REPORT

2018 Dam Safety Inspection

Pine Point Tailings Impoundment Area, Pine Point, NT

Submitted to:

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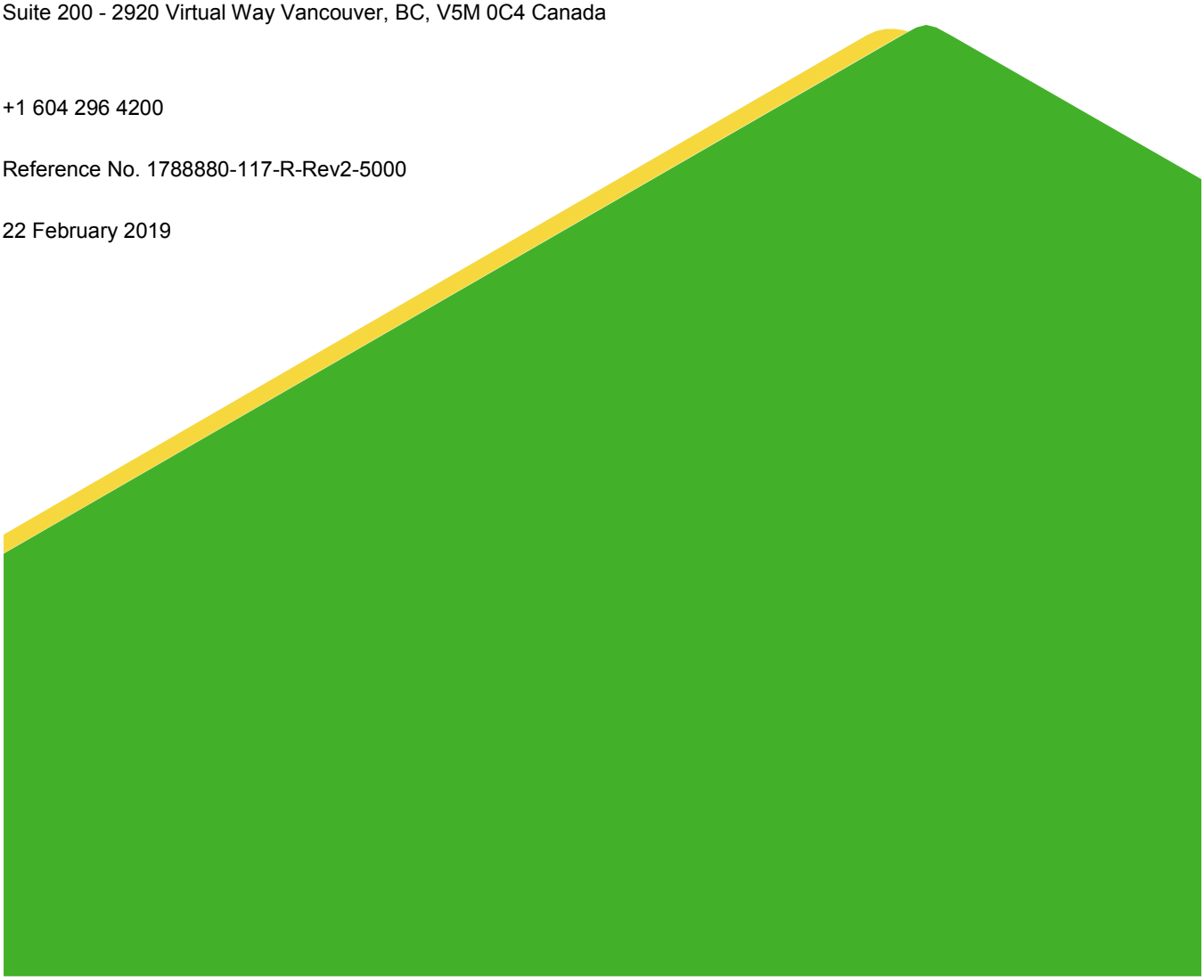

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Executive Summary

This report presents the results of the 2018 annual dam safety inspection (DSI) for the north, east, west, and south dykes of the Tailings Impoundment Area (TIA) at the closed Pine Point Mine in the Northwest Territories.

The report was prepared by Golder Associates Ltd. (Golder) at the request of Teck Metals Ltd. (Teck).

The DSI site visit was completed on 23 July 2018 by the Engineer of Record, Björn Weeks, and by Ben Wickland, both from Golder. Routine inspections were also conducted by Maskwa Engineering Ltd. (Maskwa) on 3 May and 20 October 2018, in accordance with the operation, maintenance, and surveillance (OMS) manual.

This report is to be read with the Study Limitations, provided at the beginning of the report, which form an integral part of this document.

Summary of Facility Description

The site is located approximately 75 km east of the town of Hay River and approximately 6.5 km south of Great Slave Lake in the Northwest Territories. The Pine Point TIA was closed and is in active care and maintenance. The TIA is formed by dykes located on the north, east, west and south sides and covers an area approximately 2.5 by 2.8 km in plan, or roughly 700 ha. The Teck surface lease covers an area of approximately 760 ha including 480 ha of the TIA and 280 ha of land to the north and east of the TIA. The lease boundary excludes approximately 180 ha of the TIA including the south dyke and 1.1 km of the west dyke (Figure 2).

Approximately 60 million tonnes of lead-zinc tailings are stored within the Pine Point TIA.

Summary of Key Hazards

Key potential hazards identified for the Pine Point TIA dykes include:

Overtopping

- Minimum water freeboard within the TIA has been established based on CDA (2013) guidelines.
- High water levels were observed in spring 2018.
- The maximum pond level observed up to 10 August 2018 was 202.05 m, recorded on 13 May 2018.
  - This level was 0.25 m above the maximum operating water level of 201.8 m.
  - The corresponding minimum freeboard to the north dyke crest was 1.45 m.
  - The corresponding minimum freeboard to the main pond spillway was 0.45 m.
  - Water was released, following authorization, by emergency discharge by siphoning over the spillway in the polishing pond, the risk of overtopping was controlled – details are provided in Section 4.0.

Internal Erosion (piping)

- Observations during the 2018 DSI indicated no piping-related concerns with dyke stability.

Instability

- Inspections during the 2018 site visits did not identify any sign of stress such as cracks, settling, or bulging of the dykes. The dykes therefore appeared to be stable, and this stability is in line with expectations based on previous slope stability analysis (SRK 2016), which indicated factors of safety in compliance with CDA (2013) guidelines.

Erosion

- Wave cut erosion
  - A 700 m long section of the upstream face of the north dyke was observed to be eroded. Erosion was attributed to high water levels in spring 2018.
    - An eroded bench was visible above the water line with as much as a 1 m step in the upstream face with exposed core in places.
    - Erosion did not reach the dyke crest nor reduce the dyke crest width.
    - The erosion was repaired in October 2018.
  - In 2016 repairs were made to a test section of the upstream face of the north dyke using locally sourced fill with a particle size distribution that was smaller than conventional riprap armouring. The test section was intended to evaluate if the locally sourced fill was suitable for restorative maintenance of the remaining portion of north dyke upstream face that requires repairs due to erosion by the pond. The 2016 repairs were in good condition at the time of the 2018 DSI. Following further erosion of other parts of the dyke in 2018 the recommended material for the maintenance to repair included a sized riprap for erosion protection.
- Surface erosion rills (gullies)
  - Two rills, approximately 1 m deep, were observed on the downstream face of the north dyke and located approximately 70 m from the west dyke.
    - These rills were repaired in October 2018.
  - Areas of rilling repaired prior to 2018 were observed to be in good condition.
- No impacts by erosion extended into the dyke crest.

Consequence Classification

Consequence classification is not related to the likelihood of a failure, but rather the potential impact if a failure did occur. The TIA is considered to be in the Closure – Active Care phase of mine life. The Canadian Dam Association *Dam Safety Guidelines* (CDA 2013) classify dams based on the consequences (i.e., potential damage that can be caused in the event that a dam fails). The south and east dykes are classified as Low consequence structures, while the west and north dykes are classified as Significant consequence structures (CDA 2013). There have been no changes in the guidelines, regulations, potential downstream receptors or the nature of the structures since 2017, and as such these classifications remain unchanged from the 2017 DSI.

Summary of Key Observations

Dam conditions and maintenance requirements were reviewed through site observations. This 2018 DSI report was prepared based primarily on observations made by Golder during the DSI site visit in July 2018, a special inspection in May 2018, and on inspections carried out by Maskwa Engineering Ltd. (Maskwa) between 3 May and 10 August 2018 and on 20 October 2018.

Monitoring devices at the TIA in the 2018 monitoring period were:

- a water level gauge at the culvert inlet to the polishing pond which is read each time the site is visited, typically three times per year
- flow rate meters located in the siphons at the polishing pond spillway, which are typically read daily during annual water treatment operations

The north, east, west, and south dykes of the TIA were observed to be in good condition on 23 July 2018 during the 2018 annual DSI. The following maintenance items were recommended following the site visit:

- Erosion of the upstream face of the north dyke over a 700 m length adjacent to the pond. The erosion is attributed to high pond water levels in spring. Repairs were reported by Teck to have been completed between 10 and 15 October 2018.
- Two erosion rills were observed on the downstream face of the north dyke. Repairs were reported by Teck to have been completed between 10 and 15 October 2018.
- Vegetation on the south dyke should be treated as per the OMS manual.

High water levels resulted in an authorized emergency release of water in the spring of 2018.

- Water treatment at the Pine Point TIA is typically carried out in summer each year to reduce pond levels and prepare the facility for the winter and spring freshet. Water treatment typically commences in late June each year.
- The pond alert level is 201.6 m and provides a window of opportunity for the early commencement of water treatment prior to the pond reaching the maximum operating water level of 201.8 m.

