Section 6.5
Hydrology

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

6.5 Hydrology

This section of the Environmental Assessment (EA) discusses the potential effects of the proposed Project on local hydrologic conditions of flow and quantity in the Patsy Creek, Lime Creek, Clary Creek, and lower portion of the Illiance River Watersheds. These hydrologic conditions have been identified as key aspects of the Hydrology Valued Component (VC).

The significance and likelihood of residual and cumulative effects, due to the proposed Project, on the flow and quantity within these watersheds are presented herein. Conclusions that follow are based on the assessment of predicted flow and quantity due to the proposed Project during all project phases: construction; operations; decommissioning and closure; and post-closure. Surface water flows and quantities affected by the Kitsault Mine Project (proposed Project) footprint would be managed under the proposed Project's proposed Water Management Plan (Appendix 6.4-B), which includes management of all "contact water", i.e. water in contact with a mining activity. The rationale for the selection of hydrology as a VC and its potential effect on other VCs such as water and sediment quality, aquatic resources and wildlife is also discussed. The report, "Water Quality Hydrology and Sediment Quality Baseline" in Appendix 6.5-A, provides the hydrology baseline of the proposed Project.

6.5.1 Valued Component Scoping and Rationale

Preliminary components of the Hydrology VC identified in the Application Information Requirements (AIR) included:

- Lime Creek / Patsy Creek Watershed;
- Clary Creek Watershed; and
- Lower Illiance Watershed.

These watersheds and the hydrometric stations in the proposed Project area are shown on Figure 6.5.1-1. The relationship of Project components to these watersheds are shown on Figure 6.5.1-2. All of these watersheds are either within or adjacent to the proposed Project footprint.

The predicted changes in flow and water quantity are presented at key locations within these watersheds. The Patsy Creek Watershed is a sub-watershed of the Lime Creek Watershed; Patsy Creek drains into Lime Creek which then drains into Alice Arm. The downstream end of Lime Creek has been identified as a key environmental location given the presence of various species of fish and its proximity to the intertidal zone of Alice Arm. For this reason, the effects assessment for the Lime Creek / Patsy Creek Watershed focused on the lower end of Lime Creek.

Within the Clary Creek Watershed are multiple points of environmental focus as there are many lakes and creeks within this watershed that are potentially affected by the proposed Project. The effects assessment for Clary Creek thus includes multiple locations of assessment. The Clary Creek Watershed drains into the Illiance River near Alice Arm. The Illiance River Watershed is included in the effects assessment. Nevertheless, the majority of the Illiance River Watershed has no link to potential effects from the proposed Project.

The proposed Project has the potential, with its water diversion, obstruction, and withdrawal activities, to cause changes in water flow and quantity within the three identified watersheds. In addition, this potential alteration of stream flow and / or quantity has the potential to affect other proposed Project-related VCs, such as water and sediment quality as well as aquatic resources and wildlife VCs. The importance of water flow and quantity in providing suitable habitat throughout each of the identified watersheds and this influence on other proposed Project-related VCs demonstrate the importance of this VC and the rationale for its detailed discussion throughout this section.

6.5.1.1 Lime Creek / Patsy Creek Watershed

The main stem of Lime Creek is situated to the west, outside of the mine footprint; two of its tributaries are within the footprint and a small stretch running adjacent to anticipated mine work areas. Patsy Creek, as a Lime Creek tributary, also has several small ponds, Patsy Lake and a number of streams as part of its headwaters, which are located within the mine footprint. Downstream of Patsy Creek, Lime Creek flows in a north-westerly direction past Kitsault Townsite into Alice Arm at sea level. The majority of the proposed Project facilities are located in the Lime Creek / Patsy Creek Watershed (Figure 6.5.1-2), including: the Tailings Management Facility (TMF); the Waste Rock Management Facility (WRMF); the Kitsault Pit; the south diversion channel; and the Patsy Creek diversion. The effects from these facilities on local hydrology are expected to extend from construction through to the post-closure phase.

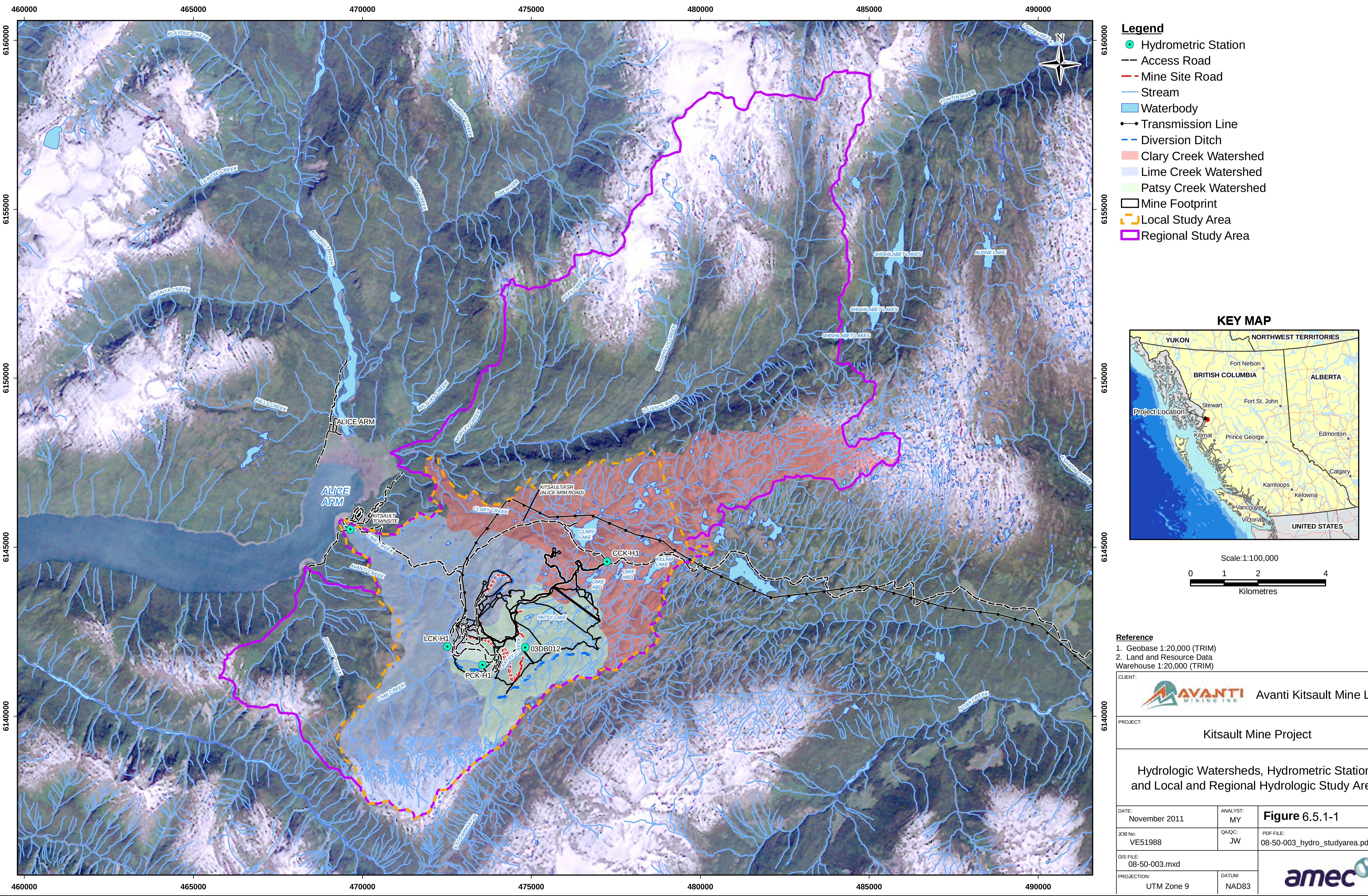
The TMF would cover Patsy Lake and modify the flow pattern of Patsy Creek Watershed. The WRMF and Kitsault Pit would also affect portions of Patsy Creek. Two diversion channels would be required to divert remaining portions of Patsy Creek to Lime Creek.

6.5.1.2 Clary Creek Watershed

The Clary Creek Watershed is situated to the north and east of the proposed Project area. Several lakes and ponds, including Clary Lake and Lake 901, are located in the headwaters of Clary Creek, which flows in a north-westerly direction and discharges into the lower Illiance River. Flowing in a south-westerly direction, the lower Illiance River discharges into Alice Arm at sea level. The proposed Project is expected to affect Clary Creek Watershed from construction to post-closure due to the establishment of the proposed TMF and withdrawal of water from Clary Lake to meet the water consumption requirements of the processing facility and the potable water needs of the camp. The TMF, though predominately within the Lime Creek / Patsy Creek Watershed, spans into the Clary Creek Watershed and thus has the potential to alter flows within a small headwater stream and lake; Lake 901 and its inflows. These potential effects substantiate the selection of the Clary Creek Watershed as part of the Hydrology VC.

6.5.1.3 Illiance River

The Illiance River Watershed upstream of the Clary Creek and Illiance River confluence has no interaction with the mining activities and thus is not part of the assessment. The Illiance River below the confluence of Clary Creek could potentially be affected by flow and quantity changes in the Clary Creek Watershed and thus is assessed in this regard (referred to herein as lower Illiance River).



Reference
1. Geobase 1:20,000 (TRIM)
2. Land and Resource Data Warehouse 1:20,000 (TRIM)

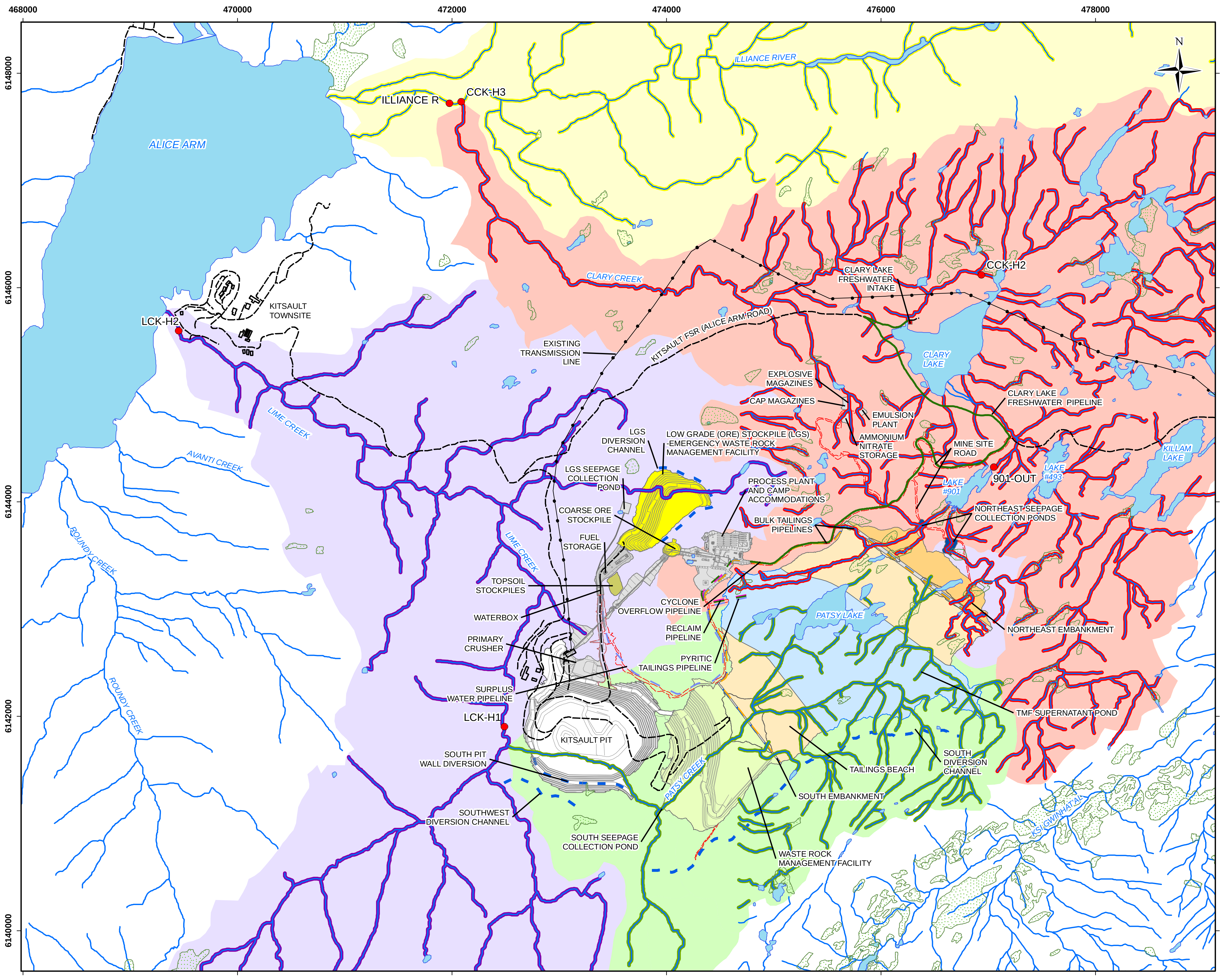
CLIENT: Avanti Kitsault Mine Ltd.

