MONTHLY UPDATE REPORT - PRIMROSE SOUTH
09-21-067-04 W4M

MARCH 25 TO APRIL 21, 2014

1 Introduction

The Canadian Natural Resources Limited Primrose South in situ oil sands project is located primarily in the Cold Lake Air Weapons Range approximately 65 km north-northeast of Bonnyville, Alberta. Canadian Natural operations staff discovered a flow to surface (FTS) bitumen emulsion at 09-21-067-04 W4M on June 24, 2013. The FTS area is beneath an unnamed water body within the Canadian Natural Primrose South production area.

On September 24, 2013, Alberta Environment and Sustainable Resource Development (ESRD) issued an Environmental Protection Order (EPO No. EPO-2013-33/NR), requesting the preparation of a Comprehensive Remedial Plan (CRP), as well as the preparation of a monthly progress report.
This report summarizes the progress towards the realization of this plan and includes data collected and reported between March 25 and April 21, 2014.

2 Summary of Activities to Date

2.1 Individual Plan Submissions

As required by the EPO, the CRP includes the development, submission, and implementation of several specific plans. The status of these plans is indicated in Table 1:

Table 1: Components of the Comprehensive Remedial Plan

Item	Plan Name	Due Date	Submission Date	Approval Date	Implementation Start Date	Completion Date	Section Discussed
1.	**Water Management Plan for Dewatering**	September 26, 2013	September 26, 2013	September 27, 2013	September 27, 2013	October 22, 2013	2.2
2.	**Water Body Monitoring Plan**	September 26, 2013	September 26, 2013	September 27, 2013	September 27, 2013	Ongoing	3.0
3.	**Erosion and Sedimentation Prevention Plan**	September 26, 2013	September 26, 2013	September 27, 2013	September 27, 2013	Ongoing	3.4
4.	**Phase II Environmental Assessment Plan**	October 15, 2013	October 3, 2013	October 17, 2013	December 16, 2013	Ongoing	--
5.	**Bitumen Emulsion Delineation and Containment Plan**	October 6, 2013	October 3, 2013	October 17, 2013	October 18, 2013	Ongoing	3.5

Item	Plan Name	Due Date	Submission Date	Approval Date	Implementation Start Date	Completion Date	Section Discussed
6.	**Amphibian Salvage Plan**	September 26, 2013	September 25, 2013	September 27, 2013	September 27, 2013	October 22, 2013	Completed
7.	**Fish and Fish Habitat Assessment Plan**	September 26, 2013	September 25, 2013	September 27, 2013	September 27, 2013	October 30, 2013	Completed
8.	**Wetlands Impact Assessment Plan**	September 30, 2013	September 25, 2013	September 27, 2013	September 27, 2013	October 30, 2013	Completed
9.	**Water Body Restoration Plan**	November 30, 2013	Revised Plan March 27, 2014	March 27, 2014	March 27, 2014	Ongoing	2.2, 3
10.	**Wildlife Management Plan**	N/A	Revised Plan October 23, 2013	October 23, 2013	October 23, 2013	Ongoing	3.6
11.	**Waste Management Plan**	N/A	Revised Plan October 24, 2013	October 24, 2013	October 24, 2013	Ongoing	3.7
12.	**Bitumen Emulsion Delineation and Containment Plan**	October 6, 2013	Revised Plan December 22, 2013	February 7, 2014	November 27, 2013	Pending	3.5

2.2 Water Management for Dewatering and Refilling

The water body was divided into four basins as indicated on Figures 1 and 2. Basins 1, 2, and 3 were dewatered, while Basin 4 and a nearby borrow pit are being used to store the water from Basins 1, 2, and 3. Three independent pumping systems were used to pump water from Basins 1, 2, and 3. This configuration allowed Canadian Natural to adjust pumping rates in the various basins as specified in the approved Water Management Plan for Dewatering.

Pumping started on September 27, 2013 and on October 22, 2013 pumping was stopped. The dewatering activities took place in accordance with the conditions specified in the Water Management Plan for Dewatering and in the Erosion and Sedimentation Prevention Plan (Table 1, Items 1 and 3).

Refilling of the water body was initiated on March 27, 2014 and is ongoing. The refilling activities are taking place in accordance with the conditions specified in the Water Body Restoration Plan (Table 1, Item 9).

3 Water Body Monitoring

In accordance with the Water Body Restoration Plan (Table 1, Item 9), an extensive water quality and water quantity monitoring program was implemented on March 19, 2014. This ongoing program is tailored to the refilling taking place at the 9-21 FTS site and complements the ongoing water quality and quantity monitoring implemented in June 2013.

Details of the monitoring program are provided in the following subsections.

3.1 Refilling Water Quantity

3.1.1 Basins 1, 3, and 4, Borrow Pit, and Downstream Fen

- Refilling of Basin 3 from Basin 4 was initiated on March 27, 2014 and continued through this reporting period.

- The cumulative volume of water pumped from Basin 4 into Basin 3 since March 27, 2014 is 133,000 m^3. A summary of daily pumping results from March 27 through April 21, 2014 is presented in Appendix A1 and on Appendix A2.

- Daily staff gauge monitoring was initiated on March 27, 2014, coinciding with spring breakup and the beginning of water body refilling. An overview of the staff gauge and water level monitoring locations is presented on Figure 1. The results of the staff gauge readings for Basins 3 and 4 are shown on Appendix A3. The results of the staff gauge readings for the downstream fen and the borrow pit are shown on Appendix A4. Throughout this time period, several of the gauges remained ice bound; therefore, no readings could be taken and only the available data is presented.

3.2 Refilling Water Quality

Weekly water sampling was initiated on March 19, 2014. During the refilling program, water quality was compared to the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (ESRD 2014) and/or *Surface Water Quality Guidelines for Use in Alberta* (AENV 1999) at all sampling locations. Sampling locations are shown on Figure 2. New ESRD guidelines for surface water quality have been released as of April 11, 2014; these guidelines will be used for water quality comparisons within the May 2014 and subsequent monthly reports.

3.2.1 Basins 1, 3, and 4 and Downstream Fen

Water quality samples were collected weekly from established surface water sampling sites in Basins 1, 3, and 4 and the downstream fen during the refilling period (Figure 2). The samples were tested to ensure that water quality in the water body was not being affected by the refilling operations. Water quality results are presented in Appendix B.

