**REPORT**

# Louvicourt Mine Tailings Storage Facility and Polishing Pond

*2019 Dam Safety Inspection*

Submitted to:

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## Executive Summary

This report presents the 2019 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, Quebec. This report was prepared based on a site visit carried out on September 24, 2019 by Laurent Gareau and Simon Chapuis of Golder Associates Ltd (Golder), Morgan Lypka and Jason McBain of Teck Resources Limited (Teck, Owner), Jonathan Charland of Glencore Canada (Glencore, Owner) and Rene Fontaine of WSP (who conducts routine inspections with Glencore personnel), 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. Golder performed an inspection in 2009, and then has performed annual inspections of the facilities since 2014. Laurent Gareau assumed the role of EOR for the Louvicourt tailings facility in 2018. The objective of the site visit component of a DSI for any such facility is to observe the physical condition of the structures of the facility and look for any signs of changing 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 a facility.

The annual DSI is supplemented by routine inspections, instrumentation monitoring, and water quality monitoring carried out at the facility by external consultants and Glencore 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, Quebec, north of Highway 117. The TSF is located some 8.5 km northwest of the former mine site. The Louvicourt property is currently owned by Teck Resources (55%) and Glencore Canada Corporation (45%). The TSF and polishing pond facilities are managed by Teck.

Infrastructure at the site comprises a tailings pond juxtaposed to a polishing pond. The polishing pond is located immediately downstream (east) of the tailings pond. The tailings pond is bounded by Dams 1A, 1B and 1C to the north and by Dams 1D and 1E to the east, Dams 2A and 2B to the west, and natural topography 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, Dam 1D (acting as a boundary between the polishing pond and the tailings pond) to the west and by high ground to the south and east. An operational spillway and an emergency spillway are located at the north end of the pond, to the east of Dam 4B.

The facility is inspected weekly during the summer period and monthly through the winter months.

### *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 2019 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. This has been the case throughout operation and through the mine closure period.

**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 TSF 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. Additional instrumentation is being installed at the site and the data will be reviewed as part of the ongoing stability review.

Survey monuments were surveyed between October 4th and 15th, 2019 by Corriveau J.L. & Assoc. (Corriveau), a surveyor based in Val-d'Or. The data (Appendix B) 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 27 mm in any case.
- One anomalous settlement data point was recorded in 2019 for SP-11-3. The differential GPS survey suggested a settlement of 30 mm. This is not supported by the total station survey result, which indicated 3 mm of settlement. The differential survey point is considered anomalous and is not considered representative of actual site conditions, on the basis of the entire database of survey data. The total station settlement measurement is considered more accurate than the GPS measurement.
- Incremental settlements in the past year (2018 to 2019) were generally less than 2 mm (which is the stated survey accuracy). The maximal incremental settlement was 7 mm for one instrument (SP-11-5 at dam 4B).
- There is no sign of accelerating settlements.
- The horizontal data shows that 8 of 18 survey monuments indicated total movements since installation smaller than they were in 2018 – that is, that the survey monuments moved closer to their initial location from 2018 to 2019. The remainder of the survey monuments had incremental movements of less than 10 mm (the stated survey accuracy), and total horizontal movements since installation of less than 25 mm.

There is a program in execution as of the preparation of this report that will result in increasing the monitoring system at the site. The system will include additional piezometers (standpipe and VWP), additional v-notch weirs and thermistors. The additional information will be summarized in the next annual inspection and in subsequent inspections. A dedicated weather station is also being considered.

Based upon the monitoring results, deformation and potential instability was not a concern noted for the facility in 2019.

**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 2019, the available freeboard was greater than the minimum requirement of the CDA at all times. These conditions 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 classifications are in the process of being reviewed and should be addressed again as part of the next DSR (planned for 2020).

## Summary of Key Observations

**Summary of Field Observations**

A site inspection was carried out on September 24, 2019 by Laurent Gareau and Simon Chapuis of Golder, and Morgan Lypka and Jason McBain of Teck. Jonathan Charland (Glencore) and Rene Fontaine (WSP) participated in the inspection as well. Mr. Charland and Fontaine are respectively responsible for conducting weekly and monthly inspections at the site. The following principal observations were made at the time of the DSI inspection:

- 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.
- 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 2A, which is experiencing higher than anticipated ponding levels due to downstream beaver activity. It was recommended that the beaver blockage be removed; this was completed in October 2019. Other seepage and ponding features do not represent any dam safety concerns.
- Beaver activity in the culverts northwest of the tailings pond are resulting in increased ponding in the unnamed creek to the west of Dam 2B. It was recommended that the beaver blockage be removed; this was completed in October 2019.

- 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.
- A 15 m wide area east of the main spillway at the polishing pond was designed to serve as an emergency spillway, with a crest elevation of 309.3 m. Rock fill material has been placed across this section of the emergency spillway to approximate elevation 309.8 m (estimated 0.5 m of fill) to allow access for equipment to service the main spillway. Analysis is ongoing to confirm that the presence of the rockfill material to the east does not impact the overflow section to the west of the operational spillway's ability to adequately pass the design flood event.

**Climate and Water Balance Summary**

The reporting period for climate data was from November 1, 2018 to October 31, 2019. The 2018/2019 winter precipitation generally remained below monthly multi-annual averages. 2019 spring precipitation was higher than the multi-annual averages. Specifically, June (134.3 mm) was a very wet month (50% higher than the average), whereas significantly less precipitation than average was observed in July (48.4 mm, -107%). However, the total precipitation over the considered period is 2% higher than the long-term average.

Based on a high-level water balance analysis, it was estimated that 0.53 million $m^3$ of water was discharged to the polishing pond via the tailings pond operational spillway.

## *Summary of Significant Changes*

In 2019, additional stoplogs were inserted into the spillway structure of the polishing pond to raise the invert to elevation 307.14 m and the trash grate across the spillway was removed and replaced with a trash rack downstream of the facility, in the Parshall flume. Cameras were added at the tailings pond and polishing pond operational spillways to permit real-time observation of spillway performance. The cameras permit early monitoring of changing conditions, particularly blockages due to beaver activity. This allows maintenance efforts to be implemented in a timely manner, which in turns improves the safety of the facility.

## *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 ensure the format is 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. Anticipated completion of the update is Q1 of 2020.

The emergency preparedness and response plan (EPRP) was last updated in March of 2019. The EPRP is appropriate for its intended purpose.

## *Dam Safety Review*

An independent DSR of the TSF and polishing pond was conducted in 2015 (SNC-Lavalin, 2015). The next DSR is planned for 2020.

### *Status of Dam Safety Inspections Key Recommended Actions*

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

| Structure | ID | Deficiency or Non-conformance | Applicable Regulation or OMS Reference | Recommended Action | Priority | Recommended Deadline/Status |
|---|---|---|---|---|---|---|
| **Previous Recommendations Closed / Superseded** | | | | | | |
| Dam 1E | 2018-01 | Debris in the tailings pond operational spillway | OMS Manual Section 6.2 | Remove debris from spillway. | 3 | CLOSED – Q4 2018 (Completed) |
| **Previous Recommendations Ongoing** | | | | | | |
| Dam 1E | 2018-02 | Trash rack at inlet to the tailings pond operational spillway is damaged | OMS Manual Section 6.2 | Repair trash rack. | 3 | Q2 2020 |
| 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 | IN PROGRESS – Survey data has been collected. Erosion analysis to be done by Q2 2020. |
| 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 Q3 2019; finalization of analysis to be delayed until completion of additional instrumentation installation (instrumentation installed in January 2020). Target completion Q2 2020. |
| 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 | CLOSED – Q4 2019 Completed. |

| Structure | ID | Deficiency or Non-conformance | Applicable Regulation or OMS Reference | Recommended Action | Priority | Recommended Deadline/Status |
|---|---|---|---|---|---|---|
| **2019 Recommendations** | | | | | | |
| Dam 4B | 2019-01 | Beaver dam constructed across natural outflow point is causing excess ponding in the vicinity of the dam. | CDA 2007 Section 3.5.8 | Remove beaver blockage. | 2 | CLOSED – Q1 2019 Completed. |
| Dam 4B | 2019-02 | Granular fill has been placed east of the main spillway, in an area designed as an emergency spillway. | CDA 2013 Section 3.5.5 | Assess whether the current configuration can pass the design storm. Preliminary indications are that the current configuration does not pose any overtopping issues. | 2 | IN PROGRESS - Q2 2020 Remedial measures may be required if the preliminary calculations are not confirmed. |
| Dam 2B | 2019-03 | Beaver activity in culverts across the creek to the northwest of the dam is causing excess ponding of water. | CDA 2007 Section 3.5.8 | Remove beaver blockage. | 2 | CLOSED – Q1 2019 Completed. |

| 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.

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**APPENDIX B**



**APPENDIX C**



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# 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 2019 Dam Safety Inspection (DSI) at the Louvicourt Mine tailings storage facility and polishing pond located near Val-d'Or, Quebec. The 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 24, 2019 and the review of available surveillance data for the reporting period (September 2018 to September 2019) by the Engineer of Record, Laurent Gareau of Golder. The previous annual DSI for the tailings facility dams was carried out in September 2018, and is reported in the 2018 DSI report (Golder, 2019).

The 2019 inspection included the inspection of all of the polishing and tailings facility dams:

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

This report has been prepared in accordance with the Teck Guideline for Tailings and Water Retaining Structures (Teck, 2019). 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". The reader is encouraged to read the limitations and intended uses of the report, following the text, which is an integral part of the report.

## 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 (Ministère de l'Énergie et des Ressources naturelles du Québec) et MDDELCC[1] (Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques), Novembre 2016
- *Directive 019 sur l'industrie minière*, MELCC, Mars 2012

The annual DSI is a requirement of the certificate of authorization no. 7610-08-01-70141-52 issued by MELCC 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 with the support of 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

[1] MDDELCC refers to the Ministère du développement durable, de l'environnement et de la lutte contre le changement climatique, who is responsible for mining projects in Quebec. It is noted that the name of this ministry has evolved over time (previously MDDEP, currently MELCC) and where these acronyms are used in the document, it is intended to refer interchangeably to the current ministry or any of its predecessors.

Gingras. Since the beginning of 2019, the site has been managed by Kathleen Willman and Morgan Lypka of Teck Legacy Properties. Routine inspections of the facility are undertaken by staff of Glencore (Jonathan Charland) and WSP (Rene Fontaine) (who conducts routine inspections with Glencore personnel).

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 TSF and polishing pond facilities. Figure 2 shows a typical dam cross-section of the facilities.

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 adjustment of 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 2019, additional stoplogs were inserted into the spillway structure of the polishing pond to raise the invert to elevation 307.14 m and the trash grate across the spillway was removed and replaced with a trash rack downstream of the facility, in the Parshall flume. To affect this construction, fill was placed on an area to the east of the main spillway, up to approximate elevation 309.8 m. No other construction or operation occurred in 2019. The maintenance and surveillance activities performed in 2019 included the following:

- Routine inspections
- Survey of monuments
- Removal of debris in the tailings pond and polishing pond active spillway canals
- Removal of beaver activity downstream of the facility

# 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 1, 2018 to October 31, 2019. 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 1951-2019, 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 1951-2019 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 – 2019 | Main station until 2011 |
| VAL-D'OR, 7098603 | 48.06, -77.79 | 338.9 | 2008 – 2019 | Main station since 2012 |
| VAL-D'OR A, 7098605 | 48.05, -77.78 | 337.4 | 2011 - 2019 | Used for missing data |

The 2018/2019 winter precipitation generally remained below monthly multi-annual averages. 2019 spring precipitation was higher than the multi-annual averages. Specifically, June (134.3 mm) was a very wet month (50% higher than the average), whereas significantly less precipitation than average was observed in July (-107%). The total precipitation over the considered period is 2% higher than the long-term average.

**Table 2: Monthly Precipitation Data from November 2018 to October 2019**

| Month - Year | Total Precipitation Recorded at Val-d'Or (mm) * | Monthly Multi-Annual Average at Val-d'Or (mm) ** | Difference (%) *** |
|---|---|---|---|
| November 2018 | 94.3 | 82.2 | 15% ↑ |
| December 2018 | 62.3 | 67.6 | -9% ↓ |
| January 2019 | 51.9 | 59.7 | -15% ↓ |
| February 2019 | 51.8 | 47.8 | 8% ↑ |
| March 2019 | 31.0 | 55.3 | -78% ↓ |
| April 2019 | 109.9 | 60.4 | 82% ↑ |
| May 2019 | 90.9 | 70.6 | 29% ↑ |
| June 2019 | 134.3 | 89.2 | 50% ↑ |
| July 2019 | 48.4 | 100.1 | -107% ↓ |
| August 2019 | 68.6 | 94.3 | -37% ↓ |
| September 2019 | 99.4 | 101.3 | -2% ↓ |
| October 2019 | 89.8 | 84.0 | 7% ↑ |
| **Total over the hydrological year Nov 2018 - October 2019** | **932.6** | **912.7** | **2%** ↑ |

*: 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 2019.

***: 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 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 long-term mean 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). The Rouyn-Noranda climate station stopped measuring solar radiation in October 2018, so it was not possible to calculate the 2018/2019 pond evaporation. The average long-term (1969 to 2018) evaporation was used for the period 2018/2019.

- 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 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 from November 1, 2018 to October 31, 2019, and for a typical year (average climate conditions). Higher precipitation for the 2018/2019 year led to higher estimated volume of water discharged at the spillway.

**Table 3: November 2018 to October 2019 Water Balance for the TSF**

| Component | Typical Year Flows (Based on an average climate year) ($m^3$/year) | Current Year Flows* ($m^3$/year) | Difference (%) | Comment/Source |
|---|---|---|---|---|
| Rainfall over the basin | 958,294 | 979,230 | 2% ↑ | Basin area = 105 ha<br>Mean annual rainfall = 912.7 mm/year<br>Current year rainfall= 932.6 mm/year |
| Surface runoff over the external watershed area | 572,786 | 585,300 | 2% ↑ | Watershed area = 104.6 ha **<br>Runoff coefficient = 0.6 |
| **Total of inflows** | **1,531,080** | **1,564,530** | **2% ↑** | |
| Pond evaporation | 656,177 | 656,177 | 0% | Based on Morton (1983)<br>Mean annual pond evaporation = 625 mm/year |
| Seepage losses | 362,664 | 362,664 | 0% | Based on analysis made prior to construction, Golder (1993)<br>Seepage flow rates = 41.4 $m^3$/h |
| Spillway discharge to the polishing pond | 512,240 | 528,837 | 3% ↑ | Estimated based on mass balance |
| **Total of outflows** | **1,531,080** | **1,564,530** | **2% ↑** | |

* Current year extends from November 2018 to October 2019.
** 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 0.53 million $m^3$ of water was discharged to the polishing pond via the operational 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 24, 2019, by Mr. Simon Chapuis, Eng. and Mr. Laurent Gareau, Eng., Engineer of Record, both from Golder. They were accompanied by Ms. Morgan Lypka, Tailings and Environment Engineer, Mr. Jason McBain, Senior Engineer, Tailings and Mine Waste, both from Teck Resources. Messrs. Jonathan Charland of Glencore Canada and Rene Fontaine of WSP participated in the inspection. The temperature during the visit was approximately 10°C under clear skies.

## 4.1 Visual Observations

The following observations were made during this DSI:

- The water level at the tailings pond was 315.90 m (water level from September 24, 2019).
- The water level at the polishing pond was 307.16 m (water level from September 24, 2019).

### Dams 1A through 1E

- The riprap on the upstream berms of Dams 1B and 1D was repaired with new riprap (photograph 1). The size of the riprap material was reviewed in 2018, and it was concluded that the material as placed provided appropriate protection to the dykes.
- The riprap on Dams 1A and 1C was unchanged from last year (Photograph 2). Replacement of the riprap will be undertaken within a reasonable timeframe. Operational procedures, including a provision in the OMS for an event-driven inspection after extreme wind events, are used to manage risk in the interim.
- The trash rack located upstream of the entry to the spillway is damaged (Photograph 3) and should be repaired. The design of a new trash rack is in progress.
- Ponding water was observed at the toe of Dams 1A to 1E at almost the same locations as last year. The water seems to be stagnant or exhibits very low flow. A typical photo of one exfiltration location is shown as Photograph 4. The location of these points is presented on Figure 1.
- The emergency spillway located between Dams 1D and 1E (denoted as the second emergency spillway) was in good condition. Vegetation in the downstream channel was cleared in 2018; there has been some regrowth in some areas (Photographs 5 and 6), which will require maintenance in the future.

Historically, the vegetation has been cleared every other year, and clearing in 2020 is appropriate. The riprap adjacent to the concrete spillway sill is in good condition. The access road at the outlet of the second emergency spillway is susceptible to erosion, which could affect the embankment of the Dam.

- The access bridge close to the spillway was rehabilitated in 2018 and appears in good condition (photograph 7).
- Several minor erosion points are visible at the crest of Dam 1E. These are not a concern but should continue to be observed.
- Vegetation is present at the downstream toe of Dams 1A, 1B and 1C (Photograph 8). This is not a stability concern.

### Dams 2A and 2B

- 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 9). The extent of ponding is increased due to beaver activities; however it is noted that this area represents a zone where the natural topography drains towards the tailings pond, such that some accumulation at this location is expected.
- The culverts located across the unnamed creek, just north and west of the tailings pond are partially blocked by beaver activity, resulting in higher than normal water levels at this location (Photograph 10). The beaver blockage was removed in 2019.

### 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. The structure was in good condition with no evidence of settlement, cracking, bulging or other deformation that would be indicative of geotechnical performance issues.
- Trees are beginning to encroach on the side slopes and crest of the 4A embankment (Photograph 11). These trees do not represent an issue of geotechnical concern, since the structure is not currently impounding water, and is not likely to impound water in the future.
- The main spillway at Dam 4B was in good condition although no flow was passing over the structure (Photograph 12).
- The outflow channel from the spillway to the Parshall flume contains significant vegetation (Photograph 13). This does not represent a performance issue for the channel; however some vegetation removal may eventually be required in the future.
- Culverts at the final effluent point were clear (Photograph 14) although some limited vegetation is present upstream of these culverts. There was no significant flow through the outflow culverts.

