhills Creek reflect inputs from Greenhill Creek, dilution by Fording River water, and whatever additional factor(s) may cause changes in concentrations. This calculation would provide an incorrect estimate for selenite because there are detectable concentrations of selenite in the upstream Fording River.[2]

Travel time was calculated for each location downstream of the source sedimentation ponds by dividing distance from source (m) by flow velocity (m/s). The rate of loss of each species was estimated by calculating the slope (k) of the relationship between the natural logarithm of dilution-corrected concentration and travel time downstream of source. The apparent half-life of each species was then calculated as $t_{1/2} = \ln(2)/-k$.

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[2] Adjusting selenite concentrations in this case would require either accurate measurements of flow and mixing for Greenhills Creek and the upstream Fording River, or measured selenite concentrations just upstream of the confluence for both watercourses. Because these measurements were not taken in this program, the longitudinal analysis could not be conducted for selenite at this location.

3.3 Seasonality

This study component was designed to repeat the seasonal analysis in Golder (2021a) at three additional sedimentation ponds to test the consistency of seasonal patterns across a range of pond conditions. Locations for seasonal sampling were selected to meet the following criteria: 1) the site must have high enough concentrations that organoselenium species will be detectable in multiple months; 2) water quality at the site must not be confounded by variable inputs such as pit dewatering; and 3) the site must be safely accessible for sampling of both influent and effluent in all months. Selected sites were the same ponds identified in Section 3.2 for longitudinal sampling: Greenhills Main Sedimentation Pond, Harmer Creek Sedimentation Pond, and EVO Dry Creek Sedimentation Pond (Attachment A).

Sampling was planned to be conducted monthly for one year, with biweekly sampling during the peak growing season (July through September). At the time of preparation of this report, data were available from sampling in September through December 2021.

Sampling and Analysis

Field sampling methods were as described in Section 4.1. On each sampling date, water samples were taken upstream and downstream of each pond for routine water chemistry and selenium speciation. Field measurements were taken of pond conditions. Water samples were collected at the pond outflow for measurement of AFDM and chlorophyll-a. Composite benthic invertebrate and periphyton tissue samples were collected in triplicate upstream and downstream of each pond for selenium analysis. Documentation of periphyton (visual assessment of dominant taxa, coverage, CABIN scores) and benthic invertebrates (taxa present and proportional contribution, presence of annelids[3]) was conducted per RAEMP methods.

Data Analysis

For the present report, the available data were summarized to illustrate partial seasonal cycles. When a full annual cycle of data is available, data analysis will follow the approach described in Golder (2021a), including a comparison across the three sedimentation ponds sampled in this program and seasonal patterns described for Bodie Creek and Gate Creek sedimentation ponds in Golder (2021a). If seasonal patterns of organoselenium concentrations differ across sedimentation ponds, these differences will be evaluated with respect to pond characteristics and conditions as part of Study Question 3.

3.4 Mechanisms

The investigation of mechanisms was designed to identify factors related to sedimentation ponds that tend to be associated with relatively high (or low) concentrations of organoselenium. The overall goal of these analyses was to develop a basis for understanding what characteristics of sedimentation ponds, and under what conditions, cause relatively large changes to speciation.The intent is that the results of this analysis will help develop a mechanistic understanding of the processes underlying these changes. Such an understanding could inform Teck’s adaptive management plan by helping to identify opportunities to mitigate the changes and thereby reduce selenium bioaccumulation risk.

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[3] Annelids can introduce variability in selenium chemistry results if included in composite tissue chemistry samples (Luoma 2021). The sampling protocol used in the RAEMP (and herein) addresses this effect as follows: if annelids are present in a sample, the field crew records on field sheets the number of annelids in the sample and the proportion of total biomass represented by annelids. If annelids represent ≤5% of total invertebrate biomass in the sample, annelids are excluded from the composite sample. If annelids represent >5%, annelids are included in the composite sample at roughly the same percentage of biomass as they are present in the kick sample and a separate annelid-only tissue sample is collected for analysis.

Rationale for the factors investigated in this analysis is provided in the study design (Golder 2021b). In brief, Golder (2021a) concluded that the mechanism of production of organoselenium is related to algal productivity and/or microbial activity. The inferred mechanism is assimilatory reduction of inorganic selenium to organoselenides, followed by enzymatic degradation and oxidation to form methylated selenium metabolites. Therefore, characteristics and conditions in sedimentation ponds that promote organoselenium production are expected to be those that promote biological activity in general, such as warm temperatures, long residence times, and ample nutrients and light. The 2021 SeSMP field program attempted to characterize these factors by measuring a range of site-specific characteristics of the sedimentation ponds (e.g., depth, aspect, vegetation, sediment, hydraulic residence time) and biogeochemical conditions in the sedimentation ponds (e.g., temperature, chlorophyll-*a*, nutrient concentrations, turbidity).

Data collected in the regional survey of sedimentation ponds were compiled into a set of dependent (*response*) variables that reflect changes to aqueous selenium speciation and a paired set of independent (*predictor*) variables that represent potential drivers of these speciation changes. The approach to data analysis was to use regression-type analysis to try to explain the variation in dependent variables using combinations of predictor variables. Exploratory ordination-type analyses were also conducted of how predictor variables vary and covary among ponds. It is anticipated that this analysis will also be able to consider seasonal patterns of predictors and dependent variables in the 2022 SeSMP annual report, when a full seasonal cycle of data is available.

There are several important caveats when interpreting the type of inferential analysis presented herein. First, correlation does not necessarily imply causation. Many of the predictor variables measured in this study are highly correlated, and regression algorithms may identify a relationship with one predictor that actually reflects an underlying causal relationship with another, correlated predictor. The measured predictor variables may also be correlated with unmeasured factors that may be the true, underlying cause of the observed patterns. Therefore, the relationships identified in such analyses must be considered indicative, not definitive, and should be interpreted in the context of other lines of evidence supporting or refuting causality. Such indicative relationships may be most useful to scope further studies, such as experimental manipulations that directly test causality. Second, the analysis herein is based on a “short and wide” dataset comprising many more potential predictors than independent observations of the dependent variable. Such an analysis is prone to an increased rate of false positive results because of the relatively large number of hypothesis tests being conducted. Applying more stringent criteria for statistical significance will reduce the rate of false positives, but will accordingly increase the rate of false negatives, potentially losing important information. For the objectives of an exploratory analysis such as that conducted herein, it may be more useful to accept an increased potential for false positives and to carefully interpret all statistically significant results in the context of other information and further studies.

Planned dependent variables for the analysis were: 1) aqueous concentrations of organoselenium species and selenite at the outflow of each pond; 2) incremental changes in organoselenium and selenite concentrations between inflow and outflow; and 3) benthic invertebrate tissue selenium concentrations downstream of each pond. Each of these dependent variables has strengths and limitations. Aqueous speciation is understood to be the main factor affecting bioaccumulation[4] and reflects the overall outcome of processes in each pond that affect speciation. As a “snapshot” measure of this outcome, aqueous speciation is also temporally matched with the measurements of most predictor variables (e.g., pond conditions and water quality) taken during the study. The incremental change in species concentrations between inflow and outflow supplements this analysis by considering the potential influence of inflow speciation, but is less directly related to effects on bioaccumulation,

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[4] In addition to total selenium concentration, uptake-modifying factors such as sulphate, and other factors; however, sufficiently large changes in organoselenium concentrations can override all of these other factors.

can be confounded by temporal variability in inflow speciation, and could not be calculated for ponds where either inflow or outflow could not be sampled. Another limitation of both sets of aqueous speciation response variables is that one-time measurements may not accurately reflect longer-term average conditions at the pond. Therefore, benthic invertebrate tissue selenium concentrations downstream of each pond were included as a third type of dependent variable to provide an indirect measure of longer-term speciation conditions.

The review of speciation data in relation to benthic invertebrate selenium concentrations and in comparison to other speciation data collected in 2021 indicated that the one-time sampling conducted for the regional survey in late August and early September did not accurately reflect summer average or peak speciation downstream of all sedimentation ponds.[5] Furthermore, the magnitude of difference between organoselenium concentrations collected in the regional survey and in other programs appeared to vary among ponds and was in some cases larger than differences among sedimentation ponds. These observations suggest that the speciation data collected in the regional survey may be subject to too much short-term variability to be relied upon for the present analysis. In light of this uncertainty, the analysis of mechanisms herein focused on benthic invertebrate selenium concentrations immediately downstream of the study sedimentation ponds as the dependent variable. Recommendations are provided in Section 6 for adjustments to the 2022 study design to better capture average speciation conditions, so that the evaluation of mechanism in future reporting will be able to include aqueous speciation as dependent variables.

Predictor variables for the analysis were site-specific characteristics of the sedimentation ponds (maximum depth, shade, various types of vegetation cover, sediment grain size and TOC, monthly mean hydraulic residence times), indicators of biogeochemical conditions in the ponds (various nutrient concentrations, chlorophyll-*a*, oxidation-reduction potential, turbidity and Secchi depth, dissolved oxygen, monthly mean temperatures), and water quality and in situ measurements taken upstream and downstream of the ponds. In total, 90 predictor variables were included in the analysis. Attachment B provides measured values of predictor variables included in the analysis. Where appropriate, predictors were $\log_{10}$-transformed to linearize correlations with dependent variables and stabilize variance (e.g., concentrations of nutrients and other water quality parameters, temperature, and hydraulic residence time; transformation was not applied to pH, percentages, or scores for vegetation and shade).

The statistical tool used to analyze relationships between dependent and predictor variables was General Linear Models (GLM). GLM is a generalized form of analysis of variance that is able to consider continuous predictors (as in multiple linear regression), categorical predictors (as in analysis of variance), or both (as in analysis of covariance). Candidate GLMs were initially identified using stepwise variable selection, which is an approach that starts with a null model and progressively adds the most significant predictors (forward selection) or starts with a model including all predictors and progressively removes the least significant predictors (backward selection). Both types of stepwise variable selection proceed until some pre-defined criterion for significance is met, which for an exploratory analysis is often a liberal criterion (e.g., $p<0.15$). Forward variable selection was employed for the present analysis to facilitate comparison of a range of models of varying complexity.

When analyzing a large number of predictors, many of which are correlated, it is likely that there will be multiple sets of predictors that provide similarly good models (multiple “islands” of model fit in the predictor space). Because it selects only one predictor at each step (the most or least significant), stepwise regression is prone to gravitating to one set of predictors and missing other sets that may provide comparable explanatory power and may provide useful insights. One solution to this issue is to exhaustively test all possible combinations of

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[5] See Section 4.5 for details. The magnitude of short-term variability apparent in the 2021 data was greater than expected based on previous seasonal sampling reported in Golder (2020a). Reasons for this short-term variability may relate to large precipitation events that occurred shortly before the 2021 SeSMP field program.

predictors, but with a large set of predictors this is not always a feasible approach. A more efficient solution was adopted herein, modelled after approaches used to address a similar issue in cladistic analysis (Maddison 1991). The approach is to start the stepwise analysis with various subsets of starting predictors, which reduces the chance that a predictor that is informative in a later model step (in combination with other retained predictors) will be removed or skipped over because is outweighed in early steps by other, correlated predictors. Testing subsets of predictors also avoids the risk of losing information from the analysis because one or more predictors was not available for a case (e.g., ponds at which an upstream water sample could not be collected). Alternative GLMs identified in the various analyses can then be considered in combination to identify patterns of predictors or correlated predictors that warrant further evaluation.

Correlations among predictors were evaluated using Principal Component Analysis (PCA). PCA is an ordination technique that identifies the strongest axes of covariance among a set of variables. These axes are referred to as principal components (PCs). PCA reduces the multi-dimensional space described by many predictors into a lower-dimensional space described by these PCs, while retaining as much of the information in the original variables as possible. PCA can then be used to visualize how each of the original predictors correlates to the PCs, identifying clusters of predictors that covary. These clusters can be considered when interpreting the results of GLM, for example by identifying when a significant predictor added to a model might be reflecting the effect of another, correlated predictor.

Sets of predictors identified by GLM were considered along with the results of PCA to draw general conclusions about the predictors, types of predictors, and combinations of predictors that can explain the variation in organoselenium concentrations among sedimentation ponds, as reflected in observed benthic invertebrate selenium concentrations immediately downstream of the ponds.

3.5 Bioaccumulation

This study component tested our current understanding of the bioaccumulative potential of organoselenium. The analysis evaluated how well the speciation bioaccumulation tool was able to predict benthic invertebrate selenium concentrations from aqueous speciation using data collected in the regional survey and the longitudinal study.[6] The degree of similarity between predicted and observed benthic invertebrate selenium concentrations in this new dataset was compared to the fit of the bioaccumulation tool to the dataset used to derive it. This comparison was performed as in de Bruyn and Luoma (2021): 1) by comparing modelled vs. measured benthic invertebrate selenium concentrations; and 2) by evaluating patterns of residuals as a function of concentrations of each selenium species.

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[6] This analysis will also consider data from the seasonality study in the 2022 SeSMP annual report, when a full seasonal cycle of data is available. This analysis will need to consider that the bioaccumulation tool was derived to predict benthic invertebrate selenium concentrations in the usual August-September sampling period. Application of the bioaccumulation tool to other months will help evaluate the magnitude and potential causes of seasonal changes in benthic invertebrate selenium concentrations.

4.0 RESULTS

4.1 Regional Survey

Field Data – Local and Regional Monitoring

Selenium speciation data are presented below for monitoring at regional compliance (Table 5) and Order stations (Table 6), permitted sedimentation pond discharges (Table 7), and locations included in the 2021 sedimentation pond study (Table 7, indicated by asterisks). Where benthic invertebrate selenium concentrations were collected under other programs in the same quarter, these data are also presented. Data from the other local and regional monitoring programs summarized in Table 4 are provided in Attachment C.

Table 5. Selenium speciation at Compliance Points specified in Section 2 of Permit 107517 (2021)

Station	Q	n	Maximum Selenium Species Concentrations per Quarter (µg/L)					BI [Se] (mg/kg dw)
			DMSeO	MeSe(IV)	MeSe(VI)	Se(IV)	Se(VI)	
FR_FRABCH - Fording River above Chauncey Creek (RG_FO22)	Q1	1	<0.01	<0.01	<0.01	0.11	91.9	-
	Q2	1	<0.01	<0.01	<0.01	0.17	94.2	9.3
	Q3	1	<0.01	0.013	<0.01	0.15	55.1	8.7
	Q4	0	-	-	-	-	-	-
GH_FR1 - Fording River below Greenhills Creek (RG_FODGH)	Q1	2	<0.01	<0.01	<0.01	0.24	60.8	-
	Q2	1	0.011	0.016	<0.01	0.27	66.8	-
	Q3	1	<0.01	0.022	<0.01	0.26	37.1	10.1
	Q4	1	0.019	0.015	<0.01	0.60	65.0	-
GH_ERC - Elk River below Thompson Creek (RG_EL20)	Q1	1	<0.01	<0.01	<0.01	0.010	2.8	-
	Q2	3	<0.01	<0.01	<0.01	0.022	3.6	-
	Q3	1	<0.01	<0.01	<0.01	0.041	1.0	7.3
	Q4	2	<0.01	<0.01	<0.01	0.048	2.1	-
LC_LCDSSLCC - Line Creek below South Line Creek (RG_LIDSL)	Q1	12	0.015	0.032	0.076	0.46	47.1	-
	Q2	13	<0.01	0.015	0.031	0.22	39.3	5.2
	Q3	12	<0.01	0.014	0.008	0.15	48.7	7.0
	Q4	12	<0.01	0.014	0.034	0.27	44.6	5.6
EV_HC1 - Harmer Creek below spillway of Harmer Dam (RG_HACKDS)	Q1	2	<0.01	0.015	<0.01	0.17	44.6	-
	Q2	4	<0.01	0.021	<0.01	0.20	30.4	-
	Q3	5	0.013	0.033	<0.01	0.46	37.1	15.0
	Q4	3	0.013	0.014	<0.01	0.25	35.7	13.8
EV_MC2 - Michel Creek below Bodie Creek (RG_MICOMP)	Q1	8	<0.01	<0.01	<0.01	0.10	13.0	-
	Q2	10	<0.01	<0.01	<0.01	0.073	10.3	-
	Q3	9	<0.01	<0.01	<0.01	0.20	11.0	4.0
	Q4	7	<0.01	<0.01	<0.01	0.13	8.0	-
CM_MC2 - Michel Creek below Corbin Creek (RG_MIDCO)	Q1	8	<0.01	<0.01	<0.01	0.072	7.9	-
	Q2	10	<0.01	<0.01	<0.01	0.06	4.2	-
	Q3	9	<0.01	<0.01	<0.01	0.08	4.7	3.7
	Q4	7	<0.01	<0.01	<0.01	0.097	9.4	-

Notes: DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; MeSe(VI) = methaneselenonic acid; Se(IV) = selenite; Se(VI) = selenate; BI [Se] = benthic invertebrate tissue selenium concentration (mean of 5 replicates); non-detect results shown in grey; these data are also shown in Attachment E as organoselenium = DMSeO + MeSe(IV)

Table 6. Selenium speciation at Order Stations specified in Section 3 of Permit 107517 (2021)

Station	Q	n	Maximum Selenium Species Concentrations per Quarter (µg/L)					BI [Se] (mg/kg dw)
			DMSeO	MeSe(IV)	MeSe(VI)	Se(IV)	Se(VI)	
GH_FR1 - Fording River below Greenhills Creek (RG_FODGH)	Q1	2	<0.01	<0.01	<0.01	0.24	60.8	-
	Q2	1	0.011	0.016	<0.01	0.27	66.8	-
	Q3	1	<0.01	0.022	<0.01	0.26	37.1	10.1
	Q4	1	0.019	0.015	<0.01	0.60	65.0	-
LC_LC5 - Fording River below Line Creek (RG_FO23)	Q1	1	<0.01	<0.01	<0.01	0.15	42.8	-
	Q2	1	<0.01	<0.01	<0.01	0.20	56.5	6.3
	Q3	2	<0.01	0.012	<0.01	0.32	35.6	7.7
	Q4	1	<0.01	<0.01	<0.01	0.26	42.3	7.1
GH_ER1 - Elk River above Fording River (RG_ELUEL)	Q1	1	<0.01	<0.01	<0.01	0.049	2.7	6.3
	Q2	1	<0.01	<0.01	<0.01	0.023	3.3	-
	Q3	1	<0.01	<0.01	<0.01	0.029	1.1	8.2
	Q4	1	<0.01	<0.01	<0.01	0.036	2.1	-
EV_ER4 - Elk River below Fording River (RG_EL19)	Q1	1	<0.01	<0.01	<0.01	0.055	14.3	-
	Q2	1	<0.01	<0.01	<0.01	0.078	13.5	-
	Q3	2	<0.01	<0.01	<0.01	0.11	13.3	7.4
	Q4	1	<0.01	<0.01	<0.01	0.055	12.1	-
EV_ER1 - Elk River below Michel Creek (RG_EL1)	Q1	1	<0.01	<0.01	<0.01	0.057	10.3	-
	Q2	1	<0.01	0.014	<0.01	0.092	17.3	-
	Q3	2	<0.01	<0.01	<0.01	0.091	10.8	6.8
	Q4	1	<0.01	<0.01	<0.01	0.058	8.7	-
RG_ELKORES - Elk River above Elko Reservoir (RG_ELELKO)	Q1	1	<0.01	<0.01	<0.01	0.099	8.5	-
	Q2	1	<0.01	<0.01	<0.01	0.051	4.0	-
	Q3	1	<0.01	0.018	<0.01	0.33	8.7	10.6
	Q4	1	<0.01	<0.01	<0.01	0.058	4.1	-
RG_DSELK - Koocanusa Reservoir below Elk River	Q1	1	<0.01	<0.01	<0.01	0.036	2.0	-
	Q2	1	<0.01	<0.01	<0.01	0.008	0.2	-
	Q3	1	<0.01	<0.01	<0.01	0.041	1.1	-
	Q4	1	<0.01	<0.01	<0.01	0.028	1.0	-

Notes: DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; MeSe(VI) = methaneselenonic acid; Se(IV) = selenite; Se(VI) = selenate; BI [Se] = benthic invertebrate tissue selenium concentration (mean of 5 replicates); non-detect results shown in grey; these data are also shown in Attachment E as organoselenium = DMSeO + MeSe(IV)

Table 7. Selenium speciation data from sedimentation pond and buffer pond discharge monitoring in 2021

Sedimentation Pond (Monitoring Location)	Date of Max. OrgSe	Maximum Selenium Species Concentrations per Quarter (µg/L)				
		DMSeO	MeSe(IV)	MeSe(VI)	Se(IV)	Se(VI)
Eagle Pond (FR_EAGLENORTH)	06 May	<0.01	<0.01	<0.01	0.29	359
Clode Main (FR_CC1)	09 Aug	0.016	0.015	<0.01	0.38	169
Henretta Pit (FR_HENLAKE)	18 Mar	<0.01	0.026	<0.01	0.75	45
Smith Ponds (FR_SP1)*	31 Aug	<0.01	0.032	<0.01	0.47	28.5
Swift-Cataract Sed. Pond (FR_SCCAT)*	31 Aug	0.018	0.13	<0.01	1.1	521
Post Sed. Ponds (FR_PP1)	23 Sep	<0.01	0.10	<0.01	3.0	282
Floodplain Widening Sed. Pond (FR_FLD)	23 Dec	<0.01	<0.01	<0.01	0	0
Greenhills Creek Sed. Pond (GH_GH1)	14 Sep	0.16	0.12	<0.01	3.4	133
Thompson Creek Sed. Pond (GH_TC1)	09 Sep	0.43	0.18	<0.01	4.4	140
Porter Creek Sed. Pond (GH_PC1)*	31 Aug	<0.01	<0.01	<0.01	0.18	77.6
Wolfram Creek Sed. Pond (GH_WC1)	22 Jun	0.037	0.11	<0.01	2.2	229
Leask Creek Sed. Pond (GH_LC1)	22 Jun	0.025	0.10	<0.01	1.7	356
Rail Loop Sed. Pond (GH_RLP)	06 Jul	0.012	0.011	<0.01	1.6	10.8
Wade Creek (GH_WADE)*	26 Aug	<0.01	0.016	<0.01	0.18	0.8
MSA North Ponds (LC_LC7)*	30 Aug	<0.01	<0.01	<0.01	0.074	7.75
LCO Dry Creek Sed. Ponds (LC_SPDC)	03 Aug	0.088	0.049	<0.01	1.8	71.9
South Pit Creek Sed. Pond (EV_SP1)*	27 Aug	0.027	0.19	<0.01	0.48	116
Milligan Creek Sed. Pond (EV_MG1)*	27 Aug	0.057	0.22	<0.01	3.8	59.3
Gate Creek Sed. Pond (EV_GT1)	26 Oct	0.087	0.083	<0.01	1.0	223
Bodie Creek Sed. Pond (EV_BC1)	05 Jul	0.18	0.097	<0.01	2.7	207
Aqueduct Creek Control Structure (EV_AQ6)*	30 Aug	<0.01	0.029	<0.01	0.44	3.8
Lindsay Creek Infiltration Basin (EV_LC1)*	30 Aug	<0.01	0.015	<0.01	0.22	1.4
Dry Creek Sed. Pond (EV_DC1)	12 Aug	0.017	0.22	<0.01	2.2	148
Main Interceptor Sed. Ponds (CM_SPD)	14 Apr	0.014	0.011	<0.01	0.39	6.4
Corbin Sed. Pond (CM_CCPD)	02 Feb	<0.01	0.007	<0.01	0.30	30.9
Harmer Creek Sed. Pond (EV_HC1)	12 Aug	0.013	0.033	<0.01	0.46	30.4
WLC AWTF Buffer Pond (WL_BFWB_OUT_SP21)	27 Apr	0.12	0.027	0.583	1.0	15.3

Notes: DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; MeSe(VI) = methaneselenonic acid; Se(IV) = selenite; Se(VI) = selenate; non-detect results shown in grey; * = sample from regional survey of sedimentation ponds (same value reported in Table 8) ; these data are also shown in Attachment E as organoselenium = DMSeO + MeSe(IV)

Field Data – 2021 Sedimentation Pond Study

Selenium speciation data and benthic invertebrate selenium concentrations upstream and downstream of the sedimentation ponds sampled in the 2021 regional survey are presented in Table 8. Sedimentation pond characteristics and conditions are summarized in Pond Summary Sheets (Attachment D) and provided in detail in tables (Attachment B).

Table 8. Selenium speciation and benthic invertebrate tissue selenium data from the regional survey of sedimentation ponds (24 August – 3 September 2021)

Sedimentation Pond		Selenium Species Concentrations (µg/L)						BI [Se] (mg/kg dw)
		DMDSe	DMSe	DMSeO	MeSe(IV)	Se(IV)	Se(VI)	
Corbin Reservoir	US	<0.01	<0.01	<0.01	<0.01	0.092	29.1	1.8
	DS	<0.01	<0.01	<0.01	0.015	0.12	23.4	6.5
SPD Pond	US	<0.01	<0.01	<0.01	<0.01	0.58	4.4	10.0
	DS	<0.01	<0.01	<0.01	0.014	0.53	4.0	11.7
Aqueduct Control	US	<0.01	<0.01	<0.01	0.019	0.38	3.63	(a)
	DS	<0.01	<0.01	<0.01	0.029	0.44	3.75	18.3
Bodie North	US	<0.01	<0.01	0.034	0.076	1.8	190	(a)
	DS	<0.01	<0.01	<0.01	0.029	1.2	195	48.7
EVO Dry Creek	US	<0.01	<0.01	<0.01	0.019	0.92	124	18.0
	DS	<0.01	0.16	<0.01	0.066	1.3	131	55.3
Harmer Creek	US	<0.01	<0.01	<0.01	0.023	0.31	30.8	14.7
	DS	<0.01	<0.01	<0.01	0.028	0.34	29.5	21.7
Gate Creek	US	<0.01	<0.01	<0.01	0.026	0.86	207	(a)
	DS	<0.01	<0.01	<0.01	0.055	0.95	202	39.3
Lindsay 2	US	<0.01	<0.01	<0.01	<0.01	0.086	2.9	(a)
	DS	<0.01	<0.01	<0.01	0.015	0.22	1.45	11.3
Milligan Creek	US	<0.01	<0.01	<0.01	0.030	1.5	82.4	21.3
	DS	0.028	0.14	0.057	0.22	3.8	59.3	62.0
South Pit Creek	US	(a)						
	DS	<0.01	<0.01	0.027	0.19	0.48	116	57.3
Swift Creek Secondary	US	<0.01	<0.01	0.018	0.096	0.52	244	34.7
	DS	<0.01	<0.01	<0.01	0.133	1.1	521	(a)
Clode Main	US	<0.01	<0.01	<0.01	<0.01	0.15	271	5.4
	DS	<0.01	<0.01	<0.01	0.015	0.32	164	17.7
Porter Creek Secondary	US	<0.01	<0.01	0.012	0.018	0.34	76.3	4.2
	DS	<0.01	<0.01	<0.01	<0.01	0.18	77.6	17.0
Smith Ponds	US	<0.01	<0.01	(b)				(a)
	DS	<0.01	0.031	<0.01	0.032	0.47	28.5	24.3
Greenhills Main	US	<0.01	<0.01	<0.01	0.031	1.1	140	17.7
	DS	<0.01	0.026	0.042	0.082	3.8	120	20.3
Thompson Lower	US	<0.01	<0.01	0.18	0.22	4.9	113	15.3
	DS	<0.01	0.075	0.013	0.071	2.3	123	45.3
Wade Pond Lower	US	<0.01	<0.01	<0.01	<0.01	0.14	0.78	20.3
	DS	<0.01	<0.01	<0.01	0.016	0.18	0.83	13.0
MSAN 1	US	(c)						
	DS	<0.01	<0.01	<0.01	<0.01	0.074	7.8	11.3
AWTF Buffer	US	<0.01	<0.01	0.023	<0.01	0.39	5.8	(a)
	DS	<0.01	<0.01	<0.01	<0.01	0.16	30.1	17.3

Notes: US = upstream; DS = downstream; DMDSe = dimethyldiselenide; DMSe = dimethylselenide; DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; Se(IV) = selenite; Se(VI) = selenate; BI [Se] = benthic invertebrate tissue selenium concentration (mean of 3 replicates); "-" = no datum available; non-detect results shown in grey; (a) = sample not collected because no suitable habitat present (e.g., because water enters or leaves the sedimentation pond through a pipe) or because inflow location could not be located; (b) = sample lost in transit; (c) = samples not collected because no safe access; these data are also shown in Attachment E as organoselenium = DMSeO + MeSe(IV)

Data Analysis

Selenium speciation data collected in regional and local monitoring (Tables 5 and 6; Attachment C), sedimentation ponds (Tables 7 and 8), and the longitudinal study (Table 10, below) were plotted on regional heat maps for each mine operation to provide a visual overview of patterns of speciation across the Elk Valley (Attachment E). As described in Section 3.1, the maps in Attachment E show the maximum measured organoselenium concentration at each location in 2021 relative to draft screening values, and the associated tables (Tables 5 and 6; Attachment C) show individual species concentrations associated with the sampling event that had that maximum measured organoselenium concentration. High-level regional patterns of maximum organoselenium concentrations apparent on the heat maps and local patterns apparent in Attachment C are discussed below.

At a regional scale, the patterns of organoselenium concentrations are consistent with the interpretation in Golder (2021b). The highest organoselenium concentrations occur immediately downstream of sedimentation ponds, with maximum reported concentrations ranging from <0.01 µg/L to >0.2 µg/L (Table 7). These concentrations decline with distance due to dilution and loss processes. Declines in concentrations are gradual along larger tributaries (e.g., Harmer Creek downstream of EVO Dry Creek) and are more discontinuous where smaller mine-affected tributaries enter larger mainstem creeks and rivers that provide high dilution (e.g., Clode Creek entering the Fording River). As a result, concentrations in upper Greenhills Creek, Harmer Creek, and Line Creek tend to be <0.025 µg/L or 0.025 – 0.05 µg/L, whereas concentrations in the upper Fording River, Elk River, and Michel Creek are usually below detection and almost always <0.025 µg/L. A reach of the Fording River immediately downstream of Greenhills Creek (GH_FR1 in Table 6) is an exception to this general pattern, with maximum organoselenium concentrations 0.025 – 0.05 µg/L, reflecting proximity to Greenhills Main Sedimentation Pond and the relatively high flow from Greenhills Creek compared to most other mine-affected tributaries.

Local monitoring programs provide more spatial resolution on the broad patterns described above in areas that have been identified with elevated uncertainty about potential changes to speciation. Detailed analyses of patterns of speciation and related factors are provided in program-specific reporting. In brief, general patterns apparent in these local monitoring programs are:

- Corbin Sedimentation Pond monitoring is described in Teck (2021). Monitoring in 2021 found few detectable organoselenium concentrations in mine works or receiving environment locations, consistent with previous sampling at CMO. Organoselenium was detected in 2021 at two locations, neither of which exceeded the draft screening value of 0.025 µg/L.
- LCO Dry Creek LAEMP monitoring is described in Minnow (2022a). Monitoring in 2021 found detectable organoselenium upstream of the LCO Dry Creek Water Management System (DCWMS), indicating that organoselenium generation is occurring either in upstream waste rock or in the reach of LCO Dry Creek between the spoils and the DCWMS. Maximum organoselenium concentrations at the outflow of the DCWMS were more than 2× higher than upstream of the DCWMS. After discharge to LCO Dry Creek, organoselenium concentrations declined progressively with distance to about one-third of the maximum outflow concentration. There was no discernible effect of LCO Dry Creek on organoselenium concentrations in the Fording River.
- LCO LAEMP monitoring is described in Minnow (2022b). Monitoring in 2021 found detectable organoselenium upstream of the WLC AWTF, indicating that organoselenium generation is occurring either in upstream waste rock or in the reach of Line Creek between the spoils and the AWTF. Maximum organoselenium concentrations at the outflow of the AWTF Buffer Pond were about 5× higher than upstream of the AWTF. Organoselenium concentrations in Line Creek declined progressively with distance from the AWTF and were below detection near the mouth of Line Creek. There was no discernible effect of Line Creek on organoselenium concentrations in the Fording River.

- Greenhills Creek and Gardine Creek monitoring is described in Minnow and Lotic (2022). Monitoring in 2021 found detectable organoselenium in upper Greenhills Creek, indicating that organoselenium generation is occurring either in upstream waste rock or in the reach of Greenhills Creek between the spoils and the sedimentation ponds. Maximum organoselenium concentrations downstream of Greenhills Main Sedimentation Pond were more than 10× higher than upstream. Organoselenium was not detected in Gardine Creek. As discussed in the regional overview above, there was a discernible effect of Greenhills Creek on organoselenium concentrations in a downstream reach of the Fording River.
- Fording River LAEMP monitoring is described in Minnow (2022c). Monitoring in 2021 found no detectable organoselenium at 14 of 19 locations along the Fording River and <0.025 µg/L organoselenium at the remaining five locations.
- EVO LAEMP monitoring is described in Minnow (2022d). Monitoring in 2021 found maximum organoselenium concentrations in Erickson Creek ranging from below detection in upstream reaches to 0.025 – 0.05 µg/L near the mouth. Higher organoselenium concentrations occurred downstream of sedimentation ponds on Gate Creek (0.05 – 0.1 µg/L) and Bodie Creek (>0.2 µg/L). Organoselenium concentrations in Michel Creek were mostly below detection and always <0.025 µg/L.
- EVO SRF monitoring is described in Minnow (2022e). Monitoring in 2021 found maximum organoselenium concentrations in the range 0.025 – 0.05 µg/L at the SRF Buffer Pond Outflow and upstream reaches of Erickson Creek, with higher concentrations (0.05 – 0.1 µg/L) near the mouth. Higher maximum organoselenium concentrations occurred downstream of sedimentation ponds on Gate Creek (>0.1 µg/L) and Bodie Creek (>0.2 µg/L). Organoselenium concentrations in Michel Creek and the Elk River were mostly below detection and always <0.025 µg/L.
- EVO Dry Creek Water Treatment Project / Harmer Dam Removal Project monitoring found the highest maximum organoselenium concentrations downstream of EVO Dry Creek Sedimentation Pond (>0.2 µg/L). Concentrations declined along Harmer Creek to <0.025 µg/L upstream of Harmer Creek Sedimentation Pond, increasing by about 1.5× downstream of the sedimentation pond.

