DEVELOPMENT OF AQUATIC COMMUNITIES IN HIGH-ALTITUDE MINE PIT LAKE SYSTEMS OF WEST-CENTRAL ALBERTA

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ABSTRACT

Reclamation on the Cardinal River and Gregg River coal mines includes the construction of mine pit lakes connected to stream environments. Key physical, chemical and biological parameters of these "truck and shovel" lakes and their streams were investigated, and hypotheses regarding ecosystems and populations were tested. Findings include:

- Sphinx Lake and Pit Lake CD exhibit meromictic (partial-mixing) tendencies, but still function in a similar fashion to shallower, natural sub-alpine lakes.
- Elevated selenium concentrations as high as 16 ug/g (dry weight) were recorded in Rainbow trout (*Oncorhynchus mykiss*) eggs taken from gravid Sphinx Lake and Pit Lake CD fish. Potential detrimental effects associated with the bioaccumulation of selenium on fish reproduction were not observed.
- Stream water temperatures downstream of Sphinx Lake and Pit Lake CD were significantly warmer than in inlet streams and streams without pit lakes.
- Streambed concretions caused by calcite precipitation were documented and found to affect portions of the upper Gregg River basin. Remediation of this concretion is important for sustainability of trout populations.
- Aquatic communities including fish, invertebrates, zooplankton and aquatic plants are present in these pit lake systems. Athabasca Rainbow trout populations are self-propagating (spawning at the outlets) with higher densities downstream than there were prior to lake reclamation.

The development of sub-alpine mine-pit lakes connected to the stream environment appears to be an appropriate and beneficial reclamation technique in this area.

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LIST OF ABBREVIATIONS

ACA	Alberta Conservation Association
ASRD	Alberta Sustainable Resources and Development
B	Stream section on Berrys Creek
BLTR	Bull trout (*Salvelinus confluentus)*
CA	Cascade stream habitat
CCME	Canadian Council of Ministers of the Environment
CMS	Cubic metres per second
CRO	Cardinal River Operations
CTTR	Cutthroat trout (*Oncorhynchus clarki*)
D/S	Downstream
EC10	Effective concentration inducing a response in 10% of a population
EPEA	Environmental Protection and Enhancement Act (Alberta)
EPLWG	End Pit Lake Working Group
EVC	Elk Valley Coal (now operating as Teck Coal)
Exp	Exposed
F	Stream section on Falls Creek
F1, F2, F3	Flats – Class 1, Class 2 or Class 3 (stream habitats)
G1, G2, G3, G4, G5	Stream sections on the Gregg River
G2a	Stream section sub-site on the Gregg River
GPS	Global positioning system
Gr	Grass and herbaceous plants
ICP-MS	Inductively coupled plasma mass spectrometry
m/s	Meters per second
NAD83	North American Datum 1983
P1, P2, P3	Pools – Class 1, Class 2 or Class 3 (stream habitats)
PIT	Passive Integrated Transponder
RF	Riffle
R1, R2, R3	Runs - Class 1, Class 2 or Class 3 (stream habitats)
RNTR	Rainbow trout (*Oncorhynchus mykiss)*
S1, S2	Stream sections on Sphinx Creek
SD	Standard deviation
SE	Standard error of the mean
SEM	Scanning electron microscope
Sh	Shrubs and bushes
TDS	Total dissolved solids
Tr	Trees (coniferous and deciduous)
US	United States
USGS	United States Geological Survey
U/S	Upstream
UTM	Universal transverse mercator
WSC	Water Survey of Canada
YOY	Young-of-the-year

CHAPTER 1: Introduction

1.1 Problem Statement

Coal mining has altered natural landscapes in Alberta, and will continue to do so. More than one-third of Canada's coal resources that are favourable for extraction occur in the southern Canadian Rocky Mountains, with major deposits of metallurgical coal occurring in the Front Ranges and Inner Foothill regions of Alberta (Bustin 1993). Metallurgical coal is a necessary ingredient in the production of steel and is an important national and international commodity. Changing national and world prices have resulted in increasing general demand for coal. For example, coal for coke plants was valued at about $45 U.S. per short ton in 2000, and rose to more than $140 U.S. per short ton by 2009 (U.S. Energy Information Administration 2010). World coal consumption is expected to increase by 56% from 2007 to 2035.

The extraction of metallurgical coal in alpine and sub-alpine environments is challenging because of the complexity of geology, topography and fragile nature of alpine and sub-alpine ecosystems. The removal of vegetation, rock and soil during the process of exposing the coal, together with the extraction, transport and processing of the coal itself; result in severely altered ecosystems. As with most extractive processes, the coal mining industry must reclaim these areas and return them back to an equivalent land capability, (EPEA 2008), focusing primarily on protection of watersheds and wildlife habitat.

The development and transformation of end pits into pit lakes has been a controversial reclamation technique (Gammons et al. 2009). This issue is especially controversial in mountainous areas of west-central Alberta, where coal mining occurs near the Jasper National Park boundary (Rasmussen et al. 2007). Numerous end-pit lakes have been introduced into the natural environment on both the Gregg River and Cardinal River Mine Lease sites, with the creation of more end-pit lakes within the Cheviot Mine Lease also a possibility. Pit lakes independent of stream environments are most common in this area (Stemo 2005, Boorman 2006), with pit lakes with connectivity to stream environments being quite rare. Pit lakes on the Gregg River and Cardinal River Mine Leases are often referred to as “truck and shovel” lakes. These truck and shovel lakes are significantly different than nearby “dragline” lakes (Luscar 1994). The “truck and shovel” lakes are remnants of the original coal pit. Footwalls and headwalls are often left intact, leaving very steep sides. Shallow areas (littoral zone) are constructed by filling in areas of the original pit with rock and fill. Slopes and littoral areas are contoured and covered with soil, with the slopes being vegetated with grasses, forbs and tree seedlings. These truck and shovel lakes are found in sub-alpine environments, are significantly deeper, and have different geological influences than dragline lakes (Luscar 1994). Some of these pit lakes are constructed with an inlet and outlet channel because of their location within a drainage basin. Pit lake systems (pit lakes connected to stream environments) are the focus of this study. These systems have the potential to influence stream communities downstream through various physical, chemical and biological changes, and can further affect the riparian environment downstream.

The recent status report on the Athabasca Rainbow trout (*Oncorhynchus mykiss*) has stated that “open-pit coal mining is the greatest threat to the loss of headwater stream habitat important to Rainbow trout" (ASRD and ACA 2009a). Compounding the pit lake controversy is the commonly held opinion that mine-pit lakes in the study area affect fish populations only in negative ways, with the mechanisms of the effects occurring via the ecotoxicology of pollutants (Rasmussen et al. 2007). Selenium concentrations in the tissue of fish from the upper McLeod River watershed, downstream of mining activities, are generally elevated (Casey and Siwik 2000, Casey 2005, Mackay 2005, Holm et al. 2005, Cesh et al. 2007, Rasmussen et al. 2007, Miller et al. 2009). The bioaccumulation of selenium in fish tissues has been linked to developmental deformities in local trout populations (Holm et al. 2005) and is thought to be a reason for low recruitment of fishes in these systems (Palace et al. 2004). The bioaccumulation of selenium in aquatic invertebrates and the possible effects on aquatic birds has also been reported (Wayland and Crosley 2006). This information has supported the opinion that pit lake systems in the area provide poor or unsuitable habitats for certain fish species.

Some literature has suggested however, that pit lakes in the western energy region may have the "potential for development of recreational lakes as part of reclamation practices" (Canton 1982) and may provide beneficial habitat for fish and other wildlife (Gammons et al. 2009). Fisheries monitoring on two pit lake systems on the Cardinal River Mine Lease has shown that fish numbers and fish biomass occupying the pit lake and stream immediately downstream was greater after reclamation than prior to mining (Schwartz 2002, Pisces 2008a).

Significant factors in the ecology of fish and quality of fish habitat may be overlooked when determining the utility of mine pit lakes connected to stream environments. Factors of special importance include stream substrate (gravel condition), habitat availability, flows, barriers and water temperature (Fraley and Shepard 1989, Nelson and Paetz 1992, Crisp 1993, Giller and Malmqvist 1998, Platts and Nelson 1998, Scott and Crossman 1998, ASRD and ACA 2009a, ASRD and ACA 2009b). Detailed field study and experimentation may help to determine whether alpine mine-pit lake systems have reduced headwater habitat, or if they may actually be used to enhance headwater habitats. Hypotheses to be tested must be based on a broad understanding of the physical, chemical and biotic environment of the potential habitat.

1.2 Physical Environment

The physical stream environment may be severely altered during and following mining. Reclamation procedures are designed to replace natural stream environments with modified stream environments that function similarly. Introducing a lentic (open waters including lakes and ponds) environment into a naturally lotic (flowing waters such as rivers and streams) ecosystem will change this balance (Wotton 1995, Simmons and Wallschläger 2005, Buffagni et al. 2009).

Nelson and Paetz (1992) have described the rationale for species to predominate in an area as a "dynamic interplay of many factors". Water clarity is an important factor, as suspended sediments and turbidity can negatively affect many aquatic species (Lloyd 1987, Newcombe and Macdonald 1991). Substrates are of prime importance in flowing habitats, as benthic invertebrates rely on substrates for resting, locomotion, reproduction, supporting substrate and protection from predators and flow (Giller and Malmqvist 1998). Clean gravel substrates are important for Rainbow trout spawning (Sterling 1986, Nelson and Paetz 1992, Scott and Crossman 1998, ASRD and ACA 2009a) and Rainbow trout and Bull trout (*Salvelinus confluentus*) use a variety of habitats during their life cycle (Nelson and Paetz 1992, Scott and Crossman 1998, ASRD and ACA 2009a, ASRD and ACA 2009b). Larger substrates help to provide holding and escape cover for various life stages of fish (Giller and Malmqvist 1998). Optimal habitats for adult Rainbow trout include streams with: pool-to-riffle ratios of 1:1, stable stream banks and water flows, water temperatures between 12 and 18°C, abundant instream cover and appropriate overwintering habitat (Raleigh et al. 1994). Natural and anthropogenic barriers and deterrents are common in areas of high relief. These obstructions to fish movement and migration can limit the distribution of fish upstream (ASRD and ACA 2009b). Weather and climate may further limit or hinder the introduction, survival, reproduction and colonization of organisms into alpine environments (Giller and Malmqvist 1998).

Growth rates, productivity, and the length and timing of life cycle events are all affected by water temperature (Giller and Malmqvist 1998). Temperatures are variable and dependent upon lentic and lotic conditions including the depth and size of the water body, directional aspect, shading, solar radiation and substrates (Bronmark and Hansson 2005). Rainbow trout in the Tri-Creek watershed of west-central Alberta have been reported to begin spawning in late May and early June when daily maximum water temperatures reach 6 to 8°C (Sterling 1986). Sterling (1986) also reported marked differences in survivorship of fry to emergence in creeks having colder water temperatures than the optimum range of 7 to 10°C. Wotton (1995) suggests that waters downstream of surface outlet lakes will be warmer and more constant during the summer with increased metabolism of the biota. The “lake effect” often diminishes rapidly with distance downstream from the outlet of a lake (Giller and Malmqvist 1998), only extending a few hundred metres for small outlet streams (Wotton 1995).

1.3 Chemical Environment

Anthropogenic influences can have profound effects on water quality. Elevated concentrations of chemical constituents in waters released or mobilized during mining activities have been documented in numerous studies. Studies measuring the effect of mine effluent in Alaska found that total dissolved solids (TDS) affected chironomid embryo development when levels greater than 1,100 mg of TDS per litre were present (Chapman et al. 2000). Stekoll et al. (2009) found TDS levels of 250 mg/litre reduced fertilization success in hatchery reared salmonid fishes. Elevated levels of selenium in water, and the bioaccumulation of selenium in fish tissues, has the potential to adversely affect the reproductive potential of fishes downstream of mining as well (Hamilton 2004, Holm et al. 2005, Lemly 2007, Rasmussen et al. 2007, Rudolph et al. 2008, Parametrix 2009).

Streams in the study area are significantly different from streams found in coal mining regions known for acidic mine drainage, due to the calcareous nature of the Alberta Rocky Mountain environment. These waters have, however, been found to contain elevated selenium levels, in some cases exceeding Canadian Council of Ministers of the Environment (CCME 1987) guidelines (Casey 2005, Holm et al. 2005, Wayland and Crosley 2006, Brock 2009). Selenium and other water chemistry parameters exceeding CCME guidelines have also been identified in several pit lakes (Stemo 2005, Boorman 2006).

1.4 Biological Environment

Physical and chemical variables may influence the natural food web, thereby changing the biological environment. Streams and water bodies at higher altitudes normally exhibit reduced diversity due to lower temperatures and reduced food levels associated with harsh environments (Giller and Malmqvist 1998). Bronmark and Hansson (1998) identify temperature as the key environmental factor for freshwater organisms that influences distribution patterns, behaviour and metabolic rates. Invertebrate egg development, survival, larval growth rates, time of emergence, adult size, and fecundity are also affected by temperature (Giller and Malmqvist 1998). Composition and dominance patterns within communities of phytoplankton and aquatic insects affect links between primary producers and the top predators in aquatic food webs (Bronmark and Hansson 1998).

Rainbow trout and Bull trout (*Salvelinus confluentus*) have been known to inhabit the upper reaches of the Gregg River drainage prior to mining (Hawryluk 1973, Slaney 1975, Carson 1996b). The Bull trout is of special interest in Alberta as this fish has provincial designation and is listed as a species of special concern (ASRD and ACA 2009b).

Research looking into potential impacts of habitat disturbance and habitat loss for Alberta Bull trout should be a priority (ASRD and ACA 2009b). The Athabasca Rainbow trout in the study area appear to be part of or possess characteristic traits of the only native Rainbow trout population in Alberta (Carl et al. 1994). Even though fish stocking using hatchery stock Rainbow trout has occurred in the McLeod River drainage in the past, the genetic strains sampled in the McLeod River system appear to be quite pure (Taylor et al. 2007). The Athabasca Rainbow trout is genetically similar to native Rainbow trout inhabiting the upper Columbia and Fraser rivers in British Columbia (Taylor et al. 2007). Athabasca Rainbow trout was listed as *may be at risk* by the General Status of Alberta Wild Species in 2005. As of June 3, 2010, the Athabasca Rainbow trout was short-listed as "In Process" on the Alberta Species at Risk list of Endangered and Threatened species (ASRD 2010).

1.5 Thesis Rationale

1.5.1 Objectives and Milestones

The objectives of this thesis study are to:

1) Investigate whether alpine streams with pit lakes are capable of maintaining self-sustaining populations of native fish species.
2) Describe the effects of pit lake modification and associated reclamation activities and consequences on aquatic ecosystems.
3) Generate new data, provide supportable interpretation and make conclusions regarding hypothesized downstream effects of mine pit lakes on stream substrate condition, barriers, water temperature and

quality of fish habitat and subsequent potential for fish recruitment, sustainable populations and expansion.

4) Provide recommendations regarding the use and construction of high-altitude mine pit lakes with stream connectivity.

1.5.2 Thesis Format

Chapter 1 provides a brief introduction of the topic. Chapter 2 describes the study sites. Chapter 3 describes the methods used in collecting data, and corresponds numerically with Chapter 4, which provides the results of the data analysis and interpretation. Chapter 5 discusses the significant findings of the study and provides recommendations regarding pit lakes with stream connectivity.

CHAPTER 2: Study Sites

2.1 Introduction and Overview

The primary study sites are located within the Cardinal River Mine Lease and the Gregg River Mine Lease, south of Hinton, Alberta, Canada (legal land description 47-24 W5M and 48-24 W5M, Figure 1). Active mining in the primary study area has ceased, and reclamation is completed or currently underway. The Gregg River watershed is a tributary to the McLeod River system, which flows into the Athabsca River and eventually the Arctic Ocean.

The secondary reference sites are located in southern Alberta. Rawson Lake (formerly known as Sarrail Lake) is located in the southern portion of Peter Lougheed Provincial Park, Alberta, and Emerald Lake is located near the British Columbia border in the Crowsnest Pass, Alberta.

All of the study sites are located in the front ranges of the Rocky Mountains in Alberta. The lakes would all be considered oligotrophic, with reduced productivity due to location, climate, water depth and various other factors (Thompson 1978, Bishop 1985, Luscar 1994, Stemo 2005, Boorman 2006).The areas are mainly forested with coniferous tree species, including lodgepole pine (*Pinus contorta*), white spruce (*Picea glauca*) or Engelmann spruce (*Picea engelmanni*) and alpine fir (*Abies lasiocarpa*). Surface waters are generally basic, having a pH of 7.5 or higher due to limestone influences. The study areas are generally located in the sub-alpine forest zone (Etter 1973, Thompson 1978, Mitchell and Prepas 1990).

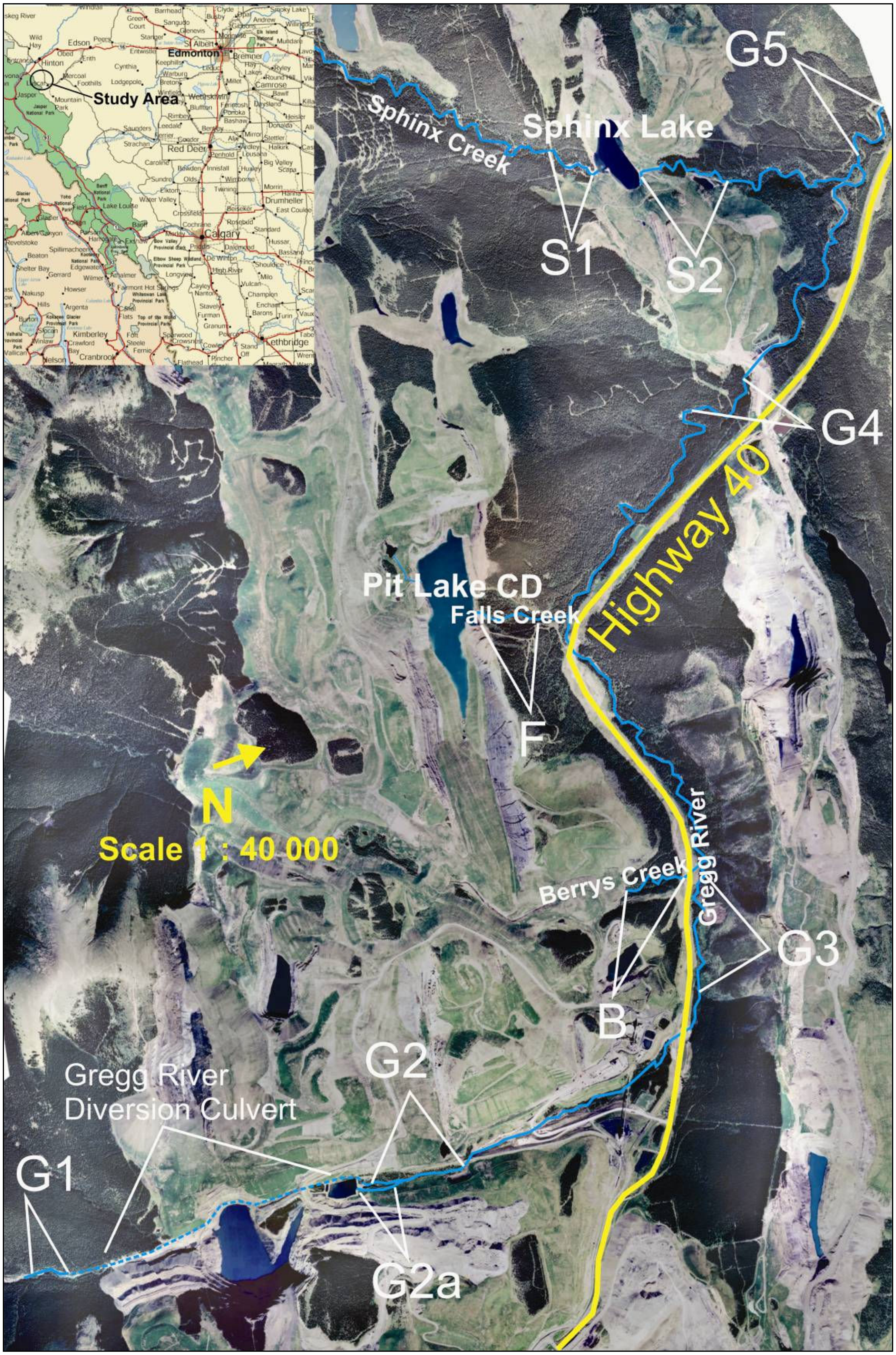

Figure 1: Primary study area within the Cardinal River and Gregg River Mine Surface Leases.

2.2 Lentic Environments

The pit lakes selected for this study were chosen based on their sub-alpine location, morphology (truck and shovel lakes) and connectivity to stream environments downstream. Natural lakes with similar morphology and attributes to the pit lakes were also selected as controls. The occurrence of natural lakes with similar attributes are rare, with no lakes identified in the immediate vicinity.

2.2.1 Sphinx Lake

Sphinx Lake is located on the Cardinal River Mine Lease near Cadomin, Alberta. In the early 1990's, Sphinx Creek was diverted through a 600-m-long culvert to allow for coal extraction beneath the stream channel. During this diversion period, the isolated population of Rainbow trout upstream was self-sustaining, and the Bull trout were allowed access to the upper reaches of the creek by trapping them below the diversion and transporting them upstream during the spawning run (Carson 1996a, Carson and Ross 1997, Allan and Goltz 1999, Schwartz 2001, Carson 2002a, Armstrong 2002, Pisces 2004, Pisces 2005, Pisces 2006). In the fall of 2005, the conversion of Pit 51-C-6 into Sphinx Lake was complete. The previously isolated section of Sphinx Creek upstream of the lake was directly connected with the lower reaches of Sphinx Creek via a lake and stream channels at the outlet and inlet of the lake. The inlet channel required the construction of numerous v-weir drop structures with plunge pools, designed to compensate for the elevational difference between the creek and the lake. These drop structures were cut into the bedrock and were designed to allow for fish movement upstream of the lake. The outlet channel uses large boulders and cobbles for erosional controls and as instream cover for fish. Fish were caught moving into and out of Sphinx Lake during trapping operations downstream of the lake in 2007 (Pisces 2008a).

2.2.2 Pit Lake CD

Pit Lake CD is located on the Gregg River Mine Lease near Cadomin, Alberta. Pit Lake CD is located in the Falls Creek drainage basin. This drainage was highly impacted during the mining operations of the Gregg River Mine. Upper reaches of the Falls Creek drainage flow through rock dumps and rock drains (Luoma 1997), made of rock and overburden that was stripped away from the coal during mining. Flows in the drainage eventually accumulate in Pit Lake CD. Falls Creek began flowing out of Pit Lake CD in October of 2002 (Brand 2009a).

A limnological assessment of Pit Lake CD was prepared for the Gregg River Mine during 2004 and 2005 (Stemo 2005). Fish presence in Pit Lake CD was, however, not documented prior to this study.

2.2.3 Lac des Roches

This pit lake, constructed in the mid-1980's, is located in the Jarvis Creek drainage on the Cardinal River Mine Lease near Cadomin, Alberta. West Jarvis Creek entered the lake via an impassable waterfall and exited the lake through an enhanced section of creek downstream of the lake. The lake and downstream portion of the creek were connected from the time the lake reached full supply level in 1987 (Luscar 1994) until the fall of

1999 (Schwartz 2002). Rainbow trout, Bull trout, Brook trout (*Salvelinus fontinalis*) and Brook stickleback (*Culaea inconstans*) were found to form the fish community in this water body. Coal interests resulted in the closure and dewatering of the lake in preparation for further mining of the 50-B-6 pit.

2.2.4 Emerald Lake

Emerald Lake (formerly known as Hart Lake) is located in the Crowsnest Pass, Alberta. Emerald Lake is a natural, deep, sub-alpine lake located in the front ranges of the Rocky Mountains in southern Alberta. Emerald Lake is fed by both ground and surface waters and is connected to Crowsnest Lake by a short stream channel. The fish community is currently believed to consist predominantly of Mountain whitefish (*Prosopium williamsoni),* Cutthroat trout (*Oncorhynchus clarki*) and Rainbow trout based on local angler knowledge and stocking records (ASRD 2007, ASRD 2009a, ASRD 2009b). Lake trout (*Salvelinus namaycush*) are likely present along with Brook trout, hybrids of Rainbow and Cutthroat trout, as well as Longnose suckers (*Catostomus catostomus*) (Bishop 1985).

2.2.5 Rawson Lake

Rawson Lake is located in Peter Lougheed Provincial Park, Alberta, approximately 2 km from upper Kananaskis Lake. This deep, natural, sub-alpine lake has a self-reproducing population of Cutthroat trout that spawn in the outlet channel of the lake in a section of the creek enhanced with spawning sized gravels.

2.2.6 Proposed Pit Lake 50A-North

The Gregg River is currently rerouted by a culvert around this existing pit. Plans are in place to create a pit lake with connectivity to the Gregg River. Plans for this system include bank and slope stabilization, creation of littoral areas, spawning channels and in-stream cover components (EVC-CRO 2006).

2.3 Lotic Environments

Sections of streams in the vicinity of pit lakes with connectivity were chosen for the purpose of this study. Streams upstream of pit lakes, downstream of pit lakes and without pit lake influence were chosen. Figure 1 gives an overview of the stream sites in proximity to the pit lakes.

The Sphinx Creek stream study sites (S1 and S2) are optimal for research and sampling given that both upstream and downstream sections (relative to the pit lake) are available.

Falls Creek section (F) is a portion immediately downstream of Pit Lake CD. This is the only fisheries section on Falls Creek because the channel upstream enters Pit Lake CD as a waterfall and does not contain fish..

Berrys Creek (B) is similar in size to Falls Creek and is located in close proximity to Falls Creek. Berrys Creek does not directly flow into or out of any pit lake.

The Gregg River accepts the flows from Sphinx Creek, Falls Creek and Berrys Creek and includes sections which are currently downstream of pit lakes (G4 and G5) and some that are not yet impacted by pit lake development (G1, G2, and G3).

All Universal Transverse Mercator (UTM) locations are reported using the North American Datum 1983 (NAD83) as determined using a handheld Global Positioning System (GPS). GPS reception at some of the sites is suspect; therefore, the GPS coordinates reported are expected to be within 50 m of the actual location.

The stream orders allocated to the drainages are based on 1:50,000 National Topographic Series mapping of the area, using the Strahler stream order classification as described in Harrel et al. (1967).

2.3.1 Sphinx Creek

Sphinx Creek is best described as a high-energy, first-order stream. Some sections of the Sphinx Creek channel are quite stable and well defined while other sections are less stable with channel movements evident. Riffle habitats with gravel and rock rubble substrates predominate (Slaney 1975).

2.3.1.1 Upstream of Sphinx Lake (S1)

The study section upstream of Sphinx Lake begins at approximately 11U 0466461 5885261 and continues upstream to 11U 0465951 5885002 (NAD 83). This stretch of creek is located upstream of the drop structures connecting Sphinx Creek to Sphinx Lake that were built in 2005. The lower half of the study section contains several habitat structures (v-weirs with plunge pools) constructed in the early 1990's. These structures were built to provide overwintering habitats for isolated stream resident fish during mining activities. The channel between and upstream of these pre-mining structures is natural. The upstream portion of the study section includes a fisheries monitoring area used for population estimates commissioned by the Cardinal River Mine.

Although this stream section is located upstream of Cardinal River mining activities, this portion of the creek still receives runoff and drainage from reclaimed Gregg River mine workings, located in the upper Sphinx Creek drainage (Luoma and Shelast 1996, Carson 2002b).

2.3.1.2 Downstream of Sphinx Lake (S2)

The section downstream of Sphinx Lake starts at the lake outlet (11U 0466807 5885525) and continues downstream to 11U 0467275 5886000. This section also contains several stream structures constructed in the 1990's. The downstream end of this section includes a fisheries monitoring section used for population estimates from 1995 to 2005 and is located within a larger fisheries monitoring section used from 2006 to 2009 (Carson 1996a, Carson and Ross 1997, Carson 1998, Allan and Goltz 1999, Carson 2000, Carson 2002a, Armstrong 2002, Pisces 2004, Pisces 2005, Pisces 2006, Pisces 2007, Pisces 2008b, Pisces 2009b, Pisces 2009c).

2.3.2 Gregg River – Main stem

The Gregg River can also be described as a high-energy, first- or second-order stream, depending on the specific site. The Gregg River follows a well-defined channel, with some channel movement evident at the upper sites. Slaney (1975) described the stream substrate as gravel, rock rubble or bedrock and indicated that banks were relatively stable. Slaney further described the nature of flow as being primarily riffle with sparse vegetative cover.

A significant waterfall with about 1 m drop is located several kilometres downstream of the study sites and is generally regarded as a barrier to fish migration upstream. This assertion is based upon the presence of Brook trout and Rocky Mountain Whitefish downstream of the falls, and their absence upstream of the falls.

2.3.2.1 Downstream of Sphinx Creek Confluence (G5)

This study section encompasses an area of the Gregg River with the downstream boundary located at 11U 0467376 5886899 and the upstream boundary located at 11U 0467484 5886635.

This section is located approximately 150 m downstream of the confluence of Sphinx Creek, and has the highest overall flow as it is located downstream of all other sections.

2.3.2.2 Upstream of Sphinx Creek Confluence (G4)

This Gregg River study section is located upstream of an existing haul road crossing on the Cardinal River Mine Lease. This study area is located upstream of the Sphinx Creek confluence, and downstream of the Falls Creek confluence. Two small contributing drainages enter the Gregg River within this section. Both are impassable to fish movement upstream. The downstream extent of the section is located at 11U 0468096 5885266 and continues upstream to 11U 0468056 5884852.

2.3.2.3 Upstream of Berrys Creek Confluence (G3)

This study site is located directly upstream of Berrys Creek and basically runs parallel with Highway 40 towards Cadomin, AB. The downstream end is located at 11U 0470118 5883188 while the upstream end is located at 11U 0470346 5882914.

2.3.2.4 Below 50A-North Culvert Diversion (G2 and G2a)

The downstream boundary is located immediately upstream of an old coal mine railway bridge at 11U 0470560 5880940 with the upstream boundary extending to the Gregg River Diversion culvert at 11U 0470266 5880510.

Site G2a is a secondary site encompassing the settling pond channel, which enters the main stem of the Gregg River (G2) downstream of the diversion culvert. The settling pond channel enters the Gregg River at 11U 0470367 5880587 with the upstream boundary of the section at 11U 0470266 5880416.

2.3.2.5 Upstream of Disturbance (G1)

This section extended upstream of the existing diversion culvert on the Gregg River located at 11U 0469774 5878783.

2.3.3 Falls Creek

Slaney (1975) described Falls Creek as a small tributary originating within the Gregg River Mine Lease. Slaney (1975) indicated that the channel was only discernible for about 1.5 km upstream of the Gregg River and was entirely riffle with no pools, and having stable banks with stream substrates consisting of small gravel-rock rubble with excessive silt deposition evident.

Mining has altered the drainage locations and characteristics of Falls Creek upstream of the lake. Much of the flow upstream travels underground through rock dumps. The creek itself percolates out of a rock dump onto a plateau above Pit Lake CD. A short section of creek then flows over the plateau before plunging over a rock face into Pit Lake CD. The outlet appears to exit at the same approximate location as before mining, with most of the Falls Creek channel downstream following the same route as reported by Slaney (1975).

Observations recorded during the Environmental Assessment in 1974 (Slaney 1975) indicated that Falls Creek was entirely riffle and that it froze completely during the winter. The current study section on Falls Creek is located immediately downstream of Pit Lake CD with the downstream end located at an old exploration road crossing located at 11U 0468397 5883420.

2.3.4 Berrys Creek

Berrys Creek is a first-order creek, approximately 7.6 km long from its source to the Gregg River (Slaney 1975). Slaney described the creek as essentially riffle with gravel and rock rubble stream substrates.

The study section on Berrys Creek starts upstream of the Highway 40 culvert at 11U 0470063 5882984 and continues upstream to the rock drain located at 11U 0469930 5882718. Significant portions of the creek upstream of this site run under large rock dumps, which channel the flows underground.

CHAPTER 3: Methods and Materials

3.1 Lentic Environments

3.1.1 Physical Attributes

3.1.1.1 Areas, Elevations, Mean and Maximum Depths

Areas, elevations, mean and maximum depth measurements were obtained from existing data and validated during field investigations, when possible. Information for Sphinx Lake, Pit Lake CD, Lac des Roches and Pit 50A-North data were obtained from monitoring reports and reclamation plans (Luscar 1994, Stemo 2005, EVC-CRO 2006, Boorman 2006, Pisces 2008a). Information for Rawson Lake and Emerald Lake was obtained from Alberta Environment, Fish and Wildlife Division Reports (Thompson 1978, Bishop 1985).

3.1.1.2 Bathymetry

Transect lengths across water bodies were determined using a Brunton Echo Laser Rangefinder with reflective targets set at the waters edge. Depths were recorded along transects using a Humminbird Piranha 1 Depth Sounder (Marine Electronics Group of Johnson Outdoors, Eufaula, Alabama, USA) as described in Wetzel and Likens (2000). Transects were travelled using boats in Sphinx Lake, Pit Lake CD and Emerald Lake. Depths were manually checked with weighted lines at various locations in Sphinx Lake, Pit Lake CD, Emerald Lake, Rawson Lake and Pit 50A-North.

Existing bathymetric information (Pisces 2008a, Stemo 2005) was supplemented by the bathymetric data collected and transposed onto enlarged aerial photographs for Sphinx Lake and Pit Lake CD. The accuracy of existing bathymetric information for Emerald Lake (Bishop 1985) and Rawson Lake (Thompson 1978) was also checked and verified for accuracy, using data collected in this study.

3.1.1.3 Light Penetration - Secchi Readings

Limnology stations were established at the approximate center of Sphinx Lake, Pit Lake CD, Pit 50A-North and Emerald Lake. A standard 20 cm diameter Secchi disk was vertically lowered on the shaded side of the boat. The depth at which the Secchi disk disappeared from sight was recorded. The disk was then slowly retrieved and the depth at which the Secchi disk reappeared was again recorded. The average of the two depths is recorded as the Secchi depth (Wetzel and Likens 2000). Secchi readings were taken on the same days and immediately following the dissolved oxygen and temperature profiles. Additional information from other studies is included (Thompson 1978, Bishop 1985, Stemo 2005, Boorman 2006).

3.1.1.4 Dissolved Oxygen and Temperature Profiles

Dissolved oxygen and temperature profiles (vertical) were measured at limnology stations in 2008 and 2009. Measurements were taken during the day, usually between 10:00 am and 6:00 pm local time. Readings at Sphinx Lake and Pit Lake CD were generally taken on a monthly basis during the open water season and once during the winter. Other sites were only sampled once or twice during the study due to logistics (remote location, personnel and watercraft were not always available). A YSI 85 Dissolved Oxygen, Temperature, Conductivity and Salinity meter with a 30.5 m cord was used. Meters were calibrated for dissolved oxygen at each site using the protocols described in the operations manual (YSI Inc, Yellow Springs, OH, USA). Variations in the accuracy on the readings would be expected as these readings were taken under varying field conditions, using different meters. The probe was lowered to depth and measurements were generally recorded at 1 m depth intervals. A slow jigging motion of the probe was employed to ensure that water movement across the probe membrane occurred.

3.1.2 Chemical Attributes

3.1.2.1 Water Chemistry

Water sampling of the epilimnion (upper stratum of the lake) and hypolimnion (lower stratum of the lake) took place in conjunction with scheduled lake monitoring programs for Sphinx Lake and Pit Lake CD in 2008 and 2009. Water samples were collected using a Kemmerer water sampler. A Sphinx Lake sample at 3 m water depth was taken on July 21, 2008 as well as samples at 5 m and 25 m water depth on February 19, 2009 (Pisces 2009a). Water sampling of Pit Lake CD occurred on July 31, 2009 with samples taken at 1.5 m and 30 m water depth. Pisces Environmental Consulting had the water samples analyzed by an independent qualified contractor.

Historical water chemistry information for all sites, except Rawson Lake, was obtained from previous reports (Bishop 1985, Stemo 2005, Boorman 2006) and unpublished data (MacNeil 1979, Fitch 1981, English 1986).

3.1.2.2 Specific Conductance - Vertical Profiles

Electrical conductivity profiles were recorded at limnology stations in 2008. Electrical conductivity and specific conductance profiles were recorded at limnology stations in 2009. These readings were taken at the same time as the water temperature and dissolved oxygen readings described previously. A YSI Model 85 Handheld Oxygen, Conductivity, Salinity Temperature meter (YSI Inc., Yellow Springs Ohio, USA) with a 30.5 m cord was used. The probe was lowered to depth and measurements were generally recorded at 1 m depth intervals. A slow jigging motion of the probe was employed to ensure that water movement across the probe membrane occurred. Variations in the accuracy on the readings would be expected as these readings were taken under varying field conditions, using different meters.

3.1.3 Biological Attributes

3.1.3.1 Zooplankton

Zooplankton were collected in Sphinx Lake and Pit Lake CD during 2008 and 2009 in conjunction with limnological investigations commissioned by Teck Coal and Sherritt Coal. Five sample sites were established on each lake with one sample site established at the approximate centre of the lake. From the central site, the lakes were divided into four quadrants, consisting of a southwest quadrant, a southeast quadrant, a northeast quadrant and a northwest quadrant. A central sample site within each quadrant was also selected.

Vertical hauls were made at each of the five sites using a No. 20 Wisconsin net, with a mouth opening of 113 cm^2, and a mesh size of 80 microns. The net was lowered to critical depth (the depth at which dissolved oxygen is < 0.5 mg/L) and lifted at a rate of 0.5 to 1.0 m/s. The zooplankton sample was then rinsed into a sampling jar, preserved with 95% ethanol and shipped to a qualified independent contractor for identification, enumeration, and population density calculations.

The sampling in Sphinx Lake occurred on August 21, 2008. The portion of the water column with dissolved oxygen values of 0.5 mg/L or higher was sampled (14 m water depth). The sampling in Pit Lake CD occurred on July 31, 2009, with the portion of the water column with dissolved oxygen values of 0.5 mg/L or higher being sampled (29 m water depth).

Additional zooplankton information is available for the pit lakes (Stemo 2005, Boorman 2006, Pisces 2009a). Information for Emerald and Rawson Lake originate from or for Alberta Sustainable Resources, Fish and Wildlife Divisions (Thompson 1978, Maywood 1983, Bishop 1985).

3.1.3.2 Macrophytes

The perimeters of Sphinx Lake and Pit Lake CD were visually surveyed using polarized eyewear several times during the open water seasons in 2008 and 2009. Surveys were executed by travelling along littoral habitats when water clarity was high. The presence of aquatic vegetation was noted, species were identified using Burland (1989) and visual estimates of vegetated area were made (m^2).

Lac des Roches, Pit 50A-North, Emerald Lake and Rawson Lake were also visually surveyed once during the fall of 2009.

3.1.3.3 Invertebrates

Benthic invertebrates were collected in Sphinx Lake and Pit Lake CD during 2008 and 2009 in conjunction with limnological investigations commissioned by Teck Coal and Sherritt Coal. Five sample sites were established on each lake, based on samplable bottom sediments.

A 15 cm by 15 cm Ekman grab sampler was used (Wetzel and Likens 2000). Samples were rinsed in the field using a micro-screen bucket (mesh size 0.583 mm) and then rinsed into a jar, preserved in 70-80% ethyl alcohol and shipped to a qualified independent contractor for identification and enumeration. Additional specimens from both Sphinx Lake and Pit Lake CD were also captured along the shorelines during 2008 and 2009 using fine mesh invertebrate nets, preserved in a similar fashion and sent to a qualified contractor for identification.

The Ekman grab sampling in Sphinx Lake occurred on August 29, 2008. All samples were collected near the inlet, as this was the only area with samplable bottom sediments. Depths ranged from 1.6 to 2.4 m with samples being taken a minimum of 10 m apart. Sediments sampled were approximately 25% gravel and 75% fine materials.

Grab sampling in Pit Lake CD occurred on July 31, 2009. All samples were collected at the east end of the lake in 0.5 to 3.0 m water depth, a minimum of 10 m between samples. The bottom sediments for three of the samples were 100% fines and the remaining two samples were 25% gravel and 75% fines.

Additional invertebrate information is available for all sites in existing reports (Thompson 1978, Mayhood 1983, Bishop 1985, Stemo 2005, Boorman 2006).

3.1.3.4 Fish Communities

Specific fisheries information was gathered for Sphinx Lake and Pit Lake CD in 2008 and 2009. Previous reports and historical records are used as supplemental information for Sphinx Lake (Pisces 2008a) and as primary sources of information for Lac des Roches (Schwartz 2002), Emerald Lake (Bishop 1985) and Rawson Lake (Thompson 1978, Mayhood 1983). No fish currently inhabit Pit 50A-North.

Population statistics for the lakes were computed using:

1. Chapman variation of the Petersen formulas for bi-census (Ricker 1975, as described in Schneider 1998)

$$N = (M+1)(C+1)/(R+1)$$

M = number of marked individuals in first capture event which are returned to the environment in normal condition

C = total number of fish captured in second capture event

R = number of fish captured in second capture event that were marked in the first capture event

N = population estimate for a given time

Variance of N = $(M+1)^2(C+1)(C-R)/ (R+1)^2(R+2)$ (used Poisson distribution of lower and upper 95% confidence coefficients for number of recaptures (R) when computing 95% confidence intervals as per Schneider 1998, the lower value often adjusted to reflect actual number of fish captured)

Standard Error = Square root of Variance

2. Software Program "Capture" (Rexstad and Burnham 1992). This is a statistical computer program often used for mark-recapture population estimates.

3.1.3.4.1 Sphinx Lake

In 2008, fish were captured moving in and out of Sphinx Lake downstream of the lake outlet. In 2009, fish were captured moving in and out of Sphinx Lake at both the outlet and the inlet. In all instances, a fish fence made of aluminum frames with removable metal dowels directed fish into wire mesh cages, capturing fish moving upstream in one cage, and fish moving downstream in another (Figure 2). The spacing between the dowels was approximately 1 cm wide. An alteration to the trap during low flow periods included a 0.6-cm mesh, which likely intercepted all fish except young-of-the-year.

Figure 2: Fish fence and trap located at the outlet of Sphinx Lake.

Fish captured in the traps were removed; anaesthetized using clove oil (Velisek et al. 2005), weighed (g), measured to fork length (mm), and visually inspected for injuries or deformities. Attempts were made to sex mature fish by external examination (i.e., expression of gametes) prior, during and immediately following spawning period. Fish with full and distended bellies indicative of gravid females, but not releasing eggs, were recorded as *ripening females*. Fish with deflated bellies, having worn anal/caudal fins and a swollen anus, but not releasing eggs, were recorded as being *suspected spent*.

All unmarked individuals approximately 80 mm and larger were adipose-clipped and implanted with a Passive Integrated Transponder (PIT) tag (12.45 mm x 2.2 mm, model TX1400L Bio Mark Inc., Boise, Idaho, USA). PIT tags were subcutaneously inserted adjacent to the dorsal fin, and provided each fish with a unique identifier code. Previously marked individuals were scanned and their identifier codes were recorded. The date and time of capture as well as the direction of travel were recorded for each specimen. Fish were returned to a holding basin of fresh creek water and allowed to fully recover from the effects of the anaesthetic. Fish were then placed in a 2 g/L sodium chloride (salt) water solution for 10 to 15 minutes. Fish were released downstream or upstream, depending upon their direction of movement into the trap.

In 2008, the outlet trap was installed on May 29, 2008, and was operated under the Sphinx Lake monitoring program (Pisces 2009b) until June 18. During that period, trapping was interrupted from 17:30 on June 11 until 09:00 on June 12, due to high water conditions. Trapping continued from June 18 to July 24, July 30 to August 4, and from August 20 to October 10 under University of Lethbridge fish research licensing for this study. On October 10, the fish fence and traps were completely removed, inspected and stored.

In 2009, the Sphinx Lake outlet trap was installed on May 29, 2009. Trapping was interrupted from 17:45 on July 9 until 17:00 on July 10. An undercut area under the fish fence was discovered and repaired on July 11 at 15:15. The trap was operated until September 16, 2009, with the fish fence and traps being removed, inspected and stored.

The Sphinx Lake inlet trap was installed on May 30, 2009. Trapping was interrupted from 14:40 on July 8 to 17:00 on July 12 and from 13:30 on July 14 to 11:00 on July 15 due to high water. The trap was operated until September 16, 2009, with the fish fence and traps being removed, inspected and stored.

3.1.3.4.2 Pit Lake CD

In 2008 and 2009, fish were captured moving in and out of Pit Lake CD downstream of the lake outlet. In both years, a fish fence made of 0.6 cm construction mesh directed fish into a two-way wire mesh cage, capturing fish moving upstream in one compartment, and fish moving downstream in another compartment. This fence and trap would likely intercept all fish except young-of-the-year. Fish were anaesthetized, inspected, measured, tagged and released using the same protocols described for the Sphinx Lake trap in 3.1.3.4. Falls Creek enters Pit Lake CD as a waterfall so trapping fish upstream of the lake was not required.

In 2008, the trap was installed on May 29. The trap was disabled on July 24. Trapping resumed on August 23 and ran consecutively until October 10. On October 10, the fish fence and traps were completely removed, inspected and stored. In 2009, the trap was installed on May 29. The trap operated continuously until being removed, inspected and stored on September 16.

Pit Lake CD was also angled and gill netted between August 1 and September 13, 2009. The lake was angled using various lures and flies for a total of 37 hours. Monofilament gill nets 46 m long, with mesh size ranging from 6.4 cm to 8.9 cm, were set at various locations and at various depths for a total combined sampling effort of 38 hours (1 to 2 hour sets). All individuals collected were processed in a fashion similar to the trapping operation.

3.1.3.4.3 Lac des Roches

Lac des Roches was likely the first man-made mountain lake in Alberta that became populated by resident fish living downstream of the water body (Luscar 1994). The lake was first studied as it was filling by RL&L Environmental Services in 1986, with numerous fisheries studies continuing into the late 1980's and into the 1990's (Luscar 1994). The fisheries aspect of Lac des Roches basically concluded in 1999, when the lake was decommissioned and fish were removed (Schwartz 2002).

The aquatic community that developed in Lac des Roches while it was connected to West Jarvis Creek is documented in a number of reports, with a summary of those results provided in Luscar (1994) and Schwartz (2002). This information was used as reference information when applicable.

A follow-up visit to the partially dewatered site took place on August 2, 2009. Areas of the lake were angled and visually surveyed to determine the presence/absence of fish.

3.1.3.4.4 Rawson Lake

Visual spawning surveys of the outlet channel, along with visual surveys of Rawson Lake occurred on July 4, 2009. Historical fisheries information for Rawson Lake is recorded in Mayhood (1983) and Thompson (1978).

3.1.3.4.5 Emerald Lake

Visual spawning surveys were carried out at the outlet of Emerald Lake during the spring of 2010. Fisheries information for Emerald Lake is documented in Clements (1972), Bishop (1985) and McCulloch (1986).

3.1.3.4.6 Pit 50A-North

As discussed previously, this water body will be reclaimed into a lake with connectivity to the Gregg River. In 2008, fish were captured moving upstream and downstream in the Gregg River (G2), where the reclaimed channel will eventually lead into Pit 50A-North. A fish fence made of aluminum frames with removable metal dowels directed fish into wire mesh cages, capturing fish moving upstream in one cage, and fish moving downstream in another. The spacing between the dowels was approximately 1 cm wide.

Fish were anaesthetized, inspected, measured, tagged and released back into the creek, using the same protocols described for the Sphinx Lake trap in 3.1.3.4.

3.2 Lotic Environments

3.2.1 Physical

3.2.1.1 Habitat Inventory

The habitat found within each study section was quantified using a modification of the O'Neil method (O'Neil and Hildebrand 1986). This method included classification and quantification of the various habitats (i.e. riffle, run), cover components (i.e., woody debris, boulder), stream substrates (as defined in Lane 1947), and riparian vegetation.

Table 1: Characteristics identified during habitat inventories of the study sections (based on 0'Neil and Hildebrand 1986).

DESCRIPTION					
Habitat type	Water depth	Surface	Flow	Substrate	Velocity
Riffle (RF)	<0.5 m	irregular broken	turbulent	coarse	high
Class 1 Run (R1)	>1.0 m	irregular	moderate	coarse	moderate to high
Class 2 Run (R2)	0.5 to 1.0 m	irregular rarely broken	moderate turbulence	coarse	moderate to high
Class 3 Run (R3)	<0.5 m	irregular rarely broken	moderate turbulence	coarse	moderate
Class 1 Pool (P1)	>1.0 m	smooth	low turbulence	variable	low, variable
Class 2 Pool (P2)	0.5 to 1.0 m	smooth	low turbulence	variable	low, variable
Class 3 Pool (P3)	<0.5 m	smooth	low turbulence	variable	low, variable
Class 1 Flat (F1)	>1.0 m	smooth	laminar	fines	low
Class 2 Flat (F2)	0.5 to 1.0 m	smooth	laminar	fines	low
Class 3 Flat (F3)	<0.5 m	smooth	laminar	fines	low
Cascade (CA)	<0.5 m	irregular, broken	very turbulent	very coarse	highly variable
Chutes (CH)	<0.5 m	irregular	shooting	bedrock	high
Instream Cover					
Woody Debris (WD)		large, in stream woody debris			
Overhanging Bank (OB)		undercut, overhanging bank			
Overhanging Vegetation (OV)		overhanging terrestrial vegetation			
Aquatic Vegetation (AV)		dense, well distributed aquatic or semi aquatic vegetation providing cover			
Boulder Garden (BG)		dense, well distributed boulders providing cover			
Substrate					
Fines (Fn)		Includes silt and sand, particle size <2 mm			
Gravel (Gr)		Particle size 2 mm-64 mm			
Cobble (Cb)		Particle Size 64 mm-256 mm			
Boulder (Bl)		Particle size >256 mm			
Bedrock (Br)		Solid rock resistant to movement and erosional forces			
Riparian Vegetation					
Exposed (Exp)		Exposed fines, gravel, cobble or bedrock			
Grass (Gr)		Include grasses and other herbaceous terrestrial plants			
Shrubs (Sh)		Deciduous plants, including willow and alder, multiple stems			
Trees (Tr)		Deciduous and coniferous trees such as spruce, aspen, pines			

3.2.1.2 Climatic Variables

A HOBO weather station (H21-001, Data logger with smart sensors, Onset Corporation) was installed near the outlet of Sphinx Lake in May 2008. The purpose of the unit was to gather site-specific and general area information on various environmental conditions. Sensors measured and recorded air temperature (1 m and 2 m above ground), lake water temperature (1 m water depth near to shore), relative humidity, and light intensity (watts/m^2) at fifteen minute intervals. The weather station was installed on May 21, 2008, with final downloaded readings recorded on October 7, 2008. The data logger malfunctioned during the winter of 2009 and data recorded after October 7, 2008, could not be recovered.

In addition to the weather station, data loggers (Stowaway Tidbit Temp Loggers, Onset Corporation, TB132-20+50) measuring hourly water temperatures were deployed (affixed by stakes to the stream bottoms) at all stream sites in May 2008. Information was downloaded several times during the study. Loggers were removed by mid October 2009.

Dissolved oxygen and temperatures were measured at stream sites in 2008 and 2009 using a YSI Model 85 Handheld Oxygen, Conductivity, Salinity Temperature meter was used. Meters were calibrated for dissolved oxygen at each site using the protocols described in the operations manual (YSI Inc, Yellow Springs, OH, USA). The probe was placed 2 cm to 4 cm above the bottom of the stream in flowing water to ensure that water movement across the probe membrane occurred.

3.2.1.3 Stream Discharges

Stream gauging stations were established in May and June of 2008. Sites were chosen based on guidelines outlined by the United States Geographical Society (Nolan et al. 2008). Gauging stations were set up to monitor flows at Upper Sphinx Creek (S1), Lower Sphinx Creek (S2), Falls Creek (F), Berrys Creek (B) and the Gregg River upstream of

Berrys Creek (G3). Water Survey of Canada site WSC 07AF015, Gregg River near the mouth, is located downstream of the study area at 11U 476222 5900326.

Gauging stations included metal t-bars pounded into the stream substrates to which meter measures were attached. Stage height measurements were manually recorded (to the nearest millimetre) on a regular basis (generally from June to October on a weekly basis, more often during spring run off and after precipitation events). Stream flows were measured using a Price Type AA-Pygmy Gurley (Gurley Precision Instruments, Troy, New York, USA) or a Global Water Model FP201 (Global Water Instrumentation, Inc., Gold River, CA, USA). Stream discharges were calculated using the mid-section velocity area method (Nolan et al. 2008), and stream rating curves were developed in conjunction with stage measurements. Hydrographs for each of the sites were derived using data collected during the 2008 and 2009 open water season and were supplemented with point discharge data provided by Alberta Environment in 2008 (Brock 2009).

3.2.1.4 Stream Substrate Concretions

Streambed concretions were observed within some of the study sections during the 2008 field season. The concretions were quantified by visually estimating the percentage area affected, per habitat unit of stream substrate, within each study section. Concretion samples were removed from the Gregg River (Site G3) and Falls Creek (F) and allowed to air dry before being analyzed. Chemical constituents of the concretion samples were analyzed by Bodycote Testing Group and further by bulk x-ray analysis carried out at the University of Lethbridge using a Hitachi TM-1000 Scanning Electron Microscope (SEM) equipped with an EDS X-ray microanalysis system. Statistical analysis of results was facilitated using JMP 7 software (ANOVA). The general protocol for the elemental distribution and bulk x-ray diffraction work included the following:

- Samples from Falls Creek and the Gregg River were gently broken into finer particles
- These particles were then randomly mounted on aluminum stubs (Ted Pella Inc, Product #16111) covered with double sticky tape.
- Samples were loaded into the SEM, and a minimum of 5 point readings were recorded for each sample at a magnification of X1000 over a time period of 100 sec.
- Each reading recorded the relative concentration of elements at that point and also included an SEM image of the area containing the scanned point.