- The 15 m area immediately to the East of the main spillway was designed to serve as an emergency spillway at an elevation of 309.3. Rock fill has been placed to approximate elevation 309.8 m at this location (photograph 15) to enable maintenance work on the main spillway structure. Preliminary analyses suggest that the overflow section to the West of the main spillway is adequate to pass the design flood flow, and this analysis will be confirmed.
- The Dam 4B crest was generally in good condition and unchanged from 2018. Survey monuments are visible. No noticeable changes were visually apparent (i.e., damage) to the survey monuments.
- Ponding water was observed at the toe of Dam 4B at almost the same locations as last year (points 13 to 15 on Figure 1). The water appears to be stagnant.

## 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 summer 2019.
- 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, PO-06-30, PO-06-31) 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 2019 was compiled by Teck (Figure 4). 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 1 and as 2011-1 to 2011-8 in Appendix C, were installed in September and October 2011. All monuments were surveyed between October 4th and 15th, 2019 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 based on total station survey. 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 2018 | Install to 2019 | Up to 2018 | 2018-2019 | Up to present |
| **Dam 1D (crest)** | | | | | | |
| B-1 (SP-1) | 2008 | 4 mm | 6 mm | 0 mm | 1 mm | 1 mm |
| B-2 (SP-2) | 2008 | 18 mm | 20 mm | 25 mm | 2 mm | 27 mm |
| B-3 (SP-3) | 2008 | 7 mm | 4 mm | 2 mm | 0 mm | 2 mm |
| **Dam 1D (berm)** | | | | | | |
| 2011-2 (SP-11-2) | 2011 | 13 mm | 15 mm | 16 mm | N/A* | N/A* |
| **Dam 1C (crest)** | | | | | | |
| B-4 (SP-4) | 2008 | 16 mm | 17 mm | -1 mm | 0 mm | -1 mm |
| B-5 (SP-5) | 2008 | 9 mm | 13 mm | -3 mm | 0 mm | -3 mm |
| **Dam 1C (berm)** | | | | | | |
| 2011-8 (SP-11-8) | 2011 | 11 mm | N/A* | 12 mm | -1 mm | 11 mm |
| **Dam 1B (crest)** | | | | | | |
| B-6 (SP-6) | 2008 | 16 mm | 15 mm | -1 mm | 1 mm | 0 mm |
| **Dam 1A (crest)** | | | | | | |
| B-7 (SP-7) | 2008 | 8 mm | 6 mm | -21 mm | -1 mm | -22 mm |
| **Dam 2B (crest)** | | | | | | |
| B-8 (SP-8) | 2008 | 11 mm | 2 mm | -1 mm | 1 mm | 0 mm |
| B-9 (SP-9) | 2008 | 12 mm | 7 mm | 0 mm | 1 mm | 1 mm |
| B-10 (SP-10) | 2008 | 6 mm | 13 mm | -9 mm | 0 mm | -9 mm |
| **Dam 2B (berm)** | | | | | | |
| B-11 (SP-11) | 2011 | 13 mm | 4 mm | 9 mm | 4 mm | 13 mm |
| 2011-6 (SP-11-6) | 2011 | 20 mm | 8 mm | 15 mm | 3 mm | 18 mm |
| 2011-7 (SP-11-7) | 2011 | 10 mm | 24 mm | -14 mm | 3 mm | -11 mm |
| **Dam 4B (crest)** | | | | | | |
| 2011-1 (SP-11-1) | 2011 | 15 mm | 14 mm | 16 mm | 3 mm | 19 mm |
| 2011-3 (SP-11-3) | 2011 | 3 mm | 8 mm | 24 mm | 3 mm | 27 mm |
| 2011-4 (SP-11-4) | 2011 | 3 mm | 10 mm | N/A* | N/A* | N/A* |
| **Dam 4B (berm)** | | | | | | |
| 2011-5 (SP-11-5) | 2011 | 8 mm | 10 mm | 4 mm | 7 mm | 11 mm |

* Measurement not taken.

The horizontal data shows that 8 of 18 survey monuments indicated total movements from installation to 2019 that were smaller than they were from installation to 2018 – that is, those 8 survey monuments moved closer to their initial locations during the 2018-2019 period. All other survey monuments had incremental movements of less than 10 mm from 2018 to 2019, and total horizontal displacements since installation of less than 25 mm. The observed movements are not an issue of geotechnical concern, but continued monitoring is recommended.

Since the previous year, the vertical data shows that 2 monuments indicated minor upward movements and 9 monuments had settlements of 2 mm or less (which is the stated survey accuracy). Six monuments showed incremental settlements greater than 2 mm (3, 4 and 7 mm). All monuments show total settlement since installation of 27 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 (crest), located in the center part of dam 1D, shows the maximum downward total displacement along dam 1, i.e., 27 mm.
- SP-11-6 (berm), located in the centre of the south half of dam 2B, shows the maximum downward total displacement along dam 2, i.e., 18 mm.
- SP-11-3 (crest), located in the north central part of dam 4B, shows the maximum downward total displacement along dam 4, i.e., 27 mm.

The total station settlement surveys are supplemented by a vertical survey by real-time differential GPS survey. A qualitative comparison of the two datasets was undertaken. In general, the two datasets represent reasonable agreement in both the direction and magnitude of movement. One exception with the 2019 dataset is for SP-11-3, located on the crest of Dam 4B. Whereas the total station dataset shows ~3 mm of settlement, the differential GPS dataset shows 30 mm of settlement. In response, the following actions were taken:

- Corriveau verified that their data acquisition procedures were according to protocol. No source for the error could be identified.
- Inspection notes from the DSI inspection were reviewed for this area of embankment. No signs of movement were observed at this location.
- Regular inspection reports were reviewed specifically to assess whether this area showed any signs of embankment movement. No signs of movement were identified.

The total station dataset is more accurate than the differential GPS for elevation, and it is concluded that the total station settlement represents the actual performance of this structure in 2018-2019. These movements are not an issue of geotechnical concern, but continued monitoring is recommended as a best practice.

### 4.3.3 Stability/Lateral Movement

Table 4 above presents total settlement and horizontal displacement for all monuments. The historic horizontal displacement data is presented as “point-of-origin” plots in Appendix D. Point-of-origin plots show the data points on a year-by-year basis, relative to the point of origin – that is the measured coordinates of the monuments at the time of installation. This type of plot allows the determination of the actual variability of the data and the visual assessment of trends that may be indicative of lateral deformation. The observed movements are low and do not indicate continuous lateral progression, which indicates there is no significant embankment movement.

The measured values of lateral displacement are very low and do not represent a dam safety concern, but annual monitoring should continue.

### 4.3.4 Discharge Flows

Seepage flows are measured through a series of 4 V-notch weirs that were 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 2019. The table also presents observations and visually estimated seepage rates during the dam safety inspection, identified by location 1 to 18 and shown in Figure 1.

Table 5: Measured Flow Rates at V-notch Weirs and Estimated Seepage Rates in 2019

| Location | Dam | Flow (point measurements) |
|---|---|---|
| V-notch 1 | 2B | 0.2 – 0.9 L/s (calculated and provided by Teck). Water was clear |
| V-notch 2 | 2B | 0.4 – 1.1 L/s (calculated and provided by Teck). Water was clear |
| V-notch 3 | 1A | 0.2 – 0.4 L/s (calculated and provided by Teck). Water was clear |
| V-notch 4 | 1C | 0.7 – 1.8 L/s (calculated and provided by Teck). Water was clear |
| 1 | 1B | Puddle, no flow |
| 2 | 1B | Puddle, very low flow, clear |
| 3 | 1B | Puddle, no flow |
| 4 | 1A | Puddle, no flow |
| 5 | 1A | Puddle, no flow |
| 6 | 1A | Puddle, no flow |
| 7 | 1A | Puddle, no flow |
| 8 | 2B | Puddle, very low flow, clear, see V-notch 2 |
| 9 | 2B | Puddle, very low flow, clear |
| 10 | 2B | Puddle, very low flow, clear, see V-notch 1 |
| 11 | 2A | Puddle, no flow |
| 12 | 1E | Puddle, no flow |
| 13 | 4B | Puddle, no flow |
| 14 | 4B | Puddle, no flow |
| 15 | 4B | Puddle, no flow |
| 16 | 1C | Puddle, no flow |
| 17 | 1C | Puddle, no flow |
| 18 | 1C | Puddle, no flow |

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 during 2019 were consistent with previous historical trends. Seepage flows measured during 2019 were also slightly under (by 5% to 17%) those measured during 2018 except at V-notch 2. The increase of seepage flow (14%) measured at V-notch 2 was possibly caused by beaver activity adjacent to Dam 2A.

The sum of the measurable flows reflects both seepage from the dam and surface water runoff due to rainfall events. The peaks shown on Figure 8 likely reflect impacts of surface runoff, whereas the lower bound values more likely represent base flows derived primarily from seepage. The lower bound range (1.5 L/s) and upper bound range (4.2 L/s) are lower than the expected seepage rate from the 1993 design studies and as assumed in the water balance (11.5 L/s). The seepage rates are low and no pattern of increasing seepage flow is discernable. 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 the Ministère de l'Environnement et Lutte contre les changements climatiques du Québec (MELCC).

## 4.5 Site Inspection Forms

The routine inspection forms completed by site reconnaissance staff were reviewed by the EoR. One significant accumulation of debris in the polishing pond spillway was observed during November 2018, and this was rectified in a timely manner. No other 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 riprap 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 and 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 (referred to as the emergency spillway). In case of blockages of the weir and first emergency spillway, flood inflows would passively 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 307.1 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. Cameras have been installed at both spillways, and the photos are reviewed regularly by several qualified personnel.

Dam Safety Inspections (DSI) are performed yearly and Dam Safety Reviews (DSR) are performed every 5 years. The next DSR should be completed 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. New instrumentation (vibrating wire piezometers, standpipe piezometers, thermistors and v-notch weirs) are being installed to supplement the monitoring network for the structures.

### 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 was then operated at elevation 306.54 m until 2018, and then at a spillway elevation of 307.1 m since. 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. New instrumentation (vibrating wire piezometers) are being installed to supplement the monitoring network for the structure.

### 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 |

| Item | Design Value |
|---|---|
| Downstream Slope | 2.0 H:1V (inter bench, without considering downstream berms) |
| Minimum freeboard (from dam crest) | 2.0 m at tailings pond<br>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 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 earth fill 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: Updated 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 reassessment of the tailings (Golder 2018b), the saturated unit weight for the tailings was revised to 21.3 kN/m$^3$. Stability analyses confirmed that this change resulted in factors of safety meeting the target values.

### 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 failure modes have been identified and assessed. This section reviews the dam safety implications of the instrumentation data and the September 24, 2019 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 a 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 internal erosion was occurring that 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 was 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 below the target. 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. Further, additional instrumentation is being installed to validate the piezometric assumptions for the analyses.

### *Movement Monitoring Instrumentation*

Detailed analysis of monitoring data is included in Section 4.3.

The CDA 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. Some trends and observations have been noticed and are commented on below:

- The survey is not done at the same period every year. Individual monuments show trends that could be attributed to seasonal effects. An effort is being made to perform the surveying at the same time of year in future.
- Monuments present movement with amplitudes similar to the survey of 2018. Monument SP-11-6 on Dam 2B exhibits the largest total displacement at the site of 20 mm in the upstream direction.
- Incremental settlements (2018 to 2019) were generally less than 2 mm (which is the stated survey accuracy). The maximal incremental settlement was 7 mm (upwards) for one instrument (SP-11-5) located on the berm of Dam 4B.
- 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 value of 27 mm total settlement). The other survey monuments present total settlements that have stabilized or are variable (minor up and down movements) through the years.
- SP-5 (crest) and SP-11 (bench) show incremental upward movements since installation. The rates of movement are small.

Vertical movements of the monuments listed in Table 4 remain relatively limited. Some trends and observations are provided below:

- Total station survey results indicate some noticeable movements attributed to frost action and survey limitations. However, the magnitudes are small and within accepted ranges.
- The largest movement (settlement of 27 mm) occurs at SP-11-3 located on Dam 4B. The magnitude of deformations indicated by the monitoring instrumentation is within accepted ranges do not present a dam safety concern but do warrant continued monitoring as a best practice.
- One anomalous settlement value was observed on SP-11-3, as discussed in Section 4.3.2. The anomalous GPS reading was not observed in the Total Station data and is therefore not representative of a trend of increasing settlement.

#### *Observed Performance*

Longitudinal cracks were reported to develop along the crest of Dam 1 during the last few winter seasons. A general observation was that the severity of crest cracking in 2019 was less pronounced than previous years. 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 2019, the freeboard varied between 1.75 and 2.05 m at the tailings area, and 3.15 to 3.39 m at the polishing pond. High water levels in both cases are associated with the spring freshet.

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. For the polishing pond the current 3.15 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 passively pass 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 is at least 1.23 m below the dam crest elevation.

#### *Instrumentation Data*

The tailings pond water level was measured via staff gauge during the open water season in 2019. For the 2011-2019 period, the pond water elevations generally varied between a minimum value of 315.95 m in the fall months to a maximum value of 316.25 m (0.15 m head over the weir level) in springtime. The historical minimum levels were recorded in fall 2010 (315.17 m) and the maximum in spring 2019 (316.25 m). This may reflect higher than average spring rainfall and an increase in the frequency of measurement which was undertaken in 2019. The minimum CDA freeboard requirements were maintained in 2018-2019.

*Observed Performance*

The water level within the tailings pond was 315.96 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. 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 Dam Consequence Classification

The dam consequence classification has evolved through time. The current dam consequence classification is “very high” for all dams except Dam 4H, which has a “high” 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 (Klohn Crippen Berger, 2011). Table 9 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 (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.<br>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.<br>Loss of marginal habitat only.<br>Restoration or compensation in kind highly possible. | Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes. |

| Dam Class | Population at Risk[(a)] | Incremental Losses | | |
|---|---|---|---|---|
| | | Loss of Life [(b)] | Environmental and Cultural Values | Infrastructure and Economics |
| 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 misadventures.

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 to less than 100. An updated 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 TSF and polishing pond is good. The observations made during the inspection are consistent with good geotechnical performance. The review of the instrumentation readings presented in Section 4.3 did not show displacement or settlement that could indicate a deterioration of physical stability.

Section 4.1 summarizes the observations made at the site and section 6.6 presents 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 the ongoing assessment of physical performance.

## 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 following the 2019 Mining Association of Canada (MAC) OMS Guide is expected to be completed in Q1, 2020.

## 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 considered to be up to date and appropriate.

# 6.0 SUMMARY AND RECOMMENDATIONS

## 6.1 Summary of Construction and Operation/Maintenance Activities

No construction occurred in 2019. Stoplogs were placed in the spillway of the polishing pond, and cameras were added to permit real time monitoring of both operational spillways at the site. 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 2018/2019 winter precipitation generally remained below monthly multi-annual averages. 2019 spring precipitation was higher than the multi-annual averages. Specifically, June (134.3 mm) was a very wet month (50% higher than the average), whereas significantly less precipitation than average was observed in July (-107 %). The total precipitation over the considered period is 2% higher than the long-term average.

Based on a high-level water balance analysis, it was estimated that 0.53 million $m^3$ of water were discharged to the polishing pond via the operational spillway.

## 6.3 Summary of Performance

The overall performance of the Louvicourt TSF and polishing pond is good and does not require major works or corrections. Minor works to be considered are summarized in Section 6.6. 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

Cameras were installed at the spillways of the tailings pond and polishing pond to allow remote monitoring of the spillways. In 2019, additional stoplogs were inserted into the spillway structure of the polishing pond to raise the invert to elevation 307.14 m and the trash grate across the spillway was removed and replaced with a trash rack downstream of the facility, in the Parshall flume.

