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9.0 FISHERIES AND AQUATIC RESOURCES

9.1 Introduction

The Korea National Oil Corporation (KNOC) BlackGold Expansion Project includes several activities that may impact fisheries and aquatic resources. These include:

- construction and operation of a temporary construction laydown area and new well pads;
- construction and operation of watercourse crossings associated with pipelines, access roads, and utility crossings; and
- groundwater withdrawals.

The objective of the fisheries and aquatics resources program is to characterize aquatic habitat, fish communities and benthic invertebrate communities within areas potentially impacted by the project. These components of the fisheries and aquatic resources program are described in the following sections.

9.2 Study Area

Three study areas were delineated to assess the potential impacts associated with the project. These include:

- Aquatic Regional Study Area (ARSA);
- Aquatic Local Study Area (ALSA); and
- the project area.

9.2.1 Aquatic Regional Study Area

The Aquatic Regional Study Area (ARSA) was delineated to determine the potential of the project to contribute to the cumulative effects on aquatic resources within the Christina Lake region ([Figure 9.2-1](#)). Numerous developments are either currently operational, have been approved, or have been proposed for development in the oil sands region. All existing, approved or proposed developments in the oil sands area were considered when selecting the ARSA.

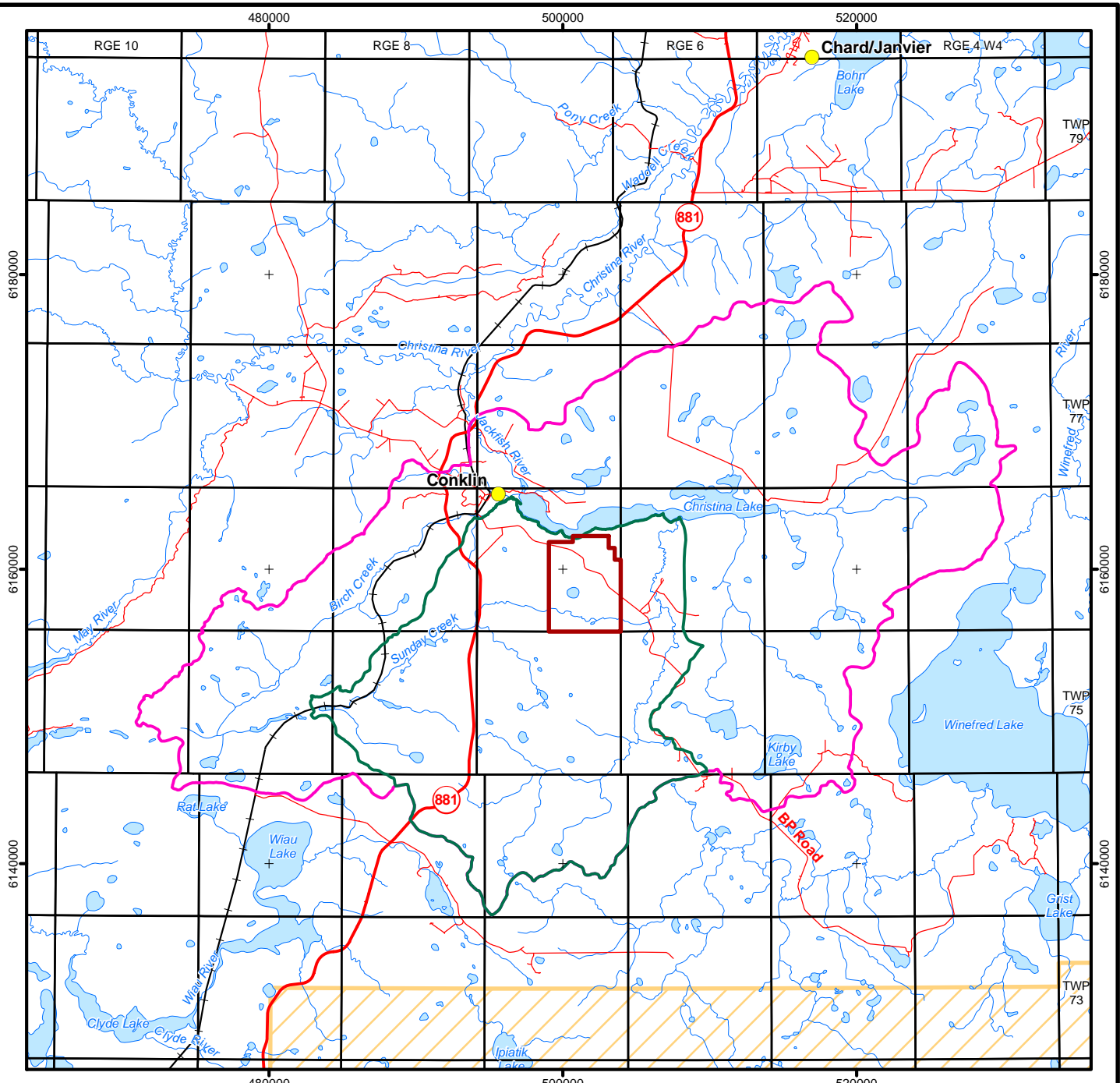
9.2.2 Aquatic Local Study Area

The Aquatic Local Study Area (ALSA) was determined based on watercourses and waterbodies that may be directly or indirectly affected by the project. The ALSA is located in the south portion of the Christina Lake drainage basin ([Figure 9.2-1](#)) and includes Sunday Creek watershed, two unnamed tributaries of Christina Lake and the lower section of Birch Creek.

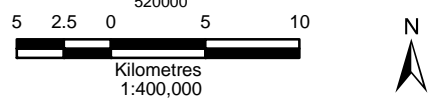
9.2.2.1 ALSA Basin and Waterbody Nomenclature

In order to simplify the discussion of hydrology, water quality, and fisheries and aquatic resources, the ALSA was divided into five separate basins and areas of direct drainage into Christina Lake, which were assigned a letter code ([Table 9.2-1](#)).

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- Legend**
- Aquatics Regional Study Area
 - Aquatics Local Study Area
 - Project Area
 - Cold Lake Air Weapons Range
 - Open Water
 - Watercourse



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**Korea
National Oil Corporation**

BlackGold Expansion Project

**Aquatics Local and Regional
Study Areas**

<small>DATE:</small> December 2009	Figure 9.2-1
<small>PROJECT:</small> CE03745/320	Fig09.02-01 Aquatic Study Areas 09-11-15
<small>ANALYST:</small> CF	<small>QA/QC:</small> KW JH DR
<small>PROJECTION/DATUM:</small> UTM Zone 12 NAD83	<small>DRAWN BY:</small> AMEC
	<small>PREPARED BY:</small> AMEC

Table 9.2-1: Basins within the ALSA and the Corresponding Basin Code

Basin	Basin Code
Sunday Creek Upstream of the project area	Basin A
Sunday Creek Downstream of the project area	Basin B
East Unnamed Creek	Basin C
West Unnamed Creek	Basin D
Birch Creek	Basins E and F

Basins A and B occupy the largest area of the ALSA and comprise the Sunday Creek watershed. Basins C and D are quite small in comparison and flow north through the KNOC lease area and discharge into Christina Lake. Basins E and F are located in the top northwest portion of the ALSA and drains the lower portion of Birch Creek and a number of tributaries before discharging into Christina Lake. Gray shaded areas on the [Figure 9.2-2](#) represent zones within the ALSA that drain directly over land into Christina Lake.