- Laboratory analysis of water samples was carried out for benzene, toluene, ethylbenzene, and xylenes (BTEX); petroleum hydrocarbons (PHCs) fraction 1 (F1; C_6-C_{10}, excluding BTEX), fraction 2 (F2; $C_{>10}$-C_{16}), fraction 3 (F3; $C_{>16}$-C_{34}), and fraction 4 (F4; $C_{>34}$); polycyclic aromatic hydrocarbons (PAHs); chlorides; total suspended solids; and turbidity.

- Water quality results were within freshwater aquatic life guidelines with the exception of four toluene measurements and one pyrene measurement. Toluene is widespread in the environment and a common source is motor vehicle exhaust. The source of pyrene is not believed to be related to the bitumen emulsion release.

3.2.2 Containment Area, Containment Cells, and Potentially Impacted Water System

Water samples were collected from within the containment structure (Figure 3) during the reporting period, and the sample results are presented in Appendix B.

A potentially impacted water (PIW) system was set up at containment Cell D during the week of March 27, 2014 to treat ice and water stored in lined containment Cells C and D. The PIW system did not discharge any water during the reporting period due to mostly frozen conditions.

3.2.3 Shallow Groundwater

No shallow groundwater quality samples were collected from March 25 to April 21, 2014.

3.3 Aquatic Surveillance

Ongoing daily monitoring for signs of bitumen emulsion (pellets or sheen) within Basins 1 and 3 (aquatic surveillance) is conducted and documented by Canadian Natural contractors. This monitoring was conducted from the shoreline during the reporting period as thin ice within the water body prevented safe access.

- Traces of sheen and isolated bitumen emulsion pellets were observed in the water body on April 8, 9, 10, and 14, 2014. These occurrences are shown on Figure 4. The source of the sheen and pellets was residual material remaining from the bitumen emulsion release that has been remobilized into the water column during the refilling process. All observed bitumen pellets and sheen were collected, using absorbent material, and disposed in the onsite hazardous waste bin.

- On April 12, 2014, absorbent booms were placed along the eastern shoreline from Section 2.1 to Section 1.3b as a result of traces of bitumen emulsion observed from April 8 to 10, 2014 (Figure 4).

3.4 Erosion and Sedimentation Prevention

The refilling activities are taking place in accordance with the conditions specified in Extension 4 of the Water Body Restoration Plan (Table 1, Item 9).

- Discharge locations from within the containment structure were visually assessed several times daily to ensure that water being discharged was clear and free from excess suspended solids. The intake hoses for all of the discharge pumps contain filter screens and were moved as needed to prevent sediment intake as the water level in the swales changed. Daily qualitative and quantitative assessments of turbidity were conducted across the water body with no issues identified.

- The fen to the south of the water body also showed no signs of erosion or channelization.

3.5 Bitumen Emulsion Remediation and Containment

3.5.1 Remedial Activities of the Release Point for Bitumen Flow to Surface

From March 25 to April 21, 2014, the following activities were carried out as part of the plan to characterize and contain the bitumen emulsion release point:

- Bitumen-impacted material from the area of the fissure was excavated and temporarily stockpiled in containment Cells A and B before being transported to the landfill for disposal. All confirmatory soil samples collected from within the fissure excavation are within guidelines for PHCs and PAHs.

- As per the approved shoreline scraping plan, the extent of the surficial excavation along the shoreline of the south end of the water body is shown on Figure 1. Ice and high ice content frozen sediments with bitumen emulsion were temporarily placed in the lined containment Cells C and D. As the material melts, the water will be treated using the PIW system and discharged to a nearby receiving area, and the sediments will be disposed of at a landfill.

- Excavation of bitumen-impacted soil and ice and removal of impacted vegetation from the shoreline areas was completed on March 27, 2014 (Figures 5 and 6). The sediment quality objectives of the shoreline scraping plan were achieved by the end of the reporting period.

- Salvaged clean sediment has been used to backfill the shoreline scraped area.

3.5.2 Temporary Containment of Bitumen Emulsion

Low clay berms have been constructed around the two fissures at 9-21 (Figure 4) to provide temporary containment of bitumen emulsion from the fissures and to keep surface runoff from coming into contact with the bitumen emulsion. The removal of bitumen emulsion accumulating within the berms was not needed during the reporting period.

3.6 Wildlife Management

Wildlife management activities between March 25 and April 21, 2014 included maintaining perimeter fencing; installing, maintaining, and frequently relocating up to four wildlife scare cannons (Zon Guns); conducting daily inspections; and installing new wildlife deterrents in preparation for refilling activities.

During the week of March 26, 2014, the construction of wildlife deterrents and fencing was completed (including those around containment Cells C and D, the fissures, and the V-formation wildlife deterrents on the water body) to prevent potential wildlife contact with bitumen.

Current wildlife management plans appear to be working and there have been no reported impacts to wildlife during the reporting period.

3.7 Waste Management

The waste management program is summarized as follows:

- Impacted soil temporarily stockpiled in Cells A and B have been transported to the landfill for disposal and both cells have now been decommissioned. Between March 25 and April 21, 2014, 60 tonnes of soil was transported to the landfill. To date, a cumulative total of 32,800 tonnes of soil containing bitumen emulsion has been taken to the landfill.

- A fourth lined containment Cell D was constructed at the former 14-1 lease to hold organic and mineral soils that cannot be transported to the landfill due to high water content.

- Materials in containment Cells C and D will be transported to the landfill for disposal in 2014, after the material has been thawed and dewatered to meet landfill criteria.

4 Conclusions

The work conducted at the 9-21 FTS site from March 25 to April 21, 2014 included:

- initiating refilling of Basins 1 and 3 from the storage area of Basin 4
- constructing a PIW treatment system at containment Cell D
- beginning early stages of construction of the 9-21 fissure containment structure
- ongoing monitoring of water quality, pumped quantity, discharge point erosion, and sedimentation during refilling and remedial activities
- monitoring the water body area for wildlife activity

The remediation activities completed over the reporting period has further removed bitumen emulsion-impacted materials from the 9-21 site. Refilling of Basins 1 and 3 by pumping water stored in Basin 4 is progressing as planned. Monitoring of the pumping operations has indicated that Basins 1 and 3 have not been adversely impacted by the bitumen emulsion release or by refilling activities. There have been no reported impacts to wildlife during the reporting period.

The work is progressing as planned and the objectives, as required by the EPO, are being achieved within the required time frame.

