Appendix 9-B

Murray River Coal Development: Fisheries Habitat Assessment

HD MINING INTERNATIONAL LTD.

MURRAY RIVER COAL DEVELOPMENT
FISHERIES HABITAT ASSESSMENT

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1 INTRODUCTION

HD Mining International Ltd. (HDMI) is currently planning to develop its Murray River coal project, located within the Murray River valley, approximately 10 km south-southwest of Tumbler Ridge, British Columbia.

Fisheries fieldwork was conducted by Diversified Environmental Services (DES) during the 2010 and 2011 field seasons to augment existing fish distribution and fish use information within the project area. Fisheries information collected by DES between 2004 and 2006 for Western Coal Corp. and reported in the WCC Herman Mine Application is applicable to the currently proposed HDMI project, and is summarized in this document with the cooperation of Walter Energy Western Coal.

The following sections describe fish distribution and habitat use in aquatic habitats potentially affected by the proposed Murray River development and will form a basis for fish habitat protection and mitigation planning for all phases of mine construction, operation and reclamation.

2 PROJECT AREA

The currently proposed HDMI Murray River project disturbance footprint lies predominantly within the Murray River valley in close proximity to the Murray River mainstem and several of its tributaries, including M19 Creek, M20 Creek, and Twenty Creek (Figure 1). The Murray River forms a significant sub-basin of the Pine River watershed, which enters the Peace River near Fort St. John, BC. The proposed Murray River project area is located on the eastern edge of the Rocky Mountain Foothills, approximately 120 km upstream of the confluence of the Murray and Pine rivers.

Tributaries draining lands on and adjacent to the proposed footprint originate on mid-elevation coniferous forests within the BWBSmw1 and ESSFmv2 biogeoclimatic zones of the Hart Foothills ecosection.

The HDMI Murray River project area is characterized by significant current and historical industrial land use and anthropogenic disturbance, including reclaimed open pit coal mines, coal transporting and processing infrastructure, forest harvesting roads and cut blocks, and natural gas production facilities, pipelines and access roads.

3 METHODS

Fish distribution and habitat use in potentially fish-bearing waters in the vicinity of the proposed HDMI Murray River coal development were investigated and described during 2010 and 2011. This involved an analysis of existing fish sampling data and habitat observations collected between 1976 and 2006 and the completion of additional fisheries fieldwork in 2010 and 2011.

The 2011 fieldwork was conducted within the drainages of M19 Creek, M20 Creek, Twenty Creek, and wetland 00313MURR, with the following objectives:

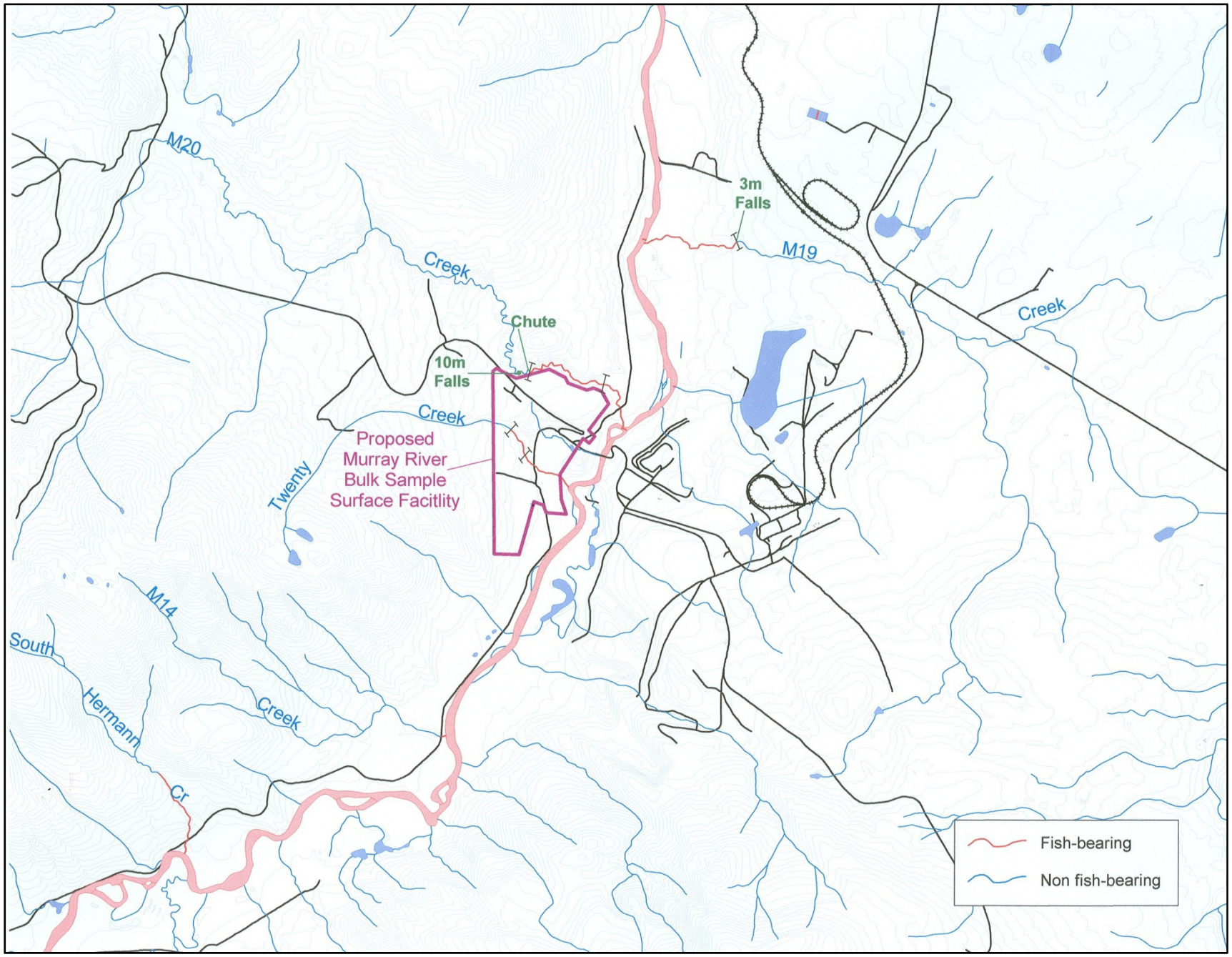

Figure 1. Location of HDMI Murray River coal project in relation of fish-bearing waters.

- confirm and update current fish species composition and relative abundance in streams for which historical sampling data exists, including potential colonization by introduced species,
- collect species distribution and habitat suitability information to fill identified data gaps for streams for which existing historical information is lacking.

New stream sample sites were established and evaluated on representative sections of M19 Creek and Twenty Creek in accordance with Reconnaissance Fish and Fish Habitat Inventory: Standards and Procedures (RISC 2001), including completion of Resource Inventory Standards Committee (RISC) Site Data Cards and site photodocumentation.

Fish species inventories at new and existing stream sample sites were undertaken 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, water conductivity, and length of fish sampled. A range of rearing and holding habitat was sampled during single-pass electro-fishing within each site. Sample sites were typically 200 m in length. Sampling specifications, species, and fork length for all fish captured were recorded on RISC Fish Collection Forms and Individual Fish Data Forms (RISC 2001). Scale samples were collected from representative sport-fish for age analysis.

4 FISH DISTRIBUTION AND HABITAT USE

4.1 Murray River

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 contains relatively high fisheries values and supports several regionally important sport-fish populations. The most significant feature defining fish distribution within the Murray mainstem is Kinuseo Falls, located 38 km upstream of the proposed HDMI Murray River project. 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*), finescale dace (*Phoxinus neogaeus*) and lake chub (*Couesius plumbeus)*.

Resident fish populations naturally occurring upstream of Kinuseo Falls include widely distributed fluvial and adfluvial sub-populations of bull trout, and resident pigmy whitefish (*Prosopium coulterii) and* longnose sucker populations in Monkman Lake. Slimy sculpin, which frequently occur in association with upstream-resident bull trout populations, appear to be absent from the Murray River drainage upstream of Kinuseo Falls.

Three non-native sport-fish species have been introduced to the Murray River system in recent decades, including rainbow trout *(Oncorhynchus mykiss)*, 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 and Quality lakes, 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 at very low densities within the project area, sampling records indicate the species has failed to establish significant self-sustaining populations in the Murray River or its tributaries.

Westslope cutthroat trout 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 River drainage.

Commencing in 1980, brook trout were introduced to 5 non fish-bearing lakes in the Murray River watershed to provide ice-fishing opportunities for recreational anglers. These included Moose Lake, Quality Lake and 3 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 had become 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 (Baxter 1996). Brook trout are now commonly found in several Murray River tributaries in the vicinity of the HDMI Murray River project area and have established a significant spawning run in Barbour Creek, located approximately 10 km upstream (DES 2006a).

