Coal Valley Resources Inc. - Coal Valley Mine

Robb Trend Project

Preliminary Fish Compensation Outline
Project Update & Revised Discussion Report

Submitted to
Department of Fisheries and Oceans Canada,
Alberta Environment and Sustainable Resource Development,
Alberta Energy Regulator, and
Canadian Environmental Assessment Agency

March 13, 2014

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1.0 INTRODUCTION

Coal Valley Resources Inc. (CVRI) submitted a Mine Permit Amendment application (Environmental Impact Assessment – EIA) for the Robb Trend Project (Project) in April, 2012.

Since then the application has been under review by public, stakeholders and government agencies (federal and provincial) including the Alberta Energy Regulator (AER), Alberta Environment and Sustainable Resource Development (ESRD), and the Canadian Environmental Assessment Agency (CEAA) and their various departments. The regulatory review has raised numerous questions, provided commentary on the proposed plans, and requested consideration of various alternatives.

Three Supplemental Information Requests (SIRs) have been made by government agencies with responses filed by CVRI for each round:

a. Response to SIR #1 was submitted December, 2012;
b. Response to SIR #2 was submitted June, 2013; and
c. SIR #3 was received October 24, 2013. A response is in preparation.

This review process has resulted in the determination that several minor ‘revisions’ to the original mine plan concept should be incorporated into the Project plan where a lesser degree of environmental impact or a greater degree of mitigation would result thus reducing potential risk of impact.

2.0 DFO REVIEW

Throughout the application process the Project Team has engaged DFO by providing them with a copy of the *Coal Valley Mine Robb Trend Project Environmental Impact Assessment and Mine Permit Application* (April 2012) as well as the subsequent SIR responses.

In addition to these documents meetings have been held with DFO to describe the proposed Project and outline implications regarding fish habitat impacts and future *Fisheries Act* approval requirements.

March 3, 2013

An initial meeting was held on March 3, 2013 at DFO Edmonton office to discuss the Project and to highlight concerns and requirements DFO expressed concerns regarding the magnitude of HADD and a seeming reliance of EPL for compensation. DFO requested further information to clarify available options to reduce these levels of risk. DFO further identified a preference to a greater degree stream channel habitat and lower level of lake habitat. In response to this meeting a *Fish Compensation Document* was provided to DFO on August 28, 2013 (See Appendix 1). This document outlined mining options including minor amendments to satisfy fish habitat compensation concerns as it relates to both disturbance and reclamation. Proposed modifications were made to the mine reclamation plan wherein some of the previously contemplated reclaimed lakes have been substituted by restored stream channels.

October 7, 2013

On October 7, 2013 representatives from CVRI, CEAA, Millennium EMS Solutions Ltd. (MEMS), and Pisces Environmental Consulting Services Ltd. (Pisces) met at the DFO Edmonton office to discuss the Project and the *Fish Compensation Document* as it related to fish and fish habitat. A Project update was provided at this meeting related to the SIR responses and potential mine plan revisions.

At the meeting, DFO identified remaining concerns and further clarification of the proposed changes. CVRI concluded the meeting with an offer to provide additional description of the Project revisions with respect to HADD and compensation values attained through reclamation.

3.0 SUPPLEMENTAL QUESTIONS RAISED BY DFO

1. End-pit lake (EPL) size and depth is a major concern. Is it possible to backfill the EPL's to decrease depth comparable to the EPL Development Guidelines?

Response:

Yes, some changes to the EPL can be accommodated to provide designs more comparable to the guidelines.

CVRI has already implemented some changes and is confident that further design refinements will result in EPL designs more closely matching the Alberta End-Pit Lake Guidelines.

CVRI has incorporated a number of revisions to the proposed mine plan in order to provide improvements to the EPL designs forecasted in the reclamation plan. These changes will be described in the forthcoming AER and ESRD SIR #3 documents. Figure 1 illustrates the locations of revisions recently implemented. A summary of the revisions, related to EPL follows:

- Lake 4 has been deleted from the proposed plan and replaced with a reclaimed stream channel.
- Revisions in the mine areas have resulted in Lakes 1, 2, 3, and 12 with decreased size and volume. This decreased volume will also decrease projected fill times.
- CVRI has noted that mine sequence of many large pits can be modified to develop the pits in a staged manner which would result in a greater degree of in pit backfill. This will result in decreased lake volumes, decreased maximum depth and increased littoral area.
- CVRI has modified the approach proposed for connecting streams across reclaimed lakes. Many of the diversions across backfilled 'land bridges' will be retained as stream channels instead of creating flow through EPL's. This change will provide additional stream channel for the original streams and improve conditions for lake outlets.
- Numerous other changes have been identified in order to decrease stream channel habitat losses and provide greater degree of channels as inlets or outlets to future lakes.
- Several of the proposed lakes will be established as 'off-stream' water bodies which will be designed to outlet into channels which flow to streams. This will allow for a greater degree of control on flows and fish passage options.

- Many of the proposed lakes will be scheduled for construction later in the Project life. This allows for a greater degree of monitoring and establishment of current EPL's in the current Mine area. Results of the research and monitoring of these current lakes will assist in future planning.
- The EPL's proposed for the Project will be developed over time, rather than clustered together. This sequence will also permit a greater degree of planning and implementation of design elements over time as EPL technology develops further.
- EPL habitat as compensation for HADD can be sequenced over several years and can be approved in stages as mining advances through the Project area. CVRI will design and construct these EPL's in alignment with Alberta End-Pit Lake Guidelines.

Table 1 is provided to illustrate the lake characteristics for the revised mine plan. Size, depth and volume of lakes will be modified through mine plan changes. Lake designs will be established during the approval process which is expected to be staged throughout the life of the Project.

Table 1 End Pit Lakes – Revised Plans

Lake	Original Plan					Revised
	Surface Area (Ha)	Maximum Depth (m)	Lake Volume (million m^3)	Littoral Area (Ha)	Fill Time (Years)	Comments
1	63.5	**75**	21.7	**5.0**	**57.1**	Size, depth, volume reduced significantly. Littoral area increased.
2	93.0	**65**	23.3	17.6	**27.7**	Size, depth, volume reduced significantly.
3	60.3	**55**	12.7	**8.3**	**44.1**	Size, depth, volume reduced significantly. Littoral area increased.
4	71.1	**45**	8.1	17.8	2.2	Deleted from plan, replaced by stream channel.
5	131.8	**45**	22.2	33.8	7.8	
6	28.9	**50**	4.4	4.9	**3.4**	
7	16.4	25	1.8	3.7	1.4	
8	20.1	40	2.0	5.9	7.0	
9	21.0	35	2.8	4.1	6.6	
10	5.5	15	0.1	2.3	.06	
11	17.7	35	2.0	4.0	5.8	
12	96.0	55	25.4	9.1	28.6	Size, depth, volume reduced significantly. Littoral area increased.

*Footnote: Red text signifies design elements that were focus of revisions.

It is important to note that the EPL's, as currently proposed, are expected to have a medium to high probability of success based on design factors outlined in the EPL Development Guidelines. Table 2 presents the anticipated 'revised' lake layouts in context with EPL guidelines design features. As shown on Table 2 most of the design parameters that are ranked has highly important (including those parameters that are dependent on lake depth) have a moderate to high probability of success as defined by the EPL Development Guidelines.

Table 2 End Pit Lakes – Guideline Parameters

Lake	Parameter	Probability of Success										
		1	2	3	5	6	7	8	9	10	11	12
	Sustainability (Water Balance)	High	High	High	High	High	High	High	High	High	High	High
	Lake Dynamic/Function	High	High	High	High	High	High	High	High	High	High	High
	Filling Method/Schedule	Low	Low	Low	Medium	High	High	Medium	Medium	High	Medium	Low
	Lake Geometry	Medium	Medium	Medium	Medium	Medium	High	Medium	Medium	High	High	Medium
	Shoreline Stability	High	High	High	High	High	High	High	High	High	High	High
	Stratification/Mixing	Low	Low	Low	Low	Medium	Medium	Medium	Medium	Low	Medium	Low
	Water Quality	High	High	High	High	High	High	High	High	High	High	High
	Potential Toxic Substances	High	High	High	High	High	High	High	High	High	High	High
	Littoral Zone	Low	Medium	Medium	High	Medium	High	High	Medium	Low	High	Low
	Substrate in Littoral Zone	High	High	High	High	High	High	High	High	High	High	High
	Connectivity	Medium	Medium	Medium	Medium	High	Medium	High	High	High	High	Medium
	Riparian	High	High	High	High	High	High	High	High	High	High	High
	Score (1-low,2-med,3-high)	26	29	29	31	33	34	33	32	32	34	28
	Total Available Score	36	36	36	36	36	36	36	36	36	36	36
	Percentage	72%	81%	81%	86%	92%	94%	92%	89%	89%	94%	78%

Other Comments

For Lake 5 can the mean depth be decreased to 15 - this will get rid of the low rating highlighted in red
For Lake 10 if %littoral can be increased from 19.5 to 20 then the ranking can be changed from Medium to High (blue highlight)
For Lake 10 the amount of littoral needs to be reduced so that it is less than 40% and average depth is increased to 4 m. This will get rid of the two low ratings highlighted in yellow

Lakes proposed for the Project have been reduced from 12 to 11. Revisions to date have resulted in improvements to lake designs with regard to EPL Guideline requirements. Additional future revisions can be expected as mine designs are revised over the life of the Project. Comments regarding the lake characteristics itemized in Table 1 include:

- Four of the proposed lakes are predicted to be large and deep. Lakes 1, 2, 3 and 12 will be developed as 'end cuts' in the mine sequenced which result in reduced backfill opportunity. These are the last pits excavated in a series of mine pits. Further refinement of mining sequence in these pits can be expected to further improve backfill.

Focus of fish habitat will be directed to Lakes 6, 7, 8, 9, 10, and 11. These lakes are smaller and shallower. Mean depths are within guidelines. A large portion of littoral zone can be provided. All of these lakes will function as 'flow through' with direct connectivity to streams.

2. Are all of the EPL designed to be fish habitat? How much fish habitat is being considered to be developed?

Response:

All EPL's will be reclaimed for utilization of fish populations. Several lakes will be established as 'flow through' water bodies fully connected with existing rivers and creeks which will provide water inflow. Additional lakes will be established as standing water bodies filled with surface and groundwater inflows but outflowing into adjacent streams. Figure 2 provides an illustration of the conceptual landscape post-reclamation including EPL's and restored channels.

The End-Pit Lake Guidelines suggest that 'flow through' lakes should be considered more favorable for fish utilization due to water circulation. However, any connection of lakes to a nearby channel would be advantageous since the lakes augment and diversify the range of habitat.

The *Fish Compensation Document* indicates that the online flow-through lakes will be designed for self-sustaining fish populations while the other lakes will be determined based on conditions at the time of reclamation (inflow/outflow). Discussions with regulators and factoring in the regional fisheries objectives will also help direct the final reclamation end land uses.

In total, the EPL's as currently designed will provide over 550 ha of fish habitat (Table 3 and 4). While some lakes may require additional modification to facilitate the establishment of fish populations in a reasonable timeframe, there are several lakes that are considered highly likely to successfully support self-sustaining fish populations as currently designed. It is CVRI's opinion that these lakes (Lakes 8, 9, 10, 11) will provide sufficient habitat to adequately compensate/offset for habitat losses and that habitat afforded by the other lakes would not be required to satisfy requirements under the *Fisheries Act*. In specific, there are 4 lakes (Lakes 8, 9, 10, and11) that have very similar characteristics to the EPL system that has already been developed in the upper Embarras River.

While monitoring results for the Embarras Lakes system are preliminary, the initial investigations suggest that the system is supporting Athabasca Rainbow Trout and densities in the Embarras River downstream of the lakes are higher now than when assessed prior to mining.

Recent reports related to monitoring of existing CVM lakes are provided for information (See Appendix 2). These reports include:

- Aquatic Monitoring Program For End Pit Lakes in the Headwaters of the Embarras River, 2011 – 2012, Pisces Environmental Consulting Services Ltd., April, 2013. This report provides early monitoring results in the 'Upper Embarras Lake' EPL system at CVM. The objective of this program is 'to assess the viability of the EPL's' once they were constructed.
- Preliminary Results for Fish Sampling Conducted in the Embarras Lakes System, Pisces Environmental Consulting Services Ltd, February 4, 2014. This report provides a brief update of 2013 fish sampling program conducted within and adjacent to the lake system.
- Recommendations for Channel Enhancement in the Embarras Lakes End Pit Lake System, Pisces Environmental Services Ltd., August 21, 2013. This report summarizes recommendations for channel enhancement of connecting channels in the Embarras Lakes End Pit Lake System. The recommended work would assist in further supporting a self-sustaining native fish population within the lakes. CVM will be implementing an enhancement program as recommended.
- 2012 Post-Construction Monitoring of the Permanent Diversion Channel on Upper Mercoal Creek for the MP2 Development, Pisces Environmental Consulting Services, March 19, 1013. This report provides a summary of Year 3 (Post-Construction) monitoring results for a diversion channel.
- Preliminary Results for Investigations Conducted on Existing End Pit Lakes in the South Block Area of the Coal Valley Mine, Pisces Environmental Services Ltd., February 18, 2014. This report provides a brief update of 2013 preliminary investigation to assess fisheries potential in older, completed EPL's within the south-east portion of the CVM.
- Macrophyte and Bathymetric Surveys in End-Pit Lakes in the Coal Valley Mine Area, Hatfield Consultants, February, 2014. This report summarizes the assessment of bathymetry and macrophyte communities in nine existing EPL's in the CVM area.

Several EPL are proposed for the Project reclamation plan. Table 3 describes the revised lake design elements for each of the proposed lakes. Significant littoral zone area will be accommodated in each lake providing appropriate fish habitat.

Fish habitat will be available as follows:

- Lake surface area will be in excess of 5,000,000 square meters.
  - Approximately 1,100,000 square meters (22%) will be provided in lakes which provide 'flow through' connectivity with established streams.
  - The remaining 3,900,000 square meters will be provided in lakes connected to nearby streams through outlet channels.
- Littoral area of approximately 1,036,000 square meters.
  - Approximately 249,000 square meters will be provided within the lakes having flow through connectivity.
  - The additional 787,000 square meters will be available in the other connected lakes.

Table 3 EPL Fish Habitat Available

Lake	Surface Area (Ha)	Littoral Zone (m^2)	Inflow Conditions
1	<63.5	+50,000	Connects to Lake 2
2	<93.0	+176,000	Outflow to Bryan Creek
3	<60.3	+83,000	Outflow to Hay Creek
4			Lake deleted, replaced with stream habitat
5	<131.8	+338,000	Outflow to Erith River
6	28.9	49,000	Halpenny Creek flow through
7	16.4	37,000	Lendrum Creek flow through
8	20.1	59,000	Lund Creek flow through
9	21.0	41,000	Lund Creek flow through
10	5.5	23,000	Lund Creek flow through
11	17.7	40,000	Lund Creek flow through
12	<96.0	+91,000	Outlet to Lund Creek
Total		**+1,036,000**	

Table 4 provides a tabulation of the ‘stream habitat’ which will be returned within the Project area. Accommodations have been made to improve the quantity of ‘stream habitat’. In many cases the opportunity will be presented to also ‘improve’ the habitat quality and diversity over what was originally in place.

Table 4 Stream Channel Habitat Available

Basin	Type	Area (m^2)	Comment
Bryan Creek	Constructed Channel		Bryan Creek will be diverted and then returned into reclaimed Mynheer Pit
	Constructed Channel		Channel will be built on land bridge between Lake 1 and 2
	Lake Outlet		Outlet of Lake 2 will flow to Bryan Creek
		15,688	
Hay Creek	Lake Outlet		Lake 3 will flow into Hay Creek
		6,363	

Table 4 Stream Channel Habitat Available

Basin	Type	Area (m^2)	Comment
Erith River	Constructed Channel		Temporary channel provided in reclaimed McPherson pit during Mynheer mining
	Constructed Channel		Final river route through Mynheer Pit in place of Lake 4
	Constructed channel		Channel on land bridge between lakes
	Lake Outlet		Lake outlets build on land bridge
		67,485	
ERT1 ERT2	Constructed Channel		Channel as bypass of Mynheer Pit
		1,406	
Bacon Creek	Constructed Channel		Channel on land bridge over pit width
	Lake Outlet		Lake outlet on land bridge
		2,777	
Halpenny Creek	Constructed Channel		Channel on land bridge over pit width
		4,129	
Lendrum Creek LET1 LET2	Constructed Channel		Channel on land bridge over pit width Downstream
		25,663	
Lund Creek			
		24,851	
Pembina East			Diversion built as channel
		660	
Total		**122, 753**	

3. Has there been any discussion or plans for discussion with ESRD in relation to the Rainbow Trout Recovery Plan?

Response:

Recovery Plan

ESRD is currently proposing a recovery plan for Athabasca Rainbow Trout in anticipation of a possible decision to move the species into a threatened species designation. Status of this decision is unknown.

CVRI has a staff member sitting on the committee which is developing the Athabasca Rainbow Trout Recovery Plan. This member is participating in the discussions and determination of the recovery steps being proposed for the plan. A rough draft of the recovery plan had been circulated in March 2013. No apparent progress has been reported since then.

CVM Participation

CVRI is also currently active in participation with ESRD in EPL development within the current mine area. This active work includes efforts to improve conditions for Athabasca Rainbow Trout in the region. A specific project involving EPL ‘Embarrass Lake’ (Pit 122) is focused on establishment of a local, self-sustaining population of Athabasca Rainbow within the upper headwaters of Embarrass Lake. A compilation of reclaimed lakes and stream channels has been identified for the project. A downstream ‘fish barrier’ was constructed to keep species from migrating into the system. ERSD has introduced native Rainbows into the system with early results showing favorable start to the project.

CVRI, ESRD and DFO continue discussions related to EPL reclamation in the area with respect to species introductions and specific habitat and migration alternatives. A co-operative approach favoring ESRD fish management requirements will continue to be followed.

There has been no direct communication between ESRD and CVRI specifically related to the Rainbow Trout Recovery Plan and Robb Trend Project. Within the *Fish Compensation Document* CVRI has identified that the main focus of the fish habitat compensation is the Athabasca Rainbow Trout.

For information, CVRI has provided recent material obtained from the ESRD website which is related to ‘species at risk’ (see Appendix 3).

4. Table 12 of the Fish Compensation Plan needs to be revised to reflect the revisions.

Response:

CVRI has also provided Table 5, 6, and 7 to illustrate the HADD levels forecast for the Project area with the revisions included.

Table 5 indicates the ‘spread’ of habitat loss over the life of the Project. Initial mining activity is focused in the Erith River area and then advances to other Project areas. The cumulative total of habitat loss would be 159,819 m^2after incorporating the recent plan revisions.

Table 5 Fish Habitat Impact Over Life of Project

		Old	New	Habitat	HABITAT AREA (M**2)																									
		Case	Case	Potential	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Bryan Creek		14208	14208	High																	-4000	-10000	-208							-14208
		1480	1480	Low																	-1480									-1480
																														0
Hay Creek		2325	6363	Low												-5000	-1363													-6363
																														0
Erith River	Main	67485	67485	High		-3000	-2000	-3000	-30000	-1000	-1000	-8500	-1000			-15000	-1000	-1000	-985											-67485
	ERT1	5834	1000	High										-1000																-1000
	ERT1A	102	0																											0
	ERT2	406	406	Low			-406																							-406
	ERT3	7751	7751	Low				-7751																						-7751
																														0
Bacon Creek		2777	2777	High								-2500	-277																	-2777
																														0
Halpenny Creek	Main	7601	4129	Low								-3500	-500	-129																-4129
	HLT1	2239	0																											0
	HLT2	219	0																											0
																														0
Lendrum Creek	Main	17468	17468	Moderate										-16000	-1468															-17468
	LET1	1923	3282	Moderate										-3282																-3282
	LET3	22161	7959	High										-7959																-7959
																														0
Lund Creek	Main	11026	16033	Moderate																	-7000	-3000	-4000	-2033						-16033
	LDT1	2991	2991	Low												-2000	-500	-491												-2991
	LDT1A	1091	1091	Low												-1091														-1091
	LDT2	209	209	Low														-209												-209
	LDT3	2507	3831	Low																-3500	-331									-3831
	LDT4	542	542	Low																	-542									-542
	LDT5	154	154	Low																	-154									-154
																														0
Pembina East	PET1	5236	660	High																	-100	-560								-660
																														0
Total		177735	159819		0	-3000	-2406	-10751	-30000	-1000	-1000	-14500	-1777	-28370	-1468	-23091	-2863	-1700	-985	-3500	-13607	-13560	-4208	-2033	0	0	0	0	0	-159819
Cumulative					0	-3000	-5406	-16157	-46157	-47157	-48157	-62657	-64434	-92804	-94272	-117363	-120226	-121926	-122911	-126411	-140018	-153578	-157786	-159819	-159819	-159819	-159819	-159819	-159819	

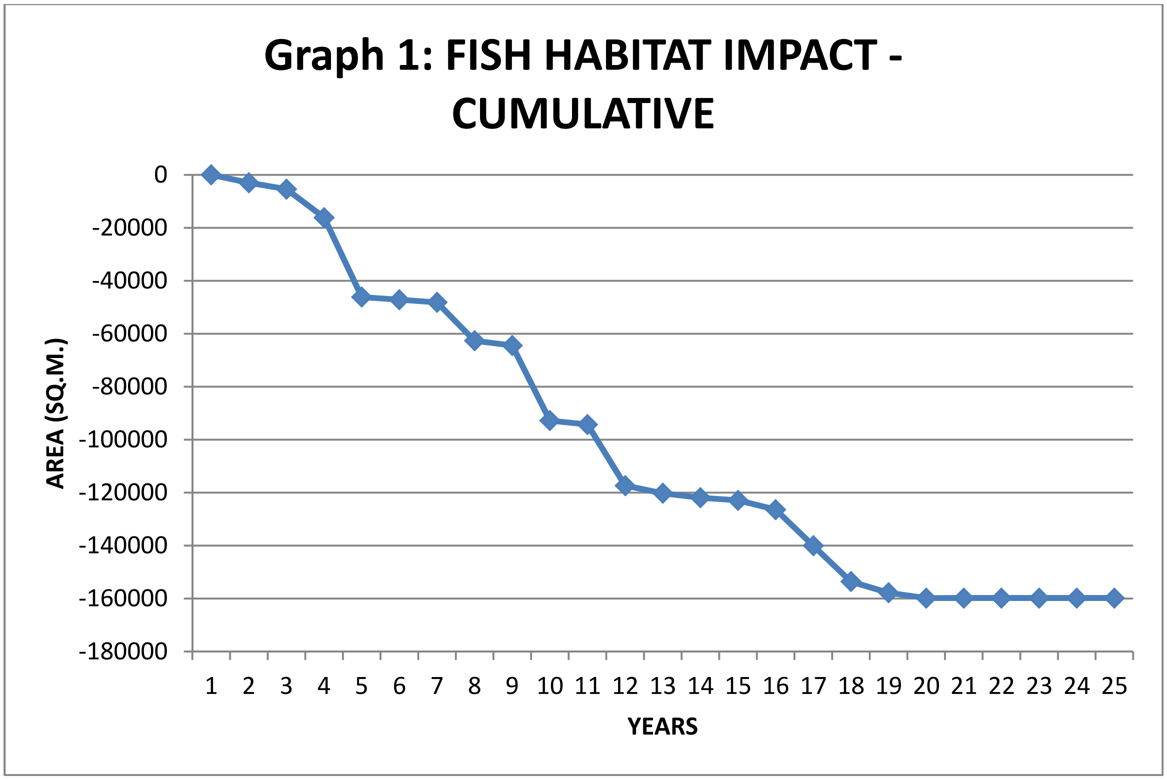


Table 6 includes the 'return' of stream channel habitat as the Project advances through time. (The table does not include any EPL contribution). Much habitat will be restored in earlier years before the loss incurs in other segments of the Project. This tabulation results in a maximum cumulative loss of about 48,000 m^2 reducing to about 38,000 m^2 at the conclusion of the Project. No 'off site' compensation has been incorporated into this schedule although opportunity is available within the surrounding region.

Table 6 Net Fish Habitat Impact Over Life of Project

		Old	New	Habitat	HABITAT AREA (M**2)																									
		Case	Case	Potential	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Bryan Creek		14208	14208	High																	-4000	-10000	-208							-14208
		1480	1480	Low																	-1480									-1480
																			Reclaimed Mynheer Pit			15688								15688
Hay Creek		2325	6363	Low												-5000	-1363													-6363
																														0
Erith River	Main	67485	67485	High		-3000	-2000	-3000	-30000	-1000	-1000	-8500	-1000			-15000	-1000	-1000	-985											-67485
	ERT1	5834	1000	High										-1000																-1000
	ERT1A	102	0																											0
	ERT2	406	406	Low			-406																							-406
	ERT3	7751	7751	Low				-7751																						-7751
									20000	20000	5000	5000					10000	6000	2861											68861
Bacon Creek		2777	2777	High								-2500	-277																	-2777
																2777														2777
Halpenny Creek	Main	7601	4129	Low								-3500	-500	-129																-4129
	HLT1	2239	0													4129														4129
	HLT2	219	0																											0
																														0
Lendrum Creek	Main	17468	17468	Moderate										-16000	-1468															-17468
	LET1	1923	3282	Moderate										-3282																-3282
	LET3	22161	7959	High										-7959																-7959
															7500	5000	7000	6163												25663
Lund Creek	Main	11026	16033	Moderate																	-7000	-3000	-4000	-2033						-16033
	LDT1	2991	2991	Low												-2000	-500	-491												-2991
	LDT1A	1091	1091	Low												-1091														-1091
	LDT2	209	209	Low														-209												-209
	LDT3	2507	3831	Low																-3500	-331									-3831
	LDT4	542	542	Low																	-542									-542
	LDT5	154	154	Low																	-154									-154
																		500	500	500	500	1500	1445							4945
Pembina East	PET1	5236	660	High																	-100	-560								-660
																						660								660
Total		177735	159819		0	-3000	-2406	-10751	-10000	19000	4000	-9500	-1777	-28370	6032	-11185	14137	10963	2376	-3000	-13107	3628	-2763	-2033	0	0	0	0	0	-37756
Cumulative					0	-3000	-5406	-16157	-26157	-7157	-3157	-12657	-14434	-42804	-36772	-47957	-33820	-22857	-20481	-23481	-36588	-32960	-35723	-37756	-37756	-37756	-37756	-37756	-37756	

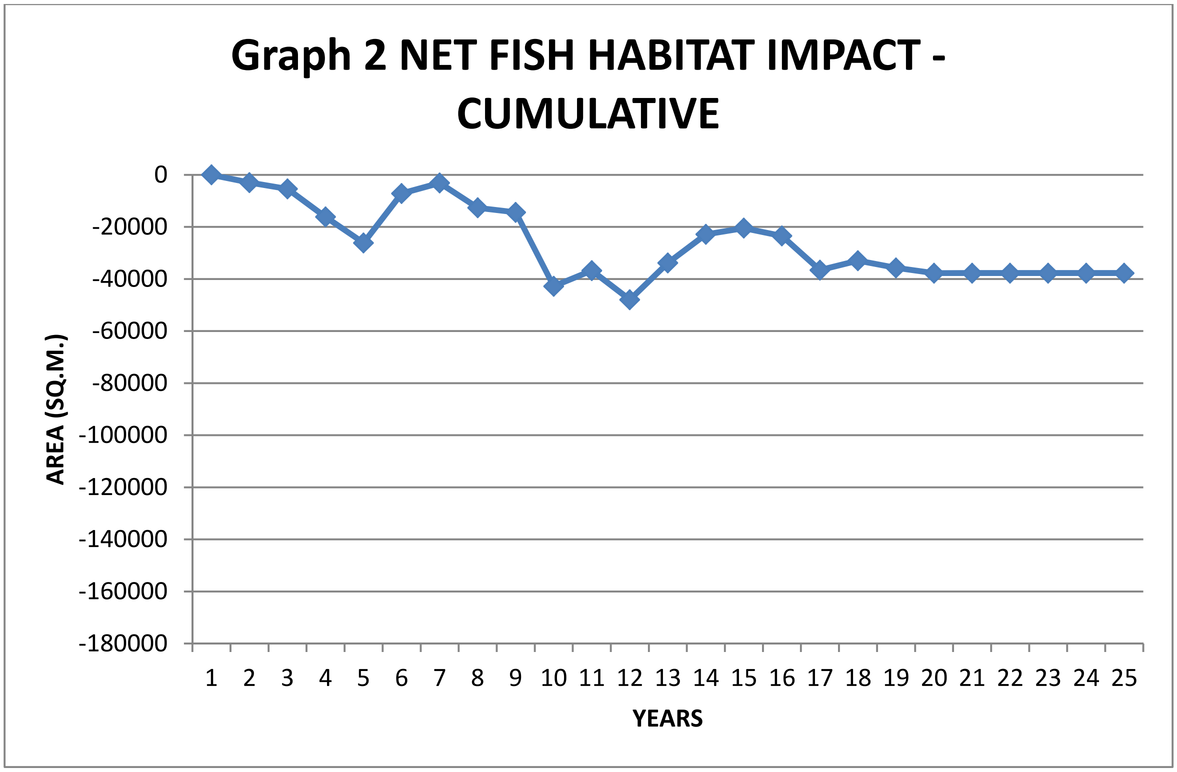
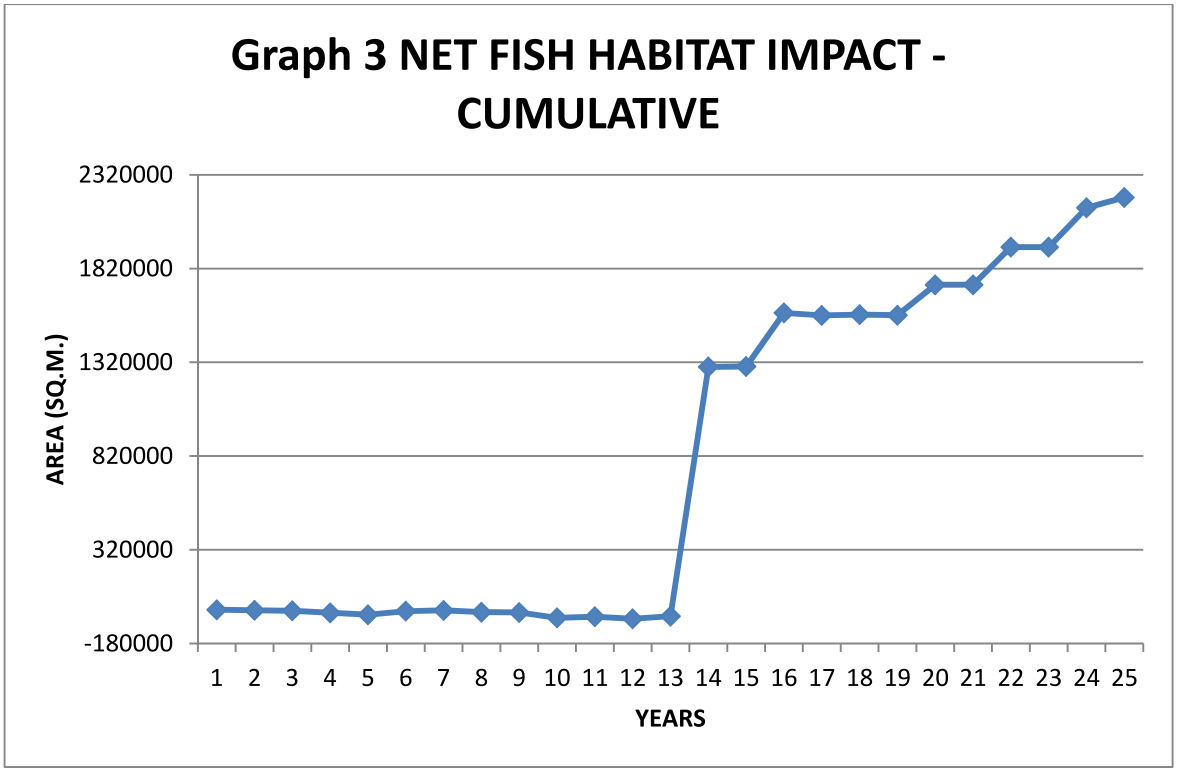


Table 7 provides a schedule which illustrates the inclusion of EPL habitat available during the Project timeline. The first lake (Lake 5) would not be available until mid-Project. Additional lakes would come on stream toward the end of the project life. Additional lakes would be available beyond the schedule timeline illustrated. EPL habitat has the opportunity to massively increase the fish habitat availability in the area.

Table 7 Net Fish Habitat Impact Over Life of Project

		Old	New	Habitat	HABITAT AREA (M**2)																									
		Case	Case	Potential	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Total
Bryan Creek		14208	14208	High																	-4000	-10000	-208							-14208
		1480	1480	Low																	-1480									-1480
																			Reclaimed Mynheer Pit			15688								15688
Hay Creek		2325	6363	Low												-5000	-1363													-6363
																														0
Erith River	Main	67485	67485	High		-3000	-2000	-3000	-30000	-1000	-1000	-8500	-1000			-15000	-1000	-1000	-985											-67485
	ERT1	5834	1000	High										-1000																-1000
	ERT1A	102	0																											0
	ERT2	406	406	Low			-406																							-406
	ERT3	7751	7751	Low				-7751																						-7751
									20000	20000	5000	5000					10000	6000	2861											68861
Bacon Creek		2777	2777	High								-2500	-277																	-2777
																2777														2777
Halpenny Creek	Main	7601	4129	Low								-3500	-500	-129																-4129
	HLT1	2239	0													4129														4129
	HLT2	219	0																											0
Lake 5																		1318000												1318000
Lendrum Creek	Main	17468	17468	Moderate										-16000	-1468															-17468
	LET1	1923	3282	Moderate										-3282																-3282
	LET3	22161	7959	High										-7959																-7959
Lake 6															7500	5000	7000	6163		289000										314663
Lund Creek	Main	11026	16033	Moderate																	-7000	-3000	-4000	-2033						-16033
	LDT1	2991	2991	Low												-2000	-500	-491												-2991
	LDT1A	1091	1091	Low												-1091														-1091
	LDT2	209	209	Low														-209												-209
	LDT3	2507	3831	Low																-3500	-331									-3831
	LDT4	542	542	Low																	-542									-542
	LDT5	154	154	Low																	-154									-154
Lake 7, 8, 9, 10																		500	500	500	500	1500	1445	164000		201000		210000	55000	634945
Pembina East	PET1	5236	660	High																	-100	-560								-660
																						660								660
Total		177735	159819		0	-3000	-2406	-10751	-10000	19000	4000	-9500	-1777	-28370	6032	-11185	14137	1328963	2376	286000	-13107	3628	-2763	161967	0	201000	0	210000	55000	2199244
Cumulative					0	-3000	-5406	-16157	-26157	-7157	-3157	-12657	-14434	-42804	-36772	-47957	-33820	1295143	1297519	1583519	1570412	1574040	1571277	1733244	1733244	1934244	1934244	2144244	2199244	



The tables are based on revisions as indicated:

- CVRI has reduced the predicted HADD areas significantly through incorporating mine changes. Important stream channel habitat has been retained to aid continued fish populations and movement and to assist in recovery during reclamation.
- CVRI has introduced revisions to reduce EPL size and depths and increase littoral areas.
- CVRI has implemented revisions to reintroduce a greater degree of stream channel habitat.
- Sequence of mining will spread HADD levels over the life of the Project.
- Reclamation will begin to return fish habitat early in the Project life before HADD occurs in the remainder of the Project area. This limits the maximum exposure levels.
- EPL will begin to return fish habitat early in the mine Project in advance of later HADD in the later years of the Project. This staged return of EPL and corresponding fish habitat will limit overall HADD levels.
- Compensation plans for the Project can be established over time as the Project advances. CVRI’s development of mining occurs in multiple stages in relation to each mine license. Each stage could include a specific compensation plan which would expand over time as the Project advances.

5. Deep online lakes are a concern with the potential increase in temperature and depleted oxygen levels. Has this concern been addressed in the mine plan revisions?

Response:

Early information collected from the Embarras Lakes system suggests that temperature and oxygen levels in EPL's are not a significant concern. See Pisces report (Appendix 2). As previously described above in the response to #2, there are several lakes that have very similar characteristics to the Embarras Lakes.

CVRI has a number of EPL's already established and additional lakes being currently developed. Monitoring of environmental conditions in these lakes is ongoing so that additional evidence regarding EPL conditions and design features will be available for EPL planning.

6. EPL fill times are a concern especially when some of the EPL's will require 57 years to reach a full water level. Has this concern been addressed in the mine plan revisions?

Response:

As previously indicated in the above response to #2, there are several lakes that have filling times that are within the recommended range for high success based on the EPL Development Guidelines.

CVRI has noted the resulting calculations indicating possible lake 'fill times'.

CVRI has incorporated changes into the proposed mine plan in order to reduce EPL volumes. Reduced volume will assist in reducing fill times. However, lake fill times will still vary considerably between the lakes. Fill times will depend on available groundwater flows and surface flows which can be directed into lakes while maintaining 'in stream' needs nearby.

Project changes (See Table 1 above) include:

- Four lakes have been predicted to be large and deep resulting in large volumes. Fill times of these would be expected to be lengthy since no direct stream flows would be available for filling. Future plans will investigate improvements to the lake designs and opportunity to import water from nearby sources for filling.
  - Lakes 1 and 2 will be adjusted through mine plan revisions to decrease volumes. Lake sizes will be decreased and depth decreased by increased in pit backfill volumes. Lake 2 has been shortened due to an adjusted in the limit of mining. Lake 3 will also be adjusted through mine plan sequencing to increase backfill. Water volume will be decreased.
- Lake 12 will also be modified through mine sequence changes.

7. **Note:** If lake/channel compensation doesn't meet regulatory standards, DFO will like a letter of credit. This process would occur at the Authorization stage.

Response:

CVRI acknowledges this DFO standard procedure.

CVRI will also anticipate proactive compensation opportunities off site as a method of establishing 'credit'.

8. Has CVRI identified any additional compensation options for example current lakes, culverts, areas off of the mine site?

Response:

CVRI has considered options regarding 'off site' compensation through habitat improvement projects in the regional area. Progress towards this option includes:

- Pisces evaluated existing culvert crossings in the Mercoal and Yellowhead Tower area with respect to fish passage limitations. Candidate crossings were identified including one site on Mercoal Creek downstream of the Mercoal Phase 1 area.
- CVRI has implemented fish habitat compensation at all stream crossings and diversions constructed for Mercoal and Yellowhead Tower mining areas. This work has included a haulroad crossing on Mercoal Creek tributary and diversion/reclamation of Mercoal Creek tributaries in Mercoal Phase 1. Mine activity in Yellowhead tower includes fish compensation features in the mine and reclamation planning.
- CVRI has continued partial funding of Foothills Research Institute (FRI) 'Stream Crossing' program by obtaining 'inventory' site reports on all stream crossings in the area surrounding the CVM and Robb Trend. In addition, information on fish species distribution has been obtained through the program. During 2013 the inventory of crossings was completed including roads for mining, wellsites, highways, railroads and mining. Such data provides opportunity to identify problematic crossings resulting in limiting fish passage or adverse stream sediment loading. CVRI now intends to move the program into evaluation of possible 'fish habitat improvement' projects for future presentation to ESRD and DFO.
- CVRI is actively developing plans for establishment of fish habitat in existing and future CVM EPL's. Field survey of current lakes have been undertaken to evaluate lake and outlet conditions regarding implementing introduction of fish utilization into the lakes. Hatfield (See Appendix 2) has completed an initial review of macrophyte conditions in the existing lakes. Continued monitoring will be used to identify changes in conditions over time. CVRI will also evaluate opportunities to establish shoreline and littoral zone vegetation. Pisces (See Appendix 2) has completed an initial review of inlet/outlet conditions on existing EPL with respect to flows and habitat conditions. CVRI will evaluate opportunities to establish improved fish habitat conditions in these channels.
- CVRI continues to initiate new and ongoing studies of many of the EPL's within the current mine site. Based on these studies CVRI is able to continue adapting reclamation procedures to improve success rates.

9. **Note:** DFO would like to provide Authorizations in stages.

Response:

CVRI agrees with this process and would wish to maintain a direct line of communication with DFO by having update meetings every few years to discuss future mining, mine progression and fish habitat related activities.

A 'staged' approach through the life of the Project will promote adaptation of reclamation technology based on experience gained from the existing and soon to be established EPL's at the CVM and in other jurisdictions. CVRI also notes that ESRD is reviewing and will likely enhance the Alberta End-Pit Lake Guidelines by incorporating 'lessons learned'.

10. Water quality of the EPL is a concern especially when they are to be directly connected to the surrounding watershed (i.e. online lakes). What actions will take place to ensure this water is suitable for fish populations?

Response:

No discharge of water from the EPL will occur unless water quality meets the Alberta water quality guidelines.

Standard practice for operation of reclaimed lakes includes:

- Completing the reclamation of areas surrounding EPL's to deter erosion.
- Completion of lake filling and control of any outflow. Any outflow is monitored for water quality.
- Reclamation of the lake including shoreline protection, inlet and outlet erosion control.
- Monitoring of lake water quality.
- Upon approval of ESRD the lake is permitted to outflow.

Long term monitoring of water quality, lake conditions, fish habitat and fish density is provided to document success of the EPL. Remediation of any problem areas is performed.

Monitoring of existing EPL's on the CVM suggest that water quality should not be of concern (Hatfield 2008, 2011).

11. Fish habitat compensation needs to focus on the species of concern in the area (i.e. Athabascan Rainbow) not just fish habitat in general.

Response:

Within the *Fish Compensation Document* CVRI has identified that the main focus of the fish habitat compensation is the Athabascan Rainbow Trout while Bull Trout and Arctic Grayling will act as secondary species of focus depending on fisheries management objectives.

CVRI will co-operate with ESRD in following fish management objectives of the region.

12. **Note:** CVRI could replace habitat that has limitations with improved habitat to increase certain fish species density.

Response:

CVRI agrees with this comment and would like to note that this statement is an objective/option within CVRI's *Fish Compensation Document*. Response to Question 8 indicates 'off-site' options that CVRI is investigating.

CVRI is currently co-operating with ESRD in following fish management objectives of the region including incorporation of fish habitat and fish movement features within the existing and current operational area. Response to Question 8 indicates some of the work ongoing.

13. Timing around habitat loss and replacement is a concern of DFO's. The example of the oil sands being given 3 years to compensate for habitat loss was given. Please provide some clarity around the timing of mining and reclamation activities.

Response:

Tables 5, 6, and 7 display the timing surrounding the removal of fish habitat and the associated mine reclamation. It needs to be stressed that the Project isn't developed all at the one time but rather in small blocks. At the licensing stage, CVRI will apply for pit and dump licenses for 3-5 year blocks. These detailed mine plans will show the location of the pit shells and dumps as well as the reclamation plan for that specific section of mining.

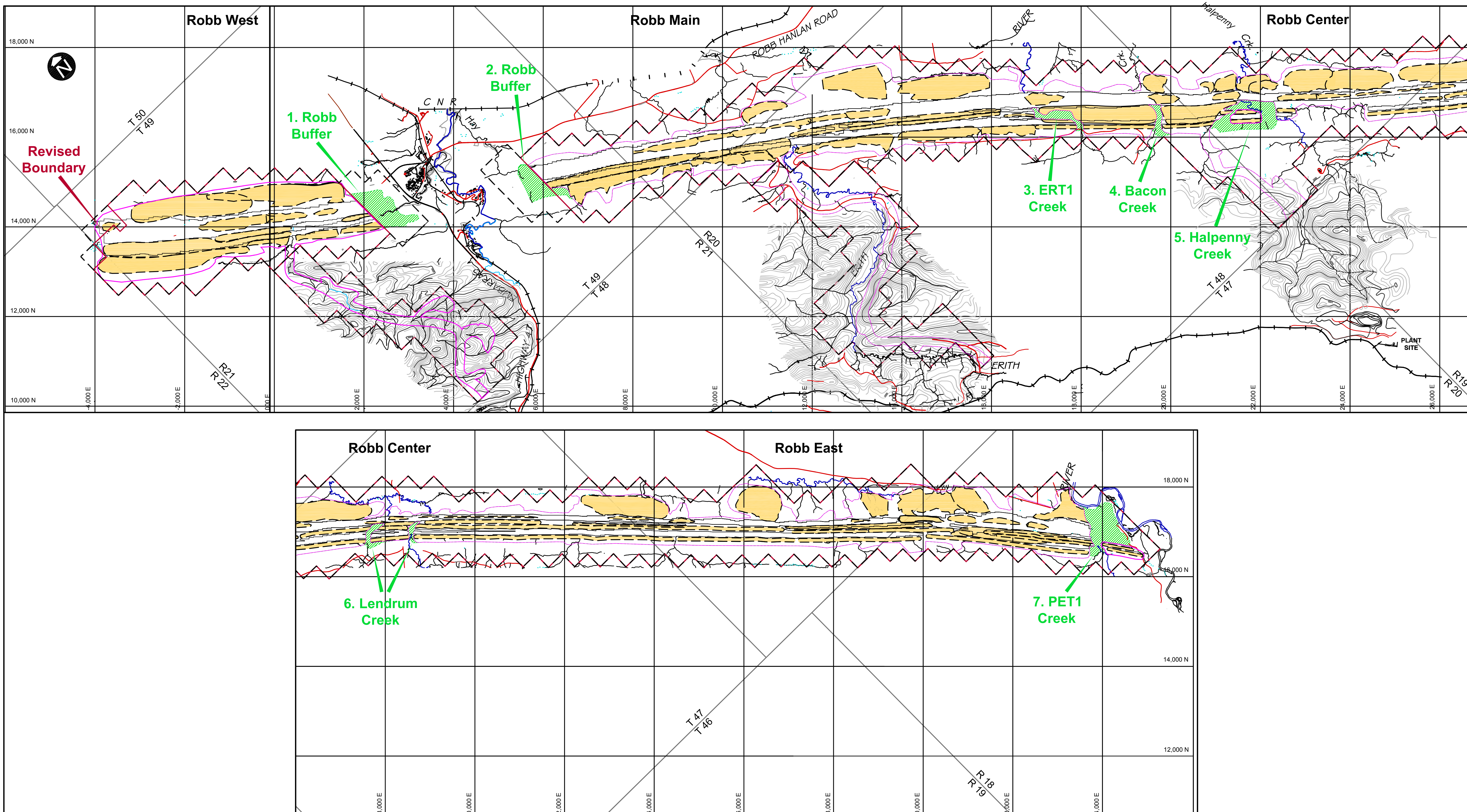
4.0 SUMMARY

CVRI believes the information above along with the supporting documents provides DFO with adequate information to make an approval decision.

- Impact on fish habitat and populations has been minimized. Suggestions and advice gained through technical review of the application have been incorporated into the final Project proposal as improvements in the conceptual plan.
- Further improvements are expected to be incorporated in the final design phases over the life of the Project. A 'staged' development over several years is expected which will involve staged approvals. This will allow 'lessons learned' through the operational phases to be fit into design plans. Monitoring of results through the life of the Project will also aid in adaptation of results.
- Habitat impact will be spread over the life of the Project and will not occur in a concentrated period. Likewise, habitat compensation will be provided throughout the same period with some compensation established before impact that will occur in later years. Therefore, the 'maximum' level of 'exposure' is limited.
- A significant portion (~80%) of the compensation will be focused on creation/enhancement of 'stream channel' habitat.
- Approximately 1,096,000 m^2 of lentic habitat will be created in lakes that are expected to have a high probability of success based on the EPL Development Guidelines (Lakes 6 to 11).

- The remaining lakes have some limitations (as currently designed) as they do meet certain design parameters of the EPL Guidelines. However, these lakes are still expected to be able to function as viable ecosystems. These lakes could provide an additional 4,446,000 m^2 of habitat.
- A large ‘lake’ habitat focused on littoral zones of EPL is available for compensation. Nearly 1,000,000m^2 of littoral area will be available in EPL combined.
- Conditions found in current EPL appear to provide good conditions for fish utilization. Ongoing monitoring of regional EPL will continue to provide data for guidance in EPL development. Alberta End-Pit Lake Guidelines will be followed in EPL designs.

Figures



Legend

Rock Dump
Area of Revision
Revised Mine Permit

0 1 2 3 4 km

SCALE 1 : 80 000

REF: CVRI, 2013.

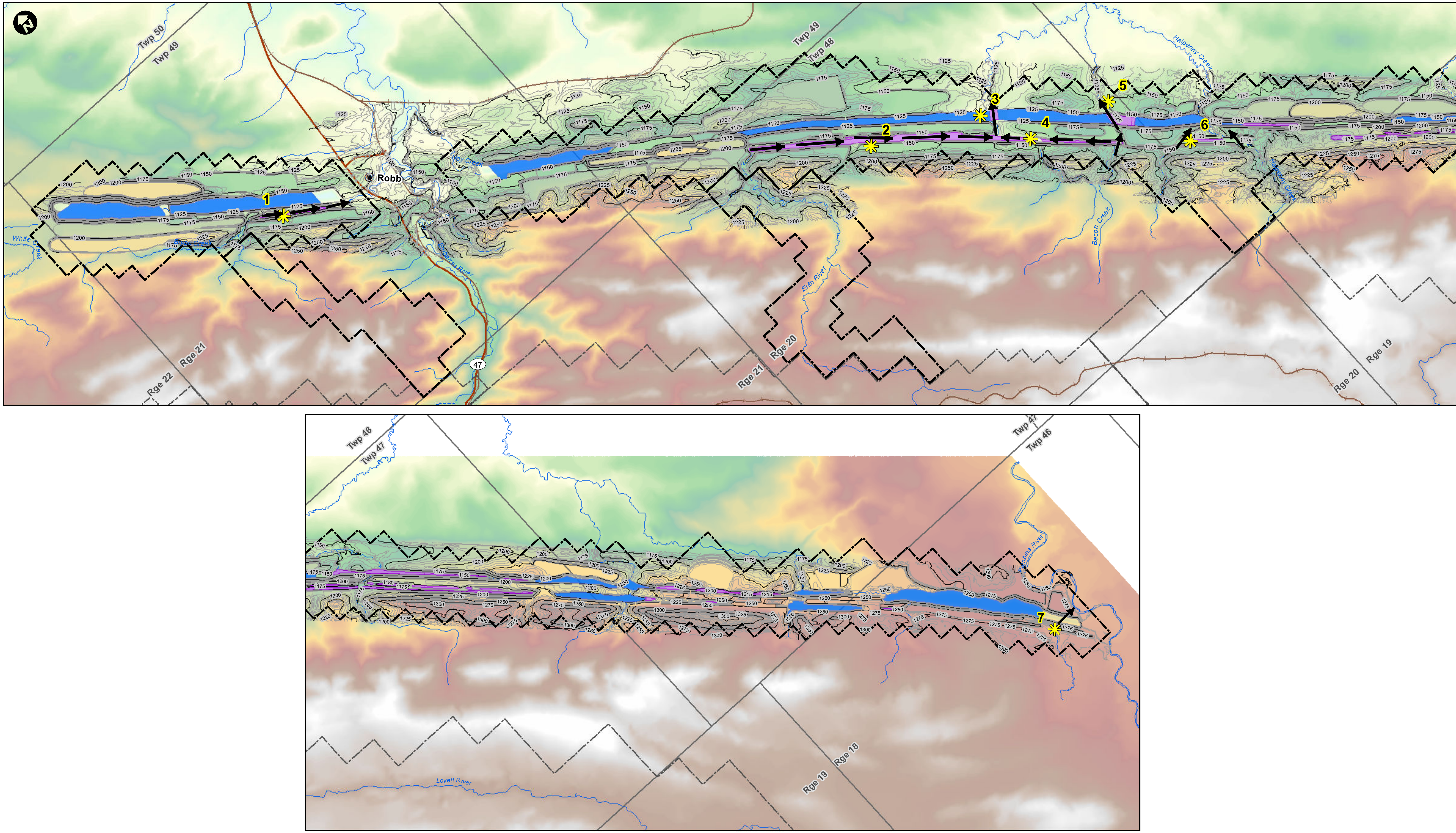
PROJECT: **Coal Valley Mine**
Robb Trend Project

TITLE: **Mine Plan Revisions**

MILLENNIUM
EMS Solutions Ltd.

...Final Docs\08-041b\2013\Fig 1 Mine Plan.dwg

DRAWN: JG	FIGURE:	
CHECKED: KP		1
DATE: Mar 14/14		
PROJECT: 08-041b		



Legend

- Water Management Area
- Constructed Streams
- Contour (Interval 10m)
- Index Contour
- Reclaimed Lake
- Reclaimed Wetland
- Existing Mine Permit Boundary
- Proposed Robb Trend Mine Permit Boundary
- Paved Road
- Railway
- Permanent Watercourse

Topography (masl)
High : 1500
Low : 1050

0 1 2 4
Kilometres

PROJECT:
Coal Valley Mine
Robb Trend Project

TITLE:
Conceptual Reclaimed Landscape - Revisions

cvri

DRAWN:	KD/JG
CHECKED:	KP
DATE:	Mar 13/14
PROJECT:	08-041

FIGURE: 2

REF: CVRI, Robb Trend Project Extents 2B.dwg, Feb 7, 2011.

Document Path: K:\Active Client\CVRI\Final Docs\08-041b\DFO\Fig 2 Conceptual Reclaimed Landscape.mxd

Appendix 1: Summary of Fish Habitat Impacts, Mitigation and Habitat Compensation Strategies, Pisces Environmental Consulting Services Inc., August 2013.

CVRI Robb Trend Project
Summary of Fish Habitat Impacts, Mitigation and Habitat Compensation Strategies

Prepared for: Coal Valley Resources Inc. Edson, AB
August 2013

PISCES ENVIRONMENTAL CONSULTING SERVICES LTD.

CVRI Robb Trend Project

Summary of Fish Habitat Impacts and Mitigation and Habitat Compensation Strategies

Prepared for:
Coal Valley Resources Inc.
Edson, Alberta

Submitted to:
Fisheries and Oceans Canada (DFO)

Prepared by:
Pisces Environmental Consulting Services Ltd.
Red Deer, Alberta

August 2013

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APPENDICES

1.0 INTRODUCTION

Coal Valley Resources Inc. (CVRI) is proposing an extension of the existing Coal Valley Mine (CVM) operation approximately 100 kilometres southwest of Edson, Alberta. Termed the Robb Trend Project (Project), the mine expansion includes development of areas to the northeast of existing operations. The Project mine permit area is approximately two kilometres wide and almost 50 kilometres long, extending in a northwest direction from the Pembina River past the Hamlet of Robb. A Project Application for the proposed expansion entitled *Robb Trend Coal Mine Expansion Project* was submitted to government regulators in April 2012 (CVRI 2012).

This document is intended to address key information requests that have been communicated by Fisheries and Oceans Canada (DFO) to CVRI. Specifically, this document provides:

- A description of updated mine plans and reclamation strategies that have been developed since the Project Application was submitted.
- A summary of direct habitat impacts resulting from the Project based on review of the updated mine plans.
- A discussion of other potential indirect impacts to fish habitat (if it was determined that the updated mine plans had changed the impact assessment scenario presented in the Project Application).
- A discussion of updated mitigation initiatives proposed by CVRI.
- A description of the proposed habitat compensation framework for the Project. It is expected that this conceptual plan will form the basis of agreement from which CVRI and DFO will work in consultation to satisfy the requirements of the federal *Fisheries Act*.
- A discussion of monitoring initiatives proposed by CVRI.

Much of the information provided in this document is summarized from, and makes reference to, sections of the Project Application as well as the responses to Supplemental Information Requests (SIRs) that were submitted as part of the review process. The analysis and conclusions presented in these documents remain applicable and should be referred to if additional details to the points raised in this document are required.

2.0 UPDATED MINE PLANS

To facilitate mine planning, the Project was divided into four areas referred to as Robb West, Robb Main, Robb Centre, and Robb East (Figure 1). The estimated Project lifespan is expected to be approximately 25 years with mine activities expected to progress as indicated below:

- Mining in the Robb West Area: 2032 to 2034
- Mining in the Robb Main Area: 2017 to 2031
- Mining in the Robb Centre Area: 2023 to 2026
- Mining in the Robb East Area: 2027 to 2039

After consultation with stakeholders, CVRI initiated a review of the original mine plan to identify solutions for concerns raised by regulators. Through this process CVRI has produced an updated mine plan that will result in reduced impacts to fish habitat and fewer on-stream/flow-through end pit lakes post reclamation.

The Project will consist of 13 main watercourse diversions; a description of each of the diversions is provided below. The anticipated schedule for development along with the predicted impacts to fish habitat are illustrated in Figure 2.

Erith River Diversion

Diversion of the Erith River involves several phases as illustrated on Figure 5.

Short sections of stream channel to route the Erith River out of the proposed McPherson Pit area will be constructed. These sections would be short, cutting off small meanders of the river and forcing the river toward the south. Once construction is completed the flow would be moved into the new channels. This diversion would last approximately three years while the McPherson Pit is mined and a new channel built in the floor of the McPherson Pit. The river would then be moved to the new McPherson Pit channel, which would be constructed to provide habitat for fish. This diversion would be in place for approximately five years while the Mynheer Pit was mined and reclaimed with a new channel in the base of the Mynheer Pit. Once the Mynheer Pit is complete, the Erith River would be moved into the new channel routed through the Mynheer Pit. This channel replaces Lake 4 (previously proposed in the Project Application). Mining of the Val d'Or Pit will also require movement of the Erith River channel to accommodate mining beneath the river. This will be accomplished by moving the river to the east into a constructed channel so that mining can be conducted on the west side of the river. Once mining is completed, a land bridge will be backfilled to the west and a new channel constructed on the land bridge as the final reclaimed river channel. All channels will be constructed to provide fish habitat. The 'switch' will take approximately four years to accomplish. Lake 5 (West and East) will outlet into the new channel.

ERT1 Diversion

Plans involving ERT1 have been revised to reduce direct impacts to fish habitat (Figure 5).

A short portion (~500 m) of the Mynheer Pit is being excluded from development in order to maintain spawning habitat in ERT1. Flows in ERT1 will be maintained to flow into the Erith River. A short diversion channel on the north side of the Mynheer Pit (highwall side) will be used to direct flows below sensitive habitat (spawning sites) that was identified during baseline investigations. This diversion will be in place approximately two years before it is discontinued as it is replaced by a new channel in the pit floor of Mynheer Pit. All channels will be constructed to provide fish habitat.

Bacon Creek Diversion

Plans involving Bacon Creek have been revised to reduce direct impacts to fish habitat (Figures 5 and 6).

A short section of the Mynheer Pit will be excluded from development in order to maintain certain sections of the existing Bacon Creek channel. However mining of the Val d'Or Pit will require that portions of Bacon Creek be moved to accommodate mining beneath the creek. This will be accomplished moving the creek to the east into a constructed channel so that mining can be conducted on the west side of the river. Once mining is completed a land bridge will be backfilled to the west and a new channel constructed on the land bridge as the final reclaimed river channel. All channels will be constructed to provide fish habitat. The 'switch' will take approximately four years to accomplish. The new channel will be located between Lake 5 and 6. Lakes will outlet into the creek.

Halpenny Creek Diversion

Plans involving Halpenny Creek have been revised to reduce direct impacts to fish impact. (Figure 6).

Two short sections of the Mynheer Pit will be excluded from development in order to ensure continued flow in the Halpenny Creek basin. Mining which directly impacted HLT1 will no longer be completed and HLT1 will continue to flow into Halpenny Creek (Main). Mining which interrupted HLT2 will no longer be completed and HLT2 will continue to flow into Halpenny Creek (Main). Mining which interrupted Halpenny Creek (Main) in the Mynheer Pit area will no longer be completed. Mining of the Val d'Or Pit will require movement of Halpenny Creek to accommodate mining beneath the creek. This will be accomplished by moving the creek to the east into a constructed channel so that mining can be conducted on the west side of the river. Once mining is completed a land bridge will be backfilled to the west and a new channel constructed on the land bridge as the final reclaimed creek channel. All channels will be constructed to provide fish habitat. The 'switch' will take approximately four years to accomplish. Lake 6 will not outlet into Halpenny Creek as it will flow westward into Bacon Creek.

Lendrum Creek Diversions

Plans involving Lendrum Creek have been revised to reduce direct impact to fish habitat (Figures 7 and 8).

Flow in LET1 will be ditched or pumped to LET3 during mining of the Mynheer Pit. This transfer is expected to be in place for approximately one year. Afterwards, the flow can be accommodated in the pit floor.

Flow in LET3 will be handled with a diversion ditch or pumping during mining of the Mynheer Pit. This transfer is expected to be in place for approximately one year. Afterward a constructed channel will be put in place as part of reclamation to handle LET1 and LET3. Flow in LET3 will be handled with a diversion ditch or channel during mining of the Val d'Or Pit. This transfer is expected to be in place for approximately two years. Further mining to the east can be isolated from LET3. Final flow of LET3 will be through Lake 7. This diversion is expected to be in place for approximately three years.

Upper Lendrum Creek will be handled by ditching during the mining of the Mynheer Pit. This transfer is expected to be in place for approximately three years until the Mynheer Pit is reclaimed. Flow would then be moved into a new channel established in the pit floor and connected to LET3. The ditching is expected to be in place for approximately three years.

Hay Creek Diversion

Mining in the Mynheer Pit will intercept drainage of the upper portion of this creek. Water caught by the mining area will be collected, treated and returned to Hay Creek. This transfer is expected to be in place for approximately four years. Lake 3 will outlet to Hay Creek (Figure 4).

Lund Creek Diversions

LDT1 will be intercepted by mining in both Mynheer and Val d'Or Pits. Land bridges provided in both pits will provide uninterrupted flow during mining. Lakes 8 and 9 will be developed as part of the reclaimed profile (Figures 8 and 9). LDT1 will flow through both Lakes 8 and 9 with a short channel between the two lakes. These relocations are expected to last approximately four years and may be completed concurrently.

LDT3 will be intercepted by mining in both Mynheer and Val d'Or Pits. Flows in both pits will be handled by pumping. Alternatives for ditching flows either to the east or west could also be considered. Lakes 10 and 11 will be developed as part of the reclaimed profile. LDT3 will flow through both Lake 10 and 11 with a short channel between the two lakes. Lake 12 will outlet into Lake 10. This interruption is expected to extend over approximately two years.

Bryan Creek Diversion

Plans involving Bryan Creek have been revised to provide restored channel on the final reclamation landscape rather than a flow-through end pit lake (Figure 3).

Short sections of stream channel to route Bryan Creek out of the proposed Mynheer Pit area will be constructed. These sections would be short, cutting off small meanders of the creek and forcing the creek toward the north. Channels would be constructed to provide fish habitat. Once construction is completed the flow will be directed into the new channels. This diversion would last approximately three years while the Mynheer Pit was completed and reclaimed with a stream channel in the base of the pit. Flow will be routed through the Mynheer Pit channel. This will be the final, reclaimed channel for the creek and would be constructed to provide fish habitat. Lake 2 will outlet into Bryan Creek below the new channel.

PET1 Diversion

Plans involving PET1 have been revised to provide restored channel on the final reclamation landscape rather than a flow-through end pit lake (Figure 9).

The easternmost end of the Val d'Or Pit nearest the Pembina River is being excluded from development. This provides an increased buffer between development and the Pembina floodplain. This revision allows for diversion of PET1 around the eastern end of the proposed Val d'Or Pit. This diversion can be accomplished prior to mining. The channel will be constructed to provide fish habitat.

3.0 SUMMARY OF EXISTING CONDITIONS

Baseline fish and fish habitat conditions within the Project area were described in detail in the Project Application (CVRI 2012). A brief summary of the information gathered during the baseline investigations is provided below.

3.1 FISH POPULATIONS

During baseline field investigations fish presence was confirmed at 53 of the 84 sites sampled (electrofishing and angling sites) in 42 waterbodies in and adjacent to the Project. Overall, 15 fish species were captured and identified (Table 1).

Rainbow Trout were the most common and widespread species within the Local Study Area (LSA) and Regional Study Area (RSA), captured in 38 of the 42 waterbodies sampled. Bull Trout, Burbot, Lake Chub, Longnose Sucker, and Spoonhead Sculpin were encountered much less frequently than Rainbow Trout but were still found at a number of different locations. Other species, including Arctic Grayling, Brook Stickleback, Brook Trout, Longnose Dace, Mountain Whitefish, Northern Pike, Pearl Dace, Trout-perch, and White Sucker were rare and found in one or two waterbodies. Rainbow Trout densities and catch-per-unit-effort (CPUE) for all sport fish captured in streams sampled during baseline investigations are presented in Figures 10 and 11 respectively.

3.2 FISH HABITAT

Habitat inventories were conducted on all streams within the LSA that exhibited habitat potential (i.e. exhibited a defined channel, did not have an excessive gradient (>12%)). Information obtained from the habitat inventories and fish sampling (local field data) was used to provide a conservative ranking of study streams in terms of their overall habitat potential/ability to support various life cycle phases of fish. The rating system was designed to provide a general understanding of habitat potential of subject watercourses based on local field data but should not be considered as a habitat suitability (HSI) ranking system. Photos depicting typical habitat conditions within Low, Moderate, and High habitat potential ranked watercourses are provided in Figure 12.

Preliminary scoping identified a total of 42 potential study streams in or immediately adjacent to the Project. A list of watercourses and general habitat characteristics is provided in Table 2.

A summary of habitat potential/utilization information and a habitat potential/utility ranking for watercourses that exhibited fish habitat potential are provided in Table 3 and Figure 13.

Table 1. Fish species distribution in watercourses in and adjacent to the Robb Trend Project.

