REPORT

TECK RESOURCES LTD.

Louvicourt Mine Tailings and Polishing Ponds 2018 Dam Safety Inspection

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Executive Summary

This report presents the 2018 annual dam safety inspection (DSI) for the tailings storage facility (TSF) and polishing pond at the closed Louvicourt mine site located near Val-d'Or, Québec. This report was prepared based on a site visit carried out on September 10, 2018 by Laurent Gareau and Nicolas Pepin of Golder Associates Ltd (Golder) and Kathleen Willman and Eric Gingras of Teck Resources Limited (Teck), as well as on a review of available data representative of conditions over the period since the previous annual DSI. Golder Associates are the original designer of the facility and have been the provider of the Engineer of Record (EOR) since 2017. Laurent Gareau assumed the role of EOR for the Louvicourt tailings facility in 2018. The objective of the site visit was to observe the various structures of the facility for signs of deteriorating geotechnical performance such as settlement, bulging, cracking, erosion, seepage and piping. The review of data supplements the visual observations and provides a historic perspective on the annual performance of the facility.

The annual DSI is supplemented by routine inspections, instrumentation monitoring, and water quality surveying carried out at the facility by Teck personnel throughout the year.

Summary of Facility Description

The Louvicourt Mine is a closed base metal mine (primarily copper and zinc, with some gold and silver) located approximately 20 km east of Val-d'Or, Québec, north of Highway 117. The TSF is located some 8.5 km northwest of the former mine site.

Infrastructure at the site comprises a tailings pond and a polishing pond located immediately downstream (east) of the tailings pond. The tailings pond is bounded by Dam 1 to the north and east, Dam 2 to the west, and high ground to the south. An operational spillway and two emergency spillways are located to the east of Dam 1E, at the northeast corner of the facility.

The polishing pond is bounded by Dam 4 to the north, the tailings pond (Dam 1D) to the west and by high ground to the south and east. An operational and an emergency spillway are located at the north end of the pond, to the east of Dam 4B.

Summary of Key Hazards and Consequences

As a required component of the DSI, a review was completed of the dam safety implications of the instrumentation data and the September 2018 site observations relative to the potential failure modes. The three key hazards for the TSF and polishing pond, failure modes that could lead to a dam safety threat, have been identified to be internal erosion, instability and overtopping. The design basis relevant to each of the potential failure modes is also presented.

Internal Erosion

Flow rates at the V-notch weirs and seepage locations around the TSF are regularly estimated or measured. The observable flow and/or water accumulation areas are regularly observed for suspended solids, or cloudy discharge, which could be indicative of internal erosion. At the time of the site visit, the measured flow rates were within normal historical operating ranges, and there was no evidence of suspended solids in the flows nor residues indicative of such solids in the flow during the past year. Although the V-notch weir flows fluctuate in response to rainfall and snowmelt events, the historical data does not suggest a trend of increasing seepage flows. The observed flows have consistently been noted to be clear and free of suspended sediments. No zones of recent subsidence or sink holes, which could be indicative of internal erosion, were observed anywhere within the overall facility. No evidence of internal erosion was therefore observed during the formal DSI inspection nor indicated by the flow monitoring.

Instability

The Canadian Dam Association, Dam Safety Guidelines (CDA, 2013) Section 3.6.3 recommends the use of dam instrumentation to supplement the regular visual assessment of dam performance relative to potential failure modes. For the Louvicourt tailings management facility, piezometers and survey monuments comprise the instrumentation used for performance monitoring.

Four piezometers are installed within the alignment of the dam footprint(s). These instruments indicate a stable piezometric level with no significant trend of increasing or decreasing levels. The need for additional instrumentation at the site will be reviewed as part of the ongoing stability review.

Survey monuments were surveyed between August 30 and September 7, 2018 by Corriveau J.L. & Assoc. (Corriveau), a surveyor based in Val d'Or. The data indicates that in most cases, incremental vertical and horizontal movements are below the stated range of accuracy of the survey. Total displacements since installation are relatively low and some seasonal movements may be occurring. The following general observations were made:

- Total settlements for all the survey monuments do not exceed 25 mm in any case.
- Incremental settlements in the past year (2017 to 2018) were generally less than 2 mm (which is the stated survey accuracy). The maximal incremental settlement was 6 mm for one instrument (SP-11-8).
- There is no sign of accelerating settlements.
- The horizontal data shows that 9 of the 19 survey monuments indicated total movements since installation smaller than they were in 2017 – that is, that the survey monuments moved closer to their initial location from 2017 to 2018. The remainder of the survey monuments had incremental movements of less than 10 mm (the stated survey accuracy), and total movements since installation of less than 20 mm.

Overtopping

The dams of the tailings pond and polishing pond were originally designed with a 2.0 m freeboard and a 1.5 m freeboard respectively. Klohn Crippen Berger (2011) reviewed the freeboard assessment for the tailings pond against the requirements of CDA (2007) in the 2010 Independent Dam Safety Review (DSR). The report provides a summary of pond levels in both the tailings and polishing ponds. In all cases, the available freeboard was greater than the minimum requirement of the CDA, but slightly lower than the original design freeboard. These do not present a concern with overtopping.

Consequence Classification

A study by SNC-Lavalin (2012) concluded that the tailings dams should be classified as "very high" consequence dams, as per the criteria in CDA 2007. The classification of Dam 4B at the polishing pond was established as "high" in the 2010 DSR (Klohn Crippen Berger, 2011). The classification was governed by the environmental consequences of a dam breach, that would produce impacts in the Bourlamaque River which are impractical to restore. At the time of preparation of this report, the dam classification is in the process of being reviewed and should be addressed again as part of the next DSR.

Summary of Key Observations

Summary of Field Observations

A site inspection was carried out on September 10, 2018 by Laurent Gareau and Nicolas Pepin of Golder, and Kathleen Willman and Eric Gingras of Teck. The following principal observations were made at that time:

- All embankments were in good condition without evidence of deteriorating geotechnical condition.
- The spillways at Dams 4B and 1D were in good condition and functional. Minor debris in the tailings pond spillway was present and should be removed as a best maintenance practice.
- The trash rack upstream of the tailings pond spillway is damaged and should be repaired as a best maintenance practice.
- Ponding water or seepage with low flows was observed at the toe of several dams, generally at the locations indicated in previous years. In general, the ponding and seepage were similar to previous years. The exception is the ponding area at the toe of Dam 1A, which is experiencing higher than anticipated ponding levels due to downstream beaver activity. The beaver blockage should be removed. Other seepage and ponding features do not represent any dam safety concerns.
- The rip-rap on Dams 1B and 1D was being upgraded at the time of the inspection in response to a best maintenance practice recommendation from the previous DSI.
- Minor erosion was observed on the dam crests from weather (freeze-thaw and wind activity). This should continue to be monitored, and maintenance efforts may be required in the future.

Climate and Water Balance Summary

The 2017/2018 winter precipitation generally remained below monthly multi-annual averages. 2018 fall precipitation was higher than the multi-annual averages. Specifically, September (180.7 mm) and October (168.1 mm) 2018 were very wet months (respectively 78% and 100% higher than the average). The total precipitation over the considered period is 12% higher than the long-term average.

Based on a high-level water balance analysis, it was estimated that 0.69 million m^3 of water were discharged to the polishing pond via the spillway.

Summary of Significant Changes

The replacement of rip-rap on Dams 1B and 1D is considered a positive significant change, with a tangible benefit in terms of structure performance. An assessment of rip-rap sizing is ongoing to document conformance with design objectives.

Summary of Review of OMS and ERP Manuals

The Operations, Maintenance and Surveillance (OMS) manual was updated in 2017. At the time of preparation of this report, a further update of the OMS is in progress to update the format to be compliant with the Teck Tailings and Water Retaining Structures (TWRS) guideline, which is fully aligned with the Mining Association of Canada's (MAC) guidance on OMS best practices.

The emergency preparedness and response plan (EPRP) was last updated in June of 2017. The EPRP is a thorough document, which has been updated in March 2019.

Dam Safety Review

An independent DSR of the TSF and polishing pond was conducted in 2015 (SNC-Lavalin, 2015). The next DSR should be completed by the end of 2020.

Status of Dam Safety Inspections Key Recommended Actions

The status of the deficiencies and non-conformances are presented in the following table.

Structure	ID	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline/Status
Previous Recommendations Closed / Superseded						
Dam 1D	2015-02	Existing rip-rap material on the upstream face has degraded and ravelled downslope.	CDA 2007 Section 3.5.3	Place new rip-rap material along the upper portions of the dam side slopes, starting with the upstream face.	2	CLOSED- Completed Sept 2018
Dam 1D	2016-05	Water flow trajectory at tailings pond second emergency spillway	CDA 2013 Section 3.5.5	Extend downstream earth berm	4	SUPERCEDED by 2018 inspection recommendation
Dam 1B	2017-01	Existing rip-rap material on the upstream face has started to degrade	CDA 2013 Section 3.5.3	Place new rip-rap material along the upper portions of the dam side slopes	2	CLOSED- Completed Sept 2018. Assessment of rip-rap size completed Q1 2019.
Previous Recommendations Ongoing						
All	2015-06	Perform a review of dam's seismic stability and liquefaction conditions	Directive 019 Section 2.9.3	Perform a review of dam's seismic stability and liquefaction conditions	4	IN PROGRESS- Investigation completed Q4 2017; analyses in progress Q2 2019; scope change and addition of seismic hazard assessment resulted in completion delay

Structure	ID	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline/Status
2018 Recommendations						
Dam 1E	2018-01	Debris in the tailings pond spillway	OMS Manual Section 6.2	Remove debris from spillway	3	CLOSED - Q4 2018 (Completed)
Dam 1E	2018-02	Trash rack at inlet to the tailings pond spillway is damaged	OMS Manual Section 6.2	Repair trash rack	3	Q4 2019
Dam 1D	2018-03	Access road at outlet of second emergency spillway is susceptible to erosion	CDA 2013 Section 3.5.5	Undertake erosion analysis to assess risk to embankment integrity. If required, install slope protection across the road and outlet channel, to route potential spillway flow away from the embankment.	3	Q4 2019
Dam 2A	2018-04	Beaver activity downstream of Seepage pt. 9 causing higher accumulation of water adjacent to Dam 2A	CDA 2007 Section 3.5.8	Control beaver activity and remove beaver dam	2	Q2 2019

Priority (defined by Teck Resources)	Description
1	A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

Note: Priority description categories are consistent with Mining Association of Canada (MAC) guidelines.

Table of Contents

TABLES

FIGURES (after text)

APPENDICES

Definitions

Abbreviation	Definition
CDA	Canadian Dam Association
DSI	Dam Safety Inspection
DSR	Dam Safety Review
ERP	Emergency Response Plan
OMS	Operation, Maintenance and Surveillance

Unit	Definition
kPa	Kilopascal
m	metre
m^3	Cubic meter
tpd	Ton per day

Term	Definition
Dam Safety Inspection (DSI)	An annual report summarizing the results of a dam safety inspection.
Dam Safety Review (DSR)	A systematic review and evaluation of all aspects of design, construction, maintenance, operation, process, and system affecting a dam's safety, including the dam safety management system (CDA 2013).
Downstream	The side of the embankment furthest away from the reservoir or pond.
Tailings	Fine grained residual material remaining after the valuable resources have been separated.
Freeboard	The vertical distance between the still water surface elevation in the reservoir and the lowest elevation at the top of the containment structure (CDA 2013).
Upstream	The side of the embankment nearest to the reservoir or pond.
Waste Rock	Coarse grained (gravel to boulder sized) mineral rockfill. Also referred to as rockfill.

1.0 INTRODUCTION

1.1 Purpose, Scope of Work and Methodology

At the request of Teck Resources Limited, Golder Associates Ltd. (Golder) has completed the 2018 Dam Safety Inspection (DSI) at the Louvicourt Mine tailings management facility located near Val-d'Or, Quebec. The tailings management facility includes the tailings pond and the polishing pond and associated appurtenant structures. The report is based on a site visit carried out on September 10, 2018 and the review of available surveillance data for the reporting period (September 2017 to September 2018) by the Engineer of Record, Laurent Gareau of Golder. The previous annual DSI for the tailings facility dams was carried out in September 2017, and is reported in the 2017 DSI report (Golder, 2018).

The 2018 inspection included the following structures:

- Dams 1A through 1E
- Dams 2A and 2B
- Dam 4B

Dam 4A was not inspected during the 2018 DSI. The dam does not currently retain any water due to the low water level in the Polishing Pond, and as such, its integrity has no impact on the current safety of the Polishing Pond. However, Dam 4A will be added to future DSI's in the event a decision is made to raise the water level in the Polishing Pond to a point where this dam would impound water.

This report has been prepared in accordance with the Teck Guideline for Tailings and Water Retaining Structures (Teck, 2014) and the Teck Dam Safety Inspection table of contents. Sections that are no longer applicable due to the facility being closed or because of the particular nature of the Louvicourt tailings facility have been identified as "not applicable".

1.2 Regulatory Requirements

In addition to Teck's requirements noted above, the dam safety inspection has also been performed in accordance with the following:

- *Guide de préparation du plan de réaménagement et de restauration des sites miniers au Québec*, MERN, Novembre 2016
- *Directive 019 sur l'industrie minière*, MDDELCC, Mars 2012

The annual DSI is a requirement of certificate of authorization no 7610-08-01-70141-52 issued by the Ministry in October 2010.

1.3 Facility Description

Louvicourt Mine is a closed base-metal mine (primarily copper and zinc, with some gold and silver) located approximately 20 km east of Val-d'Or, Quebec, north of Highway 117. A facility data sheet is included as Appendix A.

The Louvicourt property is currently owned by Teck Resources (55%) and Glencore Canada Corporation (45%). The site was managed and monitored by Golder Associates from closure until the end of 2016. From 2017 to the end of 2018, the site was managed by Teck's Supervisor, Water Treatment & Maintenance, Eric Gingras. From the beginning of 2019, the site is now managed by Kathleen Willman and supervised by a consultant to Teck, Rodrigue Ouellet, who has previously been involved in the site since closure as the lead of the Golder team previously involved with the site.

Dam infrastructure at the site comprises a tailings pond with a polishing pond located immediately downstream to the east of the tailings pond. The tailings pond is contained by Dam 1 to the north and east, Dam 2 to the west and natural topography to the south. For reference purposes, the main dams have been divided into several sub dams designated Dam 1A to Dam 1E and Dam 2A to Dam 2B, typically separated by local bedrock outcrops located along the alignment of the dams.

The polishing pond is contained by Dam 4 to the north, the tailings pond to the west and natural topography to south and east. For reference purposes, Dam 4 comprises two segments designated Dam 4A and Dam 4B, separated by a bedrock outcrop.

1.4 Background Information and History

The Louvicourt mine began operations around 1994 and had a nominal milling rate of 4,000 tpd, with a peak estimated rate of 5,000 tpd. Mining operations effectively ceased around July 2005.

Figure 1 shows a plan view of the Louvicourt tailings management site. Figure 2 shows a typical dam cross-section at the Louvicourt tailings management site.

Approximately one third of the tailings from the milling process were pumped to the tailings facility, located approximately 8.5 km northwest of the mine/mill. The remainder of the tailings was used as paste backfill for the underground mine. Tailings generated from the milling process have high sulphide content (30% to 45%) and are acid generating. The tailings within the basin are covered with a water cover, approximately 1-m thick, to prevent oxidation and generation of acid rock drainage.

Tailings were deposited within the tailings facility using floating pipelines extending from the dams into the basin. The pipeline was moved laterally as required to keep the tailings solids below elevation 315 m. During operations, regular bathymetric surveys were performed to provide information to allow adjusting the deposition plan to fill low spots and prevent overfilling in high areas. Local high tailings areas above elevation 315 m generated during deposition were generally spread using a barge-mounted dredge or a rotary harrow device.

The original design of the tailings dams and polishing pond dams was carried out by Golder in 1993. Golder performed an inspection in 2009, and then has performed annual inspections of the facilities since 2014. Mayana Kissiova of Golder became the Engineer of Record for the Tailings Facility in 2017 and Laurent Gareau succeeded Mayana Kissiova in 2018.

2.0 CONSTRUCTION, OPERATION, MAINTENANCE AND SURVEILLANCE

In 2018, placement of rip-rap material was completed along the upper portions of the Dams 1B and 1D side slopes. This was done according to the recommendations provided after the 2015 DSI (for Dam 1D) and 2017 DSI (for Dam 1B). The access bridge located near the active spillway of the tailings storage facility was also rebuilt in 2018. No other construction or operation occurred in 2018. The maintenance and surveillance activities performed in 2018 included the following:

- Routine inspections
- Survey of monuments

- Removal of vegetation in the emergency spillways
- Removal of debris in the polishing pond active spillway canal
- Cleaning of the access paths to the toes of dams 1A, 1B, 1C and 4D

3.0 CLIMATE DATA AND WATER BALANCE

3.1 Review and Summary of Climatic Information

Table 2 and Figure 3 summarize the Val-d'Or monthly total precipitation data over the period from November 2017 to October 2018. The data originates from the Environment Canada climate stations (Table 1), which are located about 15 km from the mine site. The available data from the stations presented in Table 1 were combined to form a continuous time series over the period 1951-2018, which was used for the precipitation analysis and water balance presented in this section.

For comparative purposes, the monthly multi-annual averages calculated from the combined precipitation record over the period 1951-2018 are also provided in Table 2.

Table 1: Information of the Selected Environment Canada Climate Stations

Station Name, ID	Latitude, Longitude (degrees)	Station Elevation (m)	Available Data Record	Notes
VAL-D'OR A, 7098600	48.06, -77.79	337.4	1951 – 2018	Main Station until 2011
VAL-D'OR, 7098603	48.06, -77.79	338.9	2008 – 2018	Main station since 2012
VAL D'OR A, 7098605	48.05, -77.78	337.4	2011 - 2018	Used for missing data

The 2017/2018 winter precipitation generally remained below monthly multi-annual averages. 2018 fall precipitation was higher than the multi-annual averages. Specifically, September (180.7 mm) and October (168.1 mm) 2018 were very wet months (respectively 78% and 100% higher than the average). The total precipitation over the considered period is 12% higher than the long-term average.

