9. ASSESSMENT OF FISH AND FISH HABITAT EFFECTS

9.1 INTRODUCTION

An assessment of potential fish and fish habitat effects, in relation to the Murray River Coal Project (the Project), is described in this chapter. Fish and fish habitat are critical components of the aquatic environment and are protected under the *Fisheries Act* (1985). Fish and fish habitat are thus linked to important identified valued components including surface water quality, surface water quantity, primary and secondary producers, as well as human health. Fish are also important to Canadians from an economic, recreational, and cultural perspective.

A pre-development fish and fish habitat baseline program was established to allow for the prediction and assessment, as well as mitigation and management, of potential Project-related effects. The outcomes will be incorporated into mine development and management planning. Project-specific cumulative baseline study reports and associated data covering years 2010 to 2013 are located in Appendix 9-A.

9.2 REGULATORY AND POLICY FRAMEWORK

Several federal and provincial regulations guide development where it pertains to fish and fish habitat protection. These include the:

- Canada *Fisheries Act* (1985);
- Metal Mining Effluent Regulations (SOR/2002-222);
- Canada *Species at Risk Act* (2002a);
- Canadian Biodiversity Strategy (Environment Canada 1995);
- British Columbia (BC) *Water Act* (1996);
- BC *Fish Protection Act* (1997); and
- BC *Environmental Management Act* (2003).

The following sections describe these acts, regulations, and guidelines and how they apply to the protection of fish and fish habitat.

9.2.1 Canada *Fisheries Act*

The Fisheries Protection Policy Statement (DFO 2013) supports changes made to the *Fisheries Act* (1985) in 2012. The Fisheries Protection Policy Statement replaces Fisheries and Oceans Canada's (DFO) No Net Loss Guiding Principle for fish habitat within the Policy for the Management of Fish Habitat (DFO 1986). The changes to the *Fisheries Act* include a prohibition against causing serious harm to fish that are part of or support a commercial, recreational, or Aboriginal fishery (Section 35 of the *Fisheries Act*); provisions for flow and passage (Sections 20 and 21 of the *Fisheries Act*); and a framework for regulatory decision-making (Sections 6 and 6.1 of the *Fisheries Act*). These provisions guide the Minister's decision-making process in order to provide for sustainable and productive fisheries.

The amendments centre on the prohibition against serious harm to fish and apply to fish and fish habitat that are part of or support commercial, recreational, or Aboriginal fisheries. Proponents are responsible for avoiding and mitigating serious harm to fish that are part of or support commercial, recreational, or Aboriginal fisheries. When proponents are unable to completely avoid or mitigate serious harm to fish, their projects will normally require authorization under Subsection 35(2) of the *Fisheries Act* (1985) in order for the project to proceed without contravening the Act.

DFO interprets serious harm to fish as:

- the death of fish;
- a permanent alteration to fish habitat of a spatial scale, duration, or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, nursery, rearing, food supply areas, migration corridors, or any other area in order to carry out one or more of their life processes; and
- the destruction of fish habitat of a spatial scale, duration, or intensity that results in fish no longer being able to rely on such habitats for use as spawning grounds, nursery, rearing, food supply areas, migration corridor, or any other area in order to carry out one or more of their life processes.

After efforts have been made to avoid and mitigate impacts, any residual serious harm to fish should be addressed by offsetting measures. An offset measure is one that counterbalances unavoidable serious harm to fish resulting from a project with the goal of maintaining or improving the productivity of the commercial, recreational, or Aboriginal fishery. Offset measures should support available fisheries' management objectives and local restoration priorities.

Baseline fish and fish habitat studies were designed to address the previous federal policy as well as the existing federal policy.

9.2.2 Metal Mining Effluent Regulations

Currently, the Metal Mining Effluent Regulations (MMER) do not apply to coal mines; however, a re-evaluation regarding the inclusion of both coal and diamond mines is in progress. The MMER (SOR/2002-222) regulations stipulate environmental effects testing and monitoring activities that must be undertaken by metal mines as a condition of depositing or releasing effluent. The stipulated activities examine aspects of aquatic ecosystems in receiving waterbodies that may indicate individual, ecosystem, and population-level health. The monitoring of these characteristics must be summarized in interpretive reports provided to Environment Canada.

Permission to deposit mine effluent is contingent on the completion of appropriate monitoring activities allowing the assessment of effects on aquatic ecosystems. Baseline studies were designed to meet the requirements of the MMER (SOR/2002-222) by following guidelines recommended by Environment Canada (2012).

9.2.3 Canada *Species at Risk Act*

The federal *Species at Risk Act* (SARA; 2002a) is designed to prevent Canadian indigenous species, subspecies, and distinct populations from becoming extirpated or extinct. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses and identifies species at risk. Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) are protected as a Schedule 1 (Special Concern) species under the *Species at Risk Act* (SARA; 2002a), are of “Special Concern” under COSEWIC, and are provincially ‘blue-listed’. The Murray River Watershed is outside of this species natural range. Westslope Cutthroat Trout were stocked in Upper Blue Lake in 1983. This species is now abundant in the Upper and Lower Blue lakes system, but have not been documented in any portions of the Murray River drainage near the Project.

9.2.4 British Columbia *Water Act*

The provincial *Water Act* (1996) regulates changes in or about a stream, ensuring that water quality, fish and wildlife habitat, and the rights of licence users are not compromised. The baseline study program was designed to identify fish habitat as well as streams and rivers that may not be defined as fish habitat but that may be affected by development.

9.2.5 British Columbia *Fish Protection Act*

The provincial *Fish Protection Act* (1997) focuses on ensuring sufficient water for fish, protecting and restoring fish habitat, improving riparian protection and enhancement, and providing local government with more power with regard to environmental planning. In practice, this means that any fish and fish habitat will be considered in the assessment of water withdrawals. The baseline study program identified the locations of critical fish habitat allowing for the impacts of water withdrawals on these habitats to be properly assessed.

9.2.6 British Columbia *Environmental Management Act*

The provincial *Environmental Management Act* (2003) regulates waste discharge to protect water, air, and land quality. All discharges of waste related to the Project will be assessed to determine their potential impact on water quality, and fish and fish habitat.

9.2.7 Management Plans and Agreements

Fisheries objectives and management direction are outlined in one strategic-level Land Resource Management Plan (LRMP; i.e., the Dawson Creek LRMP [BC ILMB 1999]), and one Sustainable Resource Management Plan (SRMP; i.e., the Draft Peace Moberly Tract SRMP [BC MFLNRO 2006]). The Project lies within the boundaries of these plans. The assessment of fish and fish habitat was cognizant of the information presented in these plans.

9.3 REGIONAL OVERVIEW

Many fish species serve an important role in the ecological, economic, and cultural health of BC and Canada. Salmonid species in particular are captured for food and sport, supporting local economies and cultures, while other species may serve as indicators of environmental health and water quality. The Project encompasses several fish-bearing streams, rivers, and wetlands that could potentially be impacted by Project development. The following sections review the existing fish and fish habitat information for the Project and assess the potential effects of the Project on the local and regional resource.

Planned Project infrastructure is located entirely within the Murray River Watershed. The Murray River is a low-turbidity, moderate-gradient system stretching 200 km from its origin at Upper Blue Lake, in the Hart Ranges of the Rocky Mountains, to its confluence with the Pine River on the Peace Lowlands to the northeast. The Murray River flows north into the Pine River, 40 km downstream from the Village of Chetwynd, BC. Both the Pine and Murray rivers belong to the greater Peace River drainage system, which flows into the Slave River, a tributary of the Mackenzie River Watershed (Rescan 2013). The Murray River has a drainage area of 5,550 km^2 upstream of its outlet into the Pine River (Rescan 2013).

9.4 HISTORICAL AND CURRENT ACTIVITIES

Several historic and current human activities are within close proximity to the proposed Project (see Figure 5.10-1). These include mining exploration and production, oil and gas, forestry, tourism/recreation and hunting/trapping.

The Quintette Coal Mine, approximately 20 km south of Tumbler Ridge, was an open pit mine that operated between 1982 and 2000. The mine consisted of five open pits in three discrete areas: Sheriff (Wolverine and Mesa Pits), Frame (Shikano Pit) and Babcock (Windy and Window Pits). Mine permits for the Wolverine and Mesa Pits were issued in December 1982 and mining commenced from 1983 until 1998 (Wolverine) and 2000 (Mesa). Raw coal was transported via an overland conveyor from the Mesa and Wolverine Pits to the Quintette plant site for processing. The conveyor was decommissioned in 2011. The coal processing plant is currently under care and maintenance, with mine permit applications to re-initiate mining currently under review.

The Bullmoose Coal Mine operated from 1983 to 2003 and was the largest open pit coal mine at the time, producing about 3 million tons of metallurgical coal. The 1.7-million-tonne-per-year operation consisted of an open-pit mine, a plant facility in the Bullmoose Creek valley below the mine, and a separate rail loadout facility on the B.C. Rail branch line.

Previous exploration in the area included seismic lines and drilling for oil and gas wells which helped target areas for coal exploration. Twelve cutblock licenses exist within the LSA; three of these are held by the proponent. Large portions of the LSA have been recently harvested to remove pine beetle-affected timber.

Subsistence activities, such as trapping, hunting, and fishing are common land uses regionally. Three trapping tenures and four guide-outfitting tenures overlap the RSA. Multiple recreation tenures, as well as temporary and permanent residences exist within the Project Area. The nearest trapline cabin is 1.7 km from the Project on the west bank of Murray River, the nearest campground is 9.5 km north from the Project (near Tumbler Ridge), the nearest hunt camp is 26 km west from the Project, and the nearest residential area (Tumbler Ridge) is 12.4 km north from the Project. The Murray River is popular for boating and fishing. There are two boat launches on Murray River locally, one in Tumbler Ridge, and one located at the Murray River FSR crossing, adjacent to the Project.

There are multiple previously recorded archaeological sites (pre-contact lithic scatters) within 5 km of the proposed Project infrastructure.

The Project is located near two provincial parks and protected areas. Bearhole Lake Provincial Park and Protected Area is located approximately 17 km east of the Project, and Monkman Provincial Park is located approximately 27 km south of the Project.

9.5 BASELINE STUDIES

Fish and fish habitat studies conducted for the Project from 2010 to 2013 focused on 'Receiving Environment' sites, as well as 'Reference Environment' sites located upstream of the Project.

Yearly baseline fish and fish habitat studies were conducted between 2010 and 2013 (ERM Rescan 2014). The objectives of the studies varied slightly from year to year based upon alterations to the proposed Project design; however, the overarching objectives were to:

- assess the quality of fish habitat in streams, rivers, and wetlands;
- locate and document barriers to fish movement;
- identify important habitat, particularly for spawning Arctic Grayling (*Thymallus arcticus*) and Bull Trout (*Salvelinus confluentus*);
- determine fish presence, community composition, and distribution in streams, rivers, and wetlands; and
- characterize aspects of the physiology and biology of sentinel fish species (e.g. Slimy Sculpin, *Cottus cognatus*) in the baseline study area, including tissue metal content in accordance with applicable guidelines and the *Fisheries Act* (1985).

9.5.1 Data Sources

A number of historical studies provide information on the main waterbodies in the baseline study area. Historical information relating to water bodies, fish communities, and fish habitat were compiled from a variety of sources, including:

- BC MOE's Fisheries Information Summary System (FISS) database (BC MOE 2008);
- BC Conservation Data Centre (BC CDC) Species and Ecosystem Explorer database;
- BC MOE EcoCat: the Ecological Reports Catalogue;

- Federal Species at Risk Public Registry;
- Fisheries and Oceans Canada (DFO) Mapster;
- BC MOE Habitat Wizard;
- Publically available information and sharing agreements with adjacent and nearby mine projects (e.g., Quintette Mine); and
- Personal communications with Omineca-Peace Region BC MOE staff.

A literature review was conducted, using the above data sources, to summarize historical data and reports pertaining to the Project. This literature search revealed numerous federal and provincial reports, as well as datasets and reports prepared for use by industry or other organizations.

9.5.2 Methods

9.5.2.1 Baseline Study Area

Planned Project infrastructure is located entirely within the Murray River Watershed. In the context of fish and fish habitat values, the RSA encompasses several major watersheds, including the Murray River, Wolverine River, and Flatbed Creek watersheds (Figure 9.5-1). The LSA is located primarily in the Murray River Watershed and also includes the headwaters of tributaries of the Wolverine River.

Planned infrastructure is predominately located in M20 (or Camp) Creek and Twenty Creek sub-watersheds on the west side of the Murray River, and several small tributary streams (e.g., M17, M19, M19A creeks) on the east side of the Murray River. Fish and fish habitat studies conducted for the Project from 2010 to 2013 focused on 'Receiving Environment' sites within the Mine Site Assessment Footprint and LSA, as well as 'Reference Environment' sites located within the LSA and RSA (Figure 9.5-1; Table 9.5-1).

9.5.2.2 Fish Community and Fish Habitat

Streams, lakes, and wetlands are important habitat components for fish. Fish species may use only one habitat component or move between components during various life-history stages. Stream and wetland habitat components were sampled during fish and fish habitat baseline studies. Streams are defined as areas of flowing water characterized by a continuous channel with evidence of scouring to the channel bed or deposits of mineral alluvium (RISC 2001). Wetlands are defined as shallow, open water bodies, or open water bodies in which more than 25% of the surface is covered in vegetation. For the purposes of this program only stream and wetland habitat components were assessed. Lakes within the LSA and RSA are not anticipated to be impacted by the Project.

Figure 9.5-1
Fish Habitat and Community Survey Sites, 2010 and 2013

ERM

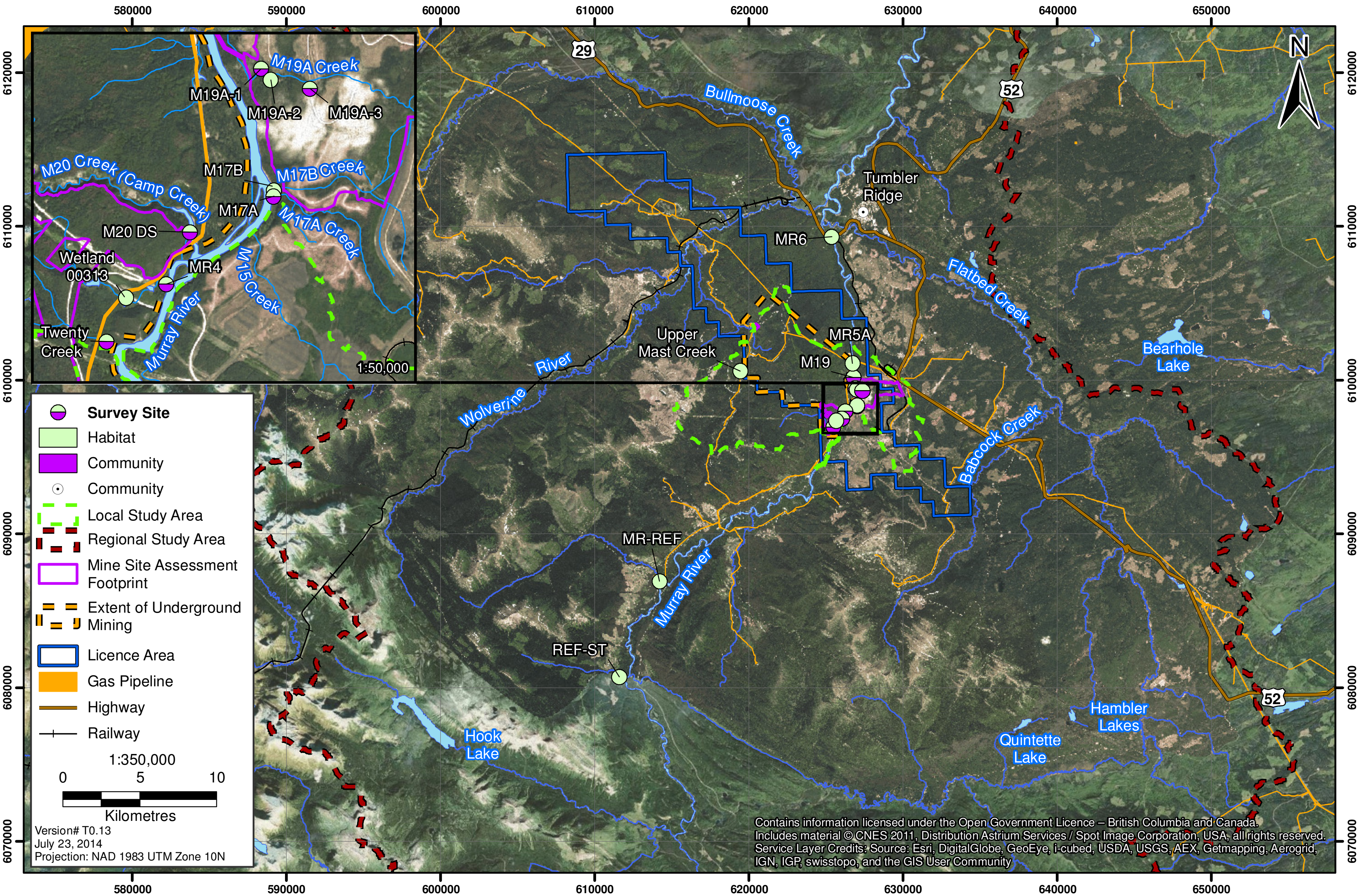


Table 9.5-1. Receiving and Reference Environments Site Rationale

Site Name	Waterbody Name	UTM Coordinates			Environment (Reference / Receiving)	Receiving Environment Class (Near-, Mid-, or Far-field)	Rationale
		Zone	Easting	Northing			
M17A	M17A Creek	10U	627021	6098288	Receiving	Near-field	Monitoring site, downstream of proposed Coal Processing Site
M17B	M17B Creek	10U	627023	6098344	Receiving	Near-field	Monitoring site, downstream of proposed Coal Processing Site
M19	M19 Creek	10U	626778	6100178	Receiving	Near-field	Monitoring site, downstream of proposed Coal Processing Site
M19A-1	M19A Creek	10 U	626904	6099476	Receiving	Near-field	Habitat monitoring site, downstream of proposed Coal Processing Site
M19A-3	M19A Creek	10 U	627360	6099292	Receiving	Near-field	Habitat monitoring site, downstream of proposed Coal Processing Site
M20 US	M20 Creek	10 U	625300	6098442	Reference	–	Fish tissue metal site for comparison of effects immediately upstream of Shaft Site on M20 Creek
M20 DS	M20 Creek	10 U	626248	6097956	Receiving	Near-field	To monitor effects at M20 Creek, downstream of Shaft Site
Twenty Creek	Twenty Creek	10 U	625500	6096907	Receiving	Near-field	Monitoring site, downstream of proposed Shaft Site
Upper Mast Creek	Mast Creek	10 U	619459	6100577	Receiving	Near-field	Monitoring site, downstream of proposed Secondary Shaft Site
Wetland 00313	Wetland 00314	10 U	625654	6097348	Receiving	Near-field	Monitoring site, downstream of proposed Shaft Site
MR US	Murray River	10 U	618494	6090320	Reference	–	Fish tissue metals site for comparison of effects far upstream of Project infrastructure
MR DS	Murray River	10 U	626711	6100880	Receiving	Far-field	Fish tissue metals site to monitor effects of all Project infrastructure on Murray River
MR 3	Murray River	10 U	625221	6095745	Reference	–	Fish tissue metals site for comparison of effects immediately upstream of Project infrastructure on Murray River
MR 4	Murray River	10 U	626712	6097950	Receiving	Near-field	Fish tissue metals site to monitor effects of all Project infrastructure on Murray River
MR 5A	Murray River	10 U	626724	6101080	Receiving	Mid-field	Monitoring site, far-field exposure site downstream of potential discharge
MR 6	Murray River	10 U	625364	6109309	Receiving	Far-field	Monitoring site, far-field exposure site downstream of potential discharge
MR-REF	Murray River	10 U	614218	6086910	Reference	–	Monitoring site, upstream Murray River reference for comparison with downstream Murray River sites
REF-ST	Club Creek	10 U	611594	6080686	Reference	–	Reference stream site, for comparison with M17, M19, M20, and Twenty tributary creeks in the receiving environment

All major watercourses in the baseline were divided into reaches based on Resource Inventory Standards Committee guidelines (RISC 2001). Reaches contain relatively homogenous habitat and reach breaks are located where there are large changes in habitat characteristics such as stream width, gradient, or morphology. Streams were assessed using methods based on the Reconnaissance 1:20,000 Fish and Fish Habitat Inventory Protocol (RISC 2001) and the Reconnaissance 1:20,000 Fish and Fish Habitat Inventory: Site Card Field Guide (RISC 1999). This protocol involved characterizing fish habitat over a 100 m-long section of stream by measuring physical attributes. Physical attributes measured or estimated included width, depth, availability of instream cover, canopy closure, substrate size, and gradient. Temperature, pH, and conductivity of the stream water were measured. Stream turbidity was estimated visually. Visual observations were made of the riparian vegetation, bank characteristics, stream morphology, and hillslope coupling. Stream features such as islands, bars, fish barriers, beaver dams, and debris jams were noted. The overall quality of the sites for fish spawning, rearing, overwintering, and migrating was described based on professional judgement. Barriers to fish movement were noted and photographs, measurements, and descriptions of each barrier were taken. All photographs can be found in the appendix of the baseline report (Appendix 9-A). Streams were classified according to the *Forest Practices Code of British Columbia Fish-Stream Identification Guidebook* (BC MOF 2002). Under this procedure, streams are classified based on mean channel width (m) and fish-bearing status. The guidebook provides criteria for classifying streams as either fish-bearing (i.e., Classes S1, S2, S3, and S4) or non-fish-bearing (i.e., S5 and S6). Streams are classified by this guidebook as non-fish-bearing if the mean gradient is greater than 20%.

Additional detailed fish habitat surveys were conducted at sites within the potential mine receiving environment. In addition to the reconnaissance level inventory following the RISC protocols (RISC 2001), the sites were surveyed based on the methodology outlined in the Fish Habitat Assessment Procedures (Johnston and Slaney 1996), a system developed for the BC Watershed Restoration Program. Representative sections of lower stream reached were chosen for assessment and individual habitat units were measured with respect to length, bankfull and wetted width and depth, substrate composition, residual pool depth, bank stability, bank height, and instream cover. These measurements allow for a greater ability to characterize changes in habitat resulting from potential mine impacts.