Mine Area	Water Body	Reach	Arctic Grayling	Brook Stickleback	Brook Trout	Bull Trout	Burbot	Lake Chub	Longnose Dace	Longnose Sucker	Mountain Whitefish	Northern Pike	Pearl Dace	Rainbow Trout	Spoonhead Sculpin	Trout-perch	White Sucker
Robb West	Bryan Creek (BR-1 to BR-3)													✔✖			
	BRT2													✔✖			
	Embarras River (EM-1 & EM-2)		✔✖		✔✖	✖	✖	✔		✔	✔✖			✔✖	✔✖	✔✖	
	EMT1											✔					
	Jackson Creek				✔									✖			
Robb Main	Hay Creek (HA-1 to HA-4)	1 2 3					✔							✔✖ ✔ ✔			
	Erith River (ER-3, ER-4, & ER-5)	1 2 3	✖ ✖			✔✖	 ✖	✔ ✔	✔	✔ ✔✖	 ✔✖			✔ ✔✖ ✔	✔ ✔✖	✔	✔ ✖
	Erith River (ER-7)					✔								✔			
	ERT1					✔								✔✖	✔		
	ERT2													✔✖	✔		
	ERT3													✔			
	ERT4													✔			
	ERT5									✔✖				✔✖			
	ERT6					✖								✔✖			
	ERT7													✔✖			
	ERT10					✖								✔✖			
	ERT12													✔✖			
	Bacon Creek (BA-2)					✖								✔✖			
Robb Centre	Halpenny Creek (HL-2 & HL-3)	1 2				✖				✖	✖		✔	✔✖ ✔	✖		
	Halpenny Creek (HL-5)													✔			
	Halpenny Creek (HL-6)													✔			
	HLT1													✔✖			
	HLT2			✔													
	HLT5													✔			
	Lendrum Creek (LE-2 & LE-3)						✔							✔			
	LET1						✔							✔✖			
	LET1B													✔			
	LET3													✔			
Robb East	Lund Creek (LD-5 & LD-7)													✔			
	LDT1					✖								✔✖			
	LDT3													✔			
	PET1				✔		✔										

✔Pisces baseline investigations (2005-2013)
✖Historical Reference (FWMIS)

Table 2. Summary of watercourses identified in the Project area.

Mine Area	Watercourse	Code	Scoping Results	Stream Class[1]
Robb West	Bryan Creek	BR	• Defined channel (3.6 m wide), perennial flow	P
	Bryan tributary #1	BRT1	• Poorly defined channel, limited discharge	E
	Bryan tributary #2	BRT2	• Defined channel (1.2 m wide), perennial flow likely	P
	Embarras tributary #1	EMT1	• Poorly defined channel that transitions to quantifiable habitat downstream near mine permit boundaries, limited discharge	I
	Jackson Creek	JA	• Defined channel (0.8 m wide), perennial flow	P
Robb Main	Bacon Creek	BA	• Defined channel (2.0 m wide), perennial flow	P
	Erith River	ER	• Defined channel (6.2 m wide), perennial flow	P
	Erith tributary #1	ERT1	• Defined channel (2.6 m wide), perennial flow likely	P
	Erith tributary #2	ERT2	• Defined channel (1.4 m wide), limited discharge, Class 3 (<0.5 m deep) habitat only	I
	Erith tributary #3	ERT3	• Defined channel (1.0 m wide), limited flows	I
	Erith tributary #4	ERT4	• Defined channel (0.7 m wide), high gradient, natural impediments to fish movement	I
	Erith tributary #5	ERT5	• Defined channel (1.4 m wide), perennial flow likely	P
	Erith tributary #6	ERT6	• Defined channel (1.8 m wide), perennial flow likely	P
	Erith tributary #7	ERT7	• Defined channel (1.7 m wide), perennial flow likely	P
	Erith tributary #8	ERT8	• Defined channel (1.3 m wide), perennial flow likely	P
	Erith tributary #10	ERT10	• Defined channel (2.2 m wide), perennial flow likely	P
	Erith tributary #12	ERT12	• Defined channel (1.3 m wide), perennial flow likely	P
	Hay Creek	HA	• Defined channel (2.5 m wide), perennial flow	P
	Hay tributary #1	HAT1	• Poorly defined channel, limited discharge, Class 3 habitat only, natural impediments to fish movement	I
	Mitchell tributary #1	MIT1	• Small channel to poorly defined channel, limited discharge, high gradient, natural impediments to fish movement	E
	Mitchell tributary #2	MIT2	• Small channel to poorly defined channel, limited discharge, high gradient, natural impediments to fish movement	E
Robb Centre	Halpenny Creek	HL	• Defined channel (4.0 m wide), perennial flow	P
	Halpenny tributary #1	HLT1	• Defined channel (1.8 m wide), perennial flow likely	P
	Halpenny tributary #2	HLT2	• Defined channel (0.9 m wide), limited discharge, natural barrier to fish movement	I
	Halpenny tributary #3	HLT3	• No defined channel	E
	Halpenny tributary #4	HLT4	• Defined channel (1.1 m wide), limited discharge, Class 3 habitat only, natural impediments to fish movement	I
	Halpenny tributary #5	HLT5	• Defined channel (0.8 m wide), limited discharge, Class 3 habitat only	I
	Halpenny tributary #8	HLT8	• Poorly defined to undefined channel	E
	Halpenny tributary #9	HLT9	• Defined channel (1.3 m wide), perennial flow likely	P
	Lendrum Creek	LE	• Defined channel (3.3 m wide), perennial flow	P
	Lendrum tributary #1	LET1	• Defined channel (2.0 m wide), perennial flow likely	P
	Lendrum tributary #2	LET2	• Poorly defined, limited discharge	E
	Lendrum tributary #3	LET3	• Defined channel (3.2 m wide), perennial flow likely	P
Robb East	Lund Creek	LD	• Defined channel (2.5 m wide), perennial flow	P
	Lund tributary #1	LDT1	• Defined channel (2.4 m wide), perennial flow likely	P
	Lund tributary #2	LDT2	• Defined channel (1.0 m wide), limited discharge, Class 3 habitat only	I
	Lund tributary #3	LDT3	• Defined channel (2.1 m wide), perennial flow likely	P
	Lund tributary #4	LDT4	• Defined channel (0.8 m wide), limited discharge, Class 3 habitat only	I
	Lund tributary #5	LDT5	• Defined channel (0.9 m wide), limited discharge, Class 3 habitat only	I
	Lund tributary #6	LDT6	• Poorly defined to undefined channel	E
	Lund tributary#7	LDT7	• Defined channel (1.3 m wide), limited discharge, Class 3 habitat only	I
	Pembina tributary #1	PET1	• Defined channel (2.5 m wide), perennial flow likely	P

[1] Stream Classification:
E = Ephemeral, not fish habitat, no defined channel or discontinuous channel over length of survey reach
I = Intermittent, marginal fish habitat, defined channel over length of survey reach, flow present only seasonally
P = Permanent, fish habitat, flowing most or all of the year

Table 3. Habitat potential/utilization, limiting factors, and overall ranking for watercourses in the Project area.

Waterbody	Habitat Potential/Utilization					Limiting Factors	Overall Rank
	Spawning		Rearing	Overwintering	Feeding		
Robb West							
Bryan Creek Reach 1	High	RNTR	High	Moderate	High	- limited cover, presence of beaver dams, absence of Class 1 (>1m deep) habitat	High
Bryan Creek Reach 2	None		Low	Moderate	Moderate	- limited cover, presence of beaver dams, lack of gravel/cobble, low pool frequency	Low
Bryan Creek Reach 3	High	RNTR	High	Low	Moderate	- limited cover, beaver dams, limited Class 1 habitat, low pool frequency	High
Bryan Creek Reach 4	None		Low	Moderate	Moderate	- beaver dams, lack of gravel/cobble, absence of pool habitat	Low
BRT2	Low	RNTR	Low	None	Low	- limited flows, absence of Class 1 habitat, absence of pool habitat	Low
Embarras River	Moderate	ARGR BKTR MNWH RNTR	Moderate	High	High	- low pool frequency, limited cover	High
EMT1	Low	NRPK	Low	None	Moderate	- absence of Class 1 habitat, low pool frequency, lack of gravel/cobble, low winter dissolved oxygen	Low
Jackson Creek	None		Low	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency	Low
Robb Main							
Hay Creek Reach 1	None		Moderate	None	Low	- absence of Class1 habitat, absence of pool habitat, no winter flow	Low
Hay Creek Reach 2	None		Low	None	Low	- limited Class 1 habitat, low pool frequency, beaver dams, no winter flow	Low
Hay Creek Reach 3	None		None	None	Low	- beaver dams, absence of pool habitat, lack of gravel/cobble, no winter flow	Low
Erith River Reach 1	Moderate	MNWH RNTR	High	Moderate	High	- limited cover, beaver dams, low pool frequency	High
Erith River Reach 2	Low	MNWH RNTR	Moderate	Moderate	High	- limited cover, beaver dams, low pool frequency, limited Class 1 habitat	High
Erith River Reach 3	Moderate	RNTR	High	Moderate	High	- limited cover, beaver dams, absence of pool habitat, limited Class 1 habitat	High
Erith River (ER-7)	Low	RNTR	Moderate	Low	Moderate	- limited Class 1 habitat, low pool frequency	Moderate
ERT1	High	RNTR	High	None	High	- absence of Class 1 habitat, limited flows	High
ERT2	Low	RNTR	Low	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency, lack of gravel	Low
ERT3	None		None	Low	Low	- beaver dams, low winter dissolved O_2, lack of gravel/cobble, limited flows	Low
ERT4	Low	RNTR	Low	None	Low	- absence of Class 1 habitat, steep gradient	Low
ERT5	Low	RNTR	Moderate	None	Moderate	- absence of Class 1 habitat	Low
ERT6	Moderate	BLTR RNTR	Moderate	None	Moderate	- absence of Class 1 habitat	Moderate
ERT7	Moderate	RNTR	Low	None	Low	- limited flows, absence of Class 1 habitat	Low
ERT8	None		Low	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency	Low
ERT10	None		Moderate	None	Moderate	- absence of Class 1 habitat, lack of gravel	Low
ERT12	Low	RNTR	Low	None	Moderate	- limited flows, absence of Class 1 habitat, absence of pool habitat	Low
Bacon Creek	High	RNTR	High	Low	Moderate	- absence of Class 1 habitat, limited pool frequency, limited cover	High
Robb Centre							
Halpenny Creek Reach 1	Moderate	RNTR	Moderate	Moderate	Moderate	- absence of Class 1 habitat, low pool frequency	High
Halpenny Creek Reach 2	None		Low	High	Low	- absence of gravel/cobble, lack of cover, beaver dams	Low
Halpenny Creek Reach 3	High	RNTR	High	Low	High	-absence of Class 1 habitat, low pool frequency, low winter flows	High
HLT1	High	RNTR	Moderate	None	Moderate	- fish passage issues, low pool frequency, absence of Class 1 habitat	Moderate
HLT2	None		Low	Moderate	Low	- limited flows, low pool frequency, lack of gravel/cobble	Low
HLT4	None		Low	None	Low	- limited flows, absence of Class 1 habitat, absence of pool habitat, lack of gravel/cobble	Low
HLT5	None		Low	None	Low	- limited flows, absence of Class 1 habitat, absence of pool habitat, lack of gravel	Low
HLT9	Low	RNTR	Low	None	Low	- limited flows, absence of Class 1 habitat, lack of cover	Low
Lendrum Creek Reach 1	Moderate	RNTR	High	High	Moderate	- low pool frequency, lack of gravel/cobble, limited cover, beaver dams, low winter dissolved O_2	High
Lendrum Creek Reach 2	Low	RNTR	Moderate	Low	Moderate	- absence of Class 1 habitat, low pool frequency, lack of gravel/cobble, limited cover, beaver dams	Moderate
LET1	Moderate	RNTR BURB	Moderate	Low	Moderate	- limited flows, absence of Class 1 habitat, low pool frequency, limited cover, beaver dams	Moderate
LET3	High	RNTR	High	Moderate	Moderate	- low pool frequency, limited cover, lack of gravel/cobble	High
Robb East							
Lund Creek	High	RNTR	Moderate	None	Moderate	- absence of Class 1 habitat, low pool frequency	Moderate
LDT1	Low	RNTR	Low	Low	Moderate	- limited flows, absence of Class 1 habitat, limited cover	Low
LDT1A	None		Low	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency	Low
LDT1C	None		Low	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency	Low
LDT1D	None		None	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency, steep gradient, fish passage issues	Low
LDT2	None		None	None	Low	- limited flows, absence of Class 1 habitat, low pool frequency, lack of gravel	Low
LDT3	Low	RNTR	Low	None	Moderate	- limited flows, absence of Class 1 habitat	Low
LDT3A	None		None	None	Low	- limited flows, absence of Class 1 habitat, lack of gravel, steep gradient, limited cover	Low
LDT4	None		None	None	Low	- limited flows, absence of Class 1 habitat, lack of gravel, limited cover	Low
LDT5	None		None	None	Low	- limited flows, absence of Class 1 habitat, lack of gravel	Low
LDT7	None		None	None	Low	- limited flows, absence of Class 1 habitat, lack of gravel	Low
PET1	High	BKTR	Moderate	Moderate	Moderate	- limited cover, lack of gravel/cobble	High
PET1A	None		None	None	Low	- limited flows, discontinuous channel	Low
PET1B	None		None	None	Low	- limited flows, discontinuous channel	Low

4.0 IMPACTS TO FISH HABITAT

The potential impacts to fisheries resources as a result of the Project are addressed in the Project Application (CVRI 2012). For the assessment presented in this document, the most recent information regarding mine planning, surface water management, and reclamation was reviewed to determine if there are resultant changes to the impact assessment scenario in terms of direct and indirect impacts to fish habitat.

4.1 DIRECT HABITAT IMPACTS

Components of the Project with the potential to result in direct habitat loss/alteration are summarized in Table 4.

Table 4. Summary of project components potentially resulting in direct habitat loss/alteration in waterbodies within the Robb Trend Project area.

<table>
<tr><th>Mine Area</th><th>Project Phase</th><th>Waterbody</th><th>Project Component Potentially Impacting Habitat</th></tr>
<tr><td rowspan="7">Robb West</td><td rowspan="3">Construction</td><td>Bryan Creek</td><td>• Watercourse crossing construction</td></tr>
<tr><td>BRT2</td><td>• Watercourse crossing construction</td></tr>
<tr><td>Jackson Creek</td><td>• Watercourse crossing construction</td></tr>
<tr><td>Operation</td><td>Bryan Creek</td><td>• Temporary diversion to maintain downstream flows during mining
• Development of mine pit</td></tr>
<tr><td rowspan="3">Reclamation</td><td>Bryan Creek</td><td>• Reclamation of watercourse crossing
• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction</td></tr>
<tr><td>BRT2</td><td>• Reclamation of watercourse crossings</td></tr>
<tr><td>Jackson Creek</td><td>• Reclamation of watercourse crossing</td></tr>
<tr><td rowspan="11">Robb Main</td><td rowspan="2">Construction</td><td>Erith River</td><td>• Watercourse crossing construction</td></tr>
<tr><td>ERT4,5,6,8,10</td><td>• Watercourse crossing construction</td></tr>
<tr><td rowspan="4">Operation</td><td>Erith River</td><td>• Temporary diversion to maintain downstream flows during mining
• Development of mine pits</td></tr>
<tr><td>ERT1,2,3</td><td>• Temporary diversion to maintain downstream flows during mining
• Development of mine pit</td></tr>
<tr><td>Bacon Creek</td><td>• Temporary diversion to maintain downstream flows during mining
• Development of mine pit</td></tr>
<tr><td>Hay Creek</td><td>• Temporary diversion to maintain downstream flows during mining
• Development of mine pit</td></tr>
<tr><td rowspan="5">Reclamation</td><td>Erith River</td><td>• Reclamation of watercourse crossing
• Permanent diversion
• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction</td></tr>
<tr><td>ERT4,5,6,8,10</td><td>• Reclamation of watercourse crossings</td></tr>
<tr><td>ERT1,2,3</td><td>• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction</td></tr>
<tr><td>Bacon Creek</td><td>• Reclamation of aquatic ecosystem to include stream reconstruction</td></tr>
<tr><td>Hay Creek</td><td>• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction</td></tr>
<tr><td colspan="4">Note: Table 4 continues on next page.</td></tr>
</table>

Table 4 continued.

Robb Centre	Construction	HLT1,9	• Watercourse crossing construction
	Operation	Halpenny Creek	• Temporary diversion to maintain downstream flows during mining • Development of mine pit
		Lendrum Creek	• Temporary diversion to maintain downstream flows during mining • Development of mine pit
		LET1,3	• Temporary diversion to maintain downstream flows during mining • Development of mine pit
	Reclamation	Halpenny Creek	• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction
		HLT1,9	• Reclamation of watercourse crossings • Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction
		Lendrum Creek	• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction
		LET1,3	• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction
Robb East	Construction	None	• No haulroad watercourse crossing construction in this area
	Operation	Lund Creek	• Temporary diversion to maintain downstream flows during mining • Development of mine pit
		LDT1,3	• Temporary diversion to maintain downstream flows during mining • Development of mine pit
		PET1	• Diversion to maintain downstream flows during mining • Development of mine pit
	Reclamation	Lund Creek	• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction
		LDT1,3	• Reclamation of aquatic ecosystem to include end pit lake and stream reconstruction
		PET1	• Reclamation of aquatic ecosystem to include stream reconstruction

4.1.1 HAULROAD CROSSINGS

In total there will be 12 haulroad crossings located on watercourses that provide fish habitat (Table 5). All of the watercourse crossings will be designed to provide for fish passage and to maintain habitat connectivity. Clear span arch structures or large culverts that are sized to accommodate fish passage will be constructed on watercourses that are fish bearing. Numerous additional culverts (minimum 0.6 m diameter) will be required in ephemeral draws to maintain natural drainage patterns (Matrix 2012).

Table 5. Description of habitat and analysis of direct habitat impacts for the haulroad crossings.

Watercourse	Culvert Diameter (m)[1]	Fish Habitat Present (overall rank)	Habitat Impact[2]
Bryan Creek	3.0	• Low habitat potential/utilization in this section of Bryan Creek	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
BRT2	2.4	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
Jackson Creek	2.0	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
Erith River	3.6	• High habitat potential/utilization	• Low since structure will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
ERT4	2.2	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
ERT5	3.0	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
ERT6	1.4	• Moderate habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
ERT8	2.2	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
ERT10	2.6	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
HLT1	3.0	• Moderate habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
HLT9	2.2	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width
HLT9A	2.2	• Low habitat potential/utilization	• Low since culvert will be designed to accommodate fish passage and will likely be sized to exceed bankfull width

[1] Subject to change based on final design
[2] A detailed assessment of the direct impacts to habitat will be completed once final design plans have been determined

4.1.2 WATERCOURSE DIVERSIONS AND PIT DEVELOPMENT

As previously described there will be a total of 13 main watercourse diversions required for the Project. A comparison of habitat impacts resulting from watercourse diversions for the original Project Application and the proposed updated mine plan is provided in Table 6.

Table 6. Planned diversions and the associated potential habitat impacts in the Robb Trend Project area.

Mine Area	Watercourse	Diversion #/ Pit Development	Fish Habitat Impacted				
			Application		Revision		
			Length (m)	Area (m²)	Length (m)	Area (m²)	Habitat Present (overall rank)
Robb West	Bryan Creek	13 Pit Dev.	4,244 TBD	14,208 TBD	4,244 1,382	14,208 1,480	• High habitat potential/utilization in Reach's 1 and 3 and low habitat potential/utilization in Reach 2 • Low habitat potential/utilization in upper Bryan Creek
Robb Main	Erith River	1	10,500	67,485	10,500	67,485	• High habitat potential/utilization • Most of Reach 1, all of Reach 2 and the lower part of Reach 3 will be impacted
	ERT1 ERT1A	2 Pit Dev.	2,315 157	5,834 102	400 0	1,000 0	• High habitat potential/utilization in ERT1 • Low habitat potential/utilization in ERT1A, no disturbances planned
	ERT2	Pit Dev.	264	406	264	406	• Low habitat potential/utilization
	ERT3	Pit Dev.	507	7,751	507	7,751	• Low habitat potential/utilization, habitat considered sub-marginal further upstream
	Bacon Creek	3	1,424	2,777 TBD	1,424	2,777	• High habitat potential/utilization • Originally was being diverted into Lake 4/5 but now flows will be maintained
	Hay Creek	10	1,368	1,804 TBD	1,368	2,325	• Low habitat potential/utilization
Robb Centre	Halpenny Creek	5	1,563	7,601	295	4,129	• Low habitat potential/utilization in Reach 2 • Mynheer Pit diversion no longer occurring
	HLT1	4	1,237	2,239	0	0	• Moderate habitat potential/utilization • No diversion planned
	HLT2	6	246	219	0	0	• Low habitat potential/utilization • No diversion planned
	Lendrum Creek	9/Pit Dev.	4,335	17,468	4,335	17,468	• Moderate habitat potential/utilization in Reach 2
	LET1	7	1,534	1,923	1,534	3,282	• Moderate habitat potential/utilization
	LET3	8	1,167	22,161	1,167	7,959	• High habitat potential/utilization
Robb East	Lund Creek	14 Pit Dev.	2,762	11,026	2,762	7,319	• Moderate habitat potential/utilization
	LDT1 LDT1A	11 Pit Dev.	909 785	2,991 1,091	909 785	2,991 1,091	• Low habitat potential/utilization
	LDT2	Pit Dev.	TBD	TBD	200	209	• Low habitat potential/utilization
	LDT3	12	1,194	2,507	1,194	3,831	• Low habitat potential/utilization
	LDT4	Pit Dev.	TBD	TBD	686	542	• Low habitat potential/utilization
	LDT5	Pit Dev.	198	154	198	154	• Low habitat potential/utilization, habitat considered sub-marginal further upstream
	PET1	15	1,587	5,236	200	660	• High habitat potential/utilization in PET1
Total			38,296	174,983	34,354	147,067	

4.2 Changes in Flow Regime

The Project Application included a description of Project components that have potential to affect surface flows and provided discussion of the potential for these surface flow impacts to affect fish habitat availability. Table 7 provides an updated description of the anticipated changes in flow regime and the corresponding impacts to fish habitat.

Table 7. Summary of surface flow impacts and corresponding effects on fish habitat in major watercourses.

Mine Area	Watercourse	Potential Change to Flow Regime		Potential Impacts to Fish Habitat
		Application	Revision [1]	
Robb West	Bryan Creek	• Moderation of peak flows • Increase in low flows • Mean annual runoff may temporarily increase by as much as 20% during pit, groundwater dewatering	• Revised mine plan will allow for natural flow regime through the Project area	• Negligible, no significant impact to fish habitat expected • Impacted habitat has high and low potential/utilization ranking
Robb Main	Bacon Creek	• Approximately 70% of lower basin lost due to diversion • 2.4 km long channel remaining with ~30% of flow	• Revised mine plan will allow for natural flow regime through the Project area	• Negligible, no significant impact to fish habitat expected • Impacted habitat has high potential/utilization ranking
	Embarras River	• Small footprint upstream of Robb, impacts during mining expected to be negligible • Maximum estimated impacts downstream of Robb equate to: 3% decrease in high flows, 10% increase in low flows, and negligible change in mean annual flows	• No change to original impact scenario expected	• Negligible, no significant impact to fish habitat expected • Impacted habitat has high potential/utilization ranking
	Erith River	• Flow regulation due to settling ponds • 10% reduction in peak flows • Maintenance or slight increase in low flows • Overall modest change in annual runoff	• Revised mine plan will allow for natural flow regime through the Project area	• Negligible, no significant impact to fish habitat expected • Impacted habitat has high potential/utilization ranking
	Hay Creek	• Up to 50% reduction in peak flows • Up to 200% increase in low flows • Mean annual runoff may temporarily increase by as much as 25% during pit, groundwater dewatering	• Temporary reduction in flows during end pit lake filling • No change to original impact scenario expected once the end pit lake has been filled	• Reduced habitat availability for 2.25 kms downstream of pit during end pit lake filling (4,038 m^2) • Impacted habitat has low potential/utilization ranking
Robb Centre	Halpenny Creek	• Approximately 20% of flows altered depending on various diversions. • Impacts expected to be short term (temporary diversions) • Flow regulation due to settling ponds • Increased total annual runoff due to road runoff	• Revised mine plan will allow for natural flow regime through the Project area	• Negligible, no significant impact to fish habitat expected • Impacted habitat has high potential/utilization ranking
	Lendrum Creek	• Moderation of peak flows • Increase in low flows • Mean annual runoff may temporarily increase by as much as 20% during pit, groundwater dewatering	• No change to original impact scenario expected	• Negligible, no significant impact to fish habitat expected • Impacted habitat has moderate potential/utilization ranking
Robb East	Lund Creek	• Moderation of peak flows • Increase in low flows • Mean annual runoff may temporarily increase by as much as 25% during pit, groundwater dewatering • Reduced flows and habitat availability downstream of pit (potential loss of upper portion of creek if flows are diverted through lakes permanently)	• No change to original impact scenario expected	• Reduced habitat availability for 2.66 kms (8,714 m^2) due to flows being diverted through lakes • Impacted habitat has moderate potential/utilization ranking
	PET1	• Small portion of watershed may be re-directed into Lund Creek	• Revised mine plan will allow for natural flow regime through the Project area	• Negligible, no significant impact to fish habitat expected • Impacted habitat has high potential/utilization ranking
	Pembina River	• Minor influence, <2% decrease in flows in Pembina River due to permanent diversion of PET1	• With revised mine plan there is no expectation for measurable changes in flows in the Pembina River	• Negligible, no significant impact to fish habitat expected

[1] Conclusions subject to review by Matrix as mine plans progress

4.3 SUMMARY OF HABITAT IMPACTS

With the updated mine plan, the Project is expected to impact almost 160,000 square metres of fish habitat (Table 8). This represents a decrease from the overall instream footprint presented in the Project Application, largely due to substantial reductions (31 %) in impacts to habitat with high potential/utilization (Table 8).

Table 8. Summary of fish habitat impacts in the Robb Trend Project area.

	Application (2012)	**Revision (2013)**
Impacts to habitat with low potential/utilization (m^2)	33,643	33,655
Impacts to habitat with moderate potential/utilization (m^2)	42,656	36,783
Impacts to habitat with high potential/utilization (m^2)	128,684	89,381
Total Habitat Impacts (m^2)	**204,983**	**159,819**

5.0 MITIGATION FOR HABITAT IMPACTS

Mitigation measures that will be implemented during the life of the Project were described in the Project Application (2012) and remain applicable. Some additional discussion regarding mitigation of potential impacts to fish habitat is provided below.

5.1 MINE PLANNING

As planning progresses, CVRI will continue to review options and scenarios to further minimize impacts to fisheries resources.

5.2 SURFACE WATER MANAGEMENT & EROSION CONTROL

Water management is a priority consideration throughout mine planning and development. Minimizing surface disturbance and completing timely reclamation are essential considerations that can affect water management. CVRI will implement a surface water management plan throughout the life of the Project to eliminate or minimize the potential adverse effects on the aquatic ecosystem associated with changes in water quality. The plan will include and/or incorporate the following:

- Mine planning to minimize the need for drainage diversions and runoff interception and to maximize vegetation buffers near waterbodies;
- Education/training of personnel to minimize disturbances while maintaining drainage and sediment controls;
- Design and construction details for settling ponds or retention and clean-out areas that will collect surface runoff and allow for settling treatment prior to release into receiving waterbodies;
- Design and construction details for watercourse diversions to ensure minimize changes of sediment loading to receiving waterbodies;

- General measures that will be implemented to contain road runoff including berms and haulroad sump/retention areas such that run-off will be intercepted and treated prior to release into the aquatic ecosystem; and
- Monitoring and maintenance of surface water management facilities.

It is assumed that the surface water management plan will provide effective mitigation of impacts to aquatic resources related to potential sediment introduction due to Project activities. TSS concentrations in the waterbodies in the LSA are not predicted to increase to be above baseline or guideline levels (Hatfield 2012). In addition, Matrix (2012) predicts that the Project will have insignificant effect on sediment loads compared to natural conditions. As such, potential increases in TSS are not expected to adversely affect aquatic resources.

Potential adverse effects associated with activities that are outside of normal operations are addressed by CVM's emergency response plan. The emergency response plan includes methods for spill containment in streams and site clean-up. Such incidents are considered highly unlikely to occur and designated emergency response personnel are on-site 24-hours/day in connection with current CVM activities. Emergency response procedures will be expanded to the Project. In order to mitigate the long term potential for sedimentation due to surface runoff it is assumed that exposed ground and riparian areas will be revegetated during reclamation.

5.3 WATERCOURSE CROSSING CONSTRUCTION

All defined watercourse crossings will be designed, and constructed to meet the regulatory requirements for approval under the provincial *Water Act* and federal *Fisheries Act*. It is the goal of CVM to adhere to the "No Net Loss Guiding Principle" (NNL principle) and minimize the instream footprint of all haulroad crossings to ensure that the productive capacity of streams is maintained. Depending on construction plans (to be developed at a later date), habitat compensation measures will be identified and implemented at specific sites as needed, in consultation with DFO, ESRD, and stakeholders, in order to ensure NNL of habitat productivity.

Watercourse crossing structures will consist of clear span arch structures or culverts that are sized to accommodate fish passage. Smaller culverts will be used to convey water in ephemeral non-fish bearing streams (Matrix 2012).

Standard practices that are proven to be effective measures to mitigate potential adverse effects during instream construction, associated with watercourse crossings, will be implemented and include the following:

- Consideration of sensitive periods during construction planning by either planning construction to avoid these periods or implementation of additional site specific mitigation;
- Design structures located on fish-bearing waters to provide fish passage;
- Isolation of instream work site if flowing water is present at time of construction;
- Completion of a fish rescue and release from isolated areas;

- Implementation of sediment and erosion controls prior to work and maintenance during the work phase until the site has been stabilized;
- Implementation of measures to minimize introduction of deleterious substances during construction including cleaning, servicing, and fuelling of equipment well away from water bodies;
- Revegetation of disturbed areas around crossing sites;
- Upon reclamation of crossings, streambed and stream banks will be reclaimed to similar pre-disturbance conditions; and
- Implementation of TSS/turbidity monitoring during instream work if deemed necessary due to site conditions or timing of works.

5.4 Stream Diversion Plans

Construction plans for planned diversions will be refined as Project plans are developed and will include detailed plans to mitigate adverse effects to aquatic resources. General mitigation measures that will be employed during the construction and operation of diversion channels will include:

- Maintenance of downstream flow and monitoring to ensure instream flow needs are met;
- Appropriate sizing of diversion channels and/or pump systems based on the design life of the diversion and considering ramifications of greater than design runoff;
- Armouring and/or lining of channels or use of flumes where appropriate;
- Installation of silt fences and/or other erosion control measures on areas adjacent to open channel diversions;
- Placement and stockpiling of excavated materials in a location that is well away from the channel route;
- Gradual diversion of flow into constructed channels to minimize potential erosion and mobilization of sediment;
- Fish rescue and release (fish salvage) of sections or channel that will be abandoned due to diversion;
- Implementation of TSS/turbidity monitoring during instream work if deemed necessary due to site conditions or timing of works;
- Consideration of sensitive periods during construction planning by either planning construction to avoid these periods or implementation of site specific mitigation; and
- Construction of open channel diversions that allow for the movements of fish. If diversions are deemed to be impassable and are impeding important spawning migration then a fish relocation programs will be implemented whereby fish will be trapped and relocated to appropriate habitat upstream of the impediment.

6.0 HABITAT COMPENSATION FRAMEWORK

Final reclamation will consist of reconstructed channels and end pit lakes (Figures 3 to 9).

6.1 PRIMARY HABITAT COMPENSATION CONCEPTS

CVRI is committed to developing and implementing habitat compensation to ensure 'no net loss' (NNL) to the productive capacity of fish and fish habitat. Key habitat compensation strategies include construction of enhanced stream channel habitat and creation of several end pit lakes. Overall, the updated closure landscape is expected to result in a 5,504,934 m^2 increase in available habitat (Table 13).

6.1.1 RECONSTRUCTED STREAM CHANNEL HABITAT

Key to the compensation strategy proposed by CVRI is the reconstruction of disturbed stream reaches to provide viable fish habitat. The updated mine plan was developed to maximize the amount of lotic habitat that will be reconstructed. Almost 100 % of habitat considered to have high potential/utilization will be reclaimed to channel (Table 9). In total, 77 % of all lotic habitat will be reclaimed to channel under the new plan (Table 9).

Table 9. Fish habitat reclaimed to channel.

	Application (2012)	**Revision (2013)**
Low habitat potential/utilization reclaimed to channel (m^2)	1,553 (7 % of total impacts to low potential/utilization streams)	13,163 (39 % of total impacts to low potential/utilization streams)
Moderate habitat potential/utilization reclaimed to channel (m^2)	982 (2 % of total impacts to moderate potential/utilization streams)	21,573 (59 % of total impacts to moderate potential/utilization streams)
High habitat potential/utilization reclaimed to channel (m^2)	12,021 (9 % of total impacts to high potential/utilization streams)	88,017 (98 % of total impacts to high potential/utilization streams)
Total Habitat Reclaimed to Channel (m^2)	**14,556 (7 % of total impacts)**	**122,753 (77 % of total impacts)**

Sections of disturbed stream habitat will be reconstructed with habitat enhancement added in order to compensate for habitat losses associated with creek diversions. Stream reconstruction will include:

- Reclamation of diversion channels to have a similar grade and channel dimensions as the pre-disturbance channel.
- Reclamation of diversion channels will be lined in this order: clay, sand/gravel, and cobble.
- Design and construction of diversion channels so that physical habitat characteristics in the new channel are similar to the pre-disturbance channel in terms of size, habitat composition, substrate and cover.
- Reclamation of riparian areas to be similar to pre-disturbance condition and revegetation of the areas with rapid establishing species and native species.

- Additional habitat enhancement (i.e. pools) on diversion channels to meet the NNL principle.

In order to meet the ‘no net loss’ of productivity requirement, CVRI proposes to evaluate productivity losses due to stream channel diversions versus productivity gains due to habitat restorations based on a Habitat Evaluation Procedures (HEP) type approach (USFWS 1980). This system estimates habitat productivity based on a combination of habitat area and habitat suitability.

In the HEP-type analysis, Habitat Units (HUs) are calculated by multiplying habitat quantity with habitat quality. Habitat quantity is represented by surface area measured in m^2 and habitat quality is an estimate of the suitability of the habitats for use by fish as defined by Habitat Suitability Index (HSI) models. HUs are dimensionless numbers representing the overall value of the habitat for fish species that are present and these HU values are used as a representation of habitat productivity. Comparison of the HUs altered as a result of stream diversions with the HUs gained through stream channel restoration will allow an assessment of the degree to which the compensation measures employed can achieve the principle of no net loss of fish habitat. The quantity of habitat lost due to stream channel diversions is known, and is presented above. Habitat quality will be estimated using the HSI value to rank the importance of available habitat for specific species and life stages of fish. HSI models are species-specific models that evaluate the suitability of the habitat in question based on specific habitat conditions, represented by model variables, that are each considered crucial to the development of a self-sustaining population. Under HEP-type analysis procedures, an HSI value ranging between 0 and 1 is determined for each waterbody or watercourse segment for each species present. This is sometimes further assessed by each life stage, for example, embryo, fry, juvenile and adult.

At this time, CVRI intends to focus quality rating on the habitat requirements of Rainbow Trout since they are the most ubiquitous fish within the Project area. However, there will be opportunity to assess habitat requirements for other species (i.e. Arctic Grayling or Bull Trout) if necessary depending on local reclamation strategies of CVRI and ESRD fisheries management objectives for the area.

6.1.2 End Pit Lakes

CVRI also proposed to construct end pit lakes to off-set habitat losses associated with the Project. There were 12 proposed end pit lakes in the Project Application; 11 end pit lakes will be constructed as part of the reclamation landscape for the revised Project (Lake 4 will no longer exist). Six of the lakes will be “flow-through” lakes (7, 8, 9, 10, 11, and 12) that are constructed on streams and will have an inlet and an outlet. Five of the lakes will be constructed “off-channel” (1, 2, 3, 5, and 6) and will have no inlet but will have an outlet to adjacent streams.

Robb West End Pit Lakes

Two end pit lakes are planned for Robb West. Figure 3 shows the location of the lakes and the drainage patterns post reclamation. Current reclamation plans indicate that Lake 1 will be connected with Lake 2 via a 700 metre constructed channel. Lake 2 will ultimately outlets into Bryan Creek.

Robb Main End Pit Lakes

Two end pit lakes will be constructed in Robb Main. Figures 4 and 5 show the location of the lakes and drainage patterns post reclamation. Current reclamation plans indicate that Lake 3 will be situated in the upper portion of the Hay Creek drainage and will flow into Hay Creek, and eventually the Embarras River. Lake 5 (West, Middle, and East) will be connected by short constructed channels and subsequently will outlet to the Erith River.

Robb Centre End Pit Lakes

Two end pit lakes are planned to be developed in Robb Centre. Figures 6 and 7 show the location of the lakes and general drainage patterns post reclamation. Current reclamation plans indicate that Halpenny Creek will flow around Lake 6. Lake 6 will outflow to Bacon Creek and Lake 7 will accept flows from LET3 and will outlet to Lendrum Creek.

Robb East End Pit Lakes

Five end pit lakes are planned to be developed in Robb East. Figures 8 and 9 show the location of the lakes and general drainage patterns post reclamation. Current reclamation plans indicate that two lakes (Lakes 8 and 9) will be situated on LDT1. The lakes will be connected by a 100 metre constructed channel. A similar configuration will exist on LDT3, with water flowing through two lakes (Lakes 10 and 11) before returning to the natural channel. The lakes will be connected by a 600 metre constructed channel. Lastly, Lake 12 will collect water from upper Lund Creek and will outlet to a 1,500 metre constructed channel that ultimately flows into Lake 10.

End Pit Lake Final Design

The flow-through lakes will be designed to maximize habitat and biological diversity and use by native fish populations. Final design will incorporate guiding principles that are described in the draft guidelines for end pit lake development at coal mine operations (EPLWG 2004) and/or procedures provided in similar guideline documents that may be available in the future. Some of the lakes may be constructed to preclude fish access but conceptually, the lakes will be designed to maximize habitat and biological diversity and use by native fish populations.

The off-channel lakes may be designed to be fishless, stocked fisheries, or possibly self-reproducing populations (depending on local conditions). The lakes may be designed to allow or preclude natural recruitment to the lake. Final design will incorporate the primary objective for the lake and will consider the guiding principles that are described in the draft guidelines for end pit lake development at coal mine operations (EPLWG 2004) and/or procedures provided in similar guideline documents that may be available in the future.

Key design features that will be considered in the planning and creation of the end pit lakes are presented in Table 10.

Table 10. Key design parameters for a self-sustaining native salmonid end pit lake.

Design Factor	Parameter Ranges and Probability of Success (from EPLWG 2003)		
	High	Medium	Low
Sustainability (water balance)	Mean annual inflow > mean annual losses	Mean annual inflows = mean annual losses	Mean annual inflows< mean annual losses
Lake dynamics/function	Very stable water level (<1m annual variation)	Stable water level (1-2m annual variation)	Unstable water level (>2m annual variation)
Filling method/schedule	1-5yrs	5-10yrs	>10yrs
Lake geometry	<25m max depth	25-75m max depth	>75m max depth
Shoreline stability	>90% stable	60-90% stable	<60% stable
Stratification/mixing	<10m mean depth <20m max depth	10-15m mean depth 20-23m max depth	>15 m mean depth >23 m max depth
Water Quality	Close to median water quality values of natural water bodies in the region	Within the range of values for natural water bodies in the region	At the extreme, or outside of the range of natural water bodies in the region
Potential toxic substances	Meets water quality guidelines	Slightly exceeds guidelines	Significantly exceeds guidelines
Littoral zone	20-40%, <3m max littoral depth	10-20%	<10%, >40%, 3-6m max littoral depth
Substrate in littoral zone (high importance in truck/shovel lakes)	High density of boulders and fines in littoral zone		Low density of boulders and fines in littoral zone
Connectivity of lake to stream	Stable surface inlet and outlet	Ephemeral outlet only	No inlet/outlet
Riparian	High diversity of well-established plants	Medium diversity of well-established plants	Poor establishment of vegetation

6.2 RATIONALE

CVRI has successfully constructed stream channels and end pit lakes in the past and is therefore confident that they will be able to construct/implement the proposed compensation concepts to ensure that the productive capacity of fish habitat is maintained.

6.2.1 RECONSTRUCTED STREAM CHANNEL HABITAT

Over the last two decades, CVRI has reconstructed and/or enhanced a number of stream channels in the CVM area. A summary of these projects including photo documentation of current conditions and a discussion of monitoring results (and associated response plans) are provided in Appendix A.

6.2.2 End Pit Lakes

End pit lakes can exhibit various attributes and their potential to serve as fish habitat is often linked to the attributes and characteristics that they possess. The morphometric, geologic, hydrogeologic, geochemical and biological attributes of these lakes, directly influences the potential uses of these water bodies (Gammons et al. 2009). CVRI has accumulated considerable information regarding existing end pit lakes in the region. The following is a brief synopsis of how this existing information supports the idea that end pit lakes can provide good quality native fish species in the region.

Water quality is often the limiting factor in determining whether or not a pit lake has the potential to become fisheries habitat (Gammons et al. 2009). The local geology and the product being mined can have a profound effect on the water quality found in an end pit lake. Acidification and the introduction of heavy metals into ground and surface waters are often difficult to mitigate and can negatively impact biological environments due to contamination of ground and surface waters (Lemly 2007, Rudolf et al. 2008, Stekoll and Smoker 2009).

Silkstone, Lovett and Pit 24 (Stirling) Lakes are the oldest fish bearing end pit lakes located on the CVM lease; having been developed in the late 1980’s and early 1990’s. Water chemistry concerns with these end pit lakes have generally been negligible and the water quality in these pit lakes is very similar to Fairfax Lake, a naturally occurring lake in the area (Hatfield 2011). The CVM Lease is located in an area where acidification of ground and surface waters is rare due to the calcareous nature of the parent material. The thermal coal mined at the CVM Lease is also significantly different than the metallurgical coal found at the nearby Cheviot and Cardinal River Mine Leases and previously on the Gregg River Mine lease. Selenium enrichment of ground and surface waters is generally of lesser concern on the CVM lease.

One of the challenges with reclamation on the CVM is that there is often an insufficient amount of overburden material available to refill the end-pits. Left as is, these end-pits would naturally fill with surface and ground waters to form a body of water. Without prescribed reclamation procedures and guidelines, these lakes would have lesser ecological value. Guidelines for the development of end pit lakes are provided by Alberta Environment (EPLWG 2002) and include various design factors including hydrological, physical, chemical and biological design factors. Additional recommendations for developing end pit lakes in this area have also been identified in various pit lake studies (Hatfield 2011, Sonnenberg 2011). In addition, CVM is currently conducting research on existing end pit lakes on the mine to increase their understanding of these systems and to identify key design factors to maximize habitat productivity for target species.

End pit lakes have provided habitat and angling opportunities for Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*) and Brook Trout (*Salvelinus fontinalis*) on or near the CVM lease. Lakes such as Silkstone, Lovett, Pit 24 (Stirling), Pit 35, Pit 44 and Pit 45 are regularly stocked with Rainbow Trout and provide recreational angling opportunities (ESRD 2013). In addition to these “put and take” fisheries, fish have moved into end pit lakes on the CVM through channels that connect the lakes to natural drainages (Pisces 2013). Fisheries and Oceans Canada (Authorization No. ED 03-3080) have approved reclamation plans on the CVM which include a series of pit lakes on the Upper Embarras River for the purpose of establishing a self-sustaining population of Athabasca Rainbow Trout. Preliminary results indicate that the barrier downstream of the lake system is working to preclude fish species downstream from moving upstream. Rainbow trout in the Embarras Lake system have also successfully spawned in the connecting channels (Pisces 2013).

Populations of Athabasca Rainbow Trout and Bull Trout have been documented in several end-pit lakes in the area including Lac des Roches, Sphinx Lake and Pit-lake CD (Schwartz 2002, Pisces 2008, Pisces 2009, Sonnenberg 2011). Spawning at the outlets and in the streams downstream of Sphinx Lake and Pit-lake CD is well documented and the Rainbow Trout populations are self-sustaining. Productivity downstream of Sphinx Lake and Pit-lake CD has increased from pre-mining conditions, likely due to the buffering and warming effect of the lake (Sonnenberg 2011).

In addition to Athabasca Rainbow Trout, Bull Trout, and Brook Trout, end pit lakes may have the potential to bolster the dwindling Arctic Grayling (*Thymallus arcticus*) population in the CVM area. Arctic Grayling are native to portions of the McLeod watershed (SRD 2005). Arctic Grayling populations are found in several lakes in Alberta and natural recruitment has been documented in several of these water bodies (SRD 2005). End-pit lakes with outlet channels may provide suitable habitat for Arctic Grayling if reclamation plans include barriers that preclude the movement of other fish species from downstream. The planned and calculated development of end pit lakes is an important part of reclamation practices on the CVM.

6.3 Quantification of Predicted Effects and Habitat Gains

Table 12 provides a summary of predicted impacts for each watercourse and identifies the type of habitat (lotic or lentic) that will be available after final reclamation.

Table 12. Summary of predicted impacts to fish habitat by watercourse.

Mine Area	Watercourse	Impacted Habitat Area (m^2)	Reclaimed Habitat	
			Reconstructed Channel (m^2)	Lake
Robb West	Bryan Creek	15,688	15,688	
Robb Main	Bacon Creek	2,777	2,777	
	Erith River	67,485	67,485	
	ERT1	1,000	1,000	
	ERT2	406	406	
	ERT3	7,751		Lake 5
	Hay Creek	6,363		Lake 3
Robb Centre	Halpenny Creek	4,129	4,129	
	Lendrum Creek	17,468	17,468	
	LET1	3,282	1,600	Lake 7
	LET3	7,959	6,595	Lake 7
Robb East	Lund Creek	16,033	2,505	Lake 12
	LDT1	2,991	640	Lake 8 & 9
	LDT1A	1,091		Lake 8 & 9
	LDT2	209		Lake 10
	LDT3	3,831	1,800	Lake 10 & 11
	LDT4	542		Lake 10
	LDT5	154		Lake 12
	PET1	660	660	
Total		**159,819**	**122,753**	***5,542,000 m^2** (total lake habitat available upon final reclamation)

* Lake dimensions presented are consistent with Project Application but are likely subject to change as mine plans progress

Table 13 compares the predicted effects and habitat gains from the original application to the updated mine plan. In total, the predicted amount of fish habitat impacted is estimated at 159,819 m^2, which is a 22 % decrease from the original application. Final reclamation of aquatic resources will consist of reconstructed channel and 11 end pit lakes, for a total habitat gain of 5,504,934 m^2. With the updated mine plan, the amount of reconstructed channel will increase from 14,556 m^2 in the original application to 122,753 m^2 (approximately 77 % of impacted habitat will be reclaimed to channel).

Table 13. Summary of predicted effects and habitat gains in the Project area.

	Habitat Loss (m^2)		Habitat Gain (m^2)		
	Application (2012)	**Revision (2013)**	**Type of Reclamation**	**Application (2012)**	**Revision (2013)**
Natural Channel	204,983	159,819	Reconstructed Channel	14,556	122,753
			*End Pit Lake	*6,253,000	*5,542,000
Total Habitat Loss	**204,983**	**159,819**	**Total Habitat Gain**	**6,267,556**	**5,664,753**
Net Change (m^2)				**+6,062,573**	**+5,504,934**

* Lake dimensions presented are consistent with Project Application but are likely subject to minor change as mine plans progress

6.4 ADDITIONAL COMPENSATION OPTIONS

As a precautionary measure CVRI has identified several other habitat compensation initiatives that could be initiated if it is determined that the primary habitat compensation concepts are not sufficient to ensure no net loss of the productive capacity of fish habitat. These include:

- Habitat Defragmentation – CVRI has partnered with the Foothills Research Institute to complete a watercourse crossing inventory in the vicinity of the CVM to document fish presence and identify potential problem sites where fish passage or sediment deposition are issues. The compensation initiative would involve the repair and/or remediation of identified problem sites.
- Habitat Enhancement in RSA – CVRI is currently investigating other instream enhancement opportunities in the Erith River outside of the Project area. The compensation initiative would involve the completion of instream enhancement work to improve habitat suitability or address potential limiting factors.
- Rainbow Trout Research Initiative – CVRI is aware that an Athabasca Rainbow Trout Recovery Plan is likely to be released in the near future. The compensation initiative would involve participation or coordination of specific projects to address identified knowledge gaps, or contribute to research, or recovery techniques identified in the Recovery Plan.

7.0 MONITORING

7.1 CONSTRUCTION PHASE

All instream construction sites will be monitored to ensure best management practices are implemented and for compliance with the conditions and requirements of any and all regulatory permits applicable to construction. The most significant aspect of instream construction monitoring will be implementation of a sediment monitoring program. Sediment monitoring protocols will be designed site-specifically, but will be based on industry standards.

7.2 OPERATION PHASE

7.2.1 SURFACE WATER MONITORING

Surface water monitoring plans were originally discussed in the Project Application, (CVRI, 2012). Monitoring will be similar to existing CVM mine areas.

Surface water quality monitoring for the Project will include:

- A water quality monitoring program designed to meet the requirements of the Project approval will be implemented for the life of the Project (Hatfield 2012; CR#11);
- Flows and TSS will be monitored at all settling ponds (Matrix 2012; CR#6);
- Regular inspections of all drainage works will be conducted (Matrix 2012; CR#6); and
- Long term monitoring of flow in each main creek will be conducted to document critical low flow conditions during pit filling periods and to define the need for any bypass pumping to maintain in-stream flows (Matrix 2012; CR#6).

7.2.2 BIOLOGICAL MONITORING

The existing CVM aquatics monitoring program will be expanded to include additional benthic macroinvertebrate sample sites. Results of the monitoring will be used to assess the effectiveness of the surface water management plan and modifications will be made, if necessary.

Fish population monitoring programs to assess fish distribution, relative abundance and population structure will be developed as the Project progresses

7.3 FOLLOW-UP MONITORING

CVRI recognizes that periodic monitoring will be required to evaluate fisheries habitat components and populations in re-established aquatic environments (reconstructed channels). Monitoring protocols will be developed in conjunction with the details of the currently proposed compensation strategies. The general monitoring approach will be to monitor habitat created or enhanced by evaluation of the physical and biological characteristics of the habitats as well as fish utilization of the habitats. Habitat improvements would be implemented, as part of an adaptive management approach, if new or enhanced habitat were not providing the required habitat components for the target fish species (i.e. Rainbow Trout).

A detailed end pit lake monitoring program will be developed two to five years prior to construction of each lake allowing for CVRI to take advantage of information regarding end pit lake development that may become available in the future and to design the lake to meet future end-use objectives and regional management strategies. In general CVRI anticipates implementing a monitoring program that will include but is not necessarily limited to the following:

- Post-construction monitoring to assess physical stability of end pit lakes and connecting channels.
- Assessment of fish community and habitat within the end pit lakes and associated channel systems.
- Assessment of various biological and chemical parameters in end pit lakes including:
    - Fish, benthic invertebrates, zooplankton, phytoplankton, macrophytes.
    - Measurement of temperature, dissolved oxygen, conductivity profiles, as well as select water quality variables.

Monitoring results will be used, if necessary, to adjust mitigation and habitat compensation measures and make design improvements as required. Habitat monitoring will be key to confirming the no net loss objective can be achieved. Should, for some reason, the proposed habitat compensation not be sufficient to achieve no net loss of the productive capacity of fish habitat, additional habitat compensation would then be developed in consultation with the appropriate regulators.

8.0 SUMMARY

This document is intended to provide an updated outline of the impacts to fish habitat and proposed strategies to mitigate and compensate for the impacts that may occur as a result of the Project. Detailed habitat compensation plans will be developed for specific phases as the project progresses. Given that this project will be developed over the next 25 years there will be opportunity to adjust and adapt mitigation and compensation strategies to ensure that the project will not result in the loss of productive capacity of fish and fish habitat.

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Figures

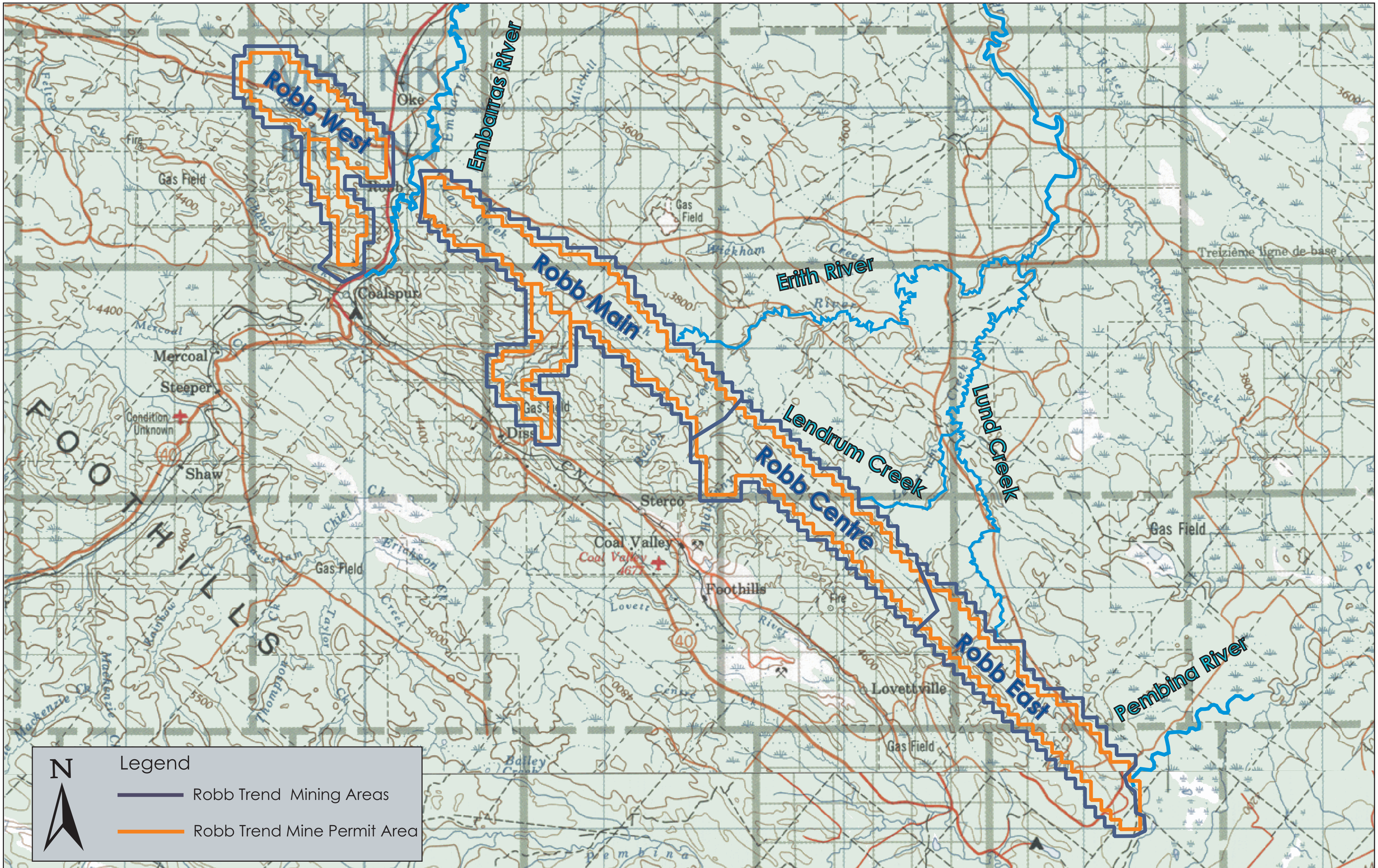


Figure 1. Robb Trend Project Area (adapted from Project Application)	Drawn by: JM	Checked by: ES
	August 2013	
Pisces Environmental Consulting Services Ltd.	CVRI Coal Valley Mine	
	Scale 1:250,000	

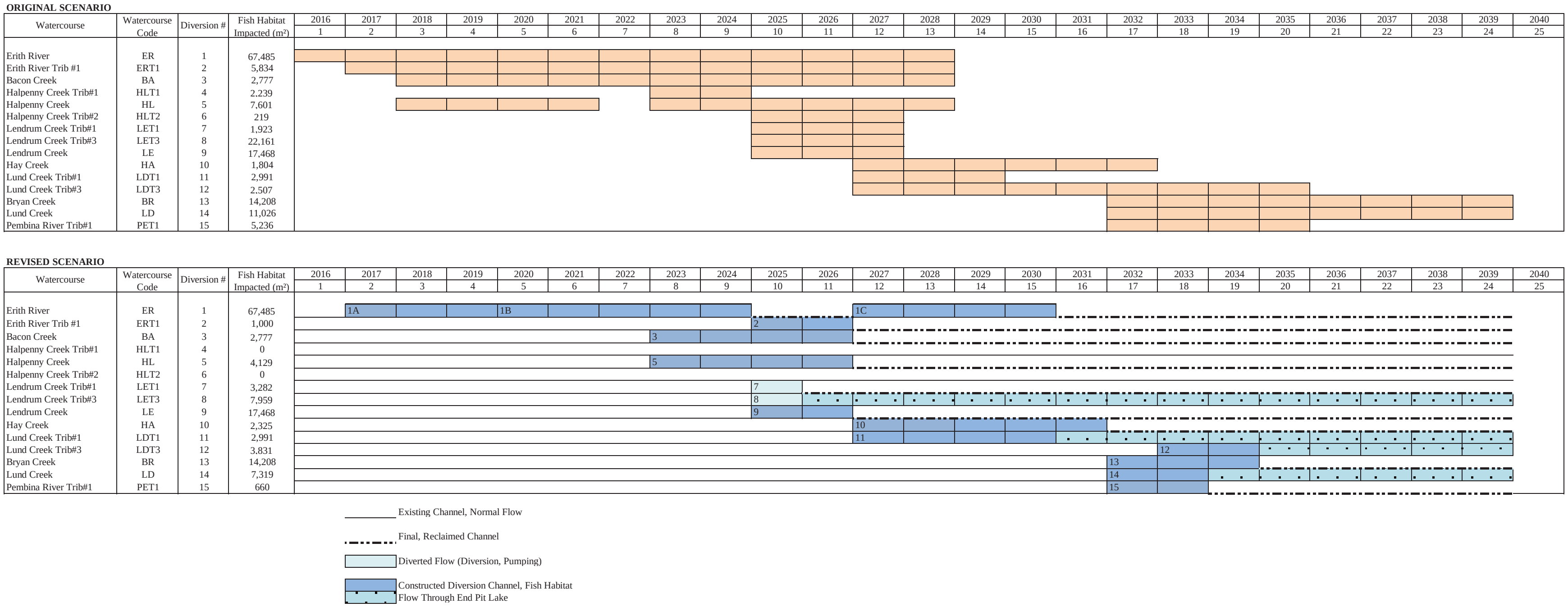
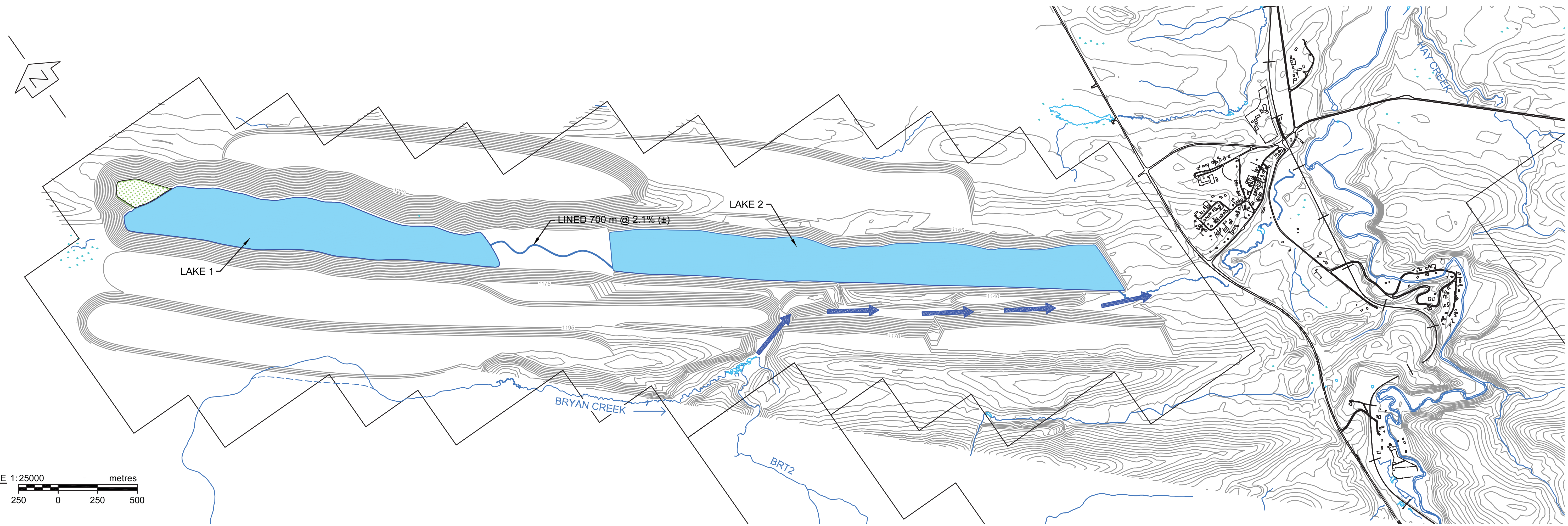


Figure 2. Anticipated schedule for mine development along with the predicted impacts to fish habitat



LEGEND

- Lake
- Wetland
- Constructed Steams

REF: Matrix Solutions Inc., December 2011.

PROJECT:

Coal Valley Mine
Robb Trend SIR - DFO Compensation Plan

cvri

TITLE:

Figure 3. Lakes 1 and 2 Reclamation Plan

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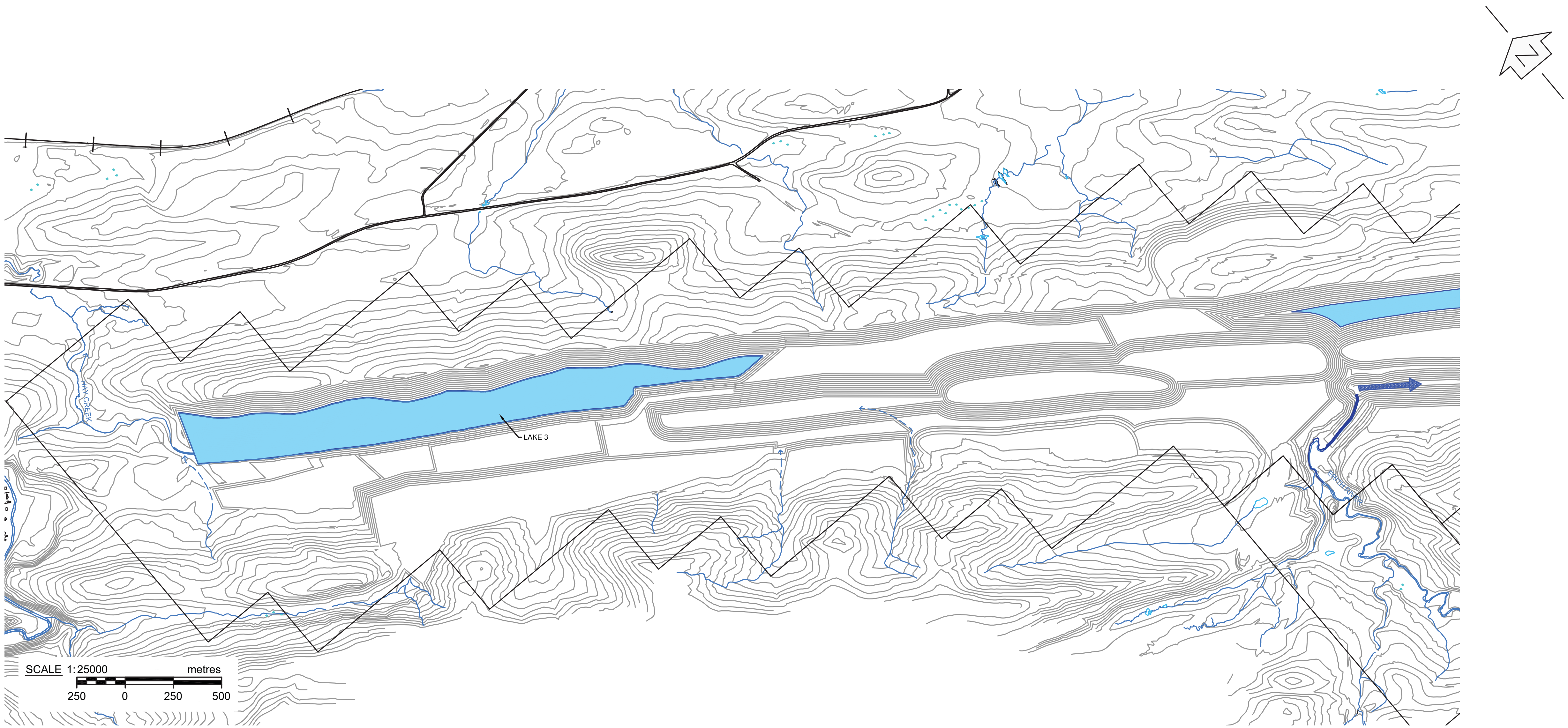
DRAWN: JG	FIGURE:
CHECKED: KP	
DATE: Aug 1/13	
PROJECT: 08-041b	



LEGEND

Lake

Wetland

REF: Matrix Solutions Inc., December 2011.