Table 2: Monthly Precipitation Data from May 2017 to October 2018

Month - Year	Total Precipitation Recorded at Val-d'Or (mm) *	Monthly Multi-Annual Average at Val-d'Or (mm) **	Difference (%) ***
November 2017	96.9	82.2	18% ↑
December 2017	61.0	67.6	-11% ↓
January 2018	65.1	59.8	9% ↑
February 2018	38.4	47.7	-24% ↓
March 2018	32.0	55.7	-74% ↓
April 2018	54.7	59.6	-9% ↓
May 2018	64.3	70.3	-9% ↓
June 2018	79.8	88.56	-11% ↓
July 2018	92.1	100.9	-10% ↓
August 2018	93.3	94.7	-2% ↓
September 2018	180.7	101.3	78% ↑
October 2018	168.1	83.9	100% ↑
Total over the hydrological year Nov 2017 - October 2018	**1026.4**	**912.5**	**12% ↑**

*: Values are based on records from Environment Canada climate stations ID 7098600, ID 7098603, ID and 7098605.
**: Values are based on records from Environment Canada climate stations ID 7098600, ID 7098603, ID and 7098605, from 1951 to 2018.
***: Difference between Val-d'Or current year precipitation and the multi-annual average precipitation.
↑ (↓): Current year precipitation higher (lower) than the multi annual average precipitation.

3.2 Review and Summary Water Balance

A high level water balance of the Louvicourt tailings storage facility (TSF) was compiled based on the recent climate data. The parameters were consistent with those from previous studies (SNC-Lavalin, 2006):

- The runoff from the external watershed area was estimated using a constant, volumetric annual average runoff coefficient of 0.6 as in the previous study. The value is consistent with regional, large watershed river flow records, but it has not been validated by local field measurements.
- The pond evaporation was calculated using the Morton model (Morton, 1983), with historical climate data from climate stations at Val d'Or (air temperature, dew point temperature, precipitation) and Rouyn-Noranda (solar radiation).

- Constant seepage flow rates were predicted by finite element seepage analyses performed by Golder (1993) prior to construction. They have not been updated since the 1993 study. The modelled seepage rates appear to be consistent with measured rates (V-notch measurements per Table 5).
- The spillway discharge is estimated based on a mass balance, assuming net zero flows for the facility and no volumes of water accumulating over time in the pond.

Table 3 summarizes the yearly flows resulting from the water balance for the considered year, namely November 2017 to October 2018, and for a typical year. Higher precipitation led to an estimated increase in the volume of water discharged at the spillway.

Table 3: November 2017 to October 2018 Water Balance for the TSF

Component	Average Year Flows (m^3/year)	Current Year Flows* (m^3/year)	Difference (%)	Comment/Source
Rainfall over the basin	958 075	1 077 720	12% ↑	Basin area = 105 ha Mean annual rainfall = 912 mm/year Current year rainfall= 1,027 mm/year
Surface runoff over the external watershed area	572,655	644,231	12% ↑	Watershed area = 104.6 ha ** Runoff coefficient = 0.6
Total of inflows	**1,530,730**	**1,721,889**	**12% ↑**	
Pond evaporation	656,177	673,029	3% ↑	Based on Morton (1983) Mean annual pond evaporation = 625 mm/year Current annual pond evaporation = 641 mm/year
Seepage losses	362,664	362,664	0%	Based on analysis made prior to construction Golder (1993) Seepage flow rates = 41.4 m^3/h
Spillway discharge to the polishing pond	511,889	686,196	34% ↑	Estimated based on mass balance
Total of outflows	**1,530,730**	**1,721,889**	**12% ↑**	

* Current year extends from November 2017 to October 2018.
** The watershed area has been updated in Louvicourt Consolidated Hydrological Report (in preparation)
↑ (↓): Current year value higher (lower) than the long-term average value.

3.3 Freeboard and Storage

Freeboard and storage are addressed in Section 5.2.3.

3.4 Water Discharge Volumes

Based on a high-level water balance analysis, it is estimated that 0.69 million m^3 of water was discharged to the polishing pond via the spillway.

3.5 Water Discharge Quality

Water discharge quality is presented in the Louvicourt annual environmental report (Suivi environnemental post-restauration) submitted by March 31 of each year to le Ministère de l'Environnement et de la Lutte contre les changements climatiques du Québec.

4.0 SITE OBSERVATIONS

A site inspection was carried out on September 10, 2018, by Mr. Nicolas Pépin, Eng. and Mr. Laurent Gareau, Eng., Engineer of Record, both from Golder. They were accompanied by Mr. Eric Gingras, former Louvicourt Supervisor, Water Treatment and Maintenance, and Mrs. Kathleen Willman, Manager, Engineering and Remediation, both from Teck Resources. The temperature during the visit was approximately 14°C under clear skies.

4.1 Visual Observations

The following observations were made during this DSI:

- The water level at the tailings pond was 316.10 m (water level from September 19, 2018).
- The water level at the polishing pond was 306.72 m (water level from September 19, 2018).

Dams 4A, 4B and Final Effluent Point

- Dam 4A is a structure that is sited at higher ground and is no longer in contact with water. No regular visits are conducted at this structure and it was not visited during the 2018 DSI.
- The spillway at Dam 4B was in good condition and functional (photograph 1).
- Culverts at the final effluent point were clean (photograph 2). The flow rate at the final effluent point was low and water was clear.
- The Dam 4B crest was generally in good condition. Geotextile is exposed at some locations (photograph 3). Survey monuments are visible. No noticeable changes were visually apparent (i.e., damage) to the survey monuments.
- Erosion is visible on the downstream slope of Dam 4B (photograph 4) and on the access road close to the spillway (photograph 5).
- An unused plastic pipe was noted in the 2017 DSI and still present at the crest of Dam 4B, buried in the granular top material.

- Ponding water was observed at the toe of Dam 4B at the same locations as last year (points 15 to 18 on Figure 1 except for point 18 where no exfiltration nor ponding water was observed. The water appears to be stagnant or exhibits very low flow.

Dams 1A through 1E

- The rip-rap on the upstream berm of Dam 1D was repaired with new rip-rap. During the site visit, the rip-rap on the upstream slope of Dam 1B was under reparation (photograph 6). The size of the rip-rap material installed is being assessed under separate cover to ensure it meets the required design criteria.
- The trash rack located upstream of the entry to the spillway is damaged (Photograph 7) and should be repaired.
- Ponding water was observed at the toe of Dams 1A, to 1E at the same locations as last year. The water seems to be stagnant or exhibits very low flow. Two new locations where observed with water pounding at the toe of the dams. Those locations are at point 1C and 3B at the toe of Dams 1A and 1B respectively. The location of these points is presented on Figure 1.
- The emergency spillway located between Dams 1D and 1E was in good condition. Vegetation in the downstream channel was cleared before the site visit (photographs 8 and 9). The access road at the outlet of second emergency spillway is susceptible to erosion, which could affect the embankment.
- The trash rack at inlet to the tailings pond spillway is damaged. Debris were also accumulated in the spillway (photograph 10).
- The access bridge close to the spillway was rehabilitated in 2018 (photograph 11).
- Several minor erosion points are visible at the crest of Dams 1A and 1B. These are to be observed.
- Geotextile fabric is visible at the downstream side of the crest of Dam 1D (2+000). Some granular material should be added to protect the geotextile from tearing.
- Vegetation is present in the water collection ditch, downstream of Dams 1A, 1B and 1C (photograph 12).
- One closed longitudinal surface crack was observed on the crest of Dam 1C. It was reported that cracking occurs seasonally; this was assessed by Golder and attributed to freeze-thaw. The crack has been dormant since the onset of spring thaw.

Dams 2A and 2B

- A few minor erosion points are visible at the crest of Dam 2B (Photograph 13). These are to be observed.
- Some stagnant water was observed at the toe of Dam 2B where previously seepage area 13 has been established, close to V-notch 2, exhibiting very low flow. Further south, seepage points 10, 11 and 12 are present in the vicinity of V-notch 1. V-notch 1 exhibits low but visible flow rates, and the water is clear.
- Stagnant water is observed at the toe of Dam 2A (Photograph 14). The extent of ponding is increased due to beaver activities.

4.2 Photographs

Key photographs of the inspection are presented in Appendix B.

4.3 Instrumentation and Data Review

The following information was available for this DSI:

- Yearly monitoring data of survey monuments.
- Records of monthly visual inspections.
- Measurement of flow at V-notches and groundwater elevations of existing piezometers since their installation to the end of 2018.
- Measurements of the water levels for the tailings and polishing ponds.

4.3.1 Water Levels

Figure 4 presents available groundwater levels for the dams. A total of four piezometers (PZ-02-04, PZ-04-04, D2A, D2B) are installed on the berms of three different dams. Six other observation wells (PBR 4, PBR 6, PBR 7, PRB 8, P06-30, P06-31) are located on natural ground, some distance away from the toe of the dams. The position of these wells is shown in Figure 1. Data for 2018 was compiled by Teck. It can be seen that recent values are quite stable for all wells and consistent with previous trends.

Piezometer PZ 02-04 is located within Dam 1D downstream berm. Groundwater at this location corresponds to seepage through Dam 1D and drains toward the polishing pond. It is therefore normal that the trend line for this well is slightly higher than the level of the polishing pond.

4.3.2 Deformation/Settlement

A series of 15 movement monitoring monuments exists along the crest and berms of the tailings pond dams and four additional monuments are located along Dam 4B of the polishing pond. Some of these monuments were installed after the 1993 construction and are identified B-1 to B-11 in Appendix C and SP-1 to SP-11 in Figure 1. Other monuments, identified as SP-11-1 to SP-11-8 in Figure 3 and as 2011-1 to 2011-8 in Appendix C were installed in September and October 2011. All monuments were surveyed between August 30 and September 7, 2018 by Corriveau J.L. & Assoc. (Corriveau), a surveyor based in Val-d'Or. The detailed report of Corriveau is presented in Appendix C. Table 4 presents total settlement and horizontal displacement of all monuments. The stated precision of these results is 10 mm for horizontal movements and 2 mm for vertical movements (settlement).

Table 4: Settlement and Horizontal Displacement

Monument	Install Year	Horizontal Movements (total)		Settlement (Negative #s = upward)		
		Install to 2017	Install to 2018	Up to 2017	2017-2018	Up to present
Dam 1D (crest)						
B-1 (SP-1)	2008	14 mm	4 mm	-1 mm	1 mm	0 mm
B-2 (SP-2)	2008	24 mm	18 mm	23 mm	2 mm	25 mm
B-3 (SP-3)	2008	4 mm	7 mm	2 mm	0 mm	2 mm
Dam 1D (berm)						
2011-2 (SP 11-2)	2011	19 mm	13 mm	18 mm	-2 mm	16 mm
Dam 1C (crest)						
B-4 (SP-4)	2008	18 mm	16 mm	-2 mm	1 mm	-1 mm
B-5 (SP-5)	2008	10 mm	9 mm	-3 mm	0 mm	-3 mm
Dam 1C (berm)						
2011-8 (SP 11-8)	2011	13 mm	11 mm	6 mm	6 mm	12 mm
Dam 1B (crest)						
B-6 (SP-6)	2008	15 mm	16 mm	-3 mm	2 mm	-1 mm
Dam 1A (crest)						
B-7 (SP-7)	2008	12 mm	17 mm	-19 mm	-2 mm	-21 mm
Dam 2B (crest)						
B-8 (SP-8)	2008	5 mm	11 mm	2 mm	-3 mm	-1 mm
B-9 (SP-9)	2008	9 mm	12 mm	-1 mm	1 mm	0 mm
B-10 (SP-10)	2008	22 mm	6 mm	-9 mm	0 mm	-9 mm
Dam 2B (berm)						
B-11 (SP-11)	2011	10 mm	13 mm	10 mm	-1 mm	9 mm
2011-6 (SP 11-6)	2011	16 mm	20 mm	13 mm	2 mm	15 mm
2011-7 (SP 11-7)	2011	21 mm	10 mm	-15 mm	1 mm	-14 mm
Dam 4B (crest)						
2011-1 (SP 11-1)	2011	6 mm	15 mm	13 mm	3 mm	16 mm
2011-3 (SP 11-3)	2011	4 mm	3 mm	20 mm	4 mm	24 mm
2011-4 (SP 11-4)	2011	3 mm	3 mm	9 mm	N/A*	N/A*
Dam 4B (berm)						
2011-5 (SP 11-5)	2011	5 mm	8 mm	4 mm	0 mm	4 mm

* The surveyor was not able to measure the elevation of this survey monument.

The horizontal data shows that 9 of the 19 survey monuments indicated total movements from installation to 2018 that were smaller than they were from installation to 2017 – that is, those 9 survey monuments moved closer to their initial locations during the 2017-2018 period. All other survey monuments had incremental movements of less than 10 mm from 2017 to 2018, and total movements since installation of less than 20 mm. These movements are not an issue of geotechnical concern, but continued monitoring is recommended.

The vertical data shows that 4 monuments indicated upward movements and 11 monuments had settlements of 2 mm or less (which is the stated survey accuracy). Three monuments showed incremental settlements greater than 2 mm (3, 4 and 6 mm). All monuments show total settlement since installation of 25 mm or less. In order to better assess the settlement data, plots of historical settlement have been prepared as Figures 5 to 7.

From this data, the following general observations are made:

- SP-2, SP11-1 SP11-3 and SP11-4 show patterns of annual settlement equal to a few millimetres per year.
- SP-5 (crest) and SP-11 (bench) show incremental upward movements since installation. The rates of movement are small.

These movements are not an issue of geotechnical concern, but continued monitoring is recommended.

4.3.3 Stability/Lateral Movement

Table 4 above presents total settlement and horizontal displacement for all monuments. The observed movements are low and do not indicate continuous lateral progression, which could be indicative of significant embankment movement. The measured values are less than triggers that would result in dam safety concern, but annual monitoring should continue.

4.3.4 Discharge Flows

Seepage flow was measured through a series of 4 V-notch weirs installed at the toe of the dams between 1997 and 2003. Table 5 presents measured flow rates at V-notch weirs as provided by Teck in 2018. The table also presents observations and visually estimated seepage rates during the dam safety inspection.

Table 5: Measured Flow Rates at V-notch Weirs and Estimated Seepage Rates in 2018

Location	Dam	Flow (point measurements)
V-notch 1	2B	0.21 – 0.75 L/s (calculated and provided by Teck). Water was clear
V-notch 2	2B	0.31 – 0.91 L/s (calculated and provided by Teck). Water was clear
V-notch 3	1A	0.21 – 0.55 L/s (calculated and provided by Teck). Water was clear
V-notch 4	1C	0.75 – 2.44 L/s (calculated and provided by Teck). Water was clear
1	1A	See V-notch 3
1A	1A	Puddle, no flow
1B	1A	Puddle, no flow
1C	1A	Puddle, no flow
2	1B	Puddle, no flow
2A	1B	Puddle, no flow
2B	1B	Puddle, no flow
3	1B	Puddle, no flow
3A	1B	Puddle, very low flow, clear

Table 5: Measured Flow Rates at V-notch Weirs and Estimated Seepage Rates in 2018

Location	Dam	Flow (point measurements)
3B	1B	Puddle, no flow
4	1C	Puddle, very low flow, clear
4A	1C	Puddle, no flow
5	1C	Puddle, very low flow, clear
6	1D	Puddle, no flow
7	1D	Humid, no flow nor water accumulation, located far from the main dam body
8	1E	Humid, no flow
9	2A	Standing water pond, flow cannot be assessed
10	2B	Puddle, very low flow, clear
11	2B	Puddle, very low flow, clear
12	2B	Puddle, low flow, clear
13	2B	Stagnant, low flow, see V-notch 2
14	2B	Dry
15	4B	Puddle, no flow
16	4B	Puddle, no flow
17	4B	Standing water pond, very low flow, clear
18	4B	Dry

Figure 8 shows the historical trend of seepage flow measurements at these V-notch weirs since their installation. The figure indicates that seepage flows measured at the end of 2017 and during 2018 were generally consistent with previous historical trends. VN-1 and VN-4 show a significant increase at the end of 2018. It is not the first time that such an increase was measured on site. For the 2018 year, this increase might be caused by the heavy rainfall events that occurred in autumn.

The sum of the measurable flows (~2,9 L/s) is approximately 35% of the expected seepage rate from the 1993 design studies and as assumed in the water balance. This is therefore considered to be within the expected range and does not indicate a dam safety concern.

4.4 Pond and Discharge Water Quality

Water discharge quality is presented in the Louvicourt annual environmental report (Suivi environnemental post-restauration) submitted by March 31 of each year to le Ministère de l’Environnement et Lutte contre les changements climatiques du Québec.

4.5 Site Inspection Forms

The routine inspection forms completed by site reconnaissance staff were reviewed by the EoR. Based on those forms, no issues of potential geotechnical concern were observed in the regular inspections.

5.0 DAM SAFETY ASSESSMENT

5.1 Design Basis Review

5.1.1 General

The Dams 1A through 1E, and 2A and 2B are comprised of a till core with rockfill/sand and gravel shoulders, a filter zone along the downstream face of the core and a drain along the base of the dam. Geotextile was placed beneath the shoulders and rip-rap protection layer. Dam height varies along the length of the alignment and ranges from a couple of metres near the abutments up to approximately 18 m in the deeper valleys of Dam 1 and Dam 2. The upper upstream and downstream faces are typically sloped at 2.5H to 1V and 2H to 1V respectively, with upstream and downstream stability berms constructed to approximately the mid height of the dams within the deeper valley sections. The stability berms reduce the overall slope to between about 3.5H:1 to as much as 7H:1V.