5 References

Alberta Environment (AENV). 1999. *Surface Water Quality Guidelines for Use in Alberta*. Environmental Assurance Division, Science and Standards Branch. Publication No. T/483. ISBN: 0-7785-0897-8. Edmonton, Alberta. November 1999. http://environment.gov.ab.ca/info/library/5713.pdf

Alberta Environment and Sustainable Resource Development (ESRD). 2014. *Alberta Tier 1 Soil and Groundwater Remediation Guidelines*. Final Draft. Land and Forestry Policy Branch, Policy Division. Edmonton, Alberta. March 18, 2014. http://esrd.alberta.ca/lands-forests/land-industrial/inspections-and-compliance/documents/AlbertaTier1Guidelines-Mar18-2014.pdf

Canadian Council of Ministers of the Environment (CCME). 2014. *Water Quality Guidelines for the Protection of Agriculture*. Canadian Environmental Quality Guidelines, Summary Table. Accessed in January 2014. http://st-ts.ccme.ca/?chems=all&chapters=2

United States Environmental Protection Agency (U.S. EPA). 2009. *National Recommended Water Quality Criteria.* Office of Water, Office of Science and Technology. 4304T. http://water.epa.gov/scitech/swguidance/standards/current/index.cfm

I:\CanadianNatural\8881\FiguresAndTables\SPL\2013\Report_MonthlySummary\April\Public_9_21\Figure-1-Staff_Gauge_Discharge_and_Water_Level_Monitoring_Locations.mxd

Easting (m)

528500 529000 529500 530000 530500 531000 531500 532000

Northing (m)

6077500 6077000 6076500 6076000 6075500 6075000 6074500 6074000 6073500 6073000 6072500 6072000

N

Containment Cell D

13-SG8

Basin 4

13-SG12 13-SG11

Basin 4

Basin 3

Basin 3

13-SG7

Basin 2

13-SG6

Basin 1

13-SG13

13-SG4

Borrow Pit

Decomissioned Containment Cell A and B

13-SG2

Basin Boundary
Containment Cell D
Decommisioned Containment Cell
Water Body
Watercourse
Road
Cut Line
Pipeline

Direction of Flow
Staff Gauge Location
Water Level Monitoring Location

1:17,500

m

180 0 180 360

NAD 1983 UTM Zone 12N

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Staff Gauge, Discharge, and Water Level Monitoring Locations

Date:	Project:	Technical:	Reviewer:	Drawn:
11 Jun 2014	8881-523	E. Henson	H. de Pennart	R. Keller

Figure 1

I:\CanadianNatural\8881\FiguresAndTables\SPL\2013\Report_MonthlySummary\April\Public_9_21\Figure-2-2014_Re-watering_and_Monitoring_Plan_Overview.mxd

Easting (m)

528500 529000 529500 530000 530500 531000 531500 532000

Northing (m)

6077500 6077000 6076500 6076000 6075500 6075000 6074500 6074000 6073500 6073000 6072500 6072000

N

Containment Cell D
PIW System
14-SW2
Re-Watering System
Basin 4
13-DP4
13-DP3
13-SW12
Basin 3
13-SW31
Re-Watering System
13-DP7
14-SW3
Containment Cell C
14-SW1-P1
13-DP5
14-SW1-P2
13-SW22
Former Borrow Pit
14-SW1
Basin 1
13-SW46
Basin 2
13-DP6
Downstream Fen
Decomissioned Containment Cell A and B
13-SW26
13-DP1
13-SW27
Pad AC-21
13-SW16

Basin Boundary
Old Borrow Area
Containment Cell
Decommisioned Containment Cell
Access
Rig Matting
Water Body
Watercourse
Containment Structure

Potentially Impacted Water System
Re-Watering System
Road
Cut Line
Pipeline
Production Well
Surface Water Sample Location
Drivepoint Piezometer Sample Location

1:17,500 m
180 0 180 360
NAD 1983 UTM Zone 12N

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2014 Re-watering and Monitoring Plan Overview

Date:	Project:	Technical:	Reviewer:	Drawn:
25 Apr 2014	8881-523	E. Henson	H. de Pennart	R. Keller

Figure 2

I:\CanadianNatural\8881\FiguresAndTables\SPL\2013\Report_MonthlySummary\April\Public_9_21\Figure-3-Containment_Structure_and_Station_Locations.mxd

Easting (m)

529050 529100 529150 529200 529250 529300

Northing (m)

6074550 6074500 6074450 6074400 6074350 6074300 6074250 6074200 6074150

N

Basin 3

Discharge Location 2

Pump 2

Discharge Location 3

Discharge Location 4 and 5

Discharge Location 6 and 7

Discharge Location 1

Swale 2

Pump 1 and 3

Pump 4 and 5

Pump 6 and 7

Swale 1

Tractor Cannon

Fissure 2

Fissure 1

Basin 1

Swale
Berm
Containment Structure
Exposed fissure
Discharge Line
Discharge Location
Pump
Tractor Cannon

1:1,250 m
10 0 10 20
NAD 1983 UTM Zone 12N

Reference: Site features provided through Matrix Solutions Inc. field efforts. Imagery (September 2013) obtained from Canadian Natural Resources Limited used under license.

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Containment Structure Pump Locations

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Figure 3

I:\CanadianNatural\8881\FiguresAndTables\SPL\2013\Report_MonthlySummary\April\Public_9_21\Figure-4-Aquatic_Surveillance_Site_Plan.mxd

Easting (m)

529100 529200 529300 529400 529500

Northing (m)

6074700 6074600 6074500 6074400 6074300 6074200 6074100

N

3.6

Basin 3

3.5

2.3 2.2 2.1

Basin 2

1.1

1.2

Fissure 2

Fissure 1

1.3a

Basin 1

1.7

1.6

1.3b

1.5a

1.4a 1.3c

1.5b

1.4b

- Access
- Rig Matting
- Bitumen Pellets and/or Sheen Detected
- Water Body
- Berm
- Containment Structure
- Exposed fissure
- Existing Silt Boom
- Existing Sorb Boom
- Zone

1:2,000

m

20 0 20 40

NAD 1983 UTM Zone 12N

Reference: Site features provided through Matrix Solutions Inc. field efforts. Imagery (September 2013) obtained from Canadian Natural Resources Limited used under license.