- 3 May 2018 – A pond water elevation of 201.82 m was recorded during a routine inspection. This level was above the maximum operating water level of 201.8 m. Emergency dyke inspections were completed as per the OMS manual.
  - 9 May 2018 – A pond water elevation of 202.02 m was recorded.
- 11 to 31 May 2018 – Daily water level checks were completed, with a final pond water elevation of 201.68 m recorded. This level is 0.12 m below the maximum operating pond level, but above the alert pond level of 201.6 m.
- 15 May 2018 – Emergency discharge was approved by the Water Resource Officer of the Department of Environment and Natural Resources. A special inspection was also completed by the Engineer of Record.
  - 16 to 31 May 2018 – Approximately 186,300 m^3 of water was released by siphoning over the polishing pond spillway.
- 31 May to 10 August 2018 – Weekly inspections were completed, with a final pond water elevation recorded of 201.52 m or 0.08 m below the alert pond level. Daily checks of weather data and forecasts from Environment and Climate Change Canada were also completed to monitor for possible high rainfall events. No evidence of seepage at the spillway or on the downstream face/toe of the dykes was observed.

Regular maintenance completed during the period included:

- 24 July to 4 August 2018 – The polishing pond was drained and mucked out to remove sludge accumulated from previous annual water treatment campaigns.
  - Approximately 8 seepage flows into the polishing pond were observed from the main pond, at estimated rates of between 5 and 10 litres per minute.
  - Seepage was observed to be clear without the presence of sediment.
  - Teck staff were present on site and in regular communication with Golder staff during this time.
- Water treatment was initiated on 20 August 2018 and completed on 29 September 2018. A total of 388,797 m^3 of treated water was released during the 2018 water treatment period.
- Repair of surface erosion on the north dyke.

The routine fall inspection was completed on 20 October 2018 by Maskwa and a water level of 200.48 m, or 1.12 m below the alert pond level, recorded.

Summary of Significant Changes

None of the information monitored indicated a concern with the integrity of the dykes. Aside from high spring water levels, no significant changes to site conditions were observed that could reasonably be expected to compromise the stability of the dykes or surface water control systems. After high water levels were addressed, conditions remained materially unchanged from the 2017 DSI.

Routine maintenance activities are recommended to address vegetation growth on the dykes.

Riprap was installed over a portion of the upstream face of the north dyke along the pond, which should reduce frequency of future maintenance.

Vibrating wire piezometers were installed within the north dyke and in the main pond on the upstream side of the polishing pond in September/October 2018. Standpipe water sampling wells were also installed within the TIA and in areas upstream and downstream of the TIA. Two climate monitoring stations were also installed.

Installation details and baseline readings from new instrumentation will be reported separately. Data from these instruments will be reviewed as part of the 2019 DSI.

Summary of Review of Operation, Maintenance, and Surveillance and Emergency Preparedness and Response Plan Manuals

The OMS manual for the Pine Point TIA was updated in February 2017 to align with the Canadian Dam Association Dam Safety Guidelines (CDA 2013), as well as the Teck *Guideline for Tailings and Water Retaining Structures* (Teck 2014).

Further updates of the OMS manual were completed in February and June 2018 (Golder 2018b) to reflect changes in the updated Water Licence (MV2017L2-007) and water treatment manual, respectively.

The emergency preparedness and response plan for the Pine Point TIA was updated in February 2017 (Golder 2017b) to align with the *Dam Safety Guidelines* (CDA 2013), the February 2018 update to the OMS manual, and the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014).

A topographic and bathymetric survey was completed in Q1 2019. The updated survey should be used to update the TIA water storage capacity curve, freeboard and pond limits, with corresponding updates to the OMS manual and EPRP.

Dam Safety Review

A dam safety review of the north, west, and south dykes was conducted by SRK Consulting in 2014 (SRK 2016). The Canadian Dam Association *Dam Safety Guidelines* (CDA 2013) recommend that a dam safety review be conducted once every 10 years for embankments with a Significant dam classification, such as the west and north TIA dykes. The next dam safety review for these dykes should be undertaken no later than the end of 2024.

Summary Table of Deficiencies and Non-conformances

Deficiency / non-conformances and recommended actions are presented in Table E-1.

Table E-1: Summary of Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline/Status
north dyke	2016-2	Erosion observed on the pond side of the north dyke with potential to cause dyke instability	OMS Manual Section 5.5.2	Continue observation and evaluation of replacement fill placed in 2016 throughout 2018 monitoring period. Should be restored area indicate adequate performance, repair the remaining sections of observed erosion in 2019 with the same fill material used in the trial. Should significant erosion occur within the test section during 2018, complete a new test restoration using coarser fill in 2019, or evaluate alternative approaches such as periodic repair work of the fill.	3	Closed
south dyke	2018-1	Vegetation encroaching on downstream face of south dyke	OMS Manual Section 5.5.2	Remove vegetation at west end of south dyke as per OMS manual. The south dyke is outside the Teck lease boundary and permission from land owner will be required to complete vegetation removal.	3	2019
polishing pond	2018-2	No written procedure for sludge removal	none	Update water treatment manual to include written maintenance procedure for removal of sludge from polishing pond including dewatering operations.	4	2019
TIA	2018-3	Inaccurate storage curve for facility	OMS Manual Section 4.3.3	Complete bathymetry and tailings topographic survey to define the facility storage curve, review flood storage capacity and water handling practices, determine capacity of spillway and update freeboard limits. Incorporate these changes in the OMS manual. Consider preparing for high water levels in spring 2019 and requirement to treat water at the freshet.	2	Survey by Q1 2019

Priority[(a)]	Description
1	High probability or dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected/implemented could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
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.

a) Source: Teck 2014.

ID = identification; OMS = operation, maintenance, and surveillance; DSR = dam safety review; CDA = Canadian Dam Association.

Study Limitations

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1.0 INTRODUCTION

As requested by Teck Metals Ltd. (Teck), Golder Associates Ltd. (Golder) prepared this 2018 annual dam safety inspection (DSI) report for the north, east, south, west dykes of the Tailings Impoundment Area (TIA) at the Pine Point Mine, Northwest Territories. This report is to be read with the Study Limitations, provided at the beginning of the report, which form an integral part of this document.

1.1 Purpose, Scope, and Methodology

The DSI report was prepared in accordance with CDA (2013), as well as the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014), and is intended to meet the requirement of the Pine Point Water Licence (MV2017L2-007) for the production of an annual geotechnical inspection report.

This report includes:

- a summary of regulatory requirements, facility description, and background information
- a summary of the construction, operating, and/or repair activities (if any) for the reporting period
- review of
  - climate data
  - facility freeboards
  - monitoring data
  - required operational documents
- dam consequence classification
- assessment of dam safety relative to potential failure modes
- findings and recommended actions
- site photographs and records of dam inspection

Water treatment at Pine Point was completed on 29 September 2018. A water balance for the 2018 period will be provided as part of the Annual Water License Report in March 2019.

This report is based primarily on observations made by Golder during the DSI site visit in July 2018, a special inspection in May 2018, and on inspections carried out by Maskwa Engineering Ltd. (Maskwa) between 3 May and 10 August 2018, and on 20 October 2018.

The previous annual DSI for the TIA was carried out in July 2017 (Golder 2018a).

1.2 Regulatory Requirements

Applicable codes, guidelines, and regulations governing the Pine Point TIA are listed in the following sections.

1.2.1 Mines Act

Mackenzie Valley Resources Management Act, S.C. 1998, c.25, last amended 12 December 2017.

1.2.2 Water Act

Mackenzie Valley Waters Act, S.N.W.T, 2015, c.1, in force 1 September 2016.

1.2.3 Permits and Licences

The Pine Point TIA has a valid Water Licence, number MV2017L2-007 from the Mackenzie Valley Land and Water Board. The Water Licence is valid to 24 October 2027.

The Pine Point TIA is closed and does not have a permit to operate.

1.2.4 Guidelines

- Canadian Dam Association (CDA) *Dam Safety Guidelines* (CDA 2013).
- *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (CDA 2014).
- Mining Association of Canada (MAC) *A Guide to the Management of Tailings Facilities* (MAC 2017).

1.3 Facility Description

The site is located approximately 75 km east of the town of Hay River and 6.5 km south of Great Slave Lake in the Northwest Territories (Figure 1). The Pine Point TIA was closed and in a state of active care and maintenance at the time of reporting. A plan showing the layout of the TIA is presented in Figure 2. The TIA is located to the north of the former Pine Point mill site on terrain that slopes gently towards the northwest. The TIA covers an area approximately 2.5 by 2.8 km in plan, or roughly 700 ha, and includes north, east, west, and south perimeter dykes that retain approximately 60 million lead-zinc tailings from historical mining operations, as well as a permanent water pond on the north side. The TIA includes a main spillway and polishing pond at the north side, with a secondary spillway used to release water from the polishing pond. The tailings are covered with approximately 0.15 m of granular material to control dust.

The Teck surface lease covers an area of approximately 760 ha including 480 ha of the TIA and 280 ha of land to the north and east of the TIA. The lease boundary excludes approximately 180 ha of the TIA including the south dyke and 1.1 km of the west dyke (Figure 2).

The total length of dykes is approximately 8.5 km, and the maximum height of dykes is between 12 and 15 m at the northwest corner. The dykes are constructed of earthfill and extend fully along the north and west sides and along portions of the south and east sides. Describing the system clockwise from the south; the south dyke varies in height from flush with existing terrain at the southeast corner of the TIA to 4 m at the southwest corner. The west dyke connects to the south dyke and has a maximum height at the northwest corner of the TIA of between 12 and 15 m. The north dyke connects the west dyke and east dykes and varies from between 12 and 15 m in height at the connection with the west dyke to 1 m in height at the east dyke. The east dyke is approximately 1 m in height and continues on the east side until the natural ground surface rises above the dyke crest elevation. The east dyke is approximately 200 m long. Typical cross-sections of the west and north dykes are presented in Figures 3 and 4, respectively.