The tailings pond level is controlled by a concrete overflow weir located at the south abutment of Dam 1E. Stoplogs were initially used during mine operations to control the pond level. These stoplogs were replaced after closure with mass concrete to form the weir at elevation 316.1 m, including an extra 0.1 m provided by a wood plank. Flood inflows into the tailings facility could be routed through a 5 m wide concrete spillway located adjacent to the overflow weir and set at elevation 316.3 m. In case of blockages of the weir and first spillway, flood inflows would be routed through a second emergency spillway located approximately 170 m north of the concrete overflow weir spillway. The emergency spillway has a single 5 m wide trapezoidal shaped concrete sill at elevation 316.5 m with 2H:1V side slopes. All flows through the overflow weir and either of the spillways report to the downstream polishing pond.

The polishing pond was built in the fall of 1995 and completed in the spring of 1996. The design of Dam 4B is similar to Dams 1 and 2. Dam 4A is built on higher ground and currently does not retain any water. Outflow from the polishing pond passes over aluminium stoplogs embedded into a concrete structure. The water level is currently controlled at elevation 306.54 m.

Information concerning the geology, stratigraphy, and groundwater conditions is presented in Golder's report (Golder 1993). The tailings facility has not been raised since its original construction.

Routine inspections have been carried out since closure in 2005. Monthly inspections are performed by walking the crest of the dams, while weekly inspections are done by driving the dams at low speed and inspecting the spillways.

Dam Safety Inspections (DSI) are performed yearly and Dam Safety Reviews (DSR) are performed every 5 years. The next DSR should be completed next year, in 2020.

5.1.2 Tailings Pond Dams (Dams 1 and 2)

The combined length of all five segments of Dam 1 is 1,650 m. Dam 1 has an average height of 8 m and a maximum height of 18 m. The combined length of the two segments of Dam 2 is 880 m. Dam 2 has an average height of 10 m and a maximum height of 18 m. A typical cross-section of the dams is shown in Figure 2. Dam crests within the central portion of Dam 1D and part of Dam 2B were intentionally built 1 m higher than the design elevation to compensate for anticipated settlement at these locations.

Vibrating wire piezometers and an inclinometer were used to monitor dam behaviour during construction and shortly after. These instruments are no longer operational. Current instrumentation at the tailings pond dams consists of 4 piezometers, 4 V-notch weirs and 15 survey monuments. Other observation wells (5) are located further downstream from the dams and are used to monitor water quality. The locations of the instruments are shown in Figure 1.

5.1.3 Polishing Pond Dam (Dam 4B)

The polishing pond was operated until 2011 at an elevation consistently lower than the design pond elevation of 309.0 m. The pond has since been operated at elevation 306.54 m. The design of Dam 4B is similar to that of Dams 1 and 2.

Current instrumentation at the polishing pond consists of 1 observation well and 4 survey monuments located on the crest and toe berm of the dam. The locations of the instruments are shown in Figure 1.

5.1.4 Dam Design Parameters

The design geometry of the dams is summarized in Table 6.

Table 6: Design Geometry

Item	Design Value
Upstream Slope	2.5 H:1V
Crest Width	8 m
Downstream Slope	2.0 H:1V (inter bench, without considering downstream berms)
Minimum freeboard (from dam crest)	2.0 m at tailings pond 1.5 m at polishing pond
Maximum level of tailings (below dam crest)	3.0 m
Minimum crest elevation of Dams 1 and 2 at the tailings area	318.0 m with parts of Dams 1D and 2B at 319.0 m
Minimum crest elevation of Dam 4B at the polishing pond	310.5 m

5.1.5 Subsurface Conditions

The dams of the tailings facility are located in a valley between bedrock outcrops of relatively high elevation. The tailings pond dams were constructed between the local bedrock outcrops to reduce overall fill requirements.

Geotechnical investigations indicate that subsurface conditions at the site are typically include the following layers:

- Surficial layer of topsoil/peat typically 100 mm to 300 mm thick.
- Overburden soils comprising layers of alluvial/lacustrine silty clay to clayey silt with consistencies ranging from soft to very stiff. A weathered upper crust of stiff clay was observed in most of the profiles, underneath which

the consistency of the soils generally significantly decreases. Silty clay and clayey silt materials typically grade to a silt material with depth and in some cases to silty sand.

- A basal glacial till layer typically ranging from silt to silty/gravelly sand in a medium dense to dense state.
- Underlain by granodiorite bedrock.

5.1.6 Embankment Fill Materials

The tailings dams and polishing pond dam are zoned earthfill embankment structures, constructed of compacted till core with a filter zone along the downstream face of the core and a drain along the base of the dams and rockfill/sand and gravel shoulders, as shown in the typical section presented in Figure 2.

Updated material properties for the tailings, the embankment fill materials and subsurface materials were used in the 2005 DSR (SNC-Lavalin, 2005). These material properties are listed in Table 7.

Table 7: Update Design Material Properties (SNC-Lavalin, 2005)

Material	Unit Weight (kN/m^3)	Total Stress Strength		Effective Stress Strength	
		Cohesion (kPa)	Friction Angle (degrees)	Cohesion (kPa)	Friction Angle (degrees)
Sand and gravel (Dams 1 and 2)	23 - 24*	-	-	0	35
Sand and gravel (Dam 4)	20.8 - 22.6*	-	-	0	35
Sand filter	20	-	-	0	35
Till (Core)	22 - 22.7*	-	-	0	35
Clay	15 – 16.5	30 – 85	0	0	26 – 29
Till (Foundation)	18.5 – 19	-	-	0	30 – 35
Tailings within the tailings pond	16	-	-	0	30

* Saturated Unit Weight.

Based on a re-assessment of the tailings (Golder 2018b), the saturated unit weight for the tailings should be revised to 21.3 kN/m^3. Stability analyses are being performed to evaluate the impact this may have on dam stability.

5.1.7 Seismicity

The seismicity values for the site were estimated by SNC-Lavalin in the 2005 DSR (SNC-Lavalin, 2005) and reviewed by Klohn Crippen Berger as part of the 2010 DSR (Klohn Crippen Berger, 2011). Both evaluations were based on the 2005 version of the National Building Code. The predicted peak ground accelerations (PGA) on very dense soils at the corresponding return period are summarized in the following table.

Table 8: Site Seismic Hazard Values from 2010 DSR (adapted from Klohn Crippen Berger, 2011)

Structure	Return Period (Years)	PGA[1] (g)
Tailings Pond Dams	1 in 10,000	0.23
Polishing Pond Dam	1 in 2,500	0.12

Note: [1] For ground site class '"C": very dense soil and soft rock foundation.

5.2 Hazards and Failure Modes Review (Assessment of Dam Safety Relative to Potential Failure Modes)

As a required component of the DSI, the key hazards and failures modes have been identified and assessed. This section reviews the dam safety implications of the instrumentation data and the September 10, 2018, site observations relative to potential failure modes. The design basis relevant to each of the typical potential failure modes is also presented.

5.2.1 Internal Erosion

Dam internal instability can be caused by materials migrating out of the dam via seepage, leaving voids. This generally happens with materials that do not have filter compatibility; that is, the fines fraction of one material can migrate into or through the voids of the adjacent material under a sufficient hydraulic gradient. Piping is caused by regressive erosion of particles towards an outside environment until a continuous pipe is formed.

Design Basis

Filter compatibility was established by Golder during the initial design phase of the structures (Golder, 1993). The initial design considered piping criteria based on grain size distributions of the till core and adjacent sand drain, and between the sand drain and the gravel located at the toe drain. Filter compatibility was briefly commented upon in section 3.4 of the SNC-Lavalin (2005) dam safety review and was described to have been set with "*conservative limits*".

Instrumentation and Observed Performance

The position of the V-notch weirs and seepage locations is shown on Figure 1. Table 5 presented measured flow rates and visually estimated seepage flows. Water flowing from the toe drains, the seepage points, and the V-notch weirs was clear and did not contain visible suspended particles. Flow rates were generally low and within the expected range.

No zones of subsidence or any sink holes were observed, the presence of which would indicate voids due to piping. No evidence of internal erosion was observed. It was concluded that no significant internal erosion was occurring which could threaten the integrity of the structures.

5.2.2 Instability

Design Basis and Subsequent Reviews

Stability analyses were conducted during the original design phase of confinement dams (Golder, 1993). The original dam geometry was established to meet a minimum factor of safety of 1.5 under end of construction conditions and operational conditions. Seismic analysis of the dams was performed at that time using a 1:1,000 year seismic acceleration. The seismic value was modulated based on a one-dimensional soil response analysis of the soil column. The resulting horizontal ground acceleration was used in a pseudo-static stability analysis. Results showed factors of safety slightly greater than 1.1 for all dams. It is noted that the original stability analyses used Bishop's method of analysis, which was common at the time. Bishop's method is not as rigorous as currently used methods and it is therefore not valid to compare these results to modern compliance criteria.

Based on the results of the original 1992 field investigation, the 2005 DSR (SNC-Lavalin, 2005) confirmed a minimum factor of safety value of 1.3 for long term operational conditions, except for Dam 1D. This led to the widening of Dam 1D downstream berm in 2005. The 1.3 factor of safety was considered adequate for the long term operational condition. A post-closure target factor of safety of 1.5 was recommended. The seismic analysis contained in the 2005 DSR used seismic values for a 1:10,000 year seismic event and also performed a one-dimensional soil response analysis to account for the presence of a soil column. The resulting horizontal ground acceleration was used in a pseudo-static stability analysis. Results confirmed factors of safety slightly greater than unity for all dams. The liquefaction potential analysis indicated that localized zones of relatively low density till present in dam foundations could potentially be liquefiable in the case of the design earthquake. Post-liquefaction analyses have confirmed that if these zones should liquefy, the dams would remain stable.

The 2010 DSR (Klohn Crippen Berger 2011) included a preliminary liquefaction and cyclic softening screening assessment based on the results of the original 1992 field investigation. The 2010 DSR concluded a more extensive presence of potentially liquefiable materials than estimated previously by SNC-Lavalin in 2005. A preliminary stability assessment concluded that post-liquefaction factors of safety for a typical section of the tailings dam do not meet current recommended guidelines. Further field and laboratory studies were recommended.

Golder performed a supplemental liquefaction assessment and post-liquefaction stability analyses in 2013 (Golder 2013). Based on the 1992 geotechnical field data, the analysis indicated that there is a potential for the silt stratum below Dam 1C and Dam 2B to liquefy under the design seismic event. For a low bound shear strength value of the liquefied silt layer, Dam 2B was predicted to have factors of safety of less than 1. However, these analyses did not account for consolidation that may have occurred subsequent to dam construction, and it was noted that the field investigation data did not include current techniques that did not exist in 1992. It was recommended that a focused geotechnical investigation program using current investigation methods be undertaken to update the analyses. The new field investigation was conducted in the fall of 2017 and subsequent analyses were underway while this report was being compiled. To support the stability analyses, a revised site-specific seismic hazard assessment has been completed.

Movement Monitoring Instrumentation

The Dam Safety Guidelines (CDA 2013) Section 3.6.3 recommends use of dam instrumentation to supplement the ongoing visual assessment of dam performance relative to potential failure modes. Section 4.3.2 presents a summary of settlement and horizontal movements measured and observed at the TSF.

Horizontal movements of the monuments listed in Table 4 remain relatively limited. However, some trends have been noticed and are commented on below:

- The survey is not done at the same period every year. Individual monuments show some trends that could be attributed to seasonal effects.
- Monuments present movement with amplitudes similar to the survey of 2017. Monument SP-11-6 on Dam 2B exhibits the largest total displacement at the site of 20 mm in the upstream direction.
- Incremental settlements (2017 to 2018) were generally less than 2 mm (which is the stated survey accuracy). The maximal incremental settlement was 6 mm for one instrument (SP-11-8).

- SP-2, SP11-1 SP11-3 and SP11-4 show patterns of annual settlement equal to a few millimetres per year. However, there is no sign of accelerating settlements and total settlements are relatively small (maximum of 25 mm). The other survey monuments present total settlements that have stabilized or that are variable through the years.
- SP-5 (crest) and SP-11 (bench) show incremental upward movements since installation. The rates of movement are small.

Vertical movements are noticeable on most monuments on a year to year basis, attributed to frost action and survey limitations. Monuments installed in 2011 seem to be more prone to these yearly movements than former monuments. Measured differences for monuments installed in 2011 are however small, the largest movement for this time interval (settlement of 24 mm) occurs at SP-11-3 located on Dam 4B.The magnitude of deformations indicated by the monitoring instrumentation do not present a dam safety concern but do warrant continued monitoring.

Measured differences in the elevation of the 2008 monuments are small, and with the exception of SP-2 (total settlement of 25 mm) no significant long-term trend can be detected for the 2008-2018 results. The magnitude of deformations indicated by the monitoring instrumentation do not present a dam safety concern but do warrant continued monitoring.

Observed Performance

Longitudinal cracks were reported to develop along the crest of Dam 1 during the last few winter seasons. One such crack was observed during the 2018 DSI conducted in September, however it had reportedly been dormant since the spring thaw. Golder (2015) inspected and analyzed the cracks and concluded that they were caused by frost action, exacerbated by eolian removal of snow on the upstream shoulder of the dam. No evidence to the contrary was observed at the time of the inspection.

It is likely that annual longitudinal cracking will continue. It may be necessary to undertake investigations to confirm that there is no associated risk to the integrity of the core. Continued monitoring of the cracks is required.

5.2.3 Overtopping

Design Basis

The dams of the tailings pond and polishing pond were originally designed with a 2.0 m freeboard and a 1.5 m freeboard respectively. During 2018, the freeboard varied between 1.81 and 1.90 m at the tailings area, and 3.30 to 3.92 m at the polishing pond. High water levels measured in the polishing pond in November 2018, which led to a freeboard of 3.3 m, are attributed to large rainfall events in September and October. Even though some settlement has occurred at Dam 1D as a result of consolidation of the clayey foundations, the freeboard is higher than the minimum requirement since parts of Dams 1D and 2B were originally built with an extra 1.0 m fill allowance to compensate for the anticipated settlement.

A review of freeboard was performed in the 2010 DSR (KCB, 2011) in accordance with CDA (2007) guidelines. Results indicated that wave run-up could reach an elevation less than or equal to 316.89 m in the TSF under normal and PMF conditions. Since this is below the existing crest elevation of nominally 318.0 m, it was concluded that protection against a wave overtopping condition was adequate for the tailings pond. As for the polishing pond, the current 3.78 m freeboard is considered to be more than adequate.

Flood routing was improved by the construction of a second emergency spillway at the tailings pond in 2005. SNC-Lavalin (2006) estimated that in the case where the operational spillway and the first emergency spillway were blocked by beaver activity, the second emergency spillway would be able to evacuate the 1:10,000 year storm event under a maximum pond elevation of 316.77 m. This level is close to the top of the till core but remains 1.23 m minimum below the dam crest elevation.

Instrumentation Data

The tailings pond water level was measured seven times in 2018. For the 2011-2018 period, the pond water elevations generally varied between a minimum value of 316.05 m in the fall months to a maximum value of 316.20 m (0.10 m head over the weir level) in spring time. The historical minimum levels were recorded in fall 2010 (315.17 m) and the maximum in fall 2009 (316.23 m). The minimum CDA freeboard requirements were maintained in 2017-2018.

Observed Performance

The water level within the tailings pond was 316.10 m during the visit. The freeboard at the time of the site inspection was greater than the minimum CDA freeboard requirements (KCB, 2011) and therefore did not present a safety concern. The presence of three spillways at the tailings pond and two spillways at the polishing pond provides a significant mitigation against overtopping potential.

5.3 Review of Downstream and Upstream Conditions

No changes to the overall conditions downstream of the tailings and polishing ponds have been reported to Golder, and observations made in the toe regions of the embankments support this conclusion. Placement of rip-rap material was completed along the upper portions of the Dams 1B and 1D side slopes. Upstream conditions only report to a very limited watershed. No changes to the watershed conditions have been reported to Golder.

5.4 Dam Classification Review

5.4.1 Previous Dam Consequence Classification

Dam consequence classifications are based on the consequences of failure irrespective of the likelihood of a potential dam failure and should not be mistaken with the risk of failure, which is a combination of likelihood and consequence. Klohn Crippen Berger assessed the dam consequence classification as part of the 2010 DSR report (Klohn Crippen Berger, 2011). Table 4 presents the dam classification criteria based on the CDA guidelines (CDA 2007). The classification of the dams at the tailings area (Dams 1 and 2) was established as “very high” to “extreme”. The classification of Dam 4B at the polishing pond was established as “high”. The tailings facility dams were classified in the “very high” to “extreme” consequence categories because the population at risk includes permanent residents in houses located within the floodway, for which the potential loss of life is estimated to be from 10 to in excess of 100. It is noted, however, that the population at risk was estimated without the benefit of a dam breach analysis, and therefore the classification must be considered qualitative.

Table 9: Dam Classification in Terms of Consequences of Failure Table (taken from Klohn Crippen Berger, 2011 and based on CDA 2007)

Dam Class	Population at Risk[(a)]	Incremental Losses		
		Loss of Life [(b)]	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short-term loss. No long-term loss.	Low economic losses; area contains limited infrastructure or service.
Significant	Temporary Only	Unspecified	No significant loss or deterioration of fish or wildlife habitat. Loss of marginal habitat only. Restoration or compensation in kind highly possible.	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes.
High	Permanent	10 of fewer	Significant loss or deterioration of important fish or wildlife habitat. Restoration or compensation in kind highly possible.	High economic losses affecting infrastructure, public transport, and commercial facilities.
Very High	Permanent	100 of fewer	Significant loss or deterioration of critical fish or wildlife habitat. Restoration or compensation in kind possible but impractical.	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances).
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat. Restoration or compensation in kind impossible.	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances).

Source: CDA (2007)

(a) Definition for population at risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

(b) Implications for loss of life:

Unspecified – The appropriate level of safety required a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

An inundation study for the tailings facility was subsequently completed by SNC-Lavalin (SNC-Lavalin, 2012) based on CDA 2007 guidelines. The study considered two potential failure scenarios and assessed the resulting impact on downstream receptors. The results indicated the consequence classification for the tailings pond dams was “very high”. The classification was governed by the environmental consequences of a dam breach, that would produce impacts in the Bourlamaque River which are impractical to restore. The reduction from “extreme” to “very high” was a result of the reduction of the estimated population at risk in the event of a dam breach. A new dam breach analysis is in progress at the time of preparation of this report.