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Aquatic Surveillance Site Plan

Date:	Project:	Technical:	Reviewer:	Drawn:
25 Apr 2014	8881-523	E. Henson	H. de Pennart	R. Keller

Figure 4

I:\CanadianNatural\8881\FiguresAndTables\SPL\2013\Report_MonthlySummary\April\Public_9_21\Figure-5-Interim_Phase_II_Borehole_Locations_9_21.mxd

Easting (m)

529100 529200 529300 529400

Northing (m)

6074600 6074500 6074400 6074300 6074200

N

14-B44 14-B43 14-B38 14-B39 14-B42 14-B41 14-B40 14-B23 14-B22 14-B21 14-B20 14-B37 14-B36 14-B35 14-B34 14-B33 14-B32 14-B31 14-B30 14-B29 14-B28 14-B27 14-B26 14-B25 14-B24 14-B19 14-B18 14-B17 14-B16 14-B15 14-B14 14-B13 14-B12 14-B11

13-BH01 13-BH02 13-BH03 13-BH04 13-BH05 13-BH06 13-BH07 13-BH08 13-BH09 13-BH10

P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15

696 696.5 697 697.5 695.5 698 698.5 699 699.5 700

Scraped to 30 cm
Excavation to Clay
Access
Laydown Area
Old Ice Road
Water Body
Berm
Exposed Fissure

Gate
GeoTech Borehole
Phase II Borehole
Probehole

Mineral Soil Depth Contour
Minor Contour
Major Contour

Note: The excavation outline is current to April 23, 2014, and is ongoing. Boreholes and probeholes may have been drilled prior to excavation at that location.

Reference: Site features provided through Matrix Solutions Inc. field efforts. Data obtained from GeoBase® under under license.

1:1,500 m
10 0 10 20
NAD 1983 UTM Zone 12N

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Primrose 09-21-067-04 W4M

Interim Phase II Borehole Locations 9-21

Date:	Project:	Technical:	Reviewer:	Drawn:
11 Jun 2014	8881-506	E. Henson	R. Reimer	R. Keller

Figure 5

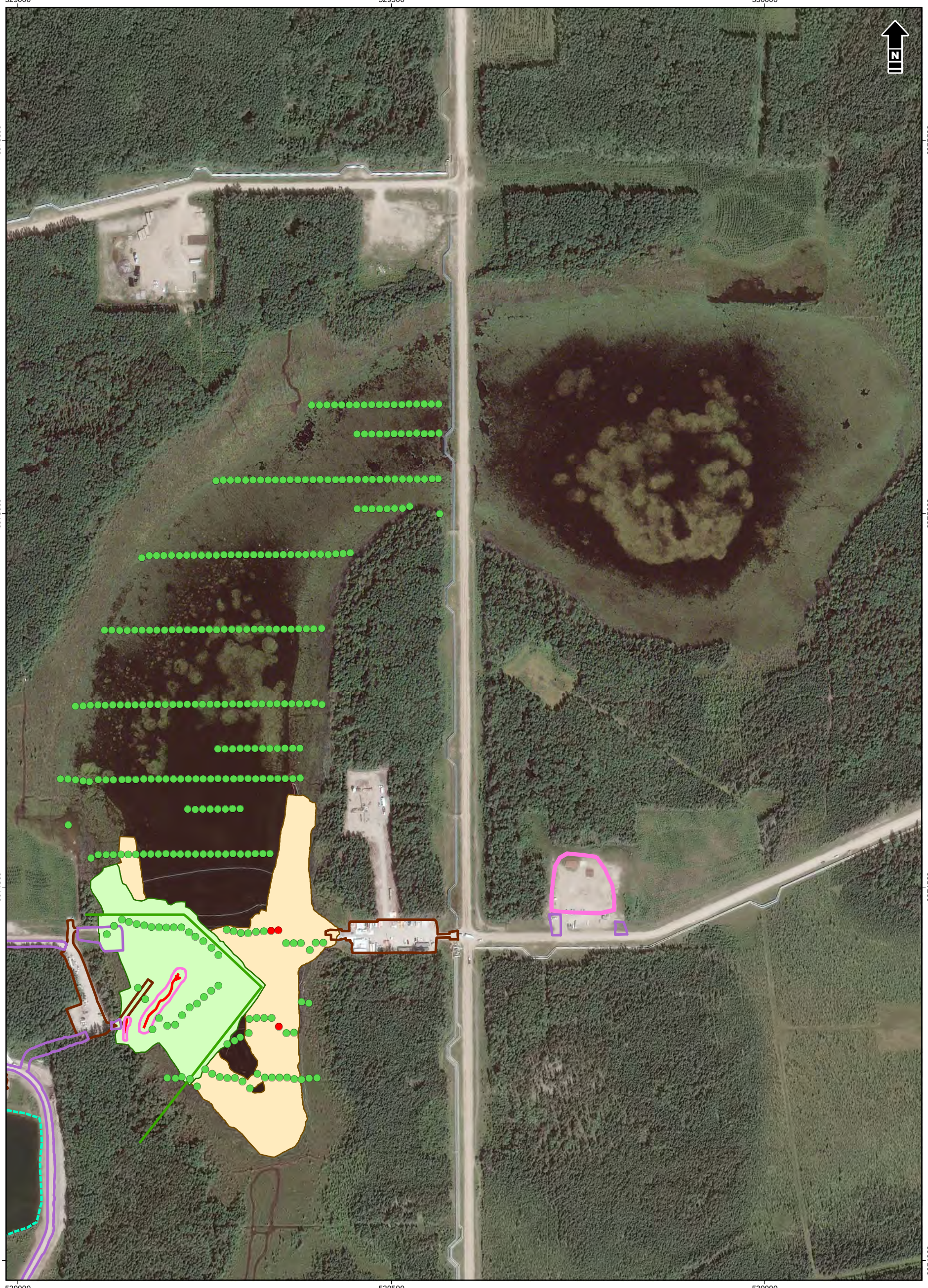
I:\CanadianNatural\8881\FiguresAndTables\SPL\2013\Report_MonthlySummary\April\Public_9_21\Figure-6-Seismic_Shotholes_9-21.mxd

Easting (m)

529000 529500 530000

Northing (m)

6075500 6075000 6074500 6074000



Scraped to 30cm
Excavation to Clay
Access
Rig Matting
Berm
Containment Structure
Exposed fissure

PrimeGeo Seismic Shothole selection
Trace Bitumen Encountered
Yes
No

1:5,000 m
50 0 50 100
NAD 1983 UTM Zone 12N

Reference: Site features provided through Matrix Solutions Inc. field efforts. Imagery (September 2013) obtained from Canadian Natural Resources Limited used under license.