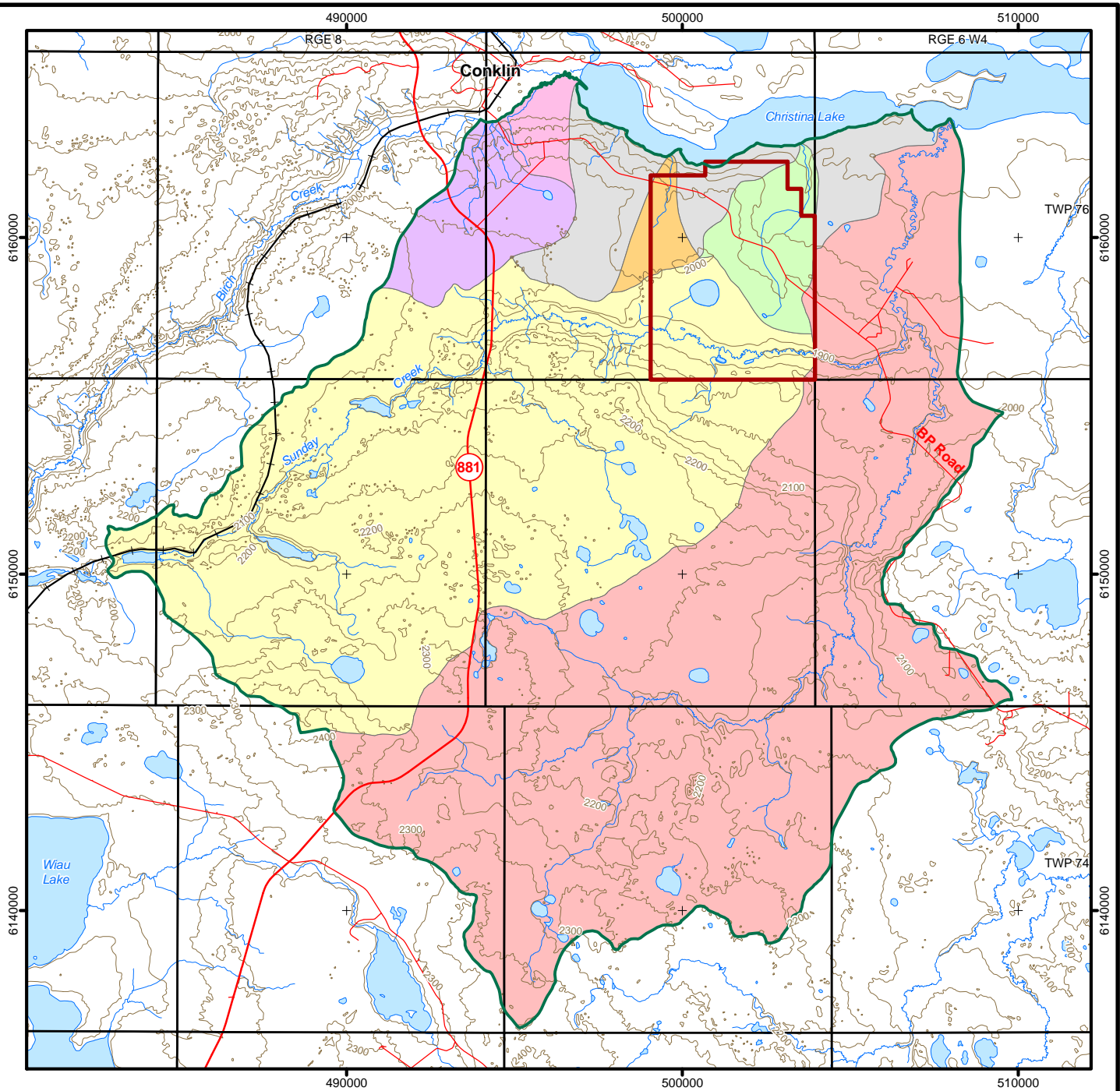
Fisheries and aquatic resources sites located within each basin have been labeled with the basin code as a prefix, followed by the site number; i.e., Site C1 would be located within Basin C.

Within each basin, named streams have not been recoded, although each unnamed watercourse or waterbody was represented by the basin code followed by a series of hyphenated numbers, with each successive number representing a new tributary encountered when moving upstream through the basin. Tributaries were numbered in upstream order from the mouth. A list of watercourse and waterbody names and the corresponding site numbers within the ALSA is provided in [Table 9.2-2](#). [Figure 9.2-3](#) shows the sampling locations.

Table 9.2-2: Names, Watershed Codes and Site Numbers for Watercourses and Waterbodies Sampled Within the ALSA

Watercourse/Waterbody	Site(s)
Basin A	
Sunday Creek	A1, A2
– Lake A3	A3-1 ¹
– Watercourse A4	A4-1, A4-2 ¹
– Lake A5	A5-1 ¹
– Watercourse A15	A15-1, A15-2
Basin B	
Sunday Creek	B1, B2
Monday Creek	B3, B4
Basin C	
Watercourse C	C1, C2
Basin D	
Watercourse D	D1, D2
Basins E and F	
Birch Creek	No sites

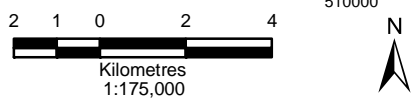
¹ Site is located on an unnamed lake.



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Legend

- Aquatics Local Study Area
 - Project Area
 - Open Water
 - Watercourse
- Drainage Basin**
- Basin A - Sunday Creek Upstream of Project Area
 - Basin B - Sunday Creek Downstream of Project Area
 - Basin C - East Unnamed Creek
 - Basin D - West Unnamed Creek
 - Basin E - Birch Creek Upstream of Project Area
 - Basin F - Birch Creek Downstream of Project Area
 - Direct Drainage to Christina Lake
 - Contour (Interval - 50 ft)



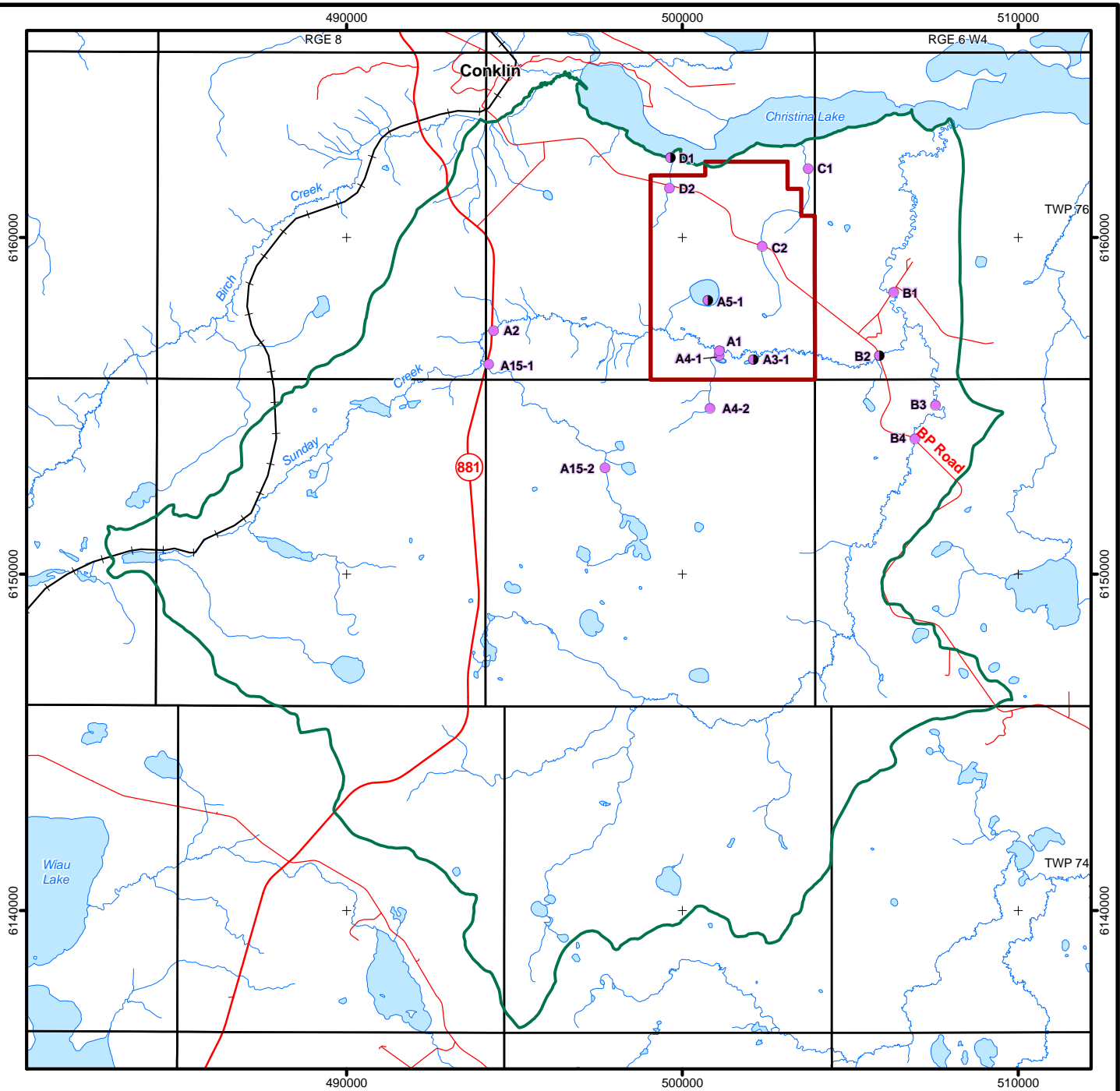
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BlackGold Expansion Project

Drainage Basins

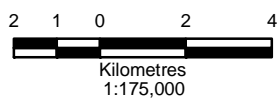
DATE: December 2009	Figure 9.2-2
PROJECT: CE03745/320	Fig09.02-02 Drainage Basins 09-11-14
ANALYST: TM	DRAWN BY: AMEC
QA/QC: KW RF DR	PREPARED BY: AMEC
PROJECTION/DATUM: UTM Zone 12 NAD83	

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Legend

- █ Aquatics Local Study Area
- █ Project Area
- █ Open Water
- Watercourse
- Fisheries Sampling Location
- Fisheries and Benthic Invertebrate Sampling Location



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Korea National Oil Corporation	
BlackGold Expansion Project	
Fisheries and Benthic Invertebrate Sampling Locations	
DATE: December 2009	Figure 9.2-3
PROJECT: CE03745/320	Fig09.02-03 Sample Sites 09-11-14
ANALYST: CF	QAI/QC: KW RF DR
DRAWN BY: AMEC	PREPARED BY: AMEC
PROJECTION/DATUM: UTM Zone 12 NAD83	DRAWN BY: AMEC

9.2.3 Project Area

The project area includes all watercourse and waterbodies found within the KNOC leases (Figure 9.2-2). This area will contain all project-related activities. The project area lies entirely within a southern portion of the Christina Lake drainage basin. Within the project area, watercourses and waterbodies of interest included:

- two small unnamed Christina Lake tributaries and a lake, which drains into one of the tributaries;
- a portion of Sunday Creek; and
- three unnamed tributaries and waterbodies, which feed Sunday Creek (Figure 9.2-2).