5.4.2 Review

No new elements are available to support dam classification modification, however it is noted that a new dam breach analysis is in progress at the time of preparation of this report, which may result in a change in classification. Class levels as determined by the 2012 dam breach analysis (SNC-Lavalin, 2012) should be maintained for this DSI.

5.5 Physical Performance

The overall performance of the Louvicourt tailings and polishing ponds is good. None of the observations made during the inspection are estimated to have a significant negative impact on their current performance. The review of the instrumentation readings presented in Section 4.3 did not show displacement or settlement that could indicate significant impact on physical stability.

Sections 4.1 and 6.6 present the most noticeable areas of improvement and the identified recommended actions in view of supporting the facility performance in the longer term. It is to be considered that the outcome of the stability analyses at Dams 1C and 2B should be considered in defining if additional instrumentation is required.

5.6 Operational Performance

The Louvicourt tailings facility is closed and there are no activities related to tailings disposal or operation of the ponds.

5.7 OMS Manual Review

The Operation, Maintenance and Surveillance (OMS) Manual for the tailings management facility was updated in March 2017 (Golder, 2017). A new version of this document shall be completed in Q4, 2019.

5.8 Emergency Preparedness and Response Review

An Emergency Preparedness and Response Plan (EPRP) for the tailings facility was finalized in 2017. Golder reviewed the version published on March 22, 2019. The EPRP is a thorough document, which has recently been updated.

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Construction and Operation/Maintenance Activities

Placement of rip-rap material was completed along the upper portions of the Dams 1B and 1D side slopes. This was done according to the recommendations provided after the 2015 DSI (for Dam 1D) and 2017 DSI (for Dam 1B). The access bridge located near the active spillway of the tailings storage facility was rebuilt. No other construction or operation occurred in 2018. The maintenance and surveillance activities performed in 2018 included the following:

- Routine inspections
- Survey of monuments
- Removal of vegetation in the emergency spillways
- Removal of debris in the polishing pond active spillway canal

- Cleaning of the access paths to the toe of Dams 1A, 1B, 1C and 4D

6.2 Summary of Climate and Water Balance

The 2017/2018 winter precipitation generally remained below monthly multi-annual averages although the annual total was 12% higher than average due to high rainfall events in September and October. Specifically, September (180.7 mm) and October (168.1 mm) 2018 were very wet months (respectively 78% and 100% higher than the average).

Based on a high-level water balance analysis, it was estimated that 0.69 million m^3 of water were discharged to the polishing pond via the spillway.

6.3 Summary of Performance

The overall performance of the Louvicourt tailings and polishing pond is good and does not require major works or corrections. All actions recommended in Sections 6.6 aim at obtaining a good long-term performance or improving the overall understanding of potential long-term stability issues.

6.4 Summary of Changes to Facility or Upstream and Downstream Conditions

Placement of rip-rap material was completed along the upper portions of the Dams 1B and 1D side slopes. No other changes were reported to or observed by Golder regarding the facility itself, or the upstream and downstream conditions.

6.5 Consequence Classification

No changes are recommended to the consequence classification of the facility. A dam breach analysis is in progress, which may result in a change to the classification.

6.6 Table of Deficiencies and Non-Conformances

Review of Previous Deficiencies and Non-Conformances

The Dams at the tailings pond and polishing pond were globally observed to be in a good condition at the time of the 2018 site visit. No significant changes were noted in the condition of the dams since the 2017 DSI, except for the addition of the rip-rap material on the upper portions of the Dams 1B and 1D side slopes. Deficiencies and non-conformances noted during the DSI and their status are presented in Table 10.

Table 10: Status of Dam Safety Inspections Key Recommended Actions

Structure	ID	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline/Status
Previous Recommendations Closed / Superseded						
Dam 1D	2015-02	Existing rip-rap material on the upstream face has degraded and ravelled downslope.	CDA 2007 Section 3.5.3	Place new rip-rap material along the upper portions of the dam side slopes, starting with the upstream face.	2	CLOSED- Completed Sept 2018
Dam 1D	2016-05	Water flow trajectory at tailings pond second emergency spillway	CDA 2013 Section 3.5.5	Extend downstream earth berm	4	SUPERCEDED by 2018 inspection recommendation
Dam 1B	2017-01	Existing rip-rap material on the upstream face has started to degrade	CDA 2013 Section 3.5.3	Place new rip-rap material along the upper portions of the dam side slopes	2	CLOSED- Completed Sept 2018. Assessment of rip-rap size completed Q1 2019.
Previous Recommendations Ongoing						
All	2015-06	Perform a review of dam's seismic stability and liquefaction conditions	Directive 019 Section 2.9.3	Perform a review of dam's seismic stability and liquefaction conditions	4	IN PROGRESS- Investigation completed Q4 2017; analyses in progress Q2 2019; scope change and addition of seismic hazard assessment resulted in completion delay
2018 Recommendations						
Dam 1E	2018-01	Debris in the tailings pond spillway	OMS Manual Section 6.2	Remove debris from spillway	3	CLOSED - Q4 2018 (Completed)
Dam 1E	2018-02	Trash rack at inlet to the tailings pond spillway is damaged	OMS Manual Section 6.2	Repair trash rack	3	Q4 2019

Structure	ID	Deficiency or Non-conformance	Applicable Regulation or OMS Reference	Recommended Action	Priority	Recommended Deadline/Status
Dam 1D	2018-03	Access road at outlet of second emergency spillway is susceptible to erosion	CDA 2013 Section 3.5.5	Undertake erosion analysis to assess risk to embankment integrity. If required, install slope protection across the road and outlet channel, to route potential spillway flow away from the embankment.	3	Q4 2019
Dam 2A	2018-04	Beaver activity downstream of Seepage pt. 9 causing higher accumulation of water adjacent to Dam 2A	CDA 2007 Section 3.5.8	Control beaver activity and remove beaver dam	2	Q2 2019

Priority (defined by Teck Resources)	Description
1	A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice – Further improvements are necessary to meet industry best practices or reduce potential risks.

Note: Priority description categories are consistent with Mining Association of Canada (MAC) guidelines.

7.0 CLOSURE

We trust that this report meets your present requirements. If you have any questions or requirements, please contact the undersigned.

Golder Associates Ltd.

Nicolas Pépin, P.Eng., M.Sc.A.
Geotechnical Engineer

Laurent Gareau, P.Eng., M.Sc.
Principal, Senior Geotechnical Engineer

NP/LG/rd/cd

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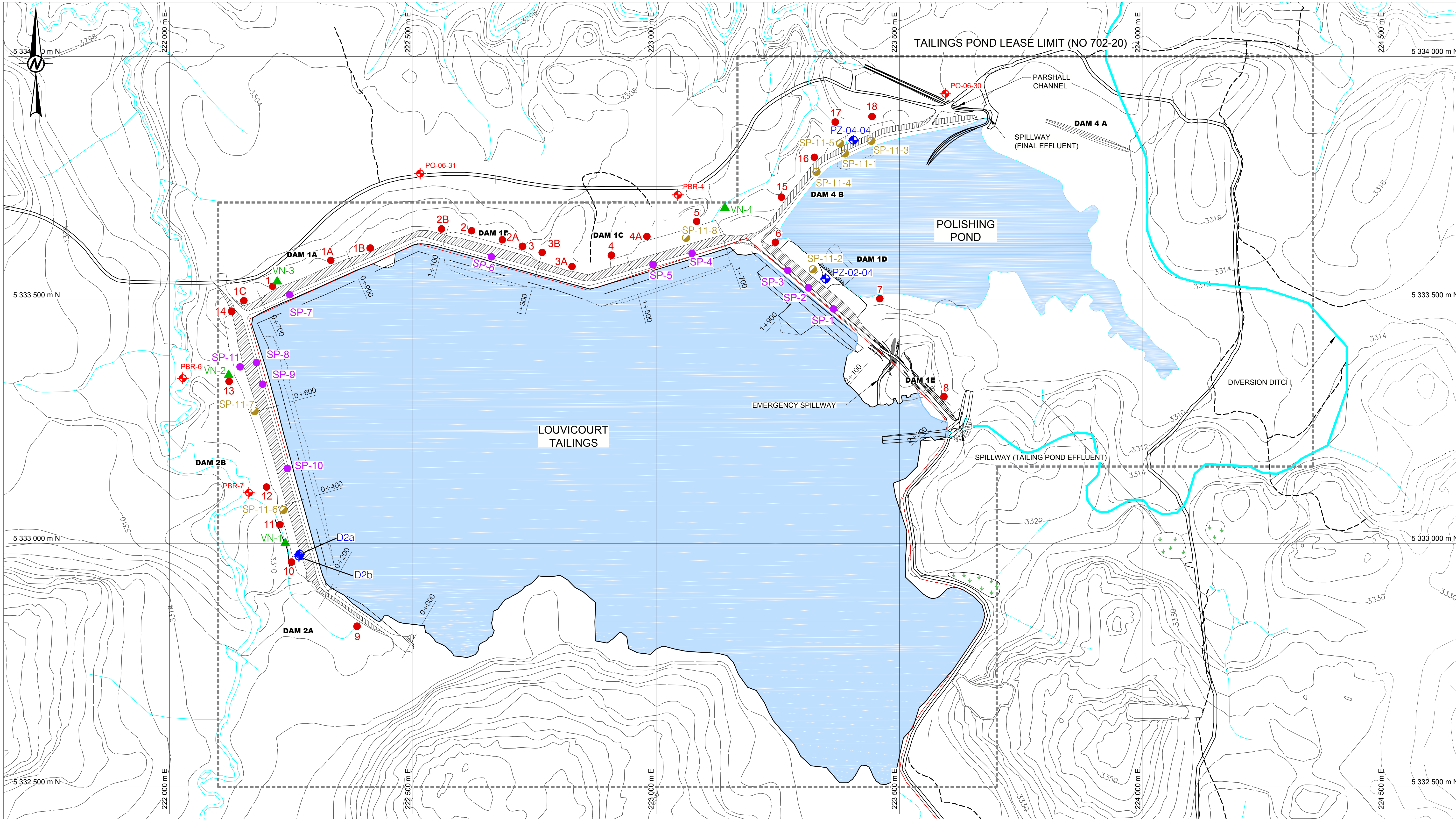
Figures



LEGEND

PIEZOMETER	SETTLEMENT POINT (GOLDER, 2011)
V-NOTCH WEIR	DOWNSTREAM FACE OF DAMS
SEEPAGE AREA	OBSERVATION WELLS
SETTLEMENT POINT	

0 125 250
1:7 500 METRES

CLIENT
TECK
MINE LOUVICOURT

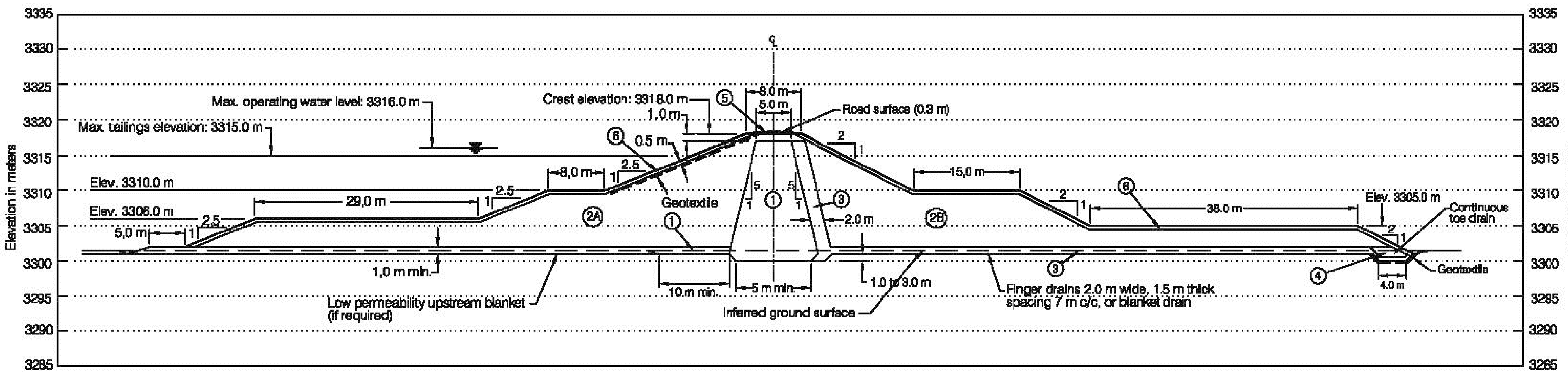
PROJECT
LOUVICOURT MINE TAILINGS POND

CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-20
DESIGNED	S. Betnesky
PREPARED	N. Pépin
REVIEWED	N. Pépin
APPROVED	L. Gareau

TITLE
GENERAL SITE PLAN

PROJECT NO.	PHASE	REV.	FIGURE
18102172	-	0	1



Legend:

1. Till core
2A. Pit-run sand or sand and gravel upstream shell
2B. Sand or sand and gravel downstream shell
3. Processed filter sand
4. Toe drain - processed gravel
5. Road surface
6. Quarried rock

CLIENT	TECK MINE LOUVICOURT
PROJECT	LOUVICOURT MINE TAILINGS POND
CONSULTANT	GOLDER
YYYY-MM-DD	2019-02-20
DESIGNED	S. Betnesky
PREPARED	N. Pépin
REVIEWED	N. Pépin
APPROVED	L. Gareau
TITLE	TYPICAL DIKE CROSS-SECTION
PROJECT NO.	18102172
PHASE	-
REV.	0
FIGURE	2