In order to measure the rate of accumulation of concretions on streambed substrate, a standardized method of sampling the degree and rate of accumulation build-up was used. Fine mesh containers (bundles) approximately 10 cm x 10 cm x 3 cm were constructed using 0.6 cm construction mesh. Bundles were filled with small gravels (between 0.5 and 1 cm in diameter) and weighed. These gravel bundles were then set horizontally into riffle type habitats, held in place using anchored nylon rope. The riffle areas had water depths varying between 8 cm and 13 cm and flow rates ranging from 0.4 m/sec to 0.6 m/sec at the time of installation. The mesh bundles were set at the sites during October 6 to 11, 2008, and were removed in the same approximate order from September 28 to

October 8, 2009. Weights and conditions of the individual bundles were recorded prior to stream treatment and after stream treatment.

In addition to the mesh bundle experiment, several artificial spawning beds were created within concretion-affected areas in the fall of 2008. Spawning beds were built using a minimum of 20 L and maximum of 60 L of clean washed gravel (approx 1.0 cm diameter). Gravels were deposited at the tails of runs or pools with areas varying from approximately 0.5 m^2 to 1.0 m^2. Bed use by spawning Rainbow trout was monitored in May and June of 2009. Gravel conditions relative to the depth and degree of concretion were physically checked in July and August of 2009.

3.2.2 Chemical

3.2.2.1 Water Chemistry

Water chemistry information for the Gregg River upstream of mining (G1), Berrys Creek (B), Falls Creek (F) and Lower Sphinx Creek (S2) was obtained from Alberta Environment for 2008 (Brock 2009). Additional information for Berrys Creek and Falls Creek in 2008 and 2009 was provided by Sherritt Coal-Gregg River Mine (Brand 2009b).

3.2.2.2 Specific Conductance

Electrical conductivity measurements and water temperatures were recorded at stream sites in 2008 and 2009. Specific conductance measurements were recorded at the same sites in 2009. Readings were generally taken once or twice a month from late May till

October. A YSI Model 85 Handheld Oxygen, Conductivity, Salinity, Temperature meter was used. The probe was placed into flowing water at or near the bottom of the water column to ensure that water movement across the probe membrane occurred. Variations in the accuracy on the readings would be expected as these readings were taken under varying field conditions, using different meters.

3.2.3 Biological

3.2.3.1 Invertebrates

Benthic invertebrates were sampled at the stream sites on several occasions using two different sampling methods. Sampling equipment included a Hess type, benthic macroinvertebrate sampler with 250 micron mesh (BioQuip Products 4219A, Rancho Dominguez, CA, USA) and aquatic drift net using 250 micron mesh (BioQuip Products 4250A). Specimens were preserved in 70-80% ethyl alcohol. Several drift samples were shipped to a qualified independent contractor for identification and enumeration (Eco-Analysts Inc., Moscow, ID, USA; Vancouver, BC, Canada) while others were identified at the University of Lethbridge using a dissecting microscope and taxonomic keys (Clifford 1991, Thorp 2001, Voshell 2002).

3.2.3.2 Fish

3.2.3.2.1 Species Composition and Attributes

Stream sites were sampled on various occasions using backpack electro-shockers. The electro-shockers used were either a Smith-Root LR24 electro-shocker or a Smith-Root

Type VII electro-shocker. Settings were adjusted to match water conditions and were set to maximize capture success and minimize injury to fish. Typically, settings ranged between 150-300 volts, with 30-40 hertz and 12%-16% duty cycles. Sampling sessions at the stream sites generally occurred during late summer or early fall of 2008 and 2009, when stream flows are usually reduced.

Figure 3: Backpack electro-fishing in Sphinx Creek.

Stream sections were isolated by installing a fine mesh seine across the width of the stream at both the upstream and downstream end. Each section was then electro-fished by slowly fishing from the downstream seine towards the upstream seine. Electro-fishing crews used polarized glasses as visual aids during electro-fishing. Crews were comprised of an electro-shocker operator with one or two netters. Fish were captured using fine mesh dip nets and were held in oxygenated stream water until being processed.

During processing, collected fish were anaesthetized using clove oil (Velisek et al. 2005), weighed (g), measured to fork length (mm), and visually inspected for injuries or deformities. All unmarked individuals approximately 80 mm and larger were adipose-clipped and implanted with a Passive Integrated Transponder (PIT) tag (12.45 mm x 2.2 mm, model TX1400L Bio Mark Inc.). PIT tags were subcutaneously inserted adjacent to the dorsal fin, and provided each fish with a unique identifier code. Previously marked individuals were scanned and their identifier codes were recorded. Fish were returned to a holding basin of fresh creek water and allowed to fully recover from the effects of the anaesthetic. Fish were then placed in a 2 g/L salt-water solution for 10 to 15 minutes. The fish were then released back into the isolated section of creek to redistribute. Isolation barriers were left in place to contain fish movements within the section for mark-recapture population estimation.

The isolated section was again electro-fished one to several days later. Similarly, individuals were captured, anaesthetized, weighed, measured and inspected. All unmarked individuals were adipose-clipped and implanted with PIT tags. Previously marked individuals were scanned and their identifier codes were recorded.

3.2.3.2.2 Species Densities

Mark-and-recapture population estimates were based on a minimum of three recaptures during the capture run, unless otherwise indicated. Total capture information was used in instances where mark-and-recapture estimates were unsuccessful. Percent capture in a single pass electro-fishing survey was used as an estimator of abundance at the furthest downstream site on the Gregg River (Site G-5) in 2009. Densities were computed by dividing the population estimate by the section size. Densities are reported as the number of fish per $100m^2$.

Population statistics for the stream sites were computed using the Chapman variation of the Petersen formulas for bi-census (Ricker 1975 as described in Schneider 1998) and Software Program "Capture" (Rexstad and Burnham 1992); both described previously in 3.1.3.4.

3.2.3.2.3 Spawning Surveys and Fry Emergence

Visual spawning surveys were completed in both 2008 and 2009 at the stream sites. Spring spawning surveys were carried out in late May, June and early July while fall spawning surveys were carried out during September and October.

Spawning activity and the presence of suspected redds was recorded. Spawning success was documented at several sites by setting fry drift nets directly downstream of the suspected redds (Figure 4). Redds producing few or no fry were excavated several weeks after fry emergence to confirm or refute suspected spawning.


Figure 4: Monitoring fry emergence by checking drift net in lower Sphinx Creek.

3.2.3.2.4 Fish Growth

The length and weights of Rainbow trout (RNTR) and Bull trout (BLTR) were recorded during the mark-recapture population estimates at the stream sites. The growth from one year to the next was determined for previously captured stream residents. The growth per day between "time a" and "time b" for weight and fork length was calculated for each fish. Stream residency was determined by looking at capture location from one year to the next and trapping information for the pit lakes during that period. Data was analyzed using Excel 2003 and JMP 7 software programs.

3.2.3.2.5 Incubation and Fry Emergence in Selenium-Enriched Waters

During the fish trapping operation on Sphinx Creek (S2) in 2008 and 2009, eggs from 10 female Rainbow trout (RNTR) (5 per year) were stripped of eggs, fertilized using the dry method (Piper et al. 1982) and placed into "*in situ* incubation chambers" similar to those used by Rubin (1995) and Bernier-Bourgault et al. (2005). Incubation chambers were then loaded with gravel substrate and fertilized eggs (between 75 and 150 eggs depending on incubator chamber diameter) and planted in the streambed. Eggs were also placed in incubation trays, similar to the design by Vibert (1949), to track egg development. A sub-sample of eggs from each individual was retained, frozen and submitted to Exova (formerly Bodycote Testing Group, Calgary) for selenium analysis using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

In addition to the Sphinx Creek experiment, RNTR eggs from five female RNTR (migrating out of Pit Lake CD in 2009) were stripped, fertilized and placed into *in situ* incubation chambers in both Sphinx Creek and Falls Creek. Chambers loaded with gravel and fertilized eggs were planted in the streambeds. Sub-samples of eggs from each individual were retained for selenium analysis.

Egg development in the incubation trays was monitored at each site until the sac fry stage was reached. Fry traps attached to the incubation chambers were used to quantify percentage emergence. Emergent fry were categorized as being healthy (swimming, normal appearance, coloration and behavior), poor (deformity, discoloration, bruising, or lethargic behavior) or dead (a mortality). Egg and egg remnants were counted to determine the number of eggs that did not hatch. The fate of a small proportion of the eggs was unknown and recorded as such.

CHAPTER 4: Results

4.1 Lentic Environments

4.1.1 Physical Attributes

4.1.1.1 Area, Elevation, Mean and Maximum Depths

Physical attributes for the study sites as reported in previous investigations are provided in Table 2.

Table 2: Physical attributes of the lake sites.

Site and Source	Area (ha)	Elevation (m)	Mean depth (m)	Max Depth (m)
Sphinx Lake (Pisces 2008a)	6.4	1491	14	50
Pit Lake CD (Stemo 2005)	20.5	1567	31	87
Lac des Roches (Luscar 1994)	16.2	1592	37	70
Rawson Lake (Thompson 1978)	17.7	2027	12	33
Emerald lake (Bishop 1985)	9.7	1372	10	33
Proposed Pit Lake 50A-North (EVC-CRO 2006)	14.5	1662	22	57

4.1.1.2 Bathymetry

The bathymetric map for Sphinx Lake is found in Figure 5 and the bathymetric map for Pit Lake CD is found in Figure 6. Bathymetric diagrams for Rawson Lake, Emerald Lake and Lac des Roches are also available (Thompson 1978, Bishop 1985, Luscar 1994). Plans for Pit Lake 50A-North suggest that 28% of the lake will have water depths less than 3.1 m deep (4 hectares) when complete.

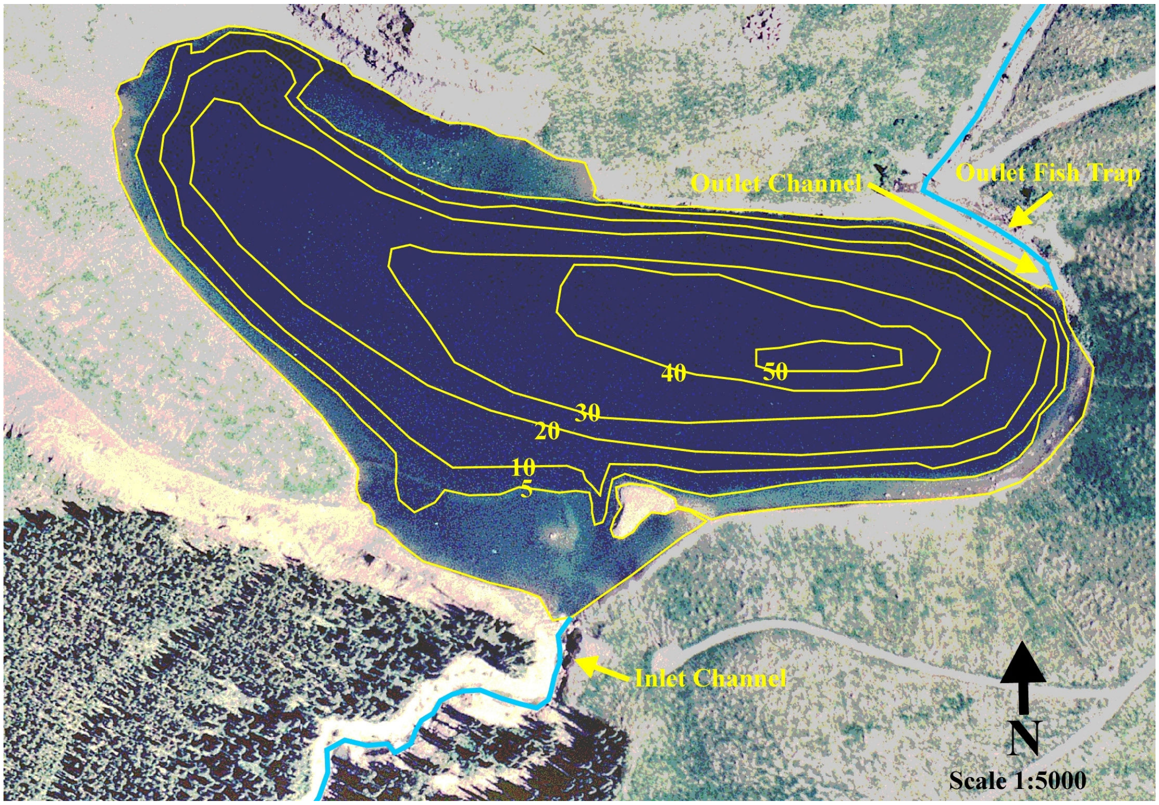

Figure 5: Sphinx Lake - Bathymetric depth intervals (m).

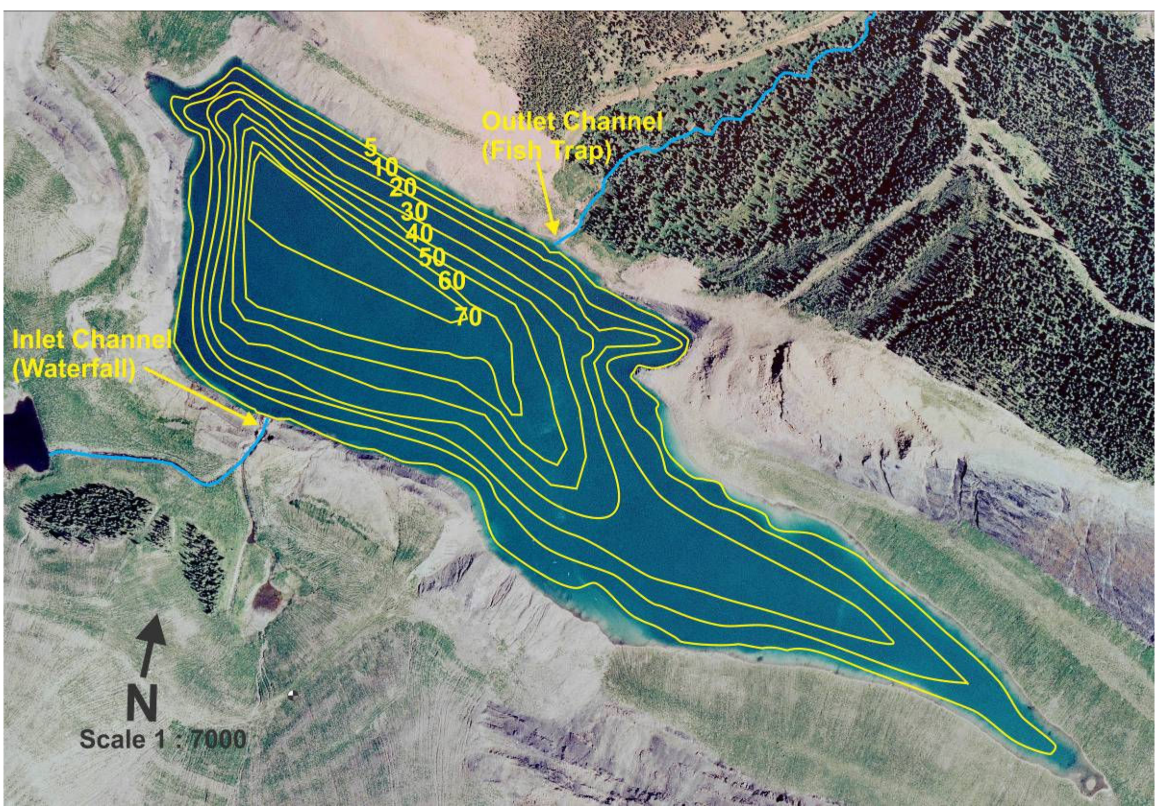

Figure 6: Pit Lake CD - Bathymetric depth intervals (m).

4.1.1.3 Light Penetration – Secchi Readings

Secchi readings recorded during this study, and previously in other studies, for Sphinx Lake, Pit Lake CD, Pit 50A-North and Emerald Lake are provided in Table 3. Rawson Lake had a recorded Secchi depth of 6 m in August of 1975 (Thompson 1978) and 3.2 m Secchi depth recorded in August of 1981 (Stelfox 1981). Lac des Roches was reported to be very turbid during the earliest investigations in 1986 (Luscar 1994). Studies undertaken in Lac des Roches during 1988 and 1989 showed vast improvement with Secchi readings greater than 4 m (Luscar 1994). A Secchi depth of 8.4 m was recorded at Lac des Roches on August 2, 2009.

Table 3: Secchi readings for Sphinx Lake, Pit Lake CD, Pit 50A-North and Emerald Lake.

Sphinx Lake	Aug. 05	Oct. 05	June 08	July 08	Oct. 08	July 09	Aug. 09	Oct. 09
	0.6 m (Boorman 2006)	1.5 m (Boorman 2006)	2.4 m	7.0 m	7.8 m	3.6 m	9.6 m 10.3 m	7.6 m

Pit Lake CD	Aug. 04	June 08	July 08	Oct. 08	July 09	Aug. 09	Oct. 09
	4.9 m (Stemo 2005)	1.7 m	4.8 m	6.9 m	2.5 m 8.1 m	7.5 m	6.9 m

Pit 50A-North	Aug. 05	Oct. 05	May 06	Aug. 09
	2.3 m (Boorman 2006)	4.4 m (Boorman 2006)	2.1 m (Boorman 2006)	2.4 m

Emerald Lake	May 79	June 79	July 79	Aug. 79	Oct. 79	Nov. 09
	6.0 m (Bishop 1985)	14.0 m (Bishop 1985)	7.0 m (Bishop 1985)	5.5 m (Bishop 1985)	8.0 m (Bishop 1985)	7.8 m

4.1.1.4 Sphinx Lake – Dissolved Oxygen Profiles

Dissolved oxygen levels recorded in Sphinx Lake during 2008 and 2009 are provided in Figure 7. Oxygen depletion below 2 mg/L occurred between 13 m and 15 m depth in 2008 and between 11 m and 12 m depth in 2009.

Limnological investigations of Sphinx Lake, prior to construction and connection of the inlet and outlet channels were carried out by Pisces Environmental Consulting in 2005. Oxygen depletion below 2 mg/L was recorded at 8 m water depth during the winter assessment (March 4, 2005) and at 9 m water depth during the spring assessment (May 27, 2005). Summer and fall monitoring found dissolved oxygen levels greater than 2 mg/L throughout the 30 m water column (Boorman 2006).

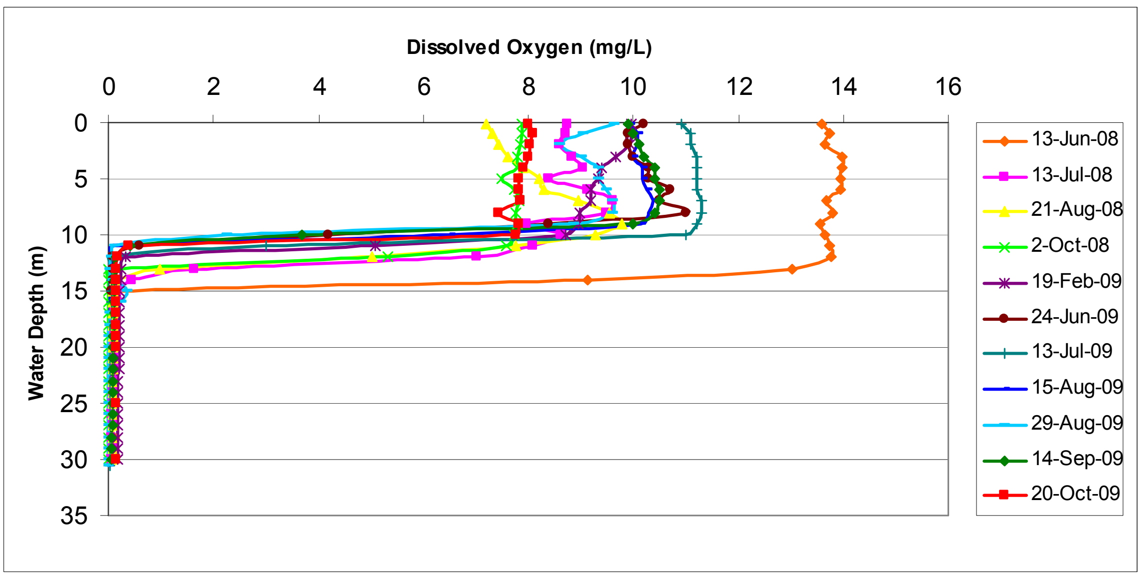

Figure 7: Dissolved oxygen profiles for Sphinx Lake in 2008 and 2009.

4.1.1.5 Sphinx Lake – Temperature Profiles

Temperature profiles for 2008 and 2009 are provided in Figure 8. Temperature recordings near the center of the lake at 1 m below the surface varied from a recorded low temperature of 0°C on Feb 19, 2009, to a maximum of 12.5°C on August 29, 2009. Temperature recordings near the center of the lake at 30 m below the surface varied from a low of 4.9°C on several occasions to a maximum of 5.7°C on September 14, 2009.

Limnological investigations of Sphinx Lake, prior to construction and connection of the inlet and outlet channels, found minimum lake water temperatures of approximately 1.5°C under the ice on March 4, 2005, and a maximum temperature of 13°C recorded on August 22, 2005, for 1 m water depth. Water temperatures at 30 m water depths ranged from 4°C to 6°C in 2005. A thermocline at 4 m water depth was observed in May 2005. Water temperatures on August 22, 2005 dropped quickly from 13°C at 1 m depth to about 6°C at 4 m depth. The remaining profile (5 m to 30 m depth) hovered near 6°C (Boorman 2006).

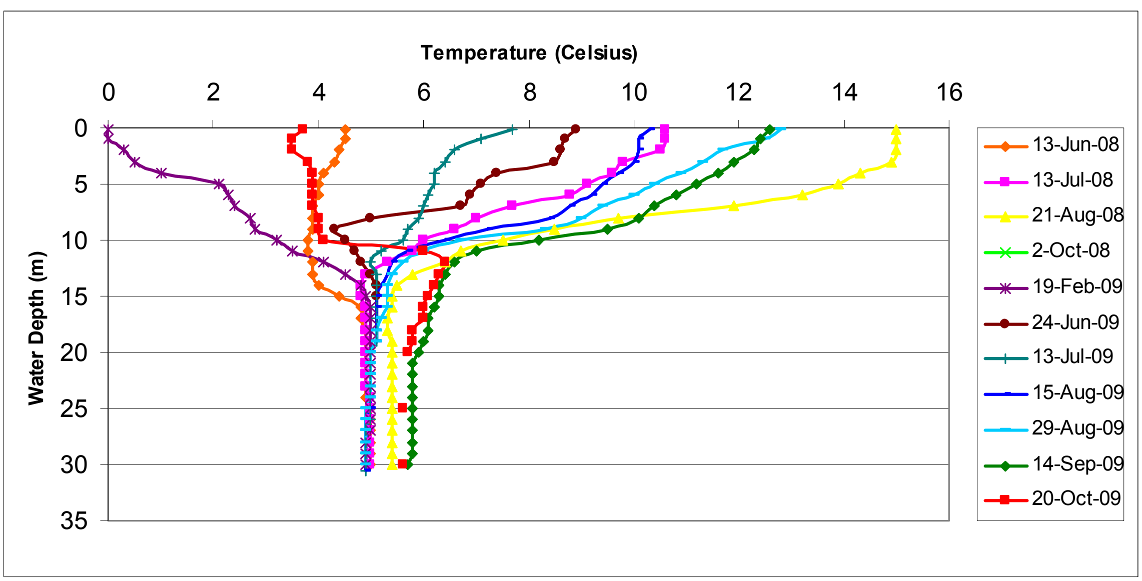

Figure 8: Vertical temperature profiles for Sphinx Lake in 2008 and 2009.

4.1.1.6 Pit Lake CD – Dissolved Oxygen Profiles

Dissolved oxygen levels recorded in Pit Lake CD during 2008 and 2009 are provided in Figure 9. Oxygen depletion below 2 mg/L occurred at or near 29 m water depth in 2008 and at or near 28 m water depth in 2009.

Pisces Environmental Consulting measured various limnological features for Pit Lake CD in 2004 and 2005 (Stemo 2005). Oxygen depletion below 2 mg/L was observed at or near 15 m water depth on Aug 28, 2004 and at or near 16 m water depth on October 21, 2004. Monitoring on March 5, 2005, and May 25, 2005, found similar oxygen depletion occurring at or near 28 m water depth.

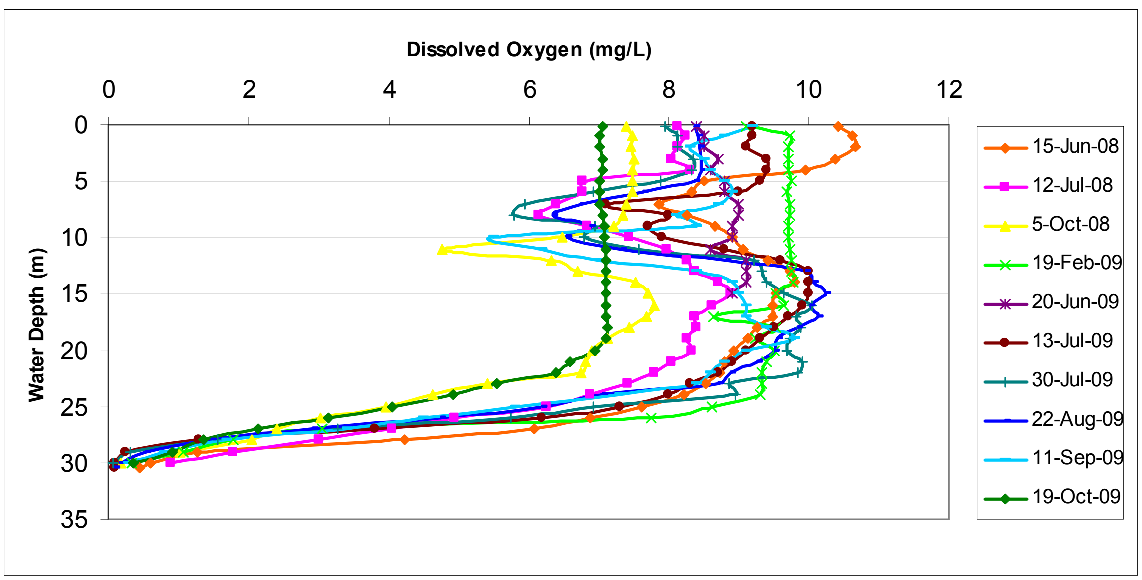

Figure 9: Dissolved oxygen profiles for Pit Lake CD in 2008 and 2009.

4.1.1.7 Pit Lake CD – Temperature Profiles

Temperature profiles for 2008 and 2009 are provided in Figure 10.Temperature recordings near the center of Pit Lake CD at 1 m below the surface varied from a recorded low temperature of 0.9°C on Feb 19, 2009, to a maximum of 18.9°C on July 30, 2009. Temperature recordings near the center of the lake at 30 m below the surface varied from a recorded low temperature of 4.0°C on June 15, 2008, to a maximum of 5.0°C recorded on July 30, 2009 and October 19, 2009.

Limnological investigations of Pit Lake CD were carried out in 2004 and 2005. The lowest water temperature recorded was 2°C at 1 m water depth on March 5, 2005. The highest temperature recorded at the 1 m water depth was 13°C on August 28, 2004. Water temperatures at 30 m water depth varied from 4°C to 5°C during the seasonal monitoring program. A thermocline was reported between 5 m and 8 m on August 28, 2004. Observed temperatures were uniform throughout the 30 m vertical profile on October 21, 2004 (4°C to 5°C) and in March 2005 (2°C to 4°C). Thermal stratification was developing on May 25, 2005, with temperatures of 10°C at 1 m depth (Stemo 2005).

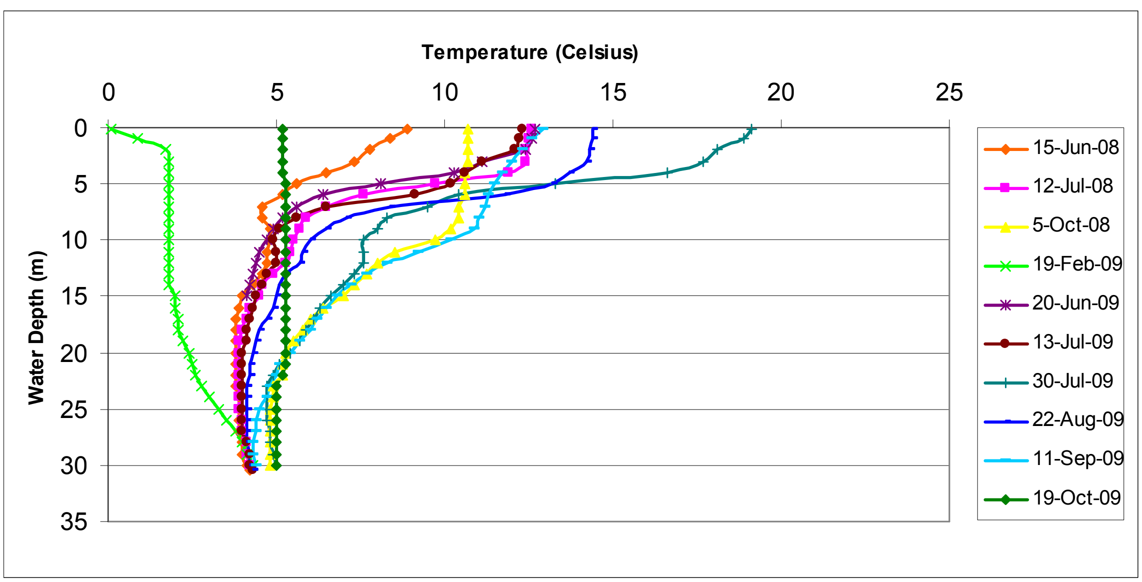

Figure 10: Vertical temperature profiles for Pit Lake CD in 2008 and 2009.

4.1.1.8 Other Sites – Dissolved Oxygen Profiles

The dissolved oxygen levels as recorded at Emerald Lake, Rawson Lake, Lac des Roches and Pit 50A-North during 2008 and 2009 are provided in Figure 11. Oxygen depletion below 2 mg/L was not identified in Rawson Lake (it was only measured to 10 m water depth due to equipment problems) but was found to occur in Emerald Lake at 24 m water depth on April 10, 2008, and at 28 m water depth on November 1, 2009. Dissolved oxygen in Lac des Roches fell below 2 mg/L at 27 m water depth on August 2, 2009, and at 17 m water depth at Pit A-North on August 8, 2009.

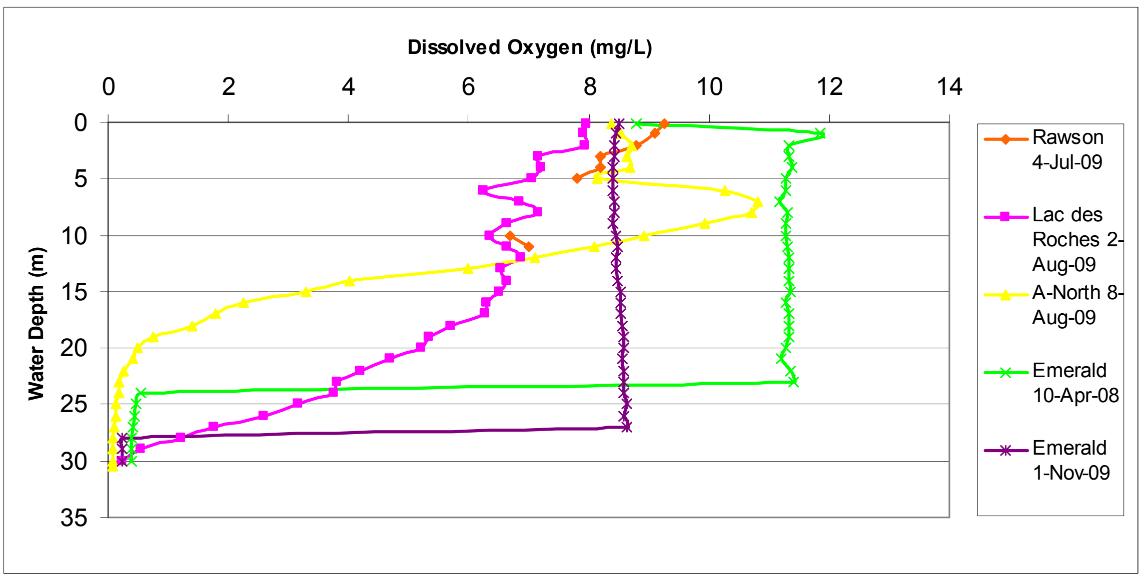

Figure 11: Dissolved oxygen profiles for Rawson Lake, Lac des Roches, Pit 50A-North and Emerald Lake in 2008 and 2009.

Historical information for Rawson Lake is limited. A dissolved oxygen profile was measured by Alberta Fish and Wildlife on August 11, 1981 (Stelfox 1981). Dissolved oxygen values between 6 mg/L near the surface and 4 mg/L at 30 m depth were recorded.

Dissolved oxygen profiles were conducted at Emerald Lake during the 1970's and 1980's by Alberta Fish and Wildlife. Dissolved oxygen values in Emerald Lake for all depths were consistently higher than 7.8 mg/L; the only known exception was a value of 2 mg/L recorded in January 1981 from 30 m water depth (Bishop 1985).

Pisces Environmental Consulting measured various limnological features for Pit 50A-North in 2005 and 2006 (Boorman 2006). Oxygen depletion below 2 mg/L was not observed during monitoring sessions on August 25 and October 27, 2005. Dissolved oxygen levels below 2 mg/L were however, recorded at and below 9 m water depth on March 8, 2006, while oxygen levels on May 16, 2006 did not record findings lower than 2 mg/L within 30 m of the surface. Golder Associates conducted similar vertical profiles of dissolved oxygen in Pit 50A-North in July of 2008. Values below 2 mg/L were recorded at 23 m water depth (Rutkowski and Christensen 2008).

Golder Associates also conducted a vertical dissolved oxygen profile in Lac des Roches during August of 2008. Values at or below 2 mg/L in Lac des Roches were recorded at 42 m depth on August 21, 2008 (Rutkowski and Christensen 2008).

4.1.1.9 Other Sites – Temperature Profiles

Temperature profiles for Rawson Lake, Emerald Lake, Pit 50A-North and Lac des Roches taken during this study are provided in Figure 12.

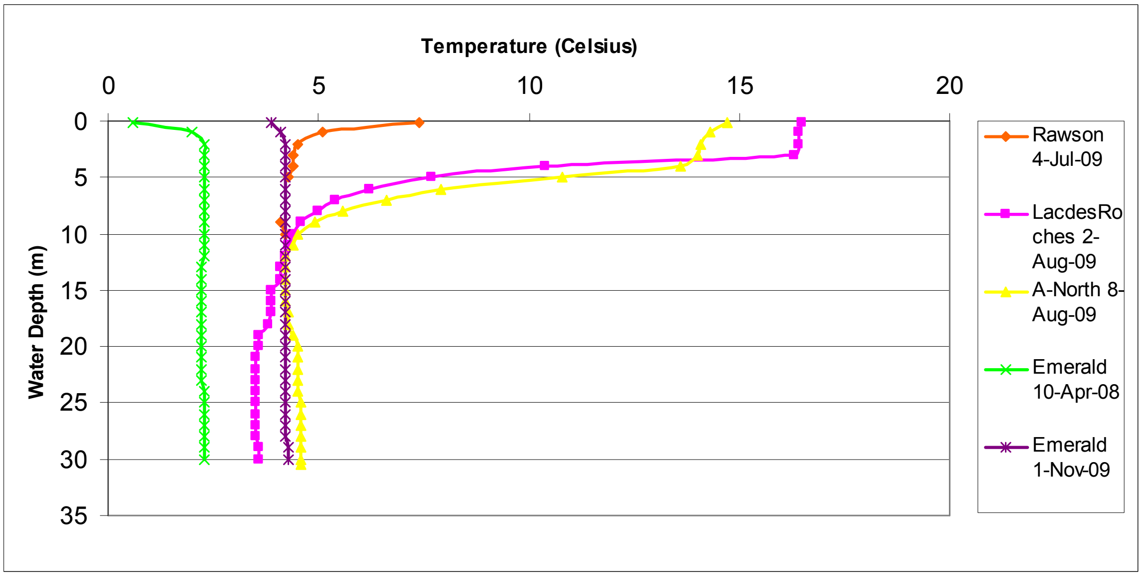

Figure 12: Vertical temperature profiles for Rawson Lake, Lac des Roches, Pit 50A-North and Emerald Lake in 2008 and 2009.

Historical temperature profile information for Rawson Lake is limited. A temperature profile was conducted by Alberta Fish and Wildlife on August 11, 1981 (Stelfox 1981). Temperatures at 1 m water depth were recorded at 12 °C. Temperatures decreased in a relatively uniform fashion to 4°C by the 10 m depth. A uniform layer of 4°C water extended vertically downward to at least the 30 m water depth.

Temperature profiles were recorded at Emerald Lake during the 1970's and 1980's by Alberta Fish and Wildlife (Bishop 1985). A minimum temperature of 0.8°C was recorded at 1 m water depth on January 8, 1981, with a maximum temperature of 15.8°C at 1 m water depth recorded on August 23, 1979. The minimum temperature recorded at 30 m depth was 1°C on January 8, 1981, and the maximum temperature observed at 30 m depth was 7.8°C on October 16, 1979. Temperature profiles on July 11, 1979 and August 23, 1979 suggested that a thermocline existed at or near 10 m water depth. Relatively uniform temperature profiles were observed through 30 m of water depth on May 15, 1979 (4.3°C to 6.2°C), June 12, 1979 (7.2°C to 10.3°C), October 19, 1979 (7.8°C to 7.9°C) and January 8, 1981 (0.8°C to 1.0°C). Clements (1972) noted a “slight thermocline” at approximately 8 m water depth in August 1972 with temperatures ranging from 13°C near the surface to 3.8°C at 30 m depth.

The uniform temperature profile ranging from 0.8°C to 1.0°C in January of 1981, with water temperatures of 1.0°C at 30 m depth is interesting. Ground water intrusion with mixing under the ice might explain these recordings.

Pisces Environmental Consulting measured vertical temperature profiles in Pit 50A-North in 2005 and 2006 (Boorman 2006). A maximum temperature of 11.5°C was recorded at the 1 m depth on August 25, 2005, with a minimum temperature of about 1.5°C recorded on March 8, 2006. The temperatures at 30 m depth ranged between 4°C and 5°C during the summer, fall, winter and spring monitoring sessions. Strong thermal stratification was observed on August 25, 2005 with a thermocline occurring near 5 m depth. Relatively uniform temperatures were observed in 30 m profiles recorded on October 27, 2005 (between 2°C and 5°C), March 8, 2006 (between 1.5°C and 4.5°C), and May 16, 2006 (between 2.5°C and 7.5 °C). Golder Associates (Rutkowski and Christensen 2008) conducted similar vertical profiles of temperature in Pit 50A-North in July of 2008. A temperature of 14.5°C was recorded at 1 m water depth with a thermocline present at 4 m to 5 m water depth.

Golder Associates also conducted a vertical temperature profile in Lac des Roches on August 21, 2008. A temperature of 15.9C was recorded at 1 m depth with a thermocline occurring at 5 m to 6 m depth (Rutkowski and Christensen 2008).

4.1.2 Chemical Attributes

4.1.2.1 Water Chemistry

Detailed water chemistry information for Emerald Lake and Rawson Lake during 2008 and 2009 was not available. Basic water quality data for Emerald Lake (MacNeil 1979, Fitch 1981, English 1986) was provided by D. Wig, Alberta Sustainable Resource Development, Crowsnest Pass Fish and Wildlife Office. Detailed historical water chemistry data for the pit lakes are found in Stemo (2005) and Boorman (2006). Sample data, collected during this study in conjunction with mine monitoring, is detailed in Pisces (2009a), and Pisces (2011). Some of the water quality characteristics are provided in Table 4 for comparative purposes. Increased total dissolved solids in the hypolimnions of the pit lakes as compared to the epilimnions, show that the water at depth is considerably different than the upper stratum.

Table 4: Specific water chemistry parameters at the lake study sites.

Site and position in water column	Date	Depth	pH	Specific conductance	Alkalinity Total $CaCO_3$	Total Hardness $CaCO_3$	Dissolved/Filtered mg/L				Total dissolved solids	Selenium
		m		µS/cm	mg/L	mg/L	Ca	Mg	Na	SO_4	mg/L	mg/L
Sphinx Lake (Epi)	*1Mar 4/05	na	8.2	902	280	401	95.7	39.3	58.3	238	602	0.0032
	Jul 21/08	3	84	483	200	219	59.6	17.9	18	69.8	284	0.0052
	Jul 21/08	9	8.3	416	174	192	61.9	15.4	12.6	55.1	240	0.0038
	Feb 19/09	5	8.1	564	223	271	71.1	21.3	21.4	95.1	347	0.0059
Sphinx Lake (Hypo)	*1Mar 4/05	na	7.9	1060	304	495	118	48.7	67.3	329	748	<0.0002
	Feb 19/09	25	7.7	1100	372	509	122	48.7	62.4	294	758	<0.0002
Pit Lake CD (Epi)	*2Aug 28/04	2.5	8.3	1480	312	395	77.1	49.2	209	433	960	0.0233
	Jul 30/09	1.5	8.3	1340	354	424	83.1	52.5	161	426	940	0.0146
Pit Lake CD (Hypo)	*2Aug 28/04	15	7.9	1870	474	346	75.9	38.0	334	476	1210	0.0134
	Jul 30/09	30	8.0	1660	484	360	80.4	38.8	263	445	1120	0.0082
Pit 50A- North (Epi)	*1Aug 27/05	na	8.4	1060	290	227	48.7	25.7	158	254	664	0.034
Pit 50A- North (Epi)	*1Aug 27/05	na	7.9	1530	415	419	94.6	44.3	207	422	1020	0.0336
Lac des Roches (Epi)	*3Aug 9/91	1	8.39	na	298	165	41.1	15.3	94.9	72.2	345	0.0025
Lac des Roches (Epi?)	*3Aug 9/91	10	8.38	na	334	148	41.3	14.9	111	73.1	352	0.0037
Lac des Roches (Epi)	*3Jul 21/93	1	8	na	267	123	27.4	13.2	156	156	515	0.007
Emerald Lake (Epi)	*4May15/79	1	8.3	260	na	na	44.8	na	<2.3	19.2	214	na
	*5Jan 8/81	top	8.28	260	na	na	38	11	2	19	224	na
	*6Jul 21/86	na	8.3	na	117	140	40	10	<2	22	143	na
Emerald Lake (Hypo)	*4May15/79	bottom	8.3	260	na	na	44.8	Na	<2.3	14.4	180	na
	*5Jan 8/81	bottom	8.4	250	na	na	39	11	2	17	217	na

(Sources: *1Boorman (2006), *2Stemo (2005), *3Luscar (1994), *4MacNeil (1979), *5Fitch (1981), *6English (1986)).

4.1.2.2 Sphinx Lake – Specific Conductance

Specific conductance and electrical conductivity were recorded in Sphinx Lake in 2009. Specific conductance was however, not recorded in 2008. Specific conductance values calculated using electrical conductivity and temperature readings in 2008 appear to have a range of values similar to the recordings in 2009 (Figure 13). Historical specific conductance information for Sphinx Lake is not available.

Pisces Environmental Consulting measured conductivity in Sphinx Lake prior to construction and connection of the inlet and outlet channels in 2005. Conductivity values between 500 and 600 uS/cm were observed in the upper 3 m and between 600 and 700 uS/cm at 4 m and 5 m depth in August 2005. A complete 30 m profile was conducted in October 2005 with values near 400 uS/cm observed in the upper 5 m and values near 600 uS/cm from 7 m to 30 m water depth (Boorman 2006). The conductivity values recorded during the present study period ranged from 285 uS/cm to 724 uS/cm on August 29, 2009 and from 266 uS/cm to 681 uS/cm on October 20, 2009. Although conductivity is temperature dependent and less useful for comparative purposes, the conductivity readings taken in 2009 and 2005 suggest that water quality in the upper portion of the lake has improved since 2005.

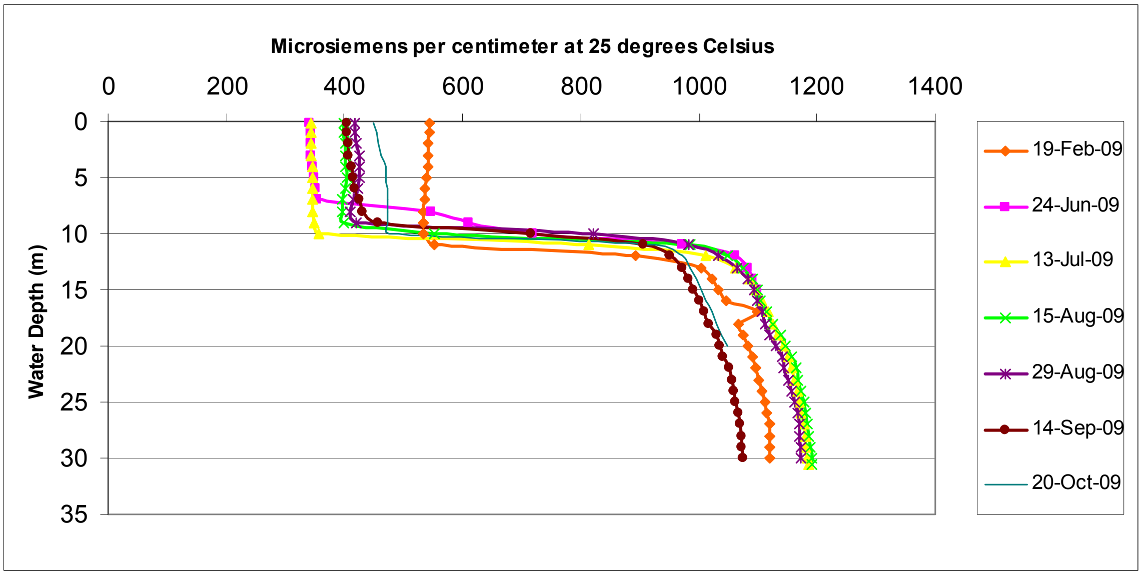

Figure 13: Specific conductance vertical profiles in Sphinx Lake in 2009.

4.1.2.3 Pit Lake CD – Specific Conductance

Specific conductance and electrical conductivity were recorded in Pit Lake CD in 2009. Specific conductance was, however, not recorded in 2008. Specific conductance values calculated from electrical conductivity and temperature readings in 2008 appear to have a range of values similar to the recordings in 2009. Specific conductance values for 2009 are presented in Figure 14. Readings recorded on July 30 and September 11, 2009, have been omitted (outliers).

Conductivity and specific conductance profiles for Pit Lake CD prior to this study are not available.

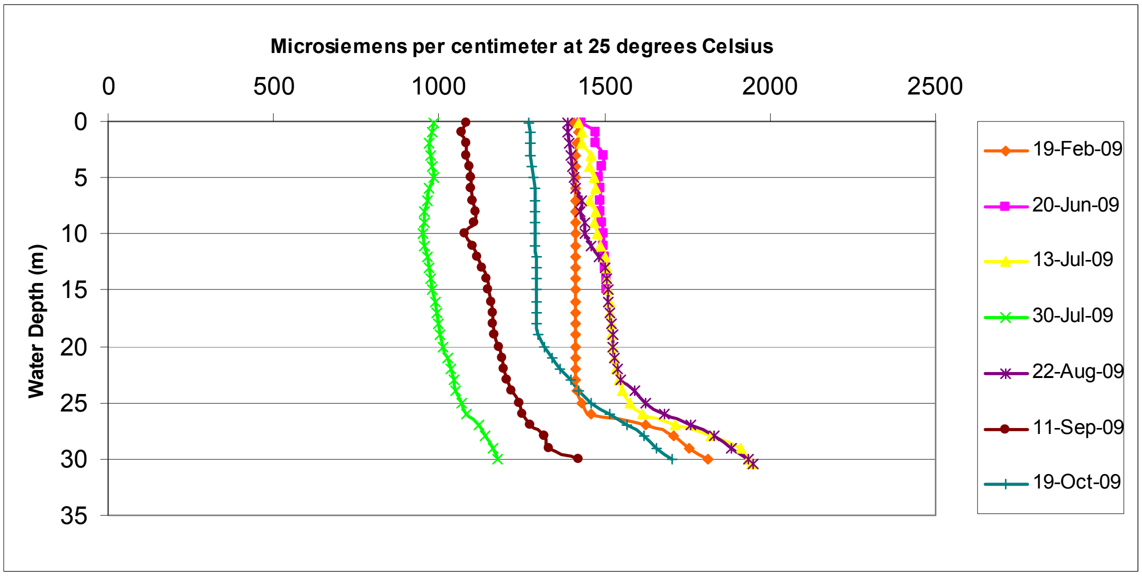

Figure 14: Specific conductance vertical profiles in Pit Lake CD in 2009.

4.1.2.4 Other Sites – Specific Conductance

Specific conductance as measured at Rawson Lake, Emerald Lake, Pit 50A-North and Lac des Roches are presented in presented in Figure 15.

Historical conductivity information for Rawson and Emerald Lake could not be located, while specific conductance profiles for Lac des Roches prior to 2009 are not available. On August 21, 2008, Golder Associates recorded conductivity readings of 1300 uS/cm near the surface and values of 1500 uS/cm at 30 m depth (Rutkowski and Christensen 2008). The observed conductivity readings recorded on August 2, 2009, had conductivity values of 986 at the surface and 830 uS/cm at 30 m depth. The corresponding specific conductance values for August 2, 2009 are shown in Figure 15.

Specific conductance profiles for Pit 50A-North prior to 2009 are unavailable; however, conductivity values for Pit 50A-North in July 2008 found readings of 1140 uS/cm near the surface and values of 1870 uS/cm at 30 m depth (Rutkowski and Christensen 2008). The conductivity readings, corresponding to the specific conductance values on August 8, 2009, (Figure 15) had values of 808 at the surface and 1040 uS/cm at 30 m depth.

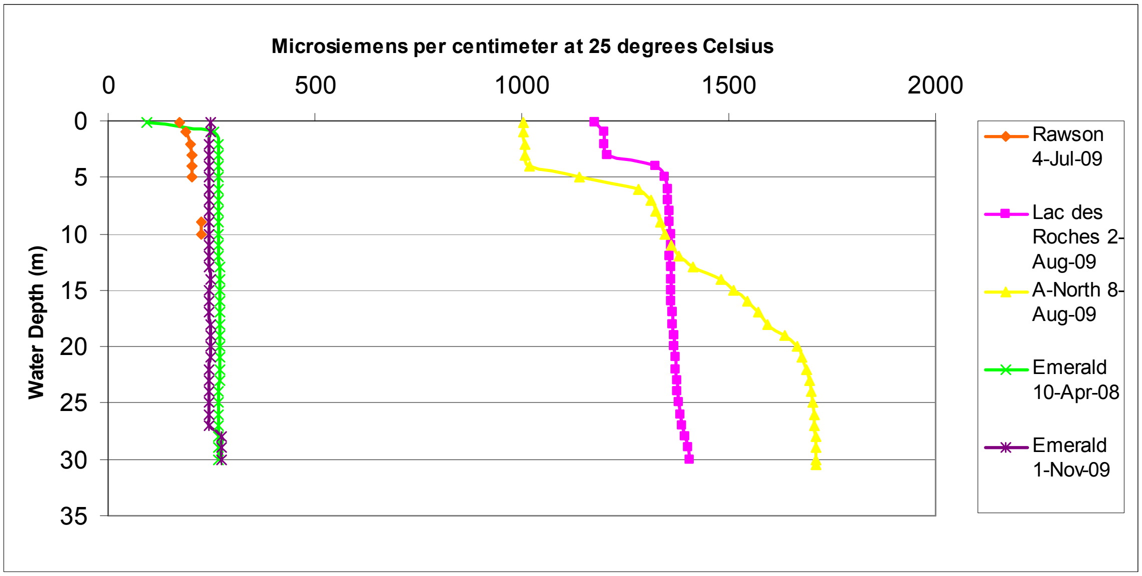

Figure 15: Specific conductance vertical profiles in Rawson Lake, Lac des Roches, Pit 50A-North and Emerald Lake as recorded in 2008 and 2009.

4.1.3 Biological Attributes

4.1.3.1 Zooplankton

Zooplankton data were compiled from monitoring reports for the Gregg River and Cardinal River Mines (Stemo 2005, Boorman 2006, Pisces 2009a, Pisces 2011) along with reports and data originating from or for Alberta Sustainable Resources, Fish and Wildlife Divisions (Thompson 1978, Stelfox 1981, Mayhood 1983, Bishop 1985).

The taxa identified during previous studies and during this study period are provided in Table 5 and Table 6. Density values have been adjusted to reflect number of organisms per m^3 of water. Nomenclature for the taxa has been adjusted to meet current standards (naming conventions in the reports for some species has changed over time).

Table 5: Crustacean zooplankton taxa and densities (number/m^3) found at lake study sites.

Taxa	Sphinx Lake 2005 (Boorman 2006)	Sphinx Lake 2008 (Pisces 2009a)	Pit Lake CD 2004 (Stemo 2005)	Pit Lake CD 2009 (Pisces 2011)	Pit 50A-North 2005 (Boorman 2006)	Lac des Roches 1993 (Luscar 1994)	Lac des Roches 1991 (Luscar 1994)	Emerald Lake-1979 (Bishop 1985)	Rawson Lake-1981 (Mayhood 1983)	Rawson Lake-1975 (Thompson 1978)
Copepoda										
Acanthocyclops vernalis	30.0		902.76		11.2					
Copepodid	3.4		233.4		8.2					
Nauplii			221.8		30.6	13240				
Arctodiaptomus arapahoensis									230	440
Diaptomus sicilis				123.5						
Diaptomus tyrelli						124	28245			
diaptomid nauplii						13240	1595			
Diacyclops bicuspidatus				97.2		13140				
Diacyclops thomasi		14.67						16900		
Calanoid										
Copepodid				242.4						
Nauplii				461.0				5100		
Cyclopoid										
Copepodid		36.41		149.1						
Nauplii				85.5		34930		42500		
Eucyclops spp										
copepodid									8	
Hesperodiaptomus arcticus										4170
Leptodiaptomus sicilus	1166.2	1.26	57.36					19200		
Copepodid	56.0		3.54							
Orthocyclops modestus		60.43								
Cladocera										
Bosmina longirostris								833		
Chydorus sphaericus		1.26								
Daphnia longispina?								567		
Daphnia pulicaria						40250	3725			
Daphnia pulex	469.2		1300.98		0.04			33		
Daphnia rosea		3.79								
Daphnia schodleri										1140
Crustacean Totals	1724.8	117.83	2719.8	1158.7	49.9	114924	33565	85133	238	5750

Table 6: Rotifer zooplankton taxa and densities (number/m^3) found at lake study sites.