9.3 Issues and Assessment Criteria

9.3.1 Issue Scoping

Issues concerning fisheries and aquatic resources were compiled from consultation with provincial regulators, through KNOC's public consultation, and from examination of previous environmental impact assessment (EIAs) of similar in-situ oil sands development projects.

Fisheries and aquatic resources issues and implications within the EIA include:

- *Potential Impacts on Buffering, Biological Productivity and Species Composition of Acid-Sensitive Rivers and Lakes* – Impacts due to deposition of acidifying substances are addressed in [Volume 2, Section 8.0](#) (Surface Water Quality). Impacts to fisheries and other aquatic resources are addressed in this section of the EIA;
- *Increased Fishing Pressures Due to Improved Access That Can Cause Reductions in Fish Populations* – Status of existing fish populations and the potential impacts on these populations due to increased fishing pressure are discussed in this section of the EIA;
- *Activities will Reduce Stream and River Flows, Resulting in Changes to Fish Habitat* – Changes in stream and river flows are addressed in [Volume 2, Section 7.0](#) (Hydrology). Potential impacts of these changes on fish populations and habitat are addressed in this section of the EIA;
- *Changes in Flows, Sediment Concentrations and Channel Regimes may Impact Fish Habitat* – Impact of sediment loading is addressed in [Volume 2, Section 7.0](#) (Hydrology). Potential impact of sediment loading on fish populations and habitat are addressed in this section of the EIA;
- *Monitoring and Assessment of Water Pollution Effects in the Downstream Region, Including Fish* – No releases of project wastewater to area waterbodies will occur; water pollution will be minimal to non-existent ([Volume 2, Section 8.0](#), Surface Water Quality). Therefore, it is not addressed in this section of the EIA;

- *Potential Effects of Industrial Effluents on Fish Health* – There will be no direct releases from the project into nearby watercourses ([Volume 2, Section 8.0](#), Surface Water Quality). Therefore, this is not addressed in this EIA; and
- *Project Activities have the Potential to Impact Special Status Fish Species* – Special status fish species may exist in the local and regional study areas. Potential impacts to these species are addressed in this section.

9.3.2 Assessment Criteria

Each of the issues above was assessed for its potential to impact fish and aquatic resources, following implementation of best management practices and other available mitigation measures.

Evaluation of mitigation measures and identification of residual impacts were based on review of available literature and on professional judgment. Evaluation of potential project impacts was qualitatively assessed at the local (project-specific impacts) and regional (cumulative effects) scales.

9.3.3 Indicator Resources

Indicator resources were selected to focus the assessment of project potential impacts on fish and aquatic resources. Potential impacts to indicator resources were not intended to imply impacts to the broader fish community but were instead used to focus the assessment to species or guilds of traditional, social, economic and/or ecological importance.

Four guilds were selected as indicator resources for this assessment: benthic invertebrates, small-bodied forage fish, large-bodied forage fish and predatory fish. These four guilds, and their habitat, were selected to assess various trophic levels potentially affected by the project. Benthic invertebrates were selected as indicator resources in all waterbodies because of their abundance and wide distribution, importance as food for fish, sensitivity to sedimentation and rapid response to environmental change.

Brook stickleback (*Culaea inconstans*) was selected as an indicator resource in all waterbodies although the species composition of this guild varied for each waterbody, depending on which species was documented. This species represents the small-bodied fish guild and are resident, spawn in the ALSA, are widely distributed and are the most abundant fish found in the ALSA. Spoonhead sculpin (*Cottus ricei*) was also selected as an indicator resource due to being listed as a special status species. Shuter (1990) suggested that populations with quick response time (i.e., short age-to-maturity and fast growth rate), small adult size and low food web position are useful as indicators of environmental stress. All species in the small-bodied forage fish guild meet these criteria and could be individually used as indicators. The small-bodied forage fish guild was selected collectively as an indicator resource because individual taxa are difficult to select objectively, their sensitivity may vary due to other factors (besides potential project impacts) and they cannot indicate the relative degree of degradation (Fausch *et al.* 1990).

Individual species from the large-bodied forage fish guild and predatory fish guild were selected instead of using the entire guild. This was done to reflect important spawning, rearing, or feeding habitats for these species, listings on provincial and regional priority lists, and importance values placed on these species by various user groups, including traditional, subsistence and recreational users.

White sucker (*Catostomus commersoni*) and longnose sucker (*Catostomus catostomus*) were selected as indicator resources for the large-bodied forage fish guild. Both species occur within the ALSA and spawn in a number of waterbodies in the ALSA. White sucker and longnose sucker feed on benthic invertebrates and spawn on clean gravel (Scott and Crossman 1973) and are sensitive to sedimentation. Juvenile sucker are also important as prey for sportfish species.

Northern pike (*Esox lucius*) and Arctic grayling (*Thymallus arcticus*) were selected as indicator resources from the predatory fish guild. Northern pike are documented in the local and regional study areas, are a preferred subsistence and sportfish (Park 2007) and are listed as a Priority 1 indicator species by CEMA (2001). Arctic grayling spawn in the regional study area, utilizing clean gravels in swift-flowing riffles that are sensitive to sedimentation. Arctic grayling, an important sportfish (Park 2007), are susceptible to over fishing, and are listed as a Priority 2 indicator species (CEMA 2001).

9.4 Methods

The baseline condition of fisheries and aquatic resources within the ALSA and project area was determined from a review of existing information and field programs previously conducted for the KNOC lease area in 2005 and 2006 (KNOC 2008). Baseline conditions in the project ARSA were described using available literature.

Primary literature sources that provided aquatic resources information for the study areas were reviewed and included:

- the Atlas of Alberta Lakes (Mitchell and Prepas 1990);
- baseline assessments related to regional oil sands developments (Van Horne 1998, Devon 2003 and 2006, MEG 2005); and
- baseline assessments conducted in 2005/2006 for the KNOC lease area (KNOC 2008).

Additional information sources included discussions with Alberta Sustainable Resource Development (SRD) and the SRD Fish and Wildlife Management Information System (FWMIS). The FWMIS database provided fisheries data for the area from additional references (Brown and Stanislawski 1995 and 1996).

9.5 Existing Conditions

9.5.1 Regional Setting

The ARSA includes the Christina Lake drainage basin and a portion of Jackfish River, which are part of the Athabasca River watershed. The drainage area of the basin is approximately 1 270 km² and the lake is fed by six main tributaries (Mitchell and Prepas 1990). The largest tributary, Sunday Creek, flows along the south boundary of the project area and then flows north, outside the project area on the east side, before discharging to Christina Lake (Figure 9.2-1).

The basin is part of a till plain that drains slowly to the northeast with most of the basin consisting of poorly drained muskeg (Mitchell and Prepas 1990). Watercourses in the project area are generally characterized by uniform run habitat over fine substrates with regular beaver activity (Devon 2003, MEG 2005). The largest tributary, Sunday Creek, is characterized by run habitat with impoundments formed by beaver activity (Devon 2006).

Christina Lake is a long, narrow lake that has three major sub-basins. The lake is approximately 33 m deep at the deepest point, and is strongly thermally stratified over the summer (Mitchell and Prepas 1990). During the winter, dissolved oxygen (DO) levels are above 5 mg/L, thus the lake provides good overwintering habitat for all fish species. Other lakes within the Christina Lake basin are generally shallow and uniform with fine substrates and are characterized by extensive littoral habitat with abundant beaver activity (Devon 2003, MEG 2005, KNOC 2008). The outlet of Christina Lake, Jackfish River, is located at the west end of the lake and travels north approximately 9 km before entering into Christina River (Mitchell and Prepas 1990).