Native fish species common in the Murray River mainstem adjacent to, and downstream of, the proposed HDMI Murray River project include mountain whitefish, bull trout, Arctic grayling, and slimy sculpin.

Mountain Whitefish

Mountain whitefish are abundant in medium to large-sized rivers throughout the Peace region and are the most numerous sport-fish species in the Murray River mainstem. All age classes are present year-round in the vicinity of the project area. Mountain whitefish in the upper Murray are predominantly mainstem spawners, broadcasting their eggs over cobble and gravel substrates within the Murray River mainstem downstream of Kinuseo Falls and in the Wolverine River mainstem, which enters the Murray 15 km downstream of the project area. Spawning in the Murray drainage typically occurs in late October (DES 2006b). Deposited eggs incubate through the winter and hatch as water temperatures begin to rise in April and May. Young-of-the-year (YOY) form loose schools by mid to late summer. A proportion of yearling and post-yearling juveniles and sub-adults make opportunistic seasonal feeding forays into tributary habitats during spring freshet and may remain until flow rates decline in late summer and early fall, before returning to the mainstem to over-winter. By mid-August YOY whitefish rearing in the mainstem are large enough to also make short-term feeding movements into the lower reaches of tributaries where sufficient surface flow is present. All return to the mainstem by October. Mainstem over-wintering distribution is typically clumped, with up to several hundred adults and sub-adults congregating in relatively few large, deep pool features within the mainstem.

Bull Trout

Bull trout inhabiting the Murray River adjacent to the project area are members of the Fellers Creek fluvial migratory sub-population. Adults of this group over-winter in the Murray River mainstem and make seasonal movements upstream to a spawning zone in Fellers Creek, a secondary tributary to Kinuseo Creek, which enters the Murray River approximately 27 km upstream of the project area. Pre-spawning movements take place through late July and August with peak spawning activity typically occurring during the first week of September. Once spawning is complete, adults make rapid downstream movements to over-wintering habitat in the Murray River mainstem. Adult over-wintering is thought to occur downstream of the Wolverine River confluence and may extend into the Pine River. Deposited eggs incubate in gravel substrates of Fellers Creek over the winter and hatch in April. YOY emerge from the substrate in May and spend their first year rearing in close proximity to the spawning zone. Yearling and post-yearling juveniles disperse progressively further downstream, distributing themselves widely at relatively low densities throughout mainstem and accessible tributary rearing habitats. By age 3-4, juvenile bull trout can be found in the vicinity of the HDMI Murray River project area, occasionally entering M20 Creek during opportunistic feeding movements.

Arctic Grayling

Arctic grayling are present in all portions of the Murray River mainstem downstream of Kinuseo Falls. Adult Arctic grayling in the Peace Region typically make seasonal movements between summer feeding habitat in the upper portions of mid to large-sized rivers and over-wintering habitat in downstream reaches. Information on Arctic grayling seasonal distribution in the vicinity of the project area was collected in the early 1980s prior to the construction of the Quintette Mine (Quintette 1982, McCart *et al*. 1985). Seining, electro-fishing, and snorkel survey results indicated that adult Arctic grayling distributed themselves throughout the upper Murray mainstem downstream of Kinuseo Falls immediately after the spring spawning period. Summer feeding activity was primarily associated with pool and run habitats. As water temperatures began to decline in early to mid September, grayling distribution shifted downstream and became concentrated in a fewer number of large, deep pools. By early October, adult grayling were uncommon upstream of the confluence with the Wolverine River; the largest over-wintering concentrations were observed downstream of the Tumbler Ridge town site. Tributaries to the Murray River containing suitable spring spawning habitat for Arctic grayling are uncommon and the spawning behavior of grayling in the vicinity of the project area is not well understood. Although grayling are known to spawn in selected tributaries entering the Murray River well downstream of the project area (e.g., Coldstream Creek), YOY grayling are also commonly captured during late summer in the Murray mainstem adjacent to the project area, suggesting nearby spawning activity. During the 1981-1984 Quintette assessment, YOY were most commonly captured downstream of M20 Creek, however adults or YOY have never been recorded in M20 Creek. More recently, DES staff captured YOY Arctic grayling in the Murray mainstem between M19 Creek and Flatbed Creek during unrelated fieldwork in 2010 and 2011 (DES unpubl. data). YOY grayling have, however, been consistently recorded in lower M19 Creek, suggesting successful spawning activity in that stream.

Slimy Sculpin

Slimy sculpin are abundant and widely distributed throughout the Peace region and are present in all reaches of the Murray River downstream of Kinuseo Falls. This species is non-migratory and typically exists as a series of contiguous resident populations with relatively small individual home ranges. Slimy sculpin within the project area are most

commonly sampled in riffle habitats on gravel/cobble substrates but can also be found in slower, sediment-dominated habitats. Resident sub-populations are also common in accessible tributaries where year-round surface flow is present, including M20 Creek. Due to their non-migratory nature, slimy sculpin are present within the project area during all seasonal periods and all annual life phases.

4.2 M19 Creek

Unnamed Murray River tributary 234-322900-56200, locally known as M19 Creek, originates in mid-elevation BWBS and ESSF coniferous forest northeast of Babcock Mountain and enters the Murray River from the east, immediately downstream of the existing Teck Quintette plant site.

Two impassable barriers, consisting of 3 m and 4 m high waterfalls, occur within a 50 m section of M19 Creek, approximately 1,500 m upstream of its confluence with the Murray River (DES 2005; UTM 10.627896.6100141). The lower of these barriers defines the upstream limit of fish distribution within the M19 Creek drainage (Plate 1). DES conducted fish sampling upstream of the barriers in July 2005. Two hundred metres of suitable seasonal rearing habitat were electro-fished at the Murray Forest Service Road (FSR) crossing of M19 Creek, approximately 2.8 km upstream of the lower barrier (UTM 10.630375.6099216; effort: 272 seconds at 300 volts). No fish were captured or observed (DES 2005); upstream-resident fish populations are assumed absent.

Plate 1. Impassable 3 m vertical impasse on M19 Creek, 1,500 m upstream of confluence with Murray River; aerial view.

The lower reach of M19 Creek was sampled in 1981, 1982, 1983, and 1984 during baseline fisheries investigations conducted for the Quintette Coal Mine (BC Research

1982, McCart *et al*. 1985). The portion of the stream lying below the lower falls was found to support mountain whitefish, Arctic grayling, bull trout, burbot, and slimy sculpin. YOY Arctic grayling were captured in August 1981 and 1983, suggesting spring spawning by adult grayling entering from the Murray River. Use by mountain whitefish, bull trout, and burbot appeared limited to juveniles entering from the Murray River on opportunistic feeding forays during spring and summer as surface flow conditions allow. Juvenile mountain whitefish were most numerous while age 3+ and 4+ juvenile bull trout are sporadically present at very low densities.

Spawning potential for fall spawning species is constrained by low seasonal flow; the stream was recorded as "dry" during sampling attempts in September/October 1983 and July 1984 (McCart *et al*. 1985).

Lower M19 Creek was re-sampled by DES on August 05 and 21, 2011 to confirm consistency with the 1981-84 results and investigate potential colonization by rainbow trout and brook trout introduced after 1985. The lower 400 m of the stream was sampled by single-pass backpack electro-fisher on August 05. Flow stage was low with continuous surface flow to the confluence. The stream 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 bank. Arctic grayling were most numerous, with 14 YOY and one yearling captured. Eight slimy sculpin, 1 longnose dace, and 2 juvenile brook trout were also sampled (Appendix I).

The lower 100 m of M19 Creek were re-sampled by DES on August 21, 2011, during an un-related project. Discharge had declined to a small trickle of surface flow between isolated pools. Eight YOY Arctic grayling, 2 YOY mountain whitefish, and 1 juvenile burbot were sampled. Natural stranding mortality appeared likely with further reduction in surface flow.

Observations and sampling results recorded during 2011 appear consistent with historical information, with the exception of the presence of introduced brook trout. The absence of juvenile bull trout from the 2011 sample is not unexpected given low habitat suitability and late summer declines in surface flow and increases in water temperature.

M19 Creek appears to be one of relatively few small tributaries in the vicinity of the project area where annual Arctic grayling spawning occurs.

4.3 M20 Creek

M20 Creek, also locally known as Camp Creek, enters the Murray River from the north approximately 2.9 km upstream from the confluence of M19 Creek and directly opposite the existing Teck Coal Plant facility. The stream originates in sub-alpine habitat in the vicinity of Herman Mountain and the abandoned Mesa Pit complex and drains the north slope of the Murray River valley.

The lower reach of M20 Creek lies immediately adjacent to the proposed HDMI Murray River project bulk sample surface facility (Figure 1) and much of the target coal deposit underlies the M20 Creek catchment area. Numerous active access road crossings occur on the M20 Creek mainstem including one approximately 200 m upstream of the confluence with the Murray River and 3 on the upper mainstem.