PROJECT: Kitsault Mine Project

Hydrologic Watersheds, Hydrometric Stations and Local and Regional Hydrologic Study Areas

DATE: November 2011	ANALYST: MY	**Figure** 6.5.1-1
JOB No: VE51988	QA/QC: JW	PDF FILE: 08-50-003_hydro_studyarea.pdf
GIS FILE: 08-50-003.mxd		
PROJECTION: UTM Zone 9	DATUM: NAD83	

Y:\GIS\Projects\VE\VE51988_Kitsault\Mapping\08_hydrology\Baseline\08-50-003.mxd



Legend

- Access Road
- Mine Site Road
- Transmission Line
- Stream
- Waterbody
- Wetland
- Pipeline - Freshwater
- Diversion Ditch
- Process Plant
- Open Pit
- Ore Stockpile
- Clary Lake Freshwater Intake
- Topsoil Stockpiles
- Waste Rock Management Facility
- Northeast Embankment
- Tailings Beach
- Tailings Management Facility (TMF) Supernatant Pond
- Watershed Model Streamflow Node
- Clary Creek
- Lime Creek
- Patsy Creek
- Illiance River
- Clary Creek Watershed
- Lime Creek Watershed
- Patsy Creek Watershed
- Illance River Watershed

KEY MAP

1 0.5 0 1

Kilometres

Scale:1:35,000

Reference

1. Base Data
Geobase 1:20,000 (TRIM)
Land and Resource Data Warehouse 1:20,000 (TRIM)
2. Kitsault Mine General Layout
Supplied by AMEC and Knight Piesold on March 2011

CLIENT: Avanti Kitsault Mine Ltd.

PROJECT: Kitsault Mine Project

Project Components and Hydrologic Watersheds

DATE: November 2011	ANALYST: MY	**Figure** 6.5.1-2	
JOB No: VE51988	QA/QC: JW	PDF FILE: 08-50-002_hydrologic_watersheds.pdf	
GIS FILE: 08-50-002.mxd			
PROJECTION: UTM Zone 9	DATUM: NAD83		

amec

Y:\GIS\Projects\VE\VE51988_Kitsault\Mapping\08_hydrology\Baseline\08-50-002.mxd

6.5.1.4 Project Interaction Matrix

The hydrology of the Lime Creek / Patsy Creek Watershed is expected to be most affected by the proposed Project. These watersheds have been assessed collectively in the interaction identification, since the Patsy Creek Watershed is a sub-watershed of the Lime Creek Watershed. The Illiance River downstream of Clary Creek is addressed only as it pertains to flow from Clary Creek, since it has no anticipated interactions with the proposed Project components and footprint. The interactions of proposed Project activities with the hydrology of Lime Creek / Patsy Creek, Clary Creek, and the lower reach of the Illiance River Watersheds are summarised in Table 6.5.1-1. Hydrology effects are primarily assessed in terms of those broad Project components, since it is the Project components that could potentially affect water quantity and flow within a watershed rather than individual mine activities. For example, the Kitsault Pit is a Project component that would include individual mine activities such as land clearing, excavation, and grading. In addition, water management facilities are treated as a Project component and include a wide range of activities, which have been grouped together for simplicity in this effects assessment.

The proposed Project components selected for interaction with hydrology in Table 6.5.1-1 were selected with this broad Project component consideration in mind. The exception to this approach occurs during the post-closure period, when the effects are assessed in terms of on-going activities.

As shown in Table 6.5.1-1, the majority of proposed Project activities that will potentially interact with surface water flow and quantity are located within the Lime Creek / Patsy Creek Watershed.

Table 6.5.1-1: Valued Component / Issue Interaction Matrix for Hydrology

Project Component	Hydrology			
	Lime Creek Watershed	Patsy Creek Watershed	Clary Creek Watershed	Illiance River*
Construction Phase				
Soil and till salvage, handling and storage, including locations, volumes, and affected areas (i.e., ore and topsoil stockpiles)	-	-	NI	NI
Mine infrastructure installations	o	o	o	NI
Process Plant and ancillary facilities	o	o	o	NI
Kitsault Pit development	o	o	NI	NI
Expansion of exploration camp to create construction and permanent camps	o	o	NI	NI
WRMF development	-	-	NI	NI
TMF development	-	-	o	NI
Water Management Facilities (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	-	-	-	NI
Operations Phase				
Soil and till salvage, handling and storage, including locations, volumes and effected areas (i.e., ore and topsoil stockpiles)	-	-	NI	NI
Mine infrastructure installations	o	o	o	NI
Process Plant and ancillary facilities	o	o	o	NI
Kitsault Pit mining	-	-	NI	NI
WRMF operations	-	-	NI	NI
TMF operations	-	-	-	NI
Water Management Facilities (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	-	-	o	NI
Process and potable water supply and storage	o	o	-	NI
Water withdrawal and discharge points	+	+	-	NI
Decommissioning and Closure				
Soil and till salvage, handling and storage, including locations, volumes and effected areas (i.e., ore and topsoil stockpiles)	-	-	NI	NI

Project Component	Hydrology			
	Lime Creek Watershed	Patsy Creek Watershed	Clary Creek Watershed	Illiance River*
Access and mine site road decommissioning and reclamation	o	o	o	NI
Kitsault Pit reclamation	-	-	NI	NI
WRMF area reclamation	-	-		NI
TMF area reclamation	-	-	o	NI
WRMF and TMF seepage management and reclamation	o	o	o	NI
Water Management Facilities reclamation (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	-	-	o	NI
Stream drainage restoration	o	o	+	NI
Fish habitat compensation	NI	NI	o	NI
Post-closure				
Monitoring and maintenance of mine drainage conditions	-	-	NI	NI
Monitoring and maintenance of habitat compensation areas	NI	NI	o	NI
Kitsault Pit and associated discharging water	-	-	NI	NI

Interaction definition: o - interaction; - - key interaction; + - benefit; NI - no interaction

Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility
* Illiance River downstream of Clary Creek has no interaction with the mining activities (referred to herein as the lower Illiance River)

6.5.1.5 Issues Scoping and Identification

The key issues of hydrological significance to be considered in this assessment are: natural streams and lakes; and surface drainage areas. The potential effects on annual and seasonal flows were included in this assessment, in addition to high and low-flow conditions. These key issues are identified based on an assessment of the proposed Project as defined in the Project Description (Section 3.0), the Water Management Plan (Appendix 6.4-B), and feedback from the Kitsault Working Group, the Nisga'a Nation, other Aboriginal Groups and the public. Tables 6.5.1-2 (construction phase), 6.5.1-3 (operations phase), 6.5.1-4 (decommissioning and closure phase), and 6.5.1-5 (post-closure phase) show the relevant key issues affected by the proposed Project components during each phase. Under the VCs, the tables show the watershed(s) affected by the Project component. The rationale for the assessment is also presented in each VC discussion.

In addition to the above, professional judgment and expertise have been used to identify the relevant key water issues in relation to proposed Project components, given that the proposed Project is expected to affect hydrology.

The following activities would change the runoff from the watersheds within the proposed Project area:

- Construction of the TMF, the Kitsault Pit, the WRMF, other mining infrastructure, and water diversions, would change flow patterns and reduce runoff;
- Creation of the TMF would increase evaporation and local seepage due to creation of a larger surface water area. This would also be the case for the Kitsault Pit once it is filled following Year 15 to 16 of operations;
- Construction of the mine facilities would affect runoff coefficients and infiltration by increasing the impervious area within the watersheds;
- Waste rock and the low grade ore stockpile would affect runoff coefficients, infiltration, and evaporation by changing the characteristics of the natural landscape; and
- Kitsault Pit de-watering would affect the groundwater flows by allowing the water to exit to the surface where it may not have before.

The following Tables 6.5.1-2 to 6.5.1-5 summarises the potential hydrological issues by Project component and the rationale for the selection of the VC.

Table 6.5.1-2: Potential Issues by Project Component and Valued Component – Construction Phase

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Soil and till salvage, handling and storage effects	Natural streams	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow Potential sediment loading
Mine infrastructure installations	Natural streams and lakes	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Process Plant and ancillary facilities	Natural streams and lakes	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Kitsault Pit development	Natural streams	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
Expansion of exploration camp to create construction and permanent camps	Natural streams	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
WRMF development	Natural streams, annual flows, high flow conditions and low flows	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
TMF development	Natural streams, lakes, drainage areas, annual flows, high flow conditions and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Water management facilities (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	Natural streams, lakes, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek, Clary Creek Watersheds	Potential effects on stream flow and lake water level, sediment loads

Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility

Table 6.5.1-3: Potential Issues by Project Component and Valued Component – Operation Phase

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Soil and till salvage, handling and storage, including locations, volumes and affected areas (i.e., ore and topsoil stockpiles)	Natural streams	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow, Potential sediment loading
Mine infrastructure installations	Natural streams and lakes	Lime Creek / Patsy Creek and Clary Creek Watersheds	Effect Potential effects on stream flow and lake water level
Process Plant and ancillary facilities	Natural streams and lakes	Lime Creek / Patsy Creek and Clary Creek Watersheds	Effect Potential effects on stream flow and lake water level
Kitsault Pit mining	Natural streams, drainage areas, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek Watershed	Effect Potential effects on stream flow
WRMF operations	Natural streams, annual flows, high flow conditions and low flows	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
TMF operations	Natural streams, lakes, drainage areas, annual flows, high flow conditions and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Water management facilities (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	Natural streams, lakes, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level. Potential sediment loading
Process and potable water supply and storage	Lake levels, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Water withdrawal and discharge points	Lake levels, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek, Clary Creek	Potential effects on stream flow and lake water level

Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility

Table 6.5.1-4: Potential Issues by Project Component and Valued Component – Decommissioning and Closure Phase

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Soil and till salvage, handling and storage, including locations, volumes and effected areas (i.e., ore and topsoil stockpiles)	Natural streams	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow. Potential sediment loading
Access and mine site road decommissioning and reclamation	Natural streams, lakes, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Kitsault Pit reclamation	Natural streams, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
WRMF area reclamation	Natural streams	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
TMF area reclamation	Natural streams, lakes, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
WRMF and TMF seepage management and reclamation	Lakes, annual flows and low flows	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Water management facilities reclamation (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	Natural streams, lakes, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek, Clary Creek and lower Illiance River Watersheds	Potential effects on stream low and lake water level. Potential sediment loading
Stream drainage restoration	Natural streams and lakes	Lime Creek / Patsy Creek and Clary Creek Watersheds	Potential effects on stream flow and lake water level
Fish habitat compensation	Natural streams and lakes	Clary Creek Watershed	Potential effects on stream flow and lake water level

Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility

Table 6.5.1-5: Potential Issues by Project Component and Valued Component – Post Closure

Project Component	Relevant Key Issues	Valued Component(s)	Rationale
Monitoring and maintenance of mine drainage conditions	Natural streams, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow
Habitat compensation areas for TMF and WRMF	Natural streams	Clary Creek and lower Illiance River Watersheds	Potential effects on stream flow
Kitsault Pit and associated discharging water	Natural streams, annual flows, seasonal distribution of flow, high flow conditions and low flows	Lime Creek / Patsy Creek Watershed	Potential effects on stream flow

Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility

6.5.1.6 Valued Component Selection Rationale

Table 6.5.1-6 provides the rationale for the selection of Hydrology VCs for this effects assessment. Tables 6.5.1-2 to 6.5.1-5 above identify those proposed Project components that are likely to have an effect on hydrology (water flow and quantity) in the identified watersheds. These key hydrological issues are in turn likely to affect water and sediment quality as well as aquatic and wildlife habitat downstream of the proposed Project area.

