RED MOUNTAIN UNDERGROUND GOLD PROJECT
VOLUME 3 | CHAPTER 13
SURFACE WATER QUALITY EFFECTS ASSESSMENT

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13 SURFACE WATER QUALITY EFFECTS ASSESSMENT

13.1 Introduction

The proposed Red Mountain Underground Gold Project (the Project) is an underground gold mine in the Bitter Creek valley, located near Stewart, in northwest British Columbia.

This Application/EIS chapter presents the effects assessment for the Surface Water Quality Valued Component (VC). The purpose of this assessment is to comprehensively evaluate the potential changes to Surface Water Quality that may result from the Project.

The introduction summarizes why Surface Water Quality was selected as a VC, what it encompasses, and linkages to other VCs. The remainder of the chapter covers: the scope of the assessment, existing aquatic conditions (i.e, baseline data), potential effects, mitigation measures, residual effects and their significance, cumulative effects, follow-up strategy, and conclusions.

Surface Water Quality was selected as a VC in order to assess the potential effects of the proposed Project on the health of aquatic ecosystems. Water quality forms one of the vital links between the abiotic and biotic environments, and is the foundation for supporting and maintaining healthy ecological processes for a rich and varied community of users (e.g., fish, wildlife, humans).

Surface Water Quality was originally screened for inclusion as an intermediate component IC, i.e., pathway component; however, through consultation and feedback with the Working Group for the Project, it was changed to a receptor VC. The Surface Water Quality VC is a key aspect of environmental health and it is closely linked to the Sediment Quality VC and is also considered a pathway component in the assessment of Aquatic Resources, Fish and Fish Habitat, Wildlife, Vegetation and Ecosystems, and Human Health.

The results of the Surface Water Quality Effects Assessment show that there will be no effects to Surface Water Quality outside of Canada.

13.2 Regulatory and Policy Setting

The Application Information Requirements (AIR) for the Project, approved by the British Columbia (BC) Environmental Assessment Office (EAO) in March 2017, outlines the requirements of the Surface Water Quality Effects Assessment to meet both the provincial and federal environmental assessment (EA) requirements under the BC Environmental Assessment Act (2002) and Canadian Environmental Assessment Act (2012), respectively.

Federal and provincial regulations and policies which guide protection to Surface Water Quality during the mine development process are summarized in Table 13.2-1.

The Canadian Council of Ministers of Environment (CCME) Water and Sediment Quality Guidelines, and the BC Approved Water Quality Guidelines cover protection of freshwater aquatic life. Guidelines are not regulatory instruments but can be defined as targets or triggers for action if not met. Generally, the BC guidelines are used where BC and CCME guidelines differ, as the BC guidelines are intended to represent more closely the conditions in BC waters, while the CCME (federal) guidelines are more general in nature.

In addition to the guidelines and legislation outlined in Table 13.2-1, BC MOE's Water and Air Baseline Monitoring Guidance Document (BC MOE 2016) outlines and defines the baseline study requirements for mining projects in BC. Information requirements for water quality (including physical and chemical parameters, aquatic sediments, tissue residues, and aquatic life), fish and fish habitat, and initial environmental impact assessment are included.

Table 13.2-1: Summary of Applicable Legislation, Regulations, and Guidelines for Surface Water Quality

Legislation/Regulation/Policy	Level of Government	Administered by	Description
Fisheries Act (1985)	Federal	Fisheries and Oceans Canada (DFO)	The Fisheries Act prohibits the carrying out of any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal (CRA) fishery, or to fish that support such a fishery. 'Serious harm' is defined as: "the death of fish or the permanent alteration to, or destruction of, fish habitat". While the act does not directly protect benthic invertebrates and periphyton, these aquatic organisms are afforded protection because they support fish and are a constituent of fish habitat.
Metal Mining Effluent Regulations	Federal	Environment and Climate Change Canada (ECCC)	The Metal Mining Effluent Regulations (MMER) are administered under section 36(3) of the *Fisheries Act*. MMER allows proponents to deposit deleterious substances into waters frequented by fish, if the Schedule 2 of the MMER is amended to designate these waters as a Tailings Impoundment Area. In addition, discharge of effluent from metal mines to surface waters is regulated through the MMER. Under MMER, if mine discharge into the receiving environment exceeds 50 m^3 per day the mine shall conduct environmental effects monitoring (EEM) studies of the potential effects of effluent on the fish populations, on fish tissue and on the benthic invertebrate community.
Environmental Management Act (2003)	Provincial	BC MOE	The *Environmental Management Act* (EMA) prohibits pollution of water, land, and air in BC. Mines require authorization under the EMA to discharge mining effluent to receiving waters, and are required to register (or include on the permit) sewage discharges greater than 100 persons. The EMA specifies environmental monitoring requirements for EMA permit holders, which should enable ongoing evaluation of waste management performance, receiving environment condition, and evaluation of impact predictions made during the permit application.

Legislation/Regulation/Policy	Level of Government	Administered by	Description
Water Sustainability Act (2016)	Provincial	BC Ministry of Forests, Lands and Natural Resource Operations (BC MoFLNRO)	The *Water Sustainability Act* (WSA) regulates the diversion and use of water resources. Under the WSA, a licence or use approval is required to make changes in and about a stream. Changes in and about a stream are defined as: • Any modification to the nature of the stream, including any modification of the land, vegetation and natural environment of a stream or the flow of water in a stream, or • Any activity or construction within a stream channel that has or may have an impact on a stream or stream channel.
CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life	Federal	CCME	Water quality guidelines are intended to provide protection of freshwater life from anthropogenic stressors such as chemical inputs or changes to physical components. Guideline values are meant to protect all forms of aquatic life and all aspects of the aquatic life cycles, including the most sensitive stage of the most sensitive species for the long term.
CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life	Federal	CCME	The CCME Sediment Quality Guidelines cover protection of freshwater aquatic life by providing scientifically-derived benchmarks for evaluating the potential for observing adverse biological effects in aquatic systems. CCME's Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs), are associated with occasional and frequent adverse biological effects, respectively.
BC Water Quality Guidelines: • Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture (2017) • Working Water Quality Guidelines (2015) • Working Sediment Quality Guidelines (2015)	Provincial	BC MOE	In BC, the definition of water quality includes sediments, therefore the Approved Water Quality Guidelines also includes sediment quality values for some parameters. These guidelines serve as benchmarks for the protection of aquatic life in freshwater and marine environments. BC MOE (2015) also has Working Water Quality Guidelines (WWQGs), and Working Sediment Quality Guidelines (WSQGs), which provide benchmarks for those substances that have not yet been fully assessed and formally endorsed by BC MOE and are obtained from other jurisdictions, including the CCME. Most WSQGs have a 'Lower WSQG' and an 'Upper WSQG', which are equivalent to CCME's Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs), respectively.

13.3 Scope of the Assessment

13.3.1 Information Sources

The information sources used to assess potential Project effects on Surface Water Quality included baseline reports, the Project Overview (Volume 2, Chapter 1), and the effects assessments for Air Quality (Volume 3, Chapter 7) and Groundwater Quality (Volume 3, Chapter 11). Information gathered during consultation with Nisga'a Nation, as represented by NLG, as well as meetings and discussion with the Project's Working Group was also incorporated.

Baseline characterization of Surface Water Quality within the Project area is summarized in Section 13.4.4. The following information sources were reviewed as part of a water quality desktop study. Complete references are provided in the *Baseline Surface Water and Groundwater Quality Report* (Volume 8, Appendix 14-A):

- *Environmental Baseline Data Report* prepared by Hallam Knight Piésold Ltd. for Lac Minerals Ltd. in 1992 (HKP 1992);
- *Preliminary Assessment, Tailings Disposal and Hydrogeology* draft report prepared by Klohn-Crippen for Lac North America Ltd. in 1994 (KC 1994a);
- *Hydrogeology Assessment* draft report prepared by Klohn-Crippen for Lac North America Ltd. in 1994 (KC 1994b);
- *Red Mountain Project 1994: Synopsis of Environmental Programs Undertaken, with Springs/Seeps Sample Locations & Environmental Files Location and Description* prepared by Rescan Consultants for Lac Minerals Ltd. In 1994 (Rescan 1994);
- *Draft Application for Mine Development Certificate* prepared by Rescan Consultants for Lac North America Ltd. In 1995 (Rescan 1995); and
- Results from the ongoing environmental baseline monitoring program (as described in Volume 8, Appendix 14-A).

As outlined in Chapter 6 (Effects Assessment Methodology), IDM has not conducted primary traditional use or traditional ecological knowledge (TEK) surveys in support of the Project due to the preferences of Nisga'a Nation, as represented by NLG, and EAO's and the Canadian Environmental Assessment Agency's direction for comparatively low levels of engagement with the other Aboriginal Groups potentially affected by the Project. IDM has committed to using TEK where that information is publicly available. As no TEK relevant to this effects assessment was publicly available at the time of writing, no TEK has been incorporated.

13.3.2 Input from Consultation

IDM is committed to open and honest dialogue with regulators, Aboriginal Groups, community members, stakeholders, and the public.

IDM conducted consultation with regulators and Aboriginal Groups through the Working Group co-led by EAO and the Agency. Where more detailed and technical discussions were warranted, IDM and Working Group members, including sometimes NLG representatives, held topic-focused discussions, the results of which were brought back to EAO and the Working Group as a whole.

Further consultation with Aboriginal Groups, community members, stakeholders, and the public has been conducted as outlined by the Section 11 Order and EIS Guidelines issued for the Project. More information on IDM's consultation efforts with Aboriginal Groups, community members, stakeholders, and the public can be found in Chapter 3 (Information Distribution and Consultation Overview), Part C (Aboriginal Consultation), Part D (Public Consultation), and Appendices 27-A (Aboriginal Consultation Report) and 28-A (Public Consultation Report). A record of the Working Group's comments and IDM's responses can be found in the comment-tracking table maintained by EAO.

Table 13.3-1 provides a summary of the consultation feedback and input that was received and that was specifically relevant to and affected issues scoping and VC selection for Surface Water Quality.

Table 13.3-1: Summary of Consultation Feedback on Surface Water Quality

Topic (VC, IC, Sub-Component)	Feedback by*				Consultation Feedback	Response
	NLG	G	P/S	O		
Aquatic Resources Fish Fish Habitat Groundwater Quality Hydrogeology Hydrology Sediment Quality Surface Water Quality	X				NLG requested a conceptual aquatic effects monitoring program (AEMP) design be included in the Application.	A conceptual AEMP has been included in Volume 5, Chapter 29 of the Application/EIS.
Surface Water Quality	X				NLG requested that Surface Water Quality be included in the assessment as a VC, rather than an IC.	IDM included Surface Water Quality as a VC in the effects assessment.

Topic (VC, IC, Sub-Component)	Feedback by*				Consultation Feedback	Response
	NLG	G	P/S	O		
Surface Water Quality	X				NLG requested that changes in surface water chemistry be evaluated by comparing chemical concentrations samples to federal and provincial water quality guidelines (WQGs).	IDM has compared changes in water quality chemistry to federal and provincial guidelines as well as baseline water quality conditions in the effects assessment.
Surface Water Quality	X				NLG requested that baseline water quality conditions be characterized in Goldslide Creek, Otter Creek, Bitter Creek, Bear River, and American Creek.	The baseline water quality for the suggested creeks and rivers has been characterized in Chapter 13 (Surface Water Quality Effects Assessment).
Surface Water Quality	X				NLG requested that baseline water chemistry data should include conventional water quality variables, major ions, nutrients, total metals, dissolved metals, and dissolved organic carbon.	IDM has included the list of parameters recommended by NLG in the baseline water quality data.
Surface Water Quality		X			ECCC recommended that the potential changes to surface water resulting from the formation of preferential groundwater pathways or conduits between underground contact water and surface water, including seepage of underground water flowing via preferential pathways or conduits, be considered in the assessment of potential effects to Surface Water Quality.	The Surface Water Quality Effects Assessment includes consideration of the potential changes resulting from preferential groundwater pathways, conduits, and seepage.
Surface Water Quality		X			ECCC recommended that seepage be included as a form of water that contacts mine surfaces and operations in the assessment of potential impacts to Surface Water Quality.	The Surface Water Quality effects assessment includes consideration of seepage.

*NLG = Nisga'a Lisims Government.
G = Government - Provincial or federal agencies.
P/S = Public/Stakeholder - Local government, interest groups, tenure and license holders, members of the public.
O = Other.

13.3.3 Valued Components, Assessment Endpoints, and Measurement Indicators

There are several potential pathways through which the Project could result in effects on Surface Water Quality. Potential effects pathways start with project activities (e.g., mine water discharge, seepage, runoff, atmospheric deposition, and instream works), which can cause changes to surface water chemistry that affect downstream values. It could also be subject to the general prohibitions of the Fisheries Act Section 36(3) and Schedule 4 of the MMER.

Changes to Surface Water Quality is a pathway of effect for the following other VCs:

- Sediment Quality;
- Aquatic Resources;
- Fish and Fish Habitat;
- Vegetation and Ecosystems;
- Wildlife; and
- Human Health.

Intermediate Components (ICs) represent the pathway of potential effect between a Project component or activity and a VC. Groundwater Quality is an ICs that is linked to Surface Water Quality.

Table 13.3-2: Assessment Endpoints and Measurement Indicators for Surface Water Quality

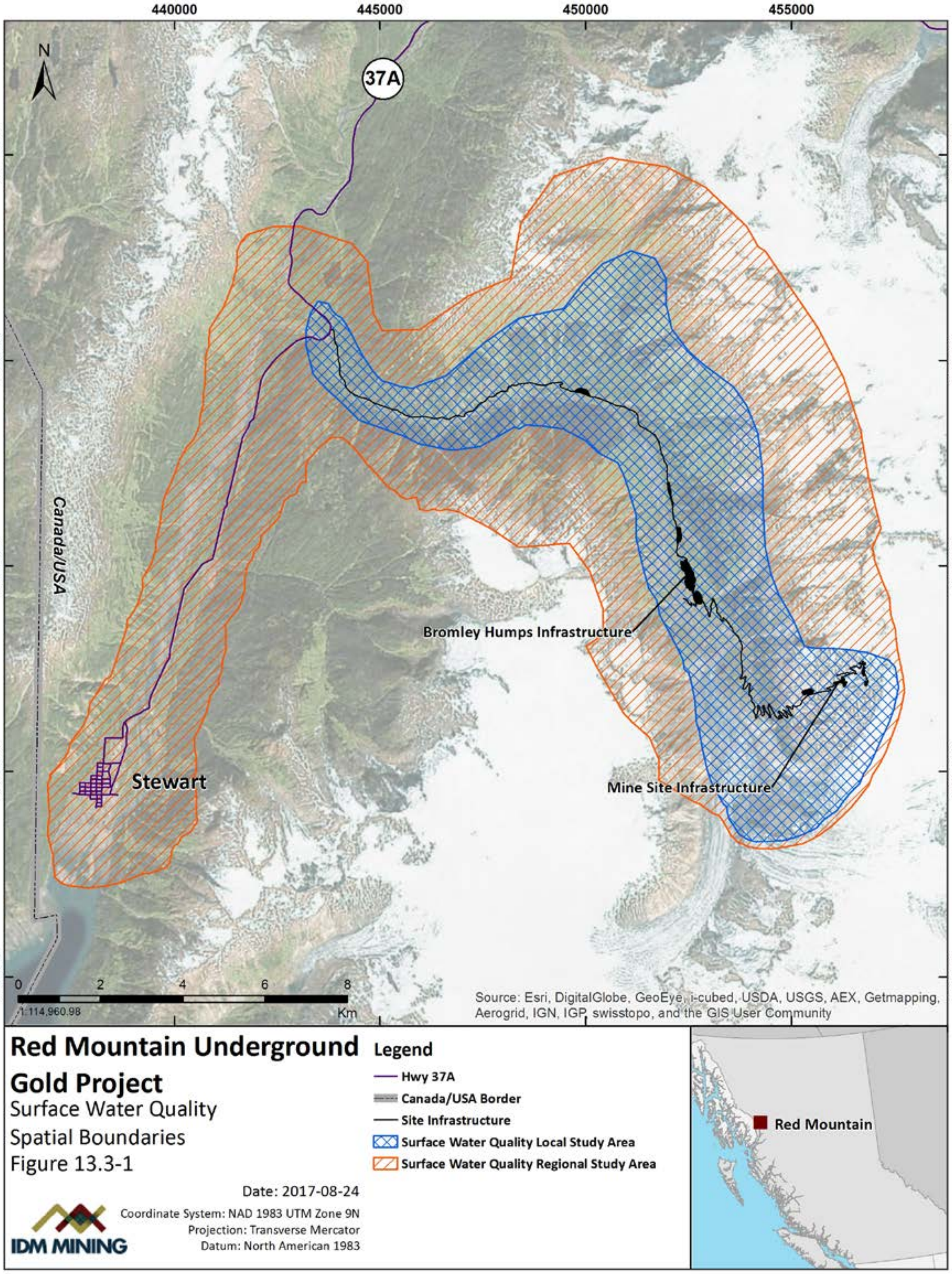
Primary Measurement Indicators	Assessment Endpoints
Change in parameter concentrations compared to baseline and provincial or federal guidelines for freshwater aquatic life. These include dissolved metals; anions / nutrients; alkalinity / acidity; total suspended solids; pH; conductivity and temperature. Total metals are not considered for reasons explained in Volume 8, Appendix 14-C.	• Maintenance of the quality of water in the receiving environment. • Maintenance of other VCs that are influenced by surface water quality.

13.3.4 Assessment Boundaries

13.3.4.1 Spatial Boundaries

The spatial boundaries for assessment of the Surface Water Quality VC consist of two spatial boundaries: the Local Study Area (LSA) and the Regional Study Area (RSA). The study area boundaries were based on the likely geographic extent of potential direct and indirect effects to Surface Water Quality from the Project (Figure 13.3-1). The LSA encompasses the zone of influence of the Project, covering the area within which there is a reasonable potential for adverse Project-specific effects to occur. For Surface Water Quality, the LSA includes the Bitter Creek watershed up to the Bromley glacier. The RSA is larger, and provides context for the assessment of potential Project effects. The RSA was used for assessment of direct and indirect Project effects and for assessment of potential cumulative effects. The RSA surrounds the LSA, and also contains portions of the Bear River watershed, from American Creek to Stewart and the northern end of the Portland Canal.

Figure 13.3-1: Local and Regional Study Areas for Surface Water Quality



13.3.4.2 Temporal Boundaries

The temporal boundaries for Surface Water Quality VC has been defined as "Life of Project", which covers the period from Construction through to the Post-Closure Phase of the Project (Table 13.3-3). These boundaries capture the time periods within which a reasonable expectation of interaction with components of the freshwater environment can be predicted.

