

of 0.7 m, will convey in excess of the 5-year peak discharge of 2.7 m³/s. If needed, the flow could be maintained in the natural channel and a backfilled bridge crossing could be constructed further to the west using a longer diversion channel alignment.

LET3, crossed next by the Mynheer Pit, is the largest channel in the Lendrum watershed. The shallow, narrow pit section here may also be mined in 2-3 months to allow temporary pumping across a pit distance of 180 m and then backfilling for a subsequent lined bridge diversion (Diversion 8). This diversion channel section, with a 1.6% grade, 2.5 m base width and active depth of 0.6 m, will convey in excess of the 5-year peak discharge of 3.2 m³/s. This will maintain natural flows and allow for fish passage until the Mynheer Pit is reclaimed. If needed, to eliminate any pumping, the flow could also be maintained in the natural channel until a backfilled bridge crossing is constructed to the west using a longer diversion channel alignment of about 450 m.

Mynheer Pit backfilling and reclamation will be completed next, such that LET1 will drain east for 950 m at 0.4% grade within the pit to join LET3. Shallow ponds with connecting channel segments will be provided for LET1 in this area. LET1 and LET3 combined will then drain into LET3 natural channel to the Val d'Or Pit which will be mined next.

The smaller west flowing Lendrum Creek channel joins LET3 just below the Val d'Or Pit. Above the LET3 confluence, Lendrum Creek will be entirely mined out along its length for 2.5 km for the Val d'Or Pit. Most of upper Lendrum Creek's flow will have been redirected to LET3 via the Mynheer Pit as it intercepts several small north flowing tributary channels east of LET3 (ESRD Figure 75a-5). Where clean water bypasses can be provided around active mining, these will be handled by pumps. The typical maximum pump around rate for upper Lendrum Creek above the pit may be up to 0.4 m³/s to handle in excess of a 2-year peak flow rate.

A 300 to 600 m long lined diversion channel, bridging 100 m over the Val d'Or Pit will be provided to convey the combined flow of LET1 and LET3 to the natural channel at the LET3-Lendrum Creek confluence. This diversion channel section, with a 1.3% grade, 3 m base width and active depth of 0.8 m, will convey in excess of the 5-year peak discharge of 5.9 m³/s. This will maintain natural flows and allow for fish passage here until the Val d'Or Pit is reclaimed and filled as end pit lake 7. Overflows or siphoned flows from the diversion plus upper Lendrum Creek channel inflow will fill this lake within 2 years. The bridge section would be left largely in place and lowered, as required, when the lake fills. Lower LET1 flows below the Val d'Or Pit could be restored with outflows from Lake 7 at the same level at elevation 1155 m (ESRD Figure 75a-5). The design width of the two outlets would control the relative magnitude of flow down each channel (currently about 38% to LET1 and 62% to the LET3/Lendrum confluence).

Alternate Drainage Plans

LET1 flow between Mynheer and Val d'Or (about a 350 m channel segment) will be eliminated as the flow will be directed over 950 m east into LET3 in the Mynheer reclaimed pit. No alternate to this flow alignment is considered feasible here. In addition, flow in lower LET1 below the Val d'Or Pit will temporarily be lost until Lake 7 is filled. Alternatively, minimum sustainable pumped bypass flows could be provided in it for a 2-4 year time period to allow for mining, reclamation and lake filling. The mean monthly flow in LET1 from May to July is estimated at below 0.14 m³/s and 2 year peak flow is estimated at 1.4 m³/s.

Lendrum Creek channel will be replaced with Lake 7 for a distance of 2.5 km. No alternatives are considered feasible for this drainage.

8.2 Pumping

Short term (2-3 months) pumping may be used for LET1 and LET3 until the bypass flow can be routed through open channels. A pump bypass is expected for upper Lendrum Creek channel above LET3 until Mynheer Pit is reclaimed for its drainage channel.

Lake 7 filling will 'skim' high flows from Lendrum Creek and its tributaries LET1 and LET3 through overflow weirs or pumping.

8.3 Fisheries

As described above, Lendrum Creek, LET1 and LET3 will each be subject to several diversions during mining. In most cases flows will be diverted via open channels that will facilitate fish movements. However, some pumping may be required for short periods of time. An estimated 2.5 km of Lendrum Creek will be permanently lost due to Val d'Or mine pit and flows will be directed into LET3. The impacted habitat in Lendrum Creek and LET1 was considered to have moderate habitat potential while LET3 was considered to have high habitat potential. The post-mining plan will result in Lendrum Creek flowing into Lake 7 which will outlet into LET3. Lake 7 would be designed to maximize habitat suitability for fish and habitat enhancements could be incorporated in the inlet and outlet channels. The attenuating effect due to the lake is expected to have minimal impact on downstream flushing flows in Lendrum Creek (see response to [ESRD SIR #77](#)).

9. Lund Creek

9.1 Mining and Drainage (Section C, Figure C.3-7 to C.3-9)

The main tributaries of Lund Creek to be cut off by mining by both Mynheer and Val d'Or Pits from west to east are: LDT1, LDT3 and Lund main (Figure 86-3). Flows in these tributaries will be handled during mining by channels across the active pits similar to the other pit crossings of the main streams.

For LDT1, a 400 m diversion with 150 m as a lined bridge over the backfilled Mynheer Pit will be required (Diversion 11). This will maintain natural flows and allow for fish passage here for about 6 years until the Mynheer Pit is reclaimed and Lake 9 is filled and established (ESRD Figure 75a-6). The typical diversion channel section, with a 2.2% grade, 2 m base width and active depth of 0.5 m, will convey in excess of the 5-year peak discharge of 2.2 m³/s. A second short 50 m diversion over the shallow McPherson Pit just above the Val d'Or Pit will also be required. When the Val d'Or Pit is mined, a 500 m long similar sized diversion across it will also be required with 300 m as a lined bridge section over the pit. This diversion bridge may be expected to remain for over 7 years until both lakes 8 and 9 are filled. All of LDT1 channel between lakes 8 and 9 will be reconstructed.

LDT3 is intercepted next by the three pits (Diversion 12). A total diversion length of 550 m on the west end, in planned backfilled areas, would divert this tributary over the mined pits. Diversion sections would be staged for each pit. The channel section would have a grade up to 4.5%, a 1.5 m base width and an active depth of 0.5 m to convey in excess of the 5-year peak discharge of 1.8 m³/s. A small east tributary to LDT3 above the Mynheer Pit would be pumped to this channel during mining. The bridge bypass would remain in place at least 7 years until both Lakes 10 and 11 are filled. When upper Lund is directed to Lake 10 via Lake 12 and out lower LDT3 (ESRD Figure 75a-7), the need for channel stabilization and enlargement of the lower 600 m reach of LDT3 to its confluence with Lund Creek will need to be investigated and undertaken, as required.

Upper Lund Creek intercepted next will be diverted west along the high wall for 200-300 m then bridge across the Mynheer Pit and back east to its natural channel (Diversion 14). This initial diversion alignment utilizes part of the final planned drainage route for upper Lund Creek. The diversion would be 500 to 750 m long at a grade of 1.3 to 1.8% with a channel section base width of 1.5 m and an active depth of 0.5 m to convey in excess of the 5-year peak discharge of 1.7 m³/s. As mining proceeds for the deep Val d'Or Pit the flow may eventually cease to allow pit filling from upper Lund flows. End pit lake 12 would collect flows from upper Lund for several years.

Alternate Drainage Plans

No alternate drainage plans are considered feasible for upper Lund Creek without significant mine plan changes.

9.2 Pumping

No pumping will be required for the bypass as flow is routed through open channels during mining. Need for pumping from Lake 12 to contribute to downstream Lund Creek flows will need to be assessed.

Lake 8 and 9 filling will ‘skim’ high flows from LDT1 through over flow weirs or pumping. Lake 10 and 11 filling will ‘skim’ high flows from LDT3 through over flow weirs or pumping. Lake 12 filling will collect flows from upper Lund Creek and PET1 for several years.

9.3 Fisheries

As indicated above there will be multiple open channel diversions constructed during mining to convey water around mine pits. These diversions would be adequately sized to convey natural flows and accommodate fish movements. Baseline investigations indicated moderate habitat potential within Lund Creek and low or sub-marginal habitat potential within Lund Creek tributaries. Habitat enhancements could be incorporated into the construction of the long-term diversions to maximize habitat suitability and maintain habitat utility. The proposed drainage scheme would involve an end pit lake system with 3 lakes that would have surface connection to the Lund Creek system. Lakes 10 and 11 would be located on LDT3 and Lake 12 would be located on Lund Creek. Under this scenario a portion of Lund Creek would remain permanently dry (above LDT3 and below Lake 12) since Lake 12 would collect flows from the upper Lund drainage and direct them to Lake 10, which would subsequently drain to Lund Creek via LDT3. CVRI will conduct additional investigations to assess baseline conditions for this section of the creek. Due to this routing the flows in LDT3 would be higher than under baseline conditions and channel stabilization work will be required. There may also be opportunity to construct habitat enhancements to improve habitat suitability. Lake inlet and outlet channels could be enhanced to maximize habitat suitability for target species. The attenuating effect due to the lake is expected to have minimal impact on downstream flushing flows in Lund Creek (see response to [ESRD SIR #77](#)).

10. Unnamed Creek – Pembina Tributary PET1

10.1 Mining and Drainage (Section C, Figure C.3-10 and C.3-11)

A tributary of the Pembina River, PET1, will be initially intercepted by mining in the Mynheer

Pit. Flows will be diverted east around the end of the pit into the original channel (Figure 86-3). This will consist of a 300 m long diversion at a grade of 0.5%. The channel section would have a 2 m base width and an active depth of 0.7 m to convey in excess of the 5-year peak discharge of 2.2 m³/s. Prior to mining in the Val d'Or Pit the flow could be directed eastward through the Mynheer Pit to flow to the Pembina River.

Following completion of mining PET1 flow will be directed into the Val d'Or end pit lake where it will exit into Lund Creek system.

Alternate Drainage Plans

An alternative is to reconstruct a creek channel into the reclaimed Mynheer Pit to keep the creek flow directed eastward to remain in the Pembina River system. This would consist of a 1 km long channel at a low grade of about 0.2% to the upper valley flat of the Pembina River. Channel development and enhancement for about 600 m of an existing local drainage in the valley flat could then be provided.

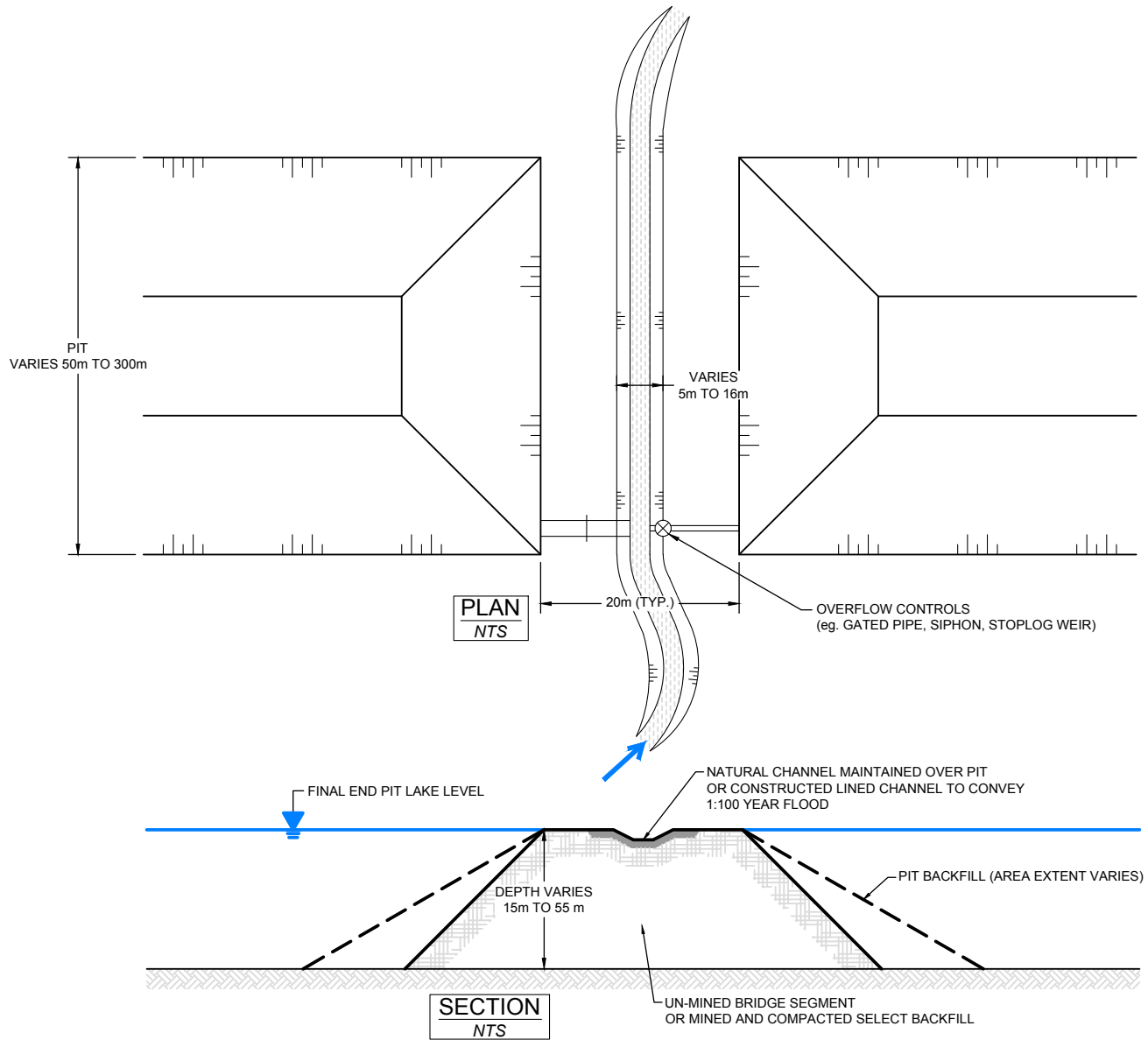
10.2 Pumping

Surface flows will be intercepted by the mining operation and enter into the pit. This water will be managed as mine waste water.

