Section 11 • Fish

11.1 Introduction

This section presents information relevant to fish habitat and fish populations in the vicinity of the proposed Hermann Mine Project. It includes a description of pre-impact fisheries resources based on historical sampling information and the results of fieldwork conducted for WCCC from 2004 to 2006. Also included is an assessment of the potential effects of project development on fish and fish habitat, a description of the methods used in the assessment, and a description of recommended mitigation measures and monitoring programs.

The assessment of project effects on fish and fish habitat builds on the findings of other sections including:

- the Hydrology (Section 7) and Groundwater (Section 8) assessments, the resulting water balance developed for the minesite area (Section 4.4: Water Management Plan) and predicted flows in fish bearing stream-reaches downstream of the mine; and
- the Water and Sediment Quality (Section 9) and Periphyton, Benthos and Fish Tissue assessments (Section 10).

Findings of the fish assessment have in turn informed the development of the Selenium Management Plan (Section 4.6) and assessment of potential effects related traditional land use (Section 19.6) in the project area.

The fish data collection and project effects assessment was conducted by Diversified Environmental Services (DES), Fort St. John, with assistance from Travis Anderson of WCCC.

11.2 Scope of Assessment

11.2.1 Project Components Assessed

Potential project effects on fish and fish habitat were assessed with respect to the two major components of the proposed Hermann Mine Project:

- the Hermann minesite, which encompasses the proposed Hermann North and Hermann Syncline pits and associated waste rock dumps, coal truck loading and mine infrastructure facilities (Figure 3.4-5); and
- the Hermann coal haul route, which will link the minesite with existing coal processing and rail loadout facilities at the nearby Wolverine Mine (Figure 3.5-1).

Project effects associated with the minesite area include potential alterations in streamflow due to mine development affecting groundwater storage and discharge, water management in the minesite area, and potential affects on water quality from ARD/ML, blasting residue, sewage treatment and ground disturbance. These effects will be largely confined to the M20 Creek drainage. Fish distribution in M20 Creek is limited to the lower two reaches, located approximately 13 km downstream from the minesite (Figure 11.2-1).

Effects of the coal haul route include potential direct effects on fish habitat from bridge or culvert replacements and sedimentation from road widening and stream crossing replacements or upgrades. Fish bearing stream reaches potentially affected by coal haul route upgrades are upper Mast Creek, where a culvert will be replaced just upstream of seasonal fish habitat, and Perry Creek and an unnamed tributary to the Wolverine River at 8.6 km, where existing clear span bridges will be replaced on the Wolverine FSR.

Figure 11.2-1: Fisheries Sampling Sites (Figures Section)

11.2.2 Selection of Valued Ecosystem Components

Valued ecosystem components (VECs) selected for assessment of project effects on fish include:

- Fish–fish species and seasonal presence in streams in the minesite area and tissue metals levels were characterized to describe baseline conditions and assess sensitivity to mine-related disturbances. Fish may be directly affected by changes in water quality with associated acute or chronic effects. The fish tissue metals analysis was conducted to develop a baseline for monitoring of potential project effects on aquatic ecosystems, in particular the potential for selenium bioaccumulation. Details of the fish tissue analysis and proposed monitoring are provided in the periphyton, benthic invertebrate and fish tissue assessment (Section 10.8) and Selenium Management Plan (Section 4.6), respectively.

  Due to the distance from the Hermann mine to fish-bearing water, no direct disturbance impacts to fish are anticipated. The nearest occupied fish habitat is located in lower M20 Creek, approximately 13 km downstream of the proposed disturbance footprint. Although fisheries values in lower M20 Creek are relatively low from a regional perspective, potential indirect downstream effects on limited fish habitat suitability are of concern. Although several sport and non-sport fish species are present in lower M20 Creek, with the exception of resident slimy sculpin, none complete the majority of their life cycle in waters directly affected by the development.

- Fish habitat–seasonal habitat use and physical habitat conditions were characterized to assess sensitivity to potential project related effects. Fish habitat may be affected by direct disturbance (e.g., instream disturbance due to culvert or bridge replacement, alterations in instream flow, sedimentation) or indirect effects (e.g., reduced benthic productivity due to changes in water quality).

Two downstream habitat values were selected for the purposes of detailed effects assessment. These are juvenile mountain whitefish summer-rearing habitat and juvenile bull trout over-wintering habitat. These two habitat values encompass the seasonal requirements of all fish species that make seasonal use of lower M20 Creek as well as the year-round requirements of resident slimy sculpin.

11.2.3 Temporal Boundaries

Four project phases were considered in the assessment of potential impacts on fisheries resources:

- baseline–represents the condition of fisheries resources prior to any project-specific developments and reflects the residual effects of past anthropogenic disturbance;
- construction–represents conditions during construction of facilities associated with the Hermann minesite and activities associated with the upgrading of segments of existing high-grade road comprising the Hermann coal haul route (Section 3.5). Road segments to be upgraded by WCCC include the Wolverine FSR along the Wolverine River, the Nabors Road SUP in the upper Mast and M20 creek basins and the Hermann Coal License, along Nabors Creek, a tributary to M20 Creek;
- operations–represents conditions during mining and coal transport operations. Potential effects on fisheries resources are expected to be similar through the operations, decommissioning and reclamation phases. Effects assessment for this phase is based on maximum predicted changes in average seasonal stream flows and during summer and winter low flow conditions (Section 7.5) and predicted changes in water quality from contaminant loadings during the operations and decommissioning phases (Section 9.5) and any related effects on benthic community composition or productivity (Section 10.5); and
- post-closure–represents conditions following mine closure and the completion of decommissioning and reclamation activities, when surface drainage and ground water discharge patterns have stabilized and the potential erosion and downstream transport of disturbed soil has been minimized. Effects assessment for this phase is based on predicted post-closure flows and water quality (Sections 7.5 and 9.5, respectively).

11.2.4 Spatial Boundaries

For the purposes of the assessment of potential impacts on fisheries resources, the study areas for the two primary project components were defined as follows (Figure 11.2-1):

- Hermann minesite–includes the M20 Creek drainage, to which all surface drainage originating within the minesite disturbance area will flow. Fish-bearing water affected by the Hermann minesite is limited to a 1.9 km segment of M20 Creek located 13 km downstream of the proposed M20 Sediment Pond. For the purposes of baseline characterization, fisheries values in four additional tributary drainages, whose headwaters lie adjacent to the footprint boundary, were also documented. No surface drainage from the development is expected to report to these tributaries, which include M14 Creek, South Hermann Creek and Canary Creek. Hermann North Pit 3 and Syncline Pit will impinge on small areas of the uppermost catchments of M14 Creek, and South Hermann Creek, respectively. All surface drainage from these areas will be directed to the M20 catchment. Potential effects on flows or water quality, due to flow diversions to the M20 catchment or groundwater seepage from the mine areas to M14 or South Hermann creeks, will not be measurable (refer to Groundwater Quality, Section 8.5.1). Although, marginal seasonal rearing habitat is present in the lower reach of both streams, no effects on fish habitat are expected; and
- Herman coal haul route–includes all streams intersected by the Wolverine FSR, Nabors Road SUP and Hermann coal license segments of existing high-grade road proposed to be upgraded by WCCC. These streams were characterized in terms of accessibility to fish and habitat, from their crossing locations downstream to their respective confluences with the Murray and Wolverine rivers.

Figure 11.2-2: Fish Sample Sites and Fish Distribution (Figures Section)

11.2.5 Influence of Consultation on the Assessment

The scope of fisheries-related issues was based on requirements to avoid harmful alteration, disruption or destruction (HADD) of fish habitat under the *Fisheries Act*. Discussions were held with federal agencies, including the Canadian Environmental Assessment Agency (CEAA), Fisheries and Oceans Canada (Major Project Office), and Transport Canada (Navigable Waters) concerning potential project effects and it was determined that no HADD is expected (Sections 2 and 21). The focus and intensity of the fisheries baseline and effects assessment program was also guided primarily by a review of concerns raised during the WCCC Brule Project assessment which involved comparable fish and fish habitat issues.