Fish distribution in M20 Creek is defined by an impassable bedrock chute located 1.9 km upstream from the confluence with the Murray River (UTM 10.625067.6098371). An additional 5 vertical waterfalls occur along the reach lying immediately upstream of the bedrock chute. The first of these is a 10 m waterfall located 250 m above the lower chute (UTM 10.624883.6098330; Plate 2).

Plate 2. 10 m high waterfall located immediately upstream of lower impassable bedrock chute on M20 Creek.

Fish sampling conducted by DES upstream of the lower barrier in 2004, 2005, and 2006 (WCC 2007) confirmed the results of extensive previous sampling, indicating the absence of resident fish populations in all portions of M20 Creek beyond the lower 1.9 km. Previous sampling of suitable habitat on reaches upstream of the barriers include electro-fishing by the BC Resource Analysis Branch in 1976 (RAB 1977), 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 mapping error.

The 1.9 km fish-bearing portion of lower M20 Creek consists of 2 reaches. 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 cobble substrates, and significant secondary components of gravel and fines. 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 originating from a natural sediment source located 5.1 km upstream of the lower barrier (UTM 10.621527.6100169). Suitability for spring and fall spawning sport-fish is restricted by high suspended sediment and low seasonal discharge, respectively. Over-wintering potential in Reach 1 is limited by low winter surface flow and the absence of deep pool habitat.

Reach 2 is 1,200 m in length and extends upstream from the upper edge for the Murray River alluvial plain to the base of the lower impassible barrier. Reach 2 is confined within the lower portion of a steep-walled canyon and is dominated by riffle/pool habitat and cobble substrates. This reach has a significant component of exposed bedrock in the streambed and a higher proportion of pool and holding habitat than Reach 1, resulting in slightly higher juvenile rearing capability. Although spawning suitability is still restricted by a high proportion of substrate fines, limited over-wintering potential exists in numerous shallow, bedrock pools where perennial surface flow is present.

Reach 3 encompasses the remainder of the incised portion of the mainstem and extends 4.5 km from the lower barrier to immediately above the uppermost waterfall. Reaches 4 and 5 are characterized by a reduced degree of confinement and decreased gradient. At the top of Reach 5, the stream diverges into the 2 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.

Historical fish sampling information for the lower portion of M20 Creek includes the results of electro-fishing conducted by the BC Resource Inventory Branch in the summer of 1976 (RAB 1977), electro-fishing conducted for Denison Mines from 1981 to 1984 (BC Research 1982, McCart *et al*. 1985), and more recent sampling conducted by DES for Western Coal Corp. in 2004, 2005, and 2006 (WCC 2007).

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) reviewed fish sampling data collected between 1976 and 1983 and concluded that, with the 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.

Limited sampling conducted for Canfor in August 1997 (Hatfield 1998), confirmed the presence of resident slimy sculpin, rearing juvenile mountain whitefish, and burbot in Reach 1 of M20 Creek. During the 2004-2006 sampling conducted for Western Coal Corp., 200 m sample sites were established on both fish-bearing reaches. One site was located on Reach 1, 300 m upstream of the confluence with the Murray River and the second was located on Reach 2 immediately downstream of the lower impassible barrier (Appendix II). Electro-fishing effort was replicated at each site in July, September, and October. Results confirmed comparable densities of the 6 species previously observed. Moderate densities of resident slimy sculpin and juvenile mountain whitefish, as well as a single sub-adult bull trout and single juvenile burbot were captured in Reach 1.

In addition to resident slimy sculpin and juvenile mountain whitefish, 2 sub-adult Arctic grayling and 4 juvenile longnose suckers were recorded in Reach 2 in July 2006. Low densities of sub-adult bull trout were also captured in Reach 2 in September and October 2005 and July 2006 (WCC 2007).

In addition to the 6 indigenous species recorded between 1976 and 2006, low densities of brook trout and rainbow trout were observed beginning in 2005-06. Five brook trout, ranging from yearling juveniles to a sexually mature male, were sampled in Reach 2 in October 2005 and 6 yearling and post-yearling juveniles were captured in July 2006. A single sub-adult was sampled in Reach 1 in October 2006. One age 2+ juvenile rainbow trout (171 mm) was sampled in Reach 2 in September 2006 (WCC 2007).

Follow-up sampling was conducted on Reach 1 of M20 Creek on August 05, 2011 to compare to species composition recorded during historical sampling. The established 200 m sample site was sampled by back-pack electro-fisher (effort: 313 sec at 250 volts). Nine juvenile mountain whitefish ranging in age from yearling to 3+ (96-332 mm), 6 slimy sculpin (41-78 mm), and one juvenile longnose sucker (145 mm) were captured.

Slimy sculpin exist year-round in M20 Creek as a resident population throughout both fish-bearing reaches, from the mouth, upstream to the base of the lower impassable chute. All other species appear to be members of their respective Murray River sub-populations and use the stream primarily as juvenile rearing habitat during the ice-free months from May through October.

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. A proportion of juvenile and sub-adult mountain whitefish enter small tributary habitats, such as M20, Creek during May and June after over-wintering in the Murray River. These fish may feed and rear in the lower portions of tributaries during the summer and return to the mainstem either when surface flow rates decline significantly in late summer or when water temperature drops in early fall. Emigration of mountain whitefish is typically complete by mid to late October.

A comparison of the results of replicate electro-fishing sessions in M20 Creek in July, September, and October 2006 found most mountain whitefish use during the early summer involved post-yearling juveniles and sub-adults (age 2+ to 5+) which had likely entered from the Murray River during or subsequent to spring freshet (WCC 2007). CPUE values for post-yearlings declined from 21.7/100 seconds on July 10 to 3.8/100 seconds by September 01 and 0.6/100 seconds by October 05, indicating significant emigration of post-yearling juveniles by early fall.

Young-of-the-year whitefish from the adjacent Murray River mainstem had begun entering the lower 100 m of M20 Creek by the July 10, 2006 sampling event (WCC 2007). In contrast to post-yearling juveniles, densities of YOY and yearlings was lowest on July 10 (CPUE 2.3/100 seconds) and increased through late summer as riffle velocity decreased and YOY grew large enough to ascend the stream. Highest YOY/yearling CPUE values were recorded in early September (19.0/100 seconds) when distribution extended into the lower half of Reach 2. By October 05 the emigration of YOY and yearlings was partially complete and most remaining fish were found in the lower 200 m of the stream (CUPE 15.0/100 seconds). No over-wintering of mountain whitefish has been recorded in M20 Creek or similar Murray River tributaries.

The use of lower M20 Creek by other sport-fish species occurs at much lower densities. Very low numbers of juvenile bull trout, ranging in age from 2+ to 4+, are typically captured during electro-fishing events. The presence of bull trout in M20 Creek is

believed to be primarily the result of post-yearling juvenile dispersal downstream from the Fellers Creek bull trout spawning zone. No YOY or yearling bull trout have been captured in M20 Creek. During the 2006 sampling, the highest number of bull trout was recorded in mid-July when the total number present in the lower 1,900 m of the stream was extrapolated to be approximately 8 fish. Bull trout density declined by approximately one half by early fall. It is likely that a lower number of juvenile bull trout may over-winter in Reach 2 where perennial base flow is present. Of 5 juvenile bull trout captured in Reach 2 on July 10, 2006, the poor body condition of one individual suggested probable over-wintering in M20 Creek the previous winter (WCC 2007).

Two 3+ juvenile Arctic grayling were sampled in Reach 2 of M20 Creek on July 10, 2006 (WCC 2007). The only other record of Arctic grayling was a single specimen captured in May 1983 (McCart *et al*. 1985). Although adult grayling are seasonally common in the adjacent Murray River, the absence of YOY and yearling juveniles from M20 Creek suggests the stream is not used for spawning.

Juvenile burbot appear to be sporadically present in M20 Creek at extremely low densities. Only 1 burbot was captured during the 2004-2006 sampling (WCC 2007) and none were observed in 2011. Seasonal use by juvenile burbot from the Murray River is likely restricted to Reach 1.

The use of lower M20 Creek by brook trout has been documented since their introduction to the Murray watershed, but appears to have stabilized at relatively low densities. 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, Buktenica 1997). Despite the presence of the mature male in spawning condition in fall 2006 (WCC 2007), no evidence of an established brook trout fall spawning run has been observed in M20 Creek.

The extremely low incidence of introduced rainbow trout in M20 Creek reflects their frequency of occurrence in the middle Murray watershed. A 2+ juvenile captured in the lower barrier plunge pool on September 01, 2006 is the only documented record of this species in the stream (WCC 2007).

4.4 Twenty Creek

Twenty Creek is a relatively small stream with limited catchment area, located on the north side of the Murray River valley approximately 1.3 km upstream from the mouth of M20 Creek. The stream crosses the Murray FSR through 3 small-diameter culverts approximately 600 m upstream of the confluence with the Murray River. The lower portion of Twenty Creek lies within the proposed HDMI Bulk Sample surface facility boundary.