10.3 Fisheries

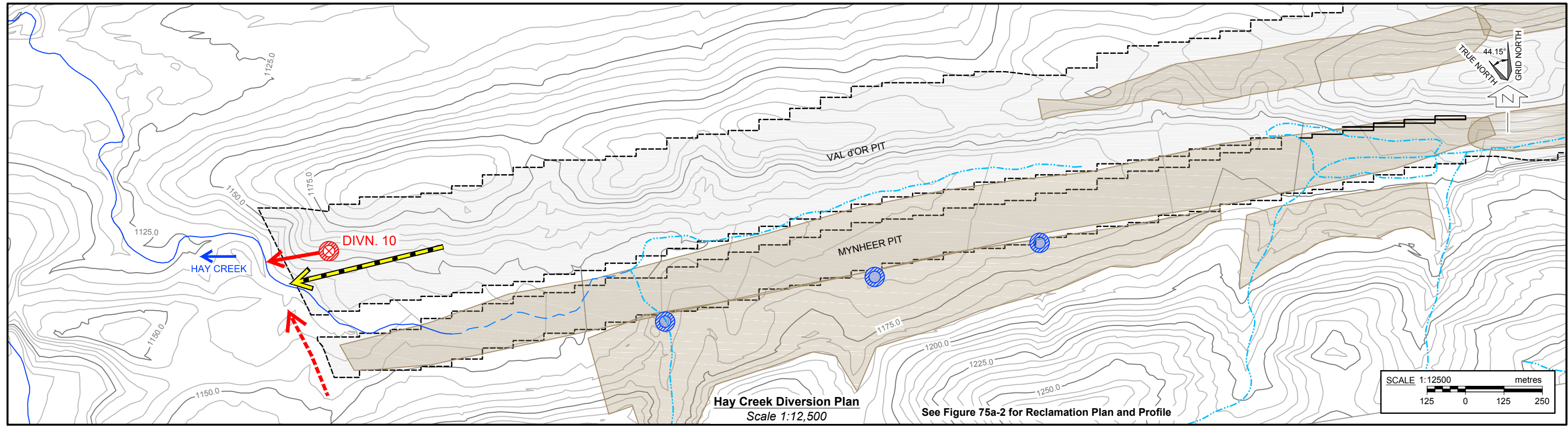
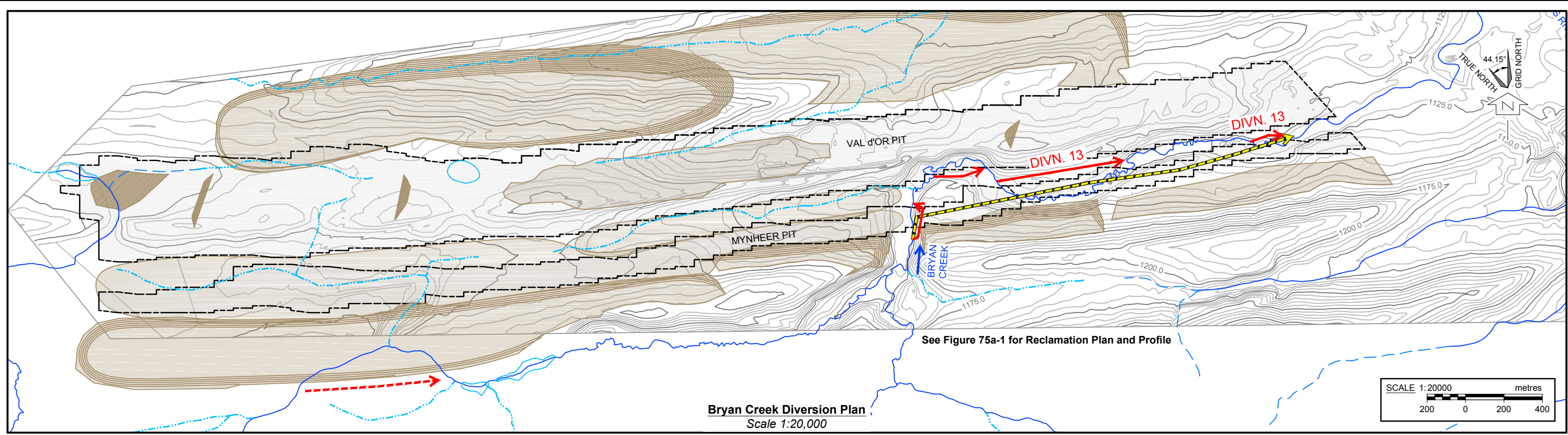
As described above, an open channel diversion would be constructed to handle flows during mining. The channel would be adequately sized to convey natural flows and accommodate fish movements. Habitat within the tributary was considered to have high habitat potential for fish resident to the Pembina basin. Following mining CVRI's proposed drainage scheme would involve permanent diversion of the flow from PET1 into the Lund Creek system via Lake 12. In order to facilitate this plan a comprehensive fish salvage would be completed to remove all fish from the PET1 drainage. Additional measures (i.e. de-watering the creek post-salvage but before connecting to the Lund system) could also be completed to ensure fish species from the Pembina basin were not transferred to the Lund system.

An alternate post-mining drainage scheme that has reduced risk to aquatic resources in the Lund system would involve re-construction of the PET1 channel to direct the creek in an easterly direction so that it remains in the Pembina River system. The constructed channel could be enhanced to maximize habitat suitability for target fish species.



COAL VALLEY RESOURCES INC.	
Bridge Diversion Channel Concept Typical	
ROBB TREND PROJECT	FIGURE 1

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LEGEND

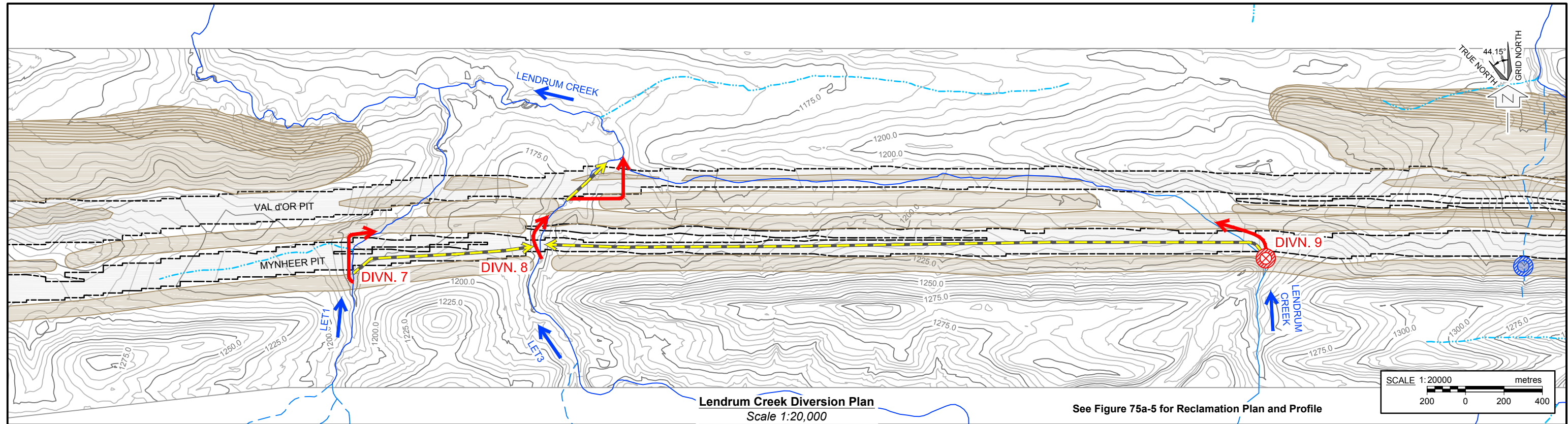
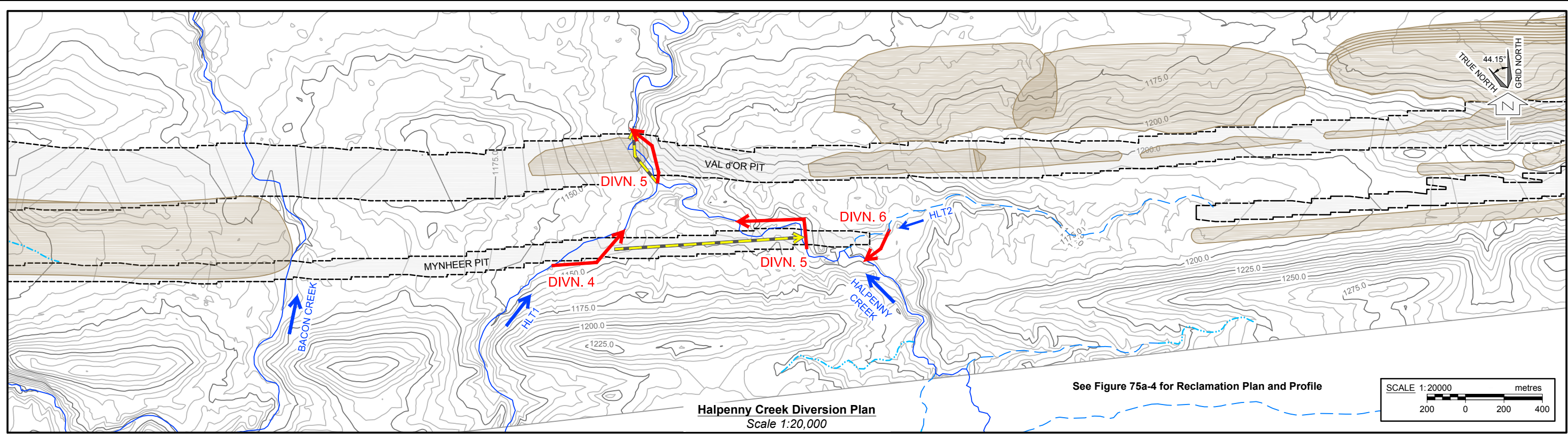
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	Proposed Temporary Pumped Diversion		Pit Dumps
	Additional Diversion Option		Permanent Watercourse
	Final/Second Stage Diversion		Intermittent Watercourse
	Potential Clean Water Sump		Ephemeral Draw

REFERENCE:
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COAL VALLEY RESOURCES INC.			
BRYAN CREEK & HAY CREEK DIVERSION PLAN			
ROBB TREND PROJECT - APPENDIX 86			
DATE: DECEMBER 2012	DESIGN: D. COOPER	DRAWN: N. DYER	FIGURE 86-1
FILE: 5867-RB-SP-12.DWG	CHECK: D. RAMSEY	DATUM: MINEGRID	