4.2 Longitudinal Patterns

Field Data

Distances of sampling locations from the study sedimentation ponds, flow velocities at each location, and calculated travel times downstream of the ponds are summarized in Table 9.

Table 9. Details of sampling locations for the longitudinal study

Site Distance (km)	Watercourse	Measured flow velocity (m/s)	Calculated travel time (h)
EVO Dry Creek Sedimentation Pond			
0.01	EVO Dry Creek	-	0.00674
0.6	Harmer Creek	0.412 ± 0.186	0.679
2.3	Harmer Creek	0.246 ± 0.314	1.71
5.4	Harmer Creek	0.373 ± 0.329	4.02
Harmer Creek Sedimentation Pond			
0.09	Harmer Creek	-	0.0536
0.55	Harmer Creek	0.467 ± 0.266	0.282
3.5	Grave Creek	0.543 ± 0.201	1.88
4.7	Grave Creek	0.516 ± 0.258	2.53
Greenhills Main Sedimentation Pond			
0.06	Greenhills Creek	-	0.0428
0.7	Fording River	0.389 ± 0.221	0.509
2.1	Fording River	0.382 ± 0.223	1.53

Notes: Distance is from sedimentation pond outflow; flow velocity is mean ± standard deviation of 5 measurements; “-” = not measured; measured flow velocity was applied to the reach between that location and the next upstream location

Selenium speciation and benthic invertebrate tissue selenium concentrations from the longitudinal study are summarized in Table 10. Note that data in Table 10 for the first location downstream of each sedimentation pond are the same data reported as “DS” for these three sedimentation ponds in Table 8.

Table 10. Selenium speciation and benthic invertebrate tissue selenium data from the longitudinal study (24 August – 3 September 2021)

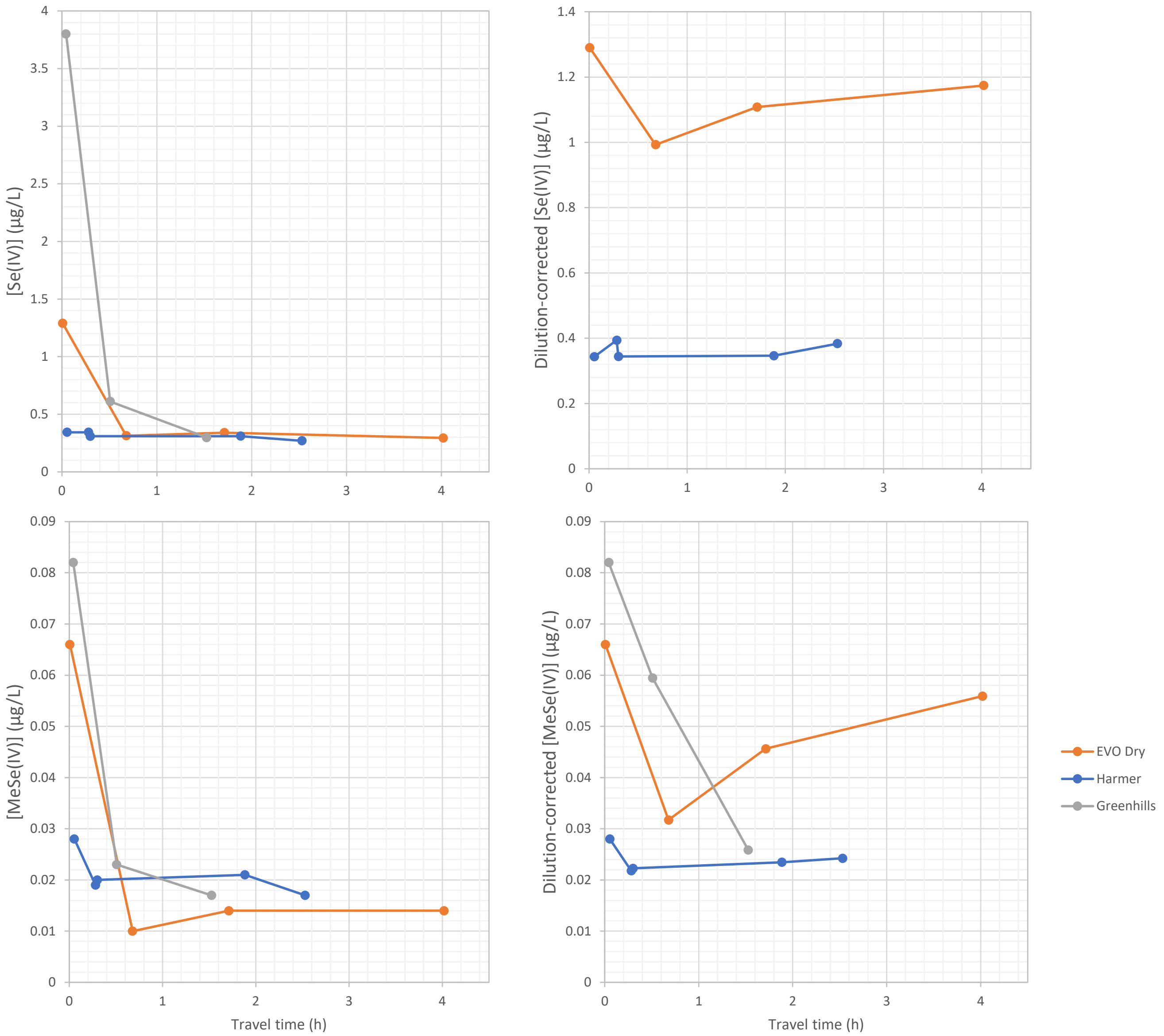
Site	Selenium Species Concentrations (µg/L)						Dissolved [Se] (µg/L)	Total [Se] (µg/L)	BI [Se] (mg/kg dw)
Distance (km)	DMDSe	DMSe	DMSeO	MeSe(IV)	Se(IV)	Se(VI)			
EVO Dry Creek Sedimentation Pond									
0.01	<0.01	0.161	<0.01	0.066	1.3	131	136	135	55.3
0.6	<0.01	<0.01	<0.01	<0.01	0.31	41.3	42.3	42.8	9.0
2.3	<0.01	<0.01	<0.01	0.014	0.34	40.2	47.7	(a)	14.7
5.4	<0.01	<0.01	<0.01	0.014	0.29	32.8	(a)		15.3
Harmer Creek Sedimentation Pond									
0.09	<0.01	<0.01	<0.01	0.028	0.34	29.5	(a)		21.7
0.55	<0.01	<0.01	<0.01	0.019	0.34	25.7	(a)		14.0
3.5	<0.01	<0.01	<0.01	0.021	0.31	26.4	21.9	22.8	12.0
4.7	<0.01	<0.01	<0.01	0.017	0.27	20.7	(a)		15.0
Greenhills Main Sedimentation Pond									
0.06	<0.01	0.026	0.042	0.082	3.8	120	(a)		20.3
0.7	<0.01	<0.01	<0.01	0.023	0.61	63.9	(a)		11.3
2.1	<0.01	<0.01	<0.01	0.017	0.30	42.0	45.1	45.2	8.53

Notes: Distance = distance from sedimentation pond outflow; DMDSe = dimethyldiselenide; DMSe = dimethylselenide; DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; Se(IV) = selenite; Se(VI) = selenate; BI [Se] = benthic invertebrate selenium concentration (mean of 3 replicates); “-” = no datum available; non-detect results shown in grey; (a) = sample broken in storage; these data are also shown in Attachment E as organoselenium = DMSeO + MeSe(IV)

Data Analysis

Longitudinal concentration gradients for selenite and MeSe(IV) are plotted in Figure 2 as raw concentrations (left panels) and adjusted for dilution (right panels). DMSeO and DMSe were detected only at the site nearest the pond on Greenhills Creek, and DMDSe was not detected at any of the longitudinal study sites. The single reported concentration of DMSe was high enough to calculate an unbounded “greater than” estimate of loss rate at EVO Dry Creek (see below) because the dilution-corrected detection limit at the next downstream site (where DMSe was not detected) was less than the reported concentration near the pond outflow. Neither DMSeO nor DMSe were high enough to estimate a loss term on Greenhills Creek because the dilution-corrected detection limits at downstream locations were equal to or greater than reported concentrations near the pond outflow (i.e., all that can be inferred is that the loss rate was greater than zero).

Figure 2. Longitudinal gradients of selenite (upper panels) and methylseleninic acid (lower panels)



Notes: MeSe(IV) = methylseleninic acid; Se(IV) = selenite

An unbounded estimate of loss rate for DMSe was calculated from the detected concentration near the outflow of EVO Dry Creek Sedimentation Pond (0.161 µg/L) and the dilution-corrected detection limit at the next downstream location (<0.0317 µg/L) over an estimated travel time of 0.672 h (see Section 3.2 for methods). The estimated loss rate was k>-2.42, giving a half-life of <0.29 h for DMSe at this location. No previous estimates of the half-life of DMSe in surface water could be identified for comparison, but such rapid loss would be consistent with the volatile nature of this species.

The analysis for selenite gave loss rate estimates near zero (no discernible loss) at EVO Dry Creek and Harmer Creek). For comparison, the estimated half-life for selenite calculated in Golder (2021a) was 3 to 5 h. These apparent differences may simply reflect variability in selenite concentrations and the selenate concentrations used to adjust for dilution, or they may indicate that conditions in Harmer Creek and Grave Creek result in slower loss of selenite compared to the reaches studied in Golder (2021a).

The analysis for MeSe(IV) gave loss rate estimates that were near zero or slightly positive (i.e., indicating no discernible change in MeSe(IV) concentration at EVO Dry Creek and Harmer Creek) to k=-0.784 (half-life 0.9 h) at Greenhills Creek. For comparison, the estimated half-life for MeSe(IV) calculated in Golder (2021a) was 1.4 to 4.5 h. The apparent lack of a decline in MeSe(IV) in EVO Dry Creek and Harmer Creek may simply reflect variability in MeSe(IV) concentrations and the selenate concentrations used to adjust for dilution, or may reflect an actual increase, for example from oxidation of DMSe (accounting for part of the DMSe loss term calculated above for EVO Dry Creek).

4.3 Seasonality

Field Data

Sampling dates for the seasonal study were established as described in Section 3.3. The first sampling event occurred during the regional survey of sedimentation ponds (Section 4.1). Thereafter, sampling was biweekly through September and monthly in October, November, and December. Monthly sampling will continue until July 2022, at which time it will again be increased to biweekly.

Selenium speciation and benthic invertebrate tissue selenium concentrations from the seasonal study are summarized in Table 11. Note that data in Table 11 for the first sampling date upstream and downstream of each sedimentation pond (26 – 28 August 2021) are the same data reported for these three sedimentation ponds in Table 8.

Table 11. Selenium speciation and benthic invertebrate tissue selenium data from the seasonal study (28 August – 7 December 2021)

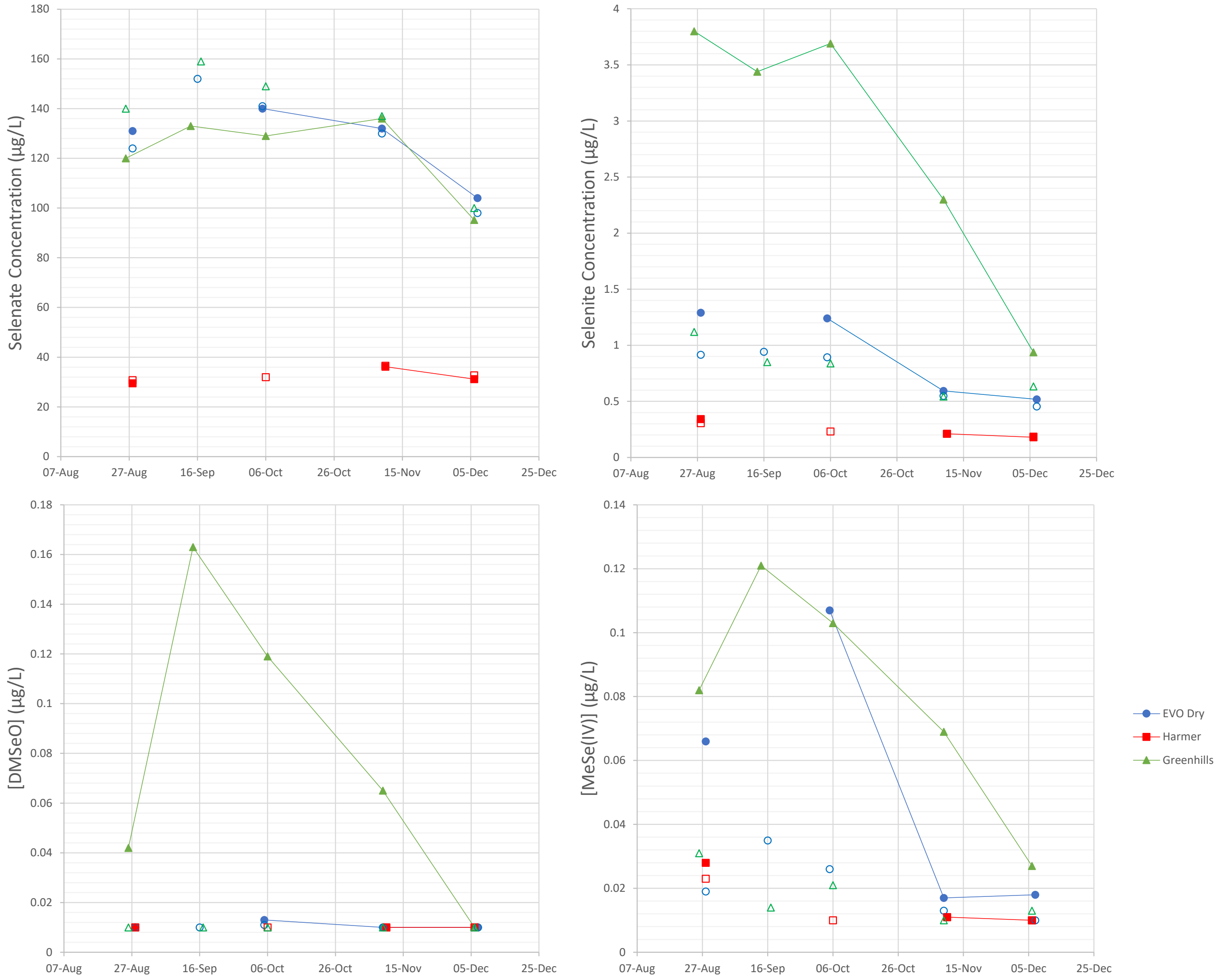
Site	Sample Date	Selenium Species Concentrations (µg/L)							Dissolved [Se] (µg/L)	Total [Se] (µg/L)	BI [Se] (mg/kg dw)
		DMDSe	DMSe	DMSeO	MeSe(IV)	OrganoSe	Se(IV)	Se(VI)			
EVO Dry Creek Sedimentation Pond											
US	28 Aug	<0.01	<0.01	<0.01	0.019	0.019	0.92	124	140	82	18.0
	16 Sep	(a)		<0.01	0.035	0.035	0.94	152	137	135	13.7
	05 Oct	<0.01	<0.01	0.011	0.026	0.037	0.89	141	140	144	18.7
	09 Nov	(a)		<0.01	0.013	0.013	0.55	130	135	134	9.4
	07 Dec	<0.01	<0.01	<0.01	<0.01	<0.01	0.46	98.0	100	99	14.3
DS	28 Aug	<0.01	0.16	<0.01	0.066	0.066	1.3	131	136	135	55.3
	16 Sep	(a)									58.3
	05 Oct	<0.01	0.10	0.013	0.107	0.12	1.2	140	144	147	64.0
	09 Nov	-	-	<0.01	0.017	0.017	0.59	132	128	129	52.0
	07 Dec	<0.01	<0.01	<0.01	0.018	0.018	0.52	104	106	106	60.3
Harmer Creek Sedimentation Pond											
US	28 Aug	<0.01	<0.01	<0.01	0.023	0.023	0.31	30.8	(a)		14.7
	06 Oct	<0.01	<0.01	<0.01	<0.01	<0.01	0.23	32.0	34	32	11.3
	10 Nov	-	-	<0.01	0.011	0.011	0.21	36.6	36	37	9.1
	06 Dec	<0.01	<0.01	<0.01	<0.01	<0.01	0.19	32.7	32	33	5.0
DS	28 Aug	<0.01	<0.01	<0.01	0.028	0.028	0.34	29.5	(a)		21.7
	06 Oct	<0.01	<0.01	(a)							16.3
	10 Nov	-	-	<0.01	0.011	0.011	0.21	36.2	37	37	10.2
	06 Dec	<0.01	<0.01	<0.01	<0.01	<0.01	0.18	31.2	31	32	15.0
Greenhills Main Sedimentation Pond											
US	26 Aug	<0.01	<0.01	<0.01	0.031	0.031	1.1	140	(a)		17.7
	17 Sep	<0.01	0.026	<0.01	0.014	0.014	0.85	159	157	157	12.5
	06 Oct	<0.01	<0.01	<0.01	0.021	0.021	0.84	149	162	151	15.3
	09 Nov	<0.01	<0.01	<0.01	<0.01	<0.01	0.54	137	139	147	9.2
	06 Dec	<0.01	<0.01	<0.01	0.013	0.013	0.63	100	99	98	7.8
DS	26 Aug	<0.01	0.026	0.042	0.082	0.124	3.8	120	(a)		20.3
	14 Sep	<0.01	0.062	0.16	0.12	0.28	3.4	133	136	136	18.7
	06 Oct	<0.01	0.053	0.12	0.10	0.22	3.7	129	142	134	22.0
	09 Nov	<0.01	<0.01	0.065	0.069	0.13	2.3	136	137	136	17.7
	06 Dec	<0.01	<0.01	<0.01	0.027	0.027	0.94	95.2	91	91	10.9

Notes: US = upstream; DS = downstream; DMDSe = dimethyldiselenide; DMSe = dimethylselenide; DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; OrganoSe = sum of DMSeO and MeSe(IV); Se(IV) = selenite; Se(VI) = selenate; BI [Se] = benthic invertebrate tissue selenium concentration (mean of 3 replicates); "-" = no datum available; non-detect results shown in grey; (a) = sample broken in storage

Data Analysis

Partial seasonal patterns of selenate, selenite, DMSeO, and MeSe(IV) upstream and downstream of the three study ponds are plotted in Figure 3. Because only a partial seasonal cycle of data was available at the time of preparing this report (because the program began in August 2021), the analysis below is preliminary and will be updated in the 2022 Annual Report when a full seasonal cycle is available.

Figure 3. Partial seasonal cycle of selenium species concentrations at the inflow (open symbols) and outflow (filled symbols) of three study sedimentation ponds



Notes: DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; open symbols are upstream and filled symbols downstream of the indicated sedimentation pond; lines join symbols in each series for ease of interpretation, and do not indicate interpolated conditions between the sampling dates

Selenite (upper right panel of Figure 3) exhibited larger seasonal variation than selenate (upper left panel) and consistent increases in concentration between inflow and outflow at Greenhills Creek and EVO Dry Creek sedimentation ponds. Peak concentrations of selenite occurred in late August through early October, declining thereafter. These patterns are consistent with the seasonal patterns at Bodie Creek and Gate Creek sedimentation ponds described in Golder (2021a). In contrast, Harmer Creek Sedimentation Pond exhibited lower concentrations of selenite, smaller variation across sampling events, and little to no difference between inflow and outflow.

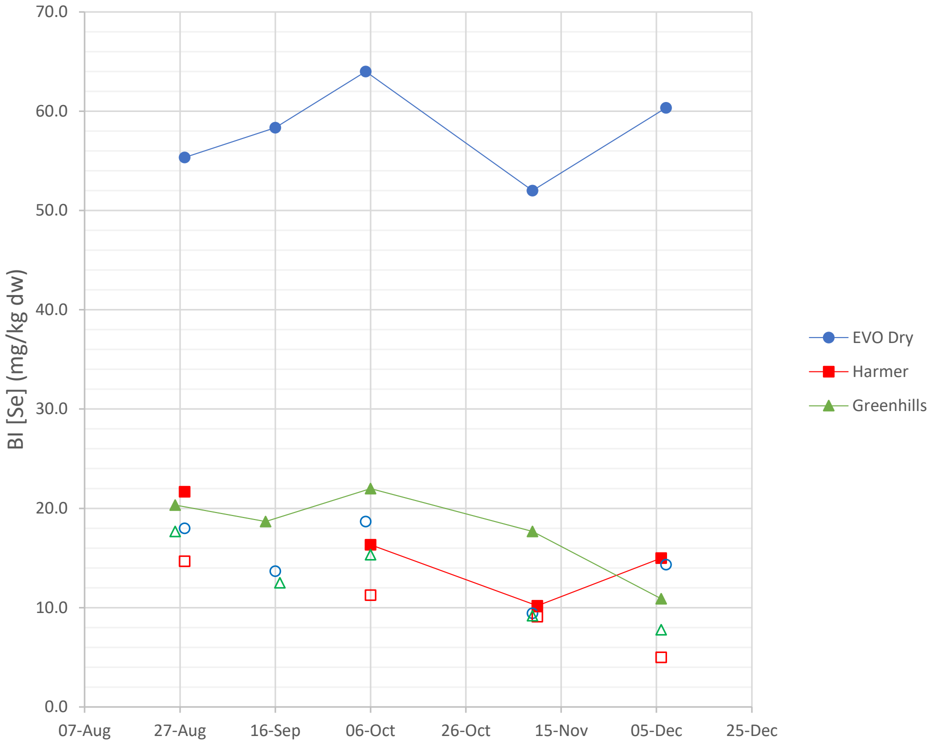
The non-volatile organoselenium species DMSeO and MeSe(IV) (bottom panels) exhibited a seasonal pattern similar to selenite in Greenhills Main Sedimentation Pond, although with a sharper peak in mid-September, later than peak selenite concentrations that occurred on or before the sampling event in late August. MeSe(IV) also exhibited a more pronounced but later peak than selenite in EVO Dry Creek Sedimentation Pond, whereas

DMSeO in this pond varied little across sampling events. As for selenite, organoselenium concentrations at Harmer Creek Sedimentation Pond were lower and varied less than in the other two study ponds.

The volatile organoselenium species DMSe and DMDSe were less often detected than other species (Tables 10 and 11). DMDSe was not detected on any date in the seasonal sampling. DMSe was detected between late August and early October downstream of EVO Dry Creek and Greenhills Main sedimentation ponds, exhibiting a roughly similar pattern to MeSe(IV). DMSe was detected both upstream and downstream of Greenhills Main Sedimentation Pond in the mid-September sampling event, which indicates production of this species both in the primary sedimentation pond immediately upstream and in the main sedimentation pond.

Partial seasonal patterns of benthic invertebrate selenium concentrations upstream and downstream of the three study ponds are plotted in Figure 4. Previous seasonal analyses (e.g., Golder 2020) have found that benthic invertebrate selenium concentrations vary across sampling events but exhibit no consistent seasonal trend. In contrast, the data plotted on Figure 4 indicate possible seasonality, with concentrations at most locations tending to be lower in November and/or December than other months. The sampling location downstream of EVO Dry Creek Sedimentation Pond, which had the highest benthic invertebrate selenium concentrations measured in this study, exhibited no apparent seasonal trend.

Figure 4. Partial seasonal patterns of benthic invertebrate selenium concentrations at the inflow (open symbols) and outflow (filled symbols) of three study sedimentation ponds



Notes: BI [Se] = benthic invertebrate selenium concentration (mean of 3 replicates); open symbols are upstream and filled symbols downstream of the indicated sedimentation pond; lines join symbols in each series for ease of interpretation, and do not indicate interpolated conditions between the sampling dates

4.4 Mechanisms

Downstream benthic invertebrate selenium concentrations were available as the dependent variable for 18 of the 20 sampled study ponds.[7] Different sets of predictors had different coverage for these 18 ponds. Many predictors were available for all 18 ponds, including in situ field parameters measured in the ponds, observations of vegetation and shade, maximum depth, presence of a liner, temperature, and hydraulic residence time. In contrast, sediment grain size and TOC could be collected at only 11 ponds. Because of differences in coverage for different sets of predictors, analyses including some predictors were not able to include all cases of the dependent variable (e.g., including sediment grain size predictors caused 7 cases to be removed from the analysis). This inconsistency in cases that could be included in the GLM may account for some of the differences in selected predictors among model runs described below.

A PCA evaluating covariance of predictors identified four PCs that were able to account for 88% of the variance in the original 90 predictors. Factor loading scores, reflecting the correlation of each predictor to each PC, are provided in Attachment F. The largest positive and negative factor loading scores (absolute value > 0.75 in the bullets below) indicate which predictors correlate most strongly to each PC, and thereby can help to understand what each PC represents. The four PCs were:

- PC1 (34% of total variance) was strongly positively correlated with major ions (downstream hardness, conductivity, TDS, sulphate), several predictors related to biological activity (upstream and downstream chlorophyll-a, upstream and downstream TOC and DOC, abundance of algae and total aquatic vegetation in the pond, downstream AFDM), and several nutrient parameters (upstream and downstream total phosphorus, nitrate, and DOC). PC1 was strongly negatively correlated with pH (upstream, downstream, and in-pond), upstream total Kjeldahl nitrogen, and upstream phycocyanins.
- PC2 (22% of total variance) was strongly positively correlated with percent silt in pond sediment, downstream pH, upstream field-measured oxidation-reduction potential and dissolved oxygen, hydraulic residence time, downstream temperature, and upstream and downstream total and dissolved selenium. PC2 was strongly negatively correlated with several measures of productivity (downstream chlorophyll-a and phycocyanins, abundance of submerged vegetation), percent gravel in pond sediment, field-measured downstream ORP, and upstream and downstream ammonia.
- PC3 (18% of total variance) was strongly positively correlated with field-measured upstream chlorophyll-a and in-pond phycocyanins, upstream pH, downstream total Kjeldahl nitrogen, and percent sand in pond sediment. PC3 was strongly negatively correlated with upstream AFDM and upstream alkalinity.
- PC4 (14% of total variance) was strongly positively correlated with field-measured chlorophyll-*a* and phycocyanins in the pond, water temperature (August mean, July mean, in-pond during sampling), major ions (upstream sulphate, upstream and downstream chloride), and abundance of emergent vegetation. PC4 was not strongly correlated with any predictor.

Results of stepwise GLM runs are summarized below for initial evaluations of subsets of predictors (Table 12) and for evaluations including multiple sets of predictors (Table 13). Sediment parameters (grain size, TOC, liner) were not significant in any GLM run, potentially because of the smaller number of ponds for which these predictors

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[7] Benthic invertebrates were not collected downstream of Swift Creek Secondary because this sedimentation pond discharges through a pipe and does not have downstream aquatic habitat prior to mixing with the Fording River. No samples were taken downstream of LCO Contingency Upper because it had no surface outflow (nor inflow) at the time of sampling.

were available. The remaining groups of predictors all produced significant GLMs that may be informative with respect to the factors driving organoselenium export from sedimentation ponds.

The columns in Tables 12 and 13 are interpreted as follows:

- Step reflects the progressive addition of predictors by the forward stepwise algorithm.
- r^2 is the proportion of total variance in the dependent variable explained by the predictors added up to and including that step. Higher r^2 indicates a more explanatory model, although explanatory power does not necessarily indicate predictive power: adding more predictors will always increase r^2 but can result in overfitting, such that the ability of the model to describe the existing data is not a good reflection of the ability of the model to predict new data.
- Predictor Variable Entered is the predictor added by the GLM algorithm in that step.
- AIC is the Akaike information criterion, which is a model selection criterion that balances the fitness of a model with the number of predictors employed. AIC penalizes models with more predictors in the interest of parsimony, thereby avoiding overfitting. The AIC value of a model can be interpreted as an estimate of the relative discrepancy between the model and the unknown true model that generated the data. The idea of model selection using AIC is to select a model with a low AIC value.
- AIC_C is an alternative (corrected) form of the AIC for small samples. AIC_C addresses a bias in the AIC calculation that can cause it to violate parsimony when the number of predictors in the model exceeds ~30% of the number of cases.
- BIC is Schwarz’s Bayesian information criterion, which is a model selection criterion similar to the AIC, but that applies a stronger penalty to more complex models. Schwarz’s BIC can also be interpreted as an estimate of relative discrepancy between the model and the unknown true model that generated the data, with low Schwarz’s BIC value indicating a preferred model.
- Std. Coefficient is the standardized coefficient (slope) of the predictor in the final GLM. Higher standardized coefficients indicate a greater influence on model outcomes, independent of the scale of each predictor.
- P-value reflects the statistical significance of the predictor in the final GLM. Low P-values indicate that the explanatory power of the predictor in the GLM is unlikely to have occurred by chance (and therefore is interpreted to be an actual effect).

Table 12. Forward stepwise GLM variable selection results for subsets of predictors

Step	r^2	Predictor Variable Entered	AIC	AIC_C	BIC	Std. Coefficient	P-value
Run 1 (n=18) – temperature, depth, hydraulic residence time, shade, vegetation abundance parameters							
1	0.29	Shade score	5.4	7.1	8.0	0.508	0.023
2	0.40	Temperature (Aug)	4.3	7.4	7.9	0.333	0.118
Run 2 (n=9) – US and DS in situ field parameters							
1	0.71	Field oxidation-reduction potential DS	-0.8	4.0	-0.2	-0.845	<0.001
2	0.86	Field temperature US	-5.3	4.7	-4.5	0.499	0.001
3	0.95	Field conductivity DS	-12.8	7.2	-11.8	0.335	0.006
4	0.99	Field dissolved oxygen DS	-24.0	18.0	-22.8	0.202	0.022
Run 3 (n=15) – DS water quality parameters							
1	0.46	Oxidation-reduction potential DS	1.3	3.5	3.4	-0.633	0.001
2	0.69	Dissolved selenium DS	-4.9	-0.9	-2.1	0.411	0.008
3	0.76	Chlorophyll-*a* DS	-7.0	-0.3	-3.4	-0.355	0.016
4	0.86	Dissolved organic carbon DS	-13.0	-2.5	-8.8	0.336	0.023
Run 4 (n=15) – US water quality parameters							
1	0.27	Dissolved selenium US	5.8	8.0	7.9	0.074	0.002
2	0.47	Hardness US	2.9	6.9	5.8	0.255	0.012
3	0.58	pH US	1.8	8.4	5.3	0.256	0.004
4	0.67	Chlorophyll-*a* US	-0.2	10.3	4.0	0.090	0.007
5	0.81	Ash-free dry mass US	-5.9	10.1	-1.0	0.106	0.013
6	0.88	Total organic carbon US	-11.3	12.7	-5.7	0.168	0.054

Notes: r^2 = model coefficient of determination; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; *n* = number of ponds that could be included in the run (constrained by availability of predictors); US = upstream of sedimentation pond; DS = downstream of sedimentation pond

The initial GLM runs summarized in Table 12 suggest the following hypotheses about potential drivers of organoselenium concentrations (as reflected in benthic invertebrate selenium concentrations) downstream of the study ponds:

- Run 1 evaluated predictors reflecting the physical structure and conditions of the sedimentation ponds. The strongest predictor in Run 1 was shade, which was a score assigned based on presence of trees, high banks, or other physical structures that could cause shading on portions of the pond. Shade score had a positive coefficient, indicating that higher benthic invertebrate selenium concentrations were associated with higher shade scores. This is the opposite of what would be expected if more shade caused lower primary productivity and thereby lower assimilatory reduction of selenium. An alternative mechanism that would have a positive coefficient would be if shade score is reflecting shelter from wind, such that higher shade scores indicate lower potential for wind-driven mixing, more stability in the water column, and a resulting greater potential for outcomes such as settling of TSS (which could increase light penetration), accumulation of floating algae, or depletion of dissolved oxygen from bacterial metabolism in the water column and/or sediment. Shade correlated strongly with PC1, where it clustered with major ions (downstream hardness, conductivity, TDS, sulphate), several predictors related to biological activity (upstream chlorophyll-a, downstream TOC and DOC, abundance of algae and total aquatic vegetation in the pond, downstream AFDM), and several nutrient parameters (upstream and downstream total phosphorus, nitrate, and DOC).

  The only other predictor added by the stepwise algorithm in Run 1 was August mean water temperature, which could reflect a direct positive effect of warmer water on algal productivity or bacterial metabolism (i.e., directly increasing assimilatory reduction), or potentially an indirect effect via mechanisms such as promotion of aquatic vegetation or depletion of dissolved oxygen from enhanced bacterial metabolism. August mean water temperature correlated strongly with PC4, where it clustered with major ions (upstream sulphate, TDS), field-measured chlorophyll-*a* and phycocyanins in the pond, and abundance of emergent vegetation.

- Run 2 evaluated the suite of in situ field parameters measured upstream and downstream of the study ponds. This run was able to include only 9 sedimentation ponds, and therefore would be more prone to overfitting. Stepwise variable selection added four predictors to this model, but AIC_C increased with each step, indicating that the model is likely overfit (noting that the number of predictors exceeded 30% of the number of cases at step 3). Therefore, the first and second predictors added to this model are more likely informative, whereas the third and fourth may not be.

