



BC EAO EAC Application – Tenas Project

Section 4.0 Environmental Effects Assessment

Chapter 4 Groundwater Valued Component

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VERSION 1.0

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Submitted by:	Telkwa Coal Limited Suite 1410 – 409 Granville Street Vancouver, BC V6C 1T2

Tenas Project

Section 4.0 Environmental Effects Assessment Chapter 4 Groundwater Valued Component

TABLE OF CONTENTS

Table of Contents	i
List of Figures	iii
List of Tables	iii
List of Appendices	iv
Abbreviations and Acronyms	v
Units of Measure	vii
Executive Summary	viii
1. Introduction	1
2. Regulatory Context	2
3. Scope of the Assessment	3
3.1 Issues Scoping	3
3.2 Rationale for Selection of Groundwater Valued Component (VC)	3
3.2.1 Valued Component (VC)	3
3.2.2 Subcomponents	4
3.2.3 Indicators	4
3.2.4 Assessment Boundaries	6
3.2.4.1 Spatial Boundaries	6
3.2.4.2 Temporal Boundaries	8
3.2.4.3 Administrative Boundaries	8
3.2.4.4 Technical Boundaries	8
4. Existing Conditions	9
4.1 Background Information and Studies	9
4.1.1 Traditional Knowledge (TK)	9
4.1.2 Scientific and Other Information	9
4.1.3 Baseline Studies	10
4.2 Description of Existing Conditions	13
4.2.1 Groundwater in the Context of the Regional Study Area (RSA)	13
4.2.2 Groundwater Resources	14
4.2.3 Groundwater Users	17
4.2.4 Past and Current Human Activities	17
4.2.5 Baseline Groundwater Quantity (Flow System)	17

4.2.5.1	Shallow Overburden System	19
4.2.5.2	Deep Bedrock System	19
4.2.6	Baseline Groundwater Quality	21
5.	Assessment of Project-related Effects	25
5.1	Potential Project-related Interactions with Groundwater Valued Component (VC)	25
5.2	Potential Project-related Effects.....	29
5.2.1	Groundwater Quantity Subcomponent	29
5.2.1.1	Change in Groundwater Levels in the Area of Private Wells	29
5.2.1.2	Change in Groundwater Discharge Rates to Creeks and Rivers	29
5.2.2	Groundwater Quality Subcomponent.....	30
5.2.2.1	Change in Groundwater Quality in the Area of Private Wells.....	30
5.2.2.2	Changes in Quality of Groundwater Discharging to Creeks and Rivers.....	31
5.3	Mitigation Measures	31
5.3.1	Limit Project Footprint and Project Area	32
5.3.2	Blasting Measures	32
5.3.3	Management, Control, and Water Storage Pond Designs	33
5.3.4	Management of Metal Leaching/Acid Rock Drainage (ML/ARD)	33
5.3.5	Project Use of Water	35
5.3.6	Flooding of the Open Pit in Decommissioning and Reclamation, and Post-closure Phases of the Project	35
5.3.7	Spill Management	36
5.3.8	Chemical and Materials Storage and Handling	36
5.3.9	Additional Valued Component (VC)-specific Measures to Reduce Nitrogen Release	37
5.3.10	Summary of Mitigation Measures	38
5.4	Residual Effects and Significance of Residual Effects	41
5.4.1	Description of Evaluation Criteria.....	41
5.4.1.1	Residual Effects Characteristics.....	41
5.4.2	Groundwater Quantity Subcomponent	44
5.4.2.1	Changes to Groundwater Levels in the Area of Private Wells	44
5.4.2.2	Change in Groundwater Discharge Rates to Creeks and Rivers	45
5.4.3	Groundwater Quality Subcomponent.....	46
5.4.3.1	Changes to Groundwater Quality in the Area of Private Wells.....	46
5.4.3.2	Change in Quality of Groundwater Discharging to Creeks and Rivers.....	47
5.5	Summary of Project-related Residual Adverse Effects and Significance	48
6.	Cumulative Effects Assessment (CEA).....	51
6.1	Potential Cumulative Effects	51
6.2	Additional Mitigation Measures	53
6.3	Cumulative Effects and Characterisation of Significance	53
6.3.1	Groundwater Quantity Subcomponent	53

6.3.1.1	Changes to Groundwater Level in the Area of Private Wells	53
6.3.1.2	Changes in Groundwater Discharge Rates to Creeks and Rivers	54
6.3.1.3	Summary of Cumulative Effects to Groundwater Quantity	54
6.3.2	Groundwater Quality Subcomponent.....	55
6.3.2.1	Changes to Groundwater Quality in the Area of Private Wells.....	55
6.3.2.2	Change in Quality of Groundwater Discharging to Creeks and Rivers.....	56
6.3.2.3	Summary of Cumulative Effects for the Groundwater Quality Subcomponent	57
6.4	Summary of Cumulative Effects Assessment (CEA)	57
7.	Summary of Effects Assessment For Groundwater Valued Component (VC)	59
8.	Follow-up Strategy	60
9.	References.....	67

LIST OF FIGURES

Figure 3.2-1:	Local and Regional Study Areas for Groundwater	7
Figure 4.2-1:	Aquifers and Private Wells in the Local Study Area	16
Figure 4.2-2:	Groundwater tables in overburden and bedrock in the Tenas area	18
Figure 8-1:	Proposed Groundwater Monitoring Locations	65

LIST OF TABLES

Table 3.2-1:	Summary of Rationale for Selection of Groundwater Valued Component (VC) and Subcomponents and Their Linkages	5
Table 3.2-2:	Indicators for Groundwater Valued Component (VC).....	5
Table 3.2-3:	Spatial Boundary Definitions for Groundwater Valued Component (VC)	6
Table 3.2-4:	Temporal Boundaries for the Tenas Project.....	8
Table 4.1-1:	Summary of Desktop and Field Studies Related to the Groundwater Valued Component (VC)	11
Table 4.1-2:	Summary of the Available Groundwater Data	13
Table 4.2-1:	Description of the Minor Aquifers in the Local Study Area (LSA).....	14
Table 4.2-2:	Overburden Hydrostratigraphic Units in the Local Study Area (LSA).....	19
Table 4.2-3:	Bedrock Hydrostratigraphic Units in the Local Study Area (LSA).....	20
Table 4.2-4:	Summary of the Skeena Group Equivalent Hydraulic Conductivity (K) Analysis in the Local Study Area (LSA)	20

Table 4.2-5:	Summary Statistics for Baseline Groundwater Quality	22
Table 5.1-1:	Potential for an Interaction between Groundwater Valued Component (VC) and the Tenas Project	25
Table 5.1-2:	Interactions between the Groundwater Valued Component (VC) and the Tenas Project	26
Table 5.3-1:	Summary of Potential Effects and Mitigation Measures for Groundwater Valued Component (VC)	39
Table 5.4-1:	Effect Characteristics Considered when Determining the Significance of Residual Effects on Groundwater Valued Component (VC)	42
Table 5.4-2:	Summary of Effect Characteristics Ratings for the Changes in Groundwater Levels in Areas of Private Well Users	44
Table 5.4-3:	Summary of Effect Characteristics Ratings for the Changes in Groundwater Discharge Rates to Creeks and Rivers	45
Table 5.4-4:	Summary of Effect Characteristics Ratings for the Changes to Groundwater Quality in Private Wells	46
Table 5.4-5:	Summary of Effect Characteristics Ratings for the Change in Quality of Groundwater Discharging to Creeks and Rivers	47
Table 5.5-1:	Summary of Residual Adverse Effects for Groundwater Valued Component (VC)	49
Table 6.1-1:	Projects Included in the Assessment for the Groundwater Valued Component (VC) Based on Spatial and Temporal Interaction	52
Table 6.3-1:	Summary of Cumulative Effects for the Groundwater Quantity Subcomponent	55
Table 6.3-2:	Summary of Cumulative Effects for the Groundwater Quality Subcomponent	57
Table 6.4-1:	Summary of Cumulative Effects on the Groundwater Valued Component (VC)	58
Table 8-1:	Proposed Groundwater Monitoring Stations	61

LIST OF APPENDICES

Appendix 4.4-A	SRK, Groundwater Technical Report for the Tenas Coal Project, Telkwa
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ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
ACMPR	Access to Cannabis for Medical Purposes Regulations
AIR	Application Information Requirements
ANP	Ammonium Nitrate Prill
BC	British Columbia
BC EAO	British Columbia Environmental Assessment Office
BC MECCS	British Columbia Ministry of Environment and Climate Change Strategy
BC MEMLI	British Columbia Ministry of Energy, Mines and Low Carbon Innovation
BC MEMPR	British Columbia Ministry of Energy Mines and Petroleum Resources
BC MOE	British Columbia Ministry of Environment
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BC WQG	British Columbia Water Quality Guidelines
BMPs	best management practices
Cassiar	Cassiar Geoscience Consulting Ltd.
CEA	cumulative effects assessment
CEAA	Canadian Environmental Assessment Agency
C	Chapter
CMSTHP	Chemicals and Materials, Storage, Transfer, and Handling Plan (S13.0-C3)
CPP	Coal Processing Plant
Crossroads	Crossroads Cultural Resource Management
CUS	Cultural Use Study
DEM	Digital Elevation Model
DEM	Digital Elevation Model
DWS	Drinking Water Sources
EA	environmental assessment
EAA	<i>Environmental Assessment Act</i> , SBC 2002, c 43 (Government of British Columbia [GovBC] 2002)
EAC	Environmental Assessment Certificate
EMA	<i>Environmental Management Act</i> , SBC 2003, c 53 (GovBC 2003)
EMP	Explosives Management Plan (S13.0-C6)
FAL	Freshwater Aquatic Life
FMSCP	Fuel Management and Spill Control Plan (S13.0-C7)
FSRs	Forest Service Roads
GovBC	Government of British Columbia
GovCan	Government of Canada

Abbreviation or Acronym	Long Form of Abbreviation or Acronym
HSU	Hydrostratigraphic Units
JAIR	Joint Application Information Requirements for <i>Mines Act</i> and <i>Environmental Management Act</i> , Permits (British Columbia Ministry of Energy, Mines and Petroleum Resources [BC MEMPR] and British Columbia Ministry of Environment and Climate Change Strategy [BC MECCS] 2019)
K	hydraulic conductivity
Klohn	Klohn Leonoff Consulting Engineers
LIDAR	Light Detection and Ranging
LSA	Local Study Area
ML/ARD	metal leaching/acid rock drainage
ML/ARDMP	Metal Leaching (ML)/Acid Rock Drainage (ARD) Management Plan (S13.0-C12)
MSDS	Material Safety Data Sheet
MW (only in tables)	monitoring wells
MWMP	Minesite Water Management Plan (S13.0-C11)
NRCAN	Natural Resources Canada
NRMSE	normalized root mean squared error
Orica	Orica Canada Inc
OW	Office of the Wet'suwet'en
PAG	potentially acid generating
Piteau	Piteau Engineering Ltd.
Project	Tenas Project
RCP	Reclamation and Closure Plan (S13.0-C15)
ROM	run-of-mine
RSA	Regional Study Area
SC	subcomponent
SRK	SRK Consulting (Canada) Inc.
Stantec	Stantec Inc.
TAC	Tenas Access Corridor
TCL	Telkwa Coal Limited
TDG	Transportation of Dangerous Goods
TK	Traditional Knowledge
VC	Valued Components
WQG	Water Quality Guideline
WMPRE	Waste Management Plan for Refuse and Emissions (S13.0-C20)

UNITS OF MEASURE

Abbreviation or Acronym	Long form of Abbreviation or Acronym
>	greater than
%	percent
cm	centimetre
km	kilometres
km ²	square kilometres
kV	kilovolt
L/s	litres per second
m	metres
m ³ /d	cubic metres per day
masl	metre above sea level
mbgs	metres below ground surface
m/s	metres per second

EXECUTIVE SUMMARY

This chapter presents the assessment of potential Tenas Project (Project)-related effects and cumulative effects on the Groundwater Valued Component (VC). The purpose of this assessment is to analyze the potential changes to the groundwater system (i.e., quantity and quality) because of the Project.

The conceptual model of the groundwater system at the scale of the Regional Study Area (RSA) is based on topographical, geomorphological, and geological information, and the common understanding of hydrogeological systems within the profession. The recharge occurs in the highlands in the form of snowmelt and/or rain infiltration, and the discharges occur as baseflow and/or sub-stream flow in the creeks and riverbeds, and possibly in smaller order streams, gullies, breaks in slope, and geologic discontinuities. Some flow systems may be perched and have localized seepage areas. Groundwater is contained either in the fractured rock or in valley fill deposits. In fractured bedrock, flows are expected to be typically slower, with longer residence time as bedrock is generally characterised by low to moderate hydraulic conductivity (K). In valleys, groundwater fills the glacial and fluvial sandy gravely deposits. These deposits are expected to have a larger capacity than bedrock to transmit groundwater (i.e., moderate to high K) resulting in shorter residence times. The water table is expected to be a subdued replica of topography, with depths to groundwater typically greater in the uplands relative to the valley bottoms. Groundwater flows from the mountain's summits in the south towards the Telkwa River valley in the north. The tributaries of the Telkwa River form secondary shallow flow systems dominated by discharges from shallow bedrock and overburden.

The potential interactions between groundwater and the Project components and activities were identified based on professional experience with other mining projects in British Columbia (BC) and through multi-disciplinary consultation with consultants working on behalf of Telkwa Coal Limited (TCL). Four (4) potential Project-related effects have been identified related to groundwater quantity or quality:

1. changes to the groundwater level around private wells;
2. change in groundwater discharge rates to creeks and rivers;
3. changes to groundwater quality around private wells; and
4. change in the quality of groundwater discharging to creeks and rivers.

The effects of potential changes in groundwater quality and quantity on surface water receptors are assessed in **Section (S) 4.0-Chapter (C) 3 Surface Water VC** of the **Environmental Assessment Certificate (EAC) Application**.

Mitigation measures have been implemented during the planning stages of the Project. See **5.3 Mitigation Measures**. These include Project design such as site selection, selection of best available technologies to-date for Project infrastructure and mining equipment, and a commitment to progressive reclamation. Following technical evaluations of the soil treatment facility ponds designs, the management ponds and the control pond have been designed with low permeability liners to minimize the infiltration of contact water underneath the facilities. In addition, several management plans will define the standard operating procedures, the best management practices (BMPs), the adherence to existing environmental regulations, and the use of appropriate design criteria. Many of them have linkages to groundwater and its protection.

The analyses of the Project's residual effects on groundwater quantity and quality were performed using a three (3)-dimensional numerical groundwater flow model. Based on the model results:

- ▶ The potential change of groundwater levels around private well users resulting from Project activities is considered **Not Significant** because the predicted Magnitude of level changes is **Negligible**;
- ▶ The change in groundwater discharge rates to creeks and rivers due to Project activities are considered **Not Significant** because the predicted changes are expected to be of **Low** Magnitude;
- ▶ The changes to groundwater quality around private well users due to Project activities are considered **Not Significant** because the predicted changes are expected to be **Low** in Magnitude; and
- ▶ The change to the quality of groundwater discharging to creeks and rivers due to the Project activities are considered **Not Significant** because the effect Magnitude is predicted to be **Low** and only Local in Extent.

The analyses are based on the site-specific and public data available about the Project, therefore the Level of Confidence for the model predictions is rated as Moderate. As no other project or activity was identified as having a potential interaction with the predicted Project residual effects, the characterisation and significance of the cumulative effects remain identical to those for the Project's residual effects.

TCL has identified a **Follow-up Strategy** (see 8.0) to evaluate the accuracy of effects predictions and effectiveness of proposed mitigation measures regarding groundwater. The strategy focuses on implementation of a monitoring program, which involves the implementation of widely recognized BMPs and the development of procedural mitigation measures to minimize anticipated effects. The proposed monitoring program will evaluate the effectiveness of implemented mitigations, promote continuous improvement, and detect unanticipated effects where adaptive management protocols will be triggered. The monitored parameters will include groundwater levels (automated and manual), creek flow rates, and groundwater and surface water quality. The results of the monitoring program will be reviewed on a frequency to be stipulated by future permit conditions however at least quarterly is expected; statistical analyses will be performed to evaluate the trends in monitoring indicators; and TCL will submit detailed reports as required by the operational permits.

If original predictions of effects and mitigation effectiveness are not as expected, adaptive management principles and strategies will be implemented. Performance objectives (i.e., groundwater level and groundwater quality measurements) will be developed by TCL prior to the Construction Phase but may be adjusted if and as necessary as part of the adaptive management approach, e.g., if legislation or guidelines change, measurable parameters or thresholds need be adjusted. The adaptive management approach will also require consideration of management reviews, incident investigations, shared traditional, cultural, or local knowledge, new or improved scientific methods, regulatory changes, or other Project-related changes. The mitigation and monitoring strategies for groundwater will be updated to maintain consistency with action plans, management plans, and BMPs that may become available during the life of the Project. Stakeholders, Indigenous groups, and government agencies will be involved, as necessary, in developing effective strategies and additional mitigation.

1. INTRODUCTION

This chapter presents the assessment of potential Tenas Project (Project)-related effects and cumulative effects on the Groundwater Valued Component (VC). The purpose of this assessment is to analyse the potential changes to the groundwater system (i.e., quantity and quality) because of the Project.

The assessment includes:

- ▶ **Regulatory Context:** A description of the applicable legislation, policies, standards, and guidelines pertaining to the protection of the Groundwater VC;
- ▶ **Scope of the Assessment:** A description of the assessment scope including issues scoping, rationale for the selection of the Groundwater VC, subcomponents and indicators, and definition of the spatial and temporal boundaries of the assessment;
- ▶ **Existing Conditions:** A description of the baseline studies undertaken for the Project, other relevant information, and descriptions of the Groundwater VC within the defined spatial boundaries;
- ▶ **Assessment of Project-related Effects:** A description of the potential interactions between the Project and the Groundwater, potential effects, proposed mitigation measures, an evaluation of potential residual effects that remain following implementation of the proposed mitigation measures, and an assessment of their significance;
- ▶ **Cumulative Effects Assessment (CEA):** A characterisation of the cumulative effects on the Groundwater VC and their significance considering the residual effects of the Project in combination with the residual effects of past, present, and reasonably foreseeable future projects and activities and, (if/where necessary) the development of additional mitigation measures;
- ▶ **Summary of Effects Assessment:** A summary description of the Project-related effects, residual effects, and the cumulative effects (and their significance) on the Groundwater VC; and
- ▶ **Follow-up Strategy:** A presentation of monitoring programs to verify assessment predictions and evaluate mitigation effectiveness, and a discussion of adaptive management program(s) to be implemented to address any unexpected Project effects on the Groundwater VC.

2. REGULATORY CONTEXT

The Tenas Project Application Information Requirements (AIR) (British Columbia Environmental Assessment Office [BC EAO] 2022) for the Project outlines the requirements of the groundwater quantity and quality effects assessment to meet the provincial environmental assessment (EA) requirements under the British Columbia (BC) *Environmental Assessment Act*, SBC 2002, c 43 (Government of British Columbia [GovBC] 2002) (EAA).

Groundwater is a VC of the biological and physical environment and is protected under the Groundwater Protection Regulation, BC Reg 39/2016 (GovBC 2016) of the *Water Sustainability Act*, SBC 2014, c 15 (GovBC 2014), and the *Mines Act*, RSBC 1996, c 293 (GovBC 1996). The Project is expected to be subject to the federal *Fisheries Act*, 1985, c F-14 (Government of Canada [GovCan] 1985b) via potential harmful alteration, disturbance and destruction of fish habitat and the future Coal Mining Effluent Regulations which are currently in development and expected to be finalized in 2023 (GovCan 2021), as well as the provincial *Environmental Management Act*, SBC 2003, c 53 (GovBC 2003) (EMA) via a Waste Discharge Authorization permit.

Additional applicable environmental regulations and guidelines are listed below and were consulted to help with the characterisation of groundwater conditions and the assessment of the potential Project influences on groundwater:

- ▶ Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators Version 2 (British Columbia Ministry of the Environment [BC MOE] 2016);
- ▶ Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities (BC MOE 2012);
- ▶ Framework for a Hydrogeologic Study in support of an Application for an Environmental Assessment Certificate under the Environmental Assessment Act and Regulations (BC MOE 2019);
- ▶ Draft Guidelines for the Preparation of an Environmental Impact Statement, December 2015 (Canadian Environmental Assessment Agency [CEAA] 2015); and
- ▶ Joint Application Information Requirements for *Mines Act* and *Environmental Management Act*, Permits (British Columbia Ministry of Energy, Mines and Petroleum Resources [BC MEMPR] and British Columbia Ministry of Environment and Climate Change Strategy [BC MECCS] 2019) (JAIR)

3. SCOPE OF THE ASSESSMENT

The assessment of Project-related effects and cumulative effects on groundwater was conducted according to the methods set out in **Section (S) 3.0-Chapter (C) 1 Assessment Methodology** of the **Environmental Assessment Certificate (EAC) Application**. The assessment boundaries for the Groundwater VC are provided in **3.2.4** and the characterisation criteria specific to groundwater are provided in **5.4**. A calibrated 3D groundwater flow model was used to support the effects assessment. Refer to **Appendix 4.4-A Groundwater Technical Report for the Tenas Coal Project, Telkwa (SRK)**.