Demonstration of preservation of existing fish stock and water quality is important to Nisg̱a'a Lisims Government (NLG) and Aboriginal Groups. Additionally, hydrology as a VC falls under the jurisdiction, regulations, and guidelines of several governmental agencies and stakeholders, all of which are interested in the effects of the proposed Project on hydrology, as summarised in Table 6.5.1-6.

Based on the rationale presented, the following VCs associated with hydrology have been carried forward and included in the assessment:

- Lime Creek / Patsy Creek Watershed; and
- Clary Creek Watershed.

Although there are no direct interactions between the Project components and the lower portion of Illiance River Watershed, the assessment includes information about this watershed for its importance to NLG.

Table 6.5.1-6: Hydrology Valued Component Selection Rationale

Valued Component	Rationale							
	Interaction with Proposed Project Activities	**Scientific Literature and Professional Judgement**	**Nisga'a Lisims Government**	**Aboriginal Groups included by BC EAO**	**Applicable Government Agencies**	**Land and Resource Management Plans**	**The Public and Other Stakeholders**	**Federal and Provincial Regulations and Guidelines**
Lime Creek / Patsy Creek Watershed	The TMF, Kitsault Pit, WRMF, mine infrastructures, ore stockpiles, process plant and camp accommodations, water management facilities and mine infrastructure installations have the potential to affect natural streams, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Changes in stream flow, particularly reduction in low flows are likely to affect, water and sediment quality, aquatic and wildlife habitat downstream.	NLG will seek to ensure preservation of existing fish stocks and water quality.	Identified as a VC through BC EAO Working Group process.	BC MOE, DFO, EC.	Central and North Coast EBM (BC ILMB 2008); Nass South SRMP (BC ILMB 2009 Draft); Kitsault-Stagoo Special Forest Management Area.	Potential effects on fisheries and wildlife; Mining Watch Canada.	*Water Act, Fisheries Act*

Valued Component	Rationale							
	Interaction with Proposed Project Activities	Scientific Literature and Professional Judgement	Nisga'a Lisims Government	Aboriginal Groups included by BC EAO	Applicable Government Agencies	Land and Resource Management Plans	The Public and Other Stakeholders	Federal and Provincial Regulations and Guidelines
Clary Creek Watershed	The TMF, water management facilities and water withdrawal have the potential to affect natural streams, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows and lake levels.	Changes in stream flow, particularly reduction in low flows are likely to affect, water and sediment quality, aquatic and wildlife habitat downstream.	NLG will seek to ensure preservation of existing fish stocks and water quality.	Identified as a VC through BC EAO Working Group process.	BC MOE, DFO, EC.	Central and North Coast EBM (BC ILMB 2008); Nass South SRMP (BC ILMB 2009 Draft); Kitsault-Stagoo Special Forest Management Area.	Potential effects on fisheries and wildlife; Mining Watch Canada.	*Water Act, Fisheries Act*

Note: BC EAO - British Columbia Environmental Assessment Office; BC ILMB - British Columbia Integrated Land Management Bureau; BC MOE - British Columbia Ministry of Environment; DFO - Fisheries and Oceans Canada; EBM - Ecosystem-Based Management; EC - Environment Canada; NLG - Nisga'a Lisims Government; SRMP - Sustainable Resource Management Plan; TMF - Tailings Management Facility; VC - Valued Component; WRMF - Waste Rock Management Facility

6.5.2 VCs: Hydrology of Lime Creek / Patsy Creek, Clary Creek and Illiance River Watersheds

6.5.2.1 Introduction

As discussed in Section 6.5.1, watersheds within the proposed Project area are considered as VCs for this assessment because of anticipated changes to water quantity and flow, and in turn the potential associated effects on water and sediment quality as well as aquatic resources and wildlife.

The scoping process concluded that the proposed Project has the potential to affect Lime Creek / Patsy Creek Watershed due to the development of the TMF, Kitsault Pit, and WRMF. The Clary Creek Watershed could be affected due to the development of the TMF and the utilisation of Clary Lake as a freshwater source (refer to Figure 6.5.1-2).

The following sections describe spatial boundaries (Local Study Area (LSA), Regional Study Area (RSA)) and temporal boundaries for the Hydrology VC.

6.5.2.1.1 Spatial Boundaries

Spatial boundaries used for the effects assessment of hydrology are significantly overlapping with those used for the proposed Project's groundwater and freshwater aquatic resource assessments. Spatial boundaries are defined and presented below.

6.5.2.1.1.1 Local Study Area

The hydrology LSA (Figure 6.5.1-1) is based on the proposed Project footprint and activities that could affect surface water quantity and flow as they relate to assessing aquatic habitat and fish populations.

6.5.2.1.1.2 Regional Study Area

The hydrology RSA (Figure 6.5.1-1) includes the following watersheds:

- Lime Creek (including Patsy Creek): There is the potential for effects from the proposed Project facilities footprint; and changes in stream flow due to mine effluent and water management features;
- Clary Creek: There are potential changes to stream flow and lake levels due to utilisation of Clary Lake as a freshwater source, mine effluent, and water management features; and
- Illiance River (the lower portion downstream of Clary Creek): Potential changes to stream flow are anticipated due to freshwater extraction from Clary Lake for mining activities.

Only the potential changes to the above watersheds have been addressed in this assessment. Effects attributed to all past activities are assumed to be included in the baseline studies conducted for this section (Appendix 6.5-A).

Roundy Creek was included in the hydrology RSA in the AIR for the proposed Project but it has not been included in this assessment because the current mine plan does not overlap with the Roundy Creek Watershed.

6.5.2.1.2 Temporal Boundaries

The temporal boundaries for the Hydrology VC are the four primary phases as described in Section 3.0. These phases include: construction; operations; decommissioning and closure; and post-closure. Activities associated with the proposed Project during each of these phases would affect watersheds included in the RSA.

Preliminary temporal boundaries of the proposed Project which are contingent on permitting include four primary phases:

1. Construction Phase – estimated 25 month period:
    - Site clearing and preparation, earthworks such as excavating and site grading;
    - Construction of access and haul roads and transmission line;
    - Facilities such as the processing plan, TMF South Embankment, and water management facilities;
    - Camp complex; and
    - May include the Patsy Creek diversion;
2. Commissioning / Operations Phase – estimated at approximately two months of commissioning, and 15 to 16 years of mining plus an additional two years of milling low grade ore;
3. Decommissioning and Closure Phase – estimated at 15 to 17 years; and
4. Post-closure and Abandonment Phase – estimated at five years.

6.5.2.2 Information Sources and Methods

Meteorological and hydrological data have been collected at the proposed Project site since late 2008. Between 1960s and the 1990s, data was collected by others. Where available, on-site meteorological and hydrological data was used, in conjunction with historical site and regional data, to develop long-term meteorological and hydrological estimates for the proposed Project site. A description of the baseline conditions at the proposed Project site is presented in the report “Engineering Hydrometeorology Report” (from Knight Piésold), which is located in Section 6.2, Appendix 1 of Appendix 6.2-A. The letter “Kitsault Mine Climate Change Assessment” in Appendix 6.5-B provides an assessment of potential climate change scenarios and the applicability of such scenarios to the proposed Project.

A watershed model to simulate monthly groundwater and surface water flows at various locations in the vicinity of the proposed Project was also developed. The watershed model was used to assess the potential effects on hydrology within the Lime Creek / Patsy Creek and Clary Creek Watersheds for all phases of the proposed Project. This model has been calibrated using the measured stream flows within these watersheds. A description of the watershed model is available in the Knight Piésold report, "Hydrogeology and Watershed Model" Knight (Appendix 6.4-A) and in the Knight Piésold report, "Water Quality Model" (Appendix 6.6-A). The water flow results from this watershed model are presented in the letter, "Surface Water Hydrology Flow Changes" (Appendix 6.5-C).

Peak instantaneous and seven-day low baseline flows were estimated from a regional hydrologic model developed by Obedkoff (2001) for the 10-year return period. Scaling factors were used to obtain other return period estimates. For construction, operations, closure, and post-closure conditions, the low and peak flow return period values were scaled from the baseline estimates according to effective changes in drainage area (Appendix 6.5-C). Values for the 10-year and 200-year return periods were used to represent peak flows in the assessment; values for the 10-year and 100-year return periods were used for the assessment of seven-day low flows. All peak and low-flow estimates are presented in the letter, "Surface Water Hydrology Flow Changes" (Appendix 6.5-C).

The flows estimated using the watershed model and regional hydrologic model described above were used as the basis to assess the key hydrologic issues of annual flows, seasonal distribution of flow, high-flow conditions and low flows within a watershed. Figure 6.5.1-2 shows the watershed model stream flow nodes in the affected watersheds (Appendix 6.5-C). The following stream flow nodes were deemed important in terms of identifying effects of the proposed Project on the Hydrology VC within the Lime Creek / Patsy Creek and Clary Creek Watersheds:

- Lime Creek downstream from confluence with Patsy Creek (LCK-H1);
- Lime Creek near the mouth (LCK-H2);
- Clary Creek at the outlet of Clary Lake (CCK-H2);
- Clary Creek upstream of the confluence with Illiance River (CCK-H3); and
- Outlet of Lake 901 (901-OUT).

The Illiance River downstream of Clary Creek has no interaction with the mining activities and therefore does not warrant detailed investigation due to the limited potential effects from the proposed Project. Nevertheless, the extent to which the proposed Project would affect the quantity of the water in the lower Illiance River will be discussed later in this section to show that this is a valid contention. The stream flow node on the Illiance River downstream of confluence with Clary Creek (ILLIANCE R) will be also evaluated.

Baseline daily flows for the Clary Lake and Lake 901 outlets were estimated by scaling a Patsy Creek daily flow series based on drainage area and then applying monthly changes in flow due to mine phases, as predicted by the watershed model (Appendix 6.5-D). This data was used to analyse the potential lake level changes during the various phases of the proposed Project on Clary Lake and Lake 901. Due to consistently wet and corresponding high runoff in the proposed Project area, the inflow volumes to both lakes far exceed the lake storage volumes. Therefore, it was assumed that the 'dead storage' of each lake is constant throughout the year and the lake level fluctuation is simply a function of the change in the live storage volume (above the dead storage) and the outlet control (Knight Piésold 2011f). This analysis is detailed in the letter, "Lake Level Fluctuations in Clary Lake and Lake 901" (Appendix 6.5-D). These results will be used to assess the effects on lake water levels resulting from proposed Project activities.

6.5.2.3 Baseline Information for Hydrology

Hydrologic data are currently being collected at four stations in the proposed Project areas: two stations on Lime Creek; one station on Patsy Creek; and one station on Clary Creek downstream of Lake 901 (Appendix 1 of Appendix 6.2-A). The long-term proposed Project stream flows were derived from Water Survey of Canada (WSC) data (Appendix 1 of Appendix 6.2-A). Long-term stream flow records collected by the WSC branch of Environment Canada (EC) are available for Lime Creek (08DB013) and Patsy Creek (08DB012). The WSC station on Lime Creek was operated from 1976 to 1996 and has 15 complete years of data. The WSC station on Patsy Creek was operated from 1987 to 1996. Synthetic flows for Patsy Creek's missing years were estimated by scaling the Lime Creek WSC flows (similar watershed characteristics) to Patsy Creek flows by the ratio of their respective drainage areas.

No data is currently available for the upper Clary Creek Watershed which would represent the flows from Clary Lake. Therefore, long-term flows for upper Clary Creek were estimated by scaling the Patsy Creek flows (similar watershed characteristics) to the upper Clary Creek flows by the ratio of their respective drainage areas. For detailed baseline information, refer to Appendix 1 of Appendix 6.2-A1 and Appendix 6.4-A.