## 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 observed to be in a good condition at the time of the 2019 site visit. No significant changes were noted in the condition of the dams since the 2018 DSI. Deficiencies and non-conformances noted during the DSI and their status are presented in Table 10. Table 11 provides a description of the priority levels referenced 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 1E | 2018-01 | Debris in the tailings pond operational spillway | OMS Manual Section 6.2 | Remove debris from spillway. | 3 | CLOSED - Q4 2018 (Completed) |
| **Previous Recommendations Ongoing** | | | | | | |
| Dam 1E | 2018-02 | Trash rack at inlet to the tailings pond operational spillway is damaged | OMS Manual Section 6.2 | Repair trash rack. | 3 | Q2 2020 |
| 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 | 3 | IN PROGRESS – Survey data has been collected. Erosion analysis to be done by Q2 2020. |

| Structure | ID | Deficiency or Non-conformance | Applicable Regulation or OMS Reference | Recommended Action | Priority | Recommended Deadline/Status |
|---|---|---|---|---|---|---|
| | | | | slope protection across the road and outlet channel, to route potential spillway flow away from the embankment. | | |
| 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 Q3 2019; finalization of analysis to be delayed until completion of additional instrumentation installation (instrumentation installed in January 2020). Target completion Q2 2020. |
| 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 | CLOSED – Q4 2019. Completed. |
| **2019 Recommendations** | | | | | | |
| Dam 4B | 2019-01 | Beaver dam constructed across natural outflow point is causing excess ponding in the vicinity of the dam. | CDA 2007 Section 3.5.8 | Remove beaver blockage. | 2 | CLOSED – Q1 2019 Completed. |
| Dam 4B | 2019-02 | Granular fill has been placed east of the main spillway, in an area designed as an emergency spillway. | CDA 2013 Section 3.5.5 | Assess whether the current configuration can pass the design storm. Preliminary indications are that the current configuration does not pose any overtopping issues. | 2 | IN PROGRESS - Q2 2020 Remedial measures may be required if the preliminary calculations are not confirmed. |

| Structure | ID | Deficiency or Non-conformance | Applicable Regulation or OMS Reference | Recommended Action | Priority | Recommended Deadline/Status |
|---|---|---|---|---|---|---|
| Dam 2B | 2019-03 | Beaver activity in culverts across the creek to the northwest of the dam is causing excess ponding of water. | CDA 2007 Section 3.5.8 | Remove beaver blockage. | 2 | CLOSED – Q1 2019 Completed. |

**Table 11: Priorities and Level of risks**

| 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.**

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LG/SC/HC/AH/cd/gb

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## 9.0 STUDY LIMITATIONS

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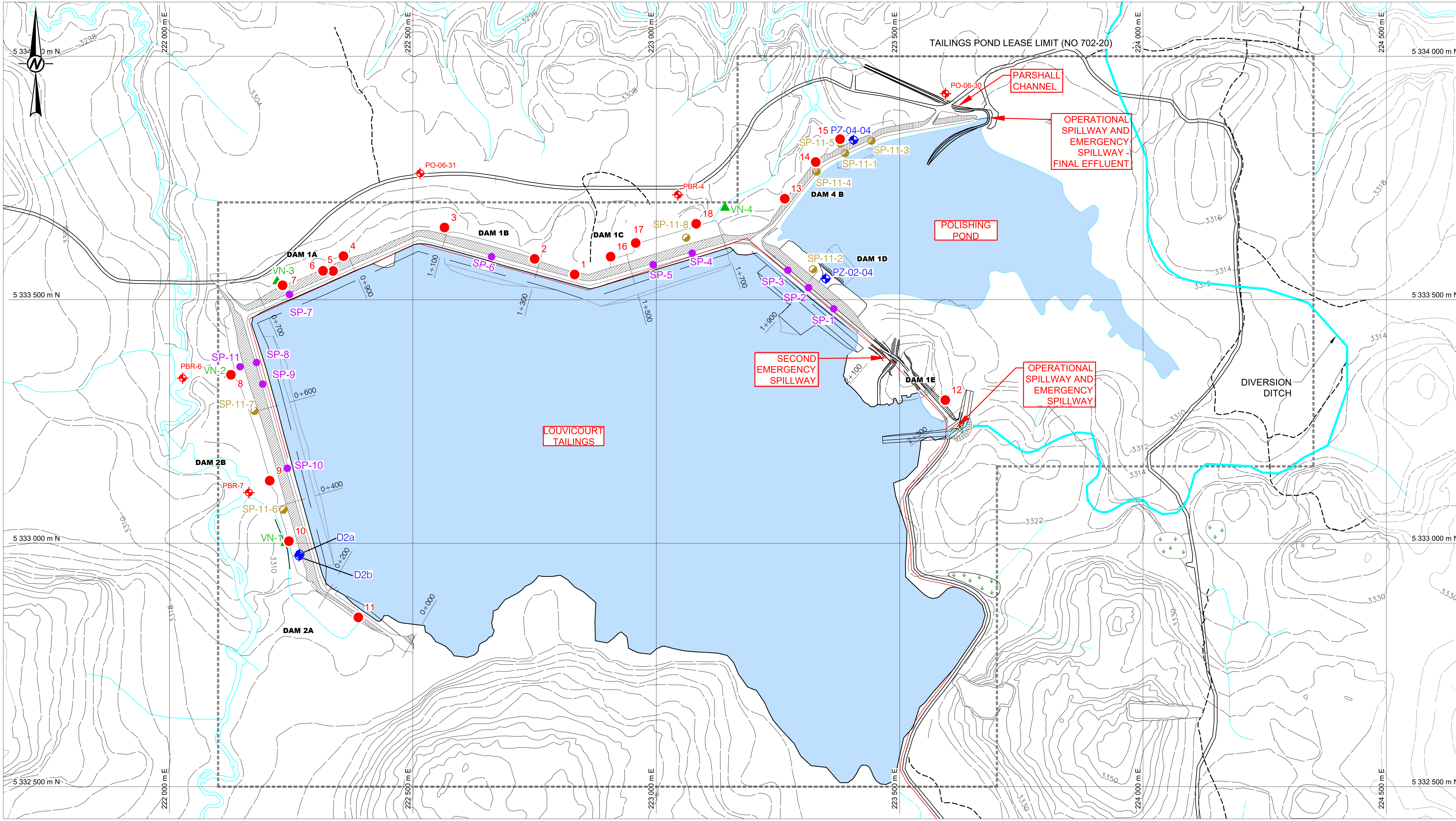
# Figures




**LEGEND**

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

0 125 250
1:7 500 METRES

CLIENT
TECK
MINE LOUVICOURT

CONSULTANT

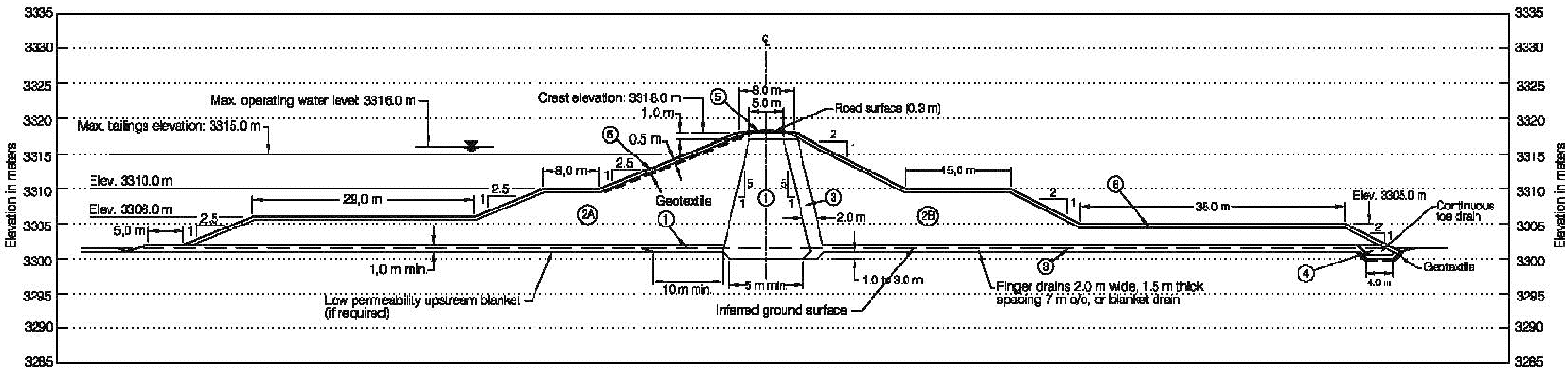
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2019-11-21 |
| DESIGNED | A. Annoual |
| PREPARED | S. Chapuis |
| REVIEWED | L. Gareau |
| APPROVED | L. Gareau |

PROJECT
LOUVICOURT MINE TAILINGS AND POLISHING PONDS 2019 DAM SAFETY INSPECTION

TITLE
**GENERAL SITE PLAN**

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 19118317 | 5000 | 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

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MINE LOUVICOURT

PROJECT
LOUVICOURT MINE TAILINGS AND POLISHING PONDS 2019 DAM SAFETY INSPECTION

CONSULTANT
GOLDER

| | |
|---|---|
| YYYY-MM-DD | 2019-11-21 |
| DESIGNED | A. Annoual |
| PREPARED | S. Chapuis |
| REVIEWED | L. Gareau |
| APPROVED | L. Gareau |

TITLE
**TYPICAL DIKE CROSS-SECTION**

| PROJECT NO. | PHASE | REV. | FIGURE |
|---|---|---|---|
| 19118317 | 5000 | 0 | 2 |

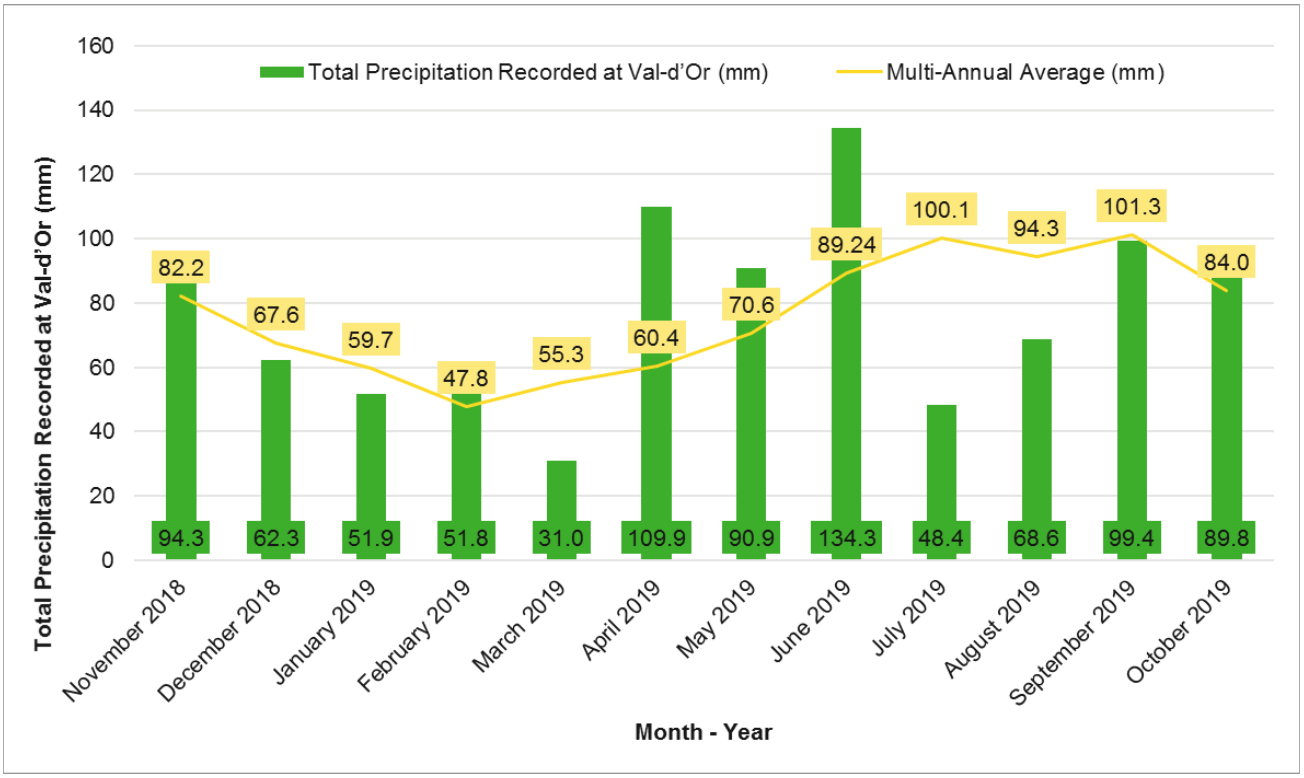
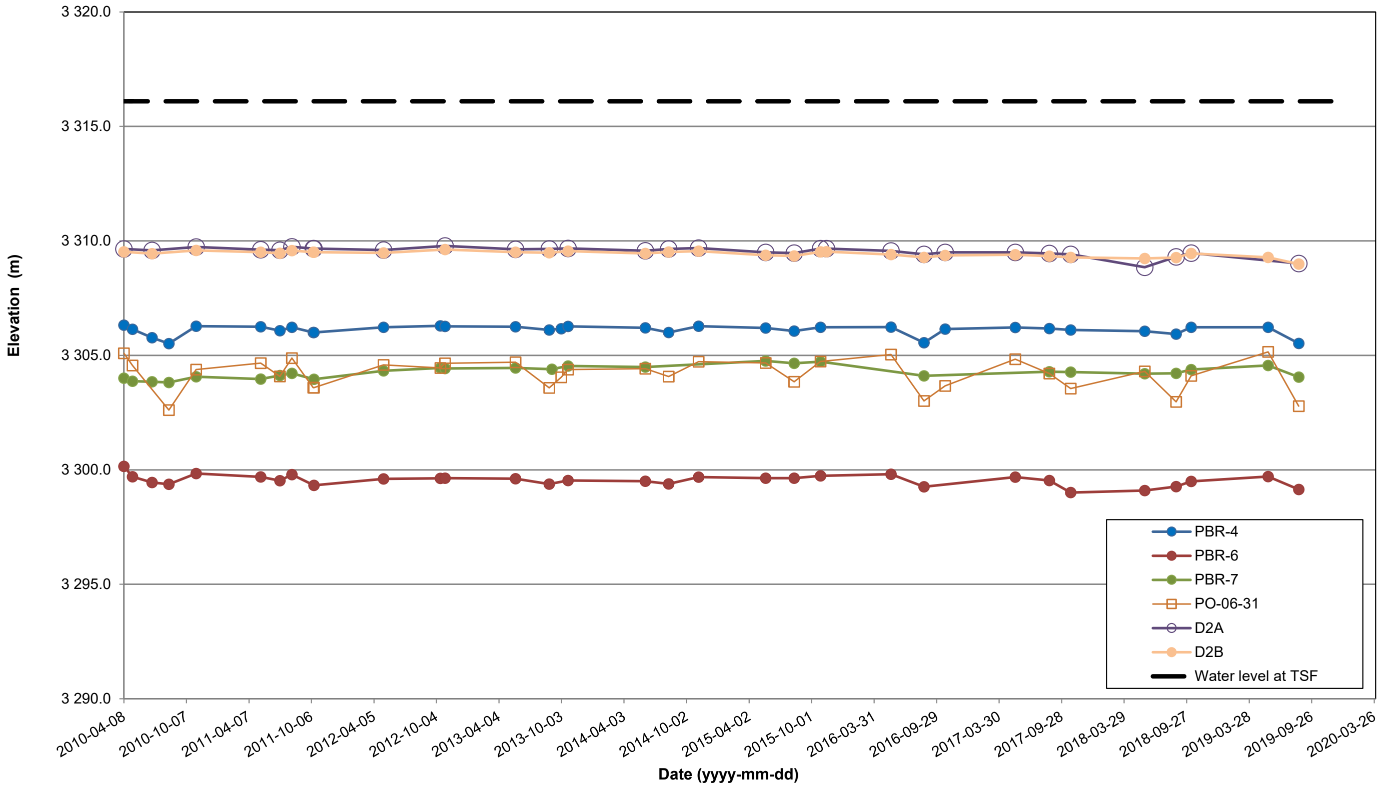
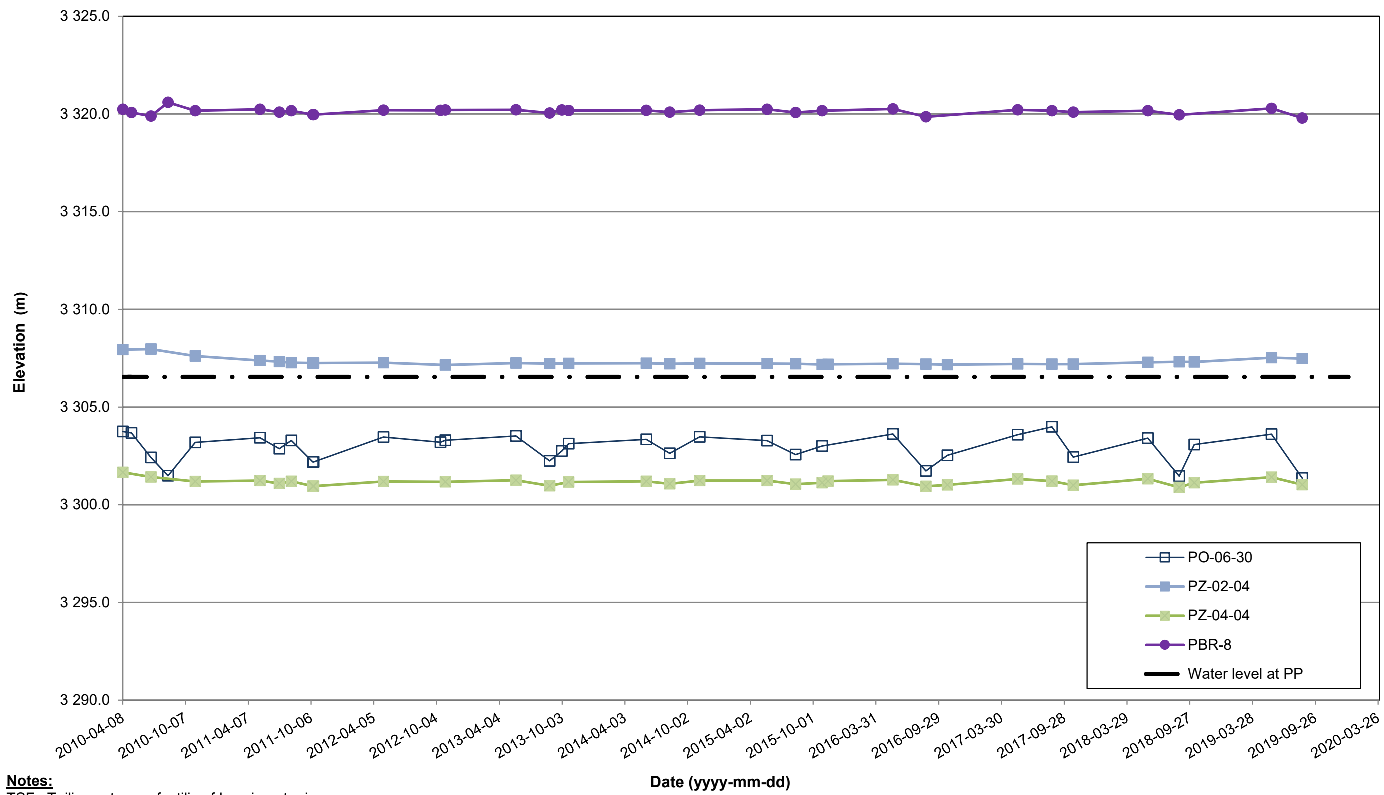



**Figure 3: Monthly Precipitation Data from November 2018 to October 2019**




**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) | | | | | |
| | Louvicourt TSF | DESSINÉ PAR: | BZ | DATE | 2019-08-20 | NO. DE PROJET: | 19118317 |
| | | VÉRIFIÉ PAR: | RO | DATE | 2019-08-20 | | Rev0 |
| | Teck Resources Ltd | REVISÉ PAR: | KW | DATE | 2019-08-20 | FIGURE: | 4 |