  The strongest predictor in Run 2 was field-measured oxidation-reduction potential (ORP) downstream of the sedimentation pond. Field ORP had a negative coefficient, indicating that higher benthic invertebrate selenium concentrations were associated with more reducing conditions in the water exiting the sedimentation pond.[8] More reducing conditions could directly promote speciation changes by favouring bacteria that use electron acceptors other than oxygen, thereby facilitating the generation of organoselenium by these biota (e.g., via assimilatory reduction). Alternatively, low ORP could be an indicator of hypoxia resulting from heterotrophic acitivity (e.g., from decomposing algal blooms), which acts to release organoselenium from organic matter into the water column. Downstream field ORP correlated strongly (negatively) with PC2, where it clustered with some measures of productivity (downstream chlorophyll-a and phycocyanins, abundance of submerged vegetation) and reduced nitrogen species (upstream and downstream ammonia and nitrite).

  The second predictor in Run 2 was field-measured water temperature upstream of the sedimentation ponds. As discussed above for Run 1, water temperature is expected to be a driver for all biological activity and could increase oganoselenium generation and/or release in a number of ways.

- Run 3 evaluated a suite of water quality parameters measured downstream of the study ponds. The strongest predictor in Run 3 was laboratory-measured ORP downstream. As in Run 2, ORP had a negative coefficient, supporting a role of reducing conditions in organoselenium production and/or release.

  The second predictor in Run 3 was dissolved selenium concentration downstream. Benthic invertebrate selenium concentrations were positively correlated with dissolved selenium concentrations (log-log regression: r^2=0.46; p=0.003), although this relationship may to some extent reflect that sedimentation ponds with low dissolved selenium concentrations typically had lower benthic invertebrate selenium concentrations, whereas ponds with higher dissolved selenium concentrations had a wider range of benthic invertebrate selenium concentrations. Dissolved selenium was moderately correlated with PC2, where it clustered with variables including total selenium, hydraulic residence time, maximum depth, percent silt, and field-measured ORP.

  The third and fourth predictors in Run 3 were downstream chlorophyll-*a* (negative coefficient) and downstream DOC (positive coefficient). These two predictors could indicate that benthic invertebrate selenium concentrations are affected by organoselenium released from decomposition of algal cells. Algae generate organoselenium by assimilatory reduction (Cooke and Bruland 1987; Eswayah et al. 2016; Ponton et al. 2020) and this organoselenium is exported from a sedimentation pond when conditions cause a die-off of algae that is indirectly reflected in lower chlorophyll-*a* and higher DOC. Downstream chlorophyll-*a* and DOC both correlate strongly and positively with PC1, despite their opposite coefficients in the Run 3 GLM.

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[8] Field ORP downstream was correlated with field ORP measured in the pond for most study ponds (log-log regression: r^2=0.24, p=0.05 for all ponds; r^2=0.59, p=0.001 excluding MSAN 1). Therefore, this predictor could reflect an effect of ORP in the pond.

- Run 4 evaluated the same suite of water quality parameters measured upstream of the study ponds. As in Run 2, AIC$_C$ started to increase after step 2, indicating that the first two predictors are potentially informative, whereas the remaining four more likely reflect overfitting.

  The first predictor added in Run 4 was dissolved selenium concentration, but this predictor had a relatively low standardized coefficient in the final GLM, indicating relatively low influence on model results. As in Run 3, inclusion of this predictor may reflect a tendency for a wider range of organoselenium concentrations to occur at sedimentation ponds with relatively high dissolved selenium concentrations, or may reflect an underlying effect of a correlated predictor.

  The strongest predictors in Run 4 were hardness and pH, which have no obvious role in organoselenium cycling. Upstream hardness was moderately correlated with PC4, where it clustered with pond temperature, major ions (upstream sulphate, TDS), field-measured chlorophyll-*a* and phycocyanins in the pond, and abundance of emergent vegetation.

Table 13. Forward stepwise GLM variable selection results for combined sets of predictors

Step	r^2	Predictor Variable Entered	AIC	AIC$_C$	BIC	Std. Coefficient	P-value
Run 5 (n=15) – DS water quality, temp, depth, HRT, shade, vegetation parameters							
1	0.46	Oxidation-reduction potential DS	1.3	3.5	3.4	-0.241	0.001
2	0.69	Dissolved selenium DS	-4.9	-0.9	-2.1	0.846	<0.001
3	0.87	Maximum depth	-15.5	-8.8	-11.9	-0.646	<0.001
4	0.93	Orthophosphate DS	-22.6	-12.1	-18.4	0.576	<0.001
5	0.96	Chloride DS	-31.2	-15.2	-26.3	0.249	<0.001
6	0.99	Algal abundance score	-44.2	-20.2	-38.6	-0.233	<0.001
7	1.00	Chlorophyll-*a* DS	-57.0	-21.0	-50.6	0.142	0.005
8	1.00	Shade score	-61.8	-6.8	-54.7	-0.066	0.113
Run 6 (n=15) – US and DS water quality, temp, depth, HRT, shade, vegetation parameters							
1	0.58	Oxidation-reduction potential DS	-2.1	0.3	-0.2	-1.061	<0.001
2	0.88	Turbidity DS	-17.5	-13.0	-14.9	-0.820	<0.001
3	0.92	Ash-free dry mass US	-20.3	-12.8	-17.1	-0.155	<0.001
4	0.95	Ammonia DS	-26.8	-14.8	-23.0	-0.213	<0.001
5	0.97	Chlorophyll-*a* DS	-31.2	-12.6	-26.8	0.273	<0.001
6	0.99	Hydraulic residence time (Aug)	-39.6	-10.8	-34.5	-0.101	0.001
7	1.00	Total Kjeldahl nitrogen US	-51.5	-6.5	-45.8	0.130	<0.001
8	1.00	Oxidation-reduction potential US	-67.2	6.1	-60.8	0.084	0.001
9	1.00	Maximum depth	-78.8	53.2	-71.8	-0.083	0.001
10	1.00	Alkalinity DS	-110	201.4	-102.9	-0.059	0.002
11	1.00	Turbidity US	-151	-	-143.3	-0.017	0.023

Notes: r^2 = model coefficient of determination; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; *n* = number of ponds that could be included in the run (constrained by availability of predictors); US = upstream of sedimentation pond; DS = downstream of sedimentation pond

The GLM runs summarized in Table 13 suggest the following hypotheses about potential drivers of organoselenium concentrations (as reflected in benthic invertebrate selenium concentrations) downstream of the study ponds:

- Run 5 evaluated predictors reflecting the physical structure and conditions of the sedimentation ponds in combination with downstream water quality. AIC$_C$ continued to decline until step 7, indicating that the increase in explanatory power over these steps outweighed the penalty for overfitting. However, the improvement in r^2 was small after about step 3, suggesting that that the first three predictors are likely the most informative.

The first predictor added in Run 5 was laboratory-measured downstream ORP, although this predictor had a relatively low standardized coefficient, indicating relatively low influence on model results. As in Run 3, downstream ORP had a negative coefficient, supporting a role of reducing conditions in organoselenium production and/or release.

The strongest predictor in Run 5 was dissolved selenium downstream. As in Run 3, inclusion of this predictor may reflect a tendency for a wider range of organoselenium concentrations to occur at sedimentation ponds with relatively high dissolved selenium concentrations, or may reflect an underlying effect of a correlated predictor.

The third predictor in Run 5 was maximum depth. Maximum depth had a negative coefficient, indicating that higher benthic invertebrate selenium concentrations tended to occur downstream of shallower sedimentation ponds. This relationship could reflect an effect of pond depth via light availability (shallower ponds would more likely have well-lit substrate), either directly by enhancing growth of attached algae or indirectly by facilitating growth of aquatic vegetation, which in turn have effects such as providing substrate for epiphytic algae, modifying sediment redox conditions by root activity and/or by creating a poorly-mixed boundary layer, or by contributing organic detritus to the sediment. Maximum depth was moderately correlated with PC2, where it clustered with variables including total and dissolved selenium, hydraulic residence time, percent silt, and field-measured ORP.

- Run 6 evaluated predictors reflecting the physical structure and conditions of the sedimentation ponds in combination with both upstream and downstream water quality. AIC_C declined only until step 2, fluctuated until 6, and then increased dramatically. These AIC_C results indicate that only the first two predictors are likely informative, the next four are likely overfit, and any subsequent to that are clearly overfit.

  The first and strongest predictor added in Run 6 was laboratory-measured downstream ORP. As in Run 5, downstream ORP had a negative coefficient, supporting a role of reducing conditions in organoselenium production and/or release.

  The second predictor in Run 6 was downstream turbidity. Downstream turbidity had a negative coefficient, indicating that higher benthic invertebrate selenium concentrations tended to occur with lower turbidity. This relationship could reflect an effect via light availability (e.g., lower turbidity increases light penetration, which increases algal productivity and thereby increases generation of organoselenium). Alternatively, it could reflect an effect of a correlated predictor. Downstream turbidity correlated strongly with PC1, where it clustered with major ions (downstream hardness, conductivity, TDS, sulphate), several predictors related to biological activity (upstream chlorophyll-a, downstream TOC and DOC, abundance of algae and total aquatic vegetation in the pond, downstream AFDM), and several nutrient parameters (upstream and downstream total phosphorus, nitrate, and DOC).

Despite different sets of predictors used in each run, some common themes emerged in the patterns of predictors that were significant in the resulting GLMs. Notably, ORP was included with a negative coefficient in the GLMs from runs 2, 3, 5, and 6, dissolved selenium concentration was included with a positive coefficient in the GLMs from runs 3, 4, and 5, and water temperature was significant with a positive coefficient in the GLMs from runs 1 and 2. Inclusion of these predictors in the GLMs indicates that these factors and/or some correlated factors play a role in driving selenium speciation changes. Further interpretation of these findings is provided in Section 5.3.

4.5 Bioaccumulation

The de Bruyn and Luoma (2021) bioaccumulation model was used to translate the speciation data in Tables 8 (regional survey) and 11 (seasonality study) into modelled benthic invertebrate selenium concentrations immediately upstream and downstream of the study sedimenation ponds. Modelled concentrations are presented in Table 14 in comparison to the benthic invertebrate selenium concentrations measured at these locations (note: these are the same data presented in the right-most columns of Tables 8 and 11).

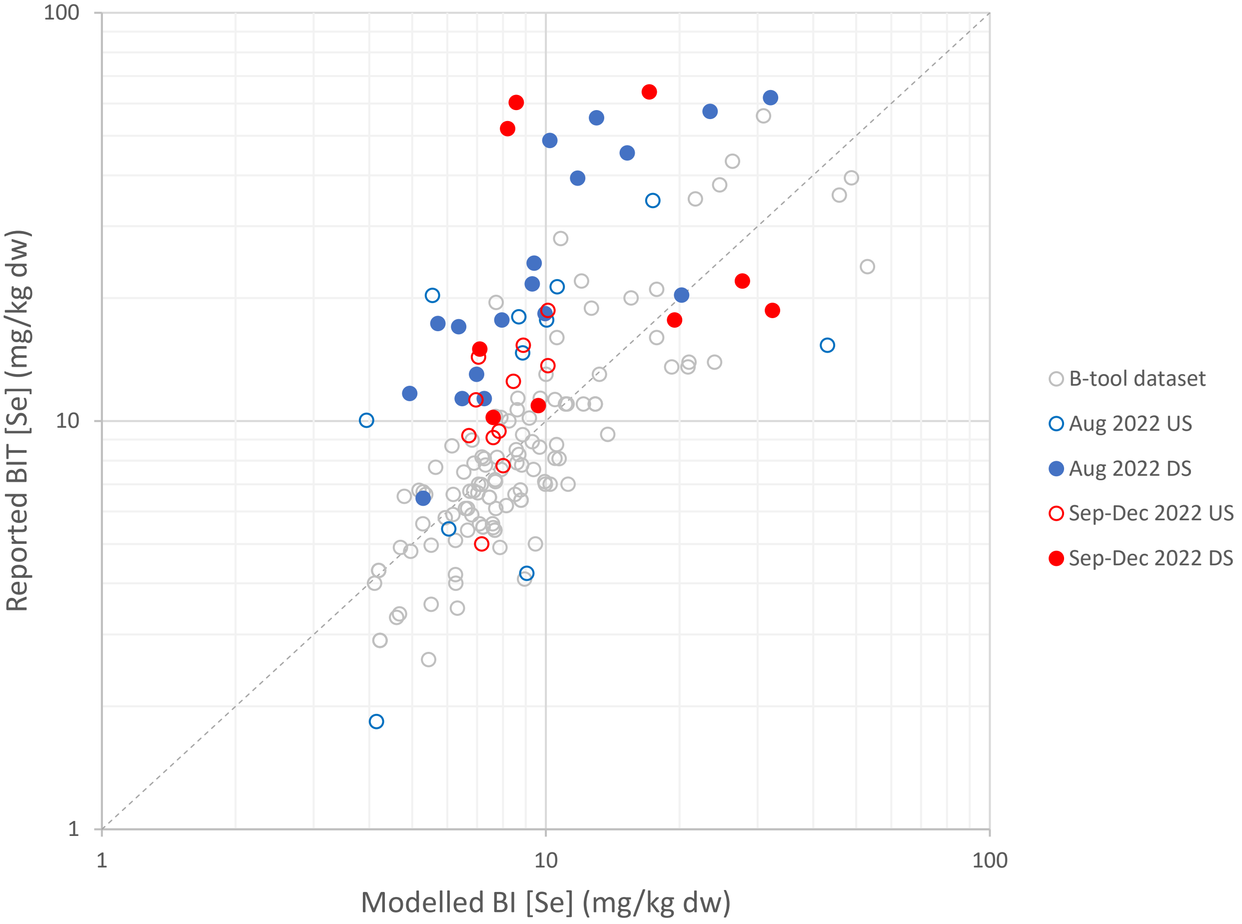
Table 14. Modelled and measured benthic invertebrate selenium data from the 2021 SeSMP

Location	Sampling Date	Upstream BI [Se] (mg/kg dw)		Downstream BI [Se] (mg/kg dw)	
		Modelled	Observed	Modelled	Observed
Corbin Reservoir	25 Aug	4.2	1.8	5.3	6.5
SPD Pond	25 Aug	3.9	10.0	4.9	11.7
Aqueduct Control	30 Aug	9.1	-	9.9	18.3
Bodie North	27 Aug	17.2	-	10.2	48.7
EVO Dry Creek	28 Aug	8.7	18.0	13.0	55.3
	16 Sep	10.1	13.7	-	58.3
	05 Oct	10.1	18.7	17.1	64.0
	09 Nov	7.8	9.4	8.2	52.0
	07 Dec	7.0	14.3	8.6	60.3
Harmer Creek	28 Aug	8.9	14.7	9.3	21.7
	06 Oct	7.0	11.3	-	16.3
	10 Nov	7.6	9.1	7.6	10.2
	06 Dec	7.2	5.0	7.1	15.0
Gate Creek	27 Aug	9.6	-	11.8	39.3
Lindsay 2	30 Aug	5.6	-	6.5	11.3
Milligan Creek	27 Aug	10.6	21.3	32.0	62.0
South Pit Creek	27 Aug	-	-	23.4	57.3
Swift Creek Secondary	31 Aug	17.4	34.7	18.1	-
Clode Main	31 Aug	6.0	5.4	8.0	17.7
Porter Creek Secondary	31 Aug	9.0	4.2	6.4	17.0
Smith Ponds	31 Aug	-	-	9.4	24.3
Greenhills Main	26 Aug	10.0	17.7	20.2	20.3
	14 Sep	8.4	12.5	32.4	18.7
	06 Oct	8.9	15.3	27.7	22.0
	09 Nov	6.7	9.2	19.5	17.7
	06 Dec	8.0	7.8	9.6	10.9
Thompson Lower	26 Aug	43.0	15.3	15.2	45.3
Wade Pond Lower	26 Aug	5.5	20.3	7.0	13.0
MSAN 1	30 Aug	-	-	7.3	11.3
AWTF Buffer	24 Aug	5.7	-	5.7	17.3

Notes: BI [Se] = benthic invertebrate selenium concentration (mean of 3 replicates)

The modelled and measured concentrations presented in Table 14 are plotted in Figure 5 in comparison to the dataset of measured and modelled benthic invertebrate selenium concentrations that was used to fit the parameters of the bioaccumulation tool. The dataset used to derive the bioaccumulation tool (grey symbols on Figure 5) illustrates the expected precision of modelled concentrations. As discussed in de Bruyn and Luoma (2021), the fitted model was able to calculate modelled concentrations within a factor of 2 of measured concentrations for 97% of the 113 cases used to fit model parameters. The expected range of modelled values is depicted by the residual scatter of grey points around the diagonal 1:1 line on Figure 5.

Figure 5: Evaluation of bioaccumulation tool performance on the derivation dataset (grey symbols) and data collected in the 2021 SeSMP (coloured symbols)



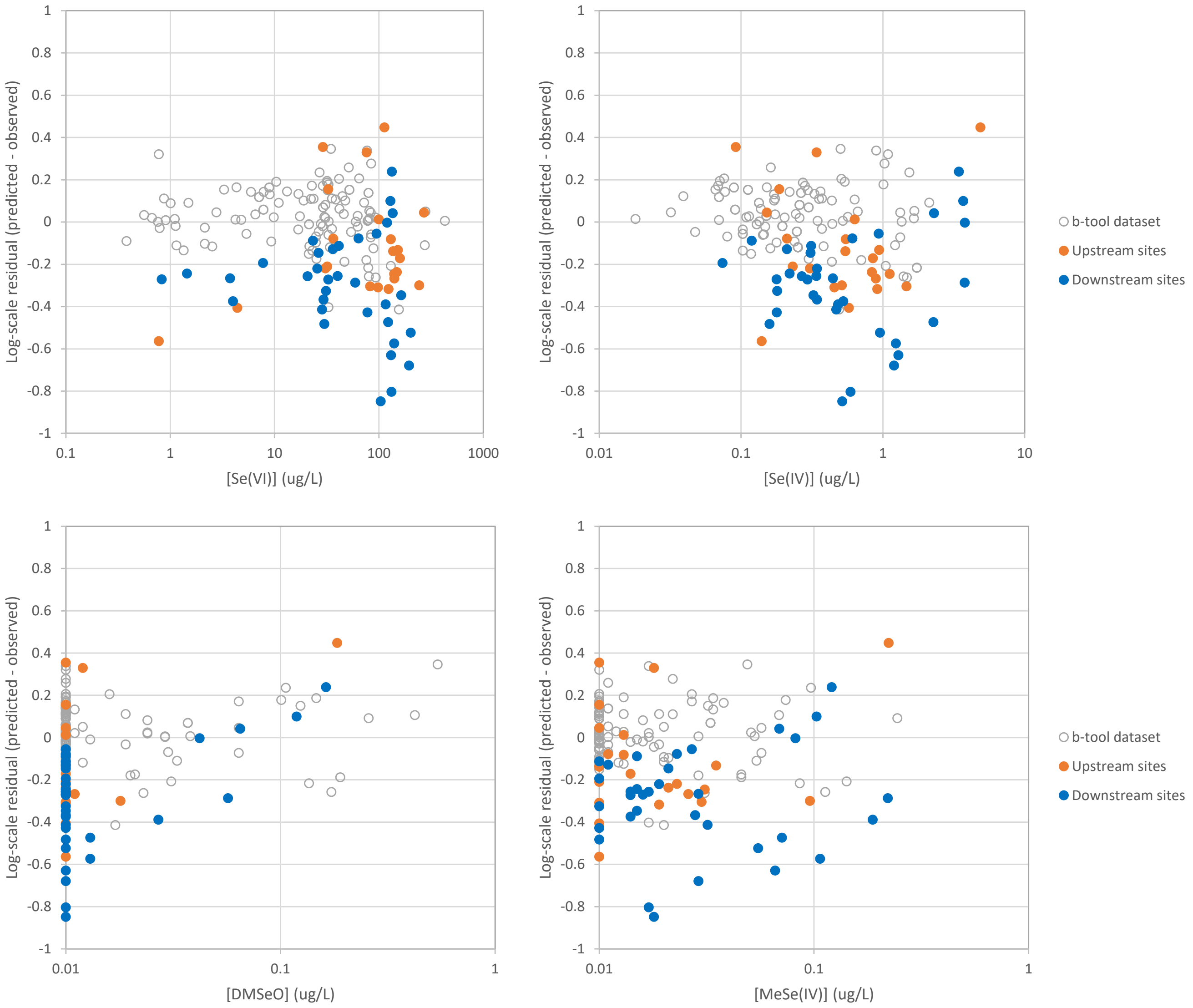
Notes: BI [Se] = benthic invertebrate selenium concentration; US = upstream; DS = downstream; reported BI [Se] is mean of 3 replicates; modelled BI [Se] was calculated from aqueous selenium speciation data collected at the time of BI sampling

Concentrations modelled from aqueous speciation measured in the 2021 SeSMP were within a factor of 2 of measured concentrations for 64% of samples collected upstream of sedimentation ponds (open blue and red symbols on Figure 5) and 44% of samples collected downstream of sedimentation ponds (filled blue and red symbols on Figure 5), indicating reduced performance of the model for this dataset compared to previously available data. In addition, modelled values more often under-predicted than over-predicted measured concentrations. Potential explanations for this reduced performance are evaluated below.

Annelids were observed in only one replicate from one location (upstream of Corbin Reservoir), and therefore are not expected to have influenced measured concentrations in this study.

To explore whether the tendency of the model to under-predict measured concentrations in 2021 was related to systematic under-prediction of the bioaccumulative potential of one or more selenium species, model residuals were plotted as a function of individual species concentrations (Figure 6). Systematic under-estimation of the bioaccumulative potential of a species would be evident on a residual plot as a negative slope: if the effect of a highly bioaccumulative species was being under-estimated, residuals would become increasingly negative (predictions would increasing under-estimate observations) as the influence of that species on measured concentrations increased and the model failed to accurately reflect that influence.

Figure 6. Model residuals (log-scale differences between modelled and observed benthic invertebrate selenium concentrations) in relation to selenium species concentrations

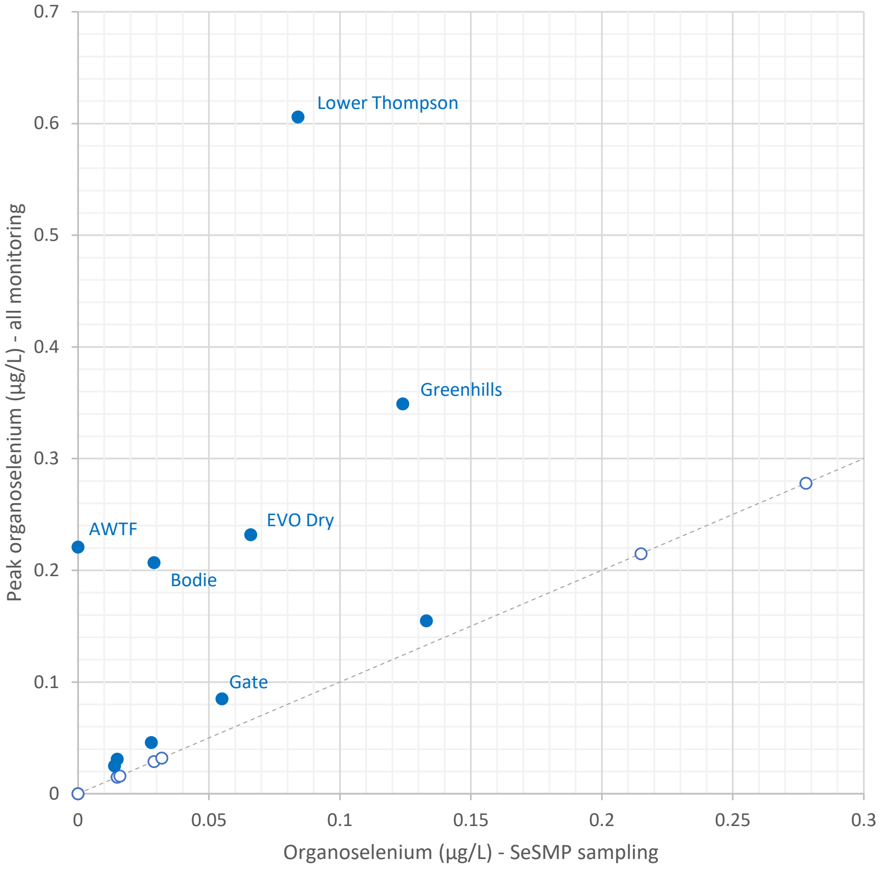


Notes: DMSeO = dimethylselenoxide; MeSe(IV) = methylseleninic acid; Se(IV) = selenite; Se(VI) = selenate

The patterns of residuals on Figure 6 do not indicate that current model systematically under-predicts the bioaccumulative potential of any species. The widest range of residuals occurred at the highest concentrations of selenate but relatively low concentrations of MeSe(IV) and the lowest concentrations (mostly below detection) of DMSeO. Data collected downstream of sedimentation ponds suggest a possible *positive* slope in the residuals for DMSeO, which could either indicate concentration dependence (i.e., higher bioaccumulative potential of DMSeO at lower concentrations, although this is not apparent in the upstream samples or the previous dataset) or, perhaps more likely, could indicate that the longer-term average influence of DMSeO on bioaccumulation was underestimated by DMSeO concentrations measured in August 2021. The latter interpretation would be consistent with the large fluctuations in organoselenium concentrations observed between sampling events in 2021 (Figure 3) in comparison to the more stable concentrations in benthic invertebrates (Figure 4). The latter interpretation would also be consistent with the greater proportion of negative residuals observed downstream (where DMSeO more often occurs) compared to upstream of sedimentation ponds (Figure 6).

The possibility that SeSMP sampling in August – September 2021 may have understimated the recent organoselenium exposure of benthic invertebrates was tested by comparing peak organoselenium concentrations measured in 2021 from all regional and site-specific monitoring (Table 7) to concentrations measured in SeSMP sampling (Table 8). Such a comparison was possible at ten of the sedimentation ponds included in the regional survey. In all cases, SeSMP data were lower than peak concentrations, and in five of those cases SeSMP data were several-fold lower (up to an order of magnitude lower) than peak concentrations (Figure 7).

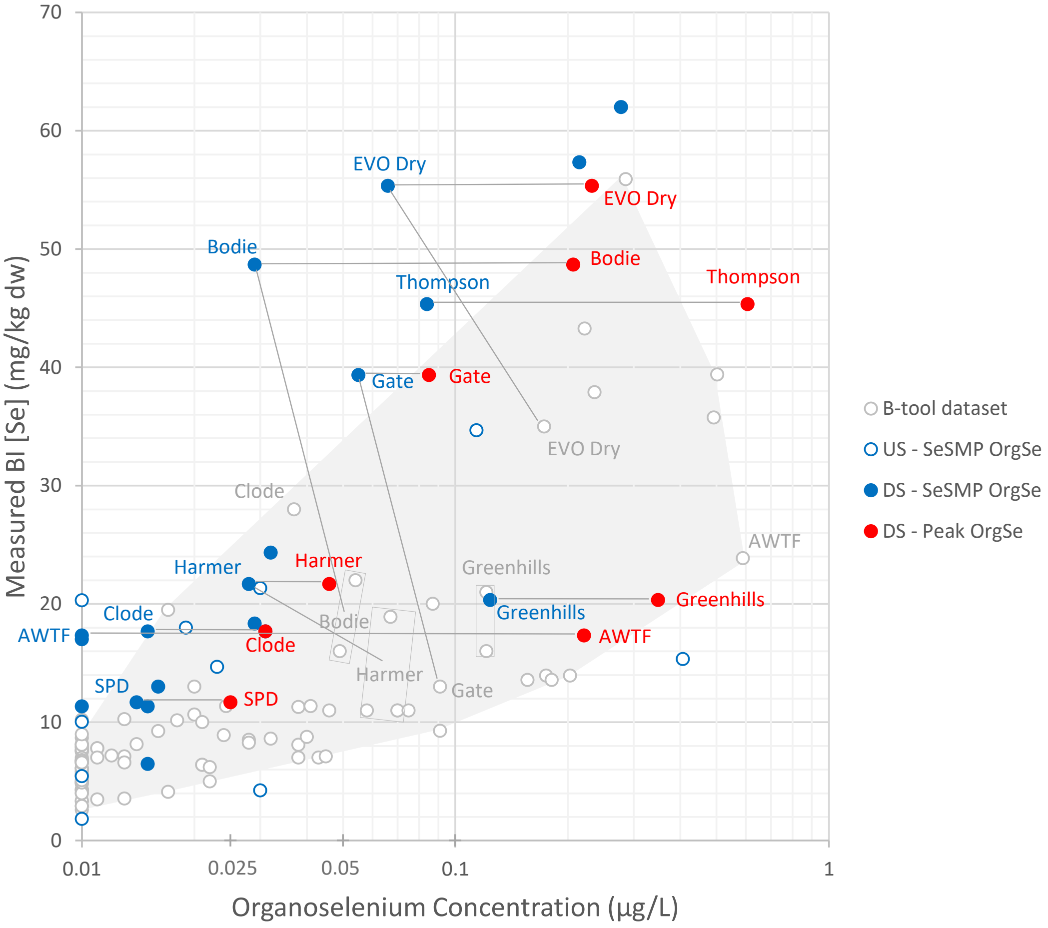
Figure 7. Maximum organoselenium concentrations reported in 2021 in comparison to concentrations measured for the SeSMP (24 August – 3 September 2021)



Notes: Organoselenium expressed as the sum of DMSeO (dimethylselenoxide) and MeSe(IV) (methylseleninic acid); dashed line is 1:1; open symbols locations with SeSMP data only, filled symbols are locations with additional monitoring data for comparison

The effect of variable organoselenium concentrations on apparent patterns of bioaccumulation is further explored in Figure 8. Figure 8 provides a somewhat simplified[9] illustration of the pattern of bioaccumulation that was described by the bioaccumulation tool: the grey symbols enclosed in a grey polygon show the range of benthic invertebrate selenium concentrations previously observed across the studied range of organoselenium concentrations (de Bruyn and Luoma 2021). Blue symbols on Figure 8 show 2021 benthic invertebrate selenium concentrations in relation to organoselenium concentrations measured in the SeSMP. Red symbols on Figure 8 show 2021 benthic invertebrate selenium concentrations in relation to peak organoselenium concentrations measured in other monitoring (as in Figure 7). Locations that exhibited notable shifts between previous sampling (mostly in 2018) and sampling in 2021 are annotated on Figure 8 and discussed further below.

Figure 8. Relationship between benthic invertebrate selenium concentrations, organoselenium concentrations measured in the SeSMP, and 2021 peak organoselenium concentrations measured in other monitoring



Notes: BI [Se] = benthic invertebrate selenium concentration; organoselenium is the sum of DMSeO (dimethylselenoxide) and MeSe(IV) (methylseleninic acid); grey polygon encloses data used to derive the bioaccumulation tool (grey symbols); lines connect measurements from the same site in previous BI [Se] and organoselenium data (grey), 2021 BI [Se] data relative to SeSMP organoselenium data (blue), and 2021 BI [Se] data relative to 2021 peak organoselenium data (red)

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[9] This figure does not account for the effect of selenate or selenite, which account for some of the variability in benthic invertebrate selenium concentrations at a given organoselenium concentration.

Two notable patterns are apparent on Figure 8:

- Where previous data exist for comparison, benthic invertebrate selenium concentrations measured in 2021 were almost always (with the exception of Greenhills Main) associated with lower organoselenium concentrations in 2021 (blue symbols) compared to previous years (grey symbols). This shift resulted in many of the 2021 sites falling outside the previously-described pattern of bioaccumulation (grey polygon).
- Where additional 2021 speciation data were available from other regional or local monitoring programs, benthic invertebrate selenium concentrations conformed better to the previously-described pattern of bioaccumulation (grey polygon) when associated with peak 2021 organoselenium (red symbols) compared to organoselenium measured for the SeSMP (blue symbols).

Possible interpretations of the patterns summarized above are discussed further in Section 5.4.

5.0 INTERPRETATION

5.1 Study Question 1

The answer to Study Question 1: *What is the spatial extent of detectable organoselenium?* Is discussed below in terms of regional patterns and local-scale (longitudinal) patterns.

Regional patterns of organoselenium apparent on the heat maps in Attachment E are broadly consistent with those described in Golder (2021a). Locations immediately downstream of sedimentation ponds exhibited a range of organoselenium concentrations, ranging from below detection (Porter Creek Secondary, MSAN1, AWTF Buffer) to >0.1 ug/L (Milligan Creek, South Pit Creek, Swift Secondary). Detectable organoselenium was often present immediately downstream of sedimentation ponds and in tributaries whose water quality is strongly influenced by mine-related sources of organoselenium (e.g., Line Creek, Harmer Creek). In contrast, mainstem rivers rarely had detectable organoselenium, with the exception of reaches of the Fording River immediately downstream of GHO. These patterns are consistent with the expectation that organoselenium species are highly bioavailable (de Bruyn and Luoma 2021) and degradable (Zhang et al. 1999; Zhang and Frankenberger 2000; LeBlanc and Wallschläger 2016; Jain 2017), as well as the relatively large dilution that occurs when most mine-affected tributaries enter mainstem rivers.

The analysis of longitudinal patterns of DMSeO, DMSe, and DMDSe was hindered by concentrations less than the detection limit at most or all sites. The analysis was not able to detect a decline in concentrations of selenite or MeSe(IV) downstream of EVO Dry Creek and Harmer Creek sedimentation ponds. It was possible to derive an unbounded estimate of the loss rate of DMSe, and it was hypothesized that conversion of DMSe into MeSe(IV) might explain the lack of declines in concentration with distance from two of the study sedimentation ponds. However, it was not possible with the existing data to test this hypothesis or to estimate a loss rate for MeSe(IV) at these two sedimentation ponds. Recommendations for the 2022 SeSMP to help resolve these uncertainties are provided in Section 6.

5.2 Study Question 2

The answer to Study Question 2: *Are there temporal trends in organoselenium concentrations?* is discussed below in terms of a preliminary evaluation of seasonal trends. An evaluation of long-term trends will be undertaken in a future Annual Report when enough years of data are available to support interannual comparisons.