Provisions for monitoring of potential of effects of fish habitat use levels were clarified as a result of the third party review of *Draft Terms of Reference* and *Detailed Study Plan*, conducted on behalf of First Nations and Kelly Lake communities.

No additional fisheries concerns were raised through public consultation or Working Group interactions.

11.3 Baseline Conditions

11.3.1 Approach and Methods

Fish distribution and habitat use in waters potentially affected by the development of the Hermann Mine Project were investigated between summer 2004 and fall 2006. This involved an assessment of habitat suitability and fish use in tributary drainages within, and adjacent to, the Hermann minesite and coal haul route study areas (Section 11.2.4).

Fieldwork was conducted within the drainages of M20 Creek, M14 Creek, South Hermann, Canary, Mast, Perry creeks and unnamed tributaries to the Wolverine River, with the following objectives:

- confirm and document the location and passability of all barriers to fish movement;
- describe the current limits of fish distribution within each sub-drainage;
- confirm the presence or absence of resident fish upstream of impassable barriers;
- confirm the presence and sensitivity of potential seasonal rearing, spawning and over-wintering habitat in lower M20 Creek; and
- identify fish habitat sensitivities and mitigative requirements in streams potentially affected by haul route upgrading.

Eight stream sample sites were established and evaluated in the vicinity of the Hermann mine and coal haul route, including three sites on M20 Creek (September 16, 2004; October 5, 2006 and August 10, 2004), two sites on Mast Creek (July 29, 2005 and August 11, 2005), and one site on M14 Creek (August 11, 2005), South Hermann Creek (September 16, 2005) and Canary Creek (August 10, 2005). Sample sites were located on representative segments of their respective reaches.

A standard Resource Inventory Standards Committee (RISC) Site Data Card was completed at each stream sample site, in accordance with Reconnaissance Fish and Fish Habitat Inventory: Standards and Procedures (RIC 2001). Photographs of representative habitat and channel features were taken at each sample site, including upstream and downstream ground perspectives and aerial views.

A fish species inventory was undertaken at each sample site using a Coffelt Mark X gas-generator, backpack electro-fisher. All electro-fishing was conducted using pulse frequency settings of 60 hertz. Output voltages of 200 to 300 volts were used, with adjustments made for water depth, conductivity and length of fish being sampled. A range of rearing and holding habitat was sampled during single-pass electro-fishing within each site. Sample sites were typically 100 to 200 m in length. Sampling specifications, species, and fork length for all fish captured were recorded on RIC Fish Collection Forms and Individual Fish Data Forms (RIC 2001). Scale samples were collected from representative sport-fish, for subsequent age analysis.

More intensive sampling was conducted on lower M20 Creek on three occasions between July and October 2006, for the purpose of documenting seasonal rearing and potential over-wintering use by juvenile sport-fish. Juvenile sport-fish were enumerated during single pass electro-fishing of the majority of Reaches 1 and 2 (Figure 9.1-1) on July 10, September 1 and October 5, 2006.

In addition to sample site assessments, fisheries habitat inspections were conducted at 23 drainage course crossings encountered along the proposed Hermann coal haul route during August 2005 and June 2006. Stream crossing inspections included an assessment of habitat suitability, fish presence, habitat sensitivity, potential for adverse downstream effects and mitigative requirements necessary to prevent downstream impacts. Stream crossing ID numbers were assigned numerically from the proposed Hermann Syncline Pit northward to the Wolverine minesite.

The location and passability of all barriers to fish movement in the vicinity of both project components were documented during a low-level helicopter reconnaissance of the applicable stream networks in August 2004. The UTM coordinates of barriers and notable habitat features were recorded in NAD83 datum using a Garmin hand-held Global Positioning System (GPS) receiver.

The results of baseline investigations are described in the following sections.

11.3.2 Hermann Minesite

11.3.2.1 Regional Fisheries Context

The proposed Hermann minesite encompasses the Hermann North pits, the Hermann Syncline Pit and related facilities and infrastructure. The minesite disturbance area lies predominantly within the headwaters of the upper M20 Creek drainage, with small areas of the Hermann North Pit 3 and Syncline Pit impinging on the drainage divide areas of the M14 South Hermann creeks, respectively. The headwaters of Canary Creek lie outside the minesite disturbance area to the west of Syncline Pit.

All drainages originating within the Hermann minesite disturbance area are direct tributaries to the Murray River. The Murray River is a low-turbidity, moderate-gradient system draining the east slopes and foothills of the Rocky Mountains and possesses relatively high fisheries values. The most significant feature defining fish distribution within the Murray River watershed is Kinuseo Falls, located 158 km upstream of the confluence with the Pine River. This 60 m high waterfall represents the upper limit of distribution for most fish species. Native species present downstream of the falls include mountain whitefish (*Prosopium williamsoni*), Arctic grayling

(*Thymallus arcticus*), bull trout (*Salvelinus confluentus*), northern pike (*Esox lucius*), burbot (*Lota lota*), longnose sucker (*Catostomus catostomus*), slimy sculpin (*Cottus cognatus*), longnose dace (*Rhinichthys cataractae*) and finescale dace (*Phoxinus neogaeus*).

Resident fish populations naturally occurring in the upper Murray watershed, above Kinuseo Falls, include widely distributed fluvial and adfluvial sub-populations of resident bull trout, and resident pigmy whitefish (*Prosopium coulteri*) and longnose sucker populations in Monkman Lake. Slimy sculpin, which typically exist in association with isolated, upstream-resident bull trout populations, appear to be conspicuously absent from the upper Murray drainage.

Three non-indigenous sport-fish species have been introduced to the Murray River system in recent decades. These include rainbow trout (*Oncorhynchus mykiss*), eastern brook trout (*Salvelinus fontinalis*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*).

Rainbow trout were introduced to Monkman Lake, upstream of Kinuseo Falls, in 1983 and 1989, and have been regularly stocked in Moose Lake and Quality Lake, downstream of the falls, since 1982 and 1985, respectively. Rainbow trout emigrating from these lakes are able to enter the Murray River via the Monkman and Gwillim rivers and Quality Creek. Although rainbow trout are potentially present in the majority of the watershed, sampling records indicate the species has failed to establish significant self-sustaining populations in the Murray River.

Westslope cutthroat were stocked in Upper Blue Lake, at the headwaters of the Murray River, in 1983. This species is now abundant in the Upper and Lower Blue lakes complex and its tributaries, but have not been found in downstream portions of the Murray watershed.

Commencing in 1980, eastern brook trout were introduced to five non fish-bearing lakes in the Murray River watershed, including Moose Lake, Quality Lake and three small lakes in the “Kinuseo Lakes” group. At the time of the introductions, the recipient lakes were thought to be closed systems and no downstream movement to the Murray River mainstem was anticipated. By 1990, it became apparent that brook trout were escaping from more than one of the stocked lakes and colonizing downstream drainages within the middle Murray River watershed. Concerns about potential brook trout colonization of bull trout habitat prompted the discontinuation of brook trout stocking in Quality Lake, Moose Lake and Kinuseo Lakes in 1990, 1992 and 1994, respectively.

The following sections summarize fish sampling data and habitat observations from the four Murray River tributaries draining terrain within, and adjacent to, the proposed Hermann minesite disturbance area. Site data cards, fish data forms, and representative site photographs for stream sample sites established on each of the four streams are presented in Appendix 11-1. Fish distribution and other locational data, including sample sites, reach breaks and barriers are summarized in Figure 11.2-1.

11.3.2.2 M20 Creek

All surface drainage from the Hermann minesite disturbance area is currently proposed to report to M20 Creek, also known as “Camp Creek”. M20 Creek enters the Murray River approximately 119 km upstream of its confluence with the Pine River and 39 km downstream of Kinuseo Falls. The proposed Hermann North and Hermann Syncline pits are located at the headwaters of the M20 Creek drainage approximately 15 km upstream from the mouth.