3.1 Issues Scoping

Telkwa Coal Ltd. (TCL) has undertaken an engagement and consultation process to support the scoping of issues for the Project. Please refer to **S11.0 Wet'suwet'en Rights and Interests Assessment** and **S12.0 Public Consultation** for details on the consultation and engagement program). This process included technical working groups established with Indigenous groups, government ministries, community meetings, one-on-one and small group meetings, regarding key themes of interest and discussion of candidate VCs to represent the themes of interest.

3.2 Rationale for Selection of Groundwater Valued Component (VC)

The Groundwater VC and associated subcomponents were selected during the pre-Application phase of the Project following the VC selection process outlined **S3.0-C1 Assessment Methodology** of the **EAC Application** and used the methodology provided in the Guideline for the Selection of Valued Components and Assessment of Potential Effects (BC EAO 2013).

3.2.1 Valued Component (VC)

VCS are components of the natural and human environment that are considered by the proponent, public, Indigenous groups, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance.

Groundwater is identified as a VC because it is protected under various legislation as discussed in **2.0 Regulatory Context**, and the Project has the potential to interact with groundwater quantity and/or quality. The open pit and the waste and water management systems can potentially have an adverse effect on humans via private groundwater wells, and to fish and other wildlife via the groundwater contributions to the streams. VC details and linkages are summarized in **Table 3.2-1**.

Project-related effects on groundwater have linkages to the following VCs:

► **Supporting:**

- Terrain and Soils (**S4.0-C2**) – Changes in groundwater quantity and quality can affect soil quality via hydrologic connectivity;
- Surface Water (**S4.0-C3**) – Changes in groundwater quantity and quality can affect creek and river flows and temperature, and surface water quality, respectively;
- Aquatic Resources (**S4.0-C5**) – Changes in groundwater quantity and quality can affect creek and river water quantity and quality which can in turn affect aquatic resources;
- Fish and Fish Habitat (**S4.0-C6**) – Changes in groundwater quantity and quality can affect creek and river water flows and quality, which can in turn affect Fish and Fish Habitat;

- ▶ **Vegetation (S4.0-C7)** – Changes in groundwater quantity and quality can affect creek and river water flows and quality, affect water available to vegetation and wetlands;
- ▶ **Wildlife (S4.0-C8)** – Changes in groundwater quantity and quality can affect creek and river water quantity and quality which can in turn affect Wildlife;
- ▶ **Avian Species (S4.0-C9)** – Changes in groundwater quantity and quality can affect creek and river water quantity and quality which can in turn affect aquatic resources; and
- ▶ **Human Health (S8.0-C1)** – Changes in groundwater quantity and quality can affect the amount of water and quality extracted by private water used for potable water.

3.2.2 Subcomponents

Subcomponents have been selected to focus the Groundwater VC assessment on key themes of interest identified through consultation and engagement, and reviews of other information. Groundwater VC subcomponents are:

- ▶ **Groundwater Quantity:** Changes in groundwater quantity may result in stream flow and groundwater level reductions, affecting surface water quantity. The Project has the potential to interact with groundwater quantity because of Project-related water management. Groundwater quantity is a pathway for effects on surface water quantity, aquatic resources, fish, vegetation, wildlife and drinking water; and
- ▶ **Groundwater Quality:** Changes in groundwater quality may affect surface water quality and other groundwater users (e.g., private wells). The Project has the potential to interact with groundwater quality because of mine water management. Groundwater quality is a pathway for effects on surface water quality, aquatic resources, fish, vegetation, wildlife and drinking water.

Subcomponents and linkages are summarized in **Table 3.2-1**.

3.2.3 Indicators

Indicators are quantitative or qualitative parameters used to describe existing VC subcomponent conditions and trends, and to evaluate potential Project effects and cumulative effects on the VC subcomponent. Indicators used in the assessment of Groundwater VC subcomponents are summarized in **Table 3.2-2**.

Table 3.2-1: Summary of Rationale for Selection of Groundwater Valued Component (VC) and Subcomponents and Their Linkages

VC or SC	Rational for Inclusion	Source of Information	VC Linkages
Groundwater (VC)	Groundwater is protected under various British Columbia (BC) legislation and the Tenas Project (Project) has the potential to interact with groundwater quantity and/or quality	- Issues scoping - Government agency - Traditional Knowledge (TK)	Supporting: - Terrain and Soils - Surface Water - Aquatic Resources - Fish and Fish Habitat - Wildlife - Vegetation - Avian Species - Human Health
Groundwater Quantity (SC)	The Project has the potential to affect groundwater quantity which could reduce baseflow to creeks and reduce groundwater levels at private wells.		
Groundwater Quality (SC)	The Project has the potential to affect groundwater quality which could affect surface water quality and drinking water quality at private wells.		

Notes: SC=subcomponent; VC=Valued Component

Table 3.2-2: Indicators for Groundwater Valued Component (VC)

Indicator	Rationale for Selection
Groundwater Quantity	
Change in groundwater levels (meters above sea level [masl]) in the area near private wells	The Project may change the spatial distribution of groundwater levels near private wells.
Change in groundwater discharge rates (m ³ /d) to creeks and rivers	The Project may affect the groundwater discharges (i.e., baseflow) contributing to creeks and rivers.
Groundwater Quality	
Change in parameter concentrations ^{1, 2} compared to provincial guidelines (BC WQG) ³ for freshwater aquatic life (FAL) and drinking water sources (DWS).	The Project may change the groundwater quality. The evaluation of baseline groundwater quality (Appendix 4.4-A SRK, Groundwater Technical Report for the Tenas Coal Project, Telkwa) includes dissolved elements, anions/nutrients, alkalinity/acidity, hardness, total dissolved solids, pH, conductivity. The evaluation of changes to groundwater quality during the Operation, and Post-closure phases includes only the parameters associated with applicable drinking water quality guidelines (i.e., total and dissolved elements, anions, and nutrients). Temperature was not evaluated as part of a change in water quality as the temperature of groundwater is not expected to be affected by the Project. Groundwater temperature was measured in the field and is presented in Appendix 6-C of Appendix 4.1-C Tenas Project 2017 to 2019 Baseline Report.

Notes: BC WQG=British Columbia Water Quality Guideline; m³/d =cubic metres per day; masl=metres above sea level; Project=Tenas Project

¹ Parameters with no applicable water quality guidelines are excluded (i.e., alkalinity/acidity, hardness, total dissolved solids, pH, and conductivity).

² Although total metal concentrations in groundwater were characterized as part of the baseline studies, they correspond to suspended particles derived from the formation (i.e., drilling and well installation disturbances) rather than natural dissolved metals in groundwater, and therefore, are excluded.

³ Where drinking water guidelines apply to total metals, these were considered in evaluating predicted changes to dissolved metal concentrations.

3.2.4 Assessment Boundaries

This subsection identifies the spatial, temporal, administrative, and technical boundaries established for the assessment of groundwater.

3.2.4.1 Spatial Boundaries

Two (2) spatial boundaries were considered for the groundwater assessment: Local Study Area (LSA) and Regional Study Area (RSA).

The LSA is defined as the area where the Project may have a direct influence on the groundwater system and/or groundwater users. The area is delimited based on watersheds, and includes the Project Area, and the private domestic wells located downgradient of the Project.

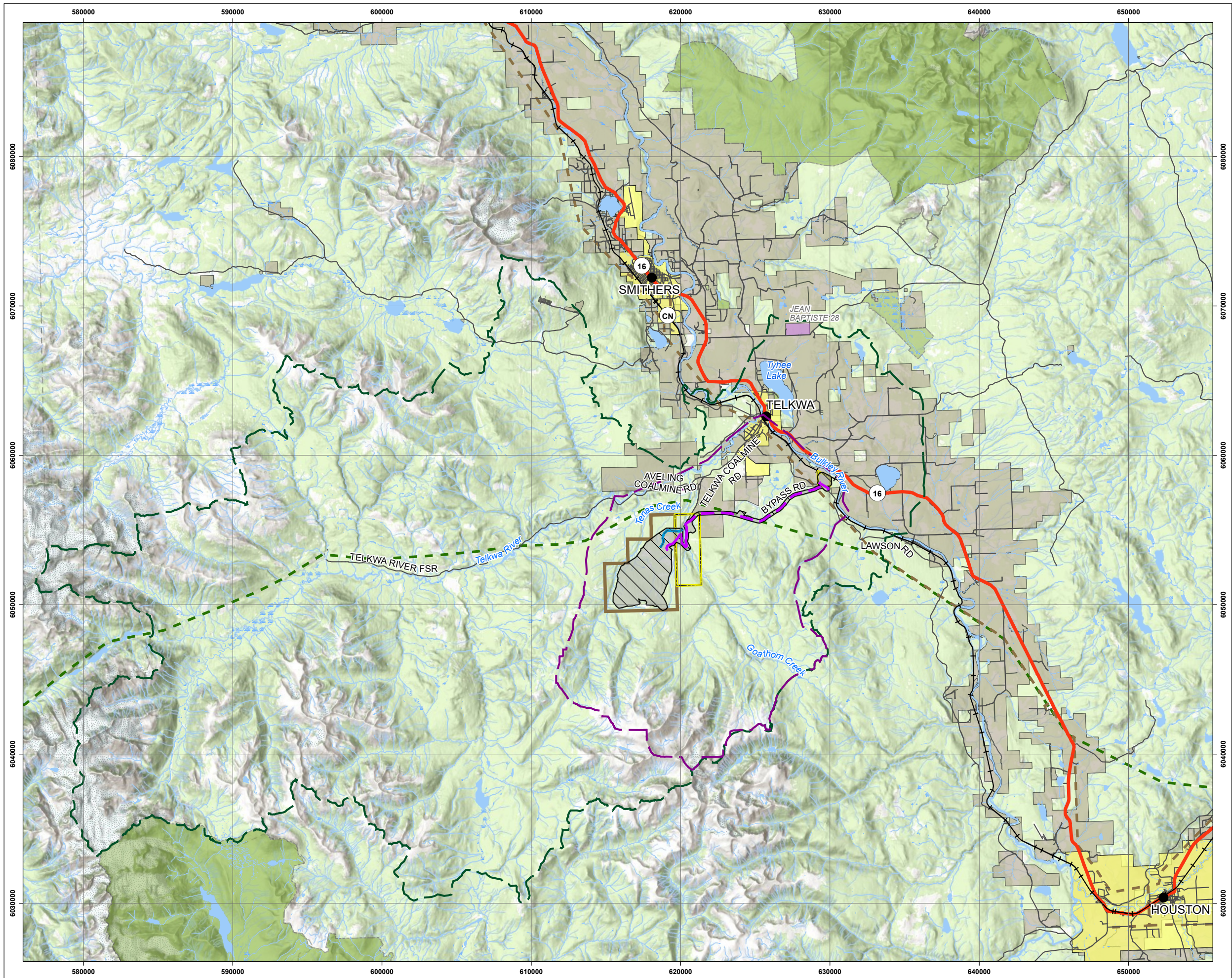
The RSA coincides with the Aquatic Resources RSA (**S4.0-C5**) given the interdependence between groundwater and surface water. The RSA encompasses the LSA and is established to provide a regional context for the assessment of Project effects. The RSA defines the boundaries of the CEA. It encompasses the area within which the residual effects of the Project are likely to interact with the residual effects of other past, present, or reasonably foreseeable future projects and/or activities.

A description of the spatial boundaries is provided in **Table 3.2-3**, and the extents of the LSA and RSA are shown on **Figure 3.2-1**.

Table 3.2-3: Spatial Boundary Definitions for Groundwater Valued Component (VC)

Spatial Boundary	Description of Study Area
Local Study Area (LSA)	The LSA is delimited by the watersheds of the Tenas Creek, and Goathorn Creek, including the Tenas Project (Project) footprint, and the private wells located between the Project and the Village of Telkwa.
Regional Study Area (RSA)	Area defined based on fish habitats in the Telkwa River watershed and in the tributaries to the Bulkley River crossed by the haul road.

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Tenas Project

Local and Regional Study Areas for Groundwater

Legend

- City/Town
- +— Rail Line
- Highway
- Tenas Access Corridor
- Road
- 138 kV Transmission Line
- 500 kV Transmission Line
- Discharge Path
- Watercourse
- Wetland
- Waterbody
- Park or Protected Area
- First Nation Reserve
- Municipal Area
- General Private Property
- Tenas Coal Licenses
- Telkwa Coal Limited Private Property
- Project Area
- Groundwater LSA
- Groundwater RSA

Notes

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

Sources

- Project Area: Allegiance Coal, April 21, 2021
- Basedata: Government of British Columbia
- Basemap: World Topo Base

N

1:250,000

0 2 4 6 8 10

Kilometres

NAD 1983 UTM Zone 9N

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TELKWA COAL LIMITED

srk consulting

3.2.4.2 Temporal Boundaries

The temporal boundaries encompass the time periods during which the Project is expected to have potential effects on groundwater. The temporal characteristics of the Project's Construction, Operation, Decommissioning and Reclamation, and Post-closure phases are described in **S1.0 Overview of Project Proponent Description** of the **EAC Application**. The relevant time periods used for the Groundwater VC effects assessment are presented in **Table 3.2-4**.

Table 3.2-4: Temporal Boundaries for the Tenas Project

Phase	Year	Duration (years)	Description of Activities
Construction	-0.5 to 0	1.5	Site clearing, soil salvage, open pit development, building construction, service and haul road development, Rail Infrastructure construction, bridge construction and development of onsite utilities and services. Development of mine rock, and overburden storage piles, stockpiling of reclamation material such as soil, overburden, and other materials suitable for reclamation. Development of water management systems and management ponds for storage of potentially acid generating (PAG) materials.
Operation	1 to 21	21	Development of the open pit through drilling, blasting, loading, and hauling functions. Development of mine rock, and overburden storage piles, stockpiling of reclamation material such as soil, overburden, and other materials suitable for reclamation. Development of water management systems and management ponds for PAG storage. Conducting coal processing, stockpiling of raw coal prior to processing, and stockpiling of processed coal prior to shipping. Progressive reclamation will be accomplished during operation including, where available, reclamation activities such as sloping, topsoil placement and revegetation.
Decommissioning and Reclamation	22 to 25	4	Tear-down of infrastructure onsite plus reclamation activities, including sloping of storage piles, backfill materials, and placement of reclamation materials including growth media, overburden and non-PAG rock for management pond covers and revegetating surfaces that are planned to be reclaimed.
Post-closure	26 to 50	10	Active: This involves the filling of the open pit with water, monitoring of vegetation growth and water quality for both groundwater and surface water and wildlife. Control and sedimentation ponds may still be needed for settling of total suspended solid levels. The management ponds are left as dry land reclamation except for portions that will be left as open water.
		15	Passive: This stage is when the control and sedimentation ponds are no longer required for settling of total suspended solid (TSS) levels and the management ponds are left as dry land reclamation except for portions that will be left as open water. Telkwa Coal Limited (TCL) is now simply monitoring the site.

3.2.4.3 Administrative Boundaries

No administrative boundaries are relevant to the Groundwater VC effects assessment.

3.2.4.4 Technical Boundaries

No technical boundaries are relevant to the Groundwater VC effects assessment.

4. EXISTING CONDITIONS

This subsection describes the existing conditions of groundwater based on Traditional Knowledge (TK), scientific information, and baseline studies undertaken for the Project.

4.1 Background Information and Studies

4.1.1 Traditional Knowledge (TK)

The purpose of this subsection is to demonstrate awareness of TK and describe how it influenced the assessment. The Groundwater LSA and RSA are situated within the Wet'suwet'en Traditional Territory. TK for the Project was obtained through a review of publicly available information as well as the **Cultural Use Study (CUS)** found in **Appendix 7.1-B of S7.0-C1 Heritage Resources Valued Component** which compiled a baseline inventory of cultural heritage resources pertaining to Wet'suwet'en communities by examining pre-existing cultural, social, historic, and economic data (Crossroads Cultural Resource Management [Crossroads] 2021). The recognition of the value of the natural environment, including water, is intrinsic throughout the **CUS**:

"The Wet'suwet'en continue to maintain a substantial connection to their hereditary lands by way of Yintah. For the Wet'suwet'en, Yintah is a central factor in their culture; it is the physical and spiritual connection that everything has to their territories (Morris et al. 2006:27; OW 2013a:14) ... [Yintah is] a concept in which all environmental components—from plants and animals to waterways and mountains—are all interconnected and linked with the human world. (OW 2011:111)" (Crossroads 2021)

TK directly related to groundwater was not available for the Groundwater VC effects assessment. However, groundwater's status as a VC reflects its importance as a factor in connected Indigenous cultural values, such as healthy waterways and watersheds. Potential effects on the Groundwater VC included in this assessment directly feed into the assessment of waterways and watersheds, such as the **Fish and Fish Habitat VC (S4.0-C6)**.

4.1.2 Scientific and Other Information

The following information was consulted to support the assessment:

- ▶ TCL 2018 drillhole database (dated 27 Nov. 2018);
- ▶ Technical reports from Klohn Leonoff Consulting Engineers (Klohn) (Klohn 1985), Piteau Engineering Ltd. (Piteau) (Piteau 1990, 1994, 1995, 1996a, 1996b, 1997a, 1997b, 1998), Stantec Inc. (Stantec) (Stantec 2016), and field and technical baseline memo/reports produced by ERM (2017, 2020), Cassiar Geoscience Consulting Ltd. (Cassiar) (2020a, 2020b), and SRK Consulting (Canada) Inc. [SRK] (SRK 2018, 2019, 2021) between 2018 and 2020;
- ▶ Digital Elevation Model (DEM) from a Light Detection and Ranging (LIDAR) survey conducted in August 2017 on behalf of TCL;
- ▶ Geological publications and maps (Clague 1984, Palsgrove 1991, Massey 2005, GovBC 2018);
- ▶ Digital maps and databases of aquifers, domestic and private wells, and water licences (GovBC 2018b, BC MOE 2018, 2020a, 2020d);
- ▶ Monthly precipitation grids for Alaska, BC, and Yukon (Stavros and Hill 2016); and
- ▶ Raster grid of a global estimation of groundwater recharge (Jasechko 2014).

4.1.3 Baseline Studies

Baseline studies were completed between 1983 and 1998 by the former owners of the Project property (Crowsnest Resources, and Manalta Coal Ltd.) TCL has continued and expanded on these studies since 2016, after acquiring the Project property. The methods used to characterise the groundwater conditions included the following activities:

- ▶ borehole drilling and logging;
- ▶ installation and development of groundwater monitoring wells;
- ▶ hydraulic conductivity (K) testing (packer tests, slug tests, pump tests);
- ▶ measurements of groundwater levels in boreholes and wells; and
- ▶ groundwater sampling.

Table 4.1-1 compiles a list of all the field programs related to groundwater, and **Table 4.1-2** provides a summary of the baseline groundwater data. Groundwater baseline data, including hydrogeology and groundwater quality, are found in Chapter 5 and 6 of **Appendix 4.1-A Tenas Project 2017 to 2019 Baseline Report (ERM) of S4.0-C1 Atmospheric Environment VC**. The report provides a complete description of the data, including a summary of historical information, the methodologies for piezometer installations, data collection, hydraulic testing, and sampling.

As recommended by relevant guidelines, historical information was reviewed. Data were compiled into spreadsheets and/or databases (i.e., Excel, Access, ArcMap, and Leapfrog) for analyses and mapping. Test analyses were reviewed and verified internally, including methodology, input values, calculations, and interpretations. Groundwater levels recorded by automatic data loggers were compensated for atmospheric pressures and checked against manual groundwater depth measurements. The monitoring measurements were plotted in three (3)-dimensional space based on the high-resolution LIDAR or surveyed collar elevation and TCL's database of drillhole surveys.