Water is typically released from the TIA each year following treatment to meet water license discharge criteria and to reduce pond levels prior to the winter. Water is released from the main pond to the polishing pond through a culvert that passes through an internal dyke. Water passing through the culvert is injected with a lime solution, allowed to mix and sediment while passing through a serpentine shaped polishing pond, then discharged via siphons through the polishing pond spillway.

Water treatment usually starts in late June and runs for four to six weeks. Treatment continues until the water in the pond reaches the culvert invert level at an approximate elevation of 201.1 m, when gravity flow through the culvert stops. An average annual volume of approximately 241,000 m^3 of water is discharged to Channel 35-1B and the wetlands south of Great Slave Lake as authorized by the current Water Licence (MV2017L2-007).

The Engineer of Record for the Pine Point TIA is Dr. Björn Weeks, P.Eng., an employee of Golder. Transition of the Engineer of Record role from Björn Weeks to Dr. Ben Wickland, P.Eng. was planned and in progress at the time of this report.

The site manager for the Pine Point TIA is Ms. Michelle Unger, an employee of Teck.

Due to the isolated location of the site, Mr. Clell Crook acts as a local consultant and is responsible for carrying out routine inspections and event-driven/special inspections. Mr. Crook is an employee of Maskwa, located in Hay River.

A facility data sheet for the Pine Point TIA is provided in Appendix A.

1.4 Background Information and History

Mine construction at Pine Point started in 1962, and mining began in 1964. High grade ore was shipped by rail starting in 1965. The mine operated at 5,000 tonnes per day initially, with expansion to 10,000 tonnes per day in 1973.

The TIA is located approximately 6.5 km south of Great Slave Lake on the Taiga Plains (Great Slave Lake plain). The project site is underlain by peat, till, gravel and sand, and clay deposits, which are underlain by sedimentary rocks of the Devonian period. The site is within the discontinuous, sporadic permafrost zone. Historical information suggests that permafrost underlies approximately 50% of the TIA site.

The TIA dykes are founded on glacial deposits and on east-west trending beaches of sand formed by Great Slave Lake during an earlier period. The north dyke is the tallest dyke at some 12 to 15 m. The dykes consist of a silt or clay upstream zone, which acts as a low hydraulic conductivity element, and a downstream zone developed with sand and gravel from local borrow sources. The downstream slopes have been developed with 2 horizontal to 1 vertical slopes.

The tailings dykes were raised and extended in several stages during the life of the mine, as required, to contain the increasing volume of mill tailings. The last three crest level increases to the dykes were:

- **1976**—The crest of the north dyke was raised to elevation 203.5 m above mean sea level or some 2.1 m above the previous crest. Also, the dyke was extended eastward to the northeast corner of the pond. Construction of a segment of the east dyke was also carried out.
- **1981**—During the summer of 1981, the west and south dykes were raised and the south dyke extended eastwards.
- **1987**—The height of the perimeter dykes was raised again in July and August 1987, to a final elevation of 205.7 m, to provide additional tailings storage. Fill was added to the south, west, and a portion of the north dyke at this time. The increase in the height of the dykes was generally 1 m or less.

No construction record or design report is available for the facility. A stability review of the west dyke was carried out as part of the 1987 raise (Golder 1987) and indicated that the dyke achieved a factor of safety for static loading of 1.5 with the inclusion of a toe 1.5 m high berm. This toe berm was developed in 1987, when the dyke crest was last raised.

The mine ceased operations in 1988, and the mill buildings and tailings conveyor (trestle) were subsequently dismantled and removed. The only remaining mining installation at the site is the closed TIA.

The tailings were covered with approximately 0.2 m of gravel to control dust.

2.0 CONSTRUCTION AND OPERATION

The Pine Point Mine has not been in operation since 1988. There were no operations in 2018, and no new tailings or other wastes were deposited within the TIA.

There was no construction in 2018.

The activities at the TIA in 2018 included:

- Authorized emergency discharge of water from the polishing pond in spring 2018.
  - Approval was obtained from the Water Resource Officer of the Department of Environment and Natural Resources on 14 May 2018 prior to discharge to the environment.
- Annual water treatment and discharge of accumulated pond water starting on 20 August 2018 and completed on 29 September 2009.
- Spring, summer and fall inspections, as well as special inspections due to high water levels in the TIA.
  - The dykes are normally inspected three times a year (spring, summer, and fall).
- Maintenance of the polishing pond, including the removal of water treatment sludge from the polishing pond and maintenance of polishing pond baffles was completed between 24 July and 4 August 2018.
  - Approval was obtained from the Water Resource Officer of the Department of Environment and Natural Resources in July 2018 prior to discharge of water within the polishing pond to the environment to allow maintenance.
  - The culvert connecting the main and polishing pond was closed during maintenance.
- Maintenance repair by placement of geotextile and riprap fill on upstream face of the north dyke between 10 and 15 October 2018.
- Maintenance repair by placement of granular fill in rills on downstream face of the north dyke between 10 and 15 October 2018.
- Site investigations of the TIA as per the Reclamation Research plan were completed between 6 September 2018 and 12 October 2018. Instrumentation was installed in the TIA as part of site investigations:
  - vibrating wire piezometers within the north dyke
  - vibrating wire piezometer to monitor the main pond on the upstream side of the polishing pond
    - vibrating wire instruments were connected to a remote monitoring system between 6 and 7 November 2018
  - standpipe water sampling wells within, upstream, and downstream of the TIA
  - two climate monitoring stations

Additional planned activities remaining in winter 2018/2019 include a topographic and bathymetric survey of the TIA.

3.0 CLIMATE DATA AND WATER BALANCE

3.1 Review and Summary of Climate Data

The climate characteristics at the Pine Point Mine were reviewed with respect to precipitation, the main driver for the water balance at the site. Air temperatures were also reviewed to provide support for the assessment of precipitation. Long-term climate characteristics from 1953 to 2017 were established for a hydrological year (September to August) at the Pine Point Mine and were compared to recent climate observations from September 2017 to August 2018. The recent climate at the Pine Point was estimated based on observations from Environment and Climate Change Canada Hay River stations (Station IDs: 2202401 and 2202402) (ECCC 2018). Missing data from Station 2202401 was infilled with data from Station 2202402. Data from these stations were adjusted to account for regional and under-catch factors as well as sublimation, following the methods in Golder (2017a). The estimated annual rainfall, snowfall, total precipitation, and air temperature at the Pine Point Mine is presented in Table 1.

Table 1: Average Climate Characteristics: September 2017 to August 2018 and Long-Term at the Pine Point Mine (September to August period)

Climate	Average Air Temperature (ºC)	Annual Precipitation (mm)		
		Rainfall	Snowfall[a]	Total Precipitation
Long-term annual average (September 1953 to August 2017)	-2.9	233	231	464
Recent (September 2017 to August 2018)	-2.2	234	211	445

a) Water equivalent inclusive of snow loss.

The recent climate data suggest that total precipitation in the period 1 September 2017 to 31 August 2018 was approximately 4% lower than the long-term average at the Pine Point Mine, and that temperatures were warmer by 0.7ºC. Monthly rainfall, snowfall, total precipitation, and air temperature at the Pine Point Mine (i.e., long-term and recent climate) are presented in Illustration 1 and indicate the following:

- Recent air temperatures were marginally higher than the long-term values throughout the year, with the exception of November 2017 and April 2018. The largest variations in temperature were in September 2017, when average daily air temperatures were 3.4°C higher than long-term values and April 2018, when average daily air temperatures were 3.3°C lower than long-term values. Recent and long-term monthly air temperatures are provided in Illustration 2.
- Lower snowfall (accounting for sublimation losses) was recorded for the period 1 September 2017 to 31 August 2018 compared to the long-term data by 9%, with October 2017, November 2017, and February 2018 having lower snowfall than the long-term values, and January 2018, March 2018, and April 2017 having higher snowfall than the long-term values.

- Rainfall amounts recorded during the period 1 September 2017 to 31 August 2018 were equivalent to the long-term values (within 1 mm). The largest variation from normal trends occurred in June 2018 when an additional 84 mm of rainfall fell compared to the long-term monthly values.