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 PLOT 1:1 = Tabloid (L)



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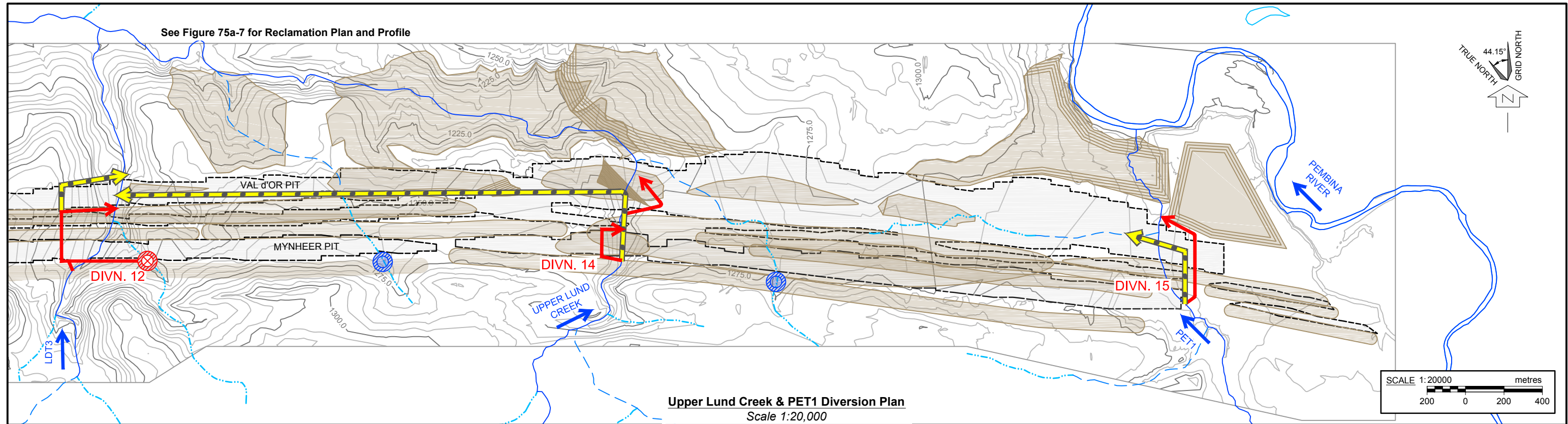
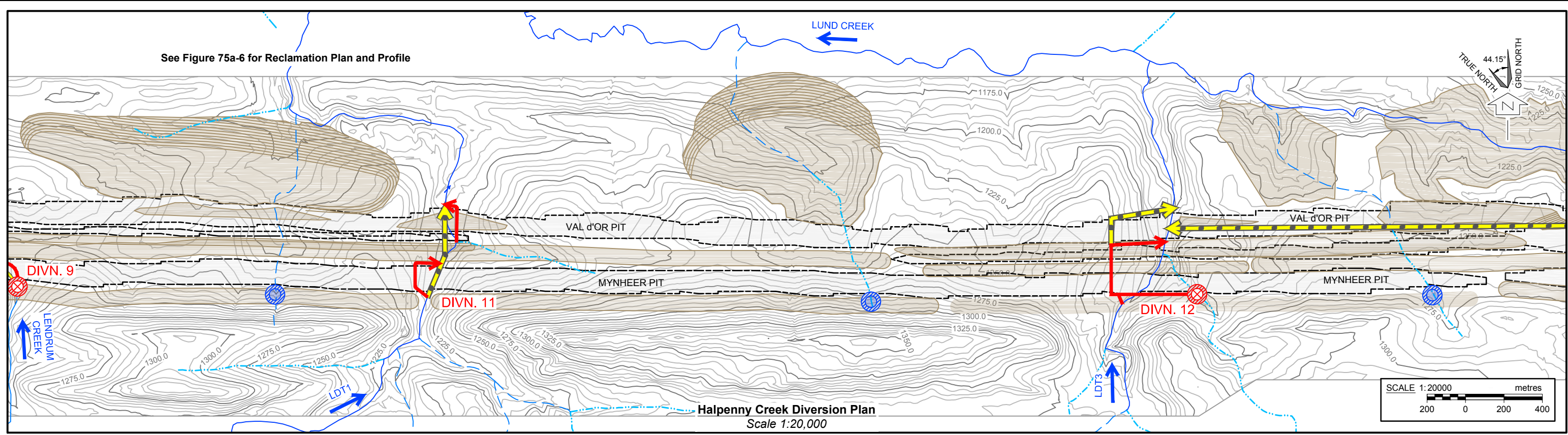
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	Proposed Temporary Pumped Diversion		Pit Dumps
	Final/Second Stage Diversion		Permanent Watercourse
	Potential Clean Water Sump		Intermittent Watercourse
			Ephemeral Draw

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HALPENNY CREEK & LENDRUM CREEK DIVERSION PLAN			
ROBB TREND PROJECT - APPENDIX 86			
DATE: DECEMBER 2012	DESIGN: D. COOPER	DRAWN: N. DYER	FIGURE 86-2
FILE: 5867-RB-SP-12.DWG	CHECK: D. RAMSEY	DATUM: MINEGRID	

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LEGEND

	Proposed Temporary Diversion		Pit Limits
	Proposed Temporary Pumped Diversion		Pit Dumps
	Final/Second Stage Diversion		Permanent Watercourse
	Potential Clean Water Sump		Intermittent Watercourse
			Ephemeral Draw

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COAL VALLEY RESOURCES INC.			
LUND CREEK, LDT1, LDT3 & PET1 DIVERSION PLAN			
ROBB TREND PROJECT - APPENDIX 86			
DATE: DECEMBER 2012	DESIGN: D. COOPER	DRAWN: N. DYER	FIGURE 86-3
FILE: 5867-RB-SP-12.DWG	CHECK: D. RAMSEY	DATUM: MINEGRID	

Appendix 137

Wetland Monitoring Program a Proposal for Alberta
Environment



**Wetland Monitoring Program
a Proposal to Alberta Environment**

Prepared for:
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June, 2011
File 10-156

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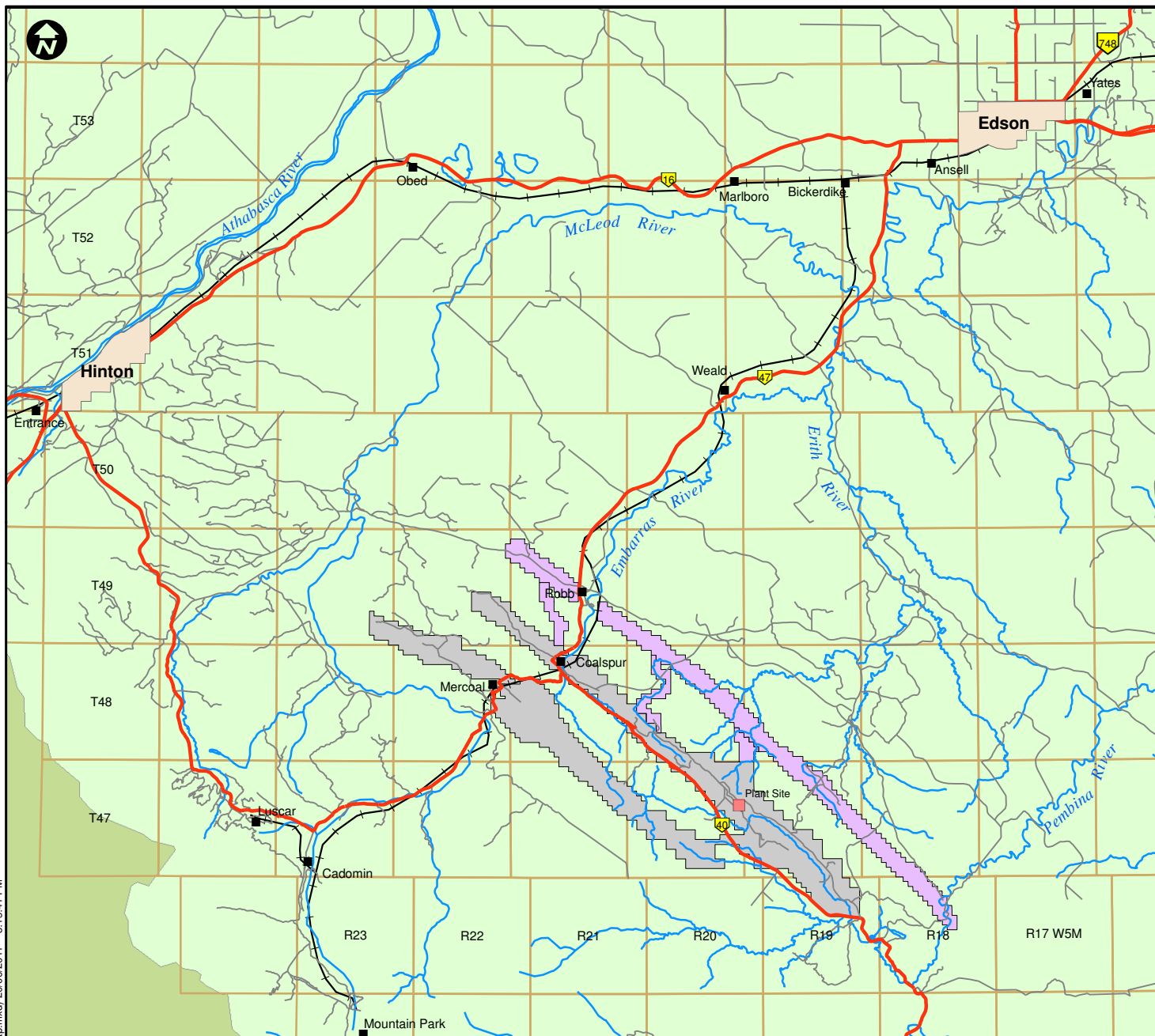


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Figure 1 Project Location

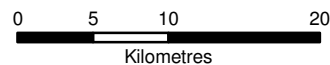
List of Appendices

Appendix A 200 Groundwater Monitoring Results
Appendix B Recommendations for Future Wetland Reclamation



Legend

- Proposed Mine Operations
- Existing Mine Operations
- Highway
- Minor Road
- Railway



Map Document: (K:\Active Projects 2010\AP 10-151 to 10-200\10-156 CVM\GIS\Wetland Monitoring\Fig 1 Location Map.mxd) 20/06/2011 -- 3:15:41 PM

PROJECT:



**Coal Valley Mine
Wetland Monitoring**



TITLE:

Project Location

DRAWN: PS
CHECKED: JL
DATE: Jun 20/11
PROJECT: 10-156B

FIGURE:

1



1.1 Pit Dewatering

There are two sources of water that enter the pit: surface runoff from adjacent areas and groundwater inflows. The groundwater inflow is not substantial so the installation of dewatering wells to lower the groundwater levels prior to mining is not required. Dewatering wells have not been used at CVM for more than 20 years where former underground workings were close to the pit.

All of the surface runoff and groundwater inflow to the pits are directed to in-pit sums where it is pumped to a settling pond for treatment.

When the pit is active with coal-extraction operations the in-pit sums are pumped regularly. As the pit operations move away from a sum it is normal for pumping to cease and for water to be allowed to accumulate in the pit until such time as the reclamation is implemented. Under normal operating conditions, pumping from a particular sum might take place for approximately six months to a year from the time that the area was excavated until operations were sufficiently distant to allow the pumping to end.

1.2 CURRENT WETLAND MONITORING PROGRAM

1.2.1 Mercoal Phase 2 Wetland Compliance

The wetland assessment conducted for the Mercoal Phase 2 Project Application (Luscar 2005) identified a number of wetlands within the proposed mine development area. In particular, a large wetland complex comprised of patterned fen was identified adjacent to proposed pits in the Mercoal Phase 2 area. A wetland monitoring plan was developed to meet requirements of the EPEA Approval No. 11066-01-07 to monitor the wetlands for effects of pit development and changes in water levels within the wetland complex. These wetlands are hereafter referred to as "South Extension Wetlands."

In 2006, nine water monitoring piezometers were advanced within the South Extension Wetlands, with seven completed with screen intervals less than 10 m below ground surface (MEMS 2006). Water levels and water chemistry were monitored in 2006, 2007, 2008, and 2009. The results of four years of monitoring within the wetlands were summarized in the 2009 annual groundwater monitoring report (MEMS 2010). Groundwater levels and water chemistry results are presented in Appendix A.