PROJECT:

Coal Valley Mine
Robb Trend SIR - DFO Compensation Plan

TITLE:

Figure 4. Lake 3 Reclamation Plan

FILE:	Final Docs\08-041b\DFO\Fig_Various.dwg
DRAWN:	JG
CHECKED:	KP
DATE:	Aug 1/13
PROJECT:	08-041b
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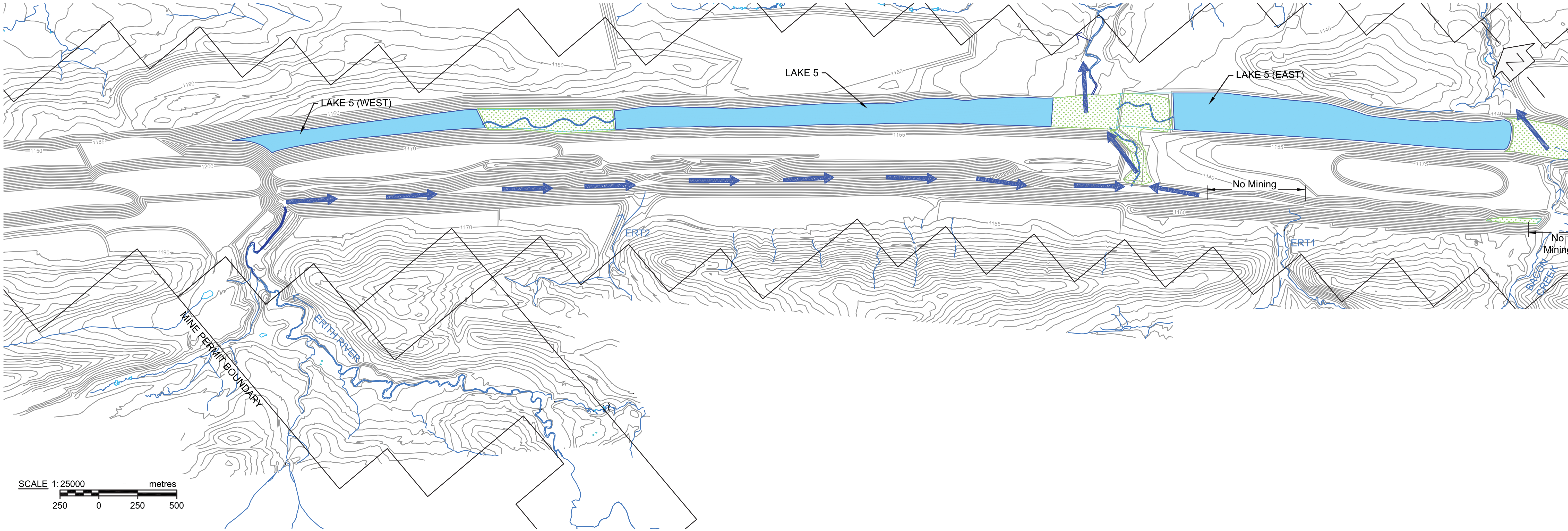


LEGEND
- Lake
- Wetland
- Constructed Streams

REF: Matrix Solutions Inc., December 2011.

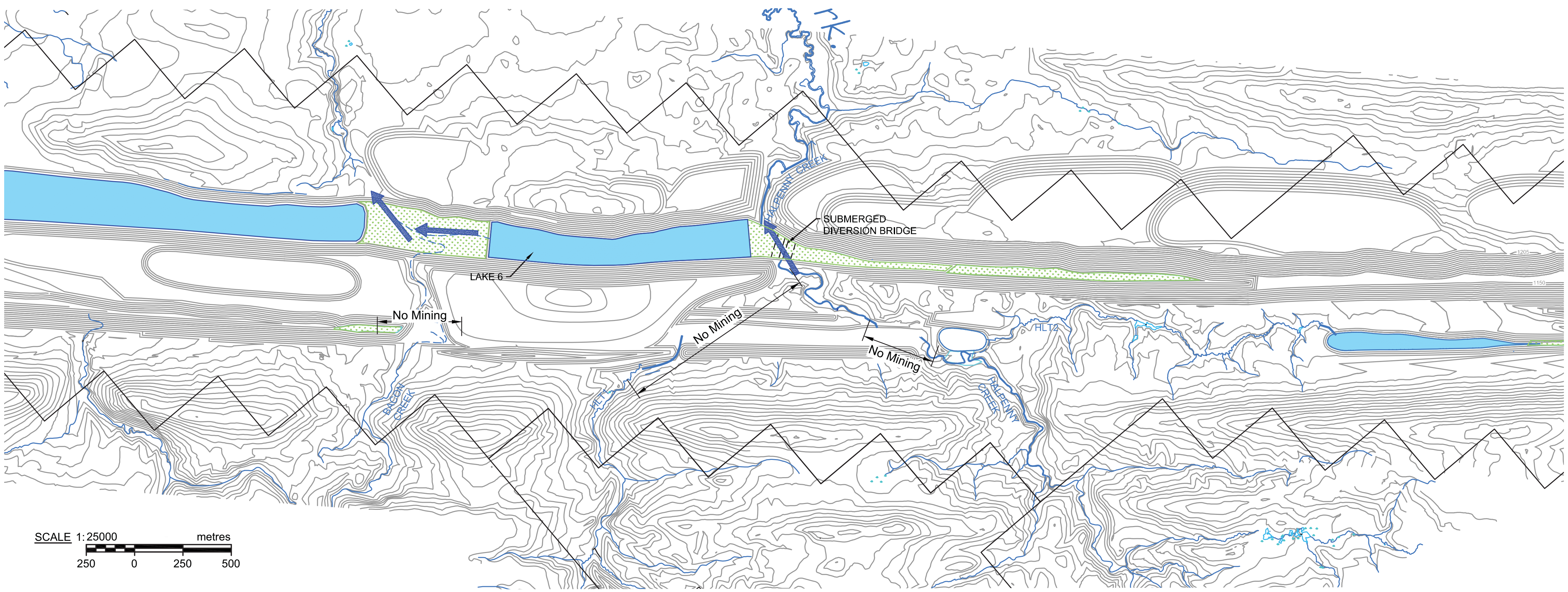
PROJECT:
Coal Valley Mine
Robb Trend SIR - DFO Compensation Plan

cvri

TITLE:
Figure 5. Lake 5 Reclamation Plan

FILE: Final Docs\08-041b\DFO\Fig_Various.dwg

DRAWN: JG		FIGURE:
CHECKED: KP		
DATE: Aug 2/13		
PROJECT: 08-041b		



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- Lake
- Wetland
- Constructed Streams

REF: Matrix Solutions Inc., December 2011.

PROJECT: **Coal Valley Mine Robb Trend SIR - DFO Compensation Plan**	cvri
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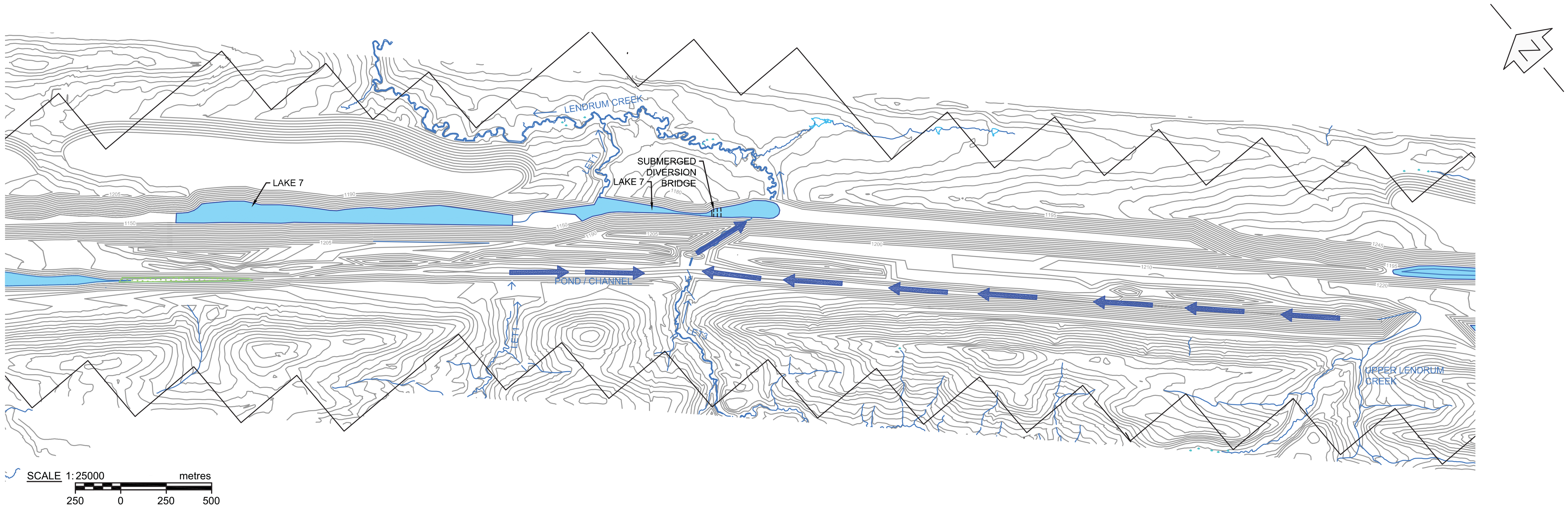

LEGEND

Lake

Wetland

Constructed Streams

REF: Matrix Solutions Inc., December 2011.

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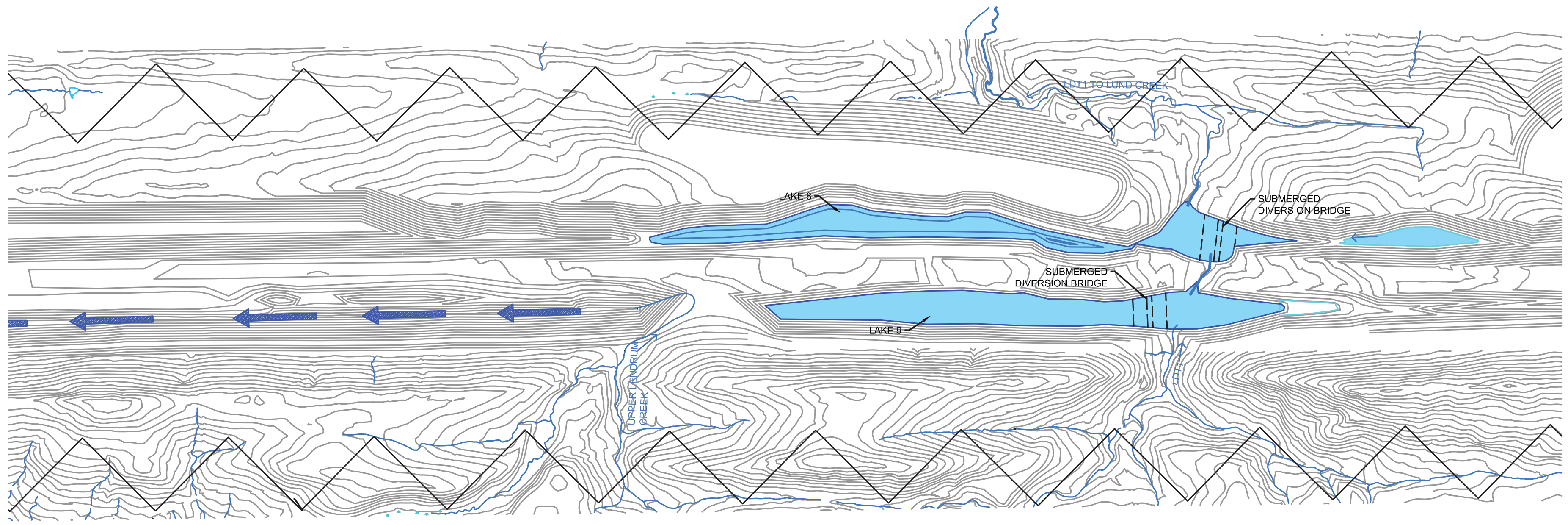

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LEGEND

- Lake
- Wetland
- Constructed Streams

REF: Matrix Solutions Inc., December 2011.

PROJECT:
Coal Valley Mine
Robb Trend SIR - DFO Compensation Plan

TITLE:
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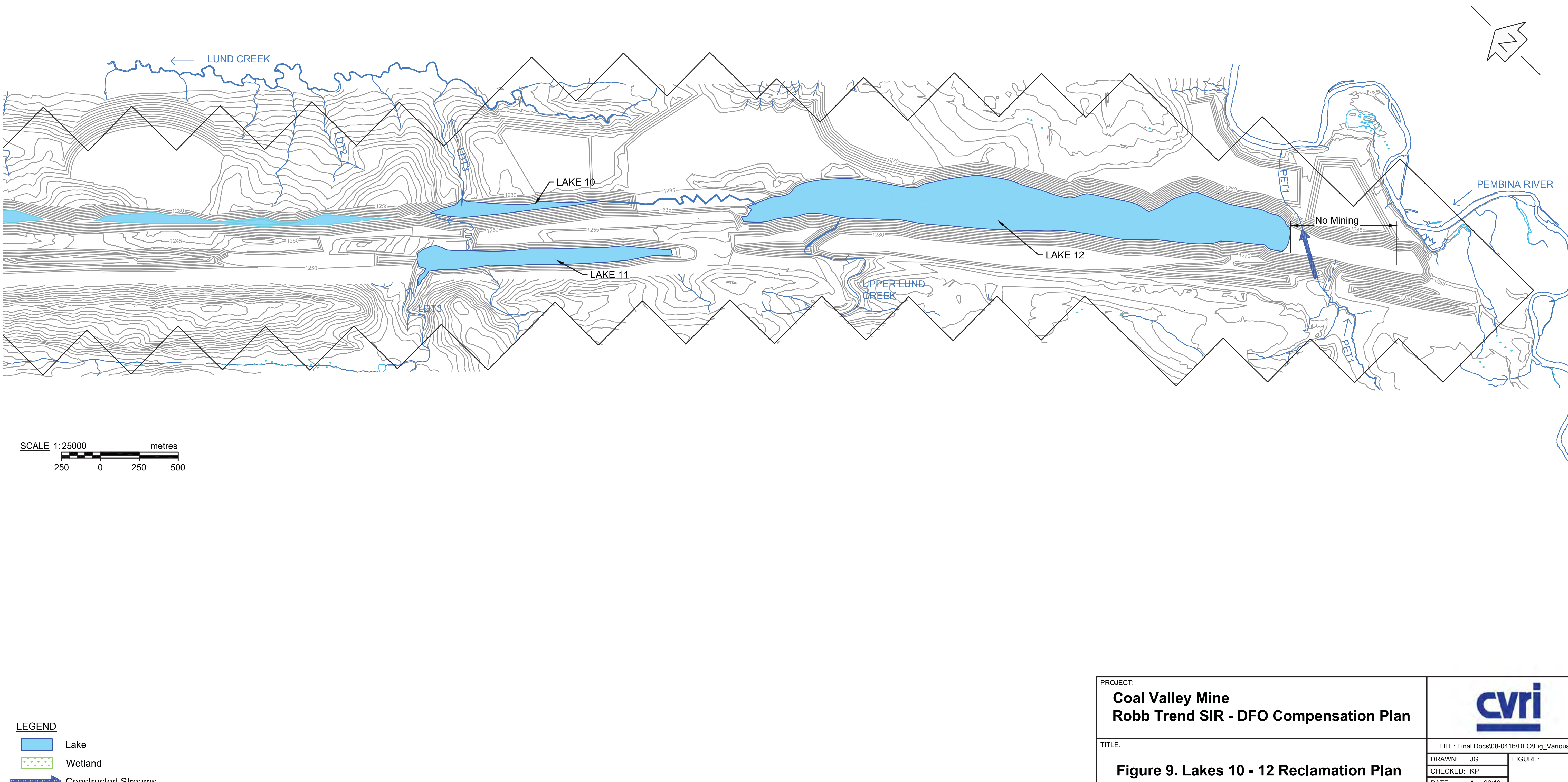
PROJECT:	08-041b

FIGURE:



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PROJECT:
Coal Valley Mine
Robb Trend SIR - DFO Compensation Plan

TITLE:
Figure 9. Lakes 10 - 12 Reclamation Plan

FILE: Final Docs\08-041b\DFO\Fig_Various.dwg

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CHECKED: KP		
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PROJECT: 08-041b		

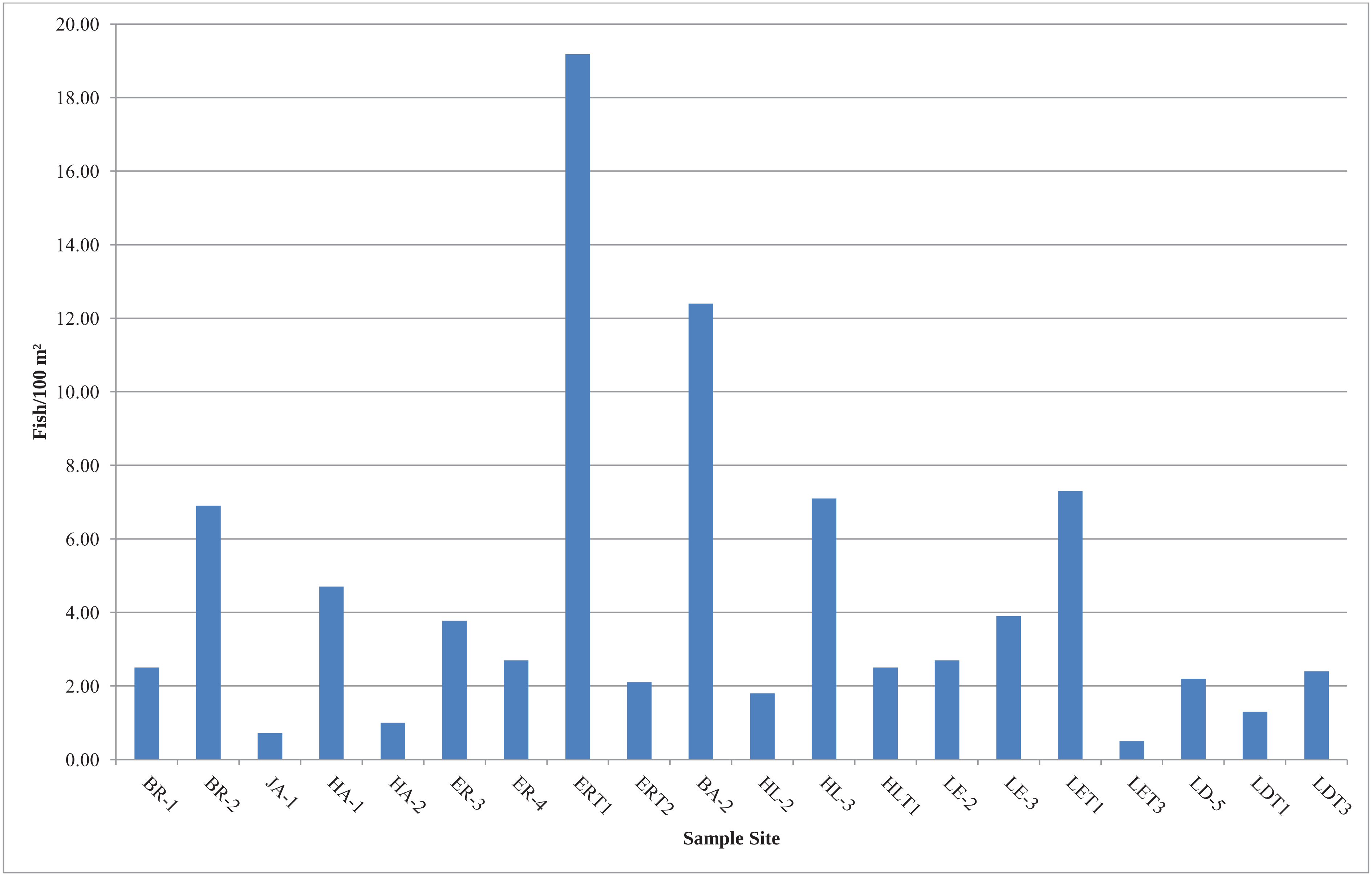

Figure 10. Rainbow Trout densities (fish/100 m^2) for population estimates performed in the Robb Trend Mine Area.	CVRI Robb Trend Project
	August 2013
	Pisces Environmental Consulting Services Ltd.

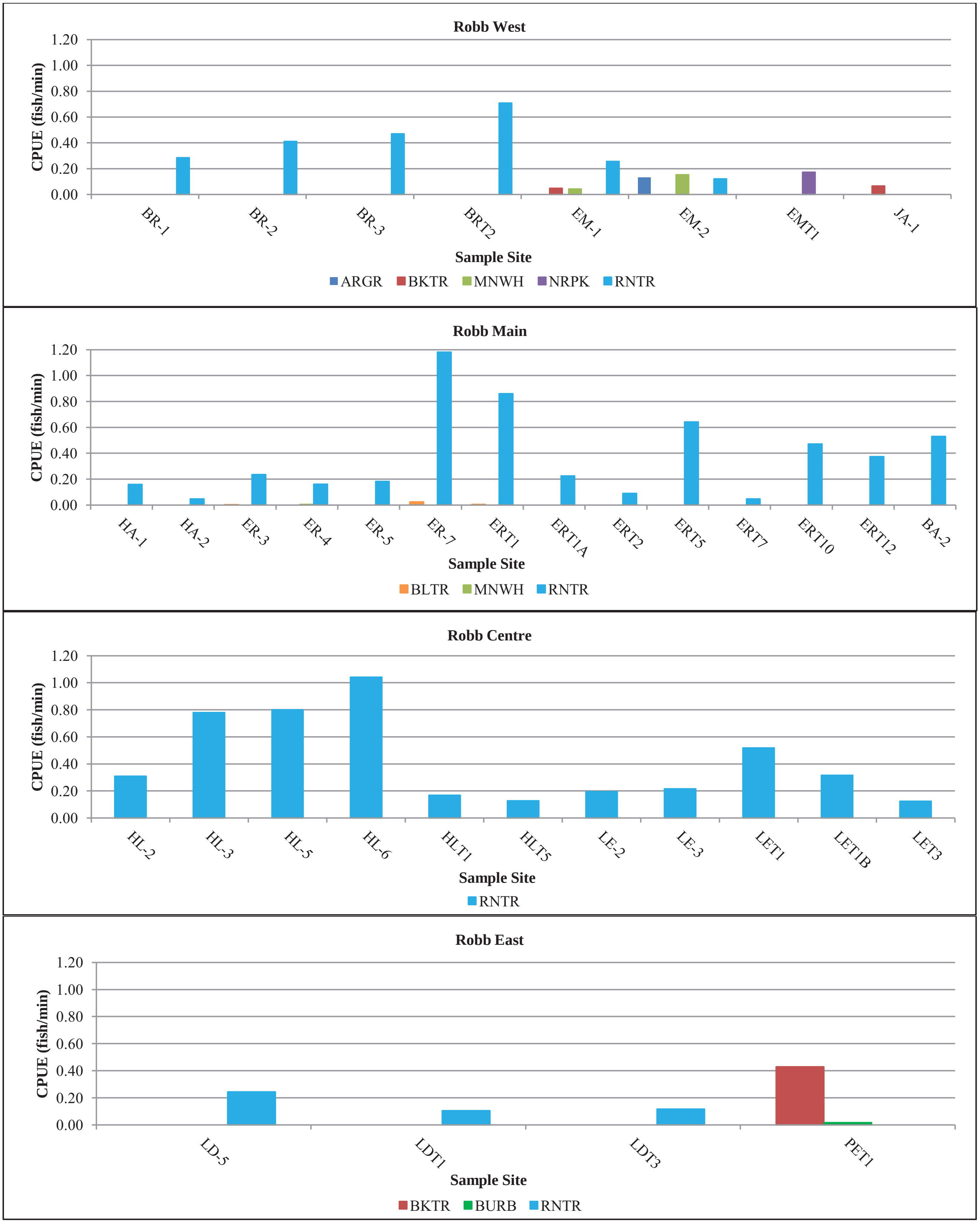

Figure 11. First-pass catch per unit effort (CPUE) for sport fish captured at Robb Trend sample sites.

Low	Moderate	High
		
Photo 1. Upper Hay Creek.	Photo 3. Unnamed tributary to Halpenny Creek #1 (HLT1).	Photo 5. Unnamed tributary to the Erith River #1 (ERT1).
		
Photo 2. Unnamed tributary to the Erith River #2 (ERT2).	Photo 4. Lendrum Creek.	Photo 6. Erith River.

Figure 12. Photos of typical habitat conditions found within Low, Moderate, and High habitat potential rankings.

CVRI Robb Trend Project

August 2013

Pisces Environmental Consulting Services Ltd.

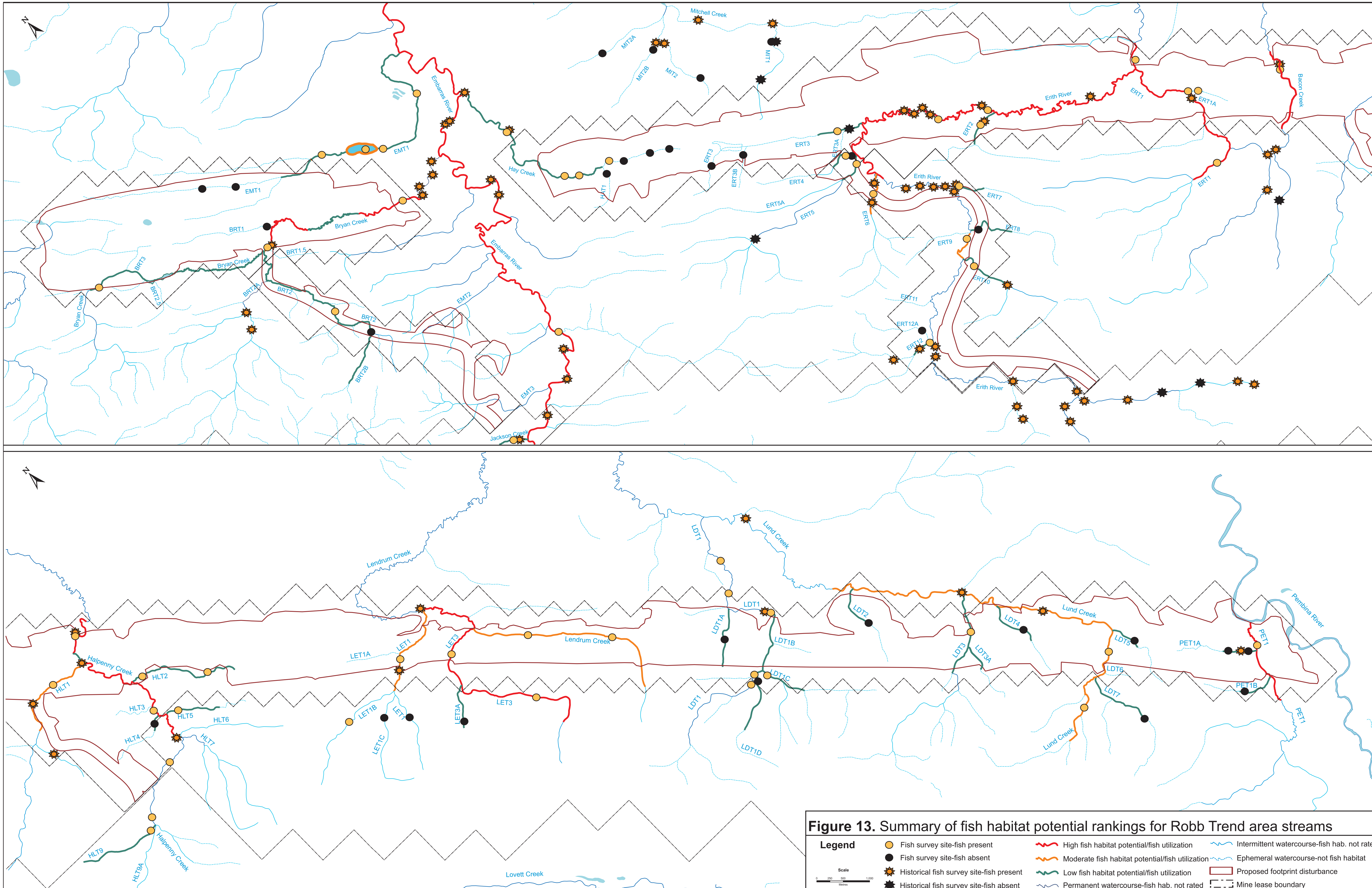

Figure 13. Summary of fish habitat potential rankings for Robb Trend area streams

Appendix A

CVRI has reconstructed several stream channels as part of past reclamation efforts. The following summarizes past work and discusses challenges and improvements in channel construction proposed for the future.

Centre Creek Tributary (1989)

In the winter of 1989, a 2.3 kilometer stretch of an unnamed tributary to Centre Creek was diverted to facilitate mining (Pisces 1989). Habitat assessments completed following the reconstruction showed the reconstructed channel exhibited good diversity, increased the amount of deep water habitat, and increased the overall habitat area of the unnamed tributary (Pisces 1989). During sampling conducted in 1996 this channel was found to have the highest Brook Trout density of all sites sampled with 56 fish/100m^2 being captured (Carson and Allan 1999). Carson and Allan (1999) also classified the habitat within the tributary as high quality habitat. Brook trout were observed spawning within the reconstructed channel during the fall of 1999 (Allan 1999).

The diverted channel as it currently exists (fall 2012) is portrayed in Figure 1.

Figure 1. Centre Creek Tributary Diversion fall 2012 (Dean Woods Photograph).

Pit 45 Lake Outflow (2000)

The Pit 45 Lake outflow channel drains Pit 45 Lake, which is managed as a quality stocked lake by AESRD. The channel has well established vegetation and exhibits no slumping or instability. No fisheries enhancements were completed within the channel and minimal discharge was noted in spring 2013.

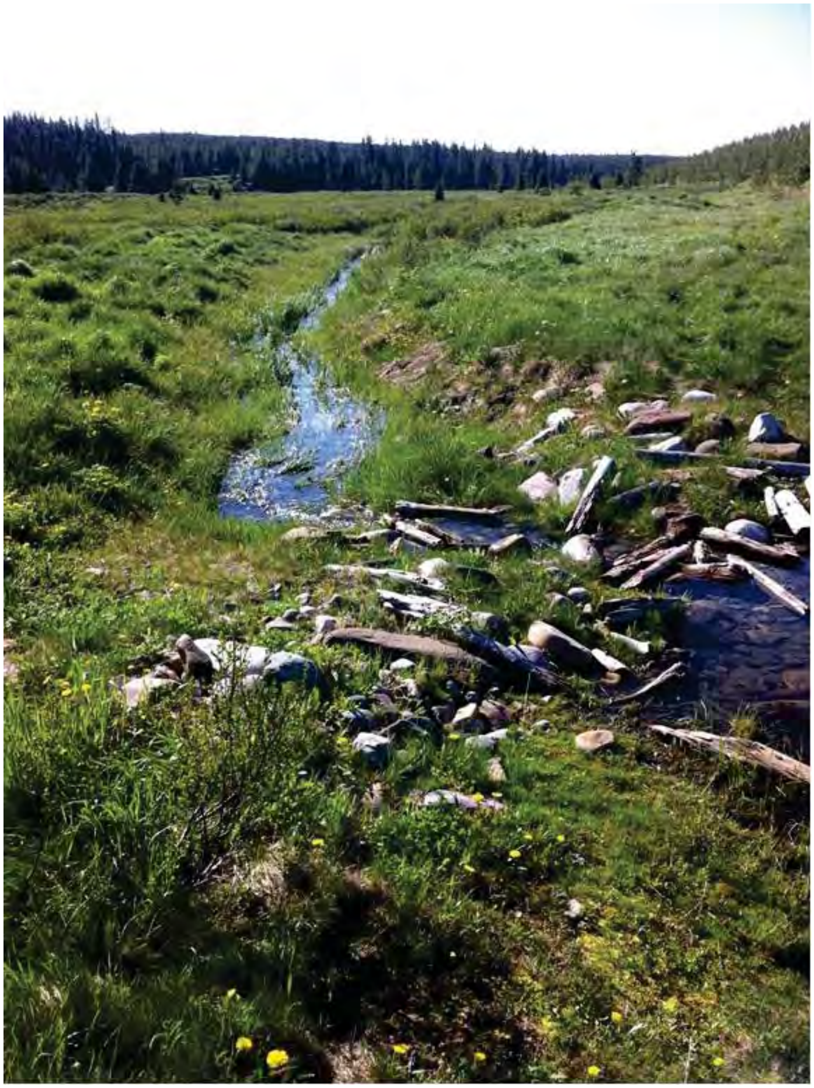

Figure 2. Pit 45 Lake Outflow Summer 2011 (Dean Woods photo)

Pit 43 W Outflow (2004)

The Pit 43W Outflow drains a small end pit lake and connects to the Lovett River (Figure 3 and 4). Fish were observed in the bottom 50 metres of channel but no sampling has been completed. Monitoring was initiated in spring 2013 and is ongoing.


Figure 3. Pit 43W outflow channel spring 2013.


Figure 4. Pit 43 W outflow channel downstream section.

Pit 34 Lake Outflow (2004)

The Pit 34 Lake outflow was constructed in 2004 but final reclamation and enhancement is ongoing in the area. Preliminary investigations conducted in spring 2013 indicate Brook Trout are occupying the constructed habitat. The channel is stable and vegetation is slowly becoming established (Figure 5). Monitoring was initiated in spring 2013 and is ongoing.

Figure 5. Pit 34 Lake Outflow spring 2013.

25E Creek Channels (2010)

CVRI has more recently completed construction of several lake outlet channels as part of the reclamation process. Monitoring of many of these outlets is ongoing but early indicators show the reclaimed landscape is providing habitat for colonizing fish species. 25E creek was heavily influenced during mining and has been reconstructed (Figure 6 and 7). Fish were observed in 25E Creek in the constructed inlet and outlet channels of Pit 25E Lake in spring 2013. Additional fisheries surveys are scheduled for summer 2013. Brook Trout were documented in 25E Lake during the winter of 2010.

Figure 6. 25E Creek immediately upstream of 25E Lake spring 2013.

Figure 7. 25E Creek at outlet of 25E Lake (looking downstream) spring 2013

Fish presence has not been documented in the headwaters of 25E Creek but monitoring of the constructed 25E Creek channel was initiated in the spring of 2013. The constructed channel exhibited significant discharge in spring 2013 and preliminary measurements indicate it is capable of providing fish habitat (Figure 8 and 9). Monitoring was initiated in spring 2013 and is ongoing.

Figure 8. 25E Creek immediately downstream of 25S Lake spring 2013

Figure 9. 25E Creek approximately 100 metres downstream of 25S Lake.

Upper Mercoal Creek Diversion (2009)

A portion of the headwaters of Mercoal Creek was diverted into an enhanced channel in the summer of 2009. The reconstructed channel appears to provide an increased amount of fish habitat compared to baseline conditions (Figure 10) and vegetation is becoming established (Figure 11). No fish have been captured in the vicinity of the diversion during fish salvage operations in 2009 or during subsequent monitoring (2010, 2012). However, large beaver dams located a substantial distance downstream of the diversion are suspected of impeding fish movements into this constructed habitat.


Figure 10. Baseline conditions of upper Mercoal Creek during fish salvage operations in 2009.


Figure 11. Upper Mercoal Creek diversion channel in summer 2012.

Embarras Lakes (2011)

The Embarras Lakes system was constructed to connect three end-pit lakes located in the headwaters of the Embarras River. Prior to mining, low densities of fish were present a short distance downstream of the mining area (Figure 12). Though the system is early in its developmental stages and some final reclamation work still needs to be completed, the constructed channels have been found to provide habitat for native Athabasca Rainbow Trout (Pisces 2013).

Although vegetation and instream habitat enhancements still need to be constructed (Figure 13 and 14) preliminary investigations show increased fish densities in the upper Embarras drainage compared to baseline conditions. Prior to mining, very few fish were present in the vicinity of the existing Embarras Lakes (single Rainbow Trout captured) while low densities of Rainbow Trout ($2.6/100m^2$), Brook Trout ($0.34/100m^2$), and a single Bull Trout were captured downstream of where the existing fish exclusion barrier is located (Boorman 2003). In August 2012, 85 Rainbow Trout were captured from within constructed channels upstream of the exclusion barrier during single pass surveys. Population estimate data collected downstream of the fish exclusion indicates Rainbow and Brook Trout densities have increased orders of magnitude over baseline conditions.

Figure 12. Upper Embarras Baseline condition (2004) downstream of existing fish exclusion barrier.

Figure 13. Reconstructed channel downstream of Lower Embarras Lake spring 2012.

Figure 14. Outlet channel of Upper Embarras Lake spring 2012.

Challenges and Future Work

Monitoring of existing diversions and reconstructed channels continues in 2013 as CVRI prepares for future reclamation projects. A significant amount of the Chance Creek channel will be constructed in the Yellowhead Tower area following mining.

CVRI has acknowledged limited fisheries work/enhancement has been carried out in several of the diversion channels. Monitoring is ongoing and preliminary results will be relied to make recommendations for enhancements. A lack of woody vegetation and fish cover components in several of the existing channels will be addressed as final replanting and reclamation occurs. Gravel and instream habitat placements are proposed in systems where self-sustaining fish populations are desired.

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Pisces. 1989. Habitat assessment of a diversion channel on an unnamed tributary to Centre Creek. Prepared by Pisces Environmental Consulting Services for Luscar Sterco Ltd. 9pp

Pisces. 2011. Aquatic Monitoring Program for End Pit Lakes in the Headwaters of the Embarras River, 2011-12. Prepared by Pisces Environmental Consulting Services Ltd. for Coal Valley Resources Inc. Edson, AB

Appendix 2: Various Supporting Reports

Hatfield
CONSULTANTS

Macrophyte and Bathymetry Surveys in End-Pit Lakes in the Coal Valley Mine Area

February 2014

Prepared for:

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MACROPHYTE AND BATHYMETRY SURVEYS IN END-PIT LAKES IN THE COAL VALLEY MINE AREA

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FEBRUARY 2014

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1.0 INTRODUCTION AND BACKGROUND

The reclamation activities of Coal Valley Resources Inc. (CVRI) in operations in the Coal Valley Mine (CVM) area include the creation of end-pit lakes. This report presents the results of an assessment of bathymetry and macrophyte communities in select, representative end-pit lakes in the CVM area, located approximately 90 km south of Edson, in west-central Alberta, on the eastern slopes of the Canadian Rocky Mountains. This study was conducted by Hatfield Consultants Partnership (Hatfield) for CVRI as part of the ongoing efforts of CVRI to improve the ecological sustainability of end-pit lakes in the CVM area. This report contains the results of surveys conducted from August 26, 2013 to August 31, 2013 on nine existing end-pit lakes in the CVM area.

1.1 BACKGROUND

1.1.1 Creation of End-Pit Lakes in Coal Mining

The development and maintenance of end-pit lakes is an integral component of the CVRI reclamation programs in the CVM area. End-pit lakes as part of a reclamation strategy provide opportunities to support productive terrestrial and aquatic environments.

Upon completion of mining, reclamation begins when pits are back filled with overburden material. End-pit lakes are created where there is an insufficient amount of overburden material available to backfill mined pits and reclaim the natural profile of the landscape. Lakes are developed when the pits are filled with water from constructed surface inflows, surface runoff, and/or groundwater intrusion. End-pit lakes are generally characterized by high maximum depth to low surface area ratio. End-pit lake morphology is a function of the original mining techniques. Dragline operations tend to produce long and narrow lakes that are asymmetrical on the long axis. These lakes tend to have one steep slope side or drop off with the opposite shore having more gradual slope. End-pit lakes created from truck and shovel operations tend to be rounder, deeper, and have consistently high slopes at one end of the lake (Mackay 1999).

Ultimately, the design of end-pit lakes provides a framework for ecological stability and functionality enhancing the landscape of the region. The objective of end-pit lakes is to provide aquatic habitat for the development and maintenance of productive and diverse lake ecosystems, supporting fish communities (End-Pit Lakes Working Group 2004). End-pit lakes in Canada are considered as potential alternatives to restoration of original landscapes in part because of their potential for fish and aquatic habitat. End-pit lakes may also provide hydrological functions such as buffers for flooding, water storage, and decreasing the movement of surface and ground water (End-Pit Lakes Working Group 2004).

1.1.2 Summary of Existing Information for End-Pit Lakes in the Coal Valley Area

Limnological, ecological, and water quality studies have been conducted on end-pit lakes in the CVM area:

1. In the 1990s, studies were conducted on Lovett, Silkstone, and Stirling (Pit 24) lakes by Luscar (1994), Agbeti (1998) and Mackay (1999);

2. In 2006, studies were conducted on Lovett, Silkstone, and Stirling (Pit 24) lakes plus Pit 35 and Pit 45 lakes (Hatfield 2008). Hatfield (2008) focused on overall limnological characterization of end-pit lakes in the CVM area and comparing and contrasting the limnological characteristics of end-pit lakes in the CVM area to limnological characteristics of Fairfax Lake, a natural lake located in the vicinity of the CVM area; and

3. In 2010 and 2011, water quality evaluations were conducted on Lovett, Silkstone, and Stirling (Pit 24) lakes plus Pit 35, Pit 45, Pit 44, Pit 142, Pit 25E and Pit 25S lakes (Hatfield 2011). A natural lake in the CVM area, Fairfax Lake, was also sampled.

The Hatfield (2008) study concluded that, because of the variation in water quality, sediment quality, and biological characteristics among the end-pit lakes and in comparison to Fairfax Lake, it was unclear which factors (i.e., time since establishment, presence of inflows and outflows, type of mixing, flushing rates, bathymetry, habitat complexity, or other characteristics), were more important to end-pit lake development, to what degree these factors influenced the ecological viability of end-pit lakes, and how these factors interacted to produce sustainable lake ecosystems.

The Hatfield (2011) study suggested that there may be fewer constraints of water quality on the ecological viability of end-pit lakes in the CVM area than those described in End-Pit Lake Working Group (2004):

1. The concentration of a number of water quality variables, such as nutrients and major ions, are higher in end-pit lakes than in natural lakes, but these higher concentrations are not at levels that would affect the ecological viability of the end-pit lakes;

2. There are relatively few instances of measured water quality variables, including metals, exceeding provincial or federal water quality guidelines;

3. The incidence of water quality guideline exceedance is not measurably greater in end-pit lakes than in natural lakes in the CVM area; and

4. The trophic status of end-pit lakes is similar to that of natural lakes in the CVM area.

The results of the study reported in Hatfield (2011) suggest that the effects of chemoclines in end-pit lakes on water quality, particularly dissolved oxygen concentrations, and the consequent inability for end-pit lakes to turnover, may be less than initially thought, and the ability of end-pit lakes to be holomictic may be less of an factor in determining amount of viable aquatic habitat than previous studies have indicated. Hatfield (2011) notes that while lake turnover is generally considered an important ecological process in most productive lakes (Hutchinson 1938, Effler and Perkins 1987 and Wetzel 2001) it is not a necessary process governing the ability of a lake to sustain healthy fish populations (Effler and Perkins 1987, Trimbee and Prepas 1988).

1.1.3 Macrophytes in the Aquatic Community

This report presents an assessment of the development of macrophyte communities in nine end-pit lakes within the CVM area. The examination of macrophyte communities aims to provide information regarding aquatic habitat of the end-pit lakes in the CVM area as an additional indicator of their ecological sustainability. In this regard, this study complements and augments the previous end-pit lake studies described in Section 1.1.2 and the guidelines for end-pit lakes provided in End-Pit Lake Working Group (2004).

Macrophytes (or aquatic plants) are fundamental in contributing to a productive lake environment (Lacoul and Freedman 2006). Aquatic plants form the base for each trophic level in a lake, providing habitat for microorganisms, invertebrates and fish. Fish depend on vegetation for habitat (cover structures), foraging opportunities, and oxygen regulation (Barko et al. 1986; Duarte et al. 1986; Randall et al. 1996; Oslon et al. 1998).

The establishment, distribution and abundance of macrophytes is dependent on several environmental factors. These include physical, chemical and biological factors that can be influenced on spatial and temporal scales (Lacoul and Freedman 2006). Several studies have documented the importance of factors such as light (including turbidity and photosynthetic potential), water chemistry and nutrient requirements, geomorphology (e.g., lake depth, slope, wave action), sediment composition, and ecology (e.g., competition between plants, role as a food source) on the development of macrophyte communities. Few studies, however, have documented how macrophytes develop in end-pit lakes.

1.2 STUDY OBJECTIVES

Because end-pit lakes are part of ongoing reclamation activities being implemented by CVRI in the CVM area and will form part of reclamation and closure plans for new and proposed mining projects, CVRI updated and expanded the bathymetric information on end-pit lakes. Macrophytes can be used as a parameter for measuring lake production leading into measuring viable aquatic habitat. This information increases understanding of ecological sustainability of end-pit lakes created from surface coal mine pits using conventional techniques and provides guidance to the design and management of future end-pit lakes.

The key objectives for this study were to:

1. Conduct updated bathymetry mapping on select, representive end-pit lakes in the CVM area;
2. Assess macrophyte communities: abundance and composition (taxonomic richness) on selected end-pit lakes in the CVM area;
3. Assess changes in macrophyte communities as lakes mature; and
4. Derive recommendations for increasing viable aquatic habitat and productivity in end-pit lakes based on macrophyte assessment.

2.0 STUDY DESIGN AND FIELD METHODOLOGIES

2.1 LAKES SAMPLED

Nine end-pit lakes were sampled from August 26, 2013 to August 31, 2013; basic information on surveyed lakes is provided in Table 1. Lakes were selected based on age, size, depth and previous monitoring history. Some lakes were included in previous studies, whereas others have not yet been studied due to age or other factors specific to the study.

Macrophyte communities were assessed using digital echo sounder technology and visual surveys. The digital echo sounder was used for both bathymetric and macrophyte mapping (canopy characterization, depth) configured for the Submersed Aquatic Vegetation Early Warning System Jr. software (hereafter SAVEWS Jr.; Sabol et al. 2002). Visual surveys included identification of macrophytes (lowest possible taxa) and underwater photography at depths. Detailed methods are described in the following sections.

2.2 BATHYMETRIC AND MACROPHYTE MAPPING

Bathymetric and macrophyte mapping were conducted simultaneously using a Lowrance depth sounder with a 200 KHz transducer combined with a downward-looking Lowrance side-scan sonar with 455 and 800 KHz transducers according to the SAVEWS Jr. User's Manual (Sabol 2002). Transducers were attached to an outboard bracket fixed to the stern of a 15′ Zebec Armada boat equipped with a 6 HP Honda engine.

Table 1 Summary information on the lakes sampled as part of this study.

Lake	Year Created (Age)[1]	Type	Location	Approximate Surface Area (ha)	Maximum Depth (m)	Mean Depth (m)	Inflow	Outflow	Monitoring History
Lovett Lake	1985 (28)	Dragline	10-47-19-W5M	6.0	18	5.5		✓[2]	1987, 1989, 1991, 1993, 1998, 2006, 2010, 2011
Silkstone Lake	1986 (28)	Dragline	9-47-19-W5M	6.4	14.8	4.7	✓	✓	1987, 1989, 1991, 1993, 1998, 2006, 2010, 2011
Pit 24 (Stirling)	1993 (20)	Truck and shovel	4-47-19-W5M	4.9	23.5	8.1			1998, 2006, 2010, 2011
Pit 34	2007 (6)	Dragline	34-46-19-W5M	5.9	5.5	2.9			None
Pit 35	1999 (14)	Dragline	26-46-19-W5M	3.5	11.4	5.7		✓	2006, 2010, 2011
Pit 43[3]	2008 (5)	Dragline	34-46-19-W5M	n/a	n/a	n/a			None
Pit 45	1999 (12)	Dragline	26-46-19-W5M	6.5	12.5	6.3	✓	✓	2006, 2010, 2011
Pit 122	2009 (4)	Dragline	29-47-21-W5M	7.8	17.3	7.0			None
Pit 142	2008 (5)	Dragline	24-47-21-W5M	7.24	7.4	2.2	✓	✓	2011

1 Lake age is based on the last year of topsoil placement and re-contouring of the lakes.

2 Outflow is through a subsurface connection to Lovett River.

3 Data collected could not be used in analysis due to issues with SAVEWS Jr. program.

A series of transects consisting of datapoints configured by Sabol et al. (2002) were run across the width of each lake, moving to and from opposite shores for the entire length of each lake. The boat speed while running transects ranged from 4 km/hr to 5 km/hr to make the rate of datapoint collection consistent. The transducer and sonar created echograms (Figure A1.1) which illustrated data (.SL2 files) of lake depth and if detected, canopy height of vegetation. Data were recorded on an 8 GB memory card inserted into the Lowrance depth sounder. While the number and length of transects varied depending on the size of the lake, approximately 20 transects were conducted on each lake. Individual transect information such as survey times, locations (latitude, longitude, UTMs) and file names were also recorded in the Lowrance unit.

Digital sonar data from the Lowrance unit were transferred to SAVEWS Jr. software (version 1.1), and echograms (Figure A1.1) displaying canopy height and lake depth data were used with default configuration files from Sabol et al. (2002). The use of configuration files with echograms generated a graphic output (Figure A1.2) that allowed for visual checks of data and optimizing the accuracy of macrophyte height and lake depth interpretations of each transect. Each lake was individually checked and configured to account for unique characteristics such as surface noise (wind/wave action), length of transect, and sediment composition (soft versus rocky bottom) that may influence data interpretation by the software. Not all transects collected in the field were successfully processed by the SAVEWS Jr. program for a variety of reasons. Only complete and correctly processed transect data was used in the analysis of each lake. Factors such as wave/wind interference sometimes caused too much surface noise which prevented the program from detecting the bottom of the lake. The SAVEWS Jr. software also had unknown incompatibility issues with some of the data that the developer was unable to correct for this study. This was a particular problem with Pit 43 Lake, where none of the data could be used for analyses even after attempts to reconfigure data were made by the software developer. This was an unknown issue until data analysis began. Completion of a new survey of Pit 43 Lake would be required to reattempt the analysis of this lake.

2.3 ANALYSIS OF SONAR DATA

Once transect data were processed and visually assessed in SAVEWS Jr. they were run through a second program, FINALIZE (version 1.0; Sabol et al. 2002) to compile transect data for each lake. In some cases, data from transects could not be interpreted by the software program (as explained in Section 2.2). Outputs from FINALIZE were ASCII files (accessed in Microsoft Excel) displaying time, location (i.e., latitude and longitude), bottom depth and calculated height (if present) and percent cover of macrophytes for each datapoint. From these data, macrophyte biovolume (defined as the percentage of the water column occupied by macrophytes) of the macrophytes was calculated for each transect using the following formula:

$$Biovolume = \frac{Percent\ cover \times Macrophyte\ height}{Bottom\ depth}$$

The ASCII files were also subsequently used for geographic information systems (GIS). The GIS data were used to interpolate depth profiles, plant height and cover within each lake, enabling the production of maps for bathymetry and macrophyte cover (biovolume). Five of the nine lakes surveyed had previously been studied by Hatfield (2008, 2011) and had accurate bathymetric maps. Old maps were updated, and new maps for newly-surveyed lakes were created.

2.4 MACROPHYTE COMMUNITY SURVEYS

In addition to digital mapping and characterization of macrophyte communities, visual assessments of macrophytes were conducted (i.e., macrophyte taxa) to determine community composition as described below. Macrophytes for the purpose of this report included flowering aquatic plants (angiosperms), mosses (bryophytes) and algae. Characterization of the macrophyte community was recorded using the same hardware and configuration used to collect bathymetry data once bathymetric transects for the entire length of the lake had been collected.

A total of 10 visual assessments were conducted within each of the three depth categories in each lake: 0 m to 1.5 m, >1.5 m to 3 m, and >3 m to 5 m. Visual assessments were conducted by the field crew from the boat for the first depth category (0 m to 1.5 m). Macrophytes were identified to the lowest possible taxonomic level (species where possible), as well as ranked dominant taxa by percent (%) composition. Macrophytes that could not be identified were numbered by lake with detailed photos by an underwater camera for later identification. Voucher specimens of the macrophytes that could not be identified were taken from Silkstone and Lovett lakes to assist with species identification after completion of the field surveys. Vouchers were kept in sealed bags with water, stored in a cool, dark place. In some cases, clarity of photos made macrophyte identification difficult and therefore unidentified specimens were grouped into "unknown species" categories.

For the other two depth categories (>1.5 m to 3 m, and >3 m to 5 m), a GoPro (Hero 3) camera in a waterproof case was attached to an apparatus (constructed stand with measured rope attachment), along with a dive light (Light and Motion SOLA Video1200) to collect underwater images. The apparatus was designed with four legs and mounts to hold the camera and a dive light approximately 0.5 m from the substrate so that any vegetation present at that depth would be illuminated and captured in a photo. With camera settings to capture images every two seconds, the apparatus was lowered to the lake bottom. After allowing time for two images to be captured, the apparatus was raised 0.5 m and held for another five seconds in order to capture taller plants and canopy structure. Details regarding location coordinates, date, time, lake bottom depth and associated depth category were recorded for each assessment. Following the assessments, images were sorted and macrophytes, if present were identified to lowest possible taxonomic levels. Macrophytes that could not be identified due to image quality were labelled as "unknown". Examples of photographs taken at depth are provided in Appendix A1 (Figure A1.3, Figure A1.4 and Figure A1.5).

3.0 RESULTS

3.1 LOVETT LAKE

3.1.1 Summary of Observations and Conditions

Lovett Lake, an end-pit lake established 28 years ago and was studied by Luscar (1994), Agbeti (1998), Mackay (1999) and Hatfield (2008, 2011), with this latter study characterizing Lovett Lake as meromictic. Lovett Lake has been and is currently being stocked with rainbow trout (*Oncorhynchus mykiss*) (Alberta Government 2013). Field observations noted evidence of recreational use of the lake, as well as well-established riparian communities including forested areas surrounding the end-pit lake.

3.1.2 Bathymetric Mapping

The bathymetric map for Lovett Lake obtained as a result of this study is presented in Figure 2.

3.1.3 Macrophyte Surveys and Analysis

Data from 14 of the 20 transects taken on Lovett Lake were used for the macrophyte analysis. The most prevalent species of macrophytes were narrowleaf bur-reed, northern watermilfoil, and bryophyte spp., comprising approximately 60% of all macrophytes identified in Lovett Lake. A total of 11 macrophyte taxa were identified across all depth categories and to a maximum depth of 4.7 m. A complete description of the macrophytes identified in Lovett Lake is presented in Table A2, and the biovolume map of macrophytes in Lovett Lake is presented in Figure 3.

3.2 SILKSTONE LAKE

3.2.1 Summary of Observations and Conditions

Silkstone Lake was studied by Luscar (1994), Agbeti (1998), Mackay (1999), and Hatfield (2008, 2011). Silkstone Lake has been characterized as meromictic (Hatfield 2008) and is 28 years old. Silkstone Lake has been and is currently being stocked with rainbow trout (Alberta Government 2013). Field observations noted evidence of recreational use of the lake area, as well established riparian communities including forested areas surrounding the end-pit lake.

3.2.2 Bathymetric Mapping

The bathymetric map for Silkstone Lake obtained as a result of this study is presented in Figure 4.

3.2.3 Macrophyte Surveys and Analysis

Data from 15 of the 21 transects taken on Silkstone Lake were used for the macrophyte analysis. The most prevalent types of macrophytes identified were *Chara* sp. and an unknown species, comprising approximately 50% of all macrophytes identified in Silkstone Lake. A total of 12 taxa were identified. The maximum depth at which macrophytes were identified in Silkstone Lake was 5 m. A complete description of the macrophytes identified in Silkstone Lake is presented in Table A2, and the biovolume map of macrophytes in Silkstone Lake is presented in Figure 5.

3.3 STIRLING (PIT 24) LAKE

3.3.1 Summary of Observations and Conditions

Stirling Lake has been studied by Luscar (1994), Agbeti (1998), Mackay (1999) and Hatfield (2008, 2011). Silkstone Lake has been characterized as meromictic (Hatfield 2008) and is 20 years old. This end-pit lake has been historically stocked with both brown (*Salmo trutta*) and rainbow trout but is currently only being stocked with rainbow trout (Alberta Government 2013). Field observations noted well-used trails around the end-pit lake indicating recreational use. The drainage area of Stirling Lake consists of steep, grass-covered slopes with some gentle sloping areas. Portions of the riparian area are forested with coniferous species.

3.3.2 Bathymetric Mapping

The bathymetric map for Stirling Lake obtained as a result of this study is presented in Figure 6.

3.3.3 Macrophyte Surveys and Analysis

Data from 13 of the 15 transects taken on Stirling Lake were used for the macrophyte analysis. A total of 10 taxa were identified, the most prevalent species were mare's tail, vernal starwort and *Chara* sp., comprising more than 60% of all macrophytes identified in Stirling Lake. Macrophytes were present at all three depth categories that were assessed and the maximum depth at which macrophytes were identified was 4.6 m. A complete description of the macrophytes identified in Stirling Lake is presented in Table A2, and the biovolume map of macrophytes in Stirling Lake is presented in Figure 7.

3.4 PIT 35 LAKE

3.4.1 Summary of Observations and Conditions

Pit 35 Lake was studied by Hatfield (2008, 2011) and is 14 years old. Field observations noted steep, grass-covered slopes with some adjacent, young tree plantations in the drainage of this end-pit lake.

3.4.2 Bathymetric Mapping

The bathymetric map for Pit 35 Lake obtained as a result of this study is presented in Figure 8.

3.4.3 Macrophyte Surveys and Analysis

Data from all 15 transects taken on Pit 35 Lake were used for the macrophyte analysis. Five taxa were identified, where *Chara* sp., comprised over 50% of the identified community of Pit 35 Lake. Macrophytes were present at all three depth categories that were assessed and the maximum depth at which macrophytes were identified in Pit 35 Lake was 5.5 m. A complete description of the macrophytes identified in Pit 35 Lake is presented in Table A2, and the biovolume map of macrophytes in Pit 35 Lake is presented in Figure 9.

3.5 PIT 45 LAKE

3.5.1 Summary of Observations and Conditions

Pit 45 Lake has been studied by Hatfield (2008, 2011). Pit 45 Lake has been characterized as meromictic (Hatfield 2008) and is 12 years old. Field observations noted steep, grass-covered slopes with some adjacent, young tree plantations in the drainage of this end-pit lake.

3.5.2 Bathymetric Mapping

The bathymetric map for Pit 45 Lake obtained as a result of this study is presented in Figure 10.

3.5.3 Macrophyte Surveys and Analysis

Data from 18 of the 20 transects taken on Pit 45 Lake were used for the macrophyte analysis. Eight taxa were identified in Pit 45 Lake. The most prevalent type of macrophyte identified was *Chara* sp., comprising approximately 80% of all macrophytes. Macrophytes were present at all three depth categories that were assessed and the maximum depth at which macrophytes were identified in Pit 45 Lake was 4.9 m. A complete description of the macrophytes identified in Pit 45 Lake is presented in Table A2, and the biovolume map of macrophytes in Pit 45 Lake is presented in Figure 11.

3.6 PIT 142 LAKE

3.6.1 Summary of Observations and Conditions

Pit 142 Lake, one of the shallower end-pit lakes in this study with a mean depth of 2.2 m, was studied by Hatfield (2011), which assessed the end-pit lake as holomictic. Pit 142 Lake is five years old. Field observations noted steep slopes with dense grass and terrestrial vegetation in the drainage of this end-pit lake. No trails or evidence of recreational use were noted.

3.6.2 Bathymetric Mapping

The bathymetric map for Pit 142 Lake obtained as a result of this study is presented in Figure 12.

3.6.3 Macrophyte Surveys and Analysis

Data from 14 of the 16 transects taken on Pit 142 Lake were used for the macrophyte analysis. Narrowleaf bur-reed and mare's tail were the only two types of macrophyte identified in Pit 142 Lake. Macrophytes were present only in the 0 m to 1.5 m depth category. A complete description of the macrophytes identified in Pit 142 Lake is presented in Table A2, and the biovolume map of macrophytes in Pit 142 Lake is presented in Figure 13.

3.7 PIT 34 LAKE

3.7.1 Summary of Observations and Conditions

This study is the first conducted on Pit 34 Lake, which is six years old. Field observations noted high turbidity in many sections of this end-pit lake. Exposed sediment was also noted along many sections of the shoreline. The riparian community consisted of grasses, sedges and some shrub species.

3.7.2 Bathymetric Mapping

The bathymetric map for Pit 34 Lake obtained as a result of this study is presented in Figure 14.

3.7.3 Macrophyte Surveys and Analysis

Data from all 23 transects taken on Pit 34 Lake were used for the macrophyte analysis. Large-sheath pondweed and narrowleaf bur-reed were the only two types of macrophyte identified in Pit 34 Lake. Macrophytes were present in the 0 m to 1.5 m and >1.5 m to 3 m depth categories. A complete description of the macrophytes identified in Pit 34 Lake is presented in Table A2, and the biovolume map of macrophytes in Pit 34 Lake is presented in Figure 15.

3.8 PIT 43 LAKE

3.8.1 Summary of Observations and Conditions

This study is the first conducted on Pit 34 Lake, which is five years old. The data from this end-pit lake could not be used to create either a bathymetric or macrophyte biovolume map because of problems with the SAVEWS Jr. software. Field observations noted large areas of exposed sediment and erosion occurring on steeper slopes of the drainage of the end-pit lake; and riparian communities consisted of grass and sedge species.

3.8.2 Bathymetric Mapping

No bathymetric map is available for Pit 43 Lake.

3.8.3 Macrophyte Surveys and Analysis

Visual surveys documented the presence of four taxa in Pit 43 Lake. *Chara* sp. accounted for over 80% of the community and were observed to depths of 2.7 m. A total of four taxa were identified. A complete description of the macrophytes identified in Pit 43 Lake is presented in Table A2. No figure is available for biovolume of Pit 43 Lake.

3.9 PIT 122 LAKE

3.9.1 Summary of Observations and Conditions

This study is the first conducted on Pit 122 Lake, which is four years old. Field observations noted a number of factors that may be inhibiting development of macrophyte communities such as lack of terrestrial vegetation, high turbidity, and steep lake basin slopes with exposed soil.

3.9.2 Bathymetric Mapping

The bathymetric map for Pit 122 Lake obtained as a result of this study is presented in Figure 16.

3.9.3 Macrophyte Surveys and Analysis

No macrophytes were observed during visual surveys and no macrophytes were detected by sonar in Pit 122 Lake.

3.10 RELATIONSHIPS BETWEEN MACROPHYTE COMMUNITIES AND AGE OF END-PIT LAKES

3.10.1 Taxonomic Richness

Taxonomic richness of macrophyte communities in end-pit lakes in the CVM area increases significantly with the age of the end-pit lake ($R^2 = 0.88$, $P < 0.001$; Figure 17). Results show that end-pit lakes in the CVM area require a minimum of 4 to 5 years in order to begin developing a community. This relationship is significant in the shallow areas (0 m to 1.5 m depth) of the end-pit lakes as well ($R^2 = 0.72$, $P < 0.01$) and greater depths ($R^2 = 0.83$, $P < 0.001$; $R^2 = 0.83$, $P < 0.001$ for >1.5 m to 3 m and >3 m to 5 m depth categories, respectively), there is a trend towards increasing taxonomic richness of macrophyte communities with increasing age of end-pit lakes at these greater depths (Figure 17).

3.10.2 Biovolume of Macrophytes

Similar to taxonomic richness, mean macrophyte biovolume in end-pit lakes in the CVM area generally increases with age, but at more shallow depths ($R^2 = 0.44$, $P = 0.07$; Figure 18). Results show that as the end-pit lakes mature, macrophyte communities continue developing, however, the rate of development changes with increasing depth (0 m to 1.5 m: $R^2 = 0.62$, $P < 0.05$; >1.5 m to 3 m: $R^2 = 0.41$, $P = 0.08$; >3 m[1]: $R^2 = 0.44$, $P = 0.24$; Figure 18). Colonization of macrophytes is greatest in shallow areas of the lake, moving to deeper areas more gradually.

4.0 DISCUSSION

4.1 MACROPHYTE DEVELOPMENT IN END-PIT LAKES

Several factors including sediment type, depth, and water chemistry can influence macrophyte colonization and growth (Barko et al. 1986; Duarte and Kalff 1986; Duarte et al. 1986; Lacoul and Freedman 2006; Caffrey et al. 2007; Gammons et al. 2009). End-pit lakes have been documented to go through four stages during the development of macrophytes (Gammons et al. 2009). These stages cover the initial stage after creation where no macrophytes are present in pit lakes, through to transition stages and lastly, the “old-age” stage (Gammons et al. 2009). End-pit lakes in the CVM area that were surveyed in this study generally reflected these various stages demonstrating movement towards increasingly diverse and abundant macrophyte communities with increasing age. Only one end-pit lake, the youngest (Pit 122 Lake), at four years of age, had no vegetation growth. Results indicate that after end-pit lakes are created, they require a minimum of 4 to 5 years before macrophyte establishment begins. In the CVM area, macrophyte colonization in end-pit lakes begins in shallow areas (i.e., 0 to 1.5 m depth). Development of areas >1.5 m begins after five years, gradually increasing establishment and richness of macrophytes in deeper areas. Overall, the greatest increases in macrophyte establishment (biovolume and taxonomic richness appears to occur after end-pit lakes reach 10 years of age.

Taxonomic richness of macrophyte communities in end-pit lakes in the CVM area has been shown in this study to increase with age of end-pit lake across each depth category. The two oldest end-pit lakes, Lovett and Silkstone at 28 years, contained the highest taxonomic richness in the macrophyte community. A total of 13 taxa (excluding unknown species) were found across all end-pit lakes. Shallow sections of end-pit lakes (0 to 1.5 m) contain greater taxonomic richness than deeper areas. Each end-pit lake, when organized by age displayed trends on community composition. Macrophyte communities in younger end-pit lakes are generally comprised of known “pioneer” species such as mare’s tail, bryophytes, algae species, *Chara* species, large-sheath pondweed and narrowleaf bur-reed. Some macrophyte species, such as white water buttercup, vernal starwort and small-leaf pondweed, were only found in older end-pit lakes (>20 years old). Overall, it appears the greatest increase in taxonomic richness in macrophytes occurs after an end-pit lake reaches 10 years of age.

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[1] Biovolume was calculated from sonar output data for all depths surveyed in end-pit lakes and therefore exceeds the maximum depth used in visual surveys of 5 m.