Table 13.3-3: Temporal Boundaries for the Effects Assessment of Surface Water Quality

Phase	Project Year	Length of Phase	Description of Activities
Construction	Year -2 to Year 1	18 months	Construction activities and construction of: Access Road, Haul Road, Powerline, declines, power supply to the underground, water management features, water treatment facilities, Tailings Management Facility (TMF), Process Plant, ancillary buildings and facilities; underground lateral development and underground dewatering; ore stockpile and ore processing start-up; and receiving environmental monitoring.
Operation	Year 1 to Year 6	6 years	Ramp up to commercial ore production and maintain a steady state of production, underground dewatering, tailings storage, water treatment, gold dore shipping, environmental monitoring, and progressive reclamation.
Reclamation and Closure	Year 7 to Year 11	5 years	Underground decommissioning and flooding; decommissioning of infrastructure at portals, Process Plant, TMF, ancillary buildings and facilities; reclamation, water treatment; removal of water treatment facilities.
Post-Closure	Year 12 - 21	10 years	Receiving environment monitoring to ensure closure objectives are satisfied.

13.3.4.3 Administrative and Technical Boundaries

Administrative boundaries refer to the limitations imposed on the assessment by political, economic, or social constraints, and consider the jurisdiction in which the Project is located. The Project falls within the resource management area boundaries of DFO's Pacific Region, BC MFLNRO's Skeena Region (Region 6), and the Regional District of Kitimat-Stikine.

The Project is located within the Nass Area and Nass Wildlife Area, as set out in Nisga'a Final Agreement (NFA). Pursuant to the NFA, Nisga'a Nation, as represented by NLG, has Treaty rights to the management and harvesting of fish, wildlife, and migratory birds within the Nass Area and Nass Wildlife Area. The Project is also within the asserted traditional territories of Tsetsaut Skii km Lax Ha (TSKLH) and Métis Nation BC (MNBC).

Technical boundaries refer to the constraints imposed on the assessment by limitations in the ability to predict the effects of a Project. Technical boundaries for the assessment of potential effects to Surface Water Quality include:

- Limitations in current knowledge;
- Limitations imposed by the constraints of the data collection methods, study design, and data coverage; and
- Assumptions required in the predictive models, specifically the Water and Load Balance Model Report (Appendix 14-C).

13.4 Existing Conditions

13.4.1 Overview of Existing Conditions

The Project area is characterized by rugged, steep terrain with weather conditions typical of the northern coastal mountains. The deposit is under the summit of Red Mountain at elevations ranging between 1,600 and 2,000 meters above sea level (masl). Temperatures are moderated year-round by the coastal influence. The mean annual air temperature (MAAT) at an elevation of 1514 meters is −0.8°C, with monthly mean values ranging between −6.4°C in December and January and 6.9°C in August (Appendix 12-A: Baseline Climate and Hydrology Report). Precipitation is significant throughout the year; October is typically the wettest month and there is significant snow accumulation in the winter (JDS 2016). The snowfall, steep terrain, and frequently windy conditions present blizzard and avalanche hazards during the winter (JDS 2016). The climatic conditions at the Project site are described in Appendix 12-A.

A deactivated logging road extends from Highway 37A for approximately 13 km along the Bitter Creek valley; however, it is currently impassable for heavy equipment due to washouts caused by Bitter Creek, and at other creek crossings (JDS 2016).

The proposed underground mine is situated at the top of the Red Mountain cirque, a short, westerly trending hanging valley above the Bromley Glacier. The cirque is drained by Goldslide Creek. Goldslide Creek flows southwest into the east side of Bromley Glacier, which extends about 1 km to the Bitter Creek headwaters. Flows in Goldslide Creek peak during freshet (typically in June) and Goldslide Creek is not glacially-influenced. Goldslide and Rio Blanco Creeks are the two uppermost tributaries to Bitter Creek. Other Bitter Creek tributaries relevant to the baseline Surface Water Quality evaluation are Otter Creek and Roosevelt Creek. Otter Creek is glacially-influenced and its discharge peaks during summer (typically in July) because of glacial melt. The winter low flow period in Otter Creek is from November to April. Like Otter Creek, Bitter Creek is glacially-influenced and its flows peak in summer (typically in July), and are low during November to April. Bitter Creek is a tributary to the Bear River, which then discharges into the Portland Canal, near Stewart (Figure 13.3-1). Flows peak in summer (July/August) in Bear River.

The Project is composed of two main areas with interconnecting access roads (Figure 13.4-1): the Mine Site with an underground mine and three portals (Upper Portal, Lower Portal and Vent Portal) at the upper elevations of Red Mountain (1,950 metres above sea level [masl]) (). The second main area, Bromley Humps is situated in the Bitter Creek valley (500 masl) and is comprised of a Process Plant, supporting infrastructure and TMF (Figure 13.4-3).

Figure 13.4-1: Project Components - Overview

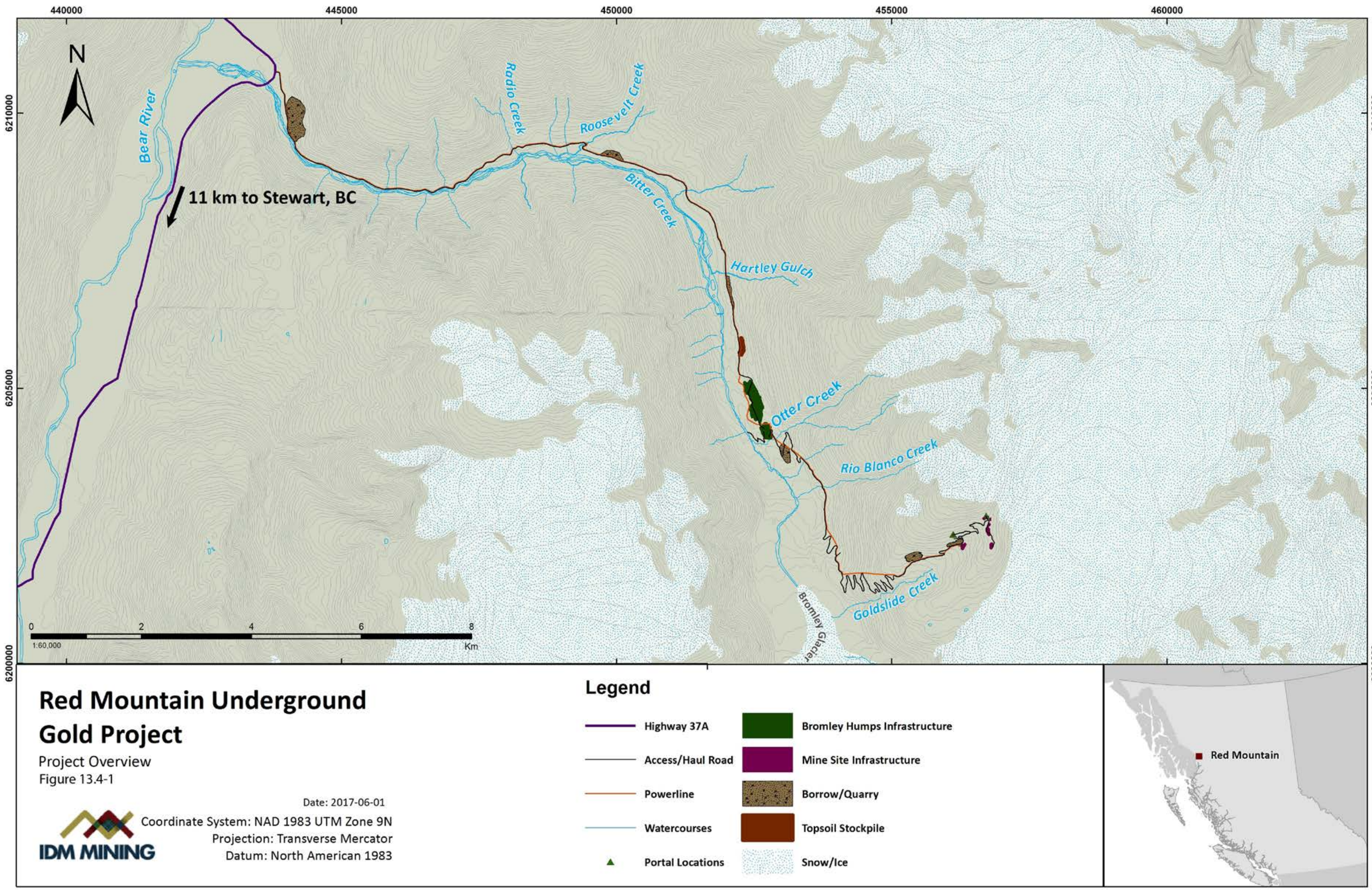


Figure 13.4-2: Project Components – Mine Site

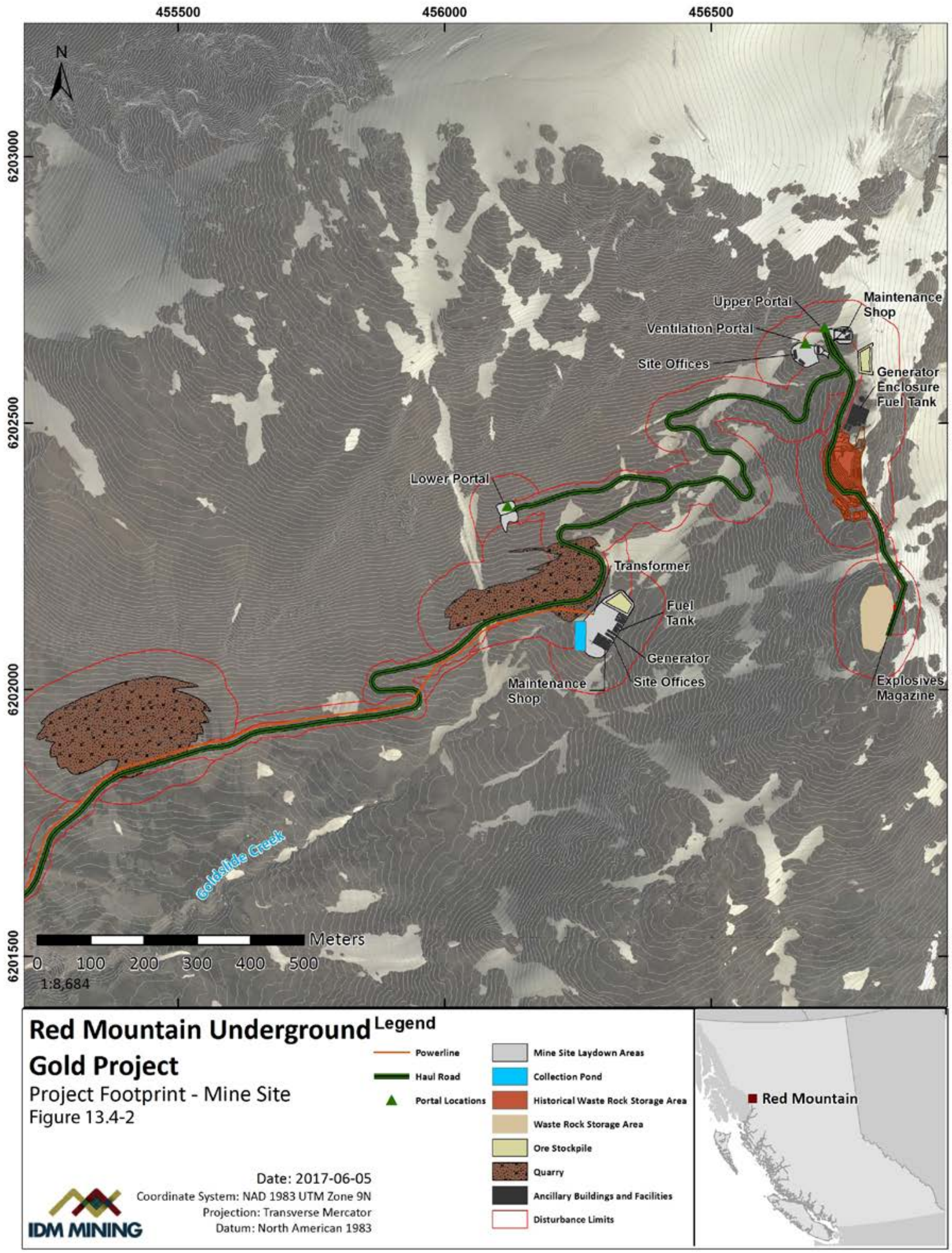
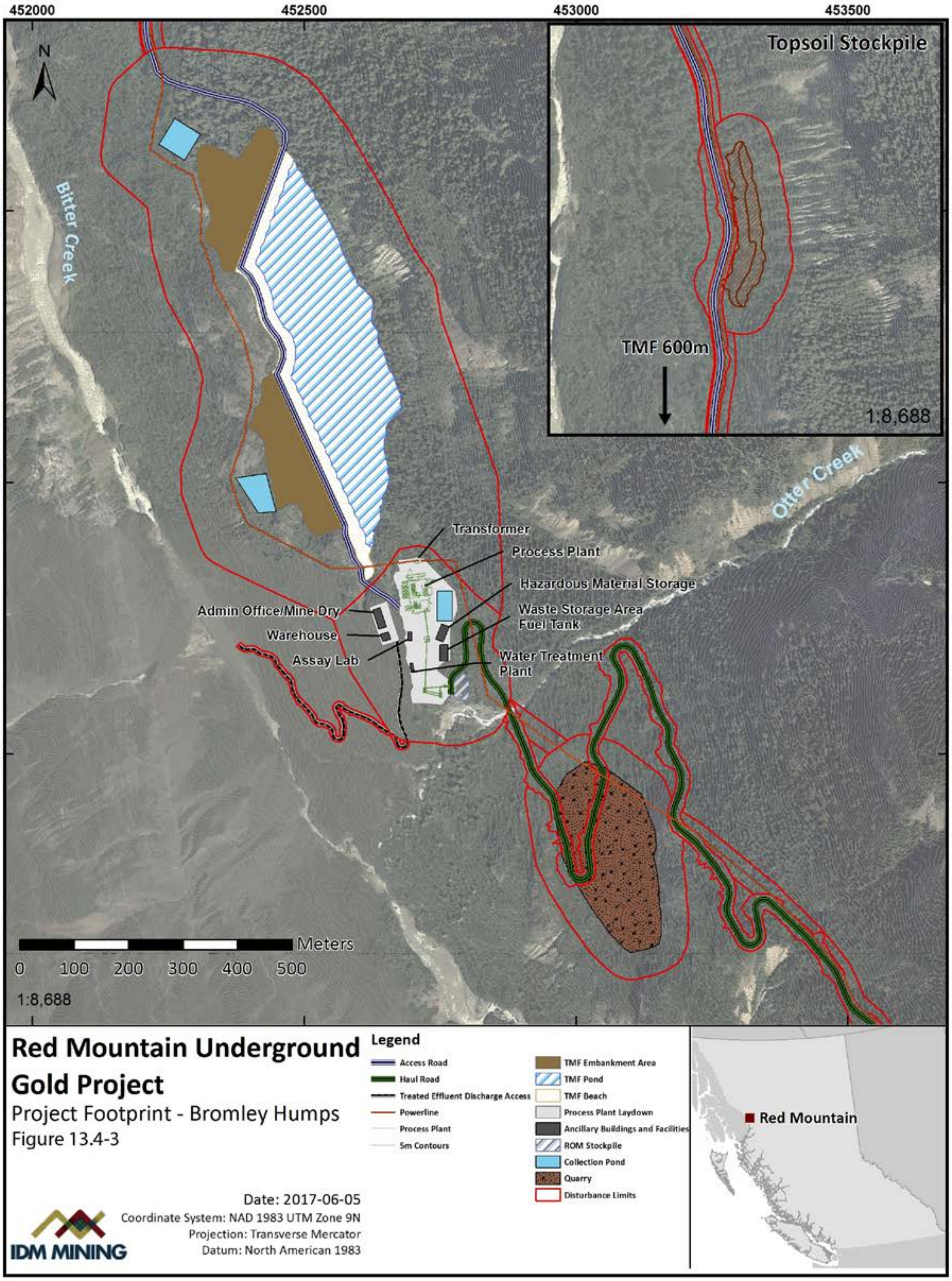


Figure 13.4-3: Project Components – Bromley Humps



13.4.2 Past and Current Projects and Activities

Placer mining commenced in Bitter Creek at the base of Red Mountain at the turn of the 20th century. In 1989, gold mineralization was discovered and surface drilling was conducted from 1991 to 1994.

Existing infrastructure on the site includes an underground decline and drift development that was developed in 1993 and 1994 for bulk sampling the mineralized Marc zone, a 50,000 tonne (t) waste rock pile, a surface tote road network, camp buildings, helipads, and used mobile equipment (JDS 2016).

Current activities include environmental baseline studies in the Bitter Creek watershed and between 2015 and 2017, a surface and underground drilling program at Red Mountain. This included the dewatering of the underground decline and obtaining material for engineering and resource estimate studies.

The dewatering program is the only significant anthropogenic activity that may have resulted in a human-caused alteration to the environmental setting of the project, and specifically surface water quality, prior to the changes that may occur as a result of the proposed Project or other project and/or activities in the area.

The discharge water from dewatering has been pumped to the Cambria Icefield and followed an eight-kilometer pathway before entering the headwaters of Bitter Creek, formed by Bromley Glacier meltwater (2016 Annual Monitoring Report (IDM, 2017)). Natural flow rates in Bitter Creek are much higher than the pumped discharge (for example, flow volumes in Bitter Creek in August 2015 were estimated at 65 m^3/s, 590 times greater than the estimated maximum rate of discharge from the underground workings (0.11 m^3/s).

Water quality monitoring during the dewatering program was conducted at BC08 (referred to as “CP2” in 2016 Dewatering Report (IDM, 2017)). The monitoring results indicated that the mine discharge has not had an effect on water quality in Bitter Creek, as there were no fluctuations in water quality parameters outside of natural variability. Dissolved metals concentrations at BC08 were well below provincial water quality thresholds, except for aluminum levels, which are naturally elevated in Bitter Creek.

13.4.3 Project-Specific Baseline Studies

13.4.3.1 Data Sources

The baseline studies included detailed review of historical and background information, data gap analysis, and field surveys. Initial baseline field surveys on Surface Water Quality were conducted in the 1990s (HKP 1992; Rescan 1995; and Royal Oak 1998), limited monitoring was conducted in 2000 (SRK 2001) and additional monitoring was conducted between 2003 and 2013 (SRK, 2004-2014) to address reclamation and permit requirements. The current baseline programs to support the Application/EIS were carried out from 2014 to 2016 (Appendix 14-A). Specific data collection programs including sampling agency and analytical laboratories used are provided in Table 13.4-1.