Fish distribution in M20 Creek is restricted by a series of impassable barriers on the middle portion of the mainstem (Reach 3). An impassable bedrock chute, located 1.9 km upstream from the confluence with the Murray River (UTM 10.625067.6098371), comprises the lowermost of these barriers (Appendix 11-1: Site 2). A series of five vertical waterfalls occur along the reach lying immediately above the bedrock chute. The first of these is a 10 m waterfall located 250 m above the lower chute (UTM 10.624883.6098330; Appendix 11-1: Site 2).

Fish sampling conducted by DES upstream of the lower barrier in 2004, 2005 and 2006 (Appendix 11-1: Site 3), confirmed the results of extensive unrelated sampling, indicating the absence of resident fish populations in all portions of the drainage upstream of the lower barrier. Historical sampling of non-fish bearing reaches above the barriers include electro-fishing by the BC Resource Analysis Branch in 1976 (RAB 1997), electro-fishing in May, August and September 1982 and June 1983 by Dension Mines Ltd. (McCart et al. 1985), electro-fishing conducted for Canfor in August 1997 (Hatfield 1998), as well as more recent sampling conducted for Canfor in September 2005 (Poulin 2006). Confusion about a reported record of a bull trout in the upper M20 Creek drainage in 1976, as discussed by Murray et al. (1983), appears to have originated from a typographical mapping error.

The fish bearing portion of the M20 Creek drainage is limited to the lower two mainstem reaches, which are accessible to fish from the Murray River. Reach 1 is approximately 700 m in length and extends across the Murray River alluvial plain, from the confluence to the lower end of the M20 Creek canyon. This reach is characterized by riffle/pool habitat with a high proportion of shallow riffle and substrates dominated by cobble, with significant secondary components of gravel and fines (Appendix 11-1: Site 1). Moderate quality seasonal rearing potential for sport and non-sport species exists, but is limited by a lack of rearing cover and holding habitat. At moderate to high flow stages, juvenile rearing suitability is also limited by high turbidity resulting from sediment input at a natural sediment source located on Reach 4 (UTM 10.621527.6100169), 5.1 km upstream of the lower barrier. Suitability for spring and fall spawning salmonids is restricted by high suspended sediment and low seasonal discharge, respectively. Over-wintering potential in Reach 1 is largely precluded by low winter surface flow and the absence of deep pool habitat.

Reach 2 is 1200 m in length and extends upstream from the edge for the alluvial plain to the base of the lower impassible barrier. The entire reach is confined within the lower portion of a steep-walled canyon. Reach 2 is also dominated by riffle/pool habitat and cobble substrates but has a significant component of exposed bedrock in the streambed and a higher proportion of pool and holding habitat (Appendix 11-1: Site 2), resulting in slightly higher juvenile rearing capability. Although spawning suitability is still restricted by a high proportion of fines present in granular substrates, limited over-wintering potential exists in numerous shallow, bedrock pools.

Reach 3 encompasses the remainder of the incised portion of the mainstem and extends 4.5 km from the lower barrier to just above the uppermost waterfall. Reaches 4 and 5 are characterized by a reduced degree of confinement and decreasing gradient. At the top of Reach 5, the stream diverges into the two sub-basins comprising the headwaters of the drainage. The east fork is designated as the upper M20 Creek mainstem while the west fork in known locally as Nabors Creek. Both streams cross the proposed North Hermann Pit area.

Historical fish sampling information for M20 Creek includes the results of electro-fishing conducted by the BC Resource Inventory Branch in the summer of 1976 (RAB 1977) and electro-fishing conducted for Denison Mines from 1982 to 1984 (McCart et al. 1985). Between 1976 and 1984, relatively low densities of mountain whitefish, Arctic grayling, bull trout, burbot, longnose sucker and slimy sculpin were recorded in Reach 1.

Murray et al. (1983) examined fish sampling data collected between 1976 and 1983 and concluded that, with the possible exception of resident slimy sculpin, fish use of lower M20 Creek was primarily limited to seasonal rearing by members of Murray River populations during the ice-free months. Murray et al. (1983) also suggested that very low catch-per-unit-effort (CPUE) values reported for lower M20 Creek during the latter half of that period may have been related to “heavy sediment loads and low invertebrate densities” partially due to access road, conveyor belt and mine construction in 1982. Limited sampling on Reach 1, undertaken for as part of a 1:20,000 Reconnaissance Inventory conducted for Canfor in August 1997 (Hatfield 1998), confirmed the presence of mountain whitefish, burbot and slimy sculpin. In addition to the five species previously captured in M20 Creek, sampling during the 2006 WCCC Hermann Mine Project investigations recorded introduced eastern brook trout and rainbow trout.

Slimy sculpin exist year-round as a resident population in M20 Creek and were observed during all sampling events. This species is present at low to moderate densities throughout both fish bearing reaches, from the mouth, upstream to the base of the lower impassable chute.

All other species present in lower M20 Creek are members of their respective Murray River mainstem populations and use the stream primarily as juvenile rearing habitat during the ice-free months.

Mountain whitefish are the most abundant sport-fish in the Murray River (Murray et al. 1983, McCart et al. 1985) and are correspondingly most abundant in lower M20 Creek. Mountain whitefish typically over-winter in deep pool habitat of large rivers such as the Murray. During spring freshet, a proportion of the juvenile cohorts undertake summer feeding forays into small tributary habitats that support favourable aquatic invertebrate densities. These fish generally begin moving back to larger mainstem habitats as surface flow in tributaries begins to decrease significantly during mid to late summer; emigration is normally complete by late October.

The results of replicate electro-fishing events in July, September and October 2006, indicated most mountain whitefish use during the early summer occurred in Reach 2 and involved two to five year old immature fish which had presumably entered from the Murray River during or subsequent to freshet. CPUE values for post-yearling juveniles, on both reaches combined, declined dramatically from 21.7/100 sec on July 10, to 3.8/100 sec by September 1 and 0.6/100 sec by October 5, indicating significant emigration of post-yearling juveniles by early fall.

On July 10, young-of-the-year (YOY) juveniles had begun entering the lower 100 m of Reach 1, from the Murray River. In contrast to post-yearling juveniles, densities of YOY and yearling juveniles was lowest on July 10 (CPUE 2.3/100 sec) and increased through late summer, with highest CPUE values attained on September 1 (19.0/100 sec), by which time YOY distribution included the lower half of Reach 2. By October 5, the majority of YOY and yearling whitefish were found in the lower 200 m of Reach 1 and CPUE had dropped to 15.0/100 sec.

Overall mountain whitefish CPUE values for 2006 (22.0 to 26.0/100 sec) were markedly higher than those calculated by Murray (1985) for the 1976 to 1984 period (0 to 0.32/100 sec). Direct comparison of these values is confounded by the fact that only Reach 1 was sampled from 1976 to 1984. With this considered, it appears that juvenile mountain whitefish densities in 2006 were still significantly higher.

The use of lower M20 Creek by the remaining five sport-fish species occurs at much lower densities. Low numbers of juvenile bull trout, ranging in age from two to four years old, were captured during all three sampling events in 2006. Bull trout were most numerous during the July 10 sampling when the total number of individuals in M20 Creek was estimated to be eight fish. The number of bull trout present had declined by approximately ½ by early fall. It is possible that a proportion of these remain in Reach 2 of M20 Creek through the winter. Of six juvenile bull trout captured on July 10, the poor body condition of one individual suggested probable over-wintering in M20 Creek. The presence of bull trout in M20 Creek is believed to be the result of typical post-yearling juvenile dispersal from suitable spawning habitat elsewhere in the Murray River system. No YOY or yearling bull trout have been captured in M20 Creek, indicating an absence of spawning activity.

Eastern brook trout appear to use lower M20 Creek at densities comparable to those of bull trout. Colonization by brook trout is viewed as an undesirable development due to potential negative impacts on native bull trout populations through hybridization and direct competition for space and food resources (Kitano et al. 1994 in Baxter 1996 and Buktenica 1997). It appears that brook trout have not currently established a spawning run in lower M20 Creek, as is the case in several other Murray River tributaries. Although one male in spawning condition was sampled on October 5, 2006 no YOY brook trout have been observed.