Taxa	Sphinx Lake 2005 (Boorman 2006)	Sphinx Lake 2008 (Pisces 2009a)	Pit Lake CD 2004 (Stemo 2005)	Pit Lake CD 2009 (Pisces 2011)	Pit 50A-North 2005 (Boorman 2006)	Lac des Roches 1993 (Luscar 1994)	Lac des Roches 1991 (Luscar 1994)	Emerald Lake-1979 (Bishop 1985)	Rawson Lake-1981 (Mayhood 1983)	Rawson Lake-1975 (Thompson 1978)
Rotifera										
Asplanchna spp.	132.5							yes		
Brachionus angularis			3.54							
Cephalobdella gibba			14.14							
Conochilus unicornis	59.38	155.92					20490			
Filinia longiseta								yes		
Kellicotia longispina	29.36				0.02			yes		
Keratella sp.						1110				
Keratella earlinae								yes		
Keratella coclearis		154.68						yes		
Keratella hiemalis		2044.44		34.2				yes		
Keratella quadrata	3109.44		813.34	136.8	28.58			yes		
Ploesoma lenticulare		155.92								
Polyartha dolichoptera			3.54		15.84			yes		
Polyartha vulgaris						7350	210	yes		
Pomopholyx sulcata	25.2		10.6							
Synchaeta oblonga							170	yes		
Trichotria pocillum						370				
Rotifera Totals	3355.9	2511.0	845.2	171	44.4	8830	20870	na	na	na

4.1.3.2 Macrophytes

A single patch of *Chara* less than 0.1 m^2 was found in Emerald Lake on the east side of the lake in 2009. No macrophytes were found in Pit 50A-North or in Rawson Lake. Rawson Lake was not, however, checked to the same degree as the other lakes due to a leaky inflatable boat. A partially dewatered Lac des Roches still had remnant stems of *Chara* present along the east end shallows in August 2009. The remnant C*hara* is not surprising given the extensive *Chara* beds which covered much of the littoral habitat on the east end of the lake in the late 1990's (Schwartz 2002).

Significant macrophyte densities were identified in Sphinx Lake and Pit Lake CD in 2008 and 2009. The only aquatic plant species identified in Sphinx Lake was *Chara* sp. The predominant species in Pit Lake CD were *Chara* sp., followed by *Potamogeton pusillus*, *Potamogeton zosteriformis* Fern., *Ceratophyllum demersum* and *Hippuris vulgaris*.

The *Chara* in Sphinx Lake in 2009 was thickest between and adjacent to the inlet channel and the island near the inlet. Chara patches were common along the east shore in 2009, and less common along the south and west shores. *Chara* was very sparse along the north shore. The occurrence of *Chara* in Sphinx Lake in 2009 is estimated to be 50 to 100% greater than the densities observed in 2008.

The aquatic vegetation found in Pit Lake CD in 2009 was more diverse (species richness) and significantly more abundant than the aquatic vegetation in Sphinx Lake. The abundance and diversity of aquatic vegetation is somewhat surprising, given the marl-like substrate covering most of the littoral areas. *Chara* was estimated to cover just over 900 m^2; *Potamogeton pusillus* was estimated at just over 200 m^2; *Potamogeton zosteriformis* Fern. at 20 m^2; *Ceratophyllum demersum* at 10 m^2; and *Hippuris vulgaris* at less than 1 m^2. The overall concentration of aquatic vegetation in 2009 is estimated to be 100 to 200% greater than in 2008.

The greatest density of aquatic vegetation in Pit Lake CD is found in the far east corner with significant patches along the south and north shores. Colonization of aquatic vegetation in Pit Lake CD is likely due in part to the activities of diving ducks that were observed frequenting the lake during late summer and early fall. The movement and dispersal of seed and plant materials by waterfowl is well documented in the literature (Figuerola and Green 2002, Mueller and van der Walk 2002).

4.1.3.3 Invertebrates

Results collected during this study and data from previous investigations are provided in Table 7. Amphipods were initially recorded in Sphinx Lake in 2008, and were much more prevalent in 2009. Amphipods were not found in Pit Lake CD in 2008, but were found in 2009.

Table 7: Invertebrates found at the lake study sites (Part 1).

Site	Taxon Shoreline Sampling	Taxon Ekman Dredge	Ekman Dredge Mean Densities n/m^2
Sphinx Lake (Eckmann sample information recorded in Pisces 2009a)	Gastropoda Coleoptera: Dytiscidae, *Hygrotus* sp. Coleoptera: Dytiscidae, *Ilybius* sp. Ephemeroptera: Siphlonuridae, *Siphlonurus* sp. Amphipoda: Gammaridae	Trichoptera: Brachycentidae, *Brachycentrus* Coleoptera: Elmidae, *Narpus* sp. Diptera: Chironomidae, Tanypodinae Diptera: Chironomidae, Orthocladinae Diptera: Chironominae, Tanytarsini Diptera: Chironominae, Chironomini Acari: Hydrachnidae, *Hydrachna* sp.	26919 (n=5, SE=6780)
Pit Lake CD (Eckmann sample information recorded in Pisces 2011)	Coleoptera: Dytiscidae, *Agabus* sp. Hemiptera: Corixidae, *Cenocorixa* sp. Coleoptera: Chrysomelidae Trichoptera: Limnephilidae, *Desmona mono* Diptera: Dixidae, *Dixa* sp. Oligochaete: Enchytraeidae Coleoptera: Gyrinidae, *Gyrinus* sp. Diptera: Chironomidae, Tanypodinae, *Thienemannimyia* group Amphipoda: Gammaridae	Trichoptera: Limnephilidae Coleoptera: Dytiscidae (larvae) Diptera: Ceratopogonidae, Ceratopogoninae Diptera: Chironomidae, Orthocladinae Diptera: Chironomidae, Tanypodinae Diptera: Chironominae, Tanytarsini Diptera: Chironominae, Chironomini Hemiptera: Corixidae (adult)	4000 (n=5, SE=1524)

Table 8: Invertebrates found at the lake study sites (Part 2).

Site	Taxon Shoreline Sampling	Taxon Ekman Dredge	Ekman Dredge Mean Densities n/m^2
Lac des Roches (Luscar 1994)		Hydra Nematoda Annelida: Oligochaeta Hirudinea Crustaceae *Gammarus/Hyalella* Ephemeroptera Trichoptera Hemiptera Diptera: Chironomidae Coleoptera Acari Gastropoda Pelecypoda	Variability ranged from 207 in June 1988 to 105333 in July 1993
Emerald Lake (Bishop 1985)		Amphipoda: Gammaridae Diptera: Chironomidae	Between 64 and 150
Rawson Lake (Thompson 1978)		*Hyallela azteca* Pelecypoda: Sphaeriidae, *Pisidium* sp. Diptera: Chironomidae (Tendipedidae) Plecoptera: Perlodidae	1660
Rawson Lake (Mayhood 1983)		Nematoda Annelida: Oligochaeta Copepoda Trombidformes, Hydracarina Plecoptera Diptera: Chironomidae Pelecypoda: Sphaeridae	2795

4.1.3.4 Fish Communities

Fisheries information collected during this study is provided for Sphinx Lake and Pit Lake CD in 2008 and 2009. Historical information for Lac des Roches, Emerald Lake and Rawson Lake is available and has been presented for comparison. No fish currently inhabit Pit 50A-North. For the sake of simplicity, fisheries information specific to the lake environments will be presented in this section. Data pertinent to both the lake and stream environments, including trapping information, will also be presented within this section.

4.1.3.4.1 Sphinx Lake

The earliest documentation of the fisheries in Sphinx Lake is found in Pisces (2008a). Further documentation of the fishery in Sphinx Lake is found in Pisces (2009a), with the latter investigation running concurrently and in cooperation with this study.

As indicated previously, the connection of Sphinx Lake and Sphinx Creek was realized in the fall of 2005. Estimated densities of RNTR upstream and downstream of the diversion culvert varied from 1.89 fish/100 m^2 to 2.11 fish/100 m^2 weeks prior to the connection (Pisces 2006). A single Bull trout (BLTR) was also captured in the creek upstream of the lake during the same time period and may have been one of 5 BLTR transferred upstream of the existing diversion culvert in the summer of 2005 as part of the migratory BLTR trapping operation commissioned by the mine. It is expected that the recruitment of RNTR and BLTR into the lake would have occurred soon after connection.

A summary of the trapping results for RNTR at the outlet of Sphinx Creek in 2008 is found in Table 9. A total of 23 RNTR were not PIT-tagged due to size. This included RNTR with fork lengths ranging from 29 to 70 mm. These smaller trout were likely comprised of young-of-the-year (hatched in 2008) and small yearlings (hatched in 2007).

Rainbow trout movements through the trap varied from single recorded movements to a maximum of seven recorded movements by the same fish. The most common recorded movements in 2008 were single recorded movements upstream or single recorded movements downstream. The final direction of movement recorded for most fish in 2008 was moving upstream into the lake.

In addition to the RNTR, two immature BLTR were captured moving upstream into the lake. The same two BLTR were captured a few days later moving downstream of the lake.

Physical abnormalities for RNTR captured in the trap in 2008 included several fish with minor fin damage, three lower jaw deformities (possible angling injuries) and one shortened operculum.

Trap shutdowns and high water allowed undetected fish movement into and out of the lake, during the open water season. Several fish, whose final movements were recorded as moving downstream in 2008, were captured in the lake during the lake population estimate work performed by Pisces Environmental in October 2008 (Pisces 2009a). Spawning in the outlet channel upstream of the trap was documented in 2008.

Table 9: Summary statistics for Rainbow trout (RNTR) captured downstream of Sphinx Lake outlet in 2008.

	Moving Downstream	Moving Upstream	Moving U/S or D/S
Capture Events	107	129	236
Total Individuals	87	118	167
Mean Fork Length-All Individuals	190 mm	146 mm	160 mm
Range of Fork Lengths-All Fish	29-441 mm	32-327 mm	29-441 mm
Final Individual Movements –PIT-tagged fish only	55*	89	144
Mean Fork Length – PIT-tagged individuals	200 mm	164 mm	178 mm
Number of confirmed ripe or spent females	14	13	23
Number of suspected ripening or spent females	16	6	14
Mean Fork Length of confirmed and suspected females	246 mm	257 mm	249 mm
Range of Fork Lengths for confirmed and suspected females	181-441 mm	177-327 mm	177-441 mm
Capture date for first confirmed ripe male	May 30	May 31	May 30
Capture date for first confirmed ripe female	May 31	June 3	May 31
Capture date for last confirmed ripe male	June 30	July 20	July 20
Capture date for last confirmed ripe female	June 27	June 22	June 27
* This number includes 3 females, captured moving downstream and used in the incubation experiment. These fish were released directly back into the lake after being stripped of their eggs.			

A summary of the trapping results for RNTR at the outlet of Sphinx Creek in 2009 is found in Table 10.

A total of 109 RNTR were not PIT-tagged due to size. This included RNTR with fork lengths ranging from 26 to 91 mm. These smaller trout were fin-clipped and likely consisted of young-of-the-year (hatched in 2009) and small yearlings (hatched in 2008). An additional 10 recapture events of these 109 RNTR occurred in the trap in 2009.

Rainbow trout movements through the trap varied from single recorded movements to a maximum of eight recorded movements through the trap. The most common recorded movements were a single recorded movement upstream or a single recorded movement downstream. The final direction of movement for most PIT-tagged fish was recorded as moving downstream of the lake. The biomass of fish with a final recorded movement into the lake (5734 g) was, however, greater than the biomass of fish exiting the lake (5314 g).

In addition to the RNTR, one immature BLTR was captured moving upstream into the lake.

Physical abnormalities for RNTR captured in the trap in 2009 included several fish with minor fin damage, one lower jaw deformity (possible angling injury), one shortened operculum, and one spinal deformity (possible electro-fishing injury).

Trap shutdowns and high water allowed undetected fish movement into and out of the lake during the open water season in 2009. Spawning in the outlet channel upstream of the trap was again documented in 2009.

Complete capture records for 2008 and 2009 are found in Appendix A.

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Table 10: Summary statistics for Rainbow trout captured downstream of Sphinx Lake outlet in 2009.

	Moving Downstream	Moving Upstream	Moving U/S or D/S
Capture Events	203	133	336
Individuals	186	116	256
Mean Fork Length-All Individuals	133 mm	141 mm	125 mm
Range of Fork Lengths-All Fish	26-358 mm	41-357 mm	26-358 mm
Final Individual Movements – PIT-tagged fish only	73*	63	136
Mean Fork Length – PIT-tagged individuals	177 mm	181 mm	173 mm
Number of confirmed ripe or spent females	24	12	26
Number of suspected ripening or spent females	15	8	16
Mean Fork Length of confirmed and suspected females	241 mm	252 mm	248 mm
Range of Fork Lengths for confirmed and suspected females	170-358 mm	171-357 mm	170-358 mm
Capture date for first confirmed ripe male	May 30	May 30	May 30
Capture date for first confirmed ripe female	May 30	June 4	May 30
Capture date for last confirmed ripe male	June 20	July 7	July 7
Capture date for last confirmed ripe female	June 17	June 26	June 26
* This number includes 2 females, captured moving downstream and used in the incubation experiment. These fish were released directly back into the lake after being stripped of their eggs.			

A fish trap was also installed in the inlet channel upstream of Sphinx Lake in 2009. A total of seven fish were recorded moving in the upstream direction and four fish were recorded in the downstream direction. Undetected fish movement upstream or downstream of the trap may have occurred between July 8 @ 14:40 and July 12 @ 17:00 due to high water conditions.

Of the seven movements upstream, four movements were RNTR and three movements were BLTR. Two of the RNTR were ripe females, one RNTR was a ripe male and one

RNTR was unknown. The two ripe RNTR females were captured on June 26 while the ripe male and other undetermined RNTR were captured on July 25. The average fork length for RNTR was 251 mm, ranging in size from 194 mm to 321 mm. The sex of the three BLTR could not be confirmed. The BLTR were captured moving through the upstream trap between July 22 and August 3. The average fork length of the BLTR was 366 mm, ranging in size from 360 to 369 mm.

The four movements downstream were made up of three BLTR and one RNTR. The single RNTR captured moving downstream had been intercepted moving upstream several days previous. The RNTR had lost 34.5 grams in weight and appeared spent. One of the BLTR moving downstream was also intercepted moving upstream the day previous. The weight of this fish did not change. Of the remaining two BLTR, one was a juvenile captured September 3 and the other one captured on September 9 was possibly a spent female.

A total of six fish captured in the inlet trap were previously PIT-tagged. All three BLTR and one RNTR had previously been captured in Sphinx Lake during angling surveys in the fall of 2007 or 2008. The remaining two RNTR were previously captured in the outlet trap in 2008.

Detailed capture data is presented in Appendix A.

Growth rates for Sphinx Lake fish, marked in the trap in 2008 and recaptured in the trap in 2009 are provided in Table 11 and Table 12 All individuals were recorded as being captured leaving the lake in 2009, had final movements into the lake in 2008, or were angled in the lake in 2008.

The population estimate for RNTR (greater than 190 mm) living in Sphinx Lake in 2008 varied from 156 to 195 individuals, with 95% confidence intervals ranging from 103 to 292 (Pisces 2009a). Additionally BLTR are inhabiting Sphinx Lake, with more than a dozen different adult BLTR caught by angling in Sphinx Lake in 2007 (Pisces 2008a), 2008 and 2009.

Table 11: Growth rates for Sphinx Lake Rainbow trout from 2008 to 2009 (shading denotes spent or probable spent females (Part 1)).

RNTR PIT# & Sex	Capture Date 2009	Fork Length (mm)	Weight (g)	Capture Date 2008	Fork Length (mm)	Weight (g)	Growth per day FL(mm)	Growth Per day (g)
46775D164B unknown	23-Jul	129	21.3	28-Aug	97	9.9	0.10	0.03
466A5D3C2E male	16-Jun	162	57.7	6-Jun	121	22	0.11	0.10
4676036117 male	8-Jun	202	84.5	30-Jun	127	21	0.22	0.19
4665237472 female	26-Jun	183	76	21-Jul	128	23.7	0.16	0.15
46616A3556 female	11-Jun	177	74.2	21-Jul	128	21.7	0.15	0.16
46622E2829 female	11-Jun	197	87.1	19-Jul	131	22.7	0.20	0.20
4677536A2F male	21-Jun	187	66.6	1-Jul	132	23.8	0.15	0.12
46652C7806 female	5-Jun	190	87.1	19-Jul	134	25.2	0.17	0.19
4676087828 male	5-Jun	205	85.2	3-Jun	136	26	0.19	0.16
46613C312A male	30-May	190	73.2	21-Jul	136	25.6	0.17	0.15
46774C1710 male	26-Jun	215	94.5	18-Jun	141	28	0.20	0.18
4675791C55 unknown	31-Jul	214	100.3	21-Jun	145	30	0.17	0.17
4677612F73 unknown	14-Aug	205	96.3	21-Aug	145	35.7	0.17	0.17
46776A4F2D male	18-Jun	223	111.9	30-May	146	37	0.20	0.20
46620C7F53 female	31-May	202	98.8	21-Jul	147	32	0.18	0.21
4661425342 male	3-Aug	223	109.5	7-Jun	148	36	0.18	0.17
46630F3155 Female	20-Jun	186	62.2	1-Aug	152	36.5	0.11	0.08
4664044019 male	15-Jun	208	87.3	22-Jun	153	38	0.15	0.14
46644A0D42 unknown	29-Jun	176	54.1	13-Sep	157	40	0.07	0.05
4665257003 female	3-Jun	241	173	9-Jun	181	83	0.17	0.25
4664493B62 unknown	24-Jun	244	142.2	13-Jul	203	98.7	0.12	0.13
466A6A4365 female?	22-Jun	249	153.6	9-Jun	205	114	0.12	0.10
46612D3F3A female	30-May	220	159.5	2-Jun	207	131	0.04	0.08
46773B5D7E female	6-Jun	230	159.0	18-Jun	212	130	0.05	0.08

Table 12: Growth rates for Sphinx Lake Rainbow trout from 2008 to 2009 (shading denotes spent or probable spent females (Part 2)).

4867750A2F female	31-May	270	234.2	7-Jun	222	146	0.13	0.25
465F6F007F female?	10-Jun	255	220.8	17-Jun	226	149	0.08	0.20
4871766059 female	8-Jun	283	278	22-Jun	232	165	0.15	0.32
46614D1230 female	10-Jun	289	281	27-Jun	247	187	0.12	0.27
4677733279 female	12-Jun	270	241.8	27-Jul	248	155.2	0.07	0.27
4675597147 female?	10-Jun	272	244.5	1-Jun	249	192	0.06	0.14
4676065A23 female	13-Jun	287	278	21-Jun	259	209	0.08	0.19
4677685546 female	16-Jun	307	251.4	25-Jun	268	151	0.11	0.28
466A531574 unknown	20-Jul	297	232.5	1-Jul	272	204.3	0.07	0.07
4662615C7E female	14-Jun	328	337	28-Jun	281	197	0.13	0.40
466A480B2A female	30-May	329	451.0	3-Jun	301	337	0.08	0.32
						Mean	0.13168	0.17653
						Standard Error	0.0084	0.01388
						Standard Deviation	0.04970	0.08211
						Sample Variance	0.00247	0.00674

4.1.3.4.2 Pit Lake CD

Pit Lake CD first reached full supply level and began flowing at the outlet during the fall of 2002 (Brand 2009a). It is suspected that RNTR recruited into the lake slowly, given that Falls Creek enters the Gregg River at a substantial waterfall. Smaller waterfalls and steep gradients in Falls Creek downstream of the lake likely hinder fish recruitment upstream out of the Gregg River. No fish were observed in Pit Lake CD during limnological investigations in 2004 and 2005 (Stemo 2005). Falls Creek was generally considered to be a fishless system prior to mining, with the creek reportedly freezing solid and ceasing to flow in the winter months (Slaney 1975).

A summary of the trapping results for RNTR at the outlet of Pit Lake CD in 2008 are found in Table 13. All RNTR were large enough to be PIT tagged. Based on the size cohorts present, no young-of-the-year were captured in 2008.

Movements of individual RNTR varied from one to five. The most common recorded movement was a single recorded movement upstream. The final direction of movement recorded for most fish was moving upstream into the lake.

Physical abnormalities for RNTR captured in the trap in 2008 included several fish with minor fin damage, two fish with protruding eyes and one spinal deformity.

Trap shutdowns may have allowed for undetected fish movement into and out of the lake during the open water season. The duration and timing of the shutdowns would suggest that no more than 10% of the fish movements during the open water season would have been missed.

Table 13: Summary statistics for Rainbow trout captured downstream of Pit Lake CD outlet in 2008.

	Moving Downstream	Moving Upstream	Moving U/S or D/S
Capture Events	28	140	168
Individuals	27	132	135
Mean Fork Length-All Individuals	129 mm	134 mm	133 mm
Range of Fork Lengths-All Fish	74-318 mm	74-390 mm	74-390 mm
Final Individual Movements–All Fish	10	125	135
Number of confirmed ripe or spent females	3	6	8
Number of suspected ripening or spent females	0	9	9
Mean Fork Length of confirmed and suspected females	260 mm	331 mm	319 mm
Range of Fork Lengths for confirmed and suspected females	198-318 mm	263-390 mm	198-390 mm
Capture date for first confirmed ripe male	Na	June 10	June 10
Capture date for first confirmed ripe female	June 5	June 6	June 5
Capture date for last confirmed ripe male	Na	June 29	June 29
Capture date for last confirmed ripe female	June 11	June 6	June 11

A summary of the trapping results for RNTR at the outlet of Pit Lake CD in 2009 are found in Table 14. All RNTR that were captured in the trap were PIT-tagged.

Movements of individual RNTR through the trap varied from one to eight. The most common recorded movement was a single recorded movement upstream. The final direction of movement recorded for most fish was moving upstream into the lake.

The trap was not shut down or disabled during the monitoring session. Trap avoidance likely occurred, as several large RNTR were observed upstream of the trap during the spawning run. Trap avoidance may have been substantial (perhaps as high as 50%), as only 10 female RNTR were recorded in 2009, down from the 17 female RNTR recorded in 2008. Spawning behaviors, including redd construction and males competing for females were observed multiple times, upstream of the trap. Successful fry emergence upstream of the trap was documented on July 20, 2009 as a single RNTR fry, 19 mm long, was caught in a drift net. A spawning area upstream of the trap was excavated on July 29, 2009, with 115 dead eggs being recovered from the redd.

No physical abnormalities for RNTR captured in the trap in 2009 were recorded, except for some with minor fin damage.

Complete capture records for 2008 and 2009 are found in Appendix A.

Table 14: Summary statistics for Rainbow trout captured downstream of Pit Lake CD outlet in 2009.

	Moving Downstream	Moving Upstream	Moving U/S or D/S
Capture Events	69	121	190
Individuals	45	87	95
Mean Fork Length-All Individuals	213 mm	178 mm	193 mm
Range of Fork Lengths-All Fish	132-435 mm	129-370 mm	129-435 mm
Final Individual Movements – PIT-tagged fish only	12*	83	95
Number of confirmed ripe or spent females	7	3	9
Number of suspected ripening or spent females	0	1	1
Mean Fork Length of confirmed and suspected females	385 mm	328 mm	364 mm
Range of Fork Lengths for confirmed and suspected females	282-435 mm	211-370 mm	211-435 mm
Capture date for first confirmed ripe male	May 31	May 31	May 31
Capture date for first confirmed ripe female	June 5	na	June 5
Capture date for last confirmed ripe male	June 19	July 26	July 26
Capture date for last confirmed ripe female	June 23	na	June 23
* This number includes 4 females, captured moving downstream and used in the incubation experiment. These fish were released directly back into the lake after being stripped of their eggs.			

During trapping operations in 2009, 37 RNTR were captured that had been PIT-tagged in 2008. Twenty-two of these individuals were previously captured in the Pit Lake CD trap, 13 RNTR were previously captured in Falls Creek downstream of the lake. One RNTR migrated from Sphinx Creek downstream of the lake (site-S2), while another migrated from the main stem Gregg River, downstream of Falls Creek (site-G4).

Growth rates for Pit Lake CD fish, marked in the trap in 2008 and recaptured in the trap in 2009, are provided in Table 15. All 22 individuals were recorded as being captured leaving the lake in 2009, or had final movements into the lake in 2008.

Table 15: Growth rates for Pit Lake CD Rainbow trout from 2008 to 2009 (shading denotes spent or probable spent females).

RNTR PIT# & Sex	Capture Date 2009	Fork Length (mm)	Weight (g)	Capture Date 2008	Fork Length (mm)	Weight (g)	Growth per day FL(mm)	Growth Per day (g)
4663051271 male	1-Jun	141	33.4	1-Jul	74	4	0.20	0.09
4664767019 male	4-Jun	155	49.5	21-Jun	79	5	0.22	0.13
46647A1E50 male	5-Jun	139	33.2	1-Jul	79	5	0.18	0.08
46755E3375 male	4-Jun	143	34.7	7-Jul	82	6.3	0.18	0.09
4663057328 male	31-May	138	32.3	29-Jun	84	6	0.16	0.08
46627C683A male	4-Jun	174	62.1	22-Jun	94	8	0.23	0.16
46697F5645 male	1-Jun	156	48	27-Jun	104	11	0.15	0.11
466A4A522F male	1-Jun	172	61	29-Jun	105	12	0.20	0.15
4662361F62 male	2-Jun	198	92.5	20-Jun	123	21	0.22	0.21
4663406D47 male	31-May	180	70.1	2-Sep	144	33.9	0.13	0.13
46627F5834 unknown	24-Jul	206	89.1	24-Aug	144	30.2	0.19	0.18
46772D5E6E female	5-Jun	282	279.2	6-Jul	197	84.6	0.25	0.58
4662602032 female	13-Jun	360	449.6	18-Jun	282	246	0.22	0.57
4661787710 female	17-Jun	369	471.5	18-Jun	315	325	0.15	0.40
4663394B33 male	15-Jun	362	530.8	8-Jun	318	409	0.12	0.33
4665291947 female	15-Jul	370	455	25-Jun	321	340	0.13	0.30
4662643925 female	23-Jun	386	696	21-Jun	330	382	0.15	0.86
465E67161D female	9-Jun	384	647	4-Jul	340	444	0.13	0.77
4663224D55 female	12-Jun	410	828	25-Jun	365	518	0.13	0.88
4662211B6B male	1-Jun	400	674	2-Jul	370	475	0.09	0.60
4661583F38 female	5-Jun	423	885	8-Jun	378	575	0.12	0.86
46626A2002 female	5-Jun	435	1027.8	14-Jun	390	583	0.13	1.25
*Calculation does not include weights of 4 RNTR initially captured as spent and recaptured ripe						Mean	0.16694	*0.26437
						Standard Error	0.00934	0.04659
						Standard Deviation	0.04382	0.19768
						Sample Variance	0.00192	0.03908

Population estimates for Pit Lake CD were calculated using two different mark-and-recapture scenarios for comparison purposes. The fall 2009 population estimate used a marked pool of RNTR that were captured moving into Pit Lake CD during the spring and summer of 2009. Sampling of the lake by gill netting and angling later that year was used as the capture event. A second population estimate was calculated for the spring of 2009 using fish movement data from 2008. For this estimate, fish recorded as entering Pit Lake CD during 2008 were considered the marked pool and fish captured exiting the lake in the spring of 2009 were considered the capture event.

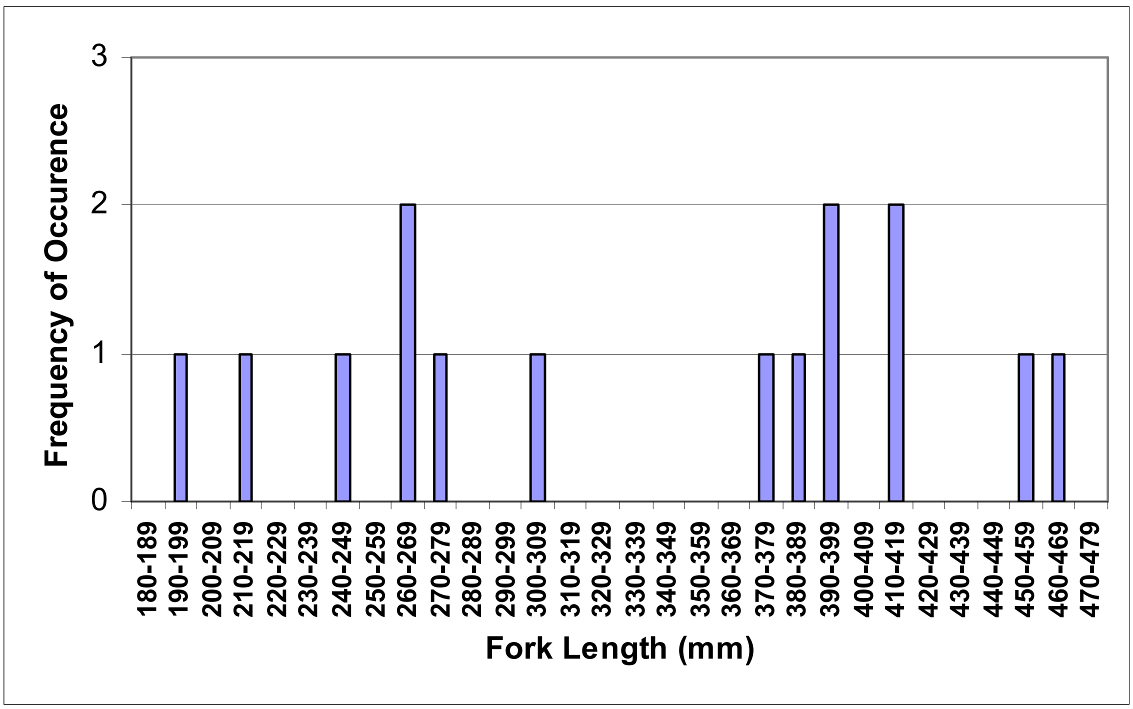

Figure 16: Length frequency histogram for Rainbow trout captured in Pit Lake CD by angling and gill netting (August 1 to September 13, 2009), n =15.

The fall 2009 population estimates were calculated using the following:

M = RNTR captured moving into the lake (fish trap May 30 to July 31) = 70

C = RNTR captured by angling and gill netting (August 1 to September 13) = 15

R = Number of RNTR captured in **C** that were previously marked in **M** = 6

The Chapman variation of the Petersen equation returned a population estimate of 162 RNTR in the lake, standard error = 43.0. The 95% confidence limits using the Poisson distribution results in a population between 81 and 355 individuals.

Program Capture (Rexstad and Burnham, 1992) returned a population estimate of 294 individuals with a standard error of 101.7. The 95% confidence interval fell between 169 and 598 individuals using this software.

The spring 2009 population estimates were calculated using the following:

M = RNTR captured moving into the lake (fish trap data from 2008) = 27

C = RNTR captured moving out of the lake (fish trap data from 2009) = 46

R = Number of RNTR captured in **C** that were previously marked in **M** = 8

The Chapman variation of the Petersen equation returned a population estimate of 146 RNTR in the lake, standard error = 41.6. The 95% confidence limits using the Poisson distribution resulted in a population between 78 and 299 individuals.

Program Capture returned a population estimate of 162 individuals with a standard error of 44.0. The 95% confidence interval fell between 107 and 291 individuals using this software.

4.1.3.4.3 Lac des Roches

During 1998 and 1999, RNTR were captured in a fish trap at the outlet of the lake in 1998 and then recaptured in a similar fashion the following year. The increase in growth of 21 individuals (aged 3 to 5 years by otolith in 1999) ranged from 28 mm to 142 mm in fork length and from 123 g to 516 g in weight (Schwartz 2002). Data for these individuals as presented in Schwartz 2002 was used to calculate the mean growth per day (Table 16).

Table 16: Growth rates for Lac des Roches Rainbow trout from 1998 to 1999 (based on Schwartz 2002), days between capture vary from 355 to 371 days, n = 18.

	Growth per day Fork Length (mm)	Growth per day Weight (g)
Mean	0.14797	0.65705
Standard Error	0.01305	0.04546
Standard Deviation	0.05537	0.19288
Sample Variance	0.00307	0.03720

Schwartz (2002) estimated that fish populations in Lac des Roches in 1998 consisted of 215 to 231 Rainbow trout, 52 to 89 Brook trout and 23 to 40 Bull trout. Statistical calculations suggested that 93% of the trout were removed during the salvage operation in 1999 (Schwartz 2002). Observations and a brief angling survey of Lac des Roches in August of 2009 suggest that few or no fish currently inhabit this water body.

4.1.3.4.4 Emerald Lake

Emerald Lake contains several species of fish. Species reported in Emerald Lake include Rocky Mountain whitefish, Rainbow trout, Cutthroat trout (CTTR), Brook trout and Longnose suckers (Clements 1972, Bishop 1985). Other species in Emerald Lake may include Lake trout and Brown trout (*Salmo trutta*), as these species have been captured in Crowsnest Lake, which connects to Emerald Lake by a small stream.

Age and growth data for Rainbow trout and suspected Cutthroat-Rainbow hybrids is sparse. Data compiled from Clements (1972) is found in Table 17.

Table 17: Age and size information for Emerald Lake Rainbow trout and hybrid Rainbow trout as described in Clements (1972).

Species	Age	Fork Length (mm)	Weight (g)
Rainbow trout	2	161	49
Rainbow trout	2	165	53
Rainbow trout	5	387	514
Rainbow-Cutthroat hybrid	2	176	51

4.1.3.4.5 Rawson Lake

No fish were captured during gill netting operations in Rawson Lake in 1975, 1976 and 1977 (Thompson 1978). Limnological investigations of the lake suggested that the lake could support a self-reproducing trout population. Rawson Lake was stocked with 6030 fingerlings in the fall of 1976 (Thompson 1978). The mean stocking rate for CTTR was approximately 2700 per year from 1977 to 1981 (Mayhood 1983). Rawson Lake has supported a recreational catch and release Cutthroat (CTTR) trout fishery for many years, without any additional fish stocking requirements (Alberta Sustainable Resource Development, 2008, 2009, 2010), strongly suggesting that the current population is self-propagating.

Sampling in Rawson Lake in 1981 and 1982 resulted in the capture of 41 CTTR. Thirty-seven 3-year-old CTTR were captured with a mean weight of 305.3 g and four 4-year-old CTTR were captured with a mean weight of 375 g (Mayhood 1983).

Fisheries observations were recorded on a trip to Rawson Lake on July 4, 2009. Cutthroat trout (estimated to be 50 to 100 individuals) were exhibiting spawning behaviours at the outlet. Fork lengths were visually estimated to range from 350 to 450 mm for the majority of the fish at the outlet. Smaller individuals were observed feeding at the surface in various areas of the lake.

4.1.3.4.6 Pit 50A-North

As mentioned previously, no fish inhabit Pit 50A-North at this time. A fish trap was however installed and operated for 96 days in 2008 in the Gregg River, downstream of the future lake outlet. Only BLTR were captured in the trap. The fork lengths of these BLTR individuals ranged from 220 mm to 340 mm with an average fork length of 264 mm. The weights ranged from 112.5 g to 364 g with an average weight of 195 g. The sex of these fish was unknown, except for a ripe male captured on August 24, 2008.

4.2 Lotic Environments

4.2.1 Physical

4.2.1.1 Habitat Inventory

Results for the habitat inventory work describing the stream section environments are compiled in Tables 18-22.

Table 18: Physical measurements of stream study sections.

Site Description	Section Length (m)	Mean Width (m)	Section Area (m2)	Other Attributes
Sphinx Creek Site S1	802.0	4.3	3481.8	Clean substrates
Sphinx Creek Site S2	950.5	4.7	4495.5	Algae prevalent on substrate. Large Beaver dam located downstream of study section
Gregg River Site G5	478.0	7.7	3677.3	Beavers tried to construct a dam in this section in 2008.
Gregg River Site G4	571.0	6.6	3743.5	Stream substrates highly concreted.
Gregg River Site G3	450.0	5.3	2390.5	Stream substrates highly concreted.
Gregg River Site G2	598.0	4.5	2707.0	Clean substrates
Settling Channel Site G2A	230.5	4.0	912.5	Stream substrates highly concreted.
Falls Creek Site F	551.0	3.1	1694.3	Stream substrates highly concreted. Two intact beaver dams within section
Berrys Creek Site B	431.0	3.8	1652.8	Aufwuchs (epi-lithic algae and organics present on rocks) are common on stream substrates.

Table 19: Prevalence of habitat components identified within the stream study sections, as described in *Table 1: Characteristics identified during habitat inventories of the study sections (based on 0'Neil and Hildebrand 1986).*

Site	%RF	%R1/P1	%R2	%R3	%P2	%P3	%F1/F2	%F3	%CA	%Other
Sphinx Site S1	39.4	1.6	1.3	42.3	2.6	0.9	0	0.2	11.9	0
Sphinx Site S2	35.4	0.2	1.7	56.8	1.6	0.7	1.3	1.0	1.20	0.1
Gregg Site G5	38.3	2.0	7.5	52.0	0	0.2	0	0	0	0
Gregg Site G4	49.5	0	2.1	46.7	0	1.6	0	0.1	0	0
Gregg Site G3	63.6	0	0	35.4	0	0.3	0	0	0.6	0
Gregg Site G2	55.0	0	0.4	37.4	0.6	1.0	0	0	5.5	0
Gregg G2A	25.5	15.8	0	36.1	0	7.0	0	0	15.6	0
Falls Site F	18.3	0.5	5.6	35.4	2.1	2.0	3.7	12.4	19.6	0.5
Berrys Site B	47.3	0	0.5	42.1	0	0.6	0	0.2	9.4	0

Table 20: Percentage of instream cover identified at each site.

Site	%Woody Debris	%Overhanging Bank	%Overhanging Vegetation	%Boulder Garden	%Aquatic Vegetation
Sphinx Site S1	1.2	1.3	0.6	2.6	
Sphinx Site S2	1.1	1.1	0.4	3.2	0.3
Gregg Site G5	0.9	0.7	0.1	0.5	
Gregg Site G4	0.8	0.1	0.2	0.9	
Gregg Site G3	0.4	0.2	0.6	2.1	
Gregg Site G2	0.1	0.4	0.4	2.4	
Gregg G2A	0.2	0.1	0.2	3.0	0.1
Falls Site F	12.0	3.2	7.8	3.7	1.0
Berrys Site B	1.3	1.2	1.6	2.3	

Table 21: Percent occurrence of various streambed substrates identified at each site.

Site	%Fines	%Gravel	%Cobble	%Boulder	%Bedrock
Sphinx Site S1	0.9	27.8	40.4	29.9	1.1
Sphinx Site S2	2.4	18.1	36.2	41.2	2.1
Gregg Site G5	3.6	29.5	39.8	25.3	1.7
Gregg Site G4	2.1	26.5	31.0	31.9	8.5
Gregg Site G3	0.9	21.0	37.2	36.6	4.4
Gregg Site G2	0.3	16.7	48.4	32.9	1.7
Gregg G2A	29.0	7.5	29.9	32.5	1.1
Falls Site F	41.4	6.4	12.2	40.0	0
Berrys Site B	0.8	12.45	46.3	38.4	2.1

Table 22: Percent occurrence of predominant riparian habitat immediately adjacent to the channel at each site as described in *Table 1: Characteristics identified during habitat inventories of the study sections (based on 0'Neil and Hildebrand 1986).*

Site	%Gr/Sh	%Gr/Tr	%Gr/Exp	%Gr	%Sh/Tr	%Sh/Exp	%Sh	%Tr/Exp	%Tr	%Exp
Sphinx Site S1	15.4	8.0	1.6	0.0	63.5	5.7	0.0	0.7	0.0	5.2
Sphinx Site S2	32.3	6.6	3.3	0.0	28.8	22.7	0.0	0.8	0.0	5.5
Gregg Site G5	56.8	0.0	18.7	0.0	4.8	12.3	0.0	7.3	0.0	0.0
Gregg Site G4	59.5	8.2	1.3	0.0	27.2	1.2	0.0	1.8	0.0	0.7
Gregg Site G3	84.1	0.0	1.3	0.0	4.1	7.8	0.0	0.0	0.0	2.7
Gregg Site G2	100	0	0	0	0	0	0	0	0	0
Gregg G2A	54.0	0.0	4.3	0.0	36.4	5.2	0.0	0.0	0.0	0.0
Falls Site F	27.0	4.8	2.0	4.4	46.6	0.0	15.3	0.0	0.0	0.0
Berrys Site B	38.2	5.3	2.1	0.0	53.9	0.5	0.0	0.0	0.0	0.0

4.2.1.2 Climatic Variables

Weather station data includes air temperature, lake water temperature, solar radiation and relative humidity at Sphinx Lake during much of the 2008 open water season. A summary of the information is presented in Figure 17, Figure 18 and Figure 19.

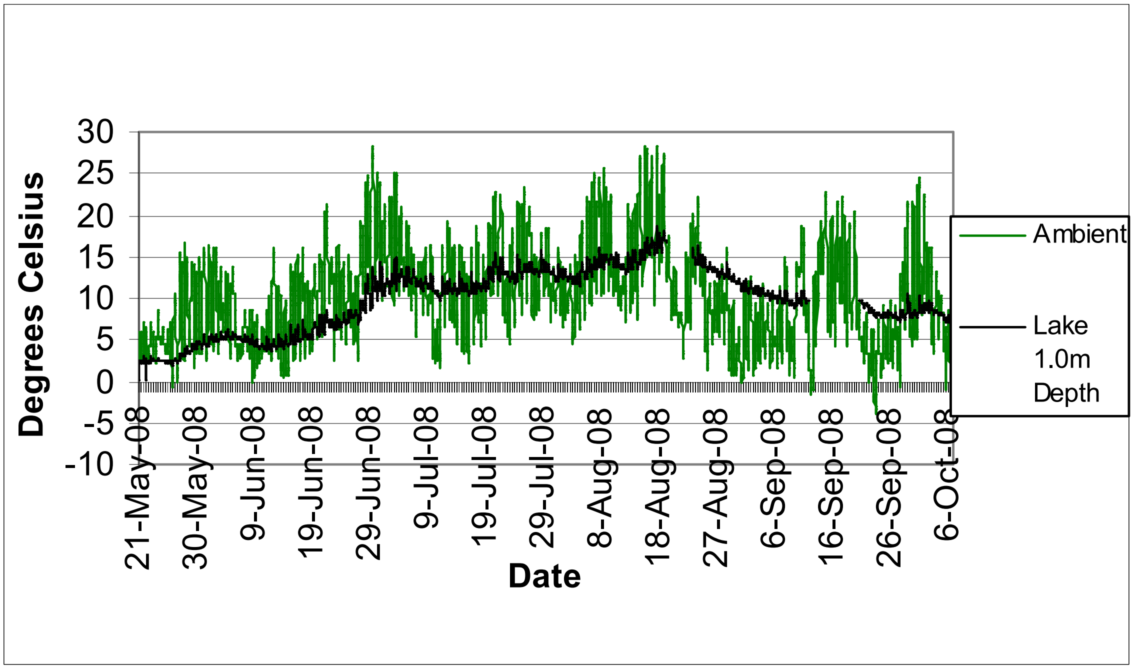

Figure 17: Air and lake water temperatures as measured at the Sphinx Lake weather station, May-Oct 2008.

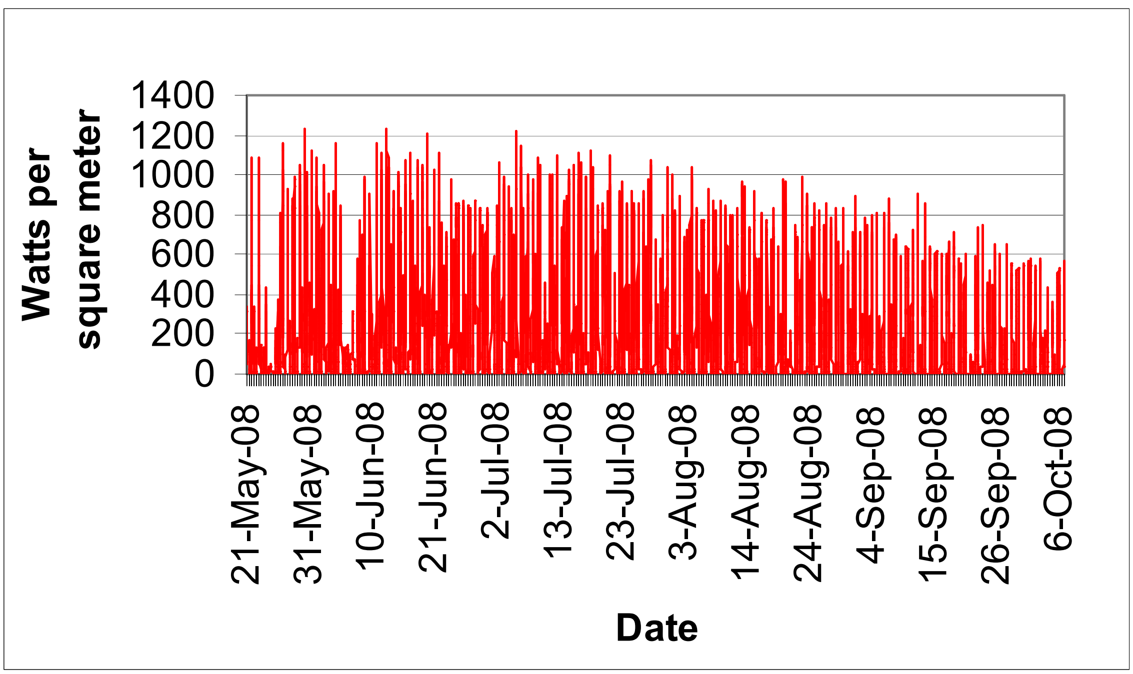

Figure 18: Solar radiation values as measured at the Sphinx Lake weather station, May-Oct 2008.

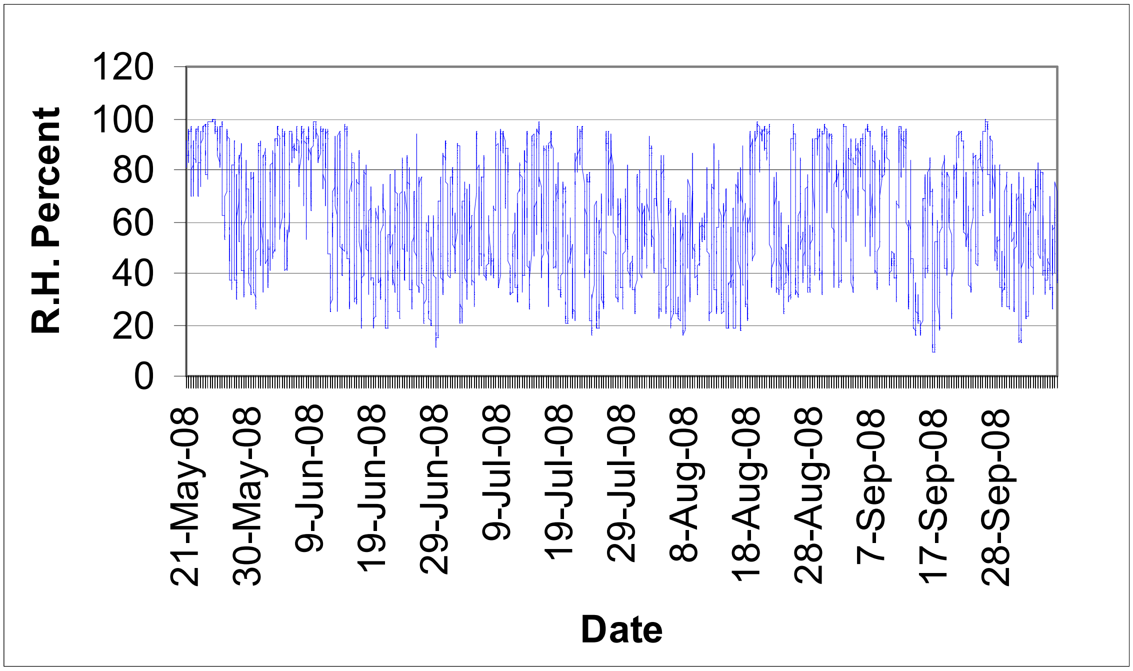

Figure 19: Relative humidity as measured at the Sphinx Lake weather station, May-Oct 2008

Temperature data logger information for the stream sites are not continuous as several data loggers were lost or malfunctioned during the study period. Data for all sites except Berrys Creek are presented in Figures 20 to 23.

Water temperatures during RNTR egg incubation influence fry emergence. The average hourly water temperature in Sphinx Creek, upstream of Sphinx Lake from June 1 to July 15 was 5.3ºC in 2008 and 4.8 ºC in 2009. The average hourly water temperature from June 1 to July 15, 2008 in Sphinx Creek, downstream of Sphinx Lake, ranged from 7.7ºC to 7.9ºC. The average hourly temperature in 2009 ranged from 7.6ºC to 7.7ºC. The maximum hourly temperature from June 1 to July 15 in Sphinx Creek downstream was recorded at 14.5ºC in 2008 and 12.2ºC in 2009. Falls Creek temperatures from June 1 to July 15, 2008 downstream of Pit Lake CD averaged 10.9ºC, with a maximum temperature of 16.8ºC. Over 80 hourly temperature readings exceeding 15ºC were recorded in Falls Creek before July 7, 2008. Falls Creek hourly temperatures from June 13 to July 15, 2009 were an average of 11.2ºC with a maximum temperature of 13.3ºC.

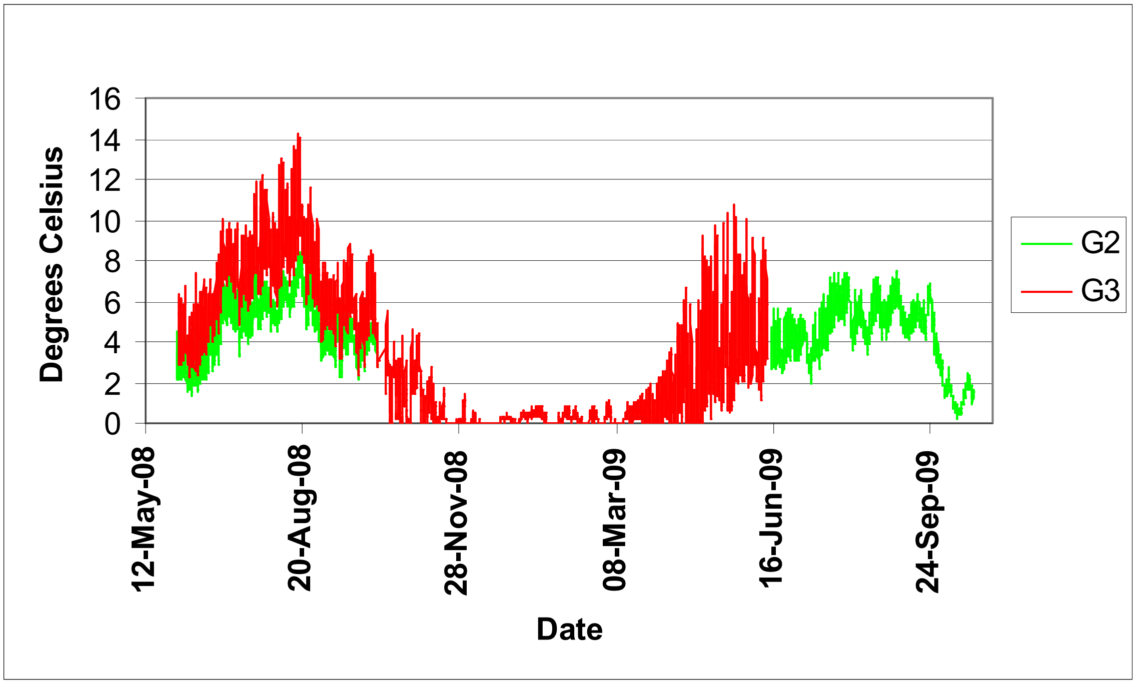

Figure 20: Stream water temperatures at Gregg River sites G2 (below diversion culvert) and G3 (upstream of Berrys Creek).

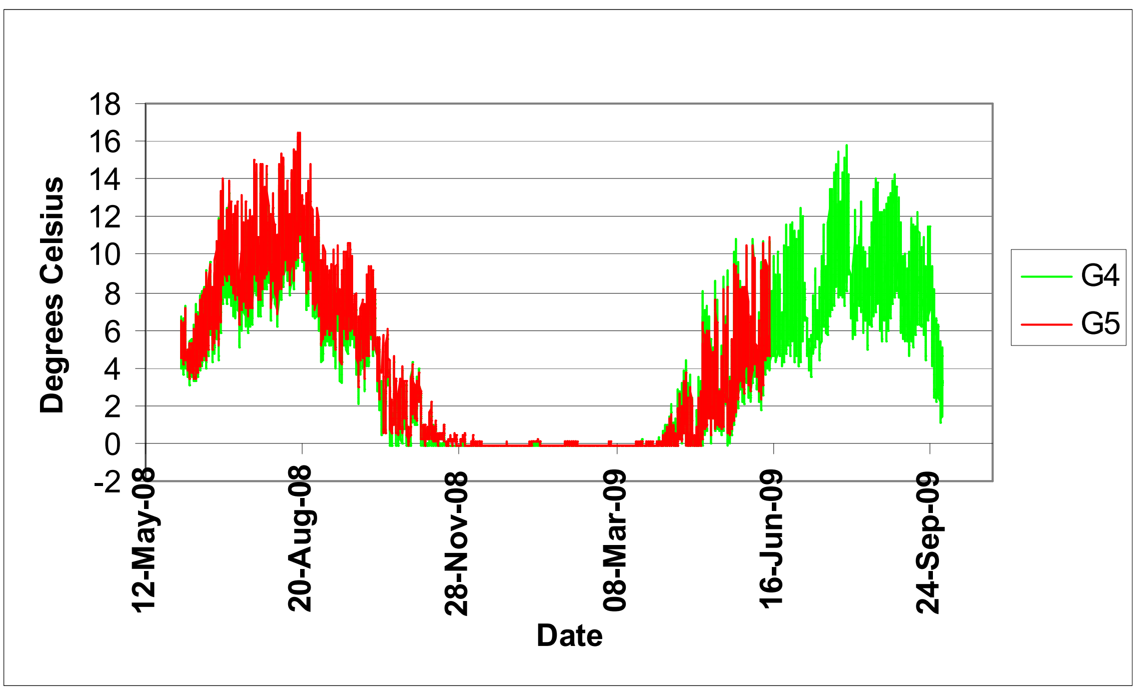

Figure 21: Stream water temperatures at Gregg River sites G4 (downstream of Falls Creek) and G5 (downstream of Sphinx Creek).