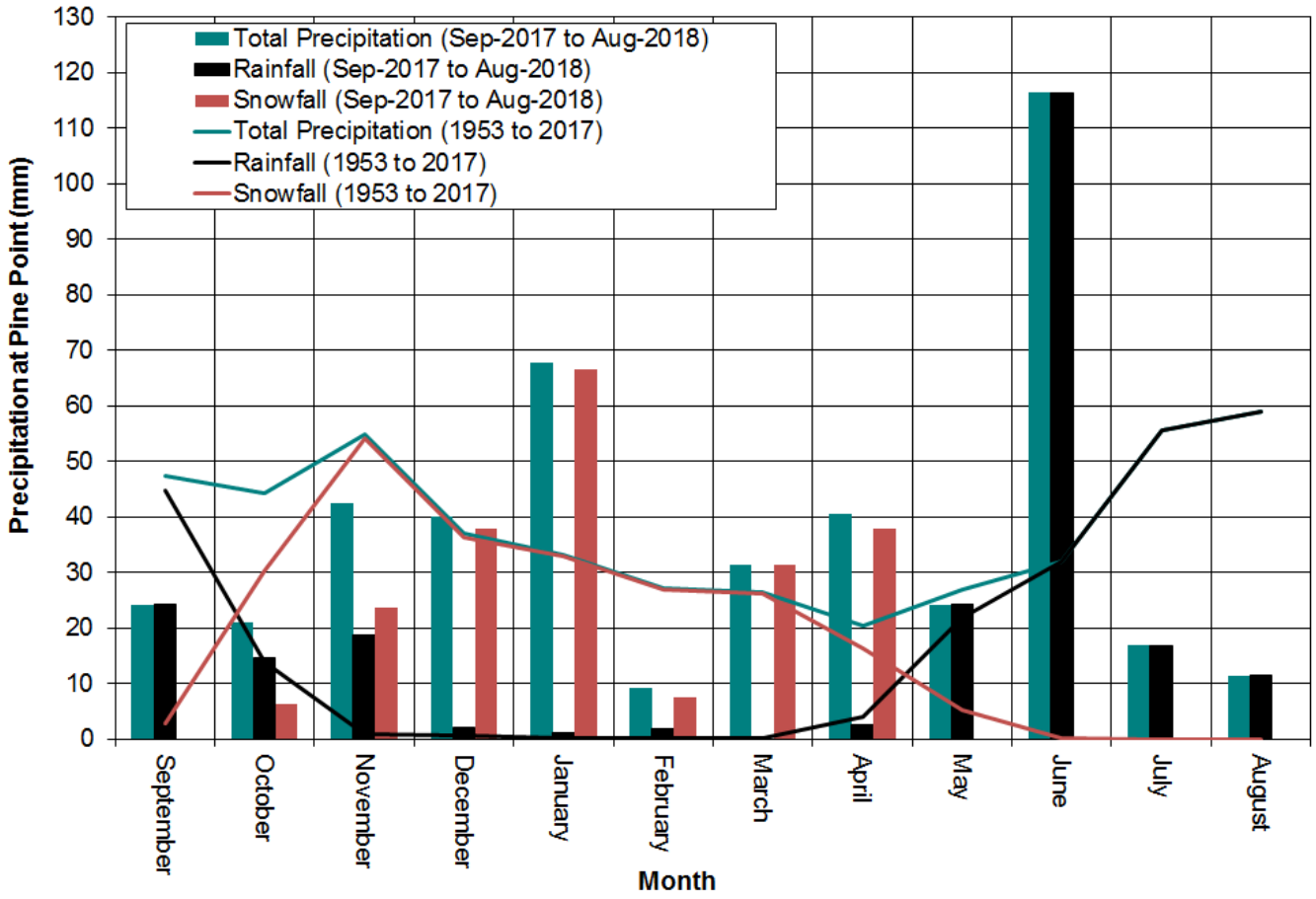

Illustration 1: Monthly Precipitation at the Pine Point Mine

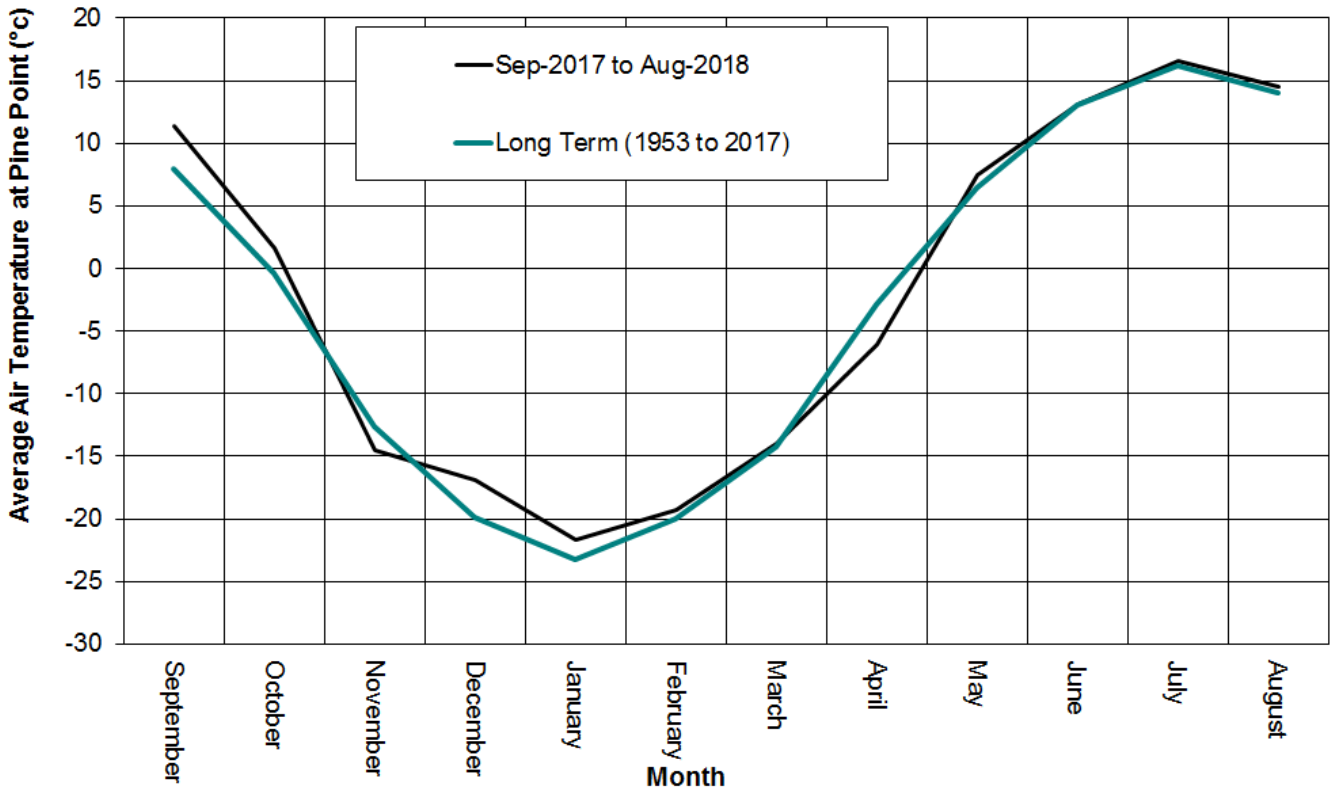

Illustration 2: Monthly Temperature at the Pine Point Mine

3.2 Water Balance

The TIA has a limited catchment area (approximately 3 km^2), and direct precipitation from rainfall and snow on the overall TIA including pond area (approximately 6 km^2) contributes the majority of the water collected in the pond. The water balance from Golder (2017a) indicated that the pond water level should vary by approximately 1 m on average throughout the year.

The water balance for 2018 is planned to be included as part of Annual Water License reporting in March 2019 (See Section 1.1).

3.3 Freeboard and Storage

The alert and maximum operating pond water levels and freeboard for the TIA were updated in 2017 in the operation, maintenance, and surveillance (OMS) manual and emergency preparedness and response plan (EPRP) (Golder 2017a, b). The levels, freeboards, and required actions are presented in Table 2.

Table 2: Quantitative Performance Objectives – Pine Point Tailings Impoundment Area Pond Level

Objective	Pond Level (m)	Freeboard (m)	Actions if Observed
Alert pond level[(a)]	201.6	1.9	The site manager should be informed immediately, and water treatment should start as early as practicable. A site inspection should take place within one week of the initial alert level observation.
Maximum operating pond level	201.8	1.7	The site manager should be informed immediately and actions to reduce the water level within the pond should commence as a matter of urgency.

a) The trigger level was established based on historical records and is equivalent to the highest water level record for the site up to February 2017. The level is intended to provide a window for water treatment operations to be commenced.

Analyses indicated that with a freeboard of less than 1.7 m (pond level of 201.8), there is a possibility of the north dyke overtopping due to waves caused by the most critical wind with a return period of 1 in 1,000 years (further details are provided in Section 5.3.1). An overtop of the north dyke by waves has the potential to cause erosion of the dyke fill which, if not repaired, could progress to damage the integrity of the dyke.

The alert pond level is specified to allow time for action to prevent exceedance of the maximum operating pond level. The level is set based on historic records so as not to be regularly exceeded during normal operations. The alert level of 201.6 m (1.9 m of freeboard) was adopted in the 2017 OMS manual and EPRP updates, as at the time of selection the level of 201.6 m was the highest water level on record for the site. Applying this alert level to the historical data would have triggered four alerts since May 2001, including one in spring 2018. The trigger level was established to provide a window for the commissioning of water treatment operations in time to maintain the water level below the maximum operating level (201.8 m).

The pond level is typically at the invert elevation of the culvert (201.1 m) after water treatment. Pond storage capacity calculations (presented in Golder 2018b) indicate a difference in pond volume of 407,639 m^3 between the culvert invert (201.1 m) and the maximum operating pond (201.8 m) levels. Based on an approximate watershed area of the TIA of 9 km^2, this is equivalent to 45.3 mm of precipitation, without allowance for infiltration of run-off from the 3 km^2 external catchment area. The 24-hour duration storm with an annual probability of exceedance of between a 1-in-2 year produces 31 mm of precipitation; the 1-in-10 year produces 53 mm of precipitation.

The difference in pond volume of between the alert (201.6 m) and maximum operating pond (201.8 m) levels is 132,300 m^3. Based on an approximate watershed area of the TIA of 9 km^2, this is equivalent to 14.7 mm of precipitation, without allowance for infiltration of run-off from the 3 km^2 external catchment area.

The alert and maximum operating levels should be revisited following the generation of a storage curve based on new bathymetry and topographic surveys.

3.4 Water Discharge Volumes

Water was discharged from the TIA in two instances in 2018:

1) 186,300 m^3 of water was released between 16 and 30 May 2018. Following the observation of pond water levels above the maximum operating water level (201.8 m) permission was sought from the Water Resource Officer of the Department of Environment and Natural Resources on 14 May 2018 to commence emergency decant of water from the TIA. This request was approved 15 May 2018 and records of daily discharge volume were maintained. Further details are provided in Sections 4.0 and 5.4.1.

2) 388,797 m^3 of water was released between 20 August and 29 September 2018 as part of annual water treatment.