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Seismic Shotholes 9-21

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11 Jun 2014	8881-523	E. Henson	R. Reimer	R. Keller

Figure 6

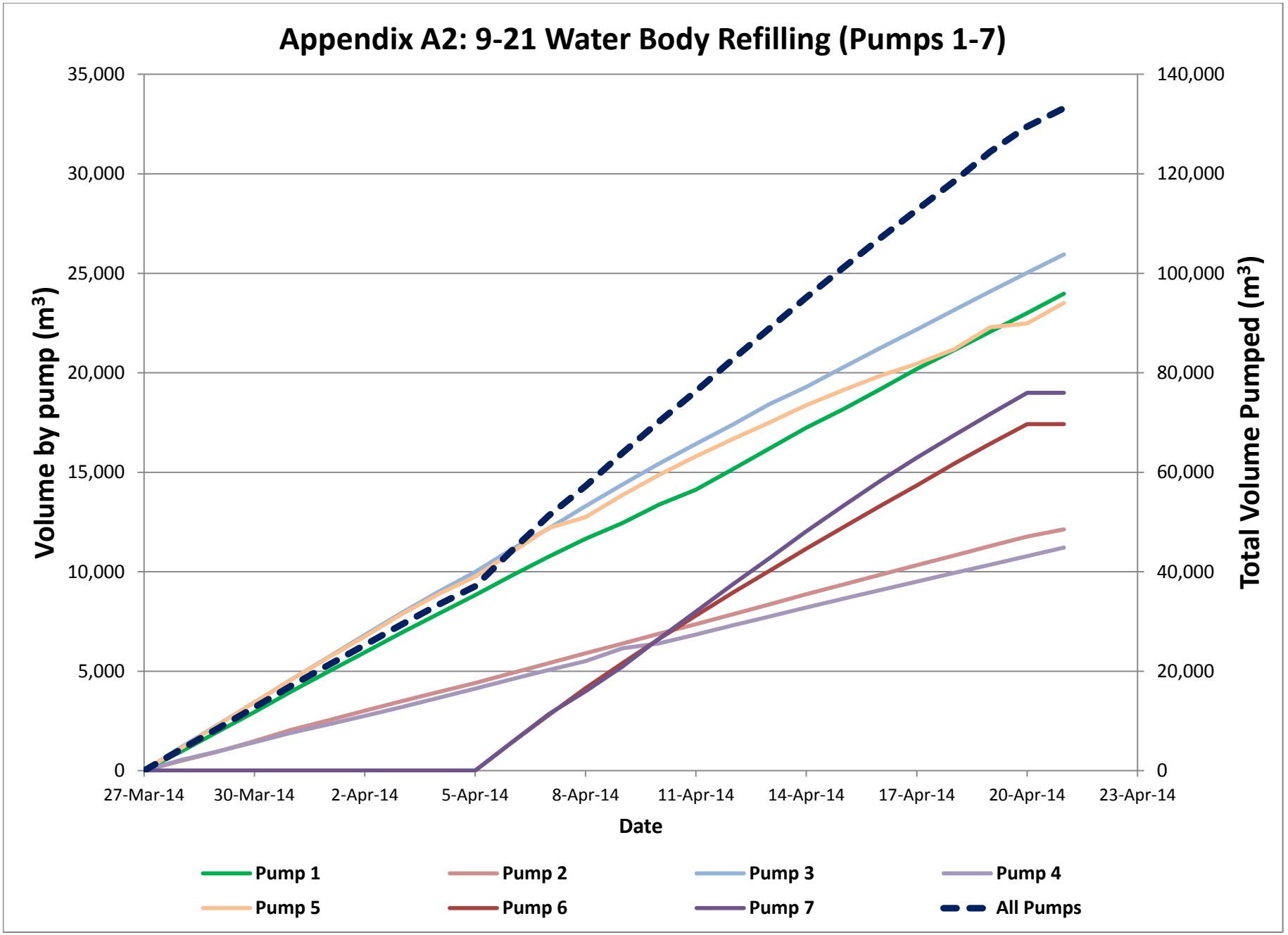
APPENDIX A

WATER LEVELS AND PUMP VOLUMES

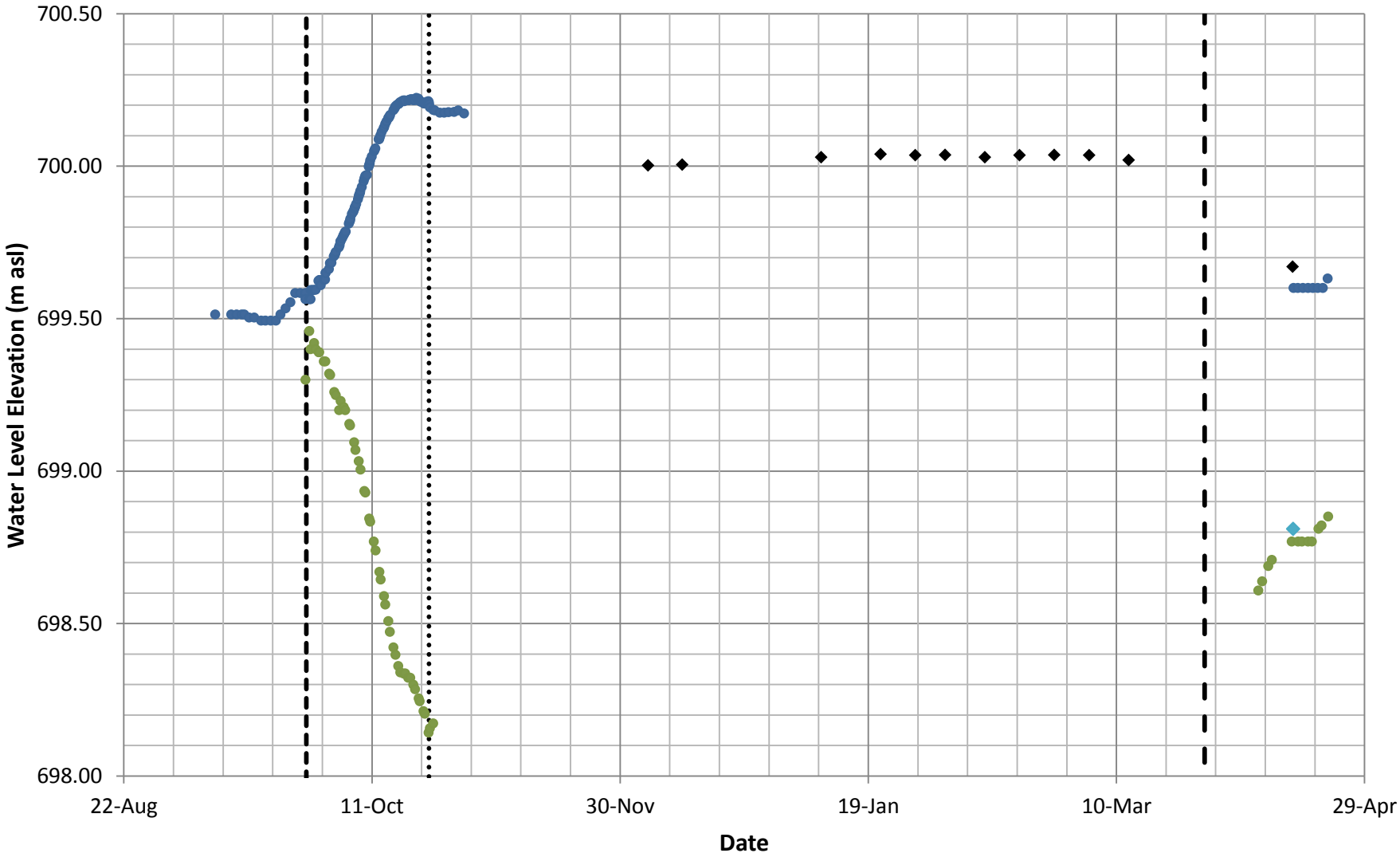
Appendix A1: Daily Flow Volumes

CNRL Primrose 09-21 Water Body: Refilling Phase (Pumps 1-7)

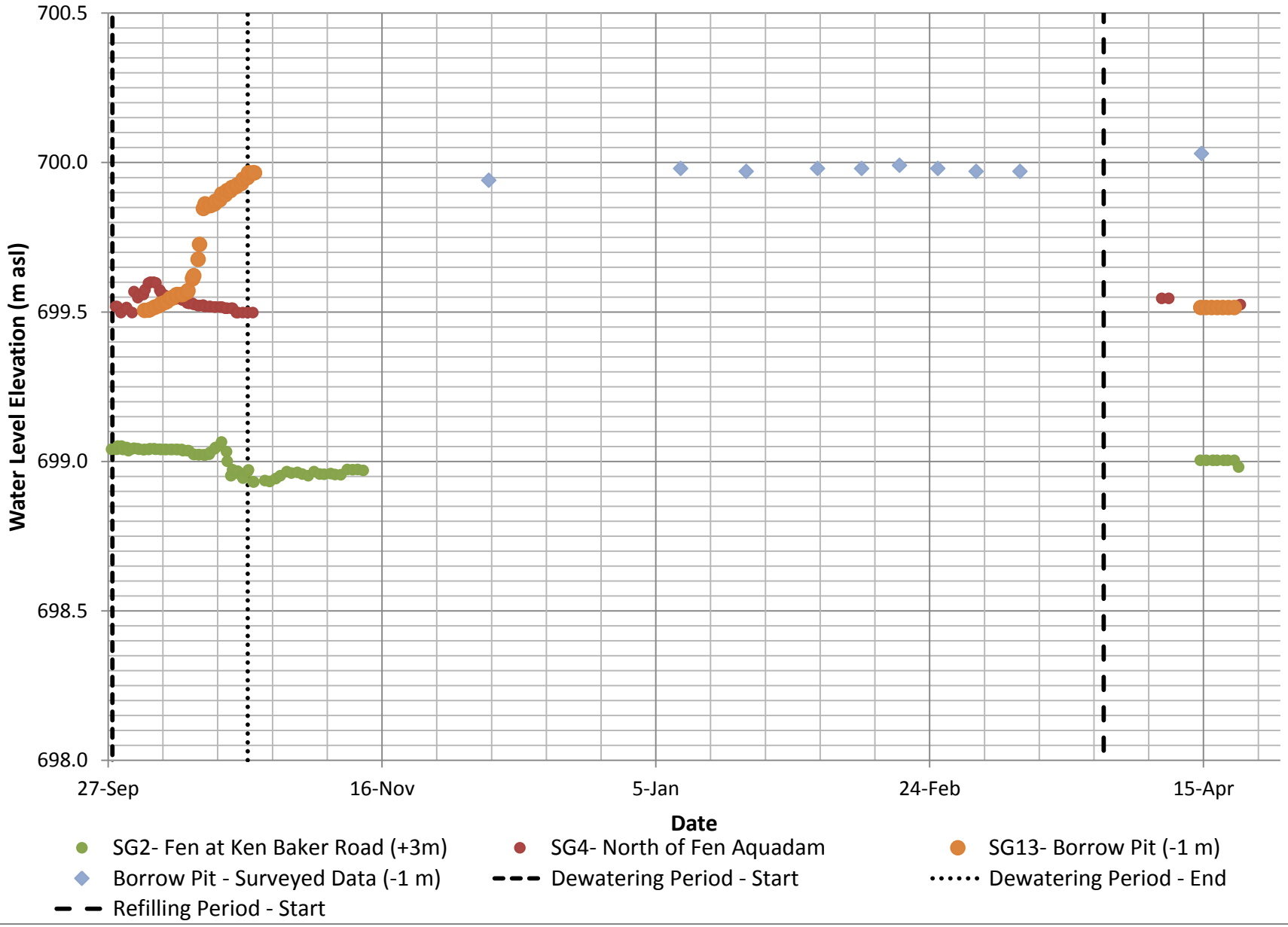
Date	Rewatering Volume (m^3/day)	Cumulative Pumped (m^3)	Rewatering Volume (m^3/day)	Cumulative Pumped (m^3)	Rewatering Volume (m^3/day)	Cumulative Pumped (m^3)	Rewatering Volume (m^3/day)	Cumulative Pumped (m^3)	Rewatering Volume (m^3/day)	Cumulative Pumped (m^3)	Rewatering Volume m^3/day	Cumulative Pumped (m^3)	Rewatering Volume m^3/day	Cumulative Pumped (m^3)	Daily Volume to Water Body from Pumps 1-7 (m^3/day)	Cumulative Total to Water Body from Pumps 1-7 (m^3)
	Basin 4															
	Pump 1		Pump 2		Pump 3		Pump 4		Pump 5		Pump 6		Pump 7			
27-Mar-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-Mar-14	958	958	493	493	1,168	1,168	534	534	1,129	1,129	-	-	-	-	4,283	4,283
29-Mar-14	993	1,951	466	959	1,130	2,298	428	962	1,145	2,274	-	-	-	-	4,162	8,445
30-Mar-14	993	2,944	528	1,487	1,140	3,438	462	1,425	1,155	3,429	-	-	-	-	4,277	12,722
31-Mar-14	1,030	3,973	564	2,051	1,137	4,575	478	1,902	1,136	4,565	-	-	-	-	4,344	17,067
1-Apr-14	995	4,969	474	2,525	1,129	5,704	424	2,327	1,110	5,676	-	-	-	-	4,134	21,200
2-Apr-14	973	5,942	492	3,017	1,117	6,821	423	2,750	1,062	6,738	-	-	-	-	4,068	25,268
3-Apr-14	988	6,930	473	3,491	1,104	7,925	449	3,199	1,123	7,861	-	-	-	-	4,138	29,406
4-Apr-14	952	7,882	468	3,959	1,065	8,990	460	3,658	1,008	8,869	-	-	-	-	3,953	33,359