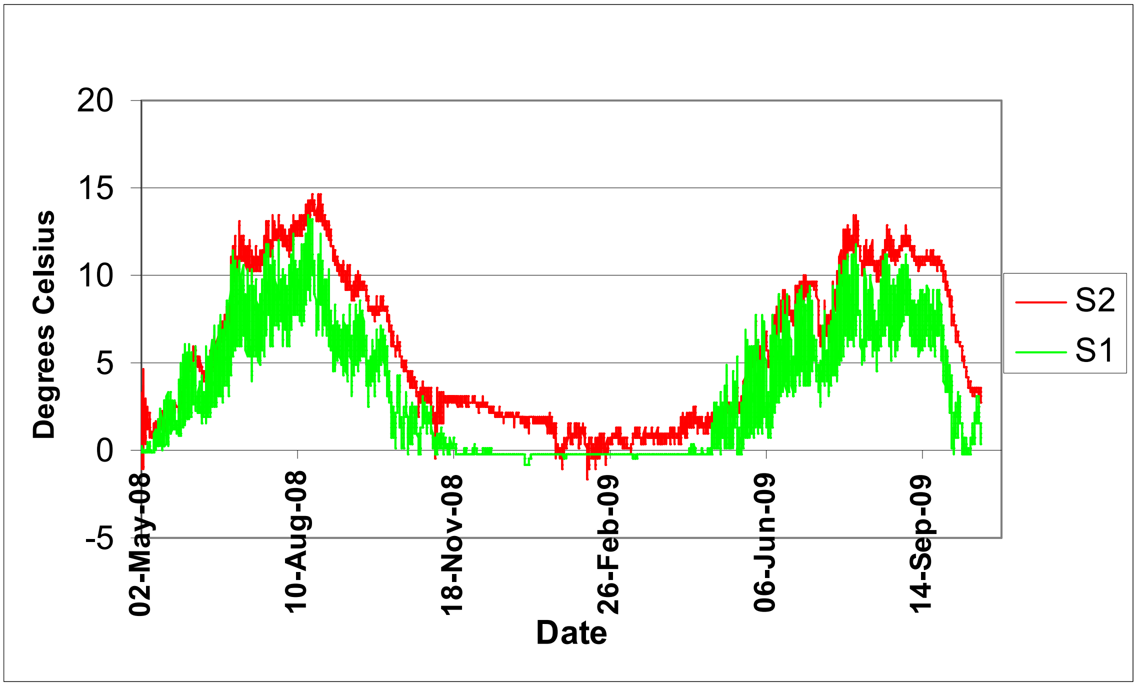

Figure 22: Stream water temperatures in Sphinx Creek at S1 (upstream of Sphinx Lake), and S2 (Sphinx Creek downstream of the lake).

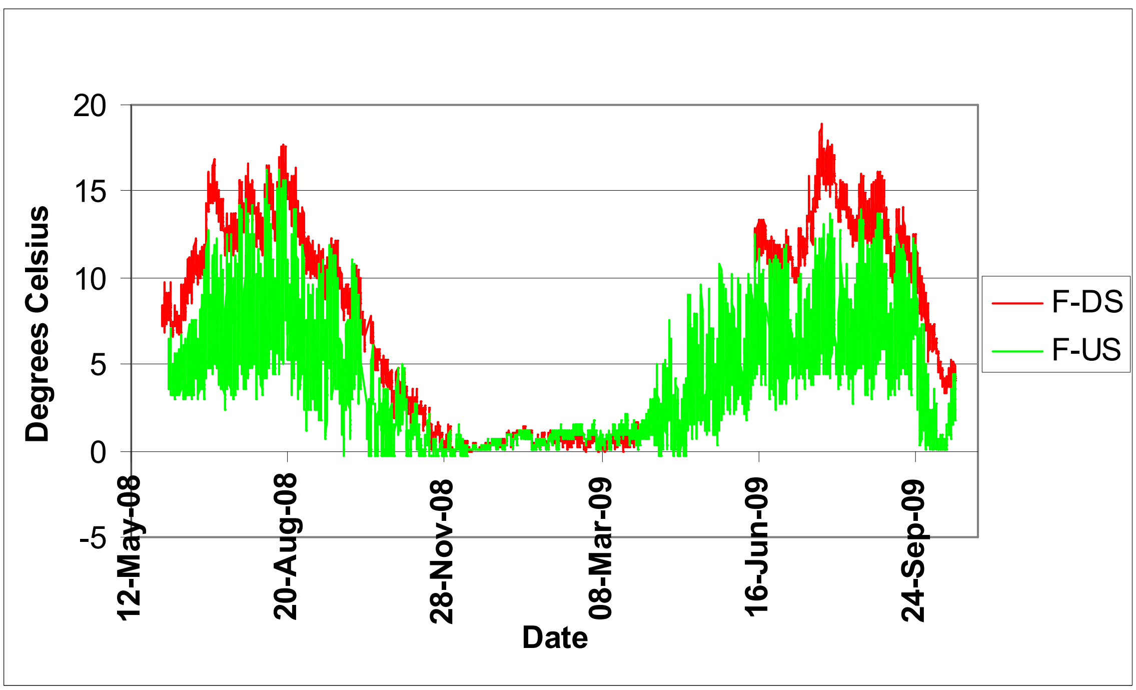

Figure 23: Stream water temperatures at F-DS (Falls Creek downstream of Pit Lake CD) and F-US (Falls Creek entering Pit Lake CD).

During the study period, data loggers recorded 2953 coinciding stream temperature readings at each of the sites. These readings included stream temperatures taken during all seasons. The warmest mean temperature was Falls Creek downstream of Pit Lake CD with the upper Gregg River, below the diversion culvert having the coolest mean temperature (Table 23).

Table 23: Statistical differences and ranking of stream temperatures using Tukey HSD, n = 29530, α=0.05.

Level									Least Sq Mean
Falls Creek downstream of Pit-lake CD - F	A								11.811029
Sphinx Creek downstream of Sphinx Lake - S2		B							10.022763
Sphinx Creek immediately downstream of Sphinx Lake		B							9.835415
Gregg River downstream of Sphinx Creek - G5			C						8.474734
Gregg River downstream of Falls Creek - G4				D					7.875679
Gregg River upstream of Berrys Creek - G3					E				6.867000
Sphinx Creek upstream of Sphinx Lake - S1					E	F			6.741372
Falls Creek at the inlet of Pit-lake CD						F			6.557321
Berrys Creek – B							G		5.189499
Gregg River at the diversion culvert - G2								H	4.784968

Levels not connected by same letter are significantly different

4.2.1.3 Stream Discharges

Sphinx Creek, Falls Creek, and Berrys Creek are the major tributaries entering the Gregg River as it flows through the mine lease areas. The associated discharges measured and calculated in 2008 and 2009 are provided in Figure 24 and Figure 25. Several unnamed tributaries along with Camp Creek and Cabin Creek also contribute some flow into the main stem of the Gregg River within the area for much of the year. Stream rating curves are provided in Appendix A.

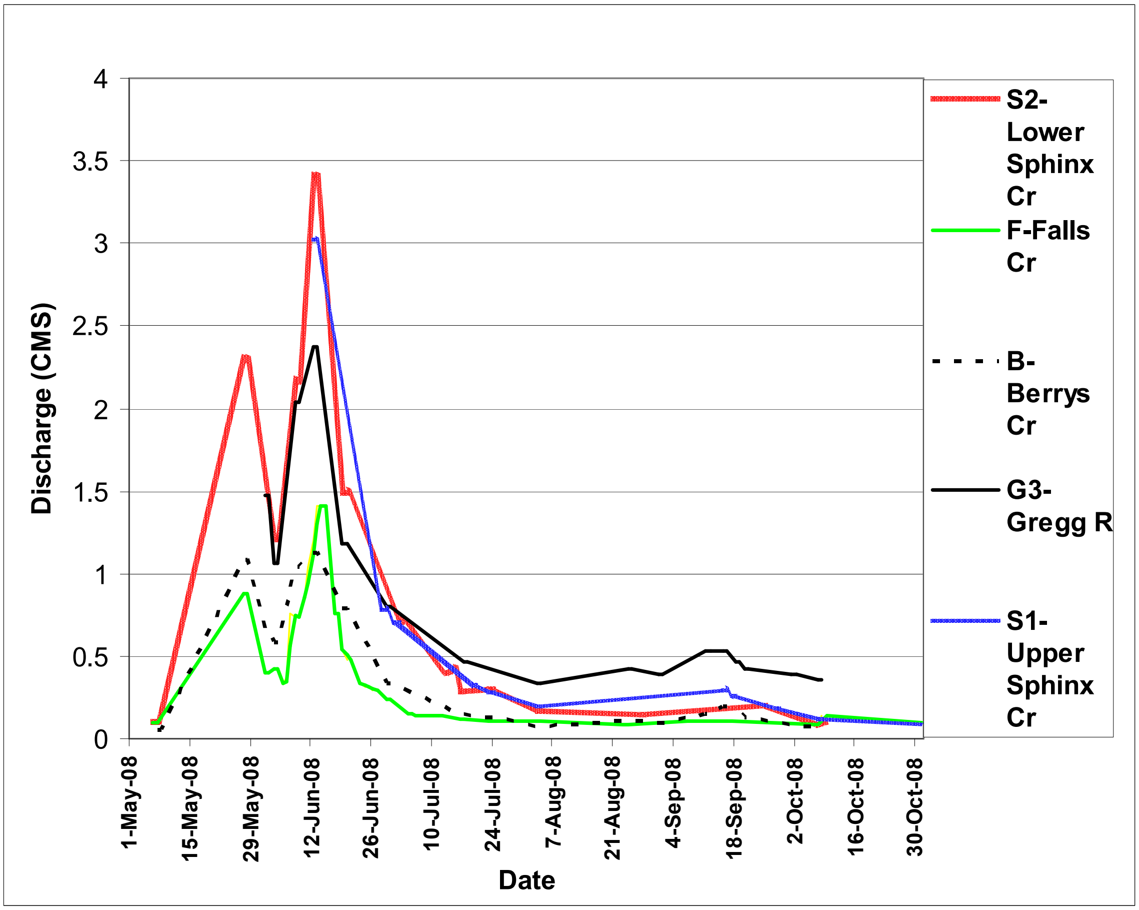

Figure 24: Hydrograph depicting flows at study sites during the 2008 open water season.

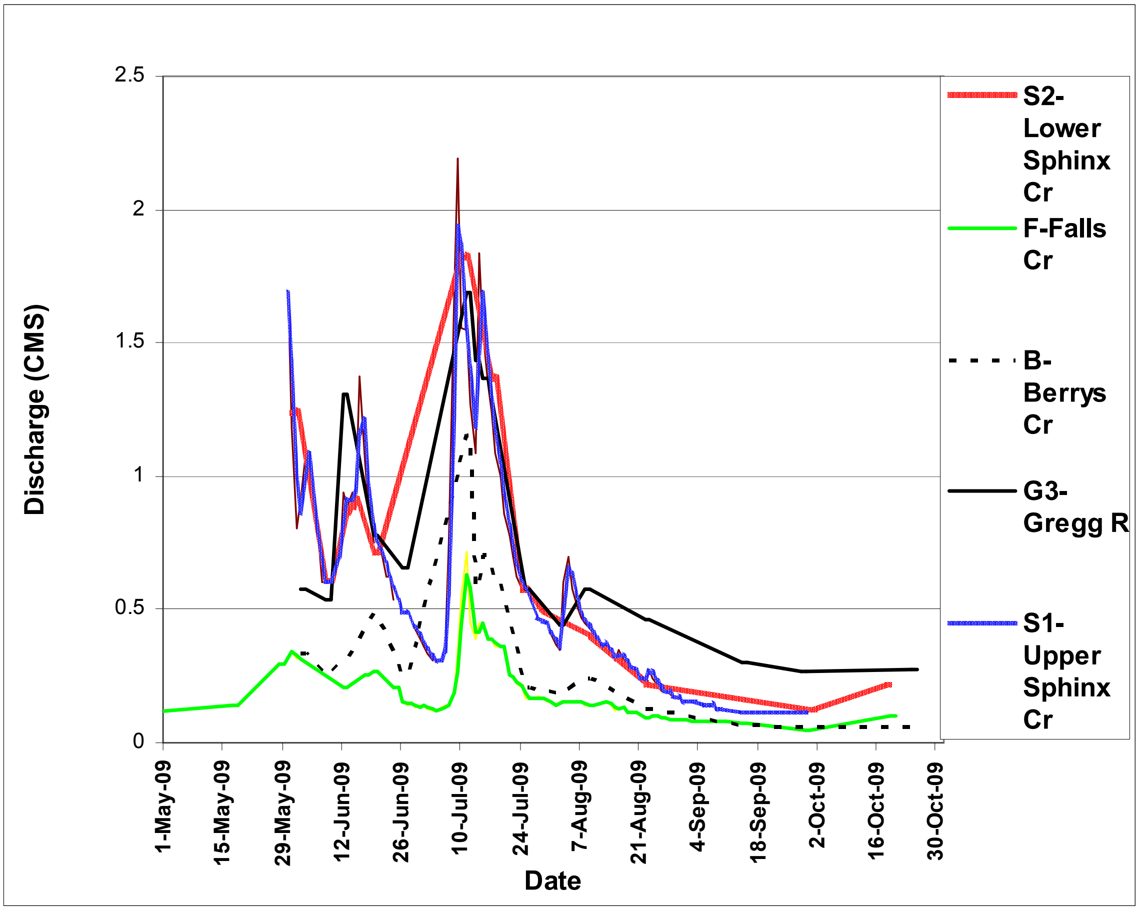

Figure 25: Hydrograph depicting flows at study sites during the 2009 open water season.

The Water Survey of Canada (WSC) has measured flows in the Gregg River at a site directly upstream of the McLeod River confluence since 1985. The flows originating and flowing through the existing mine leases are significant when compared to the overall flows in the Gregg River. The contribution of tributary flow in 2008 and 2009 to the overall Gregg River at WSC 07AF015 are depicted in Figure 26, Figure 27, and Table 24.

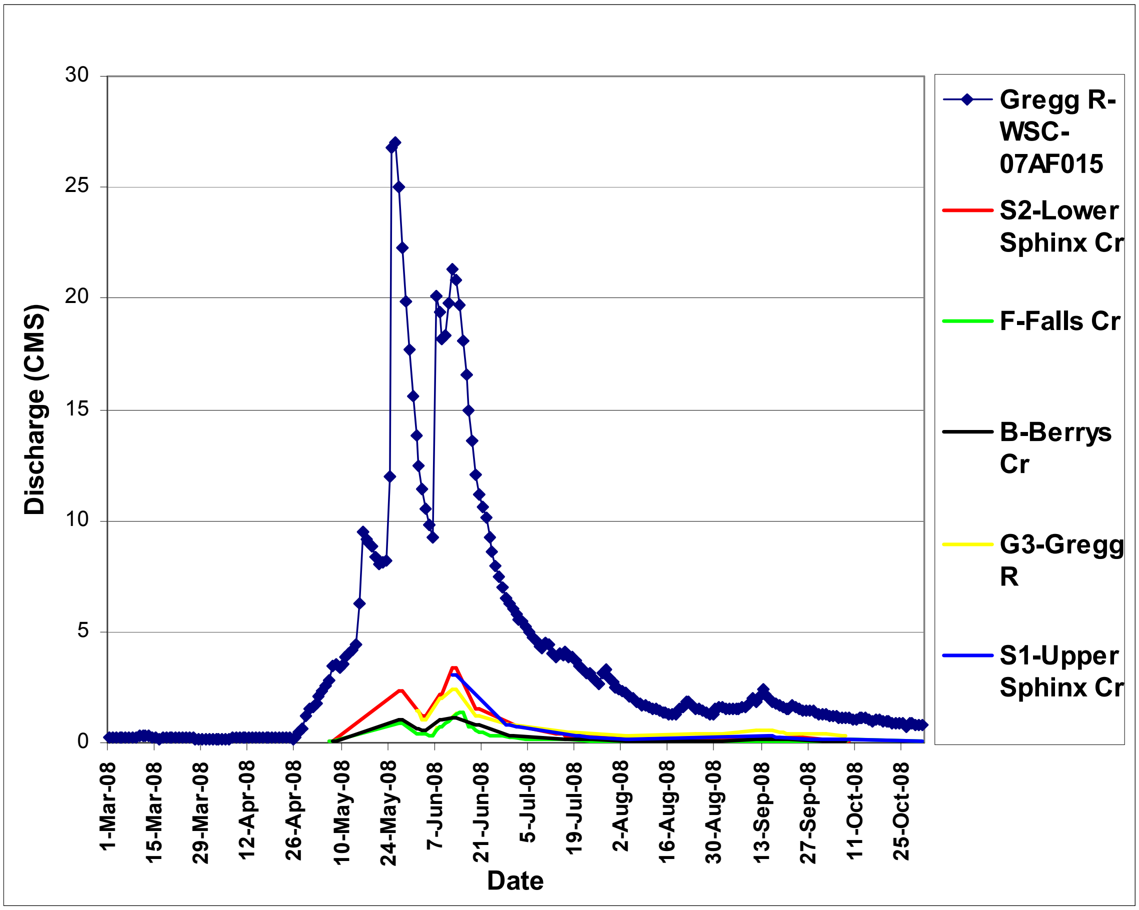

Figure 26: Hydrograph depicting tributary flows to the overall flow of the Gregg River downstream at Water Survey of Canada Stream Gauging Station, 07AF015 in 2008.

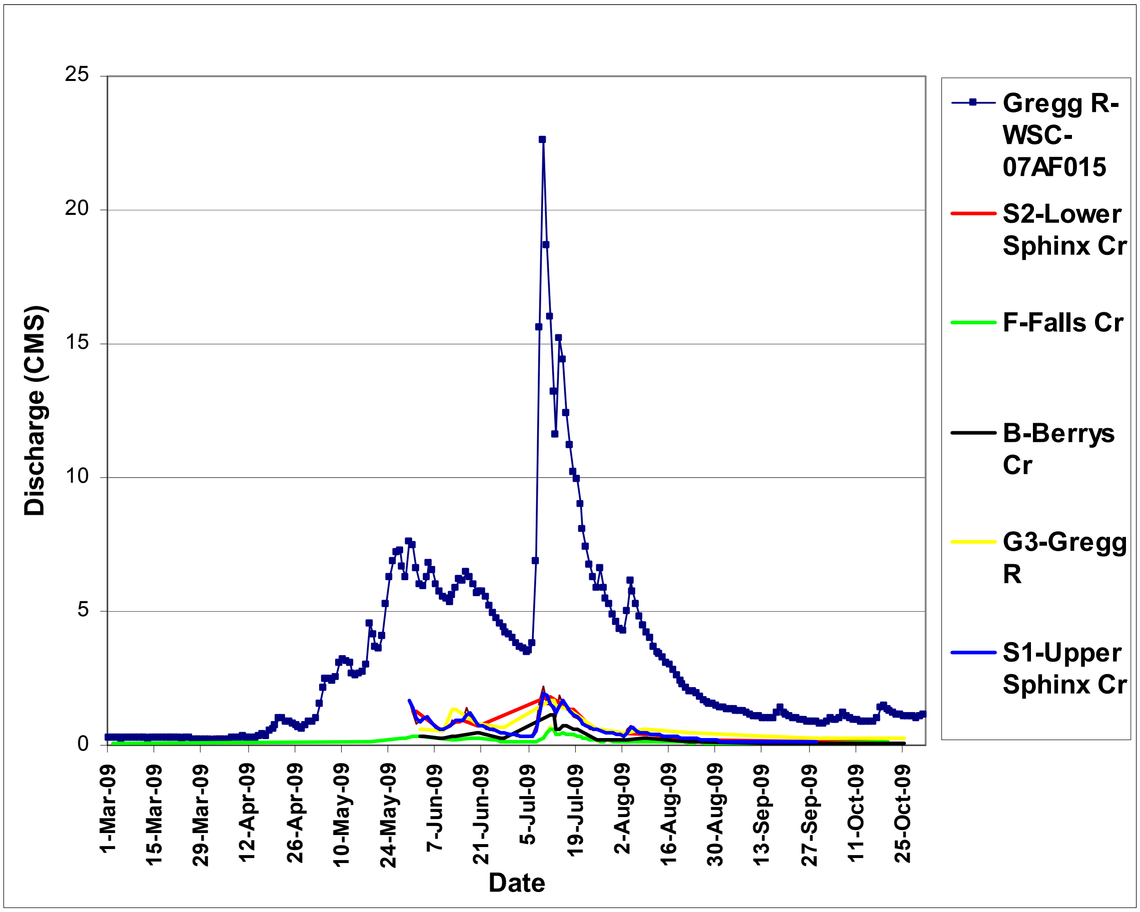

Figure 27: Hydrograph depicting tributary flows to the overall flow of the Gregg River downstream at Water Survey of Canada Stream Gauging Station, 07AF015 in 2009.

Table 24: Tributary contribution to overall Gregg River discharge, measured at stream gauging stations and the Water Survey of Canada stream gauging station 07AF015, during the field seasons in 2008 and 2009.

Site	Mean %	Number of Readings	Minimum %	Maximum %	Standard Deviation
Sphinx Site S2	11.2	29	3.8	12.9	2.9
Gregg Site G3	18.1	31	9.3	32.8	8.5
Falls Site F	4.3	97	1.2	14.1	2.0
Berrys Site B	5.8	35	1.5	9.8	1.7

4.2.1.4 Stream Substrate Concretions

Streambed concretions were identified during preliminary site investigations in the spring of 2008. The first area identified was in a drainage channel downstream of a large settling pond on the Cardinal River Mine Lease, flowing into the upper Gregg River (Site G2a). Evidence of the concretion in the main channel of the upper Gregg River was limited to the undiluted settling pond discharge area and disappeared almost immediately upon entering the Gregg River. Similar concretions were also observed in lower Falls Creek early in the spring of 2008. The concretion in Falls Creek appeared to be greatest in riffles and cascade areas and least prevalent in deeper pools and runs. The other study sites did not exhibit significant streambed concretion accumulation (were uncemented) during the spring of 2008.

In late July and early August of 2008, concretions were observed to be forming at two additional study sites along the main stem of the Gregg River (Sites G3 and G4). By the fall of 2008, the stream substrates in the two previously uncemented study sites were cemented to a degree deemed unusable for trout spawning. Study site size and extent of concretions were measured in September of 2008 (Table 25). The degree of substrate concretion did not appear to change significantly in 2009.

Table 25: Percentage of stream substrates affected by concretion per site.

Site ID	Study Site - Description	Site Size (m^2)	Percentage of substrate affected by concretion
G1	Gregg River – U/S (Upstream) of Mining Activities	na	0
G2	Gregg River – D/S (Downstream) of Diversion Culvert (does not include upper settling pond channel)	2707	1
G2a	Upper Gregg River Settling Pond Channel	913	*62
G3	Gregg River U/S of Berrys Creek	2391	96
B	Berrys Creek	1653	0
F	Falls Creek	1694	*63
G4	Gregg River D/S of Falls Creek	3744	73
S1	Sphinx Creek – U/S of Sphinx Lake	3482	0
S2	Sphinx Creek – D/S of Sphinx Lake	4496	0
G5	Gregg River D/S of Sphinx Creek	3677	3
*overall percentage of concretion is reduced because of deep water habitats found at these sites			

Concretions in Falls Creek appeared to precipitate out of solution and formed a relatively homogenous layer on substrates and organic materials, including dead and living vegetation. The concretions in the Gregg River appeared to cement sand, gravel and cobble particulate together. The Gregg River and Falls Creek concretions both exhibited an orange hue. Microscopic examination showed that a crystalline structure, very much like the crystalline structure of calcite, was apparent in both the Falls Creek and Gregg River concretion samples.

The analytical report for a single concretion (soil) sample from Falls Creek (Site F) did not find any heavy metal concentrations exceeding Canadian Council of Ministers of the Environment (CCME) guidelines for sediments (CCME 2002) or soils (CCME 2007). Water-soluble parameters for the Falls Creek sample had a bicarbonate value of 720 ug/g while the Gregg River bicarbonate value was 660 ug/g. Values for carbonate and hydroxide were less than 250 ug/g in both samples. Calcium in the Falls Creek sample had a value of 256000 mg/kg and the Gregg River sample yielded 341000 mg/kg.

Elemental distribution and bulk X-ray diffraction was used to quantify the elements present in both solid samples. This method does not allow for the detection of elements below carbon (C) in the periodic table. The detection of elements below sodium (Na) is also limited. The relative strength of calcium (Ca) was greatest in samples from both sites, followed by silicon (Si), aluminium (Al), potassium (K), iron (Fe) and magnesium (Mg). A single reading for tungsten (W) was recorded in Falls Creek and a single reading for titanium (Ti) was recorded in the Gregg River. A sample point scan report is found in Figure 28.

The relative signal strengths for Ca and Al in the Falls Creek samples and Gregg River samples are statistically indistinguishable. The relative signal strengths for Falls Creek samples and the Gregg River samples are statistically discernible for Si, K, Fe and Mg (Figure 29).

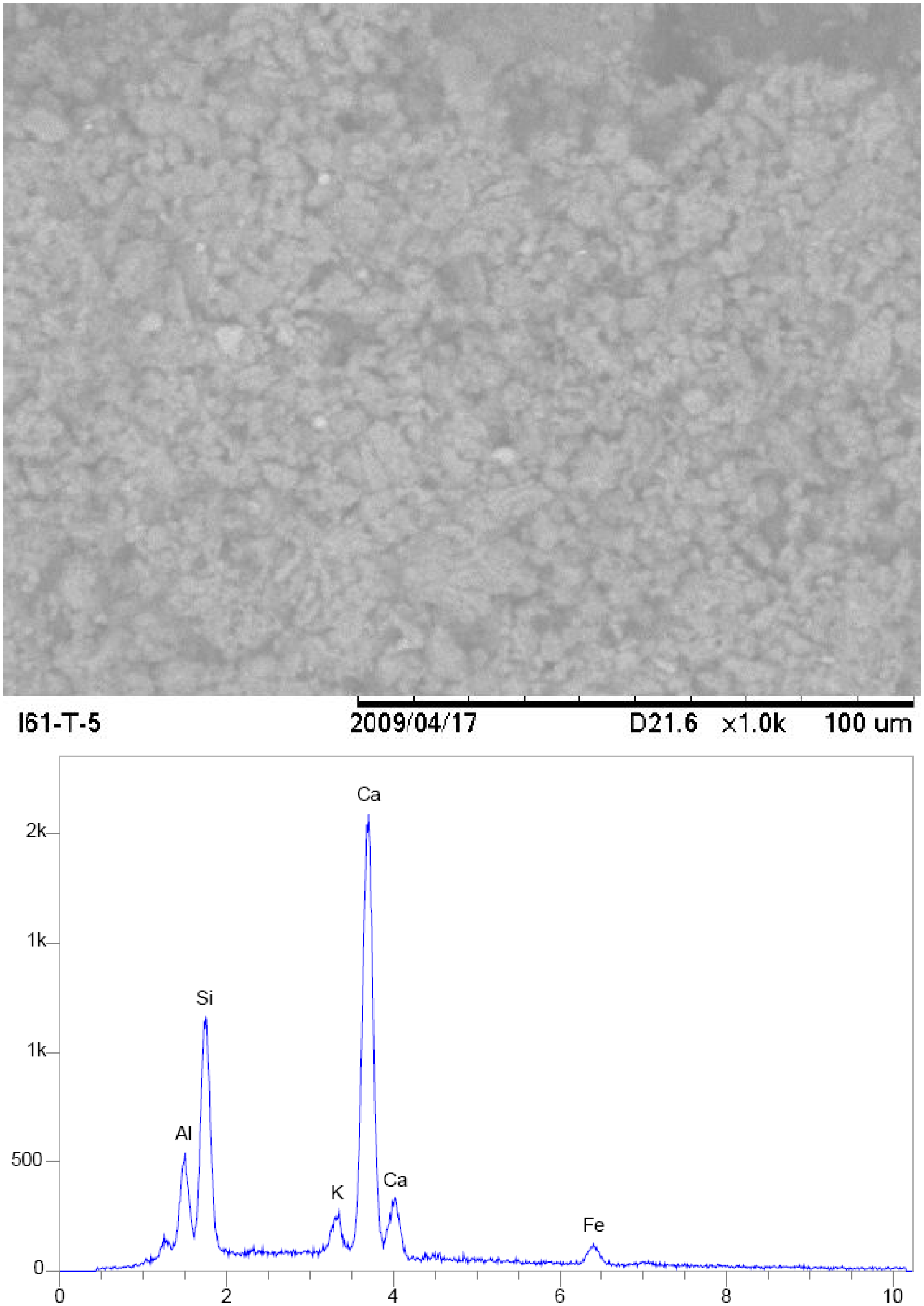

Figure 28: SEM image and elemental analysis report for concretion sample G3-1.

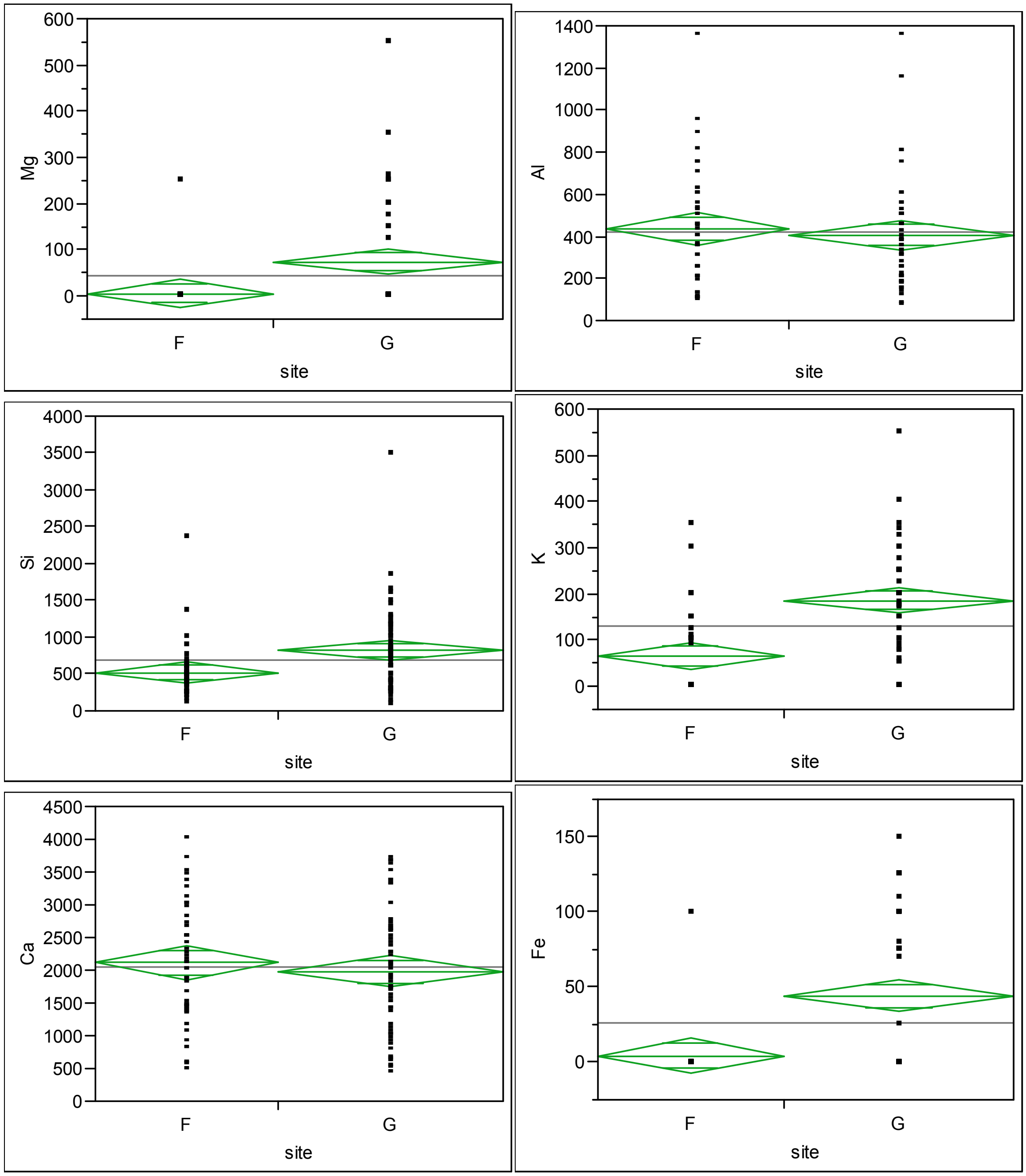

Figure 29: One-way analysis of signal strength for the main elements identified during elemental analysis of concretions from Falls Creek (F) and the Gregg River (G), Mg (n=103, t=3.392 p=0.0010), Al (n =103, t=-0.582, p=0.5622), Si (n=103, t=3.226 p=0.001), K (n=103, t=6.0885 p<0.0001), Ca (n=103, t=-0.754 p=0.4528), Fe (n=103, t=4.924 p<0.001) by site.

Weights of the mesh bundles filled with gravels were recorded prior to stream placement and after collection from the streams with the results presented in Table 26. Photographs in Figure 30 and Figure 31 are representative of mesh bundle conditions at sites where concretions are evident and at sites where concretions are generally absent.

Eight artificial gravel beds at site G2A, G3, and F were also constructed during the fall of 2008. All were generally cemented and unusable for RNTR spawning by the spring of 2009, with the exception of two gravel beds at the outlet of Pit Lake CD on Falls Creek. Thickness and coverage of the concretion on the gravel substrates varied. Some gravel beds appeared to be "capped" (only the upper approximately 5 cm of gravel was concreted) and others were completely concreted (up to 20 cm deep, well into the interstitial spaces of the gravel).

Table 26: Gravel bundle changes in mass over approximately 1 year, at various sites.

Site ID	Study Site - Description	Initial Weight (g)	Final Weight (g)	Weight Change (g)	Concretion Impacted
G2	Upper Gregg	439.4	462.0	22.6	no
G2A	Settling Channel	422.0	635.3	213.3	yes
G3	Gregg US Berrys	496.7	651.5	154.8	yes
B	Berrys Creek	480.6	476.6	-4.0	no
F	Falls Creek	459.2	650.1	190.9	yes
G4	Gregg D/S Falls	418.0	452.2	34.2	yes
S1	Sphinx U/S Lake	402.3	398.6	-3.7	no
S2	Sphinx D/S Lake	461.8	462.1	0.3	no
G5	Gregg D/S Sphinx	436.8	441.7	4.9	no
*	Luscar Creek	518.0	714.0	196.0	yes
*Luscar Creek was included in this experiment as it is a nearby creek where concretions were previously identified. Luscar Creek is located on the Cardinal River Mine Lease and also receives mine drainage.					

Figure 30: Falls Creek (site F) mesh gravel bundle October 7, 2008 (left) and September 30, 2009 (right).

Figure 31: Lower Sphinx Creek (site S2) mesh gravel bundle October 8, 2008 (left) and October 1, 2009 (right).

4.2.2 Chemical

4.2.2.1 Water Chemistry

Alberta Environment (Brock 2009) and Sherritt Coal (Brand 2009b) provided water chemistry information for stream sites in 2008 (Table 27). Selenium concentrations in Falls Creek were the highest. The pH values exceeded 8 in all systems. Total dissolved solids were highest in Falls Creek and the Gregg River (G3 and G4), corresponding with the occurrence of stream bed concretions at those sites.

Table 27: Water chemistry parameters for stream sites in 2008.

Site ID and Stream	Date	pH	Specific conductance	AlkalinityTotal $CaCO_3$	Total Hardness$CaCO_3$	Dissolved/Filtered mg/L				Total dissolved solids (recoverable)	Selenium-total (recoverable)
			µS/cm	mg/L	mg/L	Ca	Mg	Na	SO_4	mg/L	mg/L
G1 Gregg River (above mine)	Feb. 19	8.3	445	122	233	59.7	20.5	>1	104	259	0.000619
	May 7	8.1	386	117	191	48.4	17.1	>1	72.4	210	0.000390
	May 27	8.2	296	116	155	42.1	12	1	39.5	164	0.000442
	July 16	8.2	375	115	196	51.3	16.6	>1	66.9	205	0.000664
	Oct. 8	8.0	419	119	214	54.7	18.3	>1	101	247	0.000931
G3 Gregg River	Oct. 16	8.3	Na	Na	307	na	na	na	na	528	0.0109
B Berrys Creek	May 7	8.2	711	211	348	88.7	30.7	17	155	428	0.0136
	July 16	8.3	548	183	288	75.5	24.2	7	98.6	318	0.00802
	Oct 7	8.3	578	195	309	81.6	25.5	7	123	358	0.00667
F Falls Creek	May 6	8.4	1170	320	341	74.0	38	140	296	761	0.00979
	July 16	8.48.3	1430	323	423	79.3	54.6	170	398	920	0.0218
	Oct 7		1350	314	378	70.5	49	159	391	881	0.0178
G4 Gregg River	Oct. 16	8.3	Na	Na	370	na	na	na	na	730	0.0115
S1 Sphinx Creek	Oct. 16	8.3	Na	Na	243	na	na	na	na	304	0.0051
S2 Sphinx Creek	May 6	8.3	559	213	267	70.5	22	18	87.5	329	0.00655
	July 16	8.48.4	468	181	226	60.5	18.3	15	64.4	271	0.00535
	Oct 7		486	188	228	60.6	18.5	14	71.8	283	0.00440
G5 Gregg River	Feb. 21	8.5	1100	309	369	89.1	35.6	117	262	705	0.00706
	May 7	8.4	722	212	239	58.4	22.6	62	141	431	0.00634
	May 28	8.3	568	191	226	56.2	20.7	38	108	345	0.0105
	July 16	8.4	806	229	309	74.1	30.0	62	176	488	0.0109
	Oct. 8	8.3	839	234	299	51.3	30.9	68	208	533	0.0108

4.2.2.2 Specific Conductance

Specific conductance readings were recorded regularly at all the stream sites except G1 in 2009. Readings spanning the 2009 field season are provided in Figure 32.

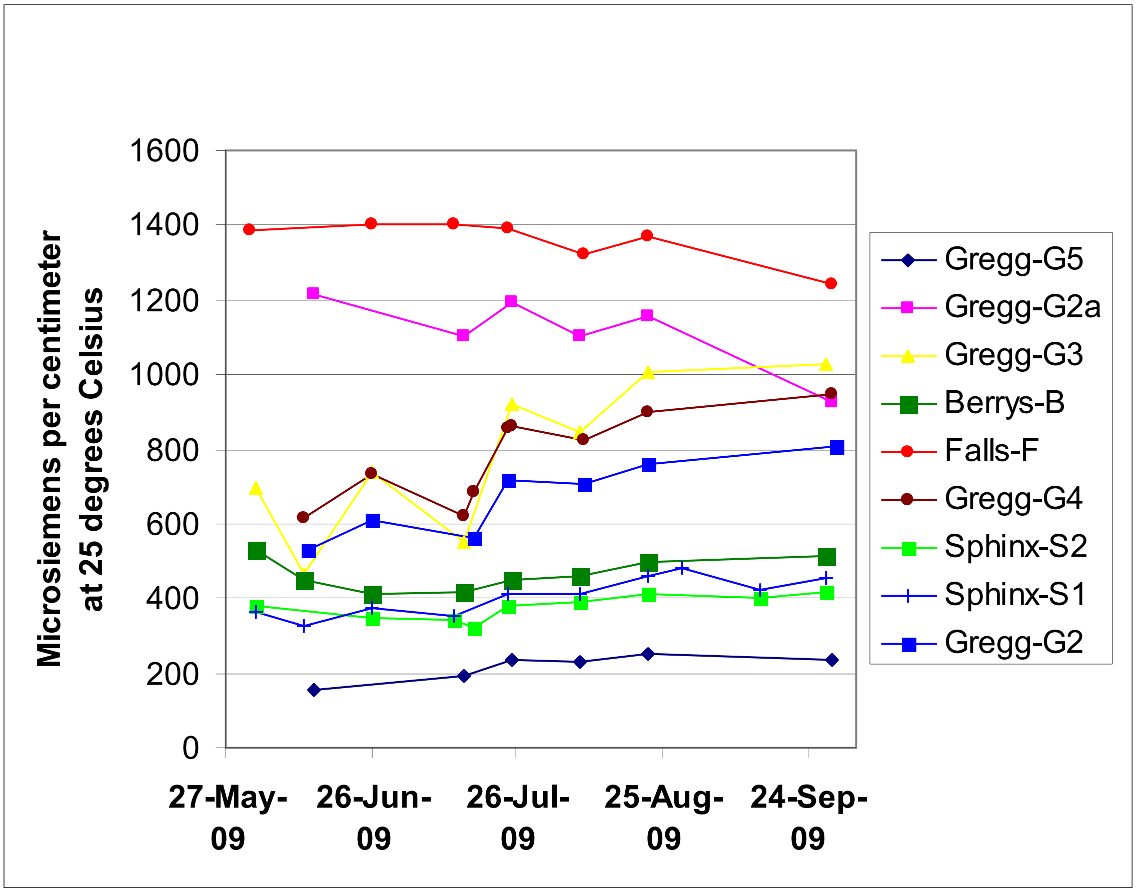

Figure 32: Specific conductance (electrical conductivity adjusted to 25 degrees Celsius) as recorded at the various stream sites in 2009.

4.2.3 Biological

4.2.3.1 Invertebrates

The stream invertebrate community information for stream sites is provided in Table 28, Table 29, and Table 30. Species richness and diversity was the lowest in the upper Gregg River (Site G2).

In addition to invertebrates, numerous frogs (Ranidae) and toads (Bufonidae) were inadvertently captured in drift traps. These amphibians ranged in size from about 1 cm to 6 cm in body length and would be expected to be part of the diets for larger RNTR and BLTR in the study area.

Table 28: Stream invertebrate species identified in 2008 and 2009 (Part 1).

Site ID and Description	Species Present		Most abundant	Percent Occurrence of abundant species
G2 Upper Gregg (September 23, 2008)	Ephemeroptera *Ameletus* sp. *Baetis bicaudatus* *Cinygmula* sp. *Epeorus deceptivus/hesperus* *Rhithrogena* sp. Plecoptera Chloroperlidae *Megarcys* sp. *Sweltsa* sp. *Taenionema* sp. *Zapada columbiana* *Zapada frigida* *Zapada oregonensis* gr. Hemiptera Aphididae *Cenocorixa* sp. Cicadellidae	Coleoptera Staphylinidae Diptera Chironomidae Chironomidae *Orthocladius* sp. Diptera Diptera *Pericoma/Telmatoscopus* sp. Sciaridae Tipulidae Trichoptera *Apatania* sp. Limnephilidae Other Insecta Hymenoptera Acari *Sperchon* sp.	Ephemeroptera *Ameletus* sp. *Rhithrogena* sp. Plecoptera *Taenionema* sp.	 6 10 59
B Berrys Creek (September 22, 2008)	Ephemeroptera *Acentrella turbida* *Ameletus* sp. *Baetis bicaudatus* *Baetis tricaudatus* *Cinygmula* sp. *Epeorus deceptivus/hesperus* *Epeorus grandis/permagnus* Ephemeroptera *Rhithrogena* sp. Plecoptera *Capnia* sp. Chloroperlidae Perlodidae *Megarcys* sp. *Sweltsa* sp. Taeniopterygidae *Zapada columbiana* *Zapada oregonensis* gr. Hemiptera Aphididae Diptera-Chironomidae *Brillia* sp. Chironomidae *Diamesa* sp. *Eukiefferiella gracei* gr. *Micropsectra* sp. Orthocladiinae Orthocladius (*Euorthocladius*) sp. *O. E. rivicola* gr. *O. E. rivulorum* gr. *Orthocladius* sp. *Tvetenia bavarica* gr.	Diptera Empididae Trichoptera Arctopsychinae *Rhyacophila* sp. Trichoptera Other Insecta Braconidae Heteroptera Acari *Hygrobates* sp. *Sperchon* sp. Crustacea Ostracoda Other Organisms Araneae	Plecoptera *Zapada columbiana* Diptera Chironomidae *Orthocladius* sp. Diptera Empididae	 10 16 10 10

Table 29: Stream invertebrate species identified in 2008 and 2009 (Part 2).

F Falls Creek (September 29, 2008)	Ephemeroptera *Baetis tricaudatus* Callibaetis sp. Plecoptera Capniidae *Hesperoperla pacifica* *Isoperla* sp. Perlodidae *Sweltsa* sp. Taeniopterygidae *Zapada cinctipes* Hemiptera Aphididae Cicadellidae Coleoptera Carabidae? Coleoptera *Sanfillipodytes* sp. Staphylinidae *Stictotarsus* sp. Diptera-Chironomidae *Alotanypus* sp. *Brillia* sp. Chironomidae *Eukiefferiella brevicalcar* gr. *Eukiefferiella gracei* gr. *Orthocladius* sp. *Procladius* sp.	Diptera *Bezzia/Palpomyia* sp. Empididae *Simulium* sp. Stratiomyidae *Stratiomys* sp. Tipulidae Trichoptera Limnephilidae Limnephilidae *Hesperophylax* sp *Limnephilus* sp. *Psychoglypha* sp. *Rhyacophila betteni* gr. *Rhyacophila brunnea* gr. *Rhyacophila* sp. Other Insecta Chalcidoidea Onychiuridae Acari Acari *Atractides* sp. *Hygrobates* sp. Gastropoda Gastropoda Crustacea Calanoida Cyclopoida Ostracoda Other Organisms Araneae	Plecoptera *Zapada cinctipes* Diptera-Chironomidae Chironomidae Crustacea *Calanoida*	 14 11 34
S1 Sphinx U/S Lake (September 24, 2009)	Ephemeroptera *Ameletus* sp. Baetidae *Baetis bicaudatus* *Baetis tricaudatus* *Cinygmula* sp. *Epeorus grandis/permagnus* *Epeorus* sp. Ephemeroptera *Rhithrogena* sp. Plecoptera *Capnia* sp. Chloroperlidae Leuctridae *Megarcys* sp. Perlodidae *Sweltsa* sp. Taeniopterygidae *Zapada cinctipes* *Zapada columbiana* *Zapada oregonensis* gr. Hemiptera Aphididae Coleoptera *Heterlimnius corpulentus* Diptera-Chironomidae Chironomidae *Eukiefferiella gracei* gr. *Tvetenia bavarica* gr.	Diptera Diptera Empididae Mycetophilidae Sciaridae *Simulium* sp. Trichoptera Arctopsychinae *Glossosoma* sp. Limnephilidae *Oligophlebodes* sp. *Rhyacophila vofixa* gr. Other Insecta Formicidae Heteroptera Isotomidae Proctotrupoidea Symphyta Acari *Lebertia* sp. *Sperchon* sp. Other Organisms Araneae *Polycelis* sp.	Ephemeroptera *Epeorus* sp. Ephemeroptera Plecoptera *Zapada columbiana*	 13 13 9

Table 30: Stream invertebrate species identified in 2008 and 2009 (Part 3).

S2 Sphinx D/S Lake (October 1, 2009)	Ephemeroptera *Ameletus* sp. *Baetis bicaudatus* *Cinygmula* sp Drunella coloradensis *Epeorus* sp. *Ephemerella inermis/infrequens* Hydropsychidae *Parapsyche elsis* Rhithrogena sp. Plecoptera *Capnia* sp. *Megarcys* sp. Nemouridae Perlodidae *Sweltsa* sp. Taeniopterygidae *Visoka cataractae* *Zapada cinctipes* *Zapada columbiana* *Zapada oregonensis* gr. Diptera-Chironomidae *Brillia* sp. Chironomidae *Constempellina* sp. *Micropsectra* sp. *Orthocladius* sp. *Parochlus* sp. *Rheocricotopus* sp. *Tvetenia bavarica* gr.	Diptera Bibionidae *Chelipoda* sp. Empididae Mycetophilidae Sciaridae *Simulium* sp. Trichoceridae Coleoptera Coleoptera Trichoptera *Lepidostoma* sp. Limnephilidae *Micrasema* sp. *Parapsyche elsis* *Rhyacophila vofixa* gr. Other Insecta Neuroptera Heteroptera Hexapoda Collemboda Isotomidae Sminthuridae Acari *Lebertia* sp. *Sperchon* sp. Crustacea Cyclopoida Ostracoda Other Organisms Araneae	Ephemeroptera *Baetis bicaudatus* Diptera- Chironomidae *Brillia* sp. Crustacea Ostracoda	 33 8 9
G5 Gregg D/S Sphinx (September 25, 2008)	Ephemeroptera *Ameletus* sp. *Baetis bicaudatus* *Cinygmula* sp. *Drunella doddsi* Ephemeroptera *Rhithrogena* sp. Plecoptera *Capnia* sp. Capniidae Chloroperlidae *Isoperla* sp. *Megarcys* sp. *Sweltsa* sp. Taeniopterygidae *Zapada cinctipes* *Zapada columbiana* *Zapada oregonensis* gr. Coleoptera *Heterlimnius corpulentus* *Liodessus* sp. Staphylinidae Diptera-Chironomidae *Brillia* sp. Chironomidae *Eukiefferiella gracei* gr. *Orthocladius(Euorthocladius)*sp. *Orthocladius* sp. *Tvetenia bavarica* gr.	Diptera Mycetophilidae Phoridae Simuliidae *Simulium* sp. Hemiptera Aphididae Cicadellidae Trichoptera *Brachycentrus* *americanus* *Dicosmoecus atripes* Limnephilidae *Parapsyche elsis* *Rhyacophila brunnea* gr. *Rhyacophila* sp. Other Insecta Hemerobiidae Hymenoptera Formicidae Tenthredinidae Gastropoda Gastropoda Acari *Lebertia* sp. *Sperchon* sp. Crustacea Ostracoda Other Organisms Araneae	Ephemeroptera *Baetis bicaudatus* *Cinygmula* sp. Plecoptera *Zapada oregonensis* gr.	 9 9 9

4.2.3.2 Fish

4.2.3.2.1 Species Composition and Attributes

Two species of fish, Rainbow trout and Bull trout, were captured within the stream study sites. A compilation of this information is provided in Table 31 and Table 32

Table 31: Rainbow trout (all ages) captured at the stream sites during electro-fishing population estimates.

	2008					2009				
Site	Individuals Captured #	Mean Fork Length (mm)	Fork Length Range (mm)	Mean Weight (g)	Weight Range (g)	Individuals Captured #	Mean Fork Length (mm)	Fork Length Range (mm)	Mean Weight (g)	Weight Range (g)
Gregg Site G2	3	193	161-216	97.3	56.0-133.0	1	223	na	158	na
Gregg Site G3	17	182	135-225	81.5	27.8-174.6	2	180	129-230	103.1	23.8-182.4
Berrys Site B	7	194	143-218	107.3	38.1-158.2	0				
Falls Site F	94	147	110-204	39.6	15.8-111.6	40	156	46-233	61.2	1.1-154.3
Gregg Site G4	54	137	40-246	39.1	1.0-181.0	67	127	75-208	127.4	75.0-208.0
Sphinx Site S1	57	132	91-207	35.3	8.0-129.6	37	119	53-214	34.3	1.6-134
Sphinx Site S2	*421	87	28-222	16.1	0.6-124.3	564	95	25-206	12.4	0.1-94.7
Gregg Site G5	Not e-fished					**123	108	32-216	21.6	0.3-114.4
* Adjusted data to reflect the same site size as 2009 (calculated from a longer mine monitoring section in 2008 (Pisces 2009b)). ** Single-pass electro-fishing survey only										

Table 32: Bull trout captured at the stream sites during electro-fishing population estimates.

Site	2008					2009				
	Individuals Captured #	Mean Fork Length (mm)	Fork Length Range (mm)	Mean Weight (g)	Weight Range (g)	Individuals Captured #	Mean Fork Length (mm)	Fork Length Range (mm)	Mean Weight (g)	Weight Range (g)
Gregg Site G2	21	247	169-300	167.7	46.0-269.0	8	231.5	177-258	139.2	58.3-213.0
Gregg Site G3	9	171	124-190	48.2	16.9-62.8	0				
Berrys Site B	1	172		56.3		0				
Falls Site F	2	179	167-190	56.7	41.5-71.8	0				
Gregg Site G4	12	167	123-286	55.0	16.4-222.0	8	151	130-227	36.6	21.5-106.0
Sphinx Site S1	8	160	47-363	163.6	1.1-464.5	23	72	36-114	6.0	0.4-16.3
Sphinx Site S2	*5	182	118-275	81.7	14.1-203.4	0				
Gregg Site G5	Not e-fished					**9	122	73-204	26.4	3.8-83.5

* Adjusted data to reflect the same site size as 2009 (calculated from a longer mine monitoring section in 2008 (Pisces 2009b)).
** Single-pass electro-fishing survey only

In addition to the 2008 and 2009 capture results, observations regarding physical abnormalities were noted and are listed in Table 33.

Table 33: Observed physical abnormalities in fish captured during electro-fishing population estimates in 2008 and 2009.