As shown in Table 1, the precipitation (rainfall, snowfall and total precipitation) for the period 1 September 2017 to 31 August 2018 was comparable to the long-term average. However, the monthly distribution varied from the long-term average, including the period of the year that contributes to the generation of the water inventory in the tailings pond in May (i.e., November to April, based on pond drawdown completion in October). The following differences in precipitation during the 1 November 2017 to 30 April 2018 period from long term averages for the same period are noted:

- The 1 November 2017 to 30 April 2018 period recorded a total precipitation approximately 30 mm greater than the long-term average. Assuming all other conditions (i.e., sublimation, snow redistribution) remained similar to the long-term average, it is reasonable to assume this greater total precipitation resulted in greater water inventory in the tailings pond in May 2018.
- The November 2017 period recorded an unusual rainfall amount of 20 mm, compared to the long-term average of virtually no rainfall (<1 mm). As shown in Illustration 2, the average temperature in November 2017 was below zero degrees Celsius, indicating that rainfall occurred during periods of warm weather in between cold days. Runoff from this rainfall would have reported to the tailings pond and remained throughout the winter period (i.e., would be subject to minimal evaporative losses). Under average annual conditions, minimal rainfall runoff water would be expected to collect in the pond between the November to April period, and pond volumes prior to the onset of freshet would typically be similar to that at the completion of drawdown in the previous October.

Pond water levels in September 2017 were also higher than the historical values observed in the pond in September. This may also have contributed to the higher pond levels in Spring 2018.

The above variations from the long-term average conditions likely contributed to the greater than average water inventory observed in the TIA in May 2018.

Loss of pond water to groundwater as a result of seepage through and beneath the dykes will also contribute to discharges from the facility. Seepage losses are not measured and are accounted as part of the general losses from the TIA in the annual water balance. The water balance for 2018 is planned to be included as part of Annual Water License reporting in March 2019 (See Section 1.1).

3.5 Water Discharge Quality

Water quality results are submitted to the Mackenzie Valley Land and Water Board as part of the Annual Water Licence report in March the year following the operational period covered, i.e., in March 2019 for the 2018 operational period. As such, the 2018 Annual Water License report was not available at the time of this 2018 DSI report.

Daily water quality testing was completed between 18 and 30 May 2018 in preparation for and during the authorized emergency discharge of water from the main pond of the TIA. The results were provided to the Water Resources Officer and will be included in the 2018 Annual Water Licence Report.

Additional water quality testing was also completed on 14, 21 and 28 June and on 5 and 12 July 2018.

Water quality testing results for 2017 were submitted to Mackenzie Valley Land and Water Board by Teck (2018). Samples of discharged water were collected at Station 35-1B, located at the polishing pond discharge, for analysis. In 2017 water was sampled on 58 occasions from 2 July through 1 September 2017. Sample and permit averages and maximum concentrations are presented in Table 3 and indicate test results were within permitted concentrations.

Table 3: 2017 Water Quality Sample Results (Station 35-1B)

Concentration	Total Arsenic	Total Copper	Cyanide	Total Lead	Total Zinc	Ammonium	Total Suspended Solids
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Sample Average	n/a	0.0082	n/a	0.0070	0.332	0.031	9.24
Permitted Average	0.5	0.15	0.10	0.20	0.50	2.00	25.00
Sample Maximum	<0.0002	0.018	<0.004	0.0119	0.44	0.034	23.00
Permitted Maximum	1.00	0.30	0.20	0.40	1.00	4.00	50.00

N/A = non-applicable.

4.0 SITE OBSERVATIONS

Site inspections by the Engineer of Record and by Maskwa in 2018 included:

- Engineer of Record
  - 15 May 2018 – special inspection in response to high water levels
  - 23 July 2018 – DSI routine summer inspection (with Maskwa)
- Maskwa
  - 3 May 2018 – routine spring inspection
  - 9 May 2018 – supplementary inspection in response to high water levels
  - 11 May to 31 May 2018 – daily supplemental inspections in response to high water levels
  - 7 June to 10 August 2018 – weekly supplemental inspections in response to high water levels
  - 20 October 2018 – routine fall inspection

The DSI site visit was carried out on 23 July 2017 by:

- Golder
  - Dr. Björn Weeks, P.Eng. (Engineer of Record)
  - Dr. Ben Wickland, P.Eng.

The inspection was accompanied by:

- Maskwa
  - Mr. Clell Crook
- Teck
  - Ms. Kathleen Willman, P.Eng.
  - Ms. Morgan Lypka
  - Mr. Stephen Paris also visited the site during the inspection

The temperature during the visit was approximately 20°C and the weather was sunny to overcast with light cloud and a light breeze. The July inspection report is presented in Appendix B and includes site photographs and observations.

The regular annual site inspection was supplemented by routine inspections carried out by Maskwa on 3 May and 20 October 2018.

4.1 Visual Observations

General observations from the 2018 DSI site inspection include:

- The dykes were in overall good condition.
- Repairs made to a number of minor erosion features on the downstream dyke slopes by placing fill in 2016 were observed to be in place and intact.
- Two surficial erosion rills, approximately 1 m deep, were observed on the lower portion of the downstream slope of the north dyke, approximately 70 m from the northwest corner. Repair of these features was recommended following the site visit.
- Minor erosion rills in other portions of the north dyke, including 5 or 6 features at the ramp remnant, do not appear to have grown significantly and do not impact dyke integrity.
- Restoration trial works along the upstream face of the north dyke appear to have been successful in preventing ongoing erosion in this area.
- An eroded bench up to 1 m high was observed on the upstream face of the north dyke along a 700 m section west of the dogleg during the July DSI. Erosion was above the water line and attributed to higher spring water levels and associated wave and/or ice action. The erosion had exposed silty clay core in some areas but had not reached the dyke crest nor reduced the dyke crest width. Repair was recommended following the site visit.
- Vegetation was observed on the downstream side of the west end of the south dyke.

During the routine inspection visit on 3 May 2018 the pond water level was 201.82 m, which was above the maximum operating pond level of 201.8 m. A supplementary visit to read the pond water level was carried out on 9 May 2018, as per OMS manual requirements. Additional actions were completed in response to high pond levels:

- 11 to 31 May 2018 - daily water level checks were completed by Maskwa, with a final pond water elevation of 201.68 m recorded. This level is 0.12 m below the maximum operating pond level, but above the alert pond level of 201.6 m.
  - During the 13 May 2018 inspection bubbles were observed in 3 or 4 locations within the main pond immediately upstream of the north dyke.
- 15 May 2018 – special inspection of the facility by the Engineer of Record.
  - Bubbles were observed within the main pond area upstream of the north dyke.
  - Surficial erosion observed on downstream face of north dyke.
- 7 June to 10 August 2018 – weekly inspections were completed, with a final pond water elevation of 201.52 m or 0.08 m below the alert pond level.
  - No evidence of seepage at the spillway or on the downstream face/toe of the dykes was observed.

- 3 May to 10 August 2018 – daily checks of the weather data and forecast from Environment and Climate Change Canada to monitor for possible high rainfall events.
  - 50 mm of rainfall was recorded in the 72 hours prior to 13 June 2018.
    - The pond was inspected by Maskwa as part of the weekly inspection on 14 June 2018 when a pond level of 201.72 m was recorded, and indicated a 0.06 mm increase since the previous weekly inspection on 7 June 2018.

The routine fall inspection was completed on 20 October 2018 by Maskwa and a water level of 200.48 m, or 1.12 m below the alert pond level, recorded.

Maintenance of the polishing pond to remove sludge build-up and repair the baffles was carried out between 24 July and 4 August 2018. During these works approximately 8 seepage flows into the polishing pond were observed by Teck staff. These seeps were estimated at rates between 5 and 10 litres per minute and were clear without the presence of sediment. Teck staff were present on site and in regular communication with Golder staff during this time.

A timeline of key events from 3 May to 10 August 2018 is presented with recorded pond levels in Section 4.2.

4.2 Instrumentation Review

The TIA is closed and in the active care phase of mine life. There was no geotechnical instrumentation in the dykes at the Pine Point TIA during the 2018 monitoring period.

Monitoring devices during the 2018 monitoring period were:

- a water level gauge, located at the culvert inlet to the polishing pond
  - read each time the site is visited, typically three times per year (spring, summer, and fall)
- flow rate metres, located in the discharge siphons at the polishing pond (Station 35-1B)
  - typically read daily during water treatment operations
  - flow rates are reported in the annual water report by Teck

Vibrating wire piezometers were installed within the north dyke and in the main pond on the upstream side of the polishing pond in September/October 2018. Standpipe water sampling wells were also installed within, upstream, and downstream of the TIA. Two climate monitoring stations were also installed.

Pond levels from May 2009 to October 2018 are presented in Illustration 3 and individual values are presented in Appendix C. For clarity of presentation, only the maximum monthly recorded pond levels are presented in Illustration 3. Pond water levels in 2018 were generally higher than those observed between 2009 and 2017.