Similarly, biovolume of macrophytes in end-pit lakes in the CVM area has also been shown in this study to increase with end-pit lake age, although there is greater variability in this relationship among end-pit lakes than the relationship between taxonomic richness and end-pit lake age. It should be noted that the biovolume data used in this analysis were generated from data obtained over the entire end-pit lakes and therefore included lake depths that in many cases exceeded depths that macrophytes can be reasonably expected to occur. The growth of many macrophyte species is optimal at depths less than 2 m, but range to maximum of 9 m (Caffrey et al. 2007). Biovolume of macrophytes overall was low in areas greater than 3 m in depth. In shallow areas, biovolume has significantly increased over time and is highest overall in those parts of the end-pit lakes 0 m to 1.5 m in depth. Silkstone Lake, an end-pit lake that is 28 years old contains the largest biovolume of macrophytes among the end-pit lakes that were surveyed in this study.

4.2 CONCLUSIONS AND RECOMMENDATIONS

The results of this study suggest that end-pit lakes in the CVM area, as measured by macrophyte communities, become more biologically-productive with age. The oldest end-pit lakes in this study, Lovett and Silkstone lakes are examples of end-pit lakes that over time have developed into productive systems supporting aquatic life. The presence of increasingly diverse and abundant (biovolume) macrophyte communities suggests that reclaimed end-pit lakes in the CVM area can develop the macrophyte component of the ecological requirements for fish populations. The performance of macrophyte establishment in end-pit lakes however has not been compared against natural lakes. A method to verify the success of developing aquatic communities in end-pit lakes would be a direct comparison against nearby natural lakes (e.g., Fairfax Lake). This would provide the opportunity to evaluate the development of macrophytes (taxonomic richness and biovolume across various depths) in end-pit lakes against a natural lake ecosystem.

Macrophytes are ecologically-important in maintaining fish productivity by supporting many life history stages of fish populations (Randall et al. 1996; Olson et al. 1998; Gammons et al. 2009). Studies from other lakes have linked macrophyte abundance with significantly higher densities of small fish in comparison to areas lacking vegetation (Olson et al. 1998; Randall et al. 1996). Aquatic vegetation in lakes provides feeding opportunities through the support of the invertebrate community and habitat diversity as cover structures (Barko et al. 1986).

To encourage macrophyte communities in the early stages of development of end-pit lakes in the CVM area, introduction of aquatic vegetation may be manually initiated through the dispersal of seeds, or transplant of whole plants, winter buds or tubers (Alberta Environment 1989; Lacoul and Freedman 2006). Seeds and plant donors can be attained from other developed lakes in the area, and should focus on known native, pioneer or early colonizing species such as mare's tail (*Hipprus vulgaris*), Canada waterweed (*Elodea canadensis*), and pondweed species (*Potamogeton* spp). These species are associated with higher production, and in particular, mare's tail is known to establish well in areas following environmental disturbance (Lacoul and Freedman 2006). Canada waterweed has also been documented to successfully grow at depths of up to 12 m (Caffrey et al. 2007).

If manual planting is to be undertaken, it is recommended that it occur in shallow, sheltered areas of the end-pit lakes. As seen in the results of this study, highest taxonomic richness and biovolume of macrophytes were found in depths of 0 m to 1.5 m. Areas with steep slopes and/or areas that are exposed to wave action will decrease the success of vegetation establishment (Canfield et al. 1985; Barko and Smart 1986; Duarte and Kalff 1986; Olson et al. 1998). Depths of tuber transplant should not exceed 2 m due to light requirements of plants, and should avoid sandy, rocky or organic rich sediment (Canfield et al. 1985; Caffrey et al. 2007).

Similar to Lovett and Silkstone lakes, enhancing riparian areas of young end-pit lakes in the CVM area would greatly contribute to end-pit lake productivity. Factors such as slope can have significant impacts on developing vegetation. Sediment run-off into lakes caused by erosion on steep slopes can inhibit productivity by smothering vegetation and other aquatic life (Lacoul and Freedman 2006). Areas with gradual slopes in the littoral areas of end-pit lakes are optimal establishment sites for vegetation and would contribute to species diversity, as well as habitat diversity for both aquatic and terrestrial life. Pioneer species that establish in the transitional riparian-littoral zone include emergent species such as cattails (*Typha* spp), bulrushes (*Scirpus* spp) and sedges (*Carex* spp) (Gammons et al. 2009). Tree and brush plantation would provide short-term and long-term benefits for the aquatic and terrestrial environments. Benefits would include the reduction of erosion and runoff, contributions of woody debris, and increasing nutrient input into the end-pit lake building a foundation for the development of trophic levels to support fish populations (Gammons et al. 2009).

Figure 1 Location of lakes sampled in current study.

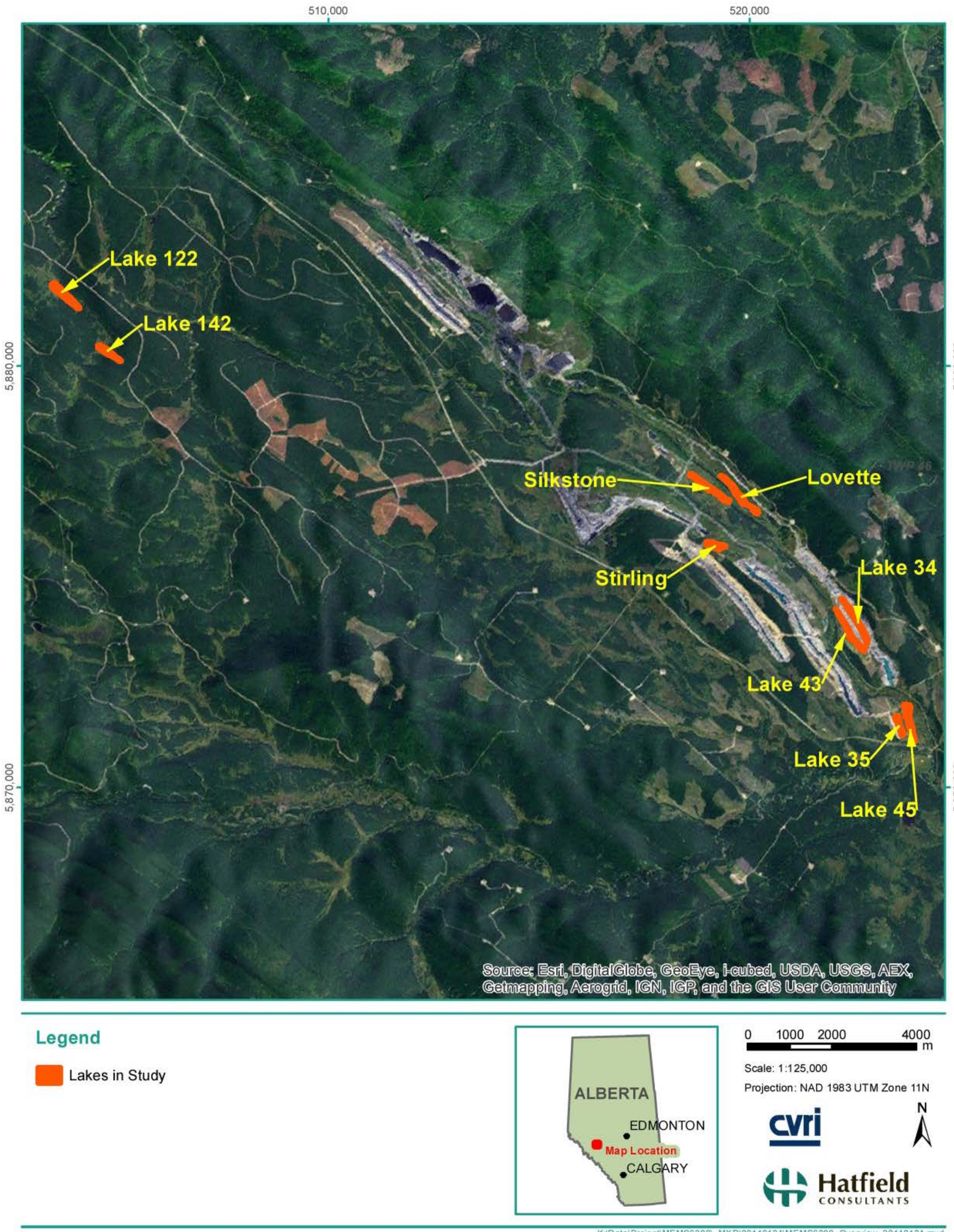


Figure 2 Bathymetric map of Lovett Lake.

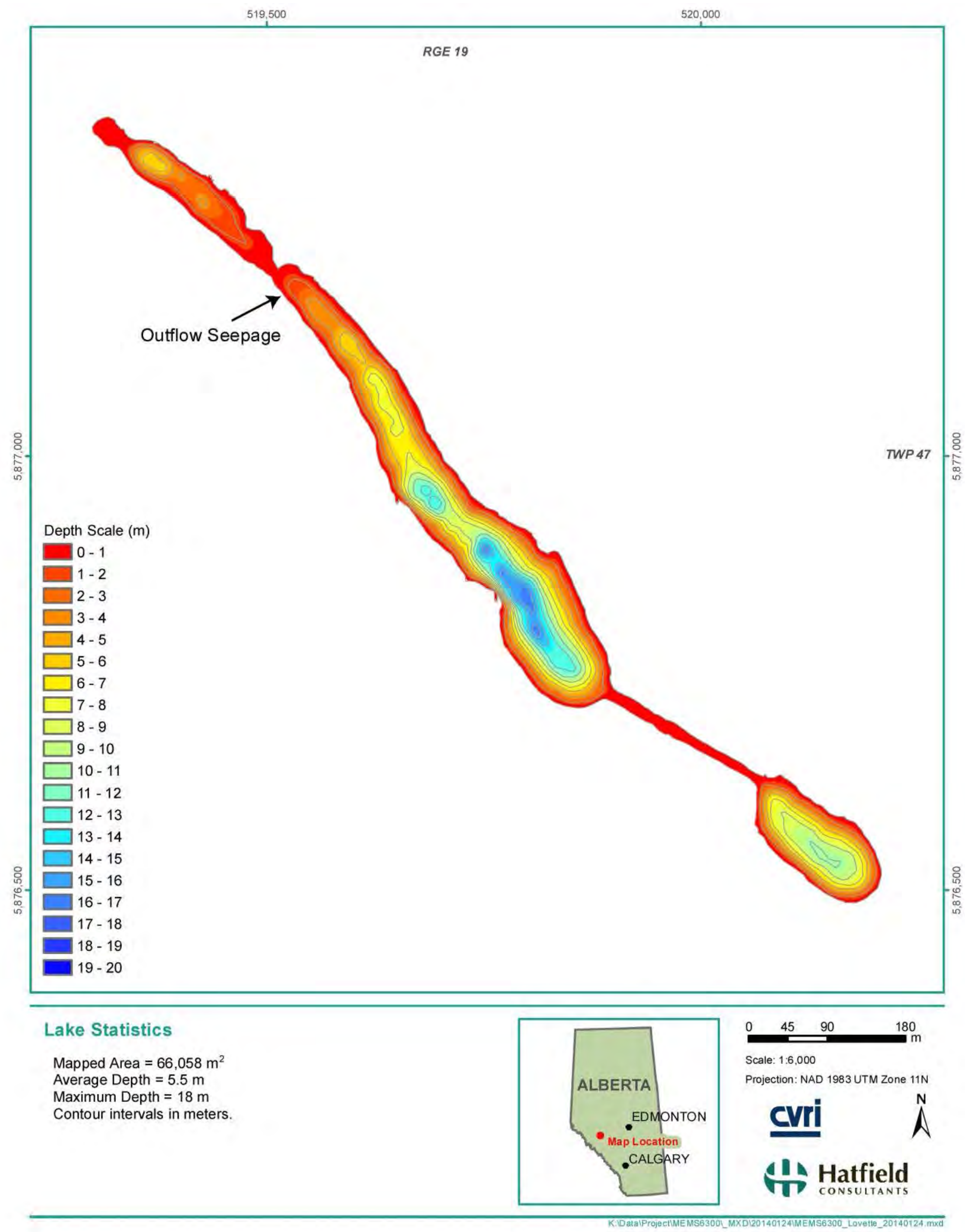


Figure 3 Biovolume map of Lovett Lake.

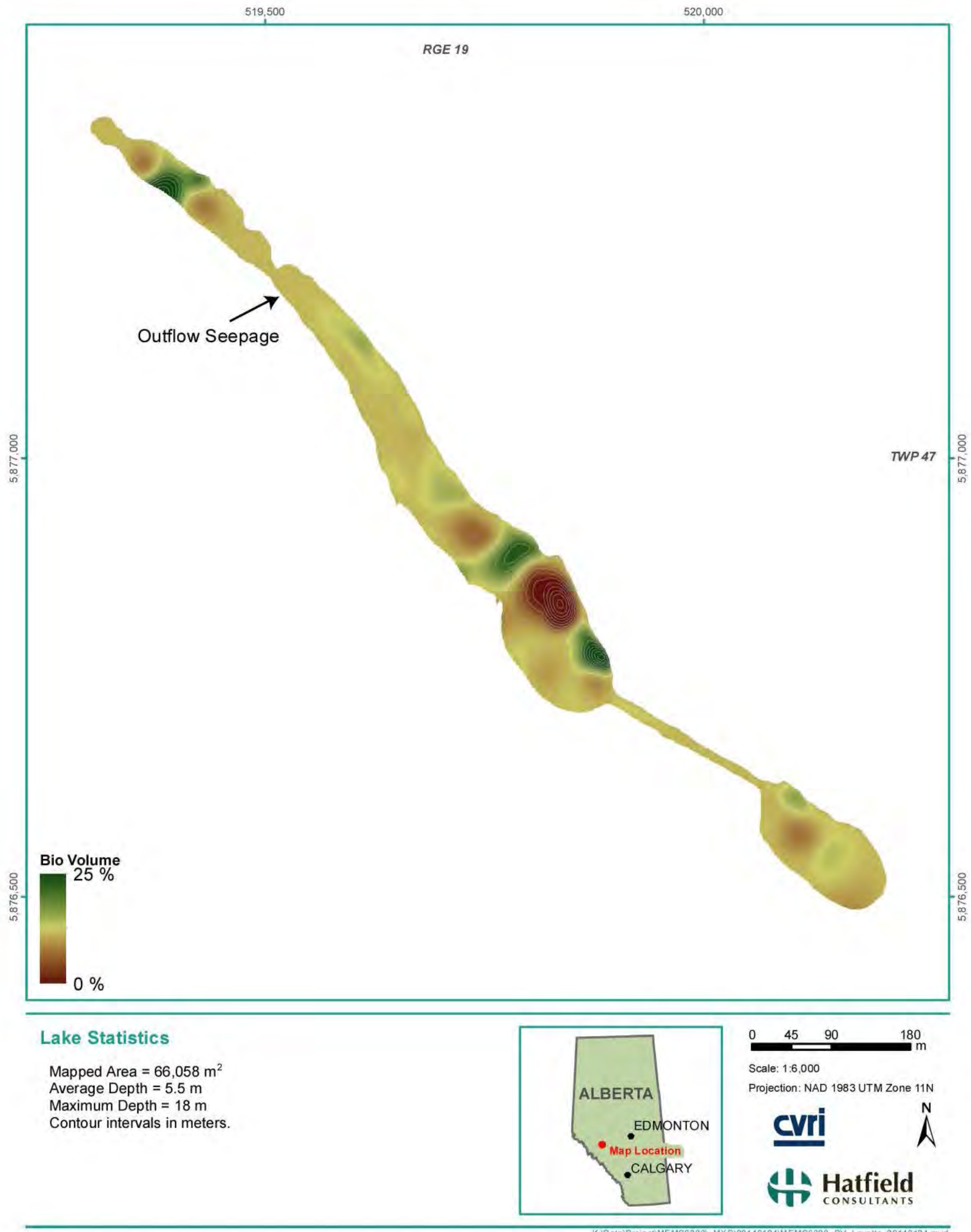


Figure 4 Bathymetric map of Silkstone Lake.

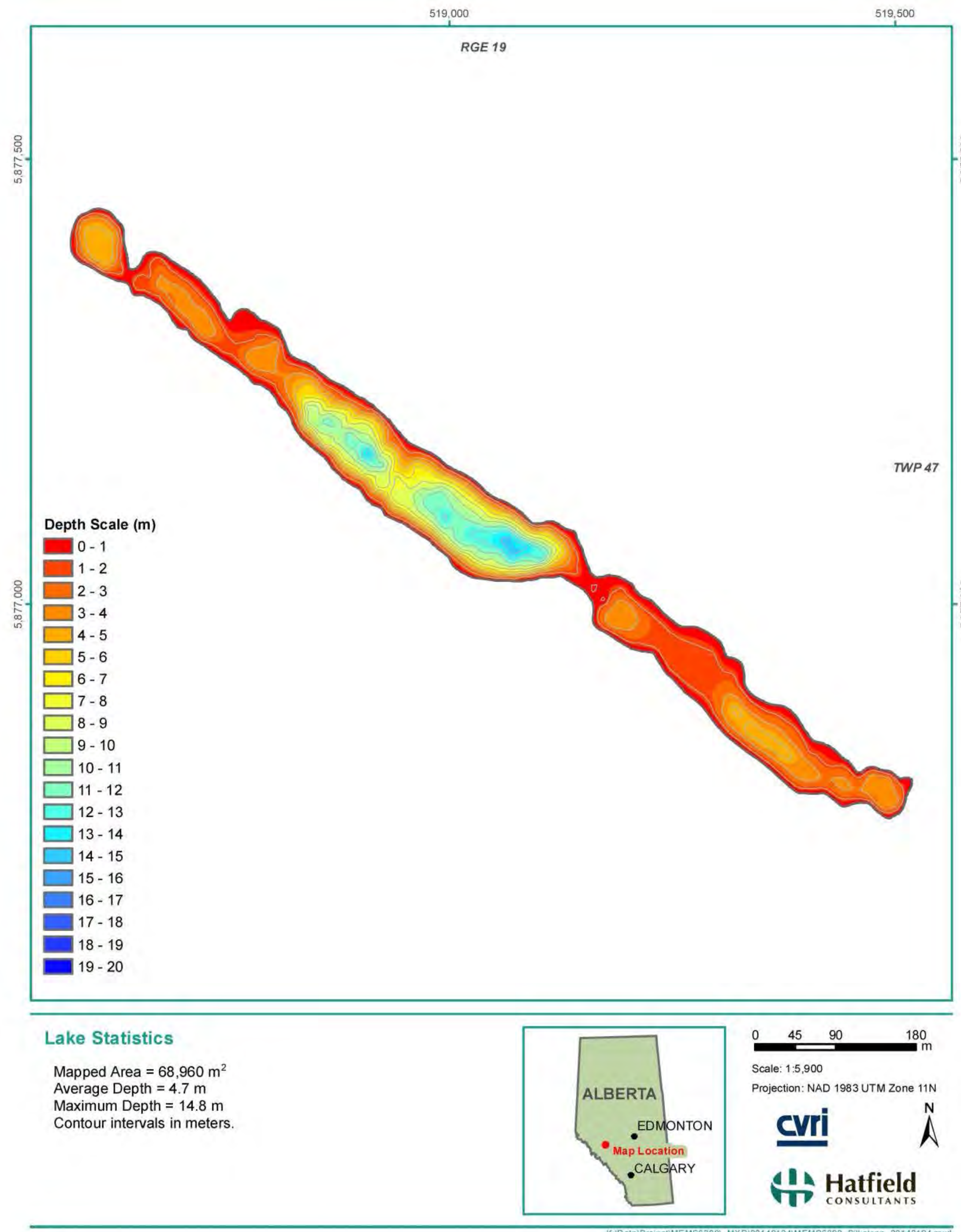


Figure 5 Biovolume map of Silkstone Lake.

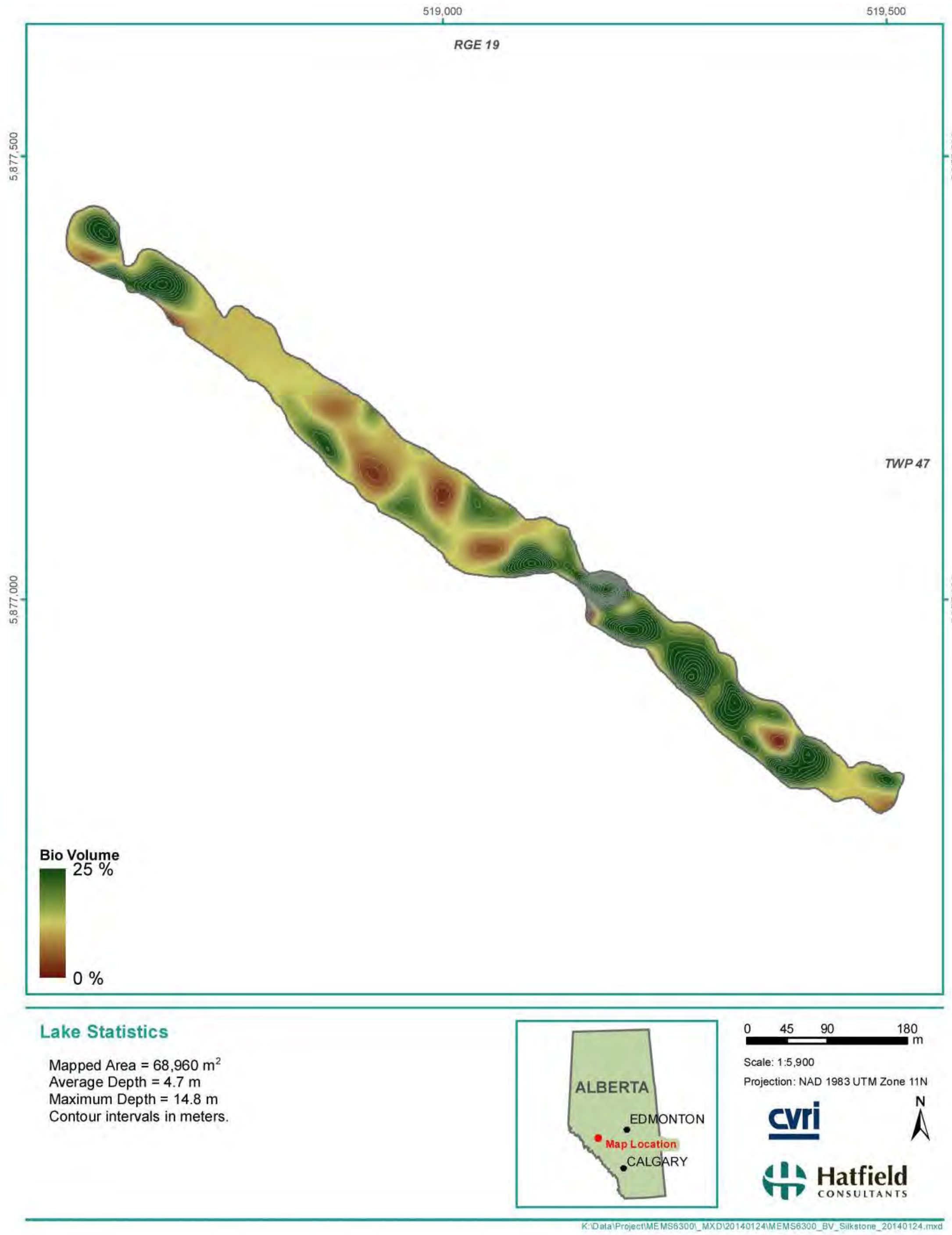


Figure 6 Bathymetric map of Stirling (Pit 24) Lake.

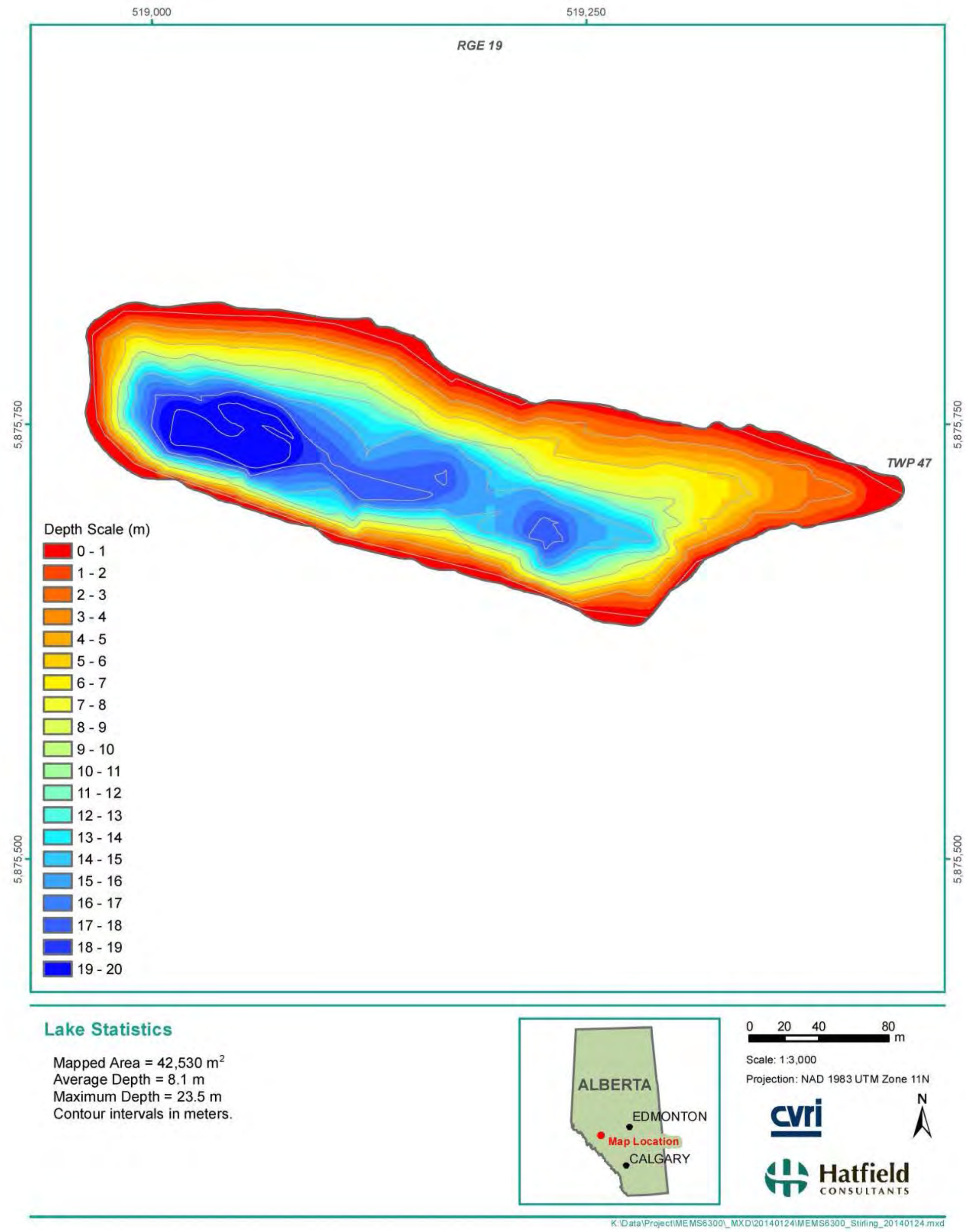


Figure 7 **Biovolume map of Stirling (Pit 24) Lake.**

Figure 8 Bathymetric map of Pit 35 Lake.

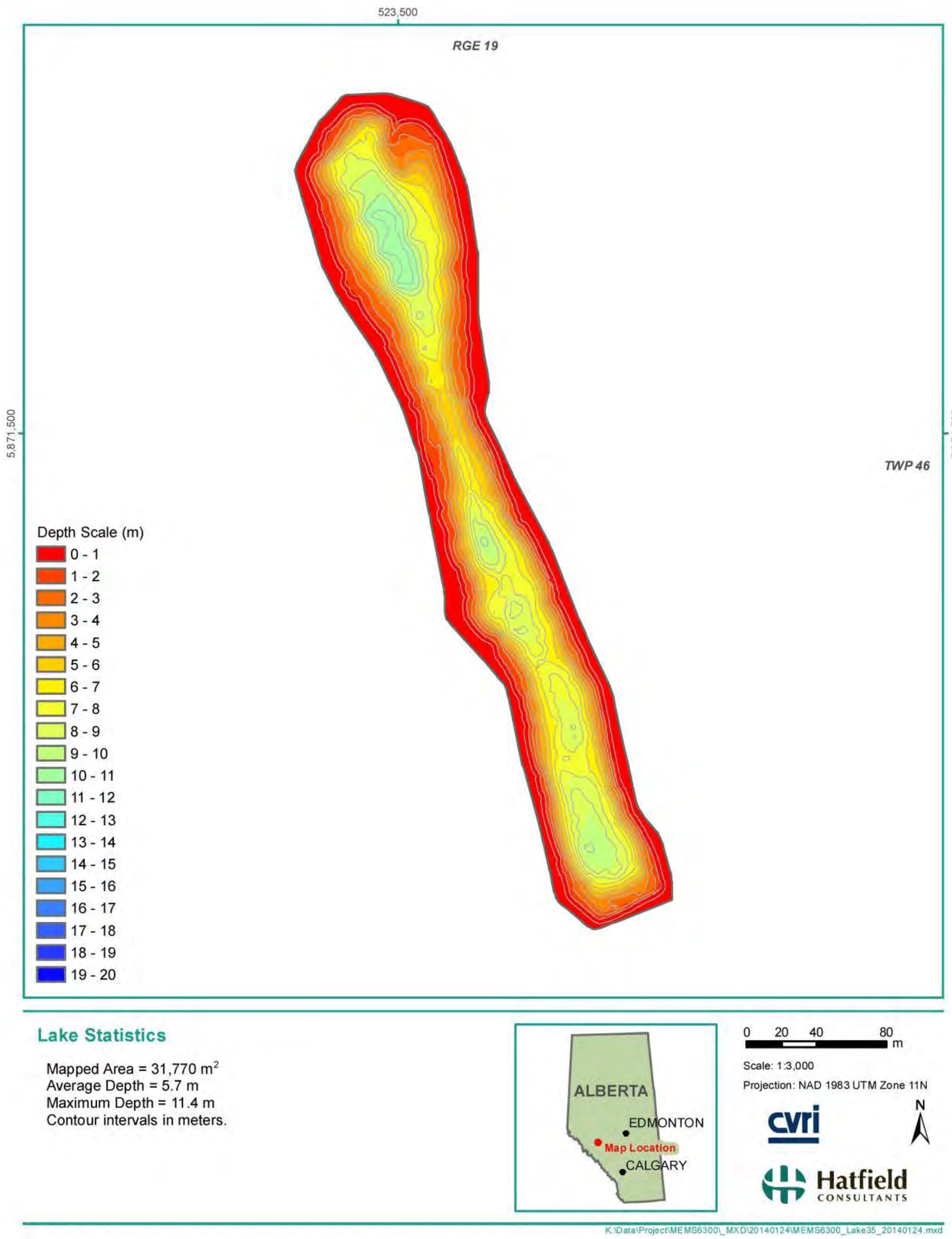


Figure 9 Biovolume map of Pit 35 Lake.

Figure 10 Bathymetric map of Pit 45 Lake.

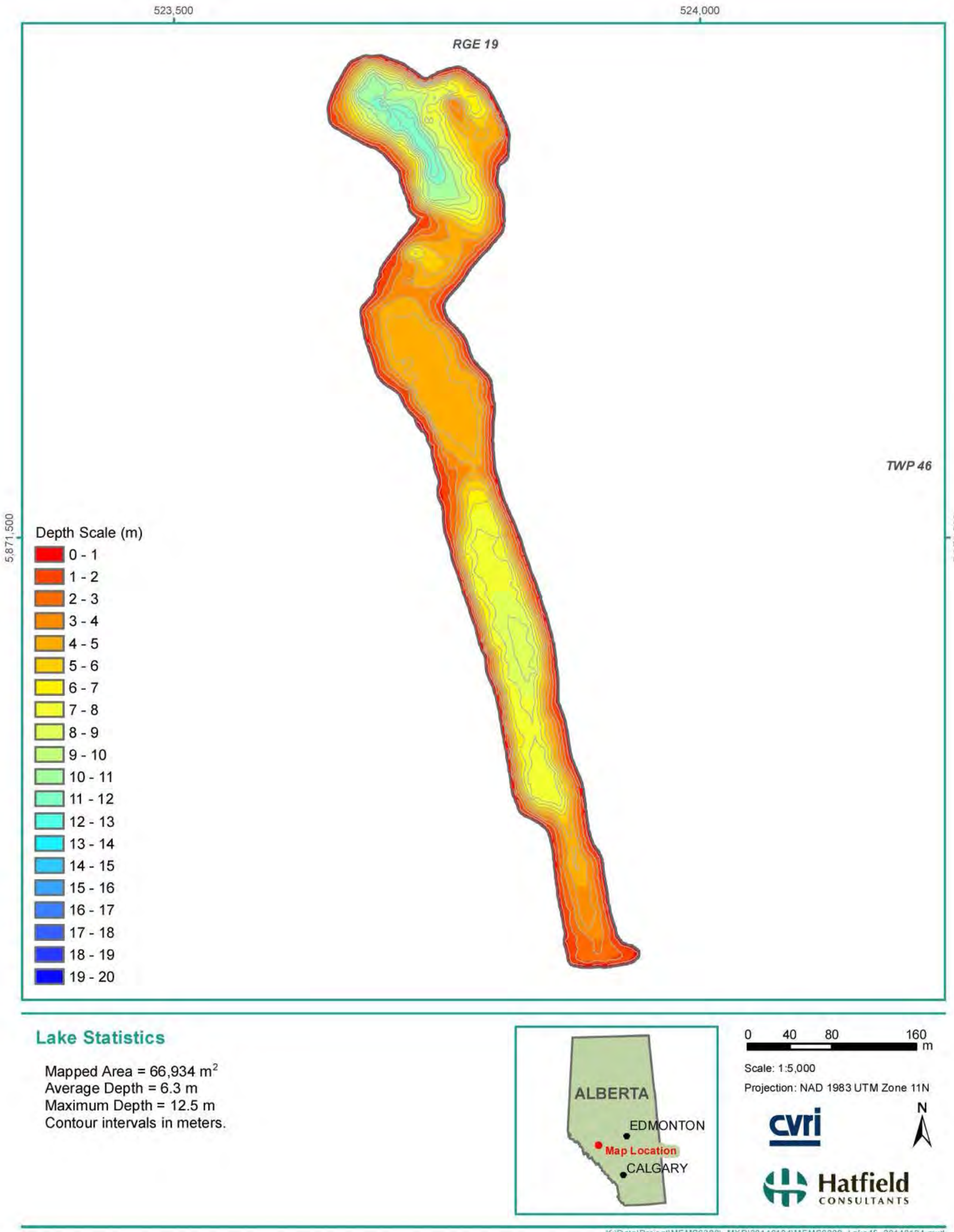


Figure 11 Biovolume map of Pit 45 Lake.

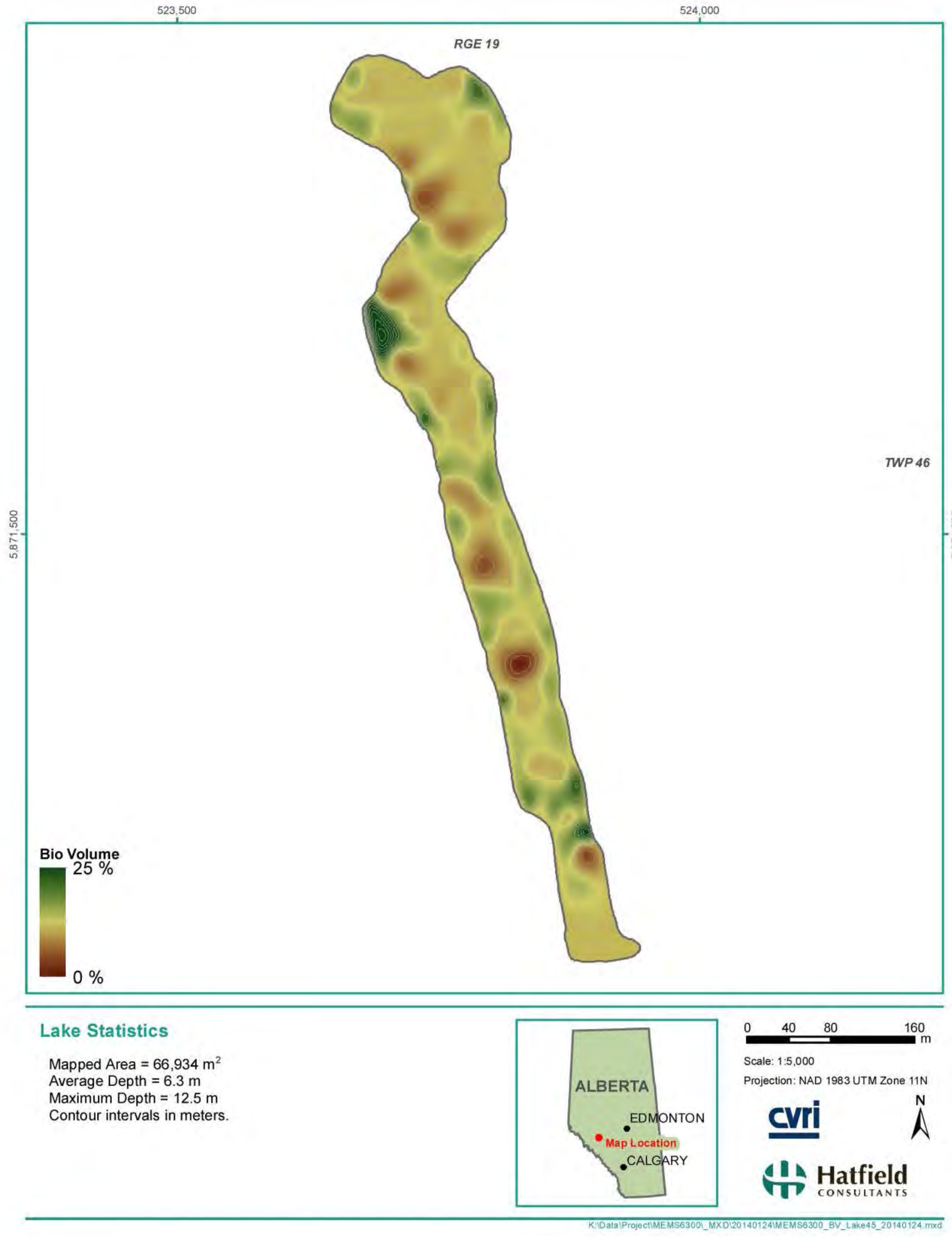


Figure 12 Bathymetric map of Pit 142 Lake.

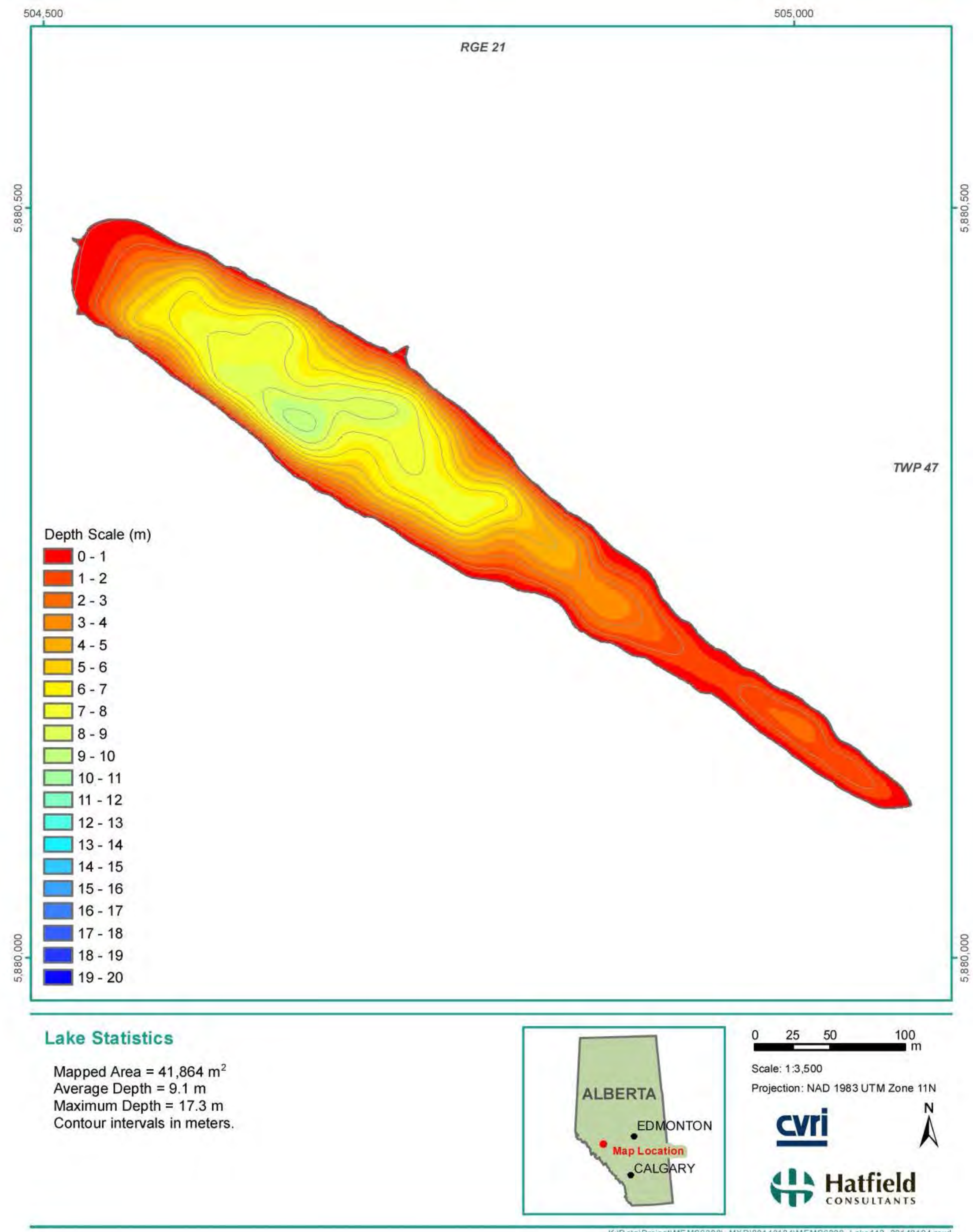


Figure 13 Biovolume map of Pit 142 Lake.

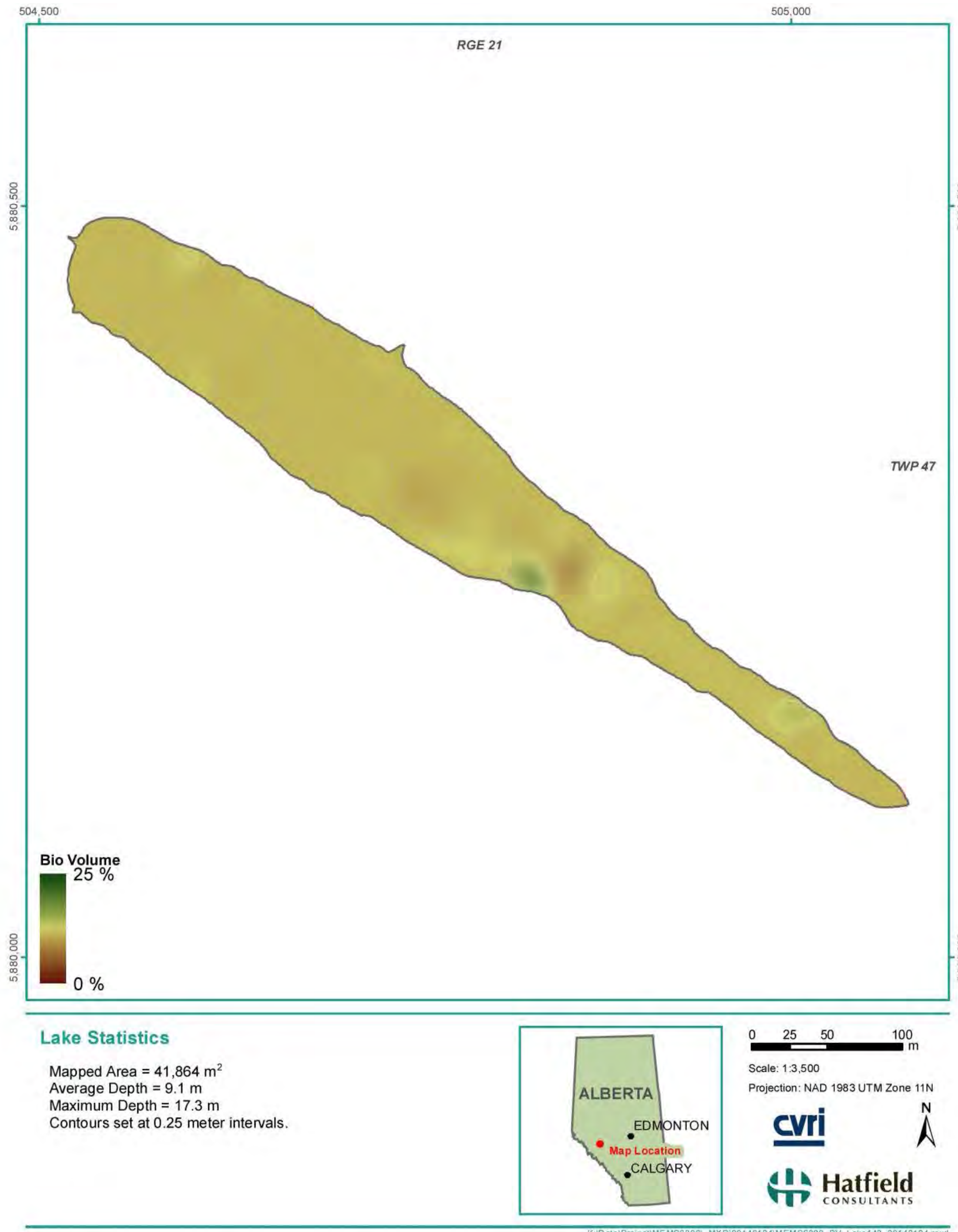


Figure 14 Bathymetric map of Pit 34 Lake.

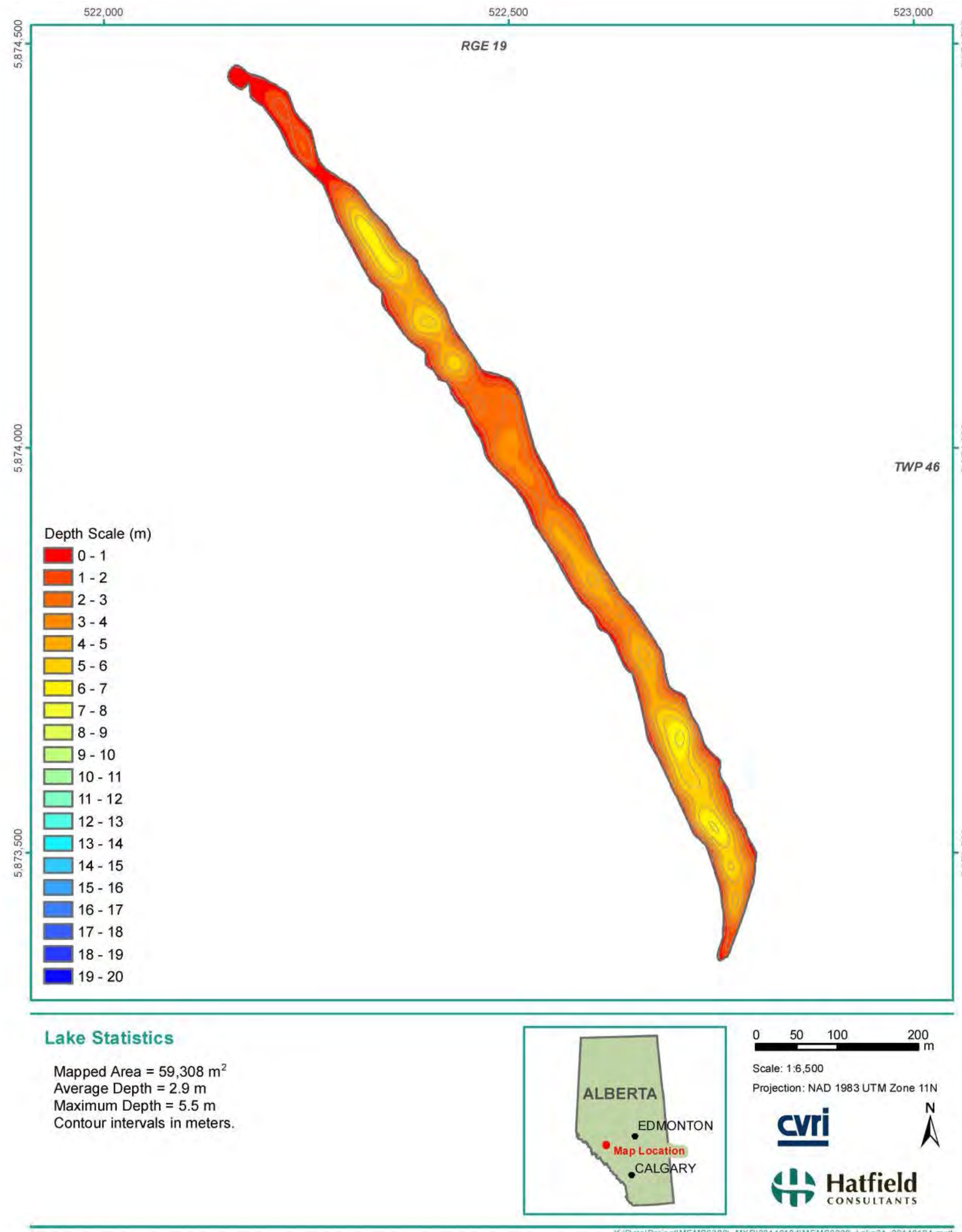


Figure 15 Biovolume map of Pit 34 Lake.

Figure 16 Bathymetric map of Pit 122 Lake.

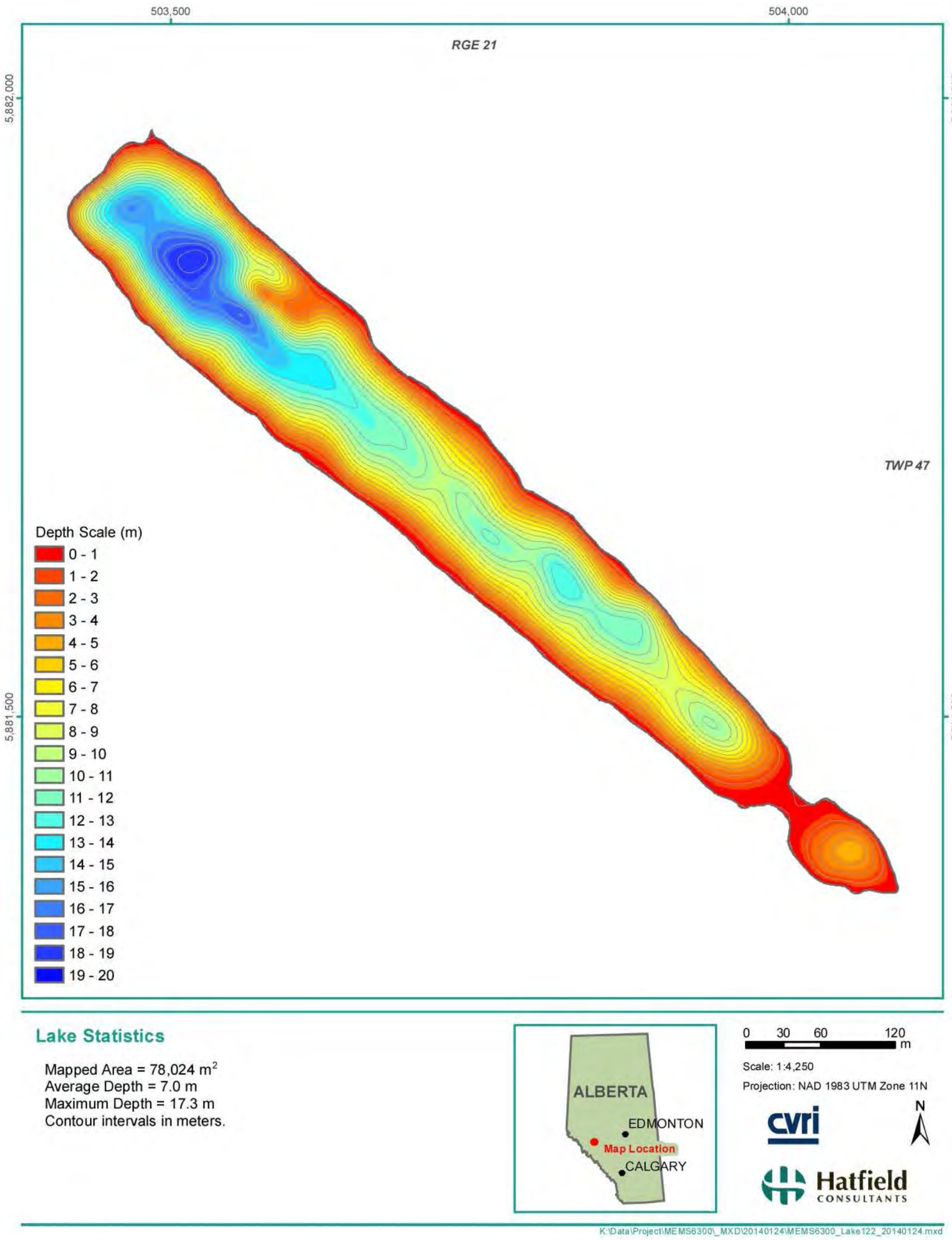


Figure 17 Relationships between macrophyte taxonomic richness and age of end-pit lakes.

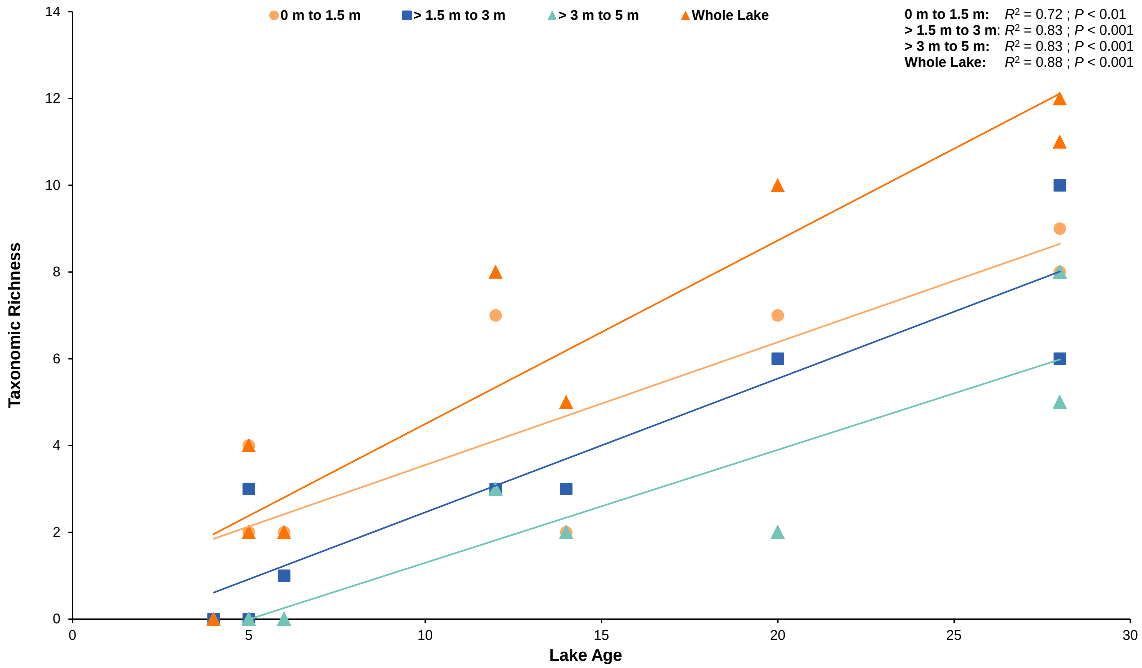
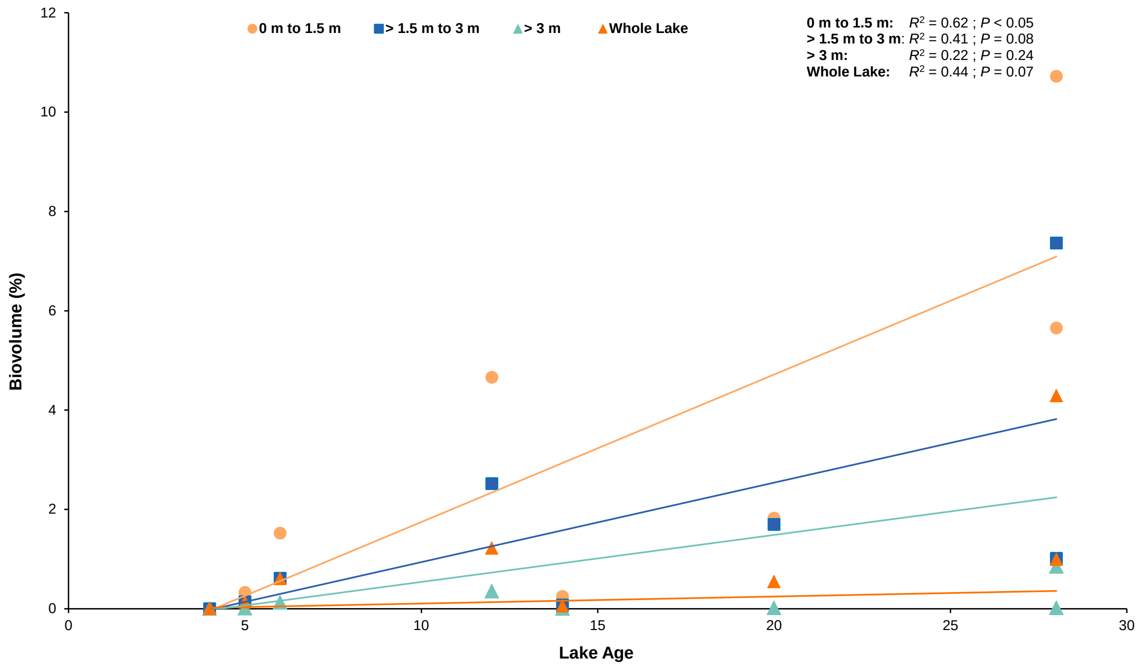


Figure 18 Relationships between biovolume of macrophytes and age of end-pit lakes.



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6.0 CLOSURE

We trust the above information meets your requirements. If you have any questions or comments, please contact the undersigned.

HATFIELD CONSULTANTS:

<original signed by>

Approved by: ______________________________ February 19, 2014

Sarah Quesnelle
Project Manager

Date

Approved by: <original signed by>

______________________________ February 19, 2014

Peter McNamee
Project Director

Date

APPENDICES

Appendix A1

Sonar Imagery and Underwater Photography

APPENDIX A1 - SONAR IMAGERY AND UNDERWATER PHOTOGRAPHY

Figure A1.1 Example of a transect echogram taken from Silkstone Lake. Increasing colour warmth (i.e., increasing blue to red) corresponds to increased reflection of objects in the water column including macrophytes and lake bottom.

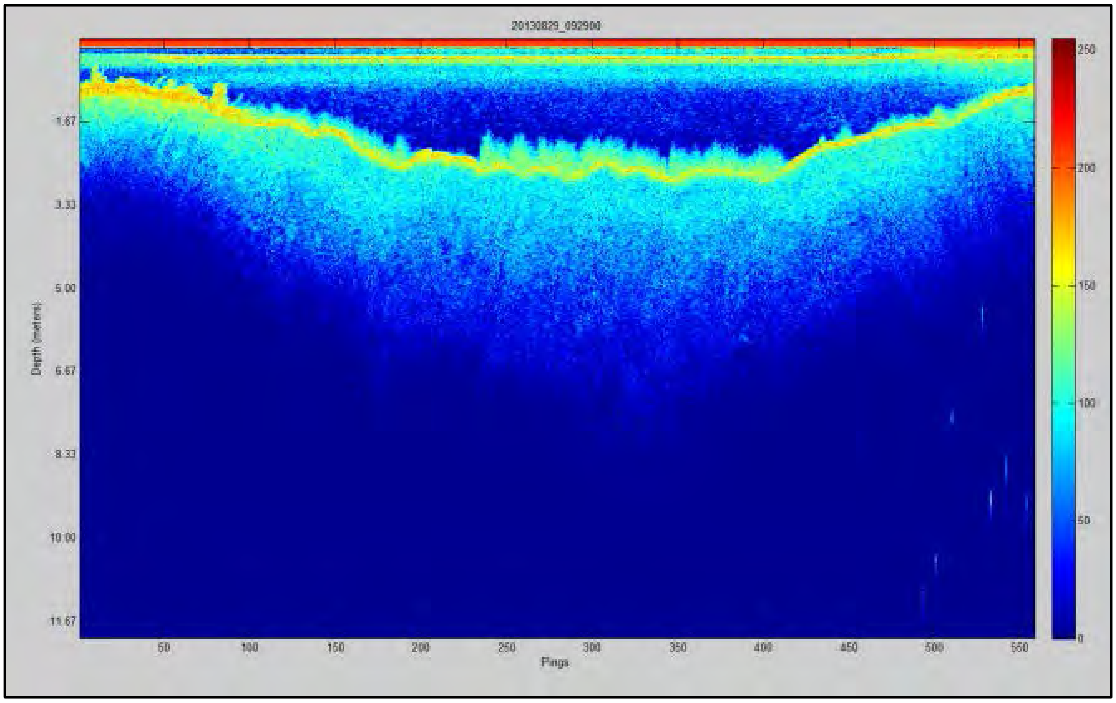


Figure A1.2 Example of graphic output of a transect in Silkstone Lake from SAVEWS Jr. software using the configuration files and echograms used to interpret recorded data of lake depth and macrophyte canopy height.

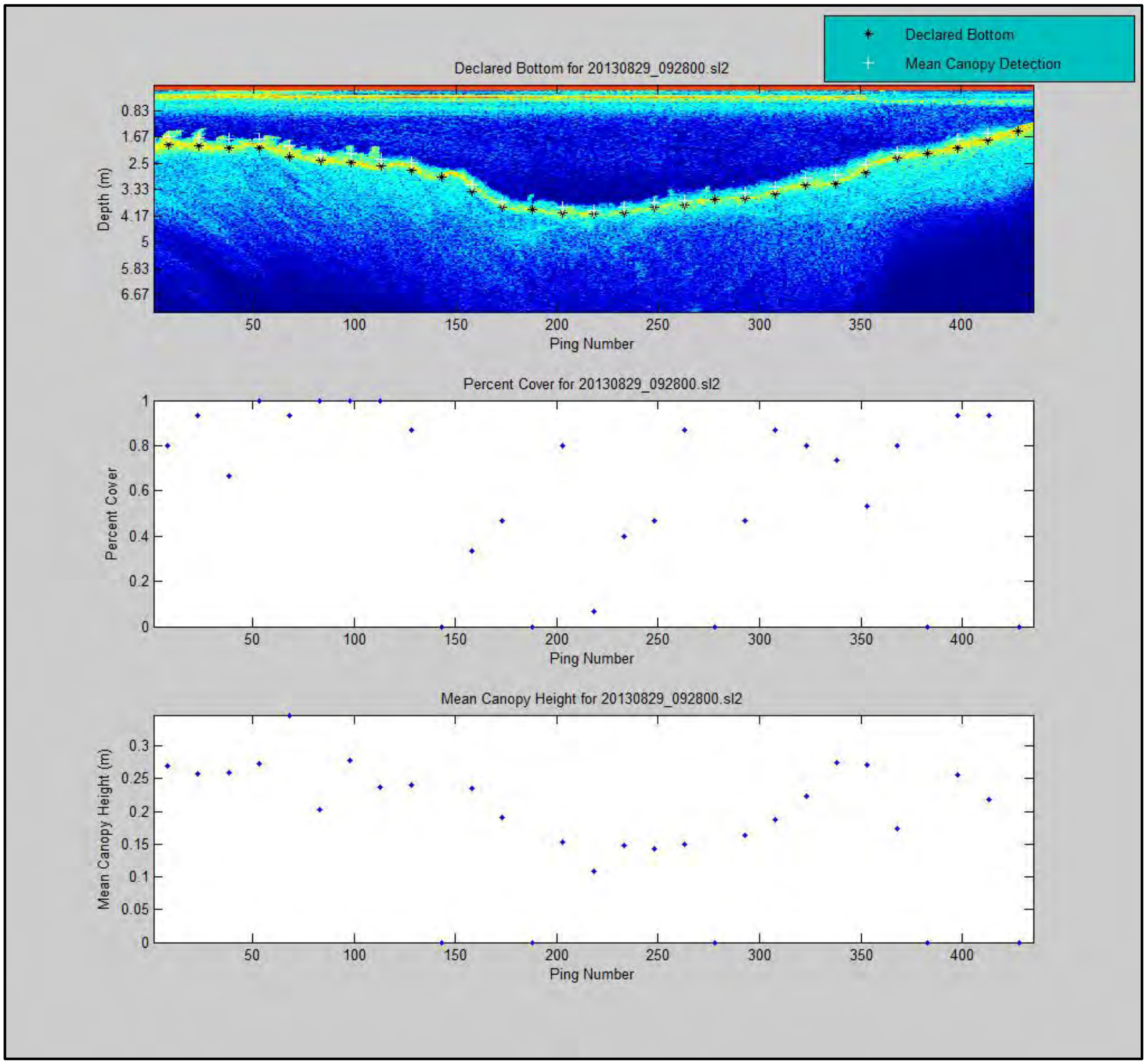


Figure A1.3   Underwater photo of macrophytes from Lovett Lake.