Two three year old juvenile Arctic grayling were sampled in Reach 2 of M20 Creek on July 10, 2006. The only other record for this species was a single specimen captured in May 1983 (McCart et al. 1985). Although Arctic grayling are common in the adjacent Murray River, high turbidity in M20 Creek reduces spring spawning and summer feeding suitability for this species.

Juvenile burbot are sporadically present in M20 Creek at extremely low densities. One burbot was captured in September 2004 while none were sampled during 2006. Limited seasonal use by juvenile burbot from the Murray River is likely limited to Reach 1.

The incidence of rainbow trout in M20 Creek reflects their frequency of occurrence in the middle Murray watershed. A two year old juvenile captured in the lower barrier plunge pool on September 1, 2006 is the only documented record of this species.

11.3.2.3 M14 Creek

Hermann North Pit 3 impinges on the extreme headwaters of M14 Creek which drains in a southeast direction from pit area. It is anticipated that no surface drainage originating on the Hermann minesite will flow to the M14 Creek drainage. M14 Creek enters the Murray River 5.5 km upstream of the mouth of M20 Creek. The drainage is comparatively small and most reaches are ephemeral in nature. The Murray Forest Service Road (FSR) crosses the lower mainstem approximately 80 m upstream of the confluence with the Murray River.

Reach 1 consists of the short segment of stream immediately below the impassable FSR culvert crossing. The channel is characterized by moderate-gradient, riffle/pool habitat with substrates composed of gravel and fines. Limited seasonal rearing potential exists for juvenile sport-fish (i.e., mountain whitefish) during periods of adequate surface flow. Lake chub and longnose sucker were captured at the outlet of the FSR culvert in July 2004 (Appendix 11-1: Site 4).

Reach 2 extends for approximately 600 m upstream of the FSR crossing. Stream gradient is dramatically reduced and substrates become dominated by fines and organic debris. The channel is poorly-defined and lentic habitats associated with beaver impoundments are common. An isolated, residual population of finescale dace occupies this reach.

Upstream of Reach 2, the drainage diverges into several small sub-basins each draining a section of the steep north slope of the Murray River valley. No fisheries habitat potential exists beyond Reach 2.

11.3.2.4 South Hermann Creek

The extreme headwaters of South Hermann Creek originate along the southeast edge of the proposed Hermann Syncline Pit. Surface drainage from a small proportion of the pit currently lying within the South Hermann Creek catchment area will be diverted to the adjacent M20 Creek drainage.

The South Hermann Creek drainage is approximately 4.6 km in length and enters the Murray River 5.5 km upstream of the mouth of M14 Creek. The lower reach of the stream extends 1.3 km upstream from the Murray River confluence and contains marginal seasonal rearing potential for sport and non-sport species. The top of Reach 1 is marked by an impassable cascade (UTM 10.620026.6092832), beyond which gradient increases to over 20%. A stream sample site was evaluated in the lower portion of Reach 1 in September 2004 (Appendix 11-1: Site 5). The Murray FSR crosses the stream 350 m upstream from the mouth. An impassable perched culvert at the FSR crossing prevents upstream fish passage. Four eastern brook trout in spawning condition were captured during electro-fishing between the mouth and the FSR crossing. Resident slimy sculpin and rearing juveniles of other species were absent. A steep riffle, 30 m in length, located immediately upstream of the mouth, may partially restrict seasonal access to the stream.

11.3.2.5 Canary Creek

The Canary Creek drainage has a slightly larger catchment area than the M14 or South Hermann drainages. The drainage divide between Canary and M20 creeks lies to the west of the Syncline Pit disturbance area.

The portion of the lower mainstem lying within the Murray River Valley is relatively unstable and has apparently changed course several times in recent decades. Surface discharge currently filters through a series of poorly-defined ephemeral channels into a large semi-permanent beaver impoundment located immediately adjacent to the Murray River (Figure 11.3-1). A significant proportion of discharge on the lower mainstem appears to flow subsurface and de-watered channel is common by mid to late summer (Figure 11.3-2). Limited seasonal use of the lower reach, by juvenile sport and non-sport fish from the Murray River, is probable during periods of continuous channel connectivity and surface flow.

Although a small number of juvenile mountain whitefish and bull trout were sampled in the lower reach in August 1982 and June 1983 (McCart et al. 1985), the current channel configuration appears to preclude seasonal access from the Murray River. The large beaver impoundment near the mouth of Canary Creek was found to support resident finescale dace during an inspection in August 2005. No fish were captured or observed in adjacent portions of Canary Creek upstream and downstream of the Murray FSR culvert crossing. Annual de-watering of the channel likely precludes the presence of resident slimy sculpin.

Figure 11.3-1: Large Beaver Dam and Impoundment Adjacent to the Murray River at the Mouth of Canary Creek

Figure 11.3-2: Canary Creek–Dry Streambed in Segment of Reach 2 Immediately Upstream of Murray FSR Culvert Crossing

A 4-m bedrock chute is present 2.5 km upstream from the Murray River, marking the upper limit of potential fish distribution (UTM 10.616817.6091611). A second impassable barrier (8 m waterfall) is located a further 900 m upstream (UTM 10.616408.6092346). A stream sample site was assessed on the mainstem reach lying upstream of these barriers, in September 2004, to confirm the absence of resident fish populations. Moderate quality seasonal rearing habitat was noted, however, no fish were present (Appendix 11-1: Site 6).

11.3.3 Hermann Coal Haul Route

The Hermann coal haul route will link the proposed Hermann minesite with coal processing and rail loadout facilities at the existing WCCC Wolverine mine to the northwest. This component of the Hermann project will involve the upgrading of three segments of existing high-grade road. These include the Hermann coal license (0.7 km), Nabors Road SUP (4.9 km) and the Wolverine FSR (6.9 km) segments. The Shell PDR segment is currently being upgraded under approval from the BC Oil and Gas Commission. Drainage course crossings along the Shell PDR segment are not addressed in this discussion.

The following sections summarize the results of fisheries habitat inspections conducted at 19 drainage course crossings identified along the three segments of haul route proposed to be upgraded by WCCC. The Hermann coal license segment lies within the M20 Creek drainage and crosses one stream. The Nabors Road SUP segment straddles the height-of-land between M20 Creek and Mast Creek, a tributary to the Wolverine River. Ten of the 19 identified crossings occur on this segment, including seven in the M20 Creek drainage and three in the Mast Creek drainage. The remaining eight crossings occur along the Wolverine FSR segment and involve the lower reach of direct tributaries to the Wolverine River, including Perry Creek. An additional four stream crossings were inspected within the minesite area, south of the coal haul route. This segment of existing road will be upgraded for use as a pit haul road.

Drainage courses not meeting the definition of a stream under the *Forest and Range Practices Act* (FRPA) have been assigned non-classified drainage (NCD) status. These drainages typically contain segments of seepage and discontinuous channel that effectively limit potential for downstream transport of sediment and debris. Drainage courses characterized by continuous alluvial streambeds and definable stream banks have been assigned fish-bearing (S1 to S4) or non-fish bearing (S5 and S6) FRPA stream classifications. Of the 18 drainages possessing definable alluvial channels, three are potentially fish-bearing in the vicinity of their respective crossings. Clear-span bridge replacements, with no instream disturbance, are planned for two of these, while a culvert replacement is proposed at the third. Information relevant to individual crossings, including UTM coordinates, crossing structure, stream classification and habitat sensitivity, are presented in Table 11.3-1.