5-Apr-14	941	8,822	447	4,407	1,004	9,994	468	4,127	887	9,756	-	-	-	-	3,747	37,105
6-Apr-14	982	9,804	500	4,906	1,146	11,139	471	4,598	1,225	10,981	1,413	1,413	1,431	1,431	7,166	44,272
7-Apr-14	954	10,758	498	5,404	1,034	12,173	464	5,062	1,215	12,196	1,392	2,804	1,415	2,845	6,972	51,243
8-Apr-14	898	11,656	495	5,899	1,127	13,300	448	5,510	542	12,738	1,342	4,146	1,147	3,993	5,999	57,243
9-Apr-14	787	12,443	494	6,392	1,080	14,381	639	6,149	1,111	13,849	1,262	5,408	1,237	5,230	6,610	63,852
10-Apr-14	929	13,371	493	6,886	1,053	15,434	247	6,396	1,021	14,869	1,216	6,625	1,404	6,634	6,363	70,215
11-Apr-14	757	14,129	474	7,359	984	16,417	442	6,838	930	15,799	1,165	7,790	1,365	8,000	6,117	76,332
12-Apr-14	1,022	15,151	499	7,858	977	17,394	467	7,305	876	16,675	1,155	8,945	1,370	9,370	6,366	82,698
13-Apr-14	1,046	16,197	496	8,355	1,032	18,426	448	7,753	818	17,494	1,107	10,052	1,309	10,679	6,257	88,955
14-Apr-14	1,038	17,235	515	8,869	856	19,282	453	8,206	880	18,374	1,110	11,162	1,352	12,031	6,203	95,158
15-Apr-14	937	18,171	484	9,353	986	20,268	432	8,638	758	19,132	1,075	12,236	1,281	13,312	5,952	101,110
16-Apr-14	990	19,161	491	9,843	961	21,229	433	9,071	711	19,843	1,065	13,301	1,242	14,554	5,893	107,003
17-Apr-14	1,032	20,194	488	10,331	943	22,173	431	9,502	614	20,457	1,042	14,344	1,178	15,732	5,729	112,732
18-Apr-14	923	21,117	479	10,810	964	23,136	429	9,931	706	21,163	1,067	15,411	1,110	16,842	5,678	118,409
19-Apr-14	945	22,062	482	11,292	953	24,089	424	10,355	1,130	22,293	1,024	16,435	1,083	17,925	6,040	124,450
20-Apr-14	938	23,000	479	11,771	940	25,030	424	10,779	193	22,486	981	17,415	1,073	18,998	5,028	129,478
21-Apr-14	980	23,979	361	12,132	920	25,949	438	11,217	1,027	23,513	0	17,415	0	18,998	3,725	133,203