Table 4.1-1: Summary of Desktop and Field Studies Related to the Groundwater Valued Component (VC)

Study Name	Date	Spatial Boundaries, Area names ⁽⁴⁾	Study Purpose
Klohn Leonoff ⁽¹⁾	1982-1984	LSA Pit 3	▪ Borehole drilling and installation of 20 piezometers within bedrock ▪ Falling head permeability tests ▪ Packer tests in selected coal horizons ▪ Groundwater sampling
Piteau ⁽²⁾	1989	RSA Pit 7&8	▪ Borehole drilling and installation of five (5) piezometers within bedrock ▪ Rising head permeability tests ▪ Measurements of groundwater levels in piezometers and open boreholes ▪ Groundwater sampling
	1993	RSA Pit 7&8	▪ Borehole drilling and installation of five (5) monitoring wells within bedrock and one (1) within overburden ▪ Rising head permeability tests ▪ Groundwater sampling
	1995	LSA Tenas Pit	▪ Borehole drilling and installation of five (5) monitoring wells within bedrock ▪ Rising head permeability tests ▪ Groundwater sampling
	1996	LSA Tenas Pit	▪ Preliminary assessment of potential groundwater inflows and dewatering requirements for the Tenas Pit ▪ Borehole drilling and installation of five (5) monitoring wells within bedrock and six (6) within overburden ▪ Rising head permeability tests ▪ Groundwater sampling
	1996	LSA Pit 3	▪ Borehole drilling and installation of five (5) monitoring wells within bedrock and six (6) within surficial sediments ▪ Rising head permeability tests ▪ Groundwater sampling
	1996	LSA Former Tailings Pond	▪ Borehole drilling and installation of six (6) monitoring wells within surficial sediments ▪ Rising head permeability tests ▪ Groundwater sampling ▪ Mapping of the surficial geology based on air-photo interpretations
	1997	LSA, RSA Pit 3, Tenas Pit, Pit 7&8	▪ A 7-hour aquifer test in the northern portion of Pit 3 ▪ Domestic well survey in an area extending three (3) to five (5) kilometres (km) north of Pit 3 ▪ Borehole drilling and installation of 27 piezometers in Reclamation Pit (test pit originally excavated in 1983) ▪ Groundwater sampling from nearby domestic wells and from all piezometers, where possible

Study Name	Date	Spatial Boundaries, Area names ⁽⁴⁾	Study Purpose
Stantec ⁽³⁾	2016	LSA Tenas Area	- Inspection of six (6) monitoring wells around the northern portion of the Tenas Pit - Of the six (6) wells inspected, only one (1) was not dry or damaged - Groundwater samples were taken from three (3) wells, two (2) from damaged wells
ERM, Cassiar, and SRK	2017-2019	LSA Tenas Area, Access Road, Rail Loadout	Baseline groundwater monitoring program: - Inspection of 22 existing monitoring wells to determine their usability for the baseline program on July 25 and 26, 2017 - Field reconnaissance of seeps along Tenas Creek and Four Creek - Drilling of 26 boreholes, and installation of one (1) pumping test well, 18 single screen and two (2) nested monitoring wells (eight (8) screens in bedrock and 15 in surficial sediments), and three (3) vibrating wire piezometers. Development of all the new wells - One (1) pumping test, 13 packer injection tests performed in three (3) boreholes, 12 rising or falling head permeability tests completed in 11 monitoring wells, and 19 hydraulic conductivity (K) values inferred from particle size distribution analyses in overburden at 17 locations - Automatic measurements of continuous groundwater levels at five (5) monitoring wells since September 2017, and 16 campaigns of manual measurements at the monitoring wells between July 2017 and November 2019 - Quarterly groundwater quality monitoring at 13 monitoring wells initiated in July 2017

Notes: LSA=Local Study Area

¹ Kohn Leonoff Consulting Engineers (1985). This original report could not be found, but the associated data is included in Piteau's technical report (1998).

² Piteau (1990, 1994, 1995a, 1996a, 1996b, 1997a, 1997b)

³ Stantec (2016)

⁴ Pit names have changed compared to the environmental assessment (EA) mine plan described by Manalta Coal Ltd. in 1998. The Tenas Area includes the Tenas North Pit and the Tenas West Pit, the Goathorn Area includes Pit 3 and Pit 6, and the North Area includes Pit 7 and Pit 8.

Table 4.1-2: Summary of the Available Groundwater Data

Parameter	Method/Type	Count
Hydraulic conductivity tests (K)	Grain size analyses	19 (ovb)
	Rising head tests	10 (ovb), 19 (bdr)
	Packer injection tests	13 (bdr)
	Pumping tests	1 (bdr)
Monitoring wells (MW)	MWs screen within ovb	26
	MWs screen within bdr	19
	Multiple screen MWs	6
Groundwater level observations	Manual	- Up to 28 levels measured in ovb in a single event and 26 in bdr (i.e., March/April 2019) - Period of records: August 1994 to November 2019
	Automated	5 loggers (2 in ovb, 3 in bdr) - Period of records: September 2017 to August 2020
Groundwater samples	4 in October 1995 (bedrock). 16 in September/October 1996 (10 bedrock/6 overburden). 24 in August/September 1997 (13 bedrock/11 overburden). 116 between November 2016 to November 2019 (58 from bedrock and 40 from overburden).	

Notes: bdr=bedrock; ovb=overburden; MW=monitoring well

4.2 Description of Existing Conditions

This subsection describes the existing (or baseline) groundwater conditions in the context of the LSA and RSA. Full details on groundwater data, as well as data location maps and analyses, are provided in the **Appendix 4.4-A Groundwater Technical Report for the Tenas Coal Project, Telkwa (SRK)**.

4.2.1 Groundwater in the Context of the Regional Study Area (RSA)

The RSA is characterised by mountainous terrain (i.e., Telkwa and Bulkley ranges) with peak elevations ranging between 2,300 and 2,500 metres above sea level (masl) and elevations at Telkwa of about 500 masl. The main drainages are the Bulkley River (watershed area of 12,400 square kilometres [km²]), and the Telkwa River (watershed area of 830 km²). The streamflow regime is nival (snowmelt) with the majority of runoff occurring in the spring and early summer.

Available information on groundwater is concentrated in the LSA, at and around the Project, and near Telkwa. There is no information at the scale of the RSA about the groundwater table or the hydraulic properties of the ground. While bedrock lithologies and major fault zones are mapped, there is no information regarding the influences of the lithologies, faults, and smaller-scale heterogeneities on the bedrock hydraulic properties; hence, regional-scale K generalizations are necessary.

The online BC water resources atlas (BC MOE 2020a) identifies sand and gravel or bedrock aquifers within the LSA, where the Telkwa River meets the Bulkley River, and along the Bulkley River; these resources

are described in the next subsection (4.2.2). There are no provincial observation wells close to the Project; the closest (greater than >] 17 kilometres [km] away) are located at Smithers (OW089, and OW377), and Houston (OW386). Private groundwater users are all located within the LSA, about 3 to 4 km from the Project (See 3.2.4.1).

The conceptual model of the groundwater system at the scale of the RSA is based on topographical, geomorphological, and geological information, and the common understanding of hydrogeological systems within the profession. The recharge occurs in the highlands in the form of snowmelt or rain infiltration, and the discharges occur as baseflow or sub-stream flow in the creek and riverbeds, and possibly in smaller order streams, gullies, breaks in slope, and geologic discontinuities. Some flow systems may be perched and have localized seepage areas.

Groundwater is contained either in the fractured rock or in valley fill deposits. In fractured bedrock, flows are expected to be typically slower, with longer residence time, as bedrock is generally characterised by low to moderate K. In valleys, groundwater fills the glacial and fluvial sandy gravely deposits. These deposits are expected to have a larger capacity than bedrock to transmit groundwater (i.e., moderate to high K) resulting in shorter residence times.

The water table is expected to be a subdued replica of topography, with depths to groundwater typically greater in the uplands relative to the valley bottoms. Groundwater flows from the mountain's summits towards the Telkwa River Valley. The tributaries of the Telkwa River form secondary shallow flow systems dominated by discharges from shallow bedrock and overburden.

4.2.2 Groundwater Resources

The aquifer classification database of BC MOE reports six (6) aquifers of limited extent with low to moderate productivity, all located near the Village of Telkwa, where the Telkwa River joins the Bulkley River, about 8 to 10 km northeast of the proposed open pit. Each aquifer is described in **Table 4.2-1**. Their outlines are mapped in **Figure 4.2-1**.

Table 4.2-1: Description of the Minor Aquifers in the Local Study Area (LSA)

Ref. Number	Class ⁽¹⁾	Rank ⁽²⁾	Size (km ²)	Description	Productivity
569	IIC	7	2.4	Confined sand and gravel aquifers within undifferentiated sediment, overlain by fluvial and glaciomarine sediments (silt and clay).	Moderate. Well yields reported range between 0.23 and 3.0 L/s, median 0.95 L/s.
576	IIC	11	5	Confined sand and gravel aquifers within undifferentiated sediment, overlain by fluvial and glaciomarine sediments (silt and clay).	High. Well yields reported range between 0.30 and 1.5 L/s, median 0.83 L/s.
578	IIC	8	159.8	Confined bedrock aquifer. Predominately Middle Jurassic extrusive igneous rock. Minor sedimentary rocks are also noted (i.e., sandstone, conglomerate, and shale).	Low. Well yields reported range between 0.005 and 1.5 L/s, median 0.15 L/s.
581	IIIC	9	26.7	Confined sand and gravel aquifers within undifferentiated sediment, overlain by fluvial and	Moderate. Well yields reported range between 0.15 and 8.18 L/s, median 0.76 L/s.

Ref. Number	Class ⁽¹⁾	Rank ⁽²⁾	Size (km ²)	Description	Productivity
				glaciomarine sediments (silt and clay).	
582	IIB	9	0.83	Unconfined sand and gravel aquifer.	Moderate. Well yields reported range between 0.38 and 3.8 L/s, median 1.1 L/s.
583	IIA	10	2.47	Unconfined sand and gravel aquifer.	Moderate. Well yields reported range between 0.23 and 1.9 L/s, median 0.91 L/s.

Source: British Columbia Ministry of the Environment (BC MOE) 2020e

Notes: km²=square kilometres; L/s=litres per second

¹ Development subclass: the level of development of an aquifer is determined by assessing demand verses the aquifer's yield or productivity - high (I), moderate (II), or low (III); Vulnerability subclass: the vulnerability of an aquifer to contamination from surface sources is assessed based on: type, thickness and extent of geologic materials overlying the aquifer, depth to water (or top of confined aquifers), and the type of aquifer materials - high (A), moderate (B), or low (C).

² A numerical measure of an aquifer's priority is provided by the aquifer's ranking value. The ranking value is determined by summing the point values for each of the following hydrogeologic and water use criteria: productivity, size, vulnerability, demand, type of use, quality concerns (that have health risk implications), and quantity concerns. Possible ranking scores range from a low of 5 to a high of 21; the higher the ranking score, the greater the aquifer's priority.

The Village of Telkwa primarily draws water from the Bulkley River for potable use. As a backup source of water during periods of high demand, groundwater is drawn from a production well located adjacent to the Highway 16 Fire Hall and about 40 metres (m) west of Highway 16. The well has a total depth of 28 m, a screened interval between 21.3 m and 28 m, and is rated with a sustainable capacity of 467 cubic metres per day (m³/d). A hydrogeological assessment concluded that there were low permeability sediments between the river and the well, which prevents direct recharge of the well aquifer by the river. The village supplements its groundwater supply with surface water from an infiltration gallery beside the Bulkley River (i.e., intake is about 70 m upstream of the Coalmine Road Bridge) (Village of Telkwa 2018).

4.2.3 Groundwater Users

Figure 4.2-1 shows known locations of private wells (BC MOE 2020b, and TCL March/July 2020) within the LSA. The closest private domestic wells are located:

- ▶ about 3.8 km north of the proposed open pit, to the west of Goathorn Creek, along the expected groundwater flow paths towards the Telkwa River; and
- ▶ about 3.1 km and 4.5 to 5.4 km northwest of the proposed open pit, to the east of Goathorn Creek; they are located downgradient of the Project but not along the expected groundwater flow paths towards the Goathorn Creek or the Telkwa River.

4.2.4 Past and Current Human Activities

Small-scale underground and surface mining began in 1918 and continued sporadically until 1985, resulting in the recovery of over 400,000 tonnes of coal, about 3.6 km north and northwest from the Project **Figure 4.2-1**. Currently, human activities within the LSA are generally limited to mining exploration, forestry, agriculture, and recreation; most human activities (i.e., mostly agriculture and forestry) are concentrated in the Village of Telkwa and along roads, trails, and rail tracks.

4.2.5 Baseline Groundwater Quantity (Flow System)

Conceptually, the groundwater system is divided into two (2) sub-systems (or Hydrostratigraphic Units, HSU): a shallow overburden system, and a deep bedrock system. Groundwater in both systems flows towards the valleys, moving away from the open pit towards Tenas Creek, the Telkwa River, and Goathorn Creek, under an average horizontal hydraulic gradient of approximately 0.04 m/m in the overburden and 0.09 m/m in the bedrock. Static water levels are generally less than 2 metres below ground surface (mbgs) in the south part of the Project Area, to more than 20 mbgs in the north part of the Project Area, where overburden thickens. **Figure 4.2-2** shows a map of the Project Area with the inferred water tables associated with the overburden and bedrock units.

The figures listed below, located in **Appendix 4.4-A**, complement the characterisation of the groundwater flow system:

- ▶ Figures 6 to 18: information about the geology;
- ▶ Figures 21 to 24: monitoring well and test locations;
- ▶ Figures 25 to 29: information about the Project K;
- ▶ Figures 37: plot of the Project K compared to published K values;
- ▶ Figures 38 to 41: modelled thicknesses of the hydrostratigraphic units; and
- ▶ Figures 42 to 46: conceptual cross-sections of the baseline groundwater system.

Groundwater tables in overburden and bedrock in the Tenas area

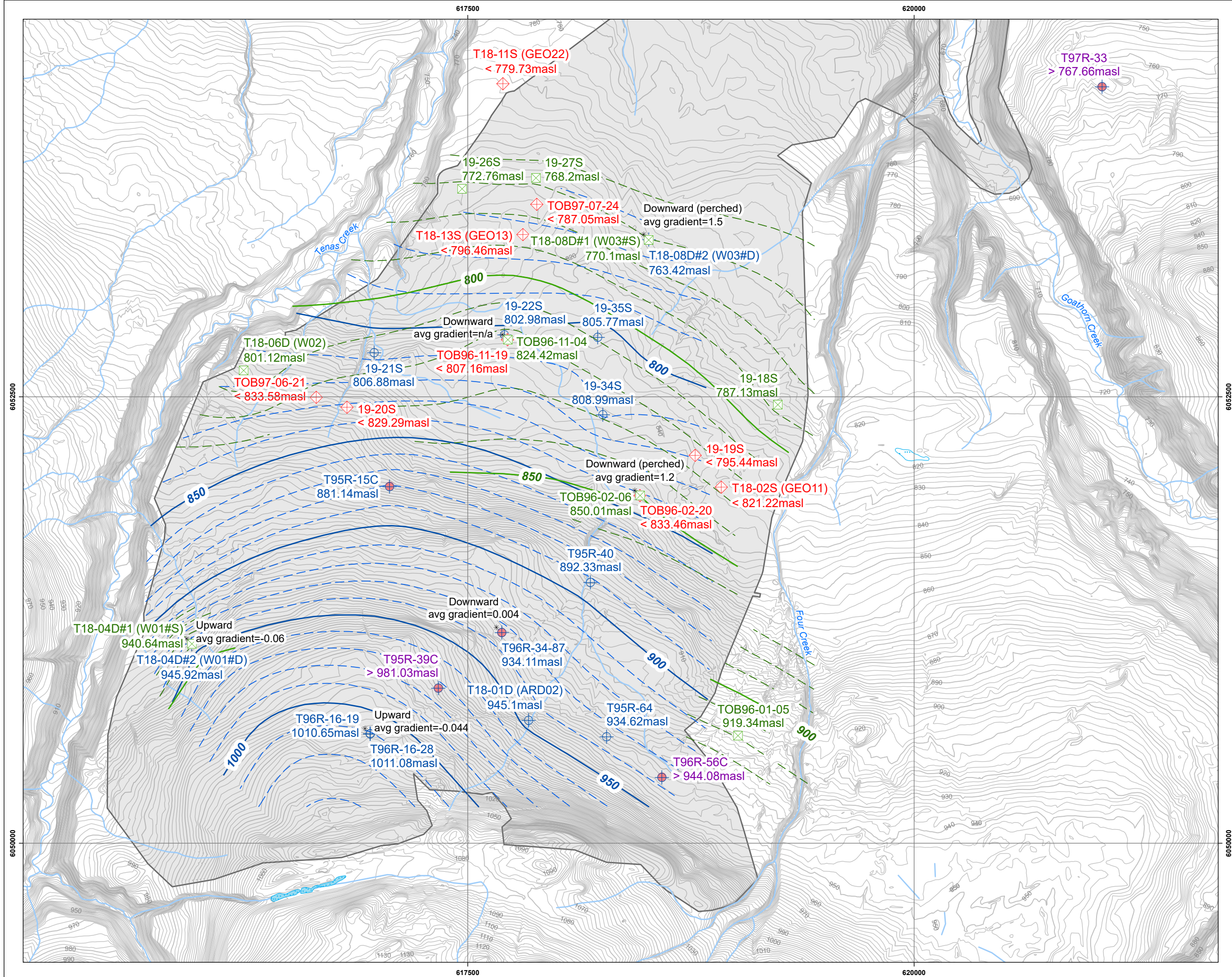
- * Vertical gradient observations
- Groundwater levels observed in overburden (avg.2019)
- Dry wells in overburden
- Groundwater level contours of overburden
- Groundwater level minor contours of overburden
- Dry wells in overburden
- Groundwater level contours of overburden
- Groundwater level minor contours of overburden
- Groundwater levels observed in bedrock (avg.2019)
- Artesian or occasionally artesian bedrock wells
- Groundwater level contours of bedrock
- Groundwater level minor contours of bedrock
- Project Area

1. All mapped features are approximate and should be used for discussion purposes only.
2. This map is not intended to be a "stand-alone" document, but a visual aid of the information contained within the referenced Report. It is intended to be used in conjunction with the scope of services and limitations described therein.

- Basedata: Government of British Columbia



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4.2.5.1 Shallow Overburden System

The surficial geology consists of glacial clay-silt-rich till, and glaciofluvial sand-gravel-rich till. South of the proposed open pit, the bedrock outcrops are close to ground surface. North of the open pit location and towards Tenas Creek and Goathorn Creek, the till deepens and exceeds 100 m. Other deposits are present locally: patches of glaciolacustrine deposits scattered throughout the morainal landscape in low ridges and depressions; fluvial deposits found in the narrow-incised floodplains of Goathorn Creek and Tenas Creek; and the wide floodplains of the Telkwa and Bulkley rivers. **Table 4.2-2** presents the conceptualized overburden hydrostratigraphic units.

Table 4.2-2: Overburden Hydrostratigraphic Units in the Local Study Area (LSA)

Unit	Type	Expected Permeability	K_{xy} range (m/s)	Extent
Fluvial sand/gravel	Unconfined aquifer	High $K_{xy} \approx K_z$	K_{xy} 10^{-4} to 10^{-2}	Stream beds and alluvial valleys
Glaciofluvial sand-gravel-rich till	Unconfined aquifer	High $K_{xy} \approx K_z$	K_{xy} 10^{-7} to 10^{-3}	Bedrock depressions north of the open pit
Glaciofluvial silt-clay-rich till	Aquitard or aquiclude	Low $K_{xy} \approx K_z$	K_{xy} 10^{-9} to 10^{-7}	Cover almost all the Project Area

Notes K_{xy} =hydraulic conductivity where (K) parallel to beddings, and K_z , K perpendicular to beddings; m/s=metres per second

The shallow overburden system is influenced by the distribution of fine material within the till. It is conceptualized as two (2) units: the silt-clay-rich glacial till, and the glaciofluvial sand-gravel-rich till. The K in the clay-silt-rich till is relatively low (K geomean 9×10^{-9} m/s), and in the sand-gravel-rich till moderately high (K geomean 1×10^{-6} m/s). Where present, the silt-clay-rich till acts as an aquitard that limits the infiltration of precipitation and promotes runoff, whereas the sand-gravel-rich till acts as an aquifer that connects the groundwater system to the stream valleys. The sand-gravel-rich till unit contains fines; it is not a clean sand and gravel unit with homogeneously high K .

The available seasonal levels of groundwater associated with overburden showed highs occur in spring following freshet and lows in winter; amplitude is about 3 m. Groundwater in overburden flows in a north-easterly direction towards Four Creek and in a north-westerly direction towards Tenas Creek, from topographic highs to adjacent topographic lows. Discharge from overburden is expected to occur in the valleys of Tenas Creek, in Four Creek and in Goathorn Creek, as well as marshes and swamps.

4.2.5.2 Deep Bedrock System

The coal-bearing sedimentary rock sequence is associated with the Lower Cretaceous age Skeena Group (marine and continental sediments interbedded with coal seams) and overlies unconformably the Jurassic-age Hazelton volcanic group (andesite, trachyte, and basalt with associated tuffs and breccias). The sedimentary sequence in the proposed open pit area is folded into a syncline. Faulting is generally near-vertical and can be subdivided into two (2) main groups, one (1) which strikes approximately northwest/southeast, and the other northeast/southwest. **Table 4.2-3** presents the conceptualized bedrock hydrostratigraphic units.

Table 4.2-3: Bedrock Hydrostratigraphic Units in the Local Study Area (LSA)

Unit	Type	Expected Permeability	K_{xy} range (m/s)	Extent
Skeena Group	Confined aquifer interbedded with aquitards/aquicludes	Moderate $K_{xy} > K_z$ ⁽¹⁾	K_{xy} 10^{-8} to 10^{-6} Anisotropy Ratio 2 to 4	Tenas and Goathorn synclines
Volcanic Group	Confined aquifer	Moderate $K_{xy} \approx K_z$	K_{xyz} 10^{-8} to 10^{-6}	Entire Project Area

Notes: ¹ K_{xy} , hydraulic conductivity where (K) parallel to beddings, and K_z , K perpendicular to beddings; m/s=metres per second

The deep bedrock system is controlled by the hydraulic properties of the Skeena sedimentary rock group, the volcanic group, fractures, and faults. At the scale of the Telkwa Watershed, the fractured rock is assumed to be equivalent to a porous medium. The sedimentary sequence of the Skeena group is simplified and represented as a single unit characterised by an anisotropy ratio perpendicular to bedding planes (i.e., K parallel to beddings higher than K perpendicular to beddings).