Shallow piezometers (less than 10 m depth) completed immediately beneath the muskeg were found to have water levels within 3 m of the land surface. Deeper piezometers (40 and 85 m deep) have water levels in the range of 1.3 to 8 m below ground surface. One nested pair of piezometers (MERWL 10 and MER 11) show a downward hydraulic gradient from the wetlands to the underlying bedrock.

TDS declined from approximately 1,100 mg/L in the initial sample to stabilize below 400 mg/L in 2009. Sodium followed a similar pattern from 475 to below 148 mg/L. Sulfate was stable at low



concentrations and nitrate was very low to not detectable. Selenium declined from an initial concentration of 0.0032 in 2006 to non-detectable in 2007.

The data shows that there were no issues with the lowering of groundwater levels as the drawdown of water levels adjacent to operating pits was minimal. There were no issues with groundwater quality that appeared to be developing within the South Extension Wetlands at the mine pits. Major ion chemistry, as indicated by an examination of sodium, sulphate and TDS in the South Extension Wetlands showed no adverse trends. Nitrate was not increased by mining activities. This compound is frequently not detectable in monitors both close to and away from mining. Selenium was very low to not detectable in most areas prior to mining and remained that way after mining. Selenium in concentration up to 0.003 mg/L was observed under natural conditions in the South Extension Wetlands.

3.3 Reclaimed Wetlands

In 2007, an evaluation of reclaimed wetlands at the mine was conducted (CVRI 2008). The study was initiated to evaluate reclaimed wetlands and riparian ecosystems at the mine by:

- determining and describing the types of wetlands
- describing plant species composition and abundance
- determining soil characteristics
- comparing reclaimed wetlands and riparian ecosystems with natural wetlands and riparian ecosystems in the region and
- defining tactical and operational strategies to develop wetlands without increasing material handling requirements.

The evaluation showed that wetlands in the reclaimed Coal Valley Mine area are providing a variety of ecological functions similar to natural wetland and riparian systems. The reclamation successes include:

- the creation of wetlands with zones closely resembling natural shrubby rich fens, sedge rich fens and Lower Foothills marshes
- the establishment of native species including lodgepole pine, willows, balsam poplar, river alder, water sedge, beaked sedge, short sedge, common horsetail, variegated horsetail, yarrow, tufted moss, and golden moss
- site occurrences of rare plant species including a rare fern and four rare mosses
- an increase in habitat value for some species of fish and waterfowl and
- an increase in the recreational fishing resource base, and as an attraction for tourism and recreation.



Most of the wetlands sampled did not closely resemble natural regional wetlands, but were found to provide important ecological functions and services. Most natural wetlands in the area are Upper Foothills peatlands. Newly created wetlands in the reclaimed area will require time for peat to accumulate. With organic matter accumulation over time the soils and plant communities on these reclaimed sites are expected to become more similar to those of natural wetlands.

Four sites had tones resembling natural mineral-soil wetlands such as, marshes or swamps. The young successional stages of other reclaimed wetlands were dominated by species not normally associated with regional mature wetlands. Often these young reclaimed wetlands had a relatively high proportion of non-native and/or weedy species.

Several factors that are expected to improve the establishment and function of wetlands at the mine were recommended. Recommendations for future wetland reclamation have been incorporated into conservation and reclamation plans for the mine and are summarized in Appendix B.

3 REVISIONS TO WETLAND MONITORING PROGRAM

3.1 Objectives

The proposed program has been developed to determine potential effects within wetlands adjacent to road and pit development, as well as to measure the success of current reclamation of wetlands. The program consists of three components:

1. Monitor surface and subsurface water levels
2. Assess vegetation communities
3. Monitor wetland reclamation success.

3.2 Methods

3.2.1 Wetland Selection

Since 1982, a great deal of data has been collected at the mine characterizing hydrology, hydrogeology and vegetative properties of wetlands across the entire mine. This information has been collected at different times, utilizing multiple methods and classification systems. To determine the appropriate wetlands to monitor at the mine, a desktop review of all wetland inventories and assessments will be conducted. All historical and current wetland information will be compiled into one database and communities will be classified using one common wetland classification system. The most up-to-date aerial photographs will be reviewed to supplement wetland mapping and a master wetland map will be created.

Wetlands will then be stratified based on wetland type, and those wetlands that are most likely to be affected by reductions in water levels will be given priority (fens, swamps, and marshes). In addition



to the type of wetlands, wetland site will also be considered in determining the selection of sites to be monitored.

A monitored wetland will be paired with a control wetland that is situated far enough away from the mine that the development will not have an effect on the wetland conditions. The control wetlands will be determined from a review of area hydrology and hydrogeology.

In undisturbed areas that are proposed for mine development, monitoring plots will be established to gather baseline data that can be evaluated and compared with monitoring data collected once active mining is adjacent to those wetlands.

3.2.2 Wetland Characterization

The characterization and delineation of wetlands will take into consideration the following characteristics:

- wetland (hydrophytic) vegetation
- hydric soils (moisture regime 7-)
- drainage (poorly to very poorly drained) and
- wetland hydrology.

3.2.3 Water Levels

Evidence of wetland hydrology (surface water) will be determined through the presence of water above (marshes or fens) or within 5 cm of the surface (swamps). Soil characteristics will also be documented to determine soil moisture regime (i.e. hydric soils). Indicators of hydric soils will include low chroma matrix colors, high organic matter, mottling and gleying within the soil profile, as well as sulfidic odor and staining by organic matter in the shallow subsurface (within 60 cm of the ground surface).

Where surface water is present, the water line will be delineated during early spring, mid-July, and early September to determine seasonal water level fluctuations. Staff gauges may also be established and monitored in select wetlands. As well, an inspection of culverts installed along roads will be conducted to evaluate any effects on adjacent wetlands related to surface run-off or disruption of flow. All records of surface water delineation and measurement will be documented and photographs will be taken from the same location at each sampling event.

Groundwater levels will be monitored in wetlands selected for monitoring (including controls). Shallow piezometers (10 m depth) will be advanced and will be monitored in late spring and during fall until mining is complete. Once groundwater levels stabilize, monitoring will be conducted annually.



3.4.4 Water Quality

Surface water quality sampling will be conducted annually in monitored and control wetlands with water above ground surface. Groundwater quality sampling will be conducted in both late spring and during fall for the first year following piezometer installation, and annually for all subsequent years. Temperature, turbidity, and pH will be measured at the time of sampling, and analysis will follow parameters evaluated in the South Extension Wetlands (Appendix A).

3.4.5 Vegetation Communities

Vegetation monitoring sites will be established in selected monitored and control wetlands. Paired sites will be surveyed within each wetland that is adjacent to mine areas to evaluate both the area immediately adjacent to the mine development and wetland conditions further from the development. A single site will be established in each control wetland.

At each monitoring site, 2 meter wide belt transects will be established, across each wetland. The start and end of each transect will be permanently marked with painted rebar pins and a metal stake labelled with wetland and transect identifying information. Surveyors will walk along each transect, recording all vegetation species observed within the 2 m width. At the center of each transect, a 20 m by 20 m nested quadrat will be established. Tree species and canopy information will be collected from the 20 m by 20 m plot. A 5 m by 5 m quadrat will be established within the 20 m by 20 m quadrat, and shrub, forb, graminoid, bryophyte and lichen information will be collected. Within each quadrat, the total aerial cover of each species will be estimated as a percentage of the quadrat area. Site and soil properties will also be recorded at each 20 m by 20 m quadrat.

Collected vegetation data will be used to evaluate wetland extent, quality and function by estimating the number and aerial coverage of plant species that are adapted to wetland conditions (hydrophytic vegetation).

3.4.6 Reclaimed Wetlands

Due to the length of time required for peat development, wetlands on reclaimed areas are not expected to resemble natural wetlands for many years. Instead, reclaimed wetlands are expected to reflect early successional states of wetlands that in time will resemble natural wetlands as peat accumulates.

Approval 11066-00 contained the following conditions regarding the reclamation of wetlands:

1.2.2 The approval holder shall calculate the percentage of reclaimed area that is expected to be reclaimed or restored.

The approval holder shall calculate the percentage of reclaimed area that is expected to be reclaimed or restored.



a) *reclaim areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland*

b) *reclaim areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland*

c) *reclaim areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland*

The intent of including the conditions in the Approval is to advance the development of the wetland reclamation process.

3.7 Measuring Wetland Reclamation Success

The evaluation of reclaimed wetland health and function will be used to evaluate the success of wetland reclamation at CVM. This requires the selection of variables that can be utilized to assess each wetland's health and function. The following variables have been selected as indicators of wetland health and function to be evaluated within reclaimed wetlands:

- connectivity to other wetlands
- hydric soils
- moisture regime
- presence, vigour, and abundance of hydrophytic vegetation
- presence and abundance of locally native species and
- presence and abundance of non-native/invasive species.

CVM will also evaluate opportunities to utilize organic soil material in the development of reclaimed wetlands and will consider the following:

a) *reclaim areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland*

b) *reclaim areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland*

c) *reclaim areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland / areas of the reclaimed wetland*

The 2007 evaluation of reclaimed wetlands (GDC 2008) produced a thorough accounting of the status of reclaimed wetlands at the mine. A subset of the surveyed reclaimed wetlands will be selected and re-evaluated to determine the state of health and function, and what changes may have taken place since the initial evaluation. During the desktop review, any mine areas reclaimed since 2007 will be identified for inspection and will be surveyed during the field monitoring program.

3.8 Timelines

It is expected that the initial components of the revised wetland monitoring program will be initiated in the late summer of 2011. A thorough desktop review will be conducted, and mine-adjacent, control, and reclaimed wetlands that will be surveyed in the field program will be determined and mapped. Shallow piezometers will be installed in the selected wetlands in the winter of 2011-12. Surface water



measurements will be conducted in early spring, mid-July, and early September of 2012, and groundwater measurements will take place in the spring and fall.

Once mining has been completed, surface drainage patterns have been restored, and groundwater levels have stabilized, water levels will be monitored annually. Water quality samples will be collected from monitored and control wetlands in the spring and fall during active mining and once mining is completed samples will be collected annually. Vegetation surveys will be conducted in the mid-summer of 2012, and every two years after that. Reclaimed wetlands will also be evaluated in 2012, and the interval for subsequent monitoring will be determined based on the measured condition of those wetlands.

Monitoring of wetlands at CVM is proposed to continue until the desired end wetland health and functioning has been determined to be achieved.

3.3 Corrective Measures

In the event that mine development is observed to have a negative effect on adjacent wetlands, corrective measures will be determined on a case specific basis.

Some of the general best management practices that will help to determine if corrective measures are necessary will include the continued and regular monitoring of sites for the early identification of issues, regular culvert inspections to ensure drainage patterns are maintained and weed management activities to prevent the spread and establishment of weed species in healthy wetland communities.



☐☐☐ **REFERENCES**

Geographic Dynamics Corp. 2008. Evaluation of Reclaimed Wetland and Riparian Resources for Coal Valley Mine: EIA Report. Prepared for Coal Valley Resources Inc., by Geographic Dynamics Corp., Edmonton, Alberta.

Millennium EMS Solutions Ltd (MEMS). 2007. 2006 Annual Report ☐ Groundwater Monitoring Coal Valley Mine. Prepared for Coal Valley Resources Inc. Edmonton, Alberta.

MEMS. 2010. 2009 Annual Report ☐ Groundwater Monitoring Coal Valley Mine. Prepared for Coal Valley Resources Inc. Edmonton, Alberta.

APPENDIX A SOUTH ESTENSION WETLANDS

Water Levels

Water Chemistry

Appendix F from MEMs 2010 report 2008 Annual Report Road Water Monitoring Report 2008 Annual Meeting.