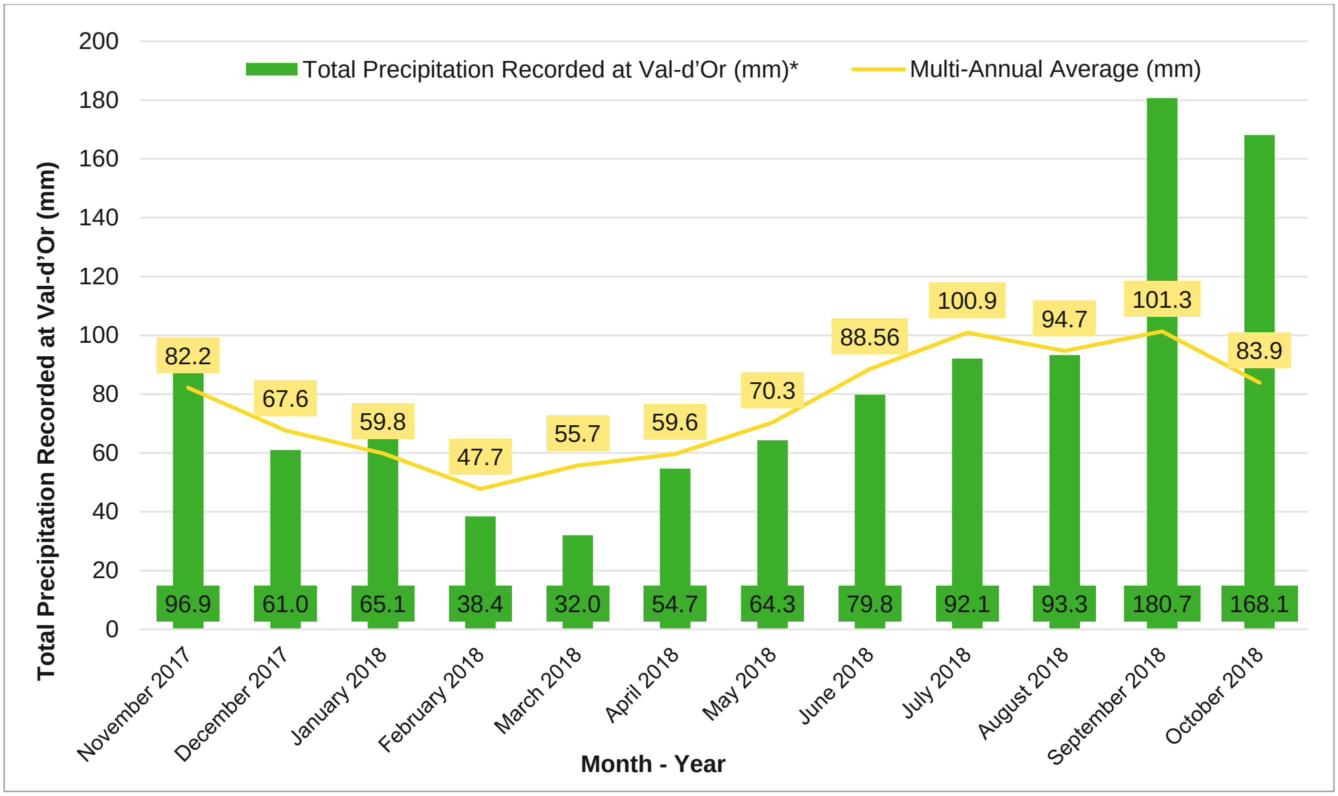
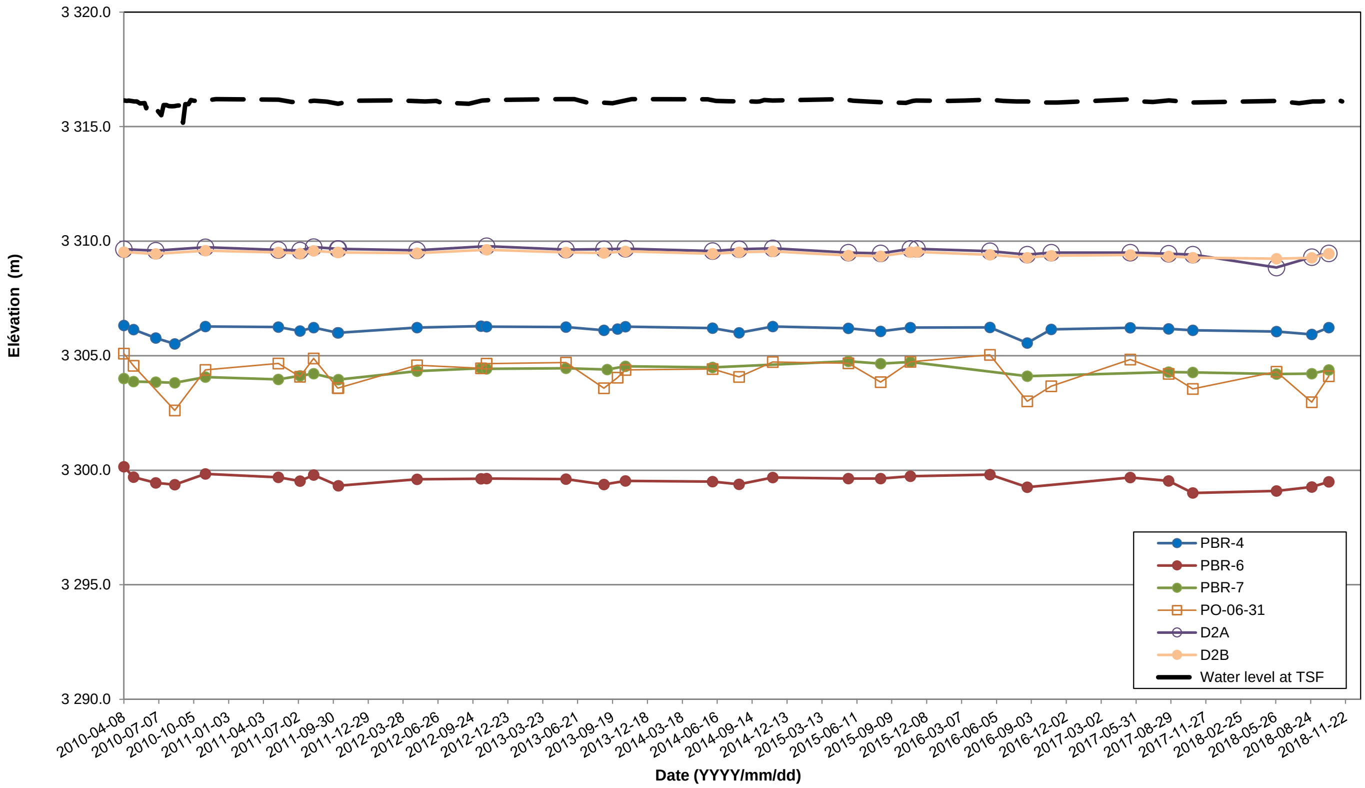
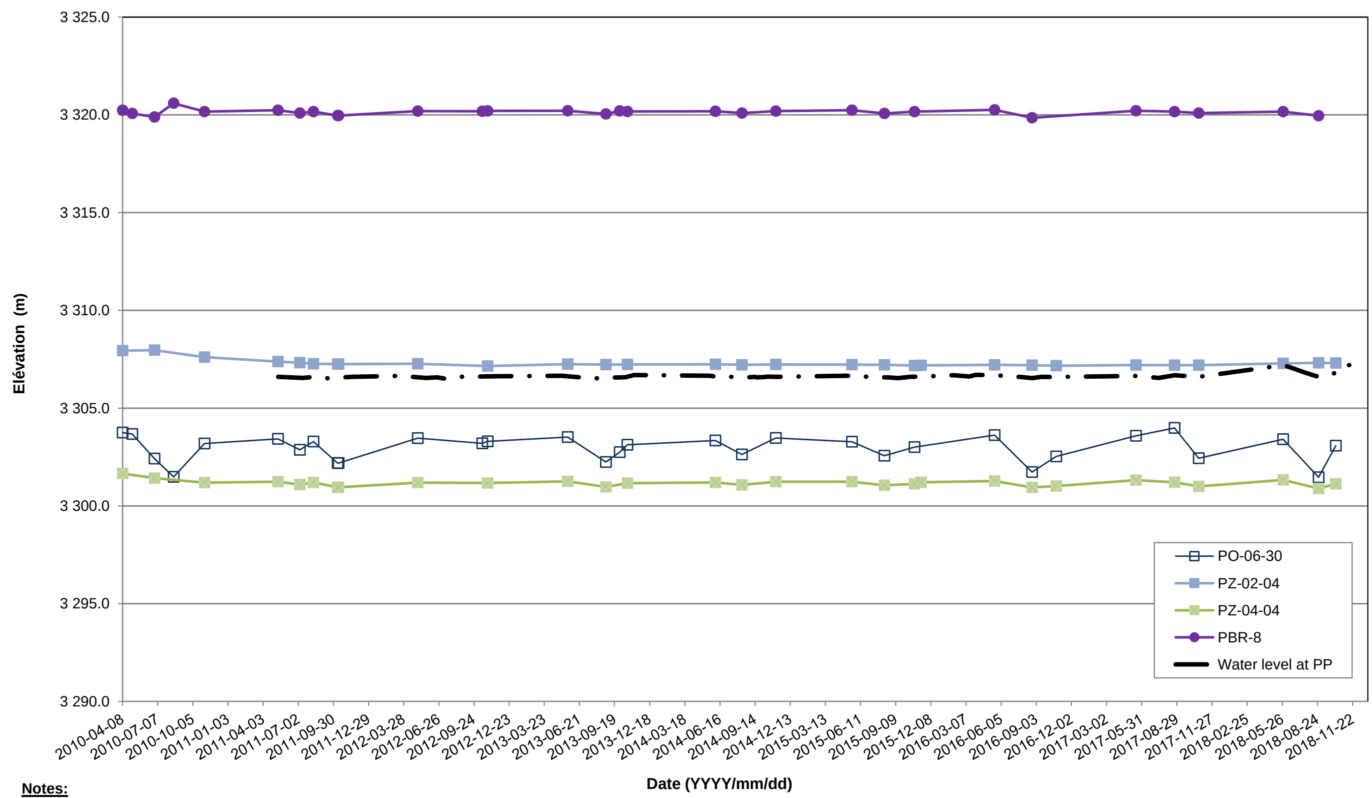


Figure 3: Monthly Precipitation Data from November 2017 to October 2018





Notes:
TSF : Tailings storage factiliy of Louvicourt mine
PP : Polishing pound of the Louvicour mine
PBR-8 : This well is located in the upstream of the TSF

Teck	**DSI 2018**	**Water level measurements - piezometers (provided by Teck)**					
		CONFIDENTIAL					
	Louvicourt TSF	DRAWN BY:	BZ	DATE	2018-12-31	PROJECT No:	18102172
	Teck Resources Ltd	VERIFIED BY:	RO	DATE	2018-12-31		
		REVIEWED BY:	RO	DATE	2018-12-31	FIGURE:	**4**

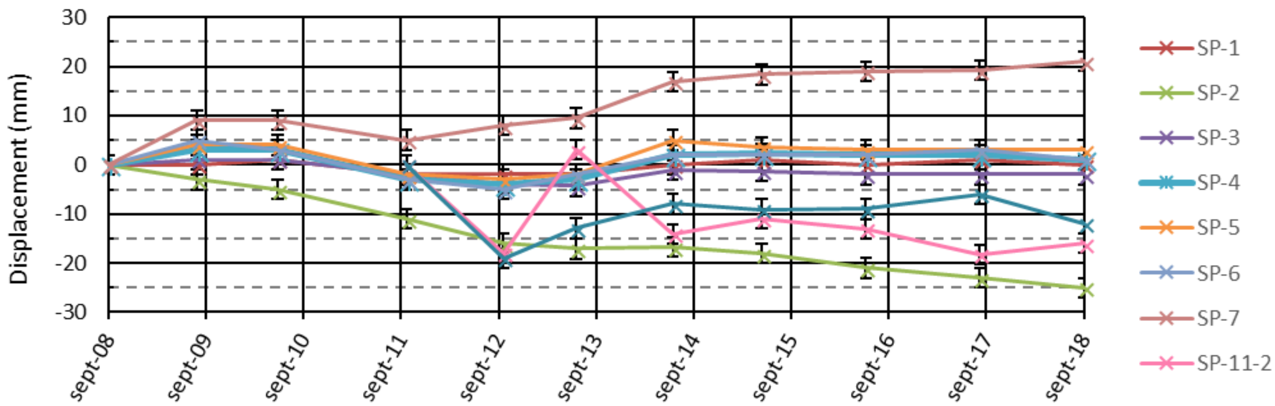


Figure 5: Vertical Displacement of the Survey Monuments at Dam 1

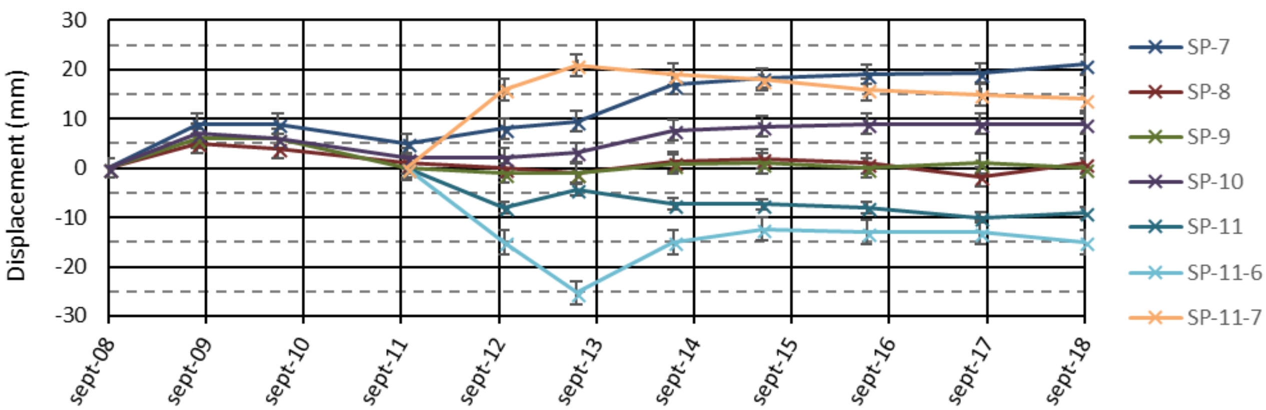


Figure 6: Vertical Displacement of the Survey Monuments at Dam 2

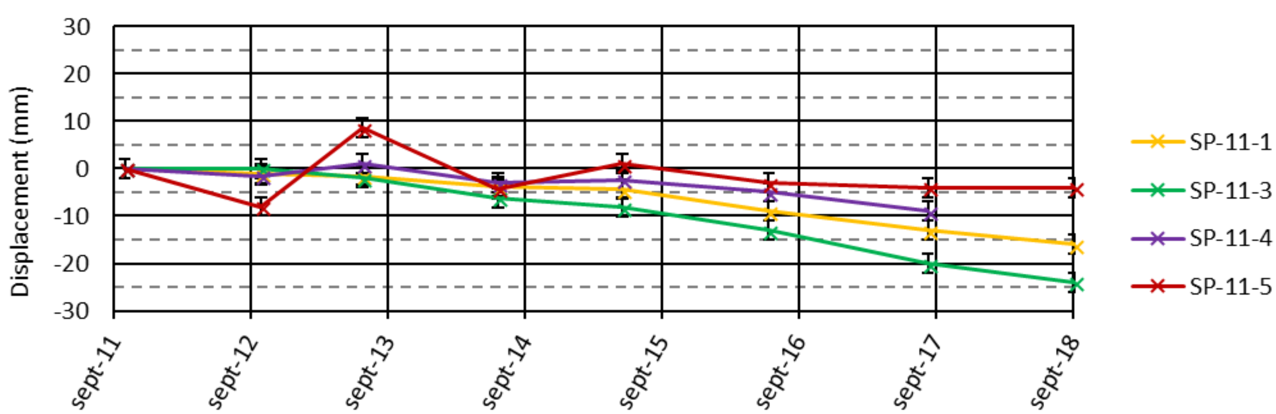
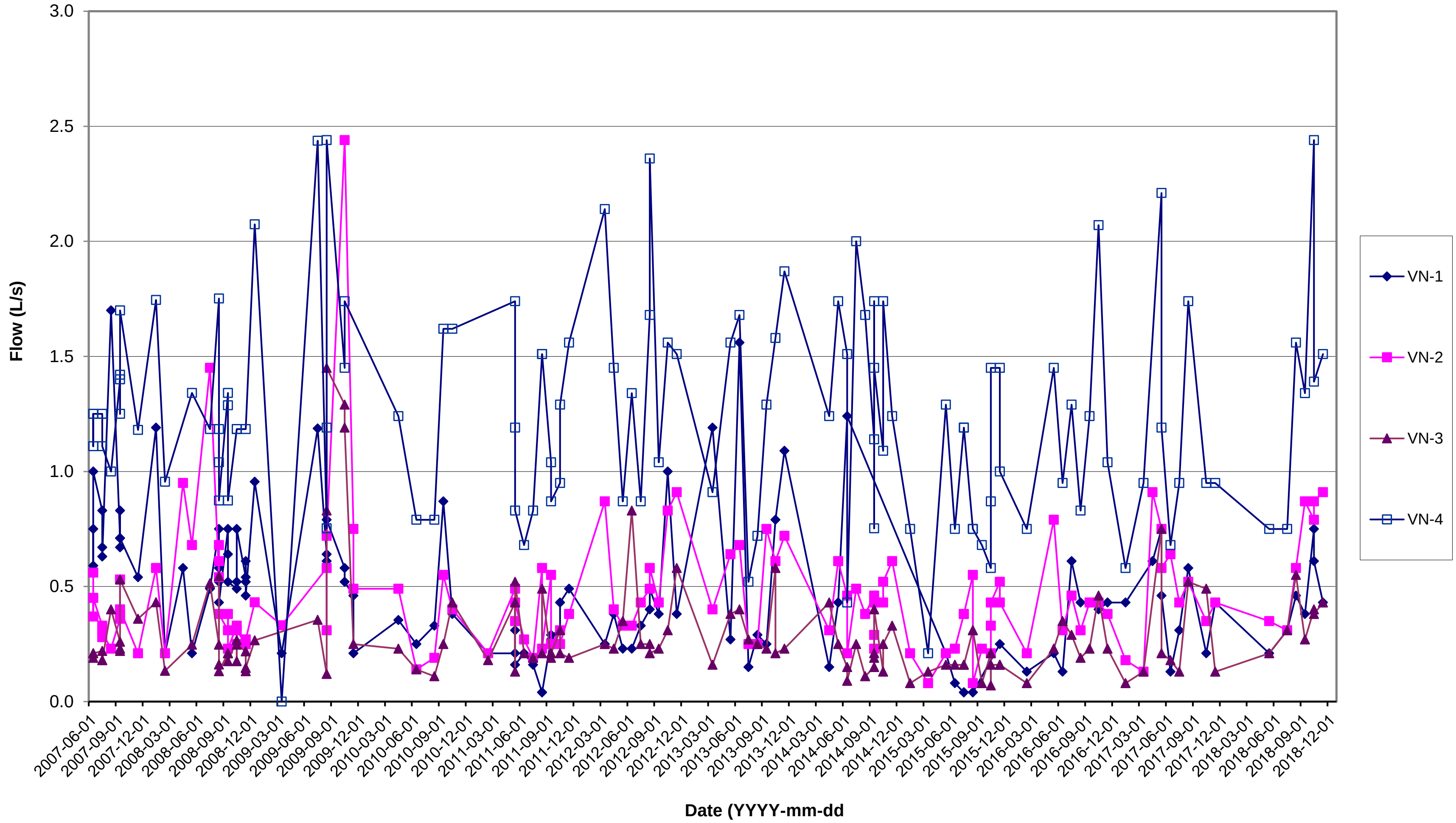


Figure 7: Vertical Displacement of the Survey Monuments at Dam 4



Teck	DSI 2018	Louvicourt Mine Tailings Pond - historical trend of seepage flow measured at the V-notch weirs CONFIDENTIAL					
	Mine Louvicourt Teck Resources Ltd	DRAWN BY:	BZ	DATE	2019-02-12	Project No.:	18102172
		VERIFIED BY:	RO	DATE	2019-02-12		
		APPROUVED BY:	ÉG	DATE	2019-02-12	FIGURE:	8

APPENDIX A

Facility Data Sheet

Facility Data Sheet

Mine TSF Dam

Dam 1

Dam Type	Till core, rock shell
Maximum Dam Height	13 m
Dam Crest Width	5 m
Impoundment Area	~1,000,000 m^2
Volume of Tailings	~6,500,000 t
Reservoir Capacity	~1,700,000 m^3 (to max spring pond elevation)
Consequence Classification	Very high
Inflow Design Flood (IDF)	PMF
Design Earthquake	1:10,000
Spillway Capacity	Combined 12.7 m^3/s at 317.0 m water level
Catchment Area	~2,100,000 m^2
Access to Dam	From crest of dam