Table 11.3-1: Summary of Information for 23 Drainage Course Crossings Identified along the Hermann Coal Haul Route and Pit Haul Road

Crossing ID	Stream Name	UTM		Fish Bearing	Stream Class	Species Present	Avg. Channel Width (m)	Proposed Crossing Structure	Sensitivity/ Downstream Effects Potential	COMMENTS
		East	North							
HR-1	Trib to Nabors Cr	618059	6096379	No	S6	n/a	-	Culvert	low	discontinuous, ephemeral channel 15.5 km upstream of fish-bearing water
HR-2	Trib to Nabors Cr	618118	6096580	No	S6	n/a	-	Culvert	low	discontinuous, ephemeral channel 15.3 km upstream of fish-bearing water
HR-3	Trib to Nabors Cr	618507	6097197	No	S6	n/a	-	Culvert	low	discontinuous, ephemeral channel 14.5. km upstream of fish-bearing water
HR-4	Trib to Nabors Cr	618548	6097309	No	S6	n/a	-	Culvert	low	discontinuous, ephemeral channel 14.4 km upstream of fish-bearing water
HR-5	M20 Cr	618804	6098707	No	S6	n/a	3.0	Clear-span Bridge	moderate	non fish-bearing due to barriers on lower M20 Creek; no instream work proposed
HR-6	Trib to M20 Cr	618651	6099591	No	S6	n/a	1.2	Culvert	low	enters non fish-bearing reach of M20 Creek 11.8 km upstream of fish-bearing water
HR-7	Trib to M20 Cr	619222	6100244	No	S6	n/a	1.0	Culvert	low	enters non fish-bearing reach of M20 Creek 10.8 km upstream of fish-bearing water
HR-8	M20 Cr	619447	6100706	No	S5	n/a	4.0	Clear-span Bridge	moderate	non fish-bearing due to barriers on lower M20 Creek; no instream work proposed
HR-9A	M20 Cr	619530	6100818	No	S5	n/a	2.5	Culvert	moderate	primary channel of M20 Creek; non fish-bearing due to barriers downstream
HR-9B	M20 Cr	619565	6100894	No	S5	n/a	2.5	Culvert	moderate	secondary channel of M20 Creek; non fish-bearing due to barriers downstream
HR-10	M20 Cr	619733	6101160	No	S5	n/a	5.0	Clear-span Bridge	moderate	non fish-bearing due to barriers on lower M20 Creek; no instream work proposed
HR-11	M20 Cr	619936	6101598	No	S5	n/a	7.0	Clear-span Bridge	moderate	bridge removed; non fish-bearing due to barriers downstream; no instream work proposed
HR-12	Trib to Mast Cr	620077	6102029	No	NCD	n/a	n/a	Culvert	very low	discontinuous, ephemeral channel
HR-13	Trib to Mast Cr	619998	6102440	No	NCD	n/a	n/a	Culvert	very low	discontinuous, ephemeral channel
HR-14	Mast Creek	620307	6103128	Yes	S3	BT	1.8	Culvert	high	existing culvert crossing at upper limit of bull trout distribution; marginal seasonal rearing downstream, unsuitable upstream; site isolation and diversion required during culvert replacement.
HR-30	Trib to Wolverine R	616361	6109197	Yes	S3	MW, BT	3.2	Clear-span Bridge	high	FSR km 8.6; existing clear-span bridge to be upgraded; limited seasonal rearing at moderate flow stage; no instream work proposed.
HR-31	Trib to Wolverine R	615612	6108631	No	S6	n/a	2.3	Culvert	low	FSR km 9.5; marginal rearing potential but no seasonal access from Wolverine River; discontinuous channel and subsurface flow at mouth
HR-32	Trib to Perry Creek	615177	6107126	No	S6	n/a	1.3	Culvert	moderate	FSR km 11.1; ephemeral flow, no seasonal rearing potential, no seasonal access
HR-33	Trib to Perry Creek	615030	6107019	No	NCD	n/a	n/a	Culvert	very low	discontinuous, ephemeral channel
HR-34	Perry Creek	614640	6106591	Yes	S2	BT, CCG	11.2	Clear-span Bridge	high	FSR km 12; resident bull trout & slimy sculpin (falls upstream, CNR culvert downstream); no instream work currently proposed
HR-35	Trib to Wolverine R	614198	6106009	No	NCD	n/a	n/a	Culvert	very low	discontinuous, ephemeral channel
HR-36	Trib to Wolverine R	613781	6105694	No	NCD	n/a	n/a	Culvert	very low	discontinuous, ephemeral channel
HR-37	Trib to Wolverine R	612807	6105440	No	S6	n/a	3.0	Culvert (2000mm)	very low	machine-constructed channel; part of Wolverine Mine sediment management system; sediment pond downstream

11.3.3.1 M20 Creek Drainage

The southernmost 12 crossings on the pit haul road and Hermann Coal Lease and Nabors Road SUP segments of the coal haul route lie within the upper M20 Creek drainage and include five crossings of the M20 Creek mainstem, with the remainder involving minor tributaries to M20 and Nabors creeks. All crossings within the M20 Creek drainage occur on non fish-bearing reaches well upstream of the limit of fish distribution. Crossing upgrades at M20 Creek mainstem crossings HR-5, HR-8, HR-10 and HR-11 (Figure 3.5-1) will involve the replacement of clear-span bridge structures with no disturbance to the stream channel. M20 Creek mainstem crossing HR-9 currently consists of primary and secondary channels, each flowing through 900 mm culverts located 80 m apart (crossings HR-9a and HR-9b). Existing culverts are present at the six unnamed tributary crossings. The lowermost M20 Creek crossing (HR-11) is located 9 km upstream of occupied fish habitat below the lower impassable barrier.

11.3.3.2 Mast Creek Drainage

The remaining three crossings on the Nabors Road SUP segment of the route are located in the upper Mast Creek drainage. These include one crossing of the upper Mast Creek mainstem (HR-14) and two crossings of minor seasonal drainages at the extreme headwaters of mast Creek (HR-12 and HR-13).

Mast Creek is known to support bull trout and slimy sculpin populations. A cascade located 2.7 km above the mouth of the stream appears to restrict the distribution of resident slimy sculpin to the lower reach (Figure 11.2-1). Limited seasonal use by juvenile mountain whitefish has also been recorded in the lower 1 km of the mainstem (BC Research 1980). Bull trout are the only species present in the middle reaches of the drainage and may represent both resident and migratory sub-populations. The distribution of bull trout extends 9 km up the Mast Creek mainstem and into the lowermost reach of both major tributaries, Mesa Creek and South Mast Creek. Suitability for juvenile rearing in the mainstem degrades significantly, upstream of the confluence with South Mast Creek (Reach 4). A reach break located 1300 m upstream of the confluence with South Mast Creek marks the upper limit of suitability for bull trout, and the transition between moderate-gradient riffle/pool habitat (Appendix 11-1; Site 8) and the low-gradient headwaters of the drainage, which are characterized by poorly-defined channel, wetland seepage, and the absence of granular substrates and riffle habitat (Figure 11.3-3). Active beaver dams and impoundments are common upstream of this point. Although marginal seasonal rearing habitat is present immediately downstream of the reach break (Reach 4), suitable bull trout spawning and over-wintering habitat is absent.

The Nabors Road SUP crossing of Mast Creek (HR-14) is located at this reach break. The crossing currently consists of two 900 mm culverts. The inlet of the north culvert has been blocked by slumping fill material while flow through the inlet of the south culvert is partially restricted by an actively maintained beaver dam. A significant impoundment has resulted upstream of the crossing (Figure 11.3-4), while a smaller active dam has back-flooded the south culvert's outlet. Sampling by DES in August 2005 (Appendix 11-1; Site 8) resulted in the capture of a single juvenile bull trout occupying marginal seasonal rearing habitat approximately 100 m downstream of the culvert crossing. Three juvenile bull trout were captured in this reach during August 1997 (Hatfield 1998), while no fish were observed during sampling in September 2005 (Poulin 2006). Higher suitability habitat and higher densities of bull trout are present in Reach 3, downstream of the confluence with South Mast Creek (Appendix 11-1: Site 7).