APPENDIX F-1 SOUTH EXTENSION

WETLANDS WATER LEVELS

Location	South Extension Wetlands									
Piezometer Name	MER L-01	MER L-02	MER L-03	MER L-04	MER L-05	MER L-07	MER L-08	MER L-09	MER L-10	MER L-11
Ground Surface Elevation (m)	142.81	destroyed	142.56	1427.48	1428.4	1427.0			1426.00	1426.00
Stick Up (m)	1.10		1.10	1.00	1.05	1.15	1.20	1.00	1.20	1.00
Piezometer Open Interval (m)	1.4--2.6		1.3--2.8	4.7--6.2	4.5--6	3.5--5	3.6--46.6	4.0--7.0	82.6--8.0	5--8.1
Date										
16-Jan-06	142.31	142.41	1428.85	1427.4	1427.4	1425.23				
28-Apr-06	1427.60	DEST	1427.38	1427.13	1428.4	1427.03			1425.18	1425.73
22-Jun-06	1428.7		1427.84	1427.24	1428.12	1426.83			1425.64	1425.0
06-Sep-06	1428.06		1427.38	1426.0	1427.86	1426.03			1424.0	1425.62
26-Jan-07	1427.74		1427.10						1424.68	1425.0
06-Nov-07	1428.26		142.56	1426.8	1427.73	1426.0			1410.78	1421.62
05-Nov-08	1428.46		1427.71						1413.60	
12-Jan-09									1414.35	
17-Aug-09	1428.80		142.0	1427.13	1428.1	1426.50			1414.70	1422.76
17-Dec-09	142.18		Frozen	Frozen	Frozen	1426.36			1413.68	1423.06
DEPTH TO WATER ELO GROUND SURFACE (m)										
16-Jan-06	0.50	DEST	0.71	-0.46	0.55	1.86				
28-Apr-06	2.21		2.18	0.35	0.00	0.06	5.25	5.43	0.82	0.27
22-Jun-06	1.02		1.72	0.24	0.37	0.26	6.04	6.18	0.36	0.01
06-Sep-06	1.75		2.18	0.4	0.63	0.16	7.01	7.47	1.10	0.38
26-Jan-07	2.07		2.46				6.7	7.25	1.32	0.10
06-Nov-07	1.55		0.00	0.50	0.76	1.00			15.22	4.38
05-Nov-08	1.35		1.85				2.30	2.50	12.40	
12-Jan-09							1.35		11.65	
17-Aug-09	1.01		0.47	0.35	0.30	0.5	2.05	2.22	11.30	3.24
17-Dec-09	0.63		Frozen	Frozen	Frozen	0.73	5.71	6.21	12.32	2.4

Appendix F - Sout Extension Wetlands

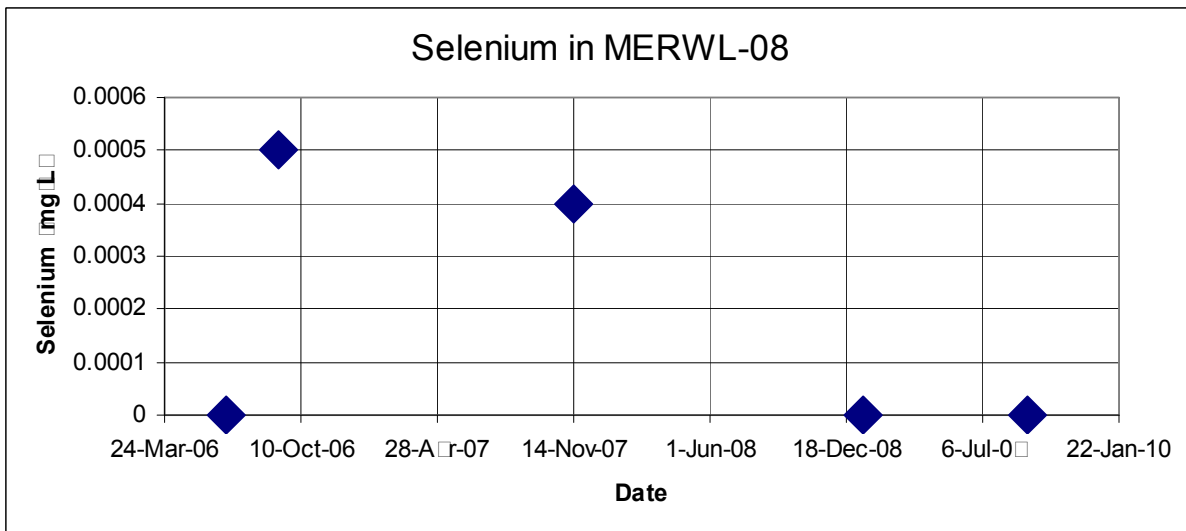
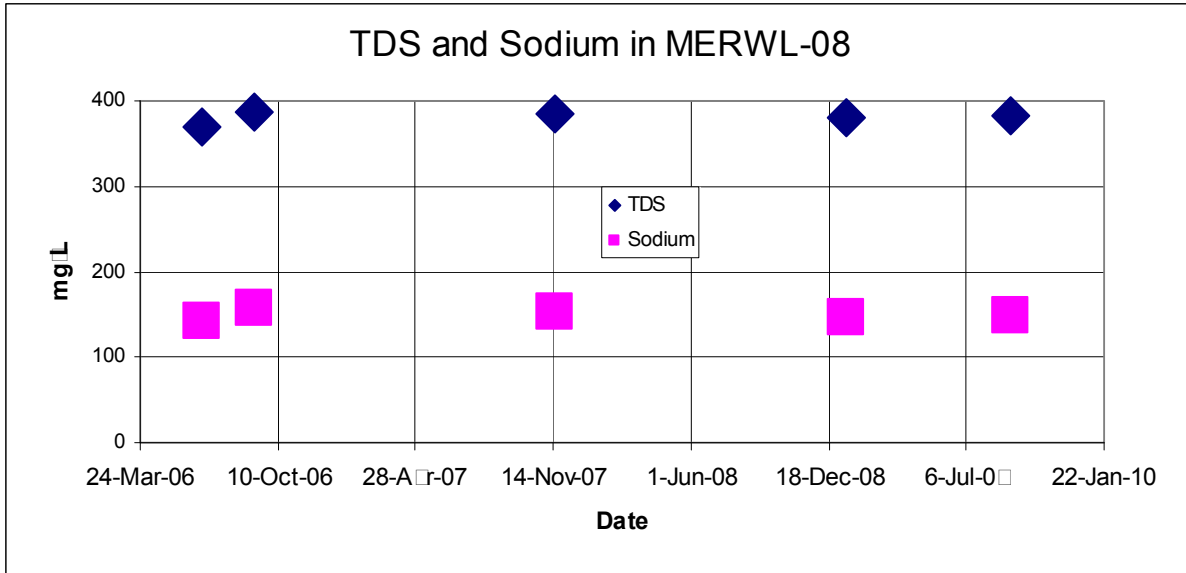
Mining Area		Sout Extension Wetlands					
Piezometer Name (dept)		MER L-1 (1-6 m)	MER L-2	MER L-3 (13-18 m)	MER L-4 (55 m)	MER L-5 (5-6 m)	MER L-7 (3.5-5 m)
Date		2-Jan-06	2-Jan-06	2-Jan-06	2-Jan-06	2-Jan-06	2-Jan-06
Parameter							
MAJOR CONSTITUENTS							
Calcium	mg/l	24	74.1	44.8	7.3	44.4	30.7
Magnesium	mg/l	4.52	18.5	7.7	1.1	8.4	3.6
Sodium	mg/l	24.2	31.1	6.8	105	6.6	25.2
Potassium	mg/l	0.8	0	0.7	0	1.2	0.7
Carbonate	mg/l	5	5	5	5	5	5
Bicarbonate	mg/l	128	31	177	255	16	153
Sulfate	mg/l	27	1	6	4	6	6
Chloride	mg/l	2	3	8	2	2	1
pH		6.5	6.7	6	8	7.4	6.5
Conductivity	US/cm	270	620	310	500	20	240
TDS	mg/l	145	340	156	23	156	124
Nitrate	mg/l	0.2	0.1	0.1	0.4	0.1	0.1
TRACE CONSTITUENTS							
Aluminum	mg/l	0.05	0.16	0.03	0.02	0.01	0.04
Antimony	mg/l	0.000	0.0006	0.0007	0.0006	0.0007	
Arsenic	mg/l	0.0027	0.0031	0.0033	0.0015	0.0006	0.001
Barium	mg/l	0.0764	0.17	0.028	0.512	0.158	
Beryllium	mg/l	0.0005	0.0005	0.0005	0.0005	0.0005	
Bismuth	mg/l	0.00005	0.00005	0.00005	0.00005	0.00005	
Boron	mg/l	0.062	0.006	0.007	0.047	0.011	0.035
Cadmium	mg/l	0.0001	0.0002	0.0001	0.0001	0.0001	
Chromium	mg/l	0.0015	0.0055	0.0048	0.0027	0.002	
Cobalt	mg/l	0.0012	0.0087	0.0006	0.0001	0.0001	
Copper	mg/l	0.00	0.0064	0.0088	0.0037	0.0082	
Iron	mg/l	2.08	10.4	0.67	0.05	0.023	
Lead	mg/l	0.0004	0.0004	0.0002	0.0004	0.0001	
Manganese	mg/l	0.01	8.64	0.62	0.01	0.16	
Mercury	mg/l	0.00001	0.00001	0.00001	0.00001	0.00001	
Molybdenum	mg/l	0.0004	0.0024	0.0006	0.0084	0.000	
Nickel	mg/l	0.0015	0.0061	0.0008	0.0005	0.0001	
Selenium	mg/l	0.0008	0.001	0.0005	0.0017	0.0006	
Silver	mg/l	0.0002	0.0002	0.0002	0.0002	0.0002	
Strontium	mg/l	0.118	0.48	0.17	0.086	0.415	
Thallium	mg/l	0.00005	0.00005	0.00005	0.00005	0.00005	
Tin	mg/l	0.0032	0.0026	0.0027	0.0007	0.0005	
Titanium	mg/l	0.0032	0.0045	0.001	0.002	0.002	
Uranium	mg/l	0.0001	0.0004	0.0001	0.0012	0.0001	
Vanadium	mg/l	0.0002	0.0004	0.0001	0.0002	0.0001	0.0002
Zinc	mg/l	0.046	0.025	0.05	0.005	0.013	0.037

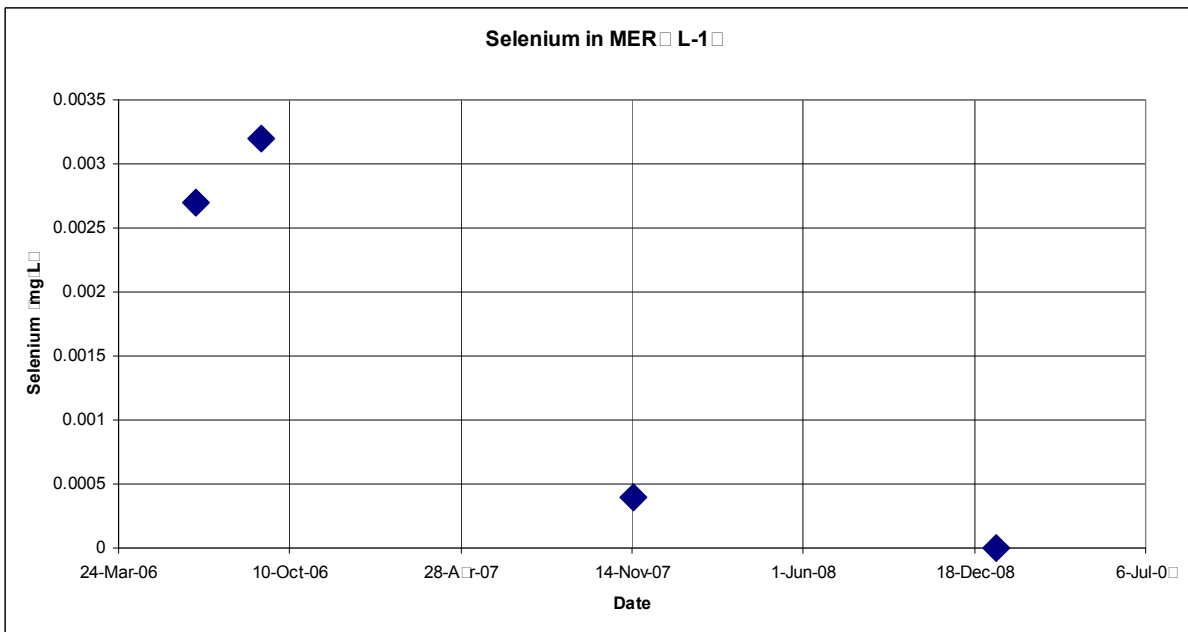
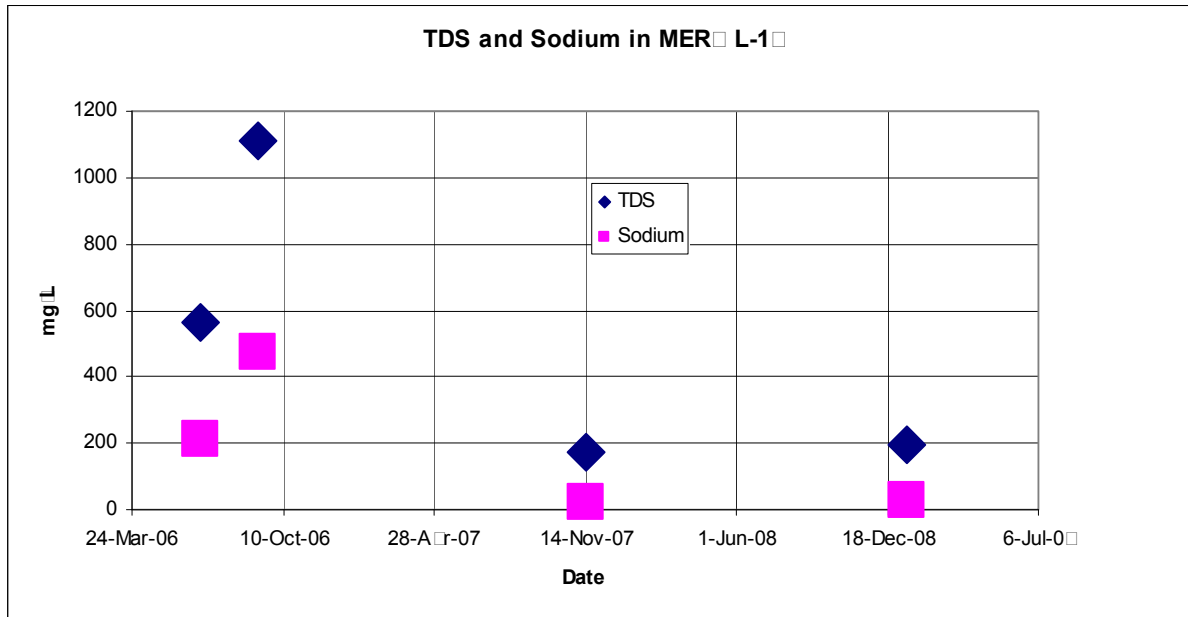
All units, except pH and conductivity, are in mg/L