The study design for fish community sampling followed RISC Fish Collection Methods and Standards (RISC 1997), Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures (RISC 2001), and the Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Fish Collection Field Guide (RISC 1999). The objectives of fish sampling were to confirm fish presence/absence and characterize fish community composition. Fish community sampling was conducted in the same locations as habitat surveys.

Each stream site where potential fish habitat was identified, was evaluated for fish community composition and sampled using backpack electrofishers following the methods detailed in Johnson et al. (2007). Electrofishing was conducted at sites where stream cover and water depth permitted. A systematic sweep was conducted across the entire wetted width from the downstream to the upstream site boundary (Stanfield 2005). Electrofishing effort was not pre-determined due to differences between site and available habitat. Electrofisher voltage (V), duty cycle (%) and frequency (Hz) settings remained consistent where possible.

Minnow traps consisted of two wire mesh cylinders (mesh size 0.63 cm) locked together using a clip attached to a rope and marker buoy. Each minnow trap was baited with an equal amount of commercial crab bait. Minnow traps were set for overnight for approximately 24 hours, and retrieved the following day. All traps were marked with contact information and the fish collection permit number.

Fish were sampled for biological data during the 2011, 2012, and 2013 field programs. Following capture, fish were identified to species and given a unique sample number. Length was measured to the nearest 1 mm and wet weight was collected to the nearest 0.01 g. Observations were recorded on the general condition of fish, noting the presence of deformities, erosions, lesions, and tumours (DELTs), and age (through the collection of scale and fin ray samples from a subsample of fish).

Additional Slimy Sculpin and Bull Trout were captured from upstream and downstream sites within the Murray River, and M20 Creek to develop a detailed dataset recommended in the Metal Mining Environmental Effects Monitoring (EEM) Technical Guidance Document (Environment Canada 2011). These parameters included indicators of energy use and storage, external and internal health indicators (such as visible tumours and parasites), and tissue metal concentrations. Slimy Sculpin were selected as the sentinel species due to their presence throughout the Mine Site Assessment Footprint, LSA, and RSA.

9.5.3 Characterization of Fish and Fish Habitat Baseline Condition

9.5.3.1 Murray River

Fish presence within the Murray River is limited by Kinuseo Falls. This 60 m waterfall is located approximately 160 km upstream of the confluence of the Murray and Pine rivers, and approximately 38 km upstream from the Project (UTM 10U 616304 E, 6072306 N). Kinuseo Falls is a permanent barrier to fish movement, and represents the upper limit of distribution for fish species and populations residing downstream of the falls.

The Murray River contains relatively high fisheries values and supports regionally important Arctic Grayling and Bull Trout populations. Bull Trout are a fish species of special concern (‘blue-listed’) in British Columbia. Arctic Grayling are currently not at risk in British Columbia, and are included on the provincial ‘yellow-list’. In addition to Arctic Grayling and Bull Trout, native fish species commonly present downstream of Kinuseo Falls include: Burbot (*Lota lota*), Finescale Dace (*Phoxinus neogaeus*), Lake Chub (*Couesius plumbeus*), Longnose Dace (*Rhinichthys cataractae*), Longnose Sucker (*Catostomus catostomus*), Mountain Whitefish (*Prosopium williamsoni*), Northern Pike (*Esox lucius*), and Slimy Sculpin. Tables 9.5-2 and 9.5-3 present summaries of known fish species occurrence in the Murray River and tributary streams, and wetlands sampled within the LSA and RSA.

Table 9.5-2. Summary of Known Fish Species Occurrence in the Murray River and Tributary Streams within the LSA and RSA

Species Comon Name	Species Scientific Name	Species Code	Murray River	M14	M15	M17	M19	M19A	M20	Twenty Creek	Barbour Creek	Fellers Creek	Mast Creek	South Hermann Creek	Waterfall Creek
Arctic Grayling[+]	*Thymallus arcticus*	GR	X			X[a]	X[a]		X[a]		X				
Brassy Minnow	*Hybognathus hankinsoni*	BMC	O												
Brook Stickleback	*Culaea inconstans*	BSB	O												
Brook Trout	*Salvelinus fontinalis*	EB	X			X[a]	X[a]		X[a]	X[a]	X			X	X
Bull Trout*	*Salvelinus confluentus*	BT	X			X[a]	X[a]		X[a]			X	X		
Burbot	*Lota lota*	BB	X			X[a]	X[a]		X[a]		X				
Finescale Dace	*Phoxinus neogaeus*	FDC	X	X											
Lake Chub	*Couesius plumbeus*	LKC		X											
Longnose Dace	*Rhinichthys cataractae*	LNC	O												
Longnose Sucker	*Catostomus catostomus*	LSU	O	X		X[a]	X[a]		X[a]						
Mountain Whitefish	*Prosopium williamsoni*	MW	X		X	X[a]	X[a]		X[a]	X[a]	X				X
Northern Pike	*Esox lucius*	NP	X												
Rainbow Trout	*Oncorhynchus mykiss*	RB	O						X[a]	X[a]					
Redside Shiner	*Richardsonius balteatus*	RSC	O												
Slimy Sculpin	*Cottus cognatus*	CCG	X		X[a]	X[a]	X[a]		X[a]		X		X		
Westslope Cutthroat Trout*	*Oncorhynchus clarkii lewisi*	WCT	O												

** Blue-listed species*

[+] Yellow-listed species

X = indicates that Project-specific sampling was utilized to confirm fish species presence in the Project LSA.

O = indicates that other sources of existing inventory data (e.g., historical literature, Habitat Wizard) were utilized to confirm fish species presence within the Murray River Watershed.

[a] Present below permanent barrier to fish migration (e.g., waterfall).

Empty cells indicate fish not present.

Table 9.5-3. Summary of Known Fish Species Occurrence in Wetlands within the LSA and RSA

Species Common Name	Species Scientific Name	Species Code	B2 Wetland	Barbour Wetland	M14 Wetland	M20 Wetland	Murray Wetland 11	Wetland 00313
Arctic Grayling⁺	*Thymallus arcticus*	GR						
Brassy Minnow	*Hybognathus hankinsoni*	BMC						
Brook Stickleback	*Culaea inconstans*	BSB						
Brook Trout	*Salvelinus fontinalis*	EB						
Bull Trout*	*Salvelinus confluentus*	BT						
Burbot	*Lota lota*	BB						
Finescale Dace	*Phoxinus neogaeus*	FDC	X	X	X	X	X	
Lake Chub	*Couesius plumbeus*	LKC						X
Longnose Dace	*Rhinichthys cataractae*	LNC						
Longnose Sucker	*Catostomus catostomus*	LSU						
Mountain Whitefish	*Prosopium williamsoni*	MW						
Northern Pike	*Esox lucius*	NP						
Rainbow Trout	*Oncorhynchus mykiss*	RB						
Redside Shiner	*Richardsonius balteatus*	RSC						
Slimy Sculpin	*Cottus cognatus*	CCG						
Westslope Cutthroat Trout*	*Oncorhynchus clarkii lewisi*	WCT						

** Blue-listed species*
⁺ Yellow-listed species
X = indicates that Project-specific sampling was utilized to confirm fish species presence in the Project LSA.
Empty cells indicate fish not present

Three non-native sport-fish species have been introduced to the Murray River system in recent decades, including Brook Trout (*Salvelinus fontinalis*), Rainbow Trout (*Oncorhynchus mykiss*), and Westslope Cutthroat Trout. Although Rainbow Trout are currently present at low densities, sampling records indicate this species has failed to establish significant self-sustaining populations in the Murray River and its tributaries. Brook Trout were stocked in several lakes until the early 1990s, and have since spread beyond stocked lakes to establish populations in the Murray River. Brook Trout are now commonly found in several Murray River tributaries in the vicinity of the Project. Westslope Cutthroat Trout were stocked in Upper Blue Lake in 1983. This species is now abundant in the Upper and Lower Blue lakes system, but have not been found in portions of the Murray River drainage near the Project. Westslope Cutthroat Trout are protected as a Schedule 1 (Special Concern) species under the *Species at Risk Act* (SARA; 2002), considered of "Special Concern" under COSEWIC, and are provincially 'blue-listed'.

The primary fish species found in the Murray River and LSA are Arctic Grayling, Bull Trout, Mountain Whitefish, and Slimy Sculpin (DES 2011). Table 9.5-4 presents a summary of species-specific life history periodicity and habitat distribution within the Murray River and LSA. The Murray River provides habitat for all life-history stages (spawning, rearing, migratory, and overwintering) for these key species.

Arctic Grayling are present in all portions of the Murray River mainstem downstream of Kinuseo Falls. Studies conducted by Quintette (1982) and McCart et al. (1985) prior to the construction of the Quintette Mine, indicated that Arctic Grayling distribution varied based upon seasonal habitat use. Immediately after the spring spawning period, Arctic Grayling were distributed throughout the upper Murray River mainstem. Summer feeding activity was associated with pool and run habitat units. With the onset of cooler water temperature in mid-September, Arctic Grayling distribution shifted downstream, and distribution was confined to the relatively fewer large, deep pools. The largest overwintering concentrations of Arctic Grayling were found downstream of Tumbler Ridge. Overwintering adult Arctic Grayling were uncommon upstream of the confluence of the Murray and Wolverine rivers, approximately 15 km downstream from the Project.

Bull Trout inhabiting the Murray River are members of the Fellers Creek fluvial migratory sub-population (DES 2011). Adults of this sub-population overwinter in the Murray River mainstem and make seasonal migrations to a spawning zone in Fellers Creek. Fellers Creek is a secondary tributary to Kinuseo Creek, located approximately 27 km upstream of the Project. Pre-spawn migrations occur from late July through August, with peak spawning occurring in early September. Post-spawn adult Bull Trout then rapidly migrate downstream to overwintering habitat located within the Murray River mainstem near the Wolverine River confluence, and possibly extending to the Pine River. Yearling and post-yearling juvenile Bull Trout migrate from Fellers Creek and into the Murray River mainstem. Bull Trout redistribute themselves in relatively low densities within the mainstem and accessible tributary stream rearing habitat.

Table 9.5-4. Summary of Species-specific Life History Periodicity and Habitat Distribution within the LSA

Species	Life stage	Habitat Distribution	Month: Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Arctic Grayling	Spawning	M19, Murray River				■	■							
	Hatching	M19, Murray River						■						
	Fry rearing/migration	M19, Murray River						■	■	■	■	■		
	Rearing/overwintering	Murray River	■	■	■	■	■	■	■	■	■	■	■	■
	Adult migration	Murray River			■	■	■	■	■	■	■	■		
Bull Trout	Spawning	Tributary Streams									■	■		
	Hatching	Tributary Streams					■	■						
	Fry rearing/migration	Tributary Streams						■	■	■	■	■		
	Rearing/overwintering	Murray River	■	■	■	■	■	■	■	■	■	■	■	■
	Adult migration	Murray River				■	■	■	■	■	■	■		
Mountain Whitefish	Spawning	Tributary Streams									■	■	■	
	Hatching	Tributary Streams				■	■	■						
	Fry emergence/ migration	Tributary Streams					■	■	■					
	Rearing/overwintering	Murray River	■	■	■	■	■	■	■	■	■	■	■	■
Slimy Sculpin	Spawning	Streams/Lakes				■	■							
	Hatching	Streams/Lakes					■	■						
	Rearing/overwintering	Streams/Lakes	■	■	■	■	■	■	■	■	■	■	■	■

Sources:
McPhail (2007)

Mountain Whitefish are the most abundant sport-fish species in the Murray River (DES 2011). Spawning primarily occurs in the mainstem downstream of Kinuseo Falls and in the Wolverine River mainstem. Mountain Whitefish typically spawn in late October, and fertilized eggs are broadcast over cobble and gravel substrates. Deposited eggs incubate through the winter and hatch in April to May when water temperatures rise. A proportion of yearling and sub-adults may make opportunistic feeding migrations into tributary streams during freshet, remaining until water levels decline in late summer, and move back into the Murray River mainstem to overwinter. Mountain Whitefish overwintering distribution is clumped, with congregations of several hundred adults and sub-adults inhabiting the few large, deep pools within the mainstem.

Slimy Sculpin are abundant and present in all reaches of the Murray River downstream of Kinuseo Falls. Slimy Sculpin are non-migratory with relatively small home ranges, and exist in a series of contiguous resident populations (DES 2011). Habitat use within the Murray River mainstem typically ranges from riffles with gravel and cobble substrate, to slower sections with fine sediment substrate. The Murray River mainstem in the RSA and LSA provides perennial habitat for all Slimy Sculpin life-history stages.

The above life-history traits and relatively high abundance also make Slimy Sculpin an ideal sentinel species for monitoring changes in baseline tissue metals concentrations for the Project (Gibbons et al. 1998, Fitzgerald et al. 1999, Ribey et al. 2002, Gray et al. 2004, Spencer et al. 2008, Arciszewski et al. 2010). Slimy Sculpin were sampled from six sites located at various distances upstream and downstream from the Project along the Murray River (Figure 9.5-2). A minimum of eight Slimy Sculpin were collected per site for whole-body tissue metals samples and corresponding biological data (e.g., length, weight, and condition). Biological and tissue metals datasets were previously developed for Slimy Sculpin from each site sampled in 2004, 2005, 2011, and 2012 (Table 9.5-5). Several additional fish species (Finescale Dace, Brook Trout, and Bull Trout) were also sampled for fish tissue metals concentrations within the LSA and RSA from 2004 to 2012. All tissue metals sampling and analytical data for all species are presented in Appendix 9-A.

Mean length, length-frequency distributions, and weight-length regressions were developed for each biological dataset. Slimy Sculpin mean total length was consistent between sites and among sampling years (mean per site ranged from 51 to 69 mm). Length-frequency histograms developed for Slimy Sculpin generally showed a bi-modal distribution. Total length categories ranging from 40 to 50 mm had the highest proportion of Slimy Sculpin, while a secondary mode (65 to 75 mm) could also be detected. All weight-length regressions calculated for Slimy Sculpin showed a significant ($P < 0.001$) relationship between weight and length, and adjusted r^2 values ranged from 0.72 to 0.98. The slopes of weight-length regressions for Slimy Sculpin were also consistent among sampling sites and years.

For tissue metals, mean mercury concentrations in Slimy Sculpin tissues were highest at Murray River mainstem sites and lowest at tributary stream sites. The highest mean concentration was recorded at MR US in 2011 and MR DS in 2012 (0.044 mg/kg wet weight (WW) at both sites), followed by MR US in 2012 (0.038 mg/kg WW). Mercury concentrations in Slimy Sculpin from all Murray River sites and all sampling years were lower than the Health Canada guideline of 0.50 mg/kg WW for maximum total mercury in fish tissue (CCME 1999; Health Canada 2011).

Figure 9.5-2
Fish Tissue Metals Sample Sites, 2004 to 2012

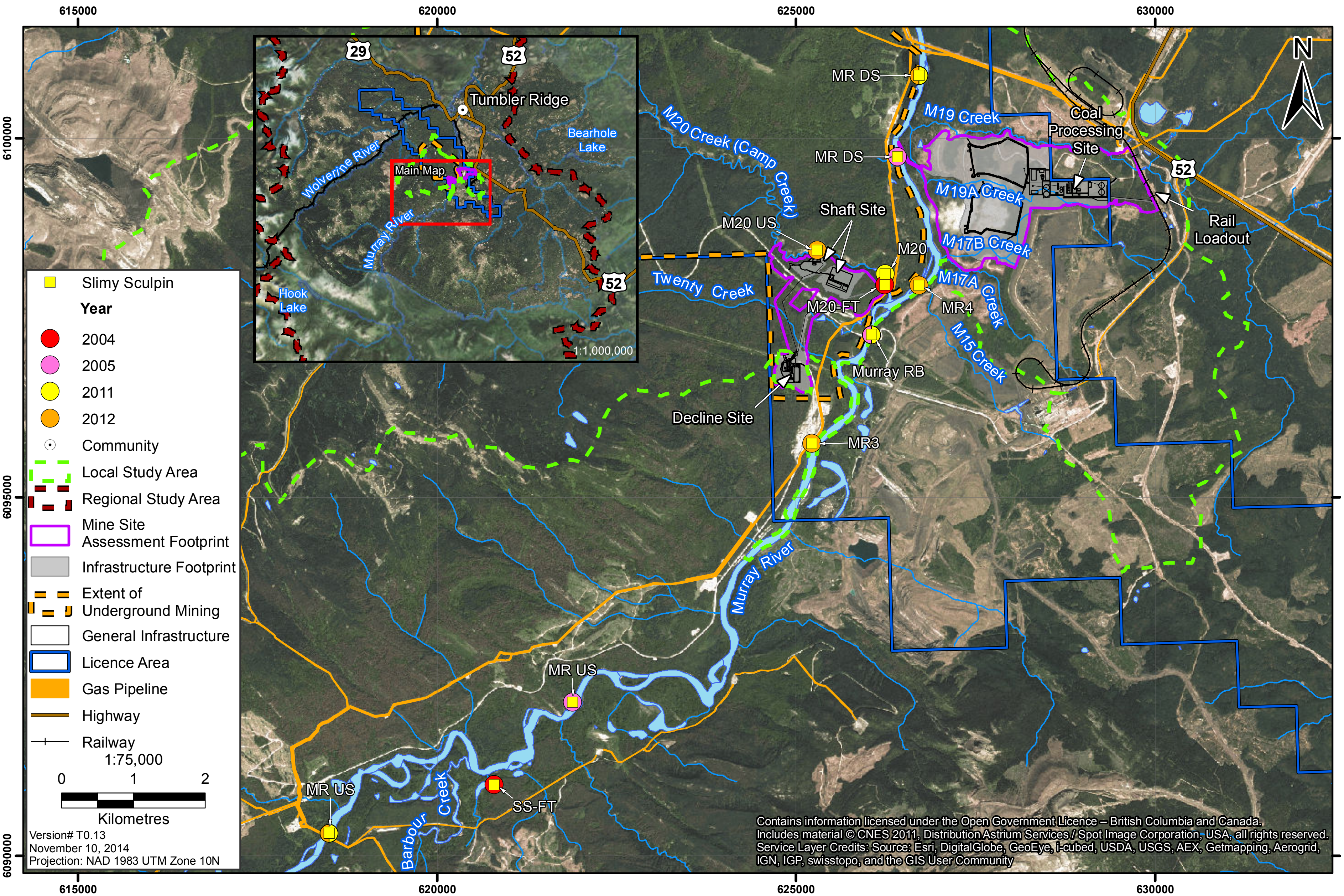


Table 9.5-5. Summary of Fish Tissue Metals Sampling Sites and Species, 2004 to 2012

Site	Waterbody	Environment (Reference / Receiving)	UTM Coordinates			2012	2011	2005	2004
			Zone	Easting	Northing				
MR3	Murray River	Reference	10 U	625221	6095745	X	-	-	-
MR4	Murray River	Receiving	10 U	626712	6097950	X	-	-	-
MR US	Murray River	Reference	10 U	618494	6090320	X	X	-	-
MR US	Murray River	Reference	10 U	621888	6092141	-	-	X	-
MR DS	Murray River	Receiving	10 U	626711	6100880	X	X	-	-
MR DS	Murray River	Receiving	10 U	626418	6099744	-	-	X	-
M20 US	M20 Creek	Receiving	10 U	625300	6098442	X	-	-	-
Murray RB	Murray River	Reference	10 U	626054	6097265	-	X	X	-
M20 DS	M20 Creek	Receiving	10 U	626242	6098112	-	-	X	-
Mast Creek	Mast Creek	Receiving	10 U	616359	6108952	-	-	X	-
SS-FT	Murray River	Reference	10 U	620794	6090991	-	-	-	X
M20 DS	M20 Creek	Receiving	10 U	626238	6097954	-	-	-	X

Notes:
X indicates Slimy Scuplin sampled
Dashes (–) indicate data not collected

Selenium showed opposite trends relative to mercury. Mean selenium concentrations measured in Slimy Sculpin were higher at tributary sites and lower at Murray River mainstem sites. Selenium concentrations (converted to units of mg/kg dry weight [DW]) in whole-body Slimy Sculpin were compared with the draft British Columbia selenium guideline of 4 mg/kg DW for fish muscle (Beatty and Russo 2012). For Murray River sites, exceedances of the draft guideline occurred at MR US (2012, 2011), MR 3 (2012), MR 4 (2012), and MR RB (2011). Mean selenium concentrations for whole-body Slimy Sculpin sampled from MR DS were slightly below 4.0 mg/kg DW in 2005, 2011, and 2012. Tissue metals baseline data and predicted changes to fish tissue are discussed in greater detail in Section 9.7.1.3.

9.5.3.2 Tributary Streams

Overview

Fish distribution in tributary streams within the Mine Site Assessment Footprint and LSA is heavily influenced by the presence of permanent barriers to fish migration (i.e., waterfalls). Figure 9.5-3 shows the geographical distribution of fish-bearing reaches and location of barriers to fish migration in the Mine Site Assessment Footprint. Permanent barriers to fish migration are present in M17, M19, M20, and Twenty creeks (Table 9.5-6). These features delineate upper and lower stream reaches, and habitat use by fish in tributary streams. Fish habitat use in tributary streams, such as M17, M19, and Twenty creeks, may also be restricted by ephemeral flow conditions. Surface flow typically declines through the summer, low flow period resulting in fragmented habitat or dewatering of the stream bed. Natural stranding mortality may occur with further reductions in surface flow.

The fish community of M17, M19, and M20 creeks is similar, and includes Arctic Grayling, Bull Trout, Burbot, Longnose Sucker, Mountain Whitefish, and Slimy Sculpin (Table 9.5-2). Only Brook Trout, Mountain Whitefish, and Rainbow Trout have been documented in Twenty Creek. Wetland environments are typically populated by Lake Chub (Table 9.5-3).

M17 Creek

M17 Creek (Figure 9.5-3) was sampled from 1982 to 1984 as part of the baseline studies for the Quintette Mine. During those surveys, M17 Creek was found to support Arctic Grayling, Brook Trout, Bull Trout, Burbot, Longnose Sucker, Mountain Whitefish, and Slimy Sculpin (Table 9.5-2).