Figure 11.3-3: Mast Creek, Reach 5: View Upstream 800 m above Crossing HR-14

Figure 11.3-4: Mast Creek: View Upstream from Crossing HR-14 at Top of Reach 4

Although conditions at the existing Mast Creek culvert crossing currently pose a physical barrier to the upstream movement of fish, it is unlikely that lack of access beyond the crossing restricts bull trout distribution, given the absence of suitable rearing habitat upstream. No isolated or residual fish populations were recorded upstream of the crossing during sampling by DES in 2005 or during previous sampling by Hatfield (1998).

Remedial work at this crossing will require instream disturbance and the controlled draw down of the upstream impoundment. Mitigative measures will be implemented to prevent degradation of downstream water quality and disruptive changes in flow volume delivered to downstream bull trout habitat (refer to Section 11.5).

The remaining two crossings lying within the Mast Creek drainage (HR-12 and HR-13) are NCDs entering Reach 5 and have no channel connectivity to fish-bearing portions of Mast Creek.

11.3.3.3 Wolverine River Tributaries

Eight drainage course crossings were identified on the Wolverine FSR segment of the proposed Hermann coal haul route. These include two fish-bearing streams (crossings HR-30 and HR-34), three non fish-bearing streams (HR-31, HR-32 and HR-37) and three NCDs.

Crossing HR-30 is located on a minor unnamed tributary to the Wolverine River, approximately 60 m upstream of its confluence. Limited seasonal rearing potential for juvenile mountain whitefish and bull trout is present in the lower 200 m of the stream during periods of moderate to high flow stage. Low surface flow typically precludes fish use from late summer though winter. The proposed upgrading of the crossing will involve the replacement of the existing clear-span bridge deck (Appendix 11-1: HR-30). No disturbance to the stream channel is proposed.

Crossing HR-34 is located on lower Perry Creek, approximately 1600 m upstream of its confluence with the Wolverine River. This reach of Perry Creek supports resident populations of bull trout and slimy sculpin that are currently isolated between an impassable waterfall located approximately 7 km upstream of the crossing and the impassable CN Rail culvert crossing located 1.2 km downstream. No disturbance within the wetted stream channel is currently anticipated during the proposed replacement of the existing clear-span structure (Appendix 11-1: HR-34). Upgrading procedures at this crossing will be finalized after an inspection of the existing abutments upon removal of the current bridge deck. In the event that replacement of abutment components is required, precautionary mitigative measures will be implemented to prevent potential impacts on bull trout habitat (Section 11.5).

Crossing HR-31 occurs on a minor ephemeral tributary to the Wolverine River, 450 m upstream of its confluence. Marginal seasonal rearing habitat for juvenile sport-fish species present in the Wolverine River exists in the vicinity of the crossing (Appendix 11-1: HR-31) however, seasonal access to the stream is precluded by discontinuous channel, and subsurface flow in first 100 m upstream of the Wolverine River.

Crossing HR-32 is located on an unnamed tributary to lower Perry Creek, which enters the Perry Creek mainstem between the FSR and CN rail crossings. Fisheries habitat potential is precluded by ephemeral flow, lack of seasonal access and absence of suitable bull trout rearing habitat downstream of the crossing (Appendix 11-1: HR-32).

Crossing HR-37 is located on an unnamed tributary to the Wolverine River within the Wolverine mine disturbance area. The stream has been machine-channelized in the vicinity of the crossing and currently forms part of the Wolverine mine surface drainage and sediment management system. The crossing occurs upstream of a manmade sedimentation pond (Appendix 11-1: HR-34).

The remaining three crossings on the Wolverine FSR (HR-33, HR-35 and HR-36) were assigned NCD status and proposed upgrading at these sites has extremely low potential for downstream impacts.

11.4 Effects Assessment Methods

The assessment of project effects on fish followed the general approach outlined in Section 6.3. Direct and indirect effects of project components, including minesite and coal haul route, on fish and fish habitat were examined with consideration for all mitigation measures identified to protect aquatic resources (Section 11.7).

In general terms, the potential impacts of industrial development on fisheries resources can include direct disturbance of fish and fish habitat, degradation of water quality (including increased suspended sediments and changes in chemical parameters), and shifts in annual surface discharge patterns resulting in changes in the capability of seasonal habitats located downstream. Due to the proximity of the Hermann mine to occupied fish habitat and the nature of proposed road upgrades at the three fish bearing haul route crossings, no direct disturbance impacts to fish or fish habitat are anticipated. The following fish and fish habitat effects assessment is therefore primarily focused on the potential indirect effects of minesite development on fish habitat in lower M20 Creek, located approximately 13 km downstream of the disturbance area. These include potential changes in downstream water quality and potential shifts in seasonal discharge patterns.

Predicted project effects on hydrology (Section 7.5), water quality (Section 9,5) and periphyton benthos and fish tissue metal concentrations (Section 10.5), in the fish bearing reaches of M20 Creek, were examined to assess implications to fish and fish habitat in the context of seasonal habitat use by fish

Criteria for characterizing project effects are provided in Table 11.4-1. Findings of the water quality assessment indicated that predicted effects are not expected to have an adverse effect on the ecological health of fish bearing reaches of M20 Creek. Accordingly, this assessment focuses on project effects on physical habitat including instream flows and suspended sediment loads important in parameters controlling fish habitat suitability in Lower M20 Creek.

Table 11.4-1: Hermann Mine Project–Effects Attributes and Significance Criteria for Fish and Fish Habitat

Criterion	Description
Direction	Adverse: reduction in seasonal fish habitat suitability
	Neutral: little or no change in seasonal fish habitat suitability
	Positive: increase in seasonal fish habitat suitability
Magnitude	Low: no or negligible measurable effect on seasonal fish habitat suitability
	Medium: a measurable effect on seasonal fish habitat suitability, but unlikely to pose a serious reduction in fish use
	High: a measurable effect on seasonal fish habitat suitability that is likely to pose a serious reduction on fish use
Geographic Extent	Site-specific: effect confined within a stream reach
	Local: effect confined within tributary drainage (e.g., M20 Creek)

Criterion	Description
	Regional: Murray/Wolverine Rivers
Duration	Short term: effect is limited to <1 year
	Medium term: effect occurs >1 year, but not beyond the life of the project
	Long term: effect lasts up to 10 years beyond the life of the project
	Far future: effect extends >10 years beyond the life of the project
Frequency	Once: occurs once
	Continuous: occurs on a regular basis and regular intervals
	Sporadic: occurs rarely and at irregular intervals
Reversibility	Reversible
	Irreversible
Ecological Context	Low: effect has low potential to affect ecological health
	Moderate: effect has moderate potential to affect ecological health
	High: effect has high potential to affect ecological health
Significance1	Significant: effects are considered to have the following significance if they have the following combination(s) of effects attributes:
	Low: low magnitude and greater than medium-term duration; to medium magnitude and short-term duration
	Moderate: medium magnitude and medium to far future, and high magnitude and short-term duration
	High: medium magnitude and far future duration, or high magnitude and greater than medium-term duration
Level of Confidence2	Low: low confidence in prediction, could vary considerably
	Medium: confidence in prediction, moderate variability
	High: confidence in prediction, low variability

Notes: 1. Effect magnitude and duration are the primary determinants or the significance rating, with geographic extent used to qualify certain ratings. **2.** Predictive confidence is defined based on status of scientific information, experience on other projects, status of data base for this project and professional judgment of investigator.

11.5 Project Effects

11.5.1 Hermann Minesite

Potential impacts to fish and fish habitat in lower M20 Creek resulting from changes in seasonal stream flows due to minesite water management, changes in downstream water associated with increased suspended sediment delivered to downstream fish bearing reaches, and changes in downstream water quality, resulting in potential selenium bioaccumulation. The risk of selenium bioaccumulation in M20 Creek is considered to be low and exposure risk for fish using M20 Creek on a seasonal basis is also low (Section 4.6). However it is difficult to predict potential effects on fish tissue selenium concentrations in resident sculpin. A program to monitor potential effects on fish tissue is described in Section 4.6 and 10.8.