The Christina Lake basin supports seven sportfish species and ten other species (Table 9.5-1). Sportfish in the basin include: Arctic grayling, burbot (*Lota lota*), cisco (*Coregonus artedii*), lake whitefish (*Coregonus clupeaformis*), northern pike, walleye (*Sander vitreus*), and yellow perch (*Perca flavescens*). Sucker species in the basin are limited to longnose sucker and white sucker. The forage fish comprising the remaining species in the basin are: brook stickleback, Iowa darter (*Etheostoma exile*), lake chub (*Couesius plumbeus*), ninespine stickleback (*Pungitius pungitius*), pearl dace (*Margariscus margarita*), slimy sculpin (*Cottus cognatus*), spoonhead sculpin, spottail shiner (*Notropis hudsonius*) and trout-perch (*Percopsis omiscomaycus*) (Mitchell and Prepas 1990, Brown and Stanislawski 1995 and 1996, Van Horne 1998, Devon 2003, MEG 2005, KNOC 2008).

Table 9.5-1: Fish Species Documented in the Christina Lake Basin

Common Name	Scientific Name
Arctic grayling	<i>Thymallus arcticus</i>
brook stickleback	<i>Culaea inconstans</i>
burbot	<i>Lota lota</i>
cisco	<i>Coregonus artedii</i>
Iowa darter	<i>Etheostoma exile</i>
lake chub	<i>Couesius plumbeus</i>
lake whitefish	<i>Coregonus clupeaformis</i>
longnose sucker	<i>Catostomus catostomus</i>
ninespine stickleback	<i>Pungitius pungitius</i>
northern pike	<i>Esox lucius</i>
pearl dace	<i>Margariscus margarita</i>
slimy sculpin	<i>Cottus cognatus</i>
spoonhead sculpin	<i>Cottus ricei</i>
spottail shiner	<i>Notropis hudsonius</i>
trout-perch	<i>Percopsis omiscomaycus</i>
walleye	<i>Sander vitreus</i>
white sucker	<i>Catostomus commersoni</i>
yellow perch	<i>Perca flavescens</i>

Source: Mitchell and Prepas (1990), Brown and Stanislawski (1995 and 1996), Van Horne (1998), Devon (2003 and 2006), MEG (2005), KNOC (2008) and SRD (2009a).

9.5.2 Local Setting

A total of nine species of fish including Arctic grayling, brook stickleback, lake chub, longnose sucker, northern pike, slimy sculpin, spoonhead sculpin, walleye and white sucker, have been documented within the ALSA (Table 9.5-2) (Van Horne 1998, Devon 2003, MEG 2005, KNOC 2008). Habitat descriptions and fish inventory results are provided for each of the basins within the ALSA in the following sections.

Table 9.5-2: Fish Species Documented within the ALSA

Common Name	Basin A	Basin B	Basin C	Basin D	Basins E & F
Arctic grayling		▲			
brook stickleback	▲	▲	▲		
lake chub		▲			
longnose sucker	▲				
northern pike	▲				▲
slimy sculpin					▲
spoonhead sculpin		▲			
sucker spp.	▲	▲			
walleye	▲				
white sucker	▲	▲			
unidentified fish				▲	

Source: Van Horne (1998), Devon (2003 and 2006), KNOC (2008) and SRD (2009a).

9.5.2.1 Basin A (Sunday Creek Upstream of the Project Area)

Sunday Creek

The headwaters of Sunday Creek originate at Edwards Lake to the southwest of the ALSA. Downstream of Edwards Lake, the creek flows for a distance of 54 km before entering the south shore of Christina Lake. Sunday Creek receives input from numerous small tributaries and one large tributary system, locally referred to as Monday Creek.

Several sites have been sampled along Sunday Creek within the ALSA ([Figure 9.2-3](#)), as follows:

- one (A1) located within the project area, sampled over 2005/2006 (KNOC 2008);
- one (A2) located upstream of the project area, sampled in 2005 (Devon 2006);
- one (B1) located downstream of the confluence with Monday Creek (KNOC 2008); and
- a group of three sites (B2) located downstream of the project area, in the vicinity of the BP Road crossing, which were sampled in 2002 (Devon 2003) and 2005/2006 (Devon 2006).

Information on sites B1 and B2 is provided in [Section 9.5.2.2](#), Basin B.

The Sunday Creek channel flows in a meandering pattern through a moderately sloped valley. Run habitat dominated pools, created by beaver impoundments, are present and occasional riffle habitat is present at both locations, but was generally limited. Fine substrate is the most common type at both sites and larger substrates (i.e., cobble and boulder) occur at the downstream site. At both sites, banks are stable and well vegetated with grasses, forbs and shrubs. Cover is primarily provided in the form of depth, surface turbulence, and instream vegetation.

Site A1

In the vicinity of Site A1, Sunday Creek meanders and is partially confined within a moderately sloped valley. Habitat is predominately run with moderate depth and occasional riffles. The substrate is typically sands and silts, with small populations of macrophytes (Devon 2006). Banks are stable and vegetated with grasses, forbs and shrubs. Overhead cover is provided by small woody debris piles, overhanging vegetation. Depth, turbulence and macrophytes provide moderate instream cover (Devon 2006).

A juvenile walleye (spring 2005), brook stickleback (summer and fall 2005) and an unidentified sucker fry species (fall 2005) were captured at site A1 (Devon 2006). The walleye captured at the site represents the furthest upstream location of any sportfish species with Sunday Creek. No fish were captured during winter 2006 sampling.

Site A2

At Site A2, Sunday Creek flows in an unconfined irregular meander channel pattern. The creek is characterized by low quality run and high quality pool habitat types. The substrate is entirely comprised of fines. Instream cover is not limited, existing predominately in the form of deep pools (55%) followed by large woody debris (40%), and overhanging vegetation (5%). Banks within this section range from 0.5 to 5.0 m in height and are stable and vegetated (Devon 2006).

Fish sampling was conducted in the spring of 2005 and a single white sucker fry was captured. No other fish were captured or observed (Devon 2006).

Unnamed Tributaries of Sunday Creek

Several unnamed lakes and tributaries to Sunday Creek have been sampled and including:

- Unnamed Lake A3 (Site A3-1);
- Unnamed Watercourse A4 (Site A4-1 (watercourse) and Site A4-2 (lake));
- Unnamed Lake A5 (Site A5-1); and
- Unnamed Watercourse A15 (Sites A15-1 and A15-2).

Unnamed Lake A3

Site A3-1 is located within the project area on a lake that has a short outlet channel, which flows east into Sunday Creek. The lake is a small, oblong waterbody bordered by black spruce (*Picea mariana*), lodgepole pine (*Pinus contorta*), muskeg and grasses (KNOC 2008). It receives input from a fen-type area with no channel development, located on the west side of the lake. The outlet is located at the east end of the lake and has a well defined channel, approximately 2 m wide. The lake is a uniform depth (maximum of 1.5 m) over fine sediment and organic substrates, which support occasional submergent and emergent macrophyte communities. DO levels are low in the winter (0.6 to 1.0 mg/L).

Juvenile northern pike and juvenile sucker species were captured in the fall, while only juvenile northern pike were captured in the summer (KNOC 2008). The lake provides rearing habitat for large-bodied species but the low winter DO levels limit overwintering potential for fish species.

Unnamed Watercourse A4

Unnamed watercourse A4 feeds Sunday Creek, and originates south of the project area. At Site A4-1, the tributary flows in a meandering pattern through a moderately sloped valley. The dominant habitat type consists of shallow run over fine substrates. Occasional cobble substrates occur within the surveyed area with cover provided primarily by overhanging vegetation and woody debris. Depths are shallow, ranging between 0.06 m and 0.16 m.

Brook stickleback were captured throughout the open water season and sucker species fry were captured during the summer (KNOC 2008). The watercourse appears to serve as a migration corridor to Lake A4-2, as well as providing seasonal rearing and feeding habitat for sucker species. The shallow depth and lack of pools suggests that no overwintering habitat is present.

Site A4-2 is located on a lake, which is part of the watercourse A4 system. This lake is slightly larger than the lake on watercourse A3 and is located towards the downstream end of the tributary system. The lake receives input from the main tributary flowing north then east into the lake. The short outlet channel is obstructed by a beaver dam and drains from the lake directly north into Sunday Creek. The lake is oblong with a bowl shaped bed profile and a maximum recorded depth of 3 m. The substrate of fine sediment and organic material supports occasional submergent macrophytes. A ring of floating vegetation (grasses/forbs) is present, several metres out from the shoreline. DO levels were above 5.5 mg/L during all surveys.

Brook stickleback were captured during the spring, summer, and fall surveys, and juvenile longnose sucker were captured in the summer and fall (KNOC 2008). Despite the presence of the beaver dam at the outlet, the capture of juvenile longnose sucker within the lake indicates that migration is possible and that the lake provides rearing habitat for large-bodied forage species and year round habitat for forage fish species.