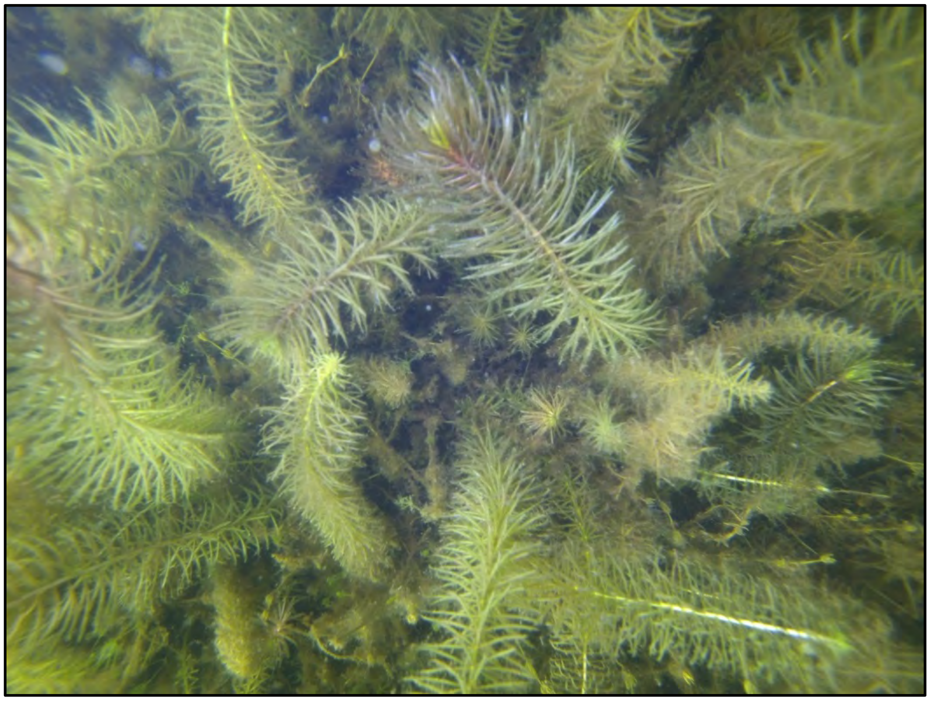


Figure A1. 4 Underwater photo of aquatic macrophyte community from Lovett Lake.

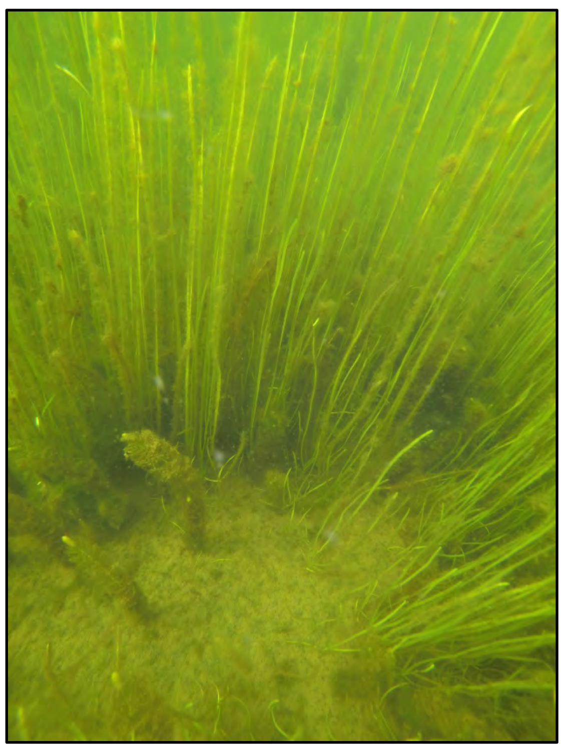
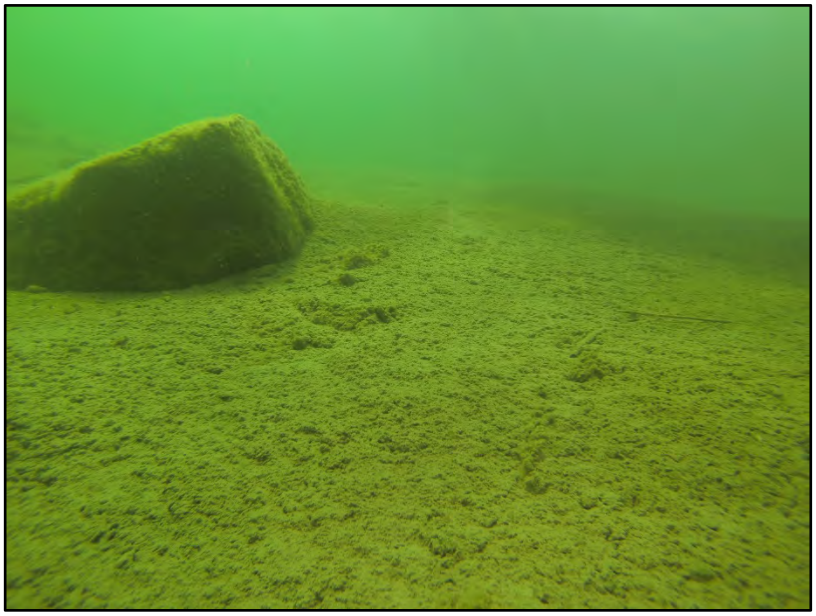


Figure A1.5 Underwater photo of lake bottom lacking vegetation of Pit 35 Lake.



Appendix A2

Macrophyte Composition in End-Pit Lakes

Table A2 Macrophyte compostition of end-pit lakes (whole lake and individual depth categories).

Scientific name	*Chara* species	*Potamogeton vaginatus*	*Potamogeton richardsonii*	*Sparganium augustifolium*	*Myriophyllum exalbescens*	*Bryophytes*	*Ceratophyllum demersum*		*Ranunculus circinatus*	*Hipprus vulgaris*	*Callitriche palustris*	*Potamogeton zosteriformis*	*Potamogeton pusillus*	
Common name		**Large-Sheath Pondweed**	**Richardson Pondweed**	**Narrowleaf bur-reed**	**Northern Watermilfoil**		**Coontail**	**Algae**	**White Waterbuttercup**	**Mare's Tail**	**Vernal Starwort**	**Flat-stemmed pondweed**	**Small-Leaf Pondweed**	**Unknown species**
Lovett Lake														
0 m to 1.5 m Composition (%)	4.5	5.5	2.0	25.5	11.0	27.0	0.0	1.5	0.0	23.0	0.0	0.0	0.0	0.0
> 1.5 m to 3 m Composition (%)	7.5	14.5	0.5	27.5	24.0	9.0	5.0	3.5	0.0	8.0	0.0	0.0	0.5	0.0
> 3 m to 5 m Composition (%)	13.6	0.0	0.0	13.1	17.6	17.1	0.0	10.6	0.0	14.6	0.0	0.0	8.5	5.0
Whole Lake Composition (%)	8.5	6.7	0.8	22.0	17.5	17.7	1.7	5.2	0.0	15.2	0.0	0.0	3.0	1.7
Silkstone Lake														
0 m to 1.5 m Composition (%)	20.0	15.3	8.0	3.7	7.3	2.2	0.0	0.0	2.0	37.5	0.0	0.0	4.0	0.0
> 1.5 m to 3 m Composition (%)	47.5	0.0	0.0	0.0	0.6	23.1	13.8	1.3	0.0	0.0	0.0	0.0	0.0	13.8
> 3 m to 5 m Composition (%)	17.8	0.0	0.0	0.0	0.0	4.4	0.0	12.2	0.0	0.0	0.0	0.0	11.1	54.4
Whole Lake Composition (%)	27.4	5.7	3.0	1.4	2.9	9.1	4.1	4.4	0.7	13.9	0.0	0.0	5.2	22.2
Stirling Lake														
0 m to 1.5 m Composition (%)	0.0	26.9	0.0	0.8	7.7	9.2	0.0	0.0	0.0	29.2	15.4	0.0	10.8	0.0
> 1.5 m to 3 m Composition (%)	20.0	4.4	0.0	0.0	47.8	0.0	14.4	0.6	0.0	12.8	0.0	0.0	0.0	0.0
> 3 m to 5 m Composition (%)	85.7	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Lake Composition (%)	34.7	9.6	0.0	0.2	25.8	2.7	5.8	0.2	0.0	13.5	4.4	0.0	3.1	0.0
Pit 35 Lake														
0 m to 1.5 m Composition (%)	0.0	0.0	0.0	0.0	0.0	66.7	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 1.5 m to 3 m Composition (%)	66.7	16.7	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0
> 3 m to 5 m Composition (%)	75.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Lake Composition (%)	53.8	7.7	0.0	0.0	0.0	15.4	7.7	15.4	0.0	0.0	0.0	0.0	0.0	0.0
Pit 45 Lake														
0 m to 1.5 m Composition (%)	56.7	13.1	3.5	0.7	8.0	16.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
> 1.5 m to 3 m Composition (%)	96.7	1.8	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 3 m to 5 m Composition (%)	85.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3
Whole Lake Composition (%)	78.9	5.7	1.3	0.3	3.5	5.9	0.0	0.0	0.0	0.0	0.0	0.7	0.0	3.7
Pit 142 Lake														
0 m to 1.5 m Composition (%)	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0
> 1.5 m to 3 m Composition (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 3 m to 5 m Composition (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Lake Composition (%)	0.0	0.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0
Pit 34 Lake														
0 m to 1.5 m Composition (%)	0.0	25.0	0.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 1.5 m to 3 m Composition (%)	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 3 m to 5 m Composition (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Lake Composition (%)	0.0	50.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pit 43 Lake														
0 m to 1.5 m Composition (%)	85.2	11.8	0.0	0.0	0.0	0.4	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0
> 1.5 m to 3 m Composition (%)	61.7	6.7	0.0	0.0	0.0	0.0	0.0	31.7	0.0	0.0	0.0	0.0	0.0	0.0
> 3 m to 5 m Composition (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Whole Lake Composition (%)	81.1	10.9	0.0	0.0	0.0	0.3	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0

Pisces Environmental Consulting Services Ltd.

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August 21, 2013

CVRI
Coal Valley Mine
Bag 5000
Edson, Alberta
T7E 1W1

ATTN: Megan Hill

RE: Recommendations for channel enhancement in the Embarras Lakes End Pit Lake System.

1.0 Introduction

Pisces Environmental Consulting Services Ltd. (Pisces) is conducting ongoing fisheries monitoring in the Embarras Lakes end-pit lake system located in 25-47-21-W5. As requested, the following summarizes Pisces' recommendations for habitat enhancement of the connecting channels in the Embarras Lakes End Pit Lake System. Information provided is based on data gathered from site investigations conducted in May, June, and July 2013 as well as water temperature monitoring and habitat utilization studies that have been ongoing since 2011.

2.0 Background

In August 2004, Fisheries and Oceans Canada (DFO) issued Fisheries Act Authorization ED-03-3080 to Coal Valley Resources Incorporated (CVRI) for the diversion of the Embarras River to facilitate mining in the Mercoal Phase 1 (MP1) area. Part of the final reclamation strategy for the MP1 extension included the development of an end pit lake system that would support a self-sustaining native fish population.

The Embarras End Pit Lake system is located in the extreme headwaters of the Embarrass River in 25-47-21-W5. The Embarras River flows into the McLeod River approximately 86 kilometers downstream of the lakes, which in turn flows into the Athabasca River near Whitecourt, Alberta. Historically, fish densities in the upper Embarras River were low and pre-mining investigations of this part of the river found fish habitat potential to be limited (Boorman 2003). Habitat diversity within this area was considered to be marginal and substrates were comprised almost exclusively of fines (Boorman 2003). However, Rainbow Trout (Oncorhynchus mykiss), Bull Trout (Salvelinus confluentus) and Brook Trout (Salvelinus fontinalis) were found just downstream of the proposed MP1 pit area during baseline investigations (Boorman 2003).

The Embarras End Pit Lake system consists of three lakes and approximately 1100 metres of constructed connecting channels. The naming convention for the lakes is as follows:

- Upper Embarras Lake (Pit 142E);
- Middle Embarras Lake (Pit 122); and
- Lower Embarras Lake (Pit 122).

The Embarras River enters the Upper Lake from a beaver pond via a constructed inlet channel that is approximately 30 metres long (Upper Embarras Channel). There are approximately 500 metres of connecting channel between the Upper and Middle Lakes (Middle Embarras Channel B) including the haulroad culvert crossing that is located just upstream of the Middle Lake. Between the Middle Lake and Lower Lake there is approximately 150 metres of connecting channel (Middle Embarras Channel A) and there is approximately 400 metres of constructed channel downstream of the Lower Lake (Lower Embarras Channel). A fish exclusion weir has been constructed at the bottom of this constructed channel to preclude Brook Trout from entering the end pit lake system.

3.0 Recommendations

Recommendations for habitat enhancements in the constructed channels include placement of instream habitat features as well as stabilization and vegetation of streambanks. Optimally a Qualified Aquatic Environment Specialist (QAES) would be onsite to provide advice and feedback during the construction of the habitat enhancements. As summary of these recommendations and suggested enhancement locations are provided in Tables 1 to 4. Additional are provided in Sections 3.1 to 3.4 and Figures 1 to 26.

Table 1. Lower Embarras Channel (exclusion weir to Lower Embarras Lake)

Site	Location (UTM's)	Enhancement Details
Figure 1	0503422 5882249	Vegetate, tree cover installations
Figure 2	503463 5882217	Vegetate, tree cover installations
Figure 3	503495 5882187	Vegetate, gravel addition, tree cover installations
Figure 4	503513 5882166	Vegetate, gravel addition, tree cover installations
Figure 5	503544 5882127	Vegetate, tree cover installations
Figure 6	503566 5882092	Vegetate, tree cover installations
Figure 7	503563 5882058	Vegetate to maximize future shade
Figure 8	503544 5882028	Stabilize, vegetate, tree cover and gravel installations
Figure 9	503510 5882022	Stabilize, vegetate, tree cover installations
Figure 10	503492 5882014	Stabilize, vegetate, tree cover and gravel installations

Table 2. Middle Embarras Channel A (Lower Embarras Lake to Middle Embarras Lake)

Site	Location (UTM's)	Enhancement Details
Figure 11	504077 5881362	Vegetate with willows and conifers.
Figure 12	504112 5881343	Vegetate, gravel addition, tree cover installations

Table 3. Middle Embarras Channel B (Middle Embarras Lake to Upper Embarras Lake)

Site	Location (UTM's)	Enhancement Details
Figure 13	504746 5880771	Vegetate with willows and conifers.
Figure 14	504793 5880736	Vegetate with willows and conifers.
Figure 15	504863 5880695	Vegetate, gravel addition, tree cover installations
Figure 16	504791 5880616	Vegetate with willows and conifers.
Figure 17	504787 5880581	Supplemental tree/ willow plantings
Figure 18	504787 5880581	Supplemental tree/ willow plantings
Figure 19	504746 5880465	Supplemental tree/ willow plantings, substrate enhancement (if possible)
Figure 20	504746 5880465	Vegetate, substrate enhancement (if possible)
Figure 21	504756 5880427	Vegetate with willows and conifers.
Figure 22	504733 5880400	Vegetate, gravel addition, tree cover installations

Table 4. Upper Embarras Channel (upstream of Upper Embarras Lakes

Site	Location (UTM's)	Enhancement Details
Figure 23	504521 5880434	Vegetate with willows and conifers.
Figure 24	504497 5880409	Vegetate, gravel addition, tree cover installations
Figure 25	504497 5880409	Vegetate, gravel addition, tree cover installations
Figure 26	504364 5880240	Vegetate, gravel addition, tree cover installations

3.1 Lower Embarras Channel

Pisces recommends the following components be incorporated into the reclamation plans for the Lower Embarras Channel. Additional details are shown on Figures 1 to 10. Existing water temperature data suggests that an important design consideration for this channel reach is to maximize stream shading. In addition, observations in 2012 and 2013 suggest lake resident fish are moving downstream past the fish exclusion weir; recommended channel enhancements (improve cover, holding habitat and spawning habitat) are intended to reduce these losses.

- Streambank cover should be installed along the reclaimed channel. Willows and/or other deciduous plantings should be established as close to the stream as possible. Coniferous tree seedling should also be established where feasible to promote long-term stream shading that will mimic natural channel conditions in the area. Plantings should be relatively dense where warranted with riparian planting densities averaging at least one tree per meter of bank. Faster growing species such as willows, aspen or balsam poplar should be considered in addition to conifers along this channel reach in order to maximize stream shading as quickly as possible. Willows should only be planted near the water, as establishment will likely be difficult at drier locations.

- Large woody debris (conifers with intact limbs anchored or embedded into the banks and protruding into the channel or brush piles) should be placed within the reclaimed channel to provide cover for fish where channel conditions allow. Bushy conifers at least three metres tall with intact root wads (if feasible) should be installed where indicated (Figures 1-10). If possible, instream conifer placements should be anchored utilizing boulders or cable/ posts. Perpendicular installations should aim to maximize stream shade area; the largest tree's that can be handled practically would be optimal. The recommended location of these habitat features could be changed slightly to accommodate the materials available for the enhancement works.
- Though successful spawning is occurring within the channel reach salmonid spawning habitat enhancements should be undertaken (Figure 3, 4, 8, and 10). These enhancements should include placement of appropriately sized gravels, and habitat suited for rearing of juvenile salmonids. The gravel should be 5 to 30 mm in size and preferably rounded rather than crushed with sharp edges. A diversity of gravel size will be appropriate as the Embarras Lakes are occupied by adult Rainbow Trout of varying size. Gravel depths should exceed 0.30 meters to increase the longevity of the enhancements since the surrounding area is unlikely to provide for much natural recruitment of this type of substrate.
- Areas of instability within the Embarras River constructed channel have been identified (Figure 8-10). Bank re-contouring should be completed with the aim of reducing slopes and reducing erosion so vegetation can be established. If re-contouring and planting is not feasible CVRI may want to consider riprap placement in problem areas. Currently, sediment is being generated from these unstable areas predominantly during spring rainstorms when Rainbow Trout reproduction is occurring. Stabilizing these areas will help protect incubating Rainbow Trout eggs and rearing fry that could be present in the connective channel.

Figure 1. Looking upstream

Figure 2. Looking upstream

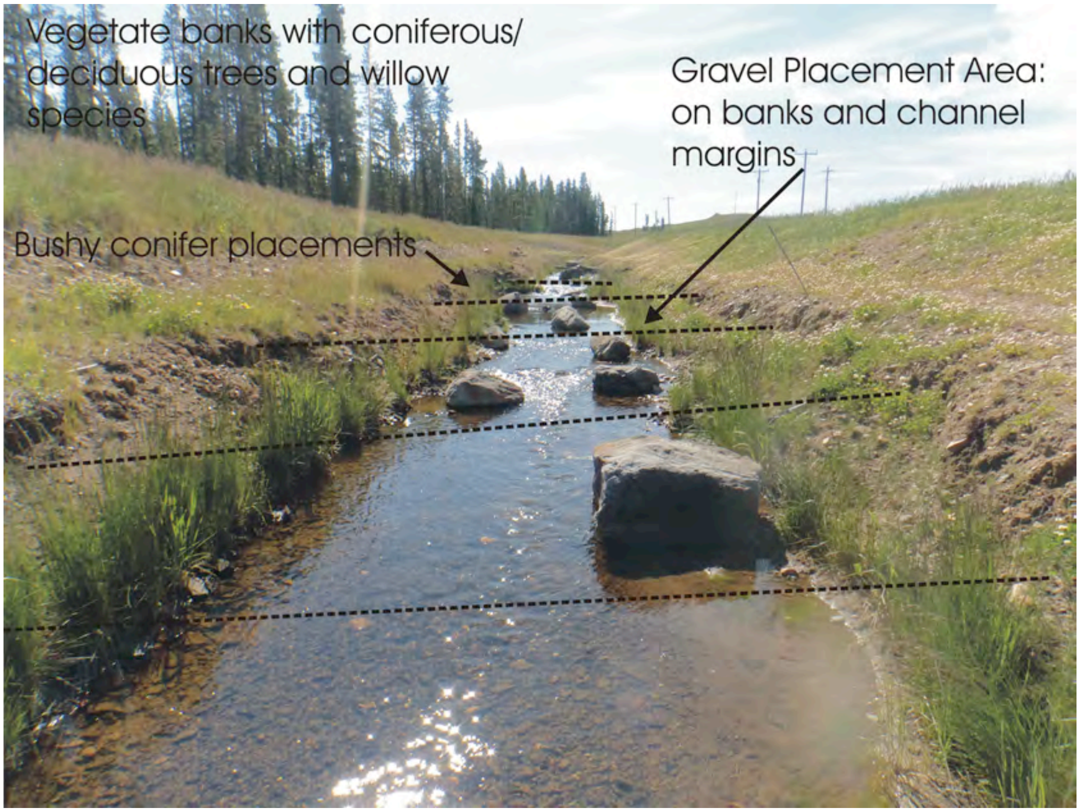

Figure 3. Looking upstream

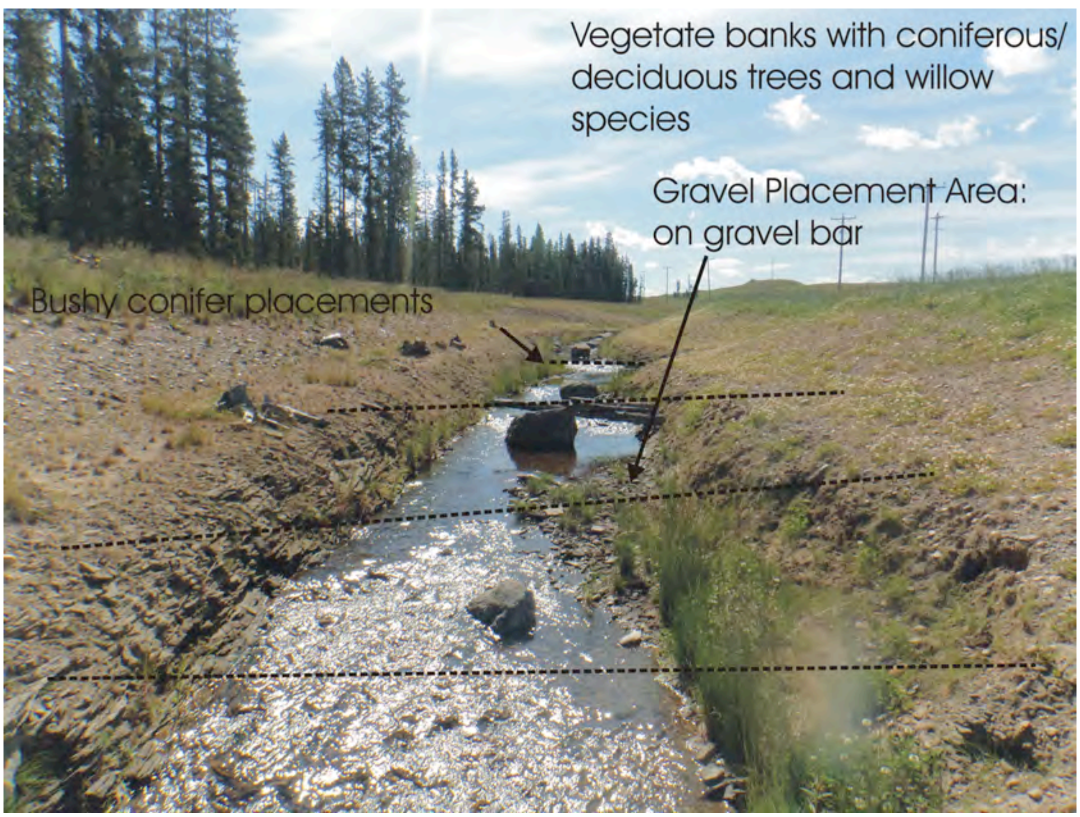

Figure 4. Looking upstream

Figure 5. Looking upstream

Figure 6.Looking upstream

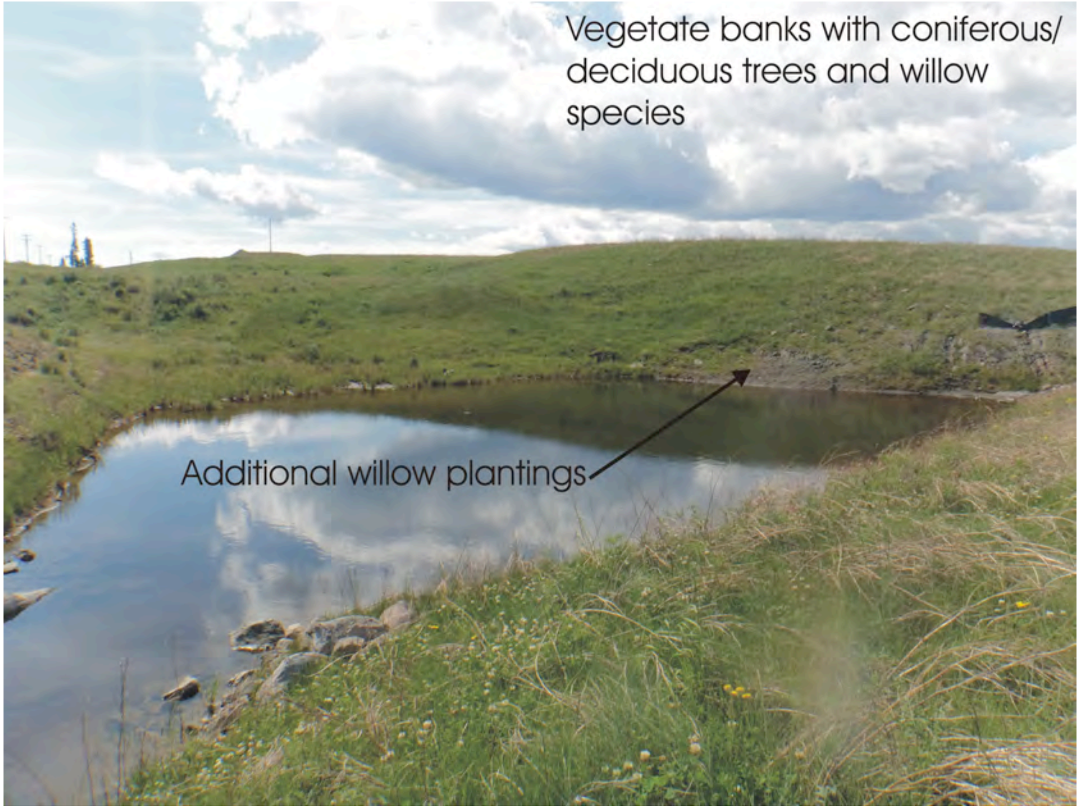

Figure 7. Looking upstream

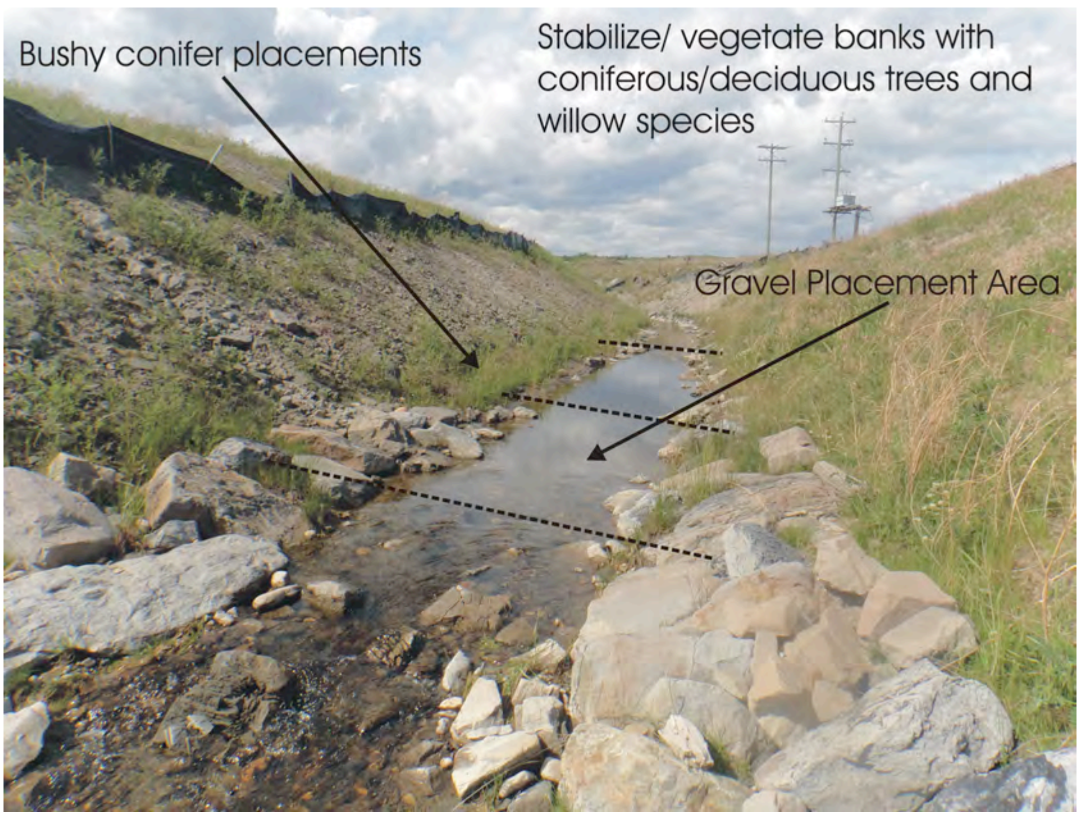

Figure 8. Looking upstream

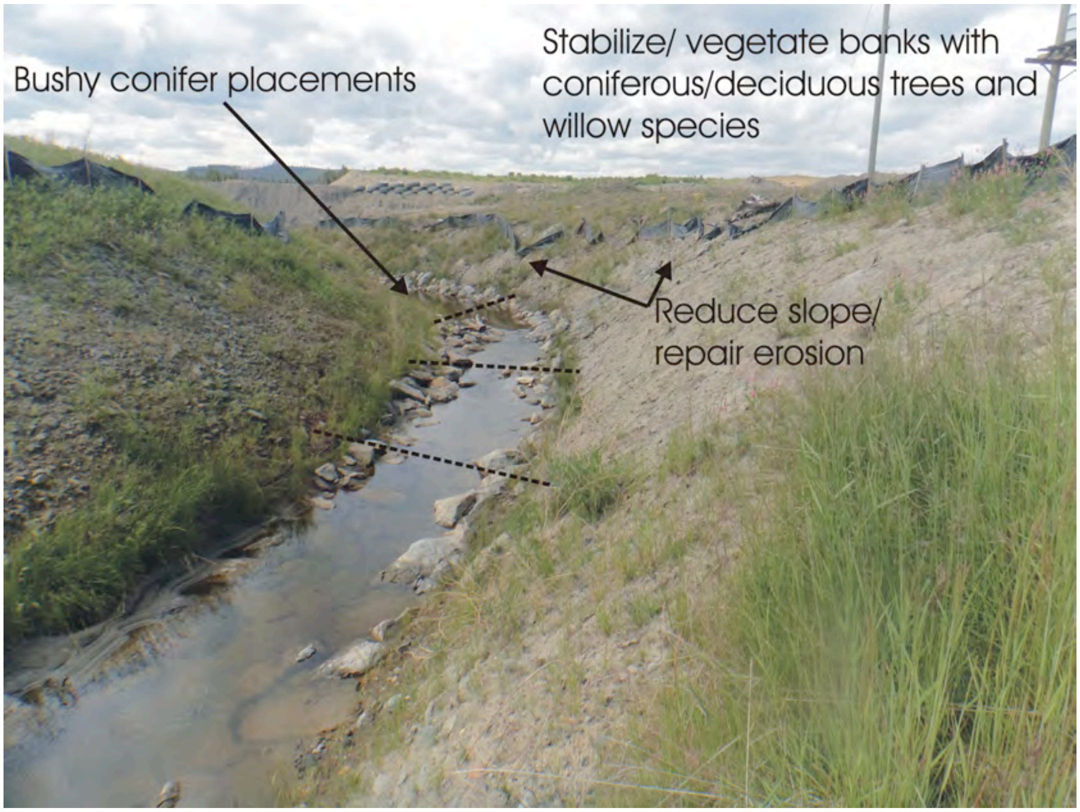

Figure 9. Looking upstream

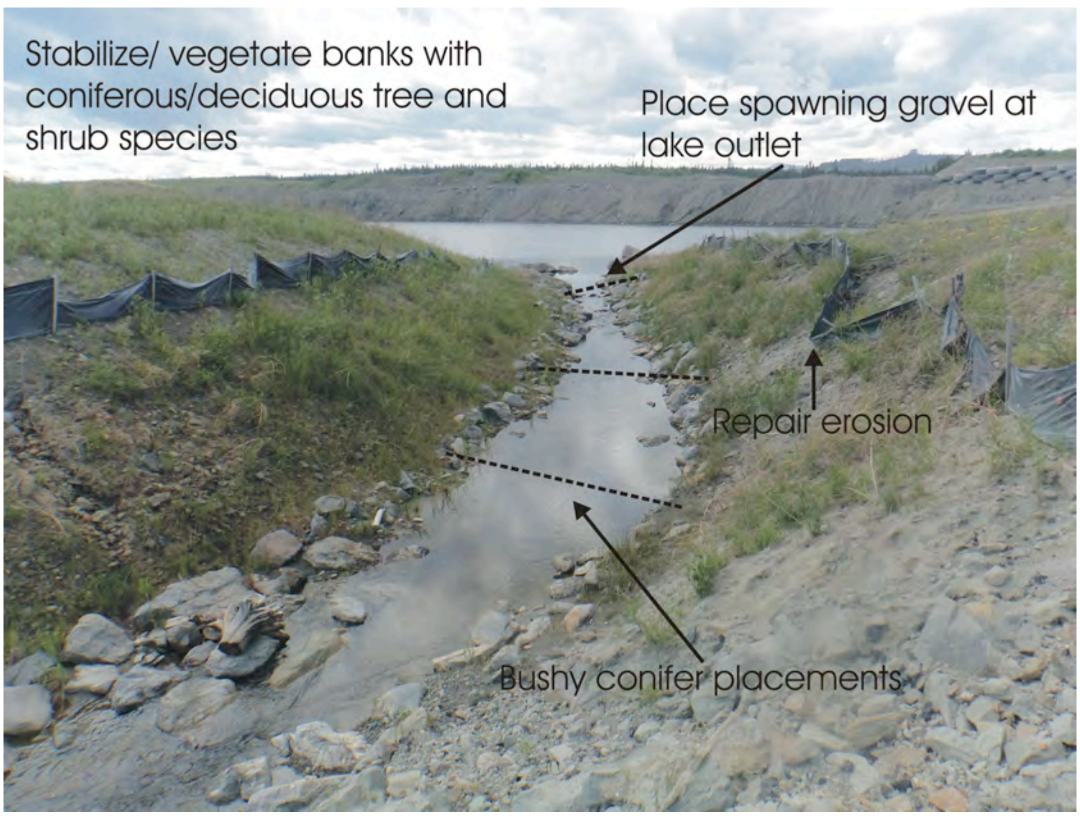

Figure 10. Looking upstream

3.2 Middle Embarras Channel A

Pisces recommends the following components be incorporated into the reclamation plans for the Middle Embarras A Channel. Additional details are shown on Figures 11 and 12. Existing water temperature data suggests that an important design consideration for this channel reach is to maximize stream shading. The substrate and cover enhancements are expected to promote the long-term success of the Embarras Lakes System.

- Streambank cover should be installed along the reclaimed channel. Willows and/or other deciduous plantings should be established as close to the stream as possible. Coniferous tree seedling should also be established where feasible to promote long-term stream shading that will mimic natural channel conditions in the area. Plantings should be relatively dense where warranted with riparian planting densities averaging at least one tree per meter of bank. Faster growing species such as willows, aspen or balsam poplar should be considered in addition to conifers along this channel reach in order to maximize stream shading as quickly as possible.
- Though successful spawning is likely occurring within the channel reach salmonid spawning habitat enhancements should be undertaken (Figure 11 and 12). These enhancements should include placement of appropriately sized gravels, and installation of woody debris cover at the outlet of the Middle Embarras Lake. The gravel should be 5 to 30 mm in size and preferably rounded rather than crushed with sharp edges; a diversity of gravel size will be appropriate as the Embarras Lakes are occupied by adult Rainbow Trout of varying size. Gravel depths should exceed 0.30 meters to increase the longevity of the enhancements since the surrounding area is unlikely to provide for much natural recruitment of this type of substrate.

Figure 11. Looking upstream

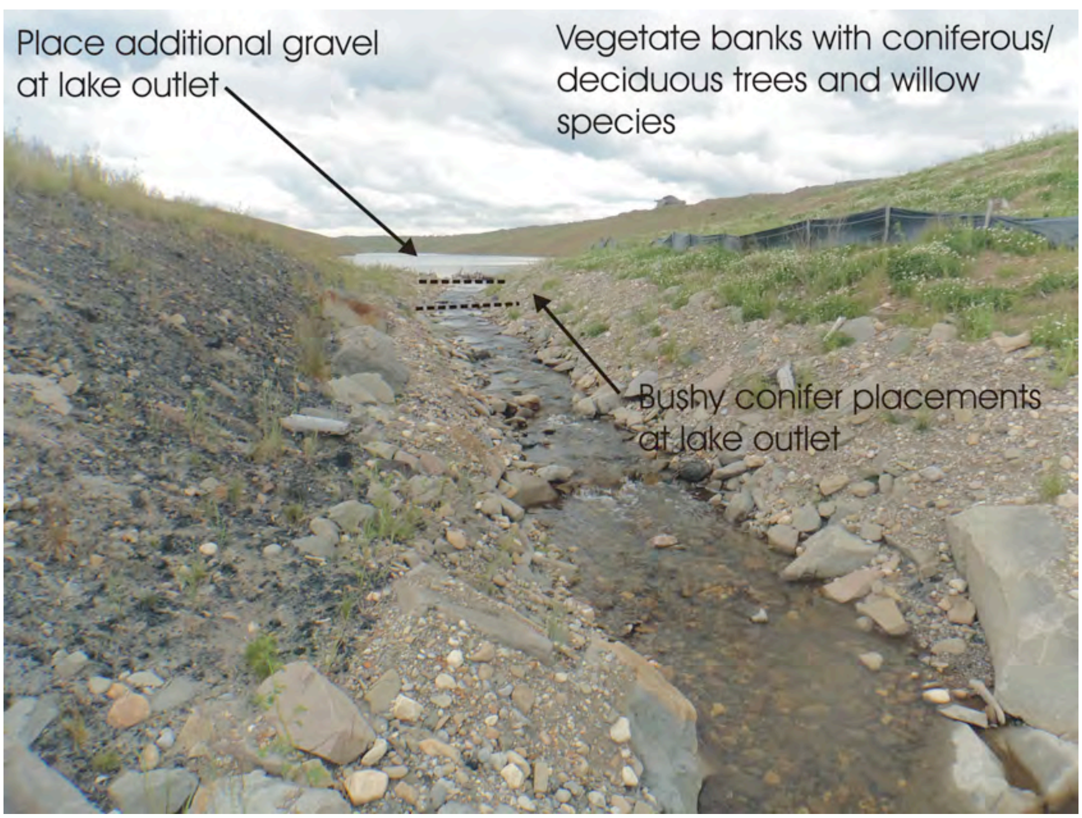

Figure 12. Looking upstream.

3.3 Middle Embarras Channel B

Pisces recommends the following components be incorporated into the reclamation plans for the Middle Embarras B Channel. Additional details are shown on Figures 13 and 22. Existing water temperature data indicates that this channel reach has exhibited a near optimal thermal regime for Rainbow Trout in 2012 and 2013. The focus of recommended enhancements is to maximize habitat use and promote the long-term success of the Embarras Lakes System. The goal of the enhancement work is to maintain and improve fry production, reduce fish egg mortality, and increase the suitability of the habitat for juvenile rearing. In addition, the vegetation of streambanks and surrounding slopes is expected to improve overall habitat conditions.

- Streambank cover should be installed along the reclaimed channel. Willows and/or other deciduous plantings should be established as close to the stream as possible. Coniferous tree seedling should also be established where feasible to promote long-term stream shading that will mimic natural channel conditions in the area. Plantings should be relatively dense where warranted with riparian planting densities averaging at least one tree per meter of bank. Faster growing species such as willows, aspen or balsam poplar should be considered in addition to conifers along this channel reach in order to maximize stream shading as quickly as possible. Fine material may be required in the margins of riprap areas in order to establish riparian vegetation.
- If possible, conifer placements should be anchored utilizing boulders or cable/ posts. Perpendicular installations should aim to maximize stream shade area. Cover enhancements within this channel will provide habitat for spawning and rearing fish. Enhancements at the outlet of the Upper Embarras Lake should also prevent ungulate trampling of incubating Rainbow Trout eggs that is suspected to have occurred in 2012 and 2013.
- Although successful spawning is occurring within this channel reach and monitoring indicates near optimal temperature regimes for Rainbow Trout reproduction, additional enhancements directed at improving salmonid spawning habitat are recommended. These enhancements should include placement of appropriately sized gravels, and habitat suited for rearing of juvenile salmonids. The gravel should be 5 to 30 mm in size and preferably rounded rather than crushed with sharp edges; a diversity of gravel size will be appropriate as the Embarras Lakes are occupied by adult Rainbow Trout of varying size. Gravel depths should exceed 0.30 meters to increase the longevity of the enhancements since the surrounding area is unlikely to provide for much natural recruitment of this type of substrate.

Figure 13. Looking upstream

Figure 14. Looking upstream

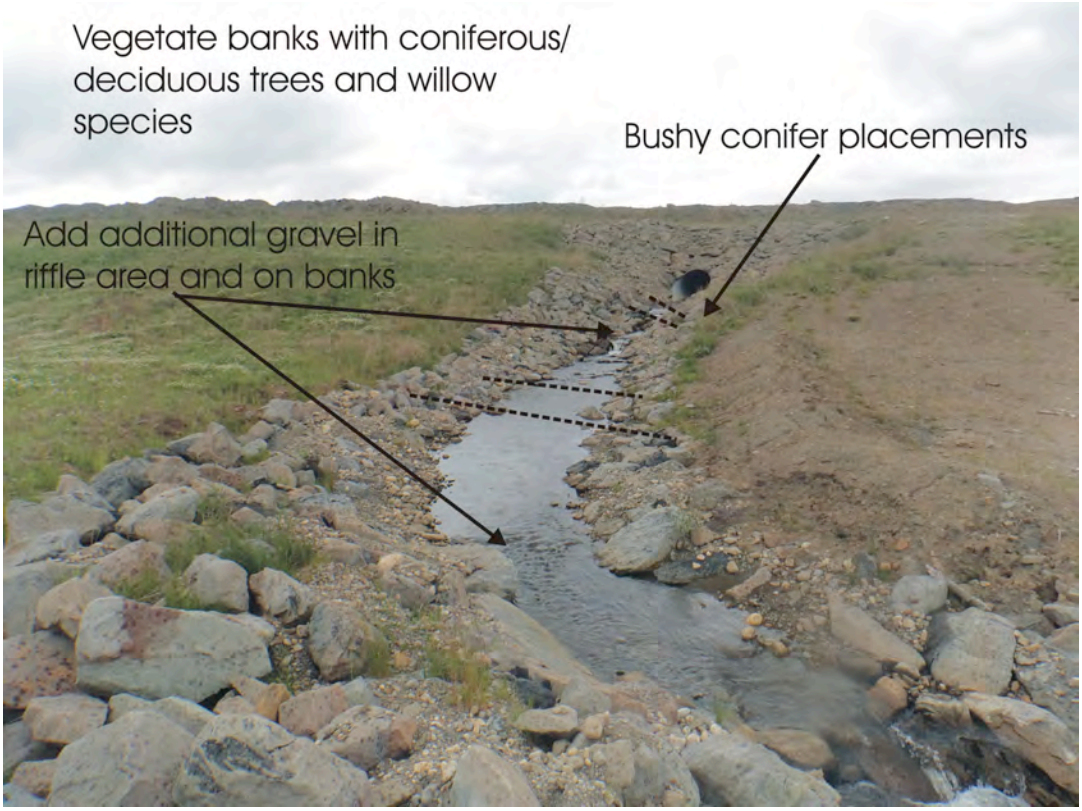

Figure 15. Looking upstream

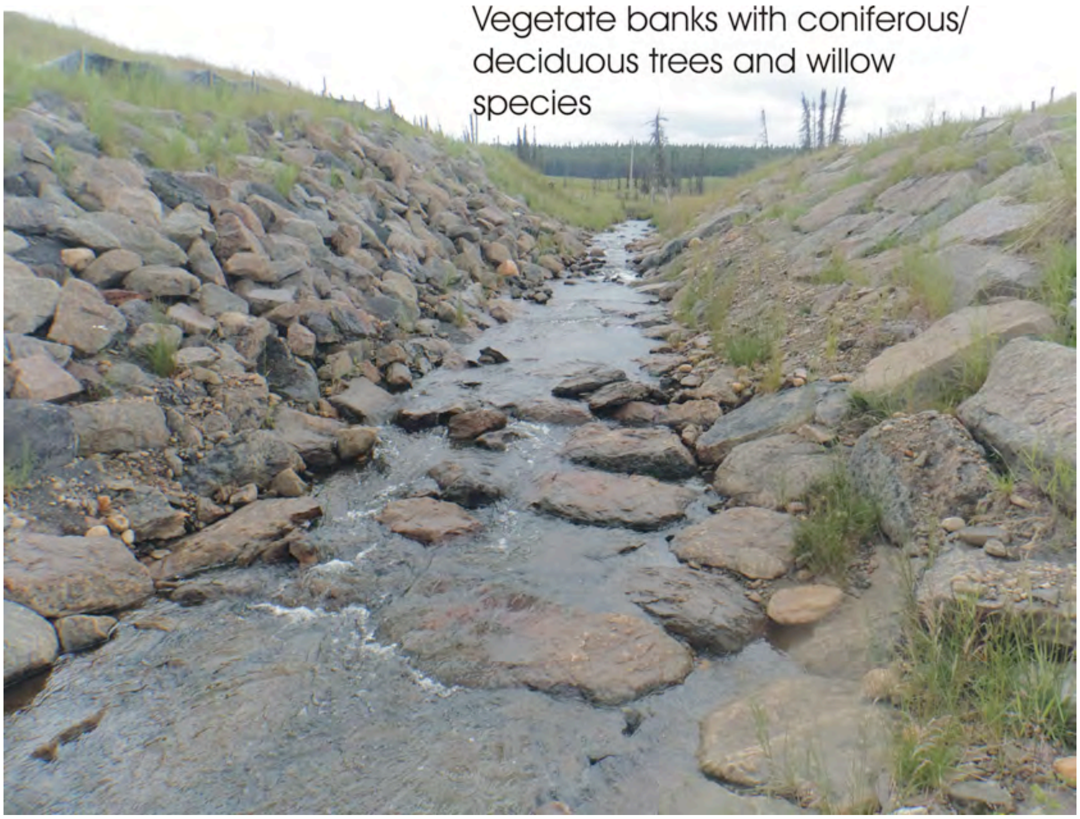

Figure 16. Looking upstream

Figure 17. Looking upstream

Figure 18. Looking upstream

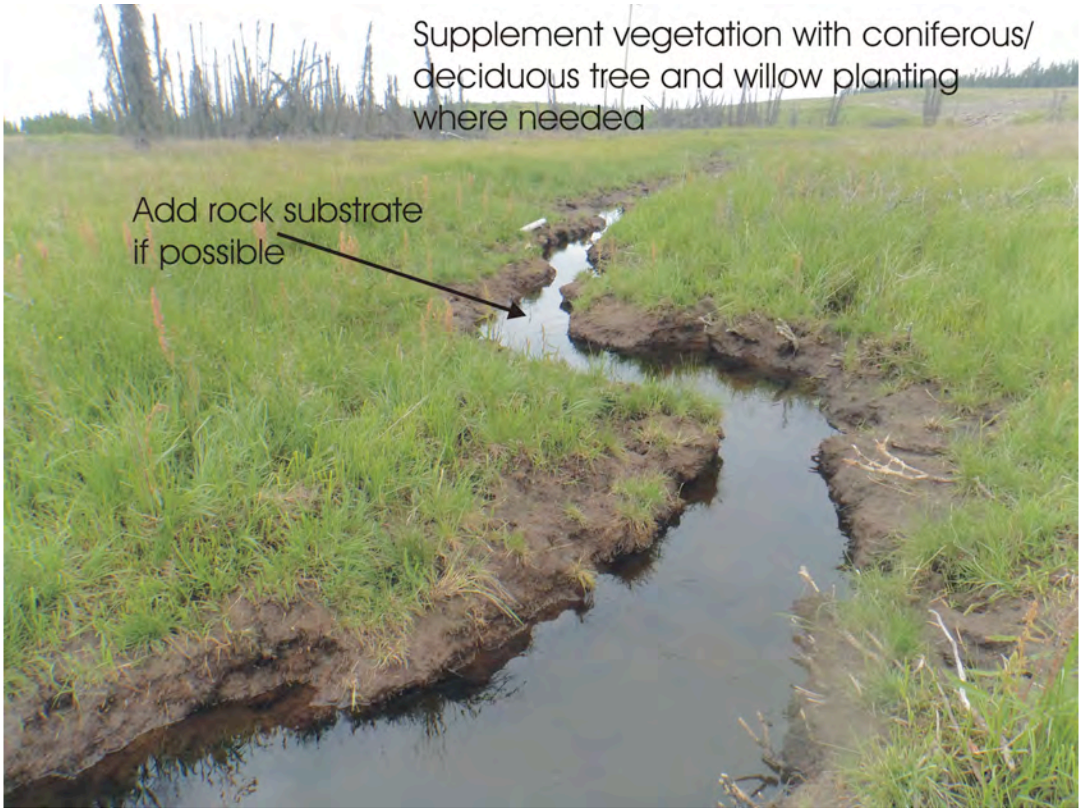

Figure 19. Looking downstream.

Figure 20. Looking upstream

Figure 21. Looking upstream

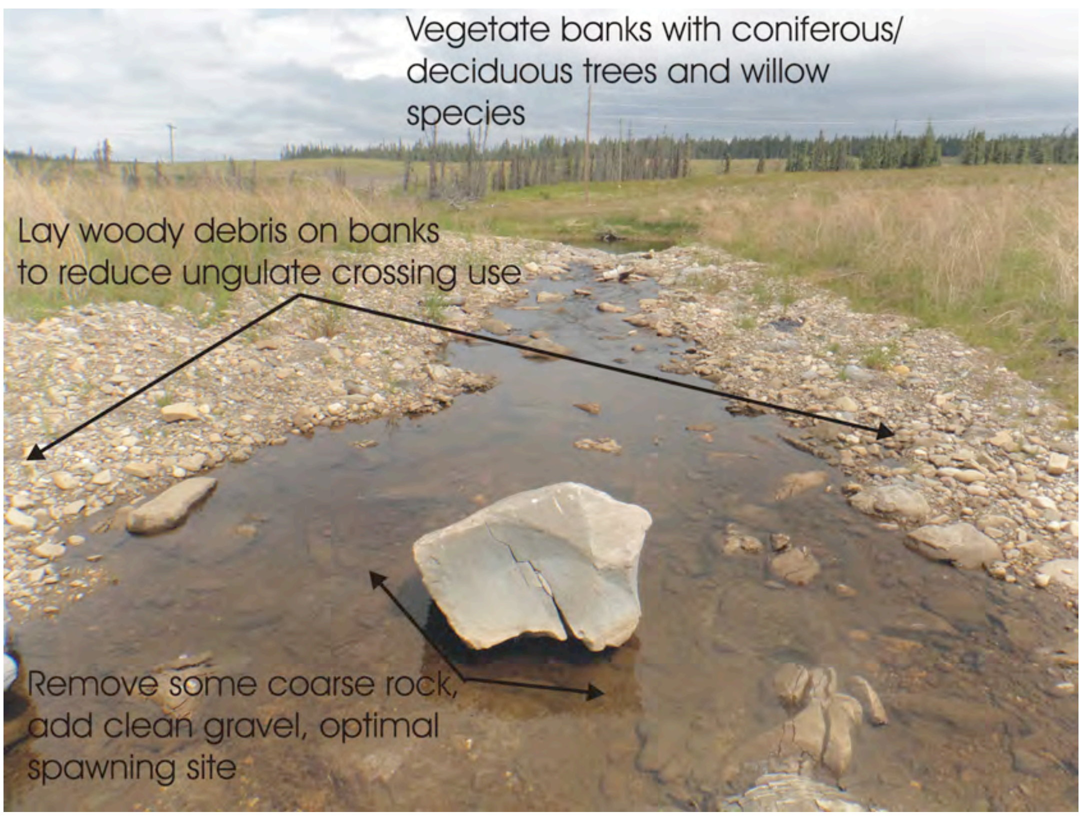

Figure 22. Looking downstream

3.4 Upper Embarras Channel

Pisces recommends the following components be incorporated into the reclamation plans for the Upper Embarras Channel. Additional details are shown on Figures 23 and 26. Existing water temperature data indicates that while channel reach is relatively cold (especially upstream of the beaver pond), it is likely suitable for Rainbow Trout reproduction during most years. However, the enhancement of habitat in this channel reach may provide a thermal refuge that would likely be beneficial during warmer than average years.

- Streambank cover should be installed along the reclaimed channel. Willows and/or other deciduous plantings should be established as close to the stream as possible. Coniferous tree seedling should also be established where feasible to promote long-term stream shading that will mimic natural channel conditions in the area. Plantings should be relatively dense where warranted with riparian planting densities averaging at least one tree per meter of bank.
- Perpendicular woody cover installations should aim to maximize stream shade area and as large of trees as possible should be utilized. Enhancements within this channel will benefit Rainbow Trout by providing cover for adults during spring spawning.
- Although successful spawning is likely occurring within this channel reach additional habitat enhancements are recommended. The Upper Embarras Channel is consistently colder than the other channel reaches and may be of particular importance for Rainbow Trout spawning during abnormally warm years. Enhancements should include placement of appropriately sized gravels, and habitat suited for rearing of juvenile salmonids. The gravel should be 5 to 30 mm in size and preferably rounded rather than crushed with sharp edges; a diversity of gravel size is appropriate since the Embarras Lakes are occupied by adult Rainbow Trout of varying size. Gravel depths should exceed 0.30 meters to increase the longevity of the enhancements since the surrounding area is unlikely to provide much natural recruitment of this type of substrate.

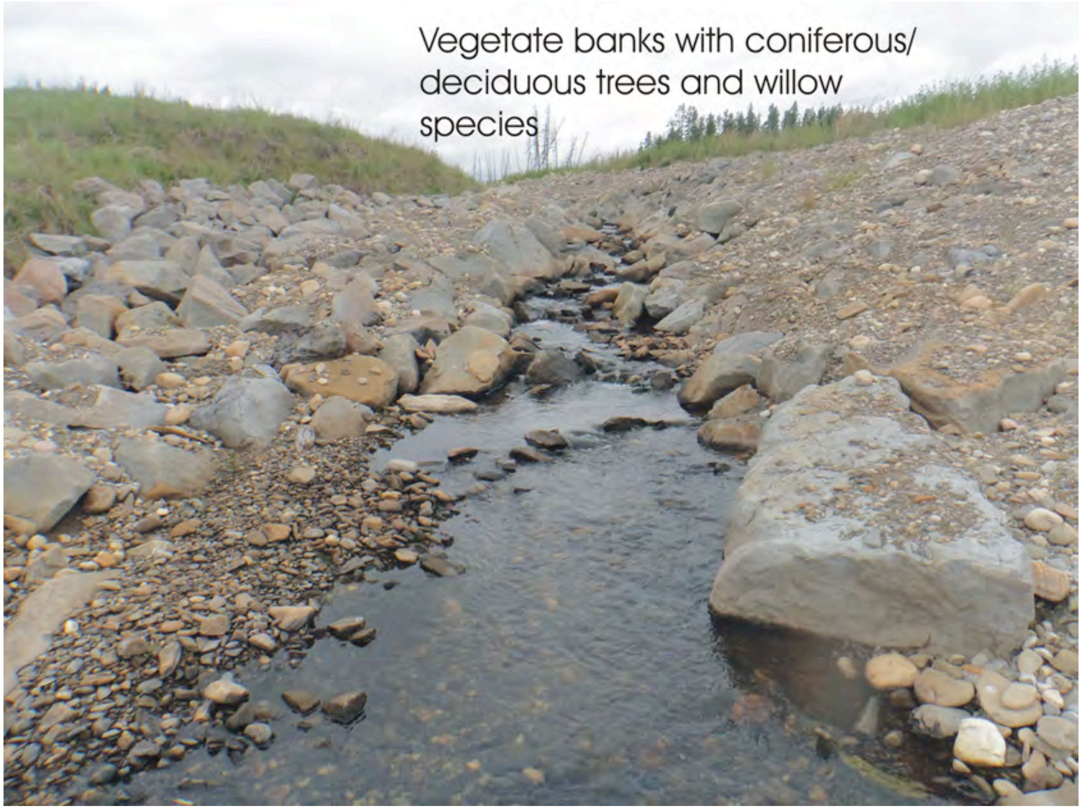

Figure 23. Looking upstream

Figure 24. Looking upstream

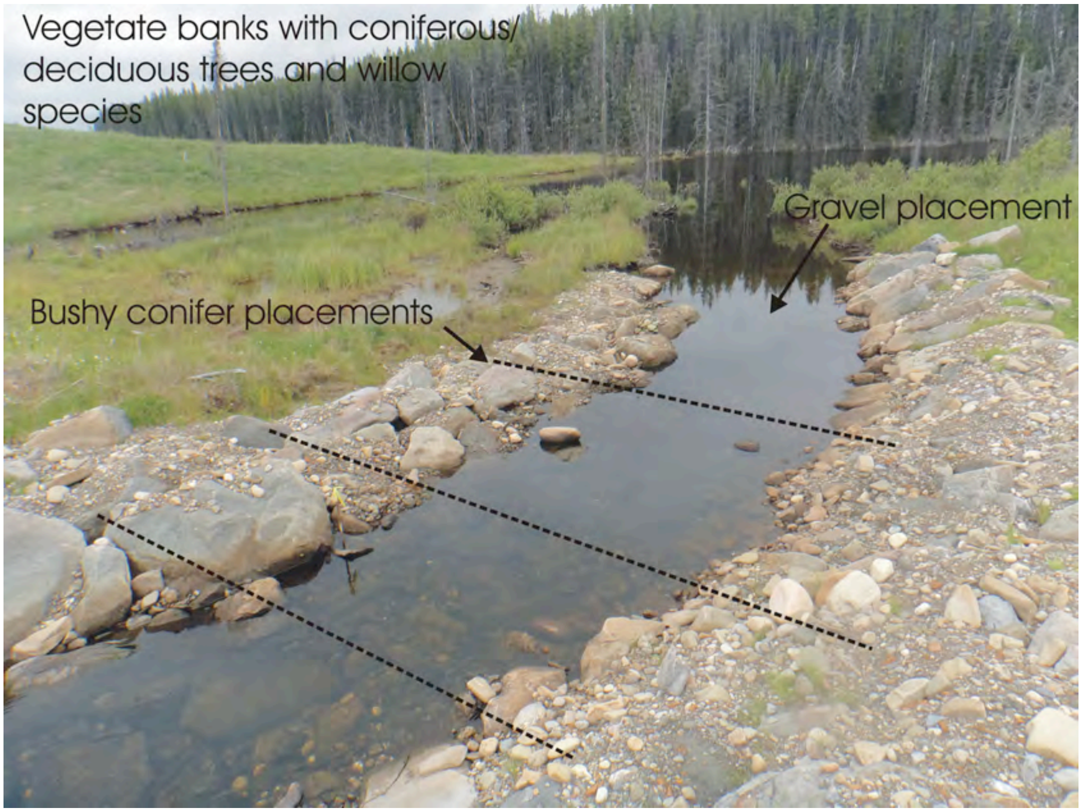

Figure 25. Looking upstream

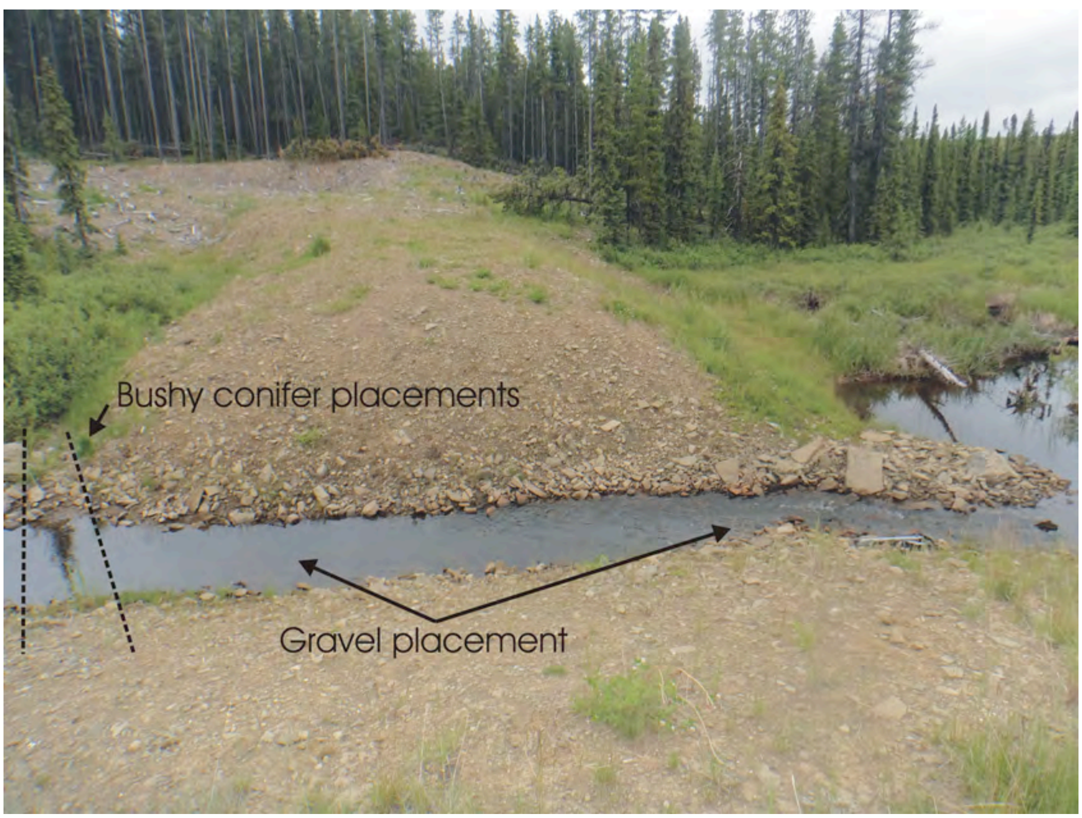

Figure 26. Looking from right upstream bank.

4.0 Other Considerations

Dependent on final reclamation objectives and the direction of AESRD there may be potential to create a seasonal or permanent connection between the Upper Embarras Lake and the Pit 142W Lake. The water level of Pit 142W Lake has not risen above the outflow channel elevation since final channel work was completed (Figure 27), under the current configuration the lake would likely require stocking if a fishery end use is desired. However, adjustment to the channel grade could be attempted to allow for seasonal recruitment of fish from the Embarras system. Alternatively, the possibility of this pit undergoing a change in final surface elevation so it could be connected via a permanent channel could be investigated if CVRI and/or AESRD wish to reduce the number of lakes that will require stocking in the future. A channel between this lake and the beaver pond upstream of the Embarras Lakes could also be investigated if connectivity is a desired end use and water surface elevations were appropriate. However, providing a surface connection to Pit 142W should likely not be completed until it is confirmed that the Rainbow Trout currently in the Embarras End Pit Lake System are native Athabasca Rainbow Trout.

Figure 27. Existing channel between Pit 142W Lake and Upper Embarras Lake.

While we recognize that the haulroad between Pit 122W and the Lower Embarras Lakes is still active there may be merit in exploring the possibility of developing a final reclamation plan that involves construction of a connecting channel between the lakes. Depending on fisheries objectives this may provide an opportunity to reduce the need for long-term fish stocking in the area.

5.0 Closure

I trust this meets your information requirements at this time. If you have any questions regarding the foregoing please contact our office at your convenience.

Sincerely,

<original signed by>

<original signed by>

Joe Sonnenberg, B.Sc.
Fisheries Biologist

Erik Stemo, P. Biol.
Senior Fisheries Biologist

Pisces Environmental Consulting Services Ltd.

References

Boorman, J. 2003. Baseline fisheries resources assessment of waterbodies on and adjacent to the proposed Mercoal East extension. Report of Pisces Environmental Consulting Services Ltd. to Luscar Ltd. Coal Valley Mine, Edson, AB. 35 pp. + App.

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• Phone 403-347-5418 • Fax 403-347-0681 •
• www.piscesenvironmental.com •

CVRI
Coal Valley Mine
Bag 5000
Edson, Alberta
T7E 1W1

March 19, 2013

ATTN: Mr. Les LaFleur

RE: 2012 post-construction monitoring of the permanent diversion channel on upper Mercoal Creek for the MP2 development.

Introduction

The Mercoal Phase 2 (MP2) project, part of ongoing mining operations at the Coal Valley Mine, required the permanent diversion (known as diversion D-E) of a portion of Mercoal Creek to facilitate mining. As required by Fisheries and Oceans Canada (DFO), a habitat compensation plan that included enhancement of the constructed channel with a goal of maximizing its productive capacity was developed for the project. In order to meet the requirements of the DFO Section 35(2) *Fisheries Act* Authorization (# ED-04-3170) issued for the project, the mine committed to conducting fish and fish habitat monitoring within the constructed channel. Key components of the monitoring program included:

- Sampling 1, 3, and 5 years following construction of the channel.
- Habitat surveys 1 and 5 years following construction of the channel.

This document presents Year 3 (post construction) monitoring results obtained by Pisces Environmental Consulting Services Ltd. (Pisces).

Background

Baseline investigations of Mercoal Creek found that fish densities were very low in the vicinity of the diversion and that Rainbow Trout (*Oncorhynchus mykiss*) were the only species to occupy this part of the creek (Boorman 2003). Habitat inventory during baseline investigations found that the majority of habitat (>75 %) affected by the diversion consisted of Class 3 habitat (<0.5 m depth, Boorman 2003). Pool habitat comprised about 2 % of the affected habitat and there was no Class 1 habitat (>1.0 m depth) in the impacted area (Boorman 2003). Modeling of the habitat suitability of Mercoal Creek for Rainbow Trout (Raleigh et al. 1984) found that both the percent pools and the pool class rating variables were limiting factors (Stemo 2005). As a result, habitat compensation efforts included the construction of pools on every meander and the placement of large woody debris within the constructed pools (Stemo 2005).