Dam 2

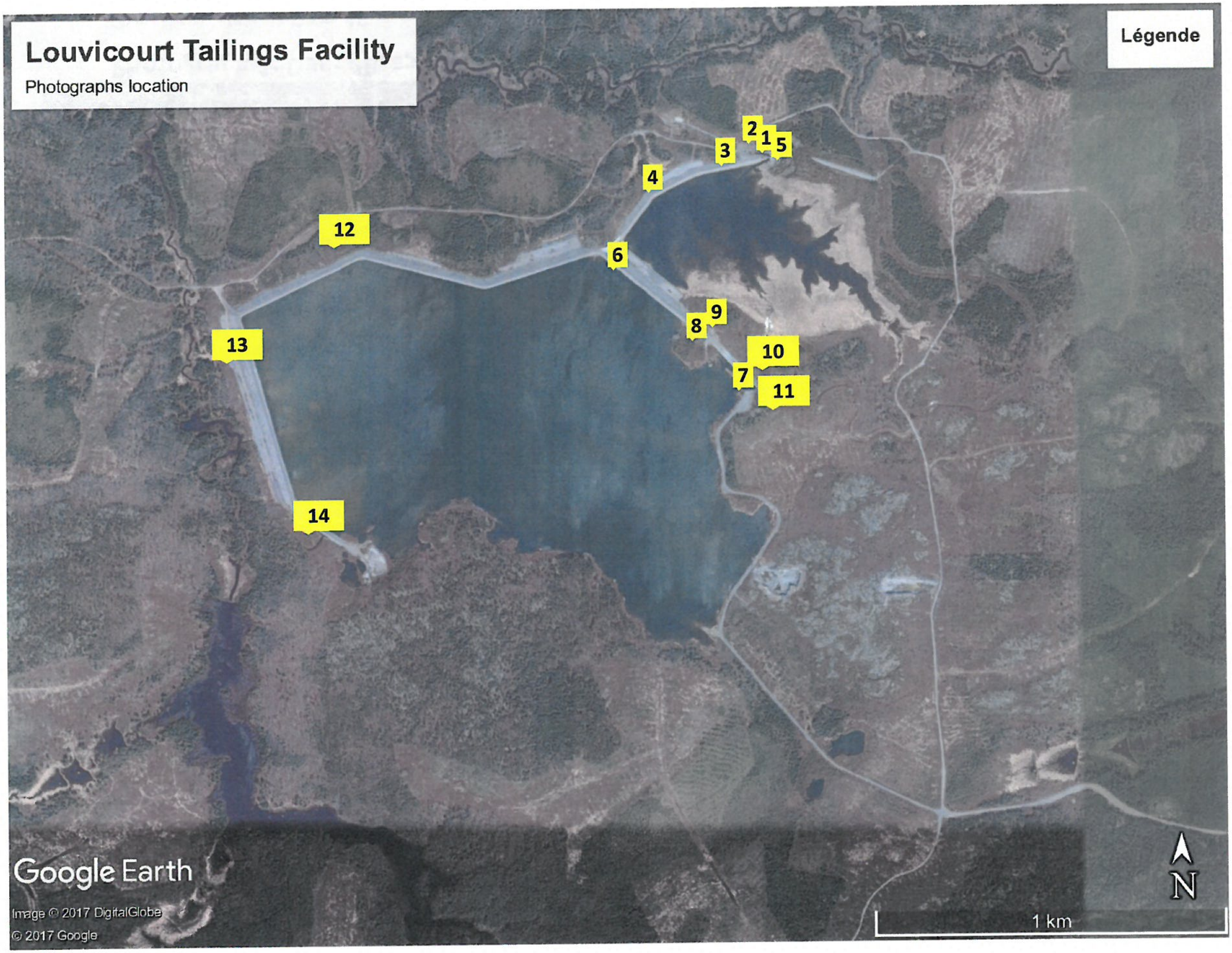
Dam Type	Till core, rock shell
Maximum Dam Height	15 m
Dam Crest Width	5 m
Impoundment Area	~1,000,000 m^2
Volume of Tailings	~6,500,000 t
Reservoir Capacity	~1,700,000 m^3 (to max spring pond elevation)
Consequence Classification	Very high
Inflow Design Flood (IDF)	PMF
Design Earthquake	1:10,000
Spillway Capacity	N/A – See Dam 1
Catchment Area	~2,100,000 m^2
Access to Dam	From crest of dam

Dam 4

Dam Type	Till core, rock shell
Maximum Dam Height	12.5 m
Dam Crest Width	5 m
Impoundment Area	150,000 m^2
Volume of Tailings	N/A
Reservoir Capacity	150,000 m^3 (to spillway crest elevation + 0.1 m)
Consequence Classification	Very high
Inflow Design Flood (IDF)	PMF
Design Earthquake	1:10,000
Spillway Capacity	Combined 22.0 m^3/s at 309.5 m water level
Catchment Area	1,150,000 m^2
Access to Dam	From crest of dam, or northeast access.

APPENDIX B

Photographs



Louvicourt Tailings Facility
Photographs location
Légende
1
2
3
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6
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9
10
11
12
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14
Google Earth
Image © 2017 DigitalGlobe
© 2017 Google
N
1 km

Photograph 1: Dam 4B, spillway

Overflow Weir at Dam 4B in good condition.

Photograph 2: Dam 4B, final effluent

Final effluent is clean, culverts in good conditions.

Photograph 3: Dam 4B, crest

Geotextile is exposed at some locations.

Photograph 4: Dam 4B, crest

Erosion is visible on downstream slope of the dam.

Photograph 5: Dam 4B, spillway

Erosion is visible on the access road leading to the spillway.

Photograph 6: Dam 1D, upstream slope

Rip-rap, upstream face where rehabilitation work was completed.

Photograph 7: Dam 1E Spillway

Trash rack upstream of spillway is damaged.

Photograph 8: Dam 1E, emergency spillway upstream

Emergency spillway – bed in excellent condition, vegetation was eradicated.

Photograph 9: Dam 1E, emergency spillway downstream

Emergency spillway –vegetation was eradicated.

Photograph 10: Tailings pond effluent

Good condition, accumulation of some debris.

Photograph 11: Dam 1E

Access bridge was rehabilitated close to the spillway.

Photograph 12: Dam 1A

Toe of downstream dam, difficult to access because of growing vegetation.

Photograph 13: Dam 2B

Erosion rills on the crest of embankment.

Photograph 14: Dam 2A

Ponding at the toe of Dam 2A is exacerbated by beaver activity.

APPENDIX C

Movement Monitoring Survey

LEVÉ EN XYZ
DE DIX-NEUF (19) REPÈRES DE TASSEMENT EXISTANTS

PAR MÉTHODE GPS TEMPS RÉEL, NIVELLEMENT GÉOMÉTRIQUE ET TRIGONOMÉTRIQUE

MINE LOUVICOURT
TECK RESOURCES LIMITED

CANTON LOUVICOURT

Corriveau J.L. & Assoc. inc.
1085, 3^{e} Avenue Ouest
Val d'Or (Québec) J9P 1T5

CORRIVEAU J.L. & ASSOCIÉS. INC

C-14421/442.18-19

2018

LEVÉ EN XYZ DE DIX-NEUF (19) REPÈRES (PLAQUES) DE TASSEMENT EXISTANTS PAR MÉTHODE GPS TEMPS RÉEL, NIVELLEMENT GÉOMÉTRIQUE ET TRIGONOMÉTRIQUE

RAPPORT D'OPÉRATION

1) INTRODUCTION :

À la demande de monsieur Éric Gingras de la compagnie Teck Resources, nous nous sommes rendus sur le site du parc à résidus de la Mine Louvicourt situé dans le canton de Louvicourt pour y effectuer le levé de dix-neuf (19) plaques de tassement en XYZ afin de contrôler leur déplacement en horizontal et en vertical, à l'aide de la méthode GPS temps réel, les méthodes de nivellement géométrique et trigonométrique.

2) TRAVAUX TERRAIN EXÉCUTÉS :

Description des travaux :

En premier lieu, les travaux consistaient à lever par GPS temps réel haute précision (± 1cm) la position XYZ de toutes les plaques de tassement. Nous avons utilisé un jalon calé avec un trépied « tripode » pour maintenir l'antenne GPS en stabilité parfaite et ainsi obtenir une meilleure précision de nos observations. De plus, chacune des plaques de tassement a fait l'objet de trois (3) séquences d'observation différentes à environ quinze (15) minutes d'intervalle ou plus pour avoir des géométries différentes de la position des satellites. Chaque séquence d'observation comptait trois (3) moyennes de dix (10) lectures chacune avec une rotation de 120° du jalon à chaque moyenne pour une plus grande justesse et annuler l'erreur de verticalité du jalon porteur du récepteur GPS. Tous les travaux ont été réalisés dans le système SCOPQ (projection MTM) fuseau 9, NAD83, mais appuyés ou comparés sur les points du « *tableau des Points d'appui et de contrôle levés au GPS Temps réel – Système SCOPQ Fuseau 9 NAD83* » (voir le point 6 du rapport), soit les mêmes points de référence ancrés dans le roc que les années précédentes.

Comme à chaque année, nous avons gardé le point **94-257** comme point de référence principal, alors que trois (3) autres points d'appui secondaires servaient de validation du point d'appui principal ainsi que de témoin de la bonne opération et de la justesse de nos méthodes de levé au GPS RTK. Notez que deux (2) points de référence (**94-256** et **94-263**) n'ont pas été observés en raison de la trop forte densité du boisé qui influence négativement la qualité des observations GPS.

La deuxième partie des travaux consistait à faire le cheminement vertical avec un niveau géométrique électronique de haute précision et une mire code-barres pour obtenir une précision verticale de quelques millimètres de toutes les plaques de tassement placées sur le sommet des digues. Le point de départ du cheminement est le repère **94-257** (ancré dans le roc) d'une élévation fixe de **3316.707m (Mine)** ou **316.707m (altitude N.M.M)**. Nous avons effectué sept (7) cheminements en boucle obtenant des écarts de fermeture de 0.2mm, 0.6mm, 0.5mm, 0.1mm, 0.4mm, 0.5mm, et 1.2mm. Le premier cheminement en boucle s'étend sur une distance totale (incluant aller et retour) de 550m entre le repère **94-257** et le moniteur **B-1** avec une erreur de fermeture de 0.2mm. Le deuxième cheminement en boucle s'étend sur une distance de 760m totale (incluant aller et retour) entre le repère **94-257** et le moniteur **JLC-2011-3** avec une erreur de fermeture de 0.6 mm. Le troisième cheminement en boucle s'étend sur une distance totale (incluant aller et retour) de 1989m entre le repère **94-257** et le moniteur **B-7** avec une erreur de fermeture de 0.5mm. Le quatrième cheminement liant le moniteur **B7** (départ) et le point d'appui **94-262** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 1350m avec une erreur de fermeture globale de 0.1mm. Le cinquième cheminement liant le point d'appui **94-257** (départ) et le moniteur **JLC-2011-2** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 371m avec une erreur de fermeture globale de 0.4 mm. Le sixième cheminement liant le point d'appui **94-257** (départ) et le moniteur **JLC-2011-8** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 256m avec une erreur de fermeture globale de 0.5mm. Enfin, le septième cheminement liant le point d'appui **94-262** (départ) et les moniteurs **JLC-2011-6**, **JLC-2011-7 et B11** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 1000m avec une erreur de fermeture globale de 1.2mm. Les plaques de tassement ont été mesurées à l'aller et au retour, soit deux (2) déterminations différentes utilisant chacune des plaques comme des « points tournant ». Nous avons ensuite fait la moyenne de ces deux (2) déterminations pour obtenir les valeurs du « *tableau des Élévations précises des plaques de tassement* » (voir le point 8 du rapport).

La troisième partie des travaux consistait à lever les plaques de tassement placées sur les bermes. Ces plaques, étant difficilement accessibles par le nivellement géométrique à cause des grandes dénivelées entre le sommet des digues et le dessus des bermes (soit de 6 à 10 mètres), la méthode a consisté à stationner une station totale sur le sommet des digues, prendre comme points d'appui temporaires deux (2) plaques de tassement de digues (déjà nivelées par niveau géométrique) et prendre en répétition (lunette directe et renversée) l'angle vertical et la distance en pente jusqu'au petit jalon vertical (d'environ 30cm de longueur) positionné sur la plaque de tassement à déterminer en vertical.

L'opération est répétée une deuxième fois à une hauteur différente d'instrument. Le tout est calculé en effectuant les moyennes à partir des angles verticaux et de la valeur des deux (2) plaques de tassement d'appui des digues prédéterminées en élévation par le cheminement géométrique. Ces deux répétitions nous donnent une moyenne d'une précision d'environ 3mm qui additionnée à la précision du nivellement géométrique se situe à environ 3 à 5mm. En 2018, seul le moniteur **JLC-2011-5** a été levé avec selon cette méthode.

3) COMMENTAIRES SUR LES OBSERVATIONS DE 2008 :

Comme déjà mentionné dans les rapports des années passées, il est possible qu'il y ait un cassé en déplacement entre les données de 2008 et les années précédentes qui ne soit pas nécessairement dû au déplacement des plaques de tassement, mais plutôt à un choix différent des points d'origine et l'incohérence des repères d'appui ou de référence. De plus, il y a sûrement une différence entre la procédure que nous utilisons pour faire les levés et celle qu'utilisait la compagnie minière, laquelle procédure ne nous a pas été indiquée, on aurait pu alors assurer une continuité plus rigoureuse dans les résultats par une même méthodologie de levé.

4) TRAVAUX BUREAU EXÉCUTÉS :

Nous avons calculé les coordonnées des points mesurés en XYZ par GPS temps réel en faisant les moyennes des répétitions, avons complété le « *tableau des Différences des coordonnées XYZ* » et avons calculé les déplacements (voir le point 7 du rapport). Il est à noter que les coordonnées XYZ obtenues par méthode GPS temps réel sont estimées avoir une précision de ± 1cm avec 1 sigma en horizontal, tandis qu'en élévation par GPS la précision n'est qu'environ 2cm.

Nous avons fait la moyenne des deux (2) lectures d'élévation obtenues par nivellement géométrique (aller et retour) de toutes les plaques de tassement des sommets de digues. Nous avons compensé le cheminement aller-retour même si l'erreur de fermeture du polygone total n'était que de quelques fractions de millimètres et n'avait pas d'incidence significative sur le résultat obtenu.

Pour les élévations des plaques de tassement des bermes, nous avons fait la moyenne des dénivelées obtenues par station totale ou par niveau géométrique pour chacune des plaques de tassement (soit la dénivelée entre les plaques d'appui au sommet des digues et celles à déterminer sur les bermes). Nous estimons que la précision des élévations (par méthode géométrique) est de l'ordre de ± 1mm à 3mm selon la longueur du cheminement; veuillez vous référer au tableau titré « *Élévations précises des plaques de tassement* » par nivellement géométrique et trigonométrique.

5) GÉNÉRALITÉS :

Les travaux ont été effectués du 30 aout au 7 septembre 2018 par une équipe de trois hommes. Les travaux ont été supervisés par Jean-Luc Corriveau, arpenteur-géomètre.

Instruments utilisés :

- Un (1) système GNSS comprenant :
- Deux (2) récepteurs GNSS modèle viva de la compagnie Leica .
  La précision du système GNSS ou GPS est de ± 0,01m horizontalement et ± 0,02m verticalement à un niveau de confiance de 1σ, selon les spécifications du fabricant; cependant, par la répétition, la proximité des points d'appui et la méthodologie, ces précisions ont pu être augmentées au demi-centimètre ou mieux.
- Un (1) niveau électronique DNA 3 compagnie Leïca avec deux mires à code-barres précision en nivellement double de 1 mm/km.
- Une (1) station totale modèle T06 de la compagnie Leïca.

6) TABLEAU DES POINTS D'APPUI ET DE CONTRÔLE LEVÉS AU GPS TEMPS RÉEL SYSTÈME SCOPQ FUSEAU 9 NAD83

Numéro		NORD (m)	EST (m)	ALTITUDE (m)***
94-257**	Théorique*	5333644.982	223183.100	316.707
Point de base	Terrain	5333644.982	223183.100	316.707
	Différence	0.000	0.000	0.000

94-258**	Théorique*	5333566.954	222891.729	311.677
Contrôle 1	Terrain 2010	5333567.016	222891.730	311.661
	Terrain 2011	5333567.027	222891.729	311.682
	Terrain 2012	5333567.011	222891.724	311.681
	Terrain 2013	5333567.022	222891.723	311.685
	Terrain 2014	5333567.020	222891.730	311.676
	Terrain 2015	5333567.019	222891.728	311.680
	Terrain 2016	5333567.028	222891.729	311.699
	Terrain 2017	5333567.015	222891.735	311.688
	Terrain 2018	5333567.020	222891.726	311.674
	Diff. Théo-2010.	-0.062	-0.001	0.016
	Diff. Théo-2011.	-0.073	0.000	-0.005
	Diff. Théo-2012.	-0.057	0.005	-0.004
	Diff. Théo-2013	-0.068	0.006	-0.008
	Diff. Théo-2014	-0.066	-0.001	0.001
	Diff. Théo-2015	-0.065	0.001	-0.003
	Diff. Théo-2016	-0.074	0.000	-0.022
	Diff. Théo-2017	-0.061	-0.006	-0.011
	Diff. Théo-2018	-0.066	0.003	0.003
	2011-2010	0.011	-0.001	0.021
	2012-2011	-0.016	-0.005	-0.001
	2013-2012	0.011	-0.001	0.004
	2014-2013	-0.002	0.007	-0.009
	2015-2014	-0.001	-0.002	0.004
	2016-2015	0.009	0.001	0.019
	2017-2016	-0.013	0.006	-0.011
	2018-2017	0.005	-0.009	-0.014

94-256**	Théorique*	5333408.957	223515.007	317.777
Contrôle 2	Terrain 2010	5333408.888	223514.937	317.774
	Terrain 2011	5333408.896	223514.929	317.784
	Terrain 2012	5333408.900	223514.927	317.782
	Terrain 2013	5333408.899	223514.929	317.786
	Terrain 2014	5333408.887	223514.932	317.772
	Terrain 2015	5333408.894	223514.932	317.773
	Terrain 2016	5333408.899	223514.929	317.792
	Terrain 2017	5333408.907	223514.939	317.801
	Terrain 2018	Trop boisé pour observation		
	Diff. Théo-2010.	0.069	0.070	0.003
	Diff. Théo-2011.	0.061	0.078	-0.007
	Diff. Théo-2012.	0.057	0.080	-0.005
	Diff. Théo-2013	0.058	0.078	-0.009
	Diff. Théo-2014	0.070	0.075	0.005
	Diff. Théo-2015	0.063	0.075	0.004
	Diff. Théo-2016	0.059	0.075	-0.015
	Diff. Théo-2017	0.050	0.075	-0.024
	2011-2010	0.008	-0.008	0.010
	2012-2011	0.004	-0.002	-0.002
	2013-2012	-0.001	0.002	0.005
	2014-2013	-0.012	0.003	-0.014
	2015-2014	0.007	0.000	0.001
	2016-2015	0.004	-0.003	0.019
	2017-2016	0.004	-0.003	0.019