The hydraulic tests showed coal seams and sandstones tended to be characterised by a moderate K and mudstone and siltstones by a lower K; as a result, the coal seams and sandstone beds should act as preferential pathways to groundwater, and the mudstone and siltstone beds as aquitards or aquicludes. This behavior is equivalent to a bedding-aligned anisotropy, with K perpendicular to bedding (K_z) lower than K parallel to bedding (K_x , K_y). Data (i.e., hydraulic tests, groundwater levels) did not indicate influences from known faults (i.e., preferential flow pathway or barrier), and there is no mapped structure that would connect directly to the Project and areas with private wells. For this assessment, the intrusions located at about 5 km east and 7 km northwest from the open pit location were merged to the Volcanic Group. They are not expected to influence the groundwater predictions during mining (Operation Phase) and the Post-closure Phase because they are located away from the potential flow paths associated with mine affected water.

The results of the hydraulic tests showed bedrock has a low to moderate K (i.e., K geomean of 2×10^{-7} m/s). K geomean values sorted by lithological types, from the least permeable to the most permeable, are conglomerate (2×10^{-8} m/s), mudstone/siltstone (7×10^{-8} m/s), volcanic rock (1×10^{-7} m/s), sandstone (2×10^{-7} m/s), and coal (5×10^{-7} m/s). The anisotropic ratio range in the Skeena sedimentary rock group was estimated based on TCL drillhole logs and K measurements; results are shown in **Table 4.2-4**.

Table 4.2-4: Summary of the Skeena Group Equivalent Hydraulic Conductivity (K) Analysis in the Local Study Area (LSA)

Lithology	K_i (m/s)	K_{xy} (m/s)	K_z (m/s)	K_{xy}/K_z ratio
Coal seams	5×10^{-7}	Min= 3×10^{-8} Max= 4×10^{-7} Geomean= 1×10^{-7}	Min= 3×10^{-8} Max= 2×10^{-7} Geomean= 5×10^{-8}	Min=1.0 Max=4.7 Average=3.0
Sandstone	3×10^{-7}			
Mudstone/Siltstone	3×10^{-8}			

Notes: m=metres; m/s=metres per second, max=maximum; min=minimum

The equivalent K parallel to bedding (K_{xy}) and equivalent K perpendicular to bedding (K_z) are calculated for each drillhole using the formula:

$$K_{xy} = (\sum_{i=1}^n B_i \times K_i) / (\sum_{i=1}^n B_i) \text{ and } K_z = (\sum_{i=1}^n B_i) / (\sum_{i=1}^n \frac{B_i}{K_i}). \text{ (Freeze and Cherry 1979)}$$

Where B_i and K_i are, respectively, the thickness and hydraulic conductivity (K) of the layer i , and K_i corresponds to the K geomean of each lithology calculated from TCL K database).

It was also noted that drillhole logs generally indicate relatively thick layers of mudstone between the open pit floor surface and the top of the volcanic group, which could limit transmission of groundwater to and from the open pit. This complexity was not accounted for in the conceptual model because the current dataset does not guarantee the absence of connections between upper and lower sub-units separated by mudstone, for example, along faults where displacements may have created connections between layers previously separated.

Automated groundwater level monitoring of the Bedrock HSU is recorded at three (3) wells. The available seasonal groundwater levels associated with bedrock wells were divided in two (2) groups. One (1) well showed seasonal variations like overburden, with highs in spring, lows in fall and winter, and an amplitude of about 1 m, suggesting it has a connection with overburden. The other two (2) wells showed highs in winter, lows in summer and fall, and an amplitude of about 0.4 m, implying recharge is delayed by several months, potentially by the low permeability of the silt-clay-rich till. Groundwater level measurements indicated groundwater flows from the upland areas in a northerly direction towards the major drainage features of the area, namely the Telkwa River and its tributaries, Tenas Creek and Goathorn Creek. Discharge from the bedrock system into riverbeds is expected to dominate in these drainages because of the elevation difference between valleys and terraces.

4.2.6 Baseline Groundwater Quality

The figures provided in **Appendix 4.4-A** and listed below summarize the information supporting the characterisation of the groundwater quality:

- ▶ Figure 33: locations of the monitoring well screens;
- ▶ Figure 34: locations of the groundwater quality exceedances above British Columbia Water Quality Guidelines (BC WQG) Freshwater Aquatic Life (FAL) and Drinking Water Sources (DWS) (BC MECCS 2020, 2021); and
- ▶ Figure 35: piper plots of the groundwater quality samples.

The shallow overburden system is characterised by local unconfined systems with relatively short residence times and low concentrations of dissolved solids, while the deep bedrock groundwater system has a large lateral extent and is characterised by confined flow, relatively long residence times in the subsurface, and higher concentrations of dissolved solids. The groundwater in overburden wells is classified as a calcium-magnesium-bicarbonate type; groundwater in bedrock wells as sodium-bicarbonate type.

The baseline groundwater quality statistics are provided in **Table 4.2-5**, and compared to BC WQG with exceedances highlighted. Full details on the groundwater quality data, and exceedances above BC WQG are available in **Appendix 4.4-A**. Exceedances above the BC WQG FAL guidelines (approved or working) were observed for fluoride, ammonia, and dissolved aluminum, cadmium, chromium, copper, iron, and silver. Exceedances above the BC WQG DWS guidelines were observed for fluoride, and the following dissolved metals: iron, cobalt, manganese, and mercury. Note, exceedances were also noted in historical data for total metals, however, the differences observed in historical wells over time, and the correlations between turbidity and total/dissolved metals concentrations indicate that exceedances of total metals were caused by suspended particles generated by disturbances (i.e., drilling and well installation) rather than natural dissolved metals in groundwater.

As part of the baseline program, five (5) private wells were sampled. Groundwater from private wells (of **Appendix 4.4-A**) is classified as a calcium-magnesium-bicarbonate type, with one well containing a higher proportion of sulfate relative to the other wells. Exceedances of BC WQG FAL and DWS guidelines for total arsenic, total manganese, total and dissolved iron, total phosphorus, and total organic carbon were also noted (see **Appendix 4.4-A**).

Table 4.2-5: Summary Statistics for Baseline Groundwater Quality

Parameter	Units	BC WQG FAL		BC WQG DWS		Overburden Water Quality			Bedrock Water Quality		
		Screening Parameter	Value	Screening Parameter	Value	P50	P95	Count	P50	P95	Count
TSS	mg/L	-	-	-	-	15	2000	48	13	230	69
TDS	mg/L	-	-	-	-	340	410	48	820	1800	69
pH (Field)	-	A, pH	6.5 to 9	-	-	7.7	8.8	46	7.7	9.2	68
Alkalinity, total	mg CaCO ₃ /L	-	-	-	-	290	400	48	760	1700	69
Hardness, total	mg CaCO ₃ /L	-	-	-	-	190	390	48	44	120	69
Specific Conductance	µS/cm	-	-	-	-	540	700	48	1300	2800	69
Bromide	mg/L	-	-	-	-	0.05	0.1	39	0.25	1	57
Chloride	mg/L	A, Cl	600	AO, Cl	250	0.52	3.3	48	2.5	10	69
Fluoride	mg/L	A, F	0.4-2.0 (H)	MAC, F	1.5	0.13	0.35	41	1.5	5.1	61
Sulfate	mg/L	A, SO ₄	100	AO, SO ₄	500	11	42	48	6	75	69
Ammonia, total	mg-N/L	A, NH ₄ -tot	0.681-28.7 (pH) (T)	-	-	0.025	0.61	44	0.32	0.69	69
Nitrate	mg-N/L	A, NO ₃	32.8	MAC, nitrate-N	10	0.005	0.17	41	0.025	0.16	58
Nitrite	mg-N/L	A, NO	0.06 (cl)	MAC, nitrite-N	1.0	0.001	0.005	41	0.005	0.02	58
Nitrogen, total	mg/L	-	-	-	-	0.54	5.9	40	0.38	2.2	64
Aluminum, dissolved	mg/L	A, Al-Diss	0.10 (pH)(1)	MAC Al-tot	9.5	0.005	0.034	44	0.0086	0.1	69
Antimony, dissolved	mg/L	-	-	MAC Sb-tot	0.006	0.0005	0.00054	37	0.0005	0.00097	61
Arsenic, dissolved	mg/L	-	-	MAC, As-tot	0.01	0.00081	0.011	44	0.0006	0.002	69

Parameter	Units	BC WQG FAL		BC WQG DWS		Overburden Water Quality			Bedrock Water Quality		
		Screening Parameter	Value	Screening Parameter	Value	P50	P95	Count	P50	P95	Count
Barium, dissolved	mg/L	W, Ba-tot	5	-	-	0.093	0.25	45	0.33	3.6	69
Beryllium, dissolved	mg/L	W, Be-tot	0.01	-	-	0.0001	0.0002	44	0.0001	0.005	69
Boron, dissolved	mg/L	A, B-tot	1.2	MAC, B-tot	5.0	0.10	0.10	44	0.16	0.34	69
Cadmium, dissolved	mg/L	A, Cd-Diss	0.0000176-0.000457 (H)(4)	MAC, Cd-tot	0.005	0.000021	0.00027	45	0.000012	0.0016	69
Calcium, dissolved	mg/L	-	-	-	-	50	86	46	14	35	68
Chromium, dissolved	mg/L	W, Cr-tot	0.001 or 0.0089 (2)	MAC, Cr-tot	0.05	0.001	0.001	44	0.001	0.002	69
Cobalt, dissolved	mg/L	A, Co-tot	0.11	MAC, Co-tot	0.001	0.0003	0.0041	44	0.0003	0.0026	69
Copper, dissolved	mg/L	A, Cu-tot	0.002 - 0.026 (H)	MAC/AO, Cu-tot	2.0 / 1.0	0.001	0.005	45	0.001	0.0039	69
Iron, dissolved	mg/L	A, Fe-Diss	0.35	AO, Fe-tot	0.30	0.03	0.099	44	0.065	0.59	69
Lead, dissolved	mg/L	A, Pb-tot	0.003 - 0.33 (H)	MAC, Pb-tot	0.005	0.0005	0.00093	44	0.0005	0.001	69
Lithium, dissolved	mg/L	-	-	-	-	0.0028	0.0067	45	0.05	0.1	66
Magnesium, dissolved	mg/L	-	-	-	-	14	51	46	1.9	8.6	68
Manganese, dissolved	mg/L	A, Mn-tot	0.80-3.80 (H)	MAC/AO, Mn-tot	0.12 / 0.02	0.052	0.57	45	0.017	0.25	69
Mercury, dissolved	mg/L	-	-	MAC, Hg-tot	0.001	0.000005	0.00018	44	0.000005	0.03	69
Molybdenum, dissolved	mg/L	A, Mo-tot	2	MAC, Mo-tot	0.088	0.001	0.015	45	0.001	0.015	69
Nickel, dissolved	mg/L	W, Ni-tot	0.025 - 0.180 (H)	MAC, Ni-tot	0.08	0.001	0.017	44	0.001	0.005	69

Parameter	Units	BC WQG FAL		BC WQG DWS		Overburden Water Quality			Bedrock Water Quality		
		Screening Parameter	Value	Screening Parameter	Value	P50	P95	Count	P50	P95	Count
Phosphorus, dissolved	mg/L	-	-	-	-	0.012	0.89	40	0.016	0.06	61
Potassium, dissolved	mg/L	W, K-tot	373 to 432	-	-	2	2	44	2	3.5	68
Selenium, dissolved	mg/L	A, Se-tot	0.002	MAC, Se-tot	0.01	0.0002	0.00096	45	0.00014	0.001	69
Sodium, dissolved	mg/L	-	-	-	-	20	110	45	320	720	68
Silver, dissolved	mg/L	A, Ag-tot	0.0001-0.003 (H)	-	-	0.00002	0.00027	44	0.00002	0.0001	68
Thallium, dissolved	mg/L	W, TI-tot	0.0017 - 0.0063 (3)	-	-	0.0002	0.0002	37	0.0002	0.0002	58
Tin, dissolved	mg/L	-	-	-	-	0.0005	0.0049	36	0.0005	0.00053	51
Titanium, dissolved	mg/L	W, Ti-tot	2	-	-	0.01	0.024	44	0.01	0.05	66
Uranium, dissolved	mg/L	W, U-tot	0.3	MAC, U-tot	0.02	0.0011	0.0032	45	0.0004	0.0071	69
Vanadium, dissolved	mg/L	-	-	-	-	0.001	0.005	45	0.00053	0.03	69
Zinc, dissolved	mg/L	A, Zn-tot	0.033-0.265 (H)	MAC/AO, Zn-tot	3.0 / 5.0	0.005	0.012	44	0.005	0.011	69

Notes: Bold and shaded=concentration exceeds BC WQG (FAL or DWS, A or W or MAC)

-=not applicable/no guideline; avg.=average; A=Approved guideline; AO=Aesthetic objective; BC WQG=British Columbia Water Quality Guidelines; Diss=dissolved; DWS=Drinking Water Sources; FAL=Fresh Aquatic Life; MAC=Maximum allowable concentration; P50=50th percentile; P95=95th percentile; Tot=total; W=Working guideline

(1) Dissolved Aluminum is pH dependent. 100 microgram per litre (ug/L) for a pH greater than or equal to 6.5 and $e(1.209 - 2.426 (pH) + 0.286K)$ where $K = (pH)^2$ for a pH less than 6.5

(2) Chromium (VI) maximum is 1.0 ug/l and Chromium (III) maximum is 8.9 ug/L

(3) Thallium - 1.7 ug/L human health, consumption of water + organism and 6.3 ug/L human health, consumption of organism only

(4) Dissolved Cadmium is hardness dependent. Lower bound for long term average guideline exposure is 0.0000176 mg/L and the upper bound is 0.000457 mg/L.

(Cl) Chloride dependent guideline

(H) Hardness dependent guideline

(pH) pH dependent guideline

(T) Temperature dependent guideline

5. ASSESSMENT OF PROJECT-RELATED EFFECTS

The information provided within this subsection includes:

- ▶ identification of potential Project-related interactions with groundwater;
- ▶ description of potential Project-related effects on groundwater;
- ▶ identification of mitigation measures; and
- ▶ characterisation of Project residual effects and determination of their significance on the Groundwater VC.

5.1 Potential Project-related Interactions with Groundwater Valued Component (VC)

A detailed exercise was undertaken to identify the Project components and activities expected to interact with the Groundwater VC and cause a potential effect on groundwater, in terms of both quantity and quality. The potential interactions were identified based on professional experience with other mining projects in BC and through multi-disciplinary consultation with consultants working on behalf of TCL. Interactions are defined as either No Interaction, or Interaction, as outlined in **Table 5.1-1**.

Table 5.1-1: Potential for an Interaction between Groundwater Valued Component (VC) and the Tenas Project

Term	Definition
No Interaction	Tenas Project (Project) activity will not interact with the Groundwater Valued Component (VC), no adverse effect is expected; no further consideration is warranted.
Interaction	Interaction between the Project activity and the Groundwater VC may have a substantive influence on the short- or long-term integrity of the VC (i.e., measurable, or detectable using the identified indicator). The potential effect(s) of the interaction is considered further in the effects assessment.

The evaluation of the interaction matrix (**Table 5.1-2**) led to identification of potential interactions between Project components or activities and Groundwater VC subcomponents, which are those that warrant further assessment as they have potential to result in residual effects or to be of greater concern to Indigenous groups, government, or the public. Where an interaction is possible, the anticipated potential effect(s) is identified and carried forward in the assessment (**5.2 Potential Project-related Effects**).

Where no interaction between the Project and a subcomponent is anticipated the interaction is not considered further in the assessment for one (1) or both of the following reasons:

- ▶ They are known to have no or negligible adverse effects (i.e., not expected to have an influence on the integrity of groundwater; effect would not be measurable or detectable using the indicators identified for the groundwater VC); or
- ▶ They are already well regulated or managed under another regulatory process.

Table 5.1-2: Interactions between the Groundwater Valued Component (VC) and the Tenas Project

Project Activities	Subcomponents	
	Groundwater Quality	Groundwater Quantity
Construction		
Transportation of equipment, materials, and personnel	X	
Site clearing (surveying, clearing, grubbing, soil salvaging)		
Construction of Surface Water Management Infrastructure, including channels and ponds (sedimentation, control, management, storage)	X	X
Construction of Bypass Road and quarries from the Minesite to the Rail Infrastructure	X	X
Improvements to existing private road and Forest Service Roads		
Construction of haul roads and service roads within the Minesite		
Construction of the permanent Goathorn Creek Bridge over Goathorn Creek		
Construction of the Coal Processing Plant		
Construction of fuel and lubricant storage facilities and distribution network	X	
Construction of administration buildings (first aid, maintenance, mine dry, warehouse, laboratory, parking, and vehicle wash facilities)		
Construction of a 25 kilovolt (kV) powerline and a 600-volt (V) substation adjacent to the Coal Processing Plant		
Construction of Rail Infrastructure including Rail Loop and Loadout connecting to the existing main Canadian National Railway line	X	
Installation of water supply wells, storage, and distribution system		X
Construction of the water discharge infrastructure		
Construction of storage piles for overburden, rock separated from coal in Coal Processing Plant, and stockpiles for topsoil and vegetation management	X	
Construction of material handling systems for Minesite, including run-of-mine coal, processed coal, process rock conveyors, and stockpiles		
Construction of solid waste management systems including recycling and composting facilities		
Construction of Explosives Magazine (storage building)		
Employment and labour		

Project Activities	Subcomponents	
	Groundwater Quality	Groundwater Quantity
Operation		
Mining the open pit (soil salvaging, drilling, and blasting, excavation of material, dewatering, loading, hauling, unloading)	X	X
Operation of Surface Water Management Infrastructure including channels and ponds (sedimentation, control, management, storage)	X	X
Maintain and use Bypass Road and quarries from the Minesite to the Rail Infrastructure		
Maintain improved private and Forest Service Roads		
Maintain haul roads within the Minesite, including service roads		
Maintain permanent bridge over Goathorn Creek		
Operate Coal Processing Plant		
Maintain fuel and lubricant storage facilities		
Maintain administration buildings (first aid, maintenance, mine dry, warehouse, laboratory, and vehicle wash facilities)		
Maintain 25 kV powerline and a 600 V substation adjacent to the Coal Processing Plant		
Transportation of equipment, materials, and personnel		
Maintain and use Rail Infrastructure including Rail Loop and Loadout connecting to the existing main Canadian National Railway line		
Operate water supply wells, storage, and distribution system		X
Operate the water discharge infrastructure		
Maintain storage piles for overburden, rock separated from coal in Coal Processing Plant, and stockpiles for topsoil and vegetation management		
Operate material handling systems for Minesite, including run-of-mine coal, processed coal, process rock conveyors, and stockpiles		
Operate solid waste management systems including recycling and composting facilities		
Maintain Explosives Magazine (storage building)		
Progressive reclamation		
Employment and labour		

Project Activities	Subcomponents	
	Groundwater Quality	Groundwater Quantity
Decommissioning and Reclamation		
Dismantle and remove mining equipment and facilities (including powerline infrastructure, Rail Infrastructure)		
Transportation of equipment, materials, and personnel		
Reclamation and closure activities at Minesite	X	X
Reclamation and closure of Bypass Road and haul roads, including and quarries		
Reclamation and closure of permanent bridge over Goathorn Creek		
Reclamation and closure of Powerline infrastructure		
Reclamation and closure of Rail Infrastructure		
Implement post-mining systems and monitoring		
Employment and labour		
Post-closure		
Maintain post-mining systems and ongoing monitoring	X	X
Transportation of equipment, materials, and personnel		
Employment and labour		

Notes:

Interaction (X): Interaction between the Project activity and the VC may have a substantive influence on the short- or long-term integrity of the VC (i.e., measurable, or detectable using the identified indicator). The potential effect(s) of the interaction is considered further in the effects assessment.

No interaction (Blank): Project activity will not interact with the VC; no adverse effect is expected; no further consideration is warranted.

5.2 Potential Project-related Effects

This subsection considers potential adverse Project-related effects on groundwater arising from the interactions identified in **Table 5.1-2**, and in relation to the indicators listed in **Table 3.2-2**. Mitigation measures for each potential effect are described in **5.3**.

5.2.1 Groundwater Quantity Subcomponent

5.2.1.1 *Change in Groundwater Levels in the Area of Private Wells*

5.2.1.1.1 *Construction Phase*

During the Construction Phase, activities will modify the characteristics of the subsurface. This may result in changes to site drainage patterns and groundwater flows because of diversions and infiltrations resulting in the lowering and/or mounding of the water table. The changes are expected to remain localized to the footprints of the respective infrastructures given the short duration relative to operations. Therefore, the Project effects on the groundwater levels in areas of private wells are anticipated to be null during this phase and is not considered further.