Mining Area		Sout E tension etlands											
Piezometer Name (dept)		MER L-8 (3-6-6 m)					MER L-1 (8-6-8 m)					MER L-11 (5-8-1 m)	
Date		22-Jun-06	6-Sep-06	15-Nov-07	12-Jan-08	03-Sep-08	22-Jun-06	6-Sep-06	15-Nov-07	12-Jan-08	03-Sep-08	22-Jun-06	6-Sep-07
Parameter													
MAJOR CONSTITUENTS													
Calcium	mg/l	6	10.4	7.6	11	8.12	4	5.7	36.2	37	46	36.2	36.1
Magnesium	mg/l	1.8	2	0.6	1.6	1.46	1.3	1.4	6.8	7.6	88	7.5	8
Sodium	mg/l	142	157	152	146	148	212	473	23	28	26	4	5
Potassium	mg/l	2.6	2.6	2.8	2.5	2.42	4.7	3	1.7	1.7	1.66	0	0
Carbonate	mg/l	16	10	14	7	14.4	5	38	5	5	5	5	5
Bicarbonate	mg/l	386.0	412.0	415	432	420	480	1150.0	200	227	255	151.0	148
Sulfate	mg/l	4	0	2	0.5	0.5	24.7	5.7	3.7	6.5	8.08	3.4	2.7
Chloride	mg/l	3	2	1	1	1.13	15	10	1	1	0.5	1	1
pH		8.7	8.5	8.6	8.5	8.5	12	8.6	8.2	8.1	8.17	8.3	8.2
Conductivity	US/cm	623	643	660	647	654	867	1760	312	351	35	233	235
TDS	mg/l	370	387	385	380	383	562	1110	171	113	218	126	125
Nitrate	mg/l	0.1	0.1	0.1	0.01	0.05	0.1	0.1	0.1	0.01	0.05	0.1	0.1
TRACE CONSTITUENTS													
Aluminum	mg/l	0.0	0.01	0.13	0.01	0.01	2.26	0.31	0.4	0.01	0.01	0.05	0.01
Antimony	mg/l	0.0004	0.0005	0.0007	0.0004	0.0004	0.0018	0.0032	0.0007	0.0004	0.0004	0.0004	0.0004
Arsenic	mg/l	0.0087	0.006	0.006	0.0067	0.00747	0.18	0.0478	0.0067	0.0013	0.00143	0.0026	0.001
Barium	mg/l	0.512	0.627	0.436	0.581	0.502	2.68	0.426	0.741	0.551	0.653	0.486	0.452
Beryllium	mg/l	0.0005	0.0005	0.0005	0.0005	0.0005	0.0018	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Bismuth	mg/l	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Boron	mg/l	0.062	0.056	0.056	0.058	0.054	0.172	0.062	0.031	0.025	0.0202	0.008	0.01
Cadmium	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium	mg/l	0.0008	0.0004	0.0006	0.0004	0.0004	0.001	0.0008	0.0008	0.0004	0.0004	0.0011	0.0004
Cobalt	mg/l	0.0001	0.0001	0.0002	0.0001	0.0001	0.0367	0.0007	0.0007	0.0002	0.00024	0.0001	0.0002
Copper	mg/l	0.002	0.0006	0.0067	0.0006	0.0006	0.014	0.002	0.0256	0.0006	0.0006	0.0008	0.0006
Iron	mg/l	0.081	0.006	0.521	0.022	0.014	16.3	0.678	0.451	0.005	0.01	0.04	0.008
Lead	mg/l	0.0008	0.0001	0.0014	0.0001	0.0001	0.048	0.0007	0.0044	0.0001	0.0001	0.0002	0.0002
Manganese	mg/l	0.012	0.00	0.036	0.007	0.0067	0.0455	0.018	0.24	0.001	0.251	0.1	0.216
Mercury	mg/l	0.00001	0.00001	0.0001	0.00001	0.00002	0.00001	0.00001	0.0001	0.00001	0.00002	0.00001	0.00001
Molybdenum	mg/l	0.0008	0.000	0.001	0.0008	0.00087	0.005	0.023	0.0016	0.0012	0.0013	0.0007	0.0006
Nickel	mg/l	0.0003	0.0004	0.0008	0.0002	0.0002	0.101	0.0033	0.002	0.001	0.00118	0.0001	0.000
Selenium	mg/l	0.0004	0.0005	0.0004	0.0004	0.0004	0.0027	0.0032	0.0004	0.0004	0.0004	0.0004	0.0004
Silver	mg/l	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Strontium	mg/l	0.27	0.34	0.25	0.345	0.323	0.2	0.306	0.58	0.601	0.811	0.445	0.463
Thallium	mg/l	0.00005	0.00005	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Tin	mg/l	0.0002	0.34	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Titanium	mg/l	0.0034	0.0006	0.004	0.0011	0.00141	0.0052	0.007	0.0061	0.001	0.00077	0.0013	0.0006
Uranium	mg/l	0.0004	0.0001	0.0004	0.0001	0.0001	0.0043	0.003	0.0007	0.0003	0.00044	0.0003	0.0002
Vanadium	mg/l	0.0007	0.0001	0.0003	0.0001	0.0001	0.0257	0.0035	0.0008	0.0002	0.00022	0.0004	0.0001
Zinc	mg/l	0.006	0.007	0.017	0.003	0.0028	0.286	0.011	0.0002	0.003	0.0056	0.003	0.013

All units, except pH and conductivity, are in mg/L

Appendix F-3 Trend Charts







APPENDIX B RECOMMENDATIONS FOR FUTURE WETLAND RECLAMATION

Appendix 173

Proposal for the Continuation of the Native Shrub
Establishment Program at Coal Valley Mine



**PROPOSAL FOR THE
CONTINUATION OF THE NATIVE SHRUB ESTABLISHMENT PROGRAM
AT
COAL VALLEY MINE**

Prepared For:

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April 2012

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Figure 1. Conceptual Planting Scheme

1.0 INTRODUCTION

Coal Valley Resources Inc. (CVRI) is seeking to continue developing techniques for establishing native shrub species on disturbed land at Coal Valley Mine. Navus Environmental Inc. (Navus), began a native shrub establishment program at Coal Valley Mine in 2010. Establishment results from the program showed that directly transplanting vegetative propagules and root plugs of mountain huckleberry (*Vaccinium membranaceum*) from undisturbed (pre-mined) land to reclaimed (post-mined) is an economical way to establish native shrub species; however, improvements to collection, planting and establishment rates could be made (Navus, 2011). The following document provides a general description of Navus' proposal for continuation of the 2010 Native Shrub Establishment Program (2010 Program). Background information, proposed revegetation projects and a general schedule, scope of work and cost estimate for each project are presented in this document. More detailed methods, a finalized schedule and cost estimate will be provided after feedback has been received from CVRI and after a site visit has been conducted.

Navus is an Edmonton, Alberta based environmental consulting firm that provides services to the oil and gas industry and coal and oil sands mining industries which include reclamation, remediation, vegetation management planning, soil and vegetation assessments, soil salvage monitoring and applied re-vegetation research.

2.0 BACKGROUND

2.1 Reclamation at Coal Valley Mine

Coal Valley Mine is owned by Coal Valley Resources Inc. and is located 100 km southwest of Edson within township 49, ranges 21, 22 and 23, township 48, ranges 20, 21 and 22, township 47, ranges 19, 20 and 21 and township 46, range 19 all west of the 5th meridian. Surface mining techniques have been used at Coal Valley Mine since 1978 and several hundred hectares have been disturbed and subsequently reclaimed.

Currently, mining and reclamation is carried out under Environmental Protection and Enhancement Act (EPEA) #00011066-02-00 (as amended) which became effective November 10, 2010. Based on this act and the reclamation plan contain in CVRI Mercoal West and

Yellowhead Tower Mine Extension Project: Project Application (CVRI, 2008), reclaimed and revegetated land at Coal Valley Mine must be capable of “supporting a self-sustaining, locally common forest ecosystem” and be revegetated to “target the establishment of a self-sustaining, locally common cordilleran forest ecosystem, integrated with the surrounding area” (Section 6.3; EPEA #00011066-02-00). On the Mercoal West and Yellowhead Tower Mine Extension Project Area, CVRI has proposed to reclaim the area to a mosaic of closed coniferous forest, open forests/grasslands and riparian areas through initial seeding of herbaceous species to stabilize the soil followed by planting of a few woody species. Infill of additional native species will occur by natural succession which will result in the establishment of a functioning forest ecosystem (CVRI, 2008).

Two studies have been conducted to examine native plant establishment and succession at Coal Valley Mine following revegetation: a vegetation survey conducted by Strong (2000) in 1996 on sites reclaimed between 1979 and 1994 and a vegetation survey looking at succession at Coal Valley Mine conducted by Longman (2007). Strong (2000) found that there were 95 locally common, native species growing on reclaimed land at Coal Valley Mine; however, the native species (other than planted trees) covered less than 5% of the surveyed area. Older reclaimed areas with tree canopy cover did tend to have a higher percentage of cover from native species, suggesting succession and infill is occurring at Coal Valley Mine but at a very slow rate. Strong (2000) suggested that reclaimed land at Coal Valley Mine had fewer shrub species and a lower density of stems than other disturbances which may be reducing tree growth and infill of other native species (ie. nitrogen fixing shrubs that enrich the soil nitrogen levels and birds being attracted to berries growing on shrubs and while feeding dropping seeds from other native species). Longman (2007) found that native vegetation establishment showed a higher correlation with lodgepole pine (*Pinus contorta*) cover than years since revegetation, and areas reclaimed in the early 1980’s still had a relatively high cover of non-native species. Longman (2007) suggested that establishing native shrubs may benefit species richness.