Table 13.4-1: Summary of Baseline Water Quality Sampling for the Red Mountain Project, 1990-2016

Year	1990-1992	1993-1994	1996-1997	2000	2003-2013	2014-2016
Sampling Agency	HKP	Rescan	Royal Oak	SRK	SRK	SRK (and Avison)*
Sampling Purpose	Baseline Monitoring for Bond Gold, then Lac Minerals	Baseline Monitoring for Lac Minerals	Baseline Monitoring for Royal Oak	Limited Baseline Monitoring for NAMC	Annual Monitoring for Reclamation permit requirements for Seabridge	Baseline Monitoring for Red Mountain
Analytical Lab	ASL	ERI	ERI	ALS	ALS	ALS
Parameters Analyzed	General Chemistry, Total and Dissolved Metals	General Chemistry, Total and Dissolved Metals	General Chemistry, Total and Dissolved Metals	General Chemistry, Total and Dissolved Metals	General Chemistry, Dissolved Metals	General Chemistry, anions, nutrients, total and dissolved metals, cyanides
Streams Sampled	Bear Creek, Bitter Creek, Goldslide Creek	Bitter Creek, Goldslide Creek, Rio Blanco Creek, Rio Blanco Bitter Valley, Roosevelt Creek	Bitter Creek, Goldslide Creek, Rio Blanco Creek, Roosevelt Creek	Bitter Creek, Goldslide Creek, Rio Blanco Creek, Roosevelt Creek	Goldslide Creek, Bitter Creek, underground mine pool	American Creek, Bitter Creek, Bear River, Goldslide Creek, Otter Creek, Roosevelt Creek, Rio Blanco Creek

*All field sampling was carried out by Avison Management Services Ltd.

13.4.3.2 Primary Data Collection and Analysis Methods

This section describes the baseline sampling areas, field sampling methods, laboratory analysis and data analysis (guideline screening).

Sampling Locations

Water quality sampling locations cover all areas that could be affected by the proposed construction, operation, and closure of the mine, including upstream and downstream of potential mine influences, as well as locations farther afield where downstream and/or cumulative effects could be assessed. The receiving watersheds in the monitoring program are Goldslide Creek, Rio Blanco Creek, Bitter Creek, and Bear River and the control watersheds are Roosevelt Creek, Otter Creek and American Creek. The current monitoring sites are as close to historical sites as possible, which allows the historical results to supplement the current water quality results. Refer to Figures 3-1 to 3-4 in Appendix 14-A for detailed baseline monitoring location maps. Listed below are the watercourses and associated sampling locations and reference sampling location.

13.4.3.2.1 Goldslide Creek

Goldslide Creek, the uppermost tributary of Bitter Creek, drains the cirque in which the proposed mine will be located. The creek drains directly into Bromley Glacier and is within a very steep gradient cirque strongly influenced by seasonal fluctuations in flow (Rescan, 1995). The highest flows are recorded during freshet months, typically in June, and the creek is not influenced by nearby glacier melt.

The four Goldslide Creek monitoring locations (GSC02, GSC05, GSC07, and CGS09) are all downstream of the proposed mining facilities. There is no upstream reference site on Goldslide Creek because of the existing development throughout the cirque and the steep topography.

13.4.3.2.2 Otter Creek

Otter Creek is a small alpine creek flowing west that drains into Bitter Creek downstream of the Rio Blanco and Bitter Creek confluence. The flow in Otter Creek is influenced both by freshet and glacial melt.

Otter Creek has three reference monitoring locations upstream of this location (OC04, OC05, and OC06) and one monitoring location (OC07) downstream of Bromley Humps.

13.4.3.2.3 Bitter Creek

Bitter Creek receives glacial melt from Bromley Glacier and the Cambria Ice Field and freshet flows from various tributaries including Goldslide Creek, Otter Creek, Rio Blanco Creek, and Roosevelt Creek. Bitter Creek discharges into Bear River.

Bitter Creek monitoring locations (BC02, BC04, BC06, and BC08) are all downstream of the proposed mining facilities. BC08 is upstream of Bromley Humps. There are no monitoring locations on Bitter Creek upstream of the Goldslide Creek confluence and thus no upstream reference location, because the creek is overlain by Bromley Glacier at, and, upstream of Bitter Creek’s confluence with Goldslide Creek.

13.4.3.2.4 Bear River

Bear River is the receiving water for all runoff from the proposed mine site. Bitter Creek drains into the Bear River, which flows past the town of Stewart, BC, and into the Portland Canal.

Bear River has one monitoring location upstream of the confluence with Bitter Creek (BR08) and two monitoring locations downstream of the confluence, BR06 and BR03 near the town of Stewart, BC.

13.4.3.2.5 Rio Blanco Creek

Reference monitoring locations were established along Rio Blanco Creek. Rio Blanco Creek runs parallel to Goldslide Creek and the monitoring location RBC02 on the lower Rio Blanco Creek is a reference monitoring location for lower Goldslide Creek (GSC02).

13.4.3.2.6 American Creek and Roosevelt Creek

Reference monitoring locations along American Creek (AC02) and Roosevelt Creek (RC02) were established for fisheries and aquatics work.

13.4.3.3 Field Sampling

The surface water quality samples were taken following the British Columbia Field Sampling Manual (MWLAP 2013) to the best of the field personnel ability and considering safety.

During each site visit, field parameters were collected *in-situ* or from a separate sub-sample and included temperature, conductivity, specific conductivity, dissolved oxygen, oxidation-reduction potential (ORP), pH and turbidity. All sampling was conducted by qualified personnel, with a minimum of one crew member having significant water quality sampling experience.

13.4.3.4 Laboratory Analyses

Samples bottles were obtained from ALS Laboratory in Burnaby, BC and were pre-cleaned to avoid cross-contamination in the field. Filtering and preservation was done by ALS, upon arrival at the testing laboratory. Samples were transported to the lab using receiving laboratory best practices to maintain sample quality.

Samples were analyzed for the following parameters:

- Physical parameters: colour, conductivity, hardness, pH, total suspended solids (TSS), total dissolved solids (TDS), and turbidity;

- Anions and nutrients: acidity, bicarbonate alkalinity, carbonate alkalinity, hydroxide alkalinity, phenolphthalein alkalinity, total ammonia, bromide, chloride, fluoride, nitrate, nitrite, total Kjeldahl nitrogen, dissolved orthophosphate, total phosphorus, total dissolved phosphorus, and sulphate;

- Total and dissolved organic carbon; and

- Total and dissolved metals: aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silicon, silver, sodium, strontium, thallium, tin, titanium, uranium, vanadium, and zinc.

13.4.3.5 Historical Data and Outliers

The baseline presented for surface water quality integrates both historical (1990-2013) and the current (2014-2016) sampling programs. Historic sampling methods are summarized in Table 13.4-1 and detailed in Appendix 14-A. Extensive review of the historical data was undertaken before supplementing the results from the current baseline monitoring program. Historical data for some water quality parameters were removed from the dataset used to calculate Project baseline summary statistics. This was due to higher laboratory detection limits than current detection limits or in some cases, parameters were not measured historically (i.e. total and dissolved bismuth, silicon, strontium and tin).

13.4.3.6 Relevant Guidelines

Baseline data were compared against a number of federal and provincial freshwater aquatic life water quality guidelines (Table 13.4-2) including the following:

- BC Approved Water Quality Guidelines, BC Ministry of Environment;
- BC Working Water Quality Guidelines, BC Ministry of Environment; and
- Canadian Water Quality Guidelines for the Protection of Aquatic Life. Canadian Council of Ministers of the Environment (CCME).

CCME and BC WQG provide a short-term guideline, a long-term average guideline, or both. The short-term guidelines are to be applied over a short period of time (several days) or to individual samples. The long-term guideline is based upon the average concentrations of samples collected over a period of time (typically 30 days). Baseline results were compared to both Provincial and Federal guidelines. Technically, the CCME guidelines are only applicable for total metals and most of the BC WQGs are also only for total metals. However, due to the high TSS measured in many of the samples at this site, results for dissolved metals are also compared to these guidelines for reference.

Table 13.4-2: Water Quality Guidelines for Freshwater Aquatic Life

Analyte	Unit	BCWQG			CCME		
		Long Term		Short Term	Long Term		Short Term
pH	S.U.	6.5 to 9		6.5 to 9	6.5 to 9		6.5 to 9
Alkalinity[3]	mg/L	Ca-D < 4 mg/L	10				
		Ca-D 4-8 mg/L	10-20				
		Ca-D >8 mg/L	>20				
Chloride	mg/L	150		600	120		640
Fluoride	mg/L	Hardness ≤ 10 mg/L	0.4		0.12		
		Hardness > 10 mg/L	[51.73+92.57log 10 (hardness)]*0.01				
Sulphate	mg/L	0 mg/L < Hardness ≤ 30 mg/L	128				
		30 mg/L < Hardness ≤ 75 mg/L	218				
		75 mg/L < Hardness ≤ 180 mg/L	309				
		180 mg/L < Hardness ≤ 250 mg/L	429				
Nitrate Nitrogen	mg/L	3		32.8	3		124
Nitrite Nitrogen	mg/L	0.02		0.06	0.06		
Ammonia Nitrogen	mg/L	Temperature and pH dependent; assumed $15^{o}C$			Temperature and pH dependent; assumed $15^{o}C$		
Aluminum, Total	mg/L				pH < 6.5	0.005	
					pH ≥ 6.5	0.1	

Analyte	Unit	BCWQG				CCME		
		Long Term		Short Term		Long Term		Short Term
Aluminum, Dissolved	mg/L	pH < 6.5	e^[1.6-3.327 (median pH)+0.402(median pH)^2]	pH < 6.5	e^[1.209-2.426(pH)+ 0.286(pH)^2]			
		pH ≥ 6.5	0.05	pH ≥ 6.5	0.1			
Antimony, Total[3]	mg/L	9						
Arsenic, Total	mg/L	0.005				0.005		
Barium, Total[3]	mg/L	1						
Beryllium, Total	mg/L	0.00013						
Boron, Total	mg/L	1.2				1.5		29
Cadmium, Total	mg/L					10^[0.83log(hardness)-2.46]		10^[1.016log(hardness)-1.71]
Cadmium, Dissolved	mg/L	e^[0.736*ln(hardness)-4.943]/1000		e^[1.03*ln(hardness)-5.274]/1000				
Chromium, hexavalent (Cr(VI))	mg/L					0.001		
Chromium, trivalent (Cr(III))	mg/L					0.0089		
Cobalt, Total	mg/L	0.004		0.11				
Copper, Total	mg/L	Hardness ≤ 50 mg/L	0.002	(0.094*hardness +2)/1000		Hardness < 82 mg/L	0.002	
		Hardness > 50 mg/L	0.04 * hardness			82 mg/L ≤ Hardness ≤ 180	(0.2*e^[0.8545ln(hardness) 1.465])/1000	
						Hardness > 180 mg/L	0.004	
Iron, Total	mg/L	1				0.3		
Iron, Dissolved	mg/L	0.35						
Lead, Total	mg/L	Hardness ≤ 8 mg/L		Hardness ≤ 8 mg/L	0.003			
		Hardness > 8 mg/L	(3.31+e^[1.273ln (hardness)-4.704)/1000	Hardness > 8 mg/L	(e^[1.273ln (hardness)1.46]) /1000			

Analyte	Unit	BCWQG				CCME		
		Long Term		Short Term		Long Term		Short Term
Manganese, Total	mg/L	0.0044*hardness + 0.605						
Mercury, Total[2]	ug/L	0.0001/(MeHg/ total Hg)				0.026		
Molybdenum, Total	mg/L	1		2		0.073		
Nickel, Total[3]	mg/L	Hardness ≤ 60 mg/L	0.025			Hardness ≤ 60 mg/L	0.025	
		60 mg/L < Hardness ≤ 180 mg/L	0.11			60 mg/L < Hardness ≤ 180 mg/L	(e^[0.76ln(hardness)+1.06]) /1000	
		Hardness > 180 mg/L	0.15			Hardness > 180 mg/L	0.15	
Selenium, Total	mg/L	0.002				0.001		
Silver, Total	mg/L	Hardness ≤ 100 mg/L	0.00005	Hardness ≤ 100 mg/L	0.0001	0.00025		
		Hardness > 100 mg/L	0.0015	Hardness > 100 mg/L	0.003			
Thallium, Total[3]	mg/L	0.0008				0.0008		
Uranium, Total[3]	mg/L	0.0085				0.015		0.033
Zinc, Total	mg/L	Hardness ≤ 90 mg/L	0.0075	Hardness ≤ 90 mg/L	0.033			
		Hardness > 90 mg/L	(7.5+0.75(hardness-90))/1000	Hardness > 90 mg/L	(33+0.75(hardness-90))/1000			
Zinc, Dissolved	mg/L					0.03		

Notes

[1] Water quality guidelines that are dependent on pH or hardness were determined independently for each water quality monitoring station. The most conservative guideline was used for every sample collected.

[2] The BC water quality guideline is based on the proportion of methyl mercury to total mercury.

[3] The BC water quality guideline is a working guideline and has not yet been approved.

13.4.4 Baseline Characterization

Table 13.4-3 lists water quality monitoring site locations and rational for inclusion. Figure 13.4-4 shows the water quality sites in relation to the Project.

Monitoring locations covered in the LSA include the following sites: BC02, BC04, BC06, and BC08 (Bitter Creek); GSC02, GSC05, GSC07, and GSC09 (Goldslide Creek); and OC04, OC05, and OC07 (Otter Creek).

Monitoring locations covered in the RSA include those in the LSA plus the following sites: BR08 BR06, BR03 (Bear River); AC02 (American Creek); RBC02 (Rio Blanco Creek); and RC02 (Roosevelt Creek).

Generally, the downstream Bear River monitoring location has significantly higher TSS and higher concentrations of TDS, sulphate, and total and dissolved metals compared to the upstream monitoring location. Both locations are circumneutral and both are dominated by calcium and bicarbonate. Rio Blanco Creek, the reference watershed for Goldslide Creek and Otter Creek, has a higher pH than Goldslide Creek and a lower pH than Otter Creek. Rio Blanco has significantly higher TSS than Goldslide and somewhat similar TSS to Otter. Rio Blanco has higher TDS, sulphate, and alkalinity than Goldslide and lower TDS, sulphate, and alkalinity than Otter. Rio Blanco has significantly higher total aluminum and total iron concentrations compared to both Goldslide and Otter Creeks.

Table 13.4-3: Baseline Surface Water Monitoring Locations and Descriptions

Watershed	Location	Description of Monitoring Location	Rationale for Inclusion
American Creek	AC02	Lower American Creek	Reference watershed for fisheries and aquatics
Bitter Creek	BC02	Lower Bitter Creek, near the Highway 37A bridge	Receiving watershed
	BC04	Middle Bitter Creek, upstream of the Roosevelt Creek confluence	Receiving watershed
	BC06	Middle Bitter Creek, downstream of the Otter Creek confluence	Receiving watershed
	BC08	Upper Bitter Creek, downstream of the Goldslide Creek confluence and the Bromley Glacier	Receiving watershed
Bear River	BR03	Bear River, Bitter Creek confluence, near the town of Stewart	Receiving watershed Monitoring far downstream effects
	BR06	Bear River, downstream of the Bitter Creek confluence	Receiving watershed Monitoring far downstream effects
	BR08	Bear River, upstream of the Bitter Creek confluence	Upstream reference location for receiving watershed
Goldslide Creek	GSC02	Lower Goldslide Creek, below the existing exploration camp	Receiving watershed
	GSC05 /GSC99[1]	Middle Goldslide Creek, near the existing exploration camp	Receiving watershed

Watershed	Location	Description of Monitoring Location	Rationale for Inclusion
	GSC07	Upper Goldslide Creek, upstream of the confluence with tributary	Receiving watershed
	GSC09	Tributary of Upper Goldslide Creek, drains area above and around the portal	Receiving watershed
Otter Creek	OC04 /OC06[2]	Upper Otter Creek, southern branch of creek	Upstream reference location for receiving watershed
	OC05	Middle Otter Creek, northern branch of creek	Upstream reference location for receiving watershed
	OC07	Lower Otter Creek, downstream of the proposed mill	Potential Receiving watershed*
Rio Blanco Creek	RBC02	Lower Rio Blanco Creek	Reference watershed for Goldslide Creek
Roosevelt Creek	RC02	Lower Roosevelt Creek	Reference watershed for fisheries and aquatics

Note:
GSC99 is an alternate winter sampling site for GSC05, which is sometimes covered by drifting snow.
GSC99 is approximately 80 m upstream and is clear during the winter.
OC06 on the southern branch of Otter Creek is an alternate sampling site for OC04 when snowpack at
OC04 makes it inaccessible
*Otter Creek is not a receiving watershed based on current project description

Figure 13.4-4: Water Quality Sampling Sites

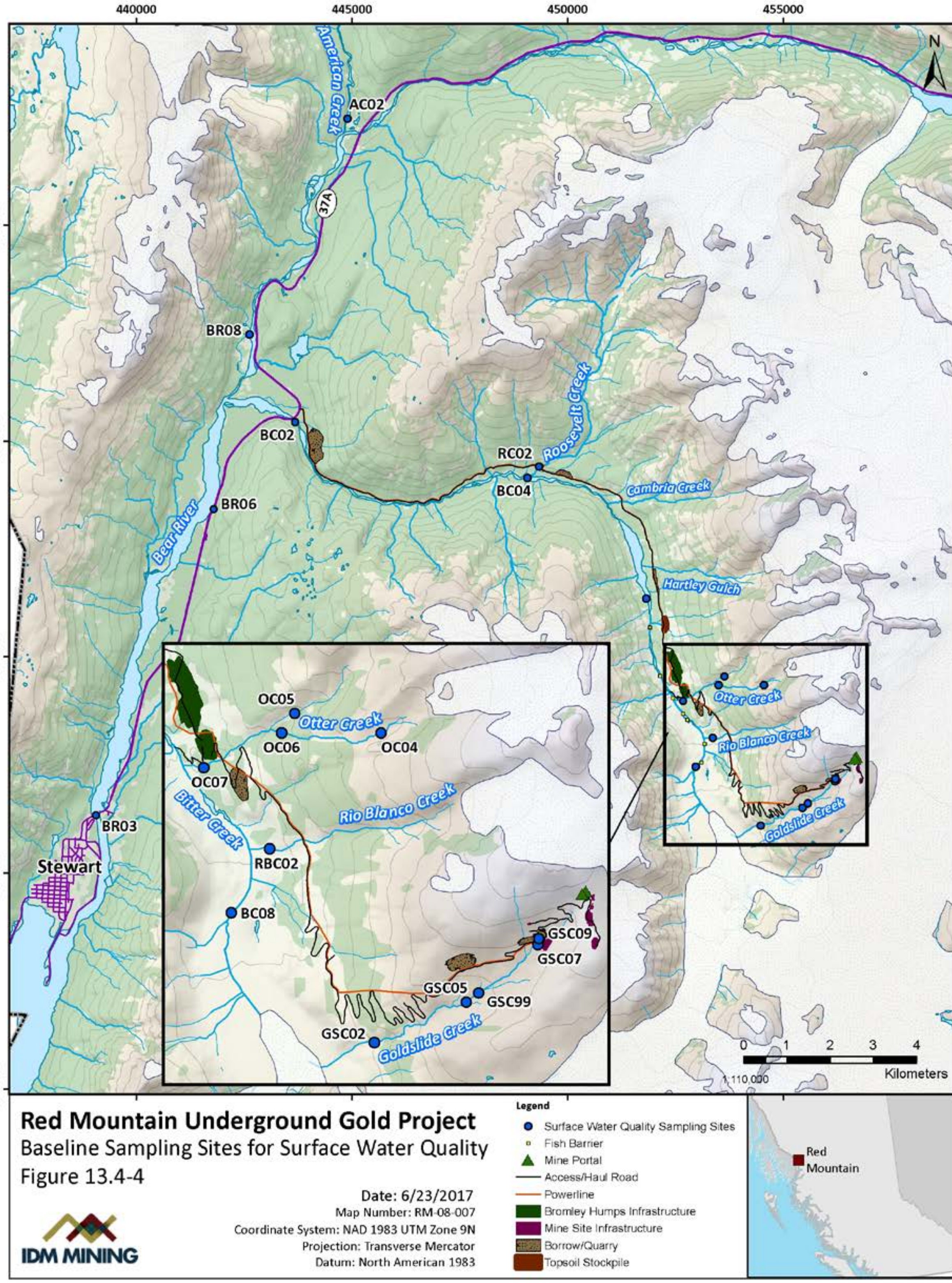


Table 13.4-4 summarizes the exceedances of BC and CCME water quality guidelines for all the baseline sampling sites for surface water quality. Note that results for both total and dissolved metals were compared to the guidelines even though most guidelines are applicable for total, or in some cases, dissolved metals. Full details are discussed in Appendix 14-A and briefly summarized below.