5.2.1.1.2 *Operation Phase*

During the Operation Phase, the development and dewatering of the open pit, and the construction and operation of the waste and water management facilities are expected to influence the groundwater levels locally and at a distance from the Minesite. Mining will likely change the physical properties of the ground and subsurface, and the site drainage patterns; the dewatering of the open pit is expected to result in a drawdown of the water table; and the waste and water management facilities will likely generate a mound underneath the facilities. As the drawdown and mound expand over time, the groundwater levels in areas of private wells may change; a drop of the groundwater levels could adversely affect the pumping yields of private users.

5.2.1.1.3 *Decommissioning and Reclamation Phase and Post-closure Phase*

At the start of the Decommissioning and Reclamation Phase, dewatering will stop, and the system is expected to progressively return to steady Post-closure Phase conditions that integrate the permanent changes to the ground and subsurface, and to the site drainage patterns. Where Post-closure Phase groundwater levels in areas of private wells were lower than baseline, it has the potential to adversely affect the pumping yields of private users.

5.2.1.2 *Change in Groundwater Discharge Rates to Creeks and Rivers*

5.2.1.2.1 *Construction Phase*

During the Construction Phase, activities are expected to modify the characteristics of the subsurface. This may result in changes to site drainage patterns and groundwater flows because of diversions and infiltrations resulting in the lowering and/or mounding of water table underneath the facilities under construction. No Project effects on groundwater flows to creeks and rivers are anticipated during this phase, as the changes are expected to be localized, and is not considered further.

5.2.1.2.2 *Operation Phase*

During the Operation Phase, the development and dewatering of the open pit, and the construction and operation of the waste and water management facilities are expected to influence the groundwater flows, locally and at a distance from the Minesite. Mining will likely change the physical properties of the ground and subsurface, and the site drainage patterns; the dewatering of the open pit will likely withdraw groundwater from the system; and the waste and water management facilities will likely generate seepage underneath the facilities. As the open pit and the waste and water management facilities expand over time, groundwater discharges to creeks and rivers will likely change, resulting in a reduction of flows to the creeks and rivers.

5.2.1.2.3 *Decommissioning and Reclamation Phase and Post-closure Phase*

At the start of the Decommissioning and Reclamation Phase, dewatering will stop, and the system is expected to progressively return to steady Post-closure conditions that integrate the permanent changes to the ground and subsurface, and to the site drainage patterns. Where the Post-closure groundwater discharges to creeks and rivers are lower than baseline, surface water discharge volumes could be adversely affected.

5.2.2 Groundwater Quality Subcomponent

5.2.2.1 *Change in Groundwater Quality in the Area of Private Wells*

5.2.2.1.1 *Construction Phase*

During the Construction Phase, activities are expected to generate dust and accidental spills may occur, which may result in changes to groundwater quality because of contact water infiltrating into the groundwater system. Potential infiltration of contact water will remain localised to the immediate footprints of the respective infrastructures. Thus, no Project-related effects on the groundwater quality (i.e., parameter concentrations) are expected in areas that support private wells during this phase and is not considered further.

5.2.2.1.2 *Operation Phase*

During the Operation Phase, contact water (i.e., from dust deposition, open pit wall weathering, metal leaching/acid rock drainage (ML/ARD), and/or blasting) is expected to infiltrate underneath the waste and water management facilities into the ground and migrate slowly through the groundwater system into the valleys. Where contact groundwater reaches areas with private wells, users may be adversely affected by an increase in parameter concentrations above the BC WQG for DWS compared to average baseline.

5.2.2.1.3 *Decommissioning and Reclamation Phase and Post-closure Phase*

At the start of the Decommissioning and Reclamation Phase, the system is expected to progressively return to steady Post-closure Phase conditions. Contact water that enters the groundwater system during the Operation Phase is expected to continue migrating while new contact water from weathering of open pit walls, end pit lakes and management ponds enters and migrate through the groundwater system. Where contact groundwater reaches areas with private wells, users may be adversely affected by an increase to parameter concentrations above the water quality guidelines for drinking water sources compared to average baseline.

5.2.2.2 Changes in Quality of Groundwater Discharging to Creeks and Rivers

5.2.2.2.1 Construction Phase

During the Construction Phase, activities will likely generate dust and accidental spills may occur, which may result in changes to groundwater quality because of contact water infiltrating into the groundwater system. However, no Project-related effects on the quality of groundwater contributed to creeks and rivers are expected during this phase. Movement of groundwater is slow so potential infiltrations of contact water are expected to remain localized to the footprints of the respective infrastructures during the Construction Phase and is not considered further.

5.2.2.2.2 Operation Phase

During the Operation Phase, contact water (i.e., from dust deposition, open pit wall weathering, ML/ARD, and/or blasting) is expected to infiltrate underneath the waste and water management facilities into the ground and migrate slowly through the groundwater system to the valleys. Where contact groundwater reaches the creeks and/or rivers, the surface water quality could be adversely affected by an increase to parameter concentrations compared to average baseline and above the BC WQG FAL.

5.2.2.2.3 Decommissioning and Reclamation Phase Through to Post-closure Phase

At the start of the Decommissioning and Reclamation Phase, the system is expected to progressively return to steady Post-closure conditions. Contact water that entered the groundwater system during the Operation Phase will likely continue migrating while new mine-affected water from weathering of open pit walls, end pit lakes, saturated waste rock, and management ponds enter and migrate through the groundwater system. Where contact groundwater reaches the creeks and rivers, the quality of the groundwater contributions could be negatively affected by an increase to parameter concentrations compared to average baseline and above the BC WQG FAL.

5.3 Mitigation Measures

This subsection describes the mitigation measures to address the potential adverse effects of the Project on the Groundwater VC. The mitigation measures are consistent with the mitigation definition provided by BC EAO (BC EAO 2013) and encompass practical means or measures taken to avoid, minimize, rehabilitate onsite, and if required, compensate, or offset the potential adverse effects of a project.

TCL has incorporated several mitigation measures in the Project's design and/or operational procedures to reduce the magnitude, duration, and extent of effects due to the Project. These Project mitigation measures are outlined in **S1.0 Overview of Project Proponent Description** of the **EAC Application** and include Project design aspects such as site selection, selection of best available technologies to-date for Project infrastructure and mining equipment, and a commitment to progressive reclamation. Project mitigation measures that are relevant to minimizing potential Project-related effects on the Groundwater VC are described in **5.3.1** to **5.3.5**.

Several environmental management plans will define the standard operating procedures, the best management practices (BMPs), the adherence to existing environmental regulations, and the use of appropriate design criteria. The following list compiles the management plans and management strategies with potential linkages to the Groundwater VC:

- ▶ **Chemicals and Materials, Storage, Transfer, and Handling Plan (S13.0-C3) (CMSTHP);**
- ▶ **Explosives Management Plan (S13.0-C6) (EMP);**

- ▶ **Fuel Management and Spill Control Plan (S13.0-C7) (FMSCP);**
- ▶ **Minesite Water Management Plan (S13.0-C11) (MWMP);**
- ▶ **ML/ARD Management Plan (S13.0-C12) (ML/ARDMP);**
- ▶ **Reclamation and Closure Plan (S13.0-C15) (RCP); and**
- ▶ **Waste Management Plan for Refuse and Emissions (S13.0-C20) (WMPRE).**

The management plans provide further direction on sequencing, monitoring and adaptive management and the mitigation measures outlined in each plan are expected to be timely and effective following implementation.

Mitigation measures are commitments that TCL has applied through mine design and to the operating principals through the life cycle of the Project. All mitigation measures for the Groundwater VC are described in detail in the following subsections and summarized in **Table 5.3-1**.

5.3.1 Limit Project Footprint and Project Area

To limit the Project footprint and Project Area the Project has been designed to:

- ▶ Cluster Project components, including the open pit, stockpiles for run-of-mine (ROM) coal, processed coal and processed rock, Coal Processing Plant (CPP), management ponds, and ancillary facilities such as the Maintenance Facility and Administration Building;
- ▶ Align linear Project features (such as powerlines, roads, water distribution) into a common ROW;
- ▶ Place Project features within existing or planned Project component footprints to limit the clearing of vegetation and the salvage of reclamation materials (surface soil, wood debris, and overburden). For example, the Minesite buildings will be built in areas previously cleared by forestry activity;
- ▶ Minimize the length of haul roads, access roads, and rail line where possible. Use or improve existing roads where practical;
- ▶ Utilize a loop design configuration for the rail that requires half the space and subsequent footprint compared to the standard teardrop shape seen at other operating or proposed coal mines in western Canada;
- ▶ Place reclamation material (surface soil and woody debris) stockpiles within development areas such as the open pit and haul roads to avoid disturbance, while overburden is directly placed on Project components for future reclamation activities;
- ▶ Limit the Tenas Access Corridor (TAC) to a single lane width for long distances and utilize existing Forest Service Roads (FSRs) or private roads where appropriate;
- ▶ Backfill approximately 50 percent (%) of non-coal material back into the open pit; and
- ▶ Place processed rock from the CPP within the management ponds versus a separate permanent pile to avoid any potential ARD from this material and reduce Project footprint.

5.3.2 Blasting Measures

The following mitigation measures apply to blasting:

- ▶ Use best management stemming techniques (e.g., type of material, size consistency, loading method, and thickness) that will minimize effects of noise and fugitive dust from blast patterns

and assist in the complete detonation of drill holes to reduce the introduction of nitrogen species into the surrounding rock per the **EMP**;

- ▶ Correctly time blasts to minimize effects of noise, vibration, and fugitive dust from blast patterns;
- ▶ Keep blast patterns small to minimize effects of noise, vibration, and fugitive dust and to reduce the time that patterns need to sleep or wait until they are blasted which reduces the introduction of nitrogen species into the surrounding rock;
- ▶ Monitor actual blast results and implement improvements as required as per the adaptive management process to reduce effects of noise, vibration, fugitive dust and reduce the introduction of nitrogen species into the surrounding rock; and
- ▶ Use electronic detonators to minimize effects of noise, vibration, and fugitive dust from blast patterns, and manage misfires to reduce the introduction of nitrogen species into the surrounding environment;

5.3.3 Management, Control, and Water Storage Pond Designs

The Project will incorporate the following pond design measures that will mitigate the potential effects on the Groundwater Quality subcomponent:

- ▶ The North, East, West management ponds, and the Tenas Control Pond have been designed with low permeability liners to minimize the seepage of contact water underneath these facilities into the groundwater system, as well as channels along their peripheries to maximize the interception of water discharges downgradient of their dams;
- ▶ Liners will cover the entire internal footprints of all ponds, except the West Management Pond where approximately 57% of the pond's internal footprint will be lined (i.e., the liner will cover the overburden portions outside of and within the open pit boundary. The open pit walls and open pit floors comprised of bedrock will not be lined);
- ▶ Liners for the North, East, and West management ponds will consist of overburden bentonite mixed materials while the Tenas Control Pond liner will consist of a bituminous geomembrane. The designs of the management ponds and the Tenas Control Pond are documented in **S1.0-1.22.4 Liners** of the **EAC Application**;
- ▶ Project is phased to allow groundwater recharge to commence from the Tenas Control Pond and North Management Pond early in the Project to offset groundwater drawdown from the open pit;
- ▶ The Potable Water Storage Pond will be lined with either a geomembrane or other appropriate type of liner to reduce seepage and the amount of water required by the Project; and
- ▶ The Wastewater Storage Pond will be lined with either a geomembrane or other appropriate type of liner to minimize the amount of water entering the groundwater system.

5.3.4 Management of Metal Leaching/Acid Rock Drainage (ML/ARD)

The following mitigation measures apply to preventing potential ARD:

- ▶ Identify and segregate PAG material while mining the open pit, and place PAG material in management ponds and submerge PAG material under a minimum of 1.0 metre (m) of water within an average of six (6) months after excavation but no longer than 12 months and under at least two (2) m of water once the management pond has met its PAG material storage requirements (North Management Pond is completed first, followed by the East Management

Pond and finally the West Management Pond) to prevent potential ARD and subsequent effects on surface water quality;

- ▶ Place approximately a one (1) to two (2) m layer of non-PAG rock on top of the submerged PAG material below the active water level of the respective management pond, followed by approximately one (1) to three (3) m layer of overburden to create a dry landform above water, followed by an approximately 30 centimetre (cm) layer of reclamation materials (surface soil) to reduce evaporative losses from the management ponds and provide a landscape more similar to pre-Project development;
- ▶ No PAG material will be used in construction of any external piles, pads, roads, embankments, buttresses, or for backfilling the open pit, to prevent potential ARD and subsequent effects on surface water quality;
- ▶ Open pit walls will be covered by non-PAG material to limit oxygen and water ingress into the open pit walls and provide a neutralizing effect on the open pit wall material below;
- ▶ Some of the open pit walls will be flooded with water to further reduce the likelihood of ARD from the covered open pit walls;
- ▶ Establish a material geochemical testing program for future Project exploration drillholes and Operation phase blast holes as part of the blasting program to verify PAG versus non-PAG materials. Maintain a PAG geological model while the open pit is being mined to reflect any changes observed;
- ▶ Maintain a database of geochemical testing results and material placement to avoid the incorrect placement of PAG material and potential ARD with subsequent effects on surface water quality;
- ▶ Establish a material tracking system to document the location and type of material being excavated and hauled to avoid misplacement of material and/or remediate any misplacement that may occur;
- ▶ Controlled open pit wall blasting will be conducted on both the highwall and footwall to limit the amount of damage to the open pit wall to minimize the potential for particle size reduction and provide pathways for water and oxygen to enter the open walls prior to them being covered;
- ▶ Majority of material near the open pit footwall will not be blasted again to minimize the potential of water and oxygen accessing this material;
- ▶ Progressive reclamation will be undertaken to reduce the infiltration of water and oxygen into the open pit walls by placing non-PAG rock and overburden on the open pit walls once mining is completed for an open pit wall section in question and people operating equipment have moved at least 100 m away from proposed backfilling operation. Furthermore, this non-PAG material is expected to provide a permanent high neutralization potential (NP) water source to prevent ARD generation from PAG material present in the open pit walls; and
- ▶ Provide annual reports to British Columbia Ministry of Energy, Mines and Low Carbon Innovation (BC MEMLI) and BC MECCS and designated Indigenous groups summarizing the results of geochemical testing.

The following mitigation measures for minimizing potential metal leaching (ML):

- ▶ Progressive reclamation will be undertaken to reduce the infiltration of water and oxygen into the non-PAG backfills, buttresses, and embankments;
- ▶ Non-PAG rock will be covered with overburden as much as material constraints allow to reduce the infiltration of water and oxygen;

- ▶ Place some non-PAG rock into management ponds that are characterized as PAG because of the mine planning process using a neutralization potential ratio (NPR) value of 2NP (neutralizing potential):1AP (acid potential [AP]) to classify non-PAG material from PAG material versus the geochemistry NPR value of 1.2NP:1AP used for classifying non-PAG material from PAG material; and
- ▶ In the Post-closure Phase, approximately half of non-PAG material will be flooded with water in the open pit to prevent oxygen ingress and further oxidization of this material resulting in a reduction of metal leaching once this occurs.

A **ML/ARDMP** has been prepared and is provided in **S13.0-C12**.

5.3.5 Project Use of Water

The Project will not use groundwater wells for process water requirements, and will incorporate the following measures that will mitigate the potential effects on the Groundwater VC:

- ▶ Maximize the use of contact water for Project water needs (i.e., use contact water for process water for the CPP and equipment washbays before withdrawing additional water from streams);
- ▶ Incorporate a contingency water supply of 2.5% of Goathorn Creek's mean annual monthly flow which was part of the effects assessment (effect is included in the flow rate of Goathorn Creek downstream of intake location) but this contingency is not incorporated into water cover simulations or the overall Project water balance;
- ▶ Use of dewatered fine processed rock to reduce Project water consumption;
- ▶ Direct water from the Maintenance Facility to the CPP to reduce Project water consumption;
- ▶ Use process water from the Tenas Control Pond, and management ponds, and CPP sedimentation pond for the CPP to limit water consumption;
- ▶ Design of the CPP allows for the introduction of additional equipment to be installed within 18 months to further reduce water consumption in the Operation Phase, if required;
- ▶ Use process water from the Tenas Control Pond for toilets in the Minesite Administration Building to reduce potable water consumption; and
- ▶ Construct engineered covers for the management ponds in the Operation and Decommissioning and Reclamation and Post-closure Phases to limit the consumption of water through evaporation losses.

5.3.6 Flooding of the Open Pit in Decommissioning and Reclamation, and Post-closure Phases of the Project

The development of the open pit for the Project causes a local area drawdown of the groundwater around it. To mitigate this, after the Operation Phase is complete, the open pit will be allowed to flood with a combination of contact and non-contact water forming several visible end pit lakes. The increased water level within the open pit will raise the groundwater table (i.e., decrease the drawdown of groundwater) closer to baseline conditions to minimize the reduction in winter streamflow values. This will also prevent non-PAG material for further oxidization by having some of these materials saturated under water due to the flooding of the open pit. Flooding of the open pit will also cover some portions of the open pit wall underwater which are comprised of PAG material and provide further reduction in oxygen ingress to prevent ARD. The portion of the open pit that has PAG material deposited within it as part of the West Management Pond water level is also assisted by allowing upstream portion of the open pit flood with water.

5.3.7 Spill Management

Accidental spills have the potential to affect surface water and groundwater quality. The potential for spills and spatial extent of spills will be minimized by implementing a spill response plan. The **FMSCP** provides guidance on spill prevention, initial spill response and follow-up, as well as outlines a spill-related emergency response plan for the Project (further information on emergency response can be found in the **MERP**). Actions will be outlined to avoid, control and/or mitigate spills and releases of hydrocarbons (e.g., fuels, lubricants, used lubricants, hydraulic fluids) into the environment, which could contaminate surface soils, overburden, mine rock, surface water, groundwater, and fish, vegetation, or wildlife habitats.

The following mitigation measures and BMPs are included in the **FMSCP**:

- ▶ TCL will incorporate BMPs for spill containment including double wall tanks for hydrocarbon storage tanks and dangerous or hazardous products and secondary containment for single wall storage tanks, with protective barriers where there is potential for an adverse effect from equipment or vehicles;
- ▶ Hydrocarbon storage vessels will have secondary containment with capacity to accommodate 100 % of the largest vessel in the area plus 10% of the remaining aggregate storage tanks in the area; and separate storage and sump systems for storage areas of incompatible products;
- ▶ At aboveground tank systems, tanks with a volume over 100,000 L will be registered, and oil/water separators will be installed at these fueling areas;
- ▶ A risk assessment matrix for land-based hydrocarbon storage facilities will be completed (see **FMSCP**);
- ▶ Operational procedures for tasks that have an identified risk such as hydrocarbon and hazardous material handling will be documented;
- ▶ Fuel and hydrocarbon storage areas will meet requirements of the BC Fire Code (GovBC 2018a) and pertinent recommendations from the document BC Fuel Guidelines, 9th Edition – 2020 (Northwest Response 2020);
- ▶ Fuel and hydrocarbon containers, including permanent storage tanks, will meet Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations, SOR/2008-197 (GovCan 2008) specifications;
- ▶ TCL will provide employees and contractors with proper training for the prevention and containment of spills;
- ▶ Only designated and approved personnel and facilities will be used for the handling, transferring, and storage of fuel and hydrocarbons; and
- ▶ Operational procedures will be documented for tasks that have an identified risk, such as fuel and hydrocarbon handling and spill response.

To limit the potential for effects on the environment from spills of fuel and hydrocarbon handling, further steps are described in the **FMSCP**.

5.3.8 Chemical and Materials Storage and Handling

- ▶ Substances transported, handled, used, stored, or disposed of for the Project will be identified as being hazardous or non-hazardous to human health and/or the environment;

- ▶ Hazardous substances will be stored in containers appropriate for their hazard classification, and in accordance with any other information contained in their respective Material Safety Data Sheet (MSDS) (and in accordance with regulatory requirements as appropriate, i.e., explosives under the *Explosives Act*, RSC 1985, c E-17 [GovBC 1985b]); and
- ▶ Hazardous substances will be transported in containers and vehicles appropriate for their Transportation of Dangerous Goods (TDG) hazard classification.

Management processes and procedures associated with dealing with chemicals and materials, some of which might be hazardous to either personnel onsite or the surrounding environment are provided in **CMSTHP**.

5.3.9 Additional Valued Component (VC)-specific Measures to Reduce Nitrogen Release

The uncontrolled release of nitrogen from blasting operations can potentially affect surface water and groundwater quality. The **EMP** covers the delivery, storage, and handling of explosives for the Project including blasting operations and nitrogen management. One (1) of the objectives of the **EMP** is to manage nitrogen releases to the receiving environment while maintaining mine production targets with the overall goals of minimizing nitrogen releases into the environment and safely achieving mine production targets.