Surface flow in Twenty Creek appears to be fed primarily by groundwater springs along the base of the north Murray River valley slope. Fisheries capability is severely constrained by low hydrological potential and resulting low surface discharge rates, as well as seasonally de-watered channel due to sub-surface infiltration across the Murray River alluvial plain.

Significant surface discharge is typically present in the lower portion of Twenty Creek for a 3-month period subsequent to spring snowmelt (i.e., May-July). During this period, the lower several hundred metres of the stream is temporarily accessible to juvenile fish entering from the Murray River on opportunistic feeding forays.

During years of average to below average rainfall, surface flow declines drastically by mid-summer and a large proportion of the lower 800 m of the stream dewaters by mid-August and remains dry for the remainder of the year (Plate 3). Juvenile fish entering the stream during freshet either return to the Murray River as flows decline in July or succumb to stranding mortality.

Plate 3. Dry channel at the Twenty Creek crossing of the Murray FSR – August 11, 2005.

The lower mainstem of the stream consists of 2 reaches. The lower reach extends 800 m upstream from the mouth, across the Murray River alluvial plain, to approximately 200 m upstream of the Murray FSR culvert crossing (UTM 10.624994.6097216). This portion of the stream contains low to moderate seasonal rearing suitability for juvenile sport-fish during periods of sufficient surface flow. Habitat is dominated by shallow riffles, with rearing cover provided by occasion pools, large and small woody debris, and overhanging vegetation. Substrates are composed primarily of gravel and fine sediments. The Murray FSR culvert crossing appears potentially passable to fish at moderate flow stages.

Reach 2 extends a further 480 m upstream and provides only marginal seasonal rearing capability constrained by lack of rearing cover, segments of unstable channel, and multiple small vertical barriers. The upper limit of potential fish distribution is marked by a 2 m high bedrock/shale barrier at the top of the reach (UTM 10.624798.6097589).

No fish sampling information existed for Twenty Creek prior to 2011. Electro-fishing was conducted by DES on June 08 and August 05, 2011 within a 200 m sample site established approximately 200 m upstream of the confluence with the Murray River (Appendix III).

During the June 08 sample session, continuous, late-freshet surface flow extended through the sample site to the confluence with the Murray River. One 2+ juvenile mountain whitefish, one 2+ juvenile rainbow trout, and 3 sub-adult brook trout were sampled (Plate 4).

Plate 4. Mountain whitefish, rainbow trout, and brook trout captured in Reach 1 of Twenty Creek on June 08, 2011.

By August 05, 2011, surface flow had decreased significantly despite considerable early summer precipitation. Water depth was 2-5 cm on riffle areas and may have posed difficulty for late-emigrating fish. Two immature male brook trout were captured; native sport-fish appeared to have returned to the Murray River.

4.5 Wetland (00313MURR)

One wetland containing marginal fisheries values occurs within the HDMI Bulk Sample Surface Facility boundary (water body ID 00313MURR). The feature is located on the north side of the Murray River immediately west of the Murray FSR and east of Twenty Creek. The wetland is currently impounded by beaver activity (Plate 5) and is fed by a minor ephemeral tributary originating on the north slope of the Murray River valley (WSC 234-323900-57700). Seasonal outflow from the wetland complex drains into the Murray River via a 215 m segment of the Murray FSR ditch (Plate 6) and enters the Murray River immediately adjacent to the FSR bridge crossing. Fish movement appears

Plate 5. Middle portion of wetland complex 00313MURR on unnamed Murray tributary 234-323900-57700 (UTM 10.625654.6097348) – Aug 05, 2011.

Plate 6. Wetland outflow through Murray FSR ditch between wetland complex and Murray River. – Nov 02, 2011.

possible along the road ditch between the Murray River and wetland complex during periods of sufficient outflow volume. Fish sampling was conducted in the wetland complex by DES in November 2010 and August 2011. Three adult lake chub were captured by electro-fishing at the lower most beaver dam on November 02, 2010 (UTM 10.6257560.6097298). On August 05, 2011, schools of adult and YOY lake chub were visually observed in the large beaver impoundment comprising the middle portion of the wetland complex (UTM 10.625654.6097348).

Lake chub are the most abundant and widespread non-sport fish species within the greater Peace Region and are typically numerous in low quality habitats where sport-fish species and most other non-sport species are unable to survive. Lake chub often exhibit high productivity in marginal habitats despite summer stagnation, high water temperatures, and near-anoxic winter conditions. They are able to re-colonize quickly after partial or major winter-kills in shallow lentic habitats. Lake chub over-wintering capability in shallow wetland complexes is often enhanced by beaver activity. The wetland complex does not provide suitable habitat for sport-fish species present in the Murray River.

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APPENDIX I

FISHERIES SAMPLE SITE DATA

(Site Data Cards, Fish Collection Forms and Site Photographs)

M19 CREEK

SITE CARD

STREAM NAME	M19 Creek											FIELD COORDINATES	10.626778.6100178				
WATERSHED CODE	234-323900-56200																
NTS MAP #	93P/3	LOCATION															
REACH #	1	SITE #	1	SITE UTM	10	626778	6100178	SITE LENGTH	400	METH	RF	ACCESS	B				
DATE	05/08/2011	TIME	1050	AGENCY	Diversified Environmental Services			CREW	BC/TE	FISH FORM	Y	X	N				

WATER

CHANNEL (m)	meth							avg	GRADIENT %		EMS		COND	
CHANNEL WIDTH	RF	7.10	7.00	7.90	7.20	7.10	9.10	7.57	meth	AL	TEMP (°C)	12.0	TURBIDITY	
WETTED WIDTH	RF	4.30	3.30	7.90	4.20	4.60	2.10	4.40	1.5		Ph		Lightly Turbid	
RES POOL DEPTH	MS	0.85	0.80	0.75	0.85	0.95	0.80	0.83	1.5					
Wb DEPTH	0.70	0.75	0.80	STAGE	Low		No Vis Chan		Dry/Int					
							Dewater		Tribs					

COVER

COVER	Total	Abundant (>20%)						
type	SWD	LWD	B	U	DP	OV	IV	
amt	S	S	N	T	D	S	N	
loc	P	P	P	P	P	P	P	

LWD FNC	Abundant	DIST	Even
LB SHAPE	Vertical	RB SHAPE	Undercut
TEXTURE	Fines	TEXTURE	Fines
RIP. VEG.	Mixed C & D	RIP. VEG.	Mixed C & D
STAGE	Mature Forest	STAGE	Mature Forest

CROWN CLOSURE	0%	1-20%	21-40%	41-70%	71-90%	>90%		
	0	1	2	3	4	5		

INSTREAM VEGETATION	None

MORPHOLOGY

FLOOD SIGNS	0.6 m
BED MATERIAL	
Dominant	Gravel (2-64 mm)
Subdom.	Fines (<2 mm)
D95 (cm)	16
D (cm)	30
Morph.	Riffle-pool

DISTURBANCE INDICATORS

O1	B1	B2	B3	D1	D2	D3	C1	C2
C3	C4	C5	S1	S2	S3	S4	S5	

PATTERN	Irregular Wandering
ISLANDS	None
BARS	Side
COUPLING	Decoupled
CONFINED	Unconfined

FEATURES

C	NID MAP #	NID #	TYPE	HT/LG (m)	mthd	PHOTO				COMMENTS	UTM		
						R		F					
						R		F					
						R		F					

DISTURBANCE INDICATOR LEGEND

O1	Beaver Dam	B3	Avulsion	D3	Recent LWD jam	C3	Elevated Bar	S1	Homogenous Bed	S4	Extensive Bars
B1	Abandoned Channel	D1	Small Woody Debris	C1	Extensive Riffles	C4	Multiple Channel	S2	Sediment Fingers	S5	Extensive Scours
B2	Eroding Bank	D2	Large Woody Debris	C2	Limited Pools	C5	Disturbed Lines	S3	Sediment Wedges		

HABITAT QUALITY

High quality seasonal rearing habitat for juvenile Arctic grayling.
Moderate quality spring spawning habitat in pool tail-outs and riffles.
Fall spawning potential and over-wintering capabiity severely constrained by seasonal low flow and late sumer/fall dry channel.