- In Goldslide Creek, BC and CCME water quality guidelines were exceeded for total and dissolved, cadmium, copper and zinc for nearly all samples that were collected. Total and dissolved aluminum exceeded guidelines in upper Goldslide Creek in all samples collected.
- In Otter Creek, guidelines were frequently exceeded for total aluminum, total iron and total and dissolved selenium.
- In Bitter Creek, guidelines were frequently exceeded for total aluminum, arsenic, beryllium, cadmium, cobalt, copper, iron, lead, nickel, selenium, silver and zinc, and dissolved aluminum and selenium.
- In Bear River, guidelines were frequently exceeded for total aluminum, copper, iron, lead, silver and zinc.
- In the reference creeks, Rio Blanco Creek, Roosevelt Creek, and American Creek, exceedances were similar to Goldslide and Otter Creeks, which included total aluminum, copper, iron, selenium and zinc.

IDM is not aware of any current users of surface water for drinking water purposes. Based on the current water quality, it is unlikely that surface water is potable, and there is very low potential for future uses as drinking water.

Table 13.4-4: Exceedance of Guidelines for All Sites

Parameter	GSC09	GSC02	GSC05	GSC07	OC04	OC05	OC07	BC02	BC04	BC06	BC08	BR03	BR06	BR08	RBC02	RC02	AC02
pH	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Fluoride	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	3 of 11	1 of 11	0 of 21	0 of 21	0 of 9	1 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Sulphate	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Aluminum T	8 of 8	4 of 12	1 of 17	1 of 11	12 of 15	7 of 11	6 of 11	20 of 21	21 of 21	9 of 9	18 of 19	6 of 8	18 of 21	16 of 21	14 of 20	14 of 19	14 of 19
Aluminum D	8 of 8	1 of 12	0 of 17	0 of 11	3 of 15	1 of 11	1 of 11	13 of 21	13 of 21	7 of 9	14 of 19	4 of 8	13 of 21	9 of 21	4 of 20	3 of 19	3 of 19
Antimony T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Antimony D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Arsenic T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	16 of 21	16 of 21	7 of 9	15 of 19	4 of 8	15 of 21	2 of 21	3 of 20	0 of 19	0 of 19
Arsenic D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Cadmium T	8 of 8	12 of 12	17 of 17	11 of 11	1 of 15	11 of 11	2 of 11	16 of 21	16 of 21	9 of 9	16 of 19	5 of 8	15 of 21	8 of 21	19 of 20	0 of 19	1 of 19
Cadmium D	8 of 8	12 of 12	17 of 17	11 of 11	0 of 15	4 of 11	0 of 11	1 of 21	1 of 21	2 of 9	2 of 19	0 of 8	0 of 21	0 of 21	19 of 20	0 of 19	0 of 19
Calcium T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Calcium D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Chromium T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Chromium D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Cobalt T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	12 of 21	13 of 21	7 of 9	11 of 19	3 of 8	7 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Cobalt D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Copper T	8 of 8	11 of 12	13 of 17	11 of 11	3 of 15	1 of 11	2 of 11	16 of 21	17 of 21	8 of 9	16 of 19	5 of 8	16 of 21	7 of 21	12 of 20	6 of 19	7 of 19
Copper D	8 of 8	9 of 12	10 of 17	11 of 11	0 of 15	0 of 11	0 of 11	0 of 21	1 of 21	1 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Iron T	0 of 8	1 of 12	1 of 17	0 of 11	8 of 15	7 of 11	6 of 11	17 of 21	17 of 21	8 of 9	17 of 19	5 of 8	16 of 21	15 of 21	8 of 20	10 of 19	12 of 19
Iron D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	1 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Lead T	0 of 8	0 of 12	0 of 17	0 of 11	1 of 15	0 of 11	0 of 11	11 of 21	12 of 21	7 of 9	12 of 19	3 of 8	10 of 21	5 of 21	0 of 20	0 of 19	1 of 19
Lead D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Manganese T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	2 of 21	1 of 21	1 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Manganese D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Mercury T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	1 of 21	1 of 21	1 of 9	0 of 19	0 of 8	0 of 21	1 of 21	0 of 20	1 of 19	0 of 19
Mercury D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Molybdenum T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Molybdenum D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Nickel T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	1 of 11	0 of 11	15 of 21	3 of 21	1 of 9	0 of 19	3 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Nickel D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	1 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19

Parameter	GSC09	GSC02	GSC05	GSC07	OC04	OC05	OC07	BC02	BC04	BC06	BC08	BR03	BR06	BR08	RBC02	RC02	AC02
Selenium T	0 of 8	11 of 12	16 of 17	1 of 11	5 of 15	10 of 11	10 of 11	18 of 21	18 of 21	9 of 9	16 of 19	5 of 8	12 of 21	0 of 21	19 of 20	3 of 19	0 of 19
Selenium D	0 of 8	11 of 12	16 of 17	2 of 11	5 of 15	9 of 11	9 of 11	9 of 21	8 of 21	3 of 9	8 of 19	3 of 8	3 of 21	0 of 21	18 of 20	4 of 19	0 of 19
Silver T	0 of 8	0 of 12	0 of 17	0 of 11	1 of 15	0 of 11	0 of 11	16 of 21	16 of 21	7 of 9	16 of 19	5 of 8	15 of 21	7 of 21	1 of 20	3 of 19	1 of 19
Silver D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Uranium T	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Uranium D	0 of 8	0 of 12	0 of 17	0 of 11	0 of 15	0 of 11	0 of 11	0 of 21	0 of 21	0 of 9	0 of 19	0 of 8	0 of 21	0 of 21	0 of 20	0 of 19	0 of 19
Zinc T	8 of 8	11 of 12	17 of 17	11 of 11	1 of 15	2 of 11	1 of 11	16 of 21	17 of 21	9 of 9	16 of 19	5 of 8	16 of 21	13 of 21	5 of 20	5 of 19	4 of 19
Zinc D	8 of 8	11 of 12	17 of 17	11 of 11	0 of 15	1 of 11	0 of 11	0 of 21	1 of 21	1 of 9	2 of 19	0 of 8	0 of 21	0 of 21	0 of 20	1 of 19	0 of 19

Notes:
1. Values above indicate the number of guideline exceedances per parameter out of the total number of samples collected
2. Guidelines include the short term and long term British Columbia and Federal water quality guidelines for the protection of freshwater aquatic life.

13.5 Potential Effects

13.5.1 Methods

Activities associated with the Project have the potential to cause adverse effects to Surface Water Quality in the immediate and downstream aquatic environments. Effects were assessed in relation to planned discharges, runoff, atmospheric deposition, and instream works for all mine components using project interaction matrices (Section 13.5.2). Once links between mine components and project interactions were identified, key potential effects were discussed in terms of potential pathways of effects to Surface Water Quality (Section 13.5.3).

This effects assessment for Surface Water Quality assumes that all Project activities will occur within the designed scope of the Project. Any potential risk due to spills, equipment malfunctions, emergencies, or accidents are assessed in Accidents and Malfunctions (Volume 3, Chapter 23), and are not discussed any further in this assessment.

13.5.2 Project Interactions

The physical works and activities to be implemented during the Project have the potential to interact with and lead to effects on the Surface Water Quality VC (Table 13.5-1). Evaluation of the interaction matrix led to identification of potential effects (Table 13.5-1).

Table 13.5-1: Potential Project Interactions, Surface Water Quality

Project Component/Activity	Potential Effect / Pathway of Interaction with Surface Water Quality
Construction Phase	
Construct Access Road and Haul Road from Hwy 37A to the Upper Portal	Changes to Surface Water Quality from erosion and sedimentation, ML / ARD, blasting, and dust deposition
Install Powerline from substation tie-in to the Lower Portal laydown area	Changes to Surface Water Quality as a result of erosion and sedimentation, dust deposition
Excavate and secure Lower Portal entrance and access tunnel	Changes to Surface Water Quality from erosion and sedimentation, dust deposition, ML / ARD and/or blasting
Construct Mine Site water management infrastructure including talus quarries and the portal collection pond, dewatering systems, and water diversion, collection and discharge ditches and swales.	Changes to Surface Water Quality from ML / ARD, discharges, erosion and sedimentation and/or dust deposition
Install and fill fuel tanks at Mine Site	Changes Surface Water Quality as result of the storage, handling, and use of chemicals and fuels at the Mine Site, Access Road, and Haul Road; changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition

Project Component/Activity	Potential Effect / Pathway of Interaction with Surface Water Quality
Construct Explosives Magazine	Changes to Surface Water Quality as a result of the manufacture, storage and use of explosives; changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition
Construct other Mine Site ancillary buildings and facilities	Changes to Surface Water Quality as a result of erosion and sedimentation, and/or dust deposition
Discharge of water from underground workings at the Mine Site	Changes to Surface Water Quality as a result of mine water discharge
Initiate underground lateral development and cave gallery excavation	Changes to Surface Water Quality as a result of ML/ARD, blasting, and groundwater interaction
Temporarily stockpile ore at the Mine Site	Changes to Surface Water Quality as a result of erosion and sedimentation, ML/ARD and dust deposition
Transport and deposit waste rock to the Waste Rock Storage Area(s)	Changes to Surface Water Quality as a result of dust deposition
Clear and prepare the TMF basin and Process Plant site pad	Changes to Surface Water Quality as a result of erosion/sedimentation and dust deposition
Excavate rock and till from the TMF basin and local borrows / quarries for construction activities (e.g., dam construction for the TMF)	Changes to Surface Water Quality from erosion and sedimentation, ML / ARD and dust deposition
Establish water management facilities including diversion ditches for the TMF and Process Plant	Changes to Surface Water Quality as a result of ML/ARD, discharges, erosion and sedimentation, and dust deposition
Construct the TMF	Changes to Surface Water Quality resulting as a result of erosion and sedimentation, and dust deposition
Construct the Process Plant and Run of Mine Stockpile location	Changes to Surface Water Quality as a result of erosion and sedimentation, ML / ARD and dust deposition
Construct water treatment facilities and test facilities at Bromley Humps	Changes to Surface Water Quality as a result of erosion/sedimentation, and dust deposition
Construct Bromley Humps ancillary buildings and facilities	Changes to Surface Water Quality as a result of from erosion, sedimentation, and dust deposition
Commence milling to ramp up to full production	Changes to Surface Water Quality as a result of dust deposition
Operation Phase	
Use Access Road for personnel transport, haulage, and delivery of goods	Changes to Surface Water Quality as a result of erosion, sedimentation, and dust deposition
Maintain Access Road and Haul Road, including grading and plowing as necessary	Changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition

Project Component/Activity	Potential Effect / Pathway of Interaction with Surface Water Quality
Maintain Powerline right-of-way from substation tie-in to portal entrance, including brushing activities as necessary	Changes to Surface Water Quality as a result of erosion, sedimentation, and dust deposition
Continue underground lateral development, including dewatering	Changes to surface water as a result of ML / ARD, blasting, and dewatering
Discharge of water from underground facilities	Changes to Surface Water Quality resulting from discharges
Haul waste rock from the portals to the Waste Rock Storage Area for disposal (waste rock transport and storage)	Changes to Surface Water Quality as a result of erosion and sedimentation, ML / ARD and dust deposition
Extract ore from the underground load-haul-dump and transport to Bromley Humps to Run of Mine Stockpile (ore transport and storage)	Changes to Surface Water Quality as a result of ML / ARD and dust deposition
Treat and discharge, as necessary, excess water from the TMF	Changes to Surface Water Quality as a result of discharge
Temporarily store hazardous substances including fuel, explosives, and mine supplies	Changes to Surface Water Quality as a result of a potential spill
Progressively reclaim disturbed areas no longer required for the Project	Changes to Surface Water Quality as a result of erosion and sedimentation, and dust deposition
Closure and Reclamation Phase	
Use and maintain Access Road for personnel transport, haulage, and removal of decommissioned components until road is decommissioned and reclaimed.	Changes to Surface Water Quality as a result of erosion, sedimentation, and dust deposition
Decommission underground infrastructure	Changes to surface water quality as a result of erosion and sedimentation
Flood underground	Changes to Surface Water Quality as a result of ML / ARD and groundwater interaction
Decommission and reclaim Lower Portal Area and Powerline	Changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition
Decommission and reclaim Haul Road	Changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition
Decommission and reclaim all remaining mine infrastructure (Mine Site and Bromley Humps, except TMF) in accordance with the Closure Plan	Changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition
Construct the closure spillway	Changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition
Treat and discharge water from the TMF	Changes to Surface Water Quality as a result of discharge, erosion and sedimentation, and dust deposition
Conduct maintenance of mine drainage, seepage, and discharge	Changes to Surface Water Quality as a result of discharges

Project Component/Activity	Potential Effect / Pathway of Interaction with Surface Water Quality
Remove discharge water line and water treatment plant	Changes to Surface Water Quality as a result of groundwater interaction and removal of discharge
Decommission and reclaim Access Road	Changes to Surface Water Quality as a result of erosion and sedimentation and dust deposition
Post-Closure Phase	
Flood underground	Changes to Surface Water Quality as a result of ML/ARD and groundwater interaction

13.5.3 Discussion of Potential Effects

For the purposes of this assessment, the potential effects were classified under the following five categories, which represent the major pathways that could lead to a change in water quality. For each category, a list of specific Project activities from Table 13.5-1 that, if left unmitigated, would be likely to influence Surface Water Quality is included.

1. Mine discharge
   - Excavate and secure Lower Portal entrance and access tunnel;
   - Initiate underground lateral development and cave gallery excavation, including dewatering, and discharge of water from underground;
   - Continue underground lateral development, including dewatering;
   - Flood underground;
   - Install and fill fuel tanks at Mine Site;
   - Construct Mine Site water management infrastructure including talus quarry and Portal Collection Pond, dewatering systems, and water diversion, collection and discharge ditches and swales;
   - Construct Explosives Magazine;
   - Temporarily stockpile ore at the Mine Site;
   - Haul waste rock from the portals to the Waste Rock Storage Area(s) for disposal (waste rock transport and storage); and
   - Extract ore from the underground load-haul-dump transport to Bromley Humps to Run of Mine (ROM) Stockpile (ore transport and storage).

2. TMF discharge
    - Treat and discharge water from the TMF;
    - Conduct maintenance of mine drainage, seepage, and discharge;
    - Excavate rock and till from the TMF basin and local borrows / quarries for construction activities (e.g., dam construction for the TMF); and
    - Construct the Process Plant and Run of Mine Stockpile.
3. Road Runoff
    - Construct Access Road and Haul Road from Hwy 37a to the Upper Portal; and
    - Install and fill fuel tanks at Mine Site.

Virtually all remaining activities listed in Table 13.5-1, including many of the ones already covered by pathways above, could result in erosion and sedimentation and dustfall effects. These will be covered by the following pathways:

4. Non-contact water runoff
5. Aerial deposition

Interactions were not identified for project activities relating to:

- Domestic sewage produced at the Project site: all sewage will be trucked to Stewart for disposal and therefore will not have the potential for interaction with the aquatic receiving environment; and
- Water withdrawal: withdrawal of water from watercourses and is expected to be minimal (reduction of flows will be between 0 and 2.7% of base flows), therefore negligible potential effects on Surface Water Quality were assumed.

13.5.3.1 Change in Surface Water Quality from Mine Discharge

Mine Water

Water from the underground mine will be affected by underground water management, drilling, blasting, excavation and backfilling activities.

During Construction, water from the underground workings will be discharged in accordance with permit conditions, via the (existing) upper mine portal into the Cambria Icefield as per the discharge activities during the exploration phase. From the discharge point, the natural drainage path is approximately 8 km to Bitter Creek, via Lost Valley and the Bromley Glacier. This discharge route has been used previously for mine exploration dewatering. Water quality monitoring at BC08 (on Bitter Creek just below the Bromley Glacier) during mine dewatering did not detect any changes to water quality at BC08 that could be attributed to the discharge to the Cambria Ice Field. Concentrations at BC08 were well below provincial water quality thresholds, except for aluminum, levels that are naturally high in Bitter Creek.

During Operations, water will continue to be pumped to the Cambria Icefield for the first 1.5 years of production, until the Lower Portal is commissioned. Water would then be pumped to the surface and will combine with other mine contact water in the Portal Collection Pond, within the cirque, before being discharged to the receiving environment. The Portal Collection Pond may receive discharge from underground dewatering during Construction and Operations, as well as runoff from the waste rock storage area and laydown areas. Goldslide Creek receives water from the Portal Collection Pond as well as discharges from the sediment ponds servicing two talus quarries.

During Operations and Closure, all water from the underground workings will be collected in underground sumps or external ponds where suspended solids will be removed and quality is evaluated prior to discharge to Goldslide Creek. In Post-Closure, all mine portals will be plugged. The discharge will include contact water pumped from mine workings, and surface water (runoff and stormwater) that may have been in contact with mining areas or mine wastes, including blasting residues and runoff from temporary waste rock storage areas. Drainage that contacts site infrastructure, particularly from ore stockpiles, has the potential to contain dissolved metals. As such, all contact water will be intercepted, contained (e.g., collection ponds or sumps), analyzed, and treated if required, before discharge to the receiving environment.

Discharge entering Goldslide Creek will flow directly into Bromley Glacier, which currently extends about 1 km before forming the headwaters of Bitter Creek.