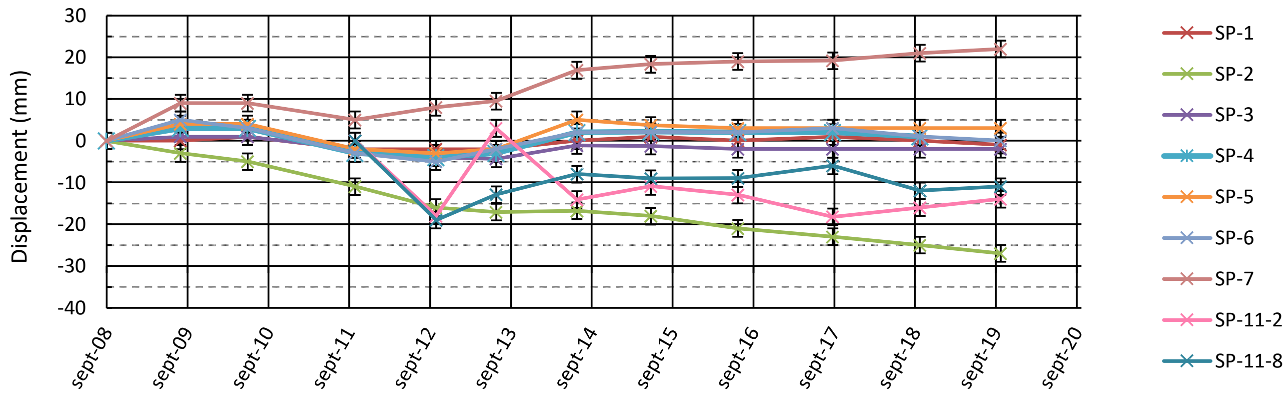



**Figure 5 : Vertical Displacement of the Survey Monuments at Dam 1**

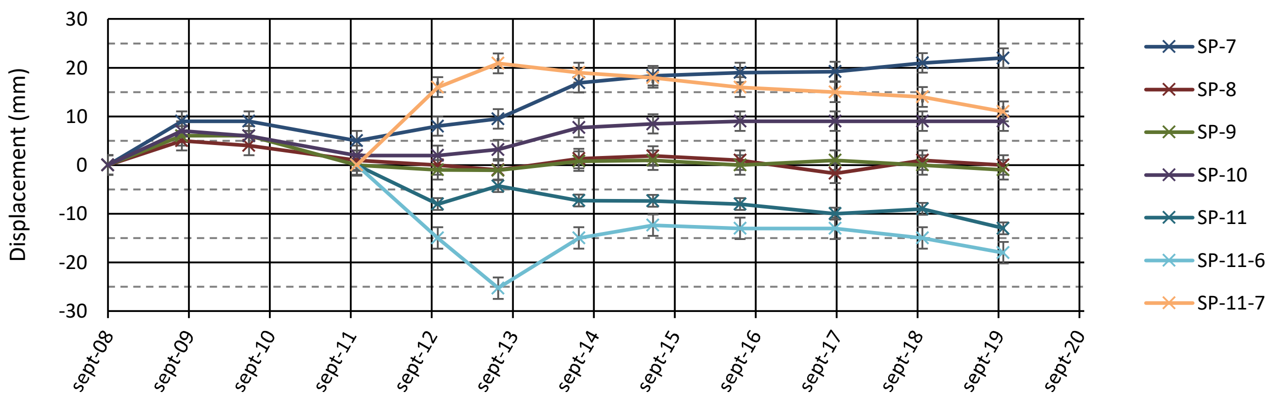



**Figure 6 : Vertical Displacement of the Survey Monuments at Dam 2**

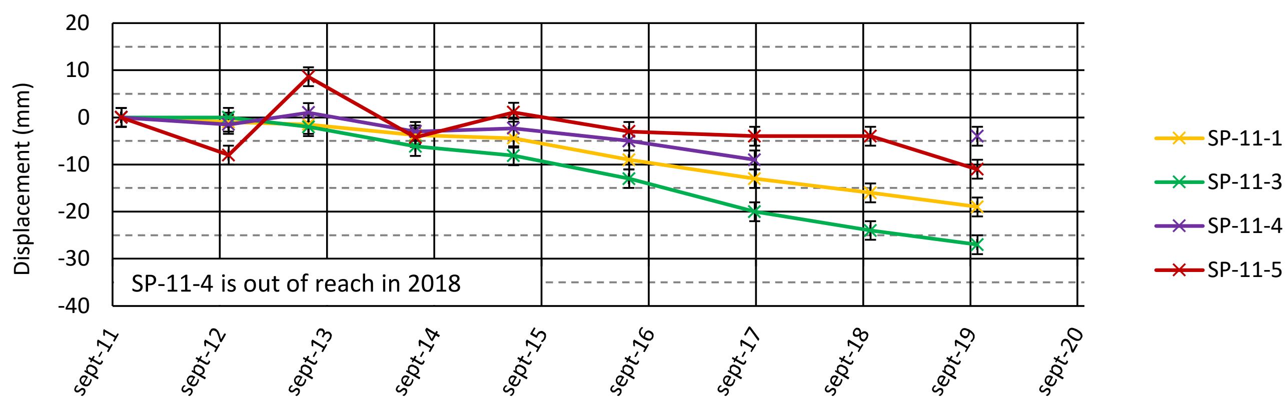
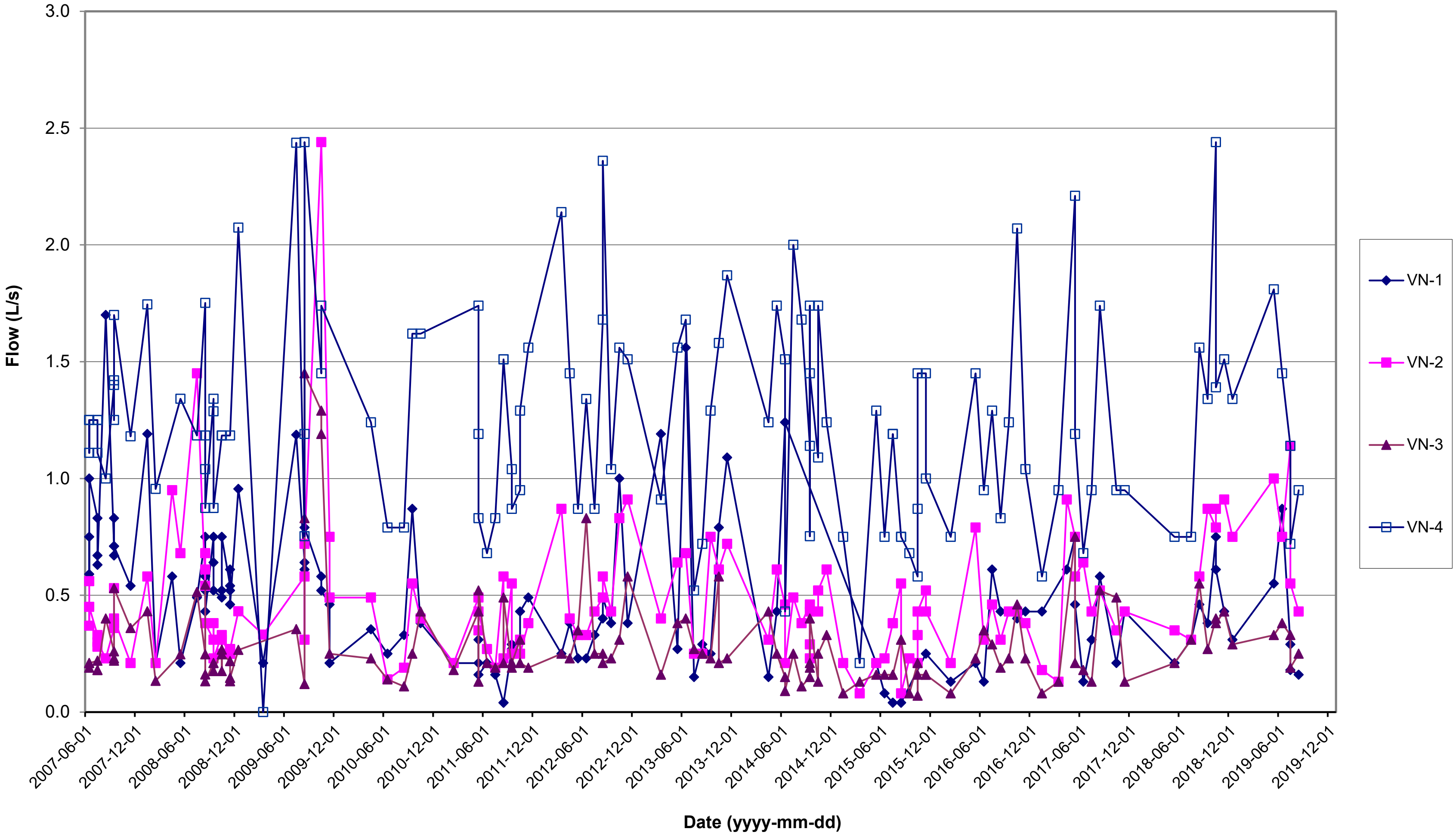



**Figure 7 : Vertical Displacement of the Survey Monuments at Dam 4**

Note: positive = upward displacement




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Teck | DSI 2019 | Louvicourt Mine Tailings Pond - historical trend of seepage flow measured at the V-notch weirs | | | | | |
| | Mine Louvicourt<br>Teck Resources Ltd | DESSINÉ PAR: | BZ | DATE | 2019-08-20 | NO. DE PROJET: | 19118317 |
| | | VÉRIFIÉ PAR: | RO | DATE | 2019-08-20 | | |
| | | APPROUVÉ PAR: | KW | DATE | 2019-08-20 | FIGURE: Rev0 | 8 |

# APPENDIX A

# Facility Data Sheet

# Facility Data Sheet

## Mine TSF and Polishing Pond Damne peux le faire cs

**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 – Polishing Pond**

| 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

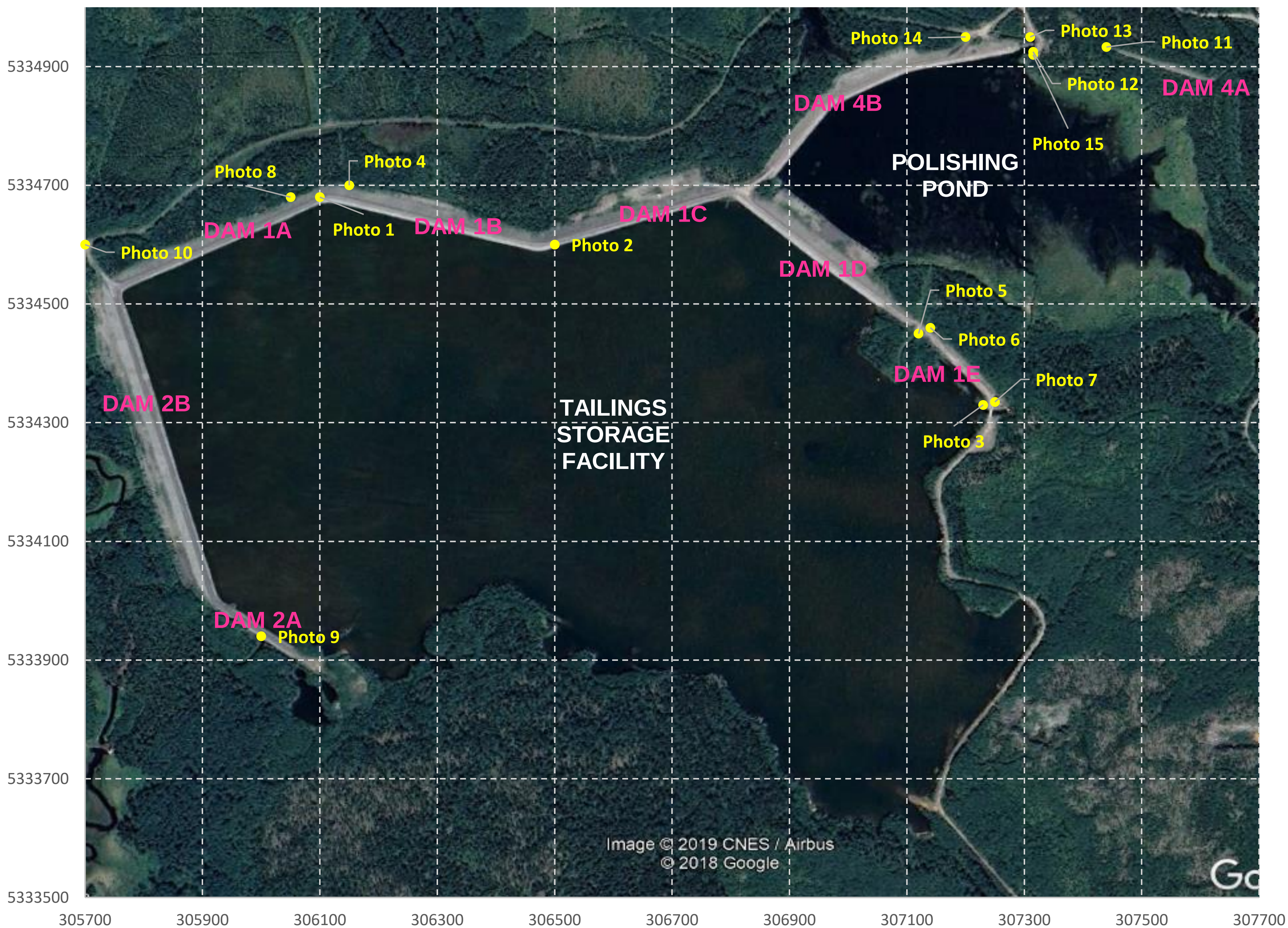


Photo 14
Photo 13
Photo 11
Photo 12
DAM 4A
DAM 4B
Photo 15
POLISHING POND
Photo 8
Photo 4
DAM 1A
Photo 1
DAM 1B
DAM 1C
Photo 10
Photo 2
DAM 1D
Photo 5
Photo 6
DAM 1E
Photo 7
DAM 2B
TAILINGS STORAGE FACILITY
Photo 3
DAM 2A
Photo 9
Image © 2019 CNES / Airbus
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5334900
5334700
5334500
5334300
5334100
5333900
5333700
5333500
305700
305900
306100
306300
306500
306700
306900
307100
307300
307500
307700

Photo 1 : Dam 1B - Photo of new rip rap placed on upstream slope.
View looking East.

Photo 2 : Dam 1C – Photo of degraded rip rap area on the upstream slope.
View looking South.

Photo 3 : Dam 1E – Photo of damaged trash rack structure.

Photo 4 : Dam 1B – Photo of seepage area at the toe of the embankment. No visible flow, area is slightly damp.

Photo 5 : Dam 1D – Photo of concrete sill and upstream spillway channel at the TSF emergency spillway. Vegetation was cleared in 2018.

Photo 6 : Dam 1D - Photo of downstream spillway channel at the TSF emergency spillway. Vegetation was cleared in 2018.

Photo 7 : Dam 1E – Spillway bridge in good condition.

Photo 8 : Dam 1A – General view of vegetative growth at the toe of the embankment.

Photo 9 : Dam 2A – water ponding at the downstream toe of the dam, similar to previous years. This is a natural topographic low, however beaver activity nearby exacerbates the ponding.

Photo 10 : Dam 2B - Photo of culverts located northwest of the TSF. The culverts are partially blocked by beaver activity.

Photo 11 : Dam 4A - Crest of dam, looking East. Note significant vegetative growth on the sideslopes of the dam.

Photo 12 : Dam 4B – View of main spillway control structure and concrete overflow section adjacent to it. Concrete appears intact.

Photo 13 : Dam 4B – Vegetative growth in the final effluent channel to be monitored.

Photo 14 : Dam 4B – final outflow culverts are clear and unobstructed by sediment. Vegetative growth to be monitored.

Photo 15 : Dam 4B – granular fill placed across part of the emergency spillway.

**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, 3e Avenue Ouest***
***Val d'Or (Québec) J9P 1T5***

## 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 Morgan Lypka 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 **94-260**) 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 Invar 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 huit (8) cheminements en boucle obtenant des écarts de fermeture de 0.6mm, 0.4mm, 1.3mm, 0.2mm, 0.2mm, 1.4 mm, 0.3mm et 0.3mm. Le premier cheminement en boucle s'étend sur une distance totale (incluant aller et retour) de 506m entre le repère **94-257** et le moniteur **B-1** avec une erreur de fermeture de 0.6mm. Le deuxième cheminement en boucle s'étend sur une distance de 713m totale (incluant aller et retour) entre le repère **94-257** et le moniteur **JLC-2011-3** avec une erreur de fermeture de 0.4 mm. Le troisième cheminement en boucle s'étend sur une distance totale (incluant aller et retour) de 2032m entre le repère **94-257** et le moniteur **B-7** avec une erreur de fermeture de 1.3mm. Le quatrième cheminement liant le moniteur **JLC-2011-8** (départ) et le point d'appui

**94-257** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 300m avec une erreur de fermeture globale de 0.2mm. Le cinquième cheminement liant le moniteur **B7** (départ) et le moniteur **94-263** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 1490m avec une erreur de fermeture globale de 0.2 mm. Le sixième cheminement liant le point d'appui **94-263** (départ) et le moniteur **B11** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 1175m avec une erreur de fermeture globale de 1.4mm. Enfin, le septième cheminement liant le moniteur **JLC-2011-4** (départ) et le moniteur **JLC-2011-2** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 560m avec une erreur de fermeture globale de 0.3mm. Finalement, le huitième cheminement liant le moniteur **JLC-2011-4** (départ) et le moniteur **JLC-2011-5** (arrivée) s'étend sur une distance totale (incluant aller et retour) de 180m avec une erreur de fermeture globale de 0.3mm. 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. Notez qu'en octobre 2019, aucun moniteur n'a été levé selon cette méthode et tous l'ont été par nivellement géométrique.