FSZ

PHOTO DOCUMENTATION

IMAGE	FOCAL LN	DIRECTION	COMMENTS
1	wd	u	view upstream from bottom of site
2	wd	obj	Eastern brook trout
3	wd	u	view upstream from centre of site
4	wd	d	view downstream from top of site

WILDLIFE

GROUP	WILDLIFE OBSERVATIONS	GROUP	WILDLIFE OBSERVATIONS

COMMENTS

C	
CX1	Electro-fishing effort: 662 seconds @ 250 volts: Arctic grayling, slimy sculpin, longnose dace, and brook trout captured.
CX2	Additional electro-fishinf conducted August 21, 2011 in lower 100 m: Arcrtic grayling, mountian whitefish, and burbot captured.
CX3	FRPA stream classification S2

FISH COLLECTION FORM

STREAM NAME	M19 Creek				LAKE	X STREAM	WETLAND
WATERSHED CODE	234-323900-56200						
PROJECT ID	Dehua Murray River			SITE/LAKE CARD ATTACHED	X Y	N	
NTS MAP #	93P/3	SITE #	1	FISH PERMIT #	FJ11-72388	RE-SAMPLE	
DATE	05/08/2011 to 21/08/2011	AGENCY	Diversified Environmental Services		CREW	BC/TE	

SITE / METHOD

SITE #	NTS MAP #	SITE UTM	METHOD/NO.		STREAM CONDITION TEMP	CON	TURB	COMMENTS
1	93P/3	10.626778.6100178	EF	1	12.0		L	

FISH SUMMARY

SITE #	MTD/NO	H/P	SPECIES	STAGE	AGE	TOTAL NO	MIN LN (mm)	MAX LN (mm)	FISH ACT	COMMENTS
1	EF/1	1	GR	Juv		15	38	99	Rearing	
			CCG	Adult		8	30	75	Rearing	
			LNC	Adult		1	87	87	Rearing	
			EB	Juv		2	60	61	Rearing	
			BB	Juv		1	84	84	Rearing	
			MW	Juv		2	50	52	Rearing	

GEAR SPECS

NET / TRAP SPECIFICATIONS

C	SITE #	MD/NO	H/P	DATE IN	TIME IN	DATE OUT	TIME OUT	NET TYPE	LENGTH	DEPTH	MESH SIZE	SET	HAB

ELECTROFISHER SPECIFICATIONS

C	SITE #	MD/NO	H/P	TIME IN	TIME OUT	EF SEC	LENGTH	WIDTH	ENCL	VOLT	FREQ	PLSE	MAKE	MDL
	1	EF/1	1	1050	1115	662	400	4.4	O	250	60	Fixed	Coffelt	Mk X

COMMENTS

C

Adddtional sampling conducted Aug 21, 2011; trickle flow between isolated pools; GR standing mortality probable.

INDIVIDUAL FISH DATA

C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE STR	AGE SAMPLE #	AGE	COMMENTS
	1	EF/1	1	GR	99			Immature	Scale		1+	
	1	EF/1	1	GR	38			Immature	Scale		0+	
	1	EF/1	1	GR	47			Immature	Scale		0+	
	1	EF/1	1	GR	46			Immature			0+	
	1	EF/1	1	GR	38			Immature			0+	
	1	EF/1	1	GR	48			Immature			0+	
	1	EF/1	1	GR	51			Immature			0+	
	1	EF/1	1	GR	45			Immature			0+	
	1	EF/1	1	GR	39			Immature			0+	
	1	EF/1	1	GR	46			Immature			0+	
	1	EF/1	1	GR	40			Immature			0+	
	1	EF/1	1	GR	40			Immature			0+	
	1	EF/1	1	GR	50			Immature			0+	
	1	EF/1	1	GR	55			Immature			0+	
	1	EF/1	1	GR	39			Immature			0+	
	1	EF/1	1	CCG	64			Maturing				
	1	EF/1	1	CCG	61			Maturing				
	1	EF/1	1	CCG	75			Maturing				
	1	EF/1	1	CCG	55			Maturing				
	1	EF/1	1	CCG	63			Maturing				
	1	EF/1	1	CCG	56			Maturing				
	1	EF/1	1	CCG	35			Maturing				
	1	EF/1	1	CCG	30			Maturing				

INDIVIDUAL FISH DATA												
C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE			COMMENTS
									STR	SAMPLE #	AGE	
	1	EF/1	1	EB	60							
	1	EF/1	1	EB	61							
	1	EF/1	1	LNC	87							
	1	EF/1	2	MW	50						0+	Aug 21/11 addtional sampling
	1	EF/1	2	MW	52						0+	Aug 21/11 addtional sampling
	1	EF/1	2	BB	84							Aug 21/11 addtional sampling
	1	EF/2	2	GR	51						0+	Aug 21/11 addtional sampling
	1	EF/3	2	GR	55						0+	Aug 21/11 addtional sampling
	1	EF/4	2	GR	53						0+	Aug 21/11 addtional sampling
	1	EF/5	2	GR	50						0+	Aug 21/11 addtional sampling
	1	EF/6	2	GR	59						0+	Aug 21/11 addtional sampling
	1	EF/7	2	GR	56						0+	Aug 21/11 addtional sampling
	1	EF/8	2	GR	51						0+	Aug 21/11 addtional sampling
	1	EF/9	2	GR	46						0+	Aug 21/11 addtional sampling

M19 Creek – Site 1, Reach 1; view upstream from bottom of site (Aug 05, 2011).

M19 Creek – Site 1, Reach 1; view upstream from centre of site (Aug 05, 2011).

APPENDIX II

FISHERIES SAMPLE SITE DATA

(Site Data Cards, Fish Collection Forms and Site Photographs)

M20 CREEK

SITE CARD

STREAM NAME	M20 Creek										FIELD COORDINATES	10.626242.6098112			
WATERSHED CODE	234-323900-57600														
NTS MAP #	93P/3	LOCATION	300 m upstream of lower bridge crossing												
REACH #	1	SITE #	1	SITE UTM	10	626242	6098112	SITE LENGTH	200	METH	RF	ACCESS	H/2WD		
DATE	2004/09/16	TIME	1130	AGENCY	Diversified Environmental Services			CREW	BC/TE	FISH FORM	Y	X	N		

CHANNEL (m)	meth							avg	GRADIENT %		EMS		COND	322
CHANNEL WIDTH	RF	7.10	9.70	9.80	7.30	8.10	9.50	8.58	meth	AL	TEMP (°C)	4.5	TURBIDITY	
WETTED WIDTH	RF	6.90	7.00	6.90	7.30	8.10	7.20	7.23	1.5		Ph		Mod turbid	
RES POOL DEPTH	MS	0.15	0.16	0.16	0.18	0.26	0.16	0.18	1.0		FLOOD SIGNS	0.8m rafted debris		
Wb DEPTH	0.90	0.90	0.80	STAGE	Moderate		No Vis Chan		Dry/Int		BED MATERIAL			
							Dewater		Tribs		Dominant	Cobble (64-256 mm)		
											Subdom.	Gravel (2-64 mm)		
											D95 (cm)	40	D (cm)	34
											Morph.	Riffle-pool		

WATER

COVER

COVER	Total	Moderate (5-20%)

type	SWD	LWD	B	U	DP	OV	IV
amt	T	T	D	T	S	T	N
loc	P	P	P	P	P	P	P

CROWN CLOSURE

0%	1-20%	21-40%	41-70%	71-90%	>90%
0	**1**	2	3	4	5

LWD FNC	Few	DIST	Clumped
LB SHAPE	Vertical	RB SHAPE	Sloping
TEXTURE	Gravel/Cobble	TEXTURE	Gravel/Cobble
RIP. VEG.	Mixed C & D	RIP. VEG.	Mixed C & D
STAGE	Mature Forest	STAGE	Mature Forest

INSTREAM VEGETATION

DISTURBANCE INDICATORS

O1	B1	**B2**	B3	**D1**	**D2**	D3	C1	**C2**
C3	C4	C5	S1	S2	S3	S4	S5	

PATTERN	Sinuous
ISLANDS	None
BARS	Side
COUPLING	Decoupled
CONFINED	Occasionally Confined

MORPHOLOGY

FEATURES

C	NID MAP #	NID #	TYPE	HT/LG (m)	mthd	PHOTO				COMMENTS	UTM		
						R		F					
						R		F					
						R		F					

DISTURBANCE INDICATOR LEGEND

O1	Beaver Dam	B3	Avulsion	D3	Recent LWD jam	C3	Elevated Bar	S1	Homogenous Bed	S4	Extensive Bars
B1	Abandoned Channel	D1	Small Woody Debris	C1	Extensive Riffles	C4	Multiple Channel	S2	Sediment Fingers	S5	Extensive Scours
B2	Eroding Bank	D2	Large Woody Debris	C2	Limited Pools	C5	Disturbed Lines	S3	Sediment Wedges		

HABITAT QUALITY

Low to moderate quality seasonal rearing for sport and non-sport species.
High proportion of shallow riffle; limited rearing cover.
High turbidity at moderate to high flow stages due to natural point sediment source on reach 3.
Over-wintering potential severely limted.