Increased sediment loads have the potential to reduce the production of invertebrate food sources as well as reduce the feeding efficiency of visual feeding fish species. The following analysis examines project effects on fish and fish habitat through effects on flow and suspended sediment and related mitigation strategies. Residual effects are characterized in Section 11.5.3.

Seasonal shifts in discharge patterns resulting from the development of the Herman minesite have the potential to affect habitat capability in lower M20 Creek in two ways:

1. reduce seasonal rearing suitability for juvenile sport-fish (particularly mountain whitefish and Arctic grayling) that move upstream from the Murray River during the May to October rearing season; and
2. reduce juvenile over-wintering capability for low densities of post-yearling juvenile bull trout in Reach 2 and resident slimy sculpin in Reach 1 and 2.

Of the eight fish species recorded in lower M20 Creek, only slimy sculpin exist as a year-round resident population. Resident slimy sculpin appear widely distributed throughout the two reaches comprising the fish-bearing portion of the stream, suggesting that base flows provide surface discharge in fish-bearing reaches throughout the year and that widespread channel de-watering does not take place.

Due to a lack of spring and fall spawning suitability and low over-wintering capability, the use of lower M20 Creek by other fish species is primarily limited to opportunistic seasonal rearing by a small proportion of juveniles belonging to their respective Murray River populations. Juveniles of these species typically move in and out of tributary rearing habitats during the ice-free period, in response to seasonal changes in flow rate, water quality and food abundance. Juvenile sport-fish occupying lower M20 Creek originate from spawning habitat elsewhere in the Murray River system and likely spend portions of one or two rearing seasons in waters potentially affected by the Hermann development. The majority of their life cycles are completed in the Murray River mainstem or in tributaries providing higher spawning and rearing suitability.

Relative to comparable middle Murray River tributaries, M20 Creek is subject to high levels of suspended sediment resulting in reduced rearing suitability for juvenile sport-fish, particularly visual feeders such as Arctic grayling and mountain whitefish. The majority of turbidity originates from a natural sediment source within the stream channel located upstream of the fish bearing reaches and downstream of the Hermann development footprint. Observations made during the collection of baseline information and the results of spot flow measurements taken during the summer and fall of 2006, indicate that sediment input rates from this source are largely dependent on surface discharge rates. Surface discharge rates of greater than approximately 0.20 m^3/sec at the M20-02 gauging station appear to result in dramatically elevated turbidity levels within the fish bearing reaches, while discharge rates below this threshold result in significantly reduced turbidity levels and much more favourable rearing conditions for juvenile sport-fish. Surface discharge rates as low as 0.03 m^3/sec, as measured at the M20-02 gauging station, provided adequate surface flow for seasonal rearing and movement throughout the lower two reaches.

Below average precipitation from April to November 2006, appeared to have resulted in lower than normal TSS levels in lower M20 Creek throughout the 2006 juvenile rearing season. As surface flow at the mouth was consistently sufficient to maintain access from the Murray River, rearing conditions were likely more favourable than average. This may partially explain why CPUE values recorded for juvenile mountain whitefish in 2006 were significantly higher than those recorded between 1976 and 1983 (Murray et al. 1983).

Seasonal flow projections for the operations and decommissioning/reclamation phases of the Hermann Mine Project suggest a reduction in late freshet flows, attenuation of peak freshet flows and summer storm flows, and an increase in summer and winter low flows in an average flow year (Section 7.5). These changes in annual flow pattern are expected to increase summer juvenile rearing suitability by reducing the duration and intensity of sediment input at the natural point source, resulting in lower mean turbidity levels during the May to October rearing season.

Water management structures will be decommissioned during the post-closure phase and natural hydrological process will be restored. Flow predictions for the post-closure phase show a 1% increase in average annual flow with a slight flow decrease of 1–2% for February of a mean year (Table 7.5.1). Projected changes in annual flow patterns at post-closure are expected to be insufficient to provide a positive or negative effect on seasonal rearing suitability.

During the 2006 summer and fall sampling events, the total number of bull trout present in lower M20 Creek was estimated to be less than 10 fish. It is possible that a minor proportion of these remain to over-winter in numerous bedrock-controlled pools in Reach 2. Forced over-wintering by a proportion of late-emigrating juvenile mountain whitefish is also probable. Resident slimy sculpin are able to successfully over-winter in wide range of pool and cobble/riffle habitats and are assumed present throughout both reaches during winter low flow conditions.

Despite near-record low flows during the fall of 2006, no segments of critically low surface flow or de-watered channels were noted in Reach 1 of lower M20 Creek, suggesting surface flow on cobble/riffle habitat is not limiting for winter-dormant slimy sculpin. Spot flow measurements recorded in 2006 (Section 7.2.3.4) indicated slightly higher surface flow in Reach 2, presumably due to lower infiltration losses over bedrock substrates. Due to lower sub-surface losses associated with bedrock as opposed to alluvial over-wintering features, fish over-wintering in Reach 2 are less susceptible to reductions in winter base flow, and can likely tolerate atypical periods of near zero late-winter discharge.

Winter low-flow projections (average precipitation year and 10-year dry year) for the operations and post-closure phases vary between significantly increased (up to 34% increase during 10 year dry year) and slightly decreased (up to 2% during average year 7-day winter low flows) (Tables 7.5-1 and 7.5-2). Given the low incidence of sport-fish over-wintering and the configuration of over-wintering features, no adverse effects on fish are anticipated due to projected changes in December to March base flows.

11.5.2 Hermann Coal Haul Route

The potential adverse effects of the upgrading of existing high-grade road segments comprising the Hermann coal haul route are primarily associated with the introduction and downstream transport of sediments from existing stream crossings. Sediment introduced directly or through long-term erosion of disturbed or exposed soils can have the following adverse effects on fish and fish habitat:

- degrade the suitability of granular spawning substrates;
- reduce the survival of incubating eggs and emerging fry;
- reduce primary production and fish forage supply;
- decrease rearing suitability due to in-filling of cover components; and
- reduce feeding efficiency for visual-feeding species through increased turbidity levels.

A total of 19 drainage course crossings were identified along the three segments of existing road. Five of these are characterized by segments of discontinuous channel, lack of direct connectivity to fish bearing water and absence of potential for downstream sediment transport (stream class NCD).

An additional 11 crossings are characterized by the presence of a scoured alluvial channel, but occur on non fish-bearing reaches upstream of the limits of fish-distribution (stream class S5/S6). Adverse effects on fish habitat downstream of non fish-bearing crossings are not anticipated during existing clear-span bridge upgrades and culvert replacement/extensions given the proposed implementation of standard mitigative measures, as prescribed by the Coal Haul Route Preliminary SEPSC Plan (Appendix 4.3-2), which includes accepted best practices protocols (e.g., Standards and Best Practices for Instream Works [WLAP 2004]).

The remaining three crossings occur on, or immediately upstream of, fish bearing water. Bridge deck replacements at existing crossings of Perry Creek and an unnamed tributary to the Wolverine River, will comply with DFO's Operational Statement for Small Clear Span Bridges and no disturbance to stream channels and no negative impacts on residents populations in Perry Creek or seasonal juvenile rearing suitability in the unnamed Wolverine tributary are anticipated. As noted above WCCC's SEPSC plan will be implemented to protect streams from sedimentation associated with bridge and road upgrading work.

The crossing of upper Mast Creek will involve the removal and replacement of existing culverts immediately upstream of marginal bull trout seasonal rearing habitat and approximately 1.5 km upstream of potential bull trout spawning and over-wintering habitat. Work at this site has moderate to high potential for negative downstream impacts. In addition to standard mitigation practices as prescribed by the SEPSC Plan, a site-specific mitigation sequence will be implemented during the upgrading of this crossing to prevent downstream impacts on bull trout habitat. The site-specific mitigation sequence will include the following procedures to be supervised by an on-site environmental supervisor:

- controlled pump-down of the upstream beaver impoundment over a 48-hour period prior to commencement of work, in order to facilitate work zone isolation and prevent discharge spikes and flushing flows in downstream bull trout habitat;
- stabilization of pumped flow diversion around work zone in order to provide consistent water supply to downstream bull trout habitat during crossing upgrade;
- maintaining dry isolation of work zone using methods appropriate to current discharge rate and channel profile;
- appropriate disposal of residual sediment-laden water from the isolation zone;
- armouring of newly constructed segments of streambed at the culvert inlet and outlet, with suitable granular substrate in order to prevent sediment flush upon reinstatement of flow; and
- armouring of newly constructed streambanks and fill slopes with suitable angular rip-rap to minimize long-term erosion, sediment introduction and downstream transport.