Recent fish and fish habitat data for M17A and M17B creeks was collected by Stantec (2011, 2013). M17A Creek exhibited a mean gradient of 6%, mean channel width of 5.5 m, and mean channel depth of 0.3 m. Channel morphology was classified as riffle-pool. Cobble and gravel were observed as the dominant and sub-dominant substrate type, respectively. The dominant cover-type for fish was boulder (40%). Habitat for spawning, rearing, overwintering were rated as fair. Migration habitat was rated as poor. Fish sampling was conducted at M17A Creek over four sampling events in August 2011 (electrofishing and minnow trapping), September 2011 (minnow trapping), May 2013 (electrofishing), and July 2013 (electrofishing).

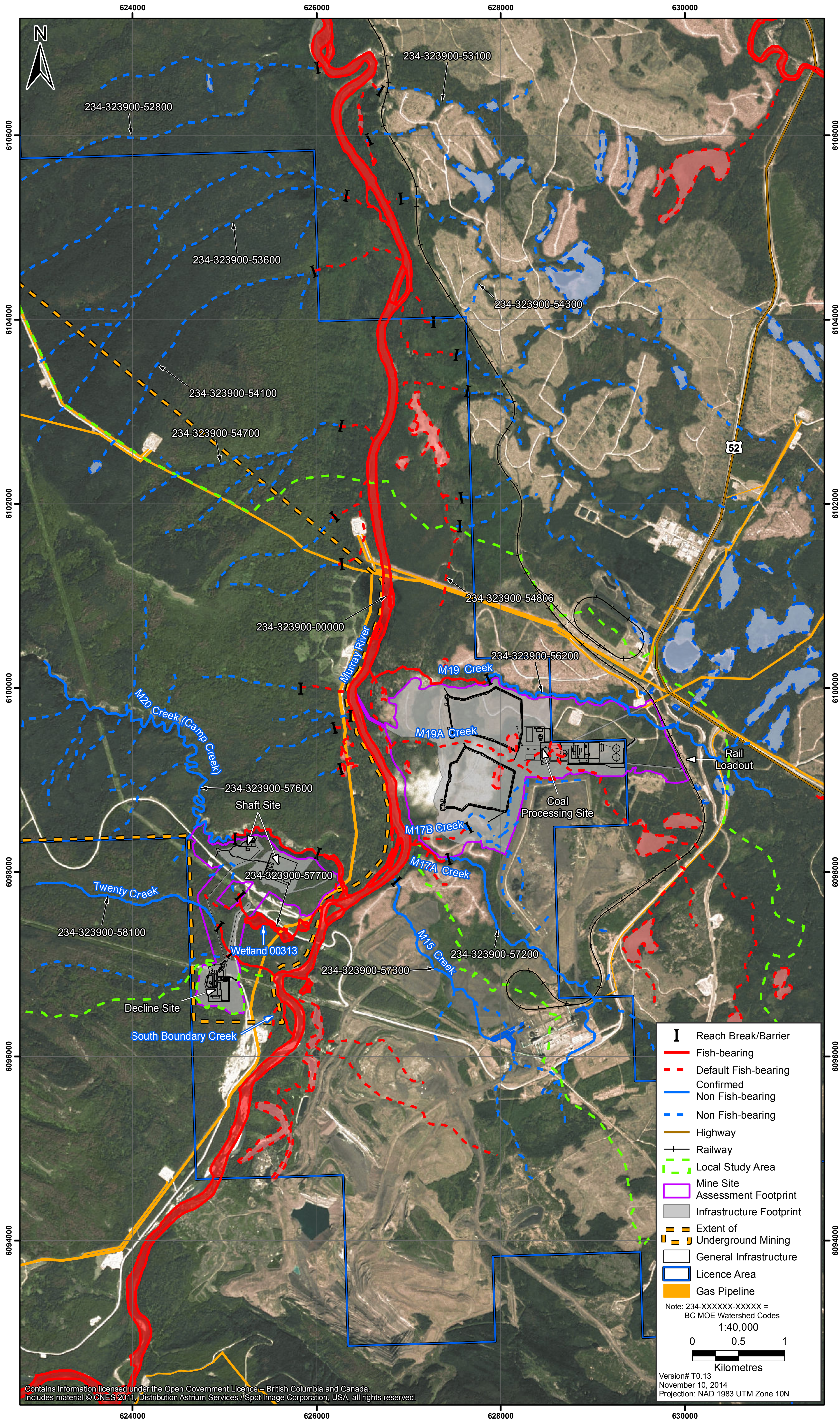
Table 9.5-6. Location and Description of Barriers to Fish Migration within the Mine Site Assessment Area

Waterbody	Environment (Reference / Receiving)	UTM Coordinates			Height (m)	Barrier Type	Distance to Murray River Confluence (km)	Fish-bearing Reach Stream Classification	Comment
		Zone	Easting	Northing					
M19 Creek	Receiving	10 U	627896	6100141	3	Waterfall	1.5	S2	Additional 4 m waterfall 50 m upstream
M20 Creek	Receiving	10 U	625067	6098371	–	Chute	1.9	S2	Additional 10 m waterfall 250 m upstream
Twenty Creek	Receiving	10 U	624798	6097589	2	Waterfall	1.3	S4	

Dashes (–) indicate no data available

Figure 9.5-3

Spatial Distribution of Fish-bearing Reaches and Barriers to Fish Migration in the LSA, 2013



In August 2011, 239 s of electrofishing was conducted, and fish were not captured. Minnow trapping gear used during the August and September events captured a total of two Bull Trout and one Burbot. In 2013, 954 s of electrofishing was conducted in May, and 470 s of electrofishing was conducted in July. Burbot, Mountain Whitefish, Slimy Sculpin, and an unidentified salmonid were captured. Burbot, Slimy Sculpin, and Mountain Whitefish were relatively equally abundant in M17A Creek. Overall, this reach of M17A Creek was fish-bearing, and classified as S3. Barriers to fish migration were identified in previous studies, located upstream for the Stantec sampling point (Figure 9.5-3). Studies and data provided by Stantec (2011, 2013) provide conflicting information regarding the presence and location of fish migration barriers.

M17B Creek was also surveyed 2013. Mean channel width was 1.9 m, mean channel depth was 0.1 m, and mean gradient was 4.7%. Channel morphology was predominantly riffle-pool. Fines and gravel were the dominant and sub-dominant substrate types, respectively. Overhanging vegetation was the dominant form of cover for fish. Habitat for all fish life-history stages were not present due to lack of flow and depth. Barriers to fish migration were not observed between the site and the Murray River; however, barriers to fish migration are present upstream (Figure 9.5-3). Although electrofishing was not possible in summer low-flow conditions, fish may have access to M17B Creek in spring, freshet conditions. Fish habitat use is likely ephemeral, and restricted to the months of May and June. Therefore, M17B Creek was classified as S4-default and fish-bearing.

<u>M19 Creek</u>

The lower reach of M19 Creek (Figure 9.5-3) was sampled yearly from 1981 to 1984 during baseline fisheries investigations conducted for the Quintette Coal Mine (BC Research 1982, McCart et al. 1985). Two impassible barriers, consisting of 3 m and 4 m waterfalls, are present within a 50 m section of M19 Creek (DES 2011). The waterfalls are located approximately 1.5 km upstream of the confluence of M19 Creek and the Murray River. The lower waterfall represents the upstream limit of fish distribution within M19 Creek.

Lower M19 Creek was sampled for fish and fish habitat in August 2011 (DES 2011; Table 9.5-2). Flow levels were low; however, continuous surface flow was present to the confluence with the Murray River. M19 Creek contained high quality seasonal rearing habitat suitable for juvenile Arctic Grayling, with abundant rearing cover provided by pools, large and small woody debris, and undercut banks. M19 Creek was the only tributary stream within the Mine Site Assessment Footprint where Arctic Grayling were consistently captured in high abundance. YOY Arctic Grayling were captured in 1981, 1983, and 2011, indicating that M19 Creek provides annual spawning and rearing habitat, which may be a limiting habitat type for Arctic Grayling in the LSA. Overall, the lower reach of M19 Creek was rated as important habitat and classified as S2, fish-bearing.

Spawning habitat for fall-spawning species (e.g., Bull Trout and Mountain Whitefish) may be constrained by low seasonal flow. Habitat surveys conducted in late-August to October indicate that M19 Creek may become seasonally de-watered, causing natural stranding mortality for fish. Thus, habitat suitability for Bull Trout and Mountain Whitefish is limited.

M19A Creek

Fish habitat in M19A Creek (Figure 9.5-3) was surveyed during mid-July (two sites) and late August (one site) in 2013 (Appendix 9-A). Mean wetted and channel width was 2.5 m and 2.6 m, respectively. Mean wetted depth varied with seasonal flow, ranging from 0.3 m in high flow to 0.1 m in low flow. Channel morphology was classified as riffle-pool. Large sections of M19A Creek were flooded by beaver dams creating wetland habitat. Gravel and fines were observed as dominant and sub-dominant substrate type, respectively. Overhanging vegetation and woody debris (both small and large) were equally abundant cover types. Crown closure ranged from 20% to 100%.

Habitat ratings for each life-history stage varied between sites. Stream sections flooded by beaver dams were rated higher for overwintering and rearing habitat, while riffle-pool sections rated higher for spawning habitat. Migratory habitat was consistently rated as poor due to the presence of beaver dams, log jams, and insufficient depth during low flow. Permanent barriers (e.g., water fall > 1 m high) to fish migration were not found within M19A Creek. Fish were not captured from M19A Creek despite intense fishing effort with multiple fishing gear at various flow periods, including 2,604 s of electrofishing and 486 h of minnow trapping (Appendix 9-A).

Overall, habitat was rated as marginal, and M19A Creek was classified as S4, default fish-bearing.

M20 Creek

M20 Creek (also known as Camp Creek; Figure 9.5-3) is situated along the northern boundary of the Infrastructure Investigation Area on the west side of the Murray River. M20 Creek is divided into three reaches: the lower 700 m section that is accessible to fish from the Murray River, the canyon section that has three waterfalls 8 to 20 m in height, and the upper reach above the barriers. There are naturally high levels of sediment in M20 Creek, originating from a source upstream of the waterfalls. The presence and abundance of fine sediment may limit spawning capacity of the lower reaches (DES 2011).

Reach 1 extends from the Murray River to the lower end of the canyon. This reach is generally shallow and riffles are the dominant habitat type. Overwintering habitat is limited due to the lack of deep pools. Reach 2 is 1,200 m in length, starting at the downstream edge of the canyon to the base of the lowest fish barrier. This reach flows through a steep canyon, and substrate is comprised of bedrock and cobbles. There is a higher component of pool and overwintering habitat due to the presence of bedrock crevasses. The upper reach of M20 Creek begins above the series of barriers and includes the remainder of the headwaters. The mainstem of the upper reach is confined by steep canyons and numerous small tributaries feed into the upper reach.

Fish distribution is well documented in M20 Creek (RAB 1977; McCart et al. 1985; Hatfield 1998; DES 2006; Poulin 2006). Several impassable barriers are located between reaches 2 and 3, including a 10 m waterfall located 1.9 km upstream from its confluence with the Murray River (WCC 2007). Extensive fish sampling using backpack electrofishing has been conducted over multiple seasons and years to confirm that fish are absent from the upper reaches of M20 Creek.

The lower reach of M20 Creek, below the falls, has been sampled on several occasions from the 1970s to the present (RAB 1977; McCart et al. 1985). DES (2011) provides a comprehensive review of fish distribution and habitat in the lower reaches of M20 Creek. The lower reach of M20 is occupied year-round by resident Slimy Sculpin, and provides limited rearing habitat for juvenile Bull Trout and Mountain Whitefish. Arctic Grayling, Burbot, and Longnose Sucker have also been sampled in M20 Creek (Table 9.5-2). These species are thought to move from the Murray River and utilize M20 Creek sporadically during suitable flow conditions.

Fish habitat was surveyed within the lower reach of M20 Creek in high flow (2010) and low flow (2012). Channel morphology was classified as riffle-pool. Mean wetted depth was 8.3 m in high flow and 3.5 m in low flow. Mean stream gradient was 2.5%. Fines, gravel, cobble, and boulder were uniformly represented as dominant substrate types. Cover for fish was also diverse, with large woody debris, overhanging vegetation, and boulders present.

Rearing habitat was rated as good due to the abundance of cover for juvenile fish. Spawning and adult feeding habitat were rated as poor due to high turbidity and sediment load. Deep pools were not observed within the site, thus overwintering habitat was not present. Overall, fish habitat within M20 Creek, Reach 1 was rated as marginal and classified as S2.

Slimy Sculpin were sampled from two sites within the lower reach of M20 Creek in 2012, 2011, and 2004 to monitor changes in baseline tissue metals concentrations (Figure 9.5-2). Five to eight Slimy Sculpin were collected per site for whole-body tissue metals samples and corresponding biological data (e.g., length, weight, and condition). Biological and tissue metals datasets were developed for Slimy Sculpin from each site sampled in 2011, and 2004.

Mean length, length-frequency distributions, and weight-length regressions were developed by site and year. Slimy Sculpin mean total length ranged from 63 to 88 mm. Length-frequency histograms developed for Slimy Sculpin generally showed a bi-modal distribution. Total length categories ranging from 50 to 60 mm had the highest proportion of Slimy Sculpin. All weight-length regressions calculated for Slimy Sculpin showed a significant ($P < 0.001$) relationship between weight and length, and adjusted r^2 values ranged from 0.85 to 0.99. The slope of weight-length regressions for Slimy Sculpin were also consistent among sampling sites and years.

Mercury concentrations of Slimy Scuplin sampled from lower M20 Creek were lower than Slimy Sculpin sampled from the Murray River. Mean mercury concentrations ranged from 0.018 mg/kg WW (2011) to 0.027 mg/kg WW (2012). Mercury concentrations in Slimy Sculpin from all sites sampled in all years were lower than the Health Canada guideline of 0.50 mg/kg WW for maximum total mercury in fish tissue (CCME 1999; Health Canada 2011).

Selenium data for whole-body Slimy Sculpin were converted from mg/kg WW to mg/kg DW for direct comparison with draft selenium guidelines for British Columbia (Beatty and Russo 2012). Mean selenium concentrations ranged from 5.1 mg/kg DW in 2004 to 9.4 mg/kg DW in 2012. Thus, mean selenium concentration in whole-body Slimy Scuplin exceeded the draft guideline of 4.0 mg/kg DW sampled from lower M20 Creek during all sampling years. Tissue metals baseline data and predicted changes to fish tissue are discussed in greater detail in Section 9.7.1.3.

South Boundary Creek

South Boundary Creek (Figure 9.5-3) is located on the west side of the Murray River. A reconnaissance of South Boundary Creek was conducted in 2010. The stream bed was dry, and classified as 'no fish habitat'. Barriers to fish migration; however, were not identified along the length of the creek. Thus, fish migration and ephemeral habitat use may be possible during freshet or years of high flow. Based on historical habitat mapping data South Boundary Creek has been classified as a default fish-bearing, S4 stream.

Twenty Creek

Fish habitat was surveyed at Twenty Creek during high flow in 2010 and during low flow in 2012 (Appendix 9-A). Twenty Creek was dry during summer low flow in 2012, thus habitat data could not be collected. In 2010, stream morphology was classified as riffle-pool, with a mean gradient of 1.3%. Mean wetted width was 2.3 m and mean channel width was 3.1 m. Mean depth was 0.2 m and mean bankfull depth was 0.7 m. Gravel and fines were the dominant and sub-dominant bed material, respectively. Cover for fish was provided in by overhanging vegetation, small woody debris, and large woody debris. Rearing and migratory habitats were limited by shallow water depth and flow, and rated as fair. Habitat for other life-history stages (spawning, feeding, and overwintering) were rated as poor or none, due to shallow depth. Overall habitat was rated as marginal.

The upper limit of fish distribution is marked by a bedrock/shale barrier at the top of Reach 2. The overall CPUE for Twenty Creek was 1.51 fish/100 s. Brook Trout were the most abundant fish species, with Mountain Whitefish and Rainbow Trout also present in Twenty Creek (Table 9.5-2). The lower reaches of Twenty Creek were classified as S4 fish-bearing.

Wetlands

One wetland (waterbody ID 00313MURR; Figure 9.5-3) containing marginal fisheries (DES 2011). This wetland feature is located on the west side of the Murray River between M20 and Twenty creeks. The wetland is fed by a small ephemeral tributary originating on the west slope of the Murray River valley. The wetland outflow is impounded by a beaver dam. Seasonal flow from the wetland complex drains through a 215 m segment of Murray FSR ditch and into the Murray River. During periods of sufficient flow, fish migration is possible between the Murray River and the wetland. Three Lake Chub were sampled by backpack electrofishing in November 2010, while schools of adult and YOY Lake Chub were visually observed in the wetland complex (DES 2011; Table 9.5-3). Electrofishing sampling effort, CPUE, and fish biological data for Wetland 00313 were not reported. The wetland complex does not provide suitable habitat for sport-fish species present in the Murray River (DES 2011).

9.6 ESTABLISHING THE SCOPE OF THE EFFECTS ASSESSMENT FOR FISH AND FISH HABITAT

This section includes a description of the scoping process used to identify potentially affected Valued Components (VCs), to select assessment boundaries, and to identify the potential effects of the Project that are likely to arise from the Project's interaction with a VC. Scoping is fundamental to focusing the Application/Environmental Impact Statement (EIS) on those issues where there is the greatest potential to cause significant adverse effects. The scoping process for the assessment of Fish and Fish Habitat consisted of the following steps:

- *Step 1:* conducting a desk-based review of available scientific data, technical reports, and other Project examples to compile a list of potentially affected VCs in the vicinity of the Project;
- *Step 2:* carrying out detailed field baseline studies to fill information gaps and confirm presence/absence of VCs;
- *Step 3:* considering feedback from the Environmental Assessment (EA) Working Group on the proposed list of VCs included in the Application Information Requirements (AIR) and the EIS Guidelines;
- *Step 4:* defining assessment boundaries for each Fish and Fish Habitat, and/or VC; and
- *Step 5:* identifying key potential effects on VCs.

9.6.1 Selecting Valued Components

VCs are components of the natural and human environment that are considered to be of scientific, ecological, economic, social, cultural, or heritage importance (CEA Agency 2013; BC EAO 2013). To be included in the EA, there must be a perceived likelihood that the VC will be affected by the proposed Project. Valued components are scoped into the environmental assessment based on issues raised during consultation on the dAIR (draft AIR) and EIS Guidelines with Aboriginal communities, government agencies, the public and stakeholders. Consideration of certain VCs may also be a legislated requirement, or known to be a concern because of previous project experience. Conservation status was determined by consulting the following sources to identify species at risk and those of conservation concern:

- Canada's *Species at Risk Act* (2002a);
- COSEWIC;
- DFO;
- BC MOE;
- BC Conservation Data Centre; and
- BC Blue List and Red List.

Fish and fish habitat was identified as a VC as a result of the scoping process, and refined as follows:

- Fish (Arctic Grayling and Bull Trout) - direct mortality, sensory disturbance, water quality degradation (metals, contaminants, total suspended solids [TSS]); and
- Fish habitat - habitat loss and alteration.

9.6.1.1 Summary of Valued Components Selected for Assessment

The federal *Fisheries Act* (1985) protects fish of commercial, recreational, and Aboriginal importance. The identified fish and fish habitat VC sub-components included in the Application/EIS process are 'fish' (including Arctic Grayling and Bull Trout), and 'fish habitat'. The identified fish species were grouped together because of similar species habitat requirements (e.g., migratory habitat use within the Murray River, and rearing habitat use in tributary streams) within the LSA and RSA. All proposed fish and fish habitat VC sub-components identified in the AIR were included in the Application/EIS process and the rationale for their inclusion in the Application/EIS process is identified in Table 9.6-1 and described further as follows:

- **Arctic Grayling:** Arctic Grayling were not included in the AIR; however, Arctic Grayling were added as a VC explicitly due to input from local First Nation community meetings. Arctic Grayling is yellow-listed species (species of concern) in BC. They are present in all portions of the Murray River mainstem downstream of Kinuseo Falls. Arctic Grayling distribution varied based upon seasonal habitat use and fish life-history stage. Important habitat use within the Murray River is associated with spring spawning migration, fall downstream migration, and overwintering habitat use downstream of Tumbler Ridge. M19 Creek was the only tributary stream within the Mine Site Assessment Footprint where Arctic Grayling were consistently captured in high abundance. M19 Creek may provide annual spawning and rearing habitat, which may be a limiting habitat type for Arctic Grayling in the LSA. Arctic Grayling were identified by First Nations as an important sport-fish species.
- **Bull Trout:** Bull Trout is a blue-listed species (species of concern) in BC. Bull Trout distribution is widespread within the LSA and RSA based on baseline and historical data. Bull Trout inhabiting the Murray River are members of the Fellers Creek fluvial migratory sub-population. Adults of this sub-population overwinter in the Murray River mainstem and make seasonal migrations to and from the Fellers Creek spawning area. Bull Trout occur in relatively low densities within the Murray River mainstem and accessible tributary stream rearing habitat. Bull Trout are sought and consumed by sport anglers, and thus are also an important sport-fish. Bull Trout were identified as a VC of concern by local First Nations.
- **Fish Habitat:** Fish habitat is defined as those parts of the environment on which fish depend, directly or indirectly, to carry out their life processes (DFO 1986). Fish habitat includes riparian habitat and physical instream features (e.g., large woody debris [LWD], boulders, and pools) that support spawning, rearing, overwintering, and migration life history stages. Potential effects to instream and riparian habitat are addressed through this assessment. Fish habitat is important to the future economic, social, and cultural wellbeing of First Nations and their citizens.