## 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 le 4, 7, 8 et 15 octobre 2019 par une équipe de deux à 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 GS14 et GS15 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 largement améliorées.
- Un (1) niveau électronique DNA 3 compagnie Leica avec deux mires à code-barres précision en nivellement double de 1 mm/km.

## 6) REMARQUE POINT 2011-3 :

Contrairement aux mesures de nivellement géométrique, les mesures GNSS temps réel au point 2011-3 montrent un écart de 30 mm par rapport aux mesures de 2018 qui semble anormal, bien que les mesures aient été prises parfaitement selon les normes (3 mesures prises à une quinzaine de minutes d'espacement donc 3 installations indépendantes) ayant chacune d'excellentes statistiques et que de plus les autres points pris dans la même période ne présentent pas de biais.

On a décidé de conserver les données obtenues et on va placer ce point en observation jusqu'au prochain contrôle.

## 7) 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 |
| | Terrain 2019 | 5333567.021 | 222891.727 | 311.681 |
| | **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** |
| | **Diff. Théo-2019** | **-0.067** | **0.002** | **-0.004** |
| | | | | |
| | **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** |
| | **2019-2018** | **0.001** | **0.001** | **0.007** |

| | | | | |
|---|---|---|---|---|
| **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 | | |
| | Terrain 2019 | 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 |
| | Terrain 2019 | 5332897.302 | 222292.385 | 315.835 |
| | **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** |
| | **Diff. Théo-2019** | **-0.236** | **0.128** | **0.007** |
| | | | | |
| | **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** |
| | **2019-2018** | **-0.009** | **-0.004** | **-0.026** |

| | | | | |
|---|---|---|---|---|
| **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 | | |
| | Terrain 2019 | 5332859.136 | 222355.488 | 317.477 |
| | **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** |
| | **Diff. Théo-2018** | **-** | **-** | **-** |
| | **Diff. Théo-2019** | **-0.218** | **0.142** | **-0.006** |
| | | | | |
| | **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** |
| | **2017-2016** | **-** | **-** | **-** |
| | **2019-2017** | **0.001** | **0.000** | **-0.047** |

- **SCOPQ (MTM) NAD83 FUSEAU 9 MÉRIDIEN CENTRAL : 76°30' OUEST**

* Coordonnées théoriques fournies par la mine dont on a ajouté 5 300 000m en Nord et 200 000m en Est et soustrait 3 000m en élévation

**Note** : On doit considérer les inscriptions au mm significatives qu'au 10mm près en horizontal et qu'au 2 cm près en vertical pour les données venant des levés GPS ou GNSS.

**Légende :**

** Point existant ancré dans le roc avec trépied témoin.

*** Précision insuffisante en vertical, se référer au nivellement géométrique pour une meilleure

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

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

**10) RÉSUMÉ :**

En résumé, notre travail contient :

| | |
|---|---|
| Nombre de plaques de tassement levées par GPS (±1cm) : | 18 |
| Nombre de plaques de tassement nivelées (± 2mm) : | 19 |
| Nombre de plaques levées par st. totale pour le vertical : | 0 |
| Nombre de plaques nivelées à partir du niveau géométrique : | 19 |
| Nombre de points d'appui localisés/contrôlés en horizontal : | 2 |
| Nombre de points d'appui en vertical (cheminement géométrique) : | 2 |
| Longueur totale des cheminements altimétriques : | 6.956 Km |

Fait à Val d'Or, le 8 novembre 2019, sous le dossier C-14891/442.18-19 et le numéro **14759** de mes minutes en référence aux dossiers : C-14421/442.18-19 (2018), 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 8 novembre 2019

Copie conforme à l'original

**CORRIVEAU J.L. & ASSOC. INC.**

**PRÉLIMINAIRE**

**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 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | Nord | 5333481.600 | 5333481.572 | -0.028 | S | 5333481.588 | 0.016 | N | 5333481.573 | -0.015 | S |
| | Est | 223364.365 | 223364.319 | -0.046 | O | 223364.310 | -0.009 | O | 223364.316 | 0.006 | E |
| | Elev. | 319.120 | 319.085 | -0.035 | B | 319.085 | 0.000 | - | 319.097 | 0.012 | H |
| B-2 | Nord | 5333524.849 | 5333524.834 | -0.015 | S | 5333524.840 | 0.006 | N | 5333524.842 | 0.002 | N |
| | Est | 223312.799 | 223312.758 | -0.041 | O | 223312.754 | -0.004 | O | 223312.766 | 0.012 | E |
| | Elev. | 318.489 | 318.450 | -0.039 | B | 318.452 | 0.002 | H | 318.454 | 0.002 | H |
| B-3 | Nord | 5333560.718 | 5333560.716 | -0.002 | S | 5333560.721 | 0.005 | N | 5333560.721 | 0.000 | - |
| | Est | 223270.316 | 223270.298 | -0.018 | O | 223270.294 | -0.004 | O | 223270.298 | 0.004 | E |
| | Elev. | 319.122 | 319.090 | -0.032 | B | 319.093 | 0.003 | H | 319.101 | 0.008 | H |
| B-4 | Nord | 5333595.764 | 5333595.789 | 0.025 | N | 5333595.793 | 0.004 | N | 5333595.798 | 0.005 | N |
| | Est | 223073.887 | 223073.882 | -0.005 | O | 223073.899 | 0.017 | E | 223073.888 | -0.011 | O |
| | Elev. | 318.136 | 318.111 | -0.025 | B | 318.134 | 0.023 | H | 318.140 | 0.006 | H |
| B-5 | Nord | 5333572.172 | 5333572.224 | 0.052 | N | 5333572.230 | 0.006 | N | 5333572.233 | 0.003 | N |
| | Est | 222993.640 | 222993.630 | -0.010 | O | 222993.641 | 0.011 | E | 222993.631 | -0.010 | O |
| | Elev. | 318.157 | 318.151 | -0.006 | B | 318.158 | 0.007 | H | 318.166 | 0.008 | H |
| B-6 | Nord | 5333588.639 | 5333588.744 | 0.105 | N | 5333588.757 | 0.013 | N | 5333588.748 | -0.009 | S |
| | Est | 222661.587 | 222661.604 | 0.017 | E | 222661.649 | 0.045 | E | 222661.613 | -0.036 | O |
| | Elev. | 318.176 | 318.139 | -0.037 | B | 318.141 | 0.002 | H | 318.150 | 0.009 | H |
| B-7 | Nord | 5333510.829 | 5333511.090 | 0.261 | N | 5333511.091 | 0.001 | N | 5333511.093 | 0.002 | N |
| | Est | 222246.790 | 222246.804 | 0.014 | E | 222246.868 | 0.064 | E | 222246.809 | -0.059 | O |
| | Elev. | 318.176 | 318.185 | 0.009 | H | 318.190 | 0.005 | H | 318.203 | 0.013 | H |
| B-8 | Nord | 5333371.342 | 5333371.603 | 0.261 | N | 5333371.609 | 0.006 | N | 5333371.606 | -0.003 | S |
| | Est | 222178.864 | 222178.871 | 0.007 | E | 222178.944 | 0.073 | E | 222178.876 | -0.068 | O |
| | Elev. | 319.031 | 319.022 | -0.009 | B | 319.020 | -0.002 | B | 319.035 | 0.015 | B |
| B-9 | Nord | 5333326.921 | 5333327.178 | 0.257 | N | 5333327.189 | 0.011 | N | 5333327.187 | -0.002 | S |
| | Est | 222191.523 | 222191.531 | 0.008 | E | 222191.610 | 0.079 | E | 222191.543 | -0.067 | O |
| | Elev. | 319.181 | 319.161 | -0.020 | B | 319.171 | 0.010 | H | 319.180 | 0.009 | H |
| B-10 | Nord | 5333154.032 | 5333154.277 | 0.245 | N | 5333154.279 | 0.002 | N | 5333154.282 | 0.003 | N |
| | Est | 222242.232 | 222242.203 | -0.029 | O | 222242.271 | 0.068 | E | 222242.254 | -0.017 | O |
| | Elev. | 318.244 | 318.220 | -0.024 | B | 318.226 | 0.006 | H | 318.234 | 0.008 | H |
| B-11 | Nord | | | | | | | | 5333362.842 | N/A | |
| | Est | | | | | | | | 222145.004 | N/A | |
| | Elev. | | | | | | | | 307.277 | N/A | |
| 2011-1 L | Nord | | | | | | | | 5333800.878 | N/A | |
| | Est | | | | | | | | 222387.811 | N/A | |
| | Elev. | | | | | | | | 310.020 | N/A | |
| 2011-2 C | Nord | | | | | | | | 5333562.623 | N/A | |
| | Est | | | | | | | | 222322.116 | N/A | |
| | Elev. | | | | | | | | 309.270 | N/A | |
| 2011-3 L | Nord | | | | | | | | 5333826.347 | N/A | |
| | Est | | | | | | | | 223442.150 | N/A | |
| | Elev. | | | | | | | | 310.354 | N/A | |
| 2011-4 L | Nord | | | | | | | | 5333763.037 | N/A | |
| | Est | | | | | | | | 223329.455 | N/A | |
| | Elev. | | | | | | | | 310.371 | N/A | |
| 2011-5 C | Nord | | | | | | | | 5333821.228 | N/A | |
| | Est | | | | | | | | 223378.028 | N/A | |
| | Elev. | | | | | | | | 303.984 | N/A | |
| 2011-6 C | Nord | | | | | | | | 5333068.318 | N/A | |
| | Est | | | | | | | | 222236.094 | N/A | |
| | Elev. | | | | | | | | 309.338 | N/A | |
| 2011-7 C | Nord | | | | | | | | 5333271.670 | N/A | |
| | Est | | | | | | | | 222174.469 | N/A | |
| | Elev. | | | | | | | | 309.156 | N/A | |
| 2011-8 C | Nord | | | | | | | | 5333627.581 | N/A | |
| | Est | | | | | | | | 223061.472 | N/A | |
| | Elev. | | | | | | | | 310.383 | N/A | |

| Plaque de tassement | | Arpentage Octobre 2012 | Différence 2012-2011 | | Arpentage Juillet 2013 | Différence 2013-2012 | | Arpentage Juin 2014 | Différence 2014-2013 | | Arpentage Juin 2015 | Différence 2015-2014 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | Nord | 5333481.567 | -0.006 | S | 5333481.574 | 0.007 | N | 5333481.565 | -0.009 | S | 5333481.569 | 0.004 | N |
| | Est | 223364.317 | 0.001 | E | 223364.319 | 0.002 | E | 223364.324 | 0.005 | E | 223364.321 | -0.003 | O |
| | Elev. | 319.089 | -0.008 | B | 319.087 | -0.002 | B | 319.082 | -0.005 | B | 319.080 | -0.002 | B |
| B-2 | Nord | 5333524.839 | -0.003 | S | 5333524.843 | 0.004 | N | 5333524.841 | -0.002 | S | 5333524.836 | -0.005 | S |
| | Est | 223312.765 | -0.001 | O | 223312.764 | -0.001 | O | 223312.774 | 0.010 | E | 223312.774 | 0.000 | - |
| | Elev. | 318.448 | -0.006 | B | 318.439 | -0.009 | B | 318.430 | -0.009 | B | 318.428 | -0.002 | B |
| B-3 | Nord | 5333560.720 | -0.001 | S | 5333560.718 | -0.002 | S | 5333560.713 | -0.005 | S | 5333560.717 | 0.004 | N |
| | Est | 223270.292 | -0.006 | O | 223270.294 | 0.002 | E | 223270.302 | 0.008 | E | 223270.297 | -0.005 | O |
| | Elev. | 319.098 | -0.003 | B | 319.096 | -0.002 | B | 319.086 | -0.010 | B | 319.087 | 0.001 | H |
| B-4 | Nord | 5333595.802 | 0.004 | N | 5333595.802 | 0.000 | N/A | 5333595.797 | -0.005 | S | 5333595.803 | 0.006 | N |
| | Est | 223073.881 | -0.007 | O | 223073.879 | -0.002 | O | 223073.885 | 0.006 | E | 223073.879 | -0.006 | O |
| | Elev. | 318.141 | 0.001 | H | 318.141 | 0.000 | N/A | 318.127 | -0.014 | B | 318.134 | 0.007 | H |
| B-5 | Nord | 5333572.227 | -0.006 | S | 5333572.231 | 0.004 | N | 5333572.233 | 0.002 | N | 5333572.232 | -0.001 | S |
| | Est | 222993.632 | 0.001 | E | 222993.625 | -0.007 | O | 222993.633 | 0.008 | E | 222993.633 | 0.000 | - |
| | Elev. | 318.164 | -0.002 | B | 318.165 | 0.001 | H | 318.160 | -0.005 | B | 318.163 | 0.003 | H |
| B-6 | Nord | 5333588.747 | -0.001 | S | 5333588.753 | 0.006 | N | 5333588.751 | -0.002 | S | 5333588.753 | 0.002 | N |
| | Est | 222661.609 | -0.004 | O | 222661.604 | -0.005 | O | 222661.610 | 0.006 | E | 222661.608 | -0.002 | O |
| | Elev. | 318.139 | -0.011 | B | 318.143 | 0.004 | H | 318.132 | -0.011 | B | 318.148 | 0.016 | H |
| B-7 | Nord | 5333511.087 | -0.007 | S | 5333511.096 | 0.009 | N | 5333511.093 | -0.003 | S | 5333511.096 | 0.003 | N |
| | Est | 222246.807 | -0.003 | O | 222246.802 | -0.005 | O | 222246.805 | 0.003 | E | 222246.803 | -0.002 | O |
| | Elev. | 318.186 | -0.017 | B | 318.203 | 0.018 | H | 318.196 | -0.007 | B | 318.204 | 0.008 | H |
| B-8 | Nord | 5333371.607 | 0.001 | N | 5333371.610 | 0.003 | N | 5333371.606 | -0.004 | S | 5333371.607 | 0.001 | N |
| | Est | 222178.872 | -0.004 | O | 222178.867 | -0.005 | O | 222178.872 | 0.005 | E | 222178.876 | 0.004 | E |
| | Elev. | 319.031 | -0.004 | B | 319.035 | 0.004 | H | 319.012 | -0.023 | B | 319.033 | 0.021 | H |
| B-9 | Nord | 5333327.193 | 0.006 | N | 5333327.189 | -0.004 | S | 5333327.179 | -0.010 | S | 5333327.182 | 0.003 | N |
| | Est | 222191.531 | -0.012 | O | 222191.528 | -0.003 | O | 222191.533 | 0.005 | E | 222191.536 | 0.003 | E |
| | Elev. | 319.186 | 0.006 | H | 319.177 | -0.009 | B | 319.154 | -0.023 | B | 319.173 | 0.019 | H |
| B-10 | Nord | 5333154.278 | -0.004 | S | 5333154.275 | -0.003 | S | 5333154.276 | 0.001 | N | 5333154.268 | -0.008 | S |
| | Est | 222242.192 | -0.062 | O | 222242.189 | -0.003 | O | 222242.196 | 0.007 | E | 222242.196 | 0.000 | - |
| | Elev. | 318.233 | -0.001 | B | 318.231 | -0.002 | B | 318.226 | -0.005 | B | 318.232 | 0.006 | H |
| B-11 | Nord | 5333362.840 | -0.002 | S | 5333362.842 | 0.002 | N | 5333362.843 | 0.001 | N | 5333362.849 | 0.006 | N |
| | Est | 222145.006 | 0.002 | E | 222145.000 | -0.006 | O | 222145.004 | 0.004 | E | 222145.004 | 0.000 | - |
| | Elev. | 307.241 | -0.036 | B | 307.266 | 0.025 | H | 307.251 | -0.015 | B | 307.255 | 0.004 | H |
| 2011-1 L | Nord | 5333800.873 | -0.005 | S | 5333800.871 | -0.002 | S | 5333800.866 | -0.005 | S | 5333800.873 | 0.007 | N |
| | Est | 222387.817 | 0.006 | E | 222387.815 | -0.002 | O | 222387.819 | 0.004 | E | 222387.817 | -0.002 | O |
| | Elev. | 310.018 | -0.002 | B | 310.018 | 0.000 | N/A | 310.001 | -0.017 | B | 310.003 | 0.002 | H |
| 2011-2 C | Nord | 5333562.637 | 0.014 | N | 5333562.632 | -0.005 | S | 5333562.627 | -0.005 | S | 5333562.627 | 0.000 | - |
| | Est | 222322.109 | -0.007 | O | 222322.107 | -0.002 | O | 222322.116 | 0.009 | E | 222322.110 | -0.006 | O |
| | Elev. | 309.252 | -0.018 | B | 309.242 | -0.010 | B | 309.240 | -0.002 | B | 309.235 | -0.005 | B |
| 2011-3 L | Nord | 5333826.349 | 0.002 | N | 5333826.347 | -0.002 | S | 5333826.343 | -0.004 | S | 5333826.350 | 0.007 | N |
| | Est | 223442.150 | 0.000 | - | 223442.153 | 0.003 | E | 223442.157 | 0.004 | E | 223442.154 | -0.003 | O |
| | Elev. | 310.345 | -0.009 | B | 310.344 | -0.001 | B | 310.332 | -0.012 | B | 310.333 | 0.001 | H |
| 2011-4 L | Nord | 5333763.041 | 0.004 | N | 5333763.040 | -0.001 | S | 5333763.036 | -0.004 | S | 5333763.040 | 0.004 | N |
| | Est | 223329.455 | 0.000 | - | 223329.456 | 0.001 | E | 223329.465 | 0.009 | E | 223329.460 | -0.005 | O |
| | Elev. | 310.359 | -0.012 | B | 310.365 | 0.006 | H | 310.349 | -0.016 | B | 310.353 | 0.004 | H |
| 2011-5 C | Nord | 5333821.227 | -0.001 | S | 5333821.221 | -0.006 | S | 5333821.222 | 0.001 | N | 5333821.227 | 0.005 | N |
| | Est | 223378.028 | 0.000 | - | 223378.028 | 0.000 | - | 223378.034 | 0.006 | E | 223378.031 | -0.003 | O |
| | Elev. | 303.978 | -0.006 | B | 303.980 | 0.001 | H | 303.967 | -0.013 | B | 303.970 | 0.003 | H |
| 2011-6 C | Nord | 5333068.305 | -0.013 | S | 5333068.308 | 0.003 | N | 5333068.307 | -0.001 | S | 5333068.308 | 0.001 | N |
| | Est | 222236.095 | 0.001 | E | 222236.096 | 0.001 | E | 222236.100 | 0.004 | E | 222236.096 | -0.004 | O |
| | Elev. | 309.334 | -0.004 | B | 309.337 | 0.003 | H | 309.324 | -0.013 | B | 309.334 | 0.010 | H |
| 2011-7 C | Nord | 5333271.658 | -0.012 | N | 5333271.660 | 0.002 | N | 5333271.666 | 0.006 | N | 5333271.661 | -0.005 | S |
| | Est | 222174.459 | -0.010 | O | 222174.458 | -0.001 | O | 222174.459 | 0.001 | E | 222174.457 | -0.002 | O |
| | Elev. | 309.159 | 0.003 | H | 309.161 | 0.001 | H | 309.149 | -0.012 | B | 309.172 | 0.023 | H |
| 2011-8 C | Nord | 5333627.573 | -0.008 | S | 5333627.577 | 0.004 | N | 5333627.571 | -0.006 | S | 5333627.574 | 0.003 | N |
| | Est | 223061.471 | -0.001 | O | 223061.467 | -0.004 | O | 223061.476 | 0.009 | E | 223061.475 | -0.001 | O |
| | Elev. | 310.369 | -0.014 | B | 310.370 | 0.001 | H | 310.355 | -0.015 | B | 310.368 | 0.013 | H |