Appendix A2: 9-21 Water Body Refilling (Pumps 1-7)
Volume by pump (m³)
Total Volume Pumped (m³)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
27-Mar-14
30-Mar-14
2-Apr-14
5-Apr-14
8-Apr-14
11-Apr-14
14-Apr-14
17-Apr-14
20-Apr-14
23-Apr-14
Date
Pump 1
Pump 2
Pump 3
Pump 4
Pump 5
Pump 6
Pump 7
All Pumps

Appendix A3: Water Levels at 9-21 Water Body



Appendix A4: Water Levels in the Downstream Fen and Borrow Pit



APPENDIX B

WATER QUALITY RESULTS SUMMARY

APPENDIX B1.

WATER QUALITY RESULTS - DISSOLVED HYDROCARBONS

Canadian Natural Resources Limited

09-21-064-04 W4M

Sample Point	Sample Date	Benzene mg/L	Toluene mg/L	Ethylbenzene mg/L	Xylenes mg/L	F1†† C_6-C_{10} mg/L	F2 $C_{>10}$-C_{16} mg/L	F3 $C_{>16}$-C_{34} mg/L	F4 $C_{>34}$-C_{50} mg/L
Surface Water Samples									
13-SW12	19-Mar-14	<0.0004	***0.0044***	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW12	27-Mar-14	<0.0004	***0.0085***	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW12	01-Apr-14	<0.0004	0.0006	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW12	08-Apr-14	<0.0004	<0.0004	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW12	15-Apr-14	<0.0004	***0.018***	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW22	01-Apr-14	<0.0004	***0.0023***	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW22	08-Apr-14	<0.0004	0.00084	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW22	15-Apr-14	<0.0004	<0.0004	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW31	08-Apr-14	<0.0004	0.0011	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW31	15-Apr-14	<0.0004	<0.0004	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
13-SW31 dup	15-Apr-14	<0.0004	<0.0004	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
Containment Structure Samples									
14-SW1-P1	01-Apr-14	<0.0004	0.00046	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
14-SW1-P2	05-Apr-14	<0.0004	0.00050	<0.0004	<0.0008	<0.1	<0.1	<0.2	<0.2
Minimal Detection Limit		**0.0004**	**0.0004**	**0.0004**	**0.0008**	**0.1**	**0.1**	**0.2**	**0.2**
AENV Freshwater Aquatic Life*		**0.37^**	**0.002^**	**0.09^**	**NS**	**NS**	**NS**	**NS**	**NS**
AENV Agriculture - Irrigation*		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
AENV Agriculture - Livestock*		**NS**	**0.024^**	**0.0024^**	**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

--- - not analyzed

NS - guideline not specified

^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, acessed on line January 2014)

* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)

†† - F1 excludes BTEX

Italics - indicates values do not meet applicable guidelines

APPENDIX B2.