2.2 2010 Native Shrub Establishment Program

In May and June 2010, Navus began a native shrub establishment program (2010 Program) to increase that rate of succession and infill of native species on reclaimed land at Coal Valley

Mine. Navus supervised and directed the Fox Creek Development group in the collection and planting of mountain huckleberry root cuttings and whole plants (root cutting with the above-ground portion of plant still attached) from undisturbed land to reclaimed land at Coal Valley Mine. The root cuttings and whole plants (vegetative propagules) were planted on plots approximately 20 m x 20 m in size on reclaimed land that had a closed or nearly-closed canopy of lodgepole pine (Pit 20/21), an area that had been seeded to a reclamation mix of grasses and legumes (Pit 131/141) and an area that had been topsoiled in 2010 but had not been seeded (Pit 28). Whole plants, root cuttings planted horizontally and root cuttings planted at a 45 degree angle (to maximize access to deeper soil moisture) were transplanted at each of these locations. The cuttings were monitored in 2010 and 2011 for new shoots and/or new leaves. In September 2011, approximately 10 to 15% of the cuttings had established (ie. produced new shoots and/or leaves). Whole plants had the highest establishment rates on areas that had been topsoiled in 2010 (Pit 28). Root cuttings had the highest establishment rates on areas where there was a closed lodgepole pine canopy (Pit 20/21). Root cuttings planted horizontally had higher establishment rates than root cuttings planted at a 45 degree angle. Erosion and poor root to soil contact resulted in lower than expected establishment rates.

Root or LFH plugs, 10 cm x 10 cm x 10 cm in size, consisting of undisturbed LFH, mineral soil (Ae horizon) and the roots contained within the LFH and mineral soil were collected from an undisturbed area and transplanted to a reclaimed land that had a closed or nearly-closed canopy of lodgepole pine (Pit 20/21) and to an area that had been seeded to a reclamation mix of grasses and legumes (Pit 131/141). Mountain huckleberry was targeted during plug collection and in September 2011 mountain huckleberry had survived in 90% of the transplanted plugs. In addition to mountain huckleberry, several other native species survived within the plugs and began to colonize areas surrounding the transplanted plug that previously had non-native grasses and legumes. Plugs transplanted to areas with a closed canopy of lodgepole pine had greater survival of huckleberry and other native species. Plug collection and planting was labour intensive and time-consuming.

As part of the 2010 Native Shrub Establishment Program, LFH and Ae soil horizons were also salvaged from pre-mined land and directly placed on an area that had been topsoiled with

stockpiled material in 2010 but had not been seeded (Pit 28). By September 2011, 12 different native species had established from the directly placed LFH and Ae soil horizons including mountain huckleberry and densities of lodgepole pine seedlings equivalent to 15,000 stems/ha (Navus, 2011).

3.0 PROPOSED REVEGETATION PROJECTS

Based on the results of 2010 Program and the meeting between Navus and CVRI on February 16, 2012, the following revegetation projects are proposed by Navus.

Note: Several projects are proposed; however, CVRI may choose to approve only the project(s) or parts of projects which are most applicable to the revegetation goals at Coal Valley Mine.

3.1 Monitoring of the 2010 Native Shrub Establishment Program

3.1.1 Rationale

Continued monitoring of the 2010 Program will help determine the long-term success of the transplanting methods used as well as the potential for the transplanted mountain huckleberry plants to colonize or spread to surrounding areas.

3.1.2 Scope of Work

The following is a proposed scope of work for continued monitoring of the 2010 Program:

- Re-stake the transplanted vegetative propagules to aid in locating them during monitoring.
- Monitor the growth and spread of the transplanted mountain huckleberry whole plants, root cuttings and root/LFH plugs in the early fall of 2012 and 2013.
- Prepare an annual report.

3.1.3 Methods

The corners of the plots (replicates) where mountain huckleberry whole plant, root cuttings and root plug (vegetative propagules) were transplanted will be re-staked using wood lathe. Each individual vegetative propagule that was planted within the plots will be located and re-marked

with painted skewers. The skewers used for re-marking the propagules will be longer than those used in the 2010 Program allowing them to be placed deeper into the soil and remain in place for several years. Monitoring and re-staking will not occur at replicates 2 and 3 as these locations were located near an undisturbed forest (<50 m) and encroachment of natural species over the past 20+ years since reclamation will make it difficult to discern the location of the planted cuttings (ie. Navus, 2011).

Monitoring of the survival, height and spread of each vegetative propagules will be carried out annually in late August or September of 2012 and 2013. Monitoring will be similar to that during the 2010 Program (Navus, 2011) and will involve determining the survival of planted root cuttings or whole plants (ie. if they have produced shoots or have green/living leaves). In addition to the 2010 Program methods, if the cutting has or whole plant has survived, its height will be determined as well as the number of new shoots produced and their distance and cardinal direction from the originally planted cutting. Height measurements will help determine growth and the long-term suitability of the planting location (ie. areas with tree canopy cover compared to recently topsoiled areas with no tree canopy cover). Determining the number of shoots and distance the shoots have spread from the originally planted cutting will help determine if cuttings can be used to colonize surrounding areas and the rate at which it occurs. These measurements will help determine an optimal planting density.

Similar to the 2010 program, monitoring of the root plugs will involve identifying each surviving species growing from the plug as well as the cover/density of each species. In addition, the number of plants that have spread from the plug to the surrounding area including the maximum distance and cardinal direction each species has grown from the plug will also be measured. To determine whether a species growing outside of the plug came from a source within the plug or from natural infill from the surrounding areas, it will be compared to species within the plug and species within the surrounding area. Measuring the distance each species has grown from the plug will help determine if plugs can be used to colonize surrounding areas with native species and the rate at which it occurs. These measurements will help determine an optimal planting density. The composition and cover of the vegetation within a 1 m radius surrounding the plug

will also be recorded to determine if there is an effect of the surrounding vegetation (ie. seed mix) on the ability of native species to colonize it.

3.2 Refinement of Whole Plant and Root Cutting Transplanting Methods

3.2.1 Rationale

Methods used to collect and plant mountain huckleberry plant whole plants and root cuttings in the 2010 Program resulted in establishment rates between 10 and 15%. Based on the results of the 2010 Program, it was recommended by Navus (2011) that the following improvements to the collection and planting techniques could result in higher establishment rates:

- Collect vegetative propagules in the fall or early spring prior to bud or leaf flush when root carbohydrate reserves are highest. Fall collection is recommended because in the spring, the optimal collection period can be easily missed if temperatures warm up rapidly.
- Ensure that root-soil contact is made during planting
- Plant the roots of whole plants at deeper depths so they have access to greater soil moisture (as long as a portion of the attached stem is above-ground) - root cuttings should not be planted deeper as the suckers/stems growing from them may not be able to reach the soil surface.
- Collect longer root cuttings as this may increase survival. In a greenhouse setting 10 cm long cuttings had similar establishment rates as 15 cm long cuttings and using 10 cm cuttings was most economical (Navus, 2009); however, the increased stress in an outdoor setting may make 15 cm long cuttings more economical due to higher establishment rates.

In addition to the recommendations made in the 2010 Program, the following improvements to the program may also increase establishment success:

- Collecting roots with fine roots attached to ensure that a root and not a stem has been collected; plant stems often grow along or within the LFH and can be easily mistaken for roots and stem cuttings typically do not establish as well as root/rhizome cuttings (Stevens, 2000).

- The use of different plant(ing) spacing treatments may affect planting efficiencies, establishment success and ability of the planted propagules to colonize surrounding areas. Planting propagules in large clusters may increase planting efficiency and allow for planting to target areas with optimal soil moisture/nutrient conditions. The established propagules may then colonize the surrounding areas.

The collection and planting methods may also be applied to locally common and native shrub species other than mountain huckleberry which was targeted in the 2010 Program. Coal Valley Mine is located within the Upper Foothills Natural Subregion of Alberta and several different ecosites are present ranging from subxeric b-ecosites and hygric h-ecosites to various wetland types in valleys (Beckingham et al, 1996). Common herbaceous species to these ecosites include bunchberry (*Cornus canadensis*), heart-leaved arnica (*Arnica cordifolia*), bishop's cap (*Mitella nuda*) and palmate-leaved coltsfoot (*Patasites palmatus*). Common shrubs to these ecosites include Labrador tea (*Ledum groenlandicum*), bog cranberry (*Vaccinium vitis-ideas*), dwarf bilberry (*Vaccinium caespitosum*) and blueberry (*Vaccinium myrtilloides*). Canada buffaloberry (*Shepherdia Canadensis*) and low-bush cranberry (*Viburnum edule*) can also be found in low densities in and around Coal Valley Mine. Willow and alder species are also found in the area; however, these species often naturally revegetate and CVRI has developed planting programs for these species.

3.2.2 Scope of Work

The following is a proposed scope of work for refinement of the whole plant and root cutting transplanting methods:

- Conduct a site visit to determine collection and planting locations
- Direct and supervise the collection and planting of vegetative propagules from three different native shrub species by local aboriginal groups (ie. Fox Creek Development) and/or CVRI summer employees
- Monitor the establishment and survival of the transplanted vegetative propagules in the early fall of 2013 and 2014
- Prepare an annual report and give recommendations for implementation at an operational scale

3.2.3 *Methods*

Mountain huckleberry will be targeted for refinement of the collection and planting techniques. Labrador tea and blueberry will also be collected and planted using the same techniques. Labrador tea and blueberry reproduce vegetatively and are commonly found in association with mountain huckleberry at Coal Valley Mine.

Root cuttings and whole plants will be collected from a pre-mined (undisturbed) location in late September of 2012 and planted on reclaimed land at Coal Valley Mine (exact locations to be determined). Local aboriginal groups or CVRI (student) employees will collect and plant the vegetative propagules but will be given detailed directions for collection and planting by Navus personnel and be supervised by Navus personnel during collection and planting. Collection locations will be located on areas where there is a high density of the targeted species to ensure maximum efficiency of collection. Collection techniques will be similar to those used in the 2010 Program (Navus, 2011); however, care will be taken to ensure that root cuttings have some fine roots attached and root cuttings will be cut to a length of approximately 15 cm.

The collected whole plants and root cuttings for each species will be planted on areas that have been recently topsoiled with stockpiled material and on areas that have a closed or nearly closed lodgepole pine canopy (exact locations to be determined). These locations had the highest establishment rates during the 2010 program. Several plant spacing treatments will be used: in evenly distributed rows (similar to the 2010 Program) and in clusters (exact size and spacing to be determined). Each species, propagule type (whole plant and root cutting) and plant spacing combination will be replicated at least 3 times at each planting area (ie. areas that have been recently topsoiled and on areas that have a closed or nearly closed lodgepole pine canopy). Each replicate will cover an area of approximately 1 ha which will include all treatment combinations. The overall planting density will be approximately 5,000 stems/ha. All replicates as well as additional programs will be planted in the same general area so that the total revegetated area is significant at an operational scale (ie mosaic of different techniques covering one large area). The design of the planting is depicted in Figure 1.

Planting methods will be similar to those used in the 2010 Program (Navus, 2011) except that the roots of whole plants will be planted at a depth of 10 to 15 cm and root cuttings will only be planted horizontally at a depth of 5 to 8 cm (deeper than during the 2010 program). Horizontal planting had higher establishment rates than planting at a 45 degree angle during the 2010 program (Navus, 2011). After the root has been placed in the ground, the slit that was cut to plant the cutting will need to be closed and root-soil contact must be made. On recently topsoiled areas, the slit can be closed by using one's foot to push the slit close, pushing loose soil onto the slit area and then packing the soil down with one's foot. On areas with a closed lodgepole pine canopy, due to the increased density of roots from the trees and roots from grasses and legumes seeded during reclamation, closing the slit can be more difficult and may require loosening up soil around the slit so that it can be pushed into the slit in and then packed down with one's foot.

The establishment and spread (colonization of surrounding areas) of the planted propagules will be monitored annually in September of 2013 and 2014. Monitoring will be carried in three 10 x 10 m randomly placed subplots for each planting scheme and species within the each planting replicate. Subplots on the clustered plant spacing will target the cluster locations. Vegetative propagules planted within these subplots will be marked to allow for easy location of the cuttings and whole plants during monitoring. In each subplot the number of root cuttings or whole plants that have survived (ie. produced new shoots or have living leaves) will be counted. Provided there is successful establishment, spread or colonization of surrounding areas can be monitored in subsequent years (ie. 2015) as the plants will not significantly spread during the first two growing seasons.

3.3 Refinement of Root Plug Transplanting Methods

3.3.1 Rationale

Collection and planting of root/LFH plugs during the 2010 Program resulted in high establishment rates of mountain huckleberry and various other locally common and native shrub and herbaceous species; however, the process was labour intensive and time consuming. Reducing plug size and determining the optimal planting spacing could reduce labour and time required for transplanting root plugs.