The annual hydrographs of the creeks in the proposed Project area typically have a bi-modal shape, with the highest peak occurring in the spring freshet period and a secondary peak occurring in the late fall or early winter period (refer to Appendix 1 of Appendix 6.2-A). The resulting mean annual unit runoff for Lime Creek at mouth, Patsy Creek at confluence with Lime Creek and upper Clary Creek are presented in Table 6.5.2.1 with their respective drainage areas. Peak instantaneous and seven-day low baseline flows were estimated from a regional hydrologic model developed by Obedkoff (2001) for the 10-year return period. Scaling factors were used to obtain other return period baseline estimates. Table 6.5.2-1 provides a summary of the 200-year peak and 10-year, seven-day low flows for Lime Creek at mouth, Patsy Creek at confluence with Lime Creek and upper Clary Creek (refer to Appendix 1 of Appendix 6.2-A for more details).

Table 6.5.2-1: Summary of Baseline Hydrology Parameters

Location	Drainage Area	Elevation	Mean Annual Unit Runoff	200-year Peak Flow	10-year 7-day Low Flow
Lime Creek near mouth	39.4 km^2	30 m	45.7 $l/s/km^2$	140 m^3/s	0.08 m^3/s
Patsy Creek at confluence with	4.68 km^2	473 m	45.1 $l/s/km^2$	22 m^3/s	0.01 m^3/s

Location	Drainage Area	Elevation	Mean Annual Unit Runoff	200-year Peak Flow	10-year 7-day Low Flow
Lime Creek					
Upper Clary Creek	29.1 km^2	n/a	45.1 $l/s/km^2$	112 m^3/s	0.06 m^3/s

Note: km^2 - kilometres squared; $L/s/km^2$ - litre per second per kilometre squared; m - metre; m^3/s - cubic metres per second; n/a - not applicable

Source: Appendix 1 of Appendix 6.2-A

The baseline for average annual flows, peak 10-year and 200-year return period flows and low 10-year and 100-year return period flows are presented in Section 6.5.2.7 for the quantitative analysis of the Lime Creek / Patsy Creek and Clary Creek Watersheds.

6.5.2.4 Relevant Legislation and Legal Framework

The British Columbia (BC) *Water Protection Act* (Government of BC 1996) and *Fish Protection Act* (Government of BC 1997) are key regulations governing surface water ownership and the protection of aquatic habitats respectively. The federal *Fisheries Act* (Government of Canada 1985) governs the protection of fish habitat and surface water within the proposed Project area.

6.5.2.5 Cultural Ecological or Community Knowledge

The following is a summary of the information provided by Dialectic Research Services (Dialectic 2011), which pertains to the Hydrology VCs. The entire Dialectic document is included in Appendix 6.5-E.

The proposed Project is located within the Nass Area and the Nass Wildlife Area (NWA) as defined by the Nisg̲a'a Final Agreement (NFA) (BC Ministry of Aboriginal Relations and Reconciliation (BC MARR 2000). The mine site falls outside of Nisg̲a'a Lands owned by the Nisg̲a'a Nation. Nisg̲a'a Lands are approximately 25 kilometres (km) to the east of the Kitsault mine site. Nevertheless, the Nisg̲a'a Nation people have and continue to inhabit and use the area in and around the Nass River. Resource use (e.g. fishing, wildlife, and plant harvesting and forestry) is still important in the Nisg̲a'a Nation way of life and economy. As such the Nisg̲a'a citizens are very concerned about maintenance of water quality to support wildlife, fish, marine, and plant resources. They also have human health and food safety concerns linked to water quality. In addition, the NFA defines Nisg̲a'a Nation rights pertaining to water volume entitlements for the Nass River and its tributaries for domestic, industrial, and commercial purposes. The NFA also designates rivers for Nisg̲a'a Nation guide angling activities and as such, water quality related to two of the 15 designated rivers in proximity to the mine site are also important to the Nisg̲a'a Nation, including Illiance River and Kitsault River.

The proposed Project would not have measurable effects on the quality of water in Nass River and its tributaries, Kwinatahl River, or Kitsault River. The Illiance River is within the hydrology RSA as Clary Creek is one of its tributaries. The Illiance River, downstream of Clary Creek, has no interaction with the mining activities and therefore does not warrant detailed investigation due to the limited potential effects resulting from the proposed Project. Nevertheless, the extent to which the proposed Project would affect the quantity of the water in the lower Illiance River will be discussed later in this section to verify that there are no potential effects.

6.5.2.6 Past, Present or Future Projects / Activities

A review of the historical and general land use activities are shown in Tables 6.5.2-2 and 6.5.2-3. These land use activities have been identified within the cumulative effects assessment (CEA) study area that overlaps with the hydrology RSA and therefore may interact with the proposed Project on hydrology. There are no reasonably foreseeable projects that overlap with the hydrology RSA at the time writing of this EA.

Table 6.5.2-2: Historical Land Use Activities in the Hydrology Regional Study Area

Project / Activity	Description
Kitsault mine and exploration	Exploration, which appears to have begun in the area in 1911, identified the presence of an ore body in late 1964. Between January 1968 and April 1972, approximately 9.3 Mt of ore were produced with about 22.9 million pounds of molybdenum recovered. The mine returned to production in 1981 but production was terminated again because of low metal prices in 1982.
Kitsault Townsite	The Kitsault Townsite, built in the 1970s and opened in 1981 to support the Kitsault Mine, was occupied for less than two years. The Kitsault Townsite, which is located approximately 5 km from the proposed Project, was purchased by Kitsault Resort Ltd. in 2005 and has been maintained by caretakers.

Note: km - kilometre; Mt - million tonnes

Table 6.5.2-3: General Land Use Activities in the Hydrology Regional Study Area

Project / Activity	Description
Transportation and access	Within the study area, Hwy 113 and Hwy 37 are used by local residents and tourists as well as commercial / industrial traffic associated with activities such as exploration. There are also several FSRs that may be used by both proposed Project traffic and local / industrial or tourism traffic. Hwy 113 (the Nisg̲a'a Highway) links the Nisg̲a'a Lands and the four Nisg̲a'a Villages (Gingolx, Gitwinksihlkw, Laxgalts'ap and New Aiyansh) to Terrace where it intersects Hwy 16. An alternate road access to and from Nisg̲a'a Lands to Terrace or Smithers is via the Nass FSR, an all-weather gravel surfaced road that runs east from New Aiyansh to Hwy 37 at Cranberry Junction and then south to Hwy 16 at Kitwanga. Alice Arm Road, an existing gravel road which provides site access from Nass FSR, is the main road located within the land use RSA. A branch off the Alice Arm Road before Clary Lake would be constructed that leads directly to the Kitsault mine site.
Mining exploration	Mining exploration activities are ongoing in the CEA study area. A number of private claims are surrounded by the proponent's Kitsault mineral tenure area.

Project / Activity	Description
Trapping and guide outfitting	The proposed Project is located entirely within one trapline. Ten other traplines fall within the RSA. The proposed Project is located entirely within one guide outfitter area. The CEA study area overlaps slightly with one other guide outfitter area located east of Hwy 37 and Cranberry Junction.

Note: CEA - Cumulative effects assessment; FSR - Forest Service Road; Hwy - Highway; km - kilometres; RSA - Regional Study Area

6.5.2.7 Potential Effects of the Proposed Project and Proposed Mitigation

The mine facilities that have the largest potential for affecting downstream flows are: the TMF; the WRMF; the Kitsault Pit; the south diversion channel; the Patsy Creek diversion and the diversion of water from Lake 493 to Lake 901 (Appendix 6.5-C). Water management structures planned for the site are explained in Appendices 6.4-B and 6.5-C. Water flow and lake water levels are the parameters which can be used to evaluate hydrology quantitatively. The water flows and lake water level results presented in the following sections were used as a basis for assessing potential effects on Hydrology VCs for all phases of the mine. The methods used to obtain the results presented herein are explained where applicable. The assessment of potential effects on Hydrology VCs are limited to the outputs from the watershed model. Potential effects associated with other affected VCs, including sediment and water quality, aquatic and wildlife habitat, will be assessed in the relevant sections of the EA.

6.5.2.7.1 Water Flow Results – Lime Creek / Patsy Creek, Clary Creek, Illiance River and the Outlet of Lake 901

A watershed model was developed to estimate monthly baseline long-term surface water and groundwater flows at various locations in the vicinity of the proposed Project and used to assess the potential effect on Hydrology VCs for all phases of the mine. Peak instantaneous and seven-day low baseline flows were estimated from a regional hydrologic model developed by Obedkoff (2001) for the 10-year return period. Scaling factors were used to obtain other return period estimates. For construction, operations, closure, and post-closure conditions, the low and peak flow return period values were scaled from the baseline estimates according to effective changes in drainage area. All water flow results from the watershed model and scaling analysis are presented in Appendix 6.5-C.

6.5.2.7.2 Modelled Scenarios

The watershed model analysis divide the life of the mine into six distinct time periods: baseline (pre-mine), construction, operations Year 13, operations Year 15, closure, and post-closure. The construction phase of the mine has been further divided into three periods. The mining activities expected during these construction phases vary by watershed and will be discussed, where applicable, below. The operations phase of the mine has been divided into two periods: Year 13 and Year 15. Year 13 represents the largest spatial extent of the waste rock and thus greatest contribution of contact water from the WRMF

(Appendix 6.4-B). In Year 15 of operations, the low grade ore stockpile would begin to be processed and the Kitsault Pit would begin to fill (Appendix 6.5-C). Year 15 of operations has been further subdivided into three scenarios for the Lime Creek / Patsy Creek Watershed to explore potential scenarios for the Patsy Creek Diversion, which will be discussed further below.

To carry out the analysis for estimating the seven-day low flows and the peak instantaneous flows, the mine life was divided into six distinct time periods. The flow estimations were based on drainage areas. Some of the mine phases were grouped, if no change in drainage area is expected. Therefore, no distinction is made for different construction phases. Nevertheless, changes in drainage areas are expected to occur during operations and due to the various scenarios for the Patsy Creek Diversion within the Lime Creek / Patsy Creek Watershed. Hence, these scenarios were modelled separately.

6.5.2.7.3 Lime Creek / Patsy Creek Watershed

The majority of the mine facilities that would have the largest potential for affecting downstream flows are located in the Lime Creek / Patsy Creek Watershed (Figure 6.5.1-2): the TMF; the WRMF; the Kitsault Pit; the south diversion channel; and the Patsy Creek diversion. The effects would be expected to start during construction and the majority would last through post-closure. Most of the effects would be within the Patsy Creek Watershed, which is a major tributary of Lime Creek. The TMF would cover Patsy Lake and considerably modify the Patsy Creek drainage. The WRMF would cover a portion of Patsy Creek. The south diversion channel has been proposed to divert flow from Patsy Creek Watershed to the south-east of the TMF around the TMF and the WRMF to Patsy Creek downstream of the WRMF (Appendix 6.5-C). The Kitsault Pit would affect a portion of Patsy Creek and, as a result, a diversion is proposed. The Patsy Creek Diversion would transfer flows from the south diversion channel along a bench of the south wall of the Kitsault Pit to Lime Creek (Appendix 6.5-C). Discharge points would be a benefit to the Lime Creek / Patsy Creek Watershed during operations, since water is released to the natural watershed at these locations. Stream drainage restoration is considered as a benefit during decommissioning and closure because this activity mitigates for streams lost to the proposed Project.

The life of the mine has been divided into six distinct time periods: baseline (pre-mine); construction; operations Year 13; operations Year 15; closure; and post-closure. In the case of the Lime Creek / Patsy Creek Watershed, these phases were divided further for construction and operations Year 15.

For the Lime Creek / Patsy Watershed, the construction phase of the mine has been divided into two distinct periods which are as follows:

- Construction Phase 1: Water would be pumped to Lime Creek from behind temporary cofferdams of the TMF and flows are assumed to be maintained at baseline levels. (Appendix 6.5-C); and

- Construction Phases 2 and 3: Water is stored behind the south embankment of the TMF (Appendix 6.5-C).