FSZ

PHOTO DOCUMENTATION

ROLL	FRAME	FOCAL LN	DIRECTION	COMMENTS
TD	82	wd	u	view upstream from bottom of site
TD	83	wd	u	view upstream from centre of site
TD	84	wd	d	view downstream from top of site
TD	85	wd	u	upstream aerial view

WILDLIFE

GROUP	WILDLIFE OBSERVATIONS	GROUP	WILDLIFE OBSERVATIONS

COMMENTS

C
CX1 Electro-fishing effort: 351 seconds @ 300 volts. Burbot, mountain whitefish and slimy sculpin captured.
CX2 Additional electro-fishing conducted July 10, Sep 01 and Oct 05, 2006. Mountain whitefish, slimy sculpin, bull trout, and eastern brook trout captured.

FISH COLLECTION FORM

STREAM NAME	M20 Creek					LAKE [ ]	STREAM [X] WETLAND [ ]
WATERSHED CODE	234-323900-57600						
PROJECT ID	WCCC Hermann Coal				SITE/LAKE CARD ATTACHED	Y [X]	N [ ]
NTS MAP #	93P/3	SITE #	1	FISH PERMIT #	VIF043196		RE-SAMPLE [ ]
DATE	2004/09/16 to 2004/09/16	AGENCY	Diversified Environmental Services		CREW	BC/TE	

SITE / METHOD

SITE #	NTS MAP #	SITE UTM	METHOD/NO.		STREAM CONDITION			COMMENTS
					TEMP	CON	TURB	
1	93P/3	10.626238.6097954	EF	1	4.5	322	M	

FISH SUMMARY

SITE #	MTD/NO	H/P	SPECIES	STAGE	AGE	TOTAL NO	MIN LN (mm)	MAX LN (mm)	FISH ACT	COMMENTS
1	EF/1	1	BB	Juv		1	340	340	Rearing	
1	EF/1	1	CCG	Adult		16	44	111	Rearing	
1	EF/1	1-4	MW	Juv		36	42	196	Rearing	
1	EF/1	4	EB	Juv		1	208	208	Rearing	
1	EF/1	2	BT	Juv		1	355	355	Rearing	

GEAR SPECS

NET / TRAP SPECIFICATIONS

C	SITE #	MD/NO	H/P	DATE IN	TIME IN	DATE OUT	TIME OUT	NET TYPE	LENGTH	DEPTH	MESH SIZE	SET	HAB

COMMENTS

ELECTROFISHER SPECIFICATIONS

C	SITE #	MD/NO	H/P	TIME IN	TIME OUT	EF SEC	LENGTH	WIDTH	ENCL	VOLT	FREQ	PLSE	MAKE	MDL
	1	EF/1	1	1135	1150	351	200	7.2	O	300	60	Fixed	Coffelt	Mk X

C Reach 1 re-sampled Jul 10 2006: EF effort 110 sec@250V

Reach 1 re-sampled Sep 05 2006: EF effort 414 sec@250V

Reach 1 re-sampled Oct 05 2006: EF effort 415 sec@250V

INDIVIDUAL FISH DATA

C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE			COMMENTS
									STR	SAMPLE #	AGE	
	1	EF/1	1	BB	340							Sep 16 2006
	1	EF/1	1	CCG	111							Sep 16 2006
	1	EF/1	1	CCG	109							Sep 16 2006
	1	EF/1	1	CCG	94							Sep 16 2006
	1	EF/1	1	CCG	76							Sep 16 2006
	1	EF/1	1	CCG	57							Sep 16 2006
	1	EF/1	1	CCG	57							Sep 16 2006
	1	EF/1	1	CCG	48							Sep 16 2006
	1	EF/1	1	CCG	55							Sep 16 2006
	1	EF/1	1	CCG	54							Sep 16 2006
	1	EF/1	1	CCG	44							Sep 16 2006
	1	EF/1	1	CCG	58							Sep 16 2006
	1	EF/1	1	CCG	70							Sep 16 2006
	1	EF/1	1	CCG	50							Sep 16 2006
	1	EF/1	1	CCG	53							Sep 16 2006
	1	EF/1	1	CCG	46							Sep 16 2006
	1	EF/1	1	CCG	49							Sep 16 2006
	1	EF/1	1	MW	125							Sep 16 2006
	1	EF/1	1	MW	174							Sep 16 2006
	1	EF/1	1	MW	109							Sep 16 2006
	1	EF/1	1	MW	139							Sep 16 2006
	1	EF/1	1	MW	196							Sep 16 2006
	1	EF/1	1	MW	112							Sep 16 2006
	1	EF/1	1	MW	121							Sep 16 2006
	1	EF/1	1	MW	110							Sep 16 2006
	1	EF/1	1	MW	61							Sep 16 2006

INDIVIDUAL FISH DATA												
C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE			COMMENTS
									STR	SAMPLE #	AGE	
	1	EF/1	2	BT	355							Jul 10 2006 re-sample
	1	EF/1	2	MW	44				Scale		0+	Jul 10 2006 re-sample
	1	EF/1	2	MW	43				Scale		0+	Jul 10 2006 re-sample
	1	EF/1	2	MW	42				Scale		0+	Jul 10 2006 re-sample
	1	EF/1	2	MW	42						0+	Jul 10 2006 re-sample
	1	EF/1	2	MW	42						0+	Jul 10 2006 re-sample
	1	EF/1	2	MW	55						0+	Jul 10 2006 re-sample
				plus 12 MW counted but not sampled								Jul 10 2006 re-sample
	1	EF/1	3	MW	46						0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	60						0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	62						0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	59						0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	72						0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	57						0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	56				Scale		0+	Sep 01 2006 re-sample
	1	EF/1	3	MW	60				Scale		0+	Sep 01 2006 re-sample
	1	EF/1	4	EB	208							Oct 05 2006 re-sample
	1	EF/1	4	MW	56				Scale		0+	Oct 05 2006 re-sample
	1	EF/1	4	MW	61				Scale		0+	Oct 05 2006 re-sample
	1	EF/1	4	MW	56							Oct 05 2006 re-sample
	1	EF/1	4	MW	58							Oct 05 2006 re-sample
				plus 26 YOY MW counted but not sampled								Oct 05 2006 re-sample
				plus 120 yearling MW in 2 schools in lower 200 m counted but not sampled								Oct 05 2006 re-sample

M20 Creek – Site 1, Reach 1; view upstream from top of site (Sep 16, 2004)

M20 Creek – Site 1, Reach 1; view upstream from bottom of site (Jul 10, 2006)

SITE CARD

STREAM NAME	M20 Creek									FIELD COORDINATES	10.625300.6098442				
WATERSHED CODE	234-323900-57600														
NTS MAP #	94P/3	LOCATION	below lower impassable barrier												
REACH #	2	SITE #	2	SITE UTM	10	625300	6098442	SITE LENGTH	200	METH	RF	ACCESS	2WD		
DATE	2006/10/05	TIME	900	AGENCY	Diversified Environmental Services			CREW	BC/TE	FISH FORM	Y	X	N		

CHANNEL (m)	meth							avg	GRADIENT %		EMS		COND	322
CHANNEL WIDTH	RF	8.20	6.00	8.20	4.00	5.00	5.10	6.08	meth	AL	TEMP (°C)	3.0	TURBIDITY	
WETTED WIDTH	RF	3.40	2.50	5.60	2.10	3.10	3.70	3.40	1.5		Ph		Clear	
RES POOL DEPTH	MS	0.45	0.32	0.30	0.20	0.24	0.30	0.30	1.5		FLOOD SIGNS	0.6m rafted debris		
Wb DEPTH	1.10	1.10	1.00	STAGE	Low		No Vis Chan		Dry/Int		BED MATERIAL			
							Dewater		Tribs		Dominant	Cobble (64-256 mm)		
											Subdom.	Fines (<2 mm)		
											D95 (cm)	60	D (cm)	22
											Morph.	Riffle-pool		

WATER

COVER

COVER	Total	Moderate (5-20%)

type	SWD	LWD	B	U	DP	OV	IV
amt	T	N	S	N	D	N	N
loc	P	P	P	P	P	P	P

CROWN CLOSURE	0%	1-20%	21-40%	41-70%	71-90%	>90%
	0	1	2	3	4	5

LWD FNC	None	DIST	
LB SHAPE	Vertical	RB SHAPE	Vertical
TEXTURE	Bedrock	TEXTURE	Bedrock
RIP. VEG.	None	RIP. VEG.	None
STAGE	NA	STAGE	NA

INSTREAM VEGETATION	None

MORPHOLOGY

DISTURBANCE INDICATORS

O1	B1	B2	B3	D1	D2	D3	C1	C2
C3	C4	C5	S1	S2	S3	S4	S5	

PATTERN	Irregular Wandering
ISLANDS	None
BARS	Side
COUPLING	Decoupled
CONFINED	Confined

FEATURES

C	NID MAP #	NID #	TYPE	HT/LG (m)	mthd	PHOTO				COMMENTS	UTM		
			CH			R		F		Impassable chute upstream of site	10	625067	6098371
						R		F					
						R		F					

DISTURBANCE INDICATOR LEGEND

O1	Beaver Dam	B3	Avulsion	D3	Recent LWD jam	C3	Elevated Bar	S1	Homogenous Bed	S4	Extensive Bars
B1	Abandoned Channel	D1	Small Woody Debris	C1	Extensive Riffles	C4	Multiple Channel	S2	Sediment Fingers	S5	Extensive Scours
B2	Eroding Bank	D2	Large Woody Debris	C2	Limited Pools	C5	Disturbed Lines	S3	Sediment Wedges		

HABITAT QUALITY

Moderate quality seasonal rearing habitat for sport and non-sport species.
spring spawning potential (RB & GR) severely limited by high turbidty.
Bull trout spawning suitability precluded by high proportion of fines and colluvial substrates.
limited juvenile over-wintering potential present in shallow bedrock pools.