Table 9.6-1. Fish and Fish Habitat Valued Components Included in the Effects Assessment

Valued Components	Identified by*			Rationale for Inclusion
	AG	G	P/S	
Arctic Grayling	X	-	-	Yellow-listed fish species
Bull Trout	X	X	X	Blue-listed fish species Indicator stream ecosystem species
Fish Habitat	X	-	X	Potential degradation or loss of habitat

**AG = Aboriginal Group; G = Government; P/S = Public/Stakeholder*

9.6.2 Selecting Assessment Boundaries

Assessment boundaries define the maximum limit within which the effects assessment is conducted. They encompass the areas within, and times during which, the Project is expected to interact with the VCs, as well as the constraints that may be placed on the assessment of those interactions due to political, social, and economic realities (administrative boundaries), and limitations in predicting or measuring changes (technical boundaries). The definition of these assessment boundaries is an integral part in scoping for Fish and Fish Habitat, and encompasses possible direct, indirect, and induced effects of the Project on Fish and Fish Habitat, as well as the trends in processes that may be relevant.

9.6.2.1 Spatial Boundaries

Local Study Area

A LSA typically encompasses watersheds or sub-watersheds in the immediate area of the Project with a potential for direct effects. For the Project, a LSA effects assessment boundary was defined according to sub-watershed boundaries within the Project as shown in Figure 9.6-1. The LSA includes tributary streams, wetlands, and section of the Murray River that are located within and downstream of the proposed Project components such as access roads, Coal Processing Site, Decline Site, Shaft Site, and extent of underground mining.

Regional Study Area

The northern boundary of the Regional Study Area (RSA) is delineated by the Murray and Wolverine river confluence, and downstream of Tumbler Ridge. The southern boundary of the RSA includes the Murray River upstream of the Project, where reference sites are located for environmental monitoring purposes. The RSA encompasses the entire Project License Area. In addition, the RSA includes numerous past, present, and future project boundaries for the purposes of cumulative environmental effects assessment.

Potential effects and habitat losses are considered with respect to fish and fish habitat existing in the RSA. Potential effects are assessed at the scale of the entire length of a tributary stream, or river reach, as appropriate for that local biological community, and to the extent that these potential effects could affect an entire community rather than individuals. Applicable potential effects on a sub-local scale are noted and considered in this assessment and in the cumulative environmental effects assessment.

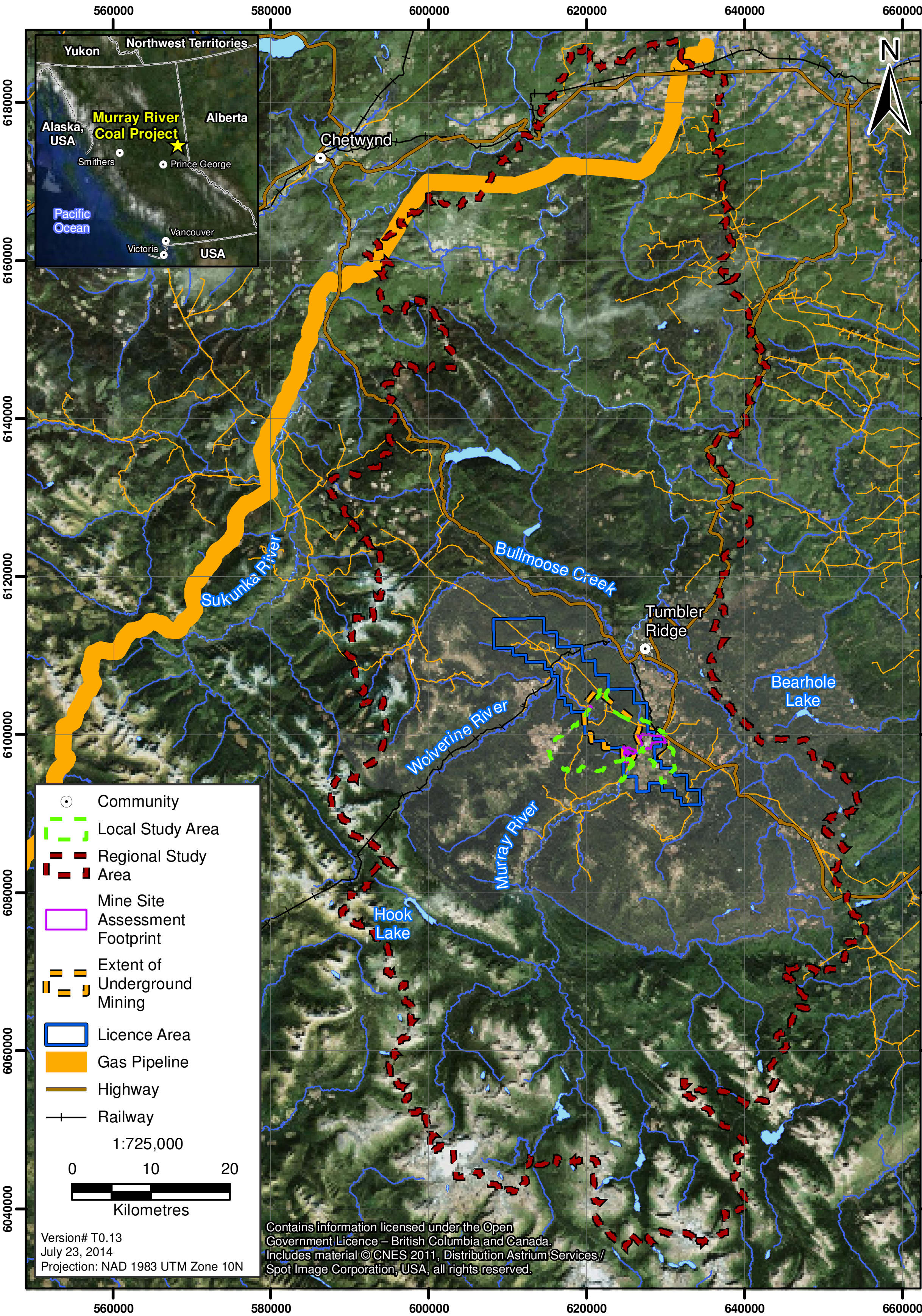
9.6.2.2 Temporal Boundaries

For the purposes of the effects assessment, the temporal boundaries include the following four phases:

- **Construction Phase**: 3 years;
- **Operation Phase**: 25-year run-of-mine life;
- **Decommissioning and Reclamation**: 3 years (includes project decommissioning, abandonment and reclamation activities, as well as temporary closure, and care and maintenance); and
- **Post Closure**: 30 years (includes ongoing reclamation activities and Post Closure monitoring).

Figure 9.6-1

Fish and Fish Habitat Local and Regional Study Area



9.6.2.3 Administrative Boundaries

Several administrative boundaries (i.e., economic realities) were encountered for the effects assessment of fish and fish habitat. Historical information and data sharing agreements were used to expand baseline data sets. These data were collected over numerous sampling years, over various spatial boundaries for projects in the LSA, and by various environmental consulting agencies. Political and social administrative boundaries did not limit the assessment of fish and fish habitat.

9.6.2.4 Technical Boundaries

Limitations in predicting or measuring changes (technical boundaries) for fish and fish habitat were primarily associated with VC fish species. Arctic Grayling and Bull Trout in the RSA are migratory, widely dispersed, and occur in low densities. Due to the following limitations pertaining to Bull Trout, Slimy Sculpin were used as a sentinel species for monitoring changes to fish tissue metals. In particular, Bull Trout from fluvial populations can vary greatly in terms of movement and dispersal within watersheds (Bryant et al. 2004). Bull Trout are also a provincially 'Blue-listed' species. Thus, Bull Trout were considered less desirable as a sentinel species to study effects of water quality changes and associated accumulation of metals in fish tissue. In addition, lethal sampling for tissue metals sample collection is typically limited to three juvenile Bull Trout per site, further prohibiting the development of adequate tissue metals data sets.

9.6.3 Identifying Potential Effects on Fish and Fish Habitat

The effects assessment explicitly addresses potential fish and fish habitat issues and concerns potentially associated with Construction, Operation, Decommissioning and Reclamation, and Post Closure of the Project. The assessment takes a VC approach, focusing on selected fish species, groups of fish species, and fish habitat. VC components include species that have conservation status; biological importance; or are regional species that have particular cultural, social, or economic significance to Aboriginal groups, the province of BC, or other Canadians.

Potential effects to fish and fish habitat identified in the AIR include:

- direct habitat effects due to construction of the mine footprint;
- changes in water quantity and quality in habitats downstream of potential discharges; and
- changes in fish harvesting patterns due to changes in access and human presence.

The Application/EIS describes the methods and standards used to determine the effects of the Project on fish and fish habitat and will consider:

- productive capacity of fish habitat (i.e., link to aquatic resources);
- seasonality of fish utilization and fish-bearing status of potentially affected streams;
- habitat loss or alteration, including aquatic vegetation and sensitive areas such as spawning grounds, nursery areas, overwintering refuges, and migration corridors;
- natural barriers to fish migration;

- changes in stream flow;
- changes in groundwater seepage quantity and quality;
- rare and/or sensitive species and habitat (as listed by COSEWIC or SARA [2002a]);
- species of cultural, spiritual, or traditional use important to First Nations groups;
- traditional ecological knowledge, when and where available;
- changes to the thermal regime of the aquatic environment;
- changes to fish harvesting;
- direct (chronic and acute toxicity) and indirect (changes in periphyton and benthic invertebrates) effects to fish due to changes in water chemistry (e.g., suspended solids, nutrients, major ions, and metals) from Project-related discharges; and
- mitigation and/or offsetting requirements based upon DFO's *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting* (DFO 2013).

Many of the issues listed above overlap in terms of definition and scope. For the purposes of the fish and fish habitat section, they are grouped into four categories for scoping of effects:

- direct mortality;
- erosion and sedimentation;
- change in water quality (e.g., petroleum product spills, sewage effluent, metals, and other chemical toxicity); and
- habitat loss (i.e., removal or physical alteration; change in water quantity; subsidence).

Direct mortality of fish can occur due to fishing (increased access may increase fishing pressure), impact from construction machinery, dewatering during construction, in addition to salvage and relocation of fish to other waterbodies during maintenance activities. Sedimentation can result in the immediate or near-immediate death of fish, such as by smothering embryos in an erosion event.

Noise and vibration were not identified in the AIR, and were not considered potential effects for the Project because there will be no interaction between noise and fish. Noise may be associated with blasting activities during mine activity; however, very limited blasting activities are anticipated for the Project.

Adverse effects to water quality can reduce the health of fish populations. Water quality changes can result in direct and indirect sublethal effects. Sublethal effects are those that may affect the relative health or behaviour of individual fish within the LSA and RSA. Examples include increased stress, decreased health or condition, habitat avoidance, and loss of primary and secondary producers causing decreased fish growth. Sub-lethal effects do not result in direct or immediate mortality, but may ultimately decrease the fitness and fecundity of individual fish, and possibly translate to population level effects in the long term. Potential effects of water quality on aquatic resources (i.e., primary and secondary producers) are addressed in Chapter 8, Assessment of Potential Aquatic Resources Effects. Water quality changes are associated with mine site water management within or immediately downstream of M17, M19, and M19A creeks. Fish are not present within M19A Creek; however, M19A Creek was classified as a default fish-bearing stream.

Habitat loss refers to the removal or physical alteration of the environment that is used either directly or indirectly by fish. The potential for habitat loss or alteration due to water quantity changes in M20, M17, M19, and M19A creeks were be evaluated based upon the results of groundwater and surface water modelling, and associated effects assessments (as described in Chapters 7 and 8, respectively). Potential changes to flow conditions in M20 Creek may occur due to drawdown of the water table, and subsidence.

Potential effects of the Project on fish and fish habitat were identified by reviewing the Project components and baseline data (Appendices 9-A and 9-B). If a Project component was considered not to have any potential for interaction (and thus no potential effect), no further consideration was given to that Project component in the assessment. Table 9.6-2 shows the ranking of potential effects on fish and fish habitat.

9.6.3.1 Summary of Potential Effects to be Assessed for Fish and Fish Habitat

<u>Construction</u>

The ranking exercise identified potential effects caused by Construction associated with direct mortality, erosion and sedimentation (including road and site runoff), and change in water quality (nutrients, and petroleum products).

The use of heavy equipment in and around water may result in direct mortality of fish during upgrades of access roads and development of various site infrastructure. Erosion and sedimentation into streams and waterbodies may be caused by the access road upgrade activities, site clearing and stripping, and development of site drainage and water management. The use of heavy equipment in and around water may result in minor petroleum product spills.

During Construction, the construction and use of sanitary sewer system and associated discharge may affect fish directly or indirectly through alteration of primary and secondary producers causing changes in fish growth.

Potential effects associated with water management and release of contact water into the receiving environment may result. Fish in the Murray River and lower M20 Creek may experience direct (increased metals uptake) and indirect (altered primary and secondary producers causing changes in fish growth) effects associated with the Shaft Site infrastructure and potential changes in water quality.

<u>Operation</u>

The ranking exercise identified potential effects caused by Operation associated with direct mortality, erosion and sedimentation, change in water quality (metals), and habitat loss (change in water quantity).

Table 9.6-2. Ranking Potential Effects on Fish and Fish Habitat

Project Activities		Potential Effects on Fish			Potential Effects on Fish Habitat
		Direct Mortality	Sediment and Erosion	Change in Water Quality	Loss of Fish Habitat
Construction	**Underground Mine**				
	Construction of Big Decline (2 headings - surface and underground)	L	L	L	L
	Haul of waste rock from Big Decline portal to North Site	L	L	L	L
	Ventilation during construction	L	L	L	L
	Development mining of underground service bays, sumps, conveyor headings, etc.	L	L	L	L
	Construct underground conveyor system	L	L	L	L
	Coal Processing Site				
	Surface Preparation				
	Establish site drainage and water management	L	M	M	M
	Site clearing and stripping (CPP site, CCR #1)	L	M	M	M
	Soil salvage for reclamation	L	M	L	L
	Upgrade access roads, parking and laydown areas	M	M	M	M
	Heavy machinery use	M	M	M	M
	Buildings and Services				
	Install domestic water system	L	L	L	L
	Install sanitary sewer system	M	M	M	L
	Install natural gas and electricity distribution network	L	L	L	L
	Construct main fuel station	L	L	L	L
	Construct buildings (e.g., maintenance, administration, warehouse)	L	L	L	L
	Construct raw coal and clean coal stockpile areas	L	L	L	L
	Construct coal preparation plant buildings and install/commission equipment	L	L	L	L
	Construct surface conveyor system	L	L	L	L
	Construct rail load-out facilities	L	L	L	L
	Shaft Site				
	Upgrades to infrastructure within existing site	L	L	L	L
	Addition of waste rock within existing storage area	L	L	L	L
	Management of runoff from waste rock pile and release to receiving environment (M20 Creek)	L	M	M	M
	Decline Site				
	Upgrades to infrastructure within existing site	L	L	L	L
	Management of water from underground activities and release by exfiltration to ground	L	L	L	L
	Traffic and Transportation				
	Transportation of materials to and from site	L	L	L	L
	Recycling and solid waste disposal	L	L	L	L
	Shuttling workforce to and from site	L	L	L	L
	Workforce and Administration				
	Hiring and management of workforce	L	L	L	L
	Taxes, contracts, and purchases	L	L	L	L

(continued)

Table 9.6-2. Ranking Potential Effects on Fish and Fish Habitat (continued)

	Project Activities	Potential Effects on Fish			Potential Effects on Fish Habitat
		Direct Mortality	Sediment and Erosion	Change in Water Quality	Loss of Fish Habitat
Operations	**Underground Mine**				
	Longwall panel mining, and development mining	L	L	L	L
	Ventilation from underground	L	L	L	L
	Methane management	L	L	L	L
	Secondary shaft construction	L	L	L	L
	Underground seepage collection and water management	L	L	L	L
	Surface subsidence	L	L	L	M
	Coal Processing Site				
	Coal Processing Plant				
	Stockpiles of raw coal	L	L	L	L
	Operation of coal preparation plant and conveyor system	L	L	L	L
	Stockpiles of clean coal and middlings	L	L	L	L
	Operation of rail loadout	L	L	L	L
	CCR				
	CCR Pile development	L	M	M	L
	Site clearing and stripping (expansion of CCR #1, construction of CCR #2)	L	M	M	M
	Seepage collection system	L	M	M	L
	Water Management				
	Management of water brought to surface from underground	L	L	M	L
	Management of seepage from CCR	L	L	M	L
	Management of other site contact water	L	L	M	L
	Maintenance of site ditching and water management infrastructure	L	M	M	M
	Release of excess contact water to receiving environment	L	M	M	M
	Shaft Site				
	Maintenance of infrastructure within existing site	L	L	L	L
	Progressive reclamation of waste rock pile	L	L	L	L
	Management of runoff from waste rock pile and release to receiving environment (M20 Creek)	L	M	M	M
	Decline Site				
	Maintenance of infrastructure within existing site	L	L	L	L
	Secondary Shafts Site				
	Site preparation and construction of shafts	L	L	L	L
	Maintenance of infrastructure within existing site	L	L	L	L
	Utilities, Power, and Waste Handling				
	Electrical power use	L	L	L	L
	Natural gas use	L	L	L	L
	Domestic water use	L	L	L	L
	Domestic sewage handling	L	L	L	L
	Recycling and solid waste disposal	L	L	L	L

(continued)

Table 9.6-2. Ranking Potential Effects on Fish and Fish Habitat (completed)

Phase	Project Activities	Potential Effects on Fish: Direct Mortality	Potential Effects on Fish: Sediment and Erosion	Potential Effects on Fish: Change in Water Quality	Potential Effects on Fish Habitat: Loss of Fish Habitat
Operations *(cont'd)*	**Heavy Machinery, Traffic, and Transportation**				
	Shuttling workforce to and from site	L	L	L	L
	Transportation of materials to and from site	L	L	L	L
	Surface mobile equipment use	L	L	L	L
	Road maintenance	M	M	M	L
	Fuel storage	L	L	L	L
	Workforce and Administration				
	Hiring and management of workforce	L	L	L	L
	Taxes, contracts, and purchases	L	L	L	L
Decommissioning and Reclamation	**Infrastructure Removal and Site Reclamation**				
	Facility tear down and removal	L	L	L	L
	Reclamation of plant site	L	L	L	L
	Reclamation of on-site roads and rail lines	M	M	M	M
	Recycling and solid waste disposal	L	L	L	L
	Heavy Machinery, Traffic, and Transportation				
	Shuttling workforce to and from site	L	L	L	L
	Transportation of materials to and from site	L	L	L	L
	Surface mobile equipment use	L	L	L	L
	Fuel storage	L	L	L	L
	CCR				
	Reclamation of CCR	L	M	M	L
	Seepage collection system	L	L	L	L
	Site water management and discharge to receiving environment	L	M	M	M
	Underground Mine				
	Infrastructure tear down and removal	L	L	L	L
	Geotechnical and hydrogeological assessment and bulkhead installation	L	L	L	L
	Groundwater monitoring	L	L	L	L
	Workforce and Administration				
	Hiring and management of workforce	L	L	L	L
	Taxes, contracts, and purchases	L	L	L	L
Post-closure	**Shaft Site**				
	Waste rock pile seepage monitoring	L	L	L	L
	CCR				
	Seepage collection system	L	L	L	L
	Site water management and discharge to receiving environment	L	M	M	M
	Underground Mine				
	Groundwater monitoring	L	L	L	L

L	*Negligible to minor adverse effect expected; implementation of best practices, standard mitigation and management measures; no monitoring required, no further consideration warranted.*
M	*Potential moderate adverse effect requiring unique active management/monitoring/mitigation; warrants further consideration.*
H	*Key interaction resulting in potential significant major adverse effect or significant concern; warrants further consideration.*

Potential effects identified for Operation are similar to those anticipated to occur during Construction. Potential effects associated with erosion and sedimentation may result predominantly from maintenance activities such as road grading and maintenance. Direct mortality may occur during maintenance of access road stream crossings.

Potential effects associated with water management and release of contact water into the receiving environment may result. Fish in the Murray River and lower M19A Creek may experience direct (increased metals uptake) and indirect (altered primary and secondary producers causing changes in fish growth) effects associated with the Coal Processing Site infrastructure and potential changes in water quality during Operation.

Habitat loss may occur due to changes in flow conditions in M20 Creek resulting from groundwater drawdown and subsidence.

Decommissioning and Reclamation, and Post Closure

The ranking exercise identified potential effects caused by the Decommissioning and Reclamation and Post Closure phases. Potential effects were associated with erosion and sedimentation, and change in water quality (metals, and petroleum products).

Most activities during these phases involve decommissioning of Project infrastructure and reclamation of the site to baseline condition. These activities will involve the use of heavy equipment in or around water for the decommissioning of Project infrastructure (e.g., road and bridges). As a result of working in and around water, erosion and sedimentation of waterbodies (e.g., sedimentation to streams from road decommissioning) could occur when conducting Decommissioning and Reclamation, and Post Closure activities.

The introduction of metals may cause fish toxicity and indirect effects (altered primary and secondary producers causing changes in fish growth) via site water management activities and discharge to receiving environment.

9.7 Effects Assessment and Mitigation for Fish and Fish Habitat

9.7.1 Key Effects on Fish and Fish Habitat

Activities during the Construction, Operation, Decommissioning and Reclamation, and Post Closure phases vary depending upon the type of infrastructure. Some of these activities could potentially affect fish and fish habitat.

From the scoping and rating assessment, four potential effects were identified. These included direct mortality, erosion and sedimentation, change in water quality (including minor petroleum product spills, sewage effluent, metals, and other chemical toxicity), as well as habitat loss and alteration (Table 9.6-2). Physical changes to fish habitat are addressed in this chapter. The direct adverse effects on primary and secondary producers and their indirect effects on fish (e.g., growth and fecundity) are also addressed within this chapter. Each of these potential effects, including mitigation and residual effects, will be discussed in detail in the following sections. Adverse effects of water quality on primary and secondary producers (i.e., related to fish habitat) are addressed in Chapter 8, Assessment of Potential Aquatic Resources Effects.

The fish and fish habitat effects assessment was prepared according to applicable scientifically defensible management guidelines. The assessment was based upon currently knowledge of species behaviour, presence, distribution, population biology, and ecology. Consideration was also given to linkages between predicted physical and biological changes resulting from the proposed development on both the individual and local population levels.