WATER QUALITY RESULTS - POLYCYCLIC AROMATIC HYDROCARBONS

Canadian Natural Resources Limited

09-21-064-04 W4M

Sample Point	Date	Acenaphthene µg/L	Acenaphthylene µg/L	Acridine µg/L	Anthracene µg/L	Benz[a]anthracene µg/L	Benzo[b+j]fluoranthene µg/L	Benzo[k]fluoranthene µg/L	Benzo[g,h,i]perylene µg/L	Benzo[c]phenanthrene µg/L	Benzo[a]pyrene µg/L	Benzo[e]pyrene µg/L	Chrysene µg/L	Dibenz[a,h]anthracene µg/L	Fluoranthene µg/L	Fluorene µg/L	Indeno[1,2,3-cd]pyrene µg/L	Naphthalene µg/L	2-Methylnaphthalene µg/L	Perylene µg/L	Phenanthrene µg/L	Pyrene µg/L	Quinoline µg/L	TOTAL PAH µg/L
Surface Water Samples																								
13-SW12	19-Mar-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW12	27-Mar-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW12	01-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW12	08-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW12	15-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	***0.065***	<0.20	0.065
13-SW22	01-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW22	08-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW22	15-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW31	08-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW31	15-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
13-SW31 dup	15-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
Containment Structure Samples																								
14-SW1-P1	01-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
14-SW1-P2	05-Apr-14	<0.10	<0.10	<0.20	<0.010	<0.0085	<0.0085	<0.0085	<0.0085	<0.050	<0.0075	<0.050	<0.0085	<0.0075	<0.010	<0.050	<0.0085	<0.10	<0.10	<0.050	<0.050	<0.020	<0.20	ND
Minimal Detection Limit		**0.1**	**0.1**	**0.2**	**0.01**	**0.0085**	**0.0085**	**0.0085**	**0.0085**	**0.05**	**0.0075**	**0.05**	**0.0085**	**0.0075**	**0.01**	**0.05**	**0.0085**	**0.1**	**0.1**	**0.05**	**0.05**	**0.02**	**0.2**	**-**
AENV Freshwater Aquatic Life*		**5.8^**	**NS**	**4.4^**	**0.012^**	**0.018^**	**NS**	**NS**	**NS**	**NS**	**0.015^**	**NS**	**NS**	**NS**	**0.015^**	**3^**	**NS**	**1.1^**	**NS**	**NS**	**0.4^**	**0.025^**	**3.4^**	**NS**
AENV Agriculture - Irrigation*		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
AENV Agriculture - Livestock*		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Notes:

--- - not analyzed

NS - not specified

^ - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, acessed on line January 2014)

* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)

Italics - indicates values do not meet applicable guidelines

APPENDIX B3.

WATER QUALITY RESULTS - ROUTINE WATER CHEMISTRY

Canadian Natural Resources Limited
09-21-064-04 W4M

Sample Point	Sample Date	Lab pH	Lab EC	Ca	Mg	Na	K	Cl	SO_4	NO_2-N	NO_3-N	NO_3+NO_2-N	Total Alkalinity^	HCO_3	Hardness^	TDS	TSS	Turbidity
			µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU
Surface Water Samples																		
13-SW12	19-Mar-14	7.56	90	12	3	0.98	2.6	1.2	<1	<0.01	<0.01	<0.001	43	52	42	46	24	10
13-SW12	27-Mar-14	---	---	---	---	---	---	1.3	---	---	---	---	---	---	---	---	6.7	3.1
13-SW12	01-Apr-14	---	---	---	---	---	---	1.5	---	---	---	---	---	---	---	---	4.0	---
13-SW12	08-Apr-14	---	---	---	---	---	---	<1	---	---	---	---	---	---	---	---	37	27
13-SW12	15-Apr-14	---	---	---	---	---	---	2.3	---	---	---	---	---	---	---	---	40	14
13-SW22	01-Apr-14	---	---	---	---	---	---	2.1	---	---	---	---	---	---	---	---	3.3	---
13-SW22	08-Apr-14	---	---	---	---	---	---	1.5	---	---	---	---	---	---	---	---	7.3	6.1
13-SW22	15-Apr-14	---	---	---	---	---	---	1.4	---	---	---	---	---	---	---	---	220	120
13-SW31	08-Apr-14	---	---	---	---	---	---	1.3	---	---	---	---	---	---	---	---	4.7	3.6
13-SW31	15-Apr-14	---	---	---	---	---	---	1.1	---	---	---	---	---	---	---	---	170	54
13-SW31 dup	15-Apr-14	---	---	---	---	---	---	1.1	---	---	---	---	---	---	---	---	420	130
Containment Structure Samples																		
14-SW1-P1	01-Apr-14	---	---	---	---	---	---	46	---	---	---	---	---	---	---	---	21	---
14-SW1-P2	05-Apr-14	---	---	---	---	---	---	22	---	---	---	---	---	---	---	---	130	---
Minimal Detection Limit		**0.1**	**1**	**0.3**	**0.2**	**0.5**	**0.3**	**1**	**0.5**	**0.003**	**0.003**	**0.003**	**0.5**	**0.5**	**0.5**	**10**	**3**	**0.1**
AENV Freshwater Aquatic Life*		**6.5-8.5**	**NS**	**NS**	**NS**	**NS**	**NS**	**230^{cc}**	**NS**	**0.06*** **	**3***^{b}**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
AENV Agriculture - Irrigation*		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**100^^**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**500^^**	**NS**	**NS**
AENV Agriculture - Livestock*		**NS**	**NS**	**1000**	**NS**	**NS**	**NS**	**NS**	**1000**	**10**	**NS**	**100**	**NS**	**NS**	**NS**	**3000**	**NS**	**NS**

Notes:

--- - not analyzed
NS - not specified
^ - expressed as $CaCO_3$
^^ - guideline level is crop dependent; criterion shown is most stringent value
^{cc} - continuous concentration guideline, National Recommended Water Quality Criteria (USEPA, 2009)
^{A} - 1 day minimum, acute guideline
^{b} - indicates long-term exposure guideline; short-term exposure guideline = 124 mg/L
* - Alberta Environment Surface Water Quality Guidelines for use in Alberta (AENV, 1999)
*** - Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, acessed on line January 2014)
Italics - indicates values do not meet applicable guidelines