Monitoring Results

The 2012 monitoring program included sampling of the compensation area as well as the natural channel adjacent to the compensation area. In addition, channel stability, general habitat conditions, and instream sedimentation was also assessed. The investigations were completed on August 14, 2012.

<u>*Habitat Condition*</u>

The channel was mostly stable and vegetated at the time of the 2012 assessment; some channel instability and erosion had occurred within the reconstructed channel (see attached photos).

The habitat inventory completed in 2010 found that the channel provided an additional 750 m^2 of habitat compared to the pre-disturbance condition. In 2012, habitat conditions were judged to be very similar to what was present in 2010. A full assessment of habitat within the study area is scheduled for 2014.

The August 14th, 2012 assessment included measurement of water quality parameters within the compensation channel (Table 1). No water quality factors were judged to be limiting for fish at the time of assessment though flows were considered to be low.

Table 1. Select Water Quality Measurements of Mercoal Creek on August 14th, 2012

Dissolved Oxygen (mg/l)	7.44
Temp (^{0}C @ time)	12.6 @ 10:00
Cond (uS)	423.3
Discharge (m^3/s)	0.0135

<u>*Fish Sampling*</u>

The 2012 fish sampling program consisted of electrofishing and angling surveys:

- 350 metres of the diversion channel was electrofished for 1381 seconds of on-time. No fish were captured or observed during this survey.
- Deep portions of 4 pools were angled due to the limited effectiveness of electrofishing within deeper water. No fish were captured or observed during 2 hours of total angling effort.
- A 200 metre section of the natural channel downstream of the diversion was electrofished for 996 seconds of on-time. No fish were captured or observed during this survey.

Summary

Consistent with the Habitat Compensation Plan (Stemo 2005), the constructed diversion channel still had substantially more Class 1 pools in 2012 as compared to the pre-disturbance condition. Based on Habitat Suitability Modelling (Raleigh et al. 1984), compensation efforts have resulted in an increase in the overall habitat quality within this portion of Mercoal Creek.

Utilization of the diversion channel was not confirmed in 2010 or 2012, however fish were also absent in the natural channel downstream of the diversion which suggests that fish densities in the headwaters of Mercoal Creek remain low (as was found during baseline studies (Boorman 2003)).

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Closure

I trust this meets your information requirements at this time. If you have any questions please contact our office at your convenience.

Sincerely,

<original signed by>

Joe Sonnenberg
Fisheries Technician

<original signed by>

Ricki-Lynn Boorman, P.Biol
Senior Fisheries Biologist

Pisces Environmental Consulting Services Ltd.

Attch.

	
Photo 1. Looking across at anchored tree within the diversion channel.	Photo 2. Looking downstream at typical habitat within the diversion channel.
	
Photo 3. View of typical habitat within the diversion channel.	Photo 4. Looking at partially exposed bank along diversion channel.
	
Photo 5. Looking at large pool with anchored trees.	Photo 6. View of typical habitat within the diversion channel.

	
Photo 7. Looking at large pool with anchored trees.	Photo 8. Looking at small pool with anchored trees.

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MEMO

Date: 18 February 2014

To: Mr. Les LaFleur

From: Mr. Joe Sonnenberg

RE: Preliminary results for investigations conducted on existing end pit lakes in the South Block Area of the Coal Valley Mine.

INTRODUCTION

Coal Valley Resources Inc. (CVRI) has established several end pit lakes in the South Block Area of the Coal Valley Mine (CVM). Reclamation in this area is ongoing and CVRI would like to develop more specific reclamation objectives for the end pit lakes. To assist CVRI with their ongoing effort to improve the design and functionality of end pit lakes, Pisces Environmental Consulting Services Ltd (Pisces) initiated some preliminary investigations to assess the fisheries potential of a number of the end pit lakes. This document provides a summary of results for investigations completed in 2013.

STUDY AREA

Investigations in 2013 were focused on five end pit lakes (Figure 1 - attached). Summary information for the lakes is provided in Table 1.

Table 1. Summary information for CVRI lakes (Hatfield 2011, Hatfield 2014).

Lake	Year Created	Approximate Surface Area (ha)	Maximum Depth (m)	Mean Depth (m)	Inflow	Outflow
Pit 44	1998	8.76	18.5	7.4	Yes	Yes
Pit 25S	1999	6.8	12.5	4.7	Yes	Yes
Pit 25E	1996	6.8	16.2	7.4	Yes	Yes
Pit 43W	unknown	unknown	unknown	unknown	Yes	Yes
Pit 34	unknown	5.9	5.5	2.9	Yes	Yes

OBJECTIVES AND METHODS

The principal objectives of the 2013 investigations were to:

- Obtain information regarding fish use of inlet/outlet streams adjacent to the end pit lakes;
- To gain a general understanding of fish habitat potential and the feasibility of establishing fish populations within the end pit lakes;
- To contribute to an overall plan for reclamation of end pit lakes on CVM.

Fish Sampling

Fish sampling consisted of single pass electrofishing surveys on streams adjacent to the end pit lakes (Table 2).

Table 2. Summary of fish sampling in 2013.

Lake	Sample Section	UTM's (zone 11U)	Date (all 2013)	Section Size (m)	Electrofishing Duration (s)	Comments
Pit 44	Pit 44 Outlet	523398E 5872396N	Jul 15	250 x 0.5	871	• Fish exclusion barrier located approximately 250 meters downstream of pit.
Pit 25S	Pit 25S Outlet (upper 25E Creek)	520806E 5872969N	Jul 17	150 x 1	408	• Habitat not suitable for sampling further downstream due to extensive overhanging bank and vegetation.
Pit 25E	Pit 25E Outlet (middle 25E Creek)	522691E 5821560N	Jul 17	200 x 1.5	1399	• All available habitat was sampled, excessive cover/ depth precluded sampling further downstream. • Numerous fish observed in lake.
	Lower 25 E Creek	523272E 5871040N	Jun 7th	50 x 2	242	• Sampled immediately downstream of Hwy 47. • Fish observed trying to pass Hwy culvert, which appears to be a barrier at high flows.
Pit 43W	Pit 43W Outlet	521219E 5875396N	Jul 18	200 x 1.5	1392	• Sampled from confluence of Lovett River to Pit 43W. • Numerous fish observed in lake.
Pit 34	Pit 34 Outlet	51973E 5874417N	Jul 18	205 x 2	1243	• Sampled from road culvert to Pit 34. • Culvert may be a partial barrier at some flows.

Habitat Potential

Habitat was visually assessed to identify major limiting factors to fisheries productivity (i.e. flows and habitat diversity). In addition, temperature loggers were deployed throughout the area to see if the thermal regime is suitable for target species.

RESULTS

Fish Sampling and Habitat Potential

Pit 44

Rainbow Trout was the only species captured from the Pit 44 outlet channel in 2013 (Table 3). All fish were captured near a patch of gravel located close to the lake outlet; these fish likely represent young of the year (YoY) fish, which suggests that stocked Rainbow Trout have successfully reproduced in the system. Rainbow Trout, Brook Trout and Brown Trout have all been stocked in Pit 44 in the past (FWMIS 2013, Miller 2011).

Table 3. Pit 44 outlet sampling summary for July 15th, 2013.

Species	Number Captured	Length (mm)	Weight (g)
RNTR	12	24.1 (21-29)	<1

Low flows likely limit habitat potential during most of the year. The Pit 44 outlet channel had minimal flow during the summer and was dry on several occasions. Based on the local habitat conditions it seemed likely that Rainbow Trout spawning occurred in an area that was back-flooded by the lake. Although there were a few deeper pools located throughout the outlet channel, no fish were captured or observed in these areas.

Pit 25S and Pit 25E and 25E Creek

There is no record of fish stocking in this system. Sampling of the channel downstream of Pit 25S failed to capture any fish, which suggests that fish have yet to colonize upper 25E Creek or Pit 25S.

Brook Trout were captured in middle 25E Creek (Table 4) and are known to occupy Pit 25E lake (Pisces 2010). Large schools of Brook Trout were observed feeding near the lake outlet on July 17th, 2013.

Table 4. Pit 25E outlet sampling summary for July 17, 2013.

Species	Number Captured	Length (mm)	Weight (g)
Brook Trout	18	144.8 (59-191)	37.6 (2-85)

Investigations on June 7, 2013 found a large congregation of fish downstream of the Highway 47 culvert. Electrofishing of the habitat resulted in the capture of Brook Trout and Mountain Whitefish (Table 5) however, sampling effectiveness was limited due to high stream flows.

Table 5. 25E Creek downstream of HWY 47 sampling summary June 7th, 2013.

Species	Number Captured	Length (mm)	Weight (g)
Brook Trout	5	181.4 (118-344)	99.4 (2-354)
Mountain Whitefish	1	283	97

25E Creek originates in the 25S Pit and flows through a small channel and reclaimed wetland area before entering Pit 25S. The outlet channel from Pit 25S contained gravel and cobble substrates but lacked instream cover and riparian vegetation. A short distance downstream of Pit 25S the creek flows through a muskeg area where beaver activity was very evident and the channel was poorly defined in places. Fines were the dominant substrate throughout this section. The habitat in the inlet to Pit 25E consisted mainly of riffle – pool complexes with cobble and boulder substrates. 25E Creek outlets from the south end of the 25S Pit, flowing over a relatively steep boulder section. The natural channel further downstream is generally low gradient with fines substrates dominant. The Highway 47 culvert appeared to be a barrier to fish movements during high flows but may be passable when discharges are lower. Downstream of this culvert the creek meanders through washed out beaver ponds.

Pit 43W

There is no record of fish stocking in this system but fish resident to the Lovett River appear to be able to access the area. A number of fish species were captured in the outlet channel from Pit 43W (Table 6). Brook Trout and Longnose Dace were the most abundant while White Sucker and Lake Chub were only captured once each.

Table 6. Pit 43W outlet sampling summary for July 17, 2013

Species	Number Captured	Length (mm)	Weight (g)
Brook Trout	33	127.8 (46-183)	32.2 (1-183)
Lake Chub	1	83	7
Longnose Dace	19	88.3 (83-93)	7.3 (4-12)
White Sucker	1	140	36

Shallow runs with cobble and boulder substrate dominated habitat within the outlet channel. There was one section, located approximately 75 metres downstream of Pit 43W, where the channel was quite steep and fish movement may be impeded at certain times of the year. Further downstream the channel transitioned to a small wetland area before flowing through a short channel that entered into the Lovett River. A limited amount of spawning gravel (suitable for salmonids) was identified downstream of the culvert located at the outlet of the lake.

Pit 34

There is no record of fish stocking for Pit 34 or Pit 43-2 (that outlets to Pit 34). Fish sampling conducted in the Pit 34 outlet channel captured Brook Trout and Longnose Dace (Table 7).

Table 7. Pit 34 outlet sampling summary for July 18th, 2013.

Species	Number Captured	Length (mm)	Weight (g)
Brook Trout	31	154.1 (103-207)	59.9 (15-140)
Longnose Dace	1	76	5

Reconnaissance conducted in the summer found that habitat within the inlet channel (from Pit 43-2) was extremely shallow and generally lacked cover for fish. Habitat within the outlet channel consisted mainly of shallow runs when assessed in the spring. Substrates consisted mainly of cobble and boulder. A culvert located in the outlet channel may impede fish movements at some flows.

Temperature Logging

Data was collected from June 11th to September 18th, 2013 (Table 8). The logger installed in the Lovett River downstream of the lakes was unusable since the logger was not submerged for long periods of time.

Table 8. Temperature logging results for end pit lake systems in the South Block Area.

			June 11- Sept 18th 2013		
Site	**Start**	**End**	**Average Daily (^{0} C)**	**Max Hourly Temperature (^{0} C)**	**Average Hourly Daily Fluctuation (^{0} C)**
Upper Lovett River	10-Jun	21-Sep	11.98	18.25	4.21
Pit 25S Lake Outlet	10-Jun	21-Sep	16.9	22.1	2.53
Pit 25E Lake Inlet	7-Jun	21-Sep	12.56	19.63	4.44
Pit 25E Lake Outlet	7-Jun	21-Sep	15.92	21.03	2.01
Lower 25E Creek	7-Jun	21-Sep	14.89	20.29	2.64
Pit 43W Pond Outlet	10-Jun	21-Sep	15.53	21.41	3.28
Pit 34 Lake Outlet	10-Jun	21-Sep	15.85	22.54	2.66

The highest stream temperatures recorded during the summer 2013 monitoring period occurred in the Pit 34 outlet and Pit 25S outlet respectively (Table 8). Under existing conditions, these channels have a high degree of sun exposure and bank cover has not been established. A significant cooling trend occurred between the Pit 25S outlet and the Pit 25E inlet in 2013 (Table 8). This is mostly attributable to cold water flow inputs from surrounding muskeg areas as well as a significant tributary which enters a short distance downstream of Pit 25S Lake.

The suitability of the systems for selected fish species is provided in the summary section of this report (Table 9) while ongoing monitoring will assess early spring conditions in 2014.

SUMMARY

The preliminary assessment data suggests that in most cases there is a moderate to high potential for development of sport fisheries in the end pit lake systems that were investigated (Table 9). Hatfield (2011) found physical characteristics and water quality values were sufficient for fish survival in Pit 44, 25S, and 25E lakes while lake investigations have not been completed in the other systems. The existing inlet and outlet channels are in reasonable condition but most would benefit from implementation of habitat enhancement. In some cases, habitat enhancement would likely be a critical step in establishing self-sustaining salmonid populations. Measurements taken during the 2013 investigations indicate that water temperatures were suitable and/or near optimal when compared to the requirements of fish species that could occupy these systems.

Table 9. Preliminary summary of fisheries potential for select pit lakes systems at the Coal Valley Mine.

Pit	Sample Section	Temperature Regime Suitability	Fisheries Potential of Inlet/Outlet Streams
Pit 44	Pit 44 Outlet	Insufficient water depth to submerge temperature logger	• Limited potential, primarily due to chronically low discharge. • Currently managed as put and take fishery by AESRD. • Some limited potential for salmonid reproduction at lake outlet during optimal years. • Evidence of RNTR reproduction in 2013.
Pit 25S	Pit 25S Outlet (upper 25E Creek)	RNTR – High BKTR – Mod ARGR - High	• High potential during spring and summer when there is sufficient discharge. Limited potential during the fall and winter when flows are lower. • No fish captured or observed in 2013. • Habitat potential of channels could be improved by increasing amount of coarse substrates and installing instream and riparian habitat enhancements.
Pit 25E	Pit 25E Lake Outlet (middle 25E Creek)	RNTR – High BKTR – High ARGR - High	• High potential. • Currently supports BKTR population but population size and production have not been assessed. • BKTR reproduction is known to occur in the outlet of Pit 25E. • Habitat potential of channels could be improved by increasing amount of coarse substrates and installing instream and riparian habitat enhancements.
	Lower 25 E Creek	RNTR – High BKTR – High ARGR - High	• High potential. • Currently supports BKTR population. Mountain Whitefish present downstream of Hwy 47. • Potential to enhance habitat upstream of Hwy 47 by increasing amount of coarse substrates.
Pit 43W	Pit 43W Lake Outlet	RNTR – High BKTR – High ARGR - High	• Moderate potential, flows are limiting factor in some months. • Appeared to support BKTR reproduction in 2013. • Existing fish community has not been assessed but appears substantial. • Habitat potential of channels could be improved by increasing amount of coarse substrates and installing instream and riparian habitat enhancements.
Pit 34 and Pit43-2	Pit 34 Lake Outlet	RNTR – High BKTR – High ARGR - High	• High potential during spring and summer when there is sufficient discharge. Limited potential during the fall and winter when flows are lower. • BKTR/forage fish utilize channel seasonally. • Habitat potential of channels could be improved by increasing amount of coarse substrates and installing instream and riparian habitat enhancements.
	Pit 43-2 Lake Outlet	RNTR – High[1] BKTR – High[1] ARGR – High[1]	• Low to moderate potential due to low flows and lack of habitat diversity (high width to depth ratio).

1. Data logger exposed during monitoring period, partial data set applied.

CLOSURE

I trust that the foregoing meets your requirements at this time. Please do not hesitate to contact me if you have any questions.

<original signed by>

Joe Sonnenberg B.Sc.
Fisheries Biologist
Author

<original signed by>

Erik Stemo, P.Biol.
Senior Fisheries Biologist
Review

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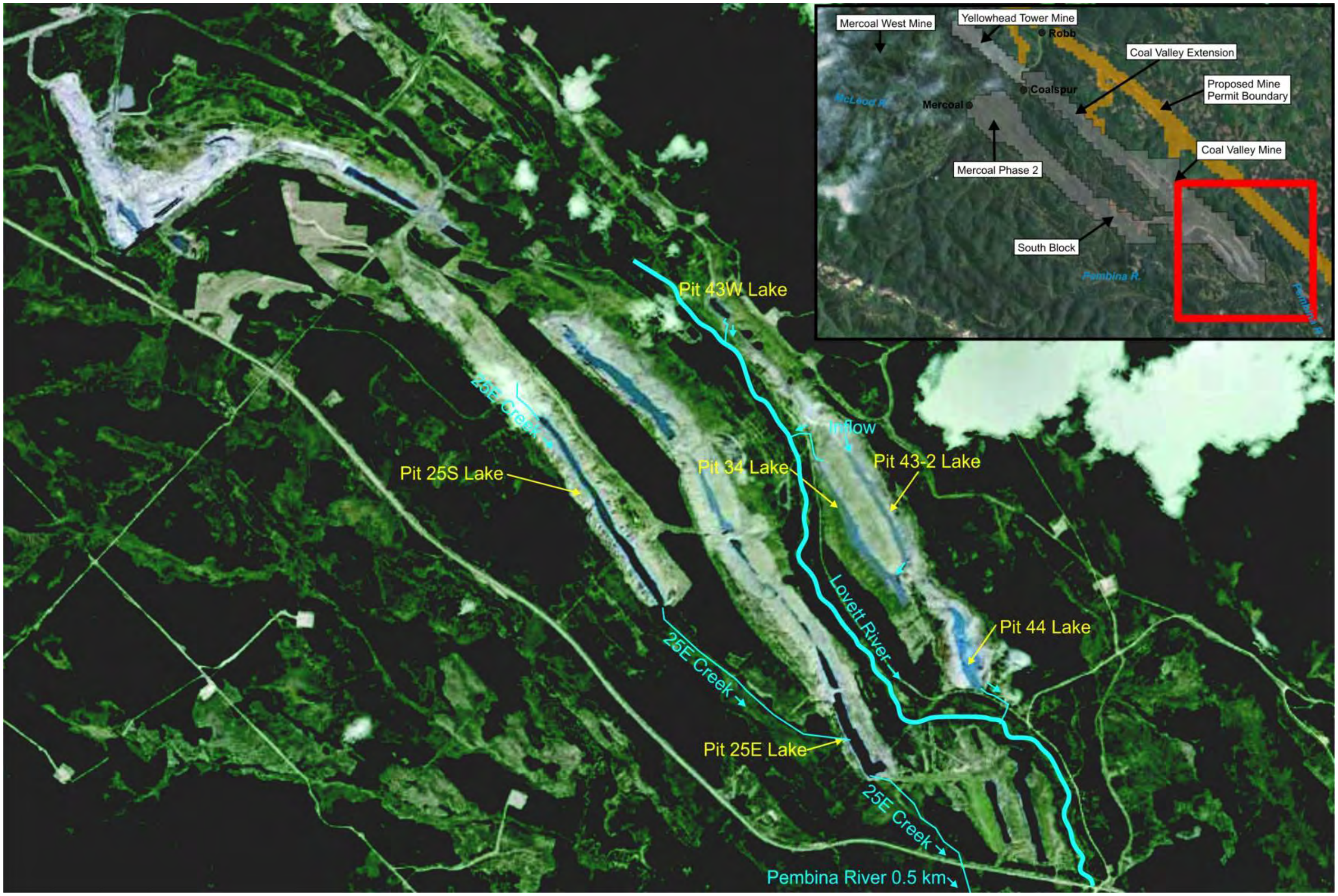

Figure 1. Location of lake systems.

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MEMO

Date: 4 February 2014

To: Mr. Les LaFleur

From: Mr. Erik Stemo

RE: Preliminary results for fish sampling conducted in the Embarras Lakes System.

INTRODUCTION

Coal Valley Resources Inc. (CVRI) developed several end pit lakes in the headwaters of the Embarras River as part of the reclamation strategy for the Mercoal Phase 1 Project. The objective was to develop a self-sustaining Athabasca Rainbow Trout (*Oncorhynchus mykiss)* population in the lakes. The purpose of this memo is to provide a brief update regarding fish sampling that has been conducted within and adjacent to the lake system to date.

BACKGROUND

The Embarras Lakes are located in the extreme headwaters of the Embarras River southwest of Robb, Alberta. Baseline habitat assessment in the area of the lakes indicated that habitat conditions were poor and fish densities were low (Boorman 2003).

CVRI completed the majority of physical works to reclaim the lake system in 2010 and 2011. As part of this reclamation, CVRI installed a fish exclusion barrier downstream of the lakes and Pisces Environmental Consulting Services Ltd. (Pisces) conducted intensive fish sampling upstream of the barrier to capture and remove Brook Trout that had moved into the diversion channel. During the latter stages of reclamation (in early 2011) approximately 80 to 100 Rainbow Trout were found to have colonized the Lower Embarras Lake (Dean Woods Personal Communication).

In September 2011, Alberta Environment and Sustainable Resource Development (AESRD) stocked 208 native Athabasca Rainbow Trout into the Upper Embarras Lake (Ryan Cox Personal Communication). The stocked fish ranged in size from 29 mm to 119 mm with a mean length of 80 mm (Ryan Cox Personal Communication).

At the request of CVRI, Pisces implemented an annual monitoring program that included seasonal assessment of the lakes and connecting channels starting in the summer of 2011. The first annual report that included assessment results for the period of summer 2011 to spring 2012 was completed in early 2013 (Sonnenberg and Stemo 2013). The second annual report (summer 2012 to spring 2013) is currently being prepared.

RESULTS SUMMARY

Fish sampling has been conducted at an established monitoring section (the Hinton Wood Products (HWP) Bridge Section) downstream of the fish exclusion barrier and also at several locations within the connecting channels and end pit lakes upstream of the exclusion barrier (Figure 1).

Fish Sampling Downstream of End Pit Lake System

Sampling of the Embarras River near the HWP Bridge has been completed on several occasions starting in 2002 (Table 1). The upstream limit of this sample section is located approximately 100 metres downstream of the exclusion device that was constructed on the Embarras River (Figure 1). Results indicate that Rainbow Trout density (n/100m^2) and catch per unit effort (CPUE) in the Embarras River downstream of pit lakes have increased substantially since the lake system was reclaimed.

Table 1. Summary of electrofishing results for the Embarras River HWP Bridge Section.

Date	Method	Section Length (m)	# RNTR	# BKTR	RNTR CPUE (fish/min/ 100m^2)	BKTR CPUE (fish/min/ 100m^2)	RNTR Density (n/100m^2)	BKTR Density (n/100m^2)
16-Jul-02	E-Fish Removal (4 pass) [1]	305	10	2	0.010	0.005	2.6[1]	0.3
15-Aug-02	E-Fish Removal (2 pass)	305	13	3	0.054	0.010	2.2	0.5
23-Jun-08	E-Fish Survey	305	6	1	0.044	0.007	n/a	n/a
18-Aug-11	E-fish Survey	300	21	50	0.081	0.194	n/a	n/a
04-Sep-12	E-Fish Mark/Recap	400	76	179	0.135	0.317	16.2[2]	49.3
27-Sep-13	E-Fish Mark/Recap	300	367	152	1.205	0.499	180.8[2]	41.0

[1]16-Jul-2002 removal estimate exhibited low capture probability (Boorman 2003)
[2]Mark/recapture estimate utilizing Chapman variation of the Lincoln-Peterson Method.

Fish Sampling Within the End Pit Lake System

Preliminary sampling indicates that relatively large Athabasca Rainbow Trout are occupying the end-pit lakes. Test angling completed by Pisces' personnel in the Upper Embarras Lake on August 20, 2013 resulted in the capture of 23 Rainbow Trout ranging in size from 213 mm fork length and 95 grams to 521 mm fork length and 1024 grams. Table 2 provides a summary of fish capture events in stream channels upstream of the fish exclusion device.

Table 2. Summary of results for single-pass electrofishing conducted in the Embarras Lake System.

Sample Section	Date	n	RNTR CPUE (fish/min/100m²)	RNTR Density[1] (n/ 100m²)	Section Characteristics and General Comments
ELS-1 (Upstream of Embarras Lakes)	17-Aug-12	10	1.520	8.89	• 75 m section extending upstream from the Upper Lake to a ponded area. Average channel width of 1.5 m
	25-Aug-13	74	6.016	65.78	
ELS-2 (Upstream of Middle Embarras Lake)	16-Aug-12	60	0.340	10.00	• 400 m section between the Middle and Upper lakes. Average channel width of 1.5 m. • Extremely high fish densities encountered in 2013 necessitated a reduction in section length to 150 m.
	25-Aug-13	190	3.221	84.44	
ELS-3 (Upstream of Lower Embarras Lake)	27-Sept-12	6	0.548	4.00	• 150 m section between the Lower and Middle Lakes. Average channel width of 1.0 m.
	9-Aug-13	71	1.902	47.33	
ELS-4 (Upstream of fish exclusion barrier)	18-Aug-11	25	0.087	3.47	• 400 m section extending upstream from the fish exclusion structure to the Lower Embarras Lake. Average channel width of 2 m. • Deep-water pond habitat not sampled. • Capture probability was likely limited due to water depth and small size of average fish captured.
	5-Oct-11	1	0.008	0.16	
	4-Sept-12	13	0.070	1.63	
	27-Sept-12	13	0.058	1.63	
	9-Aug-13	41	0.071	5.13	

[1] Estimated density is based on total catch from single pass electrofishing survey.

Rainbow Trout Spawning in the Vicinity of the End Pit Lake System

Spawning surveys conducted during spring 2012 and 2013 confirmed that Rainbow Trout spawning has occurred upstream and downstream of the fish exclusion structure (Table 3). Schools of Rainbow Trout fry numbering in the hundreds ranging from 25-30 mm length were first observed on July 14th, 2013 in the constructed channel downstream of the Lower Embarras Lake. This suggests that spawning occurred in mid to late May and indicates that successful emergence likely occurred early July.

Table 3. Summary of results for Rainbow Trout spawning surveys conducted in the vicinity of the Embarras Lake System.

Survey Date	Downstream of Exclusion	Upstream of Exclusion
May 26th, 2012	• 2 possible redds[1]	• 1 possible redd upstream of middle lake[1]
June 1st, 2012	• No spawning observed • 3 large RNTR observed attempting to move upstream at the exclusion barrier	• No spawning observed
June 21st, 2012	• No spawning observed	• No spawning observed
May 22nd, 2013	• 8 RNTR pairs observed • Numerous possible redds observed[1]	• 10 RNTR pairs observed upstream of middle lake and upper lake • Possible redds observed at outlet of lower and middle lakes[1]
May 31st, 2013	• No spawning observed	• No spawning observed
June 1st, 2013	• No spawning observed	• No spawning observed

[1]Redd defined as "possible" if there was evidence of disturbed streambed gravels but the distinct pit and tail spill associated with characteristics of a positive redd were absent.

DISCUSSION

Performance of Fish Exclusion Barrier

The fish exclusion barrier appears to be effectively precluding the movement of Brook Trout into the Embarras Lake System since Brook Trout are numerous downstream of the barrier but have not been recorded upstream.

Athabasca Rainbow Trout Population

Results obtained to date indicate that a robust population of Athabasca Rainbow Trout occupy the lake system with all life stages being supported upstream of the fish exclusion barrier. In addition to the newly established Rainbow Trout population upstream of the barrier, populations of Rainbow Trout and Brook Trout downstream of the barrier have increased dramatically compared to baseline conditions. Preliminary results, based on two years of spawning surveys, suggest that conditions in the vicinity of the lake system are beneficial to Rainbow Trout reproduction. It appears that spawning in the vicinity of the lakes may be occurring earlier than in natural systems and the capture of fry in mid-July suggests that emergence and growth of fry is accelerated compared to natural systems.

When compared to Rainbow Trout densities reported in the Alberta Status Report for Athabasca Rainbow Trout (AESRD and ACA 2009) the estimated densities (based on preliminary sampling) within the connecting channels of the lake system and in the natural channel downstream of the fish exclusion barrier appear to be among the highest in the region. For example, the density of Rainbow Trout in the HWP Bridge Section in 2013 (180.8/100m^2) compares favorably with the densities reported for Deerlick Creek (23.9/100m^2) and Wampus Creek (31.1/100m^2) (AESRD and ACA 2009). Both Deerlick and Wampus Creeks report some of the highest densities of Athabasca Rainbow Trout in the region and are considered low risk systems (ASRD and ACA 2009). The status report classified stream fish populations across the region as low risk (>5 fish/100m^2), medium risk (2-5 fish/100m^2), or high risk (<2 fish/100m^2) based on fish density. Prior to mining, densities of Rainbow Trout in the HWP Bridge Section ranged from 2.2 to 2.6/100m^2 while fish were uncommon or possibly absent within the proposed mine area (Boorman 2003). Based on this information it appears that the Athabasca Rainbow Trout population in the vicinity of the Embarras Lakes System has shifted from a medium to high risk population to a low risk population.

While additional monitoring will be required to assess the development of this fish community over the longer term and the initial monitoring results should be considered preliminary, it appears that habitat conditions for Athabasca Rainbow Trout in the upper Embarras River have improved post-reclamation.

CLOSURE

I trust that the foregoing meets your requirements at this time. Please do not hesitate to contact me if you have any questions.

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Alberta Sustainable Resource Development and Alberta Conservation Association. 2009. Status of the Athabasca Rainbow Trout (Oncorhynchus mykiss) in Alberta. Alberta Sustainable Resource Development Wildlife Status Report No. 66. Edmonton, AB. 32 pp.

PERSONAL COMMUNICATIONS

Cox, Ryan. December 2012. Fisheries Biologist Alberta Environment and Sustainable Resource Development Foothills Area, Edson, Alberta.

Woods, Dean. December 2012. Reclamation Specialist D&T Woods. Edson, Alberta.

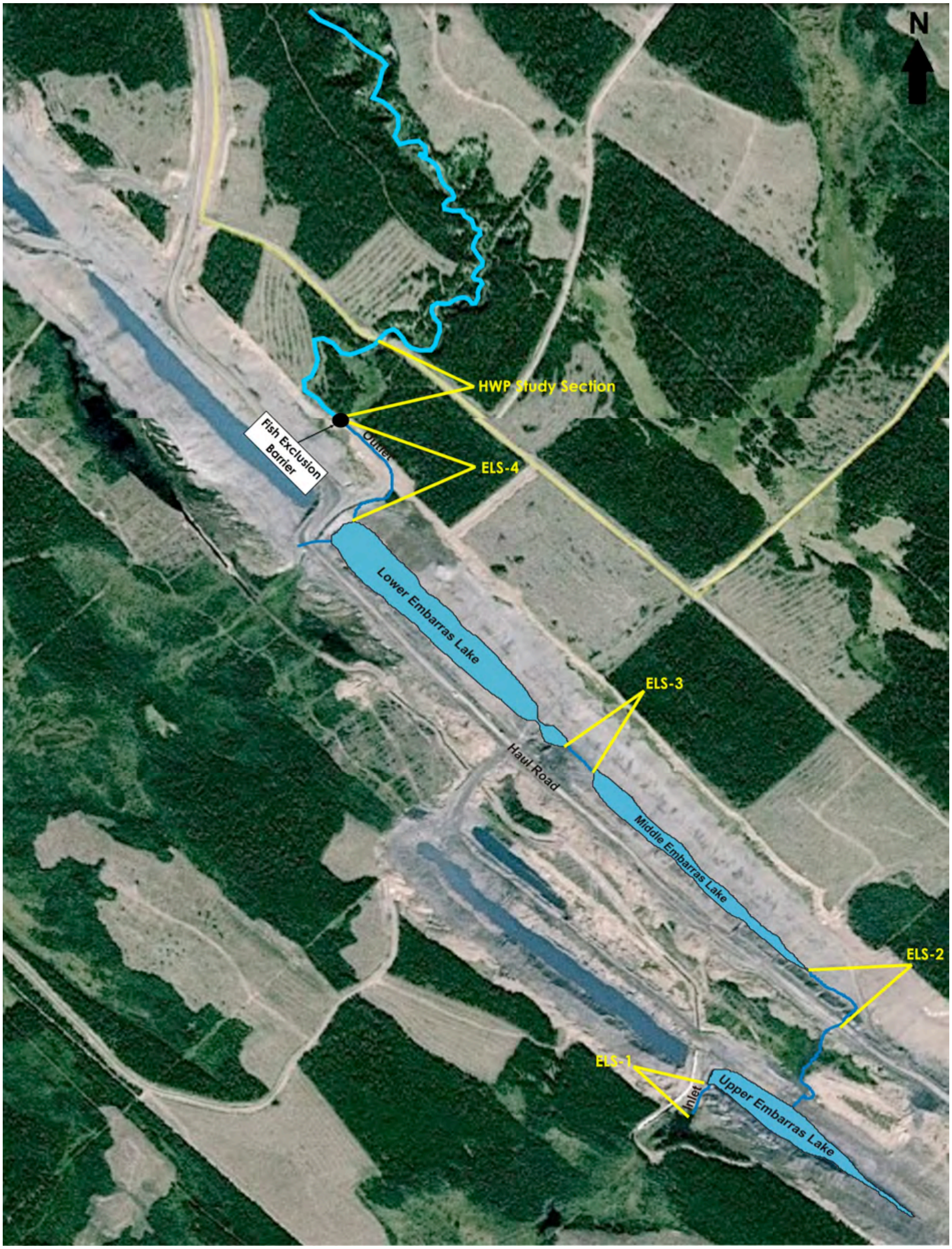

Figure 1. Embarras Lakes System

AQUATIC MONITORING PROGRAM FOR END PIT LAKES IN THE HEADWATERS OF THE EMBARRAS RIVER, 2011-2012

Prepared for: Coal Valley Resources Inc. Edson, Alberta

April 2013

PISCES ENVIRONMENTAL CONSULTING SERVICES LTD.

AQUATIC MONITORING PROGRAM FOR END PIT LAKES IN THE HEADWATERS OF THE EMBARRAS RIVER, 2011-12

Prepared For:
Coal Valley Resources Inc.
Edson Alberta

Prepared by:
Pisces Environmental Consulting Services Ltd.
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April 2013

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1.0 INTRODUCTION

In August 2004, Fisheries and Oceans Canada (DFO) issued *Fisheries Act* Authorization ED-03-3080 to Coal Valley Resources Incorporated (CVRI) for the diversion of the Embarras River to facilitate mining in the Mercoal Phase 1 (MP1) area. Part of the final reclamation strategy for the MP1 extension included the development of an end pit lake system that would support a self-sustaining native fish population. Key to the fish habitat compensation plan for this diversion was the implementation of a study to assess the viability of the end pit lakes once they were constructed. CVRI completed the physical works to reclaim the aquatic ecosystem in 2010 and monitoring was initiated in 2011. This document presents results of monitoring conducted by Pisces Environmental Consulting Services Ltd. (Pisces) from summer 2011 to spring 2012.

1.1. OBJECTIVES

The 2011-12 monitoring program was designed to evaluate the initial development of the aquatic ecosystem of the Embarras End Pit Lake system in consideration of the following:

- Requirements specified in the DFO Authorization;
- End Pit Lake Working Group (EPLWG) Guideline performance evaluation/criteria; and
- Alberta Environment and Sustainable Resource Development (AESRD) objectives for End Pit Lake closure landscape.

The primary objectives of the program are listed below. Additional study parameters will be assessed in future years as the lake system develops.

- Describe physical and chemical limnological characteristics of the End Pit Lakes;
- Assess fish population in Embarras River downstream of the Lake System;
- Assess benthic macroinvertebrate populations in End Pit Lakes and Embarras River;
- Assess zooplankton and phytoplankton communities in the End Pit Lakes;
- Assess macrophyte communities in the End Pit Lakes.

2.0 STUDY AREA

The Embarras End Pit Lake system is located in the extreme headwaters of the Embarrass River in 25-47-21-W5 (Figure 2.1). The Embarras River flows into the McLeod River approximately 86 kilometres downstream of the lakes, which in turn flows into the Athabasca River near Whitecourt, Alberta. Historically, fish densities in the upper Embarras River were low and pre-mining investigations of this part of the river found fish habitat potential to be limited (Boorman 2003). Habitat diversity within this area was considered to be marginal and substrates were comprised almost exclusively of fines (Boorman 2003). However, Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*) and Brook Trout (*Salvelinus fontinalis*) were found just downstream of the proposed MP1 pit area during baseline investigations (Boorman 2003).

The Embarras End Pit Lake system consists of three lakes and approximately 1100 metres of constructed connecting channels (Figure 2.1). The naming convention for the lakes is as follows:

- Upper Embarras Lake (Pit 142E);
- Middle Embarras Lake (Pit 122); and
- Lower Embarras Lake (Pit 122).

The Embarras River enters the Upper Lake from a natural beaver pond via a constructed inlet channel that is approximately 30 metres long. There are approximately 500 metres of connecting channel between the Upper and Middle Lakes including the haulroad culvert crossing that is located just upstream of the Middle Lake. Between the Middle Lake and Lower Lake there is approximately 150 metres of connecting channel and there is approximately 400 metres of constructed channel downstream of the Lower Lake. A fish exclusion weir has been constructed at the bottom of this constructed channel to preclude Brook Trout from entering the end pit lake system. Photos of the lake and connection channels are presented in Appendix A.

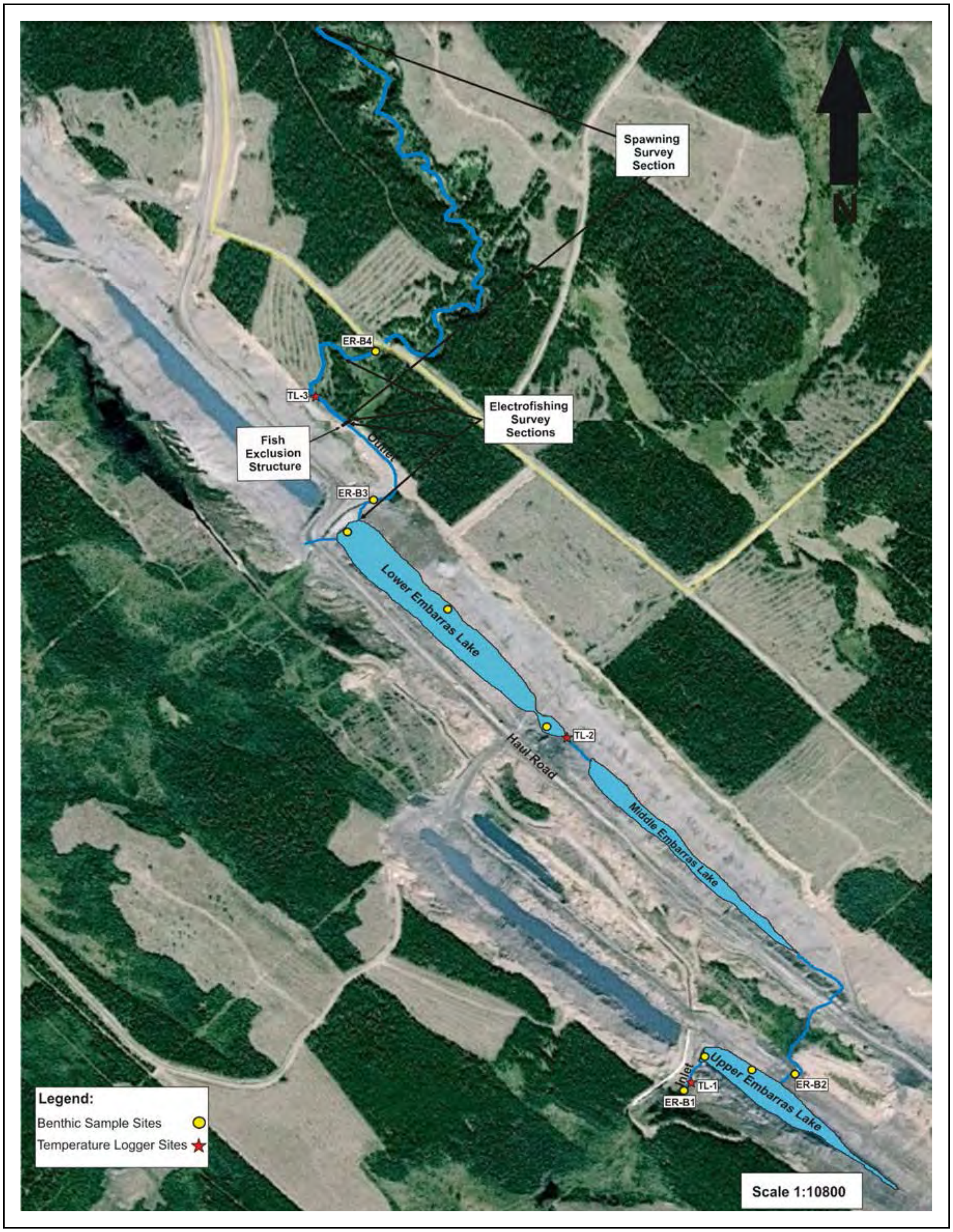


Figure 2.1. Study area and location of lakes.

3.0 METHODS

3.1. LENTIC HABITAT

3.1.1. Physical Characteristics

The basic morphology of each lake was determined based on field investigations and information provided by Sherritt Coal.

3.1.2. Limnology

A limnology station was established near the middle of each lake. Temperature, dissolved oxygen, and electrical conductivity were measured seasonally (summer, fall, winter, spring with a YSI model 85 meter at one metre intervals to a maximum depth of 30 metres. Water transparency was measured with a 20-centimetre Secchi disk during open water sampling.

3.1.3. Water Quality

In August 2011 water samples were obtained from the epilimnion and hypolimnion of the Upper and Lower Lakes using a Kemmerer bottle. Samples for chlorophyll analysis were taken from the photic zone. All samples were sent to Exova Laboratories in Edmonton, Alberta for analysis of select water quality variables (Table 3.1).

3.1.4. Benthic Invertebrates

Benthic macroinvertebrate sampling stations were established at random in the littoral zone of the Upper and Lower Lakes in October 2011. A 0.023 square metre Eckman grab sampler was used to obtain substrate samples at depths of 1.8 to 6.1 metres. Five replicate samples were taken, washed through a 583 μm sized sieve, stored and preserved with 85% ethanol. All benthic collections were submitted to an independent contractor for taxonomic analysis. Sample processing consisted of sorting, identifying and enumerating benthic invertebrates (Appendix B).

3.1.5. Zooplankton

In August 2011, five sample sites were established on both the Upper and Lower Lakes with one site located at or near the centre of the lake and the four remaining samples located in each of four quadrants. Vertical hauls were made at each site using a No. 20 Wisconsin net. The net was lowered to critical depth or near bottom of the lake and raised at 0.5 to 1.0 metres per second. The sample was rinsed into a jar, preserved with 95% ethanol and shipped to a qualified independent contractor for identification, enumeration, and population density calculations (Appendix C).

Table 3.1. Water chemistry variables measured in the Embarras End Pit Lake System in 2011-12 and Provincial and Federal water quality objectives.

Variable	Units	Surface Water Quality Objectives	
		Provincial[1]	Federal[2]
pH		6.5-8.5	6.5-9.0
EC	μMHOS/cm		
TDS	mg/L		
TSS	NTU		
T. Alkalinity	mg/LCACO$_3$		
Carbonate	mg/L		
Bicarbonate	mg/L		
Calcium	mg/L		
Magnesium	mg/L		
Sodium	mg/L		
Potassium	mg/L		
Hardness	mg/LCACO$_3$		
Chloride	mg/L		
Sulphate	mg/L		
Nitrate	mg/L as N		
Nitrite	mg/L as N		0.06
TKN	mg/L as N		
TP	mg/L as P	0.05	
Chlorophyll a (*)	μg/L		
Arsenic	mg/L	0.01	0.005
Antimony	mg/L		
Aluminium	mg/L	1	0.1 @ pH> 6.5
Barium	mg/L		
Beryllium	mg/L		
Bismuth	mg/L		
Boron	mg/L	0.5	
Cadmium	mg/L	0.01	0.0008(**) 0.0013(***) 0.0018(****(
Chromium	mg/L	0.05	0.02
Cobalt	mg/L		
Copper	mg/L	0.02	0.002(**) 0.003(***) 0.004(****)
Iron	mg/L	0.3	0.3
Lead	mg/L	0.05	0.002(**) 0.004(***) 0.007(****)
Lithium	mg/L		
Manganese	mg/L	0.05	
Mercury	mg/L	0.0001	0.0001
Molybdenum	mg/L		
Nickel	mg/L		0.065(**) 0.11(***) 0.15(****)
Selenium	mg/L	0.01	0.001
Silicon	mg/L		
Silver	mg/L	0.05	0.0001
Strontium	mg/L		
Sulphur	mg/L		
Thallium	mg/L		
Titanium	mg/L		
Uranium	mg/L		
Vanadium	mg/L		
Zinc	mg/L	0.05	0.03

1 Alberta Environment (1999)
2 Canadian Council of Ministers of Environment (2006)
Elements/Metals as Total
(*) Chlorophyll measured in photic zone (composite sample)
(**) @Hardness 60-120 mg/L CaCO$_{3,}$ (***) @ Hardness 120-180mg/L CaCO$_{3,}$ (****) @ Hardness > 180mg/L CaCO$_3$

3.1.6. Phytoplankton

Three composite samples were taken randomly from undisturbed areas of the epilimnion near the limnology station in the Upper and Lower lakes. Sampling was completed in August 2011. All samples were transferred to one litre amber bottles and shipped to an independent contractor for analysis.

3.1.7. Aquatic Macrophytes

A survey of the submergent and emergent aquatic macrophyte community in the lakes was conducted during August investigations. Aquatic macrophytes were identified to species and the abundance of each species was approximated in square metres (m^2).

3.2. LOTIC HABITAT

3.2.1. Spawning Surveys

Spawning surveys were conducted in connecting channels and in the natural channel downstream of the Lake system during the spring and fall. Spawning surveys targeting Brook Trout and Bull Trout were conducted on October 5th 2011 while surveys targeting Rainbow Trout were completed in May 2012 (Figure 2.1). The location of spawning activity was noted and the number and appropriate size of the fish on redds was recorded. To be confirmed as a positive redd the redd need to exhibit the typical depression and tail spill mound associated with salmonid spawning sites. A redd was considered to be a possible redd if there was evidence of disturbed stream bed gravels but the distinct pit and tail spill associated with characteristics of a positive redd were absent.

3.2.2. Fish Capture

Single pass electrofishing surveys using a Smith Root LR24 electrofisher were completed in connecting channels and in the natural channel downstream of the Lake system in August and October 2011 (Figure 2.1). All fish captured were identified to species, measured to fork length (mm) and weighted (g).

3.2.3. Benthic Invertebrates

Benthic invertebrate sampling sites were established at four locations on the Embarras River including: one upstream of the lakes, two within the constructed connecting channels, and one downstream of the lake system (Figure 2.1). Sample sites were selected to maintain a consistency of substrate across sites. Habitat at all sites was erosional, consisting of riffle and run habitat. Water velocity and mean depth was measured at three locations along an established transect within the sampling area and substrate composition was recorded at each site.

Three replicate samples were collected at each site using a Neill-Hess cylinder (250 micron mesh). Samples were transferred to jars, preserved with 85% ethanol and transported to a qualified independent contractor for analysis.

3.2.4. Temperature Regime

StowAway®TidbitTM temperature data loggers (Onset Computer Corporation) were installed in the Embarras River at three locations within the end pit lake system. One was located upstream of the lakes, one was located in the connecting channel between the Middle and Lower Lake, and one was located in the channel downstream of Lower Lake near the fish exclusion weir (Figure 2.1). The data loggers recorded a water temperature on an hourly basis between June 9th, 2011 and October 5th, 2011.

4.0 RESULTS

4.1. LOWER EMBARRAS LAKE

4.1.1. Morphometric Data

Morphometric data are summarized in Table 4.1. A bathymetric map of the lake showing benthic, zooplankton, and limnological sampling sites is presented on Figure 4.1.

Table 4.1. Morphometric data for Lower Embarras Lake.

Parameter	Value
Area (ha)	6.6
Volume (m^3)	483 000
Maximum length (m)	853
Maximum width (m)	111
Maximum depth (m)	18
Mean depth (m)	7.34
Surface elevation (m)	1430
Percent Littoral (<3m deep)	30%

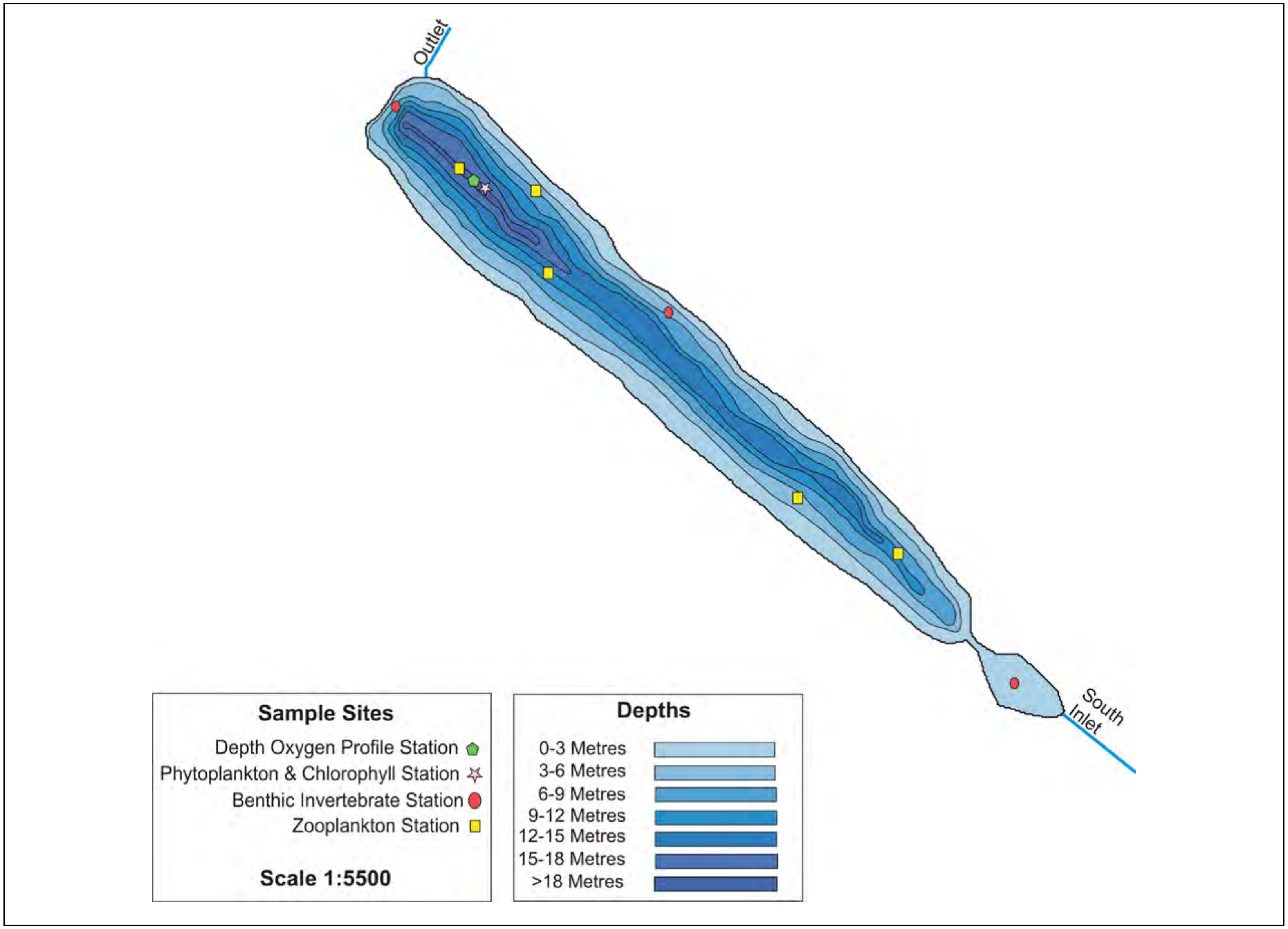


Figure 4.1. Bathymetry and Sample Locations on Lower Embarras Lake.

4.1.2. Physical and Chemical Conditions

Seasonal values for the Secchi disc transparency in Lower Embarras Lake are presented in Table 4.2.

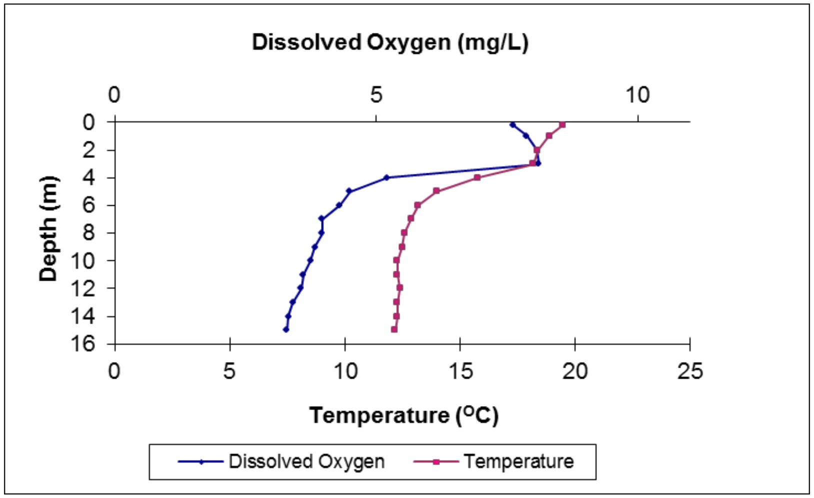
Table 4.2. Secchi disc transparency for Lower Embarrass Lake.

Date/ Season	Secchi Depth (m)	Climatic Conditions
17-Aug-11 (Summer)	1.3	Overcast- light rain
06-Oct-11 (Fall)	1.7	Overcast
26-May-12 (Spring)	1.9	Clear, strong wind

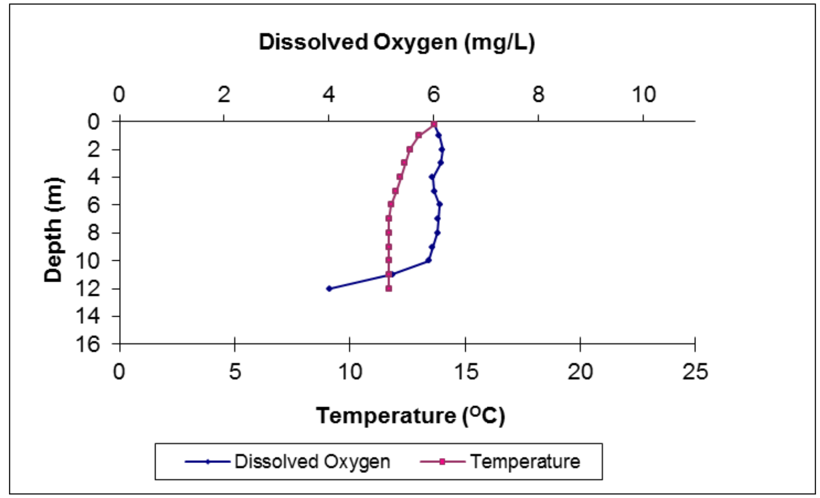
The lake was thermally stratified in the summer with the thermocline situated between 4 and 7 metres (Figure 4.2). Lake temperatures were relatively consistent through the water column in the fall ranging from all most 14^{O}C at the surface to just less than 12^{O}C near lake bottom. The lake was covered by approximately 0.70 metres of ice and 0.05 metres of snow when surveyed in February; surface temperatures had decreased to 0.6^{O}C while temperatures below 10 metres were relatively constant around 4^{O}C. The lake was beginning to stratify in the spring; temperatures ranged from 10.7^{O}C at the lake surface to 6.2^{O}C at the lake bottom with the thermocline situated between 6 and 8 metres.

The Lower Embarras Lake exhibited a clinograde oxygen profile. Oxygen concentrations were lower in the hypolimnion compared to the epilimnion in the summer and winter and were relatively constant within the water column in the spring and fall (Figure 4.2).

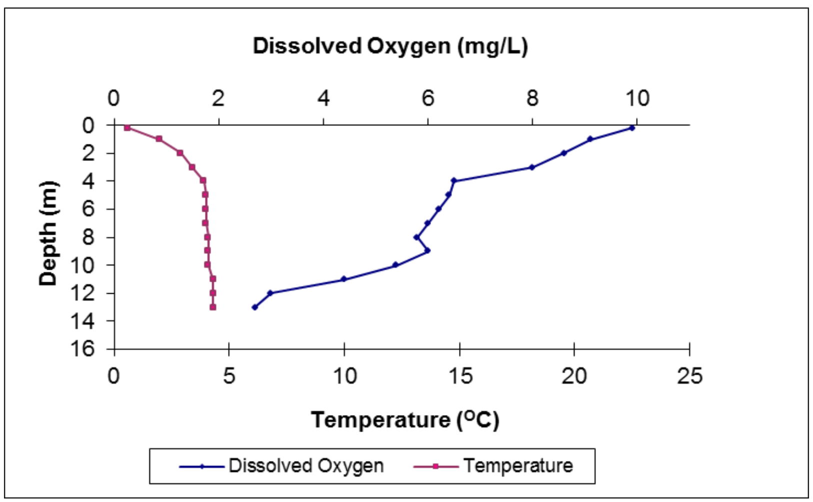
Specific conductivity varied seasonally but values were generally higher in the hypolimnion compared to the epilimnion in each season (Figure 4.3). The lowest conductivity values occurred during the spring and summer sampling period while the highest values were recorded during the winter.



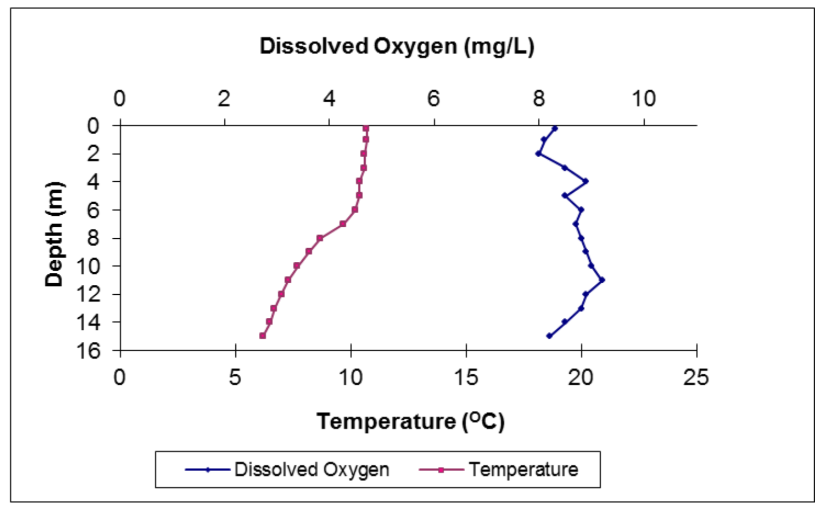
Summer



Fall



Winter



Spring

Figure 4.2. Oxygen and Temperature Profiles for Lower Embarras Lake.

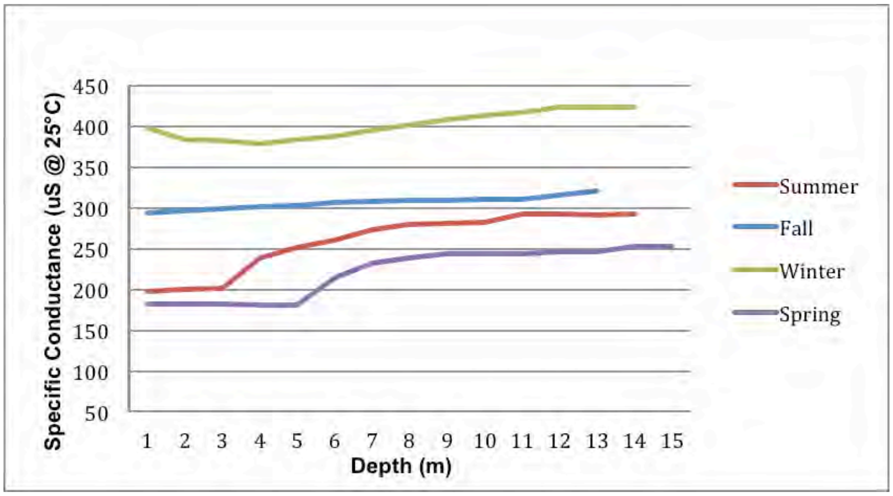


Figure 4.3. Conductivity Profiles for Lower Embarras Lake.

Alkalinity and pH values indicate that the lake was well buffered and non-acidic (Table 4.3). Water in the lake was of a bicarbonate type with an ionic hierarchy of Ca^{+} >Na^{+} > Mg^{+} > K^{+} (cations) and HCO_3^{-} > SO_4^{-} : Cl^{-}. (anions). Two variables, iron (hypolimnion and epilimnion), and aluminum (hypolimnion and epilimnion). exceeded Canadian Council of Ministers of the Environment guidelines (CCME 2006) (Table 4.3). In addition, manganese (epilimnion and hypolimnion) exceeded Provincial guidelines (Alberta Environment 1999).

Table 4.3. Water quality data for Lower Embarras Lake.

Parameter	Units	Epilimnion	Hypolimnion
Kjeldahl Nitrogen	mg/L	0.19	0.07
Phosphorus	mg/L	<0.05	<0.05
Organic Carbon	mg/L	8.2	6.3
Calcium	mg/L	26.0	40.0
Iron	mg/L	0.85	1.09
Magnesium	mg/L	5.6	9.0
Manganese	mg/L	0.112	0.098
Potassium	mg/L	1.2	1.8
Silicon	mg/L	4.15	4.92
Sodium	mg/L	9.8	11.8
Sulfur	mg/L	9.0	14.5
Mercury	mg/L	<0.0001	<0.0001
Aluminum	mg/L	0.71	1.21
Antimony	mg/L	<0.0002	0.0002
Arsenic	mg/L	0.0019	0.0009
Barium	mg/L	0.090	0.109
Beryllium	mg/L	<0.0001	<0.0001
Bismuth	mg/L	<0.0005	<0.0005
Boron	mg/L	0.016	0.023
Cadmium	mg/L	0.00002	0.00005
Chromium	mg/L	0.0014	0.0024
Cobalt	mg/L	0.0005	0.0008
Copper	mg/L	0.002	0.003
Lead	mg/L	0.0004	0.0008
Lithium	mg/L	0.004	0.005
Molybdenum	mg/L	0.004	0.004
Nickel	mg/L	0.0035	0.0045
Selenium	mg/L	<0.0002	<0.0002
Silver	mg/L	0.00002	<0.00003
Strontium	mg/L	0.243	0.408
Thallium	mg/L	<0.00005	<0.00005
Tin	mg/L	0.004	0.004
Titanium	mg/L	0.0118	0.0528
Uranium	mg/L	0.0010	0.0020
Vanadium	mg/L	0.0016	0.0035
Zinc	mg/L	0.003	0.005
Solids	mg/L	<1	<1
pH		7.90	7.74
Electrical Conductivity	µS/cm at 25 C	214	313
Chloride	mg/L	0.5	0.5
Nitrate - N	mg/L	0.3	0.56
Nitrite - N	mg/L	0.012	<0.005
Nitrate and Nitrite - N	mg/L	0.31	0.56
Sulfate (SO4)	mg/L	28	45.6
Hydroxide	mg/L	<5	<5
Carbonate	mg/L	<6	<6
Bicarbonate	mg/L	98	142
P-Alkalinity	mg/L	<5	<5
T-Alkalinity	mg/L	80	116
Total Dissolved Solids	mg/L	120	180
Hardness	mg/L	89	138
Ionic Balance	%	102	100

* composite sample
- exceedences are shaded

4.1.3. Benthic Invertebrates

Diptera were numerically dominant in the assemblage and other taxa were comparatively rare (Table 4.4). A total of 6 taxa were present.

Table 4.4. Benthic Invertebrate Composition for Lower Embarras Lake.

Taxon	Density (per 0.023 m^2) Replicate			Mean #Organisms/Sample
	1	2	3	
Plecoptera				
Perlodidae				
Isoperla sp.	4			1.3
Dipters				
Ceratopogonidae				
Ceratopogoninae		2		0.7
Chironomidae				
Orthocladiinae		19	16	11.7
Tanypodinae		4		1.3
Tanytarsini		39		13
Crustacea				
Copepoda				
Cyclopoida	4	16		6.7
Total	8	80	16	34.7
Total taxa	2	5	1	2.7

4.1.4. Zooplankton

The zooplankton community was comprised of 10 taxa in 2011-2012; Rotifers were numerically dominant while Cyclopoids, Cladocerans, Calanoids, and Cilophora comprised the remainder of the zooplankton community (Table 4.5).

Table 4.5. Zooplankton Abundance for Lower Embarras Lake.

Taxa	Density per m^3					
	Replicate #					Mean #Organisms
	1	2	3	4	5	
Calanoid						
Leptodiaptomus sicilis	555	205	364	449	251	365
Calanoid copepodid	476	614	468	374	201	4267
Calanoid *nauplii*	5774	0	0	9775	0.0	3110
Cladocera						
Daphnia pulex	4837	716	2498	2320	201	2114
Others (Cilophora)						
Vorticella sp	0	0	0	9775	0	1955
Cyclopoid						
Dicyclops bicuspidatus	2537	3682	1822	5315	3518	3375
Cyclopoid copepodid	8246	6853	5673	6930	8085	7157
Cyclopoid *(nauplii)*	11547	6278	5282	19551	7140	9965
Rotifera						
Polyathra dolicoptera Idelson	0	0	0	0	7140	1785
Total	33972	18348	16107	54489	26536	30253
Total Taxa	7	6	6	8	7	6.8

4.1.5. Phytoplankton

Phytoplankton collections in Lower Embarras Lake found a total of 17 taxa present (Table 4.6). The chlorophyll *a* concentration for the lake was 0.550 mg/m^3.