Given the hierarchical nature of biological systems, potential effects on fish are discussed with regard to changes at both the individual level (i.e., behaviour, physiological condition, and survival) and the population level (i.e., population size, distribution, mortality rate, and reproductive fitness). Potential effects on the population level are of greater concern than those at the individual and this assessment primarily focuses on the effects to local populations. However, population boundaries are not always distinct. A population is a group of organisms coexisting at the same time and place and capable of interbreeding, or is a group of non-specific organisms that occupy a loosely defined geographic region and exhibit reproductive continuity from generation to generation. Because the exact geographic boundaries for the local populations considered in this assessment are dynamic, the population level assessment is predominantly qualitative.

9.7.1.1 Direct Mortality

Project-specific modes with the potential to impose direct mortality on fish in the LSA include the construction and maintenance of roads and bridges (Table 9.6-2). For the Project, direct mortality could take place during all Project phases because the access roads and bridges will require periodic maintenance and decommissioning.

The geographic scope of direct mortality will be localized, but localized effects can result in far-reaching effects depending on the fish species affected, their life history characteristics, and abundance. Impact with construction machinery and increased fishing access can affect fish species by causing mortality to all fish life history stages.

Potential causes of direct mortality to fish in the LSA and RSA include construction equipment working in water for access road maintenance, dewatering, salvage and relocation of fish downstream during construction activities. Effects from direct mortality are expected to be low.

Another form of direct mortality is increased fishing pressure and harvesting of fish species arising from increased road access. Although all of the Project workers will not be anglers, some proportion of the workforce will be, and this influx has the potential to increase the fishing pressure on sport and traditional fish populations in reaches of the Murray River within the LSA and RSA.

9.7.1.2 Erosion and Sedimentation

Potential Project-specific sources of erosion and sedimentation include access roads, Coal Processing Site, Decline Site, Shaft Site, and sites with water management infrastructure (Table 9.6-2). Sedimentation and erosion can take place during the Construction, Operation, and Decommissioning and Reclamation phases from a number of Project activities. These activities have the potential to cause temporary increases in turbidity. The geographic scope of erosion and sedimentation can range from localized to far-reaching events, depending on the amount and type (e.g., particle size) of sediment that is introduced into the aquatic environment.

High levels of TSS can occur from erosion events during maintenance activities and construction (e.g., materials accidently pushed into streams, loosening materials along stream banks) and runoff during spring freshet and summer rains. Other sources of TSS include particulates from construction equipment activity, road runoff, and dust. Erosion and sedimentation can affect fish habitat in many ways, including the physical alterations to habitat in the form of increased turbidity. In turn, sedimentation can affect aquatic organisms by smothering primary and secondary producers at various life stages, reducing visibility, diminishing feeding efficiency, increasing exposure to elevated metal concentrations, and leading to habitat avoidance by aquatic organisms.

Erosion events can be lethal to incubating fish eggs in streambeds and larvae present in the substrate because of fine sediment being deposited within the interstitial spaces of gravel (Platts and Megahan 1975; Lisle 1989). Sediment can block oxygen transport across the membrane to the growing embryo, creating hypoxic (low oxygen) or even anoxic (no oxygen) conditions (Turnpenny and Williams 1980; Ingendahl 2001). Also, larvae that have hatched can become buried under the sediment, which creates a physical barrier that prevents them from emerging (Chapman 1988; Crisp 1996). High TSS levels can lead to behavioural changes in fish, such as alterations in migration routes and spawning behaviour (Cordone and Kelley 1961).

TSS and fine particulates produced by erosion can cause minor physical damages, such as gill damage, leading to decreased fitness because of reduced ability to feed, spawn, and avoidance predators. Increased respiratory and osmoregulatory stress can occur as a result of abrasion to the gill filaments and matting action reducing the surface area (Cordone and Kelley 1961; Newcombe and MacDonald 1991; Sutherland and Meyer 2007). Moderate gill damage to small riverine fish has been shown to occur at suspended sediment levels greater than 100 mg/L, with severe damage at 500 mg/L (Sutherland and Meyer 2007). Eye damage also is possible, but sediment loads would have to be very high in fast-moving water because the continuous secretion of mucus washes away most sediment particles and protects the eyes.

The resulting decrease in water clarity, due to increased TSS, and enhanced particle loads could reduce primary production by decreasing photosynthesis and through scouring of the substrates they adhere to. Sediments may accumulate in some streams that are shallow with low discharge rates. Silt deposited from erosion and erosion events can affect invertebrate production as gravel interstices are filled by silt, and algae are buried or abraded (Beschta et al. 1995). In these instances, invertebrate assemblages are typically made up of a few tolerant, colonizing species (Newbold, Erman, and Roby 1980; Murphy, Hawkins, and Anderson 1981; Hawkins, Murphy, and Anderson 1982; Laniberti et al. 1991). This loss of substrate complexity, including LWD, tends to decrease the diversity of aquatic invertebrates.

Recovery from sedimentation will be more rapid in high-velocity streams relative to wetlands or lakes. Many streams and rivers in the RSA have naturally high sediment loads due to natural sediment sources (e.g., M20 Creek), and thus will not be affected to the extent of clear, low-velocity streams.

9.7.1.3 Change in Water Quality

The health of fish, other aquatic life, and sediment quality are all intimately linked to the quality of the water in the aquatic environment. Chemical contaminants may enter the aquatic environment from a number of sources as a result of Project activities in all phases and may pose a risk to fish.

A number of different chemical classes may be used or naturally present within the LSA and RSA. Examples of types of chemicals that could be introduced into the aquatic environment as a result of Project activities include metals, process chemicals (e.g., chemicals used in water treatment), petroleum products, and nitrogen and phosphorus associated with sewage disposal. Each of these classes of chemicals will be discussed, including potential sources and general potential impacts on fish and fish habitat.

The potential effects considered in this section relate only to the Project activities that may occur under normal operating conditions. Effects related to substantial spills or unusual events (e.g., accidents, infrastructure failure) are addressed in Chapter 21, Accidents and Malfunctions.

Identification of metals that may be of concern to fish and fish habitat that were associated with seepage from the CCR North and South sites were determined quantitatively in Chapter 8, Assessment of Potential Surface Water Quality Effects, based on water quality predictions during various phases of the Project. The potential impacts of Project activities on fish, from the introduction of nitrogen, phosphorus, and chemicals, were assessed quantitatively.

<u>Metals</u>

Metals occur naturally in the water and sediments of the LSA and RSA due to the presence of coal-or mineral-rich deposits, sometimes at baseline concentrations above federal and/or provincial guideline limits.

Exposure of fish in the aquatic environment to high concentrations of metals can lead to both lethal and sub-lethal effects. At high enough concentrations, metals can cause mortality in exposed organisms. At lower concentrations, sub-lethal effects may occur; although these effects do not cause immediate mortality, they can affect population dynamics or stability in the long term. The interaction of water hardness/softness and acidity with metals can change metal speciation and increase the mobility and bioavailability of metals in the aquatic environment, thereby altering the toxicological implications of exposure. Changes in pH can mobilize surface-bound metals, leading to increased potential for toxic effects on fish. The toxicology of mixtures of metals and other chemicals in the aquatic environment is poorly understood, although it is known that antagonistic, additive, synergistic, or potentiating effects are possible outcomes.

Fish are sensitive to changes in environmental pH. Exposure to acidic aquatic environments can lead to sub-lethal effects such as alteration in blood acid-base regulation and disruption of ionoregulation (Wood 1992). In chronic exposures, contact with low pH can lead to decreased growth and development, impaired swimming ability, increased stress and impaired smoltification in fish (Wood 1989; Kennedy and Picard 2012).

Changes in pH have been shown to cause lethality at high concentrations and various other toxic effects at lower concentrations, which are largely attributed to the metal content. High, acutely lethal concentrations of metals or changes in pH are not expected to occur in the LSA and RSA, as addressed in Chapter 8; thus, acutely lethal effects are not considered likely to occur as a result of normal Project activities, and are not considered further.

Sub-lethal toxicity of metals in fish can manifest as effects on various physiological functions, and can be different for each metal. Toxicity occurs because of metal interaction with the external surfaces of the organism or metal uptake through water or diet and can result in osmoregulatory impairment, immunotoxicity, neurotoxicity, endocrine disruption, embryotoxicity, or behavioural changes (Evans 1987; Baatrup 1991; Kime 1998; Hansen et al. 1999; Sanchez-Dardon et al. 1999; Todd et al. 2006; Chapman et al. 2009). Exposure to metals can also cause a generalized stress response in fish that can lead to similar effects including immunosuppression, osmoregulatory imbalance, and decreased growth because of higher metabolic demands (Todd et al. 2006). The stress response is caused by metal accumulation or damage at the gill, or metal uptake and pH surges that in turn stimulate increased gas exchange (Wood 1992). Olfactory toxicity in fish has also been associated with exposure to low pH, metals, and various other contaminants (Tierney et al. 2010). Some metals, such as copper, can interact with sensory nerves located in the olfactory rosettes causing avoidance responses or impairment of the ability to “smell,” which can alter normal olfactory-mediated behaviours (Tierney et al. 2010).

Exposure of fish to metals in their aquatic habitat can lead to accumulation of those contaminants in fish tissue. Several fish species (Slimy Sculpin, Finescale Dace, Brook Trout, and Bull Trout) were sampled for fish tissue metals concentrations within the LSA and RSA from 2004 to 2012 (Figure 9.5-2; Table 9.5-5). Numerous studies emphasize the importance of including sentinel species in order to detect biological effects following environmental impact. Martinez-Gomez et al. (2010) provide multiple criteria for the selection and sampling of a sentinel species to detect biological effects after oil spills. Sentinel species should be representative of the environment, and, where possible, it should be a species for which biological-effects techniques are well documented. Sample sizes as small as eight individuals of each sex per study area may be appropriate when effects occur at low prevalence rates, but that larger sample sizes would be necessary at higher prevalence rates. Slimy Sculpin were selected because they most closely fulfil the sentinel species criteria, and they are common within the Project area.

Spencer et al. (2008) and Arciszewski et al. (2010) suggest that Slimy Sculpin are an ideal sentinel species for effects monitoring in Canada for the following reasons:

- Higher abundances and greater geographical distributions than most other northern species, and therefore they are easily collected;
- Typically sedentary and have limited home ranges due to territorial behaviour and restricted mobility. An important assumption regarding study design and sentinel species selection is that fish collected at a given site will exhibit responses and characteristics that reflect their local environments (Gibbons et al. 1998; Arciszewski et al. 2010). As such, the lack of movement between locations, especially between reference and exposure sites, is a key factor in the selection of Slimy Sculpin as a sentinel species;

- Relatively short lifespan and sexual maturation at approximately 2 years. These biological characteristics foster alterations in reproduction and growth in response to environmental change at a faster rate than other longer-lived species (e.g., Bull Trout and Mountain Whitefish);
- Easily aged using otoliths, which yield the most accurate growth estimates;
- Fecundity between 100 and 1,400 eggs; and
- Benthic position in the food web (Gray et al. 2004; Arciszewski et al. 2010). Benthivorous fish can be a good choice for fish population surveys because they are usually less mobile than pelagic species and they feed at the water-sediment interface where metals can accumulate (Ribey et al. 2002).

Tables 9.7-1 to 9.7-4 summarize mean tissue metal concentrations for Slimy Sculpin sampled within the LSA and RSA in 2004, 2005, 2011, and 2012. The concentration of 25 metals and tissue moisture were analysed for each year. Presently, mercury is the only metal for which Health Canada or CCME guidelines exist for fish tissue (CCME 1999; Health Canada 2011). The aquatic life guideline for selenium concentration in fish for British Columbia (Beatty and Russo 2012) lists two thresholds for selenium: 1) 11 µg/g DW (equivalent to 11 mg/kg DW) in ovary or eggs, and 2) 4 µg/g DW (equivalent to 4 mg/kg DW) in muscle. Thus, concentrations of mercury and selenium from Slimy Sculpin are summarized and discussed below.

Mercury can also bioaccumulate through the food chain and pose a greater risk to higher trophic level organisms. Elevated tissue mercury concentrations in fish have been associated with sublethal effects such as decreased growth, developmental and reproduction abnormalities, and neurological and behavioural effects (Kidd and Batchelar 2012). Mean mercury concentrations in Slimy Sculpin tissues were highest at Murray River mainstem sites and lowest at tributary stream sites. The highest mean concentration was recorded at MR US in 2011 and MR DS in 2012 (0.044 mg/kg WW at both sites), followed by MR US in 2012 (0.038 mg/kg WW). The lowest mean mercury concentrations were 0.018 mg/kg WW (M20, 2011) and 0.021 mg/kg WW (M20, 2004). Mercury concentrations in Slimy Sculpin from all sites sampled in all years were lower than the Health Canada guideline of 0.50 mg/kg WW for maximum total mercury in fish tissue (CCME 1999; Health Canada 2011).

Selenium has been associated with reproductive and developmental toxicity, particularly in egg-laying vertebrates (Chapman et al. 2009). Mean selenium concentrations measured in Slimy Sculpin were higher at tributary sites and lower at Murray River mainstem sites. The highest mean selenium concentrations were recorded at M20 Creek (2.4 mg/kg WW in 2012 and 2.3 mg/kg WW in 2011). The lowest mean selenium concentrations were recorded at MR DS (0.8 mg/kg WW in 2005 and 0.9 mg/kg WW in 2012).

Table 9.7-1. Summary of Mean Tissue Metal Concentrations in Slimy Sculpin, 2012

		Detection	Murray River DS (n = 7), Receiving				MR3 (n = 8), Reference				MR4 (n = 8), Receiving				Murray River US (n = 8), Reference				M20 US (n = 8), Reference			
Variable	Units	Limit	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max
Fork Length	mm	n/a	66	4	55	81	54	2	45	65	62	2	52	75	66	3	58	78	88	3	76	105
Moisture	%	0.1	75.5	0.5	73.4	77.2	73.0	0.4	71.2	74.7	74.2	0.7	70.7	76.5	73.9	0.5	70.9	74.9	74.8	0.7	71.9	77.7
Aluminum (Al)	mg/kg WW	2	33	11	6	88	25	9	5	81	80	21	18	191	24	6	4	62	44	16	6	149
Arsenic (As)	mg/kg WW	0.01	0.06	0.00	0.04	0.07	0.06	0.00	0.05	0.08	0.07	0.01	0.04	0.10	0.06	0.00	0.05	0.08	0.06	0.01	0.37	0.11
Barium (Ba)	mg/kg WW	0.01	4.44	0.30	3.26	5.53	3.66	0.28	2.53	4.96	3.78	0.49	2.00	5.57	3.55	0.60	1.07	6.49	5.09	0.68	1.47	7.08
Calcium (Ca)	mg/kg WW	2	14,929	933	11,300	17,700	15,563	952	11,900	19,700	10,419	1,332	6,560	18,400	14,368	1,896	5,130	21,400	10,701	1,752	4,660	18,100
Chromium (Cr)	mg/kg WW	0.1	0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.5	0.1	0.0	0.1	0.2	0.1	0.0	0.1	0.3
Copper (Cu)	mg/kg WW	0.01	0.72	0.05	0.56	0.86	0.66	0.04	0.54	0.90	1.28	0.19	0.81	2.46	0.70	0.07	0.57	1.17	0.63	0.03	0.52	0.73
Lead (Pb)	mg/kg WW	0.02	0.05	0.00	0.04	0.06	0.03	0.00	0.01	0.05	0.05	0.01	0.02	0.09	0.02	0.00	0.01	0.04	0.03	0.01	0.01	0.09
Magnesium (Mg)	mg/kg WW	1	403	12	371	453	432	19	358	525	408	25	310	525	429	28	257	507	375	28	245	476
Manganese (Mn)	mg/kg WW	0.01	5.32	0.47	3.71	6.93	4.57	0.42	3.43	6.83	6.08	0.68	3.34	9.01	5.46	0.63	2.71	7.90	2.55	0.36	0.75	3.66
Mercury (Hg)	mg/kg WW	0.003	0.044	0.009	0.023	0.087	0.027	0.004	0.020	0.055	0.032	0.003	0.023	0.042	0.038	0.007	0.021	0.081	0.027	0.004	0.019	0.052
Molybdenum (Mo)	mg/kg WW	0.01	0.03	0.00	0.02	0.04	0.02	0.00	0.02	0.03	0.03	0.00	0.02	0.04	0.02	0.00	0.01	0.03	0.01	0.00	0.01	0.02
Selenium (Se)	mg/kg WW	0.2	0.9	0.1	0.6	1.2	1.3	0.1	0.8	1.6	1.4	0.1	1.1	1.9	1.2	0.1	0.8	1.4	2.4	0.1	2.0	2.8
Selenium (Se)	mg/kg DW	0.2	3.7	0.3	2.7	4.9	4.9	0.4	2.9	6.2	5.4	0.4	4.3	7.3	4.5	0.3	3.1	5.3	9.4	0.4	7.8	10.8
Strontium (Sr)	mg/kg WW	0.01	10.67	0.89	7.89	13.60	10.44	0.69	7.77	13.10	7.57	1.15	4.46	14.30	9.64	1.42	3.08	16.20	9.37	1.55	4.25	17.30
Zinc (Zn)	mg/kg WW	0.1	26.8	2.4	18.0	38.2	23.5	0.9	19.6	27.0	22.5	0.8	20.4	27.4	26.7	2.7	18.5	41.8	22.5	1.5	15.8	28.0

Notes: n = number of samples, SE = standard error of the mean, min = minimum, max = maximum, WW = wet weight, DW = dry weight

Shaded cells indicate exceedance of draft guideline for selenium concentration in fish muscle of 4 mg/kg DW (Beatty and Russo 2012).

Health Canada guideline for maximum total mercury in fish tissue = 0.50 mg/kg WW (CCME 1999; Health Canada 2011).

Table 9.7-2. Summary of Mean Tissue Metal Concentrations in Slimy Sculpin, 2011

		Detection	M20 DS (n = 8), Receiving				Murray River RB (n = 8), Reference				Murray River DS (n = 8), Receiving				Murray River US (n = 7), Reference			
Variable	Units	Limit	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max
Fork Length	mm	n/a	85	2	77	95	51	2	35	75	52	3	28	89	62	3	39	98
Moisture	%	0.1	71.0	0.4	69.2	72.8	73.2	0.5	71.9	75.8	74.1	0.6	71.9	76.3	74.7	0.6	72.9	78.0
Aluminum (Al)	mg/kg WW	2	37	11	9	95	93	14	35	140	99	22	38	193	57	23	10	162
Arsenic (As)	mg/kg WW	0.01	0.05	0.00	0.03	0.07	0.07	0.00	0.06	0.08	0.06	0.01	0.04	0.12	0.06	0.01	0.04	0.09
Barium (Ba)	mg/kg WW	0.01	5.53	0.30	4.74	6.82	4.32	0.26	3.21	5.08	5.07	0.44	3.86	7.80	4.24	0.58	2.39	6.85
Calcium (Ca)	mg/kg WW	2	15,650	1,035	10,700	19,100	15,388	1,105	11,000	19,800	17,150	1,470	11,100	23,500	17,300	2,317	9,500	25,200
Chromium (Cr)	mg/kg WW	0.1	0.1	0.0	0.1	0.2	0.4	0.1	0.1	0.8	0.3	0.1	0.1	0.5	0.3	0.0	0.1	0.4
Copper (Cu)	mg/kg WW	0.01	0.75	0.04	0.55	0.92	0.94	0.03	0.85	1.10	1.05	0.06	0.77	1.35	0.80	0.05	0.66	0.98
Lead (Pb)	mg/kg WW	0.02	0.03	0.00	0.01	0.05	0.04	0.00	0.02	0.05	0.05	0.01	0.03	0.08	0.03	0.01	0.01	0.07
Magnesium (Mg)	mg/kg WW	1	459	12	418	507	454	12	392	492	491	47	402	806	470	26	385	564
Manganese (Mn)	mg/kg WW	0.01	3.66	0.44	2.13	5.66	7.23	0.44	5.54	8.94	8.38	0.94	5.10	13.50	6.49	0.76	4.08	9.45
Mercury (Hg)	mg/kg WW	0.003	0.018	0.002	0.014	0.025	0.035	0.003	0.024	0.047	0.036	0.006	0.022	0.073	0.044	0.007	0.030	0.818
Molybdenum (Mo)	mg/kg WW	0.01	0.02	0.00	0.01	0.02	0.03	0.00	0.02	0.03	0.03	0.01	0.02	0.07	0.02	0.00	0.01	0.03
Selenium (Se)	mg/kg WW	0.2	2.3	0.2	1.3	2.8	1.5	0.1	1.3	1.7	1.0	0.0	0.9	1.1	1.1	0.1	0.8	1.4
Selenium (Se)	mg/kg DW	0.2	7.9	0.6	4.2	9.5	5.6	0.3	4.8	7.2	3.9	0.1	3.4	4.1	4.3	0.3	3.4	5.6
Strontium (Sr)	mg/kg WW	0.01	12.25	0.99	7.28	15.40	10.36	0.71	7.88	13.60	11.25	0.90	7.47	15.30	10.66	1.54	5.36	16.80
Zinc (Zn)	mg/kg WW	0.1	24.4	1.0	19.4	28.9	25.5	0.7	23.4	29.1	27.5	1.4	22.2	32.8	29.6	2.5	22.0	41.8

Notes: n = number of samples, SE = standard error of the mean, min = minimum, max = maximum, WW = wet weight

Shaded cells indicate exceedance of draft guideline for selenium concentration in fish muscle of 4 mg/kg DW (Beatty and Russo 2012).

Boxed cells indicate exceedance of Health Canada guideline for maximum total mercury in fish tissue of 0.50 mg/kg WW (CCME 1999; Health Canada 2011).