Blasting Residues

Underground mining and mine development, including excavation of the Lower Portal entrance and access tunnel will require blasting. Fixed emulsion and ammonium nitrate (ANFO) will be stored on site. Residues from blasting will contain nitrogen compounds that will remain on the surface of waste rock, tailings and excavated rock and be available for transport by contact water. Nitrate-N and ammonia-N are generated through blasting, whereas nitrite-N is an intermediate species of ammonia oxidation to nitrate. Water-soluble nitrogen compounds such as ammonia and nitrate are bioavailable, meaning they are metabolized by organisms for growth. Ammonia is toxic to aquatic biota at concentrations potentially exceeded in some mine contact water.

Generally, ANFO is made up of 94% NH_4NO_3 (of which 35% is nitrogen) and 6% fuel oil (Morin and Hutt, 2009). However, during blasting the reaction often does not completely consume the explosive, leaving behind residual nitrogen. The amount of nitrogen residue is dependent on many different factors including the handling of explosives and efficiency of the blast. Limited research exists on the prediction of nitrogen species in mine site drainages from explosive residues. Ferguson and Leask (1988) found that 0.2% of explosives remain as residues and are lost to runoff in dry conditions and between 2% and 5% in wetter conditions.

During Operations, blasting residues from the underground mine will be collected and directed to the Portal Collection Pond for settling prior to discharge into Goldslide Creek.

Talus Quarries

There are two talus quarries located at the Mine Site. During Construction and Operations, contact water in the quarries may be a source of Metal Leaching / Acid Rock Drainage (ML/ARD). All contact water from the talus quarries will be directed to the Portal Collection Pond for settling prior to discharge into Goldslide Creek.

Hydrocarbons

The storage and transport petroleum products (gasoline, lubricants, hydraulic fluids, oil and solvents), as well as fueling and maintenance activities for machinery, equipment and vehicles, have the potential for introducing hydrocarbons to nearby watercourses by way of reportable spills. Potential effects from hydrocarbons may occur during Project Construction, Operations, and Closure and Reclamation. All contact water will be directed to the Portal Collection Pond for settling prior to discharge into Goldslide Creek.

13.5.3.2 Change in Surface Water Quality from TMF Discharge

The TMF area incorporates diversion ditches and Seepage Collection and Recycle Ponds to control water that may potentially transport sediment downstream. Non-contact water from the upstream catchment on the eastern side of the TMF will be diverted in a diversion ditch. A water tank located at the Process Plant will store reclaim water from the TMF for mill processing.

The process for gold recovery uses cyanide, which is toxic to aquatic organisms. To eliminate cyanide toxicity in the tailings slurry, a cyanide destruction circuit will be employed before the tailings slurry is deposited in the TMF. Process water will be recycled to the maximum practical extent, minimizing the need for input or output of water. However, discharge of excess water to Bitter Creek will be required at certain times of year. Drainage that contacts the site infrastructure, particularly from the Run of Mine (ROM) stockpile at Bromley Humps, has the potential to contain dissolved metals. These drainages would be collected and preferentially directed to the TMF, if possible. Other surface contact water may have elevated sediment loads that would be collected, allowed to settle, and either discharged to the environment or directed to the TMF.

A water balance developed for the TMF has indicated that the facility will operate in a net positive surplus throughout Operations. TMF supernatant water does not meet Metal Mining Effluent Regulations (MMER) limits for TSS, dissolved copper, or ammonia, and therefore will be treated to MMER limits before discharge into Bitter Creek. Surplus supernatant pond water will be pumped to a Water Treatment Plant, located next to the Process Plant, and then treated before being discharged to the environment. Treated effluent will be discharged into Bitter Creek at location BC06 for eight months per year during Operations and during the first year of Closure to drain the TMF pond before the facility is closed.

It is anticipated that the majority of metals entering Bitter Creek would be in the dissolved form due to the TMF functioning as a settling pond. Parameters meeting MMER discharge requirements for TSS, and seepage would be filtered to lower levels via subsurface materials prior to entering the receiving environment. Dissolved metals will mostly remain in the water column as they are flushed downstream, and will be diluted by each successive tributary and stream entering the drainage.

The TMF will be a lined facility, which will minimize the potential for seepage. The tailings solids themselves are also low permeability and most of the impoundment will eventually be blanketed in tailings, which will form a permanent seepage restriction. During Operations and Closure, the groundwater system may be affected by the minor seepage of tailings process water from the TMF. Only a limited amount of seepage from the TMF is expected to occur, mostly as a result of potential imperfections in the liner system. The seepage chemistry will be similar to that of the process water. Seepage Collection Ponds will include seepage pump back to the TMF during the Operations and Closure and Reclamation Phases.

During the Post-Closure Phase of the Project, discharge of water from the decommissioned TMF to Bitter Creek may continue.

Blasting Residues

Blasting is anticipated to occur on a daily basis during Construction. In all phases, blasting residues, including runoff from the ore stockpile, will be captured and diverted to the TMF for eventual supernatant treatment prior to discharge into Bitter Creek. Seepage from the TMF during Operations will be collected in the seepage collection ponds, downstream of the TMF embankment, and pumped back to the TMF; therefore no adverse effects to Surface Water Quality, resulting from nitrogen loading, are expected for Bitter Creek.

Hydrocarbons

The storage and transport of petroleum products (gasoline, lubricants, hydraulic fluids, oil and solvents), as well as fueling and maintenance activities for machinery, equipment and vehicles, have the potential for introducing hydrocarbons to nearby watercourses by way of reportable spills. Potential effects from hydrocarbons may occur during the Construction, Operations, and Closure and Reclamation. All contact water will be directed to the TMF for eventual treatment (if necessary) prior to discharge into Bitter Creek.

13.5.3.3 Change in Surface Water Quality from Road Runoff

Blasting Residues

Blasting residues have the potential to leach from excavated rock to the Access Road watersheds. The proposed road alignment along the north/northeast bank of Bitter Creek follows a deactivated logging road at the toe of a steep hillside on the north side of Bitter Creek. To avoid destabilizing sensitive slopes and putting road users and workers in an unsafe position, sections of the access road will require blasting. However, the vast majority of the explosives will be used for blasting ore at the mine site. It is expected that nitrogen loading from the excavated rock along the access roads will be minimal.

Quarries and Borrow Areas

There are four borrow and quarry areas located along the Access and Haul Roads: Otter Creek Quarry, Roosevelt Borrow, Hartley Gulch Borrow; and Highway 37A Quarry.

During the Construction and Operations, contact water in quarries and borrow areas may transport metals and suspended sediments into nearby watercourses. The two main geological groups present in Bromley Humps are intrusive rocks, and the Hazelton Group sediments. Other units along the access road include the Coast Plutonic complex (monzonites), and the Hazelton Group volcanics. The intrusives in the Bromley Humps area and the monzonites of the Coast Plutonic complex were classified as non-Potentially Acid Generating (nPAG) with a low potential for metal leaching. Approximately one-third of the Hazelton Group sediment and one-half of the Hazelton Group volcanic samples were PAG, with potential for metal leaching under acidic pH conditions. The Hazelton Group sediments also had some samples with anomalously high selenium levels indicating potential for selenium leaching at neutral pH. Road construction through these materials will require special management measures to minimize the potential for ML/ARD.

Hydrocarbons

The storage and transport of fuels and petroleum products (gasoline, lubricants, hydraulic fluids, oil and solvents), as well as, road salts from de-icing, and fueling and maintenance activities for machinery, equipment and vehicles, have the potential for introducing hydrocarbons to nearby watercourses by way of reportable spills. Potential effects from hydrocarbons may occur during Project Construction, Operations, and Closure and Reclamation, along the Access and Haul Roads.

13.5.3.4 Change in Surface Water Quality from Non-Contact Water Runoff

Erosion of stream banks and increased sedimentation from in-stream construction activities in waterbodies in the Project area have the potential for adverse effects on surface water quality by exceeding guidelines for total TSS. The CCME guideline for TSS is defined for clear flow and high flow conditions. During clear flows, the guideline is a maximum of 25 mg/L increase from background levels for any short-term exposure (i.e., 24-h period), and a maximum average increase of 5 mg/L from background levels for longer term exposure (i.e., between 24 h and 30 d). During high flows, the guideline is a maximum increase of 25 mg/L from background during the period when background levels are between 25 and 250 mg/L, and a maximum increase of 10% of background levels when background is ≥ 250 mg/L (CCME, 1999).

Many of the activities conducted within the Mine Site, Bromley Humps, along the Access and Haul Roads and from quarries and borrow areas, have the potential to result in elevated TSS within nearby waterbodies and are discussed by location below.

Mine Site

During the Construction Phase, some erosion and sedimentation is expected from land clearing activities including the construction mine portal facilities and water management infrastructure. Closure and Reclamation will similarly result in the disturbance, transport and relocation of surficial materials. Sediment control ponds will be constructed prior to major clearing activities during Construction, and remain until Closure and Reclamation, in all areas where sediment could enter receiving environments, such as Goldslide Creek.

Bromley Humps

During the construction of the TMF in Bromley Humps, some erosion and sedimentation is expected from clearing of overburden in preparation for the TMF basin and Plant Site pad, and excavation of rock and till from the TMF basin and local borrows for construction activities (e.g., dam construction for the TMF). Runoff from disturbed areas can carry increased sediment loads to watercourses.

During Operations non-contact water runoff will be directed away from developed areas by means of diversion channels and routed to the natural catchment draining watercourses. While there will be minimal changes expected to the existing drainage patterns which could alter sediment inputs to Bitter Creek, the change in Surface Water Quality from this activity is expected to be negligible.

Access Road

The Access Road from Highway 37A to Bromley Humps and the Haul Road from Bromley Humps to the Mine Site will be constructed early in the Construction Phase.

Construction activities will require the clearing and grubbing of vegetation, the installation of culverts and bridges, and can produce excess sedimentation into nearby creeks at the road crossings. The use of any heavy machinery required for Construction within the stream channel can lead to erosion thereby causing the addition of sediment to nearby watercourses.

Quarries and Borrow Areas

Quarries and borrow sources will be developed to meet the requirements for construction of Project infrastructure at the Mine Site, Bromley Humps and for the Access and Haul Roads. During the Construction and Operation phases, suspended sediments transported as runoff can lead to increased TSS.

13.5.3.5 Change in Surface Water Quality from Aerial Deposition

Project activities such as blasting, construction of facilities and infrastructure, construction of access and haul roads, transportation of ore and waste rock, on-site equipment and vehicle use and traffic along the access roads have the potential to affect air quality and subsequently Surface Water Quality through atmospheric deposition. The air dispersion model CALPUFF was used for the Air Quality Assessment (Volume 2, Chapter 7) to assess potential effects to air quality, including rates of particulate deposition and air concentrations of nitrogen oxides (NOx) and Sulphur oxides (SOx). Detailed model results are presented in the Air Quality Modelling Report (Volume 8, Appendix 7-A). The results of the CALPUFF model show that the dispersion of dust and emissions from project activities mainly have the potential to affect Goldslide Creek.

Potential air quality – water quality interactions are expressed through dustfall, and theoretically from acid deposition. Acid deposition could occur if levels of NO_2 and SOx were predicted to be consistently high (i.e., above guideline) and wide-spread, and effects of such deposition on the ecological environment would also need to consider the tolerance capacity of the existing environment. The primary sources of NOx and SOx emissions would be stationary equipment, as well as vehicle diesel exhaust. Dustfall, or total particulate matter, is generated at the mine mainly from blasting, crushing and hauling, and traffic and equipment use on the Access/Haul Road. Construction of the TMF would result in a period of higher potential dustfall. Dust deposition can lead to increased TSS in watercourses.

Annual maximum dustfall rates (milligrams per square decimeter per day; $mg/dm^2/day$) from Project sources, at Surface Water Quality sampling sites, were predicted to occur during Operations in Year 3. Predicted increases in dustfall rates compared with background levels were typically small (0 to 7% increase), an exception was site GSC02, where the predicted maximum annual dustfall represented an increase of 32% compared with background. However, predicted maximum annual dustfall at all sites are below the historical provincial annual air quality standard of 1.7 $mg/dm^2/day$, and therefore potential effects of dustfall on TSS levels in the LSA are expected to be minor, if not negligible.

Acid deposition forms when NOx and SOx are emitted from burning fossil fuels. Alkalinity, which determines the buffering capacity of water against acidic inputs, is low in Bitter Creek and Goldslide Creek (Appendix 14-A). CALPUFF modelling indicates that the annual maximum concentrations of SOx, NOx (micrograms per cubic meter of air; $\mu g/m^3$), at the aquatic sampling site locations will remain well below the ambient air quality objectives. Maximum SOx and NOx is predicted at GSC02 at 2.50 ug/m^3 and 7.30 ug/m^3, respectively, with air quality objectives at 13 ug/m^3 for SOx and 60 ug/m^3 for NOx. Based on this, acid deposition from these sources is considered negligible.

13.6 Mitigation Measures

13.6.1 Key Mitigation Approaches

Results from the review of best management practices, guidance documents, and mitigation measures conducted for similar projects, as well as professional judgment for the Project-specific effects and most suitable management measures, were considered in determining the mitigation measures. The approach to the identification of mitigation measures subscribed to the mitigation hierarchy, as described in the Environmental Mitigation Policy for British Columbia (http://www.env.gov.bc.ca/emop/). Technical and economic feasibility constraints dictated the highest level on the hierarchy that could be achieved for each potential effect and the identification of mitigation measures for managing these effects. The need for any proposed compensation or offset is identified where required, along with the management plan where the scope of such compensation or offset is described.

Potential Project-related changes to Surface Water Quality will be reduced through mitigation measures, management plans, and adaptive management. If mitigation measures were considered entirely effective, potential Project-related effects to the Surface Water Quality VC were not identified as residual effects.

Specific mitigation measures were identified and compiled for each category of potential effect on Surface Water Quality and presented in this section. For the purposes of this assessment, mitigation measures included any action or project design feature that will reduce or eliminate effects to Surface Water Quality. Key approaches include:

- Design Mitigation;
- Regulatory Requirements;
- Best Management Practices (BMPs); and
- Monitoring.

One key mitigation measure that will be applicable to all potential effects on Surface Water Quality is the implementation of an Aquatic Effects Management and Response Plan (AEMRP) (Volume 5, Chapter 29). This plan outlines the aquatic effects management and response to be carried out during all phases of the Project. The AEMRP will include the following:

- Monitoring streams at locations potentially affected by the Project and at reference areas well away from Project activities;

- Monitoring surface water quality, sediment quality, and aquatic biology;

- Monitoring fish populations and fish tissues; and

- If effluent (as defined in MMER regulations) is proposed for discharge to the environment, then additional sampling per MMER requirements may be conducted (effluent characterization; acute toxicity testing; site characterization studies (including hydrology); sublethal toxicity testing).

The following subsection describes primary measures to mitigate the following potential Project effects on surface water quality:

- Change in surface water quality from mine discharge;
- Change in surface water quality from TMF discharge;
- Change in surface water quality from road runoff;
- Change in surface water quality from non-contact water runoff; and
- Change in surface water quality from aerial deposition.

13.6.1.1 Mitigation Measures for Changes in Surface Water Quality from Mine Discharge

The primary measure to mitigate potential changes to Surface Water Quality from operational mine discharge, will be to direct all discharge to the Portal Collection Pond for settling to remove suspended solids and test water quality prior to discharge into Goldslide Creek. IDM would consider the potential for contingency water treatment at the Portal Collection Pond, should monitoring suggest it necessary.

The full list of mitigation measures is presented in Table 13.6-1. Monitoring and adaptive management will be used to ensure the water management goals are detailed in the Site Water Management Plan and the AEMRP (Volume 5, Chapter 29).

However, with these mitigation measures in place, the potential remains for residual effects on Surface Water Quality.

Table 13.6-1: Mitigation Measures for Mine Discharge

Potential Effects	Mitigation Measures	Rationale
Changes to surface water quality from mine discharge	The mining method being employed is longhole stoping (primary) and cut and fill (secondary) utilizing cemented rock fill as a structural backfill and backfilling of waste rock material. The mining and backfilling will be designed such that interaction with the hydraulic regime is minimized. Surface disturbance by mining will be limited to the Upper Portal, Lower Portal, and vent portal.	Reduction in surface footprint minimizes potential effects to surface water.
	Contact water will be intercepted and routed to on-site settling sumps, or holding ponds, and will be analyzed and treated as required to meet applicable discharge limits established by provincial and federal regulators and existing legislation including MMER's prior to discharge to the receiving environment.	Collection and treatment prior to release minimizes potential contamination issues.
	Excess water from the underground workings to be discharged to the receiving environment will be monitored. Treatment will be undertaken if necessary to ensure water quality meets permitted requirements.	Collection and treatment prior to release minimizes potential contamination issues.

13.6.1.2 Mitigation Measures for Changes in Surface Water Quality from TMF discharge

The potential for changes to Surface Water Quality from the TMF discharge will be mitigated by diverting all contact water away from nearby watercourses. Contact water in Bromley Humps will be collected and directed to the TMF. The TMF will be fully lined to minimize seepage losses. Seepage collection ponds will be in place during Operations to collect seepage and pump it back to the TMF. During Operations discharge from the TMF will be treated to meet MMER requirements, prior to discharge in Bitter Creek. Water treatment will lower contaminants of potential concern (COPC) to either below BC / CCME WQG, or to within natural variability of the baseline concentrations in the receiving environment of Bitter Creek and Bear River.

At closure the surface of the tailings will covered with a low permeability geosynthetic liner. Non-PAG quarry rock and sand bedding will be used to construct the cover and so runoff into Bitter Creek will be similar to baseline water chemistry. Seepage collection pump-back systems will continue to operate and seepage treated until the seepage is suitable for direct discharge, after which the seepage collection systems will be dismantled.

The full list of mitigation measures is in Table 13.6-2. Monitoring and adaptive management will be used to validate the goals and water management strategies detailed in the Site Water Management Plan, Tailings Management Plan and AEMRP (Volume 5, Chapter 29).

However, with these mitigation measures in place, there would still be a potential for residual effects on Surface Water Quality.

Table 13.6-2: Mitigation Measures for TMF Discharge

Potential Effects	Mitigation Measures	Rationale
Changes to surface water quality from TMF discharge	Infrastructure will be located, whenever feasible, on competent bedrock or appropriate base material that will limit permeability and transport of potentially poor quality water into freshwater.	Limiting the potential for contact water to enter the receiving environment (i.e., avoidance) is the first step in effective mitigation.
	Clean, non-contact catchment water will be diverted away from the TMF and other project infrastructure to maintain water quality and natural drainage networks as much as possible.	Minimizing the amount of water entering areas of potential contamination, in addition to reducing overall effects, also reduces burden on TMF thereby extending functional life of structure
	Contact water will be intercepted and routed to on-site settling sumps, holding ponds, or the TMF and will be analyzed and treated as required to meet MMER limits prior to discharge to the receiving environment. Sources of contact water include mine wastes, tailings, and surface water/storm water flow from the individual Project areas.	Collection and treatment prior to release minimizes potential contamination issues.