Species	Fork Length (mm)	Location	Abnormality
RNTR	58	S2	Upper jaw malformation
RNTR	159	S2	Center of dorsal fin gone
RNTR	130	S2	Left eye damage
BLTR	273	G2	Portion of left jaw missing
RNTR	200	S2	Portion of right jaw missing
RNTR	94	S1	Lower caudal lobe missing
RNTR	100	S1	Lower caudal lobe torn

4.2.3.2.2 Species Densities

Population estimate information for the sites is provided in Table 34 and Table 35.

Site G1 and G2a have been omitted as fish were absent upstream of the diversion culvert (G1) and no fish were captured in the settling pond channel during electro-fishing surveys in 2008/2009 (G2a).

Rainbow trout densities were generally the highest in stream sections located downstream of pit lakes. Bull trout densities are relatively low in the study area.

Table 34: Rainbow trout population estimates for age 1 and older cohorts at the stream sites.

	2008					2009				
Site	Using Chapman Variation		Using Program Capture		Calculated Density	Using Chapman Variation		Using Program Capture		Calculated Density
	n	95% CI	n	95% CI	n/100m^2	n	95% CI	n	95% CI	n/100m^2
Gregg Site G2	Only 3 Captured				0.1	Only 1 Captured				<0.1
Gregg Site G3	19	17 to 38	17	17 to 25	0.7 to 0.8	Only 2 Captured				0.1
Berrys Site B	8	7 to 19	6	6	0.4 to 0.5	None Captured				0
Falls Site F	105	90 to 145	105	97 to 122	6.2	37	33 to 61	36	34 to 46	2.1 to 2.2
Gregg Site G4	59	49 to 93	57	52 to 72	1.5 to 1.6	102	67 to 169	102	83 to 142	2.7
Sphinx Site S1	78	57 to 128	77	65 to 105	2.2	76	37 to 175	80	52 to 165	2.2 to 2.3
Sphinx Site S2	na				11.2 (Pisces 2009b)	813	703 to 964	813	730 to 897	18.1
Gregg Site G5	na					*P.C. 272				7.4

*P.C. – Percent capture - Single-pass estimate using site G4 percent capture and G4 population estimate.

Table 35: Bull trout population estimates for age 1 and older cohorts at the stream sites.

	2008					2009				
Site	Using Chapman Variation		Using Program Capture		Calculated Density	Using Chapman Variation		Using Program Capture		Calculated Density
	n	95% CI	n	95% CI	n/100m^2	n	95% CI	n	95% CI	n/100m^2
Gregg Site G2	24	21 to 44	24	23 to 33	0.9	9	8 to 22	8	8	0.3
Gregg Site G3	12	9 to 40	11	10 to 22	0.5	None Captured				0
Berrys Site B	Only 1 Captured				0.1	None Captured				0
Falls Site F	Only 2 Captured				0.1	None Captured				0
Gregg Site G4	**21	12 to 53	22	14 to 61	0.6	**12	8 to 29	11	9 to 27	0.3
Sphinx Site S1	Only 3 Captured				0.1	12 Captured				0.3
Sphinx Site S2					0.1 Pisces 2009b	None Captured				0
Gregg Site G5	na				na	*P.C. 12				0.3

*P.C. – Percent Capture – Single-pass estimate using site G4 percent capture and G4 population estimate.
** this case based on only 2 recaptures

4.2.3.2.3 Spawning Surveys and Fry Emergence

Spawning behaviour was observed on several occasions within various study sites. Driftnets captured fry as they emerged from natural redds. Young-of-the-year (YOY) were also captured or observed during fall electro-fishing sessions. Cumulative results for the spawning surveys, drift netting and YOY capture during electro-fishing is provided in Table 36.

Table 36: Compilation of results for spawning surveys, fry trapping and electro-fishing young-of-the-year Rainbow trout (RNTR) and Bull trout (BLTR) at various stream sites in 2008 and 2009.

Site ID	Year	RNTR spawning observed	YOY - RNTR captured (drift/e-shock)	YOY-RNTR fork length (mm)	BLTR spawning observed	YOY - BLTR captured (drift/e-shock)	YOY-BLTR fork length (mm)
G2	2008 2009	No no	none none	- -	no no	none none	- -
G2A	2008 2009	No no	none none	- -	no no	none none	- -
G3	2008 2009	No no	none none	- -	no no	none none	- -
B	2008 2009	No no	none none	- -	no no	none none	- -
F	2008 2009	Yes yes	none 2 - drift net 7 - e-fish	- 19 - 21 46 - 53	no no	none none	- -
G4	2008 2009	No no	3 - e-fish none	40 - 50 -	no no	none none	- -
S1	2008 2009	Yes yes	1 - drift net none	21 -	yes yes	5 - e-fish 8 - e-fish	47 - 52 37 – 48
S2	2008 2009	Yes yes	64 - drift net *119 - e-fish 98 - drift net 28 - e-fish	21 - 25 28 - 48 17 - 27 25 - 43	no no	none none	- -
G5	2008 2009	Yes yes	24 - drift 11 – e-fish	21-23 32-53	yes no	not e-fished 4 - e-fish	- 73 – 79
* Adjusted data to reflect the same site size as 2009 (calculated from a longer mine monitoring section in 2008 (Pisces 2009a)).							

4.2.3.2.4 Fish Growth

Hundreds of fish were captured during the fall electro-fishing sessions in 2008 and 2009. Twenty-six individual RNTR year-to-year recaptures occurred in stream environments upstream of pit lakes, and sixty-nine RNTR year-to-year recaptures occurred in stream environments downstream of pit lakes. The time span between RNTR captures at *time a* and *time b* is approximately 1 year (350 to 384 days apart), with the exception of several previously marked fish (Pisces 2007 and 2008c) that spanned 2 years (734 to 738 days apart). These fish are believed to have spent the entire year as stream residents, based on their location of capture and trapping data for the inlet and outlets of the pit lakes. Results are provided in Table 37, Figure 33 and Figure 34.

Table 37: Daily growth statistics from year to year, for stream resident Rainbow trout captured upstream and downstream of pit lakes.

	Fork Length Gain (mm)	n	Standard error	Coefficient of Variation	
Upstream	0.0622	26	0.0051	41.9700	
Downstream	0.1152	69	0.0050	36.0831	
	Weight Gain (g)	n	Standard error	Coefficient of Variation	
Upstream	0.0494	26	0.0057	59.1572	
Downstream	0.0951	69	0.0079	69.3963	
Analysis of Variance-Fork Length Gain					
Source	DF	Sum of Squares	Mean Square	F Ratio	P
Model	1	0.0532	0.0532	36.7483	<.0001**
Error	93	0.1345	0.0014		
Total	94	0.1877			
Analysis of Variance-Weight Gain					
Source	DF	Sum of Squares	Mean Square	F Ratio	P
Model	1	0.0394	0.0394	11.5410	0.0010*
Error	93	0.3173	0.0034		
Total	94	0.3567			

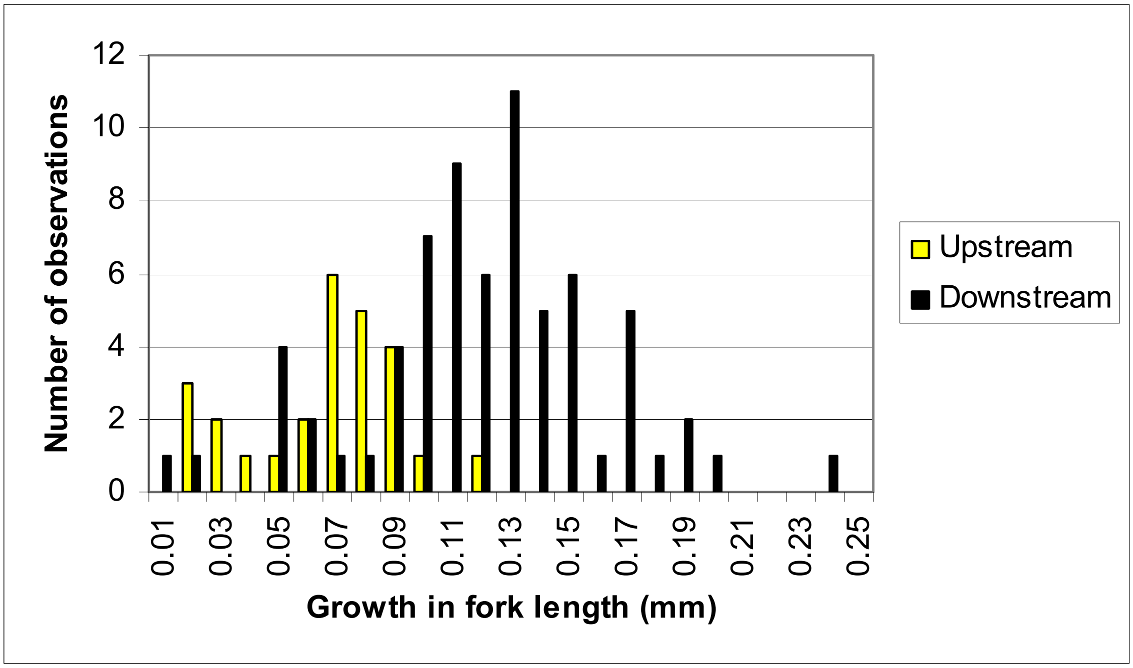

Figure 33: Stream-resident Rainbow trout growth per day in fork length upstream (n =26) and downstream (n=69) of pit lakes.

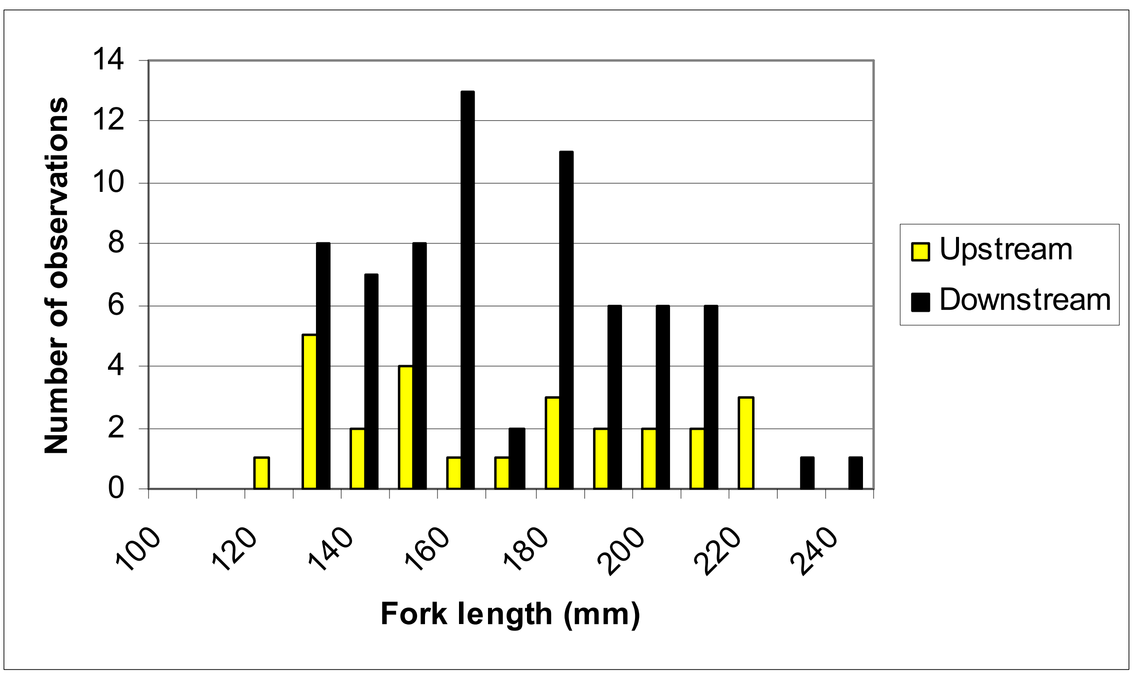

Figure 34: Fork lengths of Rainbow trout at second capture event, upstream of pit lakes (n =26) and downstream of pit lakes (n=69).

One BLTR captured downstream of Sphinx Lake (S1) in 2006 was re-captured in the Gregg River (G4) downstream of Pit Lake CD in 2008. A total of nine year-to-year recaptures were caught in the upper Gregg River (G2) during the study period. Growth information for these individual is provided in Table 38.

Table 38: Growth information for Bull trout caught in multiple years in the upper Gregg River.

BLTR PIT#	Capture Date	Fork Length (mm)	Weight (g)	Previous Capture Date	Fork Length (mm)	Weight (g)	Growth per day FL (mm)	Growth Per day (g)
Gregg – G2								
4662104345	28-Aug-08	300	264	26-Aug-07	271	195	0.08	0.19
4662692837	28-Aug-08	279	216	26-Aug-07	261	170	0.05	0.13
4664483609	28-Aug-08	277	196	26-Aug-07 @ G2a	235	129	0.11	0.18
4664517071	30-Aug-08	216	105.2	26-Aug-07 @ G2a	139	28	0.21	0.21
4868790043	28-Aug-08	238	130	26-Aug-07 @ G2a	199	83	0.11	0.13
467754351C	28-Aug-08	284	224	26-Aug-07 @ G2a	258	178	0.07	0.13
467767267D	28-Aug-08	282	222	26-Aug-07 @ G2a	250	155	0.09	0.18
4663360324	28-Aug-08	242	162	26-Aug-07	218	114	0.07	0.13
4663360324	21-Oct-09	257	213	28-Aug-08	242	162	0.04	0.12
Gregg – G4								
48641C2B29	29-Sep-08	286	222	24-Aug-06	206	88	0.10	0.18

4.2.3.2.5 Incubation and Fry Emergence in Selenium Enriched Waters

Results for the incubation and fry emergence experiment are found in Table 39. Egg selenium concentration (ug/g) is reported for wet weight.

The reduced emergence rate of Falls Creek eggs incubated in Sphinx Creek is likely attributable to the extra handling and stress introduced during transport. Field notes also indicate a small amount of blood present in the eggs of Falls Creek fish 465E671610 (FE1 and FE2). Appearance (increased whitening and uneven coloration of the eggs) suggested that eggs from fish 466178771 (FD1 and FD2) may have been overripe.

Table 39: Sphinx Creek and Falls Creek fry emergence and egg selenium concentration.

Sphinx RNTR incubated in Sphinx Creek			Fork Length	1st-Fry	%	%	%	%	Selenium(egg)
Incubator	Female PIT#	Date	(mm)	Emerge	healthy	poor/mort	no hatch	unknown	ug/g
A1	4663065661	16-Jun-08	225	4-Aug-08	97.00	0.00	3.00	0.00	5.5
B1	4677111445	17-Jun-08	225	30-Jul-08	40.00	0.00	5.00	55.00	8.0
B2	4677111445	17-Jun-08	225	4-Aug-08	56.00	2.00	21.00	21.00	8.0
C1	466420224C	18-Jun-08	228	4-Aug-08	35.00	0.00	2.00	63.00	4.7
D1	46754F4713	18-Jun-08	267	4-Aug-08	41.00	0.00	19.00	40.00	4.8
D2	46754F4713	18-Jun-08	267	4-Aug-08	45.00	0.00	9.00	46.00	4.8
E1	46773B5D7E	18-Jun-08	217	4-Aug-08	86.00	0.00	4.00	10.00	4.0
E2	46773B5D7E	18-Jun-08	217	4-Aug-08	69.00	0.00	20.00	11.00	4.0
SA1	46773B5D7E	7-Jun-09	233	4-Aug-09	70.00	6.00	14.00	10.00	4.2
SB1	465F0A0A62	7-Jun-09	216	1-Aug-09	69.00	0.00	16.00	15.00	4.0
SB2	465F0A0A62	7-Jun-09	216	1-Aug-09	76.00	0.00	17.00	7.00	4.0
SC1	46652C7806	7-Jun-09	191	4-Aug-09	87.00	3.00	5.00	5.00	4.8
SD1	4662615C7E	11-Jun-09	329	1-Aug-09	87.33	4.67	6.00	2.00	7.1
SD2	4662615C7E	11-Jun-09	329	7-Aug-09	52.00	18.00	13.00	17.00	7.2
SE1	4665257003	7-Jun-09	241	1-Aug-09	98.00	0.00	2.00	0.00	5.3
SE3	4665257003	7-Jun-09	241	1-Aug-09	84.00	0.00	14.67	1.33	5.3
Falls RNTR incubated in Falls Creek									
FA1	46626A2002	6-Jun-09	435	10-Jul-09	0.00	0.67	44.67	54.67	8.1
FB1	46772D5E6E	6-Jun-09	282	10-Jul-09	30.00	27.00	3.00	40.00	6.7
FC1	4661583F38	6-Jun-09	423	15-Jul-09	32.67	28.67	2.00	36.67	7.8
FD1	4661787710	9-Jun-09	372	na	0.00	0.00	82.00	18.00	9.6
FD2	4661787710	9-Jun-09	372	na	0.00	0.00	84.00	16.00	9.6
FE1	465E671610	6-Jun-09	385	10-Jul-09	3.33	0.00	59.33	37.33	6.9
Falls RNTR incubated in Sphinx Creek									
FA2	46626A2002	6-Jun-09	435	na	0.00	0.00	81.33	18.67	8.1
FB2	46772D5E6E	6-Jun-09	282	1-Aug-09	1.00	24.00	38.00	37.00	6.7
FC2	4661583F38	6-Jun-09	423	7-Aug-09	0.67	0.00	54.00	45.33	7.8
FE2	465E671610	6-Jun-09	385	1-Aug-09	0.00	0.67	93.33	6.00	6.9

Two of the egg samples submitted for selenium analysis were duplicate samples taken from fish with extra eggs. The results were within 0.2 ug/g of each other, with the average of both samples recorded in Table 39. One of the RNTR used in the 2008 Sphinx Creek incubation experiment (46773B5D7E) was also used in the 2009 Sphinx Creek incubation experiment. The egg selenium concentration is within 0.2 ug/g for the samples taken from this individual in 2008 and 2009.

Tissue samples were taken from four RNTR, which died during the study. A vertical wedge of skin and flesh between the adipose and anal fin was removed from each individual and submitted for analysis. Falls Creek RNTR 46626A2002 (FA1 and FA2) was one of the individuals. The other three RNTR were Sphinx Creek trap mortalities from 2008. The Sphinx Creek RNTR were gravid and egg samples were also sent away for analysis. Results are presented in Table 40.

Table 40: Rainbow trout tissue and egg selenium concentrations.

Incubators	Female PIT#	Mortality Date	Location	Fork Length (mm)	Weight (g)	Selenium Tissue ug/g	Selenium Egg ug/g
FA1, FA2	46626A2002	11-Sep-09	Falls	468	1145	3.0	8.1
NA	NA	30-May-08	Sphinx	271	234	1.5	6.7
NA	NA	30-May-08	Sphinx	225	170	1.5	5.6
NA	NA	30-May-08	Sphinx	245	191	2.0	7.1

Fecundity was measured by counting the number of eggs released during egg stripping for the incubation experiment. Nine fish that were thought to be completely stripped were used for fecundity calculations. The average number of eggs per fish was 693, ranging from 375 eggs to 1568 eggs.

CHAPTER 5: Discussion

5.1 Lentic Environments

Sphinx Lake and Pit Lake CD are existing pit lakes with connectivity to the stream environment. Lac des Roches was an existing pit lake with connectivity, but is now similar to Pit 50A-North, a water body devoid of fish, which in the future will have direct connection to the stream environment. Emerald Lake and Rawson Lake are natural lakes with basin sizes and shapes similar to the pit lakes, also connected to stream systems downstream and act as controls for the purpose of this study.

5.1.1 Physical Attributes

The pit lakes in this study varied in surface area from 6.4 ha to 20.5 ha while the two natural systems were 9.7 ha and 17.7 ha in size. The pit lakes' elevation falls between the elevations of Emerald Lake (1372 m) and Rawson Lake (2021 m). The mean depths and maximum depths of the pit lakes are greater than Emerald and Rawson Lake, as well as most natural lakes in the Rocky Mountains of Alberta (Mayhood and Anderson 1976, Anderson and Donald 1978a, Anderson and Donald 1978b, Thompson 1978).

Productivity in lakes is highly influenced by the littoral region of a lake. The littoral region may be described as the "interface zone" between the surrounding land mass and open water habitats (Wetzel 2001). The guidelines for littoral habitat creation during reclamation suggest that water depths of less than 3 m be constructed with sediments able to sustain aquatic vegetative growth (EPLWG 2002). The littoral regions of Rawson Lake would appear to be similar in size to the littoral regions of Sphinx Lake. Approximately

22% of Sphinx Lake is less than 3 m deep (Pisces 2008a). The 28% littoral area in proposed Pit Lake 50A-North (EVC-CRO 2006) is expected to exceed the littoral area of Sphinx Lake, and significantly exceeds Lac des Roches at 5% littoral (Luscar 1994), Pit Lake CD (estimated at 10% littoral), and Emerald Lake (estimated at 5% littoral). Although littoral area was limited in Lac des Roches, and is limited in Pit Lake CD, mountain lakes with small proportions of littoral zone, naturally occur in the Rocky Mountains of Alberta (Bishop 1985, Anderson and Donald 1978b, Thompson 1978).

Figure 35: Springtime image of Pit Lake CD.

Secchi depths provide an indication of the transparency of water to light, which is important because solar radiation is the major energy source responsible for productivity in aquatic ecosystems (Wetzel 2001). Secchi depth may also be an indicator of the trophic state and overall productivity of a water body (Carlson 1977). Soil erosion, pollution, algal growth and zooplankton are common causes of turbid water conditions and result in shallower Secchi readings (Swift et al. 2006). Although Secchi depths have the potential to dramatically change because of ambient (i.e. wind) and lake conditions (i.e. turnover), the transparencies of Pit Lake CD, Sphinx Lake and Lac des Roches (after stream connectivity) appear similar or within the range of Secchi readings of those recorded at both Rawson Lake and Emerald Lake (Table 3).

The Secchi data further suggest that Sphinx Lake was less transparent prior to the connection of Sphinx Creek. The same relative change was noted in Lac des Roches prior to and following stream connectivity (Luscar 1994). Secchi readings recorded in Pit 50A-North suggest that this water body also has reduced transparency. The revegetation of surrounding slopes, combined with clear stream flow, should improve water clarity and transparency in Pit 50A-North after connectivity to the Gregg River is completed.

The temperature, specific conductance, and dissolved oxygen profiles in Pit Lake CD and Sphinx Lake suggested that the lakes displayed meromictic tendencies, meaning that the lower portions of the lakes did not mix with upper portions. Terminology used to describe the different lake stratum is found in Wetzel 2001. The mixolimnion (portion of the lake that mixes) in Pit Lake CD was between 28 m and 29 m from the surface during 2008 and 2009. Evidence of a monimolimnion (a portion of the lake that doesn't mix) was observed at the 29 m and 30 m depths. The mixolimnion in Sphinx Lake appeared to be significantly shallower, close to 15 m in 2008 and 12 m in 2009. The monimolimnions in both lakes displayed tendencies of a chemolimnion (a saline monimolimnion), given the differences in specific conductance and water quality parameters, specifically alkalinity and total dissolved solids. Alkalinity and total dissolved solids in the epilimnions of Sphinx Lake and Pit Lake CD in 2009 are considerably lower than the values observed in the hypolimnions during the same year.

The difference in mixolimnion depth in Sphinx Lake and Pit Lake CD is most likely due to the reduced sun and wind exposure of Sphinx Lake. The salinity gradient in a chemolimnion is known to strengthen the boundary between the mixolimnion and the monimolimnion in lakes (Wetzel 2001). The relative stability of these layers in Sphinx Lake and Pit Lake CD would suggest that a similar effect could be occurring. Historical data for Sphinx Lake suggests that a shallower mixolimnion existed in 2005 (prior to the connection of the creek). Historical data for Pit Lake CD suggests that the mixolimnion was perhaps greater than 30 m deep in 2004, with a mixolimnion near 29 m water depth present in Pit Lake CD in early 2005.

Wetzel (2001) suggests that meromictic lakes are relatively common. Data collected in Emerald Lake during 2008 and 2009 suggested that temporary meromixis might have occurred in Emerald Lake during the study period. Specific conductance within the lower confines of Emerald Lake did not suggest the persistence of a chemolimnion. Evidence supporting the absence of a chemolimnion in Emerald Lake is supported by the historically low TDS (total dissolved solids) values observed in 1979, 1981 and 1986, with relatively low electrical conductivities ranging from 190 to 340 uS/cm during the same period. The maximum recorded specific conductance during this study period of 275.8 uS/cm (electrical conductivity of 166.4 uS/cm) was recorded at 30 m depth on November 1, 2009. Emerald Lake appears to have holomictic (complete mixing) and temporary meromictic tendencies. Conclusions regarding Rawson Lake are difficult to ascertain.

Meromictic tendencies were recorded within vertical profiles recorded for Lac des Roches and Pit 50A-North. Luscar (1994) suggested that the lower stratum of Lac des Roches does not mix with the upper stratum, with a mixolimnion extending to about 20 m deep in Lac des Roches. Recent dissolved oxygen profile information suggests that the mixolimnion in Lac des Roches extends even deeper. A reading of 2 mg/L was observed at the 27 m depth in 2009 and at 42 m depth in 2008 (Rutkowski and Christensen 2008). It is difficult to predict the mixolimnion depth of Pit 50A-North after reclamation is complete, but based on sun and wind exposure, a mixolimnion near or deeper than 15 m is expected.

Pit lakes and natural lakes all exhibited thermal stratification near the surface during the summer monitoring sessions (Figure 8, Figure 10, Figure 12). Dissolved oxygen levels recorded in 2008 and 2009 were adequate for fish to at least the 10 m water depth in all lakes (Figure 7, Figure 9, and Figure 11). Adequate oxygen for fish was recorded at depths approaching 30 m in Emerald Lake and Lac des Roches on several occasions. Adequate oxygen for fish at depths approaching 30 m was regularly observed in Pit Lake CD.

5.1.2 Chemical Attributes

Water quality sampling generally suggests that selenium enrichment is the primary water quality concern for fish living within the pit lake systems in this mountainous region. Water sampling at Lac des Roches, Pit 50A-North, Pit Lake CD and Sphinx Lake consistently result in selenium concentrations exceeding the 0.001 mg/litre guideline for this mineral, with the exception of the anoxic lower confines of Sphinx Lake. Precipitation of selenium may be occurring at depth, as redox precipitation of selenium under anaerobic conditions has been documented in the literature (Hockin and Gadd 2003, Sasaki et al. 2008). It should be noted, however, that selenium enrichment is not restricted to pit lakes and pit lake systems (Table 4 and Table 27). Water quality data for coal mine-impacted creeks in the area also exceed selenium guidelines. Alberta Environment water quality data from 2004 to 2008 (Brock 2009) reported total recoverable selenium concentrations ranging from >0.0001 mg/litre to 0.0011 mg/litre in the upper Gregg River headwaters. Selenium concentrations near or exceeding the 0.001 mg/litre federal guideline in this natural area (upstream of coal mining activities), would suggest that selenium enrichment is and has been naturally occurring in the area. Other water quality parameters, including levels of phosphorous, cyanide, mercury, aluminium, arsenic, cadmium, lead and copper are below federal and provincial water quality guidelines in both Sphinx Lake and Pit Lake CD. Nitrate levels in the epilimnion of Pit Lake CD were somewhat elevated in 2009 (3.95 mg/L). Nitrate levels were substantially lower than the 12.7 mg/L value recorded by Stemo (2005) in 2004. Information for selenium concentration in Emerald Lake and Rawson Lake was not available.

Routine water quality parameters for the pit lakes and Emerald Lake appear to be significantly different. Some of these differences, although acceptable from a regulatory perspective, may influence the aquatic communities. Pit Lake CD, for example, had significantly higher TDS values in the epilimnion, when compared to the epilimnions of Sphinx Lake (after reclamation), Lac des Roches and Emerald Lake (Table 4). The higher TDS values are likely due to the rock debris through which upper Falls Creek now percolates. An effect of this percolation manifests itself in the form of streambed concretions (5.2.2 Streambed Concretions) and the marl-like substrates prevalent in Pit Lake CD. The differences in water quality found at the pit lakes and the natural lakes are not surprising, given the erodibility and percolation potential of waters in reclaimed areas versus the relatively undisturbed nature of Emerald Lake. Total alkalinity and total hardness values for Lac des Roches (Luscar 1994) and Sphinx Lake (Table 4) might suggest however, that overall water quality characteristics of the epilimnion may improve over time as easily erodable substrates diminish. Although improvements in water quality are sometimes hard to detect, significant water quality improvements downstream of mining operations (i.e. heavy metals) have been documented before (Runkel et al. 2009).

5.1.3 Zooplankton

Zooplankton communities within the individual lakes themselves have changed over time, with some of this change coinciding with the introduction of fish into the system. Although information is sparse, it would appear that Sphinx Lake and Pit Lake CD experienced shifts away from some of the larger plankton species to smaller species, after connectivity to the stream environment and the subsequent colonization of fish into these systems (Table 5). Plankton populations also appeared to change in Rawson Lake, after the introduction of trout into that system (Thompson 1978, Mayhood 1983). Changes in zooplankton, linked to the introduction of fish, have been documented in other lakes as well (McNaught et al. 1999). Further effects on the zooplankton communities are difficult to delineate based on limited data and natural or anthropogenic influences, which may occur in niche, local or regional environments. Globally, environmental warming has the potential to change plankton communities found in alpine lake environments via increased water temperatures (Holzapfel 2005).

5.1.4 Invertebrates

Pit lakes with connectivity, including Sphinx Lake, Pit Lake CD and Lac des Roches, had benthic invertebrate densities similar to or greater than densities recorded in natural alpine and sub-alpine lakes, as reported in Mayhood (1983) and Thompson (1978). The benthic invertebrate communities in Sphinx Lake, Pit Lake CD and Lac des Roches also exhibit diversity that is similar to or greater than those recorded in systems similar to Emerald Lake and Rawson Lake. Midges, snails and amphipods (*Gammarus* sp. and *Hyalla* sp.) are generally considered valuable food sources for RNTR. Midges are common in Sphinx Lake and Pit Lake CD, while midges, snails and amphipods were abundant in Lac des Roches. The strong presence of snails and amphipods in Lac des Roches, soon after reclamation was complete, is likely linked to the successful introduction of invertebrates and macrophytes from local waterbodies (Luscar 1994). The establishment of amphipods and snails by natural transfer (animals, waterfowl) is expected to take longer and may explain the lower densities of amphipods and snails in Sphinx Lake and Pit Lake CD.

5.1.5 Macrophytes

The macrophytes found in Sphinx Lake and Pit Lake CD provide escape cover and foraging opportunities for invertebrates and fish. The substantial increase in macrophytes from 2008 to 2009 would suggest that the littoral areas in these pit lakes are continuing to mature, similar to the maturation observed in Lac des Roches. There are more macrophytes in the reclaimed pit lakes than in both Emerald Lake and Rawson Lake.

5.1.6 Rainbow Trout

The number of female spawners living in Sphinx Lake and spawning downstream appeared to increase consecutively, with 26 outlet spawners recorded in 2007 (Pisces 2008a), 37 in 2008, and 42 in 2009. Rainbow trout spawning at the outlet channel (upstream of the trap) was not documented in 2007, but was confirmed in 2008 and 2009. Spawning behaviour upstream of the trap may be opportunistic, or may be due to trap avoidance. Selection of spawning sites due to trap avoidance has been recorded previously in Alberta with BLTR (Stelfox 1997). Trap avoidance behaviour in RNTR greater than 300 mm has also been documented (Chandler and Richter 2000).

The majority of female RNTR movements downstream of Sphinx Lake in 2008 and 2009 were recorded during the last week of May and continued until the third week of June.

Actual spawning behaviours in the creek downstream of the lake were first observed on June 17, 2008 with completed redds located as early as June 13 in 2009. Ripe females were captured in the colder inlet channel, moving upstream in late June of 2009. Spawning behaviour in Sphinx Creek upstream of the lake was observed on June 27, 2009. Spawning upstream of Sphinx Lake is likely delayed about two weeks, relative to spawning period downstream of the lake.

The size class of RNTR captured moving upstream of Sphinx Lake would also suggest that most spawning females that chose to spawn downstream of Sphinx Lake could have travelled upstream as well. Although competition for breeding males and spawning areas would seem to be greater downstream, the majority of RNTR female spawners chose to spawn downstream (in 2009, 42 suspected and confirmed female spawners moved through the outlet trap, while 2 individuals moved through the inlet trap). Improved incubation temperatures, coupled with moderated flows downstream of the lake, may explain this behaviour. The drop structures connecting the lake to Sphinx Creek upstream may also deter movement for RNTR in the upstream direction.

Spawning opportunity for Lac des Roches, Pit Lake CD, Emerald Lake and Rawson Lake is limited to the outlet channels, as water enters these lakes as either waterfalls or seeps. Trapping operations in 2008 and 2009 encountered female RNTR moving downstream of Pit Lake CD, with spawning occurring directly upstream of the trap in 2009 as well (trap avoidance by some of the larger RNTR was suspected). Similar RNTR spawning migrations downstream of Lac des Roches are documented in Luscar (1994) and

Schwartz (2002). Cutthroat trout, exhibiting spawning behaviour, were observed at the outlet of Rawson Lake in early July 2009. Trout spawning in the outlet channel of Emerald Lake could not be confirmed. Lake resident RNTR will readily migrate downstream of pit lakes to spawn, as long as favourable conditions exist.

Movement of RNTR through the Sphinx Lake and Pit Lake CD traps were greatest during June and early July, and declined as the season progressed. Eighty-five percent of the recorded RNTR movements through the Pit Lake CD trap in 2008 and 2009 occurred before July 16 of the year (44% of the total trapping time). Fifty-five percent of the recorded movements occurred before July 16 of the year (41% of the total trapping time) in the outlet trap of Sphinx Lake (Appendix A).

Individual RNTR movements through the Sphinx Lake or Pit Lake CD fish traps varied considerably. Ripe males were regularly captured moving back and forth through the traps several times, while females usually moved through the traps less (Appendix A). This back and forth behaviour is not surprising given that spawning occurred upstream of the traps. Male RNTR will orientate and travel upstream due to directional cues and olfactory stimuli of dilute ovarian fluid in water currents (Emanuel and Dodson 1979).

The final direction of movement for 93% of the RNTR at the Pit Lake CD trap was upstream into the lake in 2008. Between 87% and 92% of the final movements were upstream into Pit Lake CD in 2009. The final direction of movement for RNTR at the Sphinx Lake outlet trap found between 62% and 64% of the final movements were upstream into the lake in 2008 and between 46% and 47% of the movements were upstream into the lake in 2009. Although more fish were recorded moving downstream in 2009, more fish biomass moved upstream into the lake in 2009. These patterns would suggest that RNTR move into the pit lakes with older, larger fish tending to remain in the lake for the season. The stronger tendencies in Pit Lake CD may be due to the lower densities of fish occupying the lake. The less directional tendency of Sphinx Lake RNTR may also be related to the longer stream channel upstream of the Sphinx Lake outlet trap and higher fish densities in Sphinx Lake.

Schwartz (2002) reported that fish growth in Lac des Roches surpassed growth rates for trout in other natural mountain lakes in Alberta. The fork length of Lac des Roches RNTR increased an average of 0.148 mm per day from 1998 to 1999. The fork length of Pit Lake CD RNTR increased an average of 0.167 mm per day from 2008 to 2009, while Sphinx Lake fish grew 0.132 mm per day over the same period. Weight gain in the Lac des Roches fish was, however, substantially greater than weight gains observed in Pit Lake CD or Sphinx Lake. Although fork length to age data is limited for both Sphinx Lake and Pit Lake CD, it would appear that the growth rates for RNTR in pit lakes with connectivity meet or exceed growth rates reported in natural mountain lakes. Rainbow trout appear healthy (Figure 36) and will likely sexually mature at younger ages in these modified systems. Length frequency information for Sphinx Creek RNTR captured during the fall in 2009 (Pisces 2009c) suggests that yearling RNTR (hatched in 2008) ranged in fork length from about 60 - 120 mm, with two year olds (hatched in 2007) ranging in size from about 130 - 170 mm. The size range and average sizes of spawning sized RNTR captured moving through the Pit Lake CD and Sphinx Lake traps (Table 9, Table 10, Table 13, and Appendix A) would suggest that most male RNTR are sexually mature by age two, with a significant number of mature females suspected to be age three. Stream resident RNTR in the area will generally mature at age three and four (Sterling 1986, Nelson and Paetz 1992).

Nine RNTR between 191 mm and 372 mm were stripped of as many eggs as possible during incubation trials in 2008 and 2009. The number of eggs stripped varied from 375 to 1568 eggs. Sterling (1986) found that the mean fecundity of stream resident RNTR in the nearby Tri-creeks Research Area was 293 plus or minus 16 eggs. The fecundity of the smallest ripe female RNTR from a pit lake system significantly surpasses the average fecundity of local stream resident trout. The average of 693 RNTR eggs per fish from Sphinx Lake and Pit Lake CD surpasses average stream resident fecundity by more than double. No impairment of reproductive capability was observed in RNTR used from Sphinx Lake during incubation trials in 2008 and 2009. The reproductive capability of RNTR from Pit Lake CD may appear to be lower, given the failure of successful natural reproduction in 2008 and lower hatch and emergence rates documented during incubation trials in 2009. The apparent spawning failure in 2008 is more likely due to lethal water temperatures for egg incubation recorded during the first week of July 2008. Fertilization success in Falls Creek may also be reduced because of elevated TDS levels. Total dissolved solid values of 250 mg/litre have been documented to reduce fertilization success in salmonid fishes (Stekoll et al. 2009). Reduced hatch and emergence rates during the Falls Creek incubation experiments in 2009 are most likely due to water temperatures, concretion of stream substrates and incubation chambers, and poor quality eggs or male donors.

Figure 36: Rainbow trout captured in the Pit Lake CD/Falls Creek trap.

Very few RNTR inhabit the upper Gregg River (site G2). No RNTR were captured moving upstream into the Gregg River fish trap in 2008 (installed downstream of the future Pit 50A-North lake outlet). Successful RNTR spawning in this area has not been documented, and is highly doubtful to have occurred, based on stream water temperature data (Table 23 and Figure 20) and electro-fishing population estimates (Carson 1996b, Carson and Ross 1997, Goltz 1998, Carson 2000, Armstrong 2002, Carson 2002a, Pisces 2004, Pisces 2005, Pisces 2006, Pisces 2007, Pisces 2008b). Given the increased temperatures and moderated flow regime downstream of pit lakes, RNTR use in this area should increase and RNTR spawning should occur downstream of the proposed lake.

However, RNTR recruitment into this new lake should take longer than the recruitment observed into Sphinx Lake. The anticipated slower recruitment is due to the higher elevation of the lake, the lower densities of RNTR living immediately downstream, and the presence of obstacles and barriers (culverts and waterfalls) downstream.

5.1.7 Bull Trout

Bull trout living in Sphinx Lake tend to move upstream of the lake to spawn. No adult BLTR were recorded moving downstream of Sphinx Lake in 2008 or 2009, while several BLTR were recorded moving upstream of Sphinx Lake in 2009. Adult BLTR from Sphinx Lake were also captured upstream of the lake during electro-fishing population estimates in 2008. Adfluvial populations of BLTR that migrate upstream of lakes has been documented previously in Alberta (Stelfox 1997). No migratory adult BLTR (Gregg River residents) were captured moving upstream into Sphinx Lake in 2008 or 2009, although historically this was a regular occurrence (Carson 1996a, Carson and Ross 1997, Allan and Goltz 1999, Schwartz 2001, Carson 2002a, Armstrong 2002, Pisces 2004, Pisces 2005, Pisces 2006). The lack of migratory BLTR may be related to beaver activity and passability issues that currently exist in Sphinx Creek downstream of the lake. The warmer stream temperatures and moderated flows downstream of Sphinx Lake may also deter the migration of Gregg River BLTR into Sphinx Creek. Declining water temperatures and increasing discharge often coincide with the migration of BLTR (Fraley and Shepard 1989). Adult BLTR were found in Lac des Roches (Schwartz 2002), however, no evidence of spawning was found. Adult BLTR were not captured in Pit Lake CD or Falls Creek, and are absent in both Emerald Lake and Rawson Lake.

Three immature BLTR were captured in the outlet trap of Sphinx Creek in 2008 and 2009. These BLTR were likely migrants from the Gregg River or Sphinx Creek upstream of the lake. All three BLTR were initially captured moving upstream into Sphinx Lake, with two of the BLTR moving back downstream several days later. Stelfox (1997) suggested that very few BLTR move into Lower Kananaskis Lake before age 3, or that survival of BLTR that entered the lake before age 3 was poor. The high density of juvenile RNTR in Sphinx Creek, downstream of Sphinx Lake, would provide an excellent food source for juvenile BLTR, and may in part explain why these BLTR returned to the creek.

Six individual BLTR were captured in the upper Gregg River fish trap in 2008, just downstream of future pit lake 50A-North. The upstream movement of adult BLTR (one of the smaller individuals was a ripe male) in this area would suggest that BLTR may attempt to spawn in the vicinity, although successful BLTR spawning in or upstream of this area has not been documented. Bull trout spawning in the Gregg River drainage downstream would have occurred within the past several years given the size of BLTR captured during electro-fishing sessions in 2008. Adult BLTR would be expected to use the new pit lake, and may potentially spawn downstream or upstream of the lake.

5.2 Lotic Environments

5.2.1 Physical Attributes

Physical attributes of the study sites varied. The smallest sub-site is the settling pond channel (G2a) which flows into the upper Gregg River below the diversion culvert on the

Gregg River (Site G2). The greatest significance of the settling pond channel is the concretions (5.2.2 Streambed Concretions) observed in this channel and the P1 habitat at the upstream end. Remaining sites vary in size from 1652 m^2 to 4496 m^2. The largest site is also the longest site, Sphinx Creek, downstream of the lake (S2). The average width of both the Gregg River and Sphinx Creek increase with distance downstream, as with most other rivers and streams.

A potentially significant factor at sites downstream of pit lakes was the presence of permanent, well-established beaver dams with ponds. Both Falls Creek (F) and Sphinx Creek downstream of the lake (S2) had beaver dams that persisted over several years. During the study period, beavers attempted to build dams in at least two different places along the Gregg River; both of these attempts were compromised by heavy runoff in the same year. The presence and longevity of beaver dams downstream of pit lakes is understandable given the moderating effect that the lakes have on flows. Although these beaver dams act as barriers and deterrents to fish movement upstream, they may prove useful in determining the long-term sustainability of the isolated population of fish upstream of these structures.

The presence of habitats greater than 50 cm in water depth was relatively rare amongst all the stream study sites (Table 19). The settling pond channel (G2a) provided the highest percentage of habitat greater than 50 cm in depth (15.8%), only due to the excavated pool at the base of the settling pond outflow. Falls Creek had the second highest amount of habitat greater than 50 cm in depth (11.9%) due to the beaver ponds located within the section. The section furthest downstream on the Gregg River (G5) had 9.5% of the habitat greater than 50 cm in water depth. The deeper runs at G5 were normally associated with scour along bedrock outcroppings. The sites on Sphinx Creek (excluding the lake) provided 5.5% and 4.8% habitats greater than 50 cm in water depth, and most of those habitats are associated with habitat structures built by the mine in the 1990's. The remaining sites had water depths greater than 50 cm in less than 2.1 % of the section. Habitat suitability information for RNTR advocates that slow deep areas with a riffle run ratio of 1:1 is optimum RNTR habitat (Raleigh et al. 1984). Sphinx Lake and Pit Lake CD provide important deep-water habitat for over-wintering and escape cover for larger adult fish (Pisces 2008a, Pisces 2009a and Figure 16). Lac des Roches also provided this habitat while it was operational (Schwartz 2002). The proposed pit lake on the upper Gregg River will presumably also provide this opportunity, as 9 BLTR and 2 RNTR were observed using the P1 habitat at site G2a (excavated pool) in June of 2008.

Raleigh et al. (1984) suggests that stream cover components exceeding 25% are adequate for adult RNTR, with a minimum of 15% cover adequate for juveniles. Stream cover at all stream sites, except Falls Creek, would appear to be lacking for RNTR in the study area. Raleigh also suggests that base flows (winter low flow periods), less than 25% of average daily flow is considered poor quality trout habitat, primarily due to the lack of over-wintering habitat. Although discharge data for the winter period is limited, one would assume that the percentage of base flow in creeks downstream of pit lakes is generally greater than the percentage of base flows in the same creek upstream of pit lakes, due to the storage capacity of pit lakes and their moderating effect on flows downstream.

Weather station data in 2008 indicated that surface water temperatures in Sphinx Lake lagged behind air temperatures during May and June. Surface water temperatures during July and early August increased at a slower rate and maintained temperatures close to the daily mean air temperature for about a month and a half. Surface water temperatures gradually began to decrease in late August and continued to do so into October, with the exception of a warming trend in mid September and early October 2008. Although only a single season of weather data was gathered, these temperature trends help to explain the increasing juvenile RNTR population downstream of the lake. Increased water temperatures in Sphinx Creek downstream of the lake appeared to favour RNTR production, while the increased temperatures during the fall may have deterred BLTR spawning downstream of the lake.

Stream temperature information derived from the data loggers (Table 23) ranks Falls Creek, downstream of Pit Lake CD (F-DS) and Sphinx Creek downstream of Sphinx Lake (S2 and DS) as having significantly warmer mean temperatures than the other stream sites. Raleigh et al. (1984) suggests that the optimal water temperature for incubation of RNTR eggs falls between 7 and 12ºC, with increased mortalities in colder and warmer waters. Rainbow trout aquacultural studies suggest that temperatures around 10ºC are optimal for RNTR egg incubation (Baeverfjord 2003).The hourly average water temperature from June 1 to July 15 in Sphinx Creek, downstream of Sphinx Lake, ranged from 7.7ºC to 7.9ºC. The average hourly temperature in 2009 ranged from 7.6ºC to 7.7ºC. Considering that the maximum hourly temperature in Sphinx Creek downstream was recorded at 14.5ºC in 2008 and 12.2ºC during the same time period in 2009, it would appear that incubation temperatures downstream of Sphinx Lake are close to optimum. Conversely, the average hourly water temperature in Sphinx Creek, upstream of Sphinx Lake from June 1 to July 15 was 5.3ºC in 2008 and 4.8ºC in 2009. On September 15, 2008, a single RNTR fry 21 mm in length was captured in Sphinx Creek upstream of Sphinx Lake. Similar sized RNTR were captured in Sphinx Creek downstream of the lake in late July of 2008, supporting the assertion that improved spawning and incubation conditions persist downstream of Sphinx Lake. These improved conditions are caused by the surface warming of lake waters and the reduced fluctuations in diurnal stream temperatures downstream of the lake.

Falls Creek temperatures downstream of Pit Lake CD in 2008 averaged 10.9ºC, with a maximum temperature of 16.8ºC over a similar time period. Falls Creek hourly temperatures from June 13 to July 15, 2009 were an average of 11.2ºC with a maximum temperature of 13.3ºC recorded. Although average temperatures in Falls Creek are near optimal, the maximum temperature of 16.8ºC in 2008 is of some concern (Figure 23). Over 80 hourly temperature readings exceeding 15ºC were recorded in Falls Creek before July 7, 2008. Crisp (1993) indicates that incubation temperatures above 15.5ºC are lethal to salmonid eggs. The absence of RNTR fry in Falls Creek in 2008, and the presence of RNTR fry in Falls Creek in 2009, may in part be linked to temperature. Temperatures in West Jarvis Creek downstream of Lac des Roches were monitored in 1995, 1998 and

1999 (Carson 2000), with average June and early July temperatures similar to temperature readings recorded in Falls Creek. The temperature recordings in West Jarvis Creek in 1998 are also similar because peak water temperatures exceeding 15ºC regularly occurred during that same time period (Schwartz and Allan 1999). The shift in population dominance to Brook trout in West Jarvis Creek in the late 1990s (Carson and Ross 1997, Schwartz and Allan 1999, Carson 2000) may be linked to springtime egg incubation temperatures lethal to RNTR eggs.

Over-wintering potential for fish downstream of pit lakes appears to be better than over-wintering potential upstream of pit lakes. Large sections of open water were observed in the streams downstream of Sphinx Lake and Pit Lake CD during wintertime visits in 2008 and 2009. Other stream sites were generally ice covered, with some stream temperature data loggers obviously being frozen. Two temperature loggers in Sphinx Creek, one immediately downstream of the lake (DS) and the other near the Gregg River confluence (S2), did not record significantly different temperatures. This suggests that the temperature effect of Sphinx Lake on the creek continues from the lake outlet downstream to the Gregg River (approximately 2 km) for much of the year.

5.2.2 Streambed Concretions

Calcite cement was recently identified in Luscar Creek, downstream of the Cardinal River Mine Lease near Hinton Alberta (Harvey and Verburg 2007). The concretions in Falls Creek and the upper Gregg River appear to be of the same general composition as those found in Luscar Creek in 2007, predominantly calcite with ferrihydrite, ($Fe(OH_3)$) imparting an orange hue to the precipitate (GR-Petrology 2007). Multivariate and pairwise correlations of the elemental analysis identify other probable compounds found in the concretions: quartz (SiO_2) and illite (KAlSiO(OH)). Differences in elemental concentrations of the Gregg River and Falls Creek samples are likely related to differences in positions and physical characteristics of the two streams.

Extensive deposits of calcite in the form of tufa and travertine have been reported throughout the world (Ford and Pedley 1996). Ford and Pedley make the clear distinction that calcite deposits at ambient temperatures are tufas and thermal deposits are travertines. They describe tufa as "the product of calcium carbonate precipitation under a cool-water regime and typically contains the remains of micro and macrophytes, invertebrates and bacteria". Tufas are generally of geological interest as many are from the late Quaternary and recent successions (Ford and Pedley 1996). Tufa deposits are relatively common and have been identified in the Rocky Mountains of Alberta, specifically at Miette Hot Springs in Jasper, Cave and Basin Hot Springs in Banff and the Fall Creek cold springs near Rocky Mountain House, Alberta (Rainey and Jones 2007).

Calcium carbonate precipitation occurs when a water source high in calcium carbonate rapidly degasses. The degassing of CO_2 cools the water, forcing the calcium out of solution (Ford and Pedley 1996). The degassing sites are commonly found at riffles, cascades, and waterfalls, and happen at a pH of 8 or higher. The tufaceous carbonate will be precipitated on available surfaces including plants, animals and rock (Ford and Pedley 1996). The concretions observed in Falls Creek and the upper Gregg River exhibit these attributes (Figure 37).


Figure 37: Microphotograph of vegetation in association with concretion as found in Falls Creek (Gregg River Mine Lease) in 2008.

The tendency of concretions to form rapidly in Falls Creek and the Gregg River is believed to be quite recent. The Environmental Impact Assessment for the Gregg River Mine (Slaney 1975) does not describe the presence of these concretions in Falls Creek or the Gregg River. The appearance of concretion in Falls Creek is also not documented in the Falls Creek Benthic Invertebrate Survey conducted in 1995 (Luoma 1997). Photographic evidence documenting the concretion in the upper Gregg River settling pond channel dates back to 2005. Calcium carbonate precipitation has been identified in other mining areas of the world, specifically with waste rock products associated with the lime industry (Gaiero et al. 1998). Given the calcareous nature of the parent material, occurrence of waste rock, water quality parameters of the water bodies, and locations of the deposits, the concretions are an indirect effect of the mining operations in the lease areas, likely associated with waste rock dumps.

As discussed previously, the upper Gregg River provides important habitat for two species of fish, BLTR and RNTR. The high percentage of concretions in the upper Gregg River basin is detrimental to both RNTR and BLTR, as basic requirements for both species include loose and unconsolidated gravel substrates for spawning.

Gravels appropriate for spawning were identified at the Gregg River - Site G4 in the spring of 2008. The capture of young-of-the-year RNTR in the fall of 2008 confirmed that RNTR spawning in the vicinity was successful earlier that year. The concretions that developed in the summer and fall of 2008 persisted, and no useable spawning gravels were identified at this site in the spring of 2009. No evidence of reproduction could be found within this section in 2009.

Spawning behaviour was observed in Falls Creek downstream of Pit Lake CD (Site F), in the spring of 2008. Successful reproduction in 2008 could not, however, be confirmed by drift netting or electro-fishing. The habitat inventory of Falls Creek (during the fall of 2008) identified only 0.5 m^2 (<0.03 %) of poor gravel substrate (large aggregate, high sediment) within this 0.5 km stretch of creek. In response to this observation, small artificial spawning beds were constructed within Falls Creek. Spawning behaviour at several of these gravel beds was observed in 2009, with fry being captured by drift netting and electro-fishing downstream of some of those beds later that year. Successful reproduction of resident RNTR in Falls Creek during the spring of 2009 was also realized using in-situ incubation chambers similar to the design of Bernier Bourgalt et al. (2005).

Substantial barriers (waterfalls and highway culverts) to fish movement exist near the confluence of Falls Creek and the Gregg River. Although spawning activity upstream of these barriers was not observed or documented in 2008 or 2009, electro-fishing data (Appendix A) suggests that successful RNTR and BLTR spawning occurred in the vicinity in previous years. Given the heavy concretions found in Falls Creek and the Gregg River Site-G3 during 2008, the availability of spawning gravels upstream of these barriers during the fall of 2008 and all of 2009 was very limited. Spawning gravels available in Berrys Creek and the upper Gregg River Site-G2 are likely of limited value to RNTR, as the thermal requirements for RNTR spawning and egg incubation appear limiting (Table 23).

Trout populations in mountain streams can vary considerably from one year to the next (Platts and Nelson 1986). It is interesting, however, to note that the total number of fish captured at Gregg River site G3, which is upstream of the barriers described earlier, dropped from 17 RNTR and 9 BLTR in 2008 (total 26 fish), to 3 RNTR and 0 BLTR in 2009. Electro-fishing the Gregg River at site G4 (located downstream of the barriers) in 2008 resulted in a capture of 54 RNTR and 12 BLTR (total 66 fish in 2008) and 67 RNTR and 8 BLTR (total 75 fish) in 2009. None of the individuals captured in 2008 at site G3 were recaptured in 2009. Several RNTR captured at site G4 in 2008 were recaptured at site G4 in 2009. It is highly doubtful that sampling technique and effort can explain the declines observed at site G3 from 2008 to 2009.