Table 9.7-3. Summary of Mean Tissue Metal Concentrations in Slimy Sculpin, 2005

		Detection	Murray River US (n = 5), Reference				Murray River DS (n = 5), Receiving				Murray River RB (n = 5), Reference			
Variable	Units	Limit	Mean	SE	Min	Max	Mean	SE	Min	Max	Mean	SE	Min	Max
Fork Length	mm	n/a	65	2	59	70	70	2	65	74	62	5	48	73
Moisture	%	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum (Al)	mg/kg WW	2	30	6	12	45	49	5	32	61	87	12	64	129
Arsenic (As)	mg/kg WW	0.01	0.07	0.01	0.05	0.09	0.05	0.00	0.05	0.06	0.07	0.01	0.06	0.10
Barium (Ba)	mg/kg WW	0.01	4.06	0.20	3.50	4.46	4.85	0.29	3.86	5.61	5.01	0.34	4.02	6.07
Calcium (Ca)	mg/kg WW	2	15,700	1,170	13,100	20,000	15,420	623	13,000	16,400	13,800	539	12,400	15,100
Chromium (Cr)	mg/kg WW	0.1	-	-	-	-	-	-	-	-	0.1	0.1	0.0	0.3
Copper (Cu)	mg/kg WW	0.01	0.82	0.04	0.72	0.94	0.67	0.03	0.59	0.73	0.95	0.04	0.86	1.06
Lead (Pb)	mg/kg WW	0.02	-	-	-	-	0.03	0.01	0.02	0.05	0.05	0.01	0.04	0.07
Magnesium (Mg)	mg/kg WW	1	415	16	376	462	410	15	366	458	432	9	407	456
Manganese (Mn)	mg/kg WW	0.01	6.08	0.54	5.14	8.17	5.01	0.36	4.01	6.04	6.57	0.37	5.65	7.30
Molybdenum (Mo)	mg/kg WW	0.01	0.02	0.00	0.01	0.03	0.02	0.00	0.01	0.02	0.03	0.00	0.02	0.03
Selenium (Se)	mg/kg WW	0.2	0.9	0.1	0.7	1.1	0.8	0.0	0.7	0.9	1.1	0.1	0.9	1.2
Selenium (Se)	mg/kg WW	0.2	3.4	0.3	2.6	4.4	3.5	0.2	2.8	3.8	3.9	0.2	3.3	4.6
Strontium (Sr)	mg/kg WW	0.01	10.79	0.80	9.07	13.70	15.18	2.56	10.90	22.50	9.74	0.39	8.39	10.50
Zinc (Zn)	mg/kg WW	0.1	26.2	1.8	22.0	30.8	25.9	2.0	20.3	31.1	20.8	0.4	19.2	21.4

Notes: n = number of samples, SE = standard error of the mean, min = minimum, max = maximum, WW = wet weight

Dashes = all samples were below detection limits

Shaded cells indicate exceedance of draft guideline for selenium concentration in fish muscle of 4 mg/kg DW (Beatty and Russo 2012).

Health Canada guideline for maximum total mercury in fish tissue = 0.50 mg/kg WW (CCME 1999; Health Canada 2011).

Table 9.7-4. Summary of Mean Tissue Metal Concentrations in Slimy Sculpin, 2004

		Detection	SS-FT (n = 5), Reference				M20 DS (n = 5), Receiving			
Variable	Units	Limit	Mean	SE	Min	Max	Mean	SE	Min	Max
Fork Length	mm	n/a	59	2	41	82	63	5	44	111
Moisture	%	0.1	76.6	0.3	75.6	77.5	77.0	0.6	76.1	79.2
Aluminum (Al)	mg/kg WW	10	21	3	14	28	36	10	11	68
Arsenic (As)	mg/kg WW	0.05	0.01	0.01	0.07	0.07	0.05	0.01	0.01	0.07
Barium (Ba)	mg/kg WW	0.05	3.02	0.18	2.51	3.51	6.14	0.47	5.43	7.98
Calcium (Ca)	mg/kg WW	10	12,136	594	10,857	14,220	16,079	2,171	10,997	23,541
Chromium (Cr)	mg/kg WW	0.5	-	-	-	-	-	-	-	-
Copper (Cu)	mg/kg WW	0.05	0.72	0.02	0.64	0.75	0.70	0.06	0.51	0.86
Lead (Pb)	mg/kg WW	0.1	-	-	-	-	-	-	-	-
Magnesium (Mg)	mg/kg WW	3	383	9	373	422	422	22	389	509
Manganese (Mn)	mg/kg WW	0.05	3.65	0.11	3.46	3.94	3.17	0.42	2.08	4.02
Mercury (Hg)	mg/kg WW	0.00125	0.03250	0.00273	0.02660	0.04190	0.02110	0.00365	0.01480	0.03440
Molybdenum (Mo)	mg/kg WW	0.05	-	-	-	-	-	-	-	-
Selenium (Se)	mg/kg WW	0.025	0.898	0.049	0.725	1.017	1.164	0.088	0.934	1.336
Selenium (Se)	mg/kg DW	0.025	3.836	0.201	3.000	4.200	5.068	0.343	3.900	5.700
Strontium (Sr)	mg/kg WW	0.05	8.44	0.39	7.49	9.65	11.79	0.98	9.42	15.01
Zinc (Zn)	mg/kg WW	0.5	22.8	0.7	20.0	23.8	26.5	1.2	23.1	30.4

Notes: n = number of samples, SE = standard error of the mean, min = minimum, max = maximum, WW = wet weight,

Dashes = all samples were below detection limits

Shaded cells indicate exceedance of draft guideline for selenium concentration in fish muscle of 4 mg/kg DW (Beatty and Russo 2012).

Health Canada guideline for maximum total mercury in fish tissue = 0.50 mg/kg WW (CCME 1999; Health Canada 2011).

Selenium data for whole-body Slimy Sculpin were converted from mg/kg WW to mg/kg DW for direct comparison with selenium guidelines for British Columbia (Beatty and Russo 2014). Table 9.7-5 shows mean selenium concentrations (mg/kg DW) in whole-body Slimy Sculpin sampled from 2004 to 2012 relative to the draft guideline of 4 mg/kg DW for fish muscle. Mean selenium concentrations exceeded the draft guideline at M20 Creek (receiving environment) and Mast Creek (receiving environment) during all sampling years. For Murray River sites, exceedances of the draft guideline occurred at MR US (2012, 2011; reference environment), MR3 (2012; reference environment), MR4 (2012; receiving environment), and MR RB (2011; reference environment). Mean selenium concentrations for whole-body Slimy Sculpin sampled from MR DS (receiving environment) were slightly below 4.0 mg/kg DW in 2005, 2011, and 2012. It is currently unknown whether fish are experiencing sub-lethal toxic effects due to selenium exposure, as the effects thresholds for fish vary between species (McDonald et al. 2010).

Table 9.7-5. Mean Selenium Concentrations (mg/kg dw) in Whole-body Slimy Sculpin, 2004 to 2012

Site	Waterbody	Year	n	Mean Whole-body Selenium Concentration (mg/kg dw)	SD	SE
MR US	Murray River	2012	8	4.5	0.7	0.3
		2011	7	4.3	0.8	0.3
		2005	5	3.4	0.6	0.3
MR DS	Murray River	2012	8	3.7	0.8	0.3
		2011	8	3.9	0.2	0.1
		2005	5	3.5	0.4	0.2
MR 3	Murray River	2012	8	4.9	1.0	0.4
MR 4	Murray River	2012	8	5.4	1.1	0.4
MR RB	Murray River	2011	8	5.6	0.8	0.3
		2005	5	3.9	0.5	0.2
SS-FT	Murray River	2004	5	3.8	0.4	0.2
M20 US	M20 Creek	2012	8	9.4	1.2	0.4
		2011	8	7.9	1.7	0.6
M20 DS	M20 Creek	2004	5	5.1	0.8	0.3
Mast Creek	Mast Creek	2005	5	4.5	0.3	0.2

Notes: n = number of tissue metals samples, SD = standard deviation of the mean, SE = standard error of the mean, dw = dry weight
Shaded cells indicate exceedance of the guideline for selenium concentration in fish muscle of 4 mg/kg dw (Beatty and Russo 2012).

The productive capacity in aquatic habitat could also be potentially altered as a result of Project activities (see Chapter 8, Assessment of Potential Aquatic Resources Effects). Changes in pH and metals leaching into aquatic environments can lead to decreased biomass, densities, and diversities in primary and secondary producer communities (Kimmel 1983; McKnight and Feder 1984). Aquatic insects are also affected by low pH, with lethality occurring below a pH of 5.4, and emergence impairment beginning at a pH of 5.9 (Bell 1971; McKean and Nagpal 1991). Therefore, direct effects on aquatic resources can have an indirect effect on fish growth and fecundity. Sediment quality can be affected by the overlying water quality, and increases in metal concentrations in the water may lead to increased partitioning of those metals into sediments or aquatic biota. Acidic aquatic pH can also lead to the liberation of sediment-bound metals, which can then enter the dissolved phase and be more bioavailable to aquatic organisms resulting in toxicity.

Petroleum Products

Potential Project-specific activities where petroleum products may be present include all Project access roads, Coal Processing Site, and sites where heavy machinery or vehicles are present. Fish and fish habitat are present within or near the above listed Project infrastructure. Minor release of petroleum products could occur due to a number of Project activities. Routine Project-related traffic creates a risk of diesel fuel or lubricants entering fish habitat, either directly or due to runoff associated with precipitation. Activities involving mechanized equipment in or near waterways, such as road, bridge, or other infrastructure construction and activities during closure and post-closure reclamation can lead to introduction of small amounts of fuel, oil, or petroleum-based lubricants into the aquatic environment.

The potential for petroleum products to enter waterways during normal Project activities is likely small in geographic scope, since only small quantities in localized areas would be introduced to aquatic environments. Petroleum products can affect fish and fish habitat in many ways, including physiological toxicity (lethal or sub-lethal effects) or behavioural changes in fish and loss of productive habitat capacity.

Most petroleum products that may enter waterways during normal Project activities (e.g., gasoline, diesel, fuel oil, and lubricants) are toxic to fish and can cause mortality at high enough levels (Tagatz 1961; Hedtke and Puglisi 1982; Lockhart et al. 1996).

Contamination of aquatic resources leading to decreased productive capacity could also potentially occur if petroleum products are released to the aquatic environment. Localized contamination of sediments may occur, because most petroleum products have constituents that are hydrophobic and will move from the water to the sediment. Accidental release of petroleum products (e.g., diesel fuel) have been shown to reduce primary and secondary producer densities and alter community structure (Lytle and Peckarsky 2001).

Nitrogen and Phosphorus

Introduction of nitrogenous compounds and phosphorus into the aquatic environment may occur as a result of Project activities involving disposal of effluent from the sanitary sewer system. The primary nitrogenous compounds that may be a concern include ammonia, nitrate, and nitrite.

Potential sources of effluent containing both nitrogenous compounds and phosphorus include the sanitary sewer system at the Decline Site and the Coal Processing Site. Effluent from the sewer system may have nitrogen (including both ammonia and nitrate) and phosphorus which, if not treated properly, can contribute to alterations in productive capacity and eutrophication, as well as the potential for toxicity to fish (CCME 2004) in downstream environments.

9.7.1.4 Effects of Habitat Loss

Fish habitat loss refers to removing or physically altering aspects of the environment that are directly or indirectly used by fish. More specifically, fish habitat loss can refer to the removal of riparian and instream habitat, the loss of fish habitat productive capacity, restricting fish passage, and the alteration of water quantity. Changes in water quantity are considered increases or decreases in the timing and discharge of streams and creeks, and/or changes in the volume of lotic habitats. Potential Project-specific fish habitat loss may occur during the upgrading of bridges and access roads, near the CCR North and South sites, intake and outfall sites located on the Murray River, and from changes in flow conditions in M20 Creek.

In addition, there are areas where Project activities may have similar effects in non-fish-bearing waterways, and these will be discussed as aquatic habitat loss and alteration. In these areas, sediment quality, periphyton, and/or aquatic invertebrates could be affected, and aquatic habitat alteration may lead to effects on productive capacity. Project-specific aquatic habitat loss or alteration may occur as a result of construction of the CCR North and South sites, and from changes in flow conditions in M20 Creek.

Project-related changes to groundwater and surface water hydrology (assessed in Chapters 7 and 8, respectively) have the potential to affect fish, fish habitat, and aquatic resources through alteration of water levels, stream discharge, and channel morphology. Potential changes to water quantity in receiving waterbodies (e.g., M20 Creek) may occur via surface and groundwater loss (as a result of water table drawdown due to inflows to the underground mine), and subsidence from the underground mine during the Operation, Decommissioning and Reclamation, and Post Closure phases.

Changes in water quantity can alter fish production. Water quantity or flow is a fundamental abiotic factor controlling ecological processes in streams (Poff et al. 1997). The natural flow regime of a watershed, characterized by the magnitude of discharge, duration, frequency, timing and rate of change, regulates both the physical and ecological processes of a lotic ecosystem. Many channel and floodplain features such as pool-riffle sequences are formed and maintained by natural flow processes (Poff et al. 1997). The aquatic food organisms, nutrients, and other aspects of fish habitat that support fish production in streams are controlled and influenced by hydrological processes. Therefore, disruptions to stream processes can alter fish production (Clarke et al. 2008).

Changes in flow can be categorized as either direct effects or physical habitat effects (Lewis et al. 2004). Direct effects are stranding, inundation, or dewatering of spawning areas; displacement of fish species; creation of fish passage/migration barriers; and increased predation risk (Clarke et al. 2008). Physical habitat effects may affect functional wetted area, depth and velocity, habitat structure and cover, temperature, nutrient dynamics, substrate quality, and sediment scour and deposition (Clarke et al. 2008). Holistically, these effects alter food supply, rearing habitat, overwintering habitat, and spawning habitat. As a result, fish population ecology is affected in terms of abundance and distribution, growth, survival, reproductive success, bioenergetics, and biodiversity. Changes to surface water quantity can affect fish and primary producer productivity primarily by physical alteration of the habitat available to carry out life processes. Water management, including diversion channels for non-contact water, affects discharge rates and stream flows and therefore may alter the wetted width availability and the stream depth necessary for fish spawning and rearing, and aquatic life colonization at different times of the year. For example, decreased water flow in summer would decrease aquatic habitat available for periphyton, salmonid rearing, and the migratory potential for salmonids. In fall, altered flow during low-flow periods could change the amount of Bull Trout spawning habitat. During winter, decreased flow rates could lead to increased ice formation and block flows in diversion channels or low-flow streams. In the other extreme, increases in water flow can cause scouring, bank erosion, and increased sediment suspension and light attenuation, all which may decrease primary producer biomass and productivity. In addition, the in situ retention of nutrients could be reduced, which could further reduce primary productivity and change nutrient spiraling lengths, with subsequent indirect effects on higher trophic levels (Newbold et al. 1983).

9.7.2 Mitigation Measures for Fish and Fish Habitat

9.7.2.1 Mitigation for Direct Mortality

Access to the Murray River by the Project staff within the LSA and RSA will be mitigated and controlled on Project access roads during Construction and Operation phases. Sport fishing for Arctic Grayling and Bull Trout already occurs within the LSA and RSA in the Murray River and larger creeks. The potential increase in fishing pressure and associated increase in fish harvesting due to the presence of the mine Construction and Operation workforces will be mitigated by the following features:

- gating of HD Mining controlled access roads to prohibit the entry by non-authorized vehicles;
- design of gates and security measures to control access and mobility of snow machines and all-terrain vehicles;
- at Decommissioning and Reclamation, all non-essential roads will be deactivated and traffic will be greatly reduced;
- implementing a company policy that prohibits employees and contractors from engaging in fishing while present at the mine site or while travelling to and from the mine on company business; and
- transporting personnel to and from the mine site such that employees have limited opportunity to engage in fishing during mine Construction and Operation phases.

As a result of these administrative and mitigation measures, there will be no sanctioned opportunities for employees or contractors to engage in fishing while on site during mine Construction or Operation phases. Access to the Murray River will not increase as a result of the Project, thus the Project will not increase fishing pressure or harvest.

To mitigate direct mortality effects within fish-bearing streams, access road and site construction and maintenance activities will be done in accordance with best management practices (BMPs) such as the Land Development Guidelines for the Protection of Aquatic Habitat (DFO 1993), Standards and Best Practices for Instream Works (BC MWLAP 2004), and DFO's operational statements for bridge and culvert maintenance (DFO 2007). Appropriate fisheries operating windows for fish-bearing streams will be adhered to where possible. Mitigation strategies include isolating Project work sites to prevent fish movement into the work site, salvaging/removing fish from the enclosed work site, and environmental monitoring.

If BMPs and plans are implemented and followed, there is a low probability that a potential effect caused by direct mortality on fish (both at the individual and population level) will not be fully mitigated. This low probability that a potential effect could occur is due to the efficiency and size selectivity of sampling gear to remove fish from a work area.

9.7.2.2 Mitigation for Erosion and Sedimentation

To minimize the effects on fish and their habitats, several mitigation measures relating to erosion and sedimentation will be required. Mitigation strategies will be tailored to address Project-specific issues associated with erosion and sedimentation. Mitigation objectives outlined in accordance with BMPs such as the DFO Land Development Guidelines for the Protection of Aquatic Habitat (DFO 1993), Standards and Best Practices for Instream Works (BC MWLAP 2004), Fish-Stream Crossing Guidebook (BC MOF 2002), and Pacific Region Operational Statements (DFO 2007) all provide guidelines for the mitigation of erosion and sedimentation effects on fish and fish habitat.

Erosion and sedimentation will be mitigated in the LSA and RSA through the implementation of BMPs, particularly during construction and road maintenance. BMPs relating to erosion and sedimentation are described under the Erosion and Sediment Control Management Plan for the Project (Chapter 24). The Erosion and Sediment Control Management Plan will provide performance-based environmental specifications for preventing and controlling the release of sediments during all phases of the Project to minimize adverse effects to downstream water quality.

These measures will be monitored and modified, as necessary, to ensure compliance with regulatory requirements and BMPs. When in-water work occurs, an environmental monitor will be on site monitoring water quality. Construction and maintenance activities near areas of fish-bearing waters will occur during appropriate fisheries operating windows for fish-bearing streams. In-water works occurring outside of fisheries operating windows will only be conducted under a permit.

Construction activities (i.e., equipment access, site clearing, etc.) will be conducted in a manner that minimizes riparian vegetation effects and maintains fish habitat and stream bank integrity.

Specific BMPs relating to the mitigation and/or minimizing of effects caused by erosion and sedimentation to the aquatic environment include:

- using water diversion structures to direct dirty water from the work zone to a sediment control area;
- installing silt fencing, geotextile cloth, straw bales, berms, or other sediment control structures;
- conducting instream work from the point farthest away from the construction access point and working backward;
- allowing constructed ponds to settle before connecting to the stream;

- storing soil, substrate, removed vegetation, and building materials in stable areas away from the channel;
- ensuring that all rock materials used in the stream are inert (non-acid generating);
- ensuring constructed banks are graded at a stable slope;
- stabilizing excavated materials and areas denuded of vegetation using temporary erosion control blankets, biodegradable mats, planted vegetation, or other erosion control techniques;
- environmental monitoring;
- repairing areas that are potential sediment sources;
- using dust suppression on roads; and
- adhering to appropriate construction operating windows for instream work.

Therefore, the effects of sedimentation during Construction, Operation, Decommissioning and Reclamation, and Post Closure should be negligible. Therefore, no residual Project effects are carried forward in the assessment.

9.7.2.3 Mitigation for Change in Water Quality

In addition to the specific mitigation measures outlined for each class of chemical in the following sections, the Water Management Plan, and Selenium Management Plan (Chapter 24) outline monitoring that will be implemented. This monitoring will detect alterations to the receiving environment, including changes to fish tissue and health. Additional monitoring of fish health will be triggered if alterations in water quality and aquatic resources are detected. This plan will include provisions for identification of causes of alteration and implementation of additional mitigation measures or adaptive management strategies, if effects are identified.

9.7.2.4 Mitigation for Metals

For the Coal Processing Site, a number of mitigation measures will be implemented under the Water Management Plan (Chapter 24). Freshwater diversion channels will be constructed to divert non-contact water away from Project infrastructure. Water that has been in contact with coal or mine infrastructure will be directed to on-site ponds, and treated as appropriate to meet applicable permit criteria prior to release to the environment. Discharges may occur year-round in all phases of the Project. They will be closely managed to minimize potential for effects in the receiving environment (i.e., Murray River). The potential for water quality effects in the Murray River (the receiving environment) will be monitored regularly through the implementation of a monitoring program.

9.7.2.5 Mitigation for Petroleum Products

Petroleum products will be in use during the Construction, Operation, and Decommissioning and Reclamation phases. To minimize the effects on fish and fish habitat, several mitigation measures relating to petroleum products will be required. Mitigation strategies will be tailored to address Project specific issues associated with petroleum product introduction into aquatic environments. Mitigation objectives outlined in accordance with DFO Land Development Guidelines for the

Protection of Aquatic Habitat (DFO 1993), BC MOE Standards and Best Practices for Instream Works (BC MWLAP 2004), and Pacific Region Operational Statements (DFO 2007) all provide guidelines for the mitigation of petroleum product effects and spills on the aquatic environment.

Petroleum product introduction into the aquatic environment will be mitigated in the LSA and RSA through the implementation of BMPs, particularly in the Construction and Operation phases. BMPs relating to petroleum spills are described under the Spill Prevention and Response Plan (Chapter 24). This plan provides performance-based environmental specifications for preventing and controlling the release of spills to minimize adverse effects to downstream water quality. These measures will be monitored and modified, as necessary, to ensure compliance with regulatory requirements and BMPs. When instream work occurs, an Environmental Monitor will be on site monitoring water quality, and for activities near areas of fish-bearing waters, appropriate fisheries operating window requirements for fish-bearing streams will be adhered to. In certain circumstances, instream work may need to occur outside of the least risk windows. Therefore, necessary permits will be obtained from appropriate agencies and work will comply with necessary conditions.

Specific BMPs relating to the mitigation and/or minimizing of effects caused by petroleum product introduction into the aquatic environment include:

- environmental monitoring;
- adhering to appropriate construction operating windows for instream work;
- fuel stored in bermed and lined containment facilities to prevent seepage into the soil;
- inspection of all equipment and machinery prior to and during instream/riparian work to ensure that it is clean and free of leaks;
- use of biodegradable fluids (fuels and oils) for machinery working within 30 m of any stream;
- placement of drip pans and spill pads underneath pumps or other stationary machinery within riparian areas;
- provision of readily accessible spill kits in all areas where machinery or fuel tanks will be used, stored, or refuelled, and training of personnel in their use prior to beginning construction;
- spill control measures (Chapter 24); and
- an emergency response plan (Chapter 24).

In summary, if the above mitigation measures are implemented effects due to the use of petroleum products are not anticipated to effect fish through the Construction, Operation, Decommissioning and Reclamation, and Post Closure phases of the project.