The filling of the Kitsault Pit has the potential to greatly affect flow within Lime Creek, since water that was previously discharged to Lime Creek from Patsy Creek will be directed to the Kitsault Pit. This diversion is not anticipated to occur until Year 15 of mine operations. Therefore, three scenarios for the Patsy Creek Diversion were explored starting in Year 15 of mine operations:

- Scenario A: The Patsy Creek Diversion is maintained and the TMF excess water is discharged directly to Lime Creek. The Kitsault Pit filling inputs are direct precipitation and discharge from the south water management pond and the low-grade (ore) stockpile (LGS) (Appendix 6.5-C);
- Scenario B: The Patsy Creek Diversion is maintained and the TMF excess water is discharged into the Kitsault Pit (Appendix 6.5-C); and
- Scenario C: The Patsy Creek Diversion channel is breached and the TMF excess water is discharged into the Kitsault Pit, therefore filling the Kitsault Pit at a faster rate than Scenario B (Appendix 6.5-C).

Table 6.5.2-4 summarises the estimated average annual flow changes in Lime Creek at nodes LCK-H1 and LCK-H2. Node LCK-H1 is located in Lime Creek downstream from the confluence with Patsy Creek and immediately downstream of the mine. Therefore, the flows at this node have the potential to be considerably affected by mine activities. Node LCK-H2 is located on Lime Creek near its outlet into Alice Arm. This node provides a good indication of the potential effect of the mine on the entire Lime Creek Watershed.

Table 6.5.2-4: Estimated Average Annual Flow Changes at Lime Creek Nodes LCK-H1 and LCK-H2

Scenario	Estimated Average Annual Flow (m^3/s)	
	Node LCK-H1	Node LCK-H2
Baseline	1.36	1.97
Construction (See Note)	1.00 to 1.36	1.58 to 1.97
% Change from Baseline	-26% to 0%	-20% to 0%
Operations (See Note)	0.82 to 1.12	1.40 to 1.70
% Change from Baseline	-40% to -18%	-29% to -14%
Decommissioning and Closure	1.05	1.63
% Change from Baseline	-23%	-17%
Post-Closure	1.41	2.01
% Change from Baseline	4%	2%

Note: A range of values have been provided where different phases and/or scenarios have been analysed in the watershed model.
m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

Table 6.5.2-4 shows that the average annual flows in Lime Creek are expected to decrease during the construction, operations, and decommissioning and closure phases of the proposed Project. Immediately downstream of the mine site, the reductions in flows could range from 18 percent (%) to 40% over the three phases. Flow reductions could range from 14% to 29% over the three phases at the outlet of Alice Arm. During post-closure, Table 6.5.2-4 indicates that the average annual flows in Lime Creek would increase over baseline conditions due to flow contributions from the TMF (Appendix 6.5-C).

Seasonal distribution of average annual flows estimated for Lime Creek at node LCK-H2 for baseline, construction, operations, decommissioning and closure, and post-closure phases of the mine are presented in Figure 6.5.2-1. The figure shows seasonal distribution as a percentage of the total expected annual average flow for each phase of the mine. Figure 6.5.2-1 shows that mining activities are not expected to affect the seasonal flow distribution although the quantity of flow is affected.

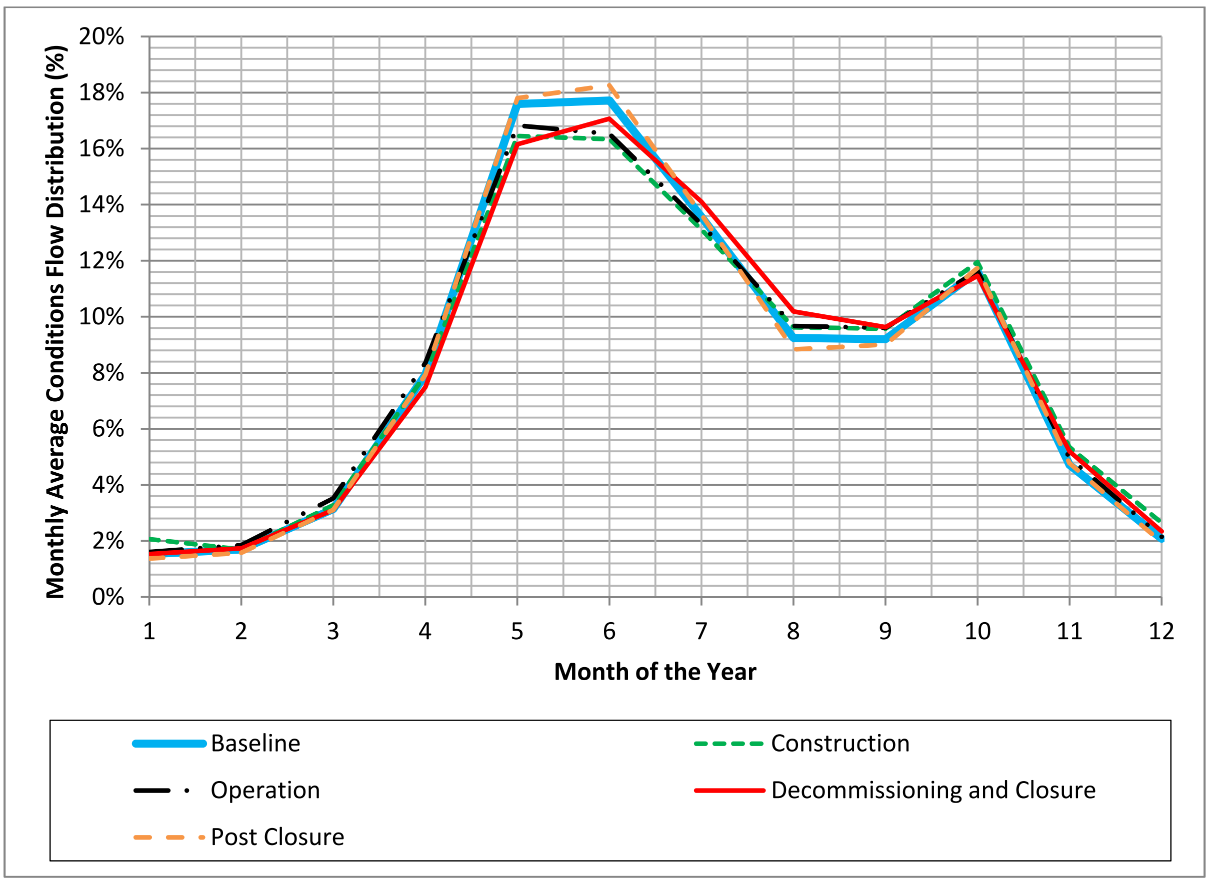


Figure 6.5.2-1: Estimate Seasonal Flow Distribution at Lime Creek Node LCK-H2

Table 6.5.2-5 summarises the estimated changes of peak instantaneous flows for Lime Creek at nodes LCK-H1 and LCK-H2. Flow values for the 10-year and 200-year return periods are presented. Additional results are available in Appendix 6.5-C.

Table 6.5.2-5: Estimated Return Period Peak Flow Changes at Lime Creek Nodes LCK-H1 and LCK-H2

Scenario	DA (km^2)	Estimated Return Period Peak Flows (m^3/s)	
		10-year	200-year
Lime Creek Node LCK-H1			
Baseline	25.1	42.4	89.4
Construction	19.1	32.2	68.0
% Change from Baseline	-24%	-24%	-24%
Operations (See Note)	15.3 to 19.1	25.8 to 32.2	54.5 to 68
% Change from Baseline	-39% to -24%	-39% to -24%	-39% to -24%
Decommissioning and Closure	19.1	32.2	68.0
% Change from Baseline	-24%	-24%	-24%
Post-Closure	27.9	47.1	99.4
% Change from Baseline	11%	11%	11%
Lime Creek Node LCK-H2			
Baseline	39.4	66.5	140.3
Construction	32.6	55.0	116.1
% Change from Baseline	-17%	-17%	-17%
Operations (See Note)	28.7 to 32.6	48.4 to 55.0	102.2 to 116.1
% Change from Baseline	-27% to -17%	-27% to -17%	-27% to -17%
Decommissioning and Closure	32.6	55.0	116.1
% Change from Baseline	-17%	-17%	-17%
Post-Closure	41.4	69.9	147.4
% Change from Baseline	5%	5%	5%

Note: Flow estimations are based on scaling of drainage areas. A range of values have been provided if different phases and / or scenarios have different drainage areas.
DA - Drainage Area; km^2 - kilometres squared; m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

The results in Table 6.5.2-5 show that 10-year and 200-year peak instantaneous flows are expected to decrease in Lime Creek during construction, operations, and decommissioning and closure. The greatest potential reduction of 39% coincides with the greatest reduction in drainage area within the Lime Creek Watershed and is expected during operations at node LCK-H1. Once decommissioning and closure processes begin, the potential effects associated with the mine development would begin to diminish. During post-closure, the 10-year and 100-year peak instantaneous flows in Lime Creek is predicted to increase by approximately 5% over baseline conditions as the drainage area is added to the Lime Creek Watershed.

Table 6.5.2-6 summarises estimated seven-day low-flow changes on Lime Creek at both nodes LCK-H1 and LCK-H2. Flow values for the 10-year and 100-year return periods are presented in this table. Additional results are available in Appendix 6.5-C.

Table 6.5.2-6: Estimated Return Period Seven-Day Low-Flow Changes at Lime Creek Nodes LCK-H1 and LCK-H2

Scenario	DA (km^2)	Estimated Return Period 7-Day Low Flows (m^3/s)	
		10-year	100-year
Lime Creek Node LCK-H1			
Baseline	25.1	0.05	0.02
Construction	19.1	0.04	0.02
% Change from Baseline	-24%	-20%	0%
Operations (See Note)	15.3 to 19.1	0.03 to 0.04	0.01 to 0.02
% Change from Baseline	-39% to -24%	-40% to -20%	-50% to 0%
Decommissioning and Closure	19.1	0.04	0.02
% Change from Baseline	-24%	-20%	0%
Post-Closure	27.9	0.06	0.03
% Change from Baseline	11%	20%	50%
Lime Creek Node LCK-H2			
Baseline	39.4	0.08	0.04
Construction	32.6	0.07	0.03
% Change from Baseline	-17%	-13%	-25%
Operations (See Note)	28.7 to 32.6	0.06 to 0.07	0.03
% Change from Baseline	-27% to -17%	-25% to -13%	-25%
Decommissioning and Closure	32.6	0.07	0.03
% Change from Baseline	-17%	-13%	-25%
Post-Closure	41.4	0.08	0.04
% Change from Baseline	5%	0%	0%

Note: Flow estimations are based on scaling of drainage areas. A range of values have been provided if different phases and / or scenarios have different drainage areas.
DA - Drainage Area; km^2 - kilometres squared; m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

The results in Table 6.5.2-6 show that the seven-day low flows for the 10-year return period are expected to be reduced by 20% to 40% for node LCK-H1 and 13% to 25% for node LCK-H2 for construction, operations, and decommissioning and closure phases in Lime Creek. The seven-day low flows for the 100-year return period are expected to be reduced by 0% to 50% for node LCK-H1 and 25% for node LCK-H2 for construction, operations, and decommissioning and closure phases in Lime Creek. During the post-closure period, both nodes show an increase in seven-day low flows of 0% to 50% for the 10-year and 100-year return periods.

Tables 6.5.2-4, 6.5.2-5 and 6.5.2-6 all show that the effect of mine activities on Lime Creek are less at the outlet to Alice Arm (LCK-H2) than immediately downstream of the mine site (LCK-H1) since effects of mining activities are smaller relative to the total Lime Creek Watershed at the outlet to Alice Arm.

6.5.2.7.4 Clary Creek Watershed

The TMF and a minor flow diversion affect small areas of the Clary Creek Watershed and have the potential to affect downstream flows. Lake 901 is located at the headwater of Clary Creek Watershed. The TMF extends over the watershed divide between the Lime Creek / Patsy Creek and the Clary Creek Watersheds. A portion of a tributary within the Clary Creek Watershed will be covered by the TMF. The drainage area of Lake 901 covered by the TMF will not contribute to flows within the Clary Creek Watershed. Hence, the inflows, lake levels and outflows from Lake 901 would be affected. In an attempt to fully mitigate the Lake 901 flows, water will be diverted from neighbouring Lake 493. The watershed model establishes full flow mitigation for Lake 901 lake levels and outflows (Appendix 6.5-C).