In addition to those outlined in **5.3.2 Blasting Measures**, the following mitigation measures and BMPs related to managing nitrogen are included in the **EMP**:

- ▶ The storage facilities will be designed to meet government regulations and will be located according to required separation distances as regulated by the Explosives Regulatory Division of Natural Resources Canada (NRCAN);
- ▶ Explosives and accessories will be stored in the Explosive Magazine and Explosive Facility sites. The Explosive Magazine and Explosive Facility are greater than 300 m apart and roughly 1,800 m from any other infrastructure as per the distance requirements under the *Explosives Act*, RSC 1985, c E-17 (GovCan 1985a) and regulations;
- ▶ Explosives and detonators will only be purchased from Orica Canada Inc. (Orica), an authorized explosive manufacturer and vendor in Canada;
- ▶ Ammonium Nitrate Prill (ANP), emulsion, and blasting accessories storage will be carried out in accordance with applicable legislation. The areas will be regularly inspected by Orica and TCL personnel for spillage and/or damage to containers, transfer equipment and/or vessels;
- ▶ Water management strategies related to blasting include:
 - ▶ To reduce potential nitrogen leaching, the Explosives Infrastructure site will evaporate all water containing high concentrations of nitrogen from its equipment wash bay to avoid wash water with high nitrogen loads from entering the surface and groundwater system;
 - ▶ Interceptor channels will be considered where feasible to capture non-contact water outside of the mining footprint to direct drainages that are not directly affected by mining around active mining areas;
 - ▶ Where water flows into open pits, perimeter channels on catch benches or roads where, feasible, will be used to divert water away from blasting activities;
 - ▶ As groundwater cannot be captured through surface channels, it will need to be collected by using wells and/or input sumps prior to bench development with the water being pumped to either the management ponds or the Tenas Control Pond; and

- ▶ Blastholes will be dewatered prior to loading with explosives and if they cannot be dewatered an emulsion based blasting agent will be used for the hole in question.

5.3.10 Summary of Mitigation Measures

Table 5.3-1 summarizes the mitigation measures that address the potential adverse effects on the Groundwater VC.

Table 5.3-1: Summary of Potential Effects and Mitigation Measures for Groundwater Valued Component (VC)

Potential Effect	Contributing Activities within the Project Phases (C, O, D, P)	Proposed Mitigation Measure	Applicable VC Subcomponent	Residual Effect (Yes/No)
Change in Groundwater Level in Areas of Private Wells	▪ Mining the open pit (O) ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Limit Project footprint and Project Area ▪ Management, control, and water storage pond designs ▪ Project use of water ▪ Flooding of the open pit in Decommissioning and Reclamation, and Post-closure phases of Project	Groundwater Quantity	Yes
Change in Groundwater Discharge Rates to Creeks and Rivers	▪ Mining the open pit (O) ▪ Operation of Surface Water Management Infrastructure including channels and ponds (O) ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Limit Project footprint and Project Area ▪ Management, control, and water storage pond designs ▪ Project use of water ▪ Flooding of the open pit in Decommissioning and Reclamation, and Post-closure phases of Project	Groundwater Quantity	Yes
Change in Groundwater Quality in Areas of Private Wells	▪ Mining the open pit (O) ▪ Operation of Surface Water Management Infrastructure including channels and ponds (O) ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Limit Project footprint and Project Area ▪ Blasting measures (refer to EMP) ▪ Management, control, and water storage pond designs ▪ Management of ML/ARD (refer to ML/ARDMP) ▪ Spill management (FMSCP) ▪ Chemical and materials storage and handling (CMSTHP) ▪ Additional VC-specific measure to reduce nitrogen release (EMP)	Groundwater Quality	Yes
Change in Quality of Groundwater Discharging to Creeks and Rivers	▪ Mining the open pit (O) ▪ Operation of Surface Water Management Infrastructure including channels and ponds (O) ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Limit Project footprint and Project Area ▪ Blasting measures (refer to EMP) ▪ Management, control, and water storage pond designs ▪ Management of ML/ARD (refer to ML/ARDMP) ▪ Spill management (FMSCP) ▪ Chemical and materials storage and handling (CMSTHP)	Groundwater Quality	Yes

Potential Effect	Contributing Activities within the Project Phases (C, O, D, P)	Proposed Mitigation Measure	Applicable VC Subcomponent	Residual Effect (Yes/No)
		Additional VC-specific measure to reduce nitrogen release (EMP)		

Notes: C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure
CMSTHP=Construction Environmental Management Plan (S13.0-C4); EMP=Explosives Management Plan (S13.0-C6); FMSCP=Fuel Management and Spill Control Plan (S13.0-C7);
ML/ARD=metal leaching/acid rock drainage; ML/ARDMP=Metal Leaching (ML)/Acid Rock Drainage (ARD) Management Plan (S13.0-C12); PAG=potentially acid generating;
Project=Tenas Project; VC=Valued Component
See **Table 5.1-2** for list of applicable activities for each listed Project phase, unless otherwise noted in this table.

5.4 Residual Effects and Significance of Residual Effects

This subsection describes the Project's anticipated residual effects on the Groundwater VC subcomponents. Residual effects are adverse Project effects that remain after the implementation of mitigation measures and management strategies and are the expected consequences of the Project on the Groundwater VC.

The approach to assessing the residual effects of the Project on the Groundwater VC subcomponents follows the methodology outlined in **S3.0 Assessment Methodology** of the **EAC Application**. For each subcomponent of the Groundwater VC, each residual effect is assessed in the context of Project activities that are expected to occur during each Project phase. As described in **5.2**, no Project-related effects on the Groundwater VC were predicted for the Construction Phase, therefore there are no residual effects for that phase. The Decommissioning and Reclamation Phase is considered as part of the Post-closure Phase since the former is relatively short compared to the duration of the later. Therefore, the residual effects assessment focuses on two (2) phases: Operation, and Post-closure. Residual effects are then characterised based on the combined predicted residual effect for these phases. The assessment includes a determination of Likelihood, Significance and the Level of Confidence associated with the prediction.

The analyses of the Project's residual effects on groundwater quantity were performed using a three (3)-dimensional groundwater flow model; full details on the modelling analyses are provided in **Appendix 4.4-A**. The model predictions for the Operation, and Post-closure phases included:

- ▶ flow rates to and from the open pit, and the waste and water management systems;
- ▶ water levels surrounding the Minesite and in areas of private wells;
- ▶ changes to baseflows in creeks and rivers; and
- ▶ contributions and travel times of contact groundwater to areas of private wells, and to creeks and rivers.

The figures provided in **Appendix 4.4-A** and listed below summarize the modelling analyses:

- ▶ Figure 47 to 51: conceptual cross-sections of the groundwater system at the Post-closure Phase;
- ▶ Figure 55 to 56: calibration plots; and
- ▶ Figure 57 to 78: predicted heads and particle paths during the Operation Phase and Post-closure Phase.

Residual effects to groundwater quality were supported by groundwater modelling results and model outputs from the Project **Tenas Project Water and Load Balance Modelling Report (Appendix 4.3-A of S4.0-C-3 Surface Water VC)**. Relevant modelling results are summarized in the following sections for each potential residual effect.

5.4.1 Description of Evaluation Criteria

5.4.1.1 Residual Effects Characteristics

Table 5.4-1 presents the criteria and general definitions used to evaluate the residual environmental effects on the Groundwater Quality and Groundwater Quantity subcomponents.

Table 5.4-1: Effect Characteristics Considered when Determining the Significance of Residual Effects on Groundwater Valued Component (VC)

Residual Effect Characteristic	Definition	Indicator	Rating
Magnitude (Groundwater Quantity)	Change in groundwater levels or discharge because of Project Interactions, relative to Pre-Mining conditions	Change to groundwater level	<u>Negligible</u> : Within measurement error +/-2 cm <u>Low</u> : Between 0.02 and 0.5 m <u>Moderate</u> : Between 0.5 and 3 m <u>High</u> : Greater than 3 m
		Change to groundwater discharge to creeks and rivers	<u>Negligible</u> : Less than 5% <u>Low</u> : Between 5 and 10% <u>Moderate</u> : Between 10 and 20% <u>High</u> : Greater than 20%
Magnitude (Groundwater Quality)	Increase of parameter concentrations compared to baseline conditions	Change to parameter concentrations	<u>Negligible</u> : no quantifiable change from baseline conditions. <u>Low</u> : exceeds the applicable water quality guideline or the 90th percentile ⁽¹⁾ by less than 2 times (x) <u>Moderate</u> : exceeds applicable water quality guideline or 90th percentile ⁽¹⁾ by less than 10x times but more than 2x <u>High</u> : exceeds applicable water quality guideline or 90th percentile ⁽¹⁾ by more than 10x The applicable water quality guidelines for groundwater are the BC WQG FAL and DWS
Geographic Extent	Spatial scale over which the residual effect is expected to occur.	All	<u>Discrete</u> : effect is limited to the immediate Project footprint <u>Local</u> : effect is limited to the Groundwater LSA <u>Regional</u> : effect occurs within the Groundwater RSA <u>Beyond Regional</u> : effect extends beyond the Groundwater RSA
Duration	Length of time over which the residual effect is expected to persist.	All	<u>Short-term</u> : effect lasts less than 1.5 years (Construction Phase). <u>Medium-term</u> : effect lasts greater than 1.5 years and less than 25 years (encompassing Operation, Decommissioning and Reclamation phases). <u>Long-term</u> : effect continues more than 25 years past the initiation of the Post-closure Phase.
Frequency	How often the residual effect is expected to occur.	All	<u>Infrequent</u> : effect occurs rarely and at sporadic intervals. <u>Frequent</u> : effect occurs on a regular basis. <u>Continuous</u> : effect occurs seasonally or constantly (i.e., year-round).
Reversibility	Whether or not the residual effect can be reversed once the activity causing	All	<u>Fully Reversible</u> : Effect occurs during construction and operations only. <u>Partially Reversible</u> : Effect occurs in the initial closure period but does not persist in steady state (through 2100)

Residual Effect Characteristic	Definition	Indicator	Rating
	the residual effect ceases.		<u>Irreversible</u> : Effect occurs in steady-state conditions (through 2100)
Context	The extent to which groundwater has been affected by past and present environmental and socio-economic processes and conditions, its potential sensitivity to the Project-related residual effect, and its ability to recover from that effect (i.e., resilience)	All	<u>Low</u>: receiving environment has a low sensitivity to imposed stresses and can respond and adapt to the effect. <u>Moderate</u>: receiving environment has a neutral resilience to imposed stresses and may be able to respond and adapt to the effect. <u>High</u>: receiving environment has a high sensitivity to imposed stresses and will not easily adapt to the effect.

Notes: %=percent; cm=centimetre; BC WQG=British Columbia Water Quality Guidelines; DWS=Drinking Water Sources; FAL=Freshwater Aquatic Life; LSA=Local Study Area; m=metre; Project=Tenas Project; RSA=Regional Study Area, VC=Valued Component

¹ The 90th percentiles are used if the parameter's concentration is naturally greater than guideline or if no guideline exists.

5.4.1.1.1 Likelihood

Likelihood refers to the probability of the predicted residual effect occurring, including consideration of the likelihood that the mitigation will be successful. The probabilities are based on qualitative judgment and common understanding of the hydrogeological system within the profession.

- ▶ **Likely:** Moderate to high probability of an effect occurring; or
- ▶ **Unlikely:** Low probability of an effect occurring

5.4.1.1.2 Significance Determination

The characterisation of residual effects is based on the review of existing conditions (4.), the assessment of Project-related effects (5.4), other relevant scientific information, and the professional judgement of the EA team. All residual effects (independent of their Significance rating) are carried forward to the CEA.

The Significance of the residual effect is rated as **Not Significant** or **Significant**, based on the following:

- Significant** A residual effect that results in a change to the Groundwater VC within the RSA that will alter its integrity to an unacceptable level; generally defined as High Magnitude effects, Regional or greater in Extent, with a Long-term Duration; or
- Not Significant** An effect that does not meet the definition of Significant. A residual effect that does not result in changes to the integrity of the Groundwater VC and its subcomponents within the Groundwater RSA beyond an acceptable level is deemed **Not Significant**. For example: residual effect is a combination of Low Magnitude, Local Geographic Extent, Short-term Duration, Infrequent, etc.

Level of Confidence is a measure of how well residual effects are understood and the quality of the input data. It considers the scientific certainty relative to the quantification of the effect, including the quality and/or

quantity of data and the understanding of effect mechanisms, as well as professional judgment based on prior experience in predicting effects and the effectiveness of mitigation measures.

A Low Level of Confidence is assigned to effects predictions with little or no empirical site-specific data, whereas a Moderate Level of Confidence is assigned to predictions that are based on site-specific data sources such as predictive model outputs and published literature. A High Level of Confidence is assigned to predictions that have direct, site-specific quantitative data to support the predictions. Based on these criteria, it was determined that an additional risk analysis was not required.

5.4.2 Groundwater Quantity Subcomponent

5.4.2.1 Changes to Groundwater Levels in the Area of Private Wells

Table 5.4-2 presents the rating assigned to each residual effect characteristic. Modelling results suggest changes to groundwater levels will be localized to near the management ponds (increase) and open pit (decrease); see **Appendix 4.4-A**. Changes are not predicted to reach any of the private wells.

Table 5.4-2: Summary of Effect Characteristics Ratings for the Changes in Groundwater Levels in Areas of Private Well Users

Residual Effects Characteristic	Rating	Rationale for Rating
Magnitude	Negligible	Neither the drawdown cone nor groundwater mound are predicted to reach areas of private wells during the Operation, or Post-closure phases.
Geographic Extent	Local	The effect is predicted to remain within the Local Study Area (LSA).
Duration	Long-term	The effect is predicted to continue at Post-closure Phase, but with a reduced spatial extent.
Frequency	Continuous	The effect is expected to occur constantly.
Reversibility	Irreversible	The effect cannot be reversed.
Context	Moderate	Private wells are in or near the alluvial plains of Goathorn Creek, the Telkwa River, or the Bulkley River. The gravel beds in the creeks and rivers are expected to transmit groundwater from upstream that would limit potential changes to groundwater levels in valleys.

5.4.2.1.1 Likelihood

The Likelihood that the predicted residual effects occur is rated as Unlikely because:

1. The changes to groundwater levels were predicted for steady state conditions, which is considered conservative, and
2. None of the modelling scenarios predicted a drop of the groundwater levels in areas of private wells including a hypothetical scenario where ponds have been removed to exclude influences of a groundwater mound.

5.4.2.1.2 Significance Determination

The predicted drop of groundwater levels in areas of private well users because of the Project is not expected to result in a change that will alter its integrity within the Groundwater RSA to an unacceptable

level because the effect is predicted to be of Negligible Magnitude, Local Extent, and Long-term Duration. Therefore, the effect is predicted to be **Not Significant**.

The Level of Confidence of this prediction is Moderate. The modelling used to inform the assessment has inherent sources of error associated with characterisation of the subsurface.

5.4.2.2 *Change in Groundwater Discharge Rates to Creeks and Rivers*

Table 5.4-3 presents the rating assigned to each residual effect characteristic. Groundwater modelling results suggest the following:

- ▶ Tenas Creek (at confluence with Goathorn Creek): During the Operation Phase, the change in groundwater discharge to Tenas Creek will peak at –6% before changing to up to +3% at Post-closure;
- ▶ Four Creek (at confluence with Goathorn Creek): During the Operation Phase, the change in groundwater discharge to Tenas Creek will peak at –5% before changing to up to +4% at Post-closure;
- ▶ Goathorn Creek (at confluence with Telkwa River): During the Operation Phase, the change in groundwater discharge to Tenas Creek will peak at –2% before changing to up to +1% at Post-closure; and
- ▶ Telkwa River (at confluence with Bulkley River): During the Operation Phase, the change in groundwater discharge to Tenas Creek will peak at –2% before changing to up to +1% at Post-closure.

Detailed modelling results are provided in **Appendix 4.4-A**. The **Surface Water VC (S4.0-C3)** of the **EAC Application** combines the changes in groundwater discharge with changes in runoff flows to provide a complete assessment of the overall residual effects to surface water quantity.

Table 5.4-3: Summary of Effect Characteristics Ratings for the Changes in Groundwater Discharge Rates to Creeks and Rivers

Residual Effects Characteristic	Rating	Rationale for Rating
Magnitude	Low	Higher order tributaries, such as Four and Tenas Creeks', show low magnitude changes. Goathorn Creek, which incorporates the catchment area of both these tributaries, has an overall negligible magnitude change.
Geographic Extent	Local	The effect is predicted to remain within the Local Study Area (LSA).
Duration	Long-term	The effect is predicted to continue at Post-closure Phase.
Frequency	Continuous	The effect occurs constantly.
Reversibility	Irreversible	The effect cannot be reversed.
Context	Moderate	Groundwater discharge to surface water is only one component of creek/river flow, runoff provides a major contribution to total creek/river discharge. It is the total flow that matters for the receiving environment, which is assessed in the Surface Water VC (S4.0-C3) the EAC Application .

5.4.2.2.1 Likelihood

The residual effect of changes in groundwater discharge rates to creeks and rivers is Likely. Watercourses are near the Project Area, and modifications to the groundwater flow regime, primarily from open pit dewatering and management pond seepage, are expected to change groundwater discharge rates to creeks and rivers.

5.4.2.2.2 Significance Determination

The residual effect of changes in groundwater discharge rates to creeks and rivers because of the Project is not expected to result in a change that will alter its integrity within the Groundwater RSA to an unacceptable level because the effect is predicted to be of **Low** Magnitude, Local and Long-Term Duration. Therefore, the effect is predicted to be **Not Significant**.

The Level of Confidence of this prediction is Moderate. The modelling used to inform the assessment has inherent sources of error associated with characterisation of the subsurface and the exact nature of the connection between groundwater and surface water.

5.4.3 Groundwater Quality Subcomponent**5.4.3.1 Changes to Groundwater Quality in the Area of Private Wells**

Table 5.4-4 presents the rating assigned to each residual effect characteristic. Seepage from mine sources (e.g., management ponds and end pit lake) has the potential to reach the groundwater system utilized by private domestic well users. However, when mixed with background groundwater, no constituent is predicted to exceed the BC WQG DWS, but a small number of parameters increased compared to baseline. See **Appendix 4.4-A** for full analysis details.

Table 5.4-4: Summary of Effect Characteristics Ratings for the Changes to Groundwater Quality in Private Wells

Residual Effects Characteristic	Rating	Rationale for Rating
Magnitude	Low	No constituent is predicted to exceed the BC WQG DWS, but some parameters are increased over baseline.
Geographic Extent	Local	Effect is limited to the LSA.
Duration	Long-term	The effect is predicted to continue beyond the Post-closure Phase.
Frequency	Continuous	The effect occurs constantly.
Reversibility	Irreversible	The effect cannot be reversed.
Context	Moderate	Private wells are in or near the alluvial plains of Goathorn Creek, the Telkwa River, or the Bulkley River. The alluvial aquifers in the creeks and river valleys are expected to transmit groundwater from upstream that has the potential to mix and flush the constituents from the valley sides. Furthermore, predictions of particle travel times and contribution of mine affected groundwater to creek and riverbeds do not account for the potential dispersion, diffusion, and natural attenuation in the groundwater system, which will likely spread the plumes of contact groundwater, and/or decrease the peak concentrations.

Notes: BC WQG= British Columbia Water Quality Guidelines; DWS= Drinking Water Sources; LSA=Local Study Area

5.4.3.1.1 Likelihood

The Likelihood that the predicted residual effects occur is rated as Likely, considering travel times and flow contributions of mine affected groundwater to creek and riverbeds were predicted for steady state and post-closure conditions (i.e., long term).

5.4.3.1.2 Significance Determination

The predicted change in groundwater quality in areas of private well users because of the Project is not expected to result in a change that will alter its integrity within the Groundwater RSA to an unacceptable level because the effect is predicted to be of Low Magnitude, Local Extent, and Long-term Duration. Therefore, the effect is predicted to be **Not Significant**. The model predictions are based on the site-specific and public data available within the Project, the Level of Confidence in the model predictions is rated as Moderate.

5.4.3.2 Change in Quality of Groundwater Discharging to Creeks and Rivers

Table 5.4-5 presents the rating assigned to each residual effect characteristic. Seepage from mine sources (e.g., management ponds and end pit lake) has the potential to reach surface water receptors via the groundwater system. **Appendix 4.3-A Tenas Project Water and Load Balance Modelling Report of S4.0-C3 Surface Water VC** predicts surface water quality of these seepages mixed with other mine and background contributing sources. In winter months, the only two (2) sources are background baseflow (i.e., natural groundwater discharge) and mine impacted baseflow; no surface contributions occur in winter. Therefore, average winter model results from the water and load balance were used to assess the residual effect of change in quality of groundwater discharging to creeks and rivers. Model results for downstream creek stations were screened against BC WQG FAL to assess the Magnitude of residual effects. This assessment approach omits transport phenomenon that would reduce concentrations further, such as natural attenuation or retardation of dissolved constituents. Only total aluminum, cadmium, selenium, and thallium exceed the BC WQG FAL in Tenas and Four Creek, but typically by less than a factor of 2. No exceedances were predicted in Goathorn creek, which encompasses all upstream creeks catchments.