| Plaque de tassement | | Arpentage Juin 2016 | Différence 2016-2015 | | Arpentage Septembre 2017 | Différence 2017-2016 | | Arpentage Octobre 2018 | Différence 2018-2017 | | Arpentage Octobre 2019 | Différence 2019-2018 | | Plaque de tassement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | Nord | 5333481.576 | 0.007 | N | 5333481.586 | 0.010 | N | 5333481.575 | -0.011 | S | 5333481.568 | -0.007 | N | B-1 |
| | Est | 223364.317 | -0.004 | O | 223364.321 | 0.004 | O | 223364.321 | 0.000 | O | 223364.323 | 0.002 | O | |
| | Elev. | 319.098 | 0.018 | H | 319.094 | -0.004 | B | 319.086 | -0.007 | B | 319.083 | -0.004 | B | |
| B-2 | Nord | 5333524.846 | 0.010 | N | 5333524.853 | 0.007 | N | 5333524.839 | -0.014 | S | 5333524.841 | 0.002 | N | B-2 |
| | Est | 223312.771 | -0.003 | O | 223312.773 | 0.002 | E | 223312.775 | 0.002 | E | 223312.776 | 0.001 | E | |
| | Elev. | 318.441 | 0.013 | H | 318.436 | -0.005 | B | 318.425 | -0.010 | B | 318.424 | -0.001 | B | |
| B-3 | Nord | 5333560.730 | 0.014 | N | 5333560.720 | -0.010 | S | 5333560.722 | 0.002 | N | 5333560.716 | -0.005 | S | B-3 |
| | Est | 223270.295 | -0.002 | O | 223270.299 | 0.004 | E | 223270.301 | 0.002 | E | 223270.302 | 0.001 | E | |
| | Elev. | 319.099 | 0.001 | H | 319.092 | -0.007 | B | 319.084 | -0.008 | B | 319.083 | -0.001 | B | |
| B-4 | Nord | 5333595.808 | 0.005 | N | 5333595.807 | -0.001 | S | 5333595.803 | -0.004 | S | 5333595.806 | 0.003 | N | B-4 |
| | Est | 223073.877 | -0.002 | O | 223073.879 | 0.002 | E | 223073.890 | 0.011 | E | 223073.878 | -0.012 | O | |
| | Elev. | 318.146 | 0.012 | H | 318.137 | -0.009 | B | 318.136 | -0.002 | B | 318.143 | 0.007 | H | |
| B-5 | Nord | 5333572.233 | 0.001 | N | 5333572.234 | 0.001 | N | 5333572.226 | -0.008 | S | 5333572.237 | 0.010 | N | B-5 |
| | Est | 222993.626 | -0.007 | O | 222993.629 | 0.003 | E | 222993.639 | 0.010 | E | 222993.628 | -0.010 | O | |
| | Elev. | 318.172 | 0.009 | H | 318.160 | -0.012 | B | 318.158 | -0.003 | B | 318.168 | 0.010 | H | |
| B-6 | Nord | 5333588.754 | 0.001 | N | 5333588.759 | 0.005 | N | 5333588.749 | -0.010 | S | 5333588.759 | 0.010 | N | B-6 |
| | Est | 222661.609 | 0.001 | E | 222661.607 | -0.002 | O | 222661.620 | 0.012 | E | 222661.608 | -0.011 | O | |
| | Elev. | 318.160 | 0.012 | H | 318.146 | -0.014 | B | 318.144 | -0.001 | B | 318.155 | 0.010 | H | |
| B-7 | Nord | 5333511.098 | 0.002 | N | 5333511.101 | 0.003 | N | 5333511.092 | -0.009 | S | 5333511.096 | 0.004 | N | B-7 |
| | Est | 222246.804 | 0.001 | E | 222246.797 | -0.007 | O | 222246.812 | 0.014 | E | 222246.802 | -0.010 | O | |
| | Elev. | 318.221 | 0.017 | H | 318.217 | -0.004 | B | 318.222 | 0.005 | H | 318.223 | 0.001 | H | |
| B-8 | Nord | 5333371.610 | 0.003 | N | 5333371.607 | -0.003 | S | 5333371.606 | -0.001 | S | 5333371.603 | -0.003 | S | B-8 |
| | Est | 222178.866 | -0.010 | O | 222178.868 | 0.001 | E | 222178.881 | 0.014 | E | 222178.869 | -0.012 | O | |
| | Elev. | 319.028 | -0.005 | B | 319.032 | 0.004 | H | 319.027 | -0.005 | B | 319.030 | 0.003 | H | |
| B-9 | Nord | 5333327.191 | 0.009 | N | 5333327.186 | -0.005 | S | 5333327.181 | -0.005 | S | 5333327.185 | 0.003 | N | B-9 |
| | Est | 222191.524 | -0.012 | O | 222191.528 | 0.004 | E | 222191.542 | 0.014 | E | 222191.532 | -0.010 | O | |
| | Elev. | 319.175 | 0.002 | H | 319.173 | -0.002 | B | 319.172 | -0.001 | B | 319.175 | 0.003 | H | |
| B-10 | Nord | 5333154.280 | 0.012 | S | 5333154.274 | -0.006 | S | 5333154.274 | 0.000 | S | 5333154.272 | -0.002 | S | B-10 |
| | Est | 222242.186 | -0.010 | O | 222242.185 | -0.001 | O | 222242.207 | 0.022 | E | 222242.191 | -0.016 | O | |
| | Elev. | 318.243 | 0.011 | H | 318.243 | 0.000 | N/A | 318.237 | -0.005 | B | 318.234 | -0.003 | B | |
| B-11 | Nord | 5333362.854 | 0.005 | N | 5333362.834 | -0.020 | S | 5333362.849 | 0.015 | N | 5333362.845 | -0.004 | S | B-11 |
| | Est | 222144.996 | -0.008 | O | 222144.997 | 0.001 | E | 222145.015 | 0.018 | E | 222145.002 | -0.013 | O | |
| | Elev. | 307.273 | 0.018 | H | 307.258 | -0.015 | B | 307.269 | 0.011 | H | 307.266 | -0.003 | B | |
| 2011-1 L | Nord | 5333800.859 | -0.014 | S | 5333800.872 | 0.013 | N | 5333800.863 | -0.009 | S | 5333800.865 | 0.002 | N | 2011-1 L |
| | Est | 222387.818 | 0.001 | E | 222387.812 | -0.006 | O | 222387.813 | 0.000 | - | 222387.816 | 0.004 | E | |
| | Elev. | 309.987 | -0.016 | B | 309.999 | 0.012 | H | 309.986 | -0.013 | B | 309.986 | 0.000 | - | |
| 2011-2 C | Nord | 5333562.629 | 0.002 | N | 5333562.632 | 0.003 | N | 5333562.636 | 0.004 | N | 5333562.638 | 0.002 | N | 2011-2 C |
| | Est | 222322.107 | -0.003 | O | 222322.099 | -0.008 | O | 222322.112 | 0.013 | E | 222322.117 | 0.005 | E | |
| | Elev. | 309.247 | 0.012 | H | 309.252 | 0.005 | H | 309.240 | -0.012 | B | 309.249 | 0.009 | H | |
| 2011-3 L | Nord | 5333826.338 | -0.012 | S | 5333826.351 | 0.013 | N | 5333826.344 | -0.007 | S | 5333826.344 | 0.000 | - | 2011-3 L |
| | Est | 223442.161 | 0.007 | E | 223442.151 | -0.010 | O | 223442.151 | 0.000 | - | 223442.157 | 0.006 | E | |
| | Elev. | 310.307 | -0.026 | B | 310.323 | 0.016 | H | 310.309 | -0.014 | B | 310.279 | -0.030 | B | |
| 2011-4 L | Nord | 5333763.033 | -0.007 | S | 5333763.039 | 0.006 | N | 5333763.037 | -0.002 | S | 5333763.030 | -0.007 | S | 2011-4 L |
| | Est | 223329.458 | -0.002 | O | 223329.458 | 0.000 | - | 223329.458 | 0.000 | - | 223329.462 | 0.004 | E | |
| | Elev. | 310.341 | -0.012 | B | 310.347 | 0.006 | H | 310.347 | 0.000 | - | 310.343 | -0.004 | B | |
| 2011-5 C | Nord | 5333821.220 | -0.007 | S | 5333821.222 | 0.002 | N | 5333821.221 | -0.001 | S | 5333821.223 | 0.002 | N | 2011-5 C |
| | Est | 223378.030 | -0.001 | O | 223378.030 | 0.000 | E | 223378.025 | -0.005 | O | 223378.037 | 0.012 | E | |
| | Elev. | 303.963 | -0.007 | B | 303.973 | 0.010 | H | 303.965 | -0.008 | B | 303.958 | -0.006 | B | |
| 2011-6 C | Nord | 5333068.313 | 0.005 | N | 5333068.302 | -0.011 | S | 5333068.314 | 0.012 | N | 5333068.310 | -0.003 | S | 2011-6 C |
| | Est | 222236.093 | -0.003 | O | 222236.094 | 0.001 | E | 222236.113 | 0.020 | E | 222236.095 | -0.018 | O | |
| | Elev. | 309.349 | 0.015 | H | 309.347 | -0.002 | B | 309.346 | -0.001 | B | 309.334 | -0.012 | B | |
| 2011-7 C | Nord | 5333271.669 | 0.008 | N | 5333271.658 | -0.011 | S | 5333271.661 | 0.003 | N | 5333271.653 | -0.008 | S | 2011-7 C |
| | Est | 222174.447 | -0.010 | O | 222174.452 | 0.005 | E | 222174.472 | 0.020 | E | 222174.452 | -0.020 | O | |
| | Elev. | 309.170 | -0.002 | B | 309.171 | 0.001 | H | 309.164 | -0.007 | B | 309.171 | 0.007 | H | |
| 2011-8 C | Nord | 5333627.574 | 0.000 | - | 5333627.568 | -0.006 | S | 5333627.571 | 0.003 | N | pas levé | | - | 2011-8 C |
| | Est | 223061.469 | -0.006 | O | 223061.470 | 0.001 | E | 223061.473 | 0.004 | E | pas levé | | - | |
| | Elev. | 310.383 | 0.015 | H | 310.369 | -0.014 | B | 310.373 | 0.004 | H | pas levé | | - | |

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 — O = déplacement vers l'Ouest — E = déplacement vers l'Est
S = déplacement vers le Sud — 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-14891/442.18-19*

# Annexe 2

**<u>TABLEAU DES *ÉLÉVATIONS PRÉCISES DES PLAQUES DE TASSEMENT*</u>**

(Obtenues par nivellement géométrique-électronique et trigonométrique)

| Plaque de tassement | Élévation Théorique selon mine | Année Sept. 2008 | Diff. (m) 2008-Théo. | Élévation Août 2009 | Diff. (m) 2009-2008 | Élévation Juin 2010 | Diff. (m) 2010-2009 | Élévation Oct. 2011 | Diff. (m) 2011-2010 | Diff. (m) 2011-2008 | Élévation Oct. 2012 | Diff. (m) 2012-2011 | Diff. (m) 2012-2008 | Élévation Juil. 2013 | Diff. (m) 2013-2012 | Diff. (m) 2013-2008 2013-2011 | Élévation Juil. 2014 | Diff. (m) 2014-2013 | Diff. (m) 2014-2008 2014-2011 | Élévation juin-15 | Diff. (m) 2015-2014 | Diff. (m) 2015-2008 2015-2011 | Élévation juin-16 | Diff. (m) 2016-2015 | Diff. (m) 2016-2008 2017-2011 | Élévation septembre.17 | Diff. (m) 2017-2016 | Diff. (m) 2017-2008 2017-2011 | Élévation octobre.18 | Diff. (m) 2018-2017 | Diff. (m) 2018-2008 2018-2011 | Élévation octobre.19 | Diff. (m) 2019-2018 | Diff. (m) 2019-2008 2019-2011 | Plaque de tassement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 94-257 | 3316.707 | 3316.707 | - | 3316.707 | - | 3316.707 | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 3316.707 | - | - | 94-257 |
| 94-262 | 3315.842 | - | - | - | - | - | - | 3315.840 | - | - | 3315.839 | -0.001 | - | 3315.859 | - | - | 3315.841 | - | - | 3315.842 | - | - | 3315.842 | - | - | 3315.878 | - | - | 3315.842 | - | - | 315.841 | - | - | 94-262 |
| B1 | 3319.120 | 3319.099 | -0.021 | 3319.099 | 0.000 | 3319.100 | 0.001 | 3319.097 | -0.003 | -0.002 | 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 | 3319.098 | -0.002 | -0.002 | B1 |
| B2 | 3318.489 | 3318.465 | -0.024 | 3318.462 | -0.003 | 3318.460 | -0.002 | 3318.454 | -0.006 | -0.011 | 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 | 3318.438 | -0.002 | -0.027 | B2 |
| B3 | 3319.122 | 3319.103 | -0.019 | 3319.104 | 0.001 | 3319.104 | 0.000 | 3319.101 | -0.003 | -0.002 | 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 | 3319.101 | -0.001 | -0.003 | B3 |
| B4 | 3318.136 | 3318.143 | 0.007 | 3318.146 | 0.003 | 3318.146 | 0.000 | 3318.140 | -0.006 | -0.003 | 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 | 3318.144 | 0.000 | 0.001 | B4 |
| B5 | 3318.157 | 3318.168 | 0.011 | 3318.172 | 0.004 | 3318.172 | 0.000 | 3318.166 | -0.006 | -0.002 | 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 | 3318.171 | 0.000 | 0.003 | B5 |
| B6 | 3318.176 | 3318.153 | -0.023 | 3318.158 | 0.005 | 3318.156 | -0.002 | 3318.150 | -0.006 | -0.003 | 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 | 3318.153 | -0.001 | 0.000 | B6 |
| B7 | 3318.176 | 3318.198 | 0.022 | 3318.207 | 0.009 | 3318.207 | 0.000 | 3318.203 | -0.004 | 0.005 | 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 | 3318.220 | 0.001 | 0.022 | B7 |
| B8 | 3319.031 | 3319.034 | 0.003 | 3319.039 | 0.005 | 3319.038 | -0.001 | 3319.035 | -0.003 | 0.001 | 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 | 3319.034 | -0.001 | 0.000 | B8 |
| B9 | 3319.181 | 3319.180 | -0.001 | 3319.186 | 0.006 | 3319.186 | 0.000 | 3319.180 | -0.006 | 0.000 | 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 | 3319.179 | -0.001 | -0.001 | B9 |
| B10 | 3318.244 | 3318.232 | -0.012 | 3318.239 | 0.007 | 3318.238 | -0.001 | 3318.234 | -0.004 | 0.002 | 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 | 3318.241 | 0.000 | 0.009 | B10 |
| **B11 | 3307.253 | - | - | - | - | - | - | 3307.277 | - | - | 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 | 3307.264 | -0.004 | -0.013 | **B11 |
| *2011-1 | - | - | - | - | - | - | - | 3310.020 | - | - | 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 | 3310.001 | -0.003 | -0.019 | *2011-1 |
| **2011-2 | - | - | - | - | - | - | - | 3309.270 | - | - | 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 | 3309.256 | 0.002 | -0.014 | **2011-2 |
| *2011-3 | - | - | - | - | - | - | - | 3310.354 | - | - | 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 | 3310.327 | -0.003 | -0.027 | *2011-3 |
| *2011-4 | - | - | - | - | - | - | - | 3310.371 | - | - | 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 | | | 3310.370 | 0.008 | -0.001 | *2011-4 |
| **2011-5 | - | - | - | - | - | - | - | 3303.984 | - | - | 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 | 3303.973 | -0.007 | -0.011 | **2011-5 |
| **2011-6 | - | - | - | - | - | - | - | 3309.357 | - | - | 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 | 3309.339 | -0.003 | -0.018 | **2011-6 |
| **2011-7 | - | - | - | - | - | - | - | 3309.156 | - | - | 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 | 3309.167 | -0.003 | 0.011 | **2011-7 |
| **2011-8 | - | - | - | - | - | - | - | 3310.383 | - | - | 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 | 3310.372 | 0.001 | -0.011 | **2011-8 |

*Trait jaune = Repères implantés en 2011

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

Note : seul le nivellement géométrique à été utilisé lors du levé des plaques  de tassement en octobre 2019.