Table 4.6. Phytoplankton Abundance for Lower Embarras Lake.

Genus/Species	Cell/Colony Density (cells/mL)
Bacillariophyta	
Achnanthes minutissima	0.62
Cymbella minuta	0.31
Navicula sp.	0.31
Nitzschia acicularis	2.99
Synedra sp. smaller	4.43
Cryptophyta	
Cryptomonas reflexa	7.86
Katablepharis ovalis	1.55
Rhodomonas	72.52
Chrysophyta	
D. divergens statospore	0.31
Kephyrion sp	111.94
Chlorophyta	
Ankistrodesmus setigera	51.90
Characium sp.	1.24
Oocystis sp.	35.87
Sphaerocystis schroeteri	26.75
Cyanophyta	
Aphanothece clathrata	36.80
Lyngbya limnetica	31.54
Phormidium	2.17
Total	389.1
Total Taxa	17

4.1.6. Aquatic Macrophytes

No submergent and/or floating leaf macrophytes were observed during the survey of the lake conducted in August.

4.2. MIDDLE EMBARRAS LAKE

4.2.1. Morphometric Data

Morphometric data are summarized in Table 4.7. A bathymetric map delineating sample sites is presented on Figure 4.4.

Table 4.7. Morphometric data for Middle Embarras Lake.

Parameter	Value
Area (ha)	3.0
Volume (m^3)	102000
Maximum length (m)	794
Maximum width (m)	62
Maximum depth (m)	10
Mean depth (m)	3.4
Surface elevation (m)	1443
Percent Littoral (<3m deep)	55

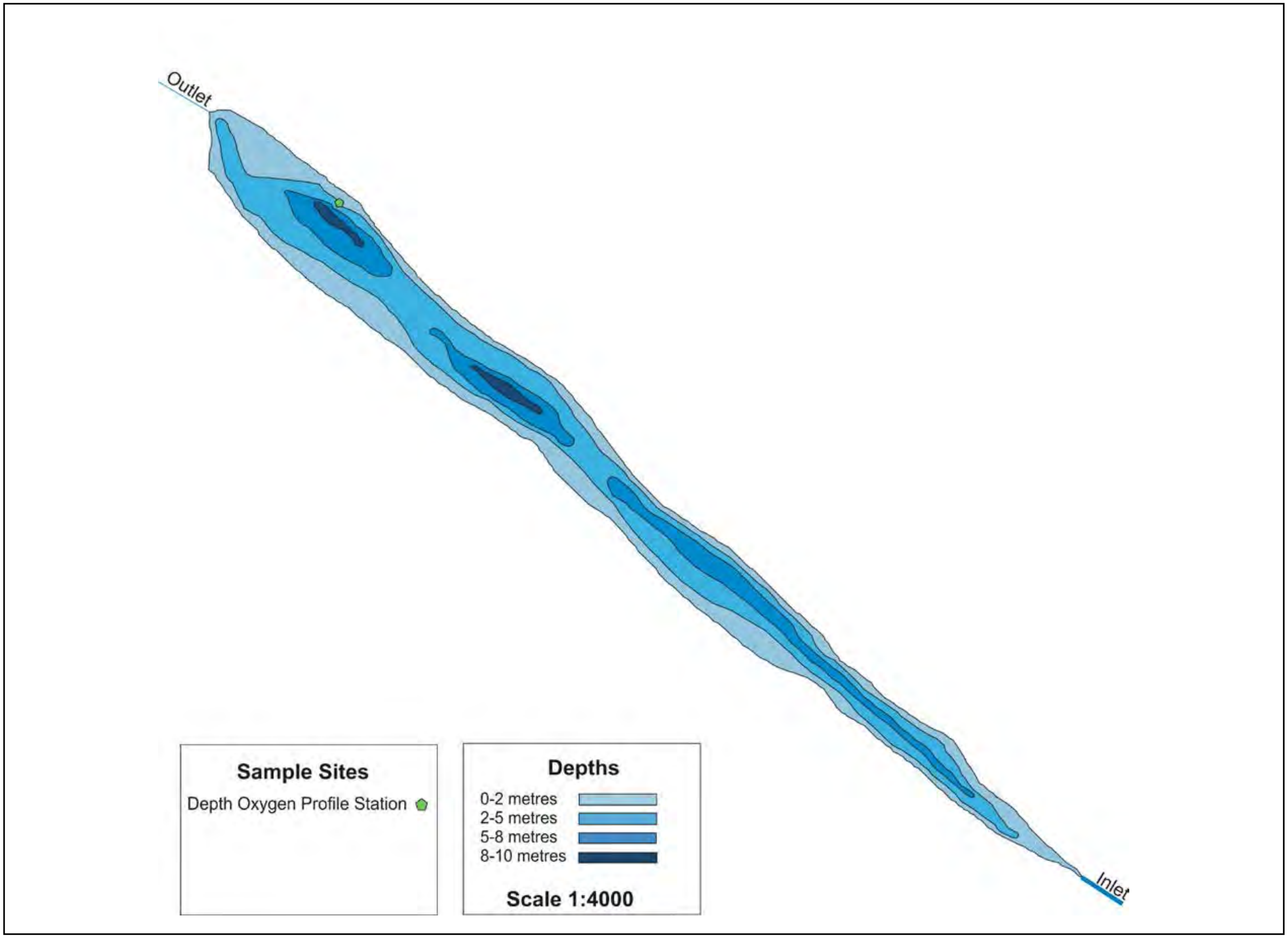


Figure 4.4. Bathymetry and Sample Locations on Middle Embarras Lake.

4.2.2. Physical and Chemical Conditions

Seasonal values for the Secchi disc transparency in Middle Embarrass Lake are presented in Table 4.8.

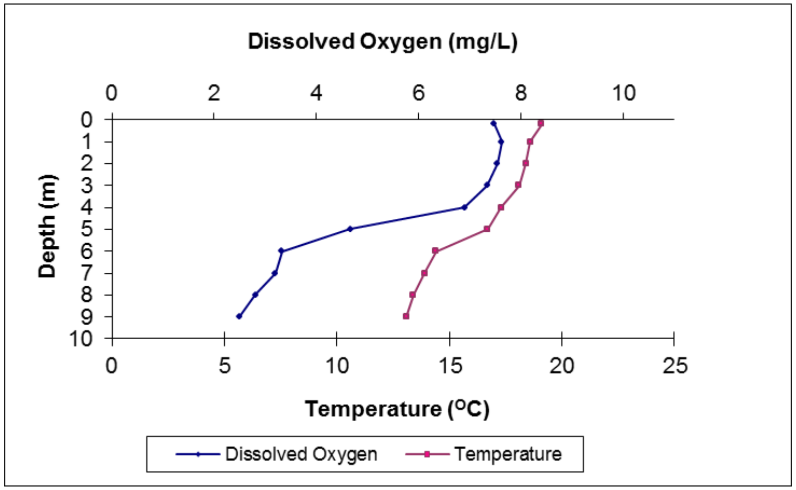
Table 4.8. Secchi disc transparency for the Middle Embarras Lake.

Date/ Season	Secchi Depth (m)	Climatic Conditions
17-Aug-11 (Summer)	0.5	Overcast, rain
5-Oct-11 (Fall)	0.5	Overcast
26-May-12 (Spring)	1.9	Clear, moderate wind.

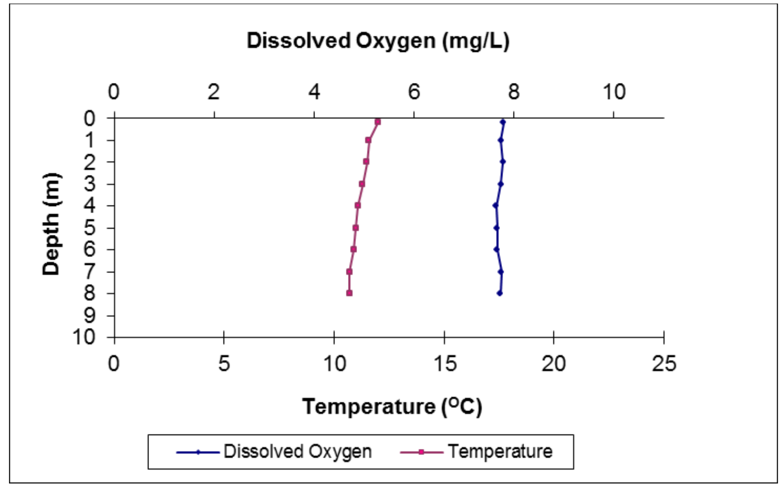
The seasonal temperature profiles obtained during the year indicated that the lake was thermally stratified during the summer with the thermocline situated between 4 and 6 metres (Figure 4.5). Isothermal conditions were present in the fall with temperatures in water column ranging from 12^{O}C near the surface to just under 11^{O}C at a depth of 8 metres. The lake was covered by approximately 0.61 metres of ice and 0.12 metres of snow when surveyed in February; surface temperatures had decreased to 0.4^{O}C while temperatures through the water column were at or near 4^{O}C. In the spring temperatures ranged from 10.5^{O}C at the surface to 6.1^{O}C near lake bottom (9 m depth) with the thermocline situated between 4 and 5 metres.

The Middle Embarras Lake exhibited a clinograde oxygen profile. Oxygen concentrations were lower in the hypolimnion compared to the epilimnion in the summer and winter and were relatively constant within the water column in the spring and fall (Figure 4.5).

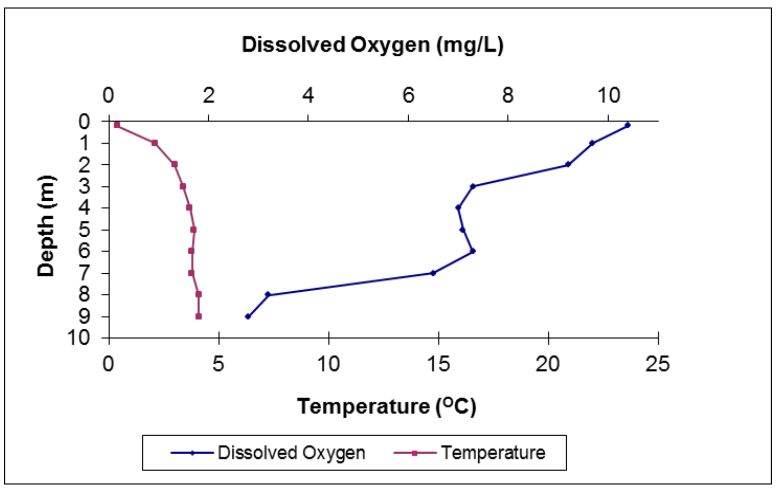
Specific conductivity within the water column was fairly constant during seasonal sampling events (Figure 4.6). However, the conductivity within the lake increased from spring season to winter season.



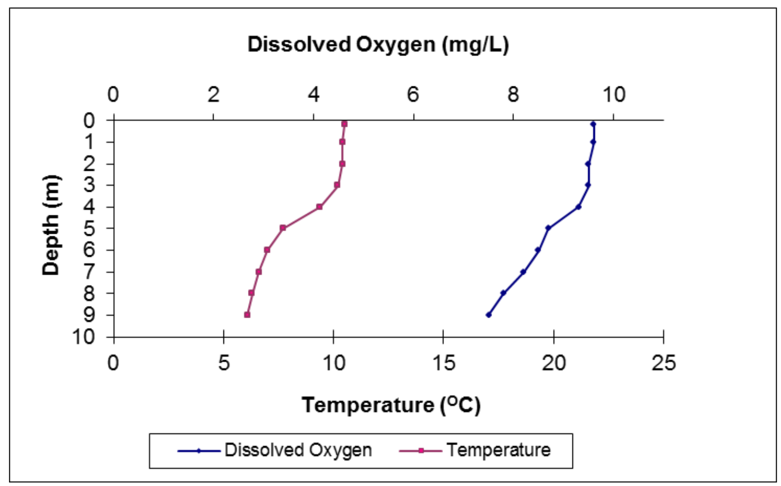
Summer



Fall



Winter



Spring

Figure 4.5. Oxygen and Temperature Profiles for Middle Embarras Lake.

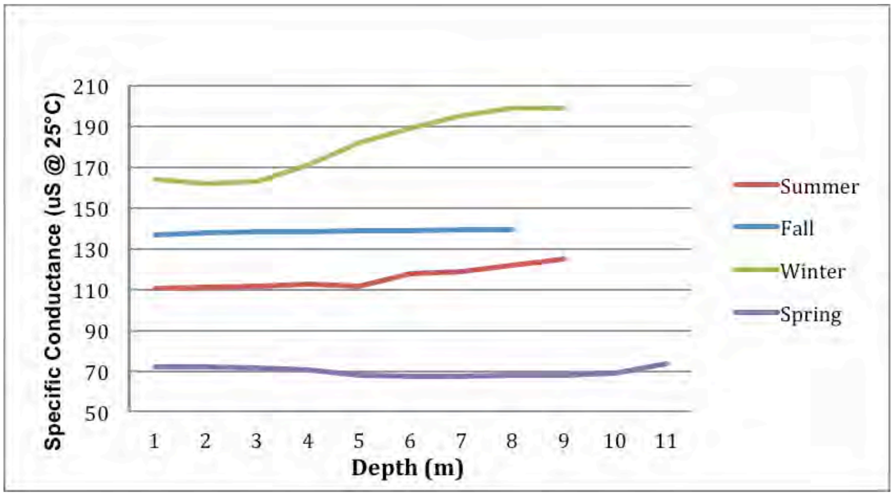


Figure 4.6. Conductivity Profiles for Middle Embarras Lake.

4.2.3. Aquatic Macrophytes

No submergent and/or floating leaf macrophytes were observed during the survey of the conducted in August.

4.3. UPPER EMBARRAS LAKE

4.3.1. Morphometric Data

Morphometric data are summarized in Table 4.9. A bathymetric map of the lake showing benthic, zooplankton, and limnological sampling sites is presented in Figure 4.7.

Table 4.9. Morphometric data for Upper Embarras Lake.

Parameter	Value
Area (ha)	5.0
Volume (m^3)	160 000
Maximum length (m)	851
Maximum width (m)	110
Maximum depth (m)	8.0
Mean depth (m)	3.2
Surface elevation (m)	1450
Percent littoral ((<3m deep)	56

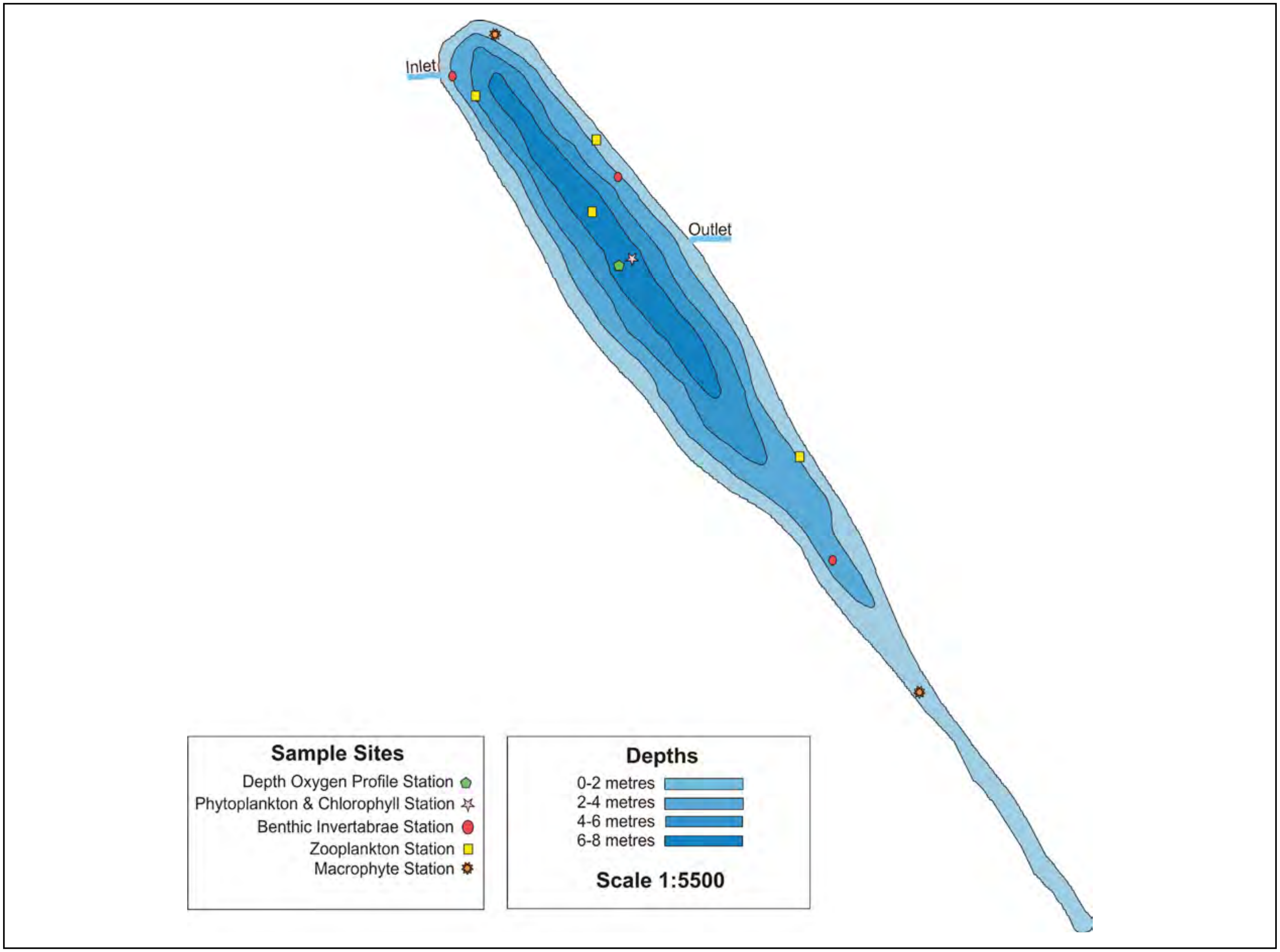


Figure 4.7. Bathymetry and Sample Locations on Upper Embarras Lake.

4.3.2. Physical and Chemical Conditions

The Secchi disc transparency in Upper Embarras Lake varied over the course of the sampling period (Table 4.10).

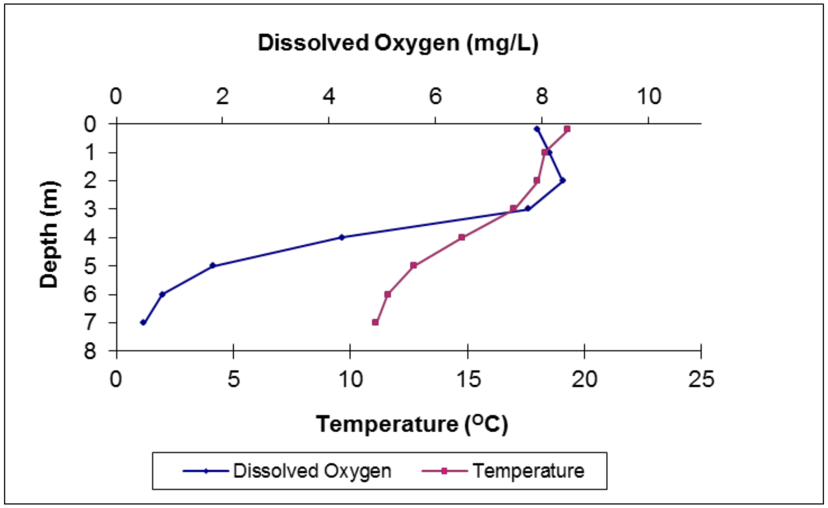
Table 4.10. Secchi disc transparency for Upper Embarras Lake.

Date/ Season	Secchi Depth (m)	Climatic Conditions
16-Aug-11 (Summer)	2.8	Partly overcast.
05-Oct-11 (Fall)	3.0	Partly sunny.
26-May-12 (Spring)	1.9	Sunny, moderate wind

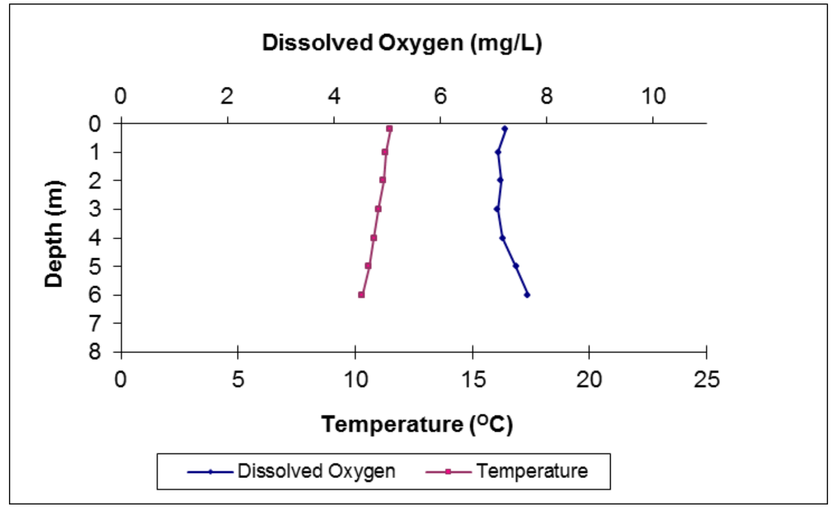
The lake was thermally stratified during the summer with temperatures ranging from about 19^{O}C near the surface of the lake to 11^{O}C at 7 m depth (Figure 4.8). Isothermal conditions persisted in the fall with temperatures near 11^{O}C throughout the water column. The lake was covered by approximately 0.67 m of ice and 0.06 m of snow when assessed in February 2012; water temperatures increased with depth from 1.0 ^{O}C at the ice surface to 4.2 ^{O}C near the lake bottom. Thermal stratification was evident in the spring with the thermocline present between 3 and 5 metres.

The Upper Embarras Lake exhibited a clinograde oxygen profile in general (Figure 4.8). Dissolved oxygen concentrations were lower in the hypolimnion than the epilimnion during the summer and winter and it appeared that the lake had already stratified when sampled in the spring. Oxygen concentrations were relatively constant within the water column in the fall.

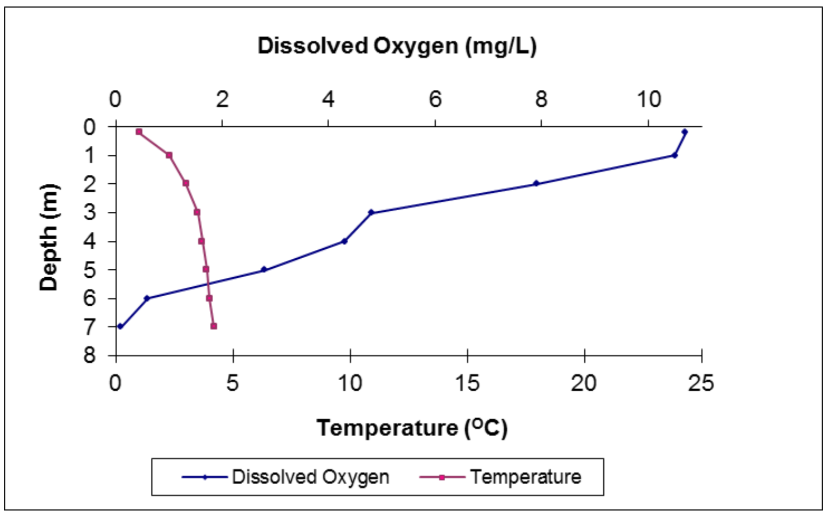
The specific conductivity of the lake water increased with depth in all seasons (Figure 4.9). In general, conductivity within the lake increased from the spring season to winter season.



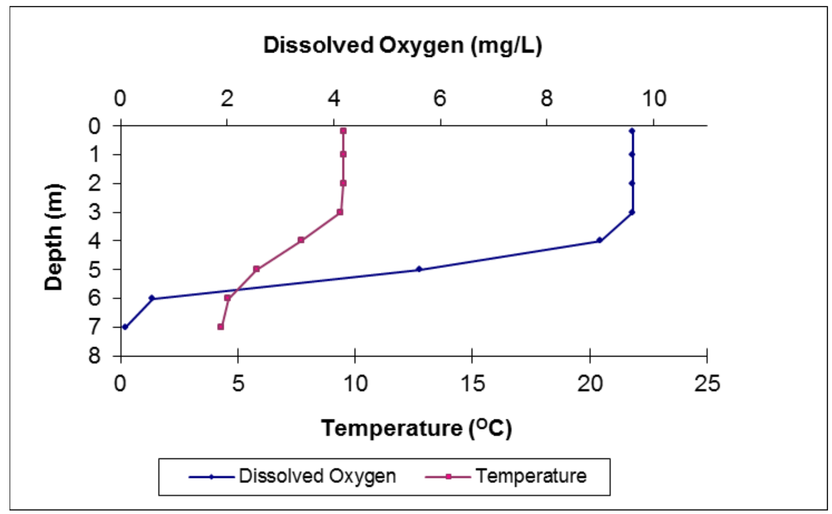
Summer



Fall



Winter



Spring

Figure 4.8. Oxygen and Temperature Profiles for Upper Embarras Lake.

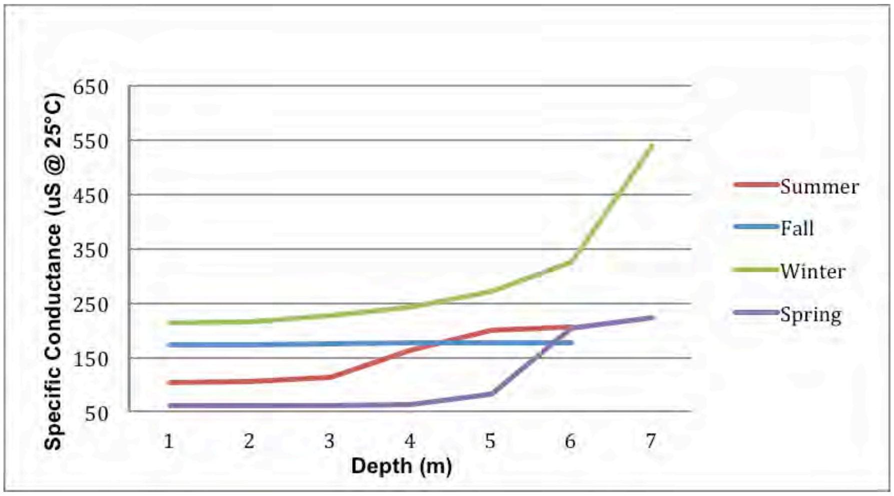


Figure 4.9. Conductivity Profiles for Upper Embarrass.

Alkalinity and pH values indicate that the lake was well buffered and non-acidic (Table 4.11). Water in the lake was of a bicarbonate-sodium type with an ionic dominance of Ca^+ > Na^+ > Mg^+ > K^+ (cations) and HCO_3^- > SO_4^- > Cl^-. (anions). With the exception of iron (epilimnion only), and manganese (hypolimnion only), all parameters were within the water quality guidelines specified by CCME and the Province of Alberta (Table 4.11).

Table 4.11. Water Quality Data for Upper Embarras Lake.

Parameter	Units	Epilimnion	Hypolimnion
Kjeldahl Nitrogen	mg/L	0.27	0.24
Phosphorus	mg/L	<0.05	<0.05
Organic Carbon	mg/L	7.5	7.6
Calcium	mg/L	13.5	24.1
Iron	mg/L	0.39	0.23
Magnesium	mg/L	2.6	4.9
Manganese	mg/L	0.036	0.197
Potassium	mg/L	0.4	0.9
Silicon	mg/L	3.73	3.82
Sodium	mg/L	5.7	9.5
Sulfur	mg/L	1.9	4.7
Mercury	mg/L	<0.0001	<0.0001
Aluminum	mg/L	0.05	0.07
Antimony	mg/L	<0.0002	<0.0002
Arsenic	mg/L	0.0006	0.0010
Barium	mg/L	0.040	0.092
Beryllium	mg/L	<0.0001	<0.0001
Bismuth	mg/L	<0.0005	<0.0005
Boron	mg/L	0.01	0.017
Cadmium	mg/L	0.00001	<0.00001
Chromium	mg/L	<0.0005	0.0008
Cobalt	mg/L	<0.0001	0.0003
Copper	mg/L	0.001	<0.001
Lead	mg/L	0.0001	<0.0001
Lithium	mg/L	0.003	0.006
Molybdenum	mg/L	<0.001	0.003
Nickel	mg/L	0.0010	0.0015
Selenium	mg/L	<0.0002	0.0003
Silver	mg/L	<0.00001	<0.00001
Strontium	mg/L	0.108	0.232
Thallium	mg/L	<0.00005	<0.00005
Tin	mg/L	0.002	0.006
Titanium	mg/L	0.0008	0.0010
Uranium	mg/L	<0.0005	0.0007
Vanadium	mg/L	0.003	0.002
Zinc	mg/L	0.003	0.002
Solids	mg/L	<1	<1
pH		7.76	7.57
Electrical Conductivity	µS/cm at 25 C	111	201
Chloride	mg/L	0.5	<0.4
Nitrate - N	mg/L	<0.01	0.03
Nitrite - N	mg/L	<0.005	<0.005
Nitrate and Nitrite - N	mg/L	<0.01	0.03
Sulfate (SO4)	mg/L	6.0	15.0
Hydroxide	mg/L	<5	<5
Carbonate	mg/L	<6	<6
Bicarbonate	mg/L	64	107
P-Alkalinity	mg/L	<5	<5
T-Alkalinity	mg/L	53	88
Total Dissolved Solids	mg/L	62	110
Hardness	mg/L	45	83
Ionic Balance	%	100	104

* composite samples
- exceedences are shaded

4.3.3. Benthic Invertebrates

Sampling for benthic invertebrates was conducted in littoral habitat (Figure 4.7). Diptera were numerically dominant and accounted for four of the seven taxa sampled (Table 4.12). Other groups were present in very low numbers.

Table 4.12. Benthic Macroinvertebrate Composition for Upper Embarras Lake.

Taxon	Density (per 0.023 m^2) Replicate			Mean #Organisms/Sample
	1	2	3	
Dipters				
Ceratopogonidae				
Ceratopogoninae			4	1.3
Chironomidae				
Orthocladiinae	22	4	10	12
Tanytarsini	43	4	82	43
Empididae				
Simuliidae		4		1.3
Crustacea				
Ostracoda				
Cyprididae	4			1.3
Cladocera				
Daphnia sp.	5		4	3
Pelecypoda				
Sphaeriidae				
Pisidium sp.	1			0.3
Total	75	12	100	62.3
Total taxa	5	3	4	7

4.3.4. Zooplankton

Eleven taxa were found in the Upper Embarras Lake; Rotifera were numerically dominant while Cyclopoida, Cladocerans, and Calanoida comprised the remainder of the zooplankton community (Table 4.13).

Table 4.13. Zooplankton Abundance for Upper Embarrass Lake.

Taxa	Density per m³					
	Replicate #					Mean
	1	2	3	4	5	#Organisms
Calanoida						
Leptodiaptomus sicilis	30	0	0	0	0	6
Calanoid copepodid	0	0	0	34	0	7
Cladocera						
Daphnia pulex	1091	2614	3546	2481	1026	2152
Bosmina longirostris	0	0	0	0	89	18
Cyclopoid						
Dicyclops bicuspidatus	1970	1352	1696	1937	2365	1864
Cyclopoid copepodid	3636	2073	2813	5335	3034	3378
Cyclopoid *(nauplii)*	23368	0	7282	18195	0	9769
Rotifera						
Ascomorpha sp	0	0	0	18195	22724	8183
Polyathra dolicoptera Idelson	0	10517	0	0	0	2103
Polyathra euryptera Wierzejski	7790	0	0	0	7140	2986
Synchaeta	15579	0	0	0	11362	5388
Total	53464	16556	15337	46177	47740	35854
Total Taxa	7	4	4	6	7	5.6

4.3.5. Phytoplankton

Phytoplankton collections in Upper Embarras Lake revealed a total of 18 taxa (Table 4.14). Chrysophyta were dominant while other types were less common. The chlorophyll *a* concentration for the lake was 0.518 mg/m^3.

Table 4.14. Phytoplankton Abundance for Upper Embarras Lake.

Genus/Species	Cell/Colony Density (cells/mL)
Bacillariophyta	
Diatoma sp.	0.67
Cryptophyta	
Cryptomonas reflexa	15.89
Katablepharis ovalis	35.63
Rhodomonas	26.10
Chrysophyta	
Chrysochromulina parva	1.00
Dinobryon divergens	224.49
D. divergens statospore	10.96
Kephyrion sp	1.34
Mallomonas sp.	0.34
Pyrrophyta	
Peridinium sp	0.34
Chlorophyta	
Ankistrodesmus setigera	2.01
Characium sp.	1.00
Monoraphidium	0.34
Sphaerocystis schroeteri	2.34
Unidentified colonial	0.67
Cyanophyta	
Lyngbya limnetica	9.03
Oscillatoria sp.	3.01
Phormidium	2.34
Total	337.49
Total Taxa	18

4.3.6. Aquatic Macrophytes

Aquatic macrophytes were present in Upper Embarras Lake in the summer of 2011; Narrow leaf pondweed (*Potamogeton strictifolius*), and broad leaf pondweed *(Potamogeton natans*) were sparsely distributed within the lake. The majority of macrophyte development had occurred along the north and south shores of Upper Embarras Lake in water less than two metres deep.

4.4. LOTIC HABITAT

4.4.1. Spawning Surveys

Spawning surveys conducted during the fall indicated that Brook Trout spawning had commenced by October 5th. Four redds and four possible redds were identified downstream of the fish exclusion weir (Table 4.15). No evidence of fall spawning was observed upstream of the weir.

Spawning surveys conducted in late May found two possible Rainbow Trout redds downstream of the fish exclusion weir and one possible redd upstream of the exclusion structure in the connecting channel between the Middle and Upper Lake (Table 5.15). No spawning was observed during subsequent spawning surveys conducted in June (Table 4.15).

Table 4.15. Summary of Spawning Survey Results.

Survey Date	Downstream of Fish Exclusion Structure	Upstream of Fish Exclusion Structure
October 5th-6th 2011	4 BKTR redds, 4 possible	No activity observed
May 26th, 2012	2 possible RNTR redds	1 possible redd upstream of middle lake
June 1st, 2012	No spawning observed, 3 large RNTR attempting to move upstream at weir	No spawning observed
June 21st, 2012	No spawning observed.	No spawning observed.

4.4.2. Fish Capture

Electrofishing surveys of the constructed channel upstream of the fish exclusion structure resulted in the capture of Rainbow Trout in both August and October (Table 4.16). In addition, fish were observed rising in the Upper Embarras Lake during summer field investigations.

Electrofishing surveys of the Embarras River downstream of the exclusion structure captured both Brook Trout and Rainbow Trout (Table 4.16). Brook Trout were more common than Rainbow Trout in August while Rainbow Trout outnumbered Brook Trout during the fall sampling. A record of sampling effort and individual fish capture data is presented in Appendix D.

Table 4.16. Summary of Fish Capture Results for the Embarras Lake System in 2011.

Sample Section	Date	Species	n	Fork Length (mm)			Weight (g)		
				Mean	Min	Max	Mean	Min	Max
u/s of exclusion structure	18-Aug-11	RNTR	25	66.0	53	78	3.0	1	6
	5-Oct-11	RNTR	1	106	-	-	18	-	-
d/s of exclusion structure	18-Aug-11	RNTR	21	133.3	56	247	39.8	3	176
		BKTR	50	171.3	71	226	64.8	4	145
	5-Oct-11	RNTR	20	140.8	83	262	40.9	4	223
		BKTR	10	161.0	82	208	50.1	5	88

4.4.3. Benthic Invertebrates

The number of taxa present was highest at ER-B4 and lowest at ER-B2 (table 4.17). Total abundance of invertebrates ranged considerably between sites, with the highest numbers at ER-B1 and the lowest at ER-B2. Chironomidae were numerically dominant at all sites but were particularly common at ER-B1 where they comprised almost 90% of the total sample. Generally, ER-B1, B2, and B3 all had a relatively low proportion of EPT (Ephemeroptera, Plecoptera, Trichoptera) counts compared to ER-B4. Oligochaeata were highest at ER-B3 and lowest at ER-B1 and Nematodes were only present at ER-B1 and B2.

Table 4.17. Summary of Benthic Invertebrate Sampling Results from Lotic Sites.

Taxon	Mean Count from 3 Replicates (per $0.1m^2$)			
	ER-B1	ER-B2	ER-B3	ER-B4
Ephemeroptera				
Baetidae				
Baetis sp.	12.0	23.0	57.7	457.7
Callibaetis sp.			43.0	
Ephemerellidae				
Serratella sp.	6.5	1.0		132.3
Heptageniidae				
Cinygmula sp.	10.0			49.0
Leptophebiidae				
Paraleptophlebia sp.			15.5	11.0
Siphlonuridae				
Parameletus.sp.	8.0	1.0		20.5
Plecoptera				
Chloroperlidae				21.0
Nemouridae				
Zapada sp.	2.0	1.0		106.0
Visoka sp.				23.7
Perlodidae				50.7
Megarcys sp.				6.5
Isoperla sp.			1.0	1.0
Isogenoides sp.				12.0
Capniidae	1.0		5.0	30.0
Trichoptera				
Brachycentridae				

Table 4.17. Continued

Brachycentrus sp.	2.0			11.0
Glossosomatidae				
Glossosoma sp.			1.0	9.5
Limnephilidae				
Dicosmoecus sp.	1.5	1.7		
Hydroptilidae				
Hydroptila sp.			1.0	10.5
Phryganeidae				
Phryganea sp.			1.0	
Rhyacophilidae				
Rhyacophila sp			4.0	14.0
Hydropsychidae				
Cheumatopsyche sp.			1.0	
Diptera				
Ceratopogonidae				
Ceratopogoninae	16.0			10.0
Chironomidae				
Orthocladiinae	215.3	454.3	524.3	142.7
Tanypodinae	18.5			11.0
Tanytarsini	3279.0	477.7	96.7	19.5
Chironomini	1.0		26.7	1102.0
Pupae	4.0	8.0		10.0
Empididae			1.0	2.0
Simuliidae	98.3	305.7	399.3	20.5
Pupae	2.0	32.5	3.0	
Tipulidae				
Limoniinae				
Dicranota sp.	4.3		7.3	32.0
Hexatoma sp.			1.0	8.0
Tipulinae				
Tipula sp.				5.0
Anthomyiidae	1.5	1.0	5.3	2.0
Psychodidae				
Pericoma/Telmatoscopus				5.5
Coleoptera				
Elmidae				55.3
adult				5.0
Dytiscidae			25.7	
adult			34.0	
Hemiptera				
Corixidae (adult)			4.0	
Nematoda	9.0	1.0		
Oligochaeta				
Naididae				
Specaria sp.	18.3	37.0	174.7	30.0
Arachnida				
Acari				
Hydrarachnidia	23.0		18.3	39.5
Crustacea				
Copepoda				
Cyclopoida	110.0	7.0	21.0	120.0
Calanoida		20.0	115.3	
Ostracoda				
Cyprididae	4.0	4.0		14.5
Cladocera				
Daphnia sp.	151.7	153.0	446.3	
Pelecypoda				
Sphaeriidae				
Sphaerium sp.		1.0		
Pisidium sp.				
Gastropoda				
Limnaeidae			1.5	
Hirudinea				
Erpobdellidae	7.0	5.7		4.0
Glossiphoniidae	29.0	2.7	1.0	18.0
Hydrozoa		267.7	30.7	
Total (average of 3 replicates)	4035.0	1805.8	2067.3	2622.8
Total Taxa	26	21	30	38

4.4.4. Temperature Regime

Temperature data collected in the Embarras Lake System in 2011 is presented in Figure 4.10. Overall, water temperatures in the Embarras River downstream of the lakes averaged approximately 2^{0}C warmer than upstream of the lakes.

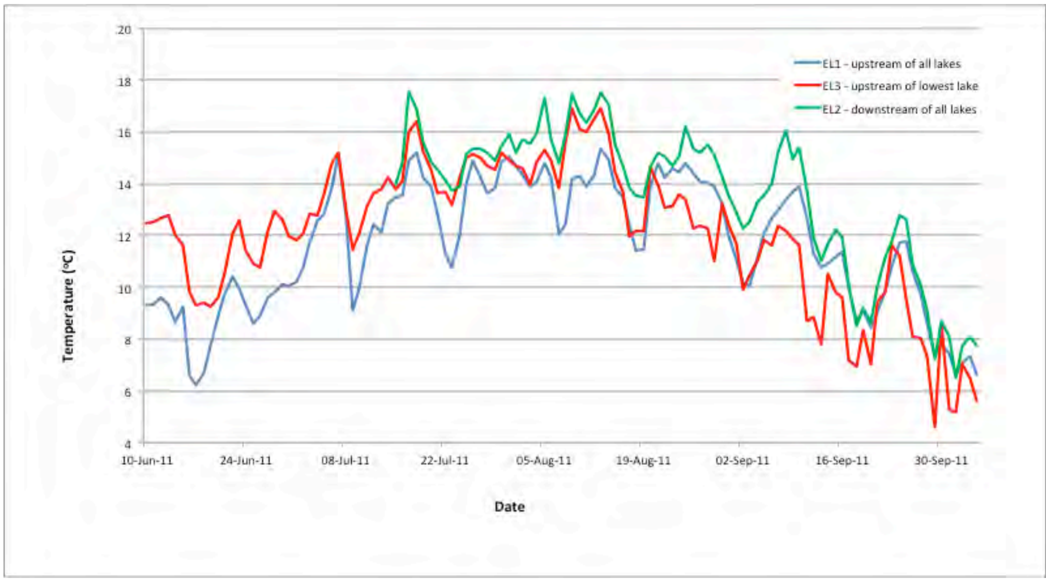


Figure 4.10. Mean Daily Temperatures in the Embarras River in 2011.

5.0 DISCUSSION

Results from monitoring conducted during the 2011-12 program represent the initial stages of lake development post reclamation and were undertaken to provide baseline information on the existing physical, chemical, and biological conditions in the lakes and connecting channels.

5.1. LENTIC HABITAT

5.1.1. Summary of 2011-12 Monitoring

The inlet and outlets of the lakes were stable (Table 5.1). Side slopes were generally stable and riparian vegetation was beginning to become established but areas of sparse vegetation, particularly on the slopes close to the haulroad, were fairly common.

Table 5.1. Characteristics of Embarras End Pit Lakes in 2011-12.

Parameter		Indicator	Lower Embarras	Middle Embarras	Upper Embarras
Physical		Inlet/Outlet Stability	Stable	Stable	Stable
		Shoreline Erosion	Some Erosion		Stable
Chemical		Circulation	Dimictic	Dimictic	Dimictic
		Water Quality[1] Exceedances	E (Fe, Al) H (Mn)	n/m	E (Fe) H (Mn)
Biological	Benthic Invertebrates	Average Density/Sample	34.7	n/m	62.3
		Total Taxa	6	n/m	8
	Zooplankton	Average Density/m^3	30253	n/m	35854
		Total Taxa	9	n/m	11
	Phytoplankton	Average Density (cells/ml)	389.1	n/m	337.5
		Total Taxa	18	n/m	18
	Aquatic Macrophytes	Present/Absent	Absent	Absent	Present
	Fish	Present/Absent	Present	Present	Present

1. E – epilimnion, H – hypolimnion

Results of the limnological investigations indicate that all three of the Embarras Lakes were dimictic with complete mixing occurring in the spring and fall (Table 5.1). Water in the lakes was of bicarbonate type and did not demonstrate a sodium ion dominance, which may indicate groundwater sources have less impact on these lakes than other end-pit lakes in the area (Brinker 1991, Hatfield, 2008, 2011, Stemo 2005, Pisces 2011). The majority of measured water quality variables did not exceed thresholds for the protection of aquatic life. Iron and aluminum concentrations exceeded CCME water quality guidelines in the Lower Embarras Lake while iron concentrations in the epilimnion of the Upper Embarras Lake also exceeded guideline levels. Both of the sampled lakes had nutrient concentrations corresponding to oligotrophic trophic status as defined in Wetzel (2001).

The benthic invertebrate assemblage within the lakes was typical of the early colonization stage in lake development. Densities were relatively low, there was limited diversity, and populations were dominated by Chironomids.

Zooplankton taxa collected from the Upper and Lower Lakes were common components of zooplankton communities in Alberta. Total taxa counts from each lake ranged from 9 to 11 and average densities ranged from 30,253 to 35,854 individuals per cubic metre (Table 5.1). Rotifers were numerically dominant in the Upper Lake while Cyclopoids were the most abundant group in the Lower Lake.

Chlorophyll *a* concentrations were quite low in both the Upper and Lower Lakes; however, the phytoplankton diversity was quite high. Phytoplankton composition in the Upper Embarras Lake was dominated by Chrysophyta while Chrysophyta, Chlorophyta and Cyanophyta were all dominant in the Lower Lake.

5.1.2. Comparision to Fairfax Lake

Draft guidelines for end pit lake development at coal mine operations were prepared in 2003 by the End Pit Lake Working Group to assist government and industry in designing, managing, monitoring, and evaluating end pit lakes (EPLWG 2003). Evaluation and performance criteria provided in the guideline document are used to assess whether a lake has met or is meeting its intended objective. While the targets/goals used to measure success in terms of physical and chemical parameters are based on specific indicators, the measure of success for biological targets/goals are typically based on comparison to “local lakes”.

There is one local natural lake in the general vicinity of the Coal Valley Mine. Fairfax Lake is a shallow (<5m mean depth) foothills lake (Radford 1979, Luscar 1992), which is generally comparable to the Embarras Lakes (Table 5.2). Overall, the biotic communities of the Embarras Lakes were similar to Fairfax Lake (Table 5.2). Zooplankton and benthic invertebrate diversity was lower in the Embarras Lakes compared to Fairfax Lake but Phytoplankton diversity was higher. Zooplankton and phytoplankton densities were lower but relatively comparable between the lakes while benthic invertebrate densities were notably lower in the Embarras Lakes compared to Fairfax Lake. Aquatic macrophyte communities have only become established in the Lower Embarras Lake

Table 5.2. Characteristics of Embarras Lakes and Fairfax Lake.

Lake	Area (Ha)	Max Depth (m)	Mean Depth (m)	Littoral (% <3 m deep)	Crustacean Zooplankton		Benthos		Phytoplankton		Macrophytes	Fish
					Density (n/l)[1]	# of taxa	Density (n/m2)	# of taxa	Density (n/ml)	# of taxa	# of taxa	Species
Lower Embarras	6.6	18	7.34	30	30.3	9	1509	6	389.1	18	0	RNTR
Middle Embarras	3.0	10	3.4	55	-	-	-	-	-	-	0	RNTR
Upper Embarras	5.0	8	3.2	56	35.9	11	2709	8	337.5	18	2	RNTR
Fairfax Lake[1]	28.4	7.6	3.2	60[2]	41.3	22	6450	11	522.9	12	-	RNTR/ BKTR

1. Hatfield 2008
2. Derrived from Hatfield 2011

5.2. LOTIC HABITAT

The inlet and outlets of the lakes and the connecting channel were all stable (Table 5.1). Proposed habitat enhancements (i.e. spawning gravel, large woody debris) for the connecting and outlet channels had not yet been constructed but are expected to be installed in 2012 or 2013. Riparian vegetation along the connecting channels was somewhat limited and was not fully established. Habitat within the connecting channels was comprised mainly of shallow run and riffle habitat. However, in October 2011, the channel between the Middle and Lower Lake was dry and the outlet channel downstream of the Lower Lake was dry for approximately 150 m.

During the later stages of construction of the end pit lake system (early 2011) approximately 80 to 100 Rainbow Trout were found to have colonized the Lower Embarras Lake (Dean Woods *Personal Communication*). In September 2011, Alberta Environment and Sustainable Resource Development stocked 208 native Athabasca Rainbow Trout into the Upper Embarras Lake (Ryan Cox *Personal Communication*). The stocked fish ranged in size from 29 mm to 119 mm with a mean length of 80 mm (Ryan Cox *Personal Communication*). Spawning surveys conducted during spring 2011 confirmed Rainbow Trout spawning downstream of the fish exclusion structure and found some evidence to indicate that spawning may be occurring in the connecting channels of the end pit lake system. Fish sampling within the connecting channels during the summer of 2011 (prior to AESRD stocking) resulted in the capture of several Rainbow Trout that ranged in size from 53 mm to 78 mm long. Sonnenberg (2011) noted that growth rates for stream resident Rainbow Trout downstream of end pit lakes were significantly greater that growth rates for Rainbow Trout observed upstream of pit lakes. Considering this information and given the thermal regime of the lake system, it seems possible that egg and fry development was accelerated (due to the slight warming effect of the lakes) such that some of the captured fish represent young of the year (yoy) age class resulting from successful spawning in the spring of 2011.

The fish exclusion structure appears to be effectively precluding the movement of Brook Trout into the Embarras Lake System since Brook Trout were found downstream of the barrier but not upstream.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Monitoring and assessing the progress of young waterbodies towards target values can be complicated by the inherent inability of an immature lake to exhibit functional equivalency to an older system (EPLWG 2003). Over time, young waterbodies typically progress from low nutrient, chemically imbalanced waters to a more fertile, chemically balanced state. The timeline and extent of this transition is variable between lakes. At present the Embarras Lakes appear to be developing towards being productive lakes that are similar to local waterbodies. Initial results indicate that certain parameters have not yet reached target goals while other parameters have (Table 6.1). Continued monitoring will document the development of the lakes and should help identify potential limiting factors. The following observations and recommendations have been made in the interest of maximizing the potential success of the Embarras End Pit Lake system. Additional reclamation and/or enhancement work may be required depending on future monitoring results.

- Unvegetated areas (including the haul road slopes) along the Middle and Lower Embarras Lakes appear to be resulting in sediment inputs into the Lake during the open water season.
- Cover within the Embarras River constructed connecting channels is limited. It is recommended that dense plantings of larger woody species (willows, deciduous trees, and coniferous trees) be installed along reconstructed channels.
- Appropriate sized Gravel (5m to 15mm) should be strategically placed within the constructed channels to create spawning and rearing habitat.
- Large woody debris (conifers with intact limbs) should be anchored at select locations within the constructed channel to provide cover for spawning fish.

Table 6.1. Pit lake evaluation/performance assessment for select chemical and biological parameters for the Embarras Lakes based on End Pit Lake Working Group (2003) guidelines.

Design Factor	Indicator	Parameters	Targets/Goals	Lake	Target/Goal Met?	Rationale
Chemical	Overturn	Summer stratification Fall mixing	Presence of annual summer stratification and fall overturn	All	Yes (dimictic)	• Table 5.1
	Water quality	Water chemistry in lake and discharge	Meet Surface Water Quality Guidelines used in Alberta Chemical end points fall within regional range	Upper Lower	Uncertain	• Table 5.1 • Most parameters are under guidelines. Only manganese and iron exceed Provincial Guideline. • Aluminum and Iron exceeded Federal Guidelines in Lower Lake, only Iron in Upper Lake.
Biological	Biodiversity Biomass Productivity	Benthic Invertebrates	Comparable to local lakes and/or regional fisheries management objectives (not applicable, no comparable local lakes). Comparable to similar natural mountain lakes.	Upper Lower	No	• Table 5.1 • Number of taxa lower than Fairfax Lake • Average densities lower than Fairfax Lake
		Zooplankton		Upper Lower	No Uncertain	• Table 5.1 • Number of taxa present fewer than Fairfax Lake • Average densities lower but comparable to Fairfax Lake
		Phytoplankton		Upper Lower	Yes	• Table 5.1 • Number of taxa present exceeds mean for Fairfax Lake • Average densities exceed mean for Fairfax Lake
		Macrophytes		All Lakes	No	• Table 5.1 • Number of taxa and distribution limited compared to Fairfax Lake.
		Fish (including non-game fish)		Uncertain		• Not applicable, Fairfax requires annual stocking. End goal self-sustaining Rainbow Trout population.

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8.0 PERSONNEL COMMUNICATIONS

Cox, Ryan. December 2012. Fisheries Biologist Foothills Area. Edson, Alberta.

Woods, Dean. December 2012. Reclamation Specialist D&T Woods. Edson, Alberta.

APPENDIX A:

Photos

Lower Embarras Lake August 2011

Middle Embarras Lake August 2011

Upper Embarras Lake August 2012

Embarras Channel Upstream of Lakes in Summer 2011


Upper Embarras Lake Outlet (looking d/s) Spring 2012


Middle Embarras Lake Outlet (looking u/s) Spring 2012

Embarras Fish Exclusion Weir Spring 2012

Looking upstream from Embarrass Exclusion Weir

APPENDIX B:

Benthic invertebrate sample processing methodology

Method Used for Picking Animals and Taxonomy

The picking of animals was performed in accordance with the process developed by Wrona et al. (1982), with slight modifications. This procedure has been used for many years. It provides a good estimate of animal population in aquatic systems based on samples.

The Picking and Sub Sampling Process

The whole sample is washed through double stacked 2 mm and 106 µm meshes. All the animals that remain on the 2 mm mesh (coarse fraction) are picked. The fine fraction from the 106 µm mesh is put into an aeration apparatus and diluted with water until the total sample plus water volume is 1 litre. The sample is aerated, and when well mixed, five 50 mL sub samples are taken out of the aeration apparatus. The entire sub samples are picked using a compound microscope at 10 times magnification for the course fraction and 40 times magnification for the fine fraction. Once picking has been completed, the course and fine fraction are saved for quality assurance. The total of animals in each sub sample is determined for all taxa. After the samples are picked, quality assurance is performed to confirm that no visible animals are left in the sample.

All the animals are classified using the keys: '*Aquatic Invertebrates'* of Alberta by Hugh F. Clifford (1991), '*Ecology and Classification of North American Freshwater Invertebrates'* by James H. Thorp and Alan P. Covich (1991), and '*Fresh Water Invertebrates of the United States'* by Robert W. Pennak (1978).

The complete hierarchical classification through Phylum, Class, Order, Family, Genus, and Species is attempted for all taxa. However, in some cases when parts of the animals are missing, complete classification cannot be performed. In that case, classification was performed to the level recognizable to the taxonomer.

Reference:

Wrona, F.J., Culp, J.M. and Davies, R.W. 1982. *Macroinvertebrate subsampling: a simplified apparatus and approach*. Can. J. Fish. Aquat. Sci. 39:1051-1054

APPENDIX C:

Zooplankton sample processing methodology

Zooplankton were enumerated from three 1-15 ml sub-samples using a dissecting microscope at magnifications 10-50x for macro-zooplankton, and at magnification 100-400x for rotifers and copepod nauplii using Nikon compound microscope.

Macro-Zooplankton were identified using keys from Brooks (1957), Edmondson (1959), Chengalath (1971), Grothe and Grothe (1977), Pennak (1978), and Clifford (1991), The micro-zooplankton were identified using keys from Chengalath (1971), Grothe & Grothe (1977), Stemberger (1979), Clifford (1991) and Thorp & Covich (1991).

Lengths were determined directly on the microscope with a micrometer in the ocular. Generally, lengths were measured for the first 50 individuals of each species or genus observed. Where less than 30 individuals occur, the number measured equaled the average number counted over all sub-samples.

Zooplankton biomass was calculated for each sample. Weights were calculated from published length-weight regressions; general equations for taxa were used where length-weight equations are not available for specific species (Table 1). For each sample, mean individual weights for each species were calculated by averaging estimated weights. Total biomass for each group (species or developmental stage) was calculated as the product of its density and estimated mean individual weight.

Table 1. Length-weight regressions used in calculating zooplankton weights.

Organism	Equation (ug=microgram)	Reference
Copepods (N I-adults)	lnW(ug) = 1.9526 + 2.399 InL(mm)	Bottrell et al. 1976
Daphnia spp.	lnW(ug) = 1.6 + 2.84' lnL(mm)	Bottrell et al. 1976
Ceriodaphnia spp.	lnW(ug) = 2.8713 + 3.079 lnL(mm)	Bottrell et al. 1976
Scapholeberis spp.	lnW(ug) = 2.5623 +3.338 lnL(mm)	Downing & Rigler 1984
Chydorus sphaericus	lnW(ug) = 4.543 + 3.6360 InL(mm)	Downing & Rigler 1984
Other Cladocerans	lnW(ug) = 1.7512 + 2.653lnL(mm)	Bottrell et al. 1976
Rotifers	lnW(ug) = -10.3815 + 1.574llnL(mm)	Sternberger & Gilbert. 1987

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Pennak, RW. 1978. Freshwater invertebrates of the United States, 2nd edition. John Wiley and Sons Inc., New York, NY. 803 p.

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APPENDIX D:

Fish Capture Record

Electrofishing Record				
Date:		18-Aug-11		
Stream Name:		Embarrass River		
UTM reference:		503436E, 5882209N, NAD 83, ZN11		
Sample Site:		Upstream of exclusion barrier		
Section length (m):		360m		
Duration (seconds):		2384		
Sample #	Species	Fork Length (mm)	Weight (g)	Comments
1	RNTR	78	6	
2	RNTR	53	1	
3	RNTR	65	3	
4	RNTR	69	3	
5	RNTR	71	3	
6	RNTR	69	3	
7	RNTR	58	2	
8	RNTR	75	4	
9	RNTR	65	2	
10	RNTR	71	4	
11	RNTR	60	2	
12	RNTR	63	3	
13	RNTR	64	2	
14	RNTR	58	2	
15	RNTR	63	2	
16	RNTR	64	3	
17	RNTR	74	4	
18	RNTR	62	2	
19	RNTR	63	2	
20	RNTR	72	4	
21	RNTR	67	4	
22	RNTR	69	4	
23	RNTR	64	4	
24	RNTR	65	3	
25	RNTR	68	3	

Electrofishing Record				
Date:		18-Aug-11		
Stream Name:		Embarrass River		
UTM reference:		503434E, 5882384N, NAD 83, ZN11		
Sample Site:		Downstream of fish exclusion barrier		
Section length (m):		300		
Duration (seconds):		1902		
Sample #	Species	Fork Length (mm)	Weight (g)	Comments
1	RNTR	154	34	
2	RNTR	147	33	

3	RNTR	62	3	
4	RNTR	165	59	
5	RNTR	104	10	
6	RNTR	73	4	
7	RNTR	56	3	
8	RNTR	66	3	
9	RNTR	160	43	
10	RNTR	179	75	
11	RNTR	148	34	
12	RNTR	216	136	
13	RNTR	247	176	
14	RNTR	184	79	
15	RNTR	102	12	
16	RNTR	70	4	
17	RNTR	110	14	
18	RNTR	97	8	
19	RNTR	156	36	
20	RNTR	164	50	
21	RNTR	140	20	
22	BKTR	187	76	
23	BKTR	176	62	
24	BKTR	74	4	
25	BKTR	158	46	
26	BKTR	174	57	
27	BKTR	201	85	
28	BKTR	179	70	
29	BKTR	179	62	
30	BKTR	166	58	
31	BKTR	222	129	
32	BKTR	71	4	
33	BKTR	75	4	
34	BKTR	191	76	
35	BKTR	173	61	
36	BKTR	190	73	
37	BKTR	165	60	
38	BKTR	226	130	
39	BKTR	220	145	
40	BKTR	74	4	
41	BKTR	163	47	
42	BKTR	166	61	
43	BKTR	138	30	
44	BKTR	180	64	
45	BKTR	175	60	
46	BKTR	156	47	
47	BKTR	145	37	
48	BKTR	159	74	

49	BKTR	215	117	
50	BKTR	157	45	
51	BKTR	188	79	
52	BKTR	170	57	
53	BKTR	177	64	
54	BKTR	225	131	
55	BKTR	195	85	
56	BKTR	192	81	
57	BKTR	186	74	
58	BKTR	175	62	
59	BKTR	194	83	
60	BKTR	178	57	
61	BKTR	185	72	
62	BKTR	180	69	
63	BKTR	175	50	
64	BKTR	164	49	
65	BKTR	163	45	
66	BKTR	164	51	
67	BKTR	197	95	
68	BKTR	195	92	
69	BKTR	171	58	
70	BKTR	178	56	
71	BKTR	160	44	

Electrofishing Record				
Date:		5-Oct-11		
Stream Name:		Embarrass Creek		
UTM reference:		503573E, 5882051N, NAD83, ZN11		
Sample Site:		Upstream of fish exclusion barrier.		
Section length (m):		300		
Duration (seconds):		1240		
Sample #	Species	Fork Length (mm)	Weight (g)	Comments
1	RNTR	106	18	

Electrofishing Record				
Date:		5-Oct-11		
Stream Name:		Embarrass River		
UTM reference:		503434E, 5882384N, NAD 83, ZN11		
Sample Site:		D/S of outfall Structure		
Section length (m):		300		
Duration (seconds):		367		
Sample #	Species	Fork Length (mm)	Weight (g)	Comments
1	RNTR	262	223	
2	RNTR	170	52	
3	RNTR	163	42	
4	RNTR	124	21	
5	RNTR	98	9	
6	RNTR	218	102	
7	RNTR	171	54	
8	RNTR	133	25	
9	RNTR	88	8	
10	RNTR	140	31	
11	RNTR	172	57	
12	RNTR	148	32	
13	RNTR	146	30	
14	RNTR	97	7	
15	RNTR	181	66	
16	RNTR	154	36	
17	RNTR	93	8	
18	RNTR	88	4	
19	RNTR	83	5	
20	RNTR	86	6	
21	BKTR	196	81	
22	BKTR	208	88	
23	BKTR	185	62	
24	BKTR	181	64	
25	BKTR	180	62	
26	BKTR	183	61	
27	BKTR	145	26	
28	BKTR	163	46	
29	BKTR	90	6	
30	BKTR	82	5	

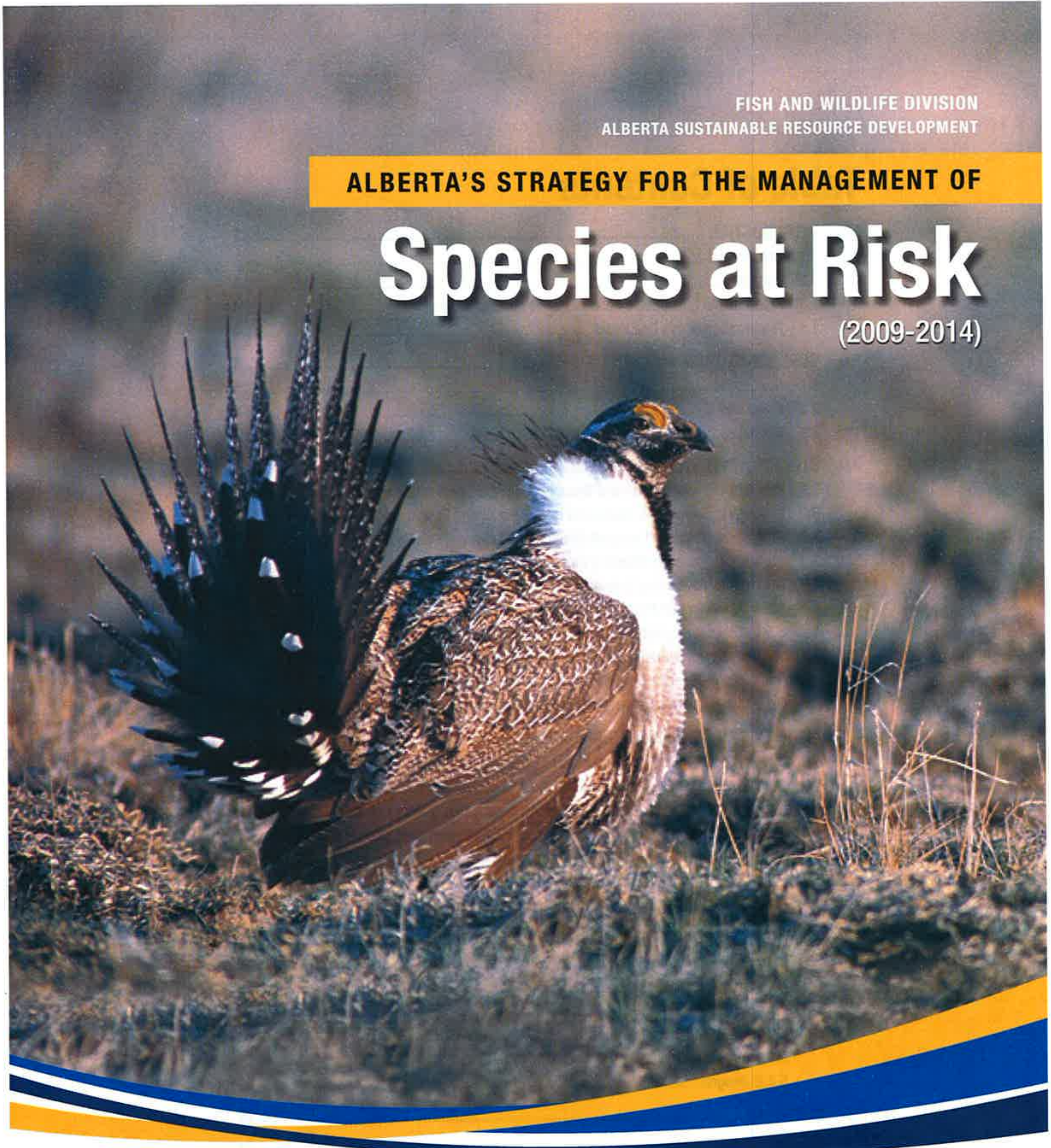
Appendix 3: Alberta Strategy for Management of Species at Risk

FISH AND WILDLIFE DIVISION
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT

ALBERTA'S STRATEGY FOR THE MANAGEMENT OF

Species at Risk

(2009-2014)



Alberta

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Publication No.: I/323
ISBN: 978-0-778-7717-1 (Printed Edition)
ISBN: 978-0-7785-7718-8 (On-line Edition)

Illustrations: Brian Huffman, Medea Curteanu (PAGE 30)

Front Cover Photographs: Gordon Court (sage grouse)
Back Cover Photographs: Gordon Court (burrowing Owl)
Karen Scott (western silvery minnow)
Emily Court (grizzly bear)

Graphic Design & Layout: Broken Arrow Solutions Incorporated

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This publication may be cited as:

Fish and Wildlife Division. 2008. Alberta's Strategy for the Management of Species at Risk (2009-2014). Alberta Sustainable Resource Development, Fish and Wildlife Division, Edmonton, AB. 30 pp.