Table 5.4-5: Summary of Effect Characteristics Ratings for the Change in Quality of Groundwater Discharging to Creeks and Rivers

Residual Effects Characteristic	Rating	Rationale for Rating
Magnitude	Low	Four (4) constituents exceed the BC WQG FAL in higher order creeks, but typically by less than a factor of 2.
Geographic Extent	Local	Effect is limited to the LSA.
Duration	Long-term	The effect is predicted to continue beyond the Post-closure Phase.
Frequency	Continuous	The effect occurs constantly.
Reversibility	Irreversible	The effect cannot be reversed.
Context	Moderate	Assessment of residual effect magnitude is conservative in that it does not account for attenuation of constituents in the groundwater system before discharge to surface water.

Notes: BC WQG= British Columbia Water Quality; FAL=Freshwater Aquatic Life; LSA=Local Study Area

5.4.3.2.1 *Likelihood*

The residual effect of change in quality of groundwater discharging to creeks and rivers is Likely, considering the proximity of the seepage sources (i.e., management ponds) to the creeks.

5.4.3.2.2 *Significance Determination*

The predicted change in the quality of the groundwater discharging to creeks and rivers because of the Project is not expected to result in a change that will alter its integrity within the Groundwater RSA to an unacceptable level; the effect is predicted to be of Low Magnitude, Local Extent, and Long-term Duration. Therefore, the effect is predicted to be **Not Significant**

5.5 Summary of Project-related Residual Adverse Effects and Significance

Four (4) potential residual effects on groundwater have been identified: (1) change to groundwater levels in private wells; (2) change in groundwater discharge rates to creeks and rivers; (3) change to groundwater quality in private wells; and (4) change in the quality of groundwater discharging to creeks and rivers. All residual effects were rated as **Not Significant**. Based on the determination of **Not Significant** for all residual effects listed in **Table 5.5-1**, it is concluded that there is no potential for a Significant residual effect on the Groundwater VC. All residual effects, Significant or Not Significant, are carried forward into the CEA.

The Level of Confidence in the determination of the **Not Significant** determination for effects on the Groundwater VC is considered Moderate because:

- ▶ the final calibrated models reproduced the regional hydrogeological system well, with a steady-state normalized root mean squared error (NRMSE) of 3.2% for hydraulic heads and 3.6% for baseflows. NRMSE values less than 10% are commonly considered to be an acceptable level of model calibration. Modelling was based on steady-state conditions for both calibration and forward predictions. The sensitivity analysis showed the model was most sensitive to recharge and the K value of the till and Skeena group units. The parameters' sensitivities affected the predictions as follows: none of the sensitivity models predicted drawdown or mounding to reach the private wells, and the travel time to private wells was more than 170 years in all runs;
- ▶ the model may be classified as moderate complexity (BC MOE 2012), defined as follows: "*These (...) are based on a reasonable, though limited, dataset and having limited calibration. These models may be used to determine the potential range of change or to "bracket" potential effects that may occur due to a given stress.*" The model is based on a unique conceptualisation of the three (3)-dimension geology; detailed characterisation of aquitards or aquicludes are not well characterised; baseflows are estimated from historical stream flow records, and the results have highest confidence in the vicinity of the Minesite area where there are relatively more data. Residual effects can be predicted to occur with a high degree of certainty, but factors influencing the timing, magnitude, and direction of these effects are difficult to predict accurately; and
- ▶ Groundwater systems in fractured and faulted terrain are heterogeneous, more effectively understood at larger spatial scales. Prediction of residual effects at small scales are therefore uncertain. Observations of site-specific conditions allow adjustment of predictions based on professional judgment, but do not allow more precise predictions.

Table 5.5-1: Summary of Residual Adverse Effects for Groundwater Valued Component (VC)

Residual Adverse Effects	Contributing Activities within the Project Phases (C, O, D, P)	Proposed Mitigation Measures	Residual Effects Characterisation								
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Changes to Groundwater Level in Area of the Private Wells	▪ Mining the open pit (O) ▪ Operation of Surface Water Management Infrastructure including channels and ponds (O). ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Limit Project footprint and Project Area ▪ Management, control, and water storage pond designs ▪ Project use of water ▪ Flooding of the open pit in Decommissioning and Reclamation, and Post-closure phases of Project	N	LSA	LT	CF	IR	M	UL	NS	M
Change in Groundwater Discharge Rates to Creeks and Rivers	▪ Mining the open pit (O) ▪ Operation of Surface Water Management Infrastructure including channels and ponds (O) ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Limit Project footprint and Project Area ▪ Management, control, and water storage pond designs ▪ Project use of water ▪ Flooding of the open pit in Decommissioning and Reclamation, and Post-closure phases of Project	L	LSA	LT	CF	IR	M	L	NS	M
Changes to Groundwater Quality at Private Wells	▪ Mining the open pit (O) ▪ Operation of Surface Water Management Infrastructure including channels and ponds (O) ▪ Reclamation and closure activities at Minesite (D) ▪ Maintain post-mining systems and ongoing monitoring (P)	▪ Management, control, and water storage pond designs ▪ Blasting measures (refer to EMP) ▪ Management of ML/ARD (refer to ML/ARDMP)	L	LSA	LT	CF	IR	M	L	NS	M
Change in Quality of Groundwater Discharging to Creeks and Rivers		▪ Spill management (FMSCP) ▪ Chemical and materials storage and handling (CMSTHP) ▪ Additional VC-specific measure to reduce nitrogen release (EMP)	L	LSA	LT	CF	IR	M	L	NS	M

Notes: C, O, D, P represent Project phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure
 CMSTHP=Chemicals and Materials, Storage, Transfer, and Handling Plan (S13.0-C3); EMP=Explosives Management Plan (S13.0-C6); FMSCP=Fuel Management and Spill Control Plan (S13.0-C7); ML/ARD=metal leaching/acid rock drainage; ML/ARDMP=Metal Leaching (ML)/Acid Rock Drainage (ARD) Management Plan (S13.0-C12); PAG=potentially acid generating; Project=Tenas Project; VC=Valued Component

Magnitude: Low (L), Moderate (M), High (H)

Geographic Extent: Project Area (PA), Local (LSA), Regional (RSA), beyond Regional (beyond RSA)

Duration: Short-term (ST), Medium-term (MT), Long-term (LT)

Frequency: Infrequent (IF), Frequent (FF), Continuous (CF)

Reversibility: Fully reversible (FR), Partially reversible (PR), Irreversible (IR)

Context: Low (L), Moderate (M), High (H)

Likelihood: Unlikely (UL), Likely (L)

Significance: Not-Significant (NS), Significant (S)

Level of Confidence: High (H), Moderate (M), or Low (L)

See **Table 5.1-2** for list of applicable activities for each listed Project phase, unless otherwise noted in this table.

6. CUMULATIVE EFFECTS ASSESSMENT (CEA)

Cumulative effects are the overall effects on a VC due to the Project's residual effects overlapping both spatially and temporally with the same residual effects resulting from other projects and activities. This subsection presents an assessment of the cumulative effects on the Groundwater VC.

The environmental effects of past and existing projects and activities are captured in the baseline conditions (i.e., existing environment; 4. **Existing Conditions**). Thus, the likelihood of cumulative effects due to ongoing and reasonably foreseeable future projects is the focus of this CEA. The approach to determining cumulative effects is described in **3.2 Rationale for Section of Groundwater**.

This subsection presents:

- ▶ projects and activities that fall within the boundary of the CEA;
- ▶ potential interactions of the residual effects of these projects and activities on the Groundwater VC with the residual effects of the Project:
 - ▶ changes to groundwater level in areas of private wells;
 - ▶ change in groundwater discharge rates to creeks and rivers;
 - ▶ changes to groundwater quality at private wells;
 - ▶ change in quality of groundwater discharging to creeks and rivers;
- ▶ potential project and activities cumulative effects on groundwater and characterisation of the effects;
- ▶ if additional mitigation measures are required and feasible to address cumulative effects; and
- ▶ the significance of the cumulative effects.

The spatial boundary of the CEA corresponds to the RSA defined in **3.2.4.1** and shown in **Figure 3.2-1**. The RSA is an area based on the fish habitats in the Telkwa River watershed and in the tributaries to the Bulkley River crossed by the haul road.

The temporal boundaries are defined in **3.2.4.2**; Project phases considered in the CEA are Operation through to Post-closure.

The baseline conditions represent past and present projects and activities including all disturbances from other projects and activities within the RSA. **Table 6.1 1** compiles the projects and activities located within the RSA with residual effects that potentially overlap with the Project residual effects on groundwater. Other projects/activities not listed here were excluded from the CEA because they were outside the RSA and did not have residual effects that extended into the RSA.

6.1 Potential Cumulative Effects

Cumulative effects resulting from ongoing and future projects are the focus of this CEA. Future projects and activities with likely overlapping residual effects on Groundwater are outlined in **Table 6.1-1**, preceded by text that provides supporting rationale.

Spatial information is not available for some future projects and most activities. The following projects and activities are expected to have residual effects on the Groundwater VC, within or extending into the Groundwater RSA (**Figure 3.2-1**):

- ▶ **Agricultural Activities:** Past and present agricultural activities including groundwater withdrawals used for irrigation and nutrient leaching related livestock and fertilizer application, can influence groundwater levels and flows, and groundwater quality, respectively;
- ▶ **Bulbous Toe:** Bulbous Toe is a slow-moving landslide with a major transmission line traversing it; one (1) of the towers requires periodic maintenance. This activity is not anticipated to interact with groundwater;
- ▶ **Forestry Activities:** Scattered parcels of forest within the Groundwater RSA are expected to be harvested over the life of the Project. However, no interaction with groundwater is expected;
- ▶ **Harvesting:** Past and present harvesting including fishing, hunting, and trapping. This activity is not expected to interact with the groundwater system, and therefore no effects on the Groundwater Quantity subcomponent are anticipated;
- ▶ **Hudson Bay Mountain Estates:** This resort development is to include the addition of a chairlift, 10 runs and a 148-lot residential component to Hudson Bay Mountain. The Area master plan has received approval for 35 lots released in Phase 1. This Project may influence the Groundwater Quantity subcomponent because of the construction and operation activities;
- ▶ **Maple Leaf Cannabis Production Facility:** Maple Leaf is currently constructing a 27,200 square foot cannabis production facility (the expansion capacity is “up to 500,000 square feet.”). The facility is anticipated to produce pesticide-free cannabis and cannabis oil utilizing biodynamic technology. Maple Leaf is currently in “Active Review” status with the Access to Cannabis for Medical Purposes Regulations, SOR/2016-230 (GovCan 2016) (ACMPR); the anticipated completion of the facility was by the end of 2019. This facility is not expected to interact with the groundwater system;
- ▶ **Prince George to Terrace Capacitors Project:** The project involves constructing three (3) new capacitor stations to increase the capacity along the 450-km, 500-kilovolt (kV) transmission line that runs between Prince George and northwest BC. This Project is not expected to interact with groundwater system; and
- ▶ **Corporation of the Village of Telkwa:** This includes past and present activities in the Village of Telkwa, including all land uses and water supply. Groundwater supply withdrawals may have an impact on Groundwater Quantity.

Table 6.1-1: Projects Included in the Assessment for the Groundwater Valued Component (VC) Based on Spatial and Temporal Interaction

Project/Activity Name	Interacts with Project-related Effects within the Regional Study Area (RSA) on the Valued Component (VC) as a Past, Present or Future Project/Activity	
	Past and Present	Future
Agricultural Activities	Yes	Yes
Bulbous Toe	No	No
Forestry Activities	No	No
Harvesting	No	No
Hudson Bay Mountain Estates	No	Yes
Maple Leaf Cannabis Production Facility	No	No
Prince George to Terrace Capacitors Project	No	No
Corporation of the Village of Telkwa	Yes	Yes

6.2 Additional Mitigation Measures

Additional mitigation measures to those considered in the assessment of Project-related effects (5.3) are not considered to be necessary to avoid or minimize the predicted cumulative effects on the Groundwater VC and its subcomponents. It is assumed that the current and future projects and activities have appropriate environmental protection measures in place as required by laws and regulations to limit their potential effects within acceptable levels.

6.3 Cumulative Effects and Characterisation of Significance

The interactions between the predicted Project residual effects and the residual effects of other projects and activities (**Table 6.1-1**) were reviewed to predict the cumulative effects on the Groundwater VC and associated subcomponents.

Cumulative effects on the Groundwater VC and subcomponents have been characterised and assessed in terms of Magnitude, Geographical Extent, Duration, Frequency, Reversibility, Context, and Likelihood, Significance, and Level of Confidence of effect. Characterisation criteria and significance definitions for this CEA are consistent with those presented in 5.4.

Due to limited information on location and quantified effects on water quality and quantity of other projects and activities, particularly those in the reasonably foreseeable future, cumulative effects were evaluated qualitatively.

6.3.1 Groundwater Quantity Subcomponent

The interactions between the predicted Project residual effects and the residual effects of past, current, and reasonably foreseeable projects and activities (**Table 6.1-1**) were reviewed to determine potential cumulative effects on the Groundwater Quantity subcomponent.

Residual effects on the Groundwater Quantity subcomponent resulting from the Project relative to the baseline conditions were identified and assessed as **Not Significant** in 5.4.2. Residual effects resulting from past, current, and reasonably foreseeable projects and activities may act cumulatively with the residual effects of the Project on Groundwater Quantity in the RSA through change to groundwater levels near private wells and change groundwater discharge rates to creeks and rivers.

6.3.1.1 Changes to Groundwater Level in the Area of Private Wells

Project related changes to groundwater levels have the potential to interact with potential changes resulting from agriculture, Hudson Bay Mountain Estates, and the Corporation of the Village of Telkwa. Groundwater withdrawal from these activities would be expected to affect groundwater levels near these projects. Withdrawals related to agriculture and the Corporation of the Village of Telkwa will likely continue for the foreseeable future, while withdrawals from Hudson Bay Mountain Estates construction are expected to be short-term. Combined amounts of groundwater withdrawal are expected to be small, and any effects localized to specific projects. Furthermore, such withdrawals will be regulated through the application of the *Water Sustainability Act*, SBC 2014, c 15 (GovBC 2014) to appropriately manage groundwater resources within the RSA.

Based on this qualitative summary, the Magnitude of the cumulative effect from changes to groundwater level in areas of private wells is expected to be Negligible. Geographical Extent is Regional since the projects, and the effects, are located within the RSA. The Duration is predicted to be Long-term, given the expectation these activities will operate for the foreseeable future. The Frequency of the effect is expected

to be Continuous since the change is expected to occur year-round. The Reversibility of the effect is expected to be expected to be Irreversible, since groundwater withdrawals from agriculture and the Corporation of the Village of Telkwa will likely continue indefinitely. The Context of the effect is expected to be Moderate, considering that these projects/activities have been ongoing in the past and groundwater withdrawals are likely small relative to groundwater availability. The Likelihood of a cumulative effect is Unlikely, based on the expected localized nature.

The cumulative effect on Groundwater Quantity is predicted to be **Not Significant**, as the change is not expected to alter its integrity within the Groundwater RSA to an unacceptable level. The effect is predicted to be of Negligible Magnitude, Regional Extent, and Long-term Duration. This prediction was deemed to have a Moderate Level of Confidence, based on the qualitative assessment.

6.3.1.2 Changes in Groundwater Discharge Rates to Creeks and Rivers

Project related changes to groundwater flows have the potential to interact with potential changes resulting from agriculture, Hudson Bay Mountain Estates, and the Corporation of the Village of Telkwa. Groundwater withdrawal from these activities would be expected to affect groundwater discharge near these projects. Withdrawals related to agriculture and the Corporation of the Village of Telkwa will likely continue for the foreseeable future, while withdrawals from Hudson Bay Mountain Estates construction are expected to be short-term. Combined amounts of groundwater withdrawal are expected to be small, and any effects localized to specific projects. Furthermore, such withdrawals will be regulated through the application of the *Water Sustainability Act*, SBC 2014, c 15 (GovBC 2014) to appropriately manage groundwater resources within the RSA.

Based on this qualitative summary, the Magnitude of the cumulative effect from changes to groundwater level in areas of private wells is expected to be Negligible. Geographical Extent is Regional since the projects, and the effects, are located within the RSA. The Duration is predicted to be Long-term, given the expectation these activities will operate for the foreseeable future. The Frequency of the effect is expected to be Continuous since the change is expected to occur year-round. The Reversibility of the effect is expected to be expected to be Irreversible, since groundwater withdrawals from agriculture and the Corporation of the Village of Telkwa will likely continue indefinitely. The Context of the effect is expected to be Moderate, considering that these projects/activities have been ongoing in the past and groundwater withdrawals are likely small relative to groundwater availability. The Likelihood of a cumulative effect is Unlikely, based on the expected localized nature.

The cumulative effect on Groundwater Quantity is predicted to be **Not Significant**, as the change is not expected to alter its integrity within the Groundwater RSA to an unacceptable level. The effect is predicted to be of Negligible Magnitude, Regional Extent, and Long-term Duration. This prediction was deemed to have a Moderate Level of Confidence, based on the qualitative assessment.

6.3.1.3 Summary of Cumulative Effects to Groundwater Quantity

Table 6.3-1 summarises the cumulative Project residual effects for the Groundwater Quantity subcomponent.

Table 6.3-1: Summary of Cumulative Effects for the Groundwater Quantity Subcomponent

Cumulative Effects	Contributing Activities within the Project Phases (C, O, D, P)	Cumulative Effects Characterisation								
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Changes to Groundwater Level in Areas of Private Wells	- Existing activities include agriculture (C, O, D, P) - Reasonably foreseeable developments within the Groundwater RSA as outlined in Table 6.1-1 (C, O, D, P) - Project-related activities that could interact with the above activities, as outlined in Table 5.5-1	N	RSA	LT	CF	IR	M	UL	NS	M
Change in Groundwater Discharge Rates to Creeks and Rivers		N	RSA	LT	CF	IR	M	UL	NS	M

Notes: C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure
Project=Tenas Project; RSA=Regional Study Area

Magnitude: Low (L), Moderate (M), High (H)

Geographic Extent: Project Area (PA), Local (LSA), Regional (RSA), beyond Regional (beyond RSA)

Duration: Short-term (ST), Medium-term (MT), Long-term (LT)

Frequency: Infrequent (IF), Frequent (FF), Continuous (CF)

Reversibility: Fully reversible (FR), Partially reversible (PR), Irreversible (IR)

Context: Low (L), Moderate (M), High (H)

Likelihood: Unlikely (UL), Likely (L)

Significance: Not-Significant (NS), Significant (S)

Level of Confidence: High (H), Moderate (M), or Low (L)

See **Table 5.1-2** for list of applicable activities for each listed Project phase, unless otherwise noted in this table. Includes all existing and reasonably foreseeable projects as outlined in **Table 6.1-1**.

6.3.2 Groundwater Quality Subcomponent

The interactions between the predicted Project residual effects and the residual effects of past, current, and reasonably foreseeable projects and activities (**Table 6.1-1**) were reviewed to determine potential cumulative effects on the Groundwater Quality subcomponent.

Residual effects on the Groundwater Quality subcomponent resulting from the Project relative to the baseline conditions were identified and assessed as **Not Significant** in **5.4.2**. Residual effects resulting from past, current, and reasonably foreseeable projects and activities may act cumulatively with the residual effects of the Project on Groundwater Quality in the RSA through change in groundwater quality at private wells and quality of groundwater discharging to creeks and rivers.

6.3.2.1 Changes to Groundwater Quality in the Area of Private Wells

Project-related changes to Groundwater Quality at private wells have the potential to interact with potential changes resulting from agriculture, as listed in **Table 6.1-1**. Agricultural activities have occurred in the past, present, and will do for the foreseeable future. Agricultural application of fertilizer and keeping of livestock may locally increase concentrations of nutrients in groundwater. However, the amount of agricultural area and the associated effect is also expected to be small relative to the total Telkwa and Bulkley watersheds. Mitigation measures would be expected to be incorporated in agricultural practices to control release of

nutrients or other chemicals. Project-related changes to nutrient concentrations in groundwater at the private wells are anticipated to be negligible (i.e., orders of magnitude below BC WQG DWS). Furthermore, water quality is regulated through the application of the *Water Sustainability Act*, SBC 2014, c 15 (GovBC 2014) to appropriately manage groundwater resources within the RSA.

Based on this qualitative summary, the Magnitude of the cumulative effect from changes to groundwater quality at private wells is expected to be Negligible, given the small agricultural area within the RSA. Geographical Extent is Regional since the projects, and the effects, are located within the RSA. The Duration is predicted to be Long-term, given the expectation agricultural activities will operate for the foreseeable future. The Frequency of the effect is expected to be Continuous since the change is expected to occur year-round. The Reversibility of the effect is expected to be Irreversible, since agricultural activities will likely continue indefinitely. The Context of the effect is expected to be Moderate, considering that this activity has been ongoing in the past. The Likelihood of a cumulative effect is Unlikely, due to the small scale of the projects in relation to the natural watersheds of the Bulkley and Telkwa River.