In total, approximately 10 kms of stream channel in the upper Gregg River basin were impacted by the formation of tufaceous carbonate by the fall of 2008 and for all of 2009. Conditions conducive for the formation of concretions have persisted in Falls Creek and the upper Gregg settling pond channel for several years, based on degrees of build-up and personal observations. The occurrence of the concretion in the main stem of the Gregg River during the summer of 2008 shows that concretions can quickly form and then persist for two seasons or longer. The degree of concretion is difficult to quantify, as it varies from site to site and appears to vary within the sites as well. These concretions will affect redd excavation and egg deposition into gravel substrates. If eggs are successfully deposited into the gravels, the calcite precipitation may further hinder egg development and reduce emergence of fry from the gravels. Substrates are also important to benthic invertebrates, and stream concretions would be expected to alter these communities as well. Changes in the benthic community may affect the food web relationships of RNTR and BLTR. Fry and juvenile trout may be impacted further as juvenile RNTR and BLTR are known to over-winter within stream substrates (Raleigh et al. 1984, Bonneau and Scarnecchia 1998). The reduction of pore space within coarse substrates also reduces the amount of escape cover for juvenile fish in concretion-impacted areas. The vulnerability of trout to adverse conditions associated with concretions upstream of the barriers would seem to be higher than the vulnerability of trout further downstream, and may explain the decreased densities at Gregg River Site G3.


Figure 38: Heavily concreted stream substrates, Falls Creek, July 16, 2008.

Specific conductance is also known as temperature-compensated conductivity. Conductivity refers to the water's ability to conduct a current, and is highly dependent upon the dissolved solids found in the liquid (USGS 2011). The specific conductance readings at stream sites in 2008 and 2009 appear to parallel streambed concretions in the area. The lower trend lines in Figure 32 are associated with sites having limited or no concretions, while the upper trend lines were recorded in habitats exhibiting moderate streambed concretion. Specific conductance values appeared to spike in the spring during runoff, with moderate fluctuations observed seasonally and from one year to the next. This variability may be related to snow pack, melting rates, and the weathering of calcareous rocks.

Calcite cement can be dissolved or prevented by reducing the amount of dissolved calcium concentration in the water or by reducing the pH (Harvey and Verburg 2007). Amelioration of stream water quality upstream of sites G2A, G3 and F should allow concretions to dissolve and prevent accumulations detrimental to the local trout population. Waste rock management that minimizes water flow through calcareous waste rock may help to reduce the opportunity for this detrimental effect to occur under similar conditions in the future.

5.2.3 Biological Attributes

The density of RNTR (age 1 and older) living in the creeks downstream of Pit Lake CD and Sphinx Lake were significantly greater than densities recorded at the other stream sites in 2008. The densities of RNTR living downstream of Sphinx Creek increased substantially in 2009 and exceeded densities of all other stream sites in that year. The density of RNTR in Falls Creek dropped substantially in 2009, but was still greater than densities of RNTR in stream sites upstream of Falls Creek. The density of Falls Creek RNTR in 2009 was similar to the densities observed in the Gregg River downstream of Falls Creek and in upper Sphinx Creek (S1). The population decline in Falls Creek is likely due to the migration of age 2 RNTR out of the creek into Pit Lake CD, combined with the absence of the 2008 RNTR year class in this creek. BLTR densities for age 1 and older individuals were greatest at site G2 and G4 on the Gregg River in 2008 and 2009, with densities dropping in 2009.

Growth rates for stream resident RNTR found in Sphinx Creek, downstream of Sphinx Lake and in Falls Creek, downstream of Pit Lake CD were significantly greater than growth rates of RNTR observed upstream of pit lakes (Table 37).

The mean concentration of selenium (wet weight) found in the eggs of Sphinx Creek RNTR was 5.52 ug/g (SE=0.36, SD=1.31, s^2=1.72, n=13). The mean concentration of selenium (wet weight) found in the eggs of Falls Creek RNTR is 7.81 ug/g (SE=0.52, SD=1.15, s^2=1.33, n=5). Water sampling in 2008 (Brock 2009) found Sphinx Creek water selenium levels ranging from 3.6 to 6.6 ug/L and Falls Creek water selenium levels ranging from 9.8 to 21.8 ug/L.

Holm et al. (2005) derived a Se EC10 of 23 ug/g dry weight for skeletal deformities in RNTR. Using the same 61.2% average moisture content for eggs as calculated by Holm (2005), the dry weight average for selenium in Sphinx Creek RNTR eggs was 9.02 ug/g and the average dry weight average for selenium in Falls Creek RNTR eggs was 12.76 ug/g. The highest selenium concentration for RNTR eggs during this study came from an individual from Pit Lake CD. The selenium concentration was 9.6 ug/g (wet weight), which, converted to dry weight, was 15.69 ug/g. This dry weight selenium concentration is well below the Se EC10 derived by Holm et al. (2005), and is also below the 17 ug/g Se EC10 derived by Deforest et al. (1999). Water temperatures and concretions may better explain the lack of successful reproduction observed in Falls Creek in 2008, and the reduced emergence success of the Pit Lake CD incubation trials.

5.3 Thesis Summary

Metallurgical coal reserves have been mined in the front ranges of the Rocky Mountains along the eastern boundary of Jasper National Park Boundary for almost 100 years. As with most extractive processes, natural landscapes are altered and the natural environment is changed.

Truck and shovel coal mining operations have operated on the Gregg River Mine Lease, Cardinal River Coals Mine Lease, and most recently in the Cheviot Mine Lease. Reclamation on the Cardinal River Coals Mine Lease and the Gregg River Mine Lease has occurred over the past 25 years, with reclamation that includes several mine pit lakes that are or were connected to stream environments. Various environmental studies have been undertaken monitoring the development of these systems, but the utility of these systems has been a question of debate.

Physical, chemical and biological parameters of these pit lakes were analyzed and compared to deep natural lakes of the Rocky Mountains. From a physical perspective, theses pit lakes are both different and similar to natural systems. Although these pit lakes are deeper, the characteristics of these pit lakes appear similar to shallower natural mountain lakes in regards to percentage of littoral habitat, thermal stratification and dissolved oxygen. From a chemical perspective, the water quality is different from the natural lakes, with selenium-enriched waters present in the epilimnion. The biological communities in Sphinx Lake and Pit Lake CD are similar to those in natural sub-alpine lakes with surface outlets. Outlet streams from pit lakes tend to produce more fish than similar nearby streams without lake systems. This increased productivity is linked to increased water temperatures and moderated flows downstream of pit lakes; and the pit lake habitats that many of these fish utilize. The principal difference between natural sub-alpine lakes with surface outlet streams and pit lakes with surface outlet streams are related to water chemistry.

Selenium concentrations in Sphinx Lake and Sphinx Creek, and in Pit Lake CD and Falls Creek exceed federal guidelines. Selenium concentrations in surface waters do not appear to be exaggerated by Pit Lake CD or Sphinx Lake. The issue appears to be a general mine drainage issue, not a problem caused by or related to lake qualities. Waters found at the deeper confines of Pit Lake CD and Sphinx Lake actually appear to have selenium concentrations lower than surface waters, and the surface waters in both lakes appear to be similar in selenium concentration to other stream and creek environments.

The highest selenium concentration observed in Rainbow trout eggs from Sphinx Lake and Pit Lake CD fish was 16 ug/g (conversion to dry weight), which falls below the Se EC10 for skeletal deformities of 23 ug/g, derived from selenium studies in the area and also the 17 ug/g Se EC10 proposed for other fish species. The potential detrimental effects associated with selenium enrichment impacts on fish reproduction were not observed during this study.

Another water quality issue, manifesting itself in the form of streambed concretions, was identified and quantified within the study area. Calcite precipitation caused by the degassing of calcium rich waters affected approximately 10 km of stream channel in the upper Gregg River basin in 2008 and 2009. Streambed materials including gravels, cobbles and fine materials were bound together into solid masses. Redd excavation and egg deposition into gravel substrates could not have occurred in most areas. If egg deposition had occurred, calcite precipitation would be expected to hinder egg development and reduce or eliminate emergence of fry from redds. Concretions would also be expected to negatively affect juvenile Rainbow trout and Bull trout escape cover and over-wintering habitat, due to the reduction of pore space within coarse substrates. Concretions occurred downstream of pit lakes and in areas where no pit lakes currently exist, and would appear to be a general mine drainage issue, rather than a problem caused by or related to lake qualities. The impact of the concretions in Falls Creek may in fact be reduced because of Pit Lake CD, as the outlet provided the only appropriate spawning substrate in Falls Creek in 2008 and 2009. Responding to the development of this concretion is important to the longevity of the Rainbow trout and Bull trout populations in the upper Gregg River and an important consideration for coal mining activities in areas with similar geological attributes.

Aquatic communities including fish, invertebrates, and zooplankton are present in the pit lakes. Populations of Rainbow trout and Bull trout have been identified and appear to be flourishing in Sphinx Lake. Rainbow trout in Sphinx Lake grow significantly bigger and faster, and mature sooner than their counterparts in nearby streams. Rainbow trout also inhabit Pit Lake CD and have growth rates slightly greater than Sphinx Lake fish. Rainbow trout population densities immediately downstream of Pit Lake CD and Sphinx Lake were much higher than they were prior to pit lake reclamation. An added benefit of

Pit Lake CD and Sphinx Lake is that these fish populations are self-propagating. Both lakes should provide angling opportunities while helping to maintain the integrity of native Athabasca Rainbow trout stocks without costly fish-stocking programs.

5.4 Recommendations

5.4.1 General Recommendations

Developing high altitude mine pits into lake habitats with connectivity to stream environments appears to have overall favourable results relative to the aquatic populations and communities, based on the observations in this study. The planned construction of pit lake systems with connectivity has the potential to expand the range and increase the density of Athabasca Rainbow trout in the area. Bull trout may also benefit under certain conditions. End Pit Lake Working Group (EPLWG 2002) guidelines regarding the hydrological, physical, chemical and biological characteristics for high altitude mine pit lakes with connectivity to the stream environment seem reasonable and address the majority of concerns regarding these systems.

Stable lake levels are an important consideration in pit lake design. The guideline of 1 m or less annual change in water level should perhaps be even less, when pit lakes with connectivity to stream environments are constructed. Lake levels in Lac des Roches were quite stable and likely fluctuated less than 0.5 m over the year. Lake levels in Pit Lake CD did not appear to change more than 0.3 m during 2008 and 2009. Lake level fluctuations are influenced by various factors, including water flow into the lake, size of water body, and the way that water enters and exits the lake. These factors and many others need to be considered on a lake-to-lake basis, and should be considered prior to mining. Lake levels in Sphinx Lake, for example, may have been better stabilized if seepage near the lake exit had been better controlled. Design criteria for pit lakes with connectivity should perhaps include a portion of littoral area at the lake outlet and in other areas where seepage concerns exist. Construction of stable littoral areas, sealed with fine materials and compacted soils, should help to reduce seepage and help to minimize water level fluctuations to some degree.

The water temperatures in Pit Lake CD during the spring egg incubation period may have been detrimental to Rainbow trout hatching success. Similar conditions may have existed at Lac des Roches. Reducing the solar heating of waters at the outlet should be a construction and reclamation consideration. Limiting the amount of shallow water habitat with dark substrates at the outlet, planting trees for shade, and constructing outlet channels in shaded areas are possible mitigative measures.

Guidelines (EPLWG 2002) suggest that a substantial portion of a pit lake be designed with shallow, littoral habitats. Littoral habitats are very important for the development of aquatic populations and communities. It may be better to disperse littoral habitats around the perimeter of a pit lake in as many regions as possible, rather than creating littoral habitats in one or two areas. Considering that these pit lakes are most often devoid of deciduous and coniferous vegetation for many years, the addition of well-secured tree and brush piles into these littoral regions is also recommended.

Another design consideration with pit lakes connected to stream environments should include the introduction of excess spawning gravels at the lake outlets. Gravel recruitment from upstream is reduced with the construction of a pit lake, as gravel migrating downstream during high flow events is lost into the lake. Although channel design considerations should include construction of spawning runs downstream, an excess of gravel dispersed at the outlet is beneficial for several reasons. Lake outlet flows are often spread over a wider, deeper and more uniform area, and may be prime areas for spawning. Gravels at the outlet would also be available for recruitment downstream, and may be helpful in the formation of future spawning areas downstream.

Long term monitoring and management of these populations is important to ensure that the biological, chemical and physical characteristics of these systems continue to develop and remain viable over time.

5.4.2 Specific Recommendations

5.4.2.1 Sphinx Lake – Sphinx Creek

Several drop structures and small waterfalls connecting Sphinx Lake to upper Sphinx Creek should be altered to allow for easier fish migration upstream. Although several Rainbow trout and Bull trout were recorded moving upstream out of Sphinx Lake into Sphinx Creek, Rainbow trout and Bull trout that were unsuccessfully attempting to circumvent these structures were also observed. The waterfall entering the lake is of prime concern because reduced lake levels may impede Bull trout migrations upstream of

Sphinx Lake during low summer flows (as the lake level drops, the waterfall height at the inlet increases).

Seepage through the berm, which separates the outlet channel from the lake, could be better sealed. This seepage is responsible for reduced lake levels in the fall and winter, loss of connectivity to the downstream creek (approximately 75 metres of creek outlet dries up during low flows), loss of lake littoral and associated winter dieback of macrophytes.

5.4.2.2 Pit Lake CD – Falls Creek

Concretion of stream substrates has virtually eliminated all available spawning sites in Falls Creek. Mitigating the development of these concretions requires further investigation, as indicated previously. The introduction of additional gravel substrates at the outlet of Pit Lake CD would provide Rainbow trout with available spawning habitat for an interim period, in an area where concretions are least apt to form. Additional spawning gravels should be placed strategically in the lower Falls Creek channel after the concretion issue is rectified.

5.4.2.3 Proposed Pit Lake 50A-North

In addition to reclamation plans (EVC 2006) and general recommendations covered earlier, the construction of stream velocity breaks with "gravel catching" capabilities upstream of proposed Pit Lake 50A-North is recommended. These structures could include v-weirs with deep pools or runs similar to those constructed upstream of Sphinx Lake. Very large boulders (greater than 1.5 m diameter), boulder clusters, or bedrock fissures may also be used to break up flows and create rough stream channel characteristics that provide holding habitat for Bull trout. The intent of these structures and channel would be to provide Bull trout the opportunity to move upstream of the lake and possibly spawn at the tails of these structures or further upstream.

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APPENDIX A: FISH CAPTURE DATA

Special Notes:

***Maturity Codes:**
I = Immature
3=Maturing Female, 4=Ripe Female, 5=Spent Female, 9 = Ripe Male, 99=Unknown

****Numerical PIT tag numbers starting with a "1", all begin with 9851210**

Electro-fishing - Mark/Recapture
Location: Sphinx Creek – Site S1
Date: August 26 and 28, 2008
Duration: Mark Run = 7923 seconds, Capture Run = 5739 seconds

Table 1: Electro-fishing - Mark/Recapture, Sphinx Creek – Site S1, August 26 and 28, 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Date	Run
BLTR	351	458.5	likely 3	R	4662784F38	26-Aug-08	Mark
BLTR	47	1.1	99	N	not tagged	26-Aug-08	Mark
BLTR	52	1.7	99	N	not tagged	26-Aug-08	Mark
BLTR	49	1.1	99	N	not tagged	26-Aug-08	Mark
BLTR	320	379.9	99	N	4664571559	26-Aug-08	Mark
BLTR	50	1.1	99	N	not tagged	26-Aug-08	Mark
BLTR	363	464.5	99	R	46624D152E	26-Aug-08	Mark
RNTR	193	98.3	99	R	48692A5818	26-Aug-08	Mark
RNTR	173	68.5	99	R	4869216C5B	26-Aug-08	Mark
RNTR	201	103.8	99	N	46627D7301	26-Aug-08	Mark
RNTR	165	57.8	99	N	46644F3755	26-Aug-08	Mark
RNTR	101	11.2	99	N	4677326D40	26-Aug-08	Mark
RNTR	205	94.5	99	R	486773192D	26-Aug-08	Mark
RNTR	105	11.5	99	N	4662571C17	26-Aug-08	Mark
RNTR	107	13.6	99	N	467558100A	26-Aug-08	Mark
RNTR	109	16.1	99	N	466441664D	26-Aug-08	Mark
RNTR	129	24.3	99	N	46650A7426	26-Aug-08	Mark
RNTR	91	9.1	99	N	465F074026	26-Aug-08	Mark
RNTR	187	86.3	99	N	46625B352A	26-Aug-08	Mark
RNTR	176	71.4	99	N	4662573E20	26-Aug-08	Mark
RNTR	207	129.6	99	N	46633D571D	26-Aug-08	Mark
RNTR	120	20.3	99	N	4677155430	26-Aug-08	Mark
RNTR	132	25.6	99	N	466502725F	26-Aug-08	Mark
RNTR	105	12.7	99	N	46625D2006	26-Aug-08	Mark
RNTR	121	22.4	99	N	4662722E51	26-Aug-08	Mark
RNTR	105	12.9	99	N	4663201573	26-Aug-08	Mark
RNTR	97	11.5	99	N	4677175A3F	26-Aug-08	Mark
RNTR	118	19.6	99	N	466A23467E	26-Aug-08	Mark
RNTR	97	10	99	N	466356695A	26-Aug-08	Mark
RNTR	102	12.7	99	N	466212527F	26-Aug-08	Mark
RNTR	94	8.8	99	N	466169755C	26-Aug-08	Mark
RNTR	125	24.2	99	N	4662530039	26-Aug-08	Mark
RNTR	106	14	99	N	46627F396D	26-Aug-08	Mark
RNTR	123	24	99	N	465E6E2D72	26-Aug-08	Mark
RNTR	179	70.5	99	N	466529343B	26-Aug-08	Mark
RNTR	146	36.5	99	R	4869127366	26-Aug-08	Mark
RNTR	206	122.3	99	N	4662692071	26-Aug-08	Mark
RNTR	188	80.8	99	R	4869115122	26-Aug-08	Mark
RNTR	101	10.7	99	N	4644A0427	26-Aug-08	Mark

RNTR	94	8.3	99	N	466A040E29	26-Aug-08	Mark
RNTR	189	84	99	N	4662532614	26-Aug-08	Mark
RNTR	189	91.4	99	R	48691C0F02	26-Aug-08	Mark
RNTR	173	62.4	99	R	4870555C78	26-Aug-08	Mark
RNTR	92	9.8	99	N	46775B077D	26-Aug-08	Mark
RNTR	119	19.4	99	N	467757021F	26-Aug-08	Mark
RNTR	111	14.7	99	N	4678106129	26-Aug-08	Mark
RNTR	93	8		mort	mort	26-Aug-08	Mark
BLTR	320	379	99	R	4664571559	28-Aug-08	Capture
BLTR	364	472	99	R	46624D152E	28-Aug-08	Capture
BLTR	50		99	N	not tagged	28-Aug-08	Capture
RNTR	131	22.8	99	N	466936204D	28-Aug-08	Capture
RNTR	120	20.4	99	R	4677155430	28-Aug-08	Capture
RNTR	183	86.6	99	R	46625B352A	28-Aug-08	Capture
RNTR	96	97	99	R	466356695A	28-Aug-08	Capture
RNTR	100	11.7	99	R	466A4E7971	28-Aug-08	Capture
RNTR	109	16.1	99	N	46646A3F1C	28-Aug-08	Capture
RNTR	121	21.7	99	N	465E7F1008	28-Aug-08	Capture
RNTR	112	15.5	99	N	46756A5C33	28-Aug-08	Capture
RNTR	96	10.7	99	N	46771C2C31	28-Aug-08	Capture
RNTR	106	15.6	99	N	466A302E5D	28-Aug-08	Capture
RNTR	93	8.6	99	R	466169755C	28-Aug-08	Capture
RNTR	118	18.6	99	N	46650B656F	28-Aug-08	Capture
RNTR	105	12.3	99	N	46645C1B15	28-Aug-08	Capture
RNTR	100	10.5	99	N	46627B024D	28-Aug-08	Capture
RNTR	115	21.8	99	R	4662722E51	28-Aug-08	Capture
RNTR	134	26.5	99	N	4664367078	28-Aug-08	Capture
RNTR	119	18.7	99	N	46754D741E	28-Aug-08	Capture
RNTR	204	124.2	99	R	46633D571D	28-Aug-08	Capture
RNTR	109	14.6	99	N	46625F301F	28-Aug-08	Capture
RNTR	163	56.2	99	R	46644F3755	28-Aug-08	Capture
RNTR	202	97.8	99	R	46627D7301	28-Aug-08	Capture
RNTR	190	88.3	99	R	48691C0F02	28-Aug-08	Capture
RNTR	105	11.5	99	R	4662571C17	28-Aug-08	Capture
RNTR	123	24	99	R	46650A7426	28-Aug-08	Capture
RNTR	193	94.1	99	R	48692A5818	28-Aug-08	Capture
RNTR	102	13.1	99	R	46627F396D	28-Aug-08	Capture
RNTR	173	66	99	R	4869216C5B	28-Aug-08	Capture
RNTR	152	43.4	99	N	465F673260	28-Aug-08	Capture
RNTR	154	48.1	99	R	48644D547F	28-Aug-08	Capture
RNTR	174	61.8	99	R	46775D347C	28-Aug-08	Capture
RNTR	112	14.2	99	R	4678106129	28-Aug-08	Capture
RNTR	207	120.1	99	R	4662692071	28-Aug-08	Capture
RNTR	116	23.9	99	R	465E6E2D72	28-Aug-08	Capture
RNTR	108	12.8	99	N	46620E1708	28-Aug-08	Capture

Electro-fishing - Mark/Recapture
Location: Sphinx Creek – Site S1
Date: August 19 and 20, 2009
Duration: Mark Run = 6260 seconds, Capture Run = 6427 seconds

Table 2: Electro-fishing - Mark/Recapture, Sphinx Creek – Site S1, August 19 and 20, 2009

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	68	3.3	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	114	16.3	N	4B1E6D2474	19-Aug-09	Mark
RNTR	*63*	*3.2*	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	60	2.7	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	84	6.4	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	55	1.9	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	72	3.9	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	105	11.6	N	4B02272742	19-Aug-09	Mark
RNTR	58	2	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	58	1.9	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	54	1.6	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	42	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	43	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	48	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	39	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	39	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	42	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	37	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
BLTR	37	0.5	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	192	96.2	R	46652C7806	19-Aug-09	Mark
RNTR	123	24	R	4677175A3F	19-Aug-09	Mark
RNTR	141	32.7	N	4B0203186F	19-Aug-09	Mark
RNTR	147	39.9	MORT	467757021F	19-Aug-09	Mark
RNTR	148	45.8	R	465E7F1008	19-Aug-09	Mark
BLTR	100	11.1	N	4B020C1847	19-Aug-09	Mark
BLTR	102	10.1	N	4B1E7C6641	19-Aug-09	Mark
BLTR	94	9.8	N	4B1E526526	19-Aug-09	Mark
RNTR	126	22.2	R	466356695A	19-Aug-09	Mark
RNTR	136	30	R	466212527F	19-Aug-09	Mark
RNTR	205	115	R	4662532614	19-Aug-09	Mark
RNTR	58	2.7	N	Lower Caudal Clip	19-Aug-09	Mark
RNTR	137	31.5	R	46646A3F1C	19-Aug-09	Mark
RNTR	174	58.6	R	46644F3755	19-Aug-09	Mark
RNTR	163	55.1	R	48644D547F	19-Aug-09	Mark
RNTR	194	101	R	4B1F01551A	19-Aug-09	Mark
RNTR	129	25.8	R	466441664D	19-Aug-09	Mark
RNTR	127	24.8	R	46625D2006	19-Aug-09	Mark
RNTR	149	37.1	N	4B02122D53	19-Aug-09	Mark

BLTR	105	12.6	N	4B1F06081D	19-Aug-09	Mark
BLTR	101	10.2	N	4B1E757A20	20-Aug-09	Mark
RNTR	127	25.7	N	4B021F497C	20-Aug-09	Capture
RNTR	59	2.4	N	Lower Caudal Clip	20-Aug-09	Capture
RNTR	*53*	*2.2*	N	Lower Caudal Clip	20-Aug-09	Capture
BLTR	43	0.5	N	Lower Caudal Clip	20-Aug-09	Capture
RNTR	62	2.4	N	Lower Caudal Clip	20-Aug-09	Capture
BLTR	39	0.6	N	Lower Caudal Clip	20-Aug-09	Capture
BLTR	36	0.4	N	Lower Caudal Clip	20-Aug-09	Capture
BLTR	104	10.8	N	4B02002330	20-Aug-09	Capture
BLTR	110	12.5	N	4A70727A34	20-Aug-09	Capture
RNTR	124	21.1	R	466356695A	20-Aug-09	Capture
RNTR	122	26.8	R	4677175A3F	20-Aug-09	Capture
BLTR	96	8.9	N	4B020F2318	20-Aug-09	Capture
BLTR	103	10.2	R	4B1E7C6641	20-Aug-09	Capture
BLTR	107	12.7	N	4B1E752930	20-Aug-09	Capture
RNTR	53	1.6	N	Lower Caudal Clip	20-Aug-09	Capture
RNTR	121	19.2	R	467558100A	20-Aug-09	Capture
RNTR	143	35.4	R	46650A7426	20-Aug-09	Capture
RNTR	172	58.1	R	46644F3755	20-Aug-09	Capture
RNTR	214	104.8	R	486773192D	20-Aug-09	Capture
RNTR	213	126.4	R	46633D571D	20-Aug-09	Capture
RNTR	119	19.9	R	46627F396D	20-Aug-09	Capture
RNTR	60	2.7	N	Lower Caudal Clip	20-Aug-09	Capture
RNTR	133	30.7	R	46646A3F1C	20-Aug-09	Capture
RNTR	149	37.1	R	4B02122D53	20-Aug-09	Capture
RNTR	214	134	N	4BIE6B3713	20-Aug-09	Capture
RNTR	133	30.1	N	4B1E697768	20-Aug-09	Capture

Electro-fishing Survey Shock
Location: Sphinx Creek – Site S2
Date: June 18, 2008
Duration: 2806 seconds

Table 3: Electro-fishing - Survey Shock, Sphinx Creek – Site S2, June 18, 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Date
RNTR	114	15	99	Recap	4665284031	18-Jun-08
RNTR	120	17	99	Recap	4662721044	18-Jun-08
RNTR	141	28	9	New	46774C1710	18-Jun-08
RNTR	108	13	99	Recap	46776B3361	18-Jun-08
RNTR	126	20	99	New	466246535D	18-Jun-08
RNTR	135	25	99	New	mort	18-Jun-08

Electro-fishing Survey Shock
Location: Gregg River Downstream of Sphinx Creek – Site G5
Date: October 21, 2009
Duration: 5208 seconds

Table 4: Electro-fishing - Survey Shock, Gregg R. Downstream of Sphinx Creek – Site S5, October 21, 2009

Species	Length (mm)	Weight (g)	Recap/New	Date
RNTR	91	8.1	New	21-Oct-09
RNTR	46	1.4	New	21-Oct-09
RNTR	91	8.5	New	21-Oct-09
RNTR	83	6.5	New	21-Oct-09
RNTR	94	8.8	New	21-Oct-09
RNTR	76	5.6	New	21-Oct-09
RNTR	125	19.4	New	21-Oct-09
RNTR	95	8.7	New	21-Oct-09
RNTR	92	9.1	New	21-Oct-09
RNTR	109	14.5	New	21-Oct-09
RNTR	112	14.7	New	21-Oct-09
RNTR	93	8.0	New	21-Oct-09
RNTR	93	10.5	New	21-Oct-09
RNTR	94	9.0	New	21-Oct-09
RNTR	96	9.4	New	21-Oct-09
RNTR	76	5.7	New	21-Oct-09
RNTR	103	12.3	New	21-Oct-09
RNTR	86	8.5	New	21-Oct-09
RNTR	85	6.9	New	21-Oct-09
RNTR	76	5.2	New	21-Oct-09
RNTR	70	4.4	New	21-Oct-09
RNTR	98	10.1	New	21-Oct-09
RNTR	103	11.3	New	21-Oct-09
RNTR	86	7.8	New	21-Oct-09
RNTR	85	7.7	New	21-Oct-09
RNTR	102	12.0	New	21-Oct-09
RNTR	81	5.5	New	21-Oct-09
RNTR	98	11.2	New	21-Oct-09
RNTR	91	8.2	New	21-Oct-09
RNTR	99	10.3	New	21-Oct-09
BLTR	73	3.8	New	21-Oct-09
BLTR	127	19.5	New	21-Oct-09
BLTR	73	4.4	New	21-Oct-09
BLTR	204	83.5	New	21-Oct-09
BLTR	128	19.6	New	21-Oct-09
RNTR	163	50.8	New	21-Oct-09
RNTR	216	114.4	New	21-Oct-09
RNTR	186	76.3	New	21-Oct-09

RNTR	163	42.3	New	21-Oct-09
RNTR	208	104.1	New	21-Oct-09
RNTR	47	1.0	New	21-Oct-09
RNTR	165	57.6	New	21-Oct-09
RNTR	126	22.2	New	21-Oct-09
RNTR	198	94.8	New	21-Oct-09
RNTR	177	71.8	New	21-Oct-09
RNTR	201	106.1	New	21-Oct-09
RNTR	196	88.4	New	21-Oct-09
RNTR	46	1.2	New	21-Oct-09
RNTR	53	1.8	New	21-Oct-09
RNTR	89	6.9	New	21-Oct-09
RNTR	88	7.0	New	21-Oct-09
RNTR	93	8.6	New	21-Oct-09
RNTR	49	1.2	New	21-Oct-09
RNTR	98	10.3	New	21-Oct-09
RNTR	97	9.4	New	21-Oct-09
RNTR	95	8.6	New	21-Oct-09
RNTR	101	11.5	New	21-Oct-09
RNTR	96	10.2	New	21-Oct-09
RNTR	102	12.0	New	21-Oct-09
RNTR	95	8.3	New	21-Oct-09
BLTR	77	4.6	New	21-Oct-09
BLTR	143	28.4	New	21-Oct-09
BLTR	193	68.8	New	21-Oct-09
BLTR	79	5.1	New	21-Oct-09
RNTR	138	30.4	New	21-Oct-09
RNTR	159	40.1	New	21-Oct-09
RNTR	43	1.0	New	21-Oct-09
RNTR	32	0.3	New	21-Oct-09
RNTR	83	5.8	New	21-Oct-09
RNTR	74	5.0	New	21-Oct-09
RNTR	80	5.5	New	21-Oct-09
RNTR	84	7.2	New	21-Oct-09
RNTR	113	15.1	New	21-Oct-09
RNTR	95	9.0	New	21-Oct-09
RNTR	41	1.0	New	21-Oct-09
RNTR	132	33.4	New	21-Oct-09
RNTR	88	7.4	New	21-Oct-09
RNTR	94	8.8	New	21-Oct-09
RNTR	95	9.3	New	21-Oct-09
RNTR	104	12.0	New	21-Oct-09
RNTR	82	6.0	New	21-Oct-09
RNTR	85	7.0	New	21-Oct-09
RNTR	96	9.5	New	21-Oct-09

RNTR	70	4.3	New	21-Oct-09
RNTR	92	9.4	New	21-Oct-09
RNTR	103	12.1	New	21-Oct-09
RNTR	94	8.3	New	21-Oct-09
RNTR	101	11.1	New	21-Oct-09
RNTR	106	13.0	New	21-Oct-09
RNTR	134	25.0	New	21-Oct-09
RNTR	91	9.9	New	21-Oct-09
RNTR	149	40.2	New	21-Oct-09
RNTR	148	37.4	New	21-Oct-09
RNTR	88	8.1	New	21-Oct-09
RNTR	123	20.0	New	21-Oct-09
RNTR	144	38.6	New	21-Oct-09
RNTR	155	41.1	New	21-Oct-09
RNTR	136	33.6	New	21-Oct-09
RNTR	145	31.5	New	21-Oct-09
RNTR	95	9.3	New	21-Oct-09
RNTR	75	5.0	New	21-Oct-09
RNTR	99	10.3	New	21-Oct-09
RNTR	112	17.2	New	21-Oct-09
RNTR	93	7.9	New	21-Oct-09
RNTR	87	8.2	New	21-Oct-09
RNTR	102	11.4	New	21-Oct-09
RNTR	37	0.6	New	21-Oct-09
RNTR	52	1.5	New	21-Oct-09
RNTR	83	5.5	New	21-Oct-09
RNTR	113	20.8	New	21-Oct-09
RNTR	45	1.0	New	21-Oct-09
RNTR	83	6.3	New	21-Oct-09
RNTR	84	6.2	New	21-Oct-09
RNTR	85	7.0	New	21-Oct-09
RNTR	119	17.3	New	21-Oct-09
RNTR	89	7.2	New	21-Oct-09
RNTR	87	7.1	New	21-Oct-09
RNTR	97	9.6	New	21-Oct-09
RNTR	97	9.7	New	21-Oct-09
RNTR	73	4.8	New	21-Oct-09
RNTR	204	105.9	New	21-Oct-09
RNTR	208	109.4	New	21-Oct-09
RNTR	165	55.2	New	21-Oct-09
RNTR	141	39.7	New	21-Oct-09
RNTR	135	26.0	New	21-Oct-09
RNTR	187	89.2	New	21-Oct-09
RNTR	170	63.0	New	21-Oct-09
RNTR	136	34.8	New	21-Oct-09

RNTR	174	44.7	New	21-Oct-09
RNTR	188	78.4	New	21-Oct-09
RNTR	151	38.1	New	21-Oct-09
RNTR	162	45.1	New	21-Oct-09

Electro-fishing - Mark/Recapture
Location: Gregg River Upstream of Sphinx Creek – Site G4
Date: Sept 29 and 30, 2008
Duration: Mark Run = 6305 seconds, Capture Run = 5838 seconds

Table 5: Electro-fishing - Mark/Recapture, Gregg R. Upstream of Sphinx Creek – Site G4, September 29 and 30, 2008

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
BLTR	184	57.9	New	12044615	29-Sep-08	Mark
BLTR	197	70.4	New	12050126	29-Sep-08	Mark
BLTR	139	27.1	New	16381589	29-Sep-08	Mark
RNTR	98	10.5	New	12053777	29-Sep-08	Mark
RNTR	145	32	New	12056519	29-Sep-08	Mark
RNTR	140	31.3	New	16373720	29-Sep-08	Mark
RNTR	110	17.6	New	11994133	29-Sep-08	Mark
BLTR	144	33.5	New	11994168	29-Sep-08	Mark
RNTR	175	52.4	New	12026891	29-Sep-08	Mark
RNTR	137	29.4	New	11992835	29-Sep-08	Mark
RNTR	244	177.5	New	12032137	29-Sep-08	Mark
RNTR	206	127.4	New	16377317	29-Sep-08	Mark
RNTR	162	47	New	12055394	29-Sep-08	Mark
RNTR	164	49.1	New	11984673	29-Sep-08	Mark
RNTR	158	44.1	New	12055468	29-Sep-08	Mark
RNTR	138	28.5	New	12044837	29-Sep-08	Mark
RNTR	148	32	New	12033534	29-Sep-08	Mark
RNTR	120	19.1	New	11990277	29-Sep-08	Mark
RNTR	144	36	New	11982934	29-Sep-08	Mark
RNTR	153	42.2	New	12045033	29-Sep-08	Mark
RNTR	145	30.6	New	14048239	29-Sep-08	Mark
RNTR	83	7	New	12048624	29-Sep-08	Mark
RNTR	146	33.2	New	12052041	29-Sep-08	Mark
RNTR	136	24.8	New	12034032	29-Sep-08	Mark
RNTR	156	45.7	New	12050059	29-Sep-08	Mark
RNTR	133	24.4	New	11991761	29-Sep-08	Mark
BLTR	123	16.4	New	11982837	29-Sep-08	Mark
RNTR	242	164	New	11983268	29-Sep-08	Mark
RNTR	246	181	New	12053843	29-Sep-08	Mark
BLTR	195	71.3	New	12033763	29-Sep-08	Mark
RNTR	83	5.7	New	12055368	29-Sep-08	Mark
RNTR	89	7.2	New	12052071	29-Sep-08	Mark
RNTR	187	68.7	New	12050302	29-Sep-08	Mark

RNTR	156	43.5	New	11992845	29-Sep-08	Mark
RNTR	151	39.6	New	12055519	29-Sep-08	Mark
RNTR	116	16	New	11993082	29-Sep-08	Mark
RNTR	164	51	New	12044677	29-Sep-08	Mark
RNTR	87	6.9	New	11981993	29-Sep-08	Mark
RNTR	90	6.8	New	11990068	29-Sep-08	Mark
RNTR	93	8	New	12050265	29-Sep-08	Mark
RNTR	81	5.5	New	12043545	29-Sep-08	Mark
RNTR	138	21.8	New	16378661	29-Sep-08	Mark
BLTR	286	222	Recap	48641C2B29	29-Sep-08	Mark
RNTR	50	approx	new	eaten?	29-Sep-08	Mark
RNTR	40	approx	new	eaten?	29-Sep-08	Mark
RNTR	133	24.5	Recap	11991761	30-Sep-08	Capture
RNTR	142	34.1	Recap	4664556C5F	30-Sep-08	Capture
RNTR	136	23.6	New	16374104	30-Sep-08	Capture
BLTR	127	19.2	New	12046352	30-Sep-08	Capture
BLTR	135	29.5	New	12055525	30-Sep-08	Capture
RNTR	138	25.7	New	12046815	30-Sep-08	Capture
BLTR	149	40.7	New	11981887	30-Sep-08	Capture
RNTR	241	161.3	Recap	11983268	30-Sep-08	Capture
RNTR	84	6	New	12043530	30-Sep-08	Capture
RNTR	147	33.2	New	11992059	30-Sep-08	Capture
RNTR	130	25.2	New	12044940	30-Sep-08	Capture
RNTR	180	67.9	Recap	12050302	30-Sep-08	Capture
RNTR	138	29.1	Recap	12044837	30-Sep-08	Capture
RNTR	158	43.7	Recap	12055468	30-Sep-08	Capture
RNTR	84	5.7	New	12030477	30-Sep-08	Capture
RNTR	161	45.8	New	11989654	30-Sep-08	Capture
RNTR	92	8.4	Recap	12050265	30-Sep-08	Capture
RNTR	246	179	Recap	12053843	30-Sep-08	Capture
RNTR	134	30.7	Recap	16373720	30-Sep-08	Capture
RNTR	140	31.3	Recap	12033534	30-Sep-08	Capture
RNTR	90	7	Recap	11990068	30-Sep-08	Capture
RNTR	146	31.3	Recap	11993242	30-Sep-08	Capture
RNTR	136	29.6	Recap	11992835	30-Sep-08	Capture
RNTR	237	171.5	Recap	12032137	30-Sep-08	Capture
RNTR	145	33	Recap	12052041	30-Sep-08	Capture
BLTR	141	26.5	Recap	16381589	30-Sep-08	Capture
RNTR	163	52	Recap	12044677	30-Sep-08	Capture
RNTR	156	40.4	New	11982073	30-Sep-08	Capture
RNTR	158	47.4	Recap	11984673	30-Sep-08	Capture
RNTR	151	37.4	New	12048358	30-Sep-08	Capture
RNTR	128	24.6	Recap	12034032	30-Sep-08	Capture
BLTR	171	45	New	12048441	30-Sep-08	Capture
BLTR	149	27.5	New	11983182	30-Sep-08	Capture

RNTR	83	7	Recap	12048624	30-Sep-08	Capture
RNTR	115	18.8	Recap	11990277	30-Sep-08	Capture
RNTR	88	7	Recap	11981993	30-Sep-08	Capture
RNTR	145	32.2	New	12049923	30-Sep-08	Capture
RNTR	132	25.5	New	16400701	30-Sep-08	Capture
RNTR	117	18.4	New	12045039	30-Sep-08	Capture
RNTR	229	159	New	11984740	30-Sep-08	Capture
BLTR	285	223.4	Recap	48641C2B29	30-Sep-08	Capture
RNTR	45		New		30-Sep-08	Capture

Electro-fishing Mark/Recapture Population Estimate
Location: Gregg River Upstream of Sphinx Creek – Site G4
Date: October 17 and 18, 2009
Duration: Mark Run = 4494 seconds, Capture Run = 5016 seconds

Table 6: Electro-fishing - Mark/Recapture, Gregg R. Upstream of Sphinx Creek – Site G4, October 17 and 18, 2009

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	88	8.3	New	Lower Caudal Clip	17-Oct-09	Mark
RNTR	101	16.7	New	4B1F034119	17-Oct-09	Mark
RNTR	106	11.9	New	4B1E665577	17-Oct-09	Mark
RNTR	145	35.6	New	4B1F066F6A	17-Oct-09	Mark
RNTR	151	39.9	New	4A705C525A	17-Oct-09	Mark
RNTR	143	31.6	New	4A7065310F	17-Oct-09	Mark
RNTR	75	4.6	New	Lower Caudal Clip	17-Oct-09	Mark
RNTR	152	36.9	New	4B02295B26	17-Oct-09	Mark
RNTR	161	47.5	New	4B020F5625	17-Oct-09	Mark
RNTR	157	43.2	New	4B1E547934	17-Oct-09	Mark
BLTR	131	22.2	New	4A705A1C20	17-Oct-09	Mark
BLTR	227	106	New	4B02136275	17-Oct-09	Mark
RNTR	140	31.3	New	4B1E412216	17-Oct-09	Mark
RNTR	167	55.5	Recap	985121011993082	17-Oct-09	Mark
RNTR	161	44.9	New	4A70752F75	17-Oct-09	Mark
RNTR	153	48.7	New	4B1F005871	17-Oct-09	Mark
RNTR	150	41	New	4B1F034D45	17-Oct-09	Mark
RNTR	125	25.9	New	4B1E4E7968	17-Oct-09	Mark
RNTR	200	93.3	New	4B1E78297F	17-Oct-09	Mark
RNTR	99	11.1	New	4B1E7C4F27	17-Oct-09	Mark
RNTR	138	30.4	New	4B1E7E184A	17-Oct-09	Mark
RNTR	122	18.9	Recap	985121011981993	17-Oct-09	Mark
BLTR	147	32	New	4B1E696B4A	17-Oct-09	Mark
RNTR	195	87.9	New	4B02265D20	17-Oct-09	Mark
RNTR	191	86	Recap	985121012048239	17-Oct-09	Mark
BLTR	130	21.5	New	4B1E644C0B	17-Oct-09	Mark
RNTR	177	80.2	New	4B022A6A0B	17-Oct-09	Mark
RNTR	130	25.3	New	4B1E6F346D	17-Oct-09	Mark

RNTR	151	38.5	New	4B021F5B36	17-Oct-09	Mark
RNTR	146	35.1	New	4B1E5F2917	17-Oct-09	Mark
RNTR	93	8.2	New	4B020B6A08	17-Oct-09	Mark
RNTR	97	10.4	New	4A70727272	17-Oct-09	Mark
RNTR	89	7.6	New	Lower Caudal Clip	17-Oct-09	Mark
RNTR	161	50.4	New	4B1E443270	17-Oct-09	Mark
RNTR	132	25.5	New	4B1F047616	17-Oct-09	Mark
RNTR	171	55.8	New	4B1E5E2145	17-Oct-09	Mark
RNTR	127	21.3	New	4B1E653164	17-Oct-09	Mark
RNTR	129	22	New	4B1F087374	17-Oct-09	Mark
RNTR	80	5.3	New	Lower Caudal Clip	17-Oct-09	Mark
RNTR	85	6.9	New	Lower Caudal Clip	17-Oct-09	Mark
RNTR	89	7.7	New	Lower Caudal Clip	17-Oct-09	Mark
RNTR	93	9.1	New	4B1E686B5E	17-Oct-09	Mark
RNTR	96	9.5	New	4B1F025347	17-Oct-09	Mark
RNTR	77	5.6	New		18-Oct-09	Capture
RNTR	99	10.7	Recap	4B1E7C4F27	18-Oct-09	Capture
RNTR	125	23.8	New	4B1E3E2D6F	18-Oct-09	Capture
RNTR	151	44.4	New	4B0218513B	18-Oct-09	Capture
RNTR	162	56.5	New	4B1E76572F	18-Oct-09	Capture
RNTR	97	9.4	Recap	4B1F025347	18-Oct-09	Capture
RNTR	87	7.6	New		18-Oct-09	Capture
RNTR	89	7.7	New		18-Oct-09	Capture
RNTR	98	9.8	New	4B1E442614	18-Oct-09	Capture
RNTR	147	32.4	New	4B02193155	18-Oct-09	Capture
RNTR	208	116.7	New	4B1F010941	18-Oct-09	Capture
RNTR	75	5.2	New		18-Oct-09	Capture
RNTR	81	6.5	New		18-Oct-09	Capture
RNTR	103	16.5	Recap	4B1F034119	18-Oct-09	Capture
RNTR	96	9.5	New	4B1E5E485A	18-Oct-09	Capture
RNTR	93	8.6	New	4B1F08247E	18-Oct-09	Capture
RNTR	138	34.2	Recap	4B1F066F6A	18-Oct-09	Capture
RNTR	136	27	New	4B02031029	18-Oct-09	Capture
RNTR	84	6.6	Recap	Lower Caudal Clip	18-Oct-09	Capture
RNTR	88	7.8	New		18-Oct-09	Capture
RNTR	107	13.3	New	4B02241578	18-Oct-09	Capture
RNTR	144	35.2	Recap	985121012052071	18-Oct-09	Capture
RNTR	104	12	New	4B1E480A10	18-Oct-09	Capture
RNTR	111	15.4	New	4B1E7A0547	18-Oct-09	Capture
RNTR	177	78.7	Recap	4B022A6A0B	18-Oct-09	Capture
RNTR	205	118.6	Recap	985121011989654	18-Oct-09	Capture
BLTR	226	108	Recap	4B02136275	18-Oct-09	Capture
BLTR	131	22.1	Recap	4A705A1C20	18-Oct-09	Capture
RNTR	123	18.5	Recap	985121011981993	18-Oct-09	Capture
RNTR	90	8.3	Recap	Lower Caudal Clip	18-Oct-09	Capture

RNTR	98	10.3	New	4B1E2B7F28	18-Oct-09	Capture
RNTR	124	20.6	New	4B02150D2F	18-Oct-09	Capture
RNTR	171	54.3	Recap	4B1E5E2145	18-Oct-09	Capture
RNTR	93	8.8	Recap	4B1E686B5E	18-Oct-09	Capture
RNTR	95	8.8	New	4B02133046	18-Oct-09	Capture
BLTR	139	25.2	New	4B1F09696C	18-Oct-09	Capture
RNTR	192	84.4	Recap	985121012048239	18-Oct-09	Capture
RNTR	162	49.6	Recap	4B1E443270	18-Oct-09	Capture
RNTR	192	99.7	Recap	985121012050059	18-Oct-09	Capture
RNTR	123	19.7	Recap	985121012043545	18-Oct-09	Capture
RNTR	133	30.8	Recap	4B1E412216	18-Oct-09	Capture
RNTR	151	39.3	Recap	4B021F5B36	18-Oct-09	Capture
RNTR	90	9.4	New	4B1E6C4C5C	18-Oct-09	Capture
BLTR	142	27.3	New	4B1F027B02	18-Oct-09	Capture
BLTR	142	27.7	New	4B1F065C00	18-Oct-09	Capture
BLTR	148	30.8	New	4B022B3D15	18-Oct-09	Capture
RNTR	95	9.5	New	4B1E371F65	18-Oct-09	Capture
RNTR	170	60.5	?Recap/New	4B02186A17	18-Oct-09	Capture
RNTR	90	8.3	Recap	4B020B6A08	18-Oct-09	Capture
RNTR	128	20.8	Recap	4B1E653164	18-Oct-09	Capture
RNTR	143	34.3	Recap	4B1E5F2917	18-Oct-09	Capture

Electro-fishing - Mark/Recapture
Location: Gregg River Upstream of Berrys Creek – G3
Date: September 30 and October 1, 2008
Duration: Mark Run = 3612 seconds, Capture Run = 2922 seconds

Table 7: Electro-fishing - Mark/Recapture, Gregg R. Upstream of Berrys Creek – Site G3, September 30 and October 1, 2008

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	184	67.6	New	Mort	30-Sep-08	Mark
RNTR	175	67.2	New	11986816	30-Sep-08	Mark
RNTR	225	174.6	New	12048634	30-Sep-08	Mark
RNTR	217	125.5	New	12053492	30-Sep-08	Mark
RNTR	188	85.8	New	11990409	30-Sep-08	Mark
RNTR	135	27.8	New	11989779	30-Sep-08	Mark
RNTR	206	120.8	New	11994169	30-Sep-08	Mark
RNTR	173	65.5	New	16380332	30-Sep-08	Mark
RNTR	164	49.7	New	12050360	30-Sep-08	Mark
BLTR	180	57	New	12026776	30-Sep-08	Mark
RNTR	141	29.1	New	12050098	30-Sep-08	Mark
BLTR	166	41.4	New	12053370	30-Sep-08	Mark
RNTR	156	44.6	New	11983464	30-Sep-08	Mark
RNTR	202	113.1	New	12050064	30-Sep-08	Mark
BLTR	171	46.1	New	12044905	30-Sep-08	Mark
BLTR	178	62.8	New	12050016	30-Sep-08	Mark

RNTR	175	65.5	New	12053748	30-Sep-08	Mark
BLTR	183	59.8	New	11981672	30-Sep-08	Mark
RNTR	202	113.2	Recap	12050064	1-Oct-08	Capture
RNTR	192	87.5	New	12051993	1-Oct-08	Capture
RNTR	206	122	Recap	12053492	1-Oct-08	Capture
RNTR	189	83.4	Recap	11990409	1-Oct-08	Capture
RNTR	185	81.9	New	11994070	1-Oct-08	Capture
RNTR	174	65.5	Recap	12053748	1-Oct-08	Capture
RNTR	220	139.8	New	12032129	1-Oct-08	Capture
RNTR	207	120	Recap	11994169	1-Oct-08	Capture
BLTR	180	54.8	Recap	12026776	1-Oct-08	Capture
RNTR	141	29.2	Recap	12050098	1-Oct-08	Capture
BLTR	180	60	Recap	11981672	1-Oct-08	Capture
RNTR	153	44	Recap	11983464	1-Oct-08	Capture
RNTR	177	67.3	Recap	11986816	1-Oct-08	Capture
RNTR	153	39.3	New	12043671	1-Oct-08	Capture
BLTR	169	41.6	New	11986808	1-Oct-08	Capture
BLTR	190	61.4	New	11981291	1-Oct-08	Capture
BLTR	174	47.2	New	12046693	1-Oct-08	Capture
BLTR	124	16.9	New	11989572	1-Oct-08	Capture
BLTR	171	44.9	Recap	12044905	1-Oct-08	Capture

Electro-fishing - Survey Shock
Location: Gregg River Upstream of Berrys Creek – G3
Date: September 14, 2009
Duration: Run 1 = 2612 seconds, Run 2 = 2552 seconds

Table 8: Electro-fishing - Survey Shock, Gregg R. Upstream of Berrys Creek – Site G4, September 14, 2009

Species	Length (mm)	Weight (g)	History	PIT Tag	Date	Run
RNTR	129	23.8	New	12035418	14-Sep-09	Run 1
RNTR	230	182.4	New	11991553	14-Sep-09	Run 1

Electro-fishing - Mark/Recapture
Location: Upper Gregg River – G2
Date: August 28 and 30, 2008
Duration: Mark Run = 6168 seconds, Capture Run = 3560 seconds

Table 9: Electro-fishing - Mark/Recapture, Upper Gregg R. – Site G2, August 28 and 30, 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Date	Run
BLTR	284	224	9	Recap	467754351C	28-Aug-08	Mark
BLTR	267	207	9	New	46640D1750	28-Aug-08	Mark
BLTR	290	269	99M?	New	4677107E59	28-Aug-08	Mark
BLTR	169	46	99	New	466A415879	28-Aug-08	Mark
BLTR	277	196	99	Recap	4664483609	28-Aug-08	Mark
BLTR	187	62	99	New	4662741B7E	28-Aug-08	Mark

BLTR	188	61	99	New	4677621618	28-Aug-08	Mark
BLTR	287	242	99F?	New	46625D7538	28-Aug-08	Mark
BLTR	282	246	9	New	46697D7E67	28-Aug-08	Mark
BLTR	174	53	99	New	4665273633	28-Aug-08	Mark
BLTR	282	222	99	Recap	467767267D	28-Aug-08	Mark
BLTR	279	216	99	Recap	4662692837	28-Aug-08	Mark
BLTR	242	162	9	Recap	4663360324	28-Aug-08	Mark
BLTR	269	218	99	New	4663260445	28-Aug-08	Mark
BLTR	300	264	9	Recap	4662104345	28-Aug-08	Mark
BLTR	299	263	99	New	4664575A6B	28-Aug-08	Mark
RNTR	216	133	99	Recap	4677626325	28-Aug-08	Mark
BLTR	238	130	9	Recap	4868790043	28-Aug-08	Mark
BLTR	195	71	99	New	4665263A7B	28-Aug-08	Mark
RNTR	202	103	99	New	46775C6B24	28-Aug-08	Mark
RNTR	161	56	99	Recap	465E5B440E	28-Aug-08	Mark
BLTR	277	250.3	99	Recap	46697D7E67	30-Aug-08	Capture
BLTR	287	268.4	99	Recap	4677107E59	30-Aug-08	Capture
BLTR	216	105.2	99	Recap	4664517071	30-Aug-08	Capture
BLTR	291	260.9	99	Recap	4664575A6B	30-Aug-08	Capture
BLTR	181	57.9	99	New	46644A7B68	30-Aug-08	Capture
BLTR	256	201.4	9	Recap	46640D1750	30-Aug-08	Capture
BLTR	192	69.6	99	Recap	4665263A7B	30-Aug-08	Capture
BLTR	185	61	99	Recap	4677621618	30-Aug-08	Capture
BLTR	234	130.2	99	Recap	4868790043	30-Aug-08	Capture
BLTR	298	259.1	9	Recap	4662104345	30-Aug-08	Capture
BLTR	275	206.7	99	New	4665210C57	30-Aug-08	Capture
BLTR	274	191.4	99	Recap	4664483609	30-Aug-08	Capture
BLTR	273	222.6	9	Recap	467754351C	30-Aug-08	Capture
RNTR	199	103.2	99	Recap	46775C6B24	30-Aug-08	Capture
RNTR	211	131.1	99	Recap	4677626325	30-Aug-08	Capture
BLTR	283	239.1	99	Recap	46625D7538	30-Aug-08	Capture