The partial seasonal cycle collected in 2021 supported the analysis in Golder (2021a) that found strong seasonal cycles in concentrations of selenite and organoselenium and expanded this characterization to include the volatile species DMSe at two of the study ponds. Peak organoselenium concentrations appeared to occur in mid-September to early October, although one possible explanation for observed patterns of bioaccumulation is that there were relatively higher organoselenium concentrations prior to the August sampling event (see Section 5.4 for further discussion). A comparison of seasonal cycles among sedimentation ponds will be included in the 2022 SeSMP Annual Report when a full annual cycle is available for the three additional sedimentation ponds studied herein. Recommendations for the 2022 SeSMP to help resolve seasonal peaks of organoselenium are provided in Section 6.

5.3 Study Question 3

The answer to Study Question 3: *What are the mechanisms of organoselenium production?* is discussed below in terms of how the results of the GLM analysis in Section 4.4 compare to the conceptual model described in Section 2.3.

The most commonly selected informative[10] predictors in the stepwise GLM analysis were ORP (negative coefficient in runs 2, 3, 5, and 6), dissolved selenium concentration (positive coefficient in runs 3, 4, and 5), and water temperature (positive coefficient in runs 1 and 2). As discussed in Section 4.4, inclusion of these predictors in a model that predicts benthic invertebrate selenium concentrations indicates that these factors and/or some correlated factors play a role in driving selenium speciation changes.

Reducing conditions (low ORP) could directly promote speciation changes by favouring bacteria that use electron acceptors other than oxygen, thereby facilitating the generation of organoselenium by these biota (e.g., via assimilatory reduction). Alternatively, low ORP could be an indicator of heterotrophic acitivity (e.g., hypoxia resulting from decomposing algal blooms) that acts to release organoselenium from organic matter into the water column (Martin et al. 2018).

A possible mechanistic role of dissolved selenium concentration in driving organoselenium concentrations is not entirely clear. Sedimentation ponds with dissolved selenium concentrations <100 µg/L had benthic invertebrate selenium concentrations <25 mg/kg dw, whereas ponds with dissolved selenium concentrations >100 µg/L had benthic invertebrate selenium concentrations ranging from 18 to 62 mg/kg dw. It seems unlikely that this weak correlation indicates a dependence of organoselenium concentrations on dissolved selenium. It is perhaps more likely that organoselenium concentrations are increased by another factor that is most often present at ponds with higher dissolved selenium concentrations. PCA indicated that this factor may be related to water temperature (discussed below), hydraulic residence time, or ORP upstream of the pond.

Warmer water could directly promote speciation changes by increasing algal productivity and/or bacterial metabolism. Alternatively or in addition, temperature could act via an indirect mechanism such as promotion of aquatic vegetation or depletion of dissolved oxygen from enhanced bacterial metabolism. Both possibilities are supported by PCA, which showed that water temperature was correlated with chlorophyll-*a* and phycocyanins in the pond (indicating greater algal productivity) and with abundance of emergent vegetation (indicating structural and biological factors that could further enhance algal productivity and/or bacterial metabolism).

Overall, the analysis of mechanisms supports the current understanding that organoselenium generation and release are biologically-driven processes (Cooke and Bruland 1987; Eswayah et al. 2016; LeBlanc and

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[10] Excluding predictors for which AIC_C and/or r^2 indicate overfitting.

Wallschläger 2016; Ponton et al. 2020) and do not necessarily require photosynthesis (Neumann et al. 2003). This interpretation highlights the importance of understanding factors that promote biological productivity and confirms the focus of the SeSMP on sedimentation ponds, where biological productivity can be locally enhanced.

5.4 Study Question 4

The ability to answer to Study Question 4: *Do new data support refinement of the speciation bioaccumulation tool?* is affected by uncertainty around selenium speciation measurements taken for the SeSMP and how well these measurements reflect the exposure of benthic invertebrates immediately downstream of the study sedimentation ponds. The interpretation outlined in Section 4.5 suggests that the poor conformance of some 2021 SeSMP data to the bioaccumulation tool may be related to an underestimation of organoselenium exposure by the sampling event in late August and early September 2021, rather than an issue with the bioaccumulation tool.

The pattern of bioaccumulation evident in the 2021 SeSMP dataset overlapped with the pattern evident in previous data, but with some notable differences that appeared to be related to a systematic under-estimation of organoselenium concentrations in 2021 SeSMP sampling (Figures 7 and 8). Where data were available for comparison, the 2021 SeSMP dataset exhibited consistently lower organoselenium concentrations compared to previous years and compared to values measured in other 2021 monitoring. As a result, 2021 data tended to be under-predicted by applying the bioaccumulation tool to speciation data collected for the SeSMP.

There are several possible explanations for the inconsistencies in patterns of bioaccumulation between 2021 data and previous data (Figure 8). The following list is intended to explore all possibilities, not all of which may be plausible or likely. Possible explanations for the patterns on Figure 8 include:

- The bioaccumulative potential of organoselenium could be greater than was previously estimated. This explanation could be supported if for some reason (perhaps chance alone) previous data did not fully characterize the effect of organoselenium on benthic invertebrate selenium concentrations. If supported, this explanation would likely warrant recalibrating the bioaccumulation tool. This explanation seems unlikely, considering the large dataset used to derive the bioaccumulation tool and the sensitivity analyses conducted in support of that derivation. Figure 8 indicates that if the bioaccumulation tool was revised to align with the 2021 data, it would not align with previous data.
- There could be additional selenium species contributing to bioaccumulation in 2021 that did not affect previous data. This explanation could be supported if conditions in 2021 resulted in production of additional selenium species (volatile species or some uncharacterized species) that was not present in previous years. If supported, this explanation would warrant expanding the bioaccumulation tool to model additional species. This explanation would not be supported by the volatile selenium species concentrations and measured in 2021, which were less than the detection limit at most sedimenation ponds.
- Benthic invertebrate selenium concentrations could be reflecting selenium speciation effects not completely captured in the SeSMP speciation data collected in late August to early September. Benthic invertebrate selenium concentrations could reflect variable organoselenium concentrations that were higher on average than was reflected in the single samples collected for the SeSMP. If supported, this explanation may warrant further study to better characterize short-term variability in organoselenium concentrations and the factors contributing to that short-term variability. Figure 8 and the supporting interpretation in Section 4.5 suggest that this may be the most likely explanation.
- Organoselenium analyses may have been biased high in previous sampling and/or biased low in SeSMP sampling, resulting in inconsistent estimates of one or more species concentrations used to calculate modelled concentrations. Alternatively, benthic invertebrate selenium concentrations may have been biased

low in previous data and/or biased high in 2021 sampling, resulting in inconsistent estimates of measured concentrations. Biased estimates could result from changes to sample handing and/or analysis methods. If supported, this explanation would warrant more careful standardization of methods and further study to evaluate if and how data from different years can be reconciled to provide a consistent interpretation. This explanation seems unlikely in light of the consistent use of standard methods recommended by the analytical laboratory. Effects on speciation from sample handling could introduce variability but would be unlikely to introduce bias.

An evaluation should be undertaken to identify plausible explanations (including but not necessarily limited to those outlined above) and evaluate the strength of evidence for each prior to finalizing an interpretation of data quality and model performance. Recommendations for such an evaluation are provided in Section 6.

6.0 RECOMMENDATIONS

6.1 2022 SeSMP Study Design

Recommendations for the 2022 SeSMP study design relate to refinements to methods and approaches in light of learnings and challenges encountered in the 2021 program. Recommendations are:

- Increase the frequency of aqueous speciation sampling in the period prior to benthic invertebrate sampling. This recommendation reflects the observation that aqueous speciation exhibited relatively large short-term variability at some sedimentation ponds, and that this variability may account for the poor conformance of some 2021 data to the bioaccumulation tool. The 2022 SeSMP study design should consider an appropriate period and sampling frequency to overcome this variability and develop a more reliable pairing of organoselenium concentrations and benthic invertebrate selenium concentrations.
- Volatile selenium analysis should continue until sufficient data exist to understand the persistence and bioaccumulative potential of these species or to conclude that these species are not important drivers of bioaccumulation. Too few detected values were obtained in the 2021 program to provide this understanding.
- A special study should be considered to evaluate the stability of both volatile and non-volatile organoselenium species after sampling. This study could involve collecting multiple water samples from a sedimentation pond at a time when organoselenium concentrations are relatively high, then handling and storing these samples in different ways to evaluate whether these factors can affect measured organoselenium concentrations. Sample treatments could include presence of headspace, exposure to light, storage temperature, hold time, or sterilization.
- Methods should be evaluated to more precisely quantify types and abundances of aquatic vegetation (e.g., via drone photography) and abundance or productivity of attached algae within ponds (e.g., by sampling from vegetation, liners, or baffles). Methods should also be evaluated to more precisely quantify shading.
- Installation of loggers should be evaluated in selected study ponds to obtain high-resolution time series of conditions such as temperature, dissolved oxygen, and ORP. These data will help understand how often (and when) these parameters need to be sampled to obtain reliable information on average conditions.
- Methods should be evaluated to obtain sediment characteristics from ponds with liners or extensive vegetation, so that the role of sediment can be more reliably tested.
- Consideration should be given to conducting longitudinal sampling downstream of more sedimentation ponds, subject to the availability of downstream reaches with suitable conditions at sedimentation ponds with sufficiently high organoselenium concentrations.

6.2 Other Recommendations

Other activities that could help attain the objectives of the SeSMP include:

- When activities are being planned that will modify a sedimentation pond (e.g., aeration, bypass, dredging), these should be treated as an opportunity to monitor how the modifications affect conditions and selenium speciation changes in the pond. Repeated monitoring should be conducted before, during, and after the modification, including aqueous speciation upstream and downstream of the pond and whatever conditions in the pond could be affected by the modification (considering what the modification will be, and drawing on the predictors considered in this study). If properly designed, such studies could directly test some of the hypothesized mechanisms for organoselenium generation and release.
- Any activities related to sedimentation ponds (e.g., use of flocculant, pumping of water in or out) should be recorded and stored in a way that is readily available to the SeSMP study team. Such information could be invaluable in helping to understand puzzling results, and could flag potential issues with data collection before they occur.
- All available engineering information on sedimentation pond characteristics (e.g., capacity, dimensions, baffles, liners) should also be compiled and stored in a way that is readily available to the SeSMP study team. Such information could help identify useful predictors of organoselenium concentrations.

Signature Page

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Owner, Senior Environmental Scientist

AMD/SED/

7.0 REFERENCES

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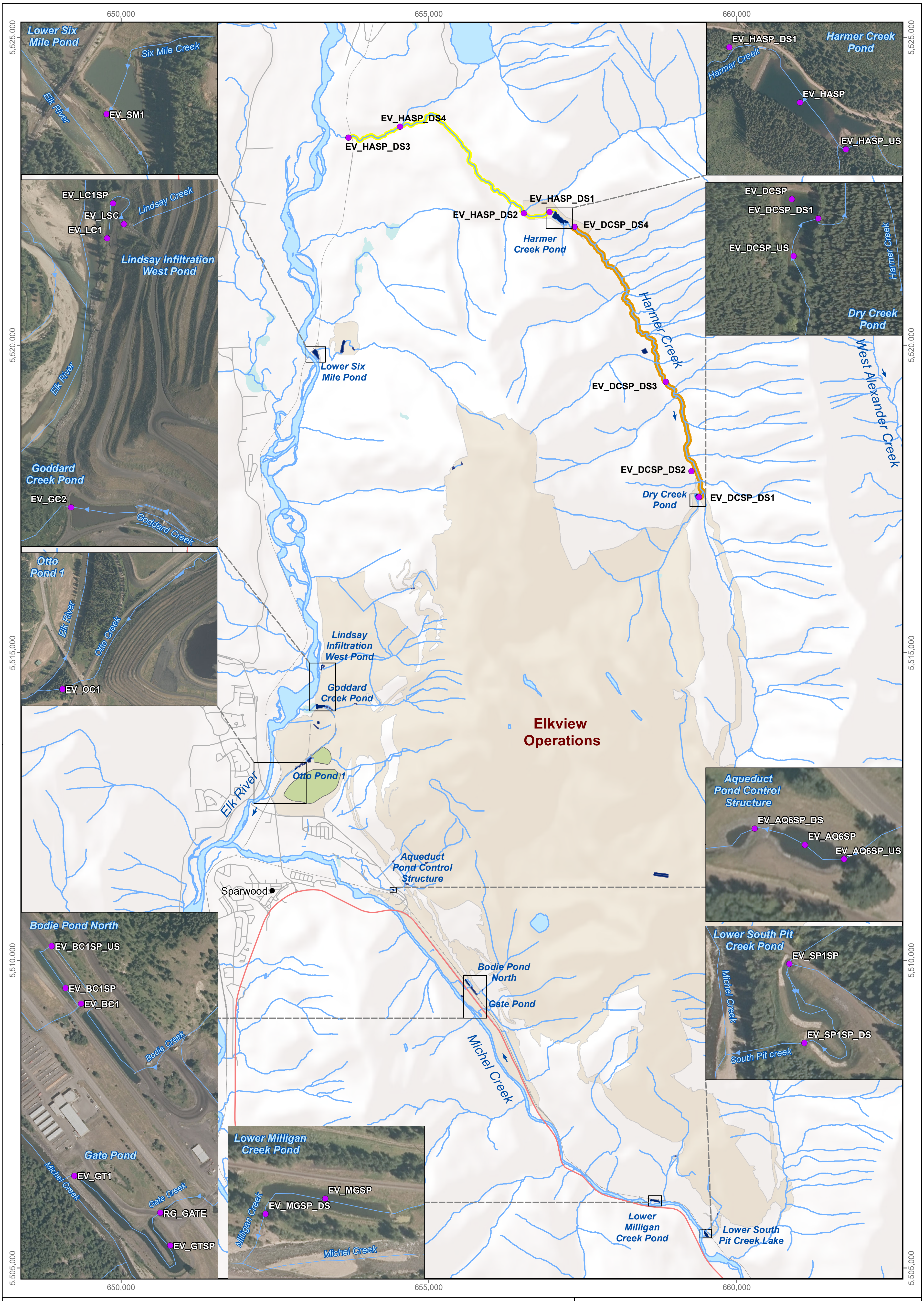
Attachment A

Speciation Sampling Locations for the 2021 Regional Survey of Sedimentation Ponds and Other Monitoring Programs



LEGEND

- ● Sampling Location
- 🟧 Longitudinal Study – Dry Creek Pond
- 🟨 Longitudinal Study – Harmer Creek Pond
- 🟦 Settling Pond
- 🟩 Tailings Pond
- ⬜ Teck Coal Mine Operation

Elkview Operation – Sampling Locations for the 2021 SeSMP Regional Survey of Sedimentation Ponds

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km

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Date: May 2022
Project 217202.0101

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Figure 3a

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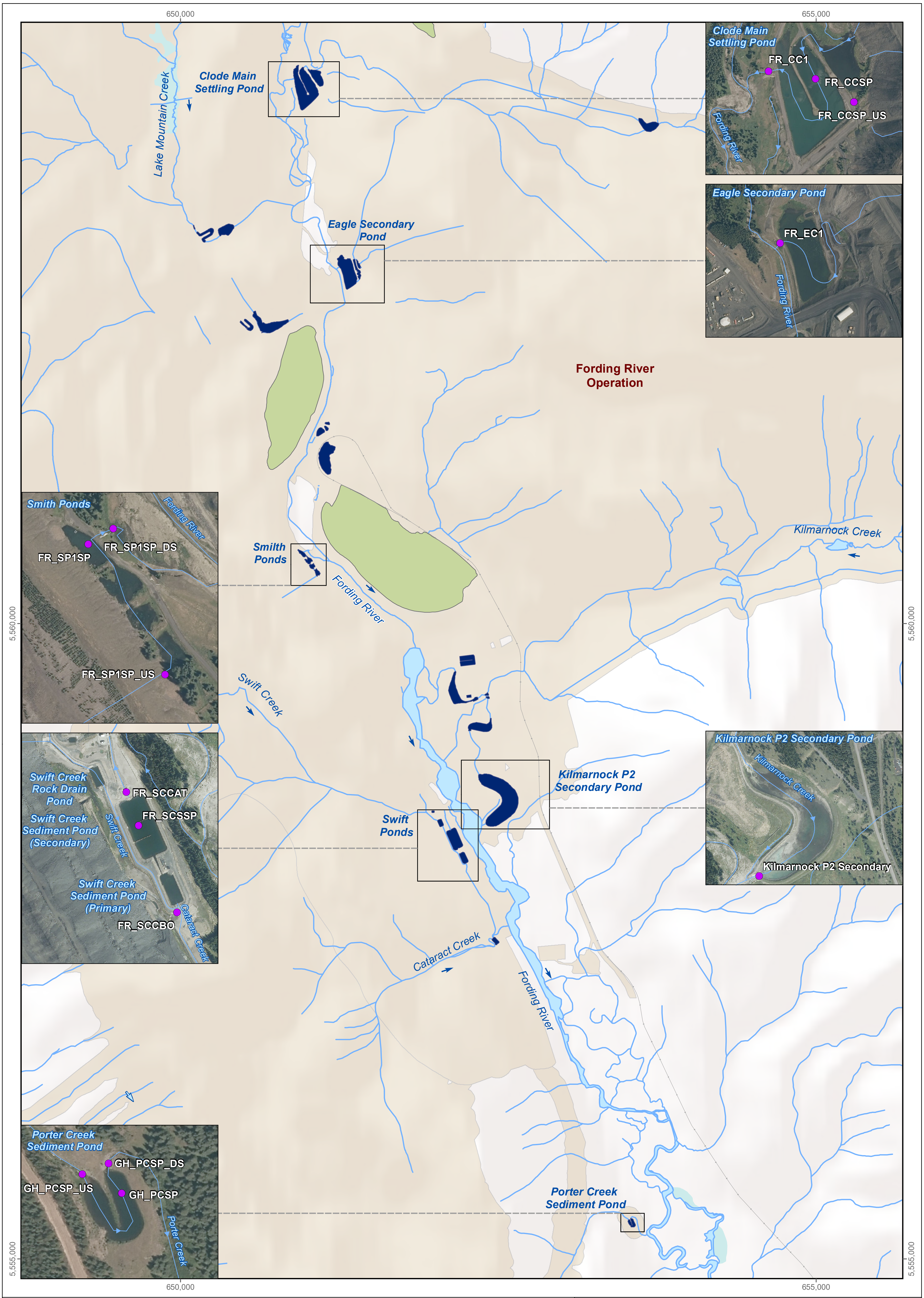

LEGEND

- ● Sampling Location
- 🟦 Settling Pond
- 🟩 Tailings Pond
- ⬜ Teck Coal Mine Operation

Fording River Operation – Sampling Locations for the 2021 SeSMP Regional Survey of Sedimentation Ponds

0 0.4 0.8 1.6
km

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Date: May 2022
Project 217202.0101

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Figure 3b

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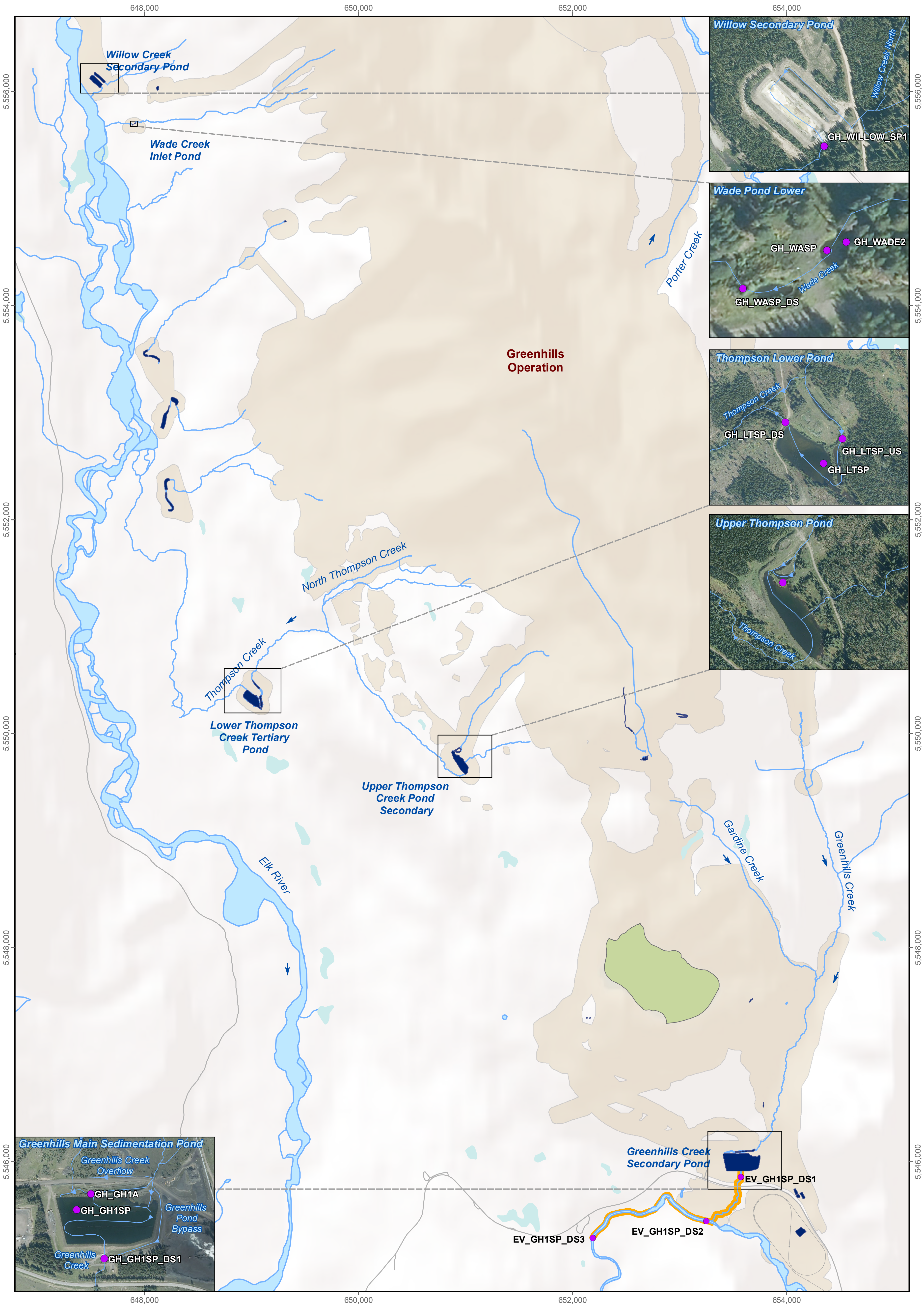

LEGEND

- ● Sampling Location
- ▬ Longtitudinal Study - Greenhills Main Sedimentation Pond
- ■ Settling Pond
- 🟩 Tailings Pond
- ▭ Teck Coal Mine Operation

Greenhills Operation – Sampling Locations for the 2021 SeSMP Regional Survey of Sedimentation Ponds

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Figure 3c

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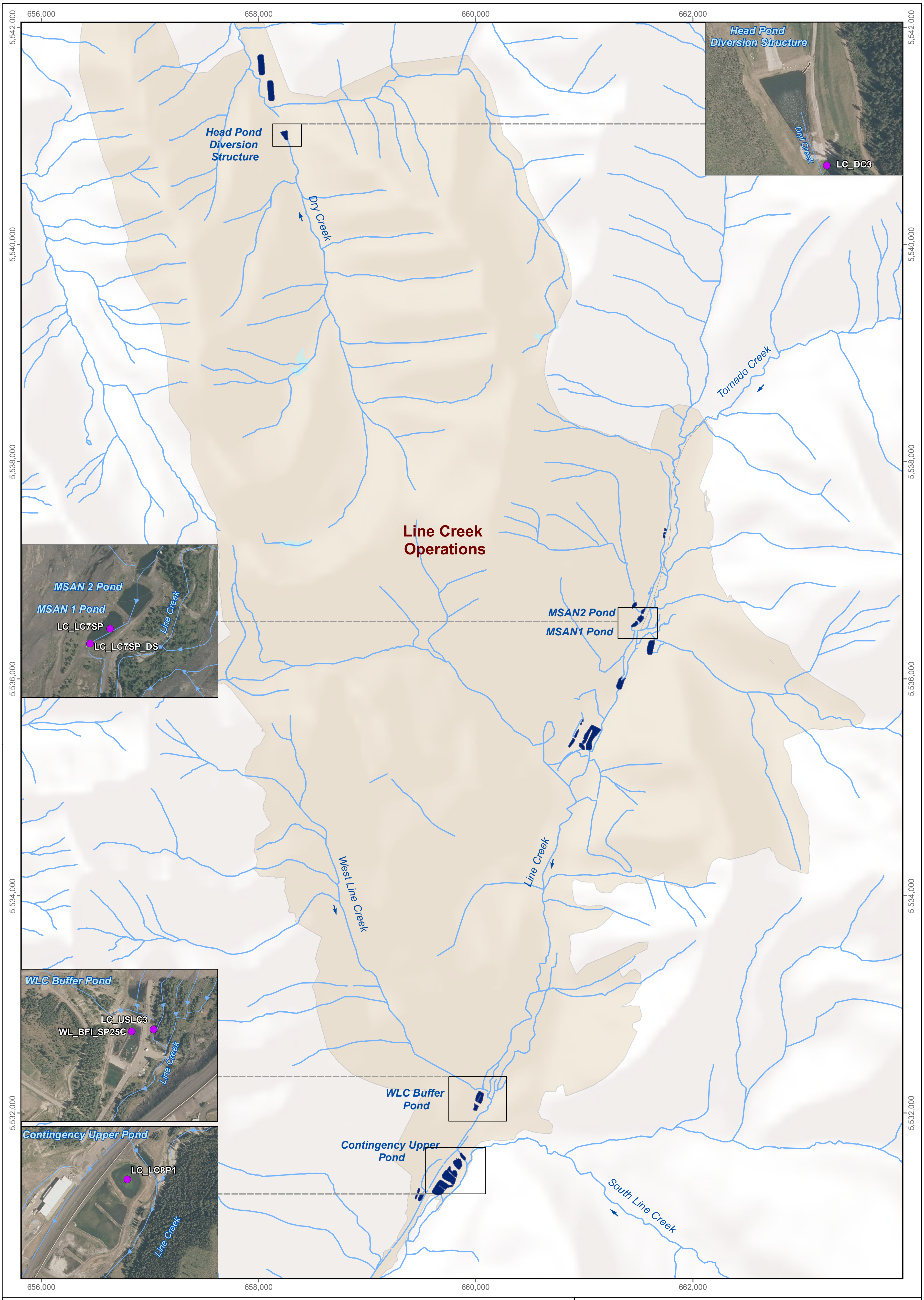

LEGEND

- ● Sampling Location
- ▇ Settling Pond
- 🟩 Tailings Pond
- ▭ Teck Coal Mine Operation

Line Creek Operation – Sampling Locations for the 2021 SeSMP Regional Survey of Sedimentation Ponds

0 0.475 0.95 1.9
km

N
W E
S

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Project 217202.0101

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Figure 3d

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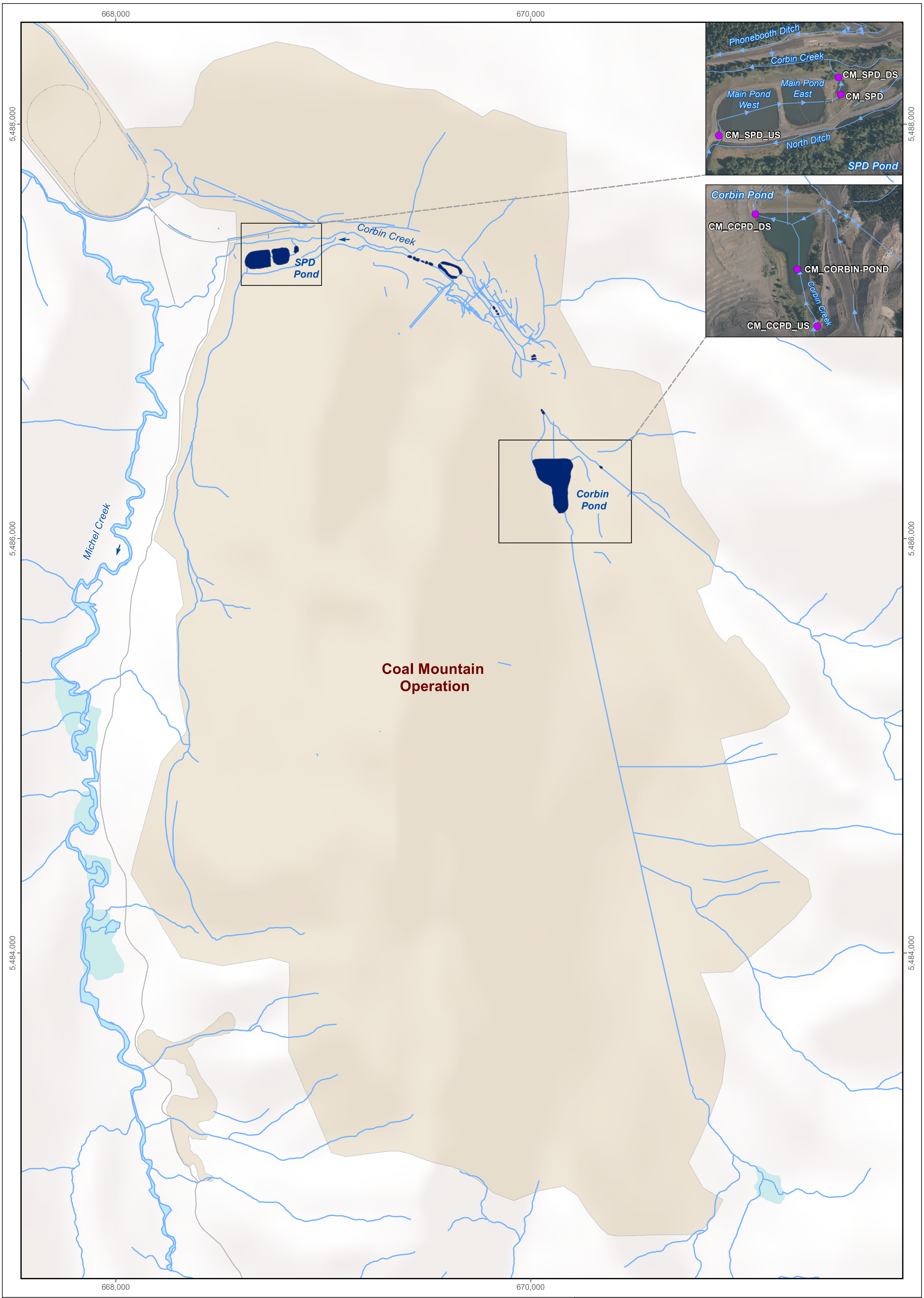

LEGEND

- ● Sampling Location
- ■ Settling Pond
- 🟩 Tailings Pond
- ▨ Teck Coal Mine Operation

Coal Mountain Mine - Sampling Locations for the 2021 SeSMP Regional Survey of Sedimentation Ponds

0 0.25 0.5 1
km

N
W E
S

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Date: May 2022
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Figure 3e

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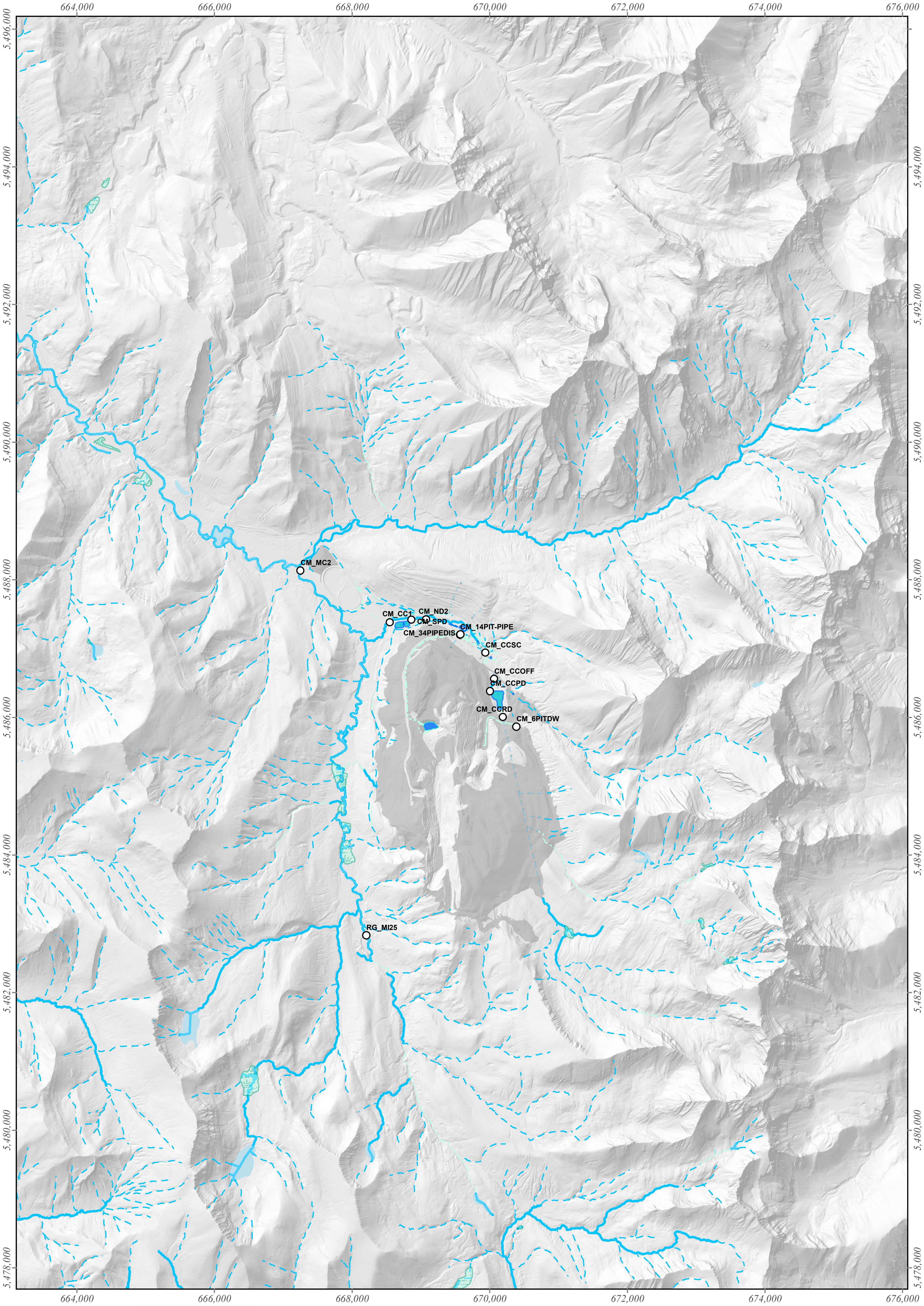