3.3.2 *Scope of Work*

The following is a proposed scope of work for refinement of root plug transplanting methods:

- Conduct a site visit to determine collection and planting locations
- Direct and supervise the collection and planting of root plugs by local aboriginal groups (ie. Fox Creek Development) and/or CVRI (summer) employees
- Monitor the establishment of native species from the transplanted root plugs in the early fall of 2013 and 2014
- Prepare an annual report and give recommendations for implementation at an operational scale

3.3.3 *Methods*

Root plugs will be collected from a pre-mined (undisturbed) location in the early summer of 2012 and planted on reclaimed land at Coal Valley Mine (exact locations to be determined). Local aboriginal groups or CVRI (student) employees will collect and plant the vegetative propagules but will be given detailed directions for collection and planting by Navus personnel and be supervised by Navus personnel during collection and planting.

Various sized plugs will be collected (exact sizes to be determined); smaller plug sizes may increase collection and planting efficiency but may affect establishment success and spread or colonization of surrounding areas. A spade was used to cut out the plugs in in the 2010 Program (Navus, 2011); however, the use or development of a coring tool (exact tool to be determined) may also increase the efficiency of collection and planting. When collecting the plugs at least one of either mountain huckleberry, Labrador tea, bog cranberry, blueberry and dwarf bilberry will be targeted (ie. growing within the collected plug).

The collected root plugs will be planted on areas that have been recently topsoiled with stockpiled material and on areas that have a closed or nearly closed lodgepole pine canopy (exact locations to be determined). The density or plant(ing) spacing will be varied for each sized plug to determine the optimal spacing for colonization of surrounding areas (exact densities to be determined). Planting may also be done in clusters similar to the planting of whole plants and root cuttings in order to target areas with the best soil and moisture conditions and increase

planting efficiency. Planting methods will be similar to those used in the 2010 Program (Navus, 2011). Each plug size and planting density combination will be replicated 3 times. Each replicate will cover an area of approximately 1 ha which will include all plug size and density combinations. The overall planting density will be approximately 2,000 plugs/ha. All replicates as well as additional programs will be planted in the same general area so that the total revegetated area is significant at an operational scale (ie mosaic of different techniques covering one large area). The design of the planting is depicted in Figure 1.

The establishment and spread (colonization of surrounding areas) of the planted propagules will be monitored annually in September of 2013 and 2014. Monitoring will be carried in three 10 x 10 m randomly placed subplots within each planting replicate. Subplots on clustered plant spacing will target the cluster locations. Monitoring of the root plugs will involve identifying each surviving species growing from the plug as well as their cover/density. The species and number of plants that have spread from the plug to the surrounding area including the maximum distance each species has grown from the plug will also be measured. To determine whether a species growing outside of the plug came from a source within the plug or from natural infill from the surrounding areas, it will be compared to species within the plug and species within the surrounding area. Measuring the distance each species has grown from the plug and the rate at which it occurs, will help determine an optimal planting density. The composition and cover of the vegetation within a 1 m radius surrounding the plug will also be recorded to determine if there is an effect of the surrounding vegetation (ie. seed mix) on the ability of native species to colonize it.

3.4 Refinement of Direct Placement Methods

3.4.1 Rationale

Salvage and direct placement of LFH and Ae soil horizons on top of areas that have already been placed with stockpiled topsoil during the 2010 Program resulted in high establishment rates of native herbaceous, shrub and tree species. These methods can be applied at an operational scale; however, it requires heavy machinery, can be costly due to long haul distances between salvage and placement locations. If placement of LFH and Ae soil horizons in small “islands” can be used to colonize surrounding areas, it may make direct placement more feasible as less material

is necessary. The use of “island” placement may also make it possible to place it underneath a forest canopy where there has been minimal understory development. Size of the “islands” could affect colonization of the surrounding area as larger islands may develop a greater diversity of species and support a higher density of plants; however, smaller islands may not support as great of a diversity but a higher density of the “islands” could be placed across the landscape.

3.4.2 *Scope of Work*

The following is a proposed scope of work for refinement of direct placement methods:

- Conduct a site visit to determine salvage and placement locations
- Direct CVRI employees in the salvage and direct placement of the LFH and Ae soil horizons
- Monitor the establishment of native species from the placed material in the early fall of 2013 and 2014
- Prepare an annual report and give recommendations for implementation at an operational scale

LFH and Ae soil horizons will be salvaged from a pre-mined (undisturbed) location in the fall of 2012 and directly placed on reclaimed land at Coal Valley Mine (exact locations to be determined). Equipment used for salvage and direct placement of the soil horizons will be organized by CVRI. Navus personnel will give directions to the equipment operators regarding salvage and placement depth of the soil horizons.

LFH and Ae soil horizons should be salvaged to a depth that will include the entire LFH soil horizon and at least 10 cm of the Ae soil horizon. Including deeper soil horizons will dilute the seed bank and propagules within the LFH and result in minimal vegetation establishment after placement (Mackenzie and Naeth, 2011). Salvaging with a smaller bulldozer (Caterpillar D6 to D8) will allow for an optimal salvage depth. The salvaged material can be loaded into trucks and transported to the placement locations.

The salvaged soil horizons will be directly placed on areas that have recently been placed with stockpiled topsoil and on areas that have a closed or nearly closed lodgepole pine canopy (exact

locations to be determined). Placement can occur in the same areas as the root cutting and root plug planting (ie. mosaic of different techniques covering one large area) (Figure 1). On the placement areas, the salvaged soil horizons will be placed in variously sized islands (number of islands to be determined depending on CVRI equipment availability). Each island size treatment will be replicated 3 times. The area each replicate covers will be determined depending on CVRI equipment availability. The design of the placement scheme is depicted in Figure 1.

Spreading the salvaged soil horizons on recently topsoiled areas will be logistically simpler than placing it under a closed or nearly closed lodgepole pine canopy. A bulldozer (Caterpillar D6 to D8) could be used to spread the soil horizons on the recently topsoiled areas where it is placed in larger islands; although smaller equipment may be more efficient for spreading the soil horizons of smaller islands (ie. Bobcat). The soil horizons should be placed at a depth similar to that which they were salvaged but not shallower than 10 cm. "Track-packing" of the placed soil horizons should be kept to a minimum and the surface should be left rough to create microsites for vegetation establishment.

For placement of the salvaged material under a closed lodgepole pine canopy, smaller equipment will be needed. The salvaged material can be transported as close to the placement locations using haul trucks and then dumped and ferried to the desired locations using small equipment (ie. Bobcat or Gator). Stands that have natural paths (ie. areas of sparse trees) and are readily accessible from a main road will be chosen for placement to limit damage to the tree stand.

The establishment and spread (colonization of surrounding areas) of the planted propagules will be monitored annually in September of 2013 and 2014. Monitoring will be carried on five placement islands (or portion of island if the island is greater than 4 m x 4 m) for each sized island within each replicate. Monitoring of the placed soil horizons will involve identifying each surviving species growing on the island as well as the cover/density of each species and the species and number of plants that have spread from the island to the surrounding area including the maximum distance each species has grown from the island. To determine whether a species growing outside of the island came from a source within the island or from natural infill from the

surrounding areas, it will be compared to species within the island and species within the surrounding area. Measuring the distance each species has grown from the island will help determine an optimal planting density. The composition and cover of the vegetation within a 1 m radius surrounding the islands will also be recorded to determine if there is an effect of the surrounding vegetation (ie. seed mix) on the ability of native species to colonize it.

3.5 Future Revegetation Programs

Based on the current revegetation requirements and any future requirements that may be implemented, the following list provides a brief description of additional revegetation programs that may aid CVRI in meeting their revegetation goals for Coal Valley Mine:

- Developing methods for revegetating wetland or riparian areas around end pit lakes using direct placement of wetland propagules or transplanting wetland propagules
- Determining if a seed mix can be developed that optimizes colonization of the reclaimed land with native species but still is suitable for erosion control
- Developing methods for establishing a greater diversity of native forb species on reclaimed land
- Developing methods to maintain the viability of propagules within stockpiled topsoil (ie. revegetating stockpiles) so they can be used as a propagule source when they are placed

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5.0 LIMITATIONS

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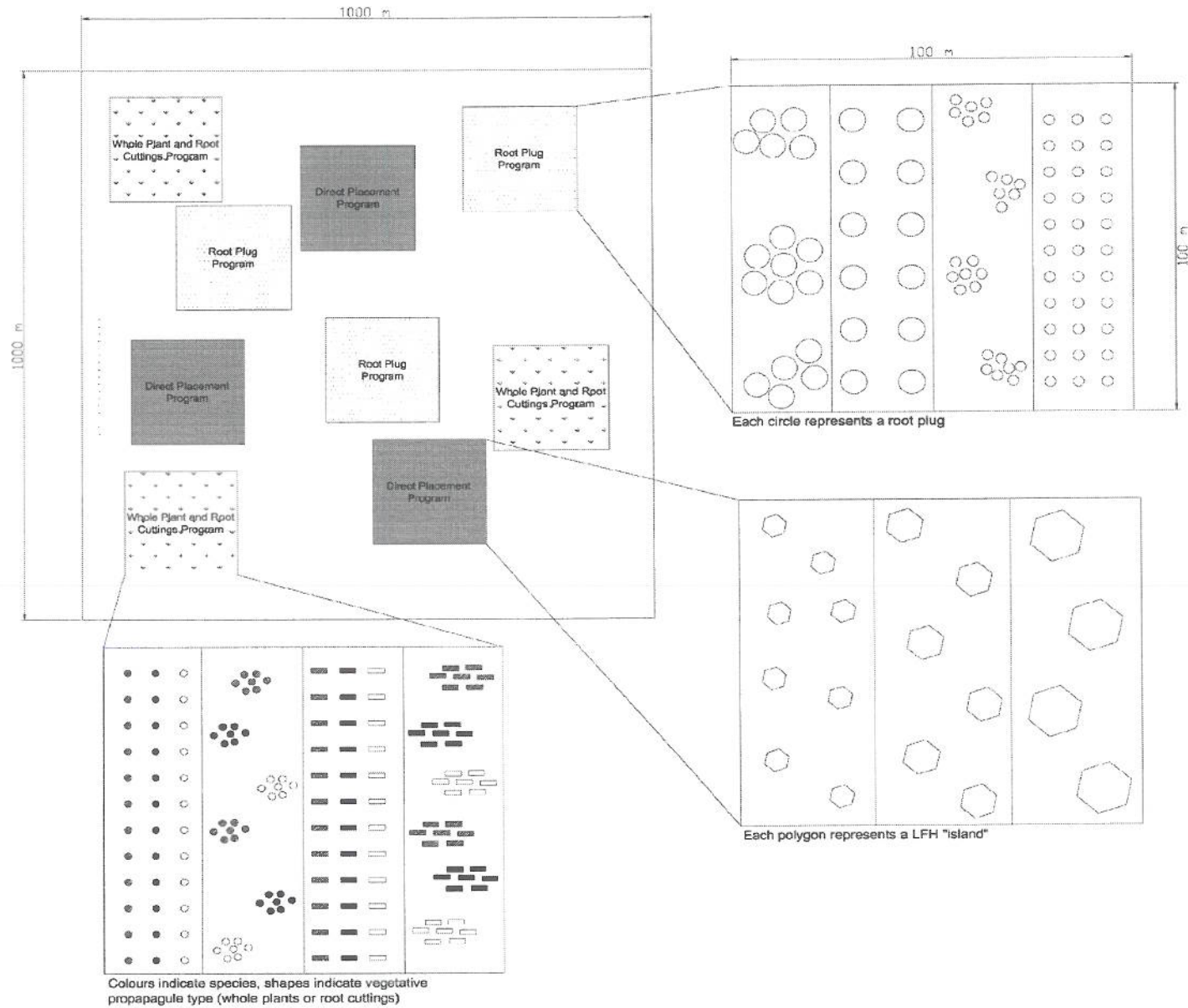


Figure 1: Conceptual Planting Scheme. The overall planting scheme will be replicated at areas with a closed lodgepole pine canopy and areas where stockpiled topsoil has been replaced. Conceptual treatment/planting design for each program are shown in detail.

Appendix 197

Bird Species Abundance in the Robb Trend LSA from
Mid-April to Mid-July, 2009-2001

Appendix 197. Bird Species Abundance in the Robb Trend LSA from Mid-April to Mid-July, 2009-2001. Sample Size is: late April = 52 plots, early May = 45 plots, early June = 67 plots, late June = 49 plots, early July = 89 plots. Abundance was Standardized as Birds per Plot.