During the post-closure phase, runoff from the TMF within Lake 901 drainage area will contribute to inflows to Lake 901 and the Clary Creek Watershed, assuming runoff water quality meets established guidelines and regulations.

There are additional potential effects to Clary Lake during operations. Clary Lake levels and outflows would be potentially affected by the withdrawal of water from the lake for mill operations and potable water.

For the Clary Creek Watershed, the mine life has been divided into six distinct time periods: baseline (pre-mine); construction; operations Year 13; operations Year 15; closure; and post-closure. Clary Creek phases were divided up further for construction as follows:

- Construction Phases 1 and 2: No change in baseline conditions (Appendix 6.5-C); and
- Construction Phase 3: North embankment is constructed and begins to store water. Northeast water management pond being constructed (Appendix 6.5-C).

Table 6.5.2-7 summarises the estimated average annual changes to flows in Clary Creek at nodes CCK-H2, CCK-H3, and 901-OUT, respectively. Node CCK-H2 is located downstream of the mine and Clary Lake. Node CCK-H3 is located on Clary Creek near its confluence with the Illiance River which provides an estimation of the potential effects of the mine on the entire Clary Creek Watershed. Node 901-OUT is located at the outlet of Lake 901.

Table 6.5.2-7: Estimated Average Annual Flow Changes at Clary Creek Nodes CCK-H2, CCK-H3 and 901-OUT

Scenario	**Estimated Average Annual Flow (m^3/s)**		
	Node CCK-H2	**Node CCK-H3**	**Node 901-OUT**
Baseline	1.55	1.87	0.16
Construction (See Note)	1.45 to 1.55	1.77 to 1.87	0.16
% Change from Baseline	-6% to 0%	-5% to 0%	0%
Operations (See Note)	1.42	1.74	0.16
% Change from Baseline	-8%	-7%	0%
Decommissioning and Closure	1.49	1.80	0.16
% Change from Baseline	-4%	-4%	1%
Post-Closure	1.49	1.80	0.16
% Change from Baseline	-4%	-4%	1%

Note: A range of values have been provided where different phases and / or scenarios have been analysed in the watershed model and produce different results.
m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

Table 6.5.2-7 shows that flows are not reduced at the outlet of Lake 901. Peak and seven-day low-flow changes will not be estimated as it is assumed that these flows can be mitigated by adjusting flows from Lake 493.

Table 6.5.2-8 shows the estimated peak instantaneous changes to flows in Clary Creek at nodes CCK-H2 and CCK-H3. Peak flow changes for the 10-year and 200-year return periods are presented; refer to Appendix 6.5-C for more details.

Table 6.5.2-8: Estimated Return Period Peak Flow Changes at Clary Creek Nodes CCK-H2 and CCK-H3

Scenario	**DA (km^2)**	**Estimated Return Period Peak Flows (m^3/s)**	
		10-year	**200-year**
Clary Creek Node CCK-H2			
Baseline	29.7	47.9	84.1
Construction and Operations (See Note)	27.5	44.7	78.5
% Change from Baseline	-7%	-7%	-7%
Decommissioning and Closure and Post-closure (See Note)	27.9	45.3	79.5
% Change from Baseline	-6%	-5%	-5%
Clary Creek Node CCK-H3			
Baseline	36.8	58.1	102.0
Construction and Operations (See Note)	34.5	54.8	96.3
% Change from Baseline	-6%	-6%	-6%
Decommissioning and Closure and Post-closure (See Note)	35	55.5	97.5

Scenario	DA (km^2)	Estimated Return Period Peak Flows (m^3/s)	
		10-year	200-year
% Change from Baseline	-5%	-4%	-4%

Note: Flow estimations are based on scaling based on drainage areas. Therefore, mining phases have been combined since the drainage areas are the same for those phases.
DA - Drainage Area; km^2 - kilometres squared; m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

Table 6.5.2-8 shows that the reductions in flows due to mining activities is relatively small at Clary Creek. The 10-year and 200-year peaks show reductions of 4% to 7% over all the phases. They are expected to be reduced the most during operations due to the constant freshwater withdrawal required to support mining operations (Appendix 6.5-C). The reductions are less during decommissioning and closure and post-closure, since, although water withdrawal is halted, a portion of the Clary Lake Watershed would be affected by the TMF. The expected flow reduction in Clary Creek is anticipated to be less in percentage terms further downstream as the effect of the mine is less relative to the total watershed of Clary Creek.

Table 6.5.2-9 summarises the estimated seven-day low-flow changes on Clary Creek at nodes CCK-H2 and CCK-H3. Only the seven-day low-flow changes for the 10-year and 100-year return periods are presented in Table 6.5.2-9 (refer to Appendix 6.5-C for more details).

Table 6.5.2-9: Estimated Return Period 7-Day Low Flow Changes at Clary Creek Nodes CCK-H2 and CCK-H3

Scenario	DA (km^2)	Estimated Return Period 7-Day Low Flows (m^3/s)	
		10-year	100-year
Clary Creek Node CCK-H2			
Baseline	29.7	0.06	0.01
Construction and Operations (See Note)	27.5	0.05	0.01
% Change from Baseline	-7%	-17%	0%
Decommissioning and Closure and Post-closure (See Note)	27.9	0.05	0.01
% Change from Baseline	-6%	-17%	0%
Clary Creek Node CCK-H3			
Baseline	36.8	0.07	0.02
Construction and Operations (See Note)	34.5	0.07	0.02
% Change from Baseline	-6%	0%	0%

Scenario	DA (km^2)	Estimated Return Period 7-Day Low Flows (m^3/s)	
		10-year	100-year
Decommissioning and Closure and Post-Closure (See Note)	35.0	0.07	0.02
% Change from Baseline	-5%	0%	0%

Note: Flow estimations are based on scaling based on drainage areas. Therefore, mining phases have been combined if the drainage areas are the same for those phases.
DA - Drainage Area; km^2 - kilometres squared; m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

As shown in Table 6.5.2-9, the seven-day low flows are expected to be reduced by 17% for the 10-year return period at node CCK-H2 and no change during the 100-year return period for all phases. For node CCK-H3, there are no changes during all the phases and return periods.

6.5.2.7.5 Illiance River Watershed

The confluence between Clary Creek and the Illiance River is located approximately 1.3 km from the outflow to Alice Arm. Therefore, only this lower section of the Illiance River currently receives water from the proposed Project area.

The Nisga'a Nation is concerned about water quality and quantity in the lower Illiance River (refer to Section 6.5.2.3). As discussed in Section 6.5.2.7.4, mining activities are expected to have minor but measurable effects on the hydrology of the Clary Lake Watershed, which is a small tributary to the lower Illiance River. Therefore, hydrological effects to the lower Illiance River are expected to be insignificant.

Estimated changes to stream flow in the lower Illiance River were calculated to confirm the magnitude of potential effects. Tables 6.5.2-10, 6.5.2-11 and 6.5.2-12 summarise the estimated average annual, peak, and seven-day low flow changes on Illiance River at node ILLIANCE R.

Table 6.5.2-10: Estimated Average Annual Conditions Flow Changes at lower Illiance River Node ILLIANCE R

Scenario	Estimated Average Annual Conditions Flows (m^3/s)
Baseline	7.79
Construction	7.69 to 7.79
% Change from Baseline	-1% to 0%
Operations (See Note)	7.66
% Change from Baseline	-2%
Decommissioning and Closure	7.73
% Change from Baseline	-1%
Post-Closure	7.73
% Change from Baseline	-1%

Note: A range of values have been provided where different phases and/or scenarios have been analysed in the watershed model and produce different results.
m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

Table 6.5.2-11: Estimated Return Period Peak Flow Changes at lower Illiance River Node ILLIANCE R

Scenario	DA (km^2)	Estimated Return Period Peak Flows (m^3/s)	
		10-year	200-year
Baseline	127.1	177.2	311.3
Construction and Operations (See Note)	124.9	174.5	306.4
% Change from Baseline	-2%	-2%	-2%
Decommissioning and Closure and Post-closure (See Note)	125.4	175.1	307.6
% Change from Baseline	-1%	-1%	-1%

Note: Flow estimations are based on scaling based on drainage areas. Therefore, mining phases have been combined since the drainage areas are the same for those phases.
DA - Drainage Area; km^2 - kilometres squared; m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

Table 6.5.2-12: Estimated Return Period 7-Day Low Flow Changes at lower Illiance River Node ILLIANCE R

Period	**DA (km^2)**	**Estimated Return Period 7-Day Low Flows (m^3/s)**	
		10-year	**100-year**
Baseline	127.1	0.24	0.06
Construction and Operations (See Note)	124.9	0.24	0.06
% Change from Baseline	-2%	0%	0%
Decommissioning and Closure and Post-closure (See Note)	125.4	0.24	0.06
% Change from Baseline	-1%	0%	0%

Note: Flow estimations are based on scaling based on drainage areas. Therefore, mining phases have been combined since the drainage areas are the same for those phases.
DA - Drainage Area; km^2 - kilometres squared; m^3/s - cubic metres per second; % - percent

Source: Appendix 6.5-C

Tables 6.5.2-10, 6.5.2-11 and 6.5.2-12 show that the mining operation is expected to have minor to no effects on average annual, peak, and seven-day low flows on the lower Illiance River. The predicted minor effects would likely not be measurable. This is because the loss of drainage in the Clary Creek Watershed from the TMF is small compared to the overall drainage area of the Illiance River.

6.5.2.7.6 Lake Level Results - Clary Lake and Lake 901

Lake 901 flows to Clary Lake. The construction of the TMF and flow diversion would affect Clary Creek Watershed and would have the potential to reduce lake levels due to an anticipated reduction in drainage area. Lake level effects on Lake 901 would be fully mitigated by the diversion of water from Lake 493 outflow to Lake 901. Lake levels in Clary Lake would be affected by the loss of a portion of the Lake 901 drainage and the withdrawal of water from Clary Lake for milling operations and potable water requirements.

Although freshwater withdrawal from Clary Lake would start and end with mining operations, the affected drainage area of the Clary Creek Watershed would remain into the post-closure period. The flow diversion from Lake 493 to Lake 901 would continue into post-closure. Decommissioning would supplement the flow with runoff from the TMF within the Lake 901 drainage area (Appendix 6.5-D).

Baseline daily flows for the Clary Lake and Lake 901 outlets were estimated by scaling a Patsy Creek daily flow series based on drainage area and then applying monthly changes in flow due to mine phases as predicted by the watershed model (Appendix 6.5-D). The flow data was used to analyse the potential lake level changes during the various phases of the proposed Project on Clary Lake and Lake 901. Due to consistently wet conditions and corresponding high runoff in the proposed Project area, the inflow volumes to both lakes far exceed the lake storage volumes. Therefore, a constant 'dead storage' of each lake was incorporated into the model throughout the hydrologic year and the lake level fluctuation is simply a function of the change in the live storage volume (above the dead storage) and the outlet control (Appendix 6.5-D). The details of the analysis are included in Appendix 6.5-D and the results have been summarised in Tables 6.5.2-13 and 6.5.2-14. The tables show the average annual lake levels above the outlet weir crests at the respective lakes, compared to baseline conditions for the construction, operations, decommissioning and closure, and post-closure phases of the mine.

Table 6.5.2-13: Estimated Average Annual Lake Levels Above the Outlet Weir Crest for Clary Lake

Scenario	Estimated Lake Levels Above the Outlet Weir Crest (m)
Baseline	0.400
Construction	0.382
% Change from Baseline	-5%
Operations	0.379
% Change from Baseline	-6%
Decommissioning and Closure and Post-Closure	0.389
% Change from Baseline	-2%

Note: m - metre; % - percent
Source: Appendix 6.5-D

Table 6.5.2-13 shows that mine development generally results in minimal reductions in lake levels in Clary Lake for all mine conditions. The majority of the contributing drainage area to Clary Lake is unaffected by the mine facilities, with the only changes being the freshwater withdrawal during operations and change in drainage area of Lake 901 (Appendix 6.5-D).