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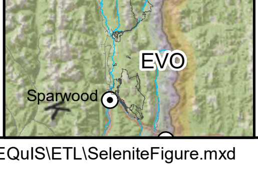


Coal Mountain Selenium Speciation Sample Locations

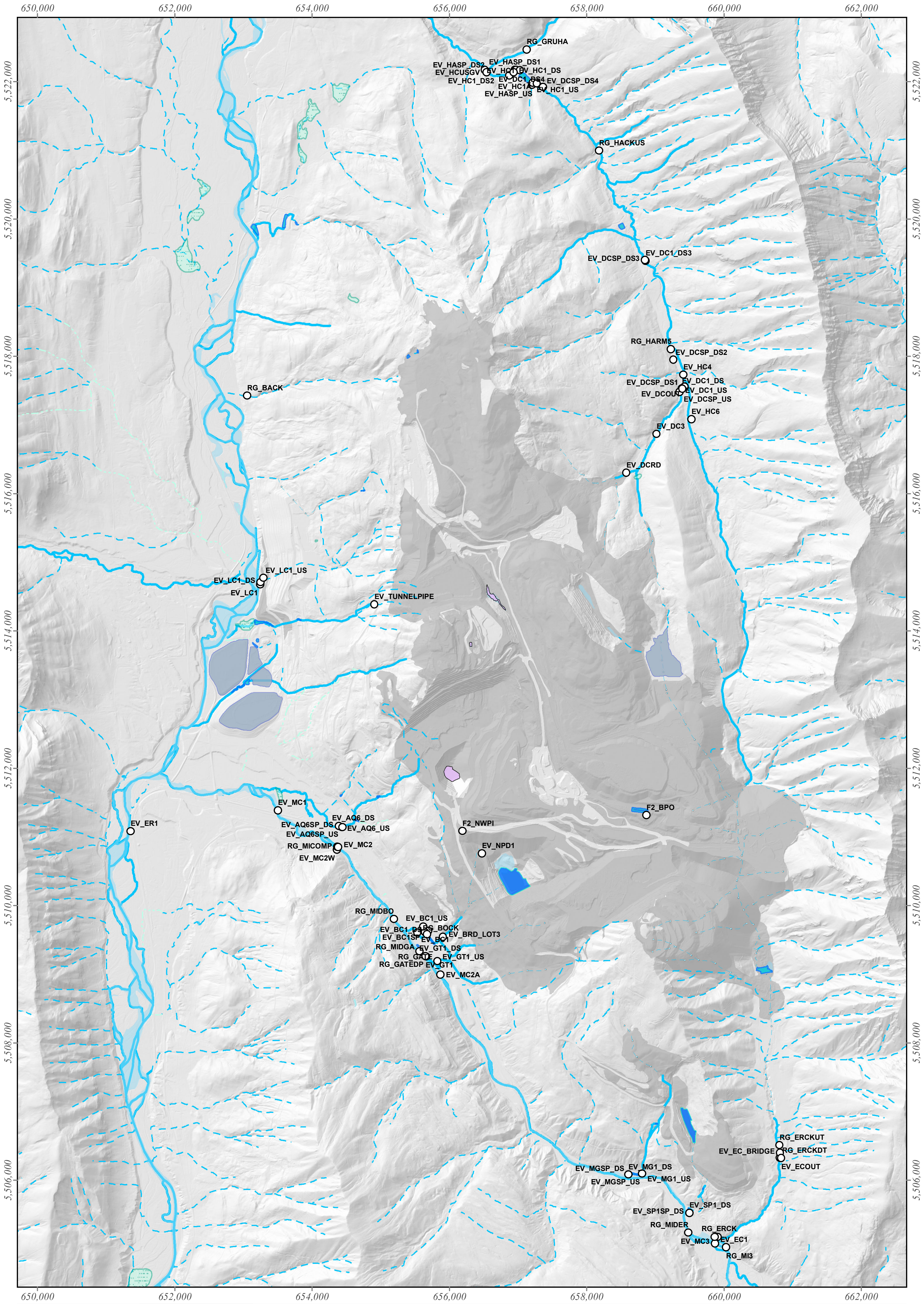
▨ Pits/Spoils
○ Monitoring Location

N

0 250 500 1,000 1,500
Meters

DATE: 4/14/2022	MINE OPERATION: Coal Mountain
SCALE: 1:50,000	COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\SeleniteFigure.mxd



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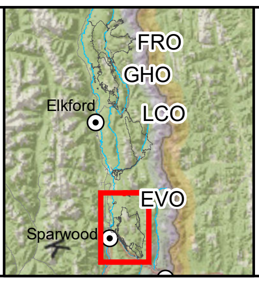

Elkview Selenium Speciation Sample Locations

▨ Pits/Spoils

○ Monitoring Location

N

0 250 500 1,000 1,500
Meters

DATE:
4/14/2022

MINE OPERATION:
Elkview

SCALE:
1:50,000

COORDINATE SYSTEM:
NAD 1983 UTM Zone 11N

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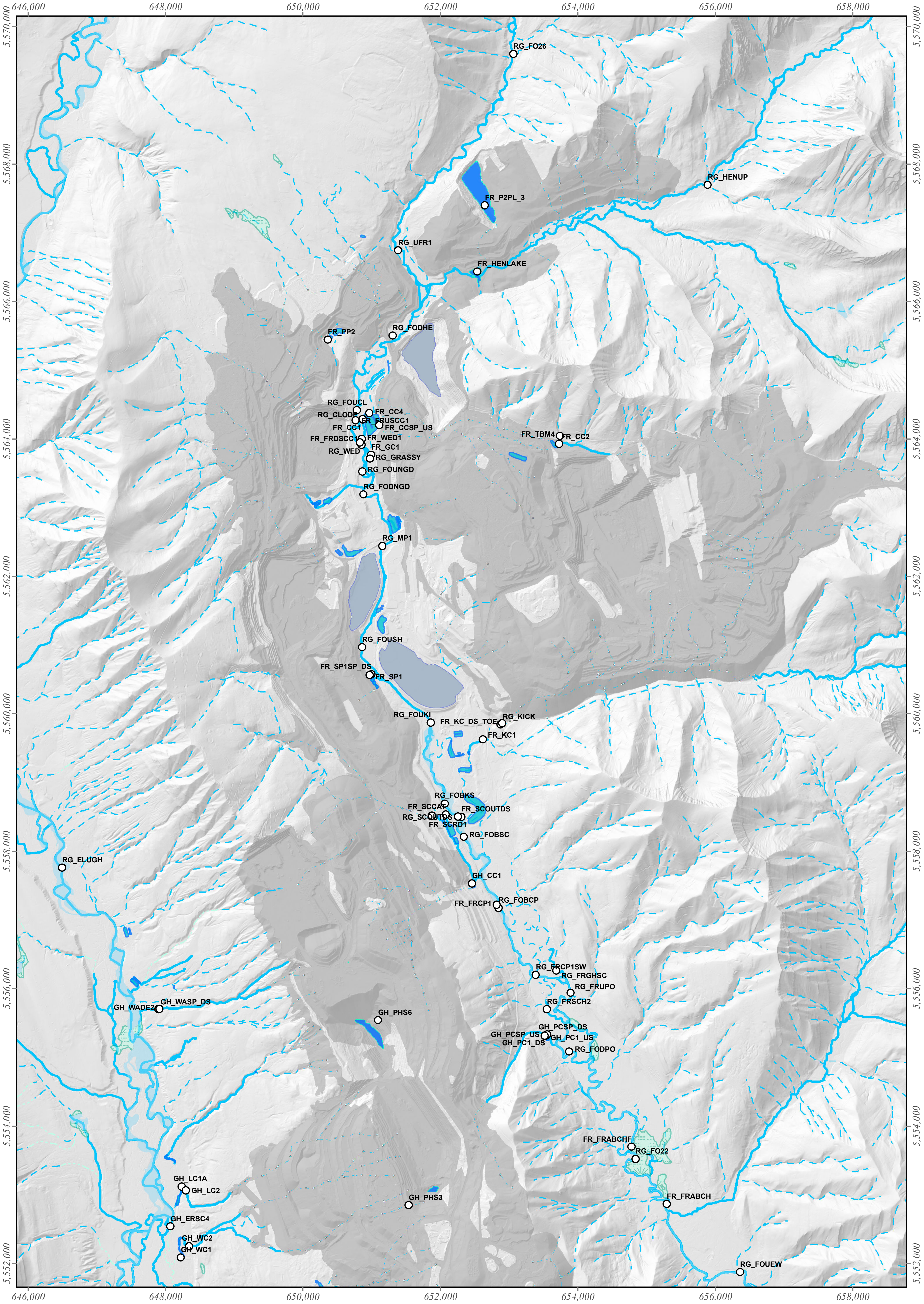

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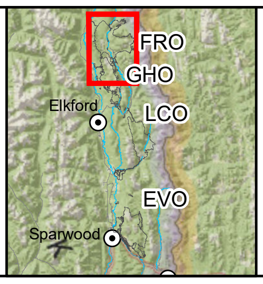


Fording River Selenium Speciation Sample Locations

▨ Pits/Spoils

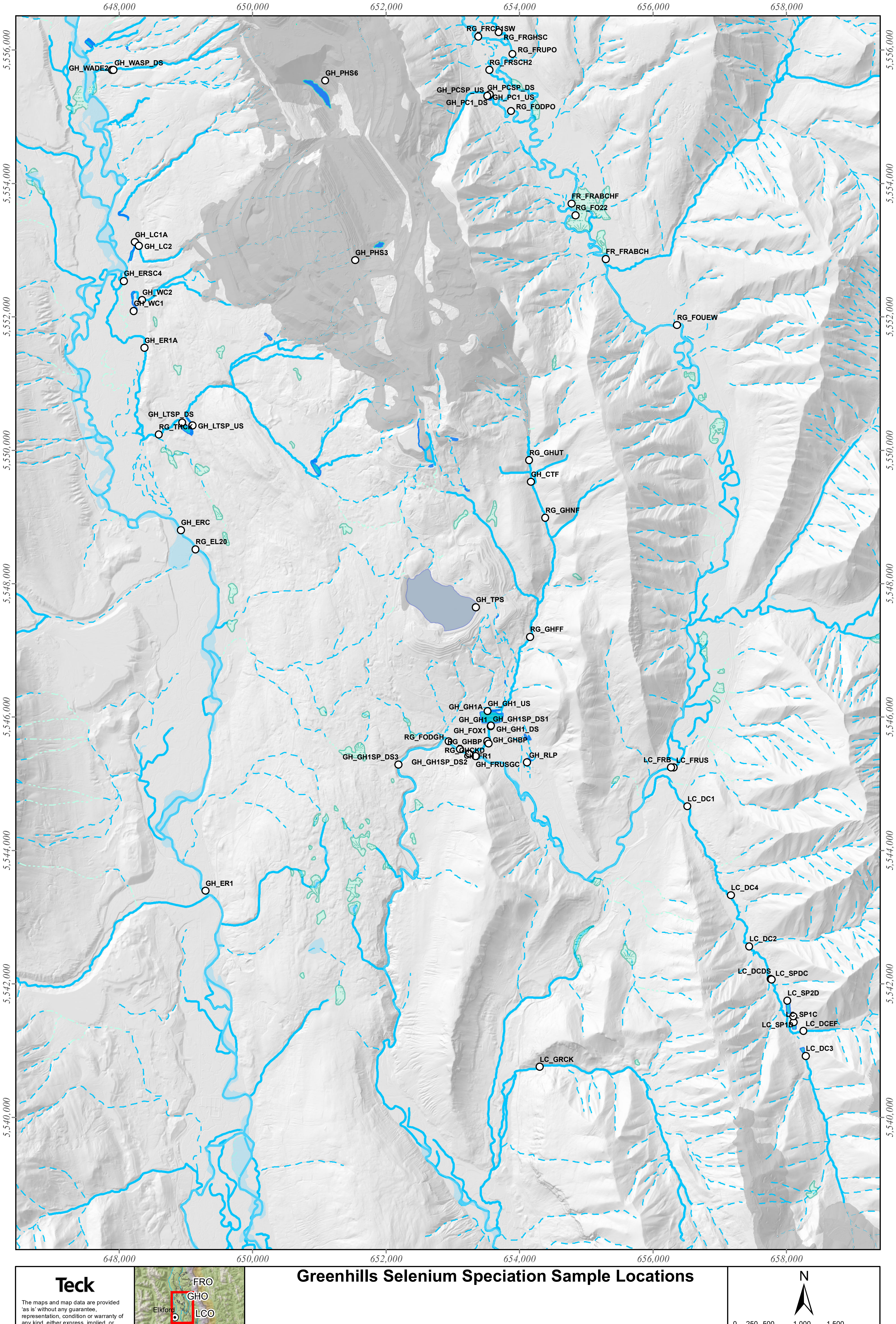
○ Monitoring Location

N

0 250 500 1,000 1,500
Meters

DATE: 4/14/2022	MINE OPERATION: Fording River
SCALE: 1:50,000	COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\SeleniteFigure.mxd



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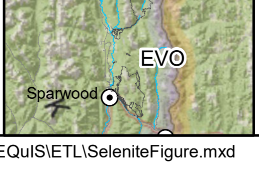

Greenhills Selenium Speciation Sample Locations

▨ Pits/Spoils
○ Monitoring Location

N

0 250 500 1,000 1,500
Meters

DATE: 4/14/2022	MINE OPERATION: Greenhills
SCALE: 1:50,000	COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

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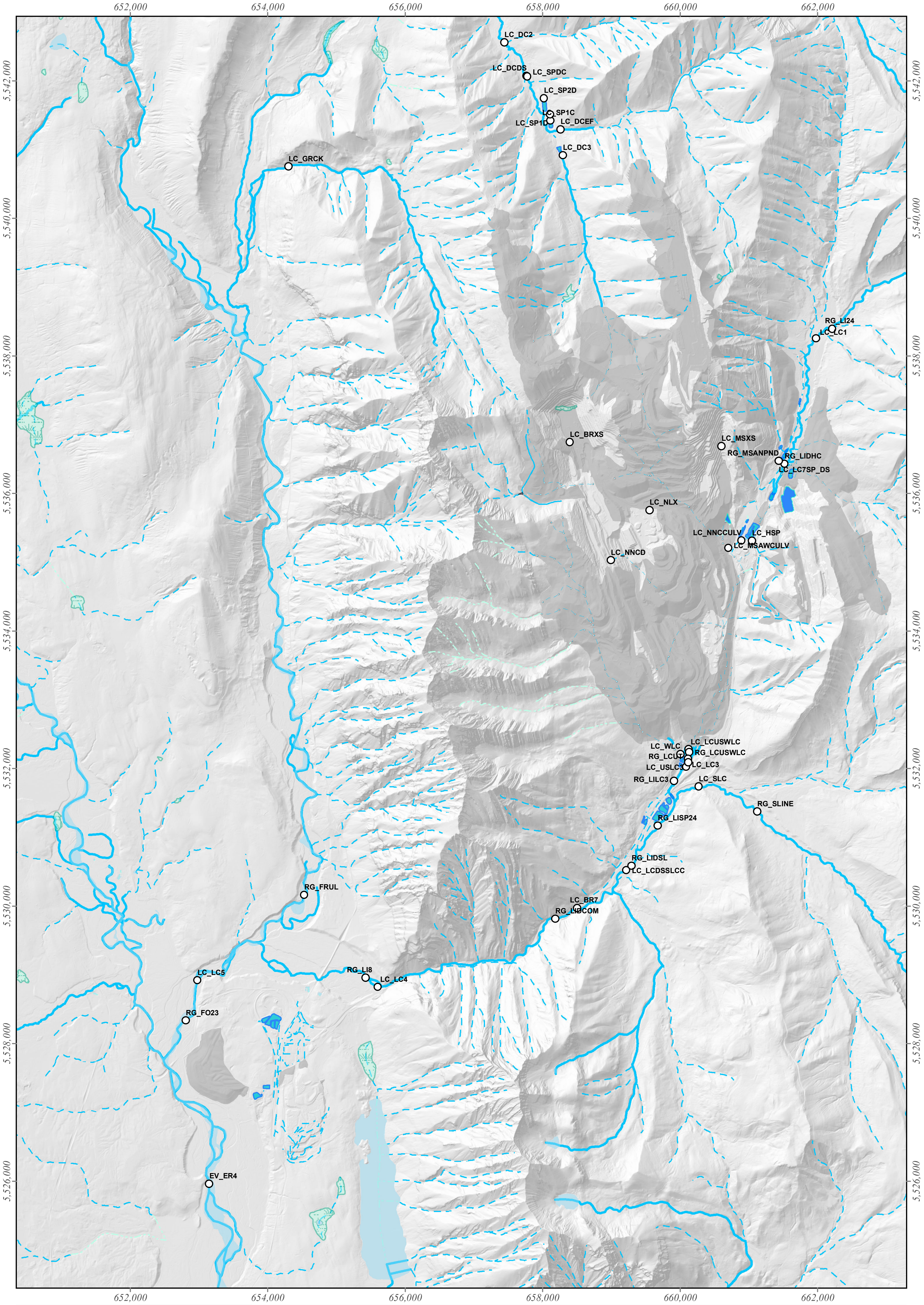
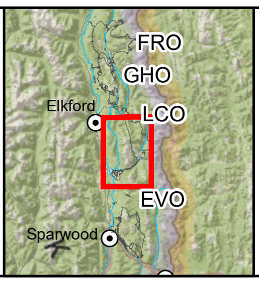


Line Creek Selenium Speciation Sample Locations

Teck



▨ Pits/Spoils

○ Monitoring Location

N

0 250 500 1,000 1,500
Meters

DATE: 4/14/2022

MINE OPERATION: Line Creek

SCALE: 1:50,000

COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\SeleniteFigure.mxd

Attachment B

Predictor Variables from the 2021 Regional Survey of Sedimentation Ponds

Attachment B. Predictor variables from the 2021 regional survey of sedimentation ponds

Parameter	Units	Corbin Reservoir	SPD Pond	Aqueduct Control	Bodie North	EVO Dry Creek	Harmer	Gate	Lindsay 2	Milligan	South Pit	Swift Creek Secondary	Clode Main	Porter Creek Secondary	Smith Ponds	Greenhills Main	Thompson Lower	Wade Pond Lower	Contingency Upper	MSAN 1	AWTF Buffer
Benthic invertebrate selenium US	mg/kg dw	1.8	10.0	-	-	18.0	14.7	-	-	21.3	-	34.7	5.4	4.2	-	17.7	15.3	20.3	-	-	-
Benthic invertebrate selenium DS	mg/kg dw	6.5	11.7	18.3	48.7	55.3	21.7	39.3	11.3	62.0	57.3		17.7	17.0	24.3	20.3	45.3	13.0	-	11.3	17.3
Alkalinity US	mg/L as CaCO$_3$	379	266	203	195	295	178	203	522	197	391	226	355	219	391	234	211	239	-	-	274
Ammonia US	mg/L as N	0.005	0.0936	0.0218	0.0337	0.005	0.018	0.0786	0.0252	0.0101	0.005	0.0182	0.005	0.0175	0.005	0.0108	0.0089	0.0058	-	-	0.0064
Ash-free Dry Mass US	mg/L	5.6	3.3	8.4	8	1.5	1.6	3.1	1.5	1.5	1.5	4.4	7.9	1.5	1.5	1.5	1.5	30.2	-	-	1.5
Chloride US	mg/L	1.17	4.37	41.7	37.3	3.36	0.87	14.3	8	0.82	0.57	1.84	6.86	0.82	0.57	1.4	11.2	0.45	-	-	91.2
Chlorophyll-a US	µg/L	0.11	0.648	0.698	1.52	-	-	1.48	0.188	1.47	0.067	3.31	0.47	0.358	0.067	0.316	1.23	3.07	-	-	0.458
Conductivity US	µS/cm	1740	1650	549	1860	1560	634	1800	990	1120	1020	1870	2960	1040	1020	1560	1800	506	-	-	1600
Dissolved Organic Carbon US	mg/L	2.42	2.1	1.36	1.52	2.23	1.44	1.63	1.12	3.91	3.79	5.77	0.69	0.93	3.79	3.31	4.06	5.22	-	-	1.48
Hardness US	mg/L as CaCO$_3$	1260	1090	291	1160	1030	360	1160	594	673	566	1020	1800	590	566	1090	1250	271	-	-	957
Nitrate US	mg/L as N	5.3	4.8	0.13	28.2	2.62	0.593	28.6	0.115	0.043	6.78	117	153	2.23	6.78	5.34	12	0.146	-	-	0.0743
Nitrite US	mg/L as N	0.005	0.0523	0.001	0.0735	0.005	0.001	0.0233	0.005	0.005	0.005	0.14	0.005	0.005	0.005	0.005	0.005	0.001	-	-	0.005
Oxidation-reduction Potential US	mV	379	461	456	271	230	445	284	267	239	463	473	478	469	463	450	469	479	-	-	454
Orthophosphate US	µg/L	0.0026	0.001	0.0024	0.0016	0.003	0.0058	0.0031	0.001	0.001	0.001	0.001	0.001	0.0044	0.001	0.0014	0.0048	0.0158	-	-	0.001
pH US	-	8.18	8.11	8.25	7.92	8.31	8.35	8.09	7.99	8.31	7.93	7.9	8.05	8.43	7.93	8.23	8.26	8.37	-	-	7.97
Total Phosphorus US	µg/L	0.002	0.0038	0.0332	0.0082	0.0037	0.0098	0.0095	0.002	0.0039	0.002	0.0908	0.002	0.0049	0.002	0.002	0.0065	0.0339	-	-	0.0109
Total Dissolved Solids US	mg/L	1370	1350	326	1530	1290	457	1480	621	901	652	1280	2410	764	652	1360	1580	312	-	-	1360
Dissolved Se US	µg/L	33.4	6.17	4.74	254	195	38.5	241	3.77	73.8	23.1	210	218	64.2	23.1	165	149	1.24	-	-	8.28
Total Se US	µg/L	34.9	6.38	4.6	231	162	35	217	3.22	73.7	24.7	230	240	70.8	24.7	172	163	1.49	-	-	7.79
Sulphate US	mg/L	819	815	37.5	857	752	185	824	64.2	486	216	444	1090	418	216	756	909	31.4	-	-	691
Total Kjeldahl Nitrogen US	mg/L as N	0.315	0.387	0.198	0.05	0.274	0.129	0.05	0.068	0.292	0.05	0.05	0.081	0.357	0.05	0.454	0.335	0.292	-	-	0.094
Total Organic Carbon US	mg/L	1.99	1.91	6.24	1.53	2.2	1.79	2.04	1.12	4.12	3.78	7.19	1.91	1.14	3.78	3.49	5.37	5.52	-	-	1.59
Total Suspended Solids US	mg/L	1	1.2	34.6	279	1	3.8	10.8	1	1.2	1	13.2	1.1	1.2	1	1.2	25.2	24.8	-	-	1
Turbidity US	NTU	0.5	2.8	19.3	154	0.15	2.19	4.47	0.25	1.52	0.1	15.8	0.15	0.42	0.1	0.66	11.2	9.15	-	-	0.52
Alkalinity DS	mg/L as CaCO$_3$	352	253	188	193	294	175	211	407	224	263	488	236	215	394	210	184	245	-	117	218
Ammonia DS	mg/L as N	0.178	0.090	0.009	0.017	0.012	0.005	0.053	0.011	0.006	0.012	0.025	0.005	0.012	0.017	0.020	0.012	0.008	-	0.005	0.009
Ash-free Dry Mass DS	mg/L	3.7	2.3	11.9	1.5	-	1.6	1.5	1.5	1.5	1.5	7.7	1.5	1.5	1.5	4.4	1.5	1.5	-	1.5	1.5
Chloride DS	mg/L	1.45	4.85	58.4	52.7	3.35	0.89	15	9.8	0.97	0.83	3.1	2.52	0.85	0.65	1.36	12	0.45	-	0.82	26
Chlorophyll-a DS	µg/L	3.84	1.09	4.83	0.366	-	-	1.16	-	0.521	0.241	16.1	1.08	0.229	0.464	1.84	3.13	0.252	-	1.08	0.38
Conductivity DS	µS/cm	1720	1620	583	1900	1560	630	1890	840	1240	1510	2990	1840	1040	1030	1510	1710	497	-	360	944
Dissolved Organic Carbon DS	mg/L	2.67	1.99	1.71	1.69	2.8	1.84	2.31	1.58	3.8	1.2	5.11	2.92	0.88	3.77	3.84	4.27	4.13	-	0.5	1.29
Hardness DS	mg/L as CaCO$_3$	1200	1030	301	1160	1000	349	1290	534	757	940	2070	1040	584	584	1020	1150	268	-	188	523
Nitrate DS	mg/L as N	4.77	4.07	0.138	27.5	2.47	0.564	25.8	0.0504	0.682	3.01	36.3	71.9	2.5	6.22	4.52	10.3	0.126	-	5.71	9.05
Nitrite DS	mg/L as N	0.0395	0.0579	0.001	0.0611	0.005	0.001	0.0763	0.005	0.005	0.0079	0.045	0.0732	0.005	0.0174	0.014	0.0102	0.001	-	0.0067	0.005
Oxidation-reduction Potential DS	mV	462	501	270	289	462	425	275	293	251	269	460	470	471	458	427	369	441	-	319	441
Orthophosphate DS	µg/L	0.0013	0.001	0.001	0.001	0.0015	0.0041	0.0012	0.001	0.0209	0.002	0.001	0.001	0.0035	0.001	0.001	0.0012	0.0137	-	0.001	0.001
pH DS	-	8.06	8.15	8.22	8.19	8.31	8.34	8.21	7.99	8.35	8.08	7.98	8.09	8.4	8.08	8.32	8.24	8.4	-	8.3	8.04
Total Phosphorus DS	µg/L	0.0043	0.0022	0.0622	0.002	0.0102	0.0082	0.0028	0.0079	0.0192	0.002	0.0257	0.002	0.0046	0.002	0.0037	0.0052	0.0139	-	0.0027	0.0043
Dissolved Se DS	µg/L	29.7	4.81	4.59	250	190	38.1	269	2.21	105	149	487	165	65.9	25.1	138	138	1.33	-	7.3	36.5
Total Se DS	µg/L	28	5.51	4.69	230	156	32	235	2.12	96.4	134	549	184	71.5	27	136	125	1.17	-	7.2	34.1
Sulphate DS	mg/L	785	785	39.5	837	734	181	905	63	538	689	1670	646	419	226	743	877	31.2	-	52	318
Total Dissolved Solids DS	mg/L	1470	1330	359	1500	1360	456	1640	534	985	1270	2550	1500	758	669	1300	1500	314	-	252	744
Total Kjeldahl Nitrogen DS	mg/L as N	0.453	0.384	0.306	0.05	0.406	0.166	0.05	0.143	0.209	0.44	0.635	0.05	0.173	0.17	0.597	0.513	0.309	-	0.347	0.393
Total Organic Carbon DS	mg/L	2.61	1.88	9.52	3.93	2.84	2.08	2.4	2.09	3.96	1.06	6.48	3.11	1.06	3.99	3.97	4.57	5.68	-	0.5	1.24
Total Suspended Solids DS	mg/L	7.6	1	72.6	1	1	1.2	3.6	3.4	3	1	15.7	1	1	1	1	2	1.4	-	1	2.9
Turbidity DS	NTU	3.16	1.26	51.9	0.43	0.25	1.51	1.43	3.33	1.79	1.02	5.51	0.58	0.66	0.25	1.3	0.89	1.19	-	0.27	1.08
Field Temperature US	°C	5.08	9.27	-	-	9.1	9.82	9.33	-	9.34	-	16.55	5.004	6.181	8.37	-	8.64	-	-	-	11.9
Field Dissolved Oxygen US	mg/L	9.02	9.6	-	-	9.72	9.98	10.12	-	9.95	-	9.89	10.22	10.42	6.44	-	10.18	-	-	-	18.05
Field Percent Saturation US	%	71.6	84.5	-	-	84.8	88.3	88.9	-	87.2	-	102.2	81.1	84.3	54.5	-	88.2	-	-	-	168.8
Field Conductivity US	µS/cm	1290	1402	-	-	1282	527	1489	-	1002	-	1819	2119	747	709	-	1453	-	-	-	1402
Field pH US	-	6.94	8	-	-	8.16	8.42	8.24	-	8.35	-	7.7	7.55	8.41	7.04	-	8.34	-	-	-	7.08
Field Oxidation-reduction Potential US	mV	156.4	0.64	-	-	95.9	88	115.5	-	95.1	-	126.5	120.2	104.1	126.2	-	105.3	-	-	-	146.9
Field Turbidity US	NTU	-0.87	1.99	-	-	-1.23	1.45	5.89	-	0.75	-	5.2	-1.15	-0.53	1.72	-	-0.05	-	-	-	-1.02
Field Chlorophyll-a US	ug/L	0.803	0.115	-	-	0.193	0.055	0.179	-	0.377	-	0.158	0.074	0.185	0.688	-	0.285	-	-	-	0.032
Field Phycocyanins US	µg/L	0.93	0.399	-	-	0.402	0.323	0.405	-	0.434	-	0.222	0.475	0.552	1.202	-	0.403	-	-	-	0.327
Field Temperature DS	°C	11.83	5.08	12.328	13.62	9.23	9.53	-	14.595	13.37	11.68	10.6	11.9	8.002	-	12.6	13.5	-	-	8.048	6.85
Field Dissolved Oxygen DS	mg/L	9.19	9.02	9.33	8.84	9.63	9.98	-	8.62	9.19	9.56	11.6	9.54	10.56	-	8.87	13.2	-	-	12.86	11.23
Field Percent Saturation DS	%	85.5	71.6	87.4	84.8	84.2	87.7	-	85	87.8	88.7	106	88.8	89.6	-	84	127.7	-	-	108.9	94.8
Field Conductivity DS	µS/cm	1546	1290	525	1694	1283	518	-	870	998	1441	2483	1569	783	-	1346	1552	-	-	287.2	746
Field pH DS	-	7.76	6.94	8.24	7.87	8.09	8.32	-	7.58	8.31	7.89	7.5	7.99	8.35	-	8.24	8.23	-	-	8.53	7.47
Field Oxidation-reduction Potential DS	mV	143	156.4	86	113.7	77.5	96	-	102.6	72.9	102.1	135.8	102.8	103.2	-	92.2	105.4	-	-	104.1	139.8
Field Turbidity DS	NTU	0.68	-0.87	4.59	7.71	-1.08	0.45	-	3.72	1.74	0.24	0.8	-0.11	-0.5	-	0.1	-0.69	-	-	-0.99	-1.21
Field Chlorophyll-a DS	µg/L	0.394	0.803	0.379	0.101	0.185	0.18	-	0.355	0.411	0.128	0.388	0.291	0.139	-	0.391	0.31	-	-	0.065	0.066
Field Phycocyanins DS	µg/L	0.382	0.93	0.362	0.264	0.402	0.387	-	0.282	0.352	0.38	0.362	0.301	0.421	-	0.356	0.32	-	-	0.392	0.466
Pond Substrate % Gravel	%	-	70.4	0	-	0	0	-	0	-	25.1	0	0	16.5	25.1	0	3.6	-	0	-	-
Pond Substrate % Sand	%	-	18.8	0	-	46.3	4.7	-	0	-	35	17.9	0	7.1	35	8.9	18.7	-	12.6	-	-
Pond Substrate % Silt	%	-	9.1	49.3	-	49.3	83.5	-	54	-	34.7	60.4	71.5	57.6	34.7	68.6	71.9	-	74.9	-	-
Pond Substrate % Clay	%	-	1.6	50.4	-	3.9	11.4	-	44.7	-	5.3	21.8	27.8	16.9	5.3	21.9	5.8	-	11.6	-	-
Pond Substrate % Total Organic Carbon	%	-	4.3	15.8	-	3.3	12.3	-	23.1	-	19.4	1.66	10.9	15.5	19.4	9.42	18.2	-	9.77	-	-
Shade Score	score	1	0	1	0	3	3	2	1	3	3	2	1	0	0	0	1	1	0	0	1
Secchi Depth	m	2.4	1.5	1	2	2.4	3.2	2.7	1.2	1.6	1.2	2.2	3.67	3.6	1	1.8	1.5	1.67	1	1	2
Secchi Depth/Maximum Depth	%	0.312	1.000	0.625	0.758	0.857	0.533	1.000	0.619	0.842	0.930	0.733	1.000	1.000	1.000	0.650	0.682	1.000	0.909	0.667	1.000
Emergent Vegetation Score	score	3	1	1	3	2	3	3	3	2	3	1	1	1	2	2	3	0	3	2	0
Submergent Vegetation Score	score	0	3	0	3	3	0	1	3	3	1	2	3	0	3	3	0	0	2	3	1
Floating Vegetation Score	score	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Algae Coverage Score	score	0	0	2	0	1	0	1	0	4	0	2	0	0	0	1	0	1	1	3	2
Total Aquatic Vegetation Score	score	3	4	3	6	6	3	5	7	9	4	5	4	1	5	6	3	1	6	8	3
Field Temperature In-pond	°C	8.5	12.0	12.2	13.7	9.1	8.1	11.0	13.9	12.4	11.9	9.2	11.8	7.6	9.5	12.6	12.0	9.97	8.4	8.0	12.4
Field Dissolved Oxygen In-pond	mg/L	9.3	9.9	10.0	9.1	9.5	10.1	12.8	6.8	14.2	9.5	11.5	9.6	10.5	8.8	9.3	13.2	10.34	9.1	12.0	19.4
Field Percent Saturation In-pond	%	83.7	92.5	92.7	88.4	83.5	85.9	117.2	66.7	133.6	88.6	101.5	89.2	87.7	78.0	87.8	121.9	91.4	78.0	98.9	149.7
Field Conductivity In-pond	µS/cm	1423	1453	526	1723	1280	500	1600	683	985	1329	2401	1358	751	822	459	907	419	-	317	1418
Field pH In-pond	-	7.4	7.9	8.3	7.9	8.1	8.3	8.3	7.3	8.3	8.0	7.4	7.9	8.4	7.4	8.3	8.3	8.4	7.6	8.3	7.1
Field Oxidation-reduction Potential In-pond	mV	136.9	106.0	85.2	116.4	68.6	97.7	121.0	94.2	100.9	108.5	130.7	104.5	105.4	118.6	93.8	99.2	105.6	-47.4	40.5	149.7
Field Turbidity In-pond	NTU	0.72	0.59	6.88	-0.44	-1.13	0.15	4.19	1.89	1.42	-0.18	-1.00	-0.04	-0.48	0.26	-0.36	-0.37	2.58	-0.89	0.93	-0.59
Field Chlorophyll-a In-pond	µg/L	0.59	0.23	0.84	0.13	0.13	0.50	0.54	0.17	0.45	0.08	0.11	0.35	0.06	0.09	0.46	0.77	0.89	0.07	0.11	0.08
Field Phycocyanins In-pond	µg/L	0.59	0.36	0.40	0.26	0.40	0.50	0.51	0.24	0.35	0.30	0.34	0.30	0.37	0.36	0.38	0.54	0.56	0.45	0.42	0.30
Presence of pond liner	yes/no	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
July Mean Hydraulic Residence Time	d	10.80	0.06	0.92	4.90	0.47	1.27	4.21	6.28	6.44	2.83	31.06	11.39	1.18	0.65	40.04	4.49	99.00	-	0.15	1.21
August Mean Hydraulic Residence Time	d	10.00	0.08	0.20	4.20	0.62	1.30	1.78	5.87	20.01	2.98	14.29	14.18	2.34	13.34	48.73	12.00	0.59	-	0.16	1.57
Maximum Depth	m	7.7	1.5	1.6	2.64	2.8	6	2.7	1.94	1.9	1.29	3	3.67	3.6	1	2.77	2.2	1.67	1.1	1.5	2
July Mean Temperature	°C	13.4	16.3	16.1	20.3	15.0	10.0	15.3	22.4	19.9	16.1	13.7	16.9	8.5	13.6	20.2	20.9	12.4	-	7.8	14.7
August Mean Temperature	°C	11.3	15.3	10.7	16.8	13.9	9.0	12.5	18.6	19.1	12.9	9.8	13.5	6.4	12.9	17.1	17.3	10.2	-	9.3	12.1