13.6.1.3 Mitigation Measures for Changes in Surface Water Quality from Road Runoff

The potential for changes to Surface Water Quality from the Road Runoff will be mitigated by avoiding spillage of petroleum and explosives products to the extent possible. Mitigation measures from Section 13.6.1.4, related to minimizing the potential for erosion will apply here as well. The use of PAG material will be minimized for construction and road material will employ a number of avoidance, fill materials and water diversions to minimize interactions with watercourses. The list of mitigation measures is in Table 13.6-3. Management plans in Volume 5, Chapter 29 will include, an Explosives Management Plan, a Fuel Management Plan, a Hazardous Materials Management Plan, a Material Handling & ML/ARD Management Plan, and a Spill Contingency Plan. Due to the mitigation measures, including monitoring and adaptive management, no residual effects from road runoff are predicted on Surface Water Quality.

Table 13.6-3: Mitigation Measures for Road Runoff

Potential Effects	Mitigation Measures	Rationale
Changes to surface water quality from road runoff	Regular inspections will be conducted to ensure drainage, erosion, and sediment control measures are effective and functioning properly; all necessary repairs and adjustments will be conducted in a timely manner.	Regular inspections allows for proactive solutions.
	Sediment loading in runoff will be minimized by the application of measures to intercept total suspended solids before it reaches the freshwater environment.	Erosion and sediment control measures (e.g., well-placed and -maintained silt fencing) are standard industry practice.
	Refuelling and maintenance activities will not occur within 15 m of a watercourse except where required due to equipment breakdown or approved activities near water.	Limiting the likelihood that potential contaminants enter the receiving environment (i.e., avoidance) is the first step in effective mitigation.

13.6.1.4 Mitigation Measures for Changes in Surface Water Quality from Non-Contact Water Runoff

The primary mitigation measure to reduce inputs of suspended sediments from non-contact water runoff is to minimize the potential for erosion and the transport of material in runoff. Diversion ditches will be established around Bromley Humps and the Mine Site to route non-contact water to the natural catchment during the Operation Phase.

Mitigation measures are provided in Table 13.6-4. Monitoring and adaptive management will be used to validate goals as detailed in the Site Water Management Plan, Erosion and Sediment Control Plan, and AEMRP (Volume 5, Chapter 29). No residual effects from non-contact water runoff are predicted on Surface Water Quality with the employment of these mitigation measures, including monitoring and adaptive management.

Table 13.6-4: Mitigation Measures for Non-Contact Water Runoff

Potential Effects	Mitigation Measures	Rationale
Changes to surface water quality from non-contact water runoff	Regular inspections will be conducted to ensure drainage, erosion, and sediment control measures are effective and functioning properly; all necessary repairs and adjustments will be conducted in a timely manner.	Regular inspections allows for proactive solutions to be implemented.
	Sediment loading in runoff will be minimized by the application of measures to intercept total suspended solids before it reaches the freshwater environment.	Erosion and sediment control measures (e.g., well-placed and -maintained silt fencing) are standard industry practice.
	The area of landscape disturbance will be minimized and ecosystem-based revegetation and progressive reclamation will occur promptly to minimize erosion potential, introduction of invasive plants, and to facilitate initiation of successional ecological processes.	Reduction in surface footprint minimizes potential effects to surface water.

13.6.1.5 Mitigation Measures for Changes in Surface Water Quality from Aerial Deposition

Effects on Surface Water Quality from acid deposition and dustfall will be minimized through adherence to Best Management Practices as outlined in the Air Quality and Dust Management Plan (Volume 5, Chapter 29). Specifically, dust suppression measures during Construction activities, proper management of stockpiles to minimize dust and the tailings disposal methods to ensure beaches are saturated will greatly reduce potential for aerial deposition into nearby watercourses. Proper maintenance of equipment and vehicles and underground mining in itself will result in significant reductions in Project emissions. As shown in Table 13.6-5, the full list of mitigation measures for dustfall and acid deposition are discussed in the effects assessment for Air Quality (Volume 3, Chapter 7). Due to the mitigation measures, including monitoring and adaptive management, no residual effects from aerial deposition are predicted on Surface Water Quality.

Table 13.6-5: Mitigation Measures for Aerial Deposition

Potential Effects	Mitigation Measures	Rationale
Changes to surface water quality from aerial deposition	Road design and ore/waste transport plans have been optimized to minimize the distance travelled, which will reduce dust and emissions.	Reducing the source of the potential effect minimizes the potential effect.
	Use of emission control measures on point source and crusher transfer point emissions (e.g., scrubbers, dust collectors)	Reducing the source of the potential effect minimizes the potential effect.

13.6.2 Environmental Management and Monitoring Plans

The following environmental management and monitoring plans will be refined and implemented to monitor water quality, aquatic habitat and aquatic communities in the LSA.

- Access Management Plan;
- Air Quality and Dust Management Plan;
- Aquatic Effects Management and Response Plan;
- Erosion and Sediment Control Plan;
- Mine Closure and Reclamation Plan;
- Material Handling & ML/ARD Management Plan;
- Spill Contingency Plan;
- Tailings Management Plan; and
- Site Water Management Plan.

13.6.3 Effectiveness of Mitigation Measures

The anticipated success of each mitigation measure is evaluated and classified as Low, Moderate, High, and Unknown effectiveness within each effects assessment chapter:

- Low effectiveness: Proposed measure is experimental, or has not been applied in similar circumstances.
- Moderate effectiveness: Proposed measure has been successfully implemented, but perhaps not in a directly comparable situation.
- High effectiveness: Proposed measure has been successfully applied in similar situations.
- Unknown effectiveness: Proposed measure has unknown effectiveness because it has not been implemented elsewhere in a comparable project or environment.

The key mitigation measures for mitigation potential effects on the Surface Water Quality VC, along with mitigation effectiveness and uncertainty, are summarized using Table 13.6-6. This table also identifies the residual effects that will be carried forward for residual effects characterization and significance determination.

The timing of effectiveness of the mitigation measures varies depending on the type of mitigation. Mitigation measures that are part of the Project design or that rely on avoidance or prevention of effect through BMPs or regulatory requirements are effective immediately. Mitigation measures that are based on monitoring are dependent on the monitoring schedule. The implementation of all the mitigation measures as a whole will generally provide close to immediate effectiveness.

The proposed mitigation measures include standard measures that are known to be effective, based on relevant and applicable experience with other mining projects, and therefore the uncertainty associated with their use is low. Any further uncertainty associated with the effectiveness of the proposed mitigation trends will be addressed through the AEMRP (Volume 5, Chapter 29.5). If monitoring indicates that effectiveness of mitigation measures is lower than predicted, further mitigation may be required as per adaptive management strategies outlined in the AEMRP.

Table 13.6-6: Proposed Mitigation Measures and Their Effectiveness

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Surface Water Quality	Changes to surface water quality from mine discharge	The mining method being employed is longhole stoping (primary) and cut and fill (secondary) utilizing cemented rock fill as a structural backfill and backfilling of waste rock material. The mining and backfilling will be designed such that interaction with the hydraulic regime is minimized. Surface disturbance by mining will be limited to the Upper Portal, Lower Portal, and vent portal.	Reduction in surface footprint minimizes potential effects to surface water.	Construction, Operation, Closure and Reclamation, Post Closure	High	Low	Yes
		Contact water will be intercepted and routed to on-site settling sumps, or holding ponds, and will be analyzed and treated as required to meet applicable discharge limits established by provincial and federal regulators and existing legislation including MMER's prior to discharge to the receiving environment.	Collection and treatment prior to release minimizes potential contamination issues.		High	Low	
		Excess water from the underground workings to be discharged to the receiving environment will be monitored. Treatment will be undertaken if necessary to ensure water quality meets permitted requirements.	Collection and treatment prior to release minimizes potential contamination issues.		High	Low	
	Changes to surface water quality from TMF discharge	Infrastructure will be located, whenever feasible, on competent bedrock or appropriate base material that will limit permeability and transport of potentially poor quality water into freshwater.	Limiting the potential for contact water to enter the receiving environment (i.e., avoidance) is the first step in effective mitigation.	Construction, Operation, Closure and Reclamation, Post Closure	High	Low	Yes
		Clean, non-contact catchment water will be diverted away from the TMF and other project infrastructure to maintain water quality and natural drainage networks as much as possible.	Minimizing the amount of water entering areas of potential contamination, in addition to reducing overall effects, also reduces burden on TMF thereby extending functional life of structure		High	Low	
		Contact water will be intercepted and routed to on-site settling sumps, holding ponds, or the TMF and will be analyzed and treated as required to meet MMER limits prior to discharge to the receiving environment. Sources of contact water include mine wastes, tailings, and surface water/storm water flow from the individual Project areas.	Collection and treatment prior to release minimizes potential contamination issues.		High	Low	
	Changes to surface water quality from road runoff	Regular inspections will be conducted to ensure drainage, erosion, and sediment control measures are effective and functioning properly; all necessary repairs and adjustments will be conducted in a timely manner.	Regular inspections allows for proactive solutions.	Construction, Operation, Closure and Reclamation	High	Low	No
		Sediment loading in runoff will be minimized by the application of measures to intercept total suspended solids before it reaches the freshwater environment.	Erosion and sediment control measures (e.g., well-placed and -maintained silt fencing) are standard industry practice.		High	Low	

VC/IC	Potential Effects	Mitigation Measures	Rationale	Applicable Phase(s)	Effectiveness[1]	Uncertainty[2]	Residual Effect
Surface Water Quality		Refuelling and maintenance activities will not occur within 15 m of a watercourse except where required due to equipment breakdown or approved activities near water.	Limiting the likelihood that potential contaminants enter the receiving environment (i.e., avoidance) is the first step in effective mitigation.		High	Low	
	Changes to surface water quality from non-contact water runoff	Regular inspections will be conducted to ensure drainage, erosion, and sediment control measures are effective and functioning properly; all necessary repairs and adjustments will be conducted in a timely manner.	Regular inspections allows for proactive solutions to be implemented.	Construction, Operation, Closure and Reclamation	High	Low	No
		Sediment loading in runoff will be minimized by the application of measures to intercept total suspended solids before it reaches the freshwater environment.	Erosion and sediment control measures (e.g., well-placed and -maintained silt fencing) are standard industry practice.		High	Low	
		The area of landscape disturbance will be minimized and ecosystem-based revegetation and progressive reclamation will occur promptly to minimize erosion potential, introduction of invasive plants, and to facilitate initiation of successional ecological processes.	Reduction in surface footprint minimizes potential effects to surface water.		High	Low	
	Changes to surface water quality from aerial deposition	Road design and ore/waste transport plans have been optimized to minimize the distance travelled, which will reduce dust and emissions.	Reduces the direct release of ambient criteria air contaminants (from point or equipment sources).	Construction, Operation, Closure and Reclamation	High	Low	No
		Use of emission control measures on point source and crusher transfer point emissions (e.g., scrubbers, dust collectors)			Moderate	Low	

[1]Effectiveness: Low = measure unlikely to result in effect reduction; Moderate = measure has a proven track record of partially reducing effects; High = measure has documented success (e.g., industry standard; use in similar projects) in substantial effect reduction

[2]Uncertainty: Low = proposed measure has been successfully applied in similar situations; Moderate = proposed measure has been successfully implemented, but perhaps not in a directly comparable situation; High = proposed measure is experimental, or has not been applied in similar circumstances.

13.7 Residual Effects Characterization

13.7.1 Summary of Residual Effects

The residual effects after application of mitigation measures are:

- Changes in Surface Water Quality from Mine Discharges; and
- Changes in Surface Water Quality from TMF Discharges.

13.7.2 Methods

Significance of residual effects was evaluated based on several criteria including: magnitude, duration, frequency, reversibility, context, and probability of occurrence, as defined for Surface Water Quality (Table 13.7-1).

13.7.2.1 Residual Effects Criteria

Table 13.7-1: Characterization of Residual Effect on Surface Water Quality

Criteria	Characterization for Surface Water Quality
Magnitude	• Negligible (N): no detectable change from baseline conditions. • Low (L): <CCME or BC WQG or ≤P90 of baseline if parameter is naturally greater than WQG or if no WQG exists. • Moderate (M): >CCME or BC WQG or >P90 of baseline if parameter is naturally greater than WQG or if no WQG exists, exceedance of either threshold is by <10X. • High (H): >CCME or BC WQG or >P90 of baseline if parameter is naturally greater than WQG or if no WQG exists, exceedance of either threshold is by >10X.
Geographical Extent	• Discrete (D): Effect is limited to the immediate receiving environment in Goldslide Creek watershed (Mine Site) or the immediate freshwater environment in Bitter Creek (TMF area, Access Road). • Local (L): Effect extends beyond the immediate receiving environment of Goldslide Creek and Bitter Creek near the TMF to the entire Bitter Creek watershed. Effects do not extend into the RSA. • Regional (R): Effect extends across the RSA. • Beyond Regional (BR): Effect extends beyond the RSA and beyond the province (transboundary effects).
Duration	• Short-term (ST): Effect lasts less than 18 months (e.g., only during the Construction Phase of the Project). • Long-term (LT): Effect lasts greater than 18 months and less than 22 years (encompassing Operation, Closure and Reclamation, and Post-Closure Phases). • Permanent (P): Effect lasts more than 22 years.

Criteria	Characterization for Surface Water Quality
Frequency	• One time (O): Effect is confined to one discrete event (month). • Sporadic (S): Effect occurs rarely and at sporadic intervals. • Regular (R): Effect occurs on a regular basis. • Continuous (C): Effect occurs constantly.
Reversibility	• Reversible (R): Effect can be reversed. • Partially reversible (PR): Effect can be partially reversed. • Irreversible (I): Effect cannot be reversed, is of permanent duration.
Context	• High: the receiving environment has a high natural resilience to imposed stresses, and can respond and adapt to the effect. • Neutral: the receiving environment has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect. • Low: the receiving environment has a low resilience to imposed stresses, and will not easily adapt to the effect.

13.7.2.2 Analytical Assessment Techniques for Surface Water Quality

13.7.2.2.1 Water Quality Model

A water and load balance model developed in GoldSim for predictions of receiving environment water quality in Goldslide Creek (GSC02), Rio Blanco Creek (RBC02), Bitter Creek (BC08, BC06, and BC02), and Bear River (BR06).

The model (Appendix 14-C) was used to assess the Project's residual effects of changes to Surface Water Quality caused by the Project over the duration of the mine life, from Construction through Post-Closure. All inputs to the model were on either a monthly or an annual basis. All outputs of the model (flow and water quality predictions) were monthly averages.

13.7.2.3 Assessment of Likelihood

Likelihood is determined per the attributes listed in the Application/EIS Methodology Chapter (Volume 3, Chapter 6).

13.7.2.4 Significance Determination

The evaluation of significance was completed by comparing predicted residual effects against thresholds, standards, trends, or objectives relevant to ecosystems, as defined below.

- Not significant: Residual effects have negligible, low or moderate magnitude; local to regional geographic extent; short- or long-term duration; could occur at any frequency, and are reversible or partially reversible in either the short- or long-term. Surface water quality for the majority of parameters is maintained within natural variability in the Project receiving environment over the life of the Project.

- Significant: Residual effects have high magnitude; regional or beyond regional geographic extent; duration is permanent; and can occur at all frequencies. Residual effects on Surface Water Quality are consequential (i.e., structural and functional changes in VCs that are influenced by Surface Water Quality) and are irreversible.

13.7.2.5 Confidence and Risk

Confidence definitions for the Application/EIS are provided in Volume 3, Chapter 6.

13.7.3 Potential Residual Effects Assessment

13.7.3.1 Change in Surface Water Quality from Mine Discharge

13.7.3.1.1 Residual Effect Analysis

Both the Mine Discharge and TMF Discharge residual effects were assessed using the predictions from the Water and Load Balance Model (Appendix 14-C) and so this analysis addresses both residual effects.

The model predicted the maximum monthly concentrations of water quality parameters in Goldslide Creek, Bitter Creek, Rio Blanco Creek, and Bear River for Operations (Years 1 to 6) and Closure/Post-Closure (Years 7 to 21). The only activity that is included in the Water and Load Balance Model during the Construction Phase is the movement of material to the temporary development waste rock storage area. This does not result in any exceedances of guidelines. The model was run beyond Post-Closure to Year 150 to account for long term influences made via groundwater. Potential contaminants of concern for Surface Water Quality were identified as those parameters predicted to exceed water quality guidelines (BC or CCME) in the expected case (P50).

The measurement indicators for assessment of residual effects on Surface Water Quality are covered in the list below of the 31 parameters in the model (Table 13.7-2).

While consideration to potential changes to turbidity, oxygen, water temperature, and ice regime in the receiving watercourses were given, no predictions were made for these parameters. Changes to turbidity are not expected given IDM's commitments to employ mitigation measures that minimize the potential for erosion and the transport of material in runoff. Oxygen levels are not expected to be influenced by any Project activities, as all the receiving watercourses are fast moving, high energy streams. Water temperature and ice regime in the Bitter Creek valley are largely controlled by the Bromley Glacier located in the headwaters of Bitter Creek, and none of the Project activities will impart enough influence on the watercourses or glacier to change this. For example, the TMF does not discharge between November and March, so there would be effect on ice cover at all.

Full results from the model are summarized by monthly maximums for background, Operations, and Post-Closure in Appendix 14-C. Comparisons of water quality predictions in the base case were made with BC and CCME guidelines. Where there were both short-term and long-term guidelines, the long-term guidelines were used as a conservative measure. A high-level summary of parameters that exceed the BC or CCME WQG is shown in Table 13.7-3.

Table 13.7-2: Surface Water Quality Parameters Included in Predictions

Parameters Included in Predictions		
Total hardness	Boron, dissolved	Mercury, dissolved
Alkalinity	Cadmium, dissolved	Molybdenum, dissolved
Acidity	Calcium, dissolved	Nickel, dissolved
Fluoride	Chromium, dissolved	Selenium, dissolved
Sulphate	Cobalt, dissolved	Silver, dissolved
Nitrate as N	Copper, dissolved	Thallium, dissolved
Nitrite as N	Iron, dissolved	Uranium, dissolved
Ammonia as N	Lead, dissolved	Zinc, dissolved
Aluminum, dissolved	Magnesium, dissolved	Cyanide, total
Antimony, dissolved	Manganese, dissolved	Cyanide, WAD
Arsenic, dissolved		

Table 13.7-3: Summary of Parameters that Exceed CCME or BC Water Quality Guidelines (Base Case)

Parameter	GSC02	RBC02	BC08	BC06	BC02	BR06
Mercury, dissolved[1]	*O, PC*	-	-	-	-	-
Nitrite as N	O	-	-	-	-	-
Antimony, dissolved[2]	O	-	-	-	-	-
Arsenic, dissolved	O	-	-	-	-	-
Cadmium, dissolved	BG, O, PC	PC	O, PC	PC	BG, O, PC	-
Cobalt, dissolved	PC	-	-	-	-	-
Copper, dissolved	BG, O, PC	-	-	-	-	-
Selenium, dissolved	BG, O, PC	BG, O, PC	BG, O, PC	BG, O, PC	BG, O, PC	BG, O, PC
Silver, dissolved	PC	PC	PC	PC	PC	-
Zinc, dissolved	BG, O, PC	PC	PC	PC	PC	-

BG = Background concentration exceeds guideline
O = Predicted concentration during operations exceeds guideline
PC = Predicted concentration during post-closure exceeds guideline
1) Hg exceeds guidelines due to model artifacts (see Appendix 14-C)

2) BC Working Water Quality Guidelines

Model Artifacts

Mercury exceeds BC WQG (0.00002 mg/L) and CCME WQG (0.000026 mg/L) during Operations in Goldslide Creek; these exceedances are due to a detection limit issue in source term development and are model artifacts.