94-260**	Théorique*	5333495.201	222157.718	312.345
Contrôle 3	Terrain 2010	5333495.447	222157.739	312.333
	Terrain 2011	5333495.453	222157.733	312.360
	Terrain 2012	5333495.443	222157.735	312.350
	Terrain 2013	5333495.453	222157.735	312.369
	Terrain 2014	5333495.451	222157.737	312.345
	Terrain 2015	5333495.447	222157.738	312.354
	Terrain 2016	5333495.453	222157.731	312.368
	Terrain 2017	5333495.435	222157.742	312.385
	Terrain 2018	5333495.441	222157.743	312.371
	Diff. Théo-2010.	-0.246	-0.021	0.012
	Diff. Théo-2011.	-0.252	-0.015	-0.015
	Diff. Théo-2012.	-0.242	-0.017	-0.005
	Diff. Théo-2013	-0.252	-0.017	-0.024
	Diff. Théo-2014	-0.250	-0.019	0.000
	Diff. Théo-2015	-0.246	-0.020	-0.009
	Diff. Théo-2016	-0.252	-0.013	-0.023
	Diff. Théo-2017	-0.234	-0.024	-0.040
	Diff. Théo-2018	-0.240	-0.025	-0.026
	2011-2010	0.006	-0.006	0.027
	2012-2011	-0.010	0.002	-0.010
	2013-2012	0.010	0.000	0.019
	2014-2013	-0.002	0.002	-0.024
	2015-2014	-0.004	0.001	0.009
	2016-2015	0.006	-0.007	0.014
	2017-2016	-0.018	0.011	0.017
	2018-2017	0.006	0.001	-0.014

Numéro		NORD (m)	EST (m)	ALTITUDE (m)***
94-262**	Théorique*	5332897.066	222292.513	315.842
Contrôle 4	Terrain 2010	5332897.303	222292.387	315.827
	Terrain 2011	5332897.306	222292.381	315.840
	Terrain 2012	5332897.307	222292.382	315.856
	Terrain 2013	5332897.304	222292.381	315.859
	Terrain 2014	5332897.311	222292.390	315.840
	Terrain 2015	5332897.313	222292.386	315.851
	Terrain 2016	5332897.325	222292.386	315.870
	Terrain 2017	5332897.307	222292.386	315.878
	Terrain 2018	5332897.311	222292.388	315.861
	Diff. Théo-2010.	-0.237	0.126	0.015
	Diff. Théo-2011.	-0.240	0.132	0.002
	Diff. Théo-2012.	-0.241	0.131	-0.014
	Diff. Théo-2013	-0.238	0.132	-0.017
	Diff. Théo-2014	-0.245	0.123	0.002
	Diff. Théo-2015	-0.247	0.127	-0.009
	Diff. Théo-2016	-0.259	0.128	-0.028
	Diff. Théo-2017	-0.241	0.127	-0.036
	Diff. Théo-2018	-0.245	0.125	-0.019
	2011-2010	0.003	-0.006	0.013
	2012-2011	0.001	0.001	0.016
	2013-2012	-0.003	-0.001	0.003
	2014-2013	0.007	0.009	-0.019
	2015-2014	0.002	-0.004	0.011
	2016-2015	0.012	0.000	0.019
	2017-2016	-0.018	0.000	0.008
	2018-2017	0.004	0.002	-0.017

94-263**	Théorique*	5332858.918	222355.630	317.471
Contrôle 5	Terrain 2010	5332859.145	222355.493	317.465
	Terrain 2011	5332859.147	222355.487	317.467
	Terrain 2012	5332859.140	222355.487	317.485
	Terrain 2013	5332859.142	222355.485	317.488
	Terrain 2014	5332859.139	222355.491	317.468
	Terrain 2015	5332859.140	222355.492	317.478
	Terrain 2016	5332859.138	222355.487	317.495
	Terrain 2017	5332859.135	222355.488	317.524
	Terrain 2018	Trop boisé pour observation		
	Diff. Théo-2010.	-0.227	0.137	0.006
	Diff. Théo-2011.	-0.229	0.143	0.004
	Diff. Théo-2012.	-0.222	0.143	-0.014
	Diff. Théo-2013	-0.224	0.145	-0.017
	Diff. Théo-2014	-0.221	0.139	0.003
	Diff. Théo-2015	-0.222	0.138	-0.007
	Diff. Théo-2016	-0.220	0.143	-0.024
	Diff. Théo-2017	-0.217	0.142	-0.053
	2011-2010	0.002	-0.006	0.002
	2012-2011	-0.007	0.000	0.018
	2013-2012	0.002	-0.002	0.003
	2014-2013	-0.003	0.006	-0.020
	2015-2014	0.001	0.001	0.010
	2016-2015	-0.002	-0.005	0.017
	2017-2016	-0.003	0.001	0.029

7) **TABLEAU DES DIFFÉRENCES DES COORDONNÉES XYZ DES PLAQUES DE TASSEMENT OBTENUES PAR MÉTHODE GPS TEMPS RÉEL** (voir annexe 1)

8) **TABLEAU DES ÉLÉVATIONS PRÉCISES DES PLAQUES DE TASSEMENT** (voir annexe 2)

9) **RÉSUMÉ :**

En résumé, notre travail contient :

Nombre de plaques de tassement levées par GPS (±1cm) :	19
Nombre de plaques de tassement nivelées (± 2mm) :	19
Nombre de plaques levées par st. totale pour le vertical :	6
Nombre de plaques nivelées à partir du niveau géométrique :	13
Nombre de points d'appui localisés/contrôlés en horizontal :	3
Nombre de points d'appui en vertical (cheminement géométrique) :	2
Longueur totale des cheminements altimétriques :	6.276 Km

Fait à Val d'Or, le 9 novembre 2018, sous le dossier **C-14421/442.18-19** et le numéro **14321** de mes minutes en référence aux dossiers : C-13907/442.18-19 (2017), C-13282/442.18 (2016), C-12762/442.18 (2015), C-12486/442.17 (2014), C-12102/442.17 (2013), C-11735/442.17 (2012), C-11471/442.17 (2011), C-10945/442.17 (2010), C-10558/442.16 (2009) et C-10178/442.15 (2008) du soussigné.

Val-d'Or, le 4 décembre 2018

CORRIVEAU J.L. & ASSOC. INC.

Copie conforme à l'original

7/Dec/2018

Jean-Luc Corriveau
A.-G., A.T.C.

Annexes

Annexe 1 Tableau des différences des coordonnées xyz des plaques de tassement obtenues par méthode GPS temps réel.

Annexe 2 Tableau des élévations précises des plaques de tassement.

Annexe 3 Plan de localisation des plaques de tassement révision du 20/10/2011 minute C-10945/442.17 du soussigné.

Annexe 1

Tableau des différences des coordonnées XYZ des plaques de tassement obtenues par méthode GPS Temps réel

PLAQUE DE TASSEMENT		Coordonnées théoriques	Arpentage Sept. 2008	Différence 2008-Théo		Arpentage Juin 2010	Différence 2010-2008		Arpentage Octobre 2011	Différence 2011-2010		Arpentage Octobre 2012	Différence 2012-2011		Arpentage Juillet 2013	Différence 2013-2012	
B-1	Nord	5333481,600	5333481,572	-0.028	S	5333481,588	0.016	N	5333481,573	-0.015	S	5333481,567	-0.006	S	5333481,574	0.007	N
	Est	223364.365	223364.319	-0.046	O	223364.310	-0.009	O	223364.316	0.006	E	223364.317	0.001	E	223364.319	0.002	E
	Elev	319.120	319.085	-0.035	B	319.085	0.000	-	319.097	0.012	H	319.089	-0.008	B	319.087	-0.002	B
B-2	Nord	5333524,849	5333524,834	-0.015	S	5333524,840	0.006	N	5333524,842	0.002	N	5333524,839	-0.003	S	5333524,843	0.004	N
	Est	223312.799	223312.758	-0.041	O	223312.754	-0.004	O	223312.766	0.012	E	223312.765	-0.001	O	223312.764	-0.001	O
	Elev	318.489	318.450	-0.039	B	318.452	0.002	H	318.454	0.002	H	318.448	-0.006	B	318.439	-0.009	B
B-3	Nord	5333560,718	5333560,716	-0.002	S	5333560,721	0.005	N	5333560,721	0.000	-	5333560,720	-0.001	S	5333560,718	-0.002	S
	Est	223270.316	223270.298	-0.018	O	223270.294	-0.004	O	223270.298	0.004	E	223270.292	-0.006	O	223270.294	0.002	E
	Elev	319.122	319.090	-0.032	B	319.093	0.003	H	319.101	0.008	H	319.098	-0.003	B	319.096	-0.002	B
B-4	Nord	5333595,764	5333595,789	0.025	N	5333595,793	0.004	N	5333595,798	0.005	N	5333595,802	0.004	N	5333595,802	0.000	N/A
	Est	223073.887	223073.882	-0.005	O	223073.899	0.017	E	223073.888	-0.011	O	223073.881	-0.007	O	223073.879	-0.002	O
	Elev	318.136	318.111	-0.025	B	318.134	0.023	H	318.140	0.006	H	318.141	0.001	H	318.141	0.000	N/A
B-5	Nord	5333572,172	5333572,224	0.052	N	5333572,230	0.006	N	5333572,233	0.003	N	5333572,227	-0.006	S	5333572,231	0.004	N
	Est	222993.640	222993.630	-0.010	O	222993.641	0.011	E	222993.631	-0.010	O	222993.632	0.001	E	222993.625	-0.007	O
	Elev	318.157	318.151	-0.006	B	318.158	0.007	H	318.166	0.008	H	318.164	-0.002	B	318.165	0.001	H
B-6	Nord	5333588,639	5333588,744	0.105	N	5333588,757	0.013	N	5333588,748	-0.009	S	5333588,747	-0.001	S	5333588,753	0.006	N
	Est	222661.587	222661.604	0.017	E	222661.649	0.045	E	222661.613	-0.036	O	222661.609	-0.004	O	222661.604	-0.005	O
	Elev	318.176	318.139	-0.037	B	318.141	0.002	H	318.150	0.009	H	318.139	-0.011	B	318.143	0.004	H
B-7	Nord	5333510,829	5333511,090	0.261	N	5333511,091	0.001	N	5333511,093	0.002	N	5333511,087	-0.007	S	5333511,096	0.009	N
	Est	222246.790	222246.804	0.014	E	222246.868	0.064	E	222246.809	-0.059	O	222246.807	-0.003	O	222246.802	-0.005	O
	Elev	318.176	318.185	0.009	H	318.190	0.005	H	318.203	0.013	H	318.186	-0.017	B	318.203	0.018	H
B-8	Nord	5333371,342	5333371,603	0.261	N	5333371,609	0.006	N	5333371,606	-0.003	S	5333371,607	0.001	N	5333371,610	0.003	N
	Est	222178.864	222178.871	0.007	E	222178.944	0.073	E	222178.876	-0.068	O	222178.872	-0.004	O	222178.867	-0.005	O
	Elev	319.031	319.022	-0.009	B	319.020	-0.002	B	319.035	0.015	B	319.031	-0.004	B	319.035	0.004	H
B-9	Nord	5333326,921	5333327,178	0.257	N	5333327,189	0.011	N	5333327,187	-0.002	S	5333327,193	0.006	N	5333327,189	-0.004	S
	Est	222191.523	222191.531	0.008	E	222191.610	0.079	E	222191.543	-0.067	O	222191.531	-0.012	O	222191.528	-0.003	O
	Elev	319.181	319.161	-0.020	B	319.171	0.010	H	319.180	0.009	H	319.186	0.006	H	319.177	-0.009	B
B-10	Nord	5333154,032	5333154,277	0.245	N	5333154,279	0.002	N	5333154,282	0.003	N	5333154,278	-0.004	S	5333154,275	-0.003	S
	Est	222242.232	222242.203	-0.029	O	222242.271	0.068	E	222242.254	-0.017	O	222242.192	-0.062	O	222242.189	-0.003	O
	Elev	318.244	318.220	-0.024	B	318.226	0.006	H	318.234	0.008	H	318.233	-0.001	B	318.231	-0.002	B
B-11	Nord								5333362,842	N/A		5333362,840	-0.002	S	5333362,642	0.002	N
	Est								222145.004	N/A		222145.006	0.002	E	222145.000	-0.006	O
	Elev								307.277	N/A		307.241	-0.036	B	307.266	0.025	H
2011-1 L	Nord								5333800,876	N/A		5333800,873	-0.005	S	5333800,871	-0.002	S
	Est								223387.811	N/A		223387.817	0.006	E	223387.815	-0.002	O
	Elev								310.020	N/A		310.018	-0.002	B	310.018	0.000	N/A
2011-2 C	Nord								5333562,623	N/A		5333562,637	0.014	N	5333562,632	-0.005	S
	Est								223322.116	N/A		223322.109	-0.007	O	223322.107	-0.002	O
	Elev								309.270	N/A		309.252	-0.018	B	309.242	-0.010	B
2011-3 L	Nord								5333826,347	N/A		5333826,349	0.002	N	5333826,347	-0.002	S
	Est								223442.150	N/A		223442.150	0.000	-	223442.153	0.003	E
	Elev								310.354	N/A		310.345	-0.009	B	310.344	-0.001	B
2011-4 L	Nord								5333763,037	N/A		5333763,041	0.004	N	5333763,040	-0.001	S
	Est								223329.455	N/A		223329.455	0.000	-	223329.456	0.001	E
	Elev								310.371	N/A		310.359	-0.012	B	310.365	0.006	H
2011-5 C	Nord								5333821,228	N/A		5333821,227	-0.001	S	5333821,221	-0.006	S
	Est								223378.028	N/A		223378.028	0.000	-	223378.028	0.000	-
	Elev								303.984	N/A		303.978	-0.006	B	303.980	0.001	H
2011-6 C	Nord								5333068,318	N/A		5333068,305	-0.013	S	5333068,308	0.003	N
	Est								222236.094	N/A		222236.095	0.001	E	222236.096	0.001	E
	Elev								309.338	N/A		309.334	-0.004	B	309.337	0.003	H
2011-7 C	Nord								5333271,670	N/A		5333271,658	-0.012	N	5333271,660	0.002	N
	Est								222174.469	N/A		222174.459	-0.010	O	222174.458	-0.001	O
	Elev								309.156	N/A		309.159	0.003	H	309.161	0.001	H
2011-8 C	Nord								5333627,581	N/A		5333627,573	-0.008	S	5333627,577	0.004	N
	Est								223061.472	N/A		223061.471	-0.001	O	223061.467	-0.004	O
	Elev								310.383	N/A		310.369	-0.014	B	310.370	0.001	H