Notes: US = upstream of sedimentation pond; DS = downstream of sedimentation pond; values below detection are shown as the detection limit

Attachment C

Selenium Speciation Associated with Maximum Reported Organoselenium Concentrations in 2021 in Local and Regional Monitoring Programs

Attachment C. Selenium speciation associated with the sampling event that reported the maximum organoselenium concentration in 2021 local and regional monitoring programs

Program / Location	Monitoring Location	Date of Max. OrgSe	Selenium Species Concentration (µg/L)					
			MeSe(IV)	DMSeO	OrganoSe	MeSe(VI)	Se(IV)	Se(VI)
FRO North Saturated Rock Fill								
Decant from Clode Sediment Pond	FR_CC1	09 Aug	0.015	0.016	0.031	<0.01	0.384	169
Corbin Sediment Pond								
Decant discharge from Corbin Sediment Pond	CM_CCPD	02 Feb	<0.01	<0.01	<0.01	<0.01	0.3	30.9
Corbin Creek at Rock Drain	CM_CCRD	19 Oct	<0.01	<0.01	<0.01	<0.01	0.081	17.8
Corbin Offtake Valve by CCPD	CM_CCOFF	16 Nov	<0.01	<0.01	<0.01	<0.01	0.213	27.4
Corbin Creek ds Scrubby Creek	CM_CCSC	07 Sep	<0.01	<0.01	<0.01	<0.01	0.076	17
Michel Creek ds CMm, 50 m us Andy Good Creek	CM_MC2	05 Oct	<0.01	<0.01	<0.01	<0.01	0.097	9.41
14 pit Dewatering Horizontal Pipe	CM_14PIT-PIPE	07 Dec	<0.01	<0.01	<0.01	<0.01	0.646	4.75
34 Pit at Pipe Discharge (14 Pit Sump)	CM_34PIPEDIS	07 Sep	0.013	0.011	0.024	<0.01	1.15	1.04
Six Pit	CM_6PITDW	21 Dec	<0.01	<0.01	<0.01	<0.01	0.09	1.6
Corbin Creek ds CMm	CM_CC1	02 Feb	<0.01	<0.01	<0.01	<0.01	0.603	17.4
North Ditch by Floc Shack	CM_ND2	14 Apr	<0.01	<0.01	<0.01	<0.01	0.401	7.76
Main Pond Decant	CM_SPD	14 Apr	0.011	0.014	0.025	<0.01	0.387	6.36
LCO Dry Creek Water Management System / LCO Dry Creek LAEMP								
Dry Creek us East Tributary	LC_DC3	15 Nov	0.02	0.041	0.061	<0.01	1.15	63.2
East Tributary of Dry Creek	LC_DCEF	06 Jan	<0.01	<0.01	<0.01	<0.01	0.015	1.23
Dry Creek Sedimentation Ponds effluent to Dry Creek	LC_SPDC	03 Aug	0.049	0.088	0.137	<0.01	1.83	71.9
Dry Creek ds Sedimentation Ponds	LC_DCDS	10 Aug	0.059	0.112	0.171	<0.01	1.91	57.9
Near mouth of Dry Creek	LC_DC1	29 Jul	0.026	0.029	0.055	<0.01	0.752	48.6
Downstream of marsh area where DCEF comes to surface	LC_DC4	03 Aug	0.026	0.044	0.07	<0.01	1.01	52.2
Fording River 100 m us Conveyance Outfall	LC_FRUS	12 Sep	0.014	0.014	0.028	<0.01	0.303	54.1
Fording River Bridge ds FRDSDC	LC_FRB	12 Sep	0.016	0.013	0.029	<0.01	0.329	54.4
Grace Creek us CP railway tracks	LC_GRCK	13 Sep	<0.01	<0.01	<0.01	<0.01	0.039	1.74
LCO LAEMP								
South Line Creek	RG_SLINE/LC_SLC	18 Jan	<0.01	<0.01	<0.01	<0.01	0.019	1.59
Line Creek us LCO	RG_LI24/LC_LC1	07 Apr	<0.01	<0.01	<0.01	<0.01	0.021	2.03
Line Creek us WLC AWTF	RG_LCUT/LC_WLC	23 Apr	0.027	<0.01	0.027	<0.01	0.096	408
Line Creek 200m ds WLC AWTF	RG_LILC3/LC_LC3	18 Jan	<0.01	0.052	0.052	0.374	0.7	45.2
Line Creek ~50m ds Contingency Pond discharge	RG_LISP24 /WL_DCP_SP24	13 Sep	0.014	<0.01	0.014	0.015	0.157	29.5
Line Creek ds South Line Creek	RG_LIDSL/LC_LCDSSLCC	25 Jan	0.02	0.015	0.035	0.062	0.391	36.9
Line Creek ds compliance location	RG_LIDCOM/LC_LCC	29 Apr	<0.01	<0.01	<0.01	0.016	0.176	31
Line Creek above Canyon	RG_LI8/LC_LC4	11 Jan	<0.01	<0.01	<0.01	<0.01	0.111	28.3
Fording River us Line Creek	RG_FRUL/LC_LC6	12 Sep	0.021	0.013	0.034	<0.01	0.399	48.1
Fording River at Elk	RG_FO23	14 Jul	0.016	<0.01	0.016	<0.01	0.194	30.8
Greenhills Creek and Gardine Creek								
Greenhills Creek us proposed treatment facility	RG_GHUT	13 Sep	<0.01	<0.01	<0.01	<0.01	0.363	230
Greenhills Near-Field ds proposed treatment facility	RG_GHNF	10 Sep	0.017	<0.01	0.017	<0.01	1.1	189
Below Greenhills Creek Sedimentation Pond	RG_GHBP	13 Sep	0.099	0.25	0.349	<0.01	4.23	132
Greenhills Far-Field ds of proposed treatment facility	RG_GHFF / RG_GHFFA	09 Sep	0.029	<0.01	0.029	<0.01	1.08	167
Biological monitoring	RG_GAUT	16 Sep	<0.01	<0.01	<0.01	<0.01	0.108	0.437
Biological monitoring	RG_GANF	15 Sep	<0.01	<0.01	<0.01	<0.01	0.112	5.39
Greenhills Creek Secondary Pond	RG_GHP/GHPS	23 Sep	0.098	0.213	0.311	<0.01	3.52	124
Lotic Sediment Toxicity								
Fording River us Kilmarnock Creek	RG_FOUKI	17 Dec	<0.01	<0.01	<0.01	<0.01	0.289	62.6
Fording River near Fording River Road	RG_FRUPO	18 Jun	<0.01	<0.01	<0.01	<0.01	0.105	58.9
Fording River at bridge ds Kilmarnock Creek, us Swift Creek	RG_FOBKS/GH_FR3	09 Sep	<0.01	<0.01	<0.01	<0.01	0.267	43.8
Elk River us Branch Creek and GHO	RG_ELUGH	10 Sep	<0.01	<0.01	<0.01	<0.01	0.075	0.776
Fording River ds Cataract Creek, us Porter Creek	RG_FOBCP/FR_FRCP1	13 Sep	0.016	<0.01	0.016	<0.01	0.383	79.7
Michel Creek us CMm	RG_MI25/CM_MC1	13 Sep	<0.01	<0.01	<0.01	<0.01	0.02	0.148
Fording River LAEMP								
Fording River us Henretta Creek	RG_UFR1/FR_UFR1	16 Dec	<0.01	<0.01	<0.01	<0.01	0.045	0.758
Henretta Creek us all mine operations	RG_HENUP/FR_HC3	16 Jun	<0.01	<0.01	<0.01	<0.01	0.021	0.305
Fording River side channel 2	RG_FRSCH2	17 Dec	<0.01	<0.01	<0.01	<0.01	0.068	86.2
Greenhouse side channel, Fording River ds FRUPO	RG_FRGHSC	13 Dec	<0.01	<0.01	<0.01	<0.01	0.095	99.6
Fording River us Clode Creek	RG_FOUCL/FR_FOUCL	13 Sep	<0.01	<0.01	<0.01	<0.01	0.08	16.8
Fording River us North Greenhills Diversion	RG_FOUNGD	16 Sep	<0.01	<0.01	<0.01	<0.01	0.116	37.8
Fording River ds Henretta Creek	RG_FODHE/FR_FR1	14 Jun	<0.01	<0.01	<0.01	<0.01	0.046	4.2
Fording River us Shandley Creek	RG_FOUSH	17 Dec	<0.01	<0.01	<0.01	<0.01	0.319	67.1
Fording River ~1150 m ds Compliance Point	RG_FRCP1SW	15 Sep	0.015	<0.01	0.015	<0.01	0.384	76.2
Fording River plate culvert Greenhills access road	RG_MP1/FR_MULTIPLATE	17 Dec	<0.01	<0.01	<0.01	<0.01	0.28	63.8
Fording River us Kilmarnock Creek	RG_FOUKI/FR_FR2	17 Dec	<0.01	<0.01	<0.01	<0.01	0.289	62.6
Fording River at Swift Creek Bridge	RG_FOBKS/FR_FR3	09 Sep	<0.01	<0.01	<0.01	<0.01	0.267	43.8
Fording River ds Swift Cataract Outfall	RG_SCOUTDS/FR_SCOUTDS	14 Sep	0.012	<0.01	0.012	<0.01	0.398	72.3
Fording River ds Swift Creek, us Cataract Creek	RG_FOBSC/FR_FR4	13 Sep	0.014	<0.01	0.014	<0.01	0.512	83.2
Fording River near Fording River Road	RG_FRUPO/FR_FRRD	18 Jun	<0.01	<0.01	<0.01	<0.01	0.105	58.9
Fording River ds Cataract Creek	RG_FOBCP/FR_FRCP1	13 Sep	0.016	<0.01	0.016	<0.01	0.383	79.7
Fording River ds Porter	RG_FODPO/GH_PC2	17 Jun	<0.01	<0.01	<0.01	<0.01	0.112	50.9
Fording River ds Chauncey Creek	RG_FOUEW/FR_FR5	11 Sep	<0.01	<0.01	<0.01	<0.01	0.245	79.2
Fording River us Chauncey Creek	RG_FO22/FR_FRABCH	12 Sep	0.012	<0.01	0.012	<0.01	0.194	87.4
West Line Creek AWTF								
WLC Active Water Treatment Pond Buffer Pond weir box	WL_BFWB_OUT_SP21	27 Apr	0.027	0.122	0.149	0.583	1.02	15.3
AWTF Influent Line Creek	WL_LCI_SP02	02 Feb	<0.01	<0.01	<0.01	<0.01	0.074	56.2
AWTF Influent West Line Creek	WL_WLCI_SP01	12 Oct	0.011	0.036	0.047	<0.01	0.132	404
EVO LAEMP								
Alexander Creek upstream of Michel Creek and EVO	RG_ALUSM /EV_AC2	12 Sep	<0.01	<0.01	<0.01	<0.01	0.015	0.562
Michel Creek upstream of CMm influence	RG_MI25 /CM_MC1	13 Sep	<0.01	<0.01	<0.01	<0.01	0.02	0.148
Upstream of proposed outfall	RG_ERCKUT	15 Sep	<0.01	<0.01	<0.01	<0.01	0.019	110
Erickson Creek ds proposed outfall	RG_ERCKDT/EV_ECOUT	15 Sep	<0.01	<0.01	<0.01	<0.01	0.064	137
Erickson Creek at Mouth	RG_ERCK/EV_EC1	10 Sep	0.018	0.017	0.035	<0.01	0.866	145
Gate Creek us sedimentation pond	RG_GATE	16 Sep	0.042	<0.01	0.042	<0.01	0.912	224
Gate Creek Sedimentation Pond Decant	RG_GATEDP	16 Sep	0.051	0.034	0.085	<0.01	0.91	201
Bodie Creek Sedimentation Pond Decant	RG_BOCK	16 Sep	0.089	0.118	0.207	<0.01	2.23	201
Michel us Erickson and ds Alexander	RG_MI3	10 Sep	<0.01	<0.01	<0.01	<0.01	0.045	1.03
Michel Creek ds Erickson Creek	RG_MIDER	09 Sep	<0.01	<0.01	<0.01	<0.01	0.076	1.85
Michel Creek ds Bodie Creek	RG_MIDBO	11 Sep	0.012	<0.01	0.012	<0.01	0.17	8.16
Michel Creek ds Hwy #3 Bridge	RG_MICOMP/EV_MC2	13 Sep	0.014	<0.01	0.014	<0.01	0.174	6.97
EVO SRF								
Natal West Pit Intake - Injection Break tank	F2_NWPI	22 Nov	<0.01	0.09	0.09	<0.01	3.62	156
Buffer Pond Outlet	F2_BPO	04 Oct	0.017	0.017	0.034	<0.01	1.54	8.37
Michel Creek ds Highway 3 Bridge	EV_MC2	30 Aug	<0.01	<0.01	<0.01	<0.01	0.11	5.13
Michel Creek immediately us Gate Creek sedimentation pond	EV_MC2a	13 Sep	<0.01	<0.01	<0.01	<0.01	0.142	3.82
Michel Creek us Erickson Creek	EV_MC3	16 Aug	<0.01	<0.01	<0.01	<0.01	0.117	1.18
Erickson Creek at Mouth	EV_EC1	27 Sep	0.022	0.039	0.061	<0.01	1.45	13.2
Erickson Creek ds SRF Outfall	EV_ECOUT	13 Sep	0.011	0.024	0.035	<0.01	1.77	15.4
Bodie Creek outlet of rock drain us water tank system	EV_BRD_LOT3	22 Mar	0.03	<0.01	0.03	<0.01	0.683	329
Bodie Creek Sedimentation Pond Decant	EV_BC1	05 Jul	0.097	0.176	0.273	<0.01	2.67	207
Gate Creek Sedimentation Pond Decant	EV_GT1	26 Oct	0.083	0.087	0.17	<0.01	1.03	223
Elk River ds Michel Creek at CPR Roadhouse	EV_ER1	07 Apr	0.014	<0.01	0.014	<0.01	0.092	17.3
Elkview Dry Creek Water Treatment Project / Elkview Harmer Dam Removal Project								
Harmer Creek Dam Spillway	EV_HC1	12 Aug	0.033	0.013	0.046	<0.01	0.455	30.4
Monitoring location	EV_HC1a	12 Aug	0.023	0.011	0.034	<0.01	0.384	31.2
Harmer Creek ds Harmer Dam	EV_HCDSDAM	12 Aug	0.033	0.016	0.049	<0.01	0.464	29.9
Monitoring location	EV_DC2a	17 Jun	0.047	<0.01	0.047	<0.01	0.971	133
Monitoring Location ds EVO Dry Creek Outfall Location	EV_DCOUT	09 Sep	0.207	0.044	0.251	<0.01	1.42	149
Fording River South AWTF								
Fording River ds Swift-Cataract Outfall	FR_SCOUTDS	29 Dec	0.012	<0.01	0.012	<0.01	0.311	107
Regional Chronic Toxicity								
Fording River us Chauncey Creek	FR_FRABCH	13 Jul	0.013	<0.01	0.013	<0.01	0.146	55.1
Fording River ds Greenhills Creek	GH_FR1	19 Oct	0.015	0.019	0.034	<0.01	0.602	65
Elk River ds Thompson Creek	GH_ERC	18 May	<0.01	<0.01	<0.01	<0.01	0.022	1.3
Line Creek Immediately ds South Line Creek confluence	LC_LCDSSLCC	25 Jan	0.02	0.015	0.035	0.062	0.391	36.9
South Line Creek west side of Main Rock Drain	LC_SLC	18 Jan	<0.01	<0.01	<0.01	<0.01	0.019	1.59
Line Creek ds LC_WTF_OUT, us confluence with SLC	LC_LC3	18 Jan	<0.01	0.052	0.052	0.374	0.7	45.2
Fording River ds Line Creek	LC_LC5	17 Aug	<0.01	<0.01	<0.01	<0.01	0.316	32.9
RAEMP (not including LAEMP sites)								
Clode Creek near mouth	RG_CLODE	17 Sep	0.015	<0.01	0.015	<0.01	0.34	164
Kilmarnock Creek ds rock drain	RG_KICK	14 Sep	<0.01	<0.01	<0.01	<0.01	0.071	140
Greenhills Creek ds sedimentation pond	RG_GHCKD	11 Sep	0.106	0.222	0.328	<0.01	4.13	127
Fording River ds Ewin Creek	RG_FODGH	17 Sep	0.019	0.014	0.033	<0.01	0.326	51.3
Alexander Creek near bend to west	RG_ALUSM	12 Sep	<0.01	<0.01	<0.01	<0.01	0.015	0.562
Harmer Creek us Harmer Pond	RG_HACKDS	04 Oct	0.022	<0.01	0.022	<0.01	0.308	27.5
Grave Creek near mouth at Elk River	RG_GRDS	11 Sep	0.019	<0.01	0.019	<0.01	0.282	21.6
Balmer Creek at CFI Road	RG_BACK	13 Sep	<0.01	<0.01	<0.01	<0.01	0.182	7.49
Elk River us Elko	RG_ELELKO	14 Sep	0.024	<0.01	0.024	<0.01	0.312	8.79
Elk River us Hwy 93 bridge and Elk River mouth	RG_ELH93	15 Sep	0.018	<0.01	0.018	<0.01	0.274	7.41

Notes: US = upstream of sedimentation pond; DS = downstream of sedimentation pond; OrganoSe = sum of DMSeO and MeSe(IV)

Attachment D

Pond Summary Sheets

Aqueduct Pond Control Structure

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	1.53
Mean Annual Discharge (m2/s):	0.02
Volume (m^3):	430
Surface Area (m^2)	411
Mean/Maximum Pond Depth (m)	0.5/1.6
Liner:	Yes
Fish Access:	Temporary fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, shrubs
Dominant Aquatic Vegetation:	Filamentous algae
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	30/Aug/2021
Temperature (°C):	12.2
Conductivity (µS/cm):	526.3
DO (mg/L):	9.95
pH:	8.30
ORP (mV):	85.2
Chlorophyll (µg/L):	0.843
Phycocyanin (µg/L):	0.396
Total Phosphorus (µg/L):	62.2

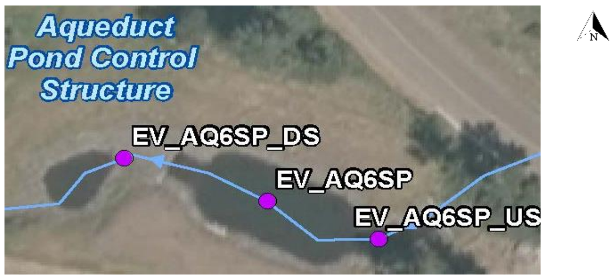
Site Description

The Aqueduct Pond Control Structure was constructed in 2015 with a primary purpose of directing flow from Aqueduct Creek into a sedimentation pond and to pass excess flow downstream. However, the construction of the Aqueduct Creek Sedimentation Pond was cancelled, thus the Aqueduct Pond Control Structure does not currently serve any purpose from a water management perspective. Substrate is silty with some filamentous algae. Shading potential exists due to steep banks and riparian trees. No evidence of fish use.

Water Flow Description

Flow enters the pond from the northeast and decants into the lower portion of Aqueduct Creek before discharging into Michel Creek. Since the new sedimentation pond has not been completed, all flows currently exit the pond via the high-flow spillway.

EV_AQ6SP UTM (11U) E: 658638 N: 5506101



Aqueduct Pond Aerial

EV_AQ6SP UTM (11U) E: 654420 N: 5511148

Aqueduct Pond 30/Aug/2021

EV_AQ6SP_US UTM (11U) E: 654441 N: 5511140

Upstream Aqueduct Pond 30/Aug/2021

EV_AQ6SP_DS UTM (11U) E: 654392 N: 5511156

Down-stream Aqueduct Pond 30/Aug/2021

AWTF Buffer Pond
Management Unit 2

Physical Characteristics

Passive Drainage Area (km^2):	-
Mean Annual Discharge (m2/s):	0.009
Volume (m^3):	7,787
Surface Area (m^2)	5,049
Mean/Maximum Pond Depth (m)	2
Liner:	Yes
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	None
Dominant Aquatic Vegetation:	Filamentous algae
Dominant Pond Substrate:	-
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	24/Aug/2021
Temperature (°C):	12.42
Conductivity (µS/cm):	1,417.67
DO (mg/L):	19.41
pH:	7.10
ORP (mV):	149.7
Chlorophyll (µg/L):	0.081
Phycocyanin (µg/L):	0.304
Total Phosphorus (µg/L):	10.9

Site Description

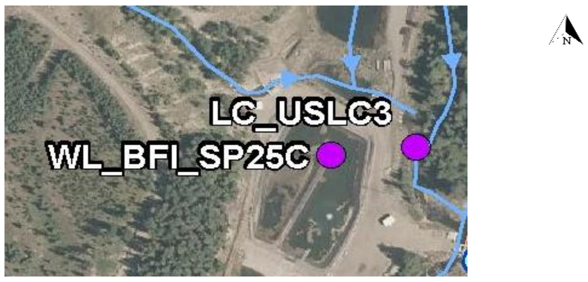
The AWTF Buffer Pond is located adjacent to the Line Creek outfall structure. The purpose of this pond is to provide a buffer between WLC AWTF effluent discharging from the plant and the receiving environment. It is not intended to or designed to provide additional water treatment, with the exception of pH. The pond has an HDPE liner and a volume of 8,000 m3 which is equivalent to just over 1 day of retention time at full plant flow.

Water Flow Description

The WLC AWTF receives water from the Line Creek Rock Drain through several flow paths. These streams converge at an area of pooled water at the intake gate where Line Creek water can be extracted for treatment at the WLC AWTF. Treated effluent from the facility is discharged to the buffer pond, which functions as a contingency containment structure supplementing the storage capacity of the AWTF effluent tank.

Teck

WL_BFI_SP25C UTM (11U) E: 660051 N: 5532169



AWTF Buffer Pond Aerial

WL_BFI_SP25C UTM (11U) E: 660051 N: 5532169

AWTF Buffer Pond 24/Aug/2021

WL_BFWB_OUT_SP21
UTM (11U)
E: 660048
N: 5532078

24/Aug/2021

Upstream AWTF Buffer Pond

LC_USLC3
UTM (11U)
E: 660121
N: 5532091

24/Aug/2021

Downstream AWTF Buffer Pond

No Photo Available

North Bodie Creek Sedimentation Pond

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	0.23
Mean Annual Discharge (m2/s):	0.11
Volume (m^3):	3,000
Surface Area (m^2)	1,228
Mean/Maximum Pond Depth (m)	1.87
Liner:	No
Fish Access:	Temporary Fish Barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Pondweed
Dominant Pond Substrate:	Fully vegetated
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	27/Aug/2021
Temperature (°C):	13.74
Conductivity (µS/cm):	1,723
DO (mg/L):	9.098
pH:	7.91
ORP (mV):	116.36
Chlorophyll (µg/L):	0.132
Phycocyanin (µg/L):	0.256
Total Phosphorus (µg/L):	8.2

Site Description

The Bodie Creek Sedimentation Pond system consists of two main sedimentation ponds (north and south) and a flocculant station located upstream. The inflow to the pond system is via a pipe (no immediate upstream habitat). The primary purpose of the pond is sedimentation control of runoff from areas with mining-related activities. The substrate is fully covered in submergent macrophyte growth (pondweed). Minimal shading potential exists. No evidence of fish use.

Water Flow Description

Flows enters the North Bodie Creek Sedimentation Pond from the South Bodie Creek Sedimentation Pond via a connection ditch (2x900 mm culverts). The Bodie Creek Control Pond located upstream makes it possible to divert flow away from the Bodie Creek Sedimentation Ponds to the Gate Creek Sedimentation Pond system via a buried pipeline and open channel. Flows discharging to the North Bodie Creek Sedimentation Pond decant into the lower portion of Bodie Creek and ultimately into Michel Creek.

Teck

EV_BC1SP UTM (11U) E: 655647 N: 5509613

North Bodie Creek Sedimentation Pond Aerial

EV_BC1SP

UTM (11U)

E: 655647

N: 5509613

27/Aug/2021

Bodie Pond North

EV_BC1_US

27/Aug/2021

Upstream Bodie Pond North

EV_BC1_DS

UTM (11U)

E: 655675

N: 5509584

30/Aug/2021

Downstream Bodie Pond North

No Photo Available

Clode Main Settling Pond

Management Unit 1

Physical Characteristics

Passive Drainage Area (km^2):	4.76
Mean Annual Discharge (m2/s):	0.07
Volume (m^3):	140,000
Surface Area (m^2)	38,383
Mean/Maximum Pond Depth (m)	1.5/3.67
Liner:	No
Fish Access:	Fish exclusion screens on culverts

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Water Milfoil
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	31/Aug/2021
Temperature (°C):	11.80
Conductivity (µS/cm):	1,358
DO (mg/L):	9.57
pH:	7.90
ORP (mV):	104.5
Chlorophyll (µg/L):	0.353
Phycocyanin (µg/L):	0.303
Total Phosphorus (µg/L):	2

Site Description

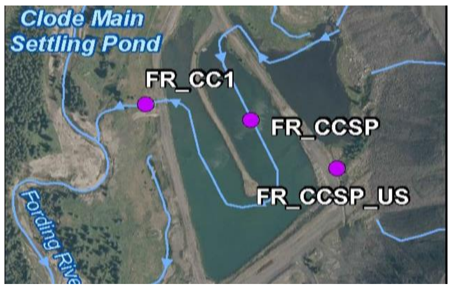
Clode Settling Ponds were constructed in 1976 and consist of a two-pond system (East and Main) separated by a separator dike. The Clode Settling Ponds are used for sediment management of pit water and mine-influenced surface water from spoils. The substrate is silty with some submerged vegetation. Minimal shading potential due to limited riparian cover. Fish exclusion screens were installed in 2014, and fish salvages have removed fish from the ponds.

Water Flow Description

Water enters the Clode East Settling Pond from the east via the Clode Rock Drain and multiple seeps around the primary (East) Pond, then flows to the Secondary (Main) Pond via a set of six CSP culverts. Water is discharged from the Secondary Pond to Clode Creek through a series of seven CSP culverts, which pass through the western dike of the Secondary Pond.

Teck

FR_CCSP UTM (11U) E: 651002 N: 5564262



Clode Main Settling Pond Aerial

FR_CCSP
UTM (11U)
E: 651002
N: 5564262

31/Aug/2021

Clode Pond

FR_CCSP_US
UTM (11U)
E: 651111
N: 5564197

31/Aug/2021

Upstream Clode Pond

FR_CC1
UTM (11U)
E: 650869
N: 5564284

31/Aug/2021

Down-stream Clode Pond

Line Creek Contingency Pond Upper

Management Unit 2

Physical Characteristics

Passive Drainage Area (km^2):	-
Mean Operating Range (m2/s):	0.009
Volume (m^3):	4,133
Surface Area (m^2)	5,496
Mean/Maximum Pond Depth (m)	0.8/
Liner:	No
Fish Access:	No inflow or outflow

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Grasses
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	30/Aug/2021
Temperature (°C):	10.58
Conductivity (µS/cm):	1,076.1
DO (mg/L):	10.7
pH:	8.01
ORP (mV):	94.5
Chlorophyll (µg/L):	0.330
Phycocyanin (µg/L):	0.411
Total Phosphorus (µg/L):	-

Site Description

The Contingency Treatment System, also known as Contingency Ponds, is located across from the WLC AWTF and receives water from the WLC Rock Drain, Line Creek Rock Drain, and the AWTF (regulated by gated culverts). When used, this system collects the entire flow of Line Creek and provides water clarification prior to release back to Line Creek. This system has not been operated since 2015. Substrate is covered in patchy golden algae and rooted macrophytes. Minimal shading potential exists and there was no evidence of fish use.

Water Flow Description

The system consists of three sedimentation cells, as well as two gated culverts. The three cells flow in series from north to south. The upper and middle cells each contain a spillway and a fish barrier. There are currently no inflows or outflows to the Contingency Upper pond.

Teck

LC_LC8P1 UTM (11U) E: 659836 N: 5531534

Line Creek Contingency Upper Aerial

LC_LC8P1

UTM (11U)

E: 659836

N: 5531534

30/Aug/2021

Contingency Pond Upper

No Samples Collected

No Photo Available

30/Aug/2021

Upstream Contingency Pond Upper

No Samples Collected

No Photo Available

30/Aug/2021

Downstream Contingency Pond Upper

Corbin Pond
Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	-
Normal Operating Range (m^2/s):	0 to 2.75
Volume (m^3):	124,450
Surface Area (m^2)	29,600
Mean/Maximum Pond Depth (m)	1.75/7
Liner:	Yes
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Grasses
Dominant Pond Substrate:	-
Secchi Depth (m):	2.4

Field Water Quality

Date(s) Collected:	25/Aug/2021
Temperature (°C):	8.58
Conductivity (µS/cm):	1,419
DO (mg/L):	9.30
pH:	7.45
ORP (mV):	123.1
Chlorophyll (µg/L):	0.533
Phycocyanin (µg/L):	0.584
Total Phosphorus (µg/L):	4.3

Site Description

Substrate is silty and grasses are the most abundant aquatic vegetation. Shading potential is limited due to minimal riparian cover, but tree cover on the east side of the pond may provide some shade. No evidence of fish use.

Water Flow Description

Corbin Pond receives flow from the upper Corbin Creek catchment area, infiltration through the overlying East Spoils, and runoff from the East Access Road and 6 Pit.