FSZ

PHOTO DOCUMENTATION

ROLL	FRAME	FOCAL LN	DIRECTION	COMMENTS
TD	3228	wd	u	view upstream to impassable chute above site
TD	3229	wd	d	view downstream from top of site
TD	3231	wd	u	view upstream from centre of site
TD	3232	wd	u	view upstream from bottom of site

WILDLIFE

GROUP	WILDLIFE OBSERVATIONS	GROUP	WILDLIFE OBSERVATIONS

COMMENTS

C	
C1	bedrock also present in streambed
C2	Deeply incised channel with high shale/bedrock slopes
CX1	Electro-fishing conducted Jul 10, Sep 01 and Oct 05, 2006: mountain whitefish, bull trout, brook trout, rainbow trout, Arctic grayling, longnose sucker and slimy sculpin captured.
CX2	Newly constructed beaver dam and impoundment downstream of site

FISH COLLECTION FORM

STREAM NAME	M20 Creek					[ ] LAKE [X] STREAM [ ] WETLAND	
WATERSHED CODE	234-323900-57600						
PROJECT ID	WCCC Hermann Coal				SITE/LAKE CARD ATTACHED	[X] Y [ ] N	
NTS MAP #	93P/3	SITE #	2	FISH PERMIT #	VIF043196	[ ] RE-SAMPLE	
DATE	2005/07/10 to 2005/10/05	AGENCY	Diversified Environmental Services		CREW	BC/TE	

SITE / METHOD

SITE #	NTS MAP #	SITE UTM	METHOD/NO.		STREAM CONDITION			COMMENTS
					TEMP	CON	TURB	
2	93P/3	10.625300.6098442	EF	1	4.5	322	M	

FISH SUMMARY

SITE #	MTD/NO	H/P	SPECIES	STAGE	AGE	TOTAL NO	MIN LN (mm)	MAX LN (mm)	FISH ACT	COMMENTS
2	EF/1	1-3	BT	Juv	2-5	11	150	315	Rearing	
2	EF/1	1	GR	Juv	3	2	242	246	Rearing	
2	EF/1	2	RB	Juv	2	1	171	171	Rearing	
2	EF/1	1,3	EB	Juv		7	75	180	Rearing	
2	EF/1	1-3	MW	Juv	0-6	45	69	240	Rearing	

GEAR SPECS

								NET / TRAP SPECIFICATIONS					
C	SITE #	MD/NO	H/P	DATE IN	TIME IN	DATE OUT	TIME OUT	NET TYPE	LENGTH	DEPTH	MESH SIZE	SET	HAB

ELECTROFISHER SPECIFICATIONS

C	SITE #	MD/NO	H/P	TIME IN	TIME OUT	EF SEC	LENGTH	WIDTH	ENCL	VOLT	FREQ	PLSE	MAKE	MDL
C	2	EF/1	1	1140	1205	607	300	6.1	O	250	60	Fixed	Coffelt	Mk X

COMMENTS

Reach 2 re-sampled Sep 05 2006: EF effort 993 sec@250V

Reach 2 re-sampled Oct 05 2006: EF effort 880 sec@250V

INDIVIDUAL FISH DATA

C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE			COMMENTS
									STR	SAMPLE #	AGE	
	2	EF/1	1	BT	150					SC	2	Jul 10, 2006
	2	EF/1	1	BT	230					SC	3	Jul 10, 2006
	2	EF/1	1	BT	315							Jul 10, 2006
	2	EF/1	1	BT	310							Jul 10, 2006
	2	EF/1	1	BT	242					SC	3	Jul 10, 2006
	2	EF/1	1	GR	242					SC	3	Jul 10, 2006
	2	EF/1	1	GR	246					SC	3	Jul 10, 2006
	2	EF/1	1	EB	75							Jul 10, 2006
	2	EF/1	1	EB	86							Jul 10, 2006
	2	EF/1	1	EB	148							Jul 10, 2006
	2	EF/1	1	EB	137							Jul 10, 2006
	2	EF/1	1	EB	118							Jul 10, 2006
	2	EF/1	1	EB	180							Jul 10, 2006
	2	EF/1	1	MW	240							Jul 10, 2006
	2	EF/1	1	MW	229					SC	6	Jul 10, 2006
	2	EF/1	1	MW	170					SC	3	Jul 10, 2006
	2	EF/1	1	MW	175					SC	3	Jul 10, 2006
	2	EF/1	1	MW	200					SC	4	Jul 10, 2006
	2	EF/1	1	MW	218					SC	5	Jul 10, 2006
	2	EF/1	1	MW	191					SC	3	Jul 10, 2006
	2	EF/1	1	MW	149					SC	3	Jul 10, 2006

INDIVIDUAL FISH DATA												
C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE			COMMENTS
									STR	SAMPLE #	AGE	
	2	EF/1	1	MW	104					SC	1	Jul 10, 2006
	2	EF/1	1	MW	180							Jul 10, 2006
	2	EF/1	1	MW	139							Jul 10, 2006
	2	EF/1	1	CCG	58							Jul 10, 2006
	2	EF/1	1	CCG	75							Jul 10, 2006
	2	EF/1	1	CCG	85							Jul 10 2006 re-sample
	2	EF/1	1	CCG	126							Jul 10 2006 re-sample
	2	EF/1	1	CCG	102							Jul 10 2006 re-sample
	2	EF/1	1	LSU	158							Jul 10 2006 re-sample
	2	EF/1	1	LSU	142							Jul 10 2006 re-sample
	2	EF/1	1	LSU	123							Jul 10 2006 re-sample
	2	EF/1	1	LSU	140							Jul 10 2006 re-sample
	2	EF/1	1	Plus 122 juvenile MW counted, not sampled								Jul 10 2006 re-sample
	2	EF/1	2	BT	195				Scale	SC14	3	Sep 05 2006 re-sample
	2	EF/1	2	BT	192				Scale	SC19	3	Sep 05 2006 re-sample
	2	EF/1	2	RB	171				Scale	SC6	2	Sep 05 2006 re-sample
	2	EF/1	2	MW	153							Sep 05 2006 re-sample
	2	EF/1	2	MW	158							Sep 05 2006 re-sample
	2	EF/1	2	MW	155							Sep 05 2006 re-sample
	2	EF/1	2	MW	152							Sep 05 2006 re-sample
	2	EF/1	2	MW	131							Sep 05 2006 re-sample
	2	EF/1	2	MW	149							Sep 05 2006 re-sample
	2	EF/1	2	MW	158					SC7	2	Sep 05 2006 re-sample
	2	EF/1	2	MW	138					SC8	2	Sep 05 2006 re-sample
	2	EF/1	2	MW	202					SC9	2	Sep 05 2006 re-sample
	2	EF/1	2	MW	118					SC10	1	Sep 05 2006 re-sample
	2	EF/1	2	MW	193					SC11	4	Sep 05 2006 re-sample
	2	EF/1	2	MW	170					SC12	3	Sep 05 2006 re-sample
	2	EF/1	2	MW	145					SC13	2	Sep 05 2006 re-sample
	2	EF/1	2	MW	98					SC1	1	Sep 05 2006 re-sample
	2	EF/1	2	MW	120					SC2	1	Sep 05 2006 re-sample
	2	EF/1	2	MW	119					SC3	1	Sep 05 2006 re-sample
	2	EF/1	2	MW	121					SC4	2	Sep 05 2006 re-sample
	2	EF/1	2	MW	110					SC5	1	Sep 05 2006 re-sample
	2	EF/1	2	MW	89					SC15	1	Sep 05 2006 re-sample
	2	EF/1	2	MW	79					SC16	0	Sep 05 2006 re-sample
	2	EF/1	2	MW	82					SC17	0	Sep 05 2006 re-sample
	2	EF/1	2	MW	81					SC18	0	Sep 05 2006 re-sample
	2	EF/1	2	Plus 40 juvenile MW counted not sampled								Sep 05 2006 re-sample
	2	EF/1	2	Plus 250 YOY MW counted not sampled								Sep 05 2006 re-sample
	2	EF/1	3	BT	244							Oct 05 2005 re-sample
	2	EF/1	3	BT	194							Oct 05 2005 re-sample
	2	EF/1	3	BT	238							Oct 05 2005 re-sample
	2	EF/1	3	BT	265							Oct 05 2005 re-sample
	2	EF/1	3	EB	225							Oct 05 2005 re-sample
	2	EF/1	3	EB	89							Oct 05 2005 re-sample
	2	EF/1	3	EB	263		M	Mature				Oct 05 2005 re-sample
	2	EF/1	3	EB	161							Oct 05 2005 re-sample
	2	EF/1	3	EB	173							Oct 05 2005 re-sample
	2	EF/1	3	MW	138							Oct 05 2005 re-sample
	2	EF/1	3	MW	126							Oct 05 2005 re-sample
	2	EF/1	3	MW	80							Oct 05 2005 re-sample
	2	EF/1	3	MW	91							Oct 05 2005 re-sample
	2	EF/1	3	MW	80			29				Oct 05 2005 re-sample