Unnamed Lake A5

Site A5-1 is located on a lake, near the center of the project area. The lake discharges through watercourse A5 to the southwest into Sunday Creek. The lake is circular, bordered by black spruce, muskeg and grasses, and has a single undefined outlet characterized by fen-type habitat, located on the southwest end of the lake. The lake is of uniform depth, with a recorded maximum of 1.3 m. The substrate consists primarily of fine sediments and organic materials and a large submergent aquatic macrophyte community is present. DO levels were below 5.5 mg/L only in the winter.

No fish were captured within the lake during spring, summer, fall, and winter fish inventories. The presence of an undefined outlet suggests that connectivity to Sunday Creek may be limited. Therefore the lake may only be able to support forage fish species tolerant of low DO levels.

Unnamed Watercourse A15

Unnamed watercourse A15 originates in a series of unnamed ponds located in the middle of the ALSA. The stream flows for approximately 11 km before entering into Sunday Creek about 40 km from its confluence with Christina Lake (Devon 2006).

Site A15-1 is located near the confluence of watercourse A15 and Sunday Creek. The stream flows in an irregular meandering channel pattern and is occasionally confined. The creek is characterized by predominately low quality run and pool habitat types. The average wetted width is 6.0 m while the average channel width was 8.0 m (Devon 2006). Pools are limited and

tend to be of poor quality, with average depths of 0.4 to 0.8 m. The largest pool along the surveyed creek is created by the impoundment of water from beaver activity and is approximately 1.5 m in depth. Substrate is primarily cobbles and gravels while pool substrate consists of fine silt and sand with some cobbles and gravels. Total available cover was not limiting (80%) and is primarily large woody debris (70%), followed by deep pools (15%) and overhanging vegetation (15%). Crown closure is approximately 60% and is made up of a combination of trees and shrubs. During the spring survey fish passage was not impeded (Devon 2006).

No fish were captured or observed at A15-1(Devon 2006).

Site A15-2 is located near the headwaters of watercourse A15. The channel pattern is sinuous in nature and consists of pool and run habitat types. Upstream of the winter access road, a large impoundment has been formed by beaver dam construction creating deep pool habitat (>1.5 m). Downstream of the access road, the habitat consists of low quality run and more shallow pool habitat. The wetted width of the non-impounded channel is 4 m and substrate consists of fines overlaying some cobble. Total available cover is not limiting (60%) and is provided predominately in the form of deep pools (80%), followed by large woody debris (10%), instream vegetation (5%) and overhanging vegetation (5%). Several beaver dams are present along the surveyed area that would impede fish movement under low flow conditions (Devon 2006).

During fish sampling, six brook stickleback were captured and nine brook stickleback were observed at Site A15-2 (Devon 2006).

9.5.2.2 Basin B (Sunday Creek Downstream of the Project Area)

Sunday Creek

Site B1

At Site B1 along the surveyed section of Sunday Creek, the creek exhibits an irregular wandering channel pattern that is occasionally confined. The surveyed area is divided by a bridge crossing that provides access to an EnCana facility.

The average wetted and channel width is 13 m. The habitat along the surveyed area is predominately shallow to moderately deep run habitat with the occasional pool and riffle. The pools that are present within the study area tend to be high quality with maximum depth exceeding 1.0 m. Riffle habitat is limited and confined to a few riffle/boulder garden complexes. Substrate at the site is comprised primarily of silt overlaying gravels and cobbles. The sporadic clusters of overhanging vegetation, large woody debris, boulders and pool habitat provided approximately 10% of the total cover.

One adult Arctic grayling, spoonhead sculpin and lake chub have been documented at the site during previous studies (Van Horne 1998). Traditional ecological knowledge collected by Devon (2003) indicates the occasional presence of Arctic grayling and northern pike within downstream portions of Sunday Creek in the spring.

Site B2

Site B2 is located downstream of the project area at the existing BP Road crossing. The channel pattern is irregular meandering and is occasionally confined (Devon 2003, 2006). Mean wetted width was 8.0 m and mean channel width was 8.5 m in 2002 but wetted widths had increased to 12 m due to beaver activity in 2005. Water depths ranged from 0.2 m to over 1.5 m in some of the high quality pools. Approximately 10% of total cover is available in the form of deep pools, large woody debris, boulder, and overhanging vegetation. Several beaver dams along the surveyed area may present a barrier to fish passage under low flow conditions. Migration barriers and low winter DO values limit the suitability of the creek for most fish species.

No fish were captured during sampling conducted in 2002 but fish inventories conducted in 2005 resulted in the capture of limited numbers of brook stickleback, unidentified sucker species, and white sucker ([Table 9.5-2](#)).

Monday Creek

In May of 2002, two sites were sampled along Sunday Creek (Devon 2003) and are as follows:

- Site B3 is located downstream of the BP Road crossing; and
- Site B4 is located in the vicinity of the BP Road crossing.

Site B3

At Site B3, the surveyed area is dominated by low quality run habitat (Class 3) with an average wetted and channel width of 4.5 m and 6.0 m, respectively. The run habitat ranges in depth from 0.25 to 0.60 m. Pools are infrequent and tend to be of moderate quality with depths exceeding 1.5 m. The largest pool at this site was created from the impoundment of water from a beaver dam. Riffle habitat is limited to one small riffle below a beaver dam. Substrate in the creek is comprised primarily of silt with lesser amounts of gravels and cobbles. Total available cover is not limiting (50%) in the study area and is provided in the form of deep pools, large woody debris, boulders and overhanging vegetation (Devon 2003). Crown closure is approximately 15% and is comprised of trees, shrubs and overhanging vegetation. Mean bank heights are 1.0 m with all of the banks rated as stable. The site had a number of beaver dams that would present at least partial barriers to fish movement under low flow conditions (Devon 2003).

Site B4

Fish habitat at Site B4 consists entirely of impoundment habitat that have been formed by beaver dams (average depth of 1.5 m). The average wetted and channel width is 14 m and 16 m, respectively (Devon 2003). Substrate in the impoundments is comprised of fines overlaying pebbles/cobbles. Instream cover is not limiting (65%) with deep pools, large woody debris and overhanging vegetation providing the cover. Small patches of aquatic macrophytes (*Myriophyllum* spp. and *Potamogeton* spp.) occurred at Site B4 in the fall. Crown closure is 50% and is provided in the form of trees, shrubs and overhanging vegetation. There are several beaver dams along the creek that would impede fish movement under most flow conditions (Devon 2003).

Dissolved oxygen levels during March ranged from 1.3 to 1.8 mg/L (Devon 2003). The low DO levels suggest limited overwintering habitat is available at Site B4.

During fish sampling in the May 2002, two brook stickleback were captured; no other species were captured or observed (Devon 2003).

9.5.2.3 Basin C (East Unnamed Creek)

The East Unnamed Creek originates from a small waterbody within the project area and flows north for approximately 5 to 6 km before discharging into Christina Lake. The creek receives input from one small tributary at its midpoint. The headwaters of the watercourse within the project area appear to be of an ephemeral nature with discontinuous channel development. The watercourse was seasonally sampled in 2005 and 2006 at two locations. The downstream site (C1) is located approximately 300 m upstream from the confluence with Christina Lake while the upstream site (C2) is located at the BP Road crossing.

Site C1

At Site C1, the watercourse is characterized by shallow run habitat over fine substrates (KNOC 2008). The channel at the downstream site is incised between steep banks. Riparian vegetation of alder and grasses, and large woody debris provide the majority of the available cover. No pool habitat, and consequently no overwintering habitat, is present at the downstream site.

No fish were captured during any season at the downstream site during 2005 fish inventory sampling (KNOC 2008). Site C1 provided seasonal rearing and feeding opportunities for sportfish species but only provided low quality habitat for spawning sportfish species.

Site C2

At Site C2, the watercourse is characterized by shallow run habitat over fine substrates (KNOC 2008). Riparian vegetation of alder and grasses, and large woody debris provide a large amount of overstream cover. Several beaver impoundments present at the upstream site created deeper pool habitat but fragment the watercourse.

Fish inventory sampling during 2005 documented the presence of brook stickleback in the spring and fall but no fish were captured in the summer and winter (KNOC 2008).

Migration along the upstream portion of the watercourse is limited due to the presence of several beaver dams. At Site C2, habitat is generally limited to shallow run sections and beaver impoundments. DO levels were below guidelines in both the summer and winter; no fish were captured (Hokanson 1977, CCME 2007). Habitat at the site is only suitable for forage fish species, which are tolerant of low DO levels (i.e., brook stickleback).

9.5.2.4 Basin D (West Unnamed Creek)

West Unnamed Creek is approximately 3 to 4 km in length and flows north through the project area before discharging into Christina Lake. The watercourse was seasonally sampled in 2005 and 2006 at two locations (KNOC 2008). The downstream site (D1) is located approximately 300 m upstream from the confluence with Christina Lake while the upstream site (D2) is located at the BP Road crossing.