9.7.2.6 Mitigation for Nitrogen and Phosphorus

Effluent from the sewer system and water treatment may include septic ground disposal systems that meet requirements for setback from waterbodies as required in the Sewerage System Regulation

(BC Reg. 326/2004) to prevent any effects to surface waters. Secondary-treated effluent from the site sanitary sewer will be discharged to the Murray River. This is not expected to have an effect outside of the initial dilution zone due to high dilution ratios. Fish exposure to sewage effluent spills or leaks to streams is not expected to occur with proper design and engineering of the sanitary sewer system.

9.7.2.7 Mitigation for Habitat Loss

Fish and fish habitat are protected under a variety of federal and provincial regulatory Acts and principles. The *Fisheries Act* prohibits serious harm to fish and fish habitat that are part of or support commercial, recreational, or Aboriginal fisheries. Proponents are responsible for avoiding and mitigating serious harm to fish that are part of or support commercial, recreational, or Aboriginal fisheries. When proponents are unable to completely avoid or mitigate serious harm to fish, their projects will normally require authorization under Subsection 35(2) of the *Fisheries Act* (1985) in order for the project to proceed without contravening the Act.

DFO interprets serious harm to fish as:

- the death of fish;
- a permanent alteration to fish habitat of a spatial scale, duration, or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, nursery, rearing, food supply areas, migration corridors, or any other area in order to carry out one or more of their life processes; and
- the destruction of fish habitat of a spatial scale, duration, or intensity that results in fish no longer being able to rely on such habitats for use as spawning grounds, nursery, rearing, food supply areas, migration corridor, or any other area in order to carry out one or more of their life processes.

After efforts have been made to avoid and mitigate impacts, any residual serious harm to fish should be addressed by offsetting. An offset measure is one that counterbalances unavoidable serious harm to fish resulting from a project with the goal of maintaining or improving the productivity of the commercial, recreational, or Aboriginal fishery. Offset measures should support available fisheries' management objectives and local restoration priorities.

To mitigate fish habitat and passage effects related to road and bridge maintenance, and/or construction and decommissioning of the water intake or outfalls on fish-bearing streams crossings, any work performed will follow applicable DFO's operational statements (DFO 2007) and DFO's (1993) Land Development Guidelines for the Protection of Aquatic Habitat. Efforts will be undertaken to minimize potential effects from the Project on fish habitat and fish passage, and to avoid serious harm to fish and fish habitat.

For all instream work within fish-bearing streams, an environmental monitor will be on site to monitor water quality and related effects. Appropriate fisheries operating windows for fish-bearing streams will be adhered to whenever feasible. Alternatively, appropriate permits will be acquired for out-of-window activities. To protect fish habitat near Project infrastructure (e.g., Coal Processing Site), appropriate riparian zones will be applied as per the *Forest and Range Practices Act* (2002c).

Mitigation measures to avoid and minimize adverse effects to surface water, groundwater, and fish habitat include a variety of diversion, collection, and storage/settlement structures to manage water for the Project. Additional surface and groundwater mitigation measures are detailed in the Water Management Plan (Section 24.6) and the Subsidence Management Plan (Section 24.15).

Changes in water quantity and their associated effects on fish habitat in M20 Creek are likely to occur gradually over time. Monitoring of flow conditions to determine if reduced flows are evident will allow for evaluation of potential mitigation measures, which could include modification of mining methods (e.g., rate of retreat, specific panel layouts) to reduce potential for flow effects during mining of subsequent panels.

The Subsidence Management Plan (Section 24.15) identifies the mitigation measures and monitoring for subsidence in M20 Creek. If monitoring indicates flows in M20 Creek are reduced due to subsidence processes, a re-assessment of the effects on fish habitat may be required and the subsequent implementation of a fisheries offsetting plan may result.

Serious harm to fish or fish habitat related to the Construction, Operation, Decommissioning and Reclamation, and Post Closure phases of the Project are not anticipated.

9.8 Residual Effects on Fish and Fish Habitat

9.8.1 Direct Mortality

Although potential effects on fish VC sub-components (Arctic Grayling and Bull Trout) through direct mortality were identified, residual effects are not anticipated when mitigation and BMPs are in place. Therefore direct mortality was not carried through to the significance rating (Table 9.8-1).

Fish may be affected by Project components that involve in- or near-water work. Such activities include the construction and decommissioning of access road bridges. Fish do not inhabit the upper reaches (i.e., upstream of barrier) of M19 Creek, and thus will not be affected by direct mortality at the proposed road crossing.

The primary goal of direct mortality mitigation strategies is to prevent machinery from impacting fish. Fishing prohibition by Project-related staff will be applied, especially in those waterbodies where fish reside. Mitigation and best management strategies are effective in minimizing direct mortality; however, a very few individual mortalities may occur.

9.8.2 Sedimentation and Erosion

Although potential effects on fish VC sub-components (Arctic Grayling and Bull Trout) through sedimentation and erosion were identified, residual effects are not anticipated when mitigation and BMPs are in place. Therefore, sedimentation and erosion was not carried through to the significance rating (Table 9.8-2).

Table 9.8-1. Summary of Residual Effects on Fish due to Direct Mortality

Valued Component	Project Phase	Project Component / Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Arctic Grayling Bull Trout	Construction Operation Closure	Upgrade of access roads; Access road maintenance; Reclamation of on-site roads; Installation of effluent discharge in Murray River	Impact with construction machinery causing fish mortality	Use of best management practices to minimize fish mortality with construction machinery; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Site isolation	None
Arctic Grayling Bull Trout	Construction Operation Closure	Access road use and maintenance; Decommissioning of access roads	Increased fishing access causing increased harvest of game fish species	Controlled access; Implement no fishing policy for employees	None

Table 9.8-2. Summary of Residual Effects on Fish and Fish Habitat due to Sedimentation and Erosion

Valued Component	Project Phase	Project Component / Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Arctic Grayling Bull Trout	Construction Operation Closure	Upgrade, maintenance, use, and decommissioning of access roads	Entry of sediment to waterbodies during instream construction and bridge/culvert removal; Entry of sediment to waterbodies from road runoff and dust during operation and maintenance	Use of best management practices to minimize sediment entry to waterbodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work and the Soil Environmental Management Plan; Riparian re-vegetation; Dust suppression on roads; Site isolation; Water quality maintenance	None
Arctic Grayling Bull Trout	Construction	Installation of the transmission line and associated towers	Entry of sediment to waterbodies during removal of riparian vegetation; Altered riparian vegetation	Use of best management practices to minimize sediment entry to waterbodies; Adhere to DFO's operational statements; Maintain riparian vegetation at Twenty Creek crossings	None
Arctic Grayling Bull Trout	Construction Operation Closure	Shaft Site and Coal Processing Site: clearing, ditching, pile development, water management	Entry of sediment to waterbodies from runoff and discharge	Use of best management practices to minimize sediment entry to waterbodies; Adhere to DFO's operational statements; Adhere to Soil Environmental Management Plan; Water quality maintenance; Apply appropriate riparian zones for fish-bearing streams according to *Forest and Range Practices Act*	None

Fish may potentially be affected by the upgrade, maintenance, use, and decommissioning of access roads, installation of the transmission line and associated towers, and clearing, ditching, pile development, water management for the Shaft Site and Coal Processing Site. Fish-bearing streams are present within or near these Project activities. Fish do not inhabit the upper reaches of most tributary streams due to the presence of numerous natural barriers; however, sediment may enter non-fish-bearing reaches and flow downstream to fish-bearing habitat.

The primary goal of sediment mitigation strategies is to prevent sediment from entering all waterbodies, especially those waterbodies where fish reside. Sediment mitigation strategies and BMPs are described in the Erosion and Sediment Control Management Plan (Chapter 24). They include, but are not limited to, using buffers or leave strips, using geotextile cloth surrounding sediment entry sites near waterbodies, isolating Project work sites, retaining vegetation and re-vegetating exposed riparian habitat, and environmental monitoring.

These mitigation and best management strategies are anticipated to be effective in minimizing sediment entry to fish-bearing waterbodies. Thus, residual effects due to erosion and sedimentation are not expected to occur.

9.8.3 Change in Water Quality

9.8.3.1 Residual Effects for Metals

Residual effects on fish VC sub-components may occur because of changes in water quality resulting from Project components in the Decommissioning and Reclamation, Post Closure phases for Arctic Grayling and Bull Trout (Table 9.8-3).

Water quality modelling was conducted to predict concentrations of various metals at water quality modelling nodes downstream of proposed Project infrastructure (see Chapter 8, Assessment of Potential Surface Water Quality Effects). Unless otherwise noted, any reference throughout this section to a predicted metal concentration in water refers to the total metal concentration, and reference to “the guidelines” indicates the BC Water Quality Guidelines for the Protection of Aquatic Life (BC MOE 2006). Details of the water quality model, analysis, and comparison to guidelines are provided in Chapter 8 and Appendix 8-G.

9.8.3.2 Selection of Contaminants of Potential Concern (COPC) based on Predicted Freshwater Quality

Water quality model predictions were compared to the BC WQGs for the protection of aquatic life, or to the CCME guidelines when BC guidelines were not available. When water quality was predicted to exceed the applicable guidelines, a comparison of the predicted water quality to baseline water quality at the site was also done. This baseline comparison was important for ensuring that only parameters that are predicted to increase due to Project-related activities are identified. This step excludes parameters that have concentrations higher than guidelines during baseline studies, as this is not a Project-related effect.

Table 9.8-3. Summary of Residual Effects on Fish and Fish Habitat due to Changes in Water Quality

Valued Component	Project Phase	Project Component / Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Arctic Grayling Bull Trout	Construction Operation Closure	Chemical and hazardous material storage, management and handling	Toxicity of fish due to introduction of chemical products into aquatic environment during normal Project activities	Use of best management practices to minimize chemical product entry to waterbodies; Adhere to the Spill Prevention and Response Plan; Spill kits; Coal Processing Site discharge treatment and water quality maintenance at M19A Creek	None
Arctic Grayling Bull Trout	Construction Operation	Construction and use of sanitary sewer treatment plant and discharge	Toxicity of fish due to introduction of nitrogenous compounds associated with sewage	Industry Standards for Wastewater Treatment; Use of best management practices and industry wastewater treatment standards to treat effluent (secondary treatment) and minimize effluent entry to waterbodies	None
Arctic Grayling Bull Trout	Construction Operation Closure	Construction of Coal Processing Site; Installation of the Transmission Line and associated towers; Upgrade and use of access roads; Transmission Line operation and maintenance; Decommissioning of access roads	Toxicity of fish due to introduction of petroleum products into aquatic environment during normal Project activities	Use of best management practices to minimize petroleum product entry to waterbodies; Adhere to DFO's operational statements; Adhere to appropriate construction operating window for instream work; Adhere to the Spill Prevention and Response Plan; Spill kits, Equipment maintenance, Stream setback distances; Water quality maintenance	None
Arctic Grayling Bull Trout	Decommissioning and Reclamation, and Post-closure phases. Only during the months of January, February, and March for each phase.	Seepage into M19A Creek from CCR North and CCR South	Predicted increase in selenium within maternal fish tissue and transfer to egg and larval stages	Use of best management practices to minimize chemical product entry to waterbodies; Adhere to the Spill Prevention and Response Plan; Spill kits; Coal Processing Site discharge treatment and water quality maintenance at M19A Creek	None

The screening procedure described here is the same as that used for COPC selection in Chapter 8, which identified selenium as the only COPC for the Project (see Section 8.8 and Appendix 8-G for additional details and COPC selection results). Selenium was found to be a COPC during the Decommissioning and Reclamation, and Post Closure phases only during January, February, and March in M19A Creek (Table 9.8-4). Aside from selenium in M19A Creek, no other COPCs for fish were identified at any other surface water modelling node.

Table 9.8-4. Selection of Contaminants of Potential Concern based upon Predicted Water Quality in the LSA

COPC	Project Phase	Location and Timing of Exceedance
Selenium	Decommissioning and Reclamation	M19A Creek during January, February, and March
	Post Closure	M19A Creek, during January, February, and March

Source: Table 8.9-3 of Chapter 8, and Appendix 8-G

9.8.3.3 Screening Level Risk Assessment for Selenium in Fish Tissue

Selenium was identified as a Project-related COPC for fish based on predicted incremental changes in water quality due to Project activities during the Decommissioning and Reclamation, and Post Closure phases of the Project. Therefore, a screening level risk assessment was done to assess the potential for effects due to selenium in fish tissues during these Project phases.

Selenium was identified as a COPC in water in M19A Creek during January, February, and March since predicted concentrations are greater than both guideline limits (2 µg/L) and baseline concentrations. Selenium is a bioaccumulative metalloid, which is typically taken up by aquatic organisms through the food web. BC recently released updated selenium guidelines that include a fish tissue screening value based upon selenium fish tissue residues (4 µg/g dry weight; Beatty and Russo 2014). This was used as the primary screening criteria for determining whether predicted fish tissue selenium concentrations may pose a risk to fish.

Mean water quality model predictions for selenium in M19A Creek were used as the water selenium concentration in the bioaccumulation model, which provided predicted fish tissue residues based on predicted water concentrations (Table 9.8-5). The potential sub-lethal toxicity to eggs and larvae associated with elevated selenium levels in M19A is not anticipated to cause residual effects to fish. Because the interval of selenium concentration exceeding guidelines is between January and March during Decommissioning and Reclamation and Post Closure, the period of potential exposure of fish to high levels of selenium in M19A will occur during the overwintering life history stage. The only potential overwintering habitat observed in M19A Creek was provided by sections of the stream flooded by beaver dams (section 9.5.3). Although the beaver dams appear to restrict fish movement from M19 Creek into M19A Creek currently, a breach in the beaver dams could provide access for fish, and to establish populations in M19A Creek. However, in the event the beaver dams are breached, the only available potential overwintering habitat will drain and be lost. Thus, the loss of potential overwintering habitat will eliminate the possibility for adults to be exposed to high selenium concentrations from January to March (Decommissioning and Reclamation and Post Closure) and decrease the likelihood of potential toxic effects in eggs in larvae to a negligible level.

Table 9.8-5. Predicted Selenium Tissue Concentrations for Slimy Sculpin during Decommissioning and Reclamation/Post Closure Phase at M19A Creek

Month	Mean Predicted Selenium Tissue Concentration (µg/g dw)
January	9.37
February	11.2
March	9.89

Notes:
dw = dry weight
Shaded cells indicate the baseline fish tissue selenium concentration exceeds the BC MOE screening value (4.0 µg/g dw; Beatty and Russo 2014).

Moreover, the likelihood of selenium levels causing sub-lethal toxicity to eggs and larvae is also lessened by the life history of the VC species. Fluvial Bull Trout and Arctic Grayling often migrate considerable distances from overwintering habitat to spawning sites. Migratory fish species have lower risk of maternal transfer of Project-related selenium from the female fish body burden to the eggs, because selenium is metabolized and Project-related body burdens may be eliminated from fish while overwintering and migrating in habitat lower in selenium concentration (Hamilton 2004).

Potential residual effects due to increases in selenium concentrations are not predicted to occur in the fish-bearing reaches of M19 Creek, M20 Creek, Twenty Creek, or the Murray River. Although M19 Creek is immediately downstream of M19A Creek, the water selenium guideline is no longer exceeded once water reaches M19 Creek and selenium concentrations are predicted to be within natural variability. Therefore, effects to Arctic Grayling, Bull Trout, and other fish species in M19 Creek are not expected. Sufficient baseline data are available for multiple reference and receiving environment sites, and will be used to monitor and detect potential changes in fish tissue metals.

9.8.3.4 Residual Effects for Nitrogen and Phosphorus

The introduction of nitrogenous compounds and phosphorus into the aquatic environment is potentially toxic to fish. Two other potential effects on aquatic life from the introduction of nutrients are increasing primary productivity (eutrophication) and altering primary producer communities. These two effects are discussed in Chapter 8, Assessment of Potential Surface Water and Aquatic Resources Effects. No residual effects for nitrogen and phosphorus are expected (Table 9.8-3).

9.8.4 Fish Habitat

<u>Change in Water Quantity</u>

Residual effects on fish habitat may occur because of changes in water quantity resulting from Project components in the Operation, Decommissioning and Reclamation, and Post Closure phases for the underground mine on M20 Creek (Table 9.8-4).

As described in the assessment of surface water quantity (see Section 8.8.1.1), very little change is predicted to flow conditions in the tributary streams on the east side of the Murray River (M17, M19A, and M19 creeks). Potential effects of the Project on stream flows are greatest on M20 Creek due to flow reductions as a result of dewatering the underground mine.

Table 6.1-1 of Appendix 7-B shows that, according to groundwater model predictions, mine dewatering may result in reductions of groundwater discharge (baseflow) in M20 Creek ranging from 3.5 to 26%, depending on the modelled scenario. The results of the groundwater modelling were converted to a temporal sequence and input to the water balance model (Appendix 8-E) to assess change in flow in M20 Creek. These results are presented in Table 8.8-7 of Chapter 8. For the Base Case, Sensitivity #1 (high groundwater inflow) and Sensitivity #2 (low groundwater inflow), monthly estimates of average change from baseline flow were derived for Construction, Operation, Decommissioning and Reclamation, and Post Closure. For baseflow conditions (e.g., winter months), the reduction in average monthly streamflow over the Operation phase is 9% (Base Case), 16% (Sensitivity #1), and 2% (Sensitivity #2). Between April and August, freshet and summer flow conditions overprint the reduction in baseflow such that the annual changes are generally less than 1%.

Sections 8.8.1.1 and 8.9.1.1 discuss the potential effects and characterization of potential residual effects due to changes in water quantity within M20 Creek on surface water and aquatic resources. This analysis concluded that the potential effects due to changes in water quantity in M20 Creek do not constitute a significant residual effect on surface water or aquatic resources. Therefore, predicted changes in flow are not expected to alter existing stream productivity or benthic invertebrate populations within M20 Creek.

As described in Section 9.5.3.2, Slimy Sculpin are the only documented fish species that utilize M20 Creek for all life history stages and on a perennial (year-round) basis. Arctic Grayling and Bull Trout may use M20 Creek in an ephemeral manner; moving from the Murray River to M20 Creek sporadically during suitable flow conditions (e.g., early summer) for opportunistic feeding forays. Habitat and habitat use during important or critical life history stages (e.g., spawning, egg incubation) of Arctic Grayling and Bull Trout have not been documented in M20 Creek. The presence and abundance of fine sediment appears to limit spawning capacity in the lower reaches of M20 Creek, and the lack of deep pools limits overwintering habitat use by VC species. Fish habitat in the lower reaches of M20 Creek was rated as marginal. Therefore, given the above characterization of fish habitat within M20 Creek, the seasonality and periodicity of fish habitat use, and the periodicity of potential changes in water quantity, residual effects to fish and fish habitat in lower M20 Creek are unlikely.

To support the above conclusions based upon documented VC fish habitat use, quantitative surface water and groundwater modelling was used to screen for potential effects on the fish-bearing reaches of M20 Creek and VC habitat use of concern. The method used to screen for potential effects was based upon a two-step process using the results of simulated average monthly streamflows at M20 Creek (see Chapter 8, Table 8.8-7), and the Arctic Grayling and Bull Trout life history periodicity table for the Murray River watershed (see Table 9.5-4). Seasonal timing of habitat use describes when and where each species would be throughout an annual cycle. Key biological activities such as spawning, incubation, migration, rearing, and overwintering were defined for M20 Creek fish-bearing reaches. Critical life history stages were then identified based upon peer-reviewed literature. The development of a life history periodicity table allows for a comparative analysis of the timing and magnitude of predicted flows changes to specific life history requirements (Estes and Orsborn 1986).

The first step involved applying standard-setting methods to predicted flow data. Standard-setting methods are primarily office-based scoping exercises that make use of existing information to predict appropriate effects of instream flow changes (Hatfield et al. 2003). Often these standard-setting methods are explicitly conservative (i.e., biased in favour of environmental protection) to account for uncertainty in predicted effects (Hatfield et al. 2003). Standard-setting methods are typically the first tier of a two-tiered processes, which is common in many jurisdictions, including British Columbia (Kulik 1990; Hatfield et al. 2003). The BC Modified-Tennant Method was applied to this flow assessment for M20 Creek. The BC Modified-Tennant Method was developed by the BC MOE and is a modification of the original Tennant Method. It incorporates local biological and physical information and provides streamflow criteria for fish in the province (Ptolemy and Lewis 2002). The timing window for each flow threshold is adjusted depending on the fish life history and ecological information for the stream. The fish life history periodicity table is used to compare predicted flows during specific time periods.

The second step involves a comparison of predicted flows throughout mine life to the standard setting flow thresholds. The maximum percent change in discharge was estimated in one of two ways, depending on whether or not the threshold values were met in baseline conditions.

1. If the BC Modified Tenant threshold was met for baseline discharge, the percent change was calculated for the month in which the difference between threshold value and discharge during mine-life was at its maximum.
2. If baseline discharge was less than the BC Modified Tenant threshold, the percent change was calculated for the month in which the difference between baseline discharge and discharge during mine life was at its maximum.

As described above, Arctic Grayling and Bull Trout are documented to sporadically use the lower fish-bearing reaches of M20 Creek during suitable flow stages (June to September) and only for potential juvenile rearing and adult feeding life stages. Therefore, analysis of both juvenile and adult Arctic Grayling and Bull Trout habitat use relative to the predicted Base Case, Sensitivity #1 (high groundwater inflow) and Sensitivity #2 (low groundwater inflow) scenarios are presented below in Figures 9.8-1, 9.8-2, and 9.8-3, respectively.

Juvenile habitat use from June to September (the period of time habitat is available for juveniles to rear and feed in M20 Creek) was considered using the Base Case, Sensitivity #1 (high groundwater inflow), and Sensitivity #2 (low groundwater inflow) models (Figures 9.8-1, 9.8-2, and 9.8-3, respectively). All models show a similar pattern of potential effects. Discharge during the months of June to August and October fall above the BC Modified tenant threshold for juvenile rearing (0.096 m^3/s), suggesting no effect of mine phases on habitat availability in M20 Creek for these months. In September, the threshold is not met for juvenile rearing across all mine phases, including baseline conditions. This suggests a sensitive period for flow reduction; however, the maximum predicted reduction in discharge, which occurs during the Operations phase, remains similar to baseline discharge. Predicted reductions from baseline conditions are 6.1% (Base Case), 10.6% (Sensitivity #1), and 1.4% (Sensitivity #2). The similarity in predicted and baseline discharge indicates that reduction is not anticipated to affect juvenile Arctic Grayling and Bull Trout habitat use in M20 Creek under any of the models examined.