CM_CORBIN-POND UTM (11U) E: 670144 N: 5486199

Corbin Pond Aerial

CM_CORBIN-POND

Corbin Pond 25/Aug/2021

CM_CCPD_US UTM (11U) E: 670209 N: 5486015

No Photo Available

Upstream Corbin Pond 25/Aug/2021

CM_CCPD_DS UTM (11U) E: 670007 N: 5486378

Downstream Corbin Pond 25/Aug/2021

EVO Dry Creek Pond

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	8.5
Mean Annual Discharge (m2/s):	0.12
Volume (m^3):	3,000
Surface Area (m^2)	2,930
Mean/Maximum Pond Depth (m)	1/2.8
Liner:	No
Fish Access:	Currently considered fish bearing

Habitat Characteristics

Dominant Riparian Vegetation:	Deciduous/Coniferous Trees. Grasses
Dominant Aquatic Vegetation:	Water Milfoil
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	28/Aug/2021
Temperature (°C):	9.11
Conductivity (µS/cm):	1,280.3
DO (mg/L):	9.55
pH:	8.11
ORP (mV):	68.6
Chlorophyll (µg/L):	0.131
Phycocyanin (µg/L):	0.399
Total Phosphorus (µg/L):	10.2

Site Description

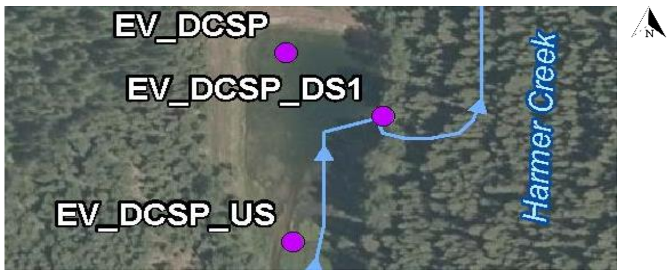
Initial sampling records for Dry Creek Sedimentation Pond started in 2005, however, the pond is thought to have been constructed around 1969. The Dry Creek Sedimentation Pond serves as a sediment removal facility for the mine-influenced waters within the Dry Creek drainage, and specifically water reporting from the Dry Creek Spoils. The Dry Creek Sedimentation Pond is an active sedimentation pond but currently receives no flow from active mining areas. Substrate is silty with some aquatic vegetation. Shading potential exists due to riparian trees. A fish salvage was conducted in 2017, but the pond is still considered fish bearing upstream of the pond decant as a permanent barrier has not yet been installed.

Water Flow Description

Flows enters the pond at the east end and decants out of the pond via a set of corrugated steel pipes in the pond's southwest corner. The pond decants into Michel Creek.

Teck

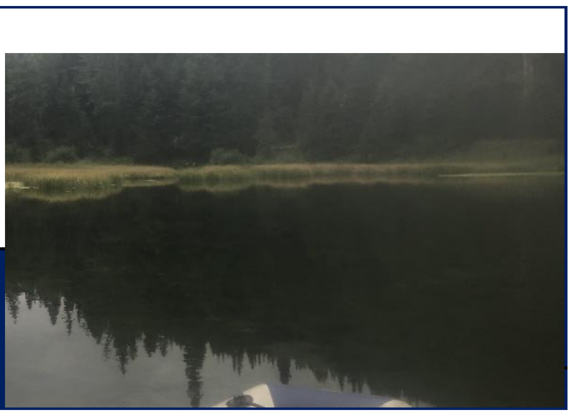
EV_DCSP UTM (11U) E: 659353 N: 5517556



Dry Creek Pond Aerial

EV_DCSP

UTM (11U)
E: 659353
N: 5517556



28/Aug/2021

Dry Creek Pond

EV_DCSP_US

UTM (11U)
E: 659355
N: 5517481

28/Aug/2021

Upstream Dry Creek Pond

EV_DCSP_DS1

UTM (11U)
E: 659388
N: 5517531

28/Aug/2021

Downstream Dry Creek Pond

Gate Creek Sedimentation Pond

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	3.45
Mean Annual Discharge (m2/s):	0.01
Volume (m^3):	7,394
Surface Area (m^2)	5,384
Mean/Maximum Pond Depth (m)	1.3/2.7
Liner:	No
Fish Access:	Permanent Fish Barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Deciduous/Coniferous Trees, Grasses
Dominant Aquatic Vegetation:	Grasses/Sedges/Rushes
Dominant Pond Substrate:	Fully vegetated
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	27/Aug/2021
Temperature (°C):	10.99
Conductivity (µS/cm):	1,600.3
DO (mg/L):	12.79
pH:	8.27
ORP (mV):	121
Chlorophyll (µg/L):	0.542
Phycocyanin (µg/L):	0.507
Total Phosphorus (µg/L):	2.8

Site Description

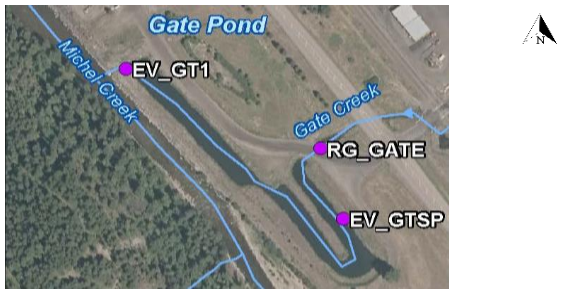
The Gate Creek Sedimentation Ponds receive runoff from Gate Creek, South Gate Creek, and Bodie Creek (via the Bodie Control Pond) with the primary purpose of sediment control/settling of suspended solids. Substrate is silty but dominated by thick submerged vegetation/macrophyte growth. Limited shading potential exists due to sparse riparian trees. Fish salvages have been conducted in the ponds and a fish barrier has been constructed.

Water Flow Description

The primary cell is U-shaped in plan, with flow entering the system through a set of twin corrugated steel pipe culverts at the north end of its east arm. narrow channel connects the primary cell to the secondary cell. The secondary cell is rectangular in shape with inflow at its southeast corner and outflow at its northwest corner. The pond discharges directly to Michel Creek through a concrete box structure with an engineered fish barrier in the outlet channel.

Teck

EV_GTSP UTM (11U) E: 655845 N: 5509125



Gate Pond Aerial

EV_GTSP
UTM (11U)
E: 655845
N: 5509125

27/Aug/2021

Gate Pond

RG_GATE
UTM (11U)
E: 655826
N: 5509187

27/Aug/2021

Upstream Gate Pond

EV_GT1
UTM (11U)
E: 655663
N: 5509257

27/Aug/2021

Downstream Gate Pond

Greenhills Creek Secondary Pond

Management Unit 1

Physical Characteristics

Passive Drainage Area (km^2):	0.14
Normal Operating Range (m^2/s):	-
Volume (m^3):	160,000
Surface Area (m^2)	49,458
Mean/Maximum Pond Depth (m)	3.12 / 5.9
Liner:	No
Fish Access:	Fish access from upstream

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Shrubs, Coniferous Trees
Dominant Aquatic Vegetation:	Grasses/Sedges
Dominant Pond Substrate:	Silt
Secchi Depth (m):	1.8

Field Water Quality

Date(s) Collected:	26/Aug/2021
Temperature (°C):	12.63
Conductivity (µS/cm):	459.4
DO (mg/L):	9.3
pH:	8.29
ORP (mV):	93.8
Chlorophyll (µg/L):	0.455
Phycocyanin (µg/L):	0.381
Total Phosphorus (µg/L):	3.7

Site Description

The Greenhills Creek Sediment Ponds provide sediment control for water transferred from upstream ponds and the Greenhills Creek catchment. Substrate is Shading potential. Sedimentation curtains were installed to increase residence time for the deposition of suspended solids. The primary and secondary ponds are accessible to fish from upper Greenhills Creek, but the spillway presents a barrier to fish from downstream.

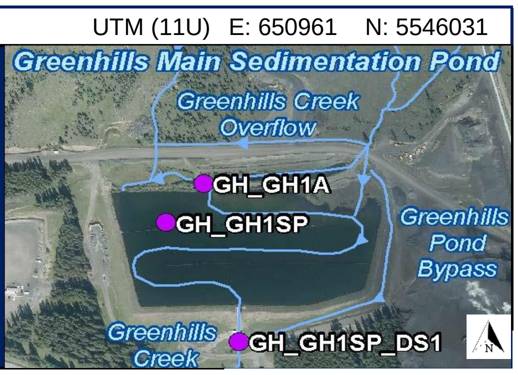
Water Flow Description

The Greenhills Creek Sediment Ponds are fish-bearing ponds connected to Greenhills Creek that collects inflows from the entire catchment prior to release to the Fording River. The system consists of three ponds: a primary pond (Greenhills Primary Settling Pond), an overflow/bypass sump (Greenhills Pond Overflow/Bypass Sump) and a large rectangular secondary pond (Greenhills Secondary Settling Pond). Flows enter the secondary pond via a low rock weir dyke and discharges through a 6 m wide concrete spillway into a stilling basin before entering lower Greenhills Creek.

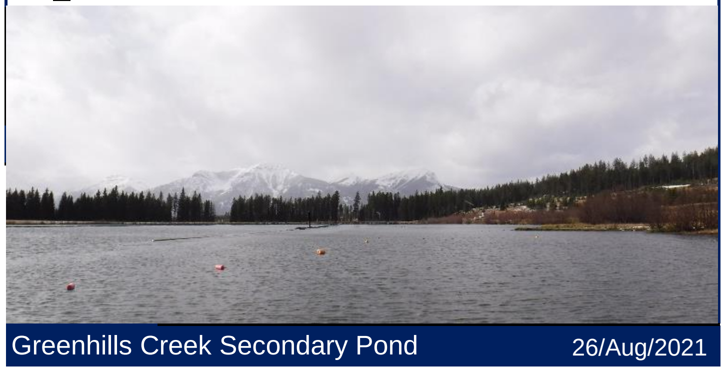
Teck

GH_GH1SP UTM (11U) E: 650961 N: 5546031

Greenhills Creek Secondary Pond Aerial



GH_GH1SP UTM (11U) E: 650961 N: 5546031



Greenhills Creek Secondary Pond 26/Aug/2021

GH_GH1A UTM (11U) E: 653525 N: 5546087

Upstream Greenhills Pond 26/Aug/2021

GH_GH1SP_DS1

UTM (11U)

E: 653571

N: 5545862

26/Aug/2021

Down-stream Greenhills Pond

Harmer Creek Sedimentation Pond (EV_HASP)

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	21.3
Mean Annual Discharge (m3/s):	0.681
Volume (m^3):	42,500
Surface Area (m^2):	15,490
Mean/Maximum Pond Depth (m):	2.0 / 5.7
Liner:	No
Fish Access:	From upstream only

Habitat Characteristics

Dominant Riparian Vegetation:	Ferns/Grasses, Shrubs, Conifers
Dominant Aquatic Vegetation:	Grasses, Burreed
Dominant Substrate:	Silt
Secchi Depth (m):	3.2

Field Water Quality

Date(s) collected:	28/Aug/2021
Temperature (*°C):	7.75
Conductivity (µS/cm):	494
DO (mg/L):	10.2
pH:	8.24
ORP (mV):	97.7
Chlorophyll (µg/L):	0.800
Phyococyanin (µg/L):	0.591
Total Phosphorus (µg/L):	9.8

Site Description

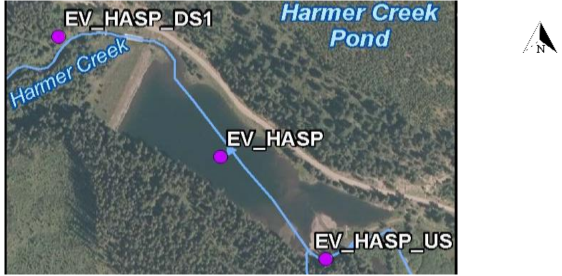
Anthropogenic sedimentation pond formed by construction of Harmer Dam in 1971. Substrate predominantly silt, some emergent grasses at pond margins, little to no submergent vegetation. Riparian trees shade the southeast side of the pond during part of the day. Shallow near inflow, steep-sided and deep elsewhere. Little to no evidence of fish use. Generally low abundance of benthic invertebrates.

Hydrology

In-line with Harmer Creek. Constructed to treat mine-influenced water from Dry Creek, a tributary of upper Harmer Creek. Harmer Creek flows in from the southeast corner of the pond and flows out over a weir in the northeast corner of the pond.

Teck

EV_HASP UTM (11U) E: 657065 N: 5522098



Harmer Creek Sedimentation Pond - Aerial

EV_HASP UTM (11U) E: 657065 N: 5522098

Pond Looking Northwest from Inflow 28/Aug/2021

EV_HASP_US UTM (11U) E: 657206 N: 5521951

Upstream 28/Aug/2021

EV_HASP_DS1 UTM (11U) E: 656953 N: 5522172

Downstream 28/Aug/2021

Lindsay Creek Infiltration Pond

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	1.13
Normal Operating Range (m^2/s):	0 - 0.05
Volume (m^3):	1,900
Surface Area (m^2)	790
Mean/Maximum Pond Depth (m)	0.75/1.5
Liner:	No
Fish Access:	Pond is unconnected

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Shrubs
Dominant Aquatic Vegetation:	Pondweed, Grasses
Dominant Pond Substrate:	Silt, Clay
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	30/Aug/2021
Temperature (°C):	13.86
Conductivity (µS/cm):	682.9
DO (mg/L):	6.80
pH:	7.34
ORP (mV):	94.2
Chlorophyll (µg/L):	0.168
Phycocyanin (µg/L):	0.238
Total Phosphorus (µg/L):	7.9

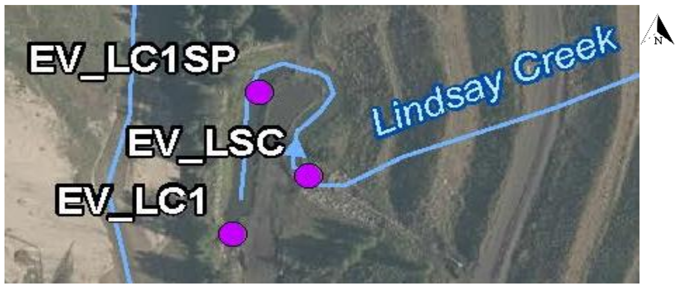
Site Description

The primary purpose of the Lindsay Creek Sediment is to provide sediment control for the CCR spoil. Substrate is dominated by silt and clay. Minimal shading potential exists due to its location at the base of the spoil with minimal riparian cover. No evidence of fish use. Most recently dredged in 2019.

Water Flow Description

The Lindsay Creek rock drain collects infiltration through the CCR Spoil and discharges at the base of the CCR into the Lindsay Creek Infiltration Ponds . Water collected within the ponds and the discharge channel infiltrates to the ground with no direct connection to the Elk River.

EV_LC1SP UTM (11U) E: 653260 N: 5514784



Lindsay Creek Infiltration Pond Aerial

EV_LC1SP
UTM (11U)
E: 653260
N: 5514784

30/Aug/2021

Lindsay Pond

EV_LSC
UTM (11U)
E: 653283
N: 5514740

30/Aug/2021

Upstream Lindsay Pond

EV_LC1
UTM (11U)
E: 653247
N: 5514709

30/Aug/2021

Downstream Lindsay Pond

Lower Milligan Creek Sedimentation Pond (EV_MGSP)

Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	1.92
Mean Annual Discharge (m2/s):	0.009
Volume (m^3):	3,093
Surface Area (m^2)	2,653
Mean/Maximum Pond Depth (m)	1.2 / 1.6
Liner:	No
Fish Access:	Downstream barrier - spillway

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, shrubs, coniferous trees
Dominant Aquatic Vegetation:	Filamentous algae
Dominant Pond Substrate:	Silt/Filamentous algae
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	27/Aug/2021
Temperature (°C):	12.44
Conductivity (µS/cm):	985.4
DO (mg/L):	14.152
pH:	8.34
ORP (mV):	100.88
Chlorophyll (µg/L):	0.4534
Phyococyanin (µg/L):	0.353
Total Phosphorus (µg/L):	3.9

Site Description

The Lower Milligan Creek Sedimentation Pond is located on the valley bottom, between Michel Creek and the CP Rail line. The pond was originally constructed in response to TSS non-compliances in Milligan creek, following the start of mining in the upper catchment. Substrate is silty but dominated by thick filamentous algae. Shading potential exists due to steep banks and riparian trees. No evidence of fish use.

Water Flow Description

Flows enters the pond at the east end and decants out of the pond via a set of corrugated steel pipes in the pond's southwest corner. The pond decants into Michel Creek.

EV_MGSP UTM (11U) E: 658638 N: 5506101

Lower Milligan Pond Aerial

EV_MGSP UTM (11U) E: 658638 N: 5506101

Lower Milligan Pond 21/Aug/2021

EV_MGSP_US UTM (11U) E: 658810 N: 5506095

Upstream Lower Milligan Pond 21/Aug/2021

EV_MGSP_DS1 UTM (11U) E: 658607 N: 5506079

Downstream Lower Milliagn Pond 21/Aug/2021

MSAN 1 Pond

Management Unit 2

Physical Characteristics

Passive Drainage Area (km^2):	
Mean Annual Discharge (m2/s):	0.009
Volume (m^3):	1826
Surface Area (m^2)	1820
Mean/Maximum Pond Depth (m)	0.3/1.5
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Filamentous Algae, Water Milfoil
Dominant Pond Substrate:	Fully vegetated
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	30/Aug/2021
Temperature (°C):	7.97
Conductivity (µS/cm):	317.175
DO (mg/L):	11.96
pH:	8.27
ORP (mV):	40.525
Chlorophyll (µg/L):	0.1105
Phycocyanin (µg/L):	0.416
Total Phosphorus (µg/L):	2.7

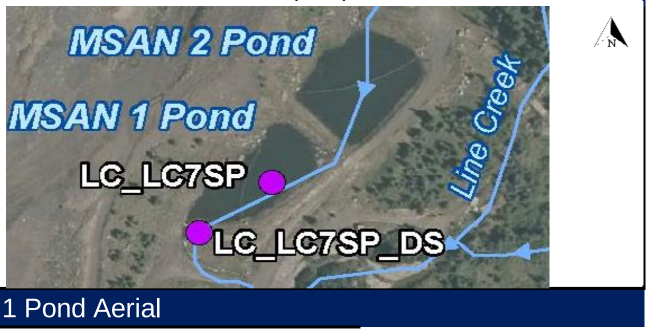
Site Description

The Mine Services Area North (MSAN) Ponds consists of three contiguous cells and located upstream from the MSA building and below the MSAN spoils. The lower cell of MSAN Pond has a fish barrier and an outlet spillway consisting of a concrete, broad-crested weir and an adjacent staff gauge for measuring water level. The substrate was covered by think macrophyte beds with a visible blue plume suggestive of algal/microbial activity. There is limited shading potential and no evidence of fish use.

Water Flow Description

The MSAN Ponds collect surface water runoff from the MSA North Pit, providing sediment collection and clarification of water prior to release to Line Creek. Flow enters the pond system through an armoured channel with a gated culvert at the north end of the facility, flows though the three contiguous cells before being discharged to Line Creek.

LC LC7SP UTM (11U) E: 661473 N: 5536499



MSAN 1 Pond Aerial

LC_LC7SP

UTM (11U)

E: 661473

N: 5536499

30/Aug/2021

MSAN 1 Pond

No Samples Collected (Upstream area in RAZ)

30/Aug/2021

Upstream MSAN 1 Pond

No Photo Available

LC_LC7SP_DS

UTM (11U)

E: 661435

N: 5536471

30/Aug/2021

Downstream MSAN 1 Pond

Teck

Porter Creek Sediment Pond
Management Unit 1

Physical Characteristics

Passive Drainage Area (km^2):	1.17
Mean Annual Discharge (m2/s):	0.009
Volume (m^3):	4,074
Surface Area (m^2)	2,348
Mean/Maximum Pond Depth (m)	- / 3.6
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Coniferous Trees
Dominant Aquatic Vegetation:	Grasses (sparse)
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	31/Aug/2021
Temperature (°C):	7.65
Conductivity (µS/cm):	750.5
DO (mg/L):	10.47
pH:	8.40
ORP (mV):	105.38
Chlorophyll (µg/L):	0.063
Phycocyanin (µg/L):	0.373
Total Phosphorus (µg/L):	4.6

Site Description

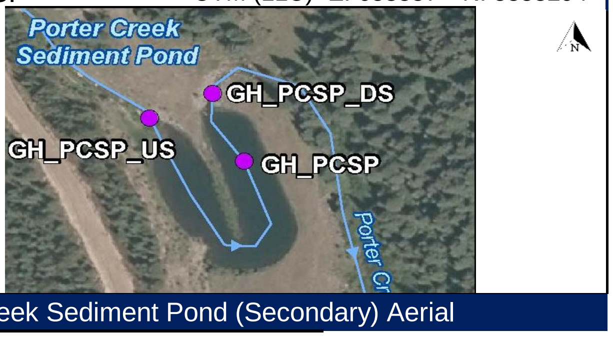
Porter Creek Sedimentation Pond consists of a single U-shaped cell with bypass works to bypass the pond as needed. The mining area above the pond has been relatively inactive over the past decade and therefore there has been no need to remove sediment. Porter Creek is considered fish bearing up to the bypass culvert above the sediment pond. Substrate is typically fine material and shading potential is minimal.

Water Flow Description

The inlet culvert discharges to an approach channel, and water levels in the pond are regulated by an open-channel outlet. In a flood event the pond can be bypassed and the water discharged directly to the Fording River.

Teck

GH_PCSP UTM (11U) E: 653557 N: 5555294



Porter Creek Sediment Pond (Secondary) Aerial

GH_PCSP
UTM (11U)
E: 653557
N: 5555294

31/Aug/2021

Porter Creek Pond

GH_PCSP_US
UTM (11U)
E: 653520
N: 5555311

31/Aug/2021

Upstream Porter Creek Pond

GH_PCSP_DS
UTM (11U)
E: 653545
N: 5555321

No Photo Available

31/Aug/2021

Downstream Porter Creek Pond

Smith Ponds
Management Unit 1

Physical Characteristics

Passive Drainage Area (km^2):	0.04
Normal Operating Range (m^2/s):	-
Volume (m^3):	2,300
Surface Area (m^2)	6,000
Mean/Maximum Pond Depth (m)	0.5/0.5
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Grasses, Water Milfoil
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	31/Aug/2021
Temperature (°C):	9.52
Conductivity (µS/cm):	821.8
DO (mg/L):	8.84
pH:	7.38
ORP (mV):	118.6
Chlorophyll (µg/L):	0.092
Phycocyanin (µg/L):	0.363
Total Phosphorus (µg/L):	2

Site Description

The Smith Ponds are located on the west side of the Fording River across from the South Tailings Pond. The ponds were originally constructed to collect pit water overflow from historical pits (2 Pit) that have since been backfilled with spoils. The ponds now provide a passive sediment removal function for runoff and seepage reporting from D and E Spoils. Substrate is silty. Shading potential is low due to minimal riparian cover. No evidence of fish use.

Water Flow Description

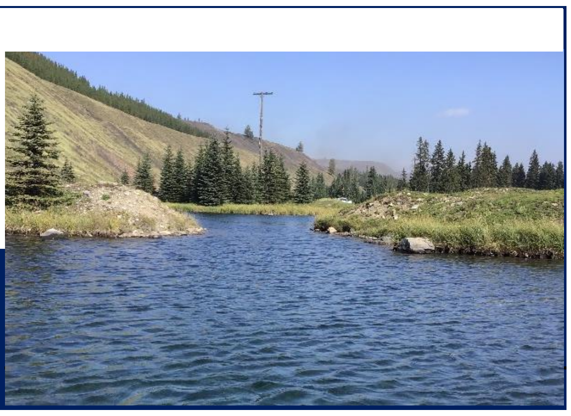
The Smith Ponds consist of a four-pond system operated in series and connected via open channels between them. The ponds discharge via two 600 mm CSP culverts elevated by approximately 10 m above the Fording River flood plain, which acts as a fish barrier. Following the water entering the flood plain it travels through a historical side channel of the Fording River for approximately 200 m prior to discharging to the Fording River.

Teck

FR SP1SP UTM (11U) E: 650961 N: 5560555

Smith Ponds Aerial

FR_SP1SP
UTM (11U)
E: 650961
N: 5560555



31/Aug/2021

Smith Ponds

FR_SP1SP_US
UTM (11U)
E: 651070
N: 5560370

31/Aug/2021

Upstream Smith Ponds

FR_SP1SP_DS
UTM (11U)
E: 650996
N: 5560576

No Photo Available

31/Aug/2021

Downstream Smith Ponds

Lower South Pit Creek Pond
Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	0.73
Mean Annual Discharge (m2/s):	0.01
Volume (m^3):	1,075
Surface Area (m^2)	1,940
Mean/Maximum Pond Depth (m)	0.5/1.3
Liner:	No
Fish Access:	Downstream fish barrier (natural drop)

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Coniferous/Deciduous Trees
Dominant Aquatic Vegetation:	Grasses
Dominant Pond Substrate:	Silt
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	30/Aug/2021
Temperature (°C):	11.90
Conductivity (µS/cm):	1,329.0
DO (mg/L):	9.52
pH:	7.97
ORP (mV):	108.5
Chlorophyll (µg/L):	0.0797
Phycocyanin (µg/L):	0.304
Total Phosphorus (µg/L):	2

Site Description

The Lower South Pit Creek Sedimentation Pond is located immediately adjacent to the CP Rail line and 50 m away from Michel Creek. It serves as a polishing pond for flows in the South Pit Creek drainage (receiving runoff and seepage from the South Pit spoil) before discharging to Michel Creek. Substrate is silty with some aquatic vegetation. Shading potential exists due to steep banks and riparian trees. A fish salvage was conducted in 2019 (trapping only).

Water Flow Description

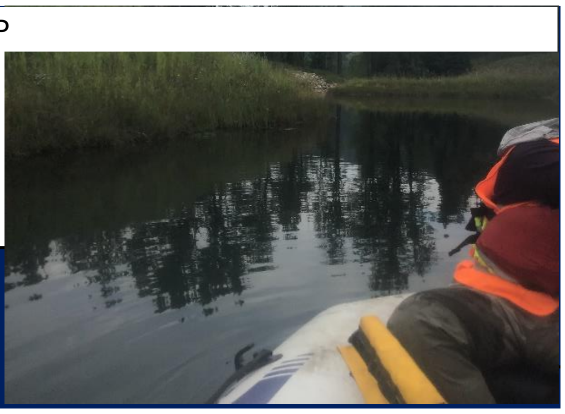
Inflow to the lower pond is through two culverts beneath the rail line at the pond's north end. The discharge pipe from the Upper South Pit Creek Sedimentation Pond passes through the lower of these two culverts, and natural flow from the original South Pit Creek drainage channel passes through the higher of the two. The pond decants into South Pit Creek before entering Michel Creek.

Teck

EV_SP1SP UTM (11U) E: 659483 N: 5505597

Lower South Pit Creek Pond Aerial

EV_SP1SP
UTM (11U)
E: 659483
N: 5505597
30/Aug/2021
South Pit Pond



EV_SP1SP_US
No Samples
30/Aug/2021
Upstream South Pit Pond

No Photo Available

EV_SP1SP_DS
UTM (11U)
E: 659497
N: 5505522
30/Aug/2021
Downstream South Pit Pond

Corbin Creek SPD Pond
Management Unit 4

Physical Characteristics

Passive Drainage Area (km^2):	-
Normal Operating Range (m^2/s):	0 - 1.36
Volume (m^3):	-
Surface Area (m^2)	585
Mean/Maximum Pond Depth (m)	0.5/1.0
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses
Dominant Aquatic Vegetation:	Water Milfoil
Dominant Pond Substrate:	Gravel
Secchi Depth (m):	Bottom

Field Water Quality

Date(s) Collected:	25/Aug/2021
Temperature (*C):	11.95
Conductivity (µS/cm):	1,453.3
DO (mg/L):	9.90
pH:	7.92
ORP (mV):	106
Chlorophyll (µg/L):	0.226
Phycocyanin (µg/L):	0.357
Total Phosphorus (µg/L):	4.3

Site Description

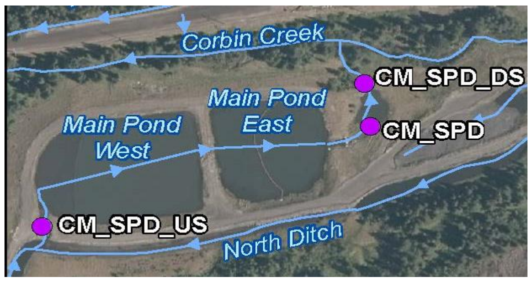
Main Pond (SPD Pond) is a two-pond sediment control system in the north-west corner of CMO. The inflow is a riprap-lined spillway in the southwest corner and then though a divider dyke spillway to the east pond. The outlet is a spillway and is an engineered fish barrier blocking upstream passage of fish from Corbin Creek into the pond. The substrates are nearly all overed by macrophytes and the shading potential is minimal.

Water Flow Description

Main (SPD) Pond collects water from the north and west areas of the CMO property. The West and North Interceptor Ditches both discharge into the Main Ponds and the discant discharges through a short-constructed channel before it converges with Corbin Creek.

Teck

CM_SPDSP UTM (11U) E: 668870 N: 5487380



SPD Pond Aerial

CM_SPDSP
UTM (11U)
E: 668870
N: 5487380

25/Aug/2021

SPD Pond

CM_SPDSP_US
UTM (11U)
E: 668861
N: 5487372

No Photo Available

25/Aug/2021

Upstream SPD Pond

CM_SPDSP_DS
UTM (11U)
E: 660558
N: 5531900

25/Aug/2021

Downstream SPD Pond

Swift Creek Sediment Pond (Secondary)

Management Unit 1

Physical Characteristics

Passive Drainage Area (km^2):	6.48
Mean Annual Discharge (m2/s):	0.13
Volume (m^3):	36,600
Surface Area (m^2)	12,800
Mean/Maximum Pond Depth (m)	1.3/2.5
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Coniferous Trees
Dominant Aquatic Vegetation:	Filamentous/Brown Algae, Chara sp.
Dominant Pond Substrate:	Silt
Secchi Depth (m):	2.2

Field Water Quality

Date(s) Collected:	31/Aug/2021
Temperature (°C):	9.17
Conductivity (µS/cm):	2,400.5
DO (mg/L):	11.5
pH:	7.39
ORP (mV):	130.7
Chlorophyll (µg/L):	0.105
Phycocyanin (µg/L):	0.344
Total Phosphorus (µg/L):	25.7

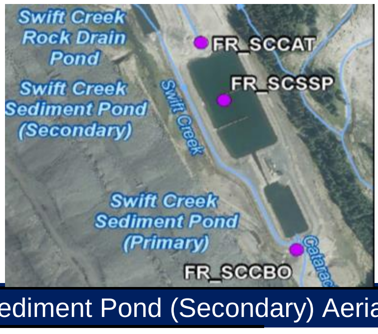
Site Description

Swift Creek Sediment Ponds consist of a Primary and a Secondary Pond that functions to settle water entering through the Swift and Cataract Creek Drainages. Substrate is silty but dominated by thick filamentous algae. Shading potential exists due to steep banks and riparian trees. No evidence of fish use.

Water Flow Description

The mine-influenced water from the Swift/Cataract Creek catchment is conveyed to the Swift Creek Sediment Ponds via the Cataract and Swift Creek Rock Drains. The two rock drains discharge into small head ponds before being piped to the Swift Creek Sediment Ponds. In addition, the Swift Primary Pond collects drainage from Swift Creek, Cataract Creek, and collection channels along the toe of the Swift South Spoil and C Spoil. Water then supplies the FRO South Active Water Treatment Facility where it is treated before being discharged into the Fording River.

FR SCSSP UTM (11U) E: 652147 N: 5558310



Swift Creek Sediment Pond (Secondary) Aerial

FR_SCSSP

UTM (11U)

E: 652147

N: 5558310

31/Aug/2021

Swift Creek Pond

FR_SCCBO

UTM (11U)

E: 652241

N: 5558097

31/Aug/2021

Upstream Swift Creek Pond

FR_SCCAT

UTM (11U)

E: 652080

N: 5558372

31/Aug/2021

Downstream Swift Creek Pond

Lower Thompson Creek Tertiary Pond

Management Unit 3

Physical Characteristics

Passive Drainage Area (km^2):	4.82
Mean Annual Discharge (m2/s):	0.009
Volume (m^3):	16,951
Surface Area (m^2)	13,382
Mean/Maximum Pond Depth (m)	1 / 1.4
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Shrubs
Dominant Aquatic Vegetation:	Grasses
Dominant Pond Substrate:	Silt
Secchi Depth (m):	1.5

Field Water Quality

Date(s) Collected:	26/Aug/2021
Temperature (°C):	12.05
Conductivity (µS/cm):	906.6
DO (mg/L):	13.24
pH:	8.25
ORP (mV):	99.2
Chlorophyll (µg/L):	0.769
Phycocyanin (µg/L):	0.540
Total Phosphorus (µg/L):	5.2

Site Description

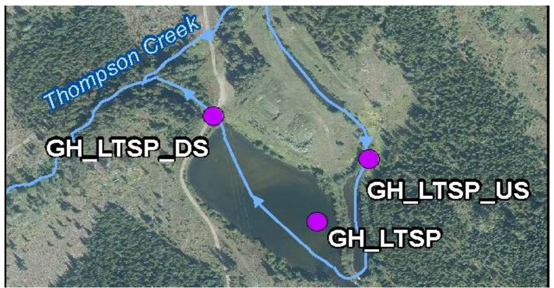
The Lower Thompson Creek Sediment Ponds system consistes of three ponds, with a bypass works to allow the bypass of the entire pond system to facilitate sediment removal and during upset condition. The Tertiary Cell is a 100 m by 170 m rectangle. The Tertiary Cell is assumed to have been constructed using traditional cut and fill methods, with the West Dam being constructed of locally excavated material. The storage volume for the facility was calculated as 53,656 m³. Substrate is macrophyte covered. Shading potential is minimal with the pond system considered to be fish-bearing.