11.5.3 Residual Project Effects and Significance

Residual effects of the Hermann Mine Project on fisheries resources are expected to be confined to the lower M20 Creek mainstem, with no measurable residual effects on fish populations in the Murray River or on marginal fish habitat in lower South Hermann Creek and lower M14 Creek. Assuming the successful implementation of mitigation measures prescribed by the coal haul route SEPSC Plan and additional site-specific mitigation measures prescribed for upper Mast Creek (Section 11.5.2), no residual project effects on fish populations in the Wolverine River or its tributaries are expected as a result of upgrade to existing segments of high-grade road. Based on the preceding characterization of potential effects, the significance of residual project effects on fisheries resources in lower M20 Creek, has been determined using the criteria in Table 11.4-1, as follows:

- juvenile mountain whitefish summer rearing habitat–the positive effects of projected reduction in late freshet flows, attenuation of peak freshet flows and summer storm flows, and an increase in summer low flow is expected to offset potential changes in water quality and provide a net effect that is neutral to positive in direction, low in magnitude, medium term in duration, and therefore of low significance;

- juvenile bull trout over-wintering habitat–projected minor variable changes in winter base flow by month and project phase, with option for flow augmentation during pit lake filling, are expected to be neutral in direction, low in magnitude and medium term in duration, and therefore of low significance; and
- fish populations–an overall slight increase in summer rearing suitability and neutral effect on over-wintering capability is expect to result in a net effect on fish populations that is neutral to positive in direction, low in magnitude, medium term in duration, and therefore of low significance.

Residual project effects are summarized in Table 11.5-1. Predictive confidence for effects determinations relating to impacts on fish and fish habitat in lower M20 Creek are rated as medium, and are limited by corresponding confidence in seasonal flow projections and water quality predictions.

Table 11.5-1: Summary of Residual Project Effects: Fish and Fish Habitat

VEC / Parameter	Project Phase1	Potential Project Effect	Residual Project Effect Characterization	RPE might Contribute Incrementally to Cumulative Effects?2	RPE Significance	Level of Confidence in Assessment
Juvenile mountain whitefish summer rearing habitat	O/D	Reduction in late freshet flows, attenuation of peak freshet flows and summer storm flows	Positive, low magnitude, local extent (M20 Creek), medium duration, continuous, reversible	No	Not significant	Medium
Juvenile mountain whitefish summer rearing habitat	C/O/D	Decreased water quality (TSS) resulting from mine development	Negative, low magnitude, local extent (M20 Creek), medium duration, sporadic, reversible	No	Not significant	Medium
Juvenile bull trout over-wintering habitat	O/D	Minor reduction in winter base flow during some months	Neutral, low magnitude, site-specific extent (M20 Creek pool below the fish passage barrier), medium duration, continuous, reversible	No	Not significant	Medium

Notes: 1. C = Construction, O = Operations, D = Decommissioning/Closure, P = Post-closure. **2.** Based on the assumption that mitigation measures are effective as planned. Refer to summary of mitigation measures.

11.6 Cumulative Effects

Fish using M20 Creek are already subject to residual effects of the Quintette Mesa Mine which are reflected in the baseline conditions. Therefore the assessment of project effects addresses cumulative effects in M20 Creek. Based on the assessment of residual project effects (Table 11.5-1), no measurable adverse impacts on fish populations or reductions in seasonal rearing suitability and over-wintering capability in lower M20 Creek, upper Mast Creek or tributaries to the Wolverine River are anticipated. As a result, the Hermann Mine Project is not expected to contribute measurably to cumulative effects on fisheries resources in the Murray and Wolverine Rivers.

11.7 Mitigation Measures

Mitigative measures prescribed for the prevention of indirect impacts to fish and fish habitat in lower M20 Creek, upper Mast Creek and tributaries to the Wolverine River, represent a composite of measures summarized in Table 11.7-1. These measures have been compiled into a Fisheries Management Plan (Section 4.7).

During the construction phase, additional site-specific mitigation measures as described in this section, or as directed by the on-site environmental supervision and monitoring, will be implemented as necessary, to minimize potential downstream sedimentation impacts on fish and fish habitat.

Table 11.7-1: Summary of Mitigation Measures and Commitments: Fish

Project Effect	Project Phase[1]	Mitigation Measures
Reduced M20 Creek baseflow during pit lake filling	D	• Maintaining the M20 and Nabors diversion channels to convey water around the Pit 1 Lake during low flow periods, and managing storage in the Pit 1 Lake and M20 Sediment Pond to provide for augmentation of baseflows, as necessary (i.e., January to March and possibly August to October in dry years)(Section 4.4)
Sedimentation during minesite construction and road upgrades	C	• Construction Management Plan (Section 4.2) • Preliminary SEPSC Plan (Section 4.3)
Degradation of water quality (suspended sediments, ML/ARD) from mining and waste rock disposal increasing risk of selenium bioaccumulation in fish tissue	O,D,P	• ARD/ML Management Source Concentration Prediction and Monitoring (Section 4.5) • Selenium Management Plan (Section 4.6) • Chemicals and Material Storage and Handling Plan (Section 4.8) • Fuel Management Plan (Section 4.9) • Water Management Plan (Section 4.10) • Conceptual Reclamation and Decommissioning Plan (Section 4.13)

Project Effect	Project Phase[1]	Mitigation Measures
Habitat disturbance during bridge replacement	C	• Preliminary SEPSC Plan (Section 4.3) • Compliance with DFO Operational Statement for Small Clear Span Bridges • Preliminary SEPSC Plan (Section 4.3)
Sedimentation, flow disruption to bull trout habitat in Mast Creek downstream of culvert replacement	C	• Preliminary SEPSC Plan (Section 4.3) • The site-specific mitigation sequence will include the following procedures to be supervised by an on-site environmental supervisor: o controlled pump-down of the upstream beaver impoundment over a 48-hour period prior to commencement of work, in order to facilitate work zone isolation and prevent discharge spikes and flushing flows in downstream bull trout habitat o stabilization of pumped flow diversion around work zone in order to provide consistent water supply to downstream bull trout habitat during crossing upgrade o maintain dry isolation of work zone using methods appropriate to current discharge rate and channel profile o appropriate disposal of residual sediment-laden water from the isolation zone o armouring of newly constructed segments of streambed at the culvert inlet and outlet, with suitable granular substrate in order to prevent sediment flush upon reinstatement of flow o armour of newly constructed streambanks and fill slopes with suitable angular rip-rap to minimize long-term erosion, sediment introduction and downstream transport

Notes: 1. C = Construction, O = Operations, D = Decommissioning/Closure, P = Post-closure.

11.8 Monitoring and Follow-up

Monitoring of factors affecting fish populations and fish habitat in lower M20 Creek is currently proposed through programs outlined in Section 7 (Climate and Surface Water Hydrology), Section 9 (Water and Sediment Quality) and Section 10 (Periphyton, Benthos and Fish Tissue).

Effective direct monitoring of fish population status in lower M20 Creek is made difficult by relatively low levels of fish use, high inter-year variability in opportunistic seasonal rearing use, and high sampling variability associated with inconsistent flow conditions and sampling conditions. Since juvenile sport-fish species spend only a limited segment of their life cycle in M20 Creek, perceived changes in their densities over time may be confounded by events taking place beyond the effects of the development (i.e., adult mortality, spawning success and incubation) success outside M20 Creek.

Long-term direct monitoring of fish populations in lower M20 Creek is not currently proposed.