Site D1

Site D1 is characterized by shallow run habitat with occasional riffles over fine substrates. The channel is shallow and defined within a large floodplain characterized by grasses, forbs and shrubs. The floodplain is bordered by a coniferous forest that provides a dense overhead canopy. The channel is defined and steep.

In 2005, seasonal fish inventory sampling was conducted and only one unknown fish was observed during the spring sampling (KNOC 2008).

Site D1 provides seasonal rearing and feeding opportunities for sportfish species but only provides low quality habitat for spawning sportfish species. Overwintering opportunities are low, as the site lacks adequate depth.

Site D2

Site D2 is characterized by shallow run habitat with occasional riffles over fine substrates. The channel is defined and steep and the riparian area consists of a wide floodplain of muskeg.

Seasonal fish inventory sampling was conducted in 2005, but no fish were captured (KNOC 2008).

Migration along the upstream portion of the watercourse (i.e., Site D2) is limited due to the presence of several beaver dams and a perched culvert along the BP Road. Habitat at the site is only suitable for forage fish species and overwintering opportunities are low, due to a lack of adequate depth.

9.5.2.5 Basins E and F (Birch Creek)

Birch Creek originates from Glover Lake and flows northeast for approximately 40 km before discharging into Christina Lake. Only a small portion of the downstream end of the Birch Creek basin is located in the ALSA. Basins E and F include approximately 5 km of Birch Creek upstream of the confluence with Christina Lake and three unnamed tributaries that drain the east side of the basin (Figure 9.2-3). Historical fisheries information for Birch Creek is limited to two locations upstream of the ALSA where both northern pike and slimy sculpin were captured (SRD 2009a). No fish habitat information is available for Birch Creek within the ALSA.

9.5.3 Special Status Species

Under the Alberta *Wildlife Act*, the Alberta's Endangered Species Conservation Committee has designated Arctic grayling as a 'Species of Special Concern' (SRD 2007). All other species documented within the ARSA are provincially classified as "Secure" (SRD 2007). Arctic grayling are not listed federally (COSEWIC 2008). However, Arctic grayling has been ranked as a high priority candidate to receive a federal assessment (COSEWIC 2009).

Provincially, spoonhead sculpin is considered as 'may be at risk' by SRD (2005), yet they are not listed according to the Alberta *Wildlife Act*. SRD status rankings define species within the 'may be at risk' category as those that 'may be at risk' of extinction or extirpation, and are therefore candidates for detailed risk assessment. Federally, COSEWIC (2008) lists spoonhead sculpin as 'not at risk'.

9.5.4 Benthic Invertebrate Communities

In the fall of 2005, benthic invertebrate sampling was conducted in two lakes (A5-1 and A3-1), Unnamed West Creek (D1) and Sunday Creek (B2) (Figure 9.2-3). Samples at both lakes were collected in soft sediment in the littoral zone, while at the watercourse samples were collected at the dominant habitat type (KNOC 2008).

Benthic communities at both lakes were similar with mean total abundances of 11 500 organisms/m² at Site A5-1 and 13 200 organisms/m² at Site A3-1. The total number of taxa collected at A5-1 was 40, while the total number of taxa collected at A3-1 was 21 (KNOC 2008). Midge larvae (Chironomidae) made up the largest group of the benthic community at A5-1. At A3-1, the largest proportion of the benthic community was comprised of crustaceans. Other common groups found were Mollusca, Ceratopogonidae, Caenidae and Hydracarina. Dominant midge groups in both lakes included Chironomini, Tanytarsini and Tanypodinae (KNOC 2008).

The benthic invertebrate community at Site D1 had a similar total abundance as both lakes with 11 300 organisms/m². The total abundance at Site B2 was quite low with only 400 organisms/m². The total number of taxa at sites D1 and B2 were 34 and 31, respectively (KNOC 2008).

The community composition at Site D1 was largely comprised of midge larvae, crustaceans, molluscs and oligochaetes. Other common benthic invertebrates included biting midge larvae, crane fly larvae, leeches and nematodes. Composition in Sunday Creek (Site B2) consisted of largely of midge larva, seed shrimp, nematodes, aquatic worms, water mites and copepods (KNOC 2008).

9.6 Potential Impacts and Mitigative Measures

The project has the potential to impact fish and other aquatic resources in the ALSA and ARSA through changes in:

- sediment loading;
- streamflow;
- acid deposition in lakes;
- fishing pressure due to increased access and workforce; and
- the abundance, habitat, or health of special status species.

Each potential impact, its potential to be mitigated and the importance of any residual effect on indicator resources, are assessed in the following sections.

Releases of industrial effluents, wastewater, and heavy metals will not occur or will be mitigated during construction, operation, or reclamation of the project ([Volume 2, Section 8.0](#)). As such, chronic and acute health effects in fish, as well as tainting of fish flesh will not occur. For similar reasons, toxicity of sediments will not change as a result of the project. Potential impacts to fish health due to increased contaminant loads and potential impacts to fish and benthic invertebrates from increased sediment toxicity are, therefore, not assessed further in this section of the EIA. Also, no change in stream or lake areas will occur due to the project and impacts from such changes are not addressed in this section of the EIA.

9.6.1 Changes in Sediment Loading

Aquatic resources can be impacted both directly and indirectly by increased sediment loads. Direct effects to fish include physiological responses such as increased cough reflex, gill trauma, and stress in juveniles and adults, and population responses from decreased quality and availability of spawning habitat and increased egg mortality (Anderson *et al.* 1996). Species that spawn in gravel riffle habitats, such as white sucker, longnose sucker, and Arctic grayling, are particularly sensitive to sedimentation. Sediments can fill in the interstitial spaces in spawning habitat and cover eggs, thus depriving eggs of sufficient gas exchange during incubation. Indirectly, increased sediment loads can decrease habitat quality, alter predation and behavioural responses, and decrease the standing stock of benthic invertebrates upon which fish depend for food.

9.6.1.1 Construction and Operation of Surface Facilities

A setback limit of 100 m from any stream or lake was chosen for the Expansion Project, including new well pads, though one well pad will be located within the 100 m setback. Construction of these facilities will not increase sediment loads in any streams within the ALSA as appropriate buffers will be in place between the facilities and adjacent watercourses, and best management practices will be incorporated to eliminate sediments from entering streams during construction and operation.

Best management practices for controlling surface erosion will be used during construction, and will be tailored specifically to the topography, drainage, and soil characteristics at each site. These management practices will include:

- installation of silt fences;
- construction of perimeter berms and/or collection ditches around all new facilities; and
- storage of muskeg and overburden in areas drained by collection ditches.

With the effective implementation of the described mitigation measures, the potential impacts of the project on aquatic resources caused by the construction and operation of the surface facilities are predicted to be:

- neutral in direction;
- local in scale;
- low in magnitude;
- short-term in duration;
- reversible; and
- with good confidence.

9.6.1.2 Construction of Stream Crossings

Streams could potentially be impacted during the construction and operation of access roads and pipelines connected to the well pads. Stream crossings must be appropriately designed to minimize downstream sedimentation during construction and throughout the life of the project. Pipelines carrying steam feed and bitumen emulsion return will parallel the access roads and will be carried above ground in racks. The potential for above ground pipelines to increase sediment loading in streams will be very low as racks will cross streams in a single span without instream construction. For this reason, the above ground pipeline crossings are not considered further.

The project will require three new road crossings: one over Sunday Creek and two over unnamed tributaries. All crossed watercourses are designated as Class C streams by AENV (2007). The restricted activity period (RAP) for the construction of the crossings is from 16 April to 15 July (AENV 2006).

Culverts will be used for the road crossings over the unnamed creek. A clear span bridge or an open bottom culvert will be used for the Sunday Creek crossing. All crossings will be designed in accordance with the *Code of Practice for Watercourse Crossings* (AENV 2007). During the installation of the road crossing structures, best management practices specified by Alberta Transportation (2009), the *Code of Practice for Watercourse Crossings* (AENV 2007), and the federal *Fisheries Act* will be followed. Best management practices will include:

- construction of the road crossings outside of the RAP;
- use of isolation techniques during instream work (AENV 2007);
- all single-span bridges can be installed at any time without isolation of the watercourse;
- design and construct bridges large enough so that bridge abutments are above active channel and no instream construction is required;
- design bridges with low side barriers to minimize gravel entering stream during road maintenance;
- installation of culverts of appropriate diameter and length to ensure fish passage, minimize hydraulic constriction during high flows and to ensure that road grading does not result in deposition of road gravel into the channel;
- installation and maintenance of appropriate erosion control measures such as silt fences around riparian disturbance areas, and ROWs until disturbed natural vegetation (e.g., muskeg) is returned or becomes re-established by seeding;
- habitat compensation if or as required by Fisheries and Oceans Canada (DFO) through the *Fisheries Act* authorization process associated with the crossings; and
- implementation of post-construction monitoring programs.