1.0 INTRODUCTION

1.1 Background

A Strategy for the Management of Species at Risk in Alberta was drafted in 1997. That original document provided guidance for 10 years of species at risk management in the province. It provided strong process direction for species' status evaluation, species' listing and recovery planning.

Since 1997 general and detailed status evaluation and recovery planning have been completed for many species. The 1997 strategy has been acted upon and many of the original objectives have been achieved or are ongoing. This revised document incorporates the strong process direction provided by that strategy and supplements it with increased emphasis on implementation of recovery actions, strategies to prevent species from becoming endangered, and conservation and stewardship programs for species at risk. Whereas the 1997 document was used to establish provincial processes, the current document describes the program that developed from that strategy and provides specific program guidance for the future. This document has been prepared to guide Alberta's species at risk program for the five fiscal years from 2009/2010 to 2013/2014.

Alberta's species at risk program is an integral component of a national process of working together to conserve and recover species at risk in all jurisdictions of Canada. Alberta is represented on the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), for assessing and classifying the national status of species. Alberta also takes an active role in

"RENEW", the Committee for the Recovery of Nationally Endangered Wildlife. When Canada signed the United Nations *Convention on Biological Diversity* in 1992, both the federal and provincial governments took steps to ensure that species assessment criteria would be built upon those developed by the International Union for the Conservation of Nature (IUCN). In 1996 Alberta signed the national *Accord for the Protection of Species at Risk*, an agreement to work together with other provinces/territories and the federal government to develop laws and programs for protection of species at risk and their habitats. In 2002 the *Species at Risk Act* (*SARA*) was passed by Canada's parliament. *SARA* applies on federal lands (e.g., national parks), but Alberta's *Wildlife Act* is still the dominant legislation for management of species at risk on private lands and public lands under provincial jurisdiction. There are several federal/provincial committees in place to ensure a cooperative approach for the management of species at risk. At the time of preparation of this strategy, a Canada-Alberta bilateral agreement was being drafted to ensure ongoing inter-jurisdictional cooperation on species at risk conservation.

A *National Framework for Species at Risk Conservation* facilitates coordination and cooperation among jurisdictions, consistency in policies and procedures, and provides a base for the development of bilateral agreements. It explains the international context for Canada's species at risk and provides an overview and direction for species at risk conservation at the national level. The national framework identifies six "foundational elements" including:

- **Conservation** - emphasizing preventative approaches and conservation of biodiversity;
- **Governance and Legal Framework** - recognizing provincial and federal government roles, plus those of aboriginal treaties and encouraging federal-provincial bilateral agreements;
- **Knowledge** - considering science, aboriginal traditional knowledge and community knowledge;
- **Consultation** - consulting with affected parties on species at risk matters;
- **Socio-economic** - incorporating socio-economic factors into decision-making;
- **Stewardship** - adopting a range of stewardship and voluntary actions including education, incentives, and technical assistance to participants.

This document, *Alberta's Strategy for the Management of Species at Risk (2009-2014)* incorporates these six foundational elements into Alberta's species at risk program. It interprets Alberta's role within the national context. The strategy represents a bridge between conceptualization and action for the conservation of species at risk in this province by directing activities that provide Alberta-specific delivery of the national framework. Alberta's strategy provides direction for provincially-led initiatives and guides projects specifically suited to Alberta's unique circumstances, the landscape and our people.

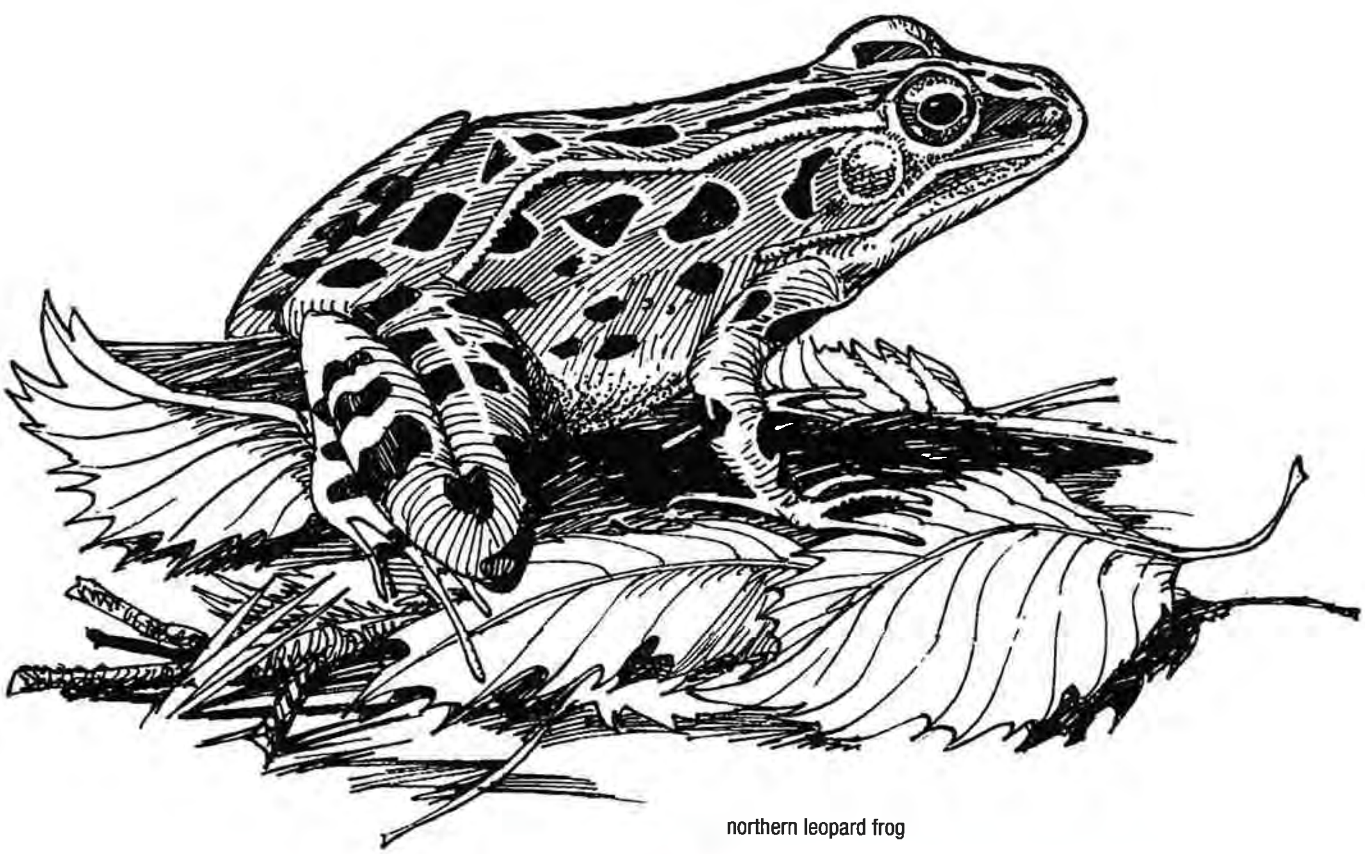
1.2 Purpose

Species at risk are the most vulnerable components of Alberta's biodiversity. The integrity of Alberta's ecosystems is dependent on their continued presence. An effective strategy is needed to sustain these rare and threatened species.

Wild species are a keystone to healthy ecological processes providing environmental stability, with a subsequent benefit to the economic stability of our province and the social and economic well-being of Albertans. This keystone role is reflected in the high value that the large majority of citizens place on conservation of species at risk.

In plain language, Albertans want to know Endangered species are being protected using our own laws and programs, without a need to turn to federal legislation.

Alberta's Strategy for the Management of Species at Risk (2009-2014) provides the framework for species at risk management in this province. It provides direction for Alberta government staff involved in species at risk management. The document will also be useful to Alberta citizens particularly those involved with recovery teams, advisory committees and project partnerships, by helping them understand species at risk program processes, priorities and activities.



northern leopard frog

Implementation of this strategy will deliver many of the *Ministerial* commitments made for species at risk. In addition to conservation benefits, it will demonstrate effective management of species at risk by the Alberta government. Under *SARA*, the province is given the first opportunity to protect listed species, but if this obligation to protect is perceived as not being done effectively, then a "safety net" clause in the Act may lead to negotiation enabling the federal government to assume management responsibility for the species. By following *Alberta's Strategy for the Management of Species at Risk (2009-2014)*, Alberta will in effect, be insuring itself against loss of provincial jurisdiction to the federal government.

1.3 Relevance to Sustainable Resource Development Business Plan

Alberta's Strategy for the Management of Species at Risk (2009-2014) is an important delivery component of the Sustainable Resource Development *Business Plan (2008-2011)*. The business plan identifies Ministry priorities, and provides Vision, Mission, Goals and Strategies. *Alberta's Strategy for the Management of Species at Risk (2009-2014)* is consistent with the SRD Vision and Mission by encouraging responsible use of resources through application of leading practices in management, science and stewardship, for the long-term benefit of Albertans.

Alberta's Strategy for the Management of Species at Risk (2009-2014) contributes in some way to all the goals in the SRD Business Plan. It is relevant to Goals 1 and 3 (Lands and Forests) to help sustain economic, environmental and social values, and encouraging actions to protect watersheds and biodiversity. *Alberta's Strategy for the Management of Species at Risk (2009-2014)* is central to Goal 4 (Fish and Wildlife), with particular application to Strategy 4.3 (Develop and implement management plans for species at risk), Strategy 4.9 (Actions to support biodiversity), Strategy 4.10 (Promote stewardship through information, education and outreach programs), and Strategy 4.11 (Programs and policies to encourage private landowners to practise stewardship to maintain and improve habitat).

Alberta's Strategy for the Management of Species at Risk (2009-2014) is the primary delivery mechanism for achievement of the SRD Business Plan Performance Measure of sustaining Alberta wildlife with less than five per cent of provincial species being listed as species at risk.

1.4 Organization of the Document

Alberta's Strategy for the Management of Species at Risk (2009-2014) is organized into seven sections. The first is this introduction, followed by a chapter describing the program goal, objectives, and six strategies for conservation and recovery of wild species. Chapter 3 provides an overview of processes relating to each of the six strategies. The fourth section describes specific activities needed to achieve conservation and recovery of Alberta's species at risk, categorized within each of the six strategies. Chapter 5 describes the resource needs of Alberta's species at risk program, the process for allocation of Departmental funds to species at risk projects and a provincial staffing strategy. Chapters 6 and 7 provide a summary and suggested readings.

2.0 GOAL, OBJECTIVES AND STRATEGIES

2.1 Goal

To ensure that populations of all wild species are protected from severe decline and that viable populations are maintained, and where possible, restored.

2.2 Objectives

1. To identify species that are, or may be at risk and those for which management will help to prevent them from becoming at risk.
2. To identify and implement actions designed to restore species at risk to viable, self-sustaining levels.
3. To identify and implement actions designed to prevent species from becoming at risk.

2.3 Strategies

STRATEGY #1: **General Status:** Rank the relative security (General Status) of all wild species to prioritize risk assessment, data collection and conservation initiatives.

STRATEGY #2: **Detailed Status:** Assess and document the risk of becoming endangered for those species having a general status that suggests serious concern regarding current or future population viability.

STRATEGY #3: ***Wildlife Act* Listing:** Formally designate species that are *Endangered* or *Threatened*, as well as Species of Special Concern.

STRATEGY #4: **Recovery Planning:** Develop Alberta Recovery Plans for all *Threatened* and *Endangered* species.

STRATEGY #5: **Preventing Species from Becoming at Risk:** Develop management plans for Species of Special Concern, to prevent them from becoming *Endangered* or *Threatened.*

STRATEGY #6: **Implementing Recovery and Management Actions:** Coordinate and facilitate the implementing of recovery plans and management plans, with actions being carried out by government, non-government organizations, and private individuals.

Cape May warbler

3.1 Strategy 1 Rank the Relative Security of all Wild Species (General Status)

Alberta supports more than 500 distinct species of vertebrates and thousands of plant and invertebrate species. The first task in managing species at risk is to determine the relative security of all species and sort them into categories based on risk of becoming endangered. This is a coarse-filter assessment to prioritize those species that may need a more detailed assessment.

The Alberta General Status process fulfils four key needs:

1. Identification of species which are or may be at risk and require more detailed assessment to determine the scope, scale, and urgency of that risk.
2. Identification of species for which current information is inadequate to assess status and for which additional data/information needs to be collected.
3. Identification of species that are sensitive to human activities and require special management to prevent them from becoming at risk.
4. Contribution of provincial General Status ranks to the National General Status of Wild Species Process.

Alberta's General Status process delivers Alberta's commitment to monitor, assess and report on the status of wildlife, as identified in the national *Accord for the Protection of Species at Risk*.

3.2 Strategy 2 Assess and Document Risk of Becoming Endangered (Detailed Status)

Amendments to Alberta's *Wildlife Act* made in 1996 (Bill 42, *Wildlife Amendment Act*) created the process and structure for assessment of the risk of becoming endangered. Section 1(1) expanded the Minister's authority to designate *Endangered* species to include all vertebrates, plants and invertebrates. Section 9.1(1) indicated that the Minister shall establish and maintain a committee to be known as the Endangered Species Conservation Committee (ESCC), to function as an advisory committee to the Minister on matters related to the legal listing of species, the preparation and adoption of recovery plans, and any other species at risk matters on which the Minister requests its advice. Section 9.1(2) indicated that the ESCC shall establish, appoint, and maintain an independent scientific sub committee (SSC) to study and assess *Endangered* species and to recommend to the ESCC organisms that should be designated *Endangered* species.

Detailed status evaluations must be carried out in a manner that is both transparent and consistent. These characteristics are achieved by use of standard criteria that can be applied equally to a wide variety of species and by anyone seeking to examine the status of a particular species, with much the same result each time. A status evaluation must also be limited to the biological status of the species in question. Consideration of potential socio-economic issues around listing and/or recovery actions should be reserved for the formal designation and/or recovery planning stages.

Alberta's SSC and ESCC operate under these principles and using these processes. The Fish and Wildlife Division provides an ESCC/SSC Secretariat.

The SSC is composed of independent Alberta scientists who have expertise on a variety of species and/or aspects of conservation biology. During their evaluation, they rely on information compiled into a detailed status report, but they may also request additional information, which might require extra expenditure or other resources to acquire.

The ESCC is chaired by an MLA appointed by the Minister. The committee fulfils a consultative role demonstrating Alberta's commitment to consultation as a "foundational element" of the *National Framework for Species at Risk Conservation* (See Sec 1.1). The ESCC is composed of stakeholders representing industrial, agricultural, conservation, aboriginal and community interests. Its role is to provide balanced advice to the minister, with representation from a broad variety of interests. The ESCC considers the evaluation of the biological status of each species that the SSC assesses, and adds their own advice as to what actions to take regarding formal designation of that species and actions needed to address the species' status.

3.3 Strategy 3 Formally Designate Endangered or Threatened Species

After each meeting, the ESCC recommends to the Minister responsible for Alberta's wildlife on matters relating to those species for which legal designation would assist in management and conservation efforts. After considering the recommendations of the ESCC, the Minister may formally designate *Threatened* and *Endangered* species by regulation under Alberta's *Wildlife Act*.

A variety of regulations provide protection for these species, including the following: up to a $100,000 fine and/or six months in jail for killing or trafficking in an *Endangered* Animal, and year-round prohibitions against disturbing the nest or den of an *Endangered* Animal. The ultimate goal of formally designating a species as *Threatened* or *Endangered* is to facilitate management and recovery efforts necessary to restore viable populations.

3.4 Strategy 4 Recovery Planning for Endangered and Threatened Species

A recovery plan must be produced for *Endangered* and *Threatened* species. A recovery plan contains three elements:

1. A summary of current biological status of the species and an evaluation of the factors which have contributed to its decline.
2. A strategy indicating recovery goals and the strategies necessary to mitigate limiting factors and maintain or recover populations.
3. An action plan that lists the specific activities (including costs, schedules, and participating agencies) that will be completed to achieve the goals of the recovery program.

The recovery planning process, including the drafting of a recovery plan, is typically managed by a recovery team. These teams are established for each *Threatened* or *Endangered* species, with multi-species teams and recovery programs being established in some cases. Teams are initiated by the Minister of Sustainable Resource Development and facilitated and chaired by a designated department biologist. Teams include biologists, species' experts and stakeholders, including community and aboriginal representation. They compile the appropriate biological information from detailed status reports and other sources, identify limiting factors, and propose appropriate recovery goals, strategies and actions. Recovery plans include a chapter addressing socio-economic factors that may influence recovery success, plus consideration of any socio-economic implications of recommended recovery actions. This delivers upon the socio-economic "foundational element" of the *National Framework for Species at Risk Conservation* (See Section 1.1). Whenever possible, teams integrate Alberta recovery plans and programs with national and international efforts. Provincial plans should be compliant with the requirements of the federal *Species at Risk Act* (*SARA*).

Draft recovery plans are forwarded to the ESCC for review. The ESCC review process serves as an opportunity to gauge public support. Careful selection of team members and ESCC review provides opportunity for community and aboriginal influence in recovery planning; however, in some cases additional public comments may also be sought through open houses or other consultation approaches. Final plans are then forwarded to the Minister for approval and publication.

Recovery plans and programs will change over time as to reflect changes in the status of species. Progress in meeting recovery goals is tracked and reported on an annual basis. Plans are updated on a regular basis, generally every five years.

In many cases, species that are listed as *Threatened* or *Endangered* in Alberta will have similar designation at the national level. In these instances, national recovery plans may be drafted by federal agencies with input and review from the provincial government. Alberta's Fish and Wildlife staff may participate in the preparation of national recovery plans to ensure that they complement provincial recovery plans or management activities. National recovery plans are reviewed by the provincial Director of Wildlife Management or Director of Fisheries Management before they are finalized.

3.5 Strategy 5 Preventing Species from Becoming At Risk

It is more biologically sound and economically cost-effective to attempt to prevent species from becoming at risk than it is to recover them once they have become *Endangered* or *Threatened.* Managing ecosystems, protecting habitats and managing human land use should be done in ways that ensure healthy, viable long-term populations of wild species. Such preventative actions help to keep species from becoming *Threatened* or *Endangered.*

wolverine

3.5.1 Management Plans

One possible outcome of the General Status Process is the identification of Sensitive species that are not endangered but require active management or conservation to prevent them from becoming at risk. High-priority Sensitive species may be further assessed through the Detailed Status Process leading to designation as Species of Special Concern. In addition, species with a general status of May be at Risk that have been assessed by the ESCC for possible listing as *Threatened* or *Endangered* but were not considered to be at immediate risk may still require special management and these may also be listed as Species of Special Concern.

Management plans will be prepared for Species of Special Concern within three years of designation, unless a shorter time frame is recommended by the ESCC or directed by the Minister. These management plans are intended to be a resource tool for the Fish and Wildlife Division and for provincial and regional land and water management agencies. The plans are designed to provide guidance for species and habitat conservation and to be used in land, water and resource management decisions.

Management plans include goals, objectives and actions. They address the biological status of the species, potential limiting factors, possible land use conflicts, data gaps and needs, and appropriate management strategies necessary to maintain viable populations. The plans are more concise than recovery plans. In some cases it may be possible to group several species with similar needs into a single plan focused on a particular ecosystem or geographic area.

Management plans are generally prepared by Fish and Wildlife biologists, and may be reviewed by species' experts. In some cases experts may be consulted earlier in the process. If other government departments or non-government organizations are identified as being responsible for actions, they should also be given the opportunity to review the plan. Upon completion of this process, each plan will be provided to the Director of Wildlife Management or Director of Fisheries Management for approval.

3.5.2 Other Prevention Initiatives

Sensitive species and Data Deficient species may also need special management to prevent them from becoming *Endangered* or *Threatened*. Although formal management plans may not be required, it is incumbent on the Fish and Wildlife Division to conserve these species. Actions needed may include inventory, monitoring, and specific management activities. In some areas it may be possible to integrate the needs of these species into biodiversity monitoring initiatives, landscape planning, and multi-species stewardship programs.

The national framework suggests conservation of biodiversity as a preventative measure. Application of biodiversity principles to land management has the potential to sustain a variety of habitat types and associated species. There are, however, shortcomings in the coarse-filter approach and simple random sampling protocols currently used in that they do not monitor the rarer habitats or smaller portions of the landscape that are important to species at risk. Given that any future reductions in Alberta's biodiversity would likely be due to losses of *Endangered* species, changes in biodiversity monitoring methods should be encouraged. A suggested modification is the initiation of long-term stratified sampling of landscapes occupied by high-priority species at risk, through methods such as intense area searches in high-quality habitats. This monitoring could help in tracking success in conservation of biodiversity and effectiveness of biodiversity approaches as a protective measure against species' endangerment.

3.6 Strategy 6 Implementing Recovery and Management Actions

Successfully implementing approved recovery and management plans is the true measure of how well the Alberta program provides for the needs of species at risk. Success can only be achieved if appropriate changes are made in the way we manage a species and its habitat. Implementing recovery actions is guided by a recovery team, relies on cooperative efforts of stakeholders and may be carried out by existing agencies, non-government organizations and concerned individuals.

In some cases, implementing recovery may include the need for regulatory changes. This may require ministerial involvement in seeking the support and participation of other departments and levels of government.

Actions identified in Species of Special Concern Management Plans are coordinated by the provincial species lead, but like those in recovery plans, may be implemented by a variety of government and non-government organizations. Implementation of management plan actions will usually rely on existing structures and organizations and on the development of new and creative partnerships with government, industry, landowners and land managers. Recovery and management plan actions should lead to direct improvement in conditions of a species' population and/or habitat. Actions may include inventory and monitoring, habitat management and conservation, public education initiatives and other activities. In some cases, plans may provide recommendations to revise existing, or develop new, policies and guidelines to assist in the long-term maintenance of the species and its habitat.

Among the most important aspects of implementation of both recovery and management actions are the transfer of information and encouraging awareness of the needs of these species. This sharing and communicating can enable land and resource managers to incorporate appropriate conservation considerations into their land-use decisions. In this context, publication of recovery plans and management plans and interpretation of appropriate information into educational and communications materials is important. Stronger working relationships with universities and other research and management agencies is also needed to fill data gaps.

Upon receiving ministerial approval, a recovery plan will be used as a resource for program development within Sustainable Resource Development, and should be integrated into the programs of other departments, as needed.

3.6.1 Single-Species Conservation and Stewardship Projects

In many cases, recovery and management can be effectively accomplished using recovery efforts specifically focused toward an individual species. These single-species efforts comprise the historical approach of the species at risk program, and continue to be the primary methods of recovery implementation. Successful examples include the peregrine falcon recovery program, the piping plover conservation program and the swift fox reintroduction program.

One advantage of single-species recovery implementation is the provision of a clear focus for activities specifically designed to recover that target species. Single-species approaches are necessary for species that require a strong emphasis on intervention (e.g., controlled breeding, reintroduction of populations, habitat development).

Single-species projects are easiest to implement in geographic areas that have only a few *Endangered* and *Threatened* species, because people in rural communities tend to respond with reduced tolerance to numerous single-species projects occurring on the same landscape. Even where a multi-species approach may be guiding conservation activities on a particular landscape, this generally involves a landscape prioritization that leads to priority single-species recovery initiatives being pursued in certain areas.

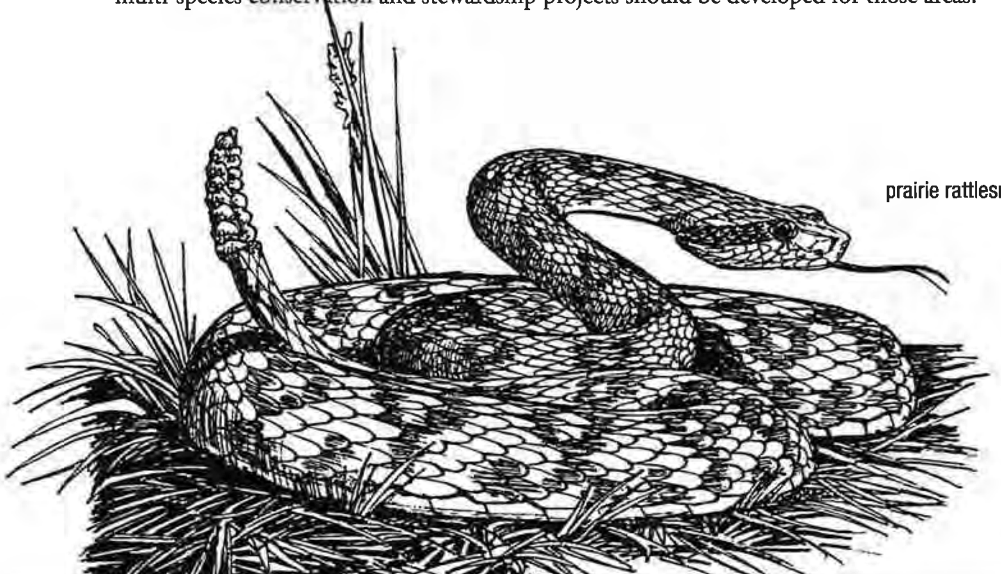
3.6.2 Multi-Species Conservation and Stewardship Projects

Multi-species initiatives are suited to landscapes where numerous species at risk occur or where there is reduced tolerance toward additional single-species activities. One example is the Grassland Natural Region where numerous species at risk are associated with remaining native prairie habitats. On such landscapes, there are efficiencies to be gained through addressing recovery needs of several species through multi-species conservation and stewardship projects.

On landscapes with several *Endangered* and *Threatened* species, single-species recovery efforts may be confounded by conflicting or competing actions being encouraged in their recovery plans. For example, it may be desirable to remove woody vegetation to benefit burrowing owl and sage grouse, whereas in the same area, the same woody vegetation may provide habitat for ferruginous hawk and loggerhead shrike. Similarly, prescribed recovery actions may conflict with other ecological needs such as range health. Under these circumstances, it may be necessary to consider the implications of such recovery actions on other species, and on habitat and ecological processes.

To be successful, multi-species conservation and stewardship projects need to include a landscape analysis to delineate appropriate geographic areas for the recovery actions of multiple *Endangered* and *Threatened* species. Detailed assessments serve to integrate single-species recovery actions with other species' objectives and to avoid conflicts with ecological processes and function. Such an assessment may include identifying areas of appropriate scale and distribution where single-species recovery actions may still be preferred. The end product of multi-species conservation and stewardship projects should be the implementation of appropriate recovery actions for priority *Endangered* and *Threatened* species on the parts of the landscape that hold the greatest potential for recovery.

Currently about 75 per cent of Alberta's species at risk reside in the native habitats of the Grassland Natural Region. Many of these are being addressed through a large multi-species conservation and stewardship program known as MULTISAR, which is a multi-partnered initiative managed by Sustainable Resource Development and the Alberta Conservation Association. As more *Endangered* and *Threatened* species are identified in other natural regions such as the boreal forest, additional multi-species conservation and stewardship projects should be developed for those areas.



prairie rattlesnake


western silvery minnow
k.j. scott

4.0 ACTIVITIES TO CONSERVE AND RECOVER SPECIES AT RISK IN ALBERTA

4.1 Strategy 1 Activities — General Status

a) Carry out an Alberta General Status exercise to evaluate the relative security of wild populations of all species, in a manner consistent with other Canadian jurisdictions using the national *Guidelines for Assessing the General Status of Wild Species in Canada.*

b) Work toward including all known vertebrate, invertebrate, and plant species, plus some selected subspecies, in the Alberta General Status process. Incorporate new taxonomic groups into the general status process according to or ahead of national timelines.

c) Report on the Alberta General Status of wild species every five years, including provision of a searchable online database and a downloadable report and communication materials.

d) Participate in the national roll-up of General Status ranks for all assessed species to facilitate preparation of National General Status ranks.

e) Develop and implement data collection strategies for species for which current data/information/knowledge is inadequate to determine status. These species may include those assessed as Undetermined by the General Status evaluation and Data Deficient by the Detailed Status evaluation, new groups of taxa for which there is little information (e.g., invertebrate and plant groups), and species assessed as May be at Risk and Sensitive.

f) Continue to build functional linkages to Fish and Wildlife databases and other data sources, including the Alberta Natural Heritage Information Centre (ANHIC). Where data and information are limited, provide opportunity for broad input and use expert knowledge and opinion. Coordinate reviews of General Status evaluations with ANHIC's review of NatureServe S-ranks.

4.2 Strategy 2 Activities — Detailed Status

a) Prioritize and select among candidates for detailed status evaluation each year. High-priority candidates may include species assessed as May be at Risk or Sensitive by the general status process, species that underwent detailed status evaluation more than five years previously (or less if directed by the Minister), and species occurring in Alberta that have been assessed, or are candidates for assessment, at the national level.

b) Collect, compile and report on the detailed information necessary to evaluate the current status and predict future risks to species selected for status assessment.

c) Prepare and publish detailed status reports for several high-priority May be at Risk and other species of concern each year. These reports will be achieved through commissioning of species' experts to compile Alberta Wildlife Status Reports summarizing all available information on the population size, trend and distribution, habitat needs and limiting factors in Alberta. These reports will continue to be directed and published jointly by the Alberta Conservation Association and the Fish and Wildlife Division. New data collection may be needed for some species.

d) Continue the SSC assessments of relative risk of extinction by measuring the current and predicted status against the guidelines of the IUCN (World Conservation Union) using information in prepared Wildlife Status Reports, plus any additional data or knowledge about the species.

e) Forward SSC recommendations to the ESCC for the development of Initial Conservation Action Statements for species. The ESCC will then make recommendations on status and conservation measures to the Minister of Sustainable Resource Development.

f) Report regularly on this process on the Species at Risk Program website and in biennial reports of Alberta's Endangered Species Conservation Committee.

g) Manage species that do not meet the criteria for *Threatened* or *Endangered* but that qualify as Species of Special Concern, and which require focused conservation effort to prevent them from becoming at risk in the future, through development and implementation of management plans, within three years of designation as Species of Special Concern. Conservation steps needed for both Species of Special Concern and those designated as Data Deficient will be recommended by the ESCC, and implemented by Sustainable Resource Development and partners.

h) Designate species for which information is considered inadequate to determine listing as Data Deficient species; develop and implement appropriate data collection strategies for these species.

4.3 Strategy 3 Activities — Formally Designate Endangered or Threatened Species

a) Upon the advice of the ESCC, and direction of the Minister, amend regulations under Alberta's *Wildlife Act* to designate species as *Threatened* or *Endangered* in Alberta.

b) Develop protective regulations under the *Wildlife Act* for fish, invertebrates, and plants, to complement those already in place for *Endangered* and *Threatened* mammals, birds, reptiles and amphibians. Develop additional regulatory amendments to extend protections to other taxa.

c) Amend Alberta's *Wildlife Act* and *Wildlife Regulation* to allow formal designation of Species of Special Concern.

d) Designate a staff biologist, at time of listing of each species, to be the provincial species coordinator to lead recovery planning and implementation.

e) Examine whether a provincial Species at Risk Act would enhance the current legal measures provided under Alberta's *Wildlife Act* to accommodate species at risk in the province.

4.4 Strategy 4 Activities — Recovery Planning for Endangered and Threatened Species

a) Establish recovery teams to develop provincial recovery plans within one year for *Endangered* species and two years for *Threatened* species.

b) Include representation from the department, appropriate technical specialists, and stakeholders on recovery teams.

c) Provide draft recovery plans to the ESCC for their review.

d) Gauge the level of public interest, through the ESCC review, and consider additional public input for some plans.

e) Submit final Alberta tecovery plans to the Minister along with any regulatory and policy requirements.

f) Initiate specific legal, regulatory, and policy authorities needed to facilitate recovery programs.

g) Where significant regulatory amendments and/or policy changes are needed, seek approval of the relevant Cabinet Policy Committee.

h) Adopt approved recovery plans as the Alberta government's policy for that species, with identified actions becoming priorities for staff and divisions of the Ministry of Sustainable Resource Development.

i) Request involvement of other departments or other levels of government when a recovery plan identifies them as having a direct role in implementation of the identified actions, or if they may be affected by implementation of the plan.

j) Integrate Alberta recovery teams and plans with national recovery plans and processes, wherever possible.

4.5 Strategy 5 Activities

Programs to Prevent Species from Becoming Endangered or Threatened

a) Identify species for which management plans are needed (primarily Species of Special Concern and some Sensitive species).

b) Prepare and publish the management plans within the prescribed time period.

c) Identify populations, limiting factors, habitat requirements, data needs, and appropriate management strategies necessary to maintain viable populations.

d) Encourage and facilitate research needed to fill data gaps for Data Deficient species and species of undetermined status.

e) Designate a department biologist species lead for each Species of Special Concern, Data Deficient and high-priority Sensitive species to coordinate management planning and other initiatives.

f) Work collaboratively to incorporate management of these species into government and non-government conservation and stewardship programs.

4.6 Strategy 6 Activities

Implementing of Recovery and Management Actions

a) Coordinate and facilitate the implementation of recovery plans for *Endangered* and *Threatened* species, with actions being carried out by government, non-government organizations, and private individuals.

b) Coordinate and facilitate the implementation of management plan actions for Species of Special Concern.

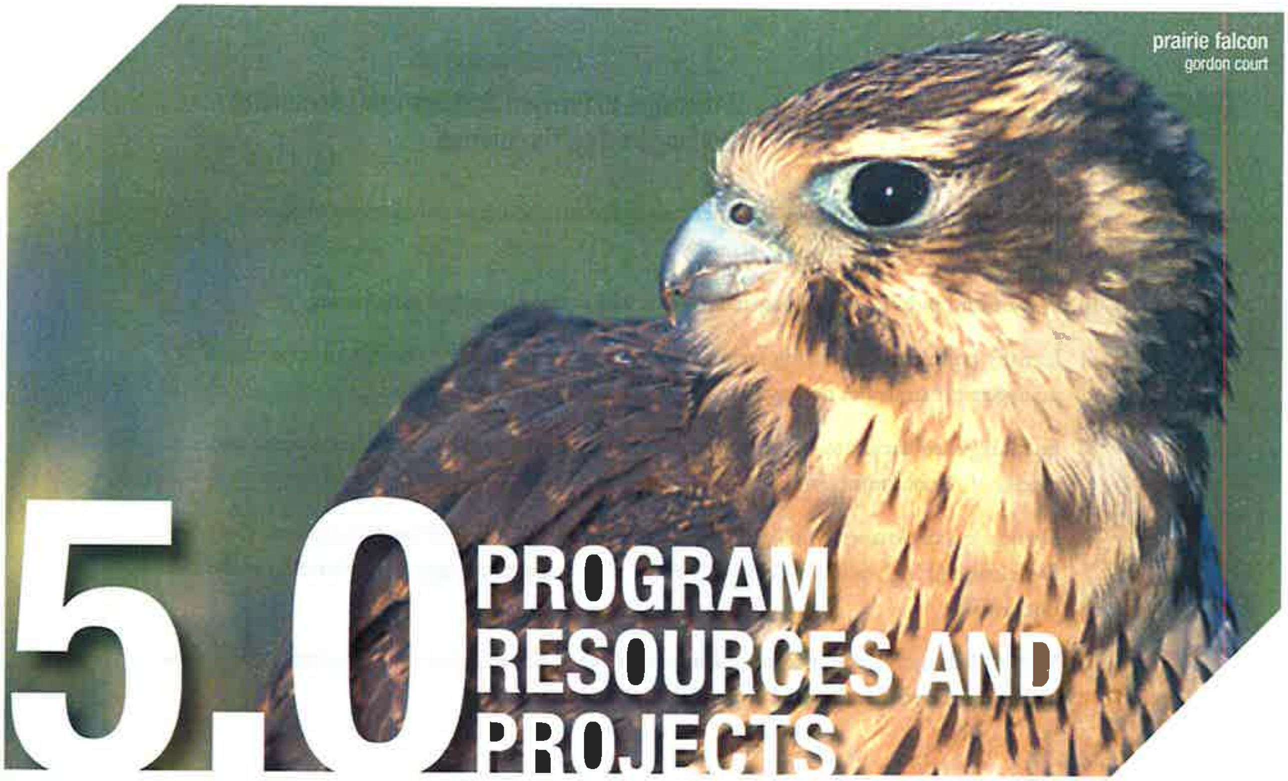
c) Implement recovery and management actions through conservation and stewardship projects with single- or multi-species' focus.

d) Encourage the development of standards, guidelines, beneficial management practices and industrial review processes to assist individuals, corporations and government in planning development activities in a manner compatible with species' recovery or management.

e) Encourage the review and revision (as needed) to land and water resource management policies and regulations to provide the needs of species at risk and to reduce likelihood of species becoming at risk.

f) Review the implementation tables in recovery plans annually to track progress in implementation of recovery actions.

g) Create new partnerships with universities, government, and non-government institutions to implement research-related recovery and management actions



5.0 PROGRAM RESOURCES AND PROJECTS

5.1 Balance Between Program Areas

Six program areas are described, based upon the strategies in the preceding chapter. They are General Status, Detailed Status, Legal Listing, Recovery Planning, Prevention Programs, and Recovery and Management Implementation. Alberta's species at risk program will strive toward a degree of balance by making progress in each of the six program areas annually. This progress will be provided by projects and activities at the provincial level and within priority landscapes.

5.2 Program Resource Needs

Continued progress in delivering Alberta's Species at Risk Program will require additional resources. Estimated needs are based upon a review of ministerial commitments, implementation tables in approved recovery plans, committee costs, and species at risk monitoring programs. The priorities identified in this strategy do not represent approved business plans or funding allocations by the Alberta government. These priorities are meant to provide suggested future direction, which may be used for planning purposes.

The following priorities are identified for the five-year period of this strategy:

- General status assessments, detailed status report contracts and publishing, operational costs of the ESCC and SSC, and Data-Deficient species surveys.
- Progressive implementation of action items identified in ministerial-approved Initial Conservation Action Statements.
- Recovery planning for all Alberta *Endangered* and *Threatened* species.
- Management planning for selected Species of Special Concern.
- Progressive implementation of action items in ministerial-approved provincial recovery plans.
- Implementation of action items in additional recovery plans that will be approved within the five-year period of this strategy.
- Emphasis on staffing program areas and geographic areas where high-priority species at risk activities are needed.

5.3 Project Prioritization

Annual projects are an important component of the species at risk program. They provide capability for the program to respond to changing priorities resulting from general and detailed status reviews, species listings, and recovery planning. The projects also allow for the development of recovery implementation strategies through funding of new single- and multi-species conservation and stewardship initiatives or through partnering in existing ones. The Species at Risk project allocations are matched, on average, by outside partner funds of three to four times the amount provided by the Department. This results in annual species at risk projects being an excellent conservation expenditure for the Alberta government.

Annual project funding prioritization is done using a process based upon the following criteria:

- Higher ranking for more highly endangered species.
- Higher ranking for projects delivering upon ministerial commitments identified in provincial recovery plans, or ministerial-approved ESCC/SSC conservation action statements.
- Higher ranking for projects providing direct and immediate benefits for species or their habitats.
- Higher ranking for projects delivering actions identified in national recovery plans.
- Consideration of levels of partnership contributions, as a secondary criterion.

Project funding is made by departmental allocation on an annual basis. The Species at Risk Section Head guides individual project decisions, based upon a prioritization table and considering input from other program and area managers, and is accountable to the Director of Wildlife Management for final decisions on project approvals.

5.4 Recommended Future Direction

5.4.1 Program Delivery and Structure

The Species at Risk Program is coordinated through a work unit within the Wildlife Management Branch. Area species at risk biologists operate within Area work units. In addition, several Area Wildlife and Fisheries Biologists spend part of their time on non-game/species at risk projects.

Work plans are determined by the managers of individual work units, but are strongly driven by the general and detailed status processes, *Wildlife Act* jurisdictional requirements, and ministerial commitments related to recovery planning and implementation of conservation and stewardship actions. The broad scope of the program requires that work plans be developed through a cooperative process involving branch and area managers and staff. Increasing demands for recovery/management planning and implementation, combined with increasing threats and emerging issues, creates the need for additional provincial species at risk staff in Alberta. Perceptions of a less than adequate provincial government resourcing could stimulate potential involvement of the federal government in management of Alberta's species at risk. This involvement could lead to increased federal staff presence in Alberta communities, delivering species at risk programs for Alberta's wildlife.

5.4.2 Program Staff

In early 2008 there were four positions in the Wildlife Management Branch's Non-game and Species at Risk unit, with species status and provincial program responsibilities. There were also four regional species at risk biologists, all working within the Prairie Area of the province. The following subsections identify several program areas and geographic areas where increased emphasis is recommended.

NORTHERN ALBERTA

- Northeastern Alberta: concentrating on management and recovery of whooping crane, peregrine falcon, shortjaw cisco, several sensitive species, and planning and approvals related to the high levels of industrial developments (e.g., oil sands).
- North-central Alberta: working closely with Provincial Parks (Boreal Centre for Bird Conservation), industry and academic institutions on development of non-game multi-species and landscape approaches for the boreal forest ecosystem.
- Northwestern Alberta: addressing recovery planning and implementation for species such as trumpeter swan, wood bison, and a large number of sensitive species.

FISH SPECIES AT RISK

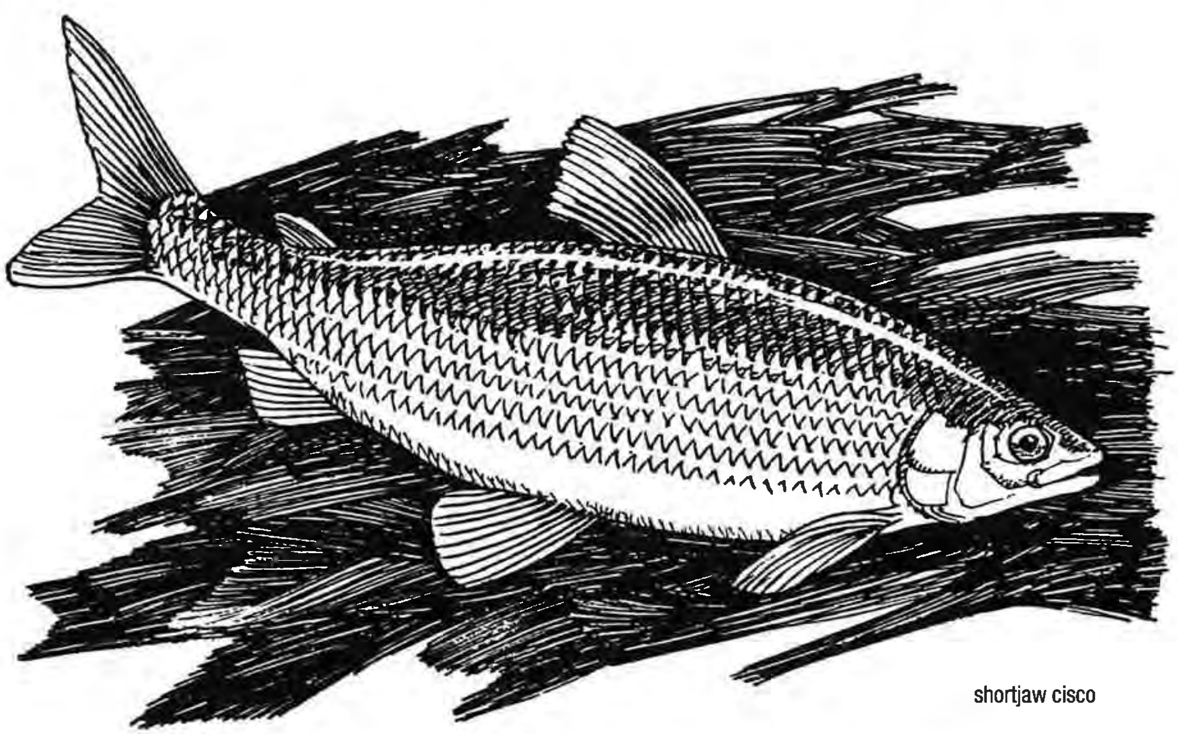
The Species at Risk Program includes responsibilities for fish listed or proposed for provincial and federal listing as *Endangered* or *Threatened* species. There are several recent ministerial commitments related to fish. There is an increased need for communication and progress on these commitments, as well as for increased recovery planning and implementation capability for lake sturgeon, western silvery minnow, east-slope sculpin, stonecat, and westslope cutthroat trout.

PLANT SPECIES AT RISK

SARA listings of Alberta plant species and third party legal challenges to Alberta's jurisdiction for *Endangered* and *Threatened* plants create the need for increased emphasis on rare plants. In addition, four plant species were recently listed in Alberta's *Wildlife Act*, and there may be more species of plants listed over the next several years. Plant regulations, in development at time of preparation of this document, will further strengthen provincial management in this area. Areas of focus would include recovery planning and implementation for listed plants, development of survey protocols, and participation in industrial mitigation measures to conserve rare plants.

MOUNTAIN/FOOTHILLS FORESTRY

Tree species in mountain and foothills ecosystems being threatened by disease and insect pests require special management. Listing and subsequent recovery planning and implementation are needed for some tree and forest plant species.



shortjaw cisco

MULTI-SPECIES CONSERVATION INITIATIVES

The MULTISAR project has demonstrated success of a multi-species stewardship initiative for species at risk on the Alberta prairie landscape. That project was initially developed for the small landscape of the Milk River Basin, and was subsequently expanded to all of prairie Alberta, largely facilitated through a temporary allocation of funds from the Innovation Program of Ministry of Advanced Education and Technology. MULTISAR would be an appropriate long-term program for management within Sustainable Resource Development.

RECOVERY PLANNING AND IMPLEMENTATION

The preparation of recovery plans is a time-sensitive, concentrated effort requiring coordination of a diverse team and access to appropriate technical and scientific experts. Some areas have several recovery planning exercises active at the same time. This situation is likely to increase over the period of this strategy, with additional emphasis needed to facilitate recovery implementation.

PRIORITY SPECIES

Focused efforts are needed for the conservation and recovery of the three currently identified priority species: caribou (*Threatened*), bison (*Endangered*) and grizzly bear (pending status designation). A provincial coordinator for priority species plus several area wildlife staff spend portions of their time on conservation and recovery of these three species. Recovery plans provide recommendations for these species. Areas of emphasis will need to include caribou range planning, grizzly conflict prevention, communication and education programs, development of industrial guidelines, and direct species' management.

woodland caribou

6.0 SUMMARY

This document outlines Alberta's strategy for conservation and recovery of species at risk. It describes general and detailed status processes, legal listing, recovery planning, measures to prevent endangerment, and recovery/management implementation.

Alberta's Strategy for the Management of Species at Risk (2009-2014) provides information on the planning processes and actions needed for the management of Alberta's species at risk within a national context. Enhancement of Alberta's species at risk program will be key to maintaining Alberta's biodiversity. It will help to ensure environmental and economic health of the province and the social well-being of Albertans.

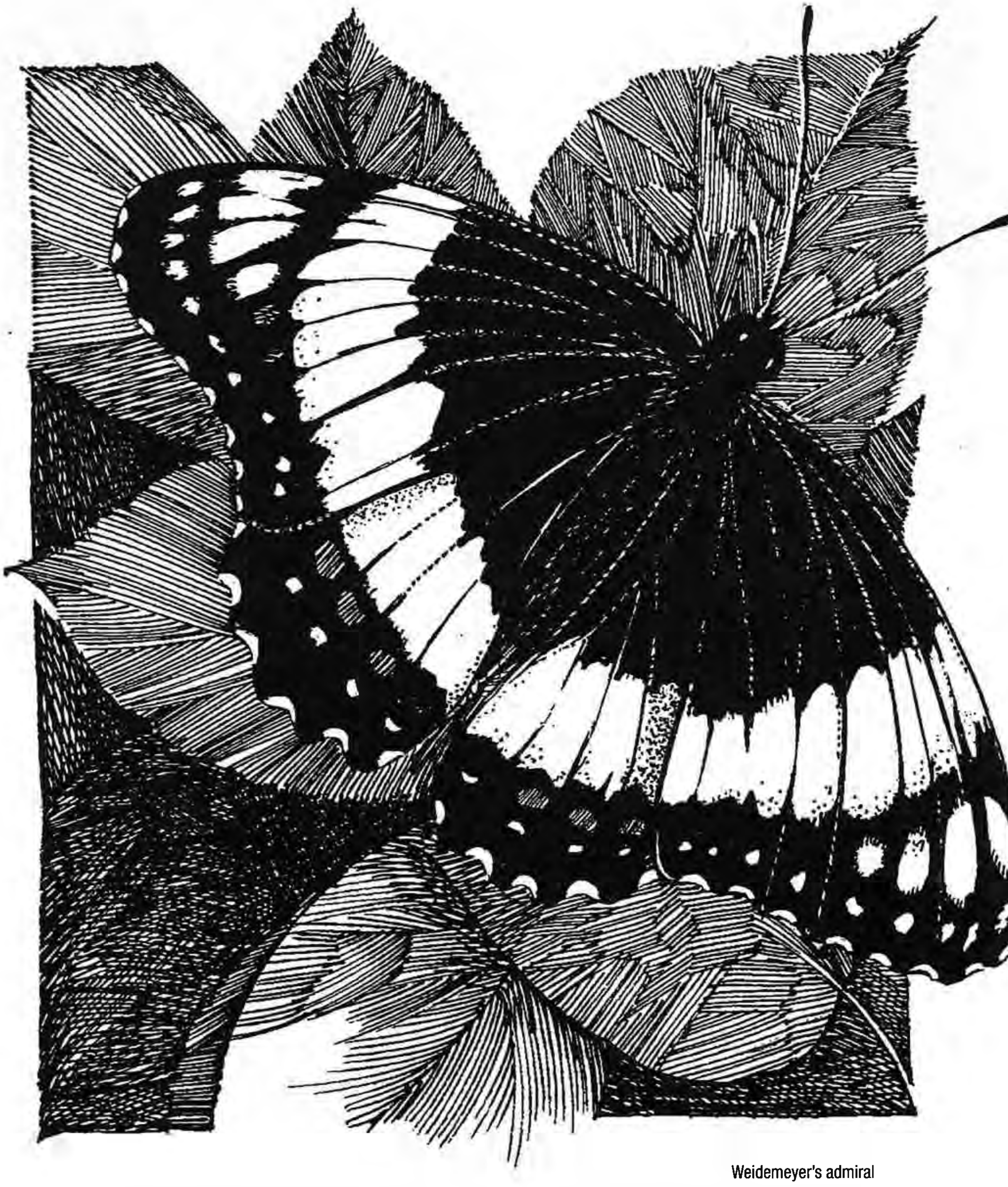
The process of managing species at risk in Alberta will be sustained by a focused and ongoing program commitment. As we gain more information, knowledge and experience, our ability to recognize problems and implement appropriate management for species at risk will improve. However, as human use of our natural environment changes, new challenges will present themselves. *Alberta's Strategy for the Management of Species at Risk (2009-2014)* will help to organize and focus Albertans' efforts to meet these demands. The strategy will need to be revisited in the 2013/2014 fiscal year, to revise it for the subsequent five years.

tiny cryptanthe

Ord's kangaroo rat
gordon court

7.0 SUGGESTED READING

- The General Status of Alberta Wild Species reports, detailed status reports, and species at risk project reports may be viewed on the provincial species at risk web page http://srd.alberta.ca/fishwildlife/speciesatrisk/
- The *Wildlife Act* and *Wildlife Regulation* may be viewed on the Alberta Queens Printer web page http://www.qp.gov.ab.ca/catalogue/
- Information on the ESCC and SSC may be viewed on the Endangered Species Conservation Committee web page http://srd.alberta.ca/fishwildlife/escc/
- Information on the federal *Species at Risk Act* and national programs and processes may be viewed on the national species at risk web page http://www.sararegistry.gc.ca/
- Sustainable Resource Development Business Plan 2008-2011 may be viewed on the Sustainable Resource Development web page http://srd.alberta.ca/



Weidemeyer's admiral


yucca moth
gordon court

8.0 APPENDIX 1

Endangered, Threatened and Special Concern Species

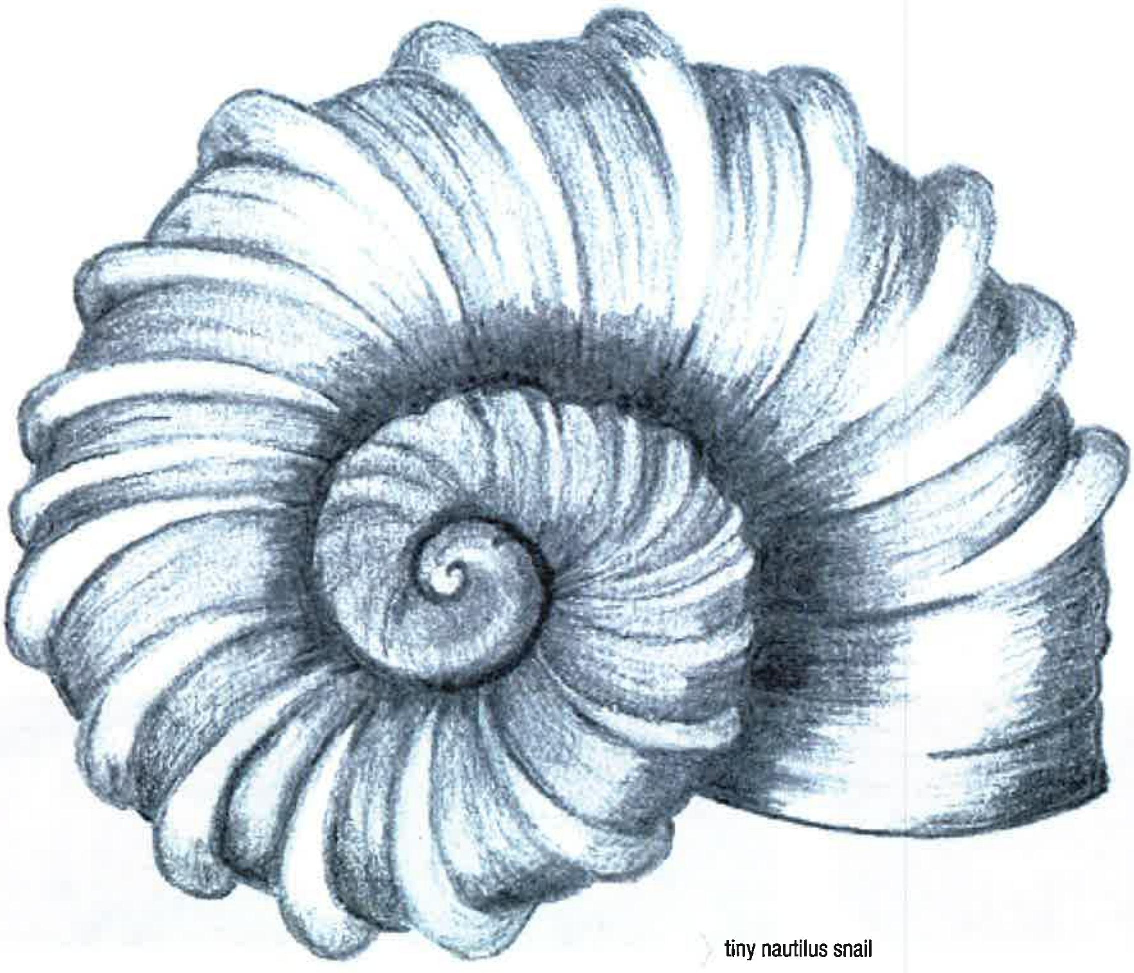
This list summarizes the *Endangered* and *Threatened* species in Alberta, as designated in Schedule 6 of the *Wildlife Regulation* in early 2008. It also includes species recommended by the Minister for Species of Special Concern status.

Endangered Species: swift fox, bison[1], whooping crane, sage grouse, piping plover, Ord's kangaroo rat, burrowing owl, ferruginous hawk, mountain plover, short-horned lizard, tiny cryptanthe, western spiderwort, soapweed,

Threatened Species: woodland caribou, barren ground caribou, northern leopard frog, trumpeter swan, peregrine falcon, small flowered sand verbena, lake sturgeon, shortjaw cisco, St. Mary sculpin, western silvery minnow, stonecat.

Species of Special Concern: Sprague's pipit, long-toed salamander, long-billed curlew, loggerhead shrike, black-throated green warbler, harlequin duck, bull trout, white-winged scoter, prairie falcon, barred owl, western blue flag.

[1]Only Bison bison (Bison) that are found or killed on or captured from the lands within the following boundaries are Endangered animals: Commencing at the intersection of the Alberta Northwest Territories boundary and primary Highway 35; thence southerly along primary Highway 35 to the north boundary of the Paddle Prairie Metis Settlement; thence westerly along the north boundary of the Paddle Prairie Metis Settlement to the sixth meridian; thence southerly along the west boundary of the Paddle Prairie Metis Settlement (the sixth meridian) to the right bank of the Chinchaga River in Township 102; thence upstream along the right bank of the Chinchaga River to the Alberta British Columbia boundary; thence northerly along the Alberta British Columbia boundary to its intersection with the Northwest Territories boundary; thence easterly along the Alberta Northwest Territories boundary to the point of commencement.



tiny nautilus snail

ALBERTA'S STRATEGY FOR THE MANAGEMENT OF

SPECIES AT RISK

(2009-2014)

Alberta

A2.5 PLANT SPECIES INDICATOR VALUES FOR 2005, 2006, 2007 AND 2009

Table A2.25 Plant Species Indicator Values for 2005, 2006, 2007 & 2009, Long Lake Wetlands Monitoring Program

Species	2005			2006			2007			2009		
	Wetland Type	*IV*	*p-value*	Wetland Type	*IV*	*p-value*	*Wetland Type*	*IV*	*p-value*	*Wetland Type*	*IV*	*p-value*
Tree Species												
Larix laricina	**Wooded Fen**	**93.7**	**0.028**	Wooded Fen	36.2	0.819	Wooded Fen	36.2	0.972	Shrubby Fen	31.0	1.000
Picea mariana	Wooded Fen	61.4	0.373	**Wooded Fen**	**95.1**	**0.022**	**Wooded Fen**	**96.9**	**0.004**	**Wooded Fen**	**82.9**	**0.008**
Shrub Species												
Alnus crispa	Shrubby Fen	75.0	0.127	-	-	-	-	-	-	-	-	-
Betula glandulosa	-	-	-	-	-	-	-	-	-	Shrubby Fen	20.0	1.000
Betula neoalaskana	-	-	-	-	-	-	-	-	-	Shrubby Fen	20.0	1.000
Betula occidentalis	-	-	-	-	-	-	-	-	-	Shrubby Fen	20.0	1.000
Betula papyrifera	-	-	-	Wooded Fen	20.0	1.000	Wooded Fen	12.1	1.000	-	-	-
Betula pumila	**Shrubby Fen**	**96.2**	**0.092**	**Shrubby Fen**	**89.1**	**0.092**	**Shrubby Fen**	**92.2**	**0.019**	**Shrubby Fen**	**99.0**	**0.009**
Ledum groenlandicum	**Wooded Fen**	**74.8**	**0.053**	**Wooded Fen**	**98.0**	**0.022**	**Wooded Fen**	**98.3**	**0.004**	**Wooded Fen**	**77.9**	**0.052**
Lonicera caerulea	-	-	-	-	-	-	-	-	-	Shrubby Fen	20.0	1.000
Oxycoccus microcarpus	**Wooded Fen**	**79.4**	**0.028**	Wooded Fen	46.3	0.659	Wooded Fen	51.6	0.503	Wooded Fen	42.4	0.875
Ribes glandulosum	Wooded Fen	25.0	1.000	-	-	-	-	-	-	-	-	-
Ribes hudsonianum	-	-	-	Wooded Fen	20.0	1.000	Wooded Fen	16.7	1.000	Wooded Fen	20.0	1.000
Rosa acicularis	Wooded Fen	25.0	1.000	-	-	-	-	-	-	-	-	-
Rubus arcticus	-	-	-	-	-	-	Shrubby Fen	36.5	0.393	Shrubby Fen	18.5	1.000
Rubus chamaemorus	Wooded Fen	50.0	0.431	Wooded Fen	40.0	0.501	**Wooded Fen**	**66.7**	**0.093**	**Wooded Fen**	**79.4**	**0.063**
Salix bebbiana	-	-	-	Wooded Fen	20.0	1.000	Wooded Fen	16.7	1.000	Wooded Fen	60.0	0.173
Salix candida	-	-	-	Shrubby Fen	33.3	1.000	Shrubby Fen	25.0	0.374	Shrubby Fen	20.0	1.000
Salix lasiocarpa	-	-	-	-	-	-	-	-	-	Shrubby Fen	20.0	1.000
Salix lucida	Shrubby Fen	68.4	0.151	-	-	-	-	-	-	-	-	-
Salix macalliana	-	-	-	-	-	-	Shrubby Fen	25.0	0.415	Shrubby Fen	12.7	1.000
Salix myrtillifolia	**Shrubby Fen**	**100.0**	**0.028**	Wooded Fen	20.0	1.000	Wooded Fen	66.7	0.137	Wooded Fen	60.0	0.173
Salix pedicellaris	-	-	-	Shrubby Fen	33.3	0.396	Shrubby Fen	44.7	0.308	**Shrubby Fen**	**80.0**	**0.033**
Salix planifolia	Wooded Fen	50.0	0.402	Shrubby Fen	53.5	0.646	Shrubby Fen	67.8	0.363	Wooded Fen	45.3	0.760
Salix pyrifolia	Wooded Fen	75.0	0.128	Shrubby Fen	33.3	0.396	Shrubby Fen	25.0	0.422	Shrubby Fen	20.0	1.000
Vaccinium vitis-idaea	**Wooded Fen**	**82.6**	**0.053**	**Wooded Fen**	**100.0**	**0.022**	**Wooded Fen**	**99.3**	**0.004**	Wooded Fen	92.1	0.004
Forb Species												
Achillea millefolium	-	-	-	-	-	-	Wooded Fen	16.7	1.000	Wooded Fen	20.0	1.000

Bold type indicates a significant indicator species for that wetland types and year

Species Assessed by Alberta's Endangered Species Conservation Committee: Short List

Alberta Species at Risk

List of Endangered and Threatened species currently listed under Alberta's *Wildlife Act* and other species assessed by the Endangered Species Conservation Committee (ESCC) and its Scientific Subcommittee (SSC)

Endangered Species

1. Swift fox (*Vulpes velox*)
2. Bison (*Bison bison athabascae*)[1]
3. Sage grouse (*Centrocercus urophasianus*)
4. Piping plover (*Charadrius melodus*)
5. Ord's kangaroo rat (*Dipodomys ordii*)
6. Whooping crane (*Grus americana*)
7. Mountain plover (*Charadrius montanus*)
8. Short-horned lizard (*Phrynosoma douglassi*)
9. Burrowing owl (*Athene cunicularia*)
10. Ferruginous hawk (*Buteo regalis*)
11. Tiny cryptanthe (*Cryptantha minima*)
12. Soapweed (*Yucca glauca*)
13. Western spiderwort (*Tradescantia occidentalis*)
14. Porsild's bryum (*Bryum porsildii*)
15. Limber pine (*Pinus flexilis*)
16. Whitebark pine (*Pinus albicaulis*)
17. Slender mouse-ear-cress (*Halimolobos virgata*)

Threatened Species

1. Peregrine falcon (*Falco peregrinus*)
2. Woodland caribou (*Rangifer tarandus caribou*)
3. Barren ground caribou (*Rangifer tarandusgroenlandicus*)
4. Trumpeter swan (*Cygnus buccinator*)
5. Northern leopard frog (*Rana pipiens*)
6. St. Mary sculpin (*Cottus bairdi punctulatus*)
7. Stonecat (*Noturus flavus*)
8. Shortjaw cisco (*Coregonus zenithicus*)
9. Western silvery minnow (*Hybognathus argyritis*)
10. Lake sturgeon (*Acipenser fulvescens*)
11. Small-flowered sand verbena (*Trypterocalyx micranthus*)
12. Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) [2]
13. Grizzly bear (*Ursus arctos*)

Species of Special Concern

1. Sprague's pipit (*Anthus spragueii*)
2. Long-toed salamander (*Ambystoma macrodactylum*)
3. Long-billed curlew (*Numenius americanus*)
4. Loggerhead shrike (*Lanius ludovicianus*)
5. Black-throated green warbler (*Dendroica virens*)
6. Harlequin duck (*Histrionicus histrionicus*)
7. Bull trout (*Salvelinus confluentus*)
8. White-winged scoter (*Melanitta fusca*)
9. Prairie falcon (*Falco mexicanus*)
10. Barred owl (*Strix varia*)
11. Western blue flag (*Iris missouriensis*)
12. Arctic grayling (*Thymallus arcticus*)
13. Weidemeyer's admiral (*Limenitis weidemeyerii*)
14. Western grebe (*Aechmophorus occidentalis*)
15. Western small-footed bat (*Myotis ciliolabrum*)

Data Deficient Species

1. Prairie rattlesnake (*Crotalus viridis*)
2. Wolverine (*Gulo gulo*)
3. Pygmy whitefish (*Prosopium coulteri*)
4. Great Plains toad (*Bufo cognatus*)
5. Canadian toad (*Bufo hemiophrys*)
6. American badger (*Taxidea taxus*)
7. Verna's Flower Moth (*Schinia verna*)
8. Northern myotis (*Myotis septentrionalis*)

In Process

1. Yucca moth (*Tegeticula yuccasella*)
2. Cape May warbler (*Dendroica tigrina*)
3. Bay-breasted warbler (*Dendroica castanea*)
4. Banff Springs snail (*Physella johnsoni*)
5. Athabasca rainbow trout (*Oncorhynchus mykiss*)

1 The only endangered bison are those found, killed or captured on land in northwestern Alberta, extending from around the Hay-Zama lakes and north and west to the N.W.T. and B.C. borders.

2 The only threatened stocks of Westslope cutthroat trout are genetically pure native stocks that are found, killed or captured from flowing waters in parts of the Oldman River and Bow River watersheds and Picklejar Lakes.