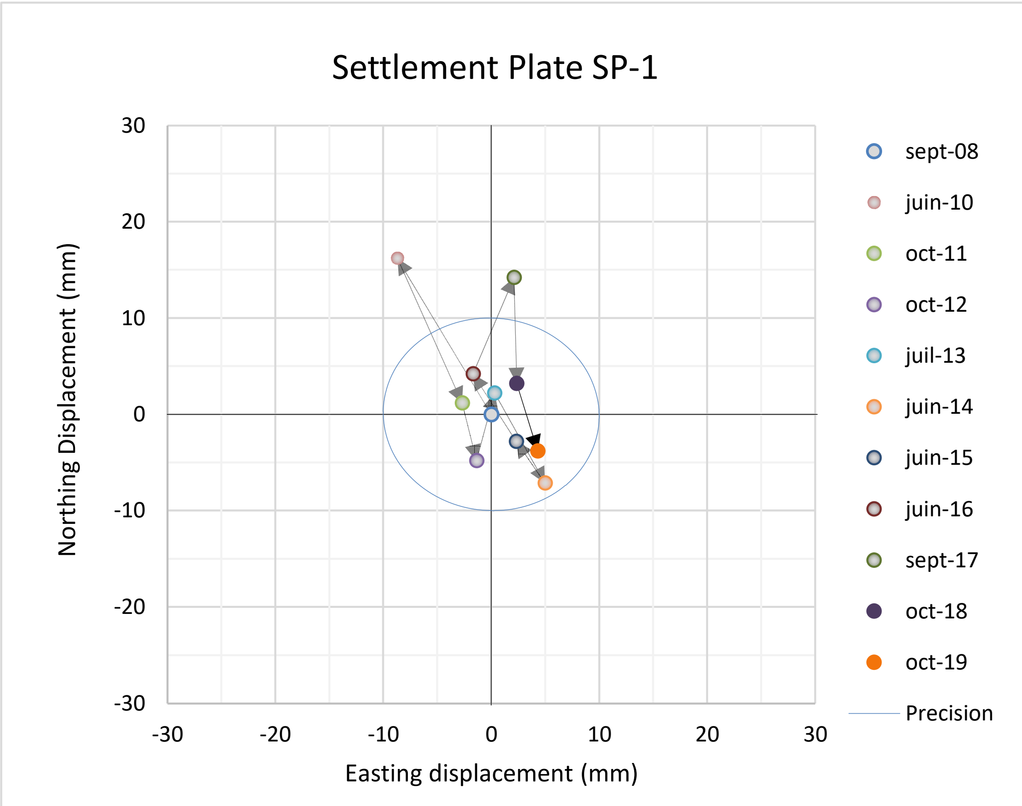
**Légende des écarts : pas de signe s'élève, signe négatif (-) s'enfonce**

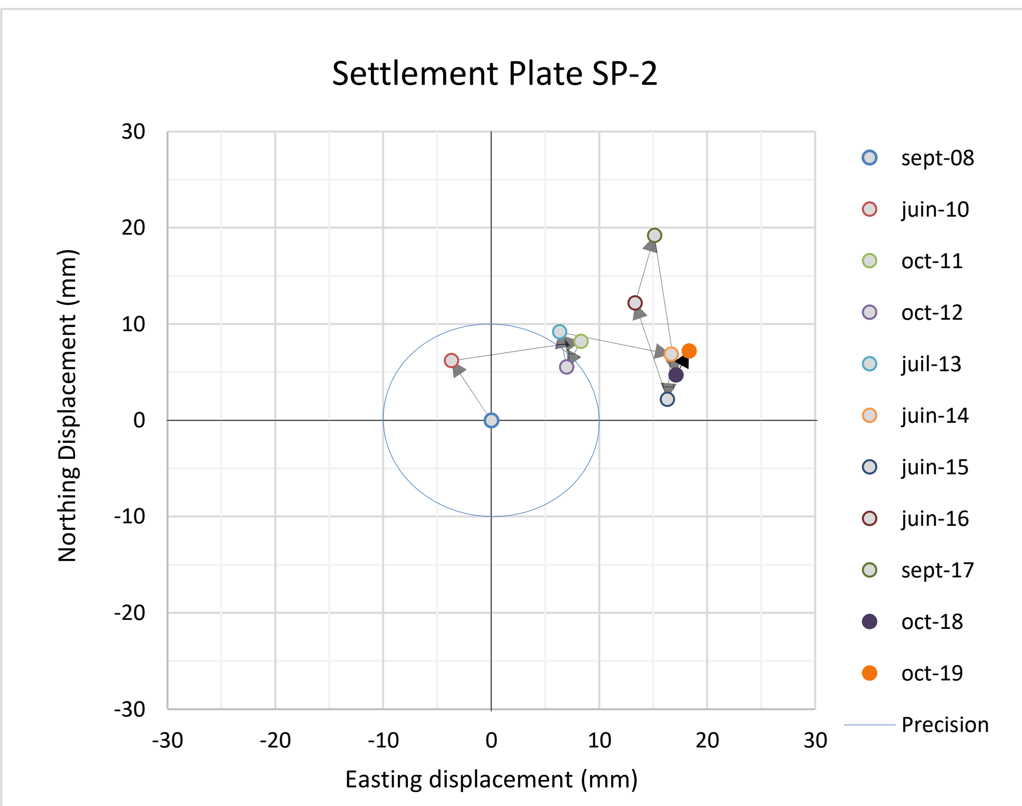
**APPENDIX D**

# Point of Origin Plots

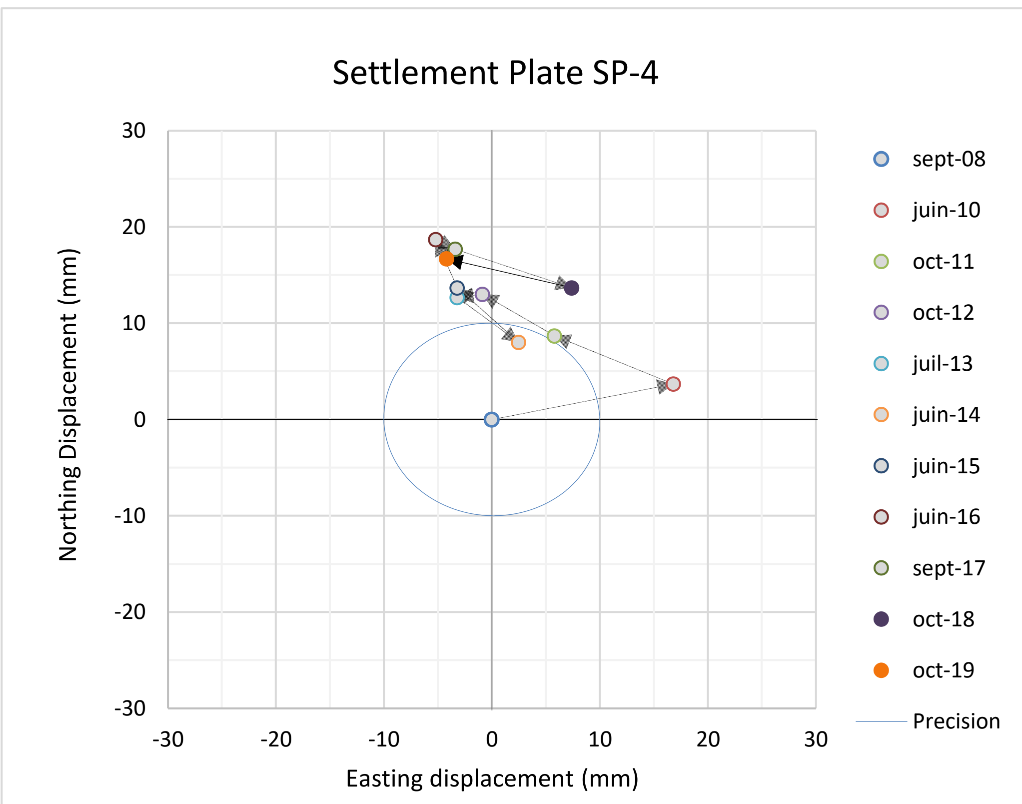
# Displacement relative to the point of origine





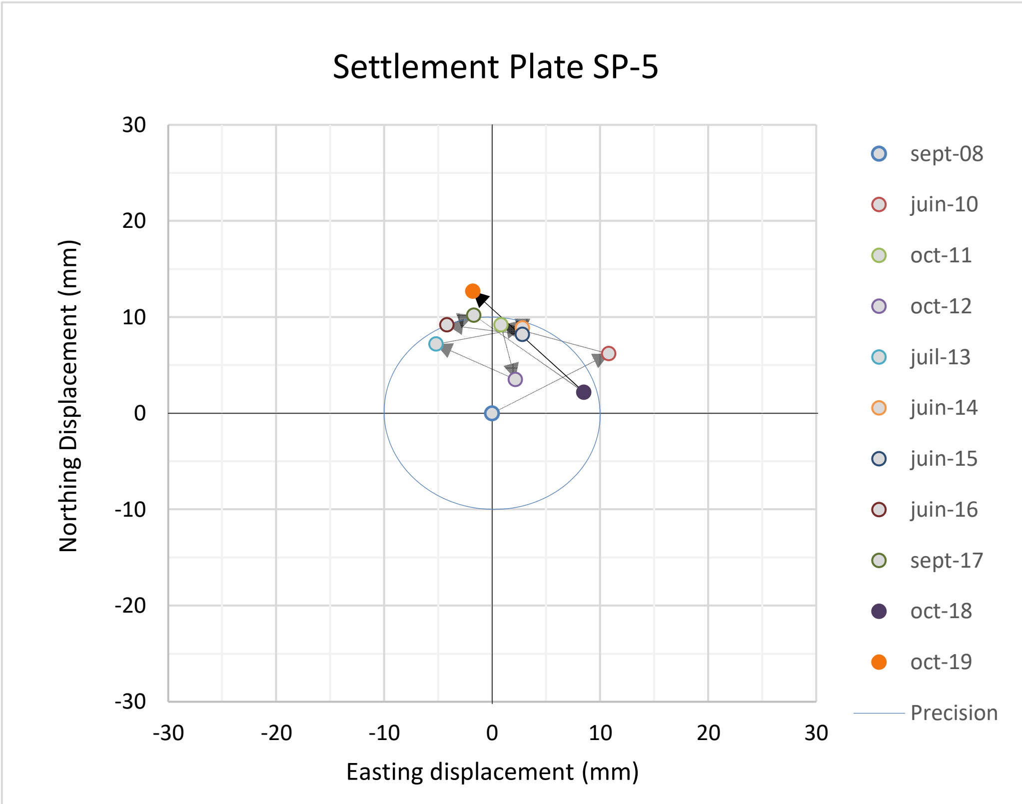



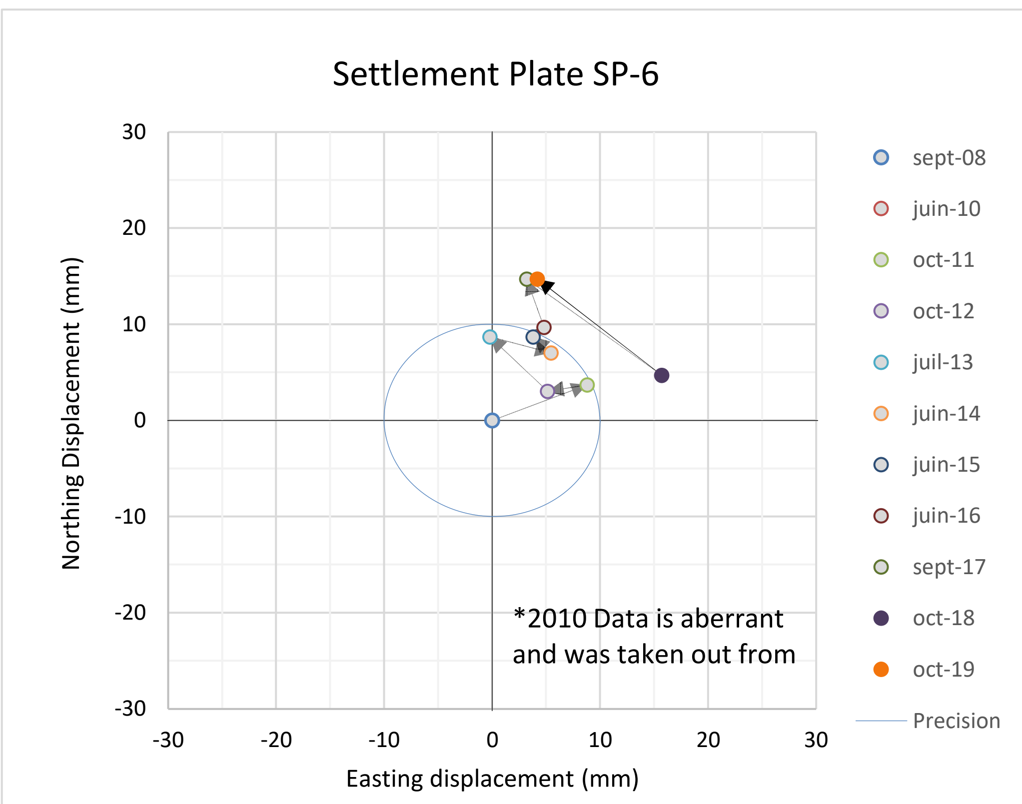

Settlement Plate SP-3
Northing Displacement (mm)
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
Easting displacement (mm)
sept-08
juin-10
oct-11
oct-12
juil-13
juin-14
juin-15
juin-16
sept-17
oct-18
oct-19
Precision


Settlement Plate SP-4
Northing Displacement (mm)
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
Easting displacement (mm)
sept-08
juin-10
oct-11
oct-12
juil-13
juin-14
juin-15
juin-16
sept-17
oct-18
oct-19
Precision