The cumulative effect on the Groundwater Quality subcomponent is predicted to be **Not Significant**, as the change is not expected to alter its integrity within the Groundwater RSA to an unacceptable level. The effect is predicted to be of Negligible Magnitude, Regional Extent, and Long-term Duration. This prediction was deemed to have a Moderate Level of Confidence, based on the qualitative assessment.

6.3.2.2 Change in Quality of Groundwater Discharging to Creeks and Rivers

Project-related changes to the quality of groundwater discharging creeks and rivers have the potential to interact with potential changes resulting from agriculture, as listed in **Table 6.1-1**. Agricultural activities are present within the LSA and RSA, and have occurred in the past, present, and will do for the foreseeable future. Agricultural application of fertilizer and keeping of livestock may locally increase concentrations of nutrients in groundwater. However, the amount of agricultural area and the associated effect is also expected to be small relative to the total Telkwa and Bulkley watersheds. Mitigation measures would be expected to be incorporated in agricultural practices to control release of nutrients or other chemicals. Project-related nutrient concentrations in mine seepage are estimated to be low (i.e., typically an order of magnitude below BC WQG FAL) and will be even lower when mixed with background groundwater sources, before being ultimately discharged to creeks or rivers. Furthermore, water quality is regulated through the application of the *Water Sustainability Act*, SBC 2014, c 15 (GovBC 2014) to appropriately manage groundwater resources within the RSA.

Based on this qualitative summary, the Magnitude of the cumulative effect from changes to the quality of groundwater quality discharging to creeks and rivers is expected to be Negligible, given the small agricultural area within the RSA. Geographical Extent is Regional since the projects, and the effects, are located within the RSA. The Duration is predicted to be Long-term, given the expectation agricultural activities will operate for the foreseeable future. The Frequency of the effect is expected to be Continuous since the change is expected to occur year-round. The Reversibility of the effect is expected to be Irreversible, since agricultural activities will likely continue indefinitely. The Context of the effect is expected to be Moderate, considering that this activity has been ongoing in the past. The Likelihood of a cumulative effect is Unlikely, due to the small scale of the projects in relation to the natural watersheds of the Bulkley and Telkwa River.

The cumulative effect on Groundwater Quality is predicted to be **Not Significant**, as the change is not expected to alter its integrity within the Groundwater RSA to an unacceptable level. The effect is predicted to be of Negligible Magnitude, Regional Extent, and Long-term Duration. This prediction was deemed to have a Moderate Level of Confidence, based on the qualitative assessment.

6.3.2.3 Summary of Cumulative Effects for the Groundwater Quality Subcomponent

Table 6.3-2 summarizes the cumulative Project residual effects for the Groundwater Quality subcomponent.

Table 6.3-2: Summary of Cumulative Effects for the Groundwater Quality Subcomponent

Cumulative Effects	Contributing Activities within the Project Phases (C, O, D, P)	Cumulative Effects Characterisation								
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood	Significance	Level of Confidence
Changes to Groundwater Quality at Private Wells	- Existing activities include agriculture (C, O, D, P) - Reasonably foreseeable developments within the Groundwater RSA as outlined in Table 6.1-1 (C, O, D, P) - Project-related activities that could interact with the above activities, as outlined in Table 5.5-1	N	RSA	LT	CF	IR	M	UL	NS	M
Change in Quality of Groundwater Discharging to Creeks and Rivers		N	RSA	LT	CF	IR	M	UL	NS	M

Notes: C, O, D, P represent Project Phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure
Project=Tenas Project; RSA=Regional Study Area

Magnitude: Low (L), Moderate (M), High (H)

Geographic Extent: Project Area (PA), Local (LSA), Regional (RSA), beyond Regional (beyond RSA)

Duration: Short-term (ST), Medium-term (MT), Long-term (LT)

Frequency: Infrequent (IF), Frequent (FF), Continuous (CF)

Reversibility: Fully reversible (FR), Partially reversible (PR), Irreversible (IR)

Context: Low (L), Moderate (M), High (H)

Likelihood: Unlikely (UL), Likely (L)

Significance: Not-Significant (NS), Significant (S)

Level of Confidence: High (H), Moderate (M), or Low (L)

See **Table 5.1-2** for list of applicable activities for each listed Project phase, unless otherwise noted in this table. Includes all existing and reasonably foreseeable projects as outlined in **Table 6.1-1**.

6.4 Summary of Cumulative Effects Assessment (CEA)

The following Project-related residual effects of the Project on the Groundwater VC were carried forward to the CEA:

- ▶ changes to groundwater level in areas of private wells;
- ▶ changes in groundwater discharge rates to creeks and rivers;
- ▶ changes to groundwater quality at private wells; and
- ▶ change in quality of groundwater discharging to creeks and rivers.

Table 6.4-1 summarizes the cumulative Project residual effects for the Groundwater VC. The residual effects of the Project, in conjunction with the comparable residual effects from past, present, and reasonably foreseeable future projects are not expected to alter the integrity of groundwater quantity or groundwater quality. Future agricultural or mining activities are expected to have the greatest contribution to cumulative effects on the Groundwater VC, however, this is expected to be mitigated with the implementation of regulatory guidance and requirements in their permit conditions.

Considering this, the cumulative effects are not expected to alter the integrity of the Groundwater VC within the Groundwater RSA beyond an acceptable level (i.e., it remains sustainable and is available to contribute to ecological function); and are predicted to be **Not Significant**.

Table 6.4-1: Summary of Cumulative Effects on the Groundwater Valued Component (VC)

VC Subcomponent	Potential Cumulative Effect	Contributing Activities within the Project Phases (C, O, D, P)	Cumulative Effect (Yes/No)	Significant (Yes/No)
Groundwater Quantity	- Changes to groundwater level in areas of private wells - Changes in groundwater discharge rates to creeks and rivers	- Existing activities include agriculture (C, O, D, P) - Reasonably foreseeable developments within the Groundwater RSA as outlined in Table 6.1-1 (C, O, D, P) - Project-related activities that could interact with the above activities, as outlined in Table 5.5-1	No	No
Groundwater Quality	- Changes to Groundwater Quality at Private Wells - Change in Quality of Groundwater Discharging to Creeks and Rivers	- Existing activities include agriculture (C, O, D, P) - Reasonably foreseeable developments within the Groundwater RSA as outlined in Table 6.1-1 (C, O, D, P) - Project-related activities that could interact with the above activities, as outlined in Table 5.5-1	No	No

Notes: C, O, D, P represent Project phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure
VC=Valued Component; RSA=Regional Study Area

See **Table 5.1-2** for list of applicable activities for each listed Project phase, unless otherwise noted in this table. Includes all existing and reasonably foreseeable projects as outlined in **Table 6.1-1**.

7. SUMMARY OF EFFECTS ASSESSMENT FOR GROUNDWATER VALUED COMPONENT (VC)

The following potential adverse effects of the Project on the Groundwater VC subcomponents are predicted to occur due to the Project:

- ▶ changes to the groundwater level around private wells;
- ▶ changes in groundwater discharge rates to creeks and rivers;
- ▶ changes to groundwater quality around private wells; and
- ▶ changes in the quality of groundwater discharging to creeks and rivers.

Mitigation measures employed during all Project phases are expected to avoid, minimize, or rehabilitate onsite the potential adverse Project effects on the Groundwater VC; however, these effects are not anticipated to be fully mitigated and residual effects are anticipated.

The Project-related residual effects on the Groundwater VC subcomponents were predicted to be **Not Significant**. All Project-related residual effects were carried forward into the CEA and were assessed in relation to their overlap in time and space with the comparable residual effects of other projects and activities within the Groundwater RSA. Future agricultural or mining activities are expected to have the greatest contribution to cumulative effects on the Groundwater VC, however, this is expected to be mitigated with the implementation of regulatory guidance and requirements in their permit conditions. Considering this, the cumulative effects are not expected to alter the integrity of the Groundwater VC within the Groundwater RSA beyond an acceptable level (i.e., it remains sustainable and is available to contribute to ecological function). As such, the cumulative effects on the Groundwater VC are predicted to be **Not Significant**.

8. FOLLOW-UP STRATEGY

TCL has identified a follow-up strategy to evaluate the accuracy of effects predictions, effectiveness of proposed mitigation measures, and to detect unanticipated effects regarding the Groundwater VC. The strategy focuses on implementation of the monitoring program outlined below and in the **Minesite Water Management Plan (S13.0-C11) (MWMP)** which involves the implementation of widely recognized BMPs and the development of procedural mitigation measures to minimize anticipated effects.

The monitoring program is intended to evaluate the effectiveness of implemented mitigation measures, to promote continuous improvement, and to detect unanticipated effects. The proposed groundwater monitoring locations are presented in **Table 8-1**; and mapped in **Figure 8-1**. The potential effects that the monitoring program is designed to investigate are:

- ▶ Seepage of contact water from Minesite sources, including the Tenas Control Pond, all three (3) management ponds, sedimentation ponds, and the end pit lakes. Monitoring groundwater quality near seepage sources will be important to confirm conclusions of the residual effects assessment for Groundwater Quality VC). Therefore, monitoring for groundwater seepage is generally located near sources with limited downgradient monitoring to monitor for potential seepage migration; and
- ▶ Monitoring of groundwater drawdown from open pit dewatering. Monitoring groundwater levels between source and receptors will be important to confirm conclusions of the residual effects assessment for Groundwater Quantity. Therefore, monitoring for drawdown is generally located along effect pathways.

The monitored parameters will include groundwater levels (automated and manual), and groundwater quality. The program and sampling methods will be based on protocols described in the Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators. Version 2. (BC MOE 2016), and the methodology specified in the British Columbia Field Sampling Manual (British Columbia Ministry of Water, Land and Air Protection [BC MWLAP] 2013).

Manual groundwater levels will be measured with a depth meter during each sampling event and/or prior to and immediately after manipulating the well instruments. Automated levels will be measured every 12 hours using level loggers. The groundwater quality parameters will be consistent with those collected for the baseline study: pH, turbidity, hardness and alkalinity, anions and nutrients, and total and dissolved metals.

In addition, monitoring of surface water will also be undertaken to support the groundwater monitoring program. Specifically, creek flow and water quality will be monitored at stations along Four, Tenas, and Goathorn Creek to compliment monitoring for potential effects to groundwater. See **Appendix 13.11-E Minesite Water Monitoring Plan** of the **MWMP** for full details of the surface water monitoring program.

The results of the monitoring program will be reviewed on a frequency to be stipulated by future permit conditions; visual analyses will be performed to evaluate the trends in monitoring indicators; and TCL will submit detailed reports as required by the operational permits. All proposed monitoring wells will be established one (1) year prior to earliest monitoring phase to establish pre-phase conditions.

Table 8-1: Proposed Groundwater Monitoring Stations

Station Name	Monitoring Rationale	Phase*	GPS Coordinates		Well Type	Geology Associated with Well Screen(s)	Measurement Frequency	Measurement Collection Method
			Easting	Northing				
T18-04S, and -04D	- Monitoring of potential water table drawdown towards Tenas Creek - Monitoring potential seepage from end pit lake towards Tenas Creek	C, O, D, P	615955	6051115	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
T18-06D	Monitoring of potential seepage from West Management Pond towards Four Creek	C, O, D, P	6616245	6052647	Single well	Overburden	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
T19-26S	Monitoring of potential seepage from North Management Pond towards Tenas Creek	C, O, D, P	617469	6053665	Single well	Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure transducers - Depth meter - Purging and pumping
T95R-40	Monitoring of potential seepage from end pit lake	D, P	618188	6051461	Single well	Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
T96R-34-87	Monitoring of potential seepage from end pit lake	D, P	617691	6051180	Single well	Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
TOB96-01-05	- Monitoring of potential water table drawdown towards Four Creek - Monitoring of potential seepage from end pit lake towards Four Creek	C, O, D, P	619014	6050602	Single well	Overburden	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure transducer - Depth meter - Purging and pumping

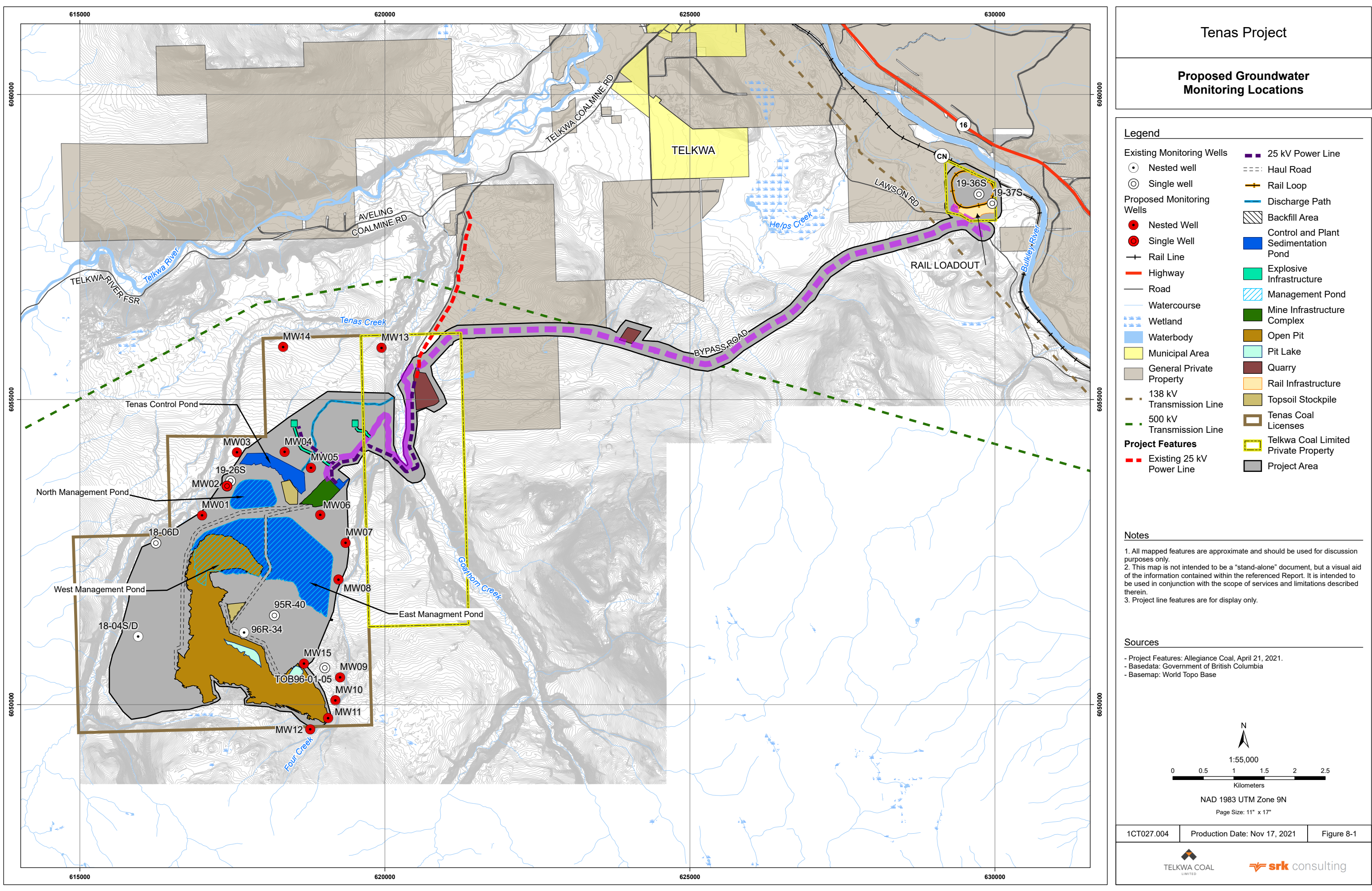
Station Name	Monitoring Rationale	Phase*	GPS Coordinates		Well Type	Geology Associated with Well Screen(s)	Measurement Frequency	Measurement Collection Method
			Easting	Northing				
T19-36S	Monitoring of potential seepage from Rail Loadout stockpile	C, O, D, P	629737	60585365	Single well	Overburden	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
T19-37S	Monitoring of potential seepage from Rail Loadout stockpile	C, O, D, P	629955	6058215	Single well	Overburden	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducer - Depth meter - Purging and pumping
MW1	Monitoring of potential seepage from West Management Pond towards Tenas Creek	C, O, D, P	617003	6053101	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducers - Depth meter - Purging and pumping
MW2	Monitoring of potential seepage from North Management Pond towards Tenas Creek	C, O, D, P	617412	6053582	Single Well	Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducer - Depth meter - Purging and pumping
MW3	Monitoring of potential seepage from Tenas Control Pond towards Tenas Creek	C, O, D, P	617575	6054132	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
MW4	Monitoring of potential seepage from Tenas Control Pond	C, O, D, P	618357	6054140	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducers - Depth meter - Purging and pumping
MW5	Monitoring of potential seepage from Tenas Control Pond	C, O, D, P	618787	6053882	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping

Station Name	Monitoring Rationale	Phase*	GPS Coordinates		Well Type	Geology Associated with Well Screen(s)	Measurement Frequency	Measurement Collection Method
			Easting	Northing				
MW6	Monitoring of potential seepage from East Management Pond towards Four Creek	C, O, D, P	618942	6053106	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
MW7	Monitoring of potential seepage from East Management Pond towards Four Creek	C, O, D, P	619357	6052651	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducers - Depth meter - Purging and pumping
MW8	Monitoring of potential seepage from East Management Pond towards Four Creek	C, O, D, P	619240	6052049	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
MW9	Monitoring of potential water table drawdown towards Four Creek	C, O, D, P	619018	6050595	Single Well	Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly	- Pressure Transducers - Depth meter
MW10	Monitoring of potential water table drawdown towards Four Creek	C, O, D, P	619106	6049985	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly	- Pressure Transducers - Depth meter
MW11	Monitoring of potential water table drawdown towards Four Creek	C, O, D, P	619069	6049779	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly	- Pressure Transducers - Depth meter
MW12	- Monitoring of potential water table drawdown towards Four Creek - Background groundwater quality	C, O, D, P	618777	6049594	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducers - Depth meter - Purging and pumping

Station Name	Monitoring Rationale	Phase*	GPS Coordinates		Well Type	Geology Associated with Well Screen(s)	Measurement Frequency	Measurement Collection Method
			Easting	Northing				
MW13	Compliance monitoring downgradient of Project at lease boundary	C, O, D, P	619945	6055847	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
MW14	Compliance monitoring downgradient of Project at lease boundary	C, O, D, P	618332	6055861	Nested well	Overburden and Bedrock	- Manual levels: Quarterly - Sampling: Quarterly	- Depth meter - Purging and pumping
MW15	Monitoring of potential seepage from end pit lake towards Four Creek	D, P	618688	6050657	Nested well	Overburden and Bedrock	- Automated Levels: 12-hour interval - Manual levels: Quarterly - Sampling: Quarterly	- Pressure Transducer - Depth meter - Purging and pumping

Notes: C, O, D, P represent Project phases: (C)onstruction, (O)peration, (D)ecommissioning and Reclamation, (P)ost-closure
GPS=Global Positioning System

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If original predictions of effects and mitigation effectiveness are not as expected, adaptive management principles and strategies will be implemented in a timely manner. Adaptive management is a planned systematic approach for continuously improving environmental management practices by learning from management outcomes; it is an important tool in effective management and achieving continual improvement in environmental performance (CEAA 2016). At the broader scope, the development and implementation of adaptive management will be guided by policy, BMPs, and guidance documents including but not limited to:

- ▶ British Columbia Mitigation Policy and Procedures for Mitigating Impacts on Environmental Values (BC MOE 2014);
- ▶ Adaptive Management Measures under the Canadian Environmental Assessment Act (CEAA 2016); and
- ▶ Environmental Code of Practice for Metal Mines (Environment Canada 2009).

Any changes to regulations, guidance documents, or BMPs will be implemented, as appropriate, and any necessary changes to management plans and procedures will be updated accordingly. In addition, adaptive management will consider a wide range of factors, including:

- ▶ the results of:
 - ▶ environmental audits or other evaluation activities;
 - ▶ environmental monitoring;
 - ▶ monitoring of the performance or condition of environmental infrastructure;
- ▶ technological developments; and
- ▶ changing environmental conditions.

Performance objectives will be developed by TCL prior to the Construction Phase. They will consist of groundwater level and groundwater quality measurements which would be adjusted if and as necessary as part of the adaptive management process, e.g., if legislation or guidelines change, measurable parameter or thresholds will be adjusted.

The adaptive management process will include consideration of management reviews, incident investigations, shared traditional, cultural, or local knowledge, new or improved scientific methods, regulatory changes, or other Project-related changes. The mitigation and monitoring strategies for groundwater will be updated to maintain consistency with action plans, management plans, and BMPs that may become available during the life of the Project, as appropriate. Stakeholders, Indigenous groups, and government agencies will be involved, as necessary, in developing effective strategies and additional mitigation.

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