With the effective implementation of the described mitigation measures, the potential impacts of the project on aquatic resources caused by the construction and operation of the stream crossings are predicted to be:

- neutral in direction;
- local in scale;
- low in magnitude;
- short-term in duration;
- reversible; and
- with good confidence.

9.6.2 Changes in Stream Flow

9.6.2.1 Construction of Surface Facilities

Clearing and development of land within a given watershed reduces the permeable area within the watershed, thus, decreasing the amount of water infiltrating into the ground and increasing the amount of run off entering streams. This results in increased peak run off, which can affect

stream biota by changing channel morphology, simplifying habitat, and increasing erosion and downstream sedimentation (OMNR 1994; Allan 1995). Increased peak flows generally result in a reduction of fish and benthic invertebrate diversity and standing stocks (Allan 1995).

Construction of the temporary construction laydown area and well pads, as well as the ROWs for pipelines, roads, and transmission lines, will involve clearing of muskeg and overburden, and back-filling and compacting of aggregate material to create more solid foundations on which to build. Well pads will be bermed to manage stormwater runoff. Following the stormwater mitigation, the hydrological analysis predicted increases in mean annual discharge, and 1:10 and 1:100 year flood event flows in East Unnamed Creek, West Unnamed Creek, Sunday Creek and direct discharge to Christina Lake (Volume 2, Section 7.0, Hydrology).

The hydrologic effects of the project on East Unnamed Creek include a 6.9% increase in mean annual flows from 0.040 m³/s to 0.046 m³/s, which is an approximate increase of 6 L/s. The 1:10 and 1:100 year flood event daily discharges are predicted to increase 7.5% and 5.1%, respectively. The mid portion of the creek, downstream of the project, flows into a wetland area where there is no defined channel. Although increased bed erosion may occur locally upstream of the BP Road crossing due to increased flows, the additional flow is expected to be dispersed among the wetland and backflooded areas downstream at the numerous beaver dams, and sediments generated from the local erosion will be captured in either the beaver dam impoundments or in the wetland area downstream. The effects of increased flows on channel geomorphology are not expected to extend as far downstream as the mouth of the creek at Christina Lake.

The hydrological analysis of East Unnamed Creek is based on the effects of increased flows on free-flowing unobstructed channel reaches. East Unnamed Creek has numerous obstructions (beaver dams) and wetland dominated sections. As a result, the creek is not considered to be free-flowing. These characteristics stabilize hydrological impacts within watercourses so that bed scouring and bank erosion are decreased (Collen and Gibson 2001). Beaver dams have the potential to retain a substantial amount of sediment (Naimen *et al.* 1988). Despite not being permanent barriers within the watercourse, beaver activity was documented throughout the East Unnamed Creek watershed and is a dominant component of the existing watercourse characteristics.

Brook stickleback were documented within the areas potentially impacted by the increased flows (i.e., upstream portions of the watercourse). This species is tolerant of low dissolved oxygen levels and is commonly found in headwater streams (Nelson and Paetz 1992; Joynt and Sullivan 2003; Stewart and Watkinson 2004). Brook stickleback are regularly associated with beaver impoundments and areas with substrates composed of fine sediments and are well adapted to increased sediment levels and increased flow events (i.e., due to beaver dam breaches). This species does not rely on clean coarse substrates for critical activities (i.e., spawning, foraging, etc.) and therefore would not be substantially impacted by increased flows or sedimentation in the upstream portions of the watercourse.

Negligible impacts to fish within East Unnamed Creek are predicted based on: 1) the natural characteristics of the watercourse (i.e., wetland and backflooded areas); 2) the local beaver activity; and 3) the fish species documented and likely to use the creek. The effects of a beaver dam breach on peak and mean annual flows, erosion and sediment transport to downstream reaches would be much greater than the anticipated effects of the project.

West Unnamed Creek is predicted to be subject to moderate flow increases including an 8.7% increase in mean annual flow, a 7.6% increase in 1:10 year flood event daily discharge, and a 5.9% increase in 1:100 year flood event daily discharge (Volume 2, Section 7.0, Hydrology). The baseline flow through the creek is the lowest of any watercourse documented in the ALSA. The increases in flow, while moderate in percentage, are still low (i.e., mean annual flow change of 0.001 m³/s). Hydrology (Volume 2, Section 7.0) describes the channel as being in a large gully and able to convey higher flow rates. Additionally, beaver dams were observed along the mid-portion of the creek, downstream of the project area. As with the East Unnamed Creek, the presence of beaver dams along the creek serve to mitigate the effects of any localized erosion and sediment transport. The effects of increased flows on channel geomorphology are not expected to extend as far downstream as the mouth of the creek at Christina Lake.

No fish species have been recorded within the areas potentially impacted by the increased flows (i.e., upstream portions of the watercourse). Only one unidentified fish was observed within West Unnamed Creek at a downstream site, near the Christina Lake confluence. Migration along the upstream portion of the watercourse is limited due to the presence of several beaver dams and a perched culvert along the BP Road. Habitat is only suitable for forage fish species and overwintering opportunities are low, due to a lack of adequate depth. Along the downstream sections of the creek, seasonal rearing and feeding opportunities for sportfish species are present but only low quality sportfish spawning habitat is available. Therefore, it is likely only forage fish species such as brook stickleback, would be present within the areas potentially impacted by the increased flows (i.e., upstream portions of the watercourse). As described above with respect to East Unnamed Creek, this species is tolerant of low dissolved oxygen levels, commonly found in headwater streams, regularly associated with beaver impoundments and areas with substrates composed of fine sediments, and well adapted to increased sediment levels and increased flow events (i.e., due to beaver dam breaches). This species does not rely on clean coarse substrates for critical activities (i.e., spawning, foraging, etc.) and therefore would not be impacted by increased flows or sedimentation in the upstream portions of the watercourse.

Negligible impacts to fish within West Unnamed Creek are predicted based on: 1) the natural characteristics of the watercourse (i.e., steep gully capable of containing flow); 2) the local beaver activity; and 3) the fish species likely to use the creek. As with East Unnamed Creek, the effects of a beaver dam breach on peak and mean annual flows, erosion and sediment transport to downstream reaches would be much greater than the anticipated effects of the project.

The hydrologic effects of the project on Sunday Creek just downstream of the project are predicted to be low, with increases in flow ranging from 0.47% to 0.65% (Volume 2, Section 7.0, Hydrology). These predicted effects are further attenuated downstream at the Sunday Creek

confluence with Christina Lake (increased flow range of 0.24 to 0.33%). Therefore, no changes to channel geomorphology are predicted ([Volume 2, Section 7.0](#), Hydrology). Based on the low increases in flow and no predicted changes to channel morphology, impacts to fisheries resources within Sunday Creek are predicted to be negligible.

Overall, with the effective implementation of the described mitigation measures, the potential impacts of the project on aquatic resources caused by the changes in stream flow are predicted to be:

- negative in direction;
- local in scale;
- low in magnitude;
- long-term in duration;
- reversible; and
- with good confidence.

9.6.2.2 Groundwater Withdrawals

Source water for the project will be withdrawn from the Clearwater Formation and recycled. Potable water will be trucked on-site. No hydraulic connection has been identified between the surface water system and the Clearwater Formation and the impact of water withdrawal on surface water is predicted to be negligible.

9.6.3 Changes in Fishing Pressure Due to Increased Access and Workforce

9.6.3.1 Increased Access

Primary access to the site will be via the BP Road and the main access will not provide access to new watercourses. Access to the project area will be controlled and watercourses in the vicinity will not be open to the public.

The project impact associated with increased access on fish populations is predicted to be:

- negative in direction;
- regional in scale;
- low in magnitude;
- mid-term in duration;
- reversible; and
- with moderate confidence.

9.6.3.2 Workforce

Although the number of new anglers in the project area during construction will be low, and even lower during operations, the potential still exists for these anglers to have an impact on the fish populations within Sunday Creek. Provincial regulations specific to the Northern Boreal Zone, limit daily harvest of key fish species (SRD 2009a). While the number of sportfish species harvested from Sunday Creek may increase due to development of the project, the increase will be low due to the low density and low diversity of fish species within the mid-stream portions of Sunday Creek.

The project impact associated with increased workforce on fish populations is predicted to be:

- negative in direction;
- regional in scale;
- low in magnitude;
- mid-term in duration;
- reversible; and
- with moderate confidence.

9.6.4 Changes in Abundance, Habitat or Health of Special Status Species

Special status species in the area include Arctic grayling and spoonhead sculpin. Project activities will be limited to East Unnamed Creek, West Unnamed Creek and Sunday Creek. Neither spoonhead sculpin nor Arctic grayling have been documented within East Unnamed Creek or West Unnamed Creek.