# Displacement relative to the point of origine





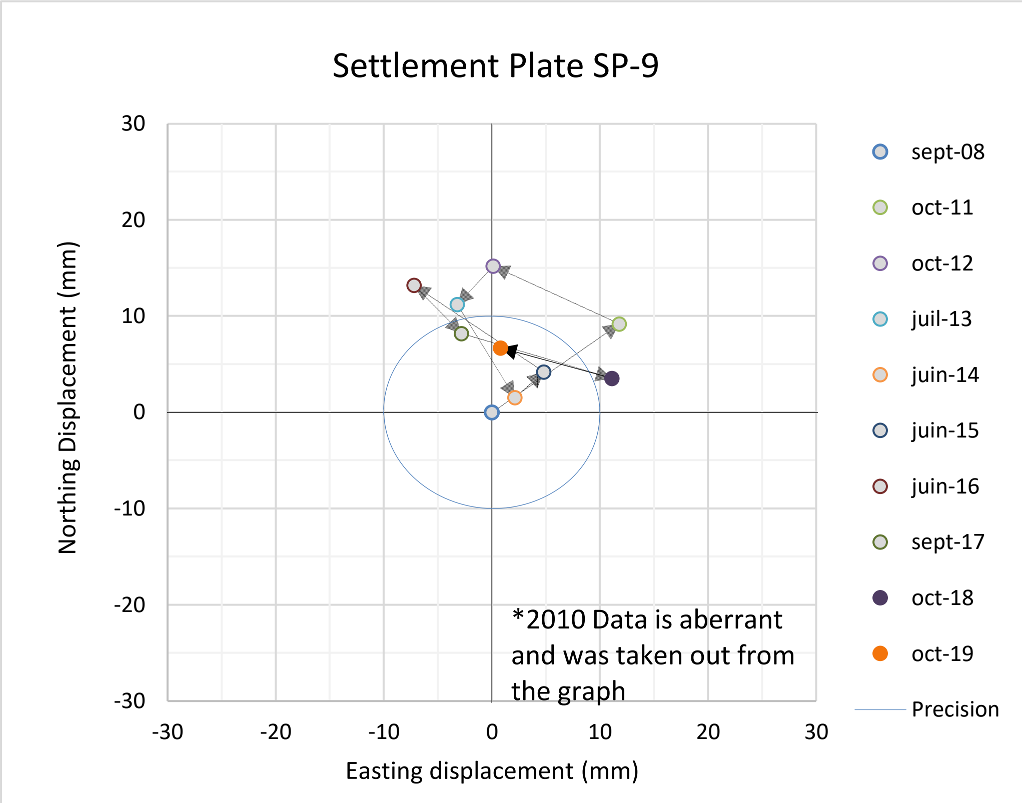



# Displacement relative to the point of origine



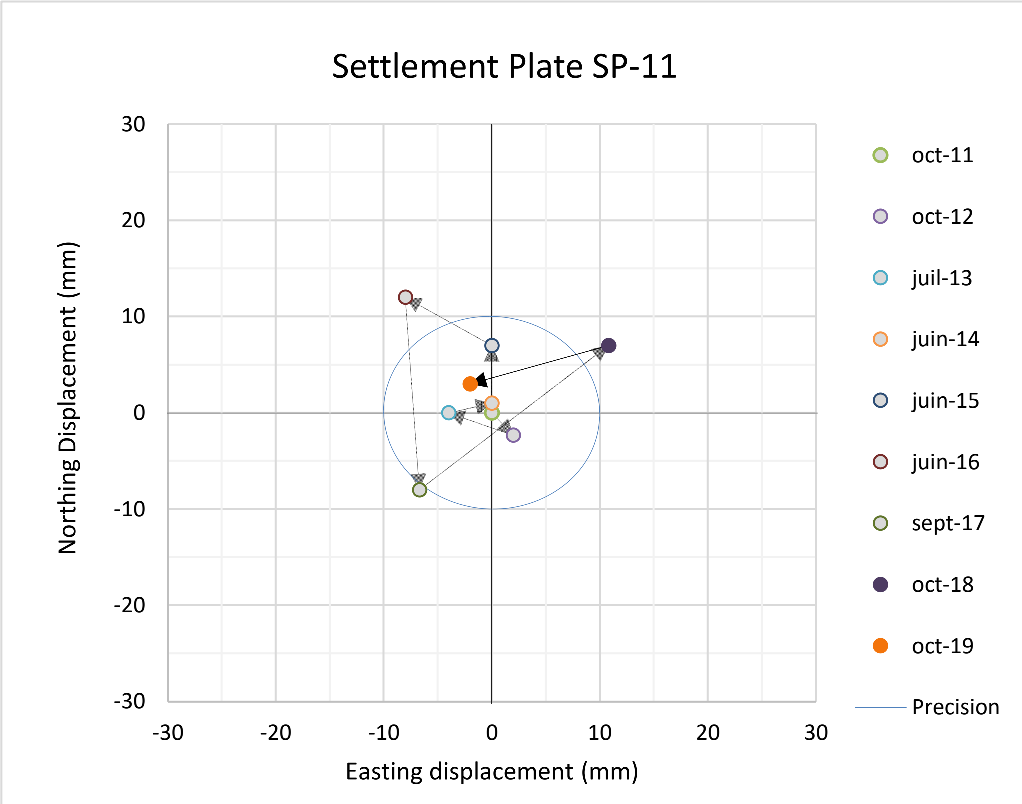

# Displacement relative to the point of origine

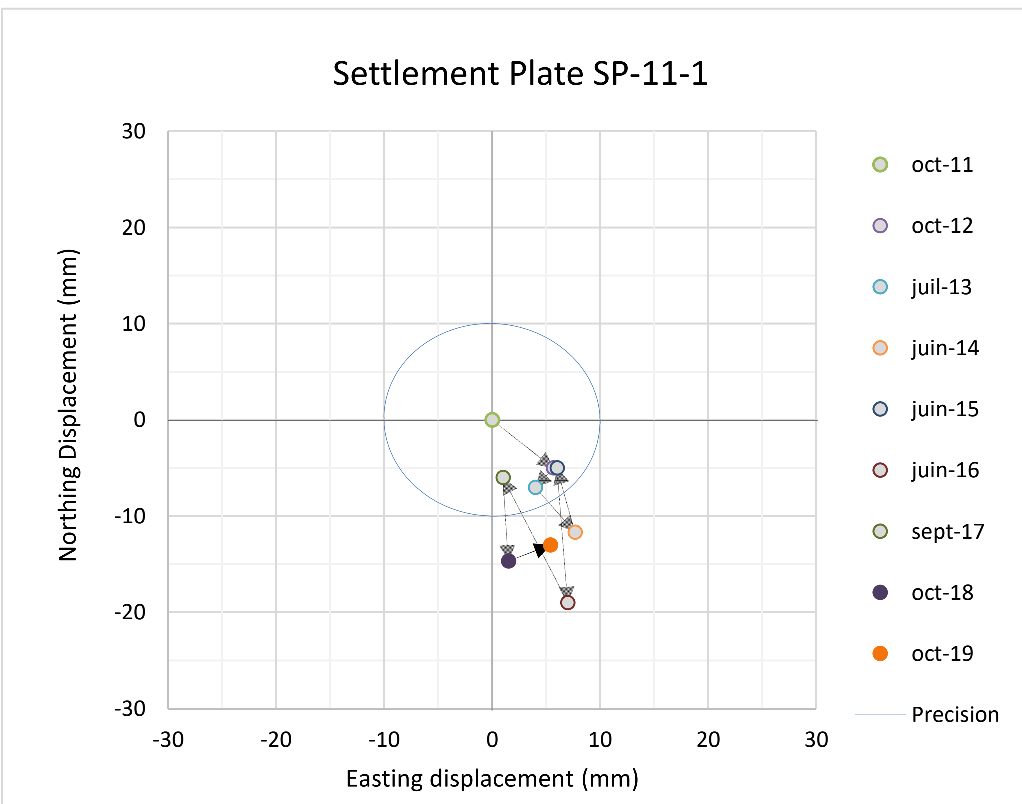


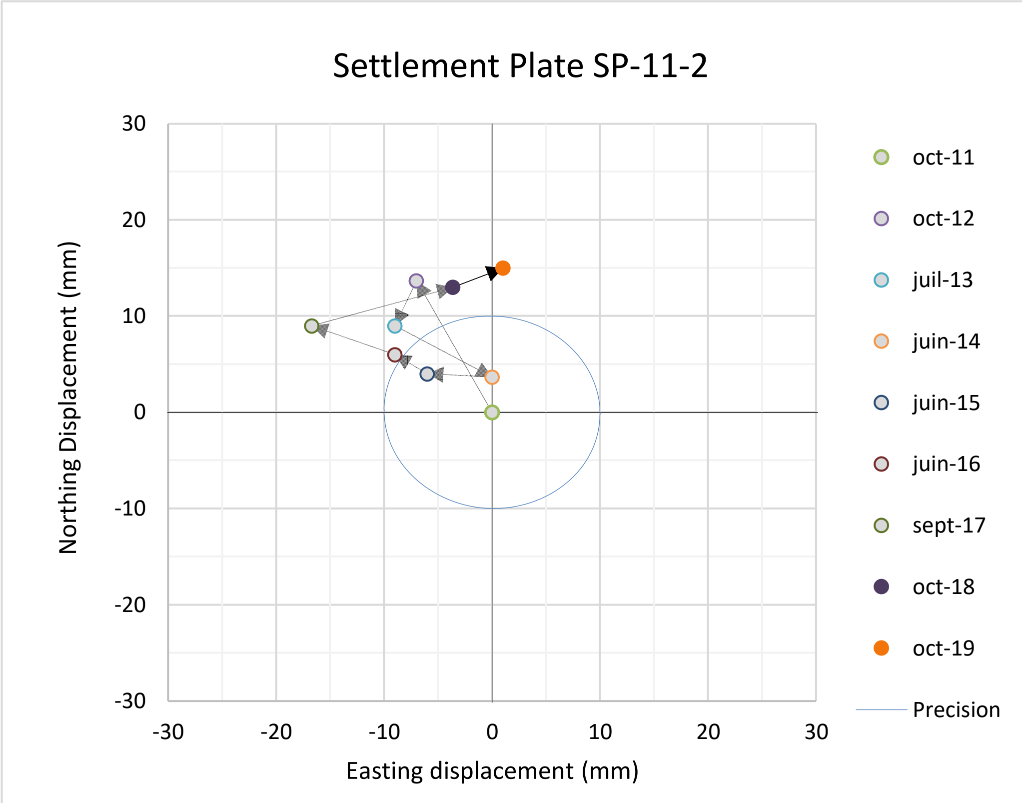



# Displacement relative to the point of origine

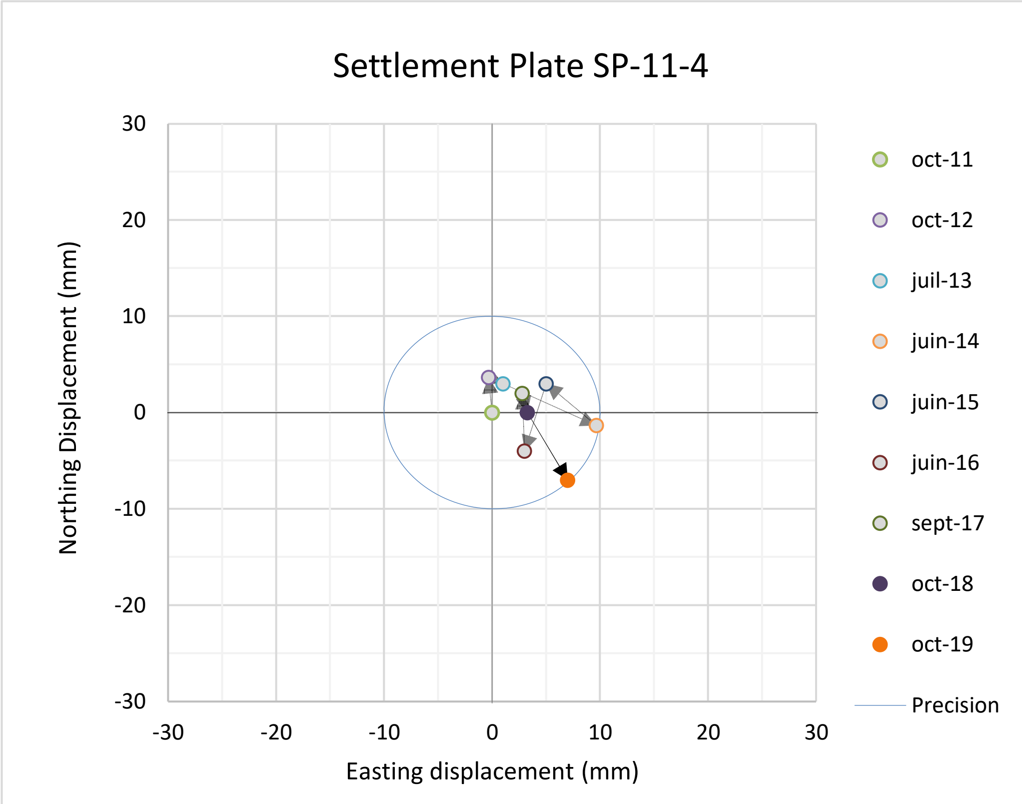





Settlement Plate SP-11-2
Northing Displacement (mm)
Easting displacement (mm)
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
oct-11
oct-12
juil-13
juin-14
juin-15
juin-16
sept-17
oct-18
oct-19
Precision

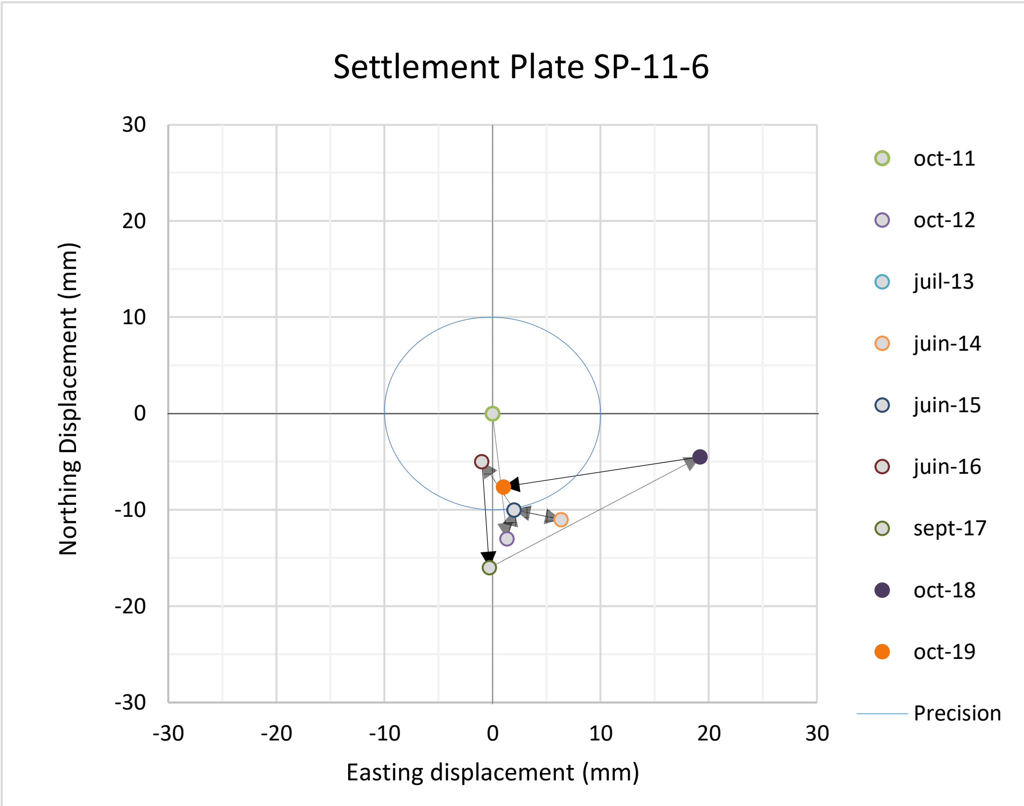

Settlement Plate SP-11-3
Northing Displacement (mm)
Easting displacement (mm)
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
oct-11
oct-12
juil-13
juin-14
juin-15
juin-16
sept-17
oct-18
oct-19
Precision

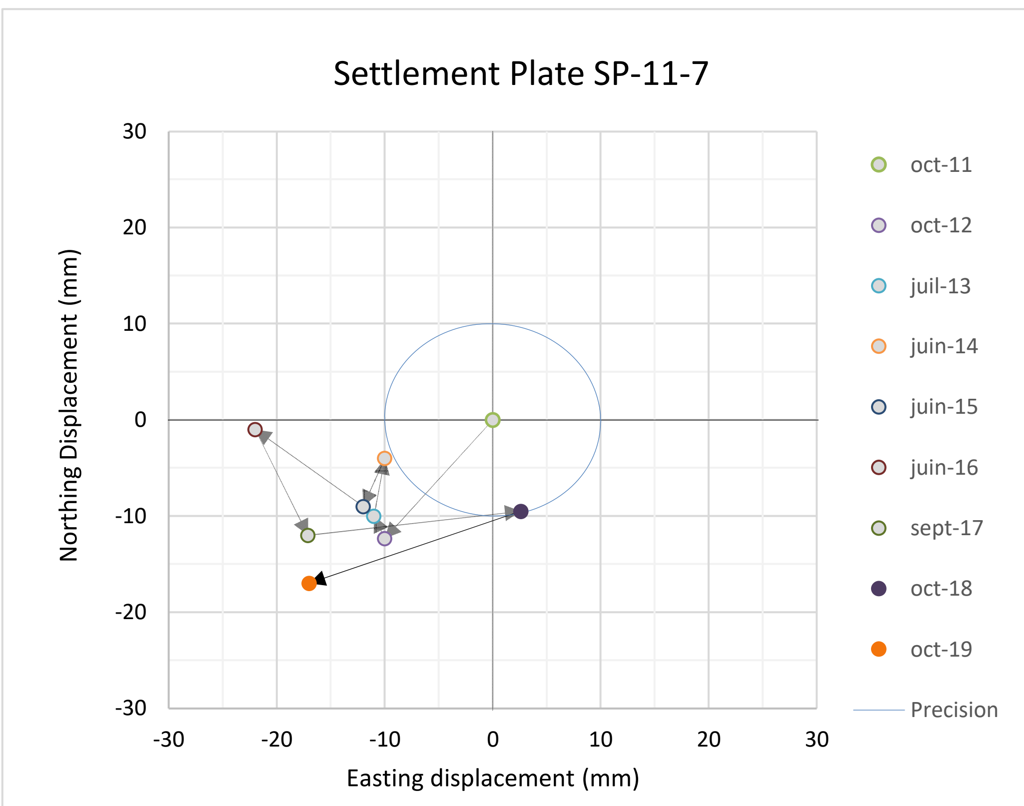

Settlement Plate SP-11-4
Northing Displacement (mm)
Easting displacement (mm)
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
oct-11
oct-12
juil-13
juin-14
juin-15
juin-16
sept-17
oct-18
oct-19
Precision


Settlement Plate SP-11-5
Northing Displacement (mm)
Easting displacement (mm)
30
20
10
0
-10
-20
-30
-30
-20
-10
0
10
20
30
oct-11
oct-12
juil-13
juin-14
juin-15
juin-16
sept-17
oct-18
oct-19
Precision

# Displacement relative to the point of origine

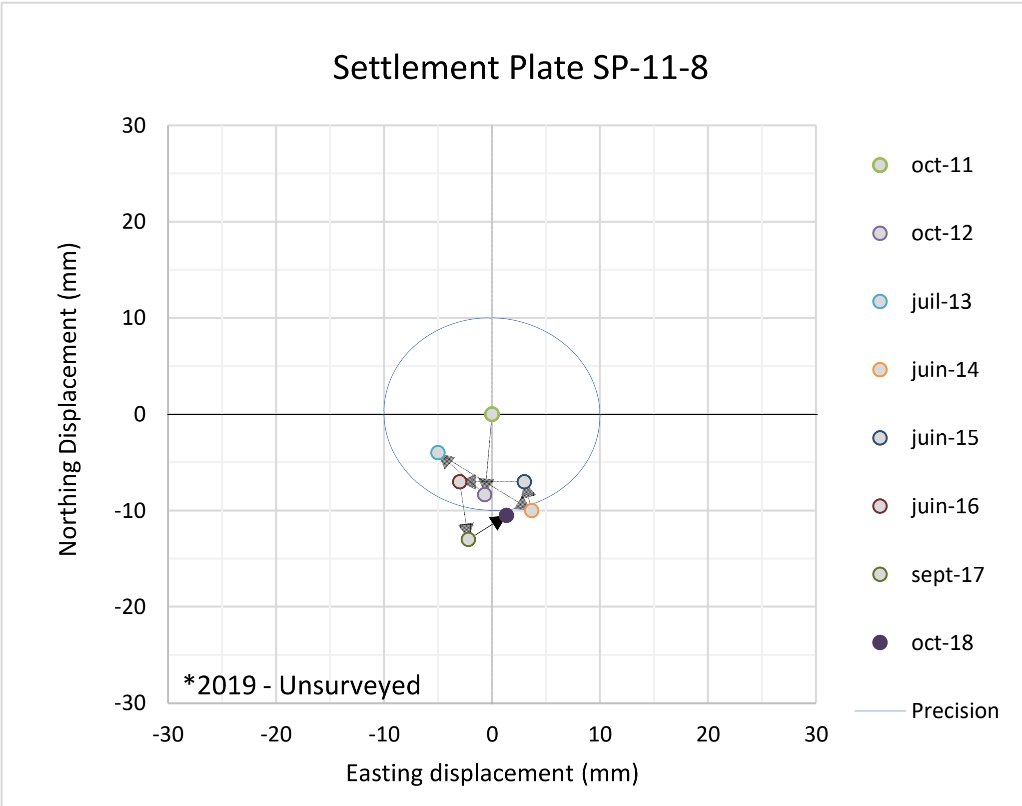




# Displacement relative to the point of origine





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