Nitrite

Predicted Nitrite exceedances of the BC WQG (0.02 mg/L) during Operations in Goldslide Creek are a result of blasting residues; however, nitrate is highly unlikely to stay in this form in surface water, as natural oxidation processes will convert the nitrite to nitrate. BC and CCME long-term and short-term WQGs for nitrate are several orders of magnitude higher than respective guidelines for nitrite and so even if all the nitrite is converted to nitrate, no guidelines will be exceeded in the nitrate form.

Antimony

Predicted antimony exceeds the BC Working WQG (0.009 mg/L) during Operations in Goldslide Creek. The maximum concentration is 0.014 mg/L (all months), which is only about 1.6 times higher than the working guideline.

Arsenic

Predicted arsenic exceeds both the BC and CCME WQGs (0.005 mg/L) during Operations in Goldslide Creek. The maximum concentration is 0.0059 mg/L (all months), which is about 1.2 times higher than the guideline.

Cadmium

Predicted cadmium exceeds both the BC and/or CCME WQGs (hardness dependent) during Operations and Post-Closure in Goldslide Creek. Either or both guidelines are exceeded during at least one project phase in Rio Blanco and Bitter Creek. There are no exceedances in Bear River. Exceedances are mainly attributable to the elevated concentrations in the background, except for the winter low flow period when discharge is less diluted by freshwater from other sources reporting to the Portal Collection Pond.

- The maximum concentration in Goldslide Creek during Operations is 0.00069 mg/L (all months), which is about 2, 2.4 and 5.1 times the BC WQG, CCME WQG, and background concentrations, respectively. During Post-Closure, the maximum concentration is predicted to be 0.00077 mg/L (all months), which is about 3.5, 4.6 and 5.7 times the BC WQG, CCME WQG, and background concentrations, respectively.
- There are no cadmium exceedances in Rio Blanco Creek during Operations. During Post-Closure, the maximum concentration in Rio Blanco Creek is 0.00044 mg/L (February), which is about 1.4, 1.8 and 4.4 times the BC WQG, CCME WQG, and background concentrations respectively.

- The maximum concentration in Bitter Creek during Operations at BC08 is 0.00029 mg/L (December), which is 1.05 times the CCME WQG. During Post-Closure, the maximum concentration (0.00019 mg/L in March) does not exceed guidelines (since Cadmium is hardness dependent). During the months of guideline exceedances (May to September), July's concentration of 0.00014 mg/L is about 1.7 times the CCME guideline and 5.9 times the background concentrations. BC WQGs are not exceeded.

- There are no cadmium exceedances in Bitter Creek at BC06 during Operations. During Post-Closure, cadmium concentrations exceeds CCME WQGs. BC WQGs are also slightly exceeded on occasion. During the months where cadmium exceeds guidelines (May to September and November to December), the maximum concentration of 0.00012 mg/L (July) is about 1.1, 1.6 and 5.7 times the BC WQG, CCME WQG, and background concentrations, respectively.

- The maximum concentration in Bitter Creek at BC02 during Operations is 0.00021 mg/L (December), which does not exceed guidelines. Both the BC and CCME WQGs are hardness dependent and exceedances occur between May and August. These exceedances are due to background concentrations. During Post-Closure, concentrations exceed guidelines between April and September and in December. During these months, the maximum concentration is 0.0015 mg/L (July) and is about 1.2, 1.7 and 1.8 times the BC WQG, CCME WQG, and background concentrations, respectively.

Cobalt

Predicted cobalt exceeds the BC WQG (0.004 mg/L) during Post-Closure in Goldslide Creek. Exceedances are attributable to elevated concentrations in the mine contact groundwater that is predicted to report to surface water decades after the underground mine refloods. The maximum concentration is predicted to be 0.0046 mg/L (all months), which exceeds the guideline by just 1.15 times.

Copper

Predicted copper exceeds BC and/or CCME WQGs (hardness dependent) during Operations and Post-Closure in Goldslide Creek; exceedances are mainly attributable to the background concentrations. Even though concentrations are elevated during the winter low flow period when discharge is less diluted by freshwater from other sources reporting to the Portal Collection Pond, concentrations remain below the guidelines during these months due to the increase in hardness.

- The maximum concentration in Goldslide Creek during Operations is 0.0041 mg/L (all months), which 1.03 times the CCME WQG, below the BC WQG and 2.2 times background concentrations. Background concentrations account for between 45% and 93% of the copper during Operations.

- During Post-Closure, the predicted concentration of copper in Goldslide Creek is 0.00498 mg/L (all months). This is about 1.2 and 2.0 times the BC and CCME WQGs, respectively. Background concentrations account for between 37% and 76% of the copper in the Post-Closure Phase.

Selenium

Predicted selenium exceeds BC (0.002 mg/L) and / or CCME WQ (0.001 mg/L) guidelines during Operations and Post-Closure at all sites. During Operations, exceedances are mainly attributable to the background concentrations, except for the winter low flow period when discharge is less diluted by freshwater from other sources reporting to the Portal Collection Pond. Exceedances in Rio Blanco are entirely due to background concentrations. During Post-Closure, exceedances are attributable to elevated concentrations in the mine contact groundwater that is predicted to report to surface water decades after the underground mine refloods.

- The maximum concentration in Goldslide Creek during Operations is 0.0044 mg/L (all months), which is about 2.2, 4.4 and 2.0 times the BC WQG, CCME WQG, and background concentrations, respectively. During Post-Closure, the maximum concentration is 0.0041 mg/L (all months), which is about 2.1, 4.1 and 1.9 times the BC WQG, CCME WQG and background concentrations, respectively.

- The maximum concentration in Rio Blanco Creek during Operations at RBC02 is 0.0045 mg/L, which is about 2.3 and 4.5 times the BC WQG and CCME WQG. Background concentrations account for 100% of the selenium during Operations. During Post-Closure, the maximum concentration is 0.0054 mg/L (October), which is about 2.7, 5.4 and 1.2 times the BC WQG, CCME WQG and background concentrations, respectively.

- The maximum concentration in Bitter Creek during Operations at BC08 is 0.0028 mg/L (December), which is about 1.4 and 2.8 times the BC WQG and CCME WQG, respectively, and about 1.6 times the background. During Post-Closure, the maximum concentration is 0.0020 mg/L (February). This is equal to the BC WQG but is about 2 times the CCME WQG and 1.2 times the background concentrations.

- The maximum concentration in Bitter Creek during Operations at BC06 is 0.0027 mg/L (December), which is about 1.2 and 2.7 times the BC WQG and CCME WQG, respectively, and about 1.5 times the background. During Post-Closure, the maximum concentration is 0.0022 mg/L (February), which is about 1.1, 2.2 and 1.2 times the BC WQG, CCME WQG and background concentrations, respectively.

- The maximum concentration in Bitter Creek during Operations at BC02 is 0.0041 mg/L (December), which is about 2.1 and 4.1 times the BC and CCME WQGs, respectively, and about 1.2 times the background. During Post-Closure, the maximum concentration is 0.0038 mg/L (February), which is about 1.8, 3.8 and 1.1 times the BC WQG, CCME WQG and background, respectively.

- The maximum concentration in Bear River during Operations is 0.0017 mg/L (December), which is lower than the BC WQG, 1.7 times the CCME WQG and 1.2 times the background. During Post-Closure, the maximum concentration is 0.0016 mg/L

(February), which is below the BC WQG, 1.6 times the CCME WQG and 1.1. times the background.

- At baseline, the maximum concentration of selenium (total and dissolved) recorded during the winter low flow period at BR08 (Bear River upstream of Bitter Creek) was 0.0004 mg/L. The maximum concentration of selenium at BR06 (Bear River downstream of Bitter Creek) was 0.0014 mg/L. Therefore, at baseline, Bear River downstream of Bitter Creek is 3.5 times higher than the upstream site.
- During Operations, the maximum concentration of selenium at BR06 is 0.0017 mg/L, which is 4.3 times higher than baseline BR08.
- During Post-Closure, the maximum concentration of selenium at BR06 is 0.0016 mg/L, which is 4.0 times higher than baseline BR08.

Silver

Predicted silver exceeds BC (hardness dependent) and / or CCME WQ (0.00025 mg/L) guidelines during Post-Closure in Goldslide Creek, Rio Blanco Creek, and Bitter Creek. Exceedances are attributable to elevated concentrations in the mine contact groundwater that is predicted to report to surface water decades after the underground mine refloods.

- The maximum concentration in Goldslide Creek at GSC02 is 0.00362 mg/L (all months), which is about 1.5 and 36 times the BC WQG and background concentrations, respectively. There are no exceedances of the CCME WQG.
- The maximum concentration in Rio Blanco Creek at RBC02 is 0.00294 mg/L (February), which is about 1.2, and 15 times the BC WQG and background concentrations, respectively. There are no exceedances of the CCME WQG.
- The maximum concentration in Bitter Creek at BC08 is 0.00010 mg/L (February), which does not exceed guidelines. The CCME WQG is hardness dependent and in April to September the guideline changes from 0.0015 mg/L to 0.00005 mg/L. Of these months, the highest concentration is 0.000088 mg/L (June), which is about 1.8 times the CCME WQG guideline, lower than the BC WQG and about 4.4 times background concentrations.
- The maximum concentration in Bitter Creek at BC06 is 0.000095 mg/L (February), which does not exceed guidelines. The CCME WQG is hardness dependent and in April to September the guideline changes from 0.0015 mg/L to 0.00005 mg/L. Of these months, the highest concentration is 0.000078 mg/L (June), which is about 1.6 times the CCME WQG guideline, lower than the BC WQG and about 4.2 times background concentrations.
- The maximum concentration in Bitter Creek at BC02 is 0.000071 mg/L (February), which does not exceed guidelines. The CCME WQG is hardness dependent and in April to September the guideline changes from 0.0015 mg/L to 0.00005 mg/L. Of these months, the highest concentration is 0.000060 mg/L (June), which is about 1.2 times the guideline, lower than the BC WQG and about 3 times background concentrations.

Zinc

Predicted zinc exceeds the BC (hardness dependent) and/or CCME (0.03 mg/L) WQGs during Operations in Goldslide Creek and during Post-Closure in Goldslide Creek, Rio Blanco Creek, and Bitter Creek. Like copper, exceedances are almost entirely attributable to the background concentrations during the spring / summer months. During the winter low flow, concentrations are elevated when discharge is less diluted by freshwater from other sources reporting to the Portal Collection Pond. During Post-Closure, exceedances are attributable to elevated concentrations in the mine contact groundwater that is predicted to report to surface water decades after the underground mine refloods.

- The maximum concentration in Goldslide Creek at GSC02 during Operations is 0.033 mg/L (all months), which is 1.1 times the CCME WQG, lower than the BC WQG, and 3 times the background concentration. During Post-Closure, the maximum concentration is 0.047 mg/L (all months), which is 2.5, 1.6, and 4.2 times the BC WQG, CCME WQG and background, respectively.

- There are no zinc exceedances during Operations in Rio Blanco Creek. During Post-Closure, the maximum concentration in Rio Blanco Creek is 0.024 mg/L (February), which does not exceed guidelines. The BC WQG is hardness dependent and in May to August guideline exceedances occur. Of these months, the highest concentration is 0.024 mg/L (July), which is about 1.7 times the BC guideline, lower than the CCME WQG and about 4.8 times background concentrations.

- There are no zinc exceedances during Operations in Bitter Creek at BC08. During Post-Closure, the maximum concentration at BC08 is 0.012 mg/L (February), which does not exceed guidelines. The BC WQG is hardness dependent and in April to August guideline exceedances occur. Of these months, the highest concentration is 0.011 mg/L (June), which is about 1.4 times the guideline, lower than the CCME WQG and 2.1 times background concentrations.

- There are no zinc exceedances during Operations in Bitter Creek at BC06. During Post-Closure, the maximum concentration at BC06 is 0.019 mg/L (November), which does not exceed guidelines. The BC WQG is hardness dependent and in April to July guideline exceedances occur. Of these months, the highest concentration is 0.0098 mg/L (June), which is about 1.3 times the guideline, lower than the CCME WQG and about 2.1 times background concentrations.

- There are no zinc exceedances during Operations in Bitter Creek at BC02. During Post-Closure, the maximum concentration in at BC02 is 0.009 mg/L (February), which does not exceed guidelines. The BC WQG is hardness dependent and the only exceedance occurs in September, at 0.0076 mg/L. This is essentially equal to the BC WQG of 0.0075 mg/L, lower than the CCME WQG and 1.9 times background concentrations.

Summary of Contaminants of Potential Concern (COPC)

A subset of the parameters discussed above is brought forward to be considered a COPC. These parameters are:

- Goldslide Creek

  Operations: antimony, cadmium, selenium, and zinc
  Post-Closure: cadmium, copper, selenium, silver, and zinc

- Rio Blanco Creek

  Operations: none
  Post-Closure: cadmium, silver, and zinc

- Bitter Creek

  Operations: selenium
  Post-Closure: cadmium, selenium, silver, and zinc

- Bear River

  Operations: none
  Post-Closure: none

Arsenic was not brought forward because the exceedances of the predicted maximum monthly concentrations occur in only 4 of 12 months in a non-fish bearing creek and the predicted monthly maximum is only 20% above the WQG, which is considered within analytical uncertainty and model error.

Cadmium was brought forward as a COPC during the Post-Closure phase in Bitter Creek. However, it was not brought forward as a COPC during the Operations phase because in Bitter Creek, the exceedances of the predicted maximum monthly concentrations occurs in only 2 of 12 months (BC08) in a non-fish bearing reach and is only 3% above the CCME WQG. Predicted maximum monthly exceedances occur in 4 months at BC02 and are about 10% higher than the CCME WQG. These predictions are considered well within natural variability and model error. In addition, the predictions only exceed the CCME WQG, not the BC WQG. The CCME WQG is more stringent than the BC guideline as it applies to waterbodies all across Canada. BC guidelines are intended to represent more closely the conditions in BC waters and are more relevant for the waters in this Project.

Cobalt was not brought forward as the predicted concentration is 1.15 times the BC long-term WQG, which is well within natural variability and model error.

Copper was not brought forward as a COPC in Goldslide Creek in the Operations phase. The BC WQG is not exceeded and the CCME WQG is just 3% above the maximum predicted concentration, which is well within model error and natural variability. Depending on the month, background concentrations account for between 45% and 93% of the copper during Operations.

Selenium was not brought forward for Rio Blanco and Bear River for Operations or Post-Closure. Exceedances in Rio Blanco are entirely due to background concentrations during Operations and within model error and natural variability during Post-Closure. Exceedances during Operations and Post-Closure in Bear River occur in 6 of 12 months and only exceed the CCME WQG, not the BC WQG. As discussed for cadmium, BC guidelines are intended to represent more closely the conditions in BC waters. In addition, background concentrations account for between 76% and 98% of the predicted concentrations during Operations, and 81% and 95% during Post-Closure, depending on the month.

13.7.3.1.2 Characterization of Residual Effect

The residual effect to Surface Water Quality from the Mine Discharge is characterized as follows:

- Magnitude is Moderate; the majority of the parameters have a negligible to low magnitude rating with up to 50% of parameters in Goldslide Creek having a moderate magnitude for certain months at the predicted maximum concentrations in the P50 case. The majority of these parameters had a moderate rating in only certain months and in many cases the moderate rating was due parameters that already exceeded guidelines at background concentrations.

- Geographical extent is Local; changes to Surface Water Quality from mine discharges is limited to the LSA.

- Duration is Permanent; some changes to Surface Water Quality from mine discharge are predicted to occur beyond Post-Closure.

- Frequency is Regular; discharges to the receiving environment (via Goldslide Creek) occur during dewatering events at the mine, which occurs regularly throughout the Operation Phase. During Closure and Post-Closure, inputs into Goldslide Creek will be from groundwater that has been influenced from the mine flooding and backfilling activities.

- Reversibility is irreversible; it is expected that the effect from the groundwater that is influenced from the mine backfill during post-closure, will result in a change in some water quality parameters over the long-term compared to baseline conditions in receiving watercourses. The likelihood of complete reversibility is so low and so far in the future, that the residual effect is characterized as irreversible..

- Context is High; the receiving watercourses in the Project LSA are dynamic, fast-moving systems that naturally experience a wide-range of flow and water chemistry conditions. The assimilative capacity of these watercourses are considered high and therefore Surface Water Quality would have a high natural resilience to the mine discharges and would be able to return to baseline conditions once the stressor has expired.

13.7.3.1.3 Likelihood

The likelihood of a residual effect on Surface Water Quality from mine discharges is predicted to be high, i.e., the effect has a greater than 80% chance of occurring. This is based on the confidence in the predictions of the Water and Load Balance (Appendix 14-C) and the use of the P50 predictions, which represent the expected case.

13.7.3.1.4 Significance

Although there will be changes to the receiving environment water quality, only a very small subset of parameters will increase above guidelines/background levels. The effect will be localized and the overall baseline conditions of the receiving environment will be maintained after the Project ceases. This residual effect is considered not significant. The maintenance of the quality of water in the receiving environment may be altered in Goldslide Creek but not to the extent that the maintenance of other VCs that are influenced by Surface Water Quality are affected.

13.7.3.1.5 Confidence and Risk

The level of confidence associated with the predicted residual effect on Surface Water Quality from Mine discharge, is moderate. The base case (P50) predictions, which represent the expected case or best estimate, were used to analyze the residual effect, and therefore confidence is highest in these predictions. However, there are inherent uncertainties associated with water quality modelling and dependencies on numerous input sources, which may affect the likelihood or significance of the predicted residual effect.

Where there were uncertainties in the model input assumptions, reasonably conservative assumptions were made to address those uncertainties and thereby reduce risk. For example, predictions for the Post-Closure phase were heavily influenced by elevated concentrations in mine contact groundwater reporting to surface water decades after the underground mine refloods. In order to model this dispersion of groundwater into downgradient creeks, multiple surface water model nodes were added to Goldslide Creek and upper Bitter Creek. While this approach attempts to model the real-life movement of the groundwater, it is a simplified approximation and does not include hydrodynamic dispersion and attenuation (sorption) of contaminants along the groundwater flow path, which would result in reductions in concentrations in the downgradient environment.