Table 6.5.2-14: Estimated Average Annual Lake Levels Above the Outlet Weir Crest for Lake 901

Scenario	Estimated Lake Levels above the Outlet Weir Crest (m)
Baseline	0.209
Construction and Operations	0.209
% Change from Baseline	0%
Decommissioning and Closure and Post-Closure	0.214
% Change from Baseline	2%

Note: m - metre; % - percent
Source: Appendix 6.5-D

Table 6.5.2-14 shows that the mine construction and operations results in no reductions in lake levels of Lake 901 for all mine conditions. During these phases of the mine, the lake levels are maintained at baseline levels due to the proposed diversion of flow from Lake 493 to replace the loss of inflow to Lake 901. During the decommissioning, closure, and post-closure phases of proposed Project activities, the lake levels in Lake 901 increase due to additional flow contributing from TMF runoff within the Lake 901 drainage area (Appendix 6.5-D).

6.5.2.7.7 Water Flow and Lake Level Analysis – Conclusions

Table 6.5.2-15 presents the results from the average flow, peak flow, low flow, and lake level quantitative analysis for the Lime Creek / Patsy Creek and Clary Creek Watersheds. The table summarises the potential effects of the phases of the proposed Project (either positive or negative) on water flows and lake levels. These effects will be carried forward into the assessment of hydrology as they may have the potential to affect other VCs such as surface water quality, aquatic resources, and wildlife.

The proposed Project is not expected to affect seasonal distribution of flow since the project description and water management plan do not include management of flow releases (i.e. regulated discharges) that differ from baseline flows that result from climatic events. Hence, this hydrologic issue will not be carried forward into the assessment.

The proposed Project has the potential to affect annual flows, high flow conditions, low flows, and lake levels. Hence, these potential effects will be carried forward into the assessment of hydrology. The majority of the potential proposed Project effects on water flows are expected in the Lime Creek / Patsy Creek Watershed where most of the mine facilities will be located. Potential effects of the proposed Project on water flows and lake levels are expected within the Clary Creek Watershed mainly due to freshwater withdrawal to support mining operation (Clary Lake levels) and altered runoff characteristics from the footprint of the TMF.

Table 6.5.2-15: Summary of Potential Project Effects to be Carried Forward Into the Assessment of Hydrology

Adverse Effects / Positive Effects	Project Phase	Direction
Lime Creek / Patsy Creek Watershed		
Decreased annual flows	C, O and D/C	Negative
Increased annual flows	PC	Negative
Decreased high flow conditions	C, O and D/C	Negative
Increased high flow conditions	PC	Negative
Decreased low flows	C, O and D/C	Negative
Increased low flows or no change	PC	Negative
Clary Creek Watershed		
Decreased annual flows	C, O, D/C and PC	Negative
Decreased high flow conditions	C, O, D/C and PC	Negative
Decreased low flows	C, O, D/C and PC	Negative
Decreased lake levels – Clary Lake	C, O, D/C and PC	Negative
Increased lake levels – Lake 901	D/C and PC	Negative

Project phase: C - construction; D/C - decommissioning and closure; O - operations; PC - post-closure

6.5.2.7.8 Identification and Analysis of Potential Project Effects

Two categories of potential effects of the proposed Project include “direct” and “indirect” effects. Direct effects involve primarily the physical footprint of the proposed Project and are caused by mining activities that occur throughout the different phases of the mine life. For the Hydrology VC in relation to the proposed Project, direct effects typically include: changes to natural streams; drainage areas; annual flows; seasonal distribution of flows; high flow conditions; low flows; and lake levels.

A likelihood of occurrence rating “likely” or “unlikely” has been determined based on the specific details of the Project Description. The “likely” rating is assigned for effects with high probability of occurrence. The “unlikely” rating is assigned for effects with low probability of occurrence.

Table 6.5.2-16 summarises the potential direct effects of the proposed Project on the Hydrology VC by Project component. The majority of the phases of the proposed Project would likely affect hydrology.

Table 6.5.2-16: Potential Direct Project Effects on Hydrology

Project Component	Project Phase	Potential Direct Project Effect	Likelihood of Occurrence
Soil and till salvage, handling	C, O and D/C	Natural streams.	Likely
Mine infrastructure installations	C, O	Natural streams and lakes.	Unlikely
Process Plant and ancillary facilities	C, O	Natural streams and lakes.	Unlikely
Kitsault Pit	C, O, D/C, PC	Natural streams, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Likely
Expansion of exploration camp to create construction and permanent camps	C	Natural streams.	Unlikely
WRMF	C, O, D/C	Natural streams, annual flows, high flow conditions and low flows.	Likely
TMF	C, O, D/C	Natural streams, lakes, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Likely
WRMF and TMF seepage management and reclamation	D/C	Annual flows and low flows.	Likely

Project Component	Project Phase	Potential Direct Project Effect	Likelihood of Occurrence
Water Management Facilities (i.e., sediment and seepage ponds, pipelines, cofferdams, pumping systems and diversion ditches)	C, O, D/C	Natural streams, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Likely
Stream drainage restoration	D/C	Natural streams.	Likely
Fish habitat compensation	D/C, PC	Natural streams.	Likely
Process and potable water supply and storage	O	Lake levels, seasonal distribution of flow, high flow conditions and low flows.	Likely
Water withdrawal and discharge points	O, PC	Lake levels, natural streams, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Likely
Access and mine site road decommissioning and reclamation	D/C	Natural streams, drainage areas, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Likely
Monitoring and maintenance of mine drainage conditions	PC	Natural streams.	Likely
Habitat compensation areas for TMF and WRMF	PC	Natural streams.	Likely
Kitsault Pit and associated discharging water	PC	Natural streams, annual flows, seasonal distribution of flow, high flow conditions and low flows.	Likely

Project Phase: C - construction; D/C - decommissioning and closure; O - operations; PC - post-closure
Note: TMF - Tailings Management Facility; WRMF - Waste Rock Management Facility

Indirect effects can occur over time and extend over a larger area than the physical footprint of the proposed Project and could affect other VCs. For the Hydrology VC in relation to the proposed Project, indirect effects typically include changes to: surface water quality and sediment; aquatic habitat; and wildlife habitat. Reductions in water flows and lake levels can degrade water quality and increase sediment. Aquatic habitat can be degraded and or displaced due to reductions in flow levels and loss of habitat. Water flows and lakes provide available drinking water for wildlife so changes in the availability of suitable or sufficient water can displace wildlife. Table 6.5.2-17 summarises the indirect potential effects of the proposed Project on other VCs due to hydrologic changes. Whether or not these potential effects are carried forward in the assessment would be determined by the respective effect assessments for the VCs listed.

Table 6.5.2-17: Potential Indirect Project Effects on Other Valued Components

Direct Project Effect (Adverse or Positive)	Project Phase	Potential Indirect Project Effect	Carry Forward (Yes / No)	Rationale
Natural streams, drainage areas, lake levels, annual flow volumes, seasonal distribution of flow, high flow conditions and low flows.	C, O, D/C and PC	Water quality and sediment in the Lime Creek / Patsy Creek and Clary Creek Watersheds.	To be determined in water quality and sediment effect assessments.	Changed flows in creeks can degrade water quality and increase sediment.
		Aquatic habitat in the Lime Creek / Patsy Creek and Clary Creek Watersheds.	To be determined in aquatic habitat effect assessments.	Changed flows in the creeks would degrade / decrease habitat. Reductions in lake levels can decrease habitat.
		Wildlife habitat in the Lime Creek / Patsy Creek and Clary Creek Watersheds.	To be determined in wildlife habitat effect assessments.	Reduction in available drinking water for wildlife.

Project Phase: C - construction; D/C - decommissioning and closure; O - operations; PC - post-closure

Table 6.5.2-18 summarises the potential interactions between hydrology effects and other VCs. Changes in hydrology could have a potential key interaction on the freshwater and sediment quality and freshwater fisheries VCs. The VCs of hydrogeology, groundwater quality, marine water quality, marine biota, terrestrial environment, wildlife and their habitat, environmental health, the Nisga'a Nation land use, and Aboriginal Groups land use could have a potential interaction with hydrology.

Table 6.5.2-18: Summary of Potential Interaction Between Project Direct Effects on Other Valued Components and Hydrology

Direct Project Effect	Air quality and Climate Change	Noise and Vibration	Hydrogeology	Groundwater Quality	Freshwater and Sediment Quality	Hydrology	Freshwater Fisheries	Marines Water Quality	Marine Biota	Terrestrial Environment	Wildlife and Their Habitat	Environmental Health	Economic	Social	Heritage	Health	Nisga'a Nation Land Use	Aboriginal Groups Land Use
Natural streams, drainage areas, lake levels, annual flows, seasonal distribution of flow, high flow conditions and low flows.	NI	NI	o	o	-	n/a	-	o	o	o	o	o	NI	NI	NI	NI	o	o

Interaction definitions: o - interaction; - - key interaction; + - benefit; NI - no interaction; n/a - not applicable

It is likely that during all phases of the proposed Project hydrology would have the potential to indirectly affect water quality, sediment, and aquatic habitat resulting from changes in flows, sediment loading and lake levels due to mine activities, water withdrawals, and discharges. It is unlikely that during all phases of the proposed Project, hydrology would have the potential to indirectly affect wildlife habitat due to the change in available flows and water quality due to mine activities. Table 6.5.2-19 summarises the potential combined effects of the proposed Project on hydrology.

Table 6.5.2-19: Potential Combined Project Effects by Project Phase on Hydrology

Potential Indirect Project Effect	Potential Combined Project Effect	Project Phase	Likelihood of Occurrence
Water quality and sediment	Change in flows and sediment loading due to mine activities, water withdrawals and discharges.	C, O, D/C and PC	Likely
Aquatic habitat	Change in flows, sediment loading and lake levels due to mine activities, water withdrawals and discharges.	C, O, D/C and PC	Likely
Wildlife habitat	Change in flows and water quality due to mine activities.	C, O, D/C and PC	Unlikely

Project phase: C - construction; D/C - decommissioning and closure; O - operations; PC - post-closure

6.5.2.7.9 Mitigation Measures

The effects assessment of the proposed Project on the Hydrology VCs considers how the mine site as a whole affects the Lime Creek / Patsy Creek and Clary Creek Watersheds in terms of surface water flow and lake water levels. The quantitative analysis of surface water flows and lake water levels was based on outputs from an existing watershed model (average annual flows) and estimations based on the scaling baseline values by drainage area ratios (peak and low flows).

The watershed model was used as a tool to evaluate the effects of mine development on the baseline surface water and groundwater flows within the Lime Creek / Patsy Creek and Clary Creek Watersheds. The proposed water management plan for the site is detailed in Appendix 6.4-B.

The aspects of the water management plan were included in the watershed model, such as pit de-watering and flooding, TMF construction, seepage collection, surface water retention and surface water diversions (Appendix 6.4-A). Therefore, the annual average surface water flow and lake levels presented earlier in this section already include the mitigation measures proposed by the proposed Project. The water management plan considered such mitigation techniques as:

- Maximising water recycling;
- Regulating discharge from mining facilities to mimic baseline conditions;

- Regulating discharge to compensate for peak and low flow periods; and
- Increasing the amount of freshwater diversions.

The estimates for the peak and low-flow values would only include mitigation measures in terms of how they affect drainage area.

6.5.2.8 Potential Residual Effects Assessment

Despite the inclusion of mitigation measures such as those discussed above, the proposed Project could have the potential to have residual effects on the Lime / Patsy Creek and Clary Creek Watersheds. Therefore, it is necessary to assess the potential residual effects for hydrology and determine their significance.

6.5.2.8.1 Potential Residual Effects After Mitigation

Table 6.5.2-15 shows that the proposed Project would likely result in measurable residual effects on the hydrology in the Lime / Patsy and Clary Watersheds. Table 6.5.2-20 lists the residual effects for Hydrology VC that may exist in the Lime Creek / Patsy Creek and Clary Creek Watersheds during various phases of the proposed Project. Potential residual effects for Lime Creek / Patsy Creek Watershed include: decreased annual flows; increased high flows; and decreased low flows. The potential residual effects for Clary Creek Watershed include: decrease annual flows; decreased low flows; and decreased lake levels.