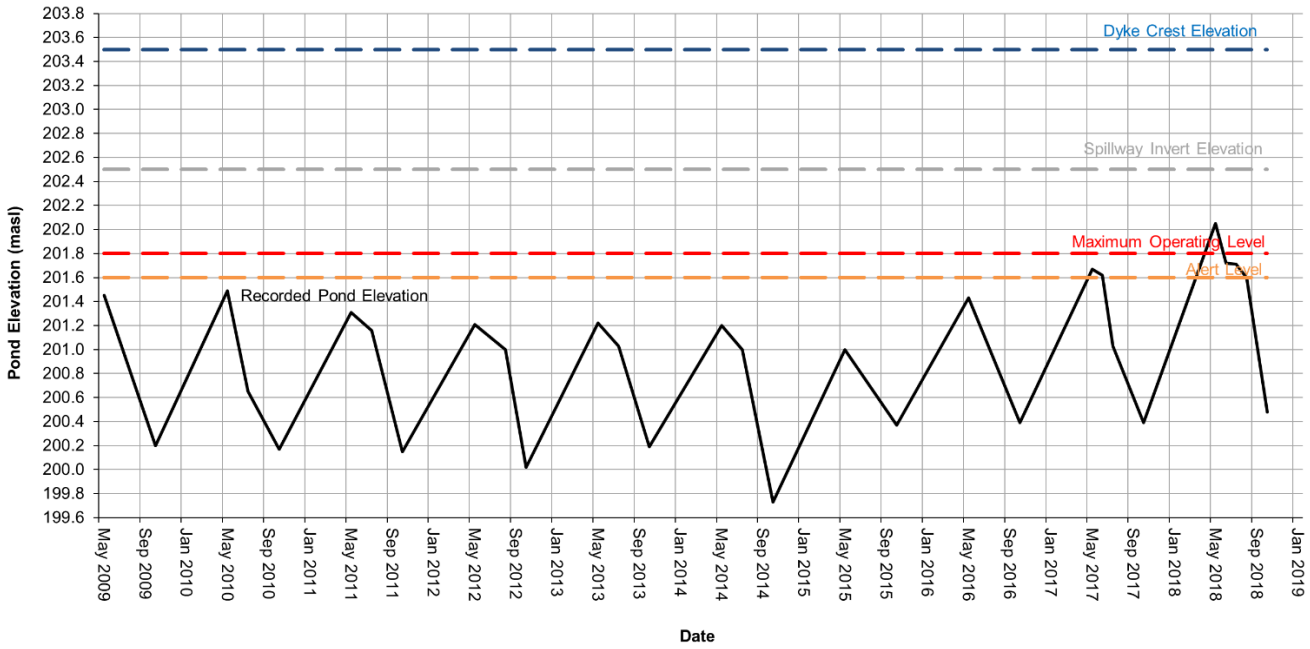

Illustration 3: Maximum Monthly Pond Water Levels May 2009 to October 2018

Pond water levels, alert and maximum operating water levels, spillway invert and dyke crest elevations, and timeline of key events from 3 May to 10 August 2018 are shown in Illustration 4.

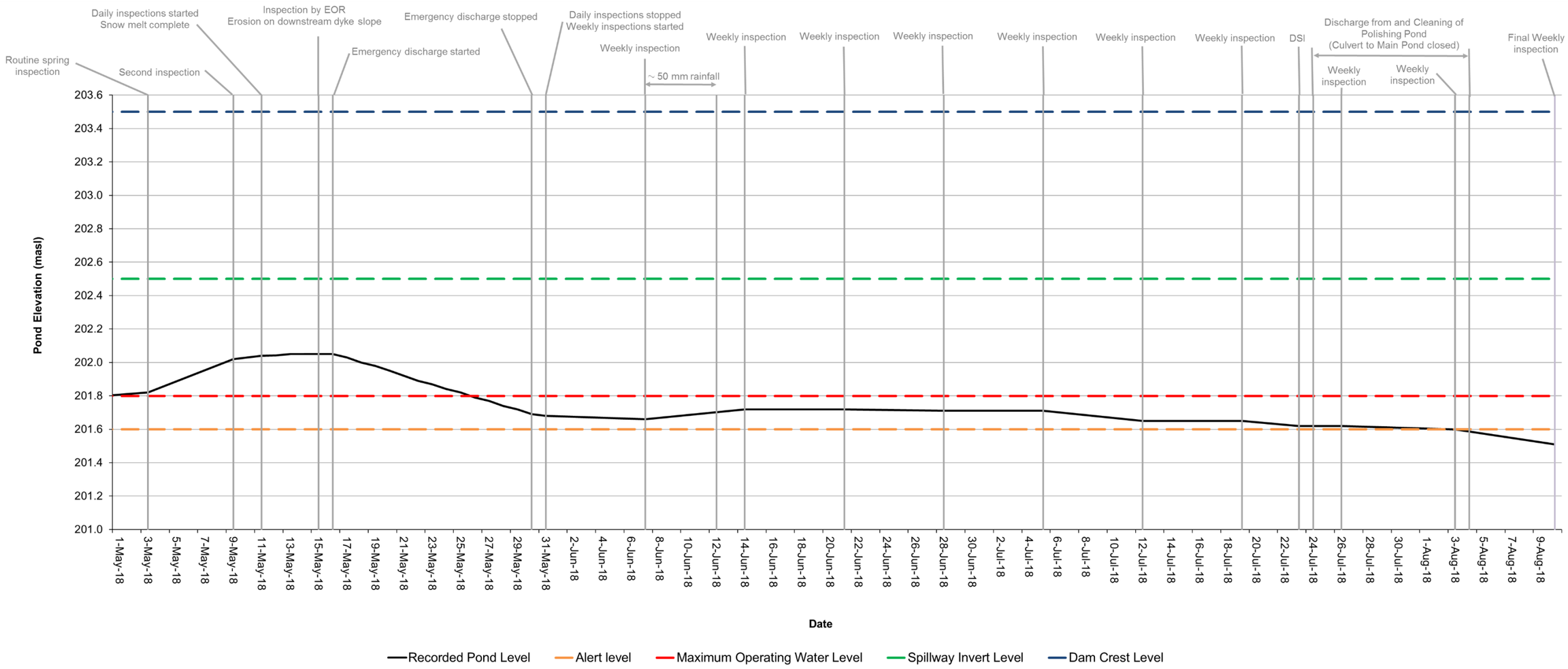

Illustration 4: Pine Point Tailings Impoundment Area Pond Levels and Timeline: 3 May to 10 August 2018

4.3 Pond Water Quality

Details of the 2017 water quality are provided in this section based on the 2017 Annual Water License report submitted to Mackenzie Valley Land and Water Board in March 2018 (Teck 2018). Water samples were collected from the TIA main pond (Station 35-1A) for analysis in spring, summer and fall 2017. Results are presented in Table 4.

Table 4: 2017 Water Sampling Results in Tailings Containment Area (Station 35-1A)

Sample Date	pH	Total Zinc	Total Lead	Total Copper
		mg/L	mg/L	mg/L
30 May 2017	7.86	1.69	<0.000050	0.00050
2 August 2017	-	0.99	0.033650	0.01100
29 August 2017	8.08	0.36	0.0068	0.008
Detection Limit		0.0001	0.000050	0.00100

- = no result provided in Teck (2018).

Concentrations of lead and copper in the TIA were lowest in May 2017 when the pond was highest. Concentrations of lead and copper were highest in early August 2017 during water treatment. Concentrations then reduced at the end of August 2017, approximately 4 days prior to the end of water treatment in 2017.

Zinc concentration values were at highest in Spring 2017 and lowest in late August 2017.

4.4 Site Inspection Forms

A site inspection form for the 23 July 2018 site visit by Golder is provided in Appendix B.

5.0 DAM SAFETY ASSESSMENT

5.1 Dam Classification Review

Consequence classification is not related to the likelihood of a failure, but rather the potential impact if a failure did occur.

CDA *Dam Safety Guidelines* (CDA 2013) present a dam classification system based on consequence of failure to define design requirements for water retaining structures and dams. The descriptions of the CDA (2013) dam classes are provided in Table 5.

Table 5: Dam Failure Consequence Classification

Dam Failure Consequences Classification	Population at Risk	Consequences of Failure		
		Loss of Life	Environment and Cultural Values	Infrastructure and Economics
Low	None[a]	There is no possibility of loss of life other than through unforeseeable misadventure	Minimal short-term loss or deterioration and no long-term loss or deterioration of: ■ fisheries habitat or wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance	Minimal economic losses mostly limited to the dam owner's property, with virtually no pre-existing potential for development within the dam inundation zone
Significant	Temporary only[b]	Low potential for multiple loss of life	No significant loss or deterioration of: ■ important fisheries habitat or important wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is highly possible	Low economic losses affecting limited infrastructure and residential buildings, public transportation or services or commercial facilities, or some destruction of or damage to locations used occasionally and irregularly for temporary purposes
High	Permanent[c]	10 or fewer	Significant loss or deterioration of: ■ important fisheries habitat or important wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is highly possible	High economic losses affecting infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to scattered residential buildings
Very High	Permanent[c]	100 or fewer	Significant loss or deterioration of: ■ critical fisheries habitat or critical wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is possible but impractical	Very high economic losses affecting important infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas
Extreme	Permanent[c]	More than 100	Major loss or deterioration of: ■ critical fisheries habitat or critical wildlife habitat ■ rare or endangered species ■ unique landscapes or sites of cultural significance ■ restoration or compensation in kind is impossible	Extremely high economic losses affecting critical infrastructure, public transportation or services or commercial facilities, or some destruction of or some severe damage to residential areas

Source: CDA (2013).

a) There is no identifiable population at risk.

b) People are only occasionally and irregularly in the dam-breach inundation zone, for example stopping temporarily, passing through on transportation routes, or participating in recreational activities.

c) The population at risk is ordinarily or regularly located in the dam-breach inundation zone, whether to live, work, or recreate.

Note 1. Definitions for populations at risk:

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

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

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

Note 2. Implications for loss of life:

Unspecified – The appropriate level of safety required at 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.

Dykes at the site are classified as Low to Significant, based on CDA (2013). Only the north dyke retains water at any time; the south and west dykes only retain tailings, while the east dyke does not retain water or tailings but is required for freeboard. The criteria for classification are evaluated as follows:

- **Population at risk**—There is the possibility of a temporary population downstream of the west and south dykes due to exploration works by an external third party. The south and west dykes do not retain water and as such are unlikely to constitute a risk to exploration activities.
- **Loss of life**—There is a low potential for multiple loss of life associated with the presence of exploration drilling work in the area. The south and west dykes do not retain water and as such are unlikely to constitute a risk to exploration activities.
- **Environmental and cultural values**—A dyke failure would impact the local environment. There is a possibility of minimal short-term loss or deterioration of wildlife habitat as a result of a failure of the south and east dykes. Failure of the north or west dykes presents a higher risk, due to the impoundment of water; however, failure would not lead to a significant loss or deterioration of important wildlife habitat or areas of cultural significance; restoration or compensation for impacts is considered highly possible.
- **Infrastructure and economics**—None. There is no development or infrastructure downstream of the TIA.