INDIVIDUAL FISH DATA												
C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE			COMMENTS
									STR	SAMPLE #	AGE	
	2	EF/1	3	MW	82							Oct 05 2005 re-sample
	2	EF/1	3	MW	79							Oct 05 2005 re-sample
	2	EF/1	3	MW	69							Oct 05 2005 re-sample
	2	EF/1	3	MW	95							Oct 05 2005 re-sample
	2	EF/1	3	MW	75							Oct 05 2005 re-sample
	2	EF/1	3	MW	71							Oct 05 2005 re-sample
	2	EF/1	3	Plus 106 YOY and yearling MW counted, not sampled								Oct 05 2005 re-sample

M20 Creek – Site 2 Reach 2; view upstream from centre of site (Jul 10, 2006)

M20 Creek – Site 2 Reach 2; view upstream from centre of site (Oct 05, 2006)

M20 Creek – Reach 2; lower impassable bedrock chute, view upstream from top of Site 2 (Oct 05, 2006)

APPENDIX III

FISHERIES SAMPLE SITE DATA

(Site Data Cards, Fish Collection Forms and Site Photographs)

TWENTY CREEK

SITE CARD

STREAM NAME	Twenty Creek											FIELD COORDINATES	10.625474.6096940				
WATERSHED CODE	234-323900-58100																
NTS MAP #	93P/3	LOCATION															
REACH #	1	SITE #	1	SITE UTM	10	625474	6096940	SITE LENGTH	200	METH	RF	ACCESS	V2				
DATE	08/06/2011	TIME	1050	AGENCY	Diversified Environmental Services			CREW	BC/DC	FISH FORM	Y	X	N				

WATER

CHANNEL (m)	meth							avg	GRADIENT %		EMS		COND	
CHANNEL WIDTH	MS	2.10	2.00	2.10	2.20	2.60	2.50	2.25	meth	AL	TEMP (°C)	6.5	TURBIDITY	
WETTED WIDTH	MS	1.60	1.80	1.70	1.90	2.10	2.00	1.85	0.5		Ph		Mod turbid	
RES POOL DEPTH	MS	0.14	0.24	0.20	0.15	0.15	0.24	0.19	0.5					
Wb DEPTH	0.45	0.40	0.36	STAGE	Moderate			No Vis Chan		Dry/Int				
								Dewater		Tribs				

COVER

COVER	Total	Moderate (5-20%)

type	SWD	LWD	B	U	DP	OV	IV
amt	S	S	T	T	D	S	N
loc	P	P	P	P	P	P	P

CROWN CLOSURE	0%	1-20%	21-40%	41-70%	71-90%	>90%
	0	1	2	3	4	5

LWD FNC	Abundant	DIST	Clumped
LB SHAPE	Vertical	RB SHAPE	Vertical
TEXTURE	Fines	TEXTURE	Fines
RIP. VEG.	Deciduous	RIP. VEG.	Deciduous
STAGE	Mature Forest	STAGE	Mature Forest

INSTREAM VEGETATION: None

MORPHOLOGY

C1

FLOOD SIGNS	0.2 m
BED MATERIAL	
Dominant	Gravel (2-64 mm)
Subdom.	Fines (<2 mm)
D95 (cm)	16
D (cm)	12
Morph.	Riffle-pool

DISTURBANCE INDICATORS

O1	B1	B2	B3	D1	D2	D3	C1	C2
C3	C4	C5	S1	S2	S3	S4	S5	

PATTERN	Sinuous
ISLANDS	None
BARS	Side
COUPLING	Decoupled
CONFINED	Unconfined

FEATURES

C	NID MAP #	NID #	TYPE	HT/LG (m)	mthd	PHOTO				COMMENTS		UTM	
						R		F					
						R		F					
						R		F					

DISTURBANCE INDICATOR LEGEND

O1	Beaver Dam	B3	Avulsion	D3	Recent LWD jam	C3	Elevated Bar	S1	Homogenous Bed	S4	Extensive Bars
B1	Abandoned Channel	D1	Small Woody Debris	C1	Extensive Riffles	C4	Multiple Channel	S2	Sediment Fingers	S5	Extensive Scours
B2	Eroding Bank	D2	Large Woody Debris	C2	Limited Pools	C5	Disturbed Lines	S3	Sediment Wedges		

HABITAT QUALITY

Low to moderate seasonal rearing potential for juvenile sport-fish entering from the Murray River May through July.
Reach 1 typically dry by late summer; no over-wintering capability or fall spawning potenital.
No resident slimy sculpin population present.

FSZ

PHOTO DOCUMENTATION

IMAGE	FOCAL LN	DIRECTION	COMMENTS
1	wd	d	view downstream from top of site
2	wd	u	view upstream from centre of site
3	wd	u	view upstream from bottom of site

WILDLIFE

GROUP	WILDLIFE OBSERVATIONS	GROUP	WILDLIFE OBSERVATIONS

COMMENTS

C	
CX1	Electro-fishing effort: 331 seconds @ 250 volts. Rainbow trout, mountain whitefish and brook trout captured.
CX2	Additional electro-fishing conducted August 05, 2011: brook trout captured.
CX3	FRPA stream classification S3

FISH COLLECTION FORM

STREAM NAME	Twenty Creek		LAKE	X	STREAM		WETLAND
WATERSHED CODE	234-323900-58100						
PROJECT ID	Dehua Murray River			SITE/LAKE CARD ATTACHED		X	Y N
NTS MAP #	93P/3	SITE #	1	FISH PERMIT #	FJ11-72388		RE-SAMPLE
DATE	08/06/2011 to 05/08/2011	AGENCY	Diversified Environmental Services		CREW	BC/DC	

SITE / METHOD

SITE #	NTS MAP #	SITE UTM	METHOD/NO.		STREAM CONDITION TEMP	CON	TURB	COMMENTS
1	93P/3	10.625474.6096940	EF	1	6.5		M	

FISH SUMMARY

SITE #	MTD/NO	H/P	SPECIES	STAGE	AGE	TOTAL NO	MIN LN (mm)	MAX LN (mm)	FISH ACT	COMMENTS
1	EF/1	1	RB	Juv		1	154	154	Rearing	
			MW	Juv		1	157	157	Rearing	
			EB	Juv		3	161	188	Rearing	

GEAR SPECS

NET / TRAP SPECIFICATIONS

C	SITE #	MD/NO	H/P	DATE IN	TIME IN	DATE OUT	TIME OUT	NET TYPE	LENGTH	DEPTH	MESH SIZE	SET	HAB

ELECTROFISHER SPECIFICATIONS

C	SITE #	MD/NO	H/P	TIME IN	TIME OUT	EF SEC	LENGTH	WIDTH	ENCL	VOLT	FREQ	PLSE	MAKE	MDL
	1	EF/1	1	1030	1050	331	200	1.85	O	250	60	Fixed	Coffelt	Mk X

COMME

C	
	Adddtional sampling conducted Aug 05, 2011; very low flow; riffle depth 3-5 cm.

INDIVIDUAL FISH DATA

C	SITE #	MD/NO	H/P	SPECIES	LENGTH (mm)	WEIGHT (gms)	SEX	MATUR	AGE STR	AGE SAMPLE #	AGE	COMMENTS
	1	EF/1	1	RB	154			Immature	Scale		2+	
	1	EF/1	1	MW	157			Immature	Scale		2+	
	1	EF/1	1	EB	188			Maturing				
	1	EF/1	1	EB	163			Immature				
	1	EF/1	1	EB	161			Immature				
	1	EF/1	2	EB	170			Immature				Aug 5/11 addtional sampling
	1	EF/1	2	EB	171			Immature				Aug 5/11 addtional sampling

Twenty Creek – Site 1, Reach 1; view upstream from centre of site (June 08, 2011).

Twenty Creek – Reach 1; view upstream to Murray FSR culvert crossing (Aug 05, 2011).