Water Flow Description

The Lower Thompson Creek Sediment Ponds catchment is downslope of the Upper Thompson Creek Sediment Ponds catchment, and it drains mine-influenced water to the Elk River

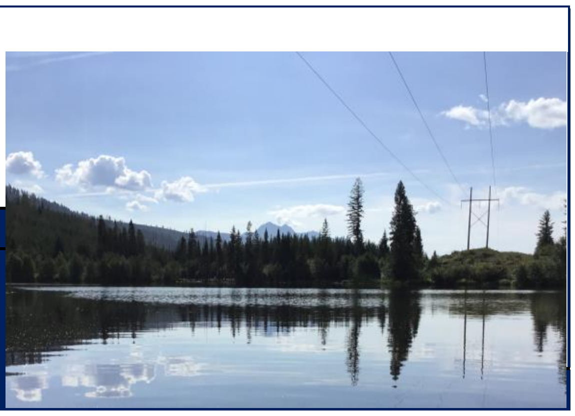
Teck

GH_LTSP UTM (11U) E: 649049 N: 5550306



Lower Thompson Creek Tertiary Pond Aerial

GH_LTSP
UTM (11U)
E: 649049
N: 5550306
26/Aug/2021



Lower Thompson Creek Pond

GH_LTSP_US
UTM (11U)
E: 649100
N: 5550371
26/Aug/2021

Upstream Thompson Pond

GH_LTSP_DS
UTM (11U)
E: 648948
N: 5550415
26/Aug/2021

No Photo Available

Down-stream Thompson Pond

Wade Creek Inlet Pond

Management Unit 3

Physical Characteristics

Passive Drainage Area (km^2):	0.59
Mean Annual Discharge (m^2/s):	0.009
Volume (m^3):	85
Surface Area (m^2)	70
Mean/Maximum Pond Depth (m)	- / 2.0
Liner:	No
Fish Access:	Downstream fish barrier

Habitat Characteristics

Dominant Riparian Vegetation:	Grasses, Shrubs, Coniferous/Deciduous Trees
Dominant Aquatic Vegetation:	Grasses
Dominant Pond Substrate:	-
Secchi Depth (m):	-

Field Water Quality

Date(s) Collected:	26/Aug/2021
Temperature (°C):	9.97
Conductivity (µS/cm):	419
DO (mg/L):	10.34
pH:	8.41
ORP (mV):	105.6
Chlorophyll (µg/L):	0.893
Phycocyanin (µg/L):	0.564
Total Phosphorus (µg/L):	13.9

Site Description

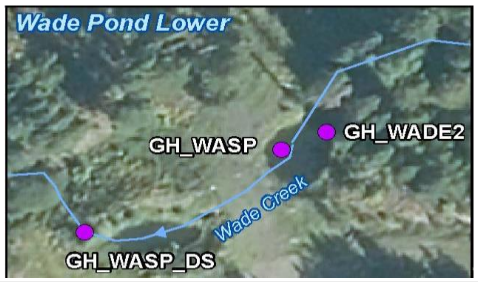
The Wade Creek Sediment Ponds include the Wade Inlet Pond (small head pond) and Wade Catch Basin with a gated culvert (manual operation) bypass of the catch basin for sediment removal and to protect infrastructure during flooding if needed. Substrate is silty and there is potential for shading (trees are located near to pond inflow). No evidence of fish use.

Water Flow Description

Wade Creek flows southwest to the Elk River from a catchment that has been affected by historic cast-over material from the development of Phase 6 Pit. The Wade Creek Sediment Ponds include the Wade Inlet Pond and the Wade Catch Basin with a manually operated gated culvert for bypass and protection of infrastructure as needed. Water levels within the system are regulated by culverts between the inlet pond and secondary pond and the outlet to the secondary pond.

Teck

GH_WASP UTM (11U) E: 647909 N: 5555701



Wade Creek Inlet Pond Aerial

GH_WASP

UTM (11U)
E: 647909
N: 5555701

26/Aug/2021

Wade Creek Inlet Pond

GH_WADE2

UTM (11U)
E: 647913
N: 5555707

26/Aug/2021

Upstream Wade Pond

GH_WASP_DS

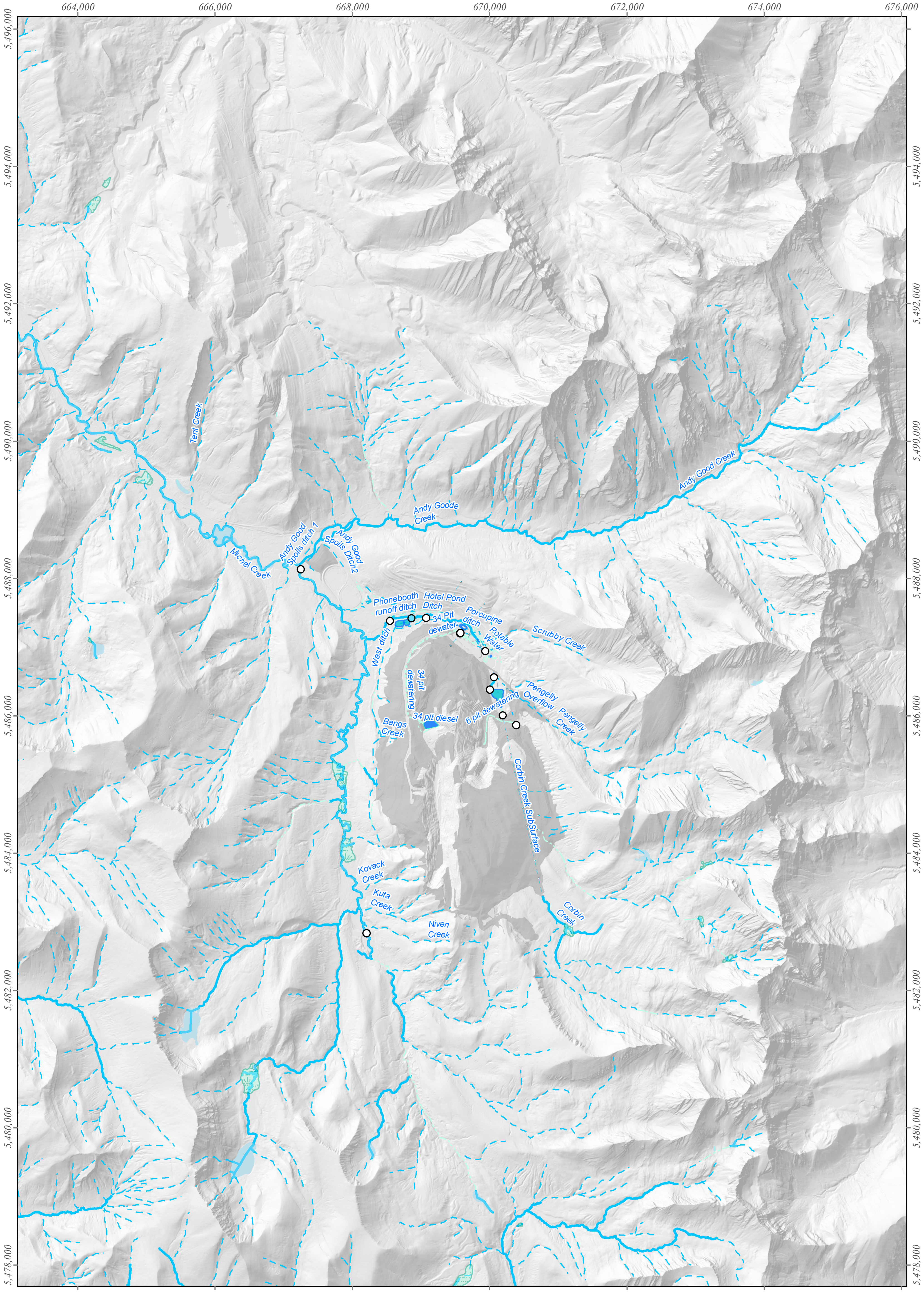
UTM (11U)
E: 647896
N: 5555701

26/Aug/2021

Downstream Wade Pond

Attachment E

Heat Maps of Maximum Organoselenium Concentrations in 2021 Regional and Local Monitoring



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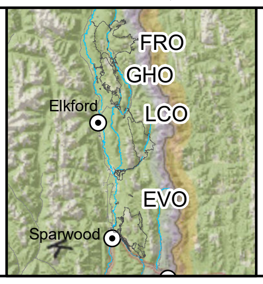


Coal Mountain Selenium Speciation Sample Locations

Sum of Dimethyl selenoxide (DMSeO) and Methyl seleninic acid (MeSe(IV))

○ <0.025 µg/L

● 0.025 µg/L - 0.0499 µg/L

● 0.05 µg/L - 0.099 µg/L

● >0.10 µg/L

▨ Pits + Spoils

N

0 250 500 1,000 1,500 Meters

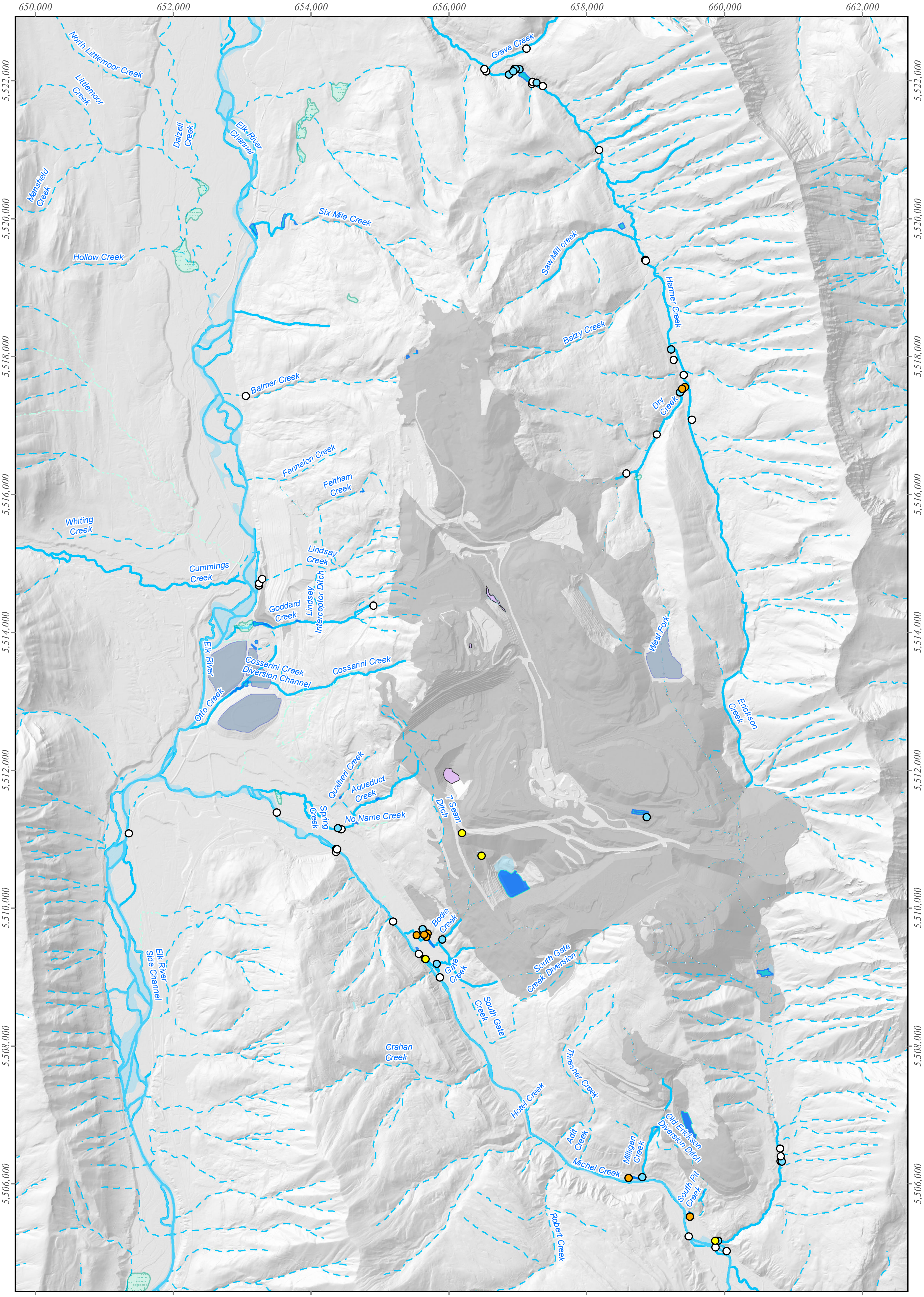
DATE: 4/12/2022

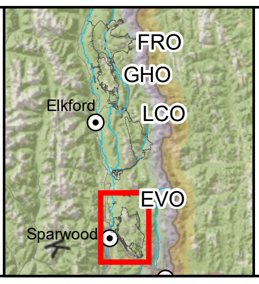
MINE OPERATION: Coal Mountain

SCALE: 1:50,000

COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\OrganoSeFigure.mxd





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Elkview Selenium Speciation Sample Locations

Sum of Dimethyl selenoxide (DMSeO) and Methyl seleninic acid (MeSe(IV))

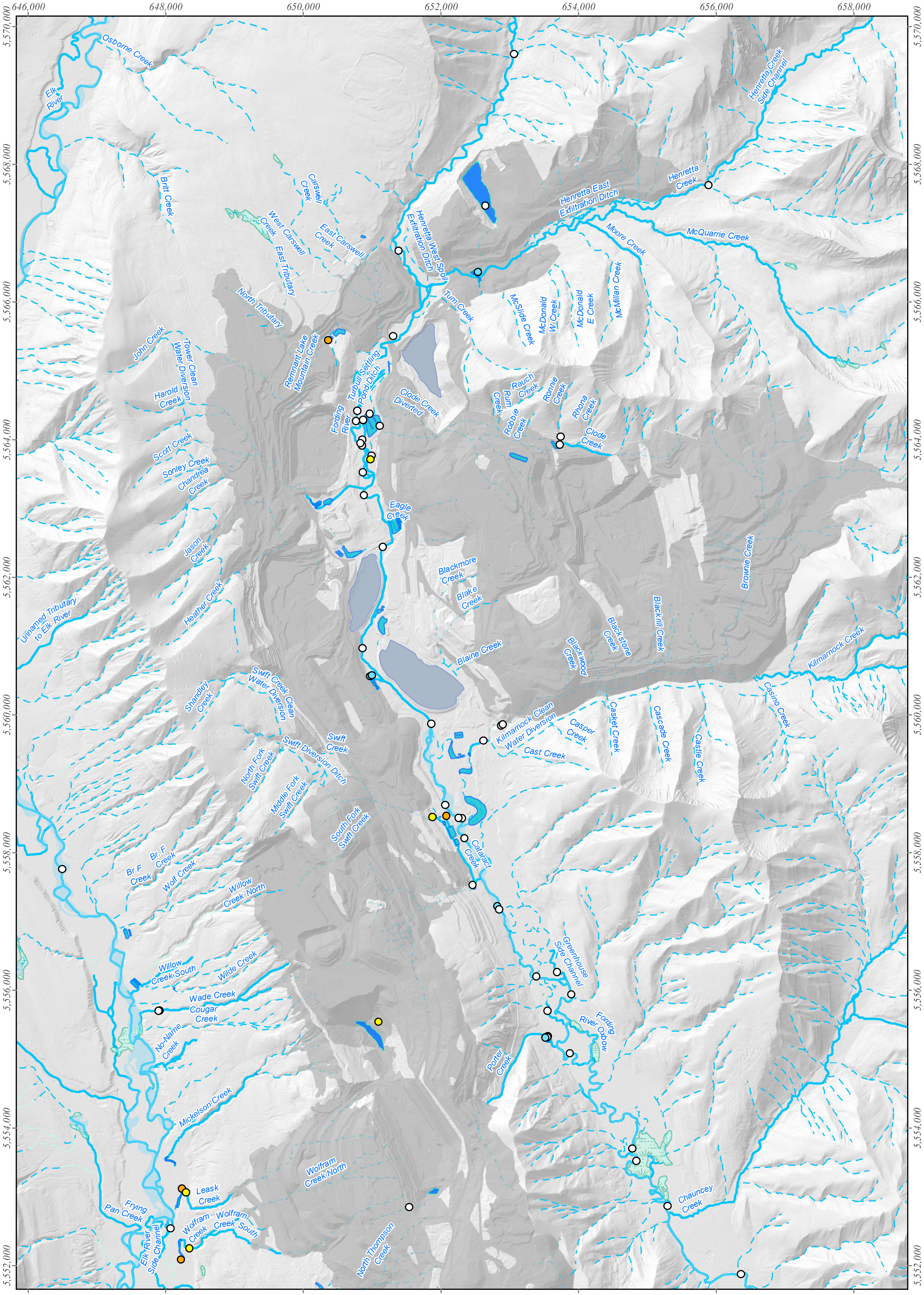
○ <0.025 µg/L
● 0.025 µg/L - 0.0499 µg/L
● 0.05 µg/L - 0.099 µg/L
● >0.10 µg/L
▨ Pits + Spoils

N

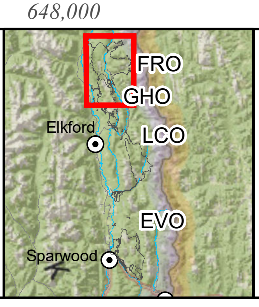
0 250 500 1,000 1,500
Meters

DATE: 4/12/2022	MINE OPERATION: Elkview
SCALE: 1:50,000	COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\OrganoSeFigure.mxd



Teck



Fording River Selenium Speciation Sample Locations

Sum of Dimethyl selenoxide (DMSeO) and Methyl seleninic acid (MeSe(IV))

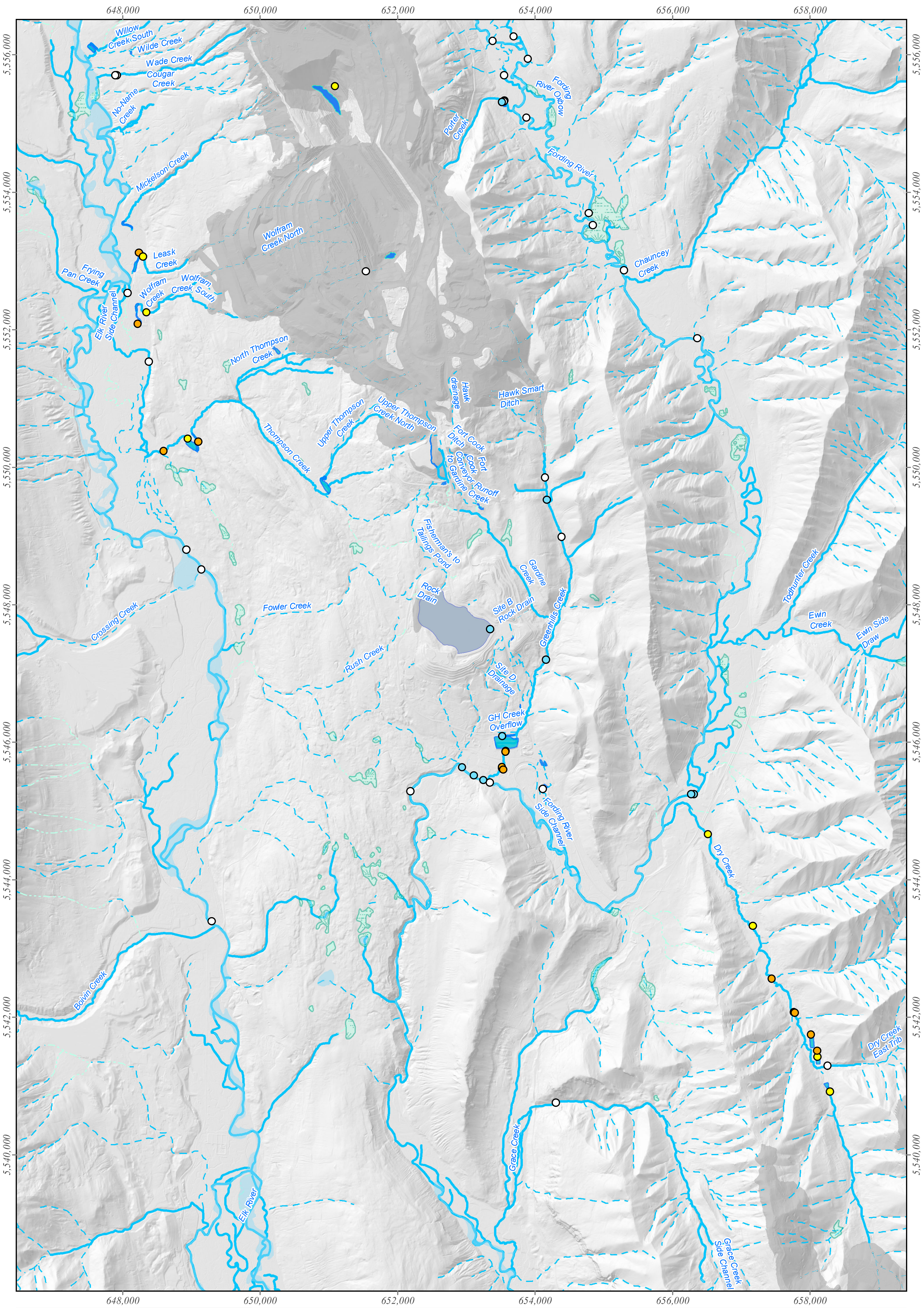
○ <0.025 µg/L
● 0.025 µg/L - 0.0499 µg/L
● 0.05 µg/L - 0.099 µg/L
● >0.10 µg/L
▨ Pits + Spoils

N

0 250 500 1,000 1,500
Meters

DATE: 4/12/2022	MINE OPERATION: Fording River
SCALE: 1:50,000	COORDINATE SYSTEM: NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\OrganoSeFigure.mxd



Teck

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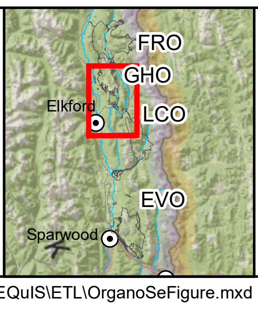


Greenhills Selenium Speciation Sample Locations

Sum of Dimethyl selenoxide (DMSeO) and Methyl seleninic acid (MeSe(IV))

- ○ <0.025 µg/L
- ● 0.025 µg/L - 0.0499 µg/L
- ● 0.05 µg/L - 0.099 µg/L
- ● >0.10 µg/L
- ▨ Pits + Spoils

N

0 250 500 1,000 1,500 Meters

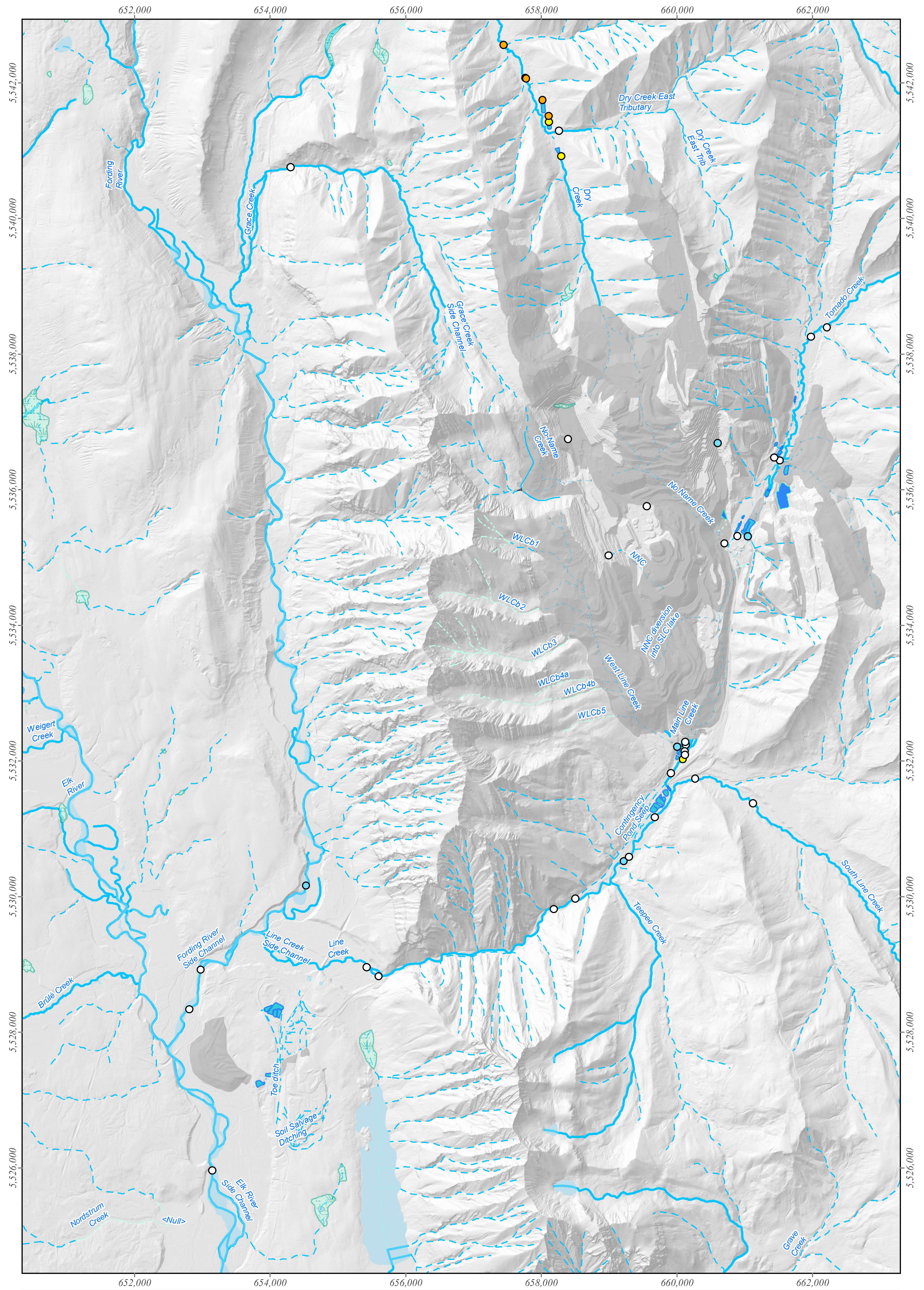
DATE:
4/12/2022

MINE OPERATION:
Greenhills

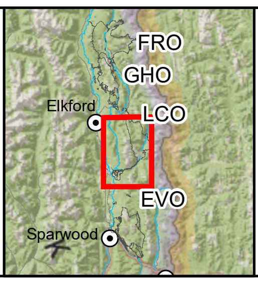
SCALE:
1:50,000

COORDINATE SYSTEM:
NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\OrganoSeFigure.mxd



Teck



Line Creek Selenium Speciation Sample Locations

Sum of Dimethyl selenoxide (DMSeO) and Methyl seleninic acid (MeSe(IV))

○ <0.025 µg/L
● 0.025 µg/L - 0.0499 µg/L
● 0.05 µg/L - 0.099 µg/L
● >0.10 µg/L
▨ Pits + Spoils

N

0 250 500 1,000 1,500 Meters

DATE:
4/12/2022

MINE OPERATION:
Line Creek

SCALE:
1:50,000

COORDINATE SYSTEM:
NAD 1983 UTM Zone 11N

Document Path: G:\Data\Projects\EQuIS\ETL\OrganoSeFigure.mxd

Attachment F

Factor Loading Scores from Principal Components Analysis of Predictor Variables

Attachment F. Factor loading scores from Principal Components Analysis of predictor variables

Parameter	**Units**	**PC1**	**PC2**	**PC3**	**PC4**
Percent Total Variance Explained	*%*	*34%*	*22%*	*18%*	*14%*
Alkalinity US	mg/L as $CaCO_3$	-0.051	-0.221	-0.951	0.211
Ammonia US	mg/L as N	-0.144	-0.875	0.416	-0.203
Ash-free Dry Mass US	mg/L	0.451	-0.269	-0.851	-0.02
Chloride US	mg/L	0.202	-0.013	-0.157	0.967
Chlorophyll-a US	µg/L	0.929	0.005	0.369	-0.036
Conductivity US	µS/cm	0.506	0.005	-0.702	0.501
Dissolved Organic Carbon US	mg/L	0.725	-0.101	0.673	0.105
Hardness US	mg/L as $CaCO_3$	0.408	-0.042	-0.591	0.695
Nitrate US	mg/L as N	0.769	0.193	-0.605	0.07
Nitrite US	mg/L as N	0.655	-0.638	0.188	-0.36
Oxidation-reduction Potential US	mV	0.358	0.677	-0.635	-0.103
Orthophosphate US	µg/L	-0.49	0.626	0.595	0.117
pH US	-	-0.856	0.352	0.378	0.009
Total Phosphorus US	µg/L	0.783	0.049	0.409	-0.466
Total Dissolved Solids US	mg/L	0.377	0.001	-0.634	0.675
Dissolved Se US	µg/L	0.464	0.85	-0.247	-0.039
Total Se US	µg/L	0.459	0.853	-0.246	-0.042
Sulphate US	mg/L	-0.056	-0.107	-0.437	0.891
Total Kjeldahl Nitrogen US	mg/L as N	-0.776	-0.178	0.529	0.293
Total Organic Carbon US	mg/L	0.894	0.158	0.352	0.226
Total Suspended Solids US	mg/L	0.659	0.381	0.583	0.283
Turbidity US	NTU	0.642	-0.134	0.742	0.139
Alkalinity DS	mg/L as $CaCO_3$	0.777	-0.254	-0.06	-0.573
Ammonia DS	mg/L as N	0.089	-0.889	0.442	-0.086
Ash-free Dry Mass DS	mg/L	0.821	-0.268	0.159	-0.478
Chloride DS	mg/L	0.412	-0.135	0.327	0.84
Chlorophyll-a DS	µg/L	0.98	-0.02	0.171	0.102
Conductivity DS	µS/cm	0.985	-0.119	-0.121	0.036
Dissolved Organic Carbon DS	mg/L	0.901	0.089	-0.002	0.425
Hardness DS	mg/L as $CaCO_3$	0.987	-0.139	0.027	0.077
Nitrate DS	mg/L as N	0.698	0.253	-0.65	0.161
Nitrite DS	mg/L as N	0.511	-0.57	-0.621	0.166
Oxidation-reduction Potential DS	mV	-0.189	-0.634	-0.467	-0.587
Orthophosphate DS	µg/L	-0.697	0.398	0.277	-0.527
pH DS	-	-0.874	0.311	0.371	-0.047
Total Phosphorus DS	µg/L	0.717	0.251	0.435	-0.483
Dissolved Se DS	µg/L	0.593	0.771	-0.133	-0.19
Total Se DS	µg/L	0.603	0.747	-0.163	-0.228
Sulphate DS	mg/L	0.964	-0.178	0.193	0.036
Total Dissolved Solids DS	mg/L	0.981	-0.115	-0.081	0.136
Total Kjeldahl Nitrogen DS	mg/L as N	0.443	-0.235	0.865	-0.007
Total Organic Carbon DS	mg/L	0.936	0.183	0.02	0.301
Total Suspended Solids DS	mg/L	0.897	0.104	0.267	-0.338
Turbidity DS	NTU	0.832	-0.262	0.304	-0.384
Field Temperature US	°C	0.762	-0.285	0.534	-0.231
Field Dissolved Oxygen US	mg/L	-0.392	0.902	-0.128	-0.128
Field Percent Saturation US	%	0.828	0.04	0.423	-0.365
Field Conductivity US	µS/cm	0.732	-0.121	-0.521	0.423
Field pH US	-	-0.596	0.219	0.771	0.052
Field Oxidation-reduction Potential US	mV	0.243	0.944	-0.126	-0.185
Field Turbidity US	NTU	0.759	-0.411	0.318	-0.393
Field Chlorophyll-a US	ug/L	0.009	0.408	0.909	0.09
Field Phycocyanins US	µg/L	-0.937	0.194	-0.222	0.187
Field Temperature DS	°C	0.421	0.852	-0.134	0.282
Field Dissolved Oxygen DS	mg/L	0.382	0.667	0.613	0.184
Field Percent Saturation DS	%	0.444	0.757	0.397	0.267
Field Conductivity DS	µS/cm	0.979	-0.051	-0.111	0.165
Field pH DS	-	-0.326	0.945	0.017	0.012
Field Oxidation-reduction Potential DS	mV	0.339	-0.907	0.218	-0.12
Field Turbidity DS	NTU	0.787	0.226	-0.234	-0.524
Field Chlorophyll-a DS	µg/L	0.384	-0.841	0.025	0.381
Field Phycocyanins DS	µg/L	-0.305	-0.921	0.236	-0.057
Pond Substrate % Gravel	%	-0.391	-0.898	0.188	0.072
Pond Substrate % Sand	%	0.395	-0.397	0.81	0.176
Pond Substrate % Silt	%	0.233	0.953	-0.182	0.061
Pond Substrate % Clay	%	0.268	0.485	-0.706	-0.441
Pond Substrate % Total Organic Carbon	%	-0.577	0.701	0.181	0.378
Shade Score	score	0.938	0.332	-0.094	-0.036
Secchi Depth	m	-0.365	0.459	-0.651	-0.482
Secchi Depth/Maximum Depth	%	-0.689	-0.381	-0.558	-0.263
Emergent Vegetation Score	score	0.067	0.44	0.526	0.725
Submergent Vegetation Score	score	0.299	-0.673	-0.674	0.057
Algae Coverage Score	score	0.851	-0.01	0.126	-0.509
Total Aquatic Vegetation Score	score	0.841	-0.419	-0.289	0.184
Field Temperature In-pond	°C	0.18	-0.309	-0.226	0.906
Field Dissolved Oxygen In-pond	mg/L	0.382	0.469	0.734	0.308
Field Percent Saturation In-pond	%	0.445	0.315	0.6	0.586
Field Conductivity In-pond	µS/cm	0.842	-0.435	-0.246	-0.201
Field pH In-pond	-	-0.87	0.348	0.251	0.241
Field Oxidation-reduction Potential In-pond	mV	0.746	-0.152	0.018	-0.648
Field Turbidity In-pond	NTU	-0.513	-0.67	-0.242	0.48
Field Chlorophyll-a In-pond	µg/L	0.137	0.1	-0.056	0.984
Field Phycocyanins In-pond	µg/L	-0.065	0.336	0.779	0.526
July Mean Hydraulic Residence Time	d	0.642	0.712	-0.252	-0.131
August Mean Hydraulic Residence Time	d	0.473	0.858	-0.2	0.017
Maximum Depth	m	-0.001	0.737	-0.466	-0.489
July Mean Temperature	°C	0.42	-0.123	-0.067	0.897
August Mean Temperature	°C	0.253	-0.277	-0.05	0.926

Notes: US = upstream of sedimentation pond; DS = downstream of sedimentation pond; conditional formatting indicates magnitude of positive (green) and negative (red) loadings