Table 6.5.2-20: Summary of Residual Effects for Hydrology

Project Phase	Residual Effect	Direction
Lime / Patsy Creek Watershed		
C, O and D/C	Decreased annual flows (-14% to -20%)	Negative
PC	Increased high flows (5% to 11%)	Negative
C, O, and D/C	Decreased low flows (-13% to -40%)	Negative
Clary Creek Watershed		
C, O, D/C and PC	Decreased annual flows (-4% to -8%)	Negative
C, O, D/C and PC	Decreased low flows (-17%)	Negative
C, O, D/C and PC	Decreased lake levels (-2% to -6%)	Negative

Project phase: C - construction; D/C - decommissioning and closure; O - operations; PC - post-closure

6.5.2.8.2 Significance of Potential Residual Effects

The rating of significance of the identified residual effects is based on the quantitative assessment but also involves professional judgement as the rating is qualitative in nature. Based on the quantitative data from Section 6.5.2.8, the significance of potential residual effects of the Project have been evaluated. Table 6.5.2-21 summarises the residual effects assessment by proposed Project development phase for hydrology. In this table, the residual effects have been grouped according to watershed, either Lime Creek / Patsy Creek or Clary Creek. There are no residual effects on the lower portion of Illiance River.

Table 6.5.2-21: Residual Effects Assessment by Project Development Phase for Hydrology

Parameter	Stage of Development / Rating			
Stage of Project development	Construction	Operations	Decommissioning and closure	Post-closure
Lime Creek / Patsy Creek Watershed				
Residual effect	**Annual flows**			
Effect attribute				
Magnitude	Low to High	Low to High	Low to High	n/a
Spatial extent	Sub-regional	Sub-regional	Sub-regional	n/a
Duration	Chronic	Chronic	Chronic	n/a
Reversibility	Yes	Yes	Yes	n/a
Direction	Negative	Negative	Negative	n/a
Certainty	High	High	High	n/a
Residual effect significance	Not significant (moderate)	Not significant (moderate)	Not significant (moderate)	n/a
Level of confidence	Medium	Medium	Medium	n/a
Residual effect	**High-flow conditions**			
Effect attribute				
Magnitude	n/a	n/a	n/a	Low
Spatial Extent	n/a	n/a	n/a	Sub-regional
Duration	n/a	n/a	n/a	Chronic
Reversibility	n/a	n/a	n/a	Yes
Direction	n/a	n/a	n/a	Negative
Certainty	n/a	n/a	n/a	High
Residual effect significance	n/a	n/a	n/a	Not significant (minor)
Level of confidence	n/a	n/a	n/a	Medium
Residual effect	**Low flows**			
Effect attribute				
Magnitude	Medium to High	Medium to High	Medium to High	n/a
Spatial extent	Sub-regional	Sub-regional	Sub-regional	n/a
Duration	Chronic	Chronic	Chronic	n/a
Reversibility	Yes	Yes	Yes	n/a
Direction	Negative	Negative	Negative	n/a
Certainty	High	High	High	n/a
Residual effect significance	Not significant (moderate)	Not significant (moderate)	Not significant (moderate)	n/a
Level of confidence	Medium	Medium	Medium	n/a
Clary Creek Watershed				
Residual effect	**Annual flows**			
Effect attribute				
Magnitude	Low	Low	Low	Low

Parameter	Stage of Development / Rating			
Stage of Project development	Construction	Operations	Decommissioning and closure	Post-closure
Spatial extent	Sub-regional	Sub-regional	Sub-regional	Sub-regional
Duration	Chronic	Chronic	Chronic	Chronic
Reversibility	Yes	Yes	Yes	Yes
Direction	Negative	Negative	Negative	Negative
Certainty	High	High	High	High
Residual effect significance	Not significant (minor)	Not significant (minor)	Not significant (minor)	Not significant (minor)
Level of confidence	Medium	Medium	Medium	Medium
Residual effect	**Low flows**			
Effect attribute				
Magnitude	Low	Low	Low	Low
Spatial extent	Sub-regional	Sub-regional	Sub-regional	Sub-regional
Duration	Chronic	Chronic	Chronic	Chronic
Reversibility	Yes	Yes	Yes	Yes
Direction	Negative	Negative	Negative	Negative
Certainty	High	High	High	High
Residual effect significance	Not significant (minor)	Not significant (minor)	Not significant (minor)	Not significant (minor)
Level of confidence	Medium	Medium	Medium	Medium
Residual effect	**Lake levels in Clary Lake**			
Effect attribute				
Magnitude	Low	Low	Low	Low
Spatial extent	Local	Local	Local	Local
Duration	Chronic	Chronic	Chronic	Chronic
Reversibility	Yes	Yes	Yes	Yes
Direction	Negative	Negative	Negative	Negative
Certainty	High	High	High	High
Residual effect significance	Not significant (minor)	Not significant (minor)	Not significant (minor)	Not significant (minor)
Level of confidence	Medium	Medium	Medium	Medium

Note: n/a - not applicable

Based solely on a percentage change in water flow in the Lime Creek / Patsy Creek Watershed, the magnitude of the effect could range from low to high depending on which phase of mine and water management scenario is being considered. Hydrology as a VC plays an important role for potential effects on water and sediment quality, aquatic resources, and wildlife VCs. This means that although on an average annual basis there could be a 40% reduction in water flow in the upper section of Lime Creek / Patsy Creek Watershed, the magnitude of this reduction would be highly localised to Patsy Creek which is void of fish, and the effect would be reversible during the post-closure phase of the proposed Project.

6.5.2.9 Potential Cumulative Effects

6.5.2.9.1 Identification and Analysis of Potential Project Cumulative Effects

Table 6.5.2-21 above provides a summary of Project related residual effects for hydrology. The rationale for carrying forward into the CEA is provided below.

Potential indirect effects will be assessed in the sections for the VCs indirectly affected in terms of hydrology.

Figure 1.12-2 in Section 1.0 of this EA shows the registered water license information near the proposed Project. Three water licenses could be affected by potential changes in flows expected from the proposed Project. Two of the water licences are located on Lime Creek in the Lime Creek / Patsy Creek Watershed: Licence #Z121409 (Active Application) for power generation; and water licensed work #38870769. The other water licence is on Clary Creek in the Clary Creek Watershed: Licence #A121408 (Active Application) is for power generation. Potential future use of these water courses should consider the status of these active license applications.

Cumulative effects are assessed with known projects (past, present, and future) occurring in the CEA. The previous mining project at Kitsault started reclamation in 1996 and was last monitored in 2011. The historical Kitsault Mine likely altered natural streams with the development of the existing Kitsault Pit area and deposition of tailings material into Lime Creek. There are no reasonably foreseeable projects that could interact with the hydrology. The Northwest Transmission Line (NTL) does not occur within the hydrology RSA boundary. Therefore, other than historical changes to hydrology associated with the Kitsualt Mine, there are no cumulative effects for the Hydrology VC.

6.5.2.10 Limitations

The potential changes to hydrology due to the proposed Project were assessed both quantitatively (baseline data and water quantity modeling) and qualitatively (residual effects ratings). The results of modelling have the following limitations:

- There is limited on-site meteorological data. Regional data has been used or approximated (Appendix 1 of Appendix 6.2-A);
- There is limited on-site hydrologic data from small drainage areas within the LSA. Long-term stream flow data were estimated using WSC stations with non-concurrent periods of records (Appendix 1 of Appendix 6.2-A);
- Synthetic data was estimated for the upper Clary Creek Watershed (downstream of Clary Lake) as no site data is available. The synthetic hydrologic data was estimated by scaling based on a ratio of drainage area (Appendix 1 of Appendix 6.2-A);

- Peak and Low baseline flow and flows due to phases of the mine have been scaled linearly based on drainage area (Appendix 1 of Appendix 6.2-A and 6.5-C) rather than modelled; and
- Climate change has been considered. Refer to Appendix 6.5-B for an explanation concerning the use of measured data for predicting future conditions.

6.5.2.11 Conclusions

Hydrology has been selected as a VC for this EA because effects to water and sediment quality can have an effect on aquatic resources and wildlife. The watersheds assessed for potential effects from the proposed Project on the Hydrology VC include Lime Creek / Patsy Creek, Clary Creek, and lower Illiance River. All of these watersheds are either within or adjacent to the proposed Project footprint. Patsy Creek has been identified as the most directly affected drainage area. The proposed Project has the potential, with its water diversion, obstruction and withdrawal activities, to cause changes in surface water flows and quantity within these watersheds.

The key issues of hydrological significance considered in this assessment were surface water flow, quantity, and level. The potential effect on annual flows, seasonal flows, and high and low-flow conditions were assessed. In addition, the potential effects on lake levels were evaluated. These key issues were evaluated in a quantitative manner based on analyses that included the proposed water management plan and mitigation measures for the site.

The majority of the proposed Project facilities are located in the Lime Creek / Patsy Creek Watershed: the TMF; the WRMF; the Kitsault Pit; the south diversion channel; and the Patsy Creek diversion. The TMF will cover Patsy Lake and considerably modify the flow pattern of the Patsy Creek drainage area. The WRMF and Kitsault Pit will cover a portion of Patsy Creek. Two diversion channels will be required to divert remaining portions of Patsy Creek to Lime Creek. The potential immediate effects of activities associated with the proposed Project are anticipated to be more noteworthy for the Patsy Creek drainage area than for the Lime Creek Watershed due to the extent of the proposed Project footprint within Patsy Creek drainage area. Based on the results of quantitative analysis, the Project has the potential to reduce average annual low flows and peak flows in the Lime Creek / Patsy Creek Watershed during construction, operations, decommissioning, and closure as a result of water diversion, obstruction and withdrawal activities. During post-closure, these flows would increase over baseline conditions as drainage area is added to the Lime Creek / Patsy Creek Watershed.

The proposed Project is expected to have effects on the Clary Creek Watershed from construction to post-closure due to the proposed TMF and the withdrawal of water from Clary Lake to fulfill the water requirements for the processing facility and the potable water needs for the camp. Based on the results from quantitative analysis, the proposed Project has the potential effect of reducing average annual flows, low flows, and high flows in the Clary Creek Watershed and causing a minor decrease in Clary Lake levels during construction, operations, decommissioning and closure, and post-closure due to water obstruction and withdrawal activities. During the construction and operations phases, no effects are expected in Lake 901, but increases are expected during decommissioning and closure, and post-closure due to continued flow diversion from Lake 493 and runoff from a portion of the Northeast Embankment.

Mining activities have no interaction with the Illiance River Watershed downstream of Clary Creek and is assessed only as it pertains to the potential affect to its water flow and quantity from Clary Creek. Based on the results from the average flow, peak flow, and low-flow quantitative analysis there are no effects expected on the lower Illiance River due to the proposed Project.

The proposed Project has the potential to affect annual flows, high-flow conditions, low flows, and lake levels. Mitigation measures will be implemented to reduce the proposed Project effects. The potential residual effects that may be present in the Lime Creek / Patsy Creek Watershed due to the proposed Project include: decreased annual flows; increased high flows; and decreased low flows. The potential residual effects that may be present in the Clary Creek Watershed due to the proposed Project include: decreased annual flows; decreased low flows; and decreased lake levels. Based on quantitative analysis and qualitative ratings these residual effects are expected to be not significant (negligible) in a range from minor to moderate effects.

The residual effects on the Hydrology VC are anticipated to be not significant (moderate) for Lime Creek / Patsy Creek Watershed during the construction, operation and decommissioning, and closure phases of the proposed Project. As well, in Clary Creek, the residual effects are considered not significant (minor) during all proposed Project phases.

Hydrology as a VC also plays a critical role in water quality, sediment, aquatic habitat, and wildlife habitat. Therefore, the extent by which surface water flow and lake water levels are affected is crucial in how other VCs are affected. Based solely on a percentage change in water flow in the Lime Creek / Patsy Creek Watershed, the magnitude of the effect could range from low to high depending on the phase of mine and water management scenario being considered. This reduction should be taken into account by other potentially affected VCs during their assessments. Hence, hydrology will be useful in assessing these other VCs.