PLAQUE DE TASSEMENT		Arpentage Juin 2014	Différence 2014-2013		Arpentage Juin 2015	Différence 2015-2014		Arpentage Juin 2016	Différence 2016-2015		Arpentage Septembre 2017	Différence 2017-2016		Arpentage Octobre 2018	Différence 2018-2017	
B-1	Nord	5333481,565	-0.009	S	5333481,569	0.004	N	5333481,576	0.007	N	5333481,586	0.010	N	5333481,575	-0.011	S
	Est	223364.324	0.005	E	223364.321	-0.003	O	223364.317	-0.004	O	223364.321	0.004	O	223364.321	0.000	O
	Elev	319.082	-0.005	B	319.080	-0.002	B	319.098	0.018	H	319.094	-0.004	B	319.088	-0.007	B
B-2	Nord	5333524,841	-0.002	S	5333524,836	-0.005	S	5333524,846	0.010	N	5333524,853	0.007	N	5333524,839	-0.014	S
	Est	223312.774	0.010	E	223312.774	0.000	-	223312.771	-0.003	O	223312.773	0.002	E	223312.775	0.002	E
	Elev	318.430	-0.009	B	318.428	-0.002	B	318.441	0.013	H	318.436	-0.005	B	318.425	-0.010	B
B-3	Nord	5333560,713	-0.005	S	5333560,717	0.004	N	5333560,730	0.014	N	5333560,720	-0.010	S	5333560,722	0.002	N
	Est	223270.302	0.008	E	223270.297	-0.005	O	223270.295	-0.002	O	223270.299	0.004	E	223270.301	0.002	E
	Elev	319.086	-0.010	B	319.087	0.001	H	319.099	0.001	H	319.092	-0.007	B	319.084	-0.008	B
B-4	Nord	5333595,797	-0.005	S	5333595,803	0.006	N	5333595,808	0.005	N	5333595,807	-0.001	S	5333595,803	-0.004	S
	Est	223073.885	0.006	E	223073.879	-0.006	O	223073.877	-0.002	O	223073.879	0.002	E	223073.890	0.011	E
	Elev	318.127	-0.014	B	318.134	0.007	H	318.146	0.012	H	318.137	-0.009	B	318.136	-0.002	B
B-5	Nord	5333572,233	0.002	N	5333572,232	-0.001	S	5333572,233	0.001	N	5333572,234	0.001	N	5333572,226	-0.008	S
	Est	222993.633	0.008	E	222993.633	0.000	-	222993.626	-0.007	O	222993.629	0.003	E	222993.639	0.010	E
	Elev	318.160	-0.005	B	318.163	0.003	H	318.172	0.009	H	318.160	-0.012	B	318.158	-0.003	B
B-6	Nord	5333588,751	-0.002	S	5333588,753	0.002	N	5333588,754	0.001	N	5333588,759	0.005	N	5333588,749	-0.010	S
	Est	222661.610	0.006	E	222661.608	-0.002	O	222661.609	0.001	E	222661.607	-0.002	O	222661.620	0.012	E
	Elev	318.132	-0.011	B	318.148	0.016	H	318.160	0.012	H	318.146	-0.014	B	318.144	-0.001	B
B-7	Nord	5333511,093	-0.003	S	5333511,096	0.003	N	5333511,098	0.002	N	5333511,101	0.003	N	5333511,092	-0.009	S
	Est	222246.805	0.003	E	222246.803	-0.002	O	222246.804	0.001	E	222246.797	-0.007	O	222246.812	0.014	E
	Elev	318.196	-0.007	B	318.204	0.008	H	318.221	0.017	H	318.217	-0.004	B	318.222	0.005	H
B-8	Nord	5333371,606	-0.004	S	5333371,607	0.001	N	5333371,610	0.003	N	5333371,607	-0.003	S	5333371,606	-0.001	S
	Est	222178.872	0.005	E	222178.876	0.004	E	222178.866	-0.010	O	222178.868	0.001	E	222178.881	0.014	E
	Elev	319.012	-0.023	B	319.033	0.021	H	319.028	-0.005	B	319.032	0.004	H	319.027	-0.005	B
B-9	Nord	5333327,179	-0.010	S	5333327,182	0.003	N	5333327,191	0.009	N	5333327,186	-0.005	S	5333327,181	-0.005	S
	Est	222191.533	0.005	E	222191.536	0.003	E	222191.524	-0.012	O	222191.528	0.004	E	222191.542	0.014	E
	Elev	319.154	-0.023	B	319.173	0.019	H	319.175	0.002	H	319.173	-0.002	B	319.172	-0.001	B
B-10	Nord	5333154,276	0.001	N	5333154,268	-0.008	S	5333154,280	0.012	S	5333154,274	-0.006	S	5333154,274	0.000	S
	Est	222242.196	0.007	E	222242.196	0.000	-	222242.186	-0.010	O	222242.185	-0.001	O	222242.207	0.022	E
	Elev	318.226	-0.005	B	318.232	0.006	H	318.243	0.011	H	318.243	0.000	N/A	318.237	-0.005	B
B-11	Nord	5333362,843	0.001	N	5333362,849	0.006	N	5333362,854	0.005	N	5333362,834	-0.020	S	5333362,849	0.015	N
	Est	222145.004	0.004	E	222145.004	0.000	-	222144.996	-0.008	O	222144.997	0.001	E	222145.015	0.018	E
	Elev	307.251	-0.015	B	307.255	0.004	H	307.273	0.018	H	307.258	-0.015	B	307.269	0.011	H
2011-1 L	Nord	5333800,866	-0.005	S	5333800,873	0.007	N	5333800,859	-0.014	S	5333800,872	0.013	N	5333800,863	-0.009	S
	Est	223387.819	0.004	E	223387.817	-0.002	O	223387.818	0.001	E	223387.812	-0.006	O	223387.813	0.000	-
	Elev	310.001	-0.017	B	310.003	0.002	H	309.987	-0.016	B	309.999	0.012	H	309.986	-0.013	B
2011-2 C	Nord	5333562,627	-0.005	S	5333562,627	0.000	-	5333562,629	0.002	N	5333562,632	0.003	N	5333562,636	0.004	N
	Est	223322.116	0.009	E	223322.110	-0.006	O	223322.107	-0.003	O	223322.099	-0.008	O	223322.112	0.013	E
	Elev	309.240	-0.002	B	309.235	-0.005	B	309.247	0.012	H	309.252	0.005	H	309.240	-0.012	B
2011-3 L	Nord	5333826,343	-0.004	S	5333826,350	0.007	N	5333826,338	-0.012	S	5333826,351	0.013	N	5333826,344	-0.007	S
	Est	223442.157	0.004	E	223442.154	-0.003	O	223442.161	0.007	E	223442.151	-0.010	O	223442.151	0.000	-
	Elev	310.332	-0.012	B	310.333	0.001	H	310.307	-0.026	H	310.323	0.016	H	310.309	-0.014	B
2011-4 L	Nord	5333763,036	-0.004	S	5333763,040	0.004	N	5333763,033	-0.007	S	5333763,039	0.006	N	5333763,037	-0.002	S
	Est	223329.465	0.009	E	223329.460	-0.005	O	223329.458	-0.002	O	223329.458	0.000	-	223329.458	0.000	-
	Elev	310.349	-0.016	B	310.353	0.004	H	310.341	-0.012	B	310.347	0.006	H	310.347	0.000	-
2011-5 C	Nord	5333821,222	0.001	N	5333821,227	0.005	N	5333821,220	-0.007	S	5333821,222	0.002	N	5333821,221	-0.001	S
	Est	223378.034	0.006	E	223378.031	-0.003	O	223378.030	-0.001	O	223378.030	0.000	E	223378.025	-0.005	O
	Elev	303.967	-0.013	B	303.970	0.003	H	303.963	-0.007	B	303.973	0.010	H	303.965	-0.008	B
2011-6 C	Nord	5333068,307	-0.001	S	5333068,308	0.001	N	5333068,313	0.005	N	5333068,302	-0.011	S	5333068,314	0.012	N
	Est	222236.100	0.004	E	222236.096	-0.004	O	222236.093	-0.003	O	222236.094	0.001	E	222236.113	0.020	E
	Elev	309.324	-0.013	B	309.334	0.010	H	309.349	0.015	H	309.347	-0.002	B	309.346	-0.001	B
2011-7 C	Nord	5333271,666	0.006	N	5333271,661	-0.005	S	5333271,669	0.008	N	5333271,658	-0.011	S	5333271,661	0.003	N
	Est	222174.459	0.001	E	222174.457	-0.002	O	222174.447	-0.010	O	222174.452	0.005	E	222174.472	0.020	E
	Elev	309.149	-0.012	B	309.172	0.023	H	309.170	-0.002	B	309.171	0.001	H	309.164	-0.007	B
2011-8 C	Nord	5333627,571	-0.006	S	5333627,574	0.003	N	5333627,574	0.000	-	5333627,568	-0.006	S	5333627,571	0.003	N
	Est	223061.478	0.009	E	223061.475	-0.001	O	223061.469	-0.006	O	223061.470	0.001	E	223061.473	0.004	E
	Elev	310.355	-0.015	B	310.368	0.013	H	310.383	0.015	H	310.369	-0.014	B	310.373	0.004	H

N.B. Valeurs des différences en "Z" significatives qu'à 2cm près; pour plus de précision, se référer au tableau des élévations prises au niveau électronique.
B-1 à B-11 Tiges existantes avec regard protecteur en métal et tige témoin.

Note: On doit considérer les inscriptions au mm significative qu'au 5 mm près

N = déplacement vers le Nord
S = déplacement vers le Sud
E = déplacement vers l'Est
O = déplacement vers l'Ouest
H = déplacement vers le Haut
B = déplacement vers le Bas

Légende
L= Repère médaillon sur longs tuyaux 2,35m x 0,33m extérieur avec 3 ailettes et bout vrillé, regard protecteur et tige témoin 2m
C= Repère médaillon sur tige d'armature de ¾ x 0,9m, regard protecteur et tige témoin de 2m.

CORRIVEAU J.L. & ASSOCIÉS. INC

C-14421/442.18-19

Annexe 2

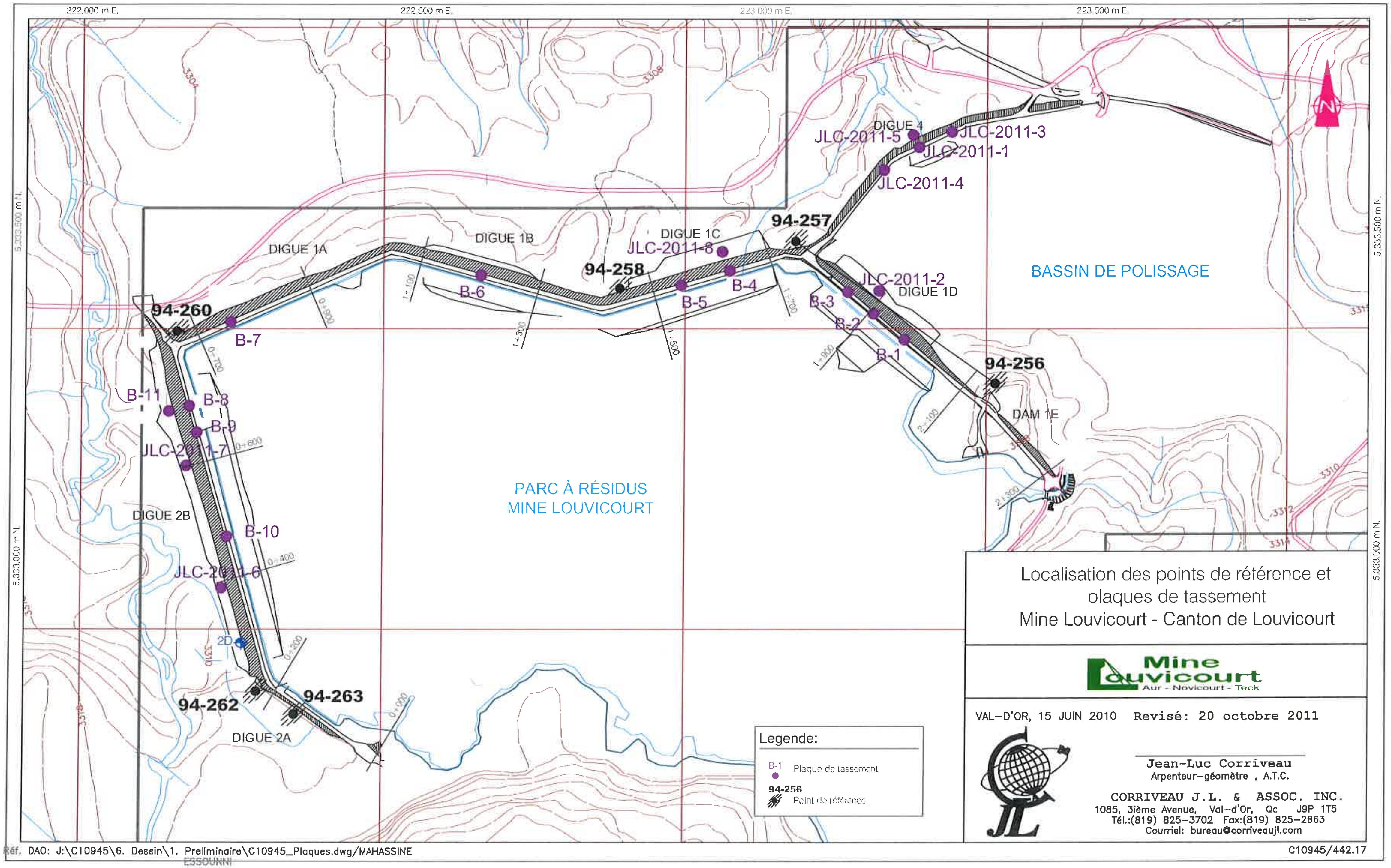
TABLEAU DES *ÉLÉVATIONS PRÉCISES DES PLAQUES DE TASSEMENT*
(Obtenues par nivellement géométrique-électronique et trigonométrique)

Élévation	Diff. (m)	Diff. (m)	Élévation	Diff. (m)	Diff. (m)	Élévation	Diff. (m)	Diff. (m)	Élévation	Diff. (m)	Diff. (m)	Élévation	Diff. (m)	Diff. (m)	Élévation	Diff. (m)	Diff. (m)	Élévation	Diff. (m)	Diff. (m)	
Oct. 2012	2012-2011	2012-2008	Juil. 2013	2013-2012	2013-2008 2013-2011	Juil. 2014	2014-2013	2014-2008 2014-2011	juin-15	2015-2014	2015-2008 2015-2011	juin-16	2016-2015	2016-2008 2017-2011	septembre.17	2017-2016	2017-2008 2017-2011	octobre.18	2018-2017	2018-2008 2018-2011	Plaque de tassement
3316.707	-	-	3316.707	-	-	3316.707	-	-	3316.707	-	-	3316.707	-	-	3316.707	-	-	3316.707	-	-	94-257
3315.839	-0.001	-	3315.859	-	-	3315.841	-	-	3315.842	-	-	3315.842	-	-	3315.878	-	-	3315.842	-	-	94-262
3319.097	0.000	-0.002	3319.097	0.000	-0.002	3319.099	0.002	0.000	3319.100	0.001	0.001	3319.099	-0.001	0.000	3319.100	0.001	0.001	3319.099	-0.001	0.000	B1
3318.449	-0.005	-0.016	3318.448	-0.001	-0.017	3318.448	0.000	-0.017	3318.447	-0.001	-0.018	3318.444	-0.003	-0.021	3318.442	-0.002	-0.023	3318.440	-0.002	-0.025	B2
3319.099	-0.002	-0.004	3319.099	0.000	-0.004	3319.102	0.003	-0.001	3319.102	0.000	-0.001	3319.101	-0.001	-0.002	3319.101	0.000	-0.002	3319.101	0.000	-0.002	B3
3318.139	-0.001	-0.004	3318.140	0.001	-0.003	3318.145	0.005	0.002	3318.145	0.000	0.002	3318.145	0.000	0.002	3318.145	0.000	0.002	3318.144	-0.001	0.001	B4
3318.165	-0.001	-0.003	3318.166	0.001	-0.002	3318.173	0.007	0.005	3318.172	-0.001	0.004	3318.171	-0.001	0.003	3318.171	0.000	0.003	3318.171	0.000	0.003	B5
3318.148	-0.002	-0.005	3318.151	0.003	-0.002	3318.155	0.004	0.002	3318.155	0.000	0.002	3318.155	0.000	0.002	3318.156	0.001	0.003	3318.154	-0.002	0.001	B6
3318.206	0.003	0.008	3318.208	0.002	0.010	3318.215	0.007	0.017	3318.216	0.001	0.018	3318.217	0.001	0.019	3318.217	0.000	0.019	3318.219	0.002	0.021	B7
3319.034	-0.001	0.000	3319.033	-0.001	-0.001	3319.035	0.002	0.001	3319.036	0.001	0.002	3319.035	-0.001	0.001	3319.032	-0.003	-0.002	3319.035	0.003	0.001	B8
3319.179	-0.001	-0.001	3319.179	0.000	-0.001	3319.181	0.002	0.001	3319.181	0.000	0.001	3319.180	-0.001	0.000	3319.181	0.001	0.001	3319.180	-0.001	0.000	B9
3318.234	0.000	0.002	3318.235	0.001	0.003	3318.240	0.005	0.008	3318.240	0.000	0.008	3318.241	0.001	0.009	3318.241	0.000	0.009	3318.241	0.000	0.009	B10
3307.269	-0.008	-	3307.273	0.004	-0.004	3307.270	-0.003	-0.007	3307.270	0.000	-0.007	3307.269	-0.001	-0.008	3307.267	-0.002	-0.010	3307.268	0.001	-0.009	**B11
3310.019	-0.001	-	3310.019	0.000	-0.001	3310.016	-0.002	-0.004	3310.016	-0.001	-0.004	3310.011	-0.005	-0.009	3310.007	-0.004	-0.013	3310.004	-0.003	-0.016	*2011-1
3309.252	-0.018	-	3309.273	0.021	0.003	3309.256	-0.017	-0.014	3309.259	0.003	-0.011	3309.257	-0.002	-0.013	3309.252	-0.005	-0.018	3309.254	0.002	-0.016	**2011-2
3310.354	0.000	-	3310.352	-0.002	-0.002	3310.348	-0.004	-0.006	3310.346	-0.002	-0.008	3310.341	-0.005	-0.013	3310.334	-0.007	-0.020	3310.330	-0.004	-0.024	*2011-3
3310.370	-0.002	-	3310.372	0.003	0.001	3310.368	-0.004	-0.003	3310.369	0.001	-0.002	3310.366	-0.003	-0.005	3310.362	-0.004	-0.009	Tige non atteignable avec la règle			*2011-4
3303.976	-0.008	-	3303.993	0.017	0.009	3303.980	-0.013	-0.004	3303.985	0.005	0.001	3303.981	-0.004	-0.003	3303.980	-0.001	-0.004	3303.980	0.000	-0.004	**2011-5
3309.342	-0.015	-	3309.332	-0.010	-0.025	3309.342	0.010	-0.015	3309.345	0.003	-0.012	3309.344	-0.001	-0.013	3309.344	0.000	-0.013	3309.342	-0.002	-0.015	**2011-6
3309.172	0.016	-	3309.177	0.005	0.021	3309.175	-0.002	0.019	3309.174	-0.001	0.018	3309.172	-0.002	0.016	3309.171	-0.001	0.015	3309.170	-0.001	0.014	**2011-7
3310.364	-0.019	-	3310.370	0.006	-0.013	3310.375	0.005	-0.008	3310.374	-0.001	-0.009	3310.374	0.000	-0.009	3310.377	0.003	-0.006	3310.371	-0.006	-0.012	**2011-8

*Trait jaune = Repères implantés en 2011

**Nivellement trigonométrique (précision estimé à +/- 5 mm

Légende des écarts : pas de signe s'élève, signe négatif (-) s'enfonce


222 000 m E.
222 500 m E.
223 000 m E.
223 500 m E.
5 333 500 m N.
5 333 000 m N.
N
DIGUE 4
JLC-2011-5
JLC-2011-3
JLC-2011-1
JLC-2011-4
94-257
DIGUE 1C
JLC-2011-8
DIGUE 1B
DIGUE 1A
94-258
B-4
B-5
B-6
B-7
94-260
JLC-2011-2
DIGUE 1D
B-3
B-2
B-1
BASSIN DE POLISSAGE
94-256
DAM 1E
B-11
B-8
B-9
JLC-2011-7
DIGUE 2B
PARC À RÉSIDUS
MINE LOUVICOURT
B-10
JLC-2011-6
2D
94-262
94-263
DIGUE 2A
Legende:
B-1 Plaque de tassement
94-256 Point de référence
Localisation des points de référence et
plaques de tassement
Mine Louvicourt - Canton de Louvicourt
Mine Louvicourt
Aur - Novicourt - Teck
VAL-D'OR, 15 JUIN 2010 Revisé: 20 octobre 2011
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