Figure 9.8-1

Predicted Discharge at M20 Creek for Base Case Model

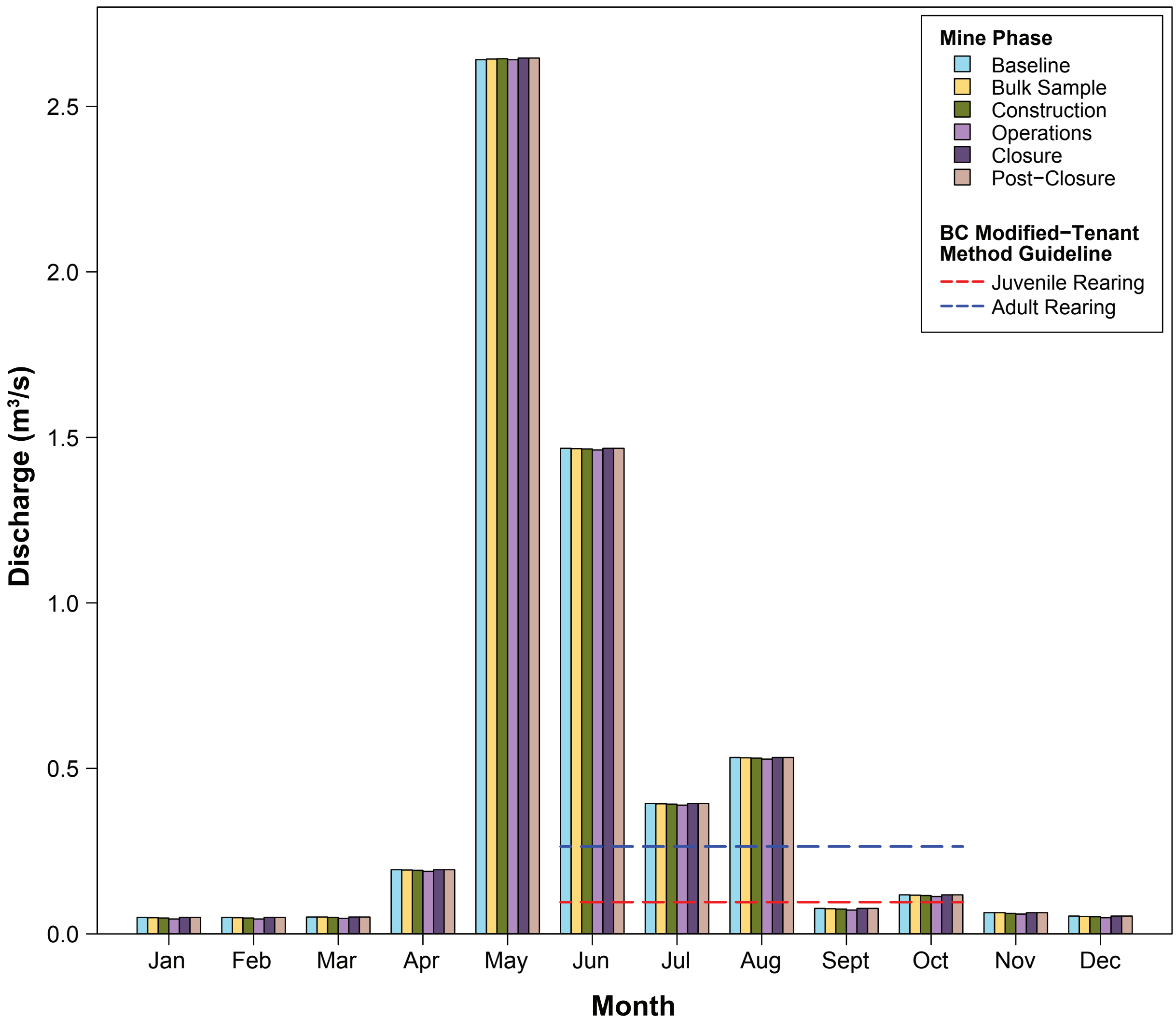


Figure 9.8-2
Predicted Discharge at M20 Creek for Sensitivity #1 Model (high groundwater inflow)

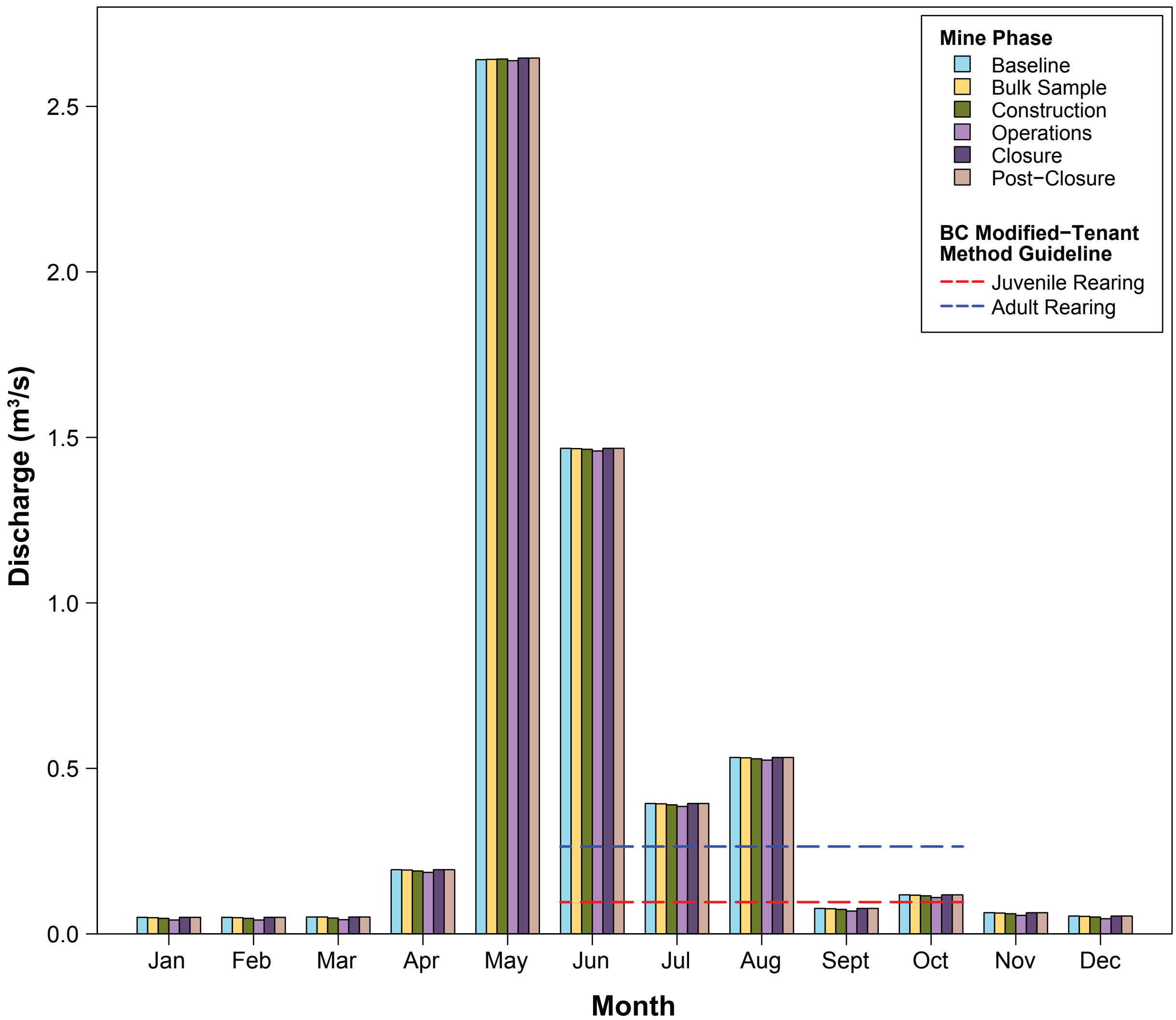
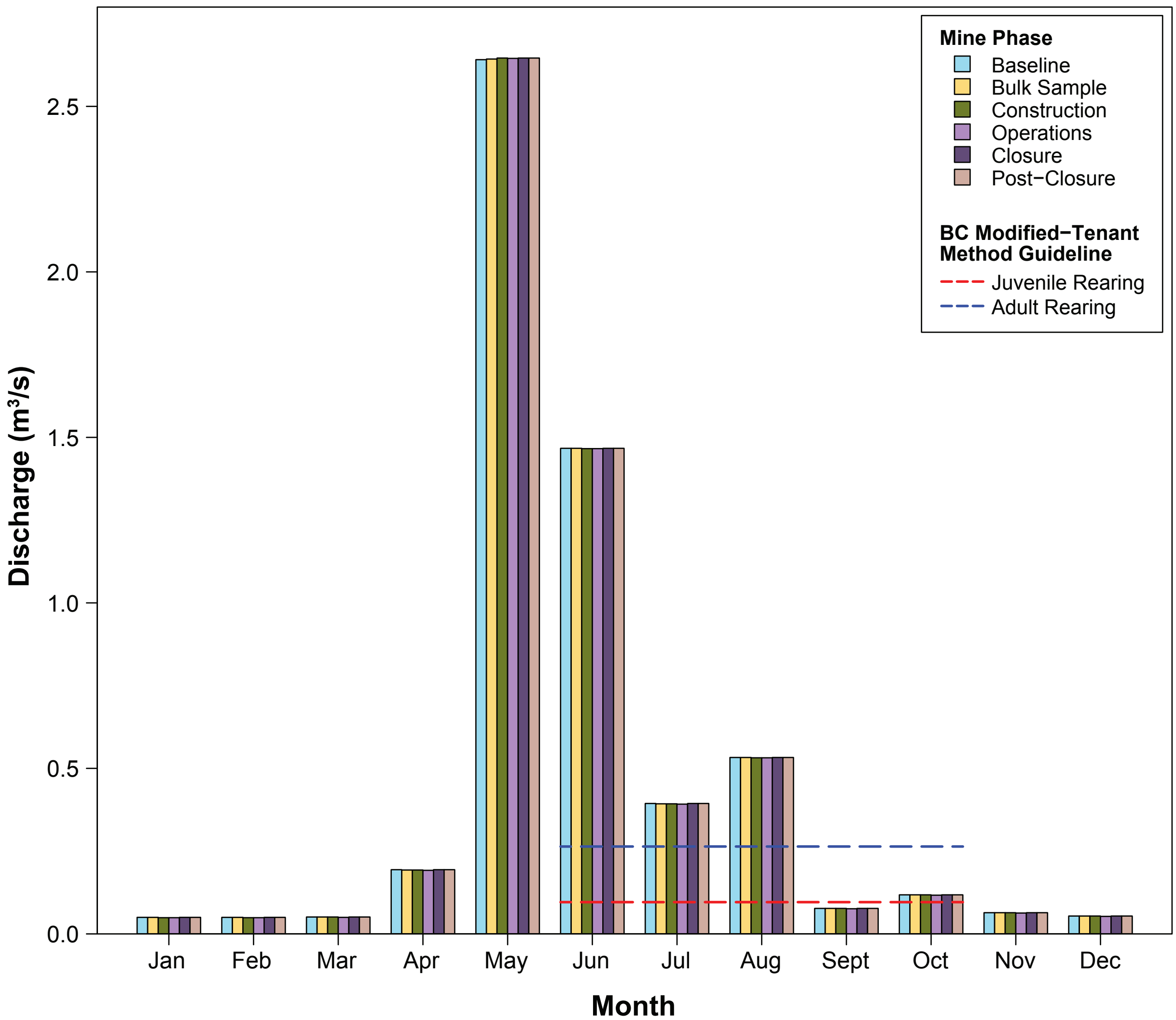


Figure 9.8-3

Predicted Discharge at M20 Creek for Sensitivity #2 Model (low groundwater inflow)



The Base Case, Sensitivity #1, and Sensitivity #2 models reveal a similar pattern of potential effects on adult feeding and rearing habitat (Figures 9.8-1, 9.8-2 and 9.8-3, respectively). From June to August (the period of time habitat is available for adult to feed and rear in M20 Creek), the BC Modified tenant threshold was met for adult rearing (0.264 m^3/s), suggesting no effect of mine phases on habitat availability in M20 Creek in these months. In September and October the threshold is not met for adult rearing across all mine phases, including baseline conditions. This suggests a sensitive period for flow reduction; however, the maximum predicted reduction in discharge, which occurs during the Operations phase, remains similar to baseline discharge. Predicted reductions from baseline conditions are 6.1% (Base Case), 10.6% (Sensitivity #1), and 1.4% (Sensitivity #2). The similarity in predicted and baseline discharge indicates that reduction is not anticipated to affect Arctic Grayling and Bull Trout and habitat use in M20 Creek.

Therefore, modelling of the Base Case, Sensitivity #1, and Sensitivity #2 scenarios relative to the BC Modified-Tennant thresholds for juvenile rearing and adult feeding indicates that VC fish habitat use in the lower fish-bearing reaches of M20 Creek will be unaffected by potential changes to surface water and groundwater.

9.8.4.2 Subsidence

Quantified effects of the Project on surface water quantity (Section 8.8.1.1) do not include potential subsidence effects. The subsidence processes associated with the planned longwall mining operations in the Project may impact the ground surface and waterbodies in the upstream (non-fish-bearing) reaches of the M20 Creek watershed. As illustrated in Figure 9.8-4, no longwall panels are located directly under the M20 Creek streamline in the fish-bearing reaches, while the Subsidence Footprint (a 200-m buffer around longwall panels) intersects a short segment at the upstream end of the fish-bearing reach. The shortest distance from the edge of a longwall panel to the fish-bearing reach is approximately 50 m (Figure 9.8-1).

As described in Section 8.7.1.1, and based on the subsidence predictions (Appendix 3-C), the highest tensile strains are expected at the edges of the panels. Areas of high strain may create cracks in the ground surface that could potentially drain surface waterbodies. Stream flows at M20 Creek could be affected by the subsidence process, particularly in areas where panel edges intersect the stream. Two processes may reduce these effects. These are:

- mining in the different coal seams will be conducted over a significant period of time (25 years), and the ground surface may self-heal some of the disturbance between the mining stages (Appendix 3-C); and
- surface water that drains into the cracks will emerge further downstream.

Given the above processes, effects of subsidence on stream flows would be diminished, particularly at the downstream, fish-bearing reaches of M20 Creek, which are located in what would naturally be within the regional groundwater discharging zone of the Murray River Valley.

Therefore, based upon the above assessment of potential changes in water quantity, residual Project-specific instream and riparian habitat loss are not anticipated through the Construction, Operation, Decommissioning and Reclamation, and Post Closure Project phases (Table 9.8-6).

Figure 9.8-4
Subsidence Footprint Relative to Fish-Bearing Streams

ERM

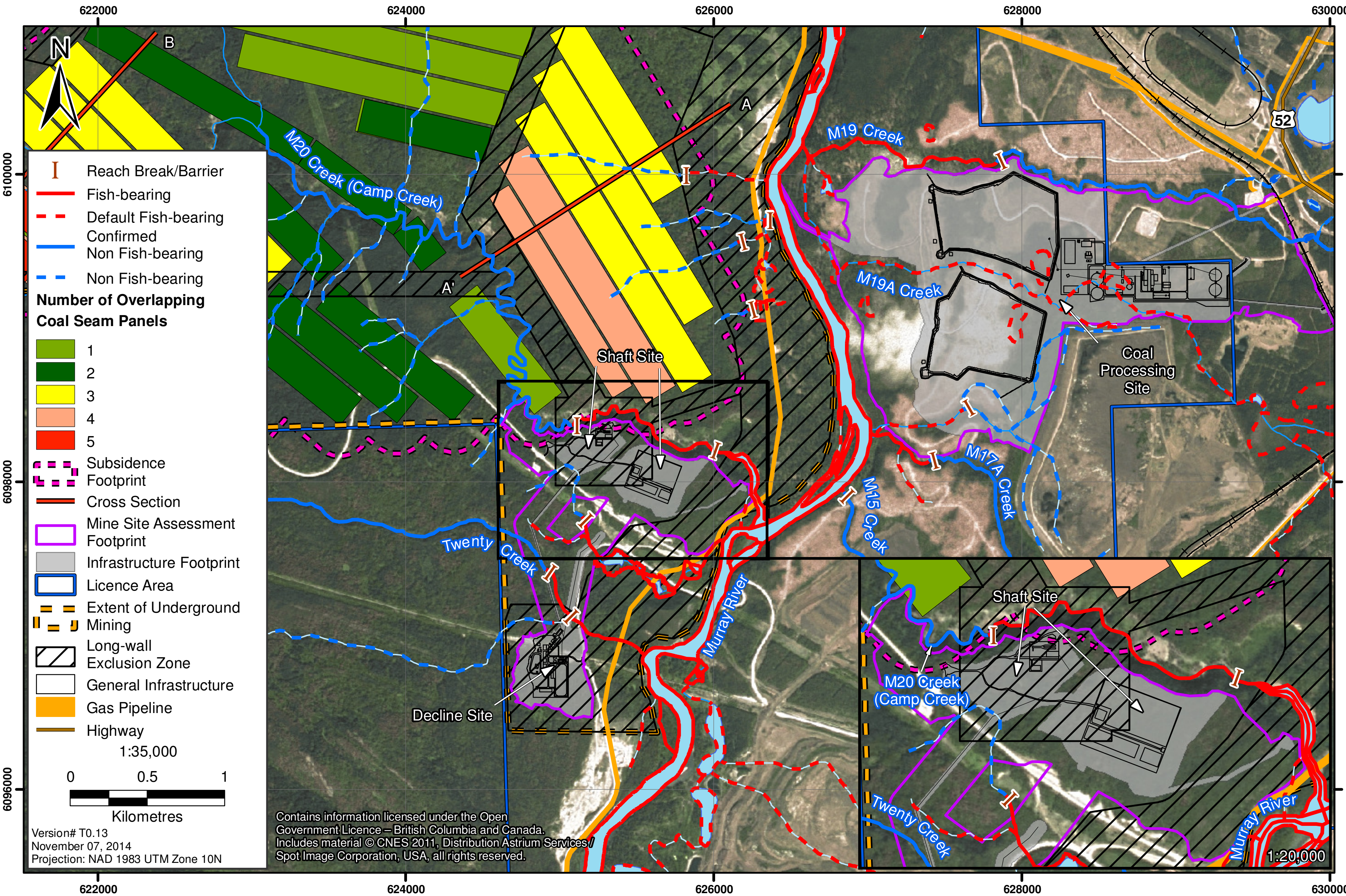


Table 9.8-6. Summary of Residual Effects on Fish Habitat due to Habitat Loss

Valued Component	Project Phase	Project Component / Physical Activity	Description of Cause-Effect	Description of Mitigation Measure(s)	Description of Residual Effect
Fish Habitat	Construction Operation Closure	Upgrade and use of access roads; Decommissioning of access roads	Loss of instream and riparian habitat at stream crossings	Adhere to DFO's operational statements	None
Fish Habitat	Construction Operation	Construction of CCR North and South sites; Construction of Shaft Site Construction of Production Decline; Installation of the Transmission Line and associated towers; Transmission Line operation and maintenance	Loss of instream and riparian habitat	Adhere to DFO's operational statements; Leave appropriate riparian zone widths for fish-bearing streams	None
Fish Habitat	Construction Operation Closure	Upgrade, use and deactivation of access roads	Entry of sediment to waterbodies from runoff and discharge	Use of best management practices to minimize sediment entry to waterbodies; Adhere to DFO's operational statements; Adhere to Soil Environmental Management Plan; Water quality maintenance; Apply appropriate riparian zones for fish-bearing streams according to *Forest and Range Practices Act*	None
Fish Habitat	Operation, Decommissioning and Reclamation, Post Closure	Dewatering of underground mine; Subsidence	Change in water quantity and loss of instream habitat in M20 Creek	Water Management Plan (Section 24.6); Subsidence Management Plan (Section 24.15); Monitoring of Flow in M20 Creek	None

9.9 Characterizing Residual Effects, Significance, Likelihood and Confidence on Fish and Fish Habitat

Given that no residual effects to fish and fish habitat were predicted due to Project-related effects on direct mortality, erosion and sedimentation, change in water quality and quantity, and fish habitat loss, no significance assessment is required (Chapter 5, Effects Assessment Methodology).

9.10 Summary of Residual Effects Assessment and Significance for Fish and Fish Habitat

After considering mitigation measures, no residual effects on fish and fish habitat were predicted due to Project-related effects on direct mortality, erosion and sedimentation, change in water quality and quantity, and fish habitat.

9.11 Cumulative Effects Assessment

Given that Project residual effects to fish and fish habitat were not identified, a cumulative effects assessment for fish and fish habitat is not required (as described by the effects assessment methodology in Chapter 5).

9.12 Effects Assessment Conclusions for Fish and Fish Habitat

The potential for Project-related effects to fish and fish habitat was assessed by determining the potential for direct mortality, erosion and sedimentation, change in water quality and quantity, and fish habitat. Quantitative information was used wherever possible in the assessment, including the outputs from the water quality predictive models.

The potential for effects to fish and fish habitat were described in Section 9.7.1 for direct mortality, erosion and sedimentation, change in water quality and quantity, and fish habitat. These sections described the key ways in which fish and fish habitat could be affected by the Project. Mitigation measures to minimize or avoid the potential for Project-related effects were described in Section 9.7.2.

After considering mitigation measures, no residual effects on fish and fish habitat due to direct mortality, erosion and sedimentation, change in water quality and quantity, or to fish habitat were identified. Based on the quantitative modelling conducted to support the environmental assessment, effects on fish and fish habitat due to potential Project related changes on water quality and quantity are not predicted. Given that no Project-related residual effects were identified, no significance determination was conducted and no residual effects on fish and fish habitat were carried forward to the cumulative effects assessment.

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