Angling Survey
Location: Upper Gregg River – G2a – Excavated Pool
Date: 2008
Duration: 2 people for 30 minutes each on June 14, 2008
2 people for 15 minutes each on August 31, 2008
Note: Observed 9 BLTR and 2 RNTR in upper pool on June 29, 2008

Table 10: Angling Survey, Upper Gregg R. - Site G2a, June 14, and August 31, 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Date
BLTR	258	194	99	Recap	467767267D	14-Jun-08
BLTR	277	232	99	New	466227021B	14-Jun-08
BLTR	269	203	99	New	46613D3F56	14-Jun-08
BLTR	263	195	99	New	4677095407	14-Jun-08
BLTR	256	190	99	New	4677487645	14-Jun-08

RNTR	200	98	4	Recap	4677626325	14-Jun-08
BLTR	299	246.1	99	Recap	466227021B	31-Aug-08
BLTR	176	53.9	99	Recap	4662520219	31-Aug-08

Electro-fishing - Mark/Recapture
Location: Upper Gregg River – G2
Date: October 21 and 22, 2009
Duration: Mark Run = 3059 seconds, Capture Run = 3065 seconds

Table 11: Electro-fishing - Mark/Recapture, Upper Gregg R. – Site G2, October 21 and 22, 2009

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	223	158.0	New	4B02285C3F	21-Oct-09	Mark
BLTR	177	58.3	New	4B02260D27	21-Oct-09	Mark
BLTR	257	213	Recap	4663360324	21-Oct-09	Mark
BLTR	227	124.5	New	4B1F093E66	21-Oct-09	Mark
BLTR	225	123.9	New	4B1E687837	21-Oct-09	Mark
BLTR	258	180.5	New	4B02026500	21-Oct-09	Mark
BLTR	231	114	New	4A705A1A0E	21-Oct-09	Mark
BLTR	245	158.4	New	4B1E7D7126	21-Oct-09	Mark
BLTR	257	213	Recap	4663360324	22-Oct-09	Capture
BLTR	258	180.5	Recap	4B02026500	22-Oct-09	Capture
RNTR	223	158.0	Recap	4B02285C3F	22-Oct-09	Capture
BLTR	225	123.9	Recap	4B1E687837	22-Oct-09	Capture
BLTR	227	124.5	Recap	4B1F093E66	22-Oct-09	Capture
BLTR	177	58.3	Recap	4B02260D27	22-Oct-09	Capture
BLTR	232	141.1	New	4B0203386C	22-Oct-09	Capture

Electro-fishing - Survey Shock
Location: Falls Creek – F
Date: May 22 and June 22, 2008
Duration: May 22 = 804 seconds, June 22 = 2390 seconds

Table 12: Electro-fishing - Survey Shock, Falls Creek – Site F, May 22 and June 22, 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	Pit Tag	Date
RNTR	82	scale?	99	New		22-May-08
RNTR	162	56	99	New	4669730C6B	22-Jun-08
RNTR	120	22	99	New	4677731660	22-Jun-08
RNTR	128	25	99	New	46646A286F	22-Jun-08
RNTR	121	21	99	New	4677240D3D	22-Jun-08
RNTR	104	12	99	New	46624E222D	22-Jun-08
RNTR	98	11	99	New	46626B6D10	22-Jun-08

Electro-fishing Mark/Recapture Population Estimate
Location: Falls Creek – F
Date: September 7 and 11, 2008
Duration: Mark Run = 6514 seconds, Capture Run = 6969 seconds

Table 13: Electro-fishing - Mark/Recapture, Falls Creek – Site F, September 7 and 11, 2008

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	204	111.6	Recap	4662110879	7-Sep-08	Mark
RNTR	159	52.5	New	16375523	7-Sep-08	Mark
RNTR	142	34.1	New	12048262	7-Sep-08	Mark
RNTR	130	24	New	12053787	7-Sep-08	Mark
BLTR	166	41.1	New	16375203	7-Sep-08	Mark
RNTR	147	35.7	New	12044941	7-Sep-08	Mark
RNTR	135	30.3	New	11984666	7-Sep-08	Mark
RNTR	152	36.6	New	11994297	7-Sep-08	Mark
RNTR	147	37.8	New	11981990	7-Sep-08	Mark
RNTR	161	49.6	New	12046515	7-Sep-08	Mark
RNTR	144	36.2	New	16383325	7-Sep-08	Mark
RNTR	158	46.5	New	11989817	7-Sep-08	Mark
RNTR	144	34.7	New	11986685	7-Sep-08	Mark
RNTR	144	40.4	New	12050035	7-Sep-08	Mark
RNTR	148	39.2	New	12056496	7-Sep-08	Mark
RNTR	152	42.7	New	11982122	7-Sep-08	Mark
RNTR	133	26.2	New	12048295	7-Sep-08	Mark
RNTR	172	50.4	New	12032347	7-Sep-08	Mark
RNTR	156	46.8	New	12043455	7-Sep-08	Mark
RNTR	143	34.5	New	12053600	7-Sep-08	Mark
RNTR	150	36.5	New	16397424	7-Sep-08	Mark
RNTR	139	30.4	New	11985145	7-Sep-08	Mark
RNTR	157	47.2	New	12033768	7-Sep-08	Mark
RNTR	161	51	New	12046564	7-Sep-08	Mark
RNTR	150	41.1	New	12055491	7-Sep-08	Mark
RNTR	148	42.4	Recap	4664347405	7-Sep-08	Mark
BLTR	189	74.5	New	16384393	7-Sep-08	Mark
RNTR	159	48.7	New	11990121	7-Sep-08	Mark
RNTR	159	57.6	New	12053383	7-Sep-08	Mark
RNTR	144	35.3	New	11990439	7-Sep-08	Mark
RNTR	142	32.6	New	16380167	7-Sep-08	Mark
RNTR	133	26.9	New	16375835	7-Sep-08	Mark
RNTR	178	65.5	Recap	466211587E	7-Sep-08	Mark
RNTR	120	23.7	New	11984735	7-Sep-08	Mark
RNTR	167	61.1	New	12053339	7-Sep-08	Mark
RNTR	144	33.3	New	12046479	7-Sep-08	Mark
RNTR	154	36.6	New	12035165	7-Sep-08	Mark
RNTR	170	65	New	12028669	7-Sep-08	Mark
RNTR	139	31	New	11991267	7-Sep-08	Mark
RNTR	169	59.4	New	11990038	7-Sep-08	Mark
RNTR	140	34.6	New	16373847	7-Sep-08	Mark

RNTR	124	22.5	New	11994840	7-Sep-08	Mark
RNTR	125	23.9	New	11992723	7-Sep-08	Mark
RNTR	129	23.9	New	12048496	7-Sep-08	Mark
RNTR	142	35.1	Recap	46624F000E	7-Sep-08	Mark
RNTR	155	40.1	Recap	46624E222D	7-Sep-08	Mark
RNTR	172	64.4	Recap	4669730C6B	7-Sep-08	Mark
RNTR	158	42	New	12055392	7-Sep-08	Mark
RNTR	140	32.7	New	12046556	7-Sep-08	Mark
RNTR	127	27.6	New	12050129	7-Sep-08	Mark
RNTR	143	33.7	New	11985419	7-Sep-08	Mark
RNTR	114	15.8	New	12048208	7-Sep-08	Mark
RNTR	127	22.4	New	12051673	7-Sep-08	Mark
RNTR	140	34	Recap	46626B6D10	7-Sep-08	Mark
RNTR	129	25.7	New	16375703	7-Sep-08	Mark
RNTR	161	50.6	Recap	4677240D3D	7-Sep-08	Mark
RNTR	163	64	New	12023659	7-Sep-08	Mark
RNTR	159	48.4	New	12048567	7-Sep-08	Mark
RNTR	150	41.8	New	12051990	7-Sep-08	Mark
RNTR	155	42.4	New	12028706	7-Sep-08	Mark
RNTR	167	52.8	New	12051565	7-Sep-08	Mark
RNTR	130	29.6	New	12050263	7-Sep-08	Mark
RNTR	142	35	New	16377443	7-Sep-08	Mark
RNTR	134	26	New	11989808	7-Sep-08	Mark
RNTR	157	47.8	Recap	4677731660	7-Sep-08	Mark
RNTR	135	33.6	New	12043386	7-Sep-08	Mark
RNTR	147	49.2	New	11991154	7-Sep-08	Mark
RNTR	150	43.6	New	12050077	7-Sep-08	Mark
RNTR	151	40.2	New	11992054	7-Sep-08	Mark
RNTR	149	38.3	New	11982041	7-Sep-08	Moved into CD
RNTR	120	17.1	New	12055301	7-Sep-08	Mark
RNTR	148	41.9	New	12053399	7-Sep-08	Mark
RNTR	146	37.1	New	12029923	7-Sep-08	Mark
RNTR	158	53.5	New	11981673	7-Sep-08	Moved into CD
RNTR	187	81.3	New	11986233	7-Sep-08	Moved into CD
RNTR	130	30.6	Recap	4677407731	7-Sep-08	Mark
RNTR	110	17.2	New	12032344	7-Sep-08	Mark
RNTR	136	33.1	New	11982354	7-Sep-08	Mark
RNTR	151	45.7	Recap	11989817	11-Sep-08	Capture
RNTR	143	36	Recap	16397424	11-Sep-08	Capture
RNTR	162	50.7	Recap	12032347	11-Sep-08	Capture
RNTR	139	29.1	Recap	11985145	11-Sep-08	Capture
RNTR	204	108	Recap	4662110879	11-Sep-08	Capture
RNTR	133	26.6	Recap	12048295	11-Sep-08	Capture
BLTR	167	41.5	Recap	16375203	11-Sep-08	Capture
RNTR	171	59.2	New	12053362	11-Sep-08	Capture
RNTR	159	49.9	Recap	16375523	11-Sep-08	Capture
RNTR	145	32.7	New	11993242	11-Sep-08	Capture
RNTR	156	46.7	Recap	12043455	11-Sep-08	Capture

RNTR	151	36.8	Recap	11994297	11-Sep-08	Capture
RNTR	148	34.3	New	12051940	11-Sep-08	Capture
RNTR	143	34.4	Recap	12048262	11-Sep-08	Capture
RNTR	167	49	Recap	12046515	11-Sep-08	Capture
RNTR	148	38.2	Recap	12056496	11-Sep-08	Capture
RNTR	137	34.7	Recap	16383325	11-Sep-08	Capture
RNTR	143	40	Recap-Mort	12055491	11-Sep-08	Capture
RNTR	124	21.9	Recap	11994840	11-Sep-08	Capture
RNTR	168	57.3	Recap	11990038	11-Sep-08	Capture
RNTR	163	40.3	New	16373584	11-Sep-08	Capture
RNTR	142	32.9	New	12032338	11-Sep-08	Capture
RNTR	150	36.7	New	12053768	11-Sep-08	Capture
RNTR	119	22.1	Recap	11984735	11-Sep-08	Capture
RNTR	127	23	Recap	11992723	11-Sep-08	Capture
RNTR	161	53.6	Recap	12053383	11-Sep-08	Capture
RNTR	163	50.3	Recap	12046564	11-Sep-08	Capture
RNTR	144	31.5	Recap	12046479	11-Sep-08	Capture
BLTR	190	71.8	Recap	16384393	11-Sep-08	Capture
RNTR	129	23.5	New	12032020	11-Sep-08	Capture
RNTR	121	23.6	New	12048466	11-Sep-08	Capture
RNTR	166	52.7	Recap	12051565	11-Sep-08	Capture
RNTR	138	31.5	Recap	16380167	11-Sep-08	Capture
RNTR	136	29.5	New	16378517	11-Sep-08	Capture
RNTR	141	33.6	Recap	11985419	11-Sep-08	Capture
RNTR	128	25.6	Recap	16375703	11-Sep-08	Capture
RNTR	134	26.5	Recap	16375835	11-Sep-08	Capture
RNTR	161	52.2	New	12055150	11-Sep-08	Capture
RNTR	132	27.2	New	11988656	11-Sep-08	Capture
RNTR	160	62.7	Recap	12023659	11-Sep-08	Capture
RNTR	156	49.7	Recap	4677240D3D	11-Sep-08	Capture
RNTR	157	47.4	Recap	12048567	11-Sep-08	Capture
RNTR	158	42.4	Recap	12055392	11-Sep-08	Capture
RNTR	140	34.4	Recap	46624F000E	11-Sep-08	Capture
RNTR	171	64	Recap	4669730C6B	11-Sep-08	Capture
RNTR	149	41	Recap	12051990	11-Sep-08	Capture
RNTR	149	42.6	Recap	12028706	11-Sep-08	Capture
RNTR	136	34.6	New	11987888	11-Sep-08	Capture
RNTR	136	34.4	New	12052817	11-Sep-08	Capture
RNTR	135	36	Recap	11982354	11-Sep-08	Capture
RNTR	152	37	Recap	11992054	11-Sep-08	Capture
RNTR	141	40	New	12048539	11-Sep-08	Capture
RNTR	139	38	New	11984570	11-Sep-08	Capture
RNTR	128	28	New	11982116	11-Sep-08	Capture
RNTR	148	45	Recap	11991154	11-Sep-08	Capture
RNTR	150	39	Recap	12050077	11-Sep-08	Capture
RNTR	146	40	Recap	12053399	11-Sep-08	Capture
RNTR	155	41	New	11986701	11-Sep-08	Capture
RNTR	147	46	New	12052035	11-Sep-08	Capture

Electro-fishing - Mark/Recapture
Location: Falls Creek – F
Date: August 27 and 29, 2009
Duration: Mark Run = 5547 seconds, Capture Run = 4331 seconds

Table 14: Electro-fishing - Mark/Recapture, Falls Creek – Site F, August 27 and 29, 2009

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	47	1.1	N	Upper Caudal Clip	27-Aug-09	Mark
RNTR	178	64.3	N	4B021C625D	27-Aug-09	Mark
RNTR	177	64.4	N	4B020F0622	27-Aug-09	Mark
RNTR	174	61.6	N	4B1E6C7B2C	27-Aug-09	Mark
RNTR	50	1.5	N	Upper Caudal Clip	27-Aug-09	Mark
RNTR	223	131.2	R	985121012046515	27-Aug-09	Mark
RNTR	173	61.6	N	4B1E7E0151	27-Aug-09	Mark
RNTR	174	56.7	N	4B02184371	27-Aug-09	Mark
RNTR	189	82.9	R	985121011991267	27-Aug-09	Mark
RNTR	233	154.3	R	985121012053768	27-Aug-09	Mark
RNTR	202	111.4	R	985121011990439	27-Aug-09	Mark
RNTR	142	37.9	R	985121011994840	27-Aug-09	Mark
RNTR	194	90.5	R	985121012032338	27-Aug-09	Mark
RNTR	180	73	R	985121016373847	27-Aug-09	Mark
RNTR	169	57.3	N	4B020D1970	27-Aug-09	Mark
RNTR	173	74	N	4B1E795707	27-Aug-09	Mark
RNTR	162	53.1	N	4B1E604178	27-Aug-09	Mark
RNTR	189	85.5	N	4B1E76272B	27-Aug-09	Mark
RNTR	166	49.4	N	4B1F031427	27-Aug-09	Mark
RNTR	170	53.2	N	4A70654725	27-Aug-09	Mark
RNTR	173	70.2	R	985121012051990	27-Aug-09	Mark
RNTR	200	100.7	R	4B0218655C	27-Aug-09	Mark
RNTR	191	82.7	R	985121011989808	27-Aug-09	Mark
RNTR	52	1.9	N	Upper Caudal Clip	27-Aug-09	Mark
RNTR	53	1.5	N	Upper Caudal Clip	27-Aug-09	Mark
RNTR	46	1.2	N	Upper Caudal Clip	27-Aug-09	Mark
RNTR	48	1.3	N	Upper Caudal Clip	27-Aug-09	Mark
RNTR	202	105.7	R	985121012048295	27-Aug-09	Mark
RNTR	178	69.2	N	4B1F046351	27-Aug-09	Mark
RNTR	173	67	N	4B1E5D382D	27-Aug-09	Mark
RNTR	191	100.8	R	985121011992723	27-Aug-09	Mark
RNTR	151	44.3	R	4662793906	27-Aug-09	Mark
RNTR	175	76.1	R	46626B6D10	27-Aug-09	Mark
RNTR	154	44.8	N	4A7068447D	27-Aug-09	Mark
RNTR	166	56.5	N	4B02051276	27-Aug-09	Mark
RNTR	229	151.9	R	985121012053768	29-Aug-09	Capture
RNTR	190	81.3	R	985121011991267	29-Aug-09	Capture
RNTR	142	37.7	R	985121011994840	29-Aug-09	Capture

RNTR	179	62.6	R	4B021C625D	29-Aug-09	Capture
RNTR	49	1.6	N		29-Aug-09	Capture
RNTR	202	107.1	R	985121016383325	29-Aug-09	Capture
RNTR	177	69.9	N	4B0219700F	29-Aug-09	Capture
RNTR	172	70.6	R	4B1E795707	29-Aug-09	Capture
RNTR	202	109.5	R	985121011990439	29-Aug-09	Capture
RNTR	131	25.9	N	4B0216072E	29-Aug-09	Capture
RNTR	194	96.2	R	985121011992723	29-Aug-09	Capture
RNTR	200	98.5	R	4B0218655C	29-Aug-09	Capture
RNTR	171	64	R	4B1E5D382D	29-Aug-09	Capture
RNTR	164	52.7	R	4B02051276	29-Aug-09	Capture
RNTR	195	103.1	R	985121012048295	29-Aug-09	Capture
RNTR	172	56.3	N	4B020C4B57	29-Aug-09	Capture
RNTR	161	48.4	R	4B1F031427	29-Aug-09	Capture
RNTR	173	70.7	R	46626B6D10	29-Aug-09	Capture
RNTR	177	68	R	985121012051990	29-Aug-09	Capture
RNTR	147	42.8	R	4662793906	29-Aug-09	Capture
RNTR	186	84.9	R	4B1E76272B	29-Aug-09	Capture
RNTR	172	53.7	R	4A70654725	29-Aug-09	Capture

Electro-fishing Mark/Recapture Population Estimate
Location: Berrys Creek – B
Date: August 31 and September 1, 2008
Duration: Mark Run = 2516 seconds, Capture Run = 1589 seconds

Table 15: Electro-fishing - Mark/Recapture, Berrys Creek – Site B, August 31 and September 1, 2008

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
RNTR	184	86.8	New	4661797C55	31-Aug-08	Marking
RNTR	217	146	New	4669733573	31-Aug-08	Marking
RNTR	213	158.2	New	466A67120E	31-Aug-08	Marking
RNTR	143	38.1	New	46653D6B17	31-Aug-08	Marking
BLTR	172	56.3	New	46757F6C3A	31-Aug-08	Marking
RNTR	190	94	New	4664747F35	31-Aug-08	Marking
RNTR	218	123.3	New	MORT	31-Aug-08	Marking
RNTR	216	142.1	Recap	4669733573	1-Sep-08	Capture
RNTR	189	92.4	Recap	4664747F35	1-Sep-08	Capture
RNTR	212	158.5	Recap	466A67120E	1-Sep-08	Capture
RNTR	196	104.6	New	4662776D27	1-Sep-08	Capture
BLTR	173	55.4	Recap	46757F6C3A	1-Sep-08	Capture

Electro-fishing Survey Shock
Location: Berrys Creek – B
Date: August 20, 2009
Duration: 1946 seconds- No fish captured or observed

Table 16: Electro-fishing - Survey Shock, Berry's Creek– Site B, August 20, 2009

Species	Length (mm)	Weight (g)	Recap/New	PIT Tag	Date	Run
No fish captured or observed					20-Aug-09	Survey

Pit-Lake CD and Falls Creek Beaver Pond angling
Date: July, August and September 2009

Table 17: Pit-lake CD and Falls Creek Beaver Pond angling in 2009

Species	Length (mm)	Weight (g)	Gear	Recap/New	PIT Tag	Site	EFFORT (minutes)	Date
RNTR	209	113.1	spinner	Recap	4B1F00261D	BD POND	10	31-Jul-09
RNTR	168	53.3	spinner	New	4B021A1125	BD POND	"	31-Jul-09
RNTR	192	91	spinner	Recap	985121012048567	CD LAKE	60	1-Aug-09
RNTR	241	190.3	spinner	New	4B1E3E3C32	CD LAKE	"	1-Aug-09
RNTR	394	724.7	spinner	Recap	4661787710	CD LAKE	1200	6-Sep-09
RNTR	452	993.5	spinner	Recap	46624E6826	CD LAKE	"	7-Sep-09
RNTR	416	710	spinner	Recap	4665207138	CD LAKE	"	7-Sep-09
RNTR	413	778	fly	Recap	4662602032	CD LAKE	"	7-Sep-09
RNTR	378	651.5	fly	Recap	4665244644	CD LAKE	"	7-Sep-09
RNTR	256	229.5	spoon	New	4B1E37110D	CD LAKE	"	7-Sep-09
RNTR	468	1145	spinner	Recap	46626A2002	CD LAKE	600	9-Sep-09
RNTR	410	792	fly	Recap	4662602032	CD LAKE	360	13-Sep-09

Pit-Lake CD Gill Netting
Date: August and September 2009
Effort: 37 hours

Table 18: Pit-lake CD gillnetting in 2009

Species	Length	Weight	Recap/New	PIT Tag	Date
RNTR	271	255	New	4B1E610870	9-Sep-09
RNTR	385	717	Recap	4663394B33	9-Sep-09
RNTR	267	237.5	Recap	46613E0304	9-Sep-09
RNTR	390	672	Recap	4665291947	9-Sep-09
RNTR	308	382	New	4B02201457	9-Sep-09
RNTR	468	1158	Recap	46626A2002	11-Sep-09
RNTR	266	268	Recap	46613E0304	11-Sep-09
RNTR	217	125	New	4B02134276	13-Sep-09
RNTR	266	231.5	Recap	4B1E37110D	13-Sep-09

Falls Creek Fish Trap - Located at the outlet of Pit-lake CD
Fish captured moving upstream into Pit-lake CD
Date: May 2008 to October 2008

Table 19: Fish captured moving upstream into Pit-lake CD, Falls Creek fish trap during 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Lift Date
RNTR	103	11	99	New	4677640C7F	2-Jun-08
RNTR	198	101	99	New	4662480245	2-Jun-08
RNTR	125	22	99	New	465E5B440E	3-Jun-08
RNTR	198	101	4	Recap	4662480245	6-Jun-08
RNTR	95	10	99	New	465F4A2C2E	7-Jun-08
RNTR	103	11	99	New	466253F0C	7-Jun-08
RNTR	96	9	99	New	4677796C26	7-Jun-08
RNTR	318	409	99F5	New	4663394B33	8-Jun-08
RNTR	378	575	99F5	New	4661583F38	8-Jun-08
RNTR	99	10	99	New	4677407731	8-Jun-08
RNTR	236	139	9	New	46696E7975	10-Jun-08
RNTR	369	478	5	New	46624E6826	11-Jun-08
RNTR	116	16	99	New	46646E1755	13-Jun-08
RNTR	301	276	99F5	New	4665207138	14-Jun-08
RNTR	390	583	5	New	46626A2002	14-Jun-08
RNTR	97	9	99	New	46755D0C30	14-Jun-08
RNTR	99	11	99	New	4664654A09	16-Jun-08
RNTR	109	14	99	New	46630F2E60	16-Jun-08
RNTR	92	9	99	New	4662534C1C	16-Jun-08
RNTR	94	8	99	New	46633E0C38	16-Jun-08
RNTR	101	11	99	New	4661763D27	16-Jun-08
RNTR	94	8	99	New	46644B221E	16-Jun-08
RNTR	83	5	99	New	46626A4541	17-Jun-08
RNTR	97	11	99	New	46613F7C5F	17-Jun-08
RNTR	315	325	99F5	New	4661787710	18-Jun-08
RNTR	87	6	99	New	466A45392C	18-Jun-08
RNTR	282	246	99F5	New	4662602032	18-Jun-08
RNTR	92	8	99	New	466278296C	18-Jun-08
RNTR	98	9	99	New	466A551B77	18-Jun-08
RNTR	93	8	99	New	46626A741F	19-Jun-08
RNTR	108	13	99	New	466268547B	20-Jun-08
RNTR	124	21	99	New	4664711D63	20-Jun-08
RNTR	101	11	99	New	466A597007	20-Jun-08
RNTR	112	15	99	New	4664590A50	20-Jun-08
RNTR	78	5	99	New	4665243D11	20-Jun-08
RNTR	313	362	99F5	Recap	4663394B33	21-Jun-08
RNTR	330	382	99F5	New	4662643925	21-Jun-08
RNTR	124	21	99	New	4664575C45	21-Jun-08
RNTR	94	9	99	New	46756F1D71	21-Jun-08
RNTR	79	5	99	New	4664767019	21-Jun-08
RNTR	120	19	99	Recap	4665065C38	22-Jun-08
RNTR	105	13	99	New	46625F1F57	22-Jun-08

RNTR	123	19	99	Recap	4662361F62	22-Jun-08
RNTR	95	10	99	New	4664347405	22-Jun-08
RNTR	98	10	99	New	466535214B	22-Jun-08
RNTR	110	14	99	New	466006672C	22-Jun-08
RNTR	85	5	99	New	4677487148	22-Jun-08
RNTR	94	8	99	New	46627C683A	22-Jun-08
RNTR	131	23	99	Recap	4664705071	23-Jun-08
RNTR	111	14	99	New	467566550D	23-Jun-08
RNTR	116	13	99	New	46774F6B3B	23-Jun-08
RNTR	97	9	99	New	466537531C	23-Jun-08
RNTR	120	19	99	Recap	4664642C49	24-Jun-08
RNTR	356	453	99F5	New	465E5C1476	24-Jun-08
RNTR	321	340	5	New	4665291947	25-Jun-08
RNTR	365	518	99F5	New	4663224D55	25-Jun-08
RNTR	128	21	99	Recap	4664711D63	25-Jun-08
RNTR	117	13	99	New	46644C1F63	25-Jun-08
RNTR	90	8	99	New	46626F6063	25-Jun-08
RNTR	82	5	99	New	46615E4F57	25-Jun-08
RNTR	94	8	99	New	465F4F737A	25-Jun-08
RNTR	94	9	99	New	4662642878	26-Jun-08
RNTR	120	18	99	Recap	46777B4527	26-Jun-08
RNTR	115	15	99	Recap	4663375C7C	26-Jun-08
RNTR	108	13	99	New	4665390E58	26-Jun-08
RNTR	104	11	99	New	46697F5645	27-Jun-08
RNTR	265	225	5	New	4665244644	28-Jun-08
RNTR	104	11	99	New	4664494320	28-Jun-08
RNTR	103	11	99	Recap	466341394E	29-Jun-08
RNTR	202	86	99	New	4662676A46	29-Jun-08
RNTR	83	6	99	New	46756F7157	29-Jun-08
RNTR	131	25	99	New	4669631B74	29-Jun-08
RNTR	127	22	99	Recap	466269746C	29-Jun-08
RNTR	107	13	99	New	46624F000E	29-Jun-08
RNTR	84	6	99	New	4663057328	29-Jun-08
RNTR	78	5	99	New	4665060063	29-Jun-08
RNTR	88	7	99	New	465F4A112C	29-Jun-08
RNTR	101	12	9	New	4661707F01	29-Jun-08
RNTR	110	14	99	New	46756E4633	29-Jun-08
RNTR	105	12	99	New	466A4A522F	29-Jun-08
RNTR	83	6	99	New	46627F246C	30-Jun-08
RNTR	195	76	99	Recap	4662480245	30-Jun-08
RNTR	105	12	99	New	46757B5639	30-Jun-08
RNTR	108	18	99	New	46616F5700	30-Jun-08
RNTR	145	37	99	New	46650B3F1A	30-Jun-08
RNTR	81	6	99	New	46646E6268	30-Jun-08
RNTR	120	18	99	New	46754E5F3F	30-Jun-08
RNTR	78	5	99	New	4662631A4E	30-Jun-08
RNTR	101	10	99	New	46782D1737	30-Jun-08
RNTR	78	5	99	New	4663186907	30-Jun-08

RNTR	117	17	99	New	4665181B1C	30-Jun-08
RNTR	92	8	99	New	466155120B	30-Jun-08
RNTR	117	18	99	New	46641B626A	30-Jun-08
RNTR	86	6	99	New	46755E7F50	30-Jun-08
RNTR	81	6	99	New	4664792870	1-Jul-08
RNTR	107	14	99	New	466A105331	1-Jul-08
RNTR	111	16	99	New	4669370C06	1-Jul-08
RNTR	91	7	99	New	4675647935	1-Jul-08
RNTR	87	7	99	New	4662553D50	1-Jul-08
RNTR	79	5	99	New	46647A1E50	1-Jul-08
RNTR	85	6	99	Recap	46763F1529	1-Jul-08
RNTR	109	13	99	Recap	46644C1F63	1-Jul-08
RNTR	74	4	99	New	4663051271	1-Jul-08
RNTR	79	6	99	New	46623C3523	1-Jul-08
RNTR	370	475	99F5	New	4662211B6B	2-Jul-08
RNTR	90	8.1	99	New	4662211614	2-Jul-08
RNTR	103	11	99	New	4664587E5A	2-Jul-08
RNTR	85	6.6	99	Recap	4665243D11	2-Jul-08
RNTR	85	6.6	99	New	46625F5A17	2-Jul-08
RNTR	94	9.4	99	New	4661776C17	3-Jul-08
RNTR	106	13	99	New	4665060E0B	3-Jul-08
RNTR	108	12.6	99	New	46757F585D	3-Jul-08
RNTR	78	5	99	New	4665381674	3-Jul-08
RNTR	340	444	5	New	465E67161D	4-Jul-08
RNTR	263	190	99F5	New	4663174667	4-Jul-08
RNTR	111	12.8	99	New	466A666A58	4-Jul-08
RNTR	106	12.3	99	New	4663364E22	4-Jul-08
RNTR	99	10.6	99	New	466A055266	4-Jul-08
RNTR	94	8	99	New	466A5E1002	4-Jul-08
RNTR	197	84.6	99	New	46772D5E6E	6-Jul-08
RNTR	168	54.6	99	Recap	466218441F	7-Jul-08
RNTR	98	9.2	99	New	46782F3670	7-Jul-08
RNTR	82	6.3	99	New	46755E3375	7-Jul-08
RNTR	101	10.2	99	New	466464325F	7-Jul-08
RNTR	121	19.2	99	New	465F51345E	14-Jul-08
RNTR	94	7.4	99	New	46770E4D63	14-Jul-08
RNTR	128	24.3	99	New	46754E1B5C	15-Jul-08
RNTR	104	12.5	99	New	46645B6B6E	16-Jul-08
RNTR	133	25.5	99	New	4677366429	17-Jul-08
RNTR	153	41.4	99	New	4665172402	21-Jul-08
RNTR	86	6.8	99	New	4663020353	22-Jul-08
RNTR	115	17	99	Recap	46613F7C5F	22-Jul-08
RNTR	119	17.8	99	Recap	4664587E5A	23-Jul-08
RNTR	103	12.1	99	New	4664036146	24-Jul-08
RNTR	144	30.2	99	New	46627F5834	24-Aug-08
RNTR	131	25	99	New	4665277B35	26-Aug-08
RNTR	144	33.9	99	New	4663406D47	2-Sep-08
RNTR	185	74.2	99	Recap	11986233	9-Sep-08

RNTR	148	36.1	99	Recap	11982041	9-Sep-08
RNTR	159	49.6	99	Recap	11981673	10-Sep-08

Falls Creek Fish Trap - Located at the outlet of Pit-lake CD
Fish captured moving upstream into Pit-lake CD
Date: May 2008 to October 2008

Table 20: Fish captured moving downstream into Falls Creek, Falls Creek fish trapping 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Lift Date
RNTR	125	22	99	Recap	465E5B440E	4-Jun-08
RNTR	198	102	4	Recap	4662480245	5-Jun-08
RNTR	318	409	4	Recap	4663394B33	9-Jun-08
RNTR	96	9	99	Recap	4677796C26	10-Jun-08
RNTR	198	102	4	Recap	4662480245	10-Jun-08
RNTR	264	220	4	New	4662504F78	11-Jun-08
RNTR	121	20	99	New	46613E0304	12-Jun-08
RNTR	121	19	99	New	4665065C38	17-Jun-08
RNTR	97	11	99	Recap	46613F7C5F	18-Jun-08
RNTR	100	10	99	New	466341394E	18-Jun-08
RNTR	130	24	99	New	4664705071	20-Jun-08
RNTR	123	21	99	New	4662361F62	20-Jun-08
RNTR	113	16	99	New	4663375C7C	20-Jun-08
RNTR	81	5	99	New	46763F1529	21-Jun-08
RNTR	129	25	99	New	4669631B74	21-Jun-08
RNTR	125	23	99	New	466269746C	22-Jun-08
RNTR	119	20	99	New	46777B4527	22-Jun-08
RNTR	119	19	99	New	4664642C49	22-Jun-08
RNTR	127	22	99	Recap	4664711D63	23-Jun-08
RNTR	96	10	99	Recap	4664347405	24-Jun-08
RNTR	118	13	99	Recap	46644C1F63	26-Jun-08
RNTR	87	7	99	New	466520013C	28-Jun-08
RNTR	117	14	99	Recap	46624F000E	30-Jun-08
RNTR	84	6	99	Recap	4665243D11	30-Jun-08
RNTR	74	4.5	99	Recap	4663051271	2-Jul-08
RNTR	117	16.7	99	Recap	4677407731	3-Jul-08
RNTR	104	11.4	99	Recap	4664587E5A	3-Jul-08
RNTR	171	56.7	99	New	466218441F	4-Jul-08

Falls Creek Fish Trap - Located at the outlet of Pit-lake CD
Fish captured moving upstream into Pit-lake CD
Date: May 2009 to September 2009

Table 21: Fish captured moving upstream into Pit-lake CD, Falls Creek fish trap during 2009

Species	Length (mm)	Weight (g)	Maturity	Gender	Recap/New	PIT Tag	Lift Date
RNTR	208	109	ripe	M	N	4BIE671D5C	31-May-09
RNTR	220	132	ripe	M	R	4B1E701A42	1-Jun-09
RNTR	165	53.5	ripe	M	R	4B020F5532	1-Jun-09
RNTR	186	79.5	ripe	M	R	4B021F6E72	1-Jun-09

RNTR	170	60.2	ripe	M	R	4B02196C2D	1-Jun-09
RNTR	177	63.1	unknown	U	N	4B1E710B0B	2-Jun-09
RNTR	140	32.6	ripe	M	R	4663051271	2-Jun-09
RNTR	198	92.7	ripe	M	R	4662361F62	3-Jun-09
RNTR	199	94.5	ripe	M	N	4B02004673	3-Jun-09
RNTR	173	63.2	ripe	M	N	4A70773213	3-Jun-09
RNTR	177	59	ripe	M	R	466A4A522F	3-Jun-09
RNTR	148	39.4	ripe	M	R	985121016373847	3-Jun-09
RNTR	159	46.3	ripe	M	N	4B1E6A137B	3-Jun-09
RNTR	194	89.1	ripe	M	N	4A706B152A	3-Jun-09
RNTR	143	34.7	ripe	M	R	46755E3375	4-Jun-09
RNTR	174	62.1	ripe	M	R	46627C683A	4-Jun-09
RNTR	246	178.3	ripe	M	R	4B1E7F755B	4-Jun-09
RNTR	237	166.3	ripe	M	N	4A70637507	4-Jun-09
RNTR	194	83.4	ripe	M	N	4B1F066E49	4-Jun-09
RNTR	183	78.1	ripe	M	R	4B1E7A207D	4-Jun-09
RNTR	170	58.5	ripe	M	R	4B02196C2D	4-Jun-09
RNTR	201	108.4	ripe	M	R	4B1E643F18	4-Jun-09
RNTR	143	31.4	ripe	M	N	4B1E63310F	4-Jun-09
RNTR	157	47.5	ripe	M	R	46697F5645	4-Jun-09
RNTR	221	128.6	ripe	M	R	4B1E701A42	4-Jun-09
RNTR	162	49.5	ripe	M	R	985121011982041	4-Jun-09
RNTR	147	37.9	ripe	M	R	985121016373847	5-Jun-09
RNTR	139	32.7	ripe	M	R	4663051271	5-Jun-09
RNTR	174	60.6	ripe	M	R	4B02092E0C	5-Jun-09
RNTR	163	53.4	ripe	M	R	4677731660	5-Jun-09
RNTR	154	47.2	ripe	M	R	4664767019	5-Jun-09
RNTR	139	33.2	ripe	M	R	46647A1E50	5-Jun-09
RNTR	165	54	ripe	M	R	4B020F5532	5-Jun-09
RNTR	132	25.6	ripe	M	R	985121012032020	5-Jun-09
RNTR	162	47.1	ripe	M	N	4B0218655C	5-Jun-09
RNTR	172	59	ripe	M	R	4A70773213	6-Jun-09
RNTR	186	75.4	ripe	M	R	4B021F6E72	6-Jun-09
RNTR	208	104.2	ripe	M	R	4B1E671D5C	6-Jun-09
RNTR	198	88.3	ripe	M	R	4662361F62	6-Jun-09
RNTR	222	124.9	ripe	M	R	4B1E71234E	6-Jun-09
RNTR	174	58.1	ripe	M	R	46627C683A	7-Jun-09
RNTR	234	152.8	ripe	M	R	4A70637507	8-Jun-09
RNTR	156	44	ripe	M	R	46697F5645	8-Jun-09
RNTR	220	124.1	ripe	M	R	4B1E701A42	8-Jun-09
RNTR	168	53	ripe	M	R	4B02196C2D	8-Jun-09
RNTR	161	48.1	ripe	M	R	985121011982041	9-Jun-09
RNTR	192	78.8	ripe	M	R	4B1F066E49	9-Jun-09
RNTR	143	29.7	ripe	M	R	985121012053787	10-Jun-09
RNTR	147	35.3	unknown	U	R	985121016375835	10-Jun-09

RNTR	201	80.3	ripe	M	R	4A706B152A	10-Jun-09
RNTR	220	118	ripe	M	N	4B1E647C76	10-Jun-09
RNTR	170	54.1	ripe	M	R	466A4A522F	11-Jun-09
RNTR	157	43.4	ripe	M	R	4B1E6A137B	11-Jun-09
RNTR	161	48.5	ripe	M	R	985121012048567	11-Jun-09
RNTR	210	103	ripe	M	R	4B1E643F18	11-Jun-09
RNTR	203	94.1	unknown	U	R	4B02065571	12-Jun-09
RNTR	162	45.4	ripe	M	R	985121011982041	12-Jun-09
RNTR	164	52	ripe	M	R	4677731660	12-Jun-09
RNTR	155	39	unknown	U	R	985121012046479	12-Jun-09
RNTR	153	40.3	ripe	M	R	4664767019	13-Jun-09
RNTR	143	28.4	ripe	M	R	985121012053787	13-Jun-09
RNTR	131	22.6	ripe	M	R	985121012050129	13-Jun-09
RNTR	139	30.7	ripe	M	R	4663051271	13-Jun-09
RNTR	160	47.5	ripe	M	R	985121012048567	13-Jun-09
RNTR	168	54.5	ripe	M	N	4B1F00261D	13-Jun-09
RNTR	360	449.6	spent	F	R	4662602032	13-Jun-09
RNTR	171	51	ripe	M	R	466A4A522F	13-Jun-09
RNTR	161	43	ripe	M	R	985121011982041	14-Jun-09
RNTR	132	23	ripe	M	R	985121012032020	14-Jun-09
RNTR	362	530.8	ripe	M	R	4663394B33	15-Jun-09
RNTR	142	26.5	ripe	M	R	985121012053787	16-Jun-09
RNTR	139	29.5	ripe	M	R	4663057328	17-Jun-09
RNTR	172	58.2	ripe	M	R	4B02092E0C	17-Jun-09
RNTR	369	471.5	spent	F	R	4661787710	17-Jun-09
RNTR	130	22.7	unknown	U	R	985121012055301	19-Jun-09
RNTR	163	44.2	ripe	M	R	4677731660	19-Jun-09
RNTR	171	56.8	ripe	M	R	4B02092E0C	19-Jun-09
RNTR	211	94.9	spent?	F?	N	4A705F2637	25-Jun-09
RNTR	175	59	unknown	U	R	4B1F093319	25-Jun-09
RNTR	156	45.2	ripe	M	R	46755E3375	3-Jul-09
RNTR	370	455	spent	F	R	4665291947	15-Jul-09
RNTR	171	59.3	unknown	U	R	985121012048539	18-Jul-09
RNTR	133	23.3	unknown	U	R	985121012050129	18-Jul-09
RNTR	171	57.7	unknown	U	N	4B020F346B	18-Jul-09
RNTR	172	54.5	unknown	U	N	4B1E7C414F	18-Jul-09
RNTR	168	49.9	unknown	U	N	4B1E4B3555	19-Jul-09
RNTR	170	55.2	unknown	U	N	4A70726C64	19-Jul-09
RNTR	165	49.5	unknown	U	N	4B1E694636	19-Jul-09
RNTR	187	79	ripe	M	R	4B1E664955	20-Jul-09
RNTR	196	80.7	unknown	U	N	4B02062456	23-Jul-09
RNTR	206	89.1	unknown	U	R	46627F5834	24-Jul-09
RNTR	144	30.3	ripe	M	N	4B02003C05	26-Jul-09
RNTR	159	40.8	unknown	U	N	4B1E663034	26-Jul-09
RNTR	149	37.3	unknown	U	N	4B02057422	27-Jul-09

RNTR	155	42.2	unknown	U	R	985121016400701	27-Jul-09
RNTR	164	44.9	unknown	U	N	4A70682978	28-Jul-09
RNTR	134	25	unknown	U	N	4A70653E44	29-Jul-09
RNTR	156	41.8	unknown	U	N	4B1E6A7B47	29-Jul-09
RNTR	159	42.7	unknown	U	N	4B02005023	29-Jul-09
RNTR	129	20.7	unknown	U	N	4A706D4D00	30-Jul-09
RNTR	140	27.7	unknown	U	N	4A7065410B	30-Jul-09
RNTR	158	41.6	unknown	U	N	4B1E477454	31-Jul-09
RNTR	162	45.5	unknown	U	N	4B02035264	31-Jul-09
RNTR	187	71.4	unknown	U	R	4663406D47	3-Aug-09
RNTR	168	46.6	unknown	U	N	4B02184252	3-Aug-09
RNTR	144	31.6	unknown	U	N	4B1E7B7E06	3-Aug-09
RNTR	182	59.1	unknown	U	N	4B1F013B08	3-Aug-09
RNTR	177	54.1	unknown	U	N	4B02190B5A	3-Aug-09
RNTR	154	37.2	unknown	U	N	4B1E6C0E11	4-Aug-09
RNTR	147	32.4	unknown	U	N	4B1F08185F	5-Aug-09
RNTR	167	50.2	unknown	U	N	4B1E642F66	5-Aug-09
RNTR	145	31.9	unknown	U	N	4B1E796F36	5-Aug-09
RNTR	148	34.6	unknown	U	R	4675520270	5-Aug-09
RNTR	154	37.4	unknown	U	N	4B1F095F3F	5-Aug-09
RNTR	145	33.3	unknown	U	N	4B1E73374D	8-Aug-09
RNTR	157	41	unknown	U	N	4B02055E53	9-Aug-09
RNTR	172	52.5	unknown	U	N	4B1E692E0A	11-Aug-09
RNTR	163	47.7	unknown	U	N	4B02151517	12-Aug-09
RNTR	148	31.1	unknown	U	N	4B1E61635B	13-Aug-09
RNTR	142	29.1	unknown	U	N	4B02056800	24-Aug-09
RNTR	187	77.5	unknown	U	R	985121011991267	2-Sep-09

Falls Creek Fish Trap - Located at the outlet of Pit-lake CD
Fish captured moving downstream of Pit-lake CD
Date: May 2009 to September 2009

Table 22: Fish captured moving downstream of Pit-lake CD, Falls Creek fish trap during 2009

Species	Length (mm)	Weight (g)	Maturity	Gender	Recap/New	PIT Tag	Lift Date
RNTR	180	70.1	ripe	M	R	4663406D47	31-May-09
RNTR	138	32.3	ripe	M	R	4663057328	31-May-09
RNTR	221	132.7	ripe	M	N	4B1E701A42	31-May-09
RNTR	171	61.7	ripe	M	N	4B02196C2D	31-May-09
RNTR	212	115	ripe	M	N	4B1E643F18	31-May-09
RNTR	185	82.2	ripe	M	N	4B021F6E72	31-May-09
RNTR	165	55.8	ripe	M	N	4B020F5532	31-May-09
RNTR	400	674	ripe	M	R	4662211B6B	1-Jun-09
RNTR	172	61	ripe	M	R	466A4A522F	1-Jun-09
RNTR	156	48	ripe	M	R	46697F5645	1-Jun-09
RNTR	141	33.4	ripe	M	R	4663051271	1-Jun-09
RNTR	180	76.5	ripe	M	N	4B1E664955	1-Jun-09

RNTR	198	92.5	ripe	M	R	4662361F62	2-Jun-09
RNTR	219	131.4	ripe	M	R	4B1E701A42	3-Jun-09
RNTR	170	61.9	ripe	M	R	4B02196C2D	3-Jun-09
RNTR	162	50	ripe	M	R	985121011982041	3-Jun-09
RNTR	184	79.6	ripe	M	N	4B1E7A207D	3-Jun-09
RNTR	140	33.1	ripe	M	R	4663051271	3-Jun-09
RNTR	246	179.3	ripe	M	N	4B1E7F755B	3-Jun-09
RNTR	159	46.6	ripe	M	R	4B1E6A137B	4-Jun-09
RNTR	164	54.4	ripe	M	R	4B020F5532	4-Jun-09
RNTR	199	90.8	ripe	M	R	4662361F62	4-Jun-09
RNTR	155	49.5	ripe	M	R	4664767019	4-Jun-09
RNTR	209	108.3	ripe	M	R	4B1E671D5C	4-Jun-09
RNTR	148	38.6	ripe	M	R	985121016373847	4-Jun-09
RNTR	224	130.1	ripe	M	N	4B1E71234E	4-Jun-09
RNTR	172	61.5	ripe	M	R	4A70773213	5-Jun-09
RNTR	187	79.6	ripe	M	R	4B021F6E72	5-Jun-09
RNTR	160	48.8	ripe	M	R	985121012048567	5-Jun-09
RNTR	423	885	ripe	F	R	4661583F38	5-Jun-09
RNTR	282	279.2	ripe	F	R	46772D5E6E	5-Jun-09
RNTR	435	1027.8	ripe	F	R	46626A2002	5-Jun-09
RNTR	385	702	ripe	F	R	465E67161D	5-Jun-09
RNTR	173	59.9	ripe	M	R	46627C683A	6-Jun-09
RNTR	172	61	ripe	M	N	4B02092E0C	6-Jun-09
RNTR	132	25.3	ripe	M	R	985121012032020	6-Jun-09
RNTR	193	80.7	ripe	M	N	4B1F066E49	6-Jun-09
RNTR	164	51.6	ripe	M	R	4677731660	6-Jun-09
RNTR	148	37.1	ripe	M	R	985121016373847	7-Jun-09
RNTR	162	46	ripe	M	N	4B0218655C	7-Jun-09
RNTR	156	46.9	ripe	M	R	46697F5645	7-Jun-09
RNTR	169	57	ripe	M	N	4B0219602D	7-Jun-09
RNTR	142	34.7	ripe	M	R	46755E3375	7-Jun-09
RNTR	220	126.3	ripe	M	N	4B1E701A42	7-Jun-09
RNTR	235	155.7	ripe	M	N	4A70637507	7-Jun-09
RNTR	211	104.6	ripe	M	N	4B1E643F18	8-Jun-09
RNTR	162	50.4	ripe	M	R	985121011982041	8-Jun-09
RNTR	140	31.7	ripe	M	R	4663051271	8-Jun-09
RNTR	191	78.6	ripe	M	N	4A706B152A	8-Jun-09
RNTR	170	56.4	ripe	M	R	466A4A522F	9-Jun-09
RNTR	372	600.6	ripe	F	R	4661787710	9-Jun-09
RNTR	364	647	ripe	F	R	465E67161D	9-Jun-09
RNTR	138	28.4	ripe	M	R	985121012053787	11-Jun-09
RNTR	373	504.8	spent?	F	R	4661787710	11-Jun-09
RNTR	162	45.7	ripe	M	R	985121011982041	11-Jun-09
RNTR	203	99	im	U	N	4B02065571	11-Jun-09
RNTR	154	42.2	ripe	M	R	4664767019	12-Jun-09
RNTR	161	47	ripe	M	R	985121012048567	12-Jun-09

RNTR	410	828	ripe	F	R	4663224D55	12-Jun-09
RNTR	170	51.5	ripe	M	R	466A4A522F	13-Jun-09
RNTR	161	44.5	ripe	M	R	985121011982041	13-Jun-09
RNTR	143	26.7	ripe	M	R	985121012053787	15-Jun-09
RNTR	168	52.2	ripe	M	R	4B1F00261D	17-Jun-09
RNTR	132	21.3	ripe	M	R	985121012050129	17-Jun-09
RNTR	162	44.8	ripe	M	R	4677731660	18-Jun-09
RNTR	171	56.8	ripe	M	R	4B02092E0C	19-Jun-09
RNTR	386	696	ripe	F	R	4662643925	23-Jun-09
RNTR	175	59.6	U	U	N	4B1F093319	24-Jun-09
RNTR	156	45.1	U	U	R	98512101989808	28-Jun-09

Gregg River Fish Trap - Located downstream of the Pit-50A-North Diversion Culvert
Fish captured moving upstream in the Gregg River
Date: May 2008 to October 2008

Table 23: Fish captured moving upstream towards the culvert in the Gregg River, Gregg River fish trapping 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Lift Date
BLTR	224	124	99	Recap	4663360324	10-Jun-08
BLTR	263	179	99	Recap	4662692837	15-Jun-08
BLTR	220	112.5	99	Recap	4868790043	3-Jul-08
BLTR	340	364	99	New	46647E1872	22-Jul-08
BLTR	242	168.3	9	Recap	4663360324	24-Aug-08
BLTR	278	211.2	99	Recap	467767267D	9-Sep-08
BLTR	279	188.5	99	Recap	4664483609	14-Sep-08

Gregg River Fish Trap - Located downstream of the Pit-50A-North Diversion Culvert
Fish captured moving downstream (after moving upstream) in the Gregg River
Date: May 2008 to October 2008

Table 24: Fish captured moving downstream of the culvert in the Gregg River, Gregg River fish trapping 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Lift Date
BLTR	267	199.4	99	Recap	4662692837	7-Jul-08
BLTR	242	168.3	9	Recap	4663360324	26-Aug-08
BLTR	279	188.5	99	Recap	4664483609	23-Sep-08

Sphinx Creek Fish Trap - Located downstream of Sphinx Lake
Fish captured moving upstream towards Sphinx Lake
Date: May 2008 to October 2008

Table 25: Fish captured moving upstream towards Sphinx Lake, Sphinx Creek outlet trapping 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Lift Date
RNTR	169	59	9	recap	46646F1F07	31-May-08
RNTR	116	16	99	new	4661532D56	1-Jun-08
RNTR	272	237	99F	recap	466A3D1C5B	1-Jun-08
RNTR	229	157	99F	recap	46614E1B26	2-Jun-08

RNTR	129	24	9	recap	46650F7D5B	3-Jun-08
RNTR	177	76	4	recap	466A05394D	3-Jun-08
RNTR	158	48	9	recap	4665365859	3-Jun-08
RNTR	292	288	99	recap	4663083530	5-Jun-08
RNTR	121	22	9	recap	466A5D3C2E	6-Jun-08
RNTR	154	40	9	recap	467760656C	6-Jun-08
RNTR	222	146	4	recap	4867750A2F	7-Jun-08
RNTR	157	44	9	recap	4665365859	15-Jun-08
RNTR	287	231	5	recap	46627A014E	17-Jun-08
RNTR	250	140	5	recap	48690C7A54	18-Jun-08
RNTR	148	34	9	recap	4661425342	19-Jun-08
RNTR	260	208	4	recap	4676065A23	22-Jun-08
RNTR	227	121	5	recap	46614E1B26	22-Jun-08
RNTR	252	161	5	recap	467570180C	22-Jun-08
RNTR	320	348	5	recap	4677121A5E	22-Jun-08
RNTR	153	37	9	recap	4664044019	22-Jun-08
RNTR	268	151	5	? new	4677685546	25-Jun-08
RNTR	122	21	9	recap	466A5D3C2E	25-Jun-08
RNTR	249	145	5P	recap	4675597147	26-Jun-08
RNTR	159	44	9	?new	46626B6F24	26-Jun-08
RNTR	124	20	9	recap	466A5D3C2E	27-Jun-08
RNTR	264	166	5P	recap	46754F4713	27-Jun-08
RNTR	258	163	5	new	465E731267	28-Jun-08
RNTR	327	326	5	recap	4677736664	28-Jun-08
RNTR	247	150	5P	recap	4662314COD	28-Jun-08
RNTR	244	164	99	new	46651A402D	28-Jun-08
RNTR	148	33	9	recap	46776A4F2D	28-Jun-08
RNTR	281	197	5	new	4662615C7E	28-Jun-08
RNTR	242	148	5	recap	46631D3B2C	28-Jun-08
RNTR	160	43	9	recap	46626B6F24	28-Jun-08
RNTR	141	27	9	recap	46774C1710	28-Jun-08
RNTR	258	164	5	recap	4676065A23	29-Jun-08
RNTR	130	22	9	new	4665015401	29-Jun-08
RNTR	152	36	9	recap	4664044019	29-Jun-08
RNTR	125	21	9	new	46647E5574	29-Jun-08
RNTR	124	19	99	new	46644A0C61	30-Jun-08
RNTR	127	21	9	new	4676036117	30-Jun-08
RNTR	141	27	99	new	46650D5274	30-Jun-08
RNTR	128	21.4	9	recap	4665015401	1-Jul-08
RNTR	132	23.8	99	recap	4677536A2F	1-Jul-08
RNTR	54	1.5	99	new	Not Tagged	3-Jul-08
RNTR	117	16	99	new	46775E082E	4-Jul-08
RNTR	273	193.4	99	recap	466A531574	4-Jul-08
RNTR	117	15.8	99	new	46651B195B	5-Jul-08
RNTR	240	139.8	5P	recap	46614D1230	6-Jul-08