Consequence classifications are summarized in Table 6.

Table 6: Dam Failure Consequence Classification for the North, East, West, and South Dykes

Dam	Dam Class	Population at Risk	Consequences of Failure		
			Loss of Life	Environment and Cultural Values	Infrastructure and Economics
north dyke	Significant	none	low to none	low to significant	none
east dyke	Low	none	low to none	low	none
west dyke	Significant	none	low to none	low to significant	none
south dyke	Low	none	low to none	low	none

Further to criteria in the *Dam Safety Guidelines* (CDA 2013), CDA has published a *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (CDA 2014), which provides recommendations on criteria for different phases of mine life. The TIA is considered to be in the Closure – Active Care phase of mine life, based on regular monitoring of the dykes and regular treatment and release of water from the facility. The design criteria for the dam therefore follow CDA (2013). Should the TIA move to the Closure – Passive Care phase, where the system is considered stable, with no water treatment or regulation of the pond, such that water may be passively released from the system, then the design criteria for the dam should be revisited based on recommendations of CDA (2014).

5.2 Review of Downstream and Upstream Conditions

There are no known changes in the upstream or downstream conditions for the Pine Point TIA in the 2018 monitoring period that could conceivably result in a change in dam consequence classification.

Exploration activities by an external party were in progress at the Pine Point Mine site during 2018. Teck staff have reported that these activities are taking place downstream of the south and west dykes. The south and west dykes do not retain water and as such are considered to be unlikely to constitute a risk to people or equipment working more than approximately 50 m downstream of the dykes.

5.3 Design Basis Review

The design criteria related to floods and seismic and static stability based on CDA (2013) guidelines are summarized in Table 7.

Table 7: Minimum Design Criteria for Pine Point Dykes

Dykes	Dam Class	Annual Exceedance Probability – Floods	Annual Exceedance Probability – Earthquakes	Factors of Safety			
				Static		Pseudo-static	Post-earthquake
				Long-Term	Full or Partial Drawdown		
north and west	Significant	between 1/100 and 1/1,000	between 1/100 and 1/1,000	1.5	1.2 to 1.3	1.0	1.2 to 1.3
south and east	Low	1/100	1/100	1.5	1.2 to 1.3	1.0	1.2 to 1.3

Note: Design criteria based on CDA 2013.

In addition, CDA (2013) provides two calculations for freeboard; the most critical of the two scenarios sets the minimum freeboard to be adopted (as presented in Golder 2018b):

- **Scenario 1**—no overtopping by 95% of the waves caused by the most critical wind with a return period of 1,000 years with the pond at its maximum normal operating elevation.
- **Scenario 2**—no overtopping by 95% of the waves caused by the most critical wind with a return period of 10 years (for Significant consequence structures), with the pond at the maximum level during the passage of the inflow design flood.

Details of how the Pine Point TIA achieves the required design criteria are discussed relative to the potential failure modes in the next sections.

5.3.1 Annual Exceedance Probability – Floods

An assessment of flood capacity to meet CDA (2013) guidelines is provided in the OMS manual (Golder 2018b) and the net annual precipitation volumes for the 1-in-100-year and 1-in-1,000-year return events determined, as presented in Table 8.

Table 8: Flood Capacity Analysis for Extreme Annual Total Precipitation Events

Return Period (years)	Total Annual Precipitation (mm)	Total Annual Losses[(c)] (mm)	Net Annual Precipitation[(d)] (mm)	Net Annual Precipitation Volume[(e)] (m^3)
100[(a)]	742	709	33	301,178
1,000[(b)]	844	806	38	342,580

a) Design criteria for south and east dykes.

b) Design criteria for north and west dykes.

c) Total annual losses include evaporation, evapotranspiration, and infiltration. Total losses are calculated based on the relationship between total precipitation and total losses presented in Illustration 5.

d) Net annual precipitation is total annual precipitation minus total annual losses.

e) Net annual precipitation volume is net annual precipitation multiplied by a watershed area of 9 km^2.

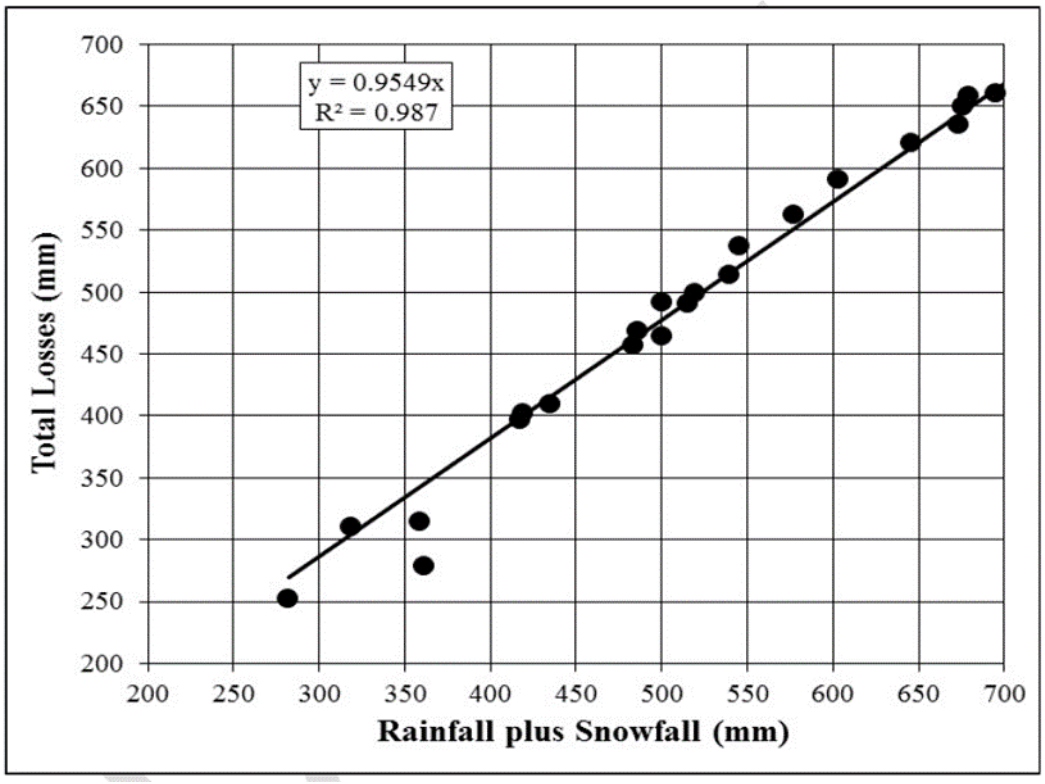

Illustration 5: Correlation between Total Losses and Total Precipitation (Golder 2018b)

5.3.2 Annual Exceedance Probability – Earthquakes

According to the 2010 National Building Code of Canada seismic hazard calculator (NRC 2011), peak ground acceleration for the Pine Point Mine site is:

- 0.003 g for the 1-in-100-year event (40% probability of exceedance in 50 years)
- 0.019 g for the 1-in-1,000-year event (5% probability of exceedance in 50 years)

5.4 Hazards and Failure Modes Review

The dykes at the Pine Point TIA were evaluated against the four most common failure modes for dykes similar to those at Pine Point which could impact the dyke safety:

- **Overtopping**—occurs when the pond level rises above the dyke crest level, resulting in flow over the dyke that may cause progressive erosion of the dyke and loss of the pond and tailings.
- **Piping**—occurs when there is development of internal erosion. This erosion can lead to loss of material, formation of a hole in the dyke, and rapid loss of water and tailings from the storage pond.
- **Instability**—occurs due to imbalance of forces resulting in movement of a part of the dyke with possible loss of integrity of the dyke.
- **Erosion**—occurs from either wave action or surface run-off, resulting in a loss of the dyke cross-section.

Other failure modes are not considered likely for the Pine Point TIA and are therefore not discussed.

5.4.1 Overtopping

Design Basis

CDA (2013) provides two calculations for freeboard (vertical distance between the dyke crest and the pond water); the more critical of the two following scenarios sets the minimum freeboard (as presented in Section 5.2).

The minimum freeboard (1.7 m) was updated as part of the 2017 update to the OMS manual. Details are provided in Section 3.3 of this report.

Instrumentation – Water Level Gauge

Readings from May 2009 to October 2018 are presented in Illustration 3 and individual values are presented in Appendix C.

The gauge is installed to a datum at 201.032 m (i.e., reads 0 m), which is the elevation of the top of the flange at the culvert between the main and polishing ponds, and does not read freeboard directly. The pond level is calculated with reference to the datum.

Observed Performance

The maximum observed water level in 2018 was 202.05 m, which was 0.25 m above the maximum operating level of 201.8 m as specified in the OMS, and represents a freeboard of 1.45 m, compared to the minimum specified in the OMS of 1.7 m. Once water levels were observed to remain above the 201.8 m level, i.e., ongoing monitoring did not indicate a reduction in pond levels, permission was sought from the Water Resource Officer of the Department of Environment and Natural Resources on 14 May 2018 by Teck, acting on the advice of the EoR, to commence the emergency decant of water from the main pond of the TIA. This request was approved 15 May 2018 and the decanting of water took place between 16 and 30 May 2018. Decanting stopped when the water level in the pond reached 201.69 m.

The dykes are also protected against overtopping by the spillway. The main pond spillway invert elevation is 202.5 m.

5.4.2 Piping

Internal instability of a dyke can be caused by materials migrating out of the dyke when water or seepage flows pass through the dyke, leaving voids. This generally happens with dyke 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 induced by regressive erosion of particles towards an outside environment until a continuous pipe is formed. This can occur in some cases along conduits or pipes through a dyke structure, but also can occur through any soils subject to seepage pressures where soil layers fail to meet applicable filter (grain size compatibility) criteria.