Both Arctic grayling and spoonhead sculpin have been documented in Sunday Creek, primarily in the downstream areas. The changes in flow within Sunday Creek are predicted to be low (i.e., less than 1%) and channel morphology will not change. The change in fishing pressure will be low and regulated by the provincial government. The watercourse crossing over Sunday Creek would be either a clear span bridge or an open bottom culvert. Therefore, Arctic grayling, spoonhead sculpin or any other fish species within Sunday Creek would not be affected.

The project impact on special status fish populations is predicted to be:

- neutral in direction;
- local in scale;
- low in magnitude;
- mid-term in duration;
- reversible; and
- with moderate confidence.

9.6.5 Mitigation and Monitoring

9.6.5.1 Mitigation

The following mitigation measures will be implemented to minimize potential impacts to aquatic resources:

- siting temporary construction laydown area, well pads and associated infrastructure 100 m from streams and lakes;
- construction of the road crossings outside of the RAP;
- use of isolation techniques during installation of watercourse crossings (AENV 2007);
- all single-span bridges can be installed at any time without isolation of the watercourse;
- design and construct bridges large enough so that bridge abutments are above active channel and no instream construction is required;
- design bridges with low side barriers to minimize gravel entering stream during road maintenance;
- installation of culverts of appropriate diameter and length;
- installation and maintenance of appropriate erosion control measures such as silt fences around riparian disturbance areas, and ROWs until disturbed natural vegetation (e.g., muskeg) is returned or becomes re-established by seeding;
- use of best practices for erosion control during construction of the facilities and road stream crossings;
- storage and replacement of muskeg to riparian areas after completion of stream crossings or re-seeding with natural vegetation;
- maintenance of erosion control measures around the facilities for the life of the project; and
- restricting access to the project area.

9.6.5.2 Monitoring

To ensure that impacts of the project on aquatic resources are avoided or mitigated, KNOC will use qualified environmental inspectors during the construction phase and implement a post-construction monitoring program. This program will include inspection and maintenance of erosion control measures around the temporary construction laydown area, well pads and stream crossings.

9.7 Cumulative Effects

All predicted impacts were rated as low in magnitude and therefore cumulative effects of the project on aquatic resources within the ARSA were not assessed.

9.8 Summary

The impacts of the project on fish, fish habitat and water quality are predicted to be low (Table 9.8-1). Mitigation measures will be implemented and a monitoring program established.

Table 9.8-1: Summary of Application Case Assessment

Indicator	Direction	Geographic Extent	Magnitude	Duration	Reversible	Confidence	Final Impact Rating
Change in sediment loading in streams	Neutral	Local	Low	Short-Term	Yes	High	Low
Change in stream flow	Negative	Local	Low	Long-Term	Yes	High	Low
Change in fishing pressure	Negative	Regional	Low	Mid-Term	Yes	Moderate	Low
Change in abundance, habitat or health of special status species	Neutral	Local	Low	Mid-Term	Yes	Moderate	Low

9.9 Literature Cited

- Alberta Environment (AENV). 2007. *Code of Practice for Watercourse Crossings*. Alberta Environment, Edmonton, Alberta.
- Alberta Environment (AENV). 2006. *Code of Practice for Watercourse Crossings – Lac La Biche Management Area Map*. Alberta Environment. Edmonton, Alberta.
- Alberta Sustainable Resource Development (SRD). 2009a. *Alberta Guide to Sportfishing Regulations 2009*. Sports Scene Publications Inc. Edmonton, Alberta.
- Alberta Sustainable Resource Development (SRD). 2009b. FWMIS Internet Mapping tool. Website: http://xnet.env.gov.ab.ca/imf/imf.jsp?site=fw_mis_pub. Accessed 4 May 2009.
- Alberta Sustainable Resource Development (SRD). 2007. *Species Currently Listed under the Wildlife Act Website*: <http://www.srd.alberta.ca/fishwildlife/escc/currentlylisted.aspx>. Accessed 4 May 2009.
- Alberta Sustainable Resource Development (SRD). 2005. *The General Status of Alberta Wild Species 2005*. Available at: <http://www.srd.gov.ab.ca/fw/wildspecies/search.htm>.
- Alberta Transportation (AT). 2009. *Fish Habitat Manual – Guidelines and Procedures for Watercourse Crossings in Alberta*. Alberta Transportation. Edmonton, Alberta.
- Allan, J.D. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman and Hall. London, UK.
- Anderson, P.G., B.R. Taylor and G.C. Balch. 1996. Quantifying the Effects of Sediment Release on Fish and Their Habitats. *Canadian Manuscript Report of Fisheries and Aquatic Sciences*. No. 2346. Vancouver, BC.

- Brown, R.S. and S. Stanislawski. 1996. *Stream Inventory of Alberta's Northeast Boreal Forest*. Data provided by: Fish Management Information System (FMIS). Alberta Sustainable Resource Development. Edmonton, Alberta.
- Brown, R.S. and S. Stanislawski. 1995. *Stream Inventory of the Alberta Pacific, Forest Management Area*. Data provided by: Fish Management Information System (FMIS). Alberta Sustainable Resource Development. Edmonton, Alberta.
- Canadian Council of Ministers for the Environment (CCME). 2007. *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. Winnipeg, Manitoba.
- Collen, P. and R.J. Gibson. 2001. The General Ecology of Beavers (*Castor* spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish – a review. *Fish Biology and Fisheries*. 10: 439-461.
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2009. *The Prioritized Candidate Species List April 1, 2009*. http://www.cosewic.gc.ca/eng/sct3/sct3_1_e.cfm. Accessed 21 April 2009.
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2008. *Canadian Species at Risk*. Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca/eng/sct0/rpt/dsp_booklet_e.htm.
- Cumulative Environmental Management Association (CEMA). 2001. *Sustainable Ecosystem Working Group, Terms of Reference and Workplan*. Fort McMurray, Alberta.
- Devon ARL Corporation (Devon). 2006. *Application for Approval of the Devon Jackfish 2 Project*. Prepared by AMEC Earth and Environmental for Devon. Calgary, Alberta
- Devon Canada Corporation (Devon). 2003. *Application for the Approval of the Devon Jackfish Project Including Supplementary Information Request*. Prepared by AMEC Earth and Environmental For Devon. Calgary, Alberta.
- Fausch, K.D., J. Lyons, J.R. Karr and P.L. Angermeier. 1990. Fish Communities as Indicators of Environmental Degradation. *American Fisheries Society Symposium*. 8:123–144.
- Hokanson, K.E.F. 1977. Temperature Requirements of Some Percids and Adaptations to the Seasonal Temperature Cycle. *Journal of Fisheries Resources Board Canada*. 34:1524-1550.
- Joynt, A. and M.G. Sullivan. 2003. *Fish of Alberta*. Lone Pine Publishing, Edmonton, Alberta.
- Korea National Oil Corporation (KNOC). 2008. *Application for Approval of the BlackGold Project*, Vol. 2, Appendix G – Surface Water and Aquatics Field Data Report. Prepared by Matrix Solutions Inc. for Newmont. Calgary, Alberta.
- MEG Energy Corporation (MEG). 2005. *Application for Approval of the Christina Lake Regional Project*. Volume 4: Aquatic Resources and Terrestrial Resources. Prepared by Golder Associates. Calgary, Alberta.

- Mitchell, P. and E. Prepas. 1990. *Atlas of Alberta Lakes*. University of Alberta Press. Edmonton, Alberta.
- Naiman, R.J., C.A. Johnston and J.C. Kelly. 1988. Alterations of North American Streams by Beaver: The Structure and Dynamics of Streams are Changing as Beaver Recolonize their Historic Habitat. *BioScience*. 38: 753-762.
- Nelson, J.S. and M.J. Paetz. 1992. *The Fishes of Alberta*. University of Alberta Press. Edmonton, Alberta.
- Ontario Ministry of Natural Resources (OMNR). 1994. *Natural Channel Systems: An Approach to Management and Design*. Queen's Printer for Ontario. Toronto, Ontario.
- Park, D. 2007. *Sport Fishing in Alberta: Summary Report from the Seventh Survey of Recreational Fishing in Canada*. Alberta Sustainable Resource Development, Fisheries Management Branch. Edmonton, Alberta.
- Scott, W.B. and E.J. Crossman. 1973. *Freshwater Fishes of Canada*. Bulletin 184, Fisheries Research Board of Canada. Ottawa, Ontario.
- Shuter, B.J. 1990. Population-Level Indicators of Stress. *American Fisheries Society Symposium*. 8:145-166.
- Stewart, K.W. and D.A. Watkinson. 2004. *The Freshwater Fishes of Manitoba*. University of Manitoba Press. Winnipeg, Manitoba.
- Van Horne. 1998. *Application for Approval of the Christina Lake Thermal Project*. Volume 3 – Supplemental Information. Prepared by Golder Associates Ltd. for Van Horne, a business unit of PanCanadian Resources. Calgary, Alberta.