RNTR	230	121.2	9	new	46645C4277	6-Jul-08
RNTR	105	11	99	recap	4664466525	6-Jul-08
RNTR	234	140.2	5	recap	466443236A	7-Jul-08
RNTR	128	19.8	99	recap	4676036117	8-Jul-08
RNTR	117	15.4	99	new	4677594828	10-Jul-08
RNTR	68	2.9	99	new	Not Tagged	11-Jul-08
BLTR	163	38.2	99	new	4662043202	12-Jul-08
RNTR	203	98.7	99	new	4664493B62	13-Jul-08
RNTR	123	18	99	recap	466257604F	14-Jul-08
RNTR	205	95.5	99F5	recap	46612D3F3A	14-Jul-08
RNTR	197	89.3	99	recap	48692D7864	14-Jul-08
BLTR	158	35.4	99	new	4661786B32	15-Jul-08
RNTR	211	95	99	recap	46773B5D7E	15-Jul-08
RNTR	172	57.6	99	recap	46646F1F07	17-Jul-08
RNTR	128	22.6	99	new	4662602B63	17-Jul-08
RNTR	128	19.4	99	new	4664413E0C	18-Jul-08
RNTR	108	12.1	99	new	4662742814	18-Jul-08
RNTR	121	18.2	99	recap	4665361E0E	19-Jul-08
RNTR	131	22.7	99	new	46622E2829	19-Jul-08
RNTR	59	2	99		Not Tagged	19-Jul-08
RNTR	134	25.2	99	new?recap	46652C7806	19-Jul-08
RNTR	126	20.1	99	recap	4665284031	20-Jul-08
RNTR	134	24.6	9	new	4669781D12	20-Jul-08
RNTR	165	44.5	99	new	4664466632	20-Jul-08
RNTR	128	23.7	99	recap	4665237472	21-Jul-08
RNTR	147	32	99	new	46620C7F53	21-Jul-08
RNTR	121	18.6	99	recap	4664404240	21-Jul-08
RNTR	150	33	99	new	4664613C2F	21-Jul-08
RNTR	125	20.7	99	new	465F603D54	21-Jul-08
RNTR	128	21.7	99	new	46616A3556	21-Jul-08
RNTR	136	25.6	99		46613C312A	21-Jul-08
RNTR	88	6.4	99	new	4662672457	22-Jul-08
RNTR	141	27.5	99	new	46633B6F4D	22-Jul-08
RNTR	137	25.4	99	recap	46633E7377	22-Jul-08
RNTR	115	14.7	99	new	46620F3226	22-Jul-08
RNTR	139	26.6	99	new	46625D7C5D	22-Jul-08
RNTR	138	26.9	99	new	46650B1814	22-Jul-08
RNTR	60	1.9	99		Not Tagged	27-Jul-08
RNTR	248	155.2	99	new	4677733279	27-Jul-08
RNTR	127	21.7	99	recap	4677145424	24-Jul-08
RNTR	139	26.7	99	new	4662476023	31-Jul-08
RNTR	152	36.5	99	new	46630F3155	1-Aug-08
RNTR	73	4	99	new	46625D4D03	1-Aug-08
RNTR	117	15.6	99	new	46647C4177	1-Aug-08
RNTR	138	25.9	99	new	465E5F7E0D	2-Aug-08

RNTR	89	6.8	99	new	46774E5E6B	2-Aug-08
RNTR	104	11	99	new	465F563118	2-Aug-08
RNTR	172	54	99	recap	46640E386B	3-Aug-08
RNTR	88	6.9	99	new	4664621419	21-Aug-08
RNTR	145	35.7	99	new	4677612F73	21-Aug-08
RNTR	183	64.9	99	recap	4675791C55	22-Aug-08
RNTR	188	70.1	99	recap	4677110C7D	22-Aug-08
RNTR	96	10.1	99	new	4661641F1B	22-Aug-08
RNTR	96	9.6	99	new	4662666B71	23-Aug-08
RNTR	109	14.5	99	new	46643C4C69	23-Aug-08
RNTR	108	12.6	99	new	46652E2214	24-Aug-08
RNTR	101	11.3	99	new	4664710E0A	24-Aug-08
RNTR	97	9.9	99	new	46775D164B	28-Aug-08
RNTR	93	8.2	99	recap	466A062D5A	29-Aug-08
RNTR	110	15.6	99	new	465E743A5D	30-Aug-08
RNTR	120	19.3	99	recap	4664727853	30-Aug-08
RNTR	105	14.3	99	new	4664250374	30-Aug-08
RNTR	145	31.6	99	recap	467803357C	31-Aug-08
RNTR	135	27.6	99	recap	46624D4975	3-Sep-08
RNTR	94	9	99	recap	46630D525F	3-Sep-08
RNTR	100	9.7	99	new	16373997	7-Sep-08
RNTR	45	1	99		Not Tagged	10-Sep-08
RNTR	49	1.3	99		Not Tagged	13-Sep-08
RNTR	38	0.5	99		Not Tagged	13-Sep-08
RNTR	157	40	99	recap	46644A0D42	17-Sep-08
RNTR	56	1.7	99		Not Tagged	21-Sep-08
RNTR	51	1.3	99		Not Tagged	21-Sep-08
RNTR	49	1.2	99		Not Tagged	21-Sep-08
RNTR	51	1.3	99		Not Tagged	21-Sep-08
RNTR	51	1.1	99		Not Tagged	21-Sep-08
RNTR	40	0.7	99		Not Tagged	26-Sep-08
RNTR	50	1.3	99		Not Tagged	26-Sep-08
RNTR	32	0.2	99		Not Tagged	27-Sep-08
RNTR	110	13	99	recap	46776D2F28	30-Sep-08
RNTR	53	1.3	99		Not Tagged	30-Sep-08
RNTR	173	58.6	99		46650F7D5B	2-Oct-08
RNTR	70	3.2	99		Not Tagged	3-Oct-08

Sphinx Creek Fish Trap - Located downstream of Sphinx Lake
Fish captured moving downstream of Sphinx Lake
Date: May 2008 to October 2008

Table 26: Fish captured moving downstream of Sphinx Lake, Sphinx Creek outlet trapping 2008

Species	Length (mm)	Weight (g)	Maturity	Recap/New	PIT Tag	Lift Date
RNTR	248	na	99	recap	4868195874	30-May-08
RNTR	151	na	99	new	46757E465F	30-May-08

RNTR	211	na	99	recap	46630C4316	30-May-08
RNTR	146	37	9	recap	46776A4F2D	30-May-08
RNTR	262	223	4	recap	4677544336	31-May-08
RNTR	157	44	9	new	466A13610B	31-May-08
RNTR	168	58	9	new	46646F1F07	31-May-08
RNTR	276	246	99F	recap	46627A3C4C	31-May-08
RNTR	249	192	99F	recap	4675597147	1-Jun-08
RNTR	272	237	99F	new	466A3D1C5B	1-Jun-08
RNTR	229	161	99F	new	46614E1B26	1-Jun-08
RNTR	129	25	9	new	46650F7D5B	2-Jun-08
RNTR	157	44	9	recap	466A13610B	2-Jun-08
RNTR	207	131	99F	new	46612D3F3A	2-Jun-08
RNTR	286	294	99F	new	46627A014E	2-Jun-08
RNTR	253	197	99	new	467570180C	2-Jun-08
RNTR	253	198	99	new	4664424013	2-Jun-08
RNTR	229	161	99F	recap	46614E1B26	2-Jun-08
RNTR	301	337	99	recap	466A480B2A	3-Jun-08
RNTR	263	224	99	new	4662666020	3-Jun-08
RNTR	265	236	99	recap	4662592533	3-Jun-08
RNTR	158	47	9	new	4665365859	3-Jun-08
RNTR	136	26	99	new	4676087828	3-Jun-08
RNTR	128	24	9	recap	46650F7D5B	3-Jun-08
RNTR	155	41	9	new	467760656C	3-Jun-08
RNTR	140	30	9	recap	46640E386B	4-Jun-08
RNTR	314	352	99	recap	4662443932	4-Jun-08
RNTR	301	334	99	recap	466A480B2A	4-Jun-08
RNTR	279	248	99F	recap	46627A3C4C	4-Jun-08
RNTR	158	46	99	recap	4665365859	4-Jun-08
RNTR	301	318	99	recap	46641C6E49	4-Jun-08
RNTR	292	288	99	recap	4663083530	5-Jun-08
RNTR	279	268	99	new	4665195945	5-Jun-08
RNTR	205	118	99	recap	48681E704E	5-Jun-08
RNTR	207	130	99F	recap	46612D3F3A	5-Jun-08
RNTR	265	213	9	recap	4661460444	6-Jun-08
RNTR	121	22	99	recap	466A5D3C2E	6-Jun-08
RNTR	148	36	9	new	4661425342	7-Jun-08
RNTR	258	219	4	new	46755E2C40	7-Jun-08
RNTR	222	146	4	recap	4867750A2F	7-Jun-08
RNTR	225	141	99F	new	4664414060	7-Jun-08
RNTR	441	687	4	recap	466A5B7060	7-Jun-08
RNTR	332	429	4	recap	4677736664	9-Jun-08
RNTR	181	83	99F	new	4665257003	9-Jun-08
RNTR	205	114	99F	new	466A6A4365	9-Jun-08
RNTR	203	121	99F	recap	467608663E	11-Jun-08
RNTR	245	196	99F	recap	4662314COD	13-Jun-08

RNTR	257	191	99	recap	46647C6B06	14-Jun-08
RNTR	225	139	4	new	4663065661	14-Jun-08
RNTR	153	37	9	recap	467760656C	15-Jun-08
RNTR	218	128	99F	new	4664666E63	17-Jun-08
RNTR	226	149	99F	new	465F6F007E	17-Jun-08
RNTR	253	192	99F	recap	4664424013	17-Jun-08
RNTR	225	153	4	new	4677111445	17-Jun-08
RNTR	124	21	9	recap	466A5D3C2E	18-Jun-08
RNTR			5	recap	46627A014E	18-Jun-08
RNTR	267	220	4	recap	46754F4713	18-Jun-08
RNTR	217	130	4	new	46773B5D7E	18-Jun-08
RNTR	228	154	4	new	466420224C	18-Jun-08
RNTR	267	198	5	recap	46754F4713	19-Jun-08
RNTR	195	103	99F	recap	48692D7864	19-Jun-08
RNTR	223	135	4	recap	4677111445	20-Jun-08
RNTR	219	149	99	recap	4869266B29	20-Jun-08
RNTR	124	21	9	recap	466A5D3C2E	20-Jun-08
RNTR	230	160	99F	new	466422797D	21-Jun-08
RNTR	259	209	99F	recap	4676065A23	21-Jun-08
RNTR	210	96	9	recap	4662295E7C	21-Jun-08
RNTR	138	33	9	recap	4663335515	21-Jun-08
RNTR	145	30	99	recap	4675791C55	21-Jun-08
RNTR	217	130	99F	recap	4664666E63	22-Jun-08
RNTR	232	165	4	recap	4871766059	22-Jun-08
RNTR	153	38	9	new	4664044019	22-Jun-08
RNTR	258	209	4	recap	4676065A23	22-Jun-08
RNTR	254	253	4	new	46647B402B	22-Jun-08
RNTR	227	122	5	recap	46614E1B26	22-Jun-08
RNTR	123	20	9	recap	466A5D3C2E	22-Jun-08
RNTR	212	108	5	recap	46773B5D7E	23-Jun-08
RNTR	168	54	9	recap	46646F1F07	25-Jun-08
RNTR	159	43	9	recap	46626B6F24	27-Jun-08
RNTR	247	187	4	new	46614D1230	27-Jun-08
RNTR	124	22	9	recap	46647E5574	30-Jun-08
RNTR	128	22	9	recap	4665015401	30-Jun-08
RNTR	128	21	9	new	4662781DOB	30-Jun-08
RNTR	127	21.3	99	recap	4676036117	1-Jul-08
RNTR	272	204.3	99	new	466A531574	1-Jul-08
RNTR	139	27.9	99	recap	46777D5706	3-Jul-08
RNTR	110	13.8	99	new	4677567421	3-Jul-08
RNTR	117	15.6	99	recap	46651B195B	6-Jul-08
RNTR	161	41	99	new	465E656173	6-Jul-08
RNTR	119	17	99	new	4677612616	8-Jul-08
RNTR	117	15.6	99	recap	4677594828	11-Jul-08
BLTR	163	37.6	99	recap	4662043202	13-Jul-08

BLTR	157	35.3	99	recap	4661786B32	16-Jul-08
RNTR	121	18.2	99	recap	4665361E0E	20-Jul-08
RNTR	166	43.2	99	recap	4664466632	21-Jul-08
RNTR	132	25.2	99	new	4664413D1B	21-Jul-08
RNTR	133	23.9	99	recap	4669781D12	21-Jul-08
RNTR	125	19.7	99	recap	4665284031	21-Jul-08
RNTR	137	25.4	99	recap	46633E7377	23-Jul-08
RNTR	116	15.8	99	new	465F4B1716	23-Jul-08
RNTR	139	26.6	99	recap	46625D7C5D	23-Jul-08
RNTR	72	4.1	99	new	46774E6773	4-Aug-08
RNTR	31	0.2	99		Not tagged	21-Aug-08
RNTR	29	0.2	99		Not Tagged	21-Aug-08
RNTR	29	0.2	99		Not Tagged	21-Aug-08
RNTR	96	10.3	99	recap	46775D164B	29-Aug-08
RNTR	59	2.1	99		Not Tagged	26-Sep-08
RNTR	65	2.7	99		Not Tagged	7-Oct-08
RNTR	65	3.1	99		Not Tagged	10-Oct-08

Sphinx Creek Fish Trap - Located downstream of Sphinx Lake
Fish captured moving upstream into Sphinx Lake
Date: May 2009 to September 2009

Table 27: Fish captured moving upstream towards Sphinx Lake, Sphinx Creek outlet trapping 2009

Species	Length (mm)	Weight (g)	Maturity	Gender	Recap/New	PIT Tag	Lift Date
RNTR	112	19	ripe	M	N	4B0205157B	30-May-09
RNTR	215	102	ripe	M	R	4661425342	3-Jun-09
RNTR	162	42.4	ripe	M	R	4665164E1E	4-Jun-09
RNTR	207	95.5	ripe	M	R	4664044019	4-Jun-09
RNTR	240	174	spent/ripe	F	R	4665257003	4-Jun-09
RNTR	224	126.2	ripe	M	R	46776A4F2D	5-Jun-09
RNTR	133	26.6	ripe	M	R	4A70751B12	6-Jun-09
RNTR	159	43.1	ripe	M	R	466A3D5C22	7-Jun-09
RNTR	202	84.5	ripe	M	R	4676036117	8-Jun-09
RNTR	166	49	ripe	M	R	466A5D3C2E	8-Jun-09
RNTR	357	448	feels tight	F?	R	46651D3933	8-Jun-09
RNTR	283	278	feels tight	F?	R	4871766059	8-Jun-09
RNTR	304	267.9	spent	F?	R	48690C2A54	10-Jun-09
RNTR	215	99.5	ripe	M	R	4661425342	10-Jun-09
RNTR	168	48.1	ripe	M	R	4662721044	10-Jun-09
RNTR	162	40.6	ripe	M	R	4665164E1E	10-Jun-09
RNTR	278	217	spent?	F?	N	4B1E755172	10-Jun-09
RNTR	171	62.2	ripe	F	R	4664551233	11-Jun-09
RNTR	117	16.7	ripe	M	R	4B0205157B	11-Jun-09
RNTR	254	161.5	spent?	F?	R	4B1E766A2D	11-Jun-09
RNTR	223	121.4	ripe	M	R	4662295E7C	11-Jun-09
RNTR	162	39.6	ripe	M	R	4665164E1E	12-Jun-09

RNTR	299	243	spent	F	R	985121012048288	12-Jun-09
RNTR	332	365.6	spent	F	R	466A480B2A	12-Jun-09
RNTR	220	108	ripe	M	R	46774C1710	13-Jun-09
RNTR	221	115	ripe	M	R	46776A4F2D	14-Jun-09
RNTR	208	88	spent	F?	R	4B02126A27	15-Jun-09
RNTR	162	39	ripe	M	R	4665164E1E	15-Jun-09
RNTR	168	45	ripe	M	R	4662721044	15-Jun-09
RNTR	208	87.3	ripe	M	R	4664044019	15-Jun-09
RNTR	210	90.1	spent	F	R	4B1E617E5A	15-Jun-09
RNTR	238	133.9	spent?	F?	R	4665257003	16-Jun-09
RNTR	307	251.4	spent?	F?	R	4677685546	16-Jun-09
RNTR	162	57.7	ripe	M	R	466A5D3C2E	16-Jun-09
RNTR	222	122	spent?	F?	R	46612D3F3A	17-Jun-09
RNTR	127	21	unknown	U	R	466423084E	17-Jun-09
RNTR	217	105	ripe	F	R	4A70651722	17-Jun-09
RNTR	223	111.9	ripe	M	R	46776A4F2D	18-Jun-09
RNTR	223	110.2	ripe	M	R	4A706C2B40	18-Jun-09
RNTR	248	159	spent	F?	R	48692D7864	18-Jun-09
RNTR	216	103.6	ripe	M	R	46774C1710	19-Jun-09
RNTR	186	62.2	ripe	F	R	46630F3155	20-Jun-09
RNTR	68	2.8	unknown	U	N	not tagged	20-Jun-09
RNTR	187	66.6	ripe	M	R	4677536A2F	21-Jun-09
RNTR	236	127.1	spent	F	R	4A706A6E6B	21-Jun-09
RNTR	255	162.3	ripe	M	N	4B1F085377	22-Jun-09
RNTR	249	153.6	spent?	F?	R	466A6A4365	22-Jun-09
RNTR	145	31.6	ripe	M	R	4B1E753726	24-Jun-09
RNTR	244	142.2	unknown	U	R	4664493B62	24-Jun-09
RNTR	129	21.1	unknown	U	N	4B1E65457A	25-Jun-09
RNTR	183	76	spent	F	R	4665237472	26-Jun-09
RNTR	247	130.5	spent?	F?	R	4678114407	26-Jun-09
RNTR	215	94.5	ripe	M	R	46774C1710	26-Jun-09
RNTR	144	30	ripe	M	R	4B1E753726	26-Jun-09
RNTR	256	162.1	unknown	U	R	4B1F085377	27-Jun-09
RNTR	158	43.1	unknown	U	N	4B1E7D383A	27-Jun-09
RNTR	176	56.1	unknown	U	R	46644A0D42	28-Jun-09
RNTR	105	11.5	unknown	U	N	4B020D0766	28-Jun-09
RNTR	64	2.9	I	U		not tagged	29-Jun-09
RNTR	127	20	unknown	U	N	4B1F003A3F	29-Jun-09
RNTR	130	22.3	unknown	U	R	4B1E716D5F	30-Jun-09
RNTR	186	67.4	unknown	U	R	4B1E666E5B	1-Jul-09
RNTR	183	58.4	unknown	U	N	4B1E732E56	1-Jul-09
RNTR	70	3.9	I	U		not tagged	2-Jul-09
RNTR	153	38.7	unknown	U	N	4A706D491A	3-Jul-09
RNTR	68	3.3	I	U		not tagged	3-Jul-09
RNTR	57	1.9	I	U		not tagged	4-Jul-09
RNTR	194	73	ripe	M	R	4B020F4156	7-Jul-09

RNTR	183	64	unknown	U	R	4B1E666E5B	7-Jul-09
RNTR	83	6	I	U		not tagged	13-Jul-09
RNTR	125	19.8	unknown	U	N	4B1E52145A	15-Jul-09
RNTR	79	4.9	I	U	N	upper caudel clip	17-Jul-09
RNTR	127	20.4	unknown	U	R	4665116F41	19-Jul-09
RNTR	297	232.5	unknown	U	R	466A531574	20-Jul-09
RNTR	139	25.8	unknown	U	R	4664587957	22-Jul-09
RNTR	66	3.1	I	U		upper caudel clip	22-Jul-09
RNTR	111	14	unknown	U	N	4B020C5F33	22-Jul-09
RNTR	79	4.6	I	U	N	upper caudel clip	23-Jul-09
RNTR	193	74.5	unknown	U	R	4665382861	24-Jul-09
RNTR	70	3.8	I	U	N	upper caudel clip	25-Jul-09
RNTR	69	3.4	I	U	N	upper caudel clip	25-Jul-09
RNTR	72	3.8	I	U	N	upper caudel clip	25-Jul-09
RNTR	65	2.9	I	U	N	upper caudel clip	25-Jul-09
RNTR	73	3.2	I	U	N	upper caudel clip	25-Jul-09
RNTR	79	5.6	I	U	N	upper caudel clip	25-Jul-09
RNTR	71	3	I	U	N	upper caudel clip	25-Jul-09
RNTR	63	2.7	I	U	N	upper caudel clip	25-Jul-09
RNTR	65	2.7	I	U	N	upper caudel clip	25-Jul-09
RNTR	70	3.1	I	U	N	upper caudel clip	26-Jul-09
RNTR	73	4.1	I	U	N	upper caudel clip	26-Jul-09
RNTR	61	2.4	I	U	N	upper caudel clip	28-Jul-09
RNTR	64	2.7	I	U	N	upper caudel clip	28-Jul-09
RNTR	89	7.4	I	U	N	4B02135F77	28-Jul-09
RNTR	171	56.4	unknown	U	N	4B1E717567	28-Jul-09
RNTR	77	4.6	I	U	R	upper caudel clip	30-Jul-09
RNTR	59	2.2	I	U	N	upper caudel clip	30-Jul-09
RNTR	118	18.5	unknown	U	N	4B1E630A23	30-Jul-09
RNTR	214	100.3	unknown	U	R	4675791C55	31-Jul-09
RNTR	68	3.5	I	U	N	upper caudel clip	1-Aug-09
RNTR	95	10.9	I	U	R	4B1E372267	1-Aug-09
RNTR	134	27.3	unknown	U	N	4B021C490F	1-Aug-09
RNTR	121	16.2	unknown	U	N	4B1F01060A	2-Aug-09
RNTR	223	109.5	unknown	U	R	4661425342	3-Aug-09
RNTR	114	15.2	unknown	U	N	4B1F054568	3-Aug-09
RNTR	117	16.4	unknown	U	N	4B02025353	3-Aug-09
RNTR	159	47.7	unknown	U	N	4B1E3A6C39	3-Aug-09
RNTR	93	8.2	I	U	N	4B1E550C1D	3-Aug-09
RNTR	80	5.1	I	U	N	upper caudel clip	4-Aug-09
RNTR	81	5.3	I	U	N	upper caudel clip	7-Aug-09
BLTR	129	20.4	I	U	N	4B1E634511	8-Aug-09
RNTR	79	5	I	U	R	upper caudel clip	9-Aug-09
RNTR	64	2.6	I	U	N	upper caudel clip	10-Aug-09
RNTR	91	7.9	I	U	N	4B0210227F	10-Aug-09
RNTR	55	1.6	I	U	N	upper caudel clip	11-Aug-09

RNTR	70	4.1	I	U	N	upper caudel clip	12-Aug-09
RNTR	90	7.5	I	U	N	4B1E750056	12-Aug-09
RNTR	87	6.7	I	U	N	upper caudel clip	13-Aug-09
RNTR	205	96.3	unknown	U	R	4677612F73	14-Aug-09
RNTR	88	7.5	I	U	N	4B1E6A1761	15-Aug-09
RNTR	73	4	I	U	N	upper caudel clip	16-Aug-09
RNTR	88	7.4	I	U	N	4B1F033A4C	16-Aug-09
RNTR	63	3	I	U	N	upper caudel clip	17-Aug-09
RNTR	64	2.6	I	U	N	upper caudel clip	17-Aug-09
RNTR	64	2.7	I	U	N	upper caudel clip	18-Aug-09
RNTR	83	5.8	I	U	N	upper caudel clip	21-Aug-09
RNTR	106	12.4	unknown	U	N	4B02094527	22-Aug-09
RNTR	74	4.4	I	U	N	upper caudel clip	22-Aug-09
RNTR	81	5.5	I	U	N	upper caudel clip	27-Aug-09
RNTR	108	12.9	I	U	R	985121012046810	4-Sep-09
RNTR	83	5.6	I	U	N	upper caudel clip	7-Sep-09
RNTR	100	9.6	I	U	R	985121016372354	7-Sep-09
RNTR	109	14.5	I	U	R	985121012056570	7-Sep-09
RNTR	41		I	U		not tagged	10-Sep-09

Sphinx Creek Fish Trap - Located downstream of Sphinx Lake
Fish captured moving downstream of Sphinx Lake
Date: May 2009 to September 2009

Table 28: Fish captured moving downstream of Sphinx Lake, Sphinx Creek outlet trapping 2009

Species	Length (mm)	Weight (g)	Maturity	Gender	Recap/New	PIT Tag	Lift Date
RNTR	358	555.0	almost	F?	R	46651D3933	30-May-09
RNTR	329	451.0	almost	F?	R	466A480B2A	30-May-09
RNTR	220	159.5	unknown	U	R	46612D3F3A	30-May-09
RNTR	198	82.0	ripe	M	N	4B1E6F5F46	30-May-09
RNTR	226	152.1	almost	F?	N	4B020C0F34	30-May-09
RNTR	171	57.1	ripe	M	R	4677612F73	30-May-09
RNTR	298	302.7	almost	F?	R	985121012048288	30-May-09
RNTR	170	66.8	unknown	U	N	4B1E781253	30-May-09
RNTR	190	73.2	ripe	M	R	46613C312A	30-May-09
RNTR	239	160.0	ripe	F	N	4B02126758	30-May-09
RNTR	256	202.1	almost	F?	N	4B1E766A2D	30-May-09
RNTR	182	73.1	unknown	U	N	4B1E44295F	30-May-09
RNTR	270	234.2	ripe	F	R	4867750A2F	31-May-09
RNTR	202	98.8	ripe	F	R	46620C7F53	31-May-09
RNTR	170	66.8	unknown	U	R	4B1E781253	31-May-09
RNTR	132	28.8	ripe	M	N	4A70751B12	31-May-09
RNTR	181	64.1	ripe	M	R	46777F1221	31-May-09
RNTR	186	76.2	ripe	M	N	4B1E666E5B	31-May-09
RNTR	149	37.6	ripe	M	N	4B1E4E465E	31-May-09
RNTR	117	18.2	ripe	M	R	4B0205157B	1-Jun-09

RNTR	188	74.9	ripe	M	R	4677536A2F	1-Jun-09
RNTR	296	300.9	almost	F?	R	4662604666	1-Jun-09
RNTR	241	173.0	ripe	F	R	4665257003	3-Jun-09
RNTR	164	43.4	ripe	M	R	4665164E1E	3-Jun-09
RNTR	186	64.7	ripe	F	R	4665382861	3-Jun-09
RNTR	208	97.4	ripe	M	R	4664044019	3-Jun-09
RNTR	202	82.7	ripe	M	R	4675791C55	4-Jun-09
RNTR	248	200.0	almost	F?	R	48692D7864	4-Jun-09
RNTR	133	27.5	ripe	M	R	4A70751B12	4-Jun-09
RNTR	216	101.6	ripe	M	R	4661425342	4-Jun-09
RNTR	214	120.5	ripe	F	R	465F0A0A62	5-Jun-09
RNTR	283	288.4	almost	F?	R	4871766059	5-Jun-09
RNTR	202	91.7	ripe	M	R	4676036117	5-Jun-09
RNTR	190	87.1	ripe	F	R	46652C7806	5-Jun-09
RNTR	205	85.2	ripe	M	R	4676087828	5-Jun-09
RNTR	230	159.0	ripe	F	R	46773B5D7E	6-Jun-09
RNTR	145	34.2	ripe	M	N	4B1E753726	7-Jun-09
RNTR	225	126.0	ripe	M	R	46776A4F2D	7-Jun-09
RNTR	240	172.3	ripe	F	R	4665257003	7-Jun-09
RNTR	231	130.0	ripe	F	R	46773B5D7E	8-Jun-09
RNTR	162	41.0	ripe	M	R	4665164E1E	8-Jun-09
RNTR	251	200.1	tight	F?	R	466A6A4365	9-Jun-09
RNTR	210	114.4	ripe	F	N	4B02126A27	9-Jun-09
RNTR	159	43.8	ripe	M	R	466A3D5C22	9-Jun-09
RNTR	170	63.6	ripe	F	R	4664551233	9-Jun-09
RNTR	218	118.7	ripe	F	N	4B1E3A3A10	9-Jun-09
RNTR	238	143.1	ripe	F	R	4665257003	10-Jun-09
RNTR	255	220.8	tight	F?	R	465F6F007F	10-Jun-09
RNTR	213	114.2	ripe	F	N	4B1E617E5A	10-Jun-09
RNTR	308	312.5	tight	F?	R	4677685546	10-Jun-09
RNTR	289	281.0	ripe	F	R	46614D1230	10-Jun-09
RNTR	272	244.5	tight	F?	R	4675597147	10-Jun-09
RNTR	207	93.2	ripe	M	R	4664044019	11-Jun-09
RNTR	177	74.2	ripe	F	R	46616A3556	11-Jun-09
RNTR	329	418.0	ripe	F	R	4662615C7E	11-Jun-09
RNTR	182	76.2	ripe	F	N	4B020C3B53	11-Jun-09
RNTR	197	87.1	ripe	F	R	46622E2829	11-Jun-09
RNTR	311	354.2	ripe	F	R	4662792F56	11-Jun-09
RNTR	168	45.8	ripe	M	R	4662721044	12-Jun-09
RNTR	223	116.0	ripe	M	R	4662295E7C	12-Jun-09
RNTR	270	241.8	ripe	F	R	4677733279	12-Jun-09
RNTR	220	110.0	ripe	M	R	46774C1710	12-Jun-09
RNTR	185	75.5	almost	F?	R	46630F3155	12-Jun-09
RNTR	184	95.3	ripe	F	R	4665237472	12-Jun-09
RNTR	163	39.2	ripe	M	R	4665164E1E	13-Jun-09
RNTR	287	278.0	ripe	F	R	4676065A23	13-Jun-09

RNTR	215	97.7	ripe	M	R	4661425342	14-Jun-09
RNTR	219	111.4	ripe	M	R	46774C1710	14-Jun-09
RNTR	328	337.0	ripe	F	R	4662615C7E	14-Jun-09
RNTR	210	107.0	ripe	F	R	985121012043440	14-Jun-09
RNTR	240	161.0	tight	F?	N	4A706A6E6B	14-Jun-09
RNTR	195	86.0	ripe	M	N	4B020F4156	14-Jun-09
RNTR	222	115.0	ripe	M	R	46776A4F2D	15-Jun-09
RNTR	177	69.5	tight	F?	R	46644A0D42	16-Jun-09
RNTR	216	114.5	ripe	F	N	4A70651722	16-Jun-09
RNTR	188	85.0	ripe	F	N	4B02291620	16-Jun-09
RNTR	167	45.9	ripe	M	R	4662721044	16-Jun-09
RNTR	162	39.1	ripe	M	R	4665164E1E	16-Jun-09
RNTR	169	59.8	ripe	F	R	4664551233	17-Jun-09
RNTR	222	111.0	ripe	M	N	4A706C2B40	17-Jun-09
RNTR	59	2.1	I	U	N	Not tagged	17-Jun-09
RNTR	106	12.4	unknown	U	R	4662581063	19-Jun-09
RNTR	221	101.6	ripe	M	R	46774C1710	20-Jun-09
RNTR	129	21.6	unknown	U	N	4B1E716D5F	22-Jun-09
RNTR	76	3.7	I	U	N	Not tagged	29-Jun-09
RNTR	176	54.1	unknown	U	R	46644A0D42	29-Jun-09
RNTR	81	5.2	I	U	--	Not tagged	30-Jun-09
RNTR	189	67.9	unknown	U	R	4B1E666E5B	2-Jul-09
RNTR	153	38.7	unknown	U	R	4A706D491A	4-Jul-09
RNTR	62	2.9	I	U	--	Not tagged	4-Jul-09
RNTR	58	2.0	I	U	--	Not tagged	5-Jul-09
RNTR	78	5.0	I	U	--	Not tagged	5-Jul-09
RNTR	69	3.5	I	U	N	upper caudel clip	16-Jul-09
RNTR	89	7.0	I	U	N	4B1E662573	16-Jul-09
RNTR	85	7.0	I	U	N	4B1E372267	18-Jul-09
RNTR	72	3.5	I	U	N	upper caudel clip	19-Jul-09
RNTR	75	4.4	I	U	N	upper caudel clip	22-Jul-09
RNTR	68	3.3	I	U	N	upper caudel clip	22-Jul-09
RNTR	67	3.0	I	U	N	upper caudel clip	22-Jul-09
RNTR	71	3.9	I	U	N	upper caudel clip	23-Jul-09
RNTR	139	25.7	unknown	U	R	4664587957	23-Jul-09
RNTR	129	21.3	unknown	U	R	46775D164B	23-Jul-09
RNTR	122	19.2	unknown	U	N	4B0224511B	23-Jul-09
RNTR	163	47.2	unknown	U	R	46776B3361	24-Jul-09
RNTR	119	17.1	unknown	U	R	4661656357	24-Jul-09
RNTR	123	19.9	unknown	U	N	4A706D2960	24-Jul-09
RNTR	117	16.4	unknown	U	N	4B1F073428	24-Jul-09
RNTR	64	2.6	I	U	N	upper caudel clip	24-Jul-09
RNTR	67	3.1	I	U	R	upper caudel clip	24-Jul-09
RNTR	79	5.0	I	U	R	upper caudel clip	24-Jul-09
RNTR	133	23.8	unknown	U	N	4B1E716945	24-Jul-09
RNTR	140	30.4	unknown	U	N	4B1E4F0B4C	24-Jul-09

RNTR	84	5.6	I	U	N	4B1E791835	25-Jul-09
RNTR	77	5.0	I	U	N	upper caudel clip	25-Jul-09
RNTR	61	2.6	I	U	N	upper caudel clip	25-Jul-09
RNTR	113	14.3	unknown	U	N	4B1E6E4821	25-Jul-09
RNTR	73	3.8	I	U	N	upper caudel clip	26-Jul-09
RNTR	146	48.1	unknown	U	N	4A70650265	26-Jul-09
RNTR	117	18.0	unknown	U	N	4B1E6B3542	26-Jul-09
RNTR	71	3.3	I	U	R	upper caudel clip	26-Jul-09
RNTR	71	3.8	I	U	N	upper caudel clip	26-Jul-09
RNTR	66	2.9	I	U	N	upper caudel clip	26-Jul-09
RNTR	74	4.1	I	U	N	upper caudel clip	26-Jul-09
RNTR	64	2.6	I	U	N	upper caudel clip	26-Jul-09
RNTR	67	3.0	I	U	N	upper caudel clip	27-Jul-09
RNTR	77	4.5	I	U	N	upper caudel clip	27-Jul-09
RNTR	67	2.7	I	U	N	upper caudel clip	27-Jul-09
RNTR	75	4.5	I	U	N	upper caudel clip	27-Jul-09
RNTR	75	4.5	I	U	N	upper caudel clip	27-Jul-09
RNTR	69	3.2	I	U	R	upper caudel clip	27-Jul-09
RNTR	94	9.8	I	U	N	4A70650934	28-Jul-09
RNTR	69	3.6	I	U	N	upper caudel clip	28-Jul-09
RNTR	71	3.5	I	U	N	upper caudel clip	28-Jul-09
RNTR	66	3.0	I	U	N	upper caudel clip	28-Jul-09
RNTR	73	4.1	I	U	N	upper caudel clip	29-Jul-09
RNTR	89	7.2	I	U	R	4B02135F77	29-Jul-09
RNTR	67	2.6	I	U	N	upper caudel clip	30-Jul-09
RNTR	84	5.9	I	U	N	4B1E753A59	30-Jul-09
RNTR	133	25.1	unknown	U	N	4B1E7A5657	30-Jul-09
RNTR	64	2.8	I	U	N	upper caudel clip	31-Jul-09
RNTR	62	2.6	I	U	N	upper caudel clip	31-Jul-09
RNTR	83	6.2	I	U	N	4B1E740355	31-Jul-09
RNTR	105	10.8	unknown	U	N	4B1E5F484E	31-Jul-09
RNTR	67	3.2	I	U	N	upper caudel clip	1-Aug-09
RNTR	67	3.3	I	U	N	upper caudel clip	1-Aug-09
RNTR	79	5.5	I	U	N	upper caudel clip	1-Aug-09
RNTR	92	8.7	I	U	N	4B1E5D5225	1-Aug-09
RNTR	69	3.6	I	U	N	low/upper caudel clip	2-Aug-09
RNTR	74	3.9	I	U	N	upper caudel clip	2-Aug-09
RNTR	143	32.0	unknown	U	R	4664687744	2-Aug-09
RNTR	114	15.1	unknown	U	R	4677652739	2-Aug-09
RNTR	106	13.2	unknown	U	N	4B02274322	2-Aug-09
RNTR	139	26.6	unknown	U	N	4B02134927	2-Aug-09
RNTR	78	4.8	I	U	N	upper caudel clip	3-Aug-09
RNTR	85	6.5	I	U	N	4B1E7D2002	3-Aug-09
RNTR	77	4.5	I	U	N	upper caudel clip	3-Aug-09
RNTR	76	4.4	I	U	N	upper caudel clip	3-Aug-09
RNTR	87	6.7	I	U	R&N	4B020C3D7D	3-Aug-09

RNTR	124	20.8	unknown	U	R	46774F4D16	4-Aug-09
RNTR	79	5.0	I	U	N	upper caudel clip	4-Aug-09
RNTR	70	3.7	I	U	N	upper caudel clip	4-Aug-09
RNTR	69	3.3	I	U	N	upper caudel clip	4-Aug-09
RNTR	91	7.6	I	U	N	4B1F063B77	5-Aug-09
RNTR	161	45.6	unknown	U	R	4B1E3A6C39	5-Aug-09
RNTR	66	3.1	I	U	N	upper caudel clip	7-Aug-09
RNTR	26		I	U	N	Not tagged	8-Aug-09
RNTR	79	5.4	I	U	N	upper caudel clip	8-Aug-09
RNTR	69	3.3	I	U	R	upper caudel clip	9-Aug-09
RNTR	63	2.8	I	U	N	upper caudel clip	10-Aug-09
RNTR	80	5.4	I	U	N	upper caudel clip	10-Aug-09
RNTR	64	2.7	I	U	N	upper caudel clip	11-Aug-09
RNTR	64	2.8	I	U	N	upper caudel clip	11-Aug-09
RNTR	65	2.8	I	U	N	upper caudel clip	11-Aug-09
RNTR	67	3.5	I	U	N	upper caudel clip	11-Aug-09
RNTR	93	9.4	I	U	N	4B1E68254F	12-Aug-09
RNTR	76	4.7	I	U	N	upper caudel clip	13-Aug-09
RNTR	73	4.3	I	U	N	upper caudel clip	13-Aug-09
RNTR	90	7.2	I	U	R	4B1E750056	13-Aug-09
RNTR	78	4.8	I	U	R	upper caudel clip	14-Aug-09
RNTR	84	6.0	I	U	R	upper caudel clip	14-Aug-09
RNTR	69	3.0	I	U	N	upper caudel clip	15-Aug-09
RNTR	59	2.0	I	U	N	upper caudel clip	18-Aug-09
RNTR	65	2.7	I	U	N	Not tagged	18-Aug-09
RNTR	67	2.9	I	U	N	upper caudel clip	20-Aug-09
RNTR	84	6.2	I	U	N	upper caudel clip	20-Aug-09
RNTR	69	3.6	I	U	N	upper caudel clip	21-Aug-09
RNTR	77	4.4	I	U	N	upper caudel clip	21-Aug-09
RNTR	73	4.2	I	U	N	upper caudel clip	21-Aug-09
RNTR	65	3.3	I	U	N	upper caudel clip	22-Aug-09
RNTR	75	4.7	I	U	N	upper caudel clip	23-Aug-09
RNTR	90	8.0	I	U	N	upper caudel clip	23-Aug-09
RNTR	69	3.7	I	U	N	upper caudel clip	23-Aug-09
RNTR	91	8.2	I	U	N	upper caudel clip	24-Aug-09
RNTR	100	9.5	unknown	U	R	985121016372354	6-Sep-09
RNTR	76	4.8	I	U	N	upper caudel clip	6-Sep-09
RNTR	68	3.0	I	U	R	low/upper caudel clip	6-Sep-09
RNTR	92	7.5	I	U	N	4B02294627	6-Sep-09
RNTR	114	15.5	unknown	U	R	985121011987121	6-Sep-09
RNTR	94	8.0	I	U	R	4B1F002C6F	6-Sep-09
RNTR	105	10.5	unknown	U	N	4B1E76551B	6-Sep-09
RNTR	88	7.2	I	U	N	upper caudel clip	7-Sep-09
RNTR	73	5.2	I	U	N	upper caudel clip	11-Sep-09
RNTR	112	14.5	unknown	U	N	4B1E78201A	11-Sep-09

Sphinx Creek Fish Trap 2 - Located upstream of Sphinx Lake
Fish captured moving upstream of Sphinx Lake
Date: May 2009 to September 2009

Table 29: Fish captured moving upstream of Sphinx Lake, Sphinx Creek upstream of Sphinx Lake trapping 2009

Species	Length (mm)	Weight (g)	Maturity	Gender	Recap/New	PIT Tag	Lift Date
RNTR	321	330.5	ripe	F	R	985121011994053	26-Jun-09
RNTR	291	258.0	ripe	F	R	467570180C	26-Jun-09
BLTR	369	491.5	unknow	U	R	467773761A	22-Jul-09
BLTR	360	450.5	unknow	U	R	985121012049922	23-Jul-09
RNTR	194	77.5	unknow	U	R	46652C7806	25-Jul-09
RNTR	196	80.7	ripe	M	N	4B1F01551A	25-Jul-09
BLTR	369	509.0	unknow	U	R	985121011990054	3-Aug-09

Sphinx Creek Fish Trap 2 - Located upstream of Sphinx Lake
Fish captured moving downstream towards Sphinx Lake
Date: May 2009 to September 2009

Table 30: Fish captured moving downstream towards Sphinx Lake, Sphinx Creek upstream of Sphinx Lake trapping 2009

Species	Length (mm)	Weight (g)	Maturity	Gender	Recap/New	PIT Tag	Lift Date
RNTR	319	296.0	spent	F	R	985121011994053	30-Jun-09
BLTR	369	509.0	unknown	U	R	985121011990054	4-Aug-09
BLTR	120	16.0	unknown	U	N	985121012048480	3-Sep-09
BLTR	345	368.0	spent?	F?	N	4A70652814	9-Sep-09

APPENDIX B: STREAM RATING CURVES

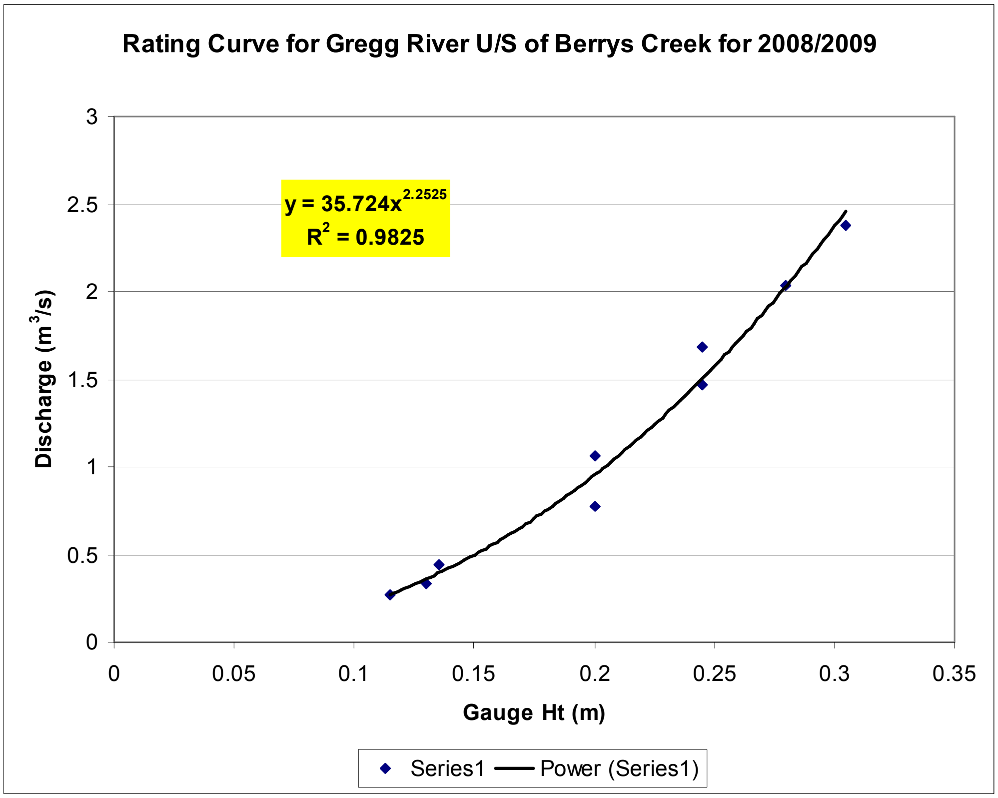

Figure 1: Stream rating curve for Gregg River (G3) in 2008 and 2009

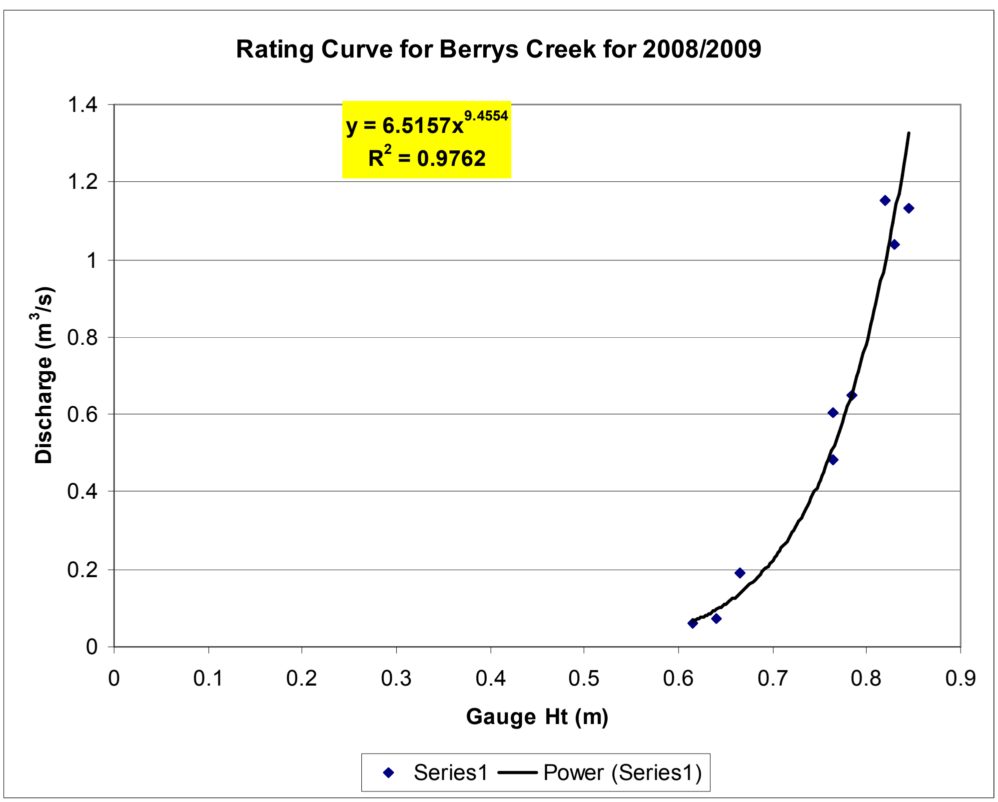

Figure 2: Stream rating curve for Berrys Creek (B) in 2008 and 2009

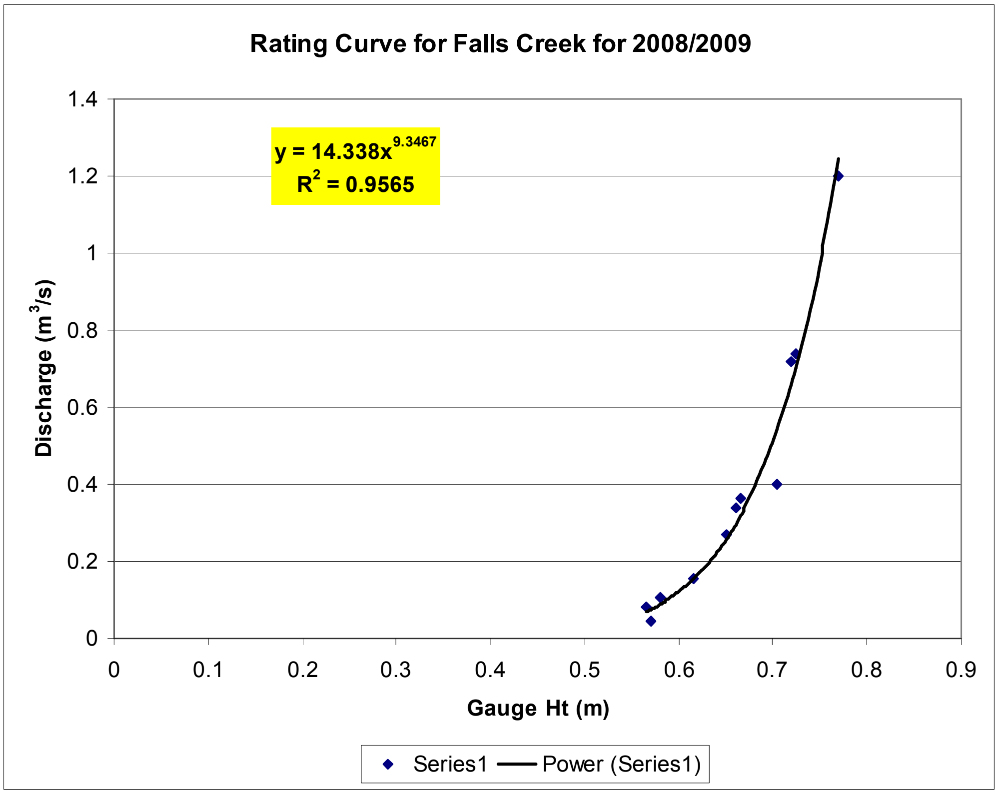

Figure 3: Stream rating curve for Falls Creek (F) in 2008 and 2009

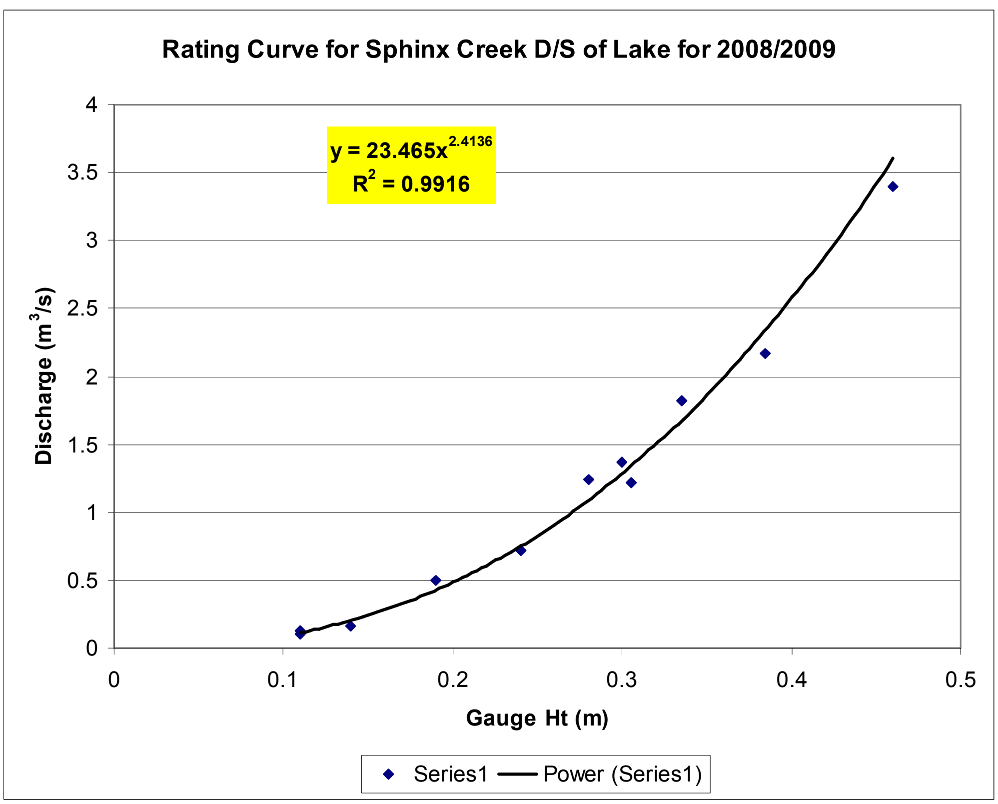

Figure 4: Stream rating curve for Sphinx Creek (S2) in 2008 and 2009