Upper case (P90) predictions representing the reasonable worst case, or the upper bound of expected water quality were also made (Appendix 14-B: Water Quality Assessment of the Reasonable Upper Limit Case). Contingency planning and/or adaptive management will be implemented if water quality concentrations above the base case are detected during monitoring. Based on the confidence in the water quality predictions, as well as review of the upper limit case predictions, it was determined that additional risk analysis was not required for the residual effect.

To reduce uncertainty and maintain the quality of water in the receiving environment of the TMF, as well as other VCs that are influenced by surface water quality, monitoring and adaptive management strategies for water quality will be implemented, as described in the AEMRP (Volume 5, Chapter 29.5) and the Adaptive Management Plan (Volume 5, Chapter 29.2). These management plans have been designed to mitigate the risk related to a residual effect on Surface Water Quality. The objectives of the AEMRP is to minimize the risk of effects to the aquatic environment through Project design, monitoring and adaptive management. The AEMRP includes an Aquatics Effects Monitoring Program (AEMP) that will provide feedback via the receiving environment on the performance of IDM’s management and mitigation during Construction, Operations, Closure and Reclamation, and Post-Closure phases of the Project. The AEMRP also includes management response measures (additional assessment, monitoring and mitigation measures) that would be implemented in response to an unanticipated effect on Surface Water Quality.

13.7.3.2 Change in Surface Water Quality from TMF Discharge

13.7.3.2.1 Residual Effect Analysis

Both the Mine Discharge and TMF Discharge residual effects were assessed using model predictions (Appendix 14-C) and so analysis from Section 13.7.3.1 applies here as well.

13.7.3.2.2 Characterization of Residual Effect

The residual effect to Surface Water Quality from the TMF Discharge is characterized as follows:

- Magnitude is Low; the majority of the parameters have a negligible to low magnitude rating with up to 20% of parameters in Bitter Creek having a moderate magnitude for certain months at the predicted maximum concentrations in the P50 case. The majority of these parameters had a moderate rating in only certain months and in many cases the moderate rating was due parameters that already exceeded guidelines at background concentrations.

- Geographical extent is Local; changes to Surface Water Quality from TMF discharges and seepage is limited to the LSA.

- Duration is Permanent; changes to Surface Water Quality from TMF discharges are predicted to occur beyond Post-Closure.

- Frequency is Sporadic; discharges to Bitter Creek are from the discharge of surplus water from the TMF, which occurs seasonally depending on precipitation and water use for the Project.

- Reversibility is Partially Reversible; once Closure and Reclamation activities are completed for the TMF, the Surface Water Quality downstream of the TMF is expected to revert back to within baseline levels for the majority of the water quality parameters after a number of years.

- Context is High; the receiving watercourses in the Project LSA are dynamic, fast-moving systems that naturally experience a wide-range of flow and water chemistry conditions. The assimilative capacity of these watercourses are considered high and therefore Surface Water Quality would have a high natural resilience to the mine discharges and would be able to return to baseline conditions once the stressor has expired.

13.7.3.2.3 Likelihood

The likelihood of a residual effect on Surface Water Quality from TMF discharges is determined to be occurring is high, i.e., the effect has a greater than 80% chance of occurring. This is based on the confidence in the predictions of the Water and Load Balance (Appendix 14-C) and the use of the P50 predictions, which represents the expected case.

13.7.3.2.4 Significance

Although there will be minor changes to the Surface Water Quality of the receiving environment, only a very small subset of parameters will increase above guidelines / background levels. The effect is localized, sporadic and partially reversible. This residual effect is considered not significant. Maintenance of the quality of water in Bitter Creek, as well as the maintenance of other VCs that are influenced by Surface Water Quality are maintained after the Project ceases.

13.7.3.2.5 Confidence and Risk

The level of confidence associated with the predicted residual effect on Surface Water Quality from TMF discharge, is moderate. The base case (P50) predictions, which represent the expected case or best estimate, were used to analyze the residual effect, and therefore confidence is highest in these predictions. However, there are inherent uncertainties associated with water quality modelling and dependencies on numerous input sources, which may affect the likelihood or significance of the predicted residual effect.

Where there were uncertainties in the model input assumptions, reasonably conservative assumptions were made to address those uncertainties and thereby reduce risk. For example, when choosing the source term for tailings process water, generally the test result with the highest concentrations was chosen as the source term for all the tailings.

The base case predictions are considered to be moderately, but not overly, conservative. Further details on the assumptions, uncertainty, and conservatism are provided in Appendix 14-C.Upper case (P90) predictions representing the reasonable worst case, or the upper bound of expected water quality were also made (Appendix 14-B: Water Quality Assessment of the Reasonable Upper Limit Case). Contingency planning and/or adaptive management will be implemented if water quality concentrations above the base case are detected during monitoring. Based on the confidence in the water quality predictions, as well as review of the upper limit case predictions, it was determined that additional risk analysis was not required for the residual effect.

To reduce uncertainty and maintain the quality of water in the receiving environment of the TMF, as well as other VCs that are influenced by surface water quality, monitoring and adaptive management strategies for water quality will be implemented, as described in the AEMRP (Volume 5, Chapter 29.5) and the Adaptive Management Plan (Volume 5, Chapter 29.2). These management plans have been designed to mitigate the risk related to a residual effect on Surface Water Quality. The objectives of the AEMRP is to minimize the risk of effects to the aquatic environment through Project design, monitoring and adaptive management. The AEMRP includes an Aquatics Effects Monitoring Program (AEMP) that will provide feedback via the receiving environment on the performance of IDM's management and mitigation during Construction, Operations, Closure and Reclamation, and Post-Closure phases of the Project. The AEMRP also includes management response measures (additional assessment, monitoring and mitigation measures) that would be implemented in response to an unanticipated effect on Surface Water Quality.

13.7.4 Summary of Residual Effects Assessment

Residual effects and the selected mitigation measures, characterization criteria, likelihood, significance determination, and confidence evaluations are summarized here.

Table 13.7-4: Summary of the Residual Effects Assessment

Residual Effect	Project Phase(s)	Mitigation Measures	Summary of Residual Effects Characterization Criteria *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence *(High, Moderate, Low)*
Mine Discharge	C, O, CR, PC	Project design mitigations, BMPs, regular inspections, Site Water Management Plan, AEMRP.	**Magnitude**: Moderate **Geographic extent**: Local **Duration**: Permanent **Frequency**: Regular **Reversibility**: Irreversible **Context:** High	High	Not Significant	Moderate
TMF Discharge	C, O, CR, PC	Project design mitigations (including water treatment, seepage collection and pump back, geomembrane cover), BMPs, regular inspections, Site Water Management Plan, Tailings Management Plan, AEMRP.	**Magnitude**: Low **Geographic extent**: Local **Duration**: Permanent **Frequency**: Sporadic **Reversibility**: Partially Reversible **Context:** High	High	Not Significant	Moderate

13.8 Cumulative Effects Assessment

Cumulative effects are the result of Project residual effects on Surface Water Quality interacting with residual effects of other physical activities (i.e., anthropogenic developments, projects, or activities) that have been or will be carried out (CEA Agency 2014a).

Guidance documents specific to the cumulative effects methodology are identified below:

- Reference Guide: Addressing Cumulative Environmental Effects (CEA Agency 1994a);

- Practitioners Glossary for the Environmental Assessment of Designated Projects under the *Canadian Environmental Assessment Act, 2012* (CEA Agency 2013);
- Guidelines for the Selection of Valued Components and Assessment of Potential Effects. British Columbia Environmental Assessment Office: Victoria, BC. (BC EAO. 2013);
- Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012*, Operational Policy Statement (CEA Agency 2014a); and
- Draft Technical Guidance for Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012* (CEA Agency, 2014b).

13.8.1 Review Residual Effects

Residual effects after application of mitigation measures are:

- Changes in Surface Water Quality from Mine Discharges; and
- Changes in Surface Water Quality from TMF Discharges.

13.8.2 Cumulative Effects Assessment Boundaries

Similar to the Project effects assessment, the cumulative effects assessment boundaries are defined as the maximum spatial and temporal scales over which there is a potential for residual Project effects on Surface Water Quality to interact with the residual effects of other past, present, and future projects and activities.

13.8.2.1 Spatial Boundaries

The spatial boundaries for the cumulative effects assessment on the Surface Water Quality VC are restricted to areas that are hydrologically linked to the residual effects of the Project. Given that the residual effects to Surface Water Quality are not predicted to extend beyond the LSA of the Project, it is reasonable to define the cumulative effects assessment boundary as the RSA, which surrounds the LSA, and also includes the Bear River watershed, from American Creek to Stewart and the northern end of the Portland Canal.

13.8.2.2 Temporal Boundaries

The following temporal boundaries are evaluated as part of the cumulative effects assessment:

1. Past: 1988 to 2014;
2. Present: 2014 to 2017, from the start of the Red Mountain Underground Gold Project's detailed baseline studies to the completion of the effects assessment; and
3. Foreseeable Future: the cutoff date for incorporating any new future developments in the cumulative effects assessment in the Application/EIS is 2029. This represents the

final anticipated year of the mine life after the Closure and Reclamation Phase is complete.

13.8.3 Identifying Past, Present, or Reasonably Foreseeable Projects and/or Activities

The list of past, present, and reasonably foreseeable projects and/or activities for consideration in the cumulative effects assessment was compiled from a variety of information sources, including municipal, regional, provincial, and federal government agencies and company websites. This list was reviewed to determine which projects and activities that have potential to interact with residual effects on Surface Water Quality. Projects and activities with potential to interact with Surface Water Quality residual effects are in Table 13.8-1.

Table 13.8-1: List of Projects and Activities with potential to interact within the Surface Water Quality Residual Effects

Project/Activity	Project Life	Location	Proponent
Bitter Creek Hydro Project	Proposed	15 km northeast of Stewart	Bridge Power
Stewart Bulk Terminal	Currently Operating	Stewart	Stewart Bulk Terminals Ltd.
Mineral exploration	Ongoing	Regional	Various
Commercial recreations	Ongoing	Regional	Various
Fishing	Ongoing	Regional	Various
Forestry	Ongoing	Regional	Various
Guide outfitting	Ongoing	Regional	Various
Transportation	Ongoing	Regional	Various
Trapping	Ongoing	Regional	Various

Figures showing location, and descriptions of scope and timing for these activities (e.g., the proposed Bitter Creek Hydro Project), is provided in the Past and Current Projects section of the Effects Assessment Methodology Chapter (Volume 3, Chapter 6).

13.8.4 Potential Cumulative Effects and Mitigation Measures

13.8.4.1 Changes in Water Quality

The land use activities outlined in Table 13.8-1 have the potential to interact with residual effects on Surface Water Quality because of increased road use: mineral exploration, commercial recreations (e.g., river rafting, guided mountaineering), fishing, guide outfitting, transportation, and trapping. Increased road use represents a pathway to a potential cumulative effect, as there is increased potential for runoff, sediment runoff (TSS), and dust deposition, along the Access Road adjacent to Bitter Creek, and at ford crossings.

Mineral exploration could also result in reduced water quality and disturbances to the aquatic habitat from drilling and trail clearing.

The Bitter Creek Hydroelectric Project could reduce flows and therefore dilution capacity in Bitter Creek.

These potential effects would add to the inputs already being received from the road use during Construction, Operations, and Closure and Reclamation of the Project.

13.8.4.2 Additional Mitigation Measures

Proposed Mitigation Measures of the Red Mountain Project are outlined in Section 13.6.

Additional mitigation measures for cumulative effects involves taking further action, where possible, to avoid or minimize cumulative effects on the Surface Water Quality VC.

It is assumed that proponents of proposed development projects will adhere to their own developed mitigation plans, including sediment and erosion mitigation around Construction activities and access roads. In conjunction with mitigation plans implemented by the Project, areas of spatial and temporal overlap between projects will be monitored and mitigated where necessary. IDM and other project proponents could also share monitoring data to help in the detection of unanticipated cumulative effects. No other additional mitigation measures were identified for the Project for mitigating cumulative effects.

The permitting and monitoring of run-of-river hydroelectric projects has additional mitigation built into its regulatory infrastructure. Applicable guidelines include:

- Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects (DFO 2012; Lewis *et al.* 2011).
- Flow Ramping Guidelines for Hydroelectric Projects: Developing, Testing, and Compliance Monitoring (Lewis *et al.* 2013).

13.8.5 Cumulative Effects Interaction Matrix

Potential cumulative effects on Surface Water Quality are based on the potential for interaction between the Surface Water Quality residual effects with the projects and activities identified in Table 13.8-1. The interaction with effects of reasonably foreseeable future projects and activities are in Table 13.8-2.

Table 13.8-2: Interaction with Effects of Reasonably Foreseeable Future Projects and Activities

Residual Effects of this Project on Surface Water Quality	Current and Ongoing Projects and Activities								Future Projects and Activities
	Mineral Exploration	Commercial Recreation	Fishing	Forestry	Guide Outfitting	Transportation	Trapping	Stewart Bulk Terminal	Bitter Creek Hydro Project
Mine Discharge	N	N	N	N	N	N	N	N	Y
TMF Discharge	N	N	N	N	N	N	N	N	N

Notes:
Y = Yes, interaction exists between the residual effect of the Project and the other past, current, or future project/activity
N = No, interaction does not exist between the residual effect of the Project and the other past, current, or future project/activity

The interaction matrix identified the Bitter Creek Hydroelectric Project as the only project with potential to interact with the residual effects on Surface Water Quality. The others were determined as not having an interaction due to the following reasons:

- The Stewart Bulk Terminal is located in the RSA, where no Surface Water Quality residual effects have been determined.
- While there are mineral exploration claims within the RSA, there are no projects that have entered the approval process and thus it is unknown whether any future projects could potentially add to the proposed Project residual effects, i.e., act cumulatively with the Project.
- The remaining land use activities listed in Table 13.8-2 have the potential to interact with residual effects on Surface Water Quality because of increased road use. Increased road use represents a pathway to a potential cumulative effect, as there is increased potential for sediment runoff into Bitter Creek. Currently, use of the Bitter Creek valley for these activities is limited:
  - There is a single commercial recreation licence, for a heli-ski operation, which does not require road use.
  - In the Stewart area, recreational fishing is limited to the upper reaches of Portland Canal and mouth of the Bear River. According to comments received during consultation with NLG, Nisga'a citizens are not known to fish in Bitter Creek (Volume 3, Chapter 19; Economic Effects Assessment).
  - There is single guider outfitter that uses the area, and one trapline.

- Use of the access road will be tightly controlled for safety reasons (including a gate at the entrance), and unauthorized use will not be permitted. IDM will also enforce a no hunting / no fishing policy for the Project workforce. At Closure and Reclamation, project roads will be decommissioned and reclaimed. As such, the potential for these activities to cause an increase in road use that would interact cumulatively with residual effects on Surface Water Quality is considered negligible and is not carried forward in the cumulative effects assessment.

13.8.6 Cumulative Effects Characterization

13.8.6.1 Changes in Water Quality

Flow reductions in the diversion reach of the Bitter Creek Hydroelectric Project have the potential to exacerbate changes in water quality in Bitter Creek from mine and TMF discharge, because there will be lower dilution through that reach.

13.8.7 Summary of Cumulative Effects Assessment

Table 13.8-3: Summary of Residual Cumulative Effects Assessment

Project Phase	VC	Residual Cumulative Effect	Characterization Criteria *(context, magnitude, geographic extent, duration, frequency, reversibility)*	Likelihood *(High, Moderate, Low)*	Significance *(Significant, Not Significant)*	Confidence* *(High, Moderate, Low)*
C, O, CR, PC	Surface Water Quality	Mine Discharge	Magnitude: Low Geographic extent: Discrete Duration: Long-term Frequency: Sporadic Reversibility: Reversible Context: High	High	Not Significant	High
C, O, CR, PC	Surface Water Quality	TMF Discharge	Magnitude: Low Geographic extent: Discrete Duration: Long-term Frequency: Regular Reversibility: Reversible Context: High	Moderate	Not Significant	High

*Confidence estimates allow the decision-maker to evaluate risk associated with the Project

13.9 Follow-up Strategy

IDM has identified a follow-up strategy to evaluate the accuracy of effects predictions and effectiveness of proposed mitigation measures in regards to the Surface Water Quality VC. The strategy focuses on implementation of the AEMRP (Volume 5, Chapter 29.5). The purpose of the AEMRP is to minimize the effects of the Project's activities on the aquatic environment, monitor the results of mitigation to ensure effectiveness, and adaptively manage for any unanticipated effects resulting from the Project. The AEMRP also provides guidance to protect and limit disturbances to the aquatic environment from Project activities.

An Aquatic Effects Monitoring Program (AEMP) with a Before/After/Control/Impact (BACI) study design is proposed as part of the AEMRP. This study design allows comparison of baseline and Project conditions during the Construction, Operations, and Post-Closure Phases, as well as exposure and reference sites. The results of the AEMP will then be compared with the predictions made in the effects assessment, to evaluate their accuracy. For example, water quality monitoring results will be compared with predictions of the Water Quality Model, as well as baseline concentrations of water quality parameters.

Adaptive management will require consideration of AEMP results, management reviews, incident investigations, shared traditional, cultural, or local knowledge, new or improved scientific methods, regulatory changes, or other Project-related changes. Mitigation and monitoring strategies for Aquatic Resources will be updated to maintain consistency with action plans, management plans, and BMPs that may become available during the life of the Project. Key stakeholders, Aboriginal Groups, and government agencies will be involved, as necessary, in developing effective strategies and additional mitigation.

13.10 Conclusion

No significant change in Surface Water Quality concentrations compared to baseline or provincial / federal guidelines are predicted to occur at a local or regional scale due to the Project. Likewise, cumulative effects are not anticipated. The maintenance of the quality of water in the receiving environment may be altered in Goldslide Creek but not to the extent that the maintenance of other VCs that are influenced by Surface Water Quality are affected.

All residual effects were considered non-significant due to the local geographical extent, and low to moderate magnitude of the anticipated effects. The assessment of significance is contingent on the successful implementation of mitigation measures. The results of this assessment have been carried forward to inform the effects assessments for Sediment Quality (Volume 3, Chapter 14), Vegetation and Ecosystems (Volume 3, Chapter 15), Wildlife and Wildlife Habitat (Volume 3, Chapter 16), Aquatic Resources (Volume 3, Chapter 17), Fish and Fish Habitat (Volume 3, Chapter 18), and Human Health (Volume 3, Chapter 22) and have been used in the development of the Screening Level Ecological Risk Assessment (Volume 8, Appendix 22-B).

The additional mitigation measures for potential cumulative effects on Surface Water Quality are expected to reduce the potential for a cumulative effect to a low or negligible level, i.e., measures will be fully effective. Residual cumulative effects that would compromise the maintenance of the quality of water in the receiving environment, as well as the maintenance of other VCs that are influenced by Surface Water Quality are therefore not anticipated.

13.11 References

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