Design Basis

Limited records from the construction of the dykes at the Pine Point Mine are available, and as such it is not possible to confirm filter compatibility between the tailings and the dyke construction fills. A site investigation was completed in fall 2018 and geotechnical samples were collected for testing to enable the completion of filter compatibility analyses. Testing was in progress at the time of this report.

Observed Performance

At the time of the visits in May, June, July, August and October the only significant volume of free water in the tailings area was ponded against a portion of the north dyke (similar to the conditions shown in Figure 2).

There were no visible signs of seepage through the dykes during inspections by Golder and Maskwa, although the healthy growth of some bushes or small trees at the outside toe of portions of the north, west, and south dykes is considered indicative of soil moisture in these areas. Ponded water at the downstream toe of the dykes may or may not be indicative of seepage through the dykes. Some of the wet areas beyond the perimeter of the disposal area was attributed to run-off of surface water, and are not indicative of seepage.

The ponded water downstream of the facility adjacent the dams was clear, and no cloudy seepage or other signs of piping was observed (cloudy seepage or seepage with a sediment load is indicative of the erosion of fine soils).

Some seepage of clear water through properly designed earthen water retaining structures is considered normal.

The observation of bubbles in the TIA was not considered to be related to seepage or piping.

Erosion rills on the north dyke downstream face were not considered to be related to a piping failure mechanism based on location, observations of field conditions, calculated gradients, and available data on dyke construction materials. There was no pond in the TIA adjacent to the rills.

5.4.3 Instability

Design Basis

A stability review was completed as part of the 2014 dam safety review (DSR) (SRK 2016). This analysis used a horizontal peak ground acceleration of 0.019 g, based on the 2010 National Building Code seismic hazard calculator (NRC 2011) for the 1-in-1,000-year event.

Stability analyses were carried out for the north and west dykes. The analyses results indicated factors of safety of between 1.4 and 1.5 for the north dyke and 1.3 and 1.6 for the west dyke under pseudo-static (seismic) loading conditions. A minimum factor of safety of 1.0 is recommended by CDA (2013) for seismic loading conditions. The dykes therefore meet the criteria for stability for a facility in the Closure – Active Care phase of mine life, as defined by CDA (2014).

Should the TIA move to the Closure – Passive Care phase, the stability of the dykes should be assessed for the 1-in-2,475-year return period earthquake (2% probability of exceedance in 50 years as per CDA 2014).

All factors of safety for static loading were in excess of the minimum value of 1.5 recommended by CDA (2013).

All analyses were conducted based on sections and material properties determined as part of the 1981 geotechnical investigation stability report (Golder 1981), with some modification to the shear strength of the foundation materials.

Observed Performance

The inspections during the 2018 site visits did not identify any sign of overall slope instability such as cracks, settling, or bulging of the dykes. Erosion on the upstream face of the north dyke due to high water levels and erosion rills on the downstream face of the north dyke are not considered to impact the overall stability of the dyke and were repaired in October 2018.

The condition of the dykes, in relation to overall stability, has otherwise remained unchanged from previous site visits. The dyke slopes appeared to be stable and, as a result, the overall stability of the perimeter dykes has continued to be satisfactory.

5.4.4 Erosion

There are two types of surface erosion occurring at the Pine Point TIA. These are:

- **Wave cut erosion—**Present on the upstream face (tailings side) of the north dyke caused by high water levels, and associated wind-driven erosion or possibly ice action. Erosion has occurred previously, and was repaired in 2008 with a rebuilt slope developed at 2 horizontal to 1 vertical. During the 2014 and 2015 inspections, erosion was observed in the central section of the north dyke at or just above the water level. In 2016 repairs were made to a test section of the upstream face of the north dyke using locally sourced granular fill with a particle size distribution that was greater that that used for the initial construction of the dykes, but smaller than sized riprap that would ordinarily be used for wave protection. The test section was intended to evaluate if the locally sourced material was suitable for restorative maintenance of the reminder of north dyke upstream face. The 2016 repairs were in good condition at the time of the 2018 DSI. However, recommendations for repair were updated to use sized rip-rap following erosion of a bench roughly 700 m long on the upstream slope of the north dyke west of the dogleg above the water line. The height of the eroded bench was observed to have increased from the May inspection to the July 2018 DSI, with a vertical bench face height of up to 1.0 m and exposed till core in places. Erosion was not observed to have reached the dyke crest or reduced the dyke crest width. Maintenance repairs were completed in October 2018 using riprap over a portion of the upstream face of the north dyke along the pond, which should reduce frequency of future maintenance.
- **Surface erosion rills (gullies)**—Two rills were observed on the downstream face of the north dyke, approximately 70 m from the northwest corner of the TIA. These rills were up to 1 m in depth and were repaired in October 2018. Other minor rills were observed on the downstream dyke faces, less than 0.1 to 0.2 m in depth, and below the 0.3 m threshold for maintenance. No rills extended into the dyke crests.

5.5 Operational Performance

The Pine Point TIA is a closed site with no ongoing operations.

Details on maintenance in 2018 are provided in Section 2.0.

Details on annual water treatment are provided in Section 2.0 and Section 3.0.

5.6 Operation, Maintenance, and Surveillance Manual Review

An OMS manual for the Pine Point Mine TIA was completed in 2009 (Golder 2009). The OMS manual was updated in February 2017 (Golder 2017a) to align with CDA (2013), as well as the Teck *Guideline for Tailings and Water Retaining Structures* (Teck 2014).

Further updates of the OMS manual were completed in February 2018 and June 2018 (Golder 2018b) to reflect changes in the updated Water Licence (MV2017L2-007) and water treatment manual, respectively.

A topographic and bathymetric survey is proposed by quarter 1 2019. Once completed these data should be used to update the pond capacity curve and the freeboard requirements presented in the OMS manual.

5.7 Emergency Preparedness and Response Plan Review

An EPRP for the Pine Point Mine TIA was completed as part of the OMS manual in 2009 (Golder 2009). The EPRP was updated in February 2017 (Golder 2017b) to align with CDA (2013), the updated OMS manual (Golder 2017a), and the Teck *Guideline for Tailings and Water Retaining Structures* (Teck Resources Ltd. 2014).

The EPRP should also be updated in conjunction with updates to the OMS manual.

5.8 Dam Safety Review

The last DSR for the south, west, and north dykes of the Pine Point TIA was conducted by SRK Consulting in 2014 (SRK 2016). The next DSR for the facilities should be carried out by the end of 2024 to comply with CDA (2013) guidelines.

6.0 SUMMARY AND RECOMMENDATIONS

6.1 Summary of Construction and Activities

There was no construction in 2018.

The following activities were completed at the Pine Point TIA in 2018:

- routine inspection on 3 May
- additional water level check on 9 May
- daily water level checks between 11 and 15 May
- special inspection by Engineer of Record on 15 May
- emergency discharge of water from the TIA, approved by the Water Resource Officer of the Department of Environment and Natural Resources, between 16 and 30 May
- daily dam inspections between 16 and 31 May
- DSI on 23 July
- weekly dam inspections between 31 May and 10 August 2018
- maintenance and repair of the polishing pond between 24 July and 4 August
- site investigations were completed between 6 September and 12 October. Instrumentation was installed in the TIA as part of site investigations:
  - vibrating wire piezometers within the north dyke
  - vibrating wire piezometer to monitor the main pond on the upstream side of the polishing pond
  - standpipe water sampling wells within the TIA and in areas upstream and downstream of the TIA
  - two climate monitoring stations
- water treatment started 20 August and finished 29 September
- maintenance repair by placement of geotextile and riprap fill on upstream face of the north dyke between10 and 15 October
- maintenance repair by placement of granular fill in rills on downstream face of the north dyke between 10 and 15 October
- routine inspection on 20 October

6.2 Summary of Climate and Water Balance

During the 2018 monitoring period (September 2017 to August 2018) the total annual precipitation was 445 mm, which was approximately 19 mm lower than the long-term average. The average air temperature was -2.2°C which was approximately 0.7°C higher than the long-term average. Water treatment was completed on 29 September 2018. An updated water balance will be provided as part of annual water license reporting in March 2019.

6.3 Summary of Performance

Overall, the dykes appear to be in good condition and were achieving their intended purpose of retaining the tailings and ponded water in a satisfactory manner.

No significant changes to the dyke stability were observed. Overall stability of the dykes was therefore unchanged from the 2017 DSI.

Higher than average pond water levels were observed in 2018 with the pond reaching a maximum elevation of 202.05 m or 0.25 m above the maximum operating pond level of the facility. Freeboard was less than the minimum operating level required in the facility OMS between 3 and 31 May 2018. Daily inspections and weather forecast checks were carried out during this period in accordance with the protocol specified in the OMS manual. Variability from the long-term average climate conditions are considered to have contributed to the greater than average water inventory observed in the TIA in May 2018.

6.4 Consequence Classification

The following consequence classifications, as per CDA (2013), which classifies dams based on the consequences (i.e., potential damage that can be caused in the unlikely event that a dam fails for the dykes at the Pine Point TIA were determined:

- north dyke: Significant
- west dyke: Significant
- east dyke: Low
- south dyke: Low

There have been no significant changes in the guidelines, regulations, potential downstream receptors or the nature of the structures since 2017, and as such these classifications remain unchanged from the 2017 DSI.

6.5 Table of Deficiencies and Non-conformances

Table 9 summarizes deficiencies / non-conformances and recommended actions for the Pine Point TIA.

Table 9: Summary of Dam Safety Inspection Recommended Actions

Structure	ID Number	Deficiency or Non-Conformance	Applicable Regulation or OMS Manual Reference	Recommended Action	Priority	Recommended Deadline/Status
north dyke	2016-2	Erosion observed on the pond side of the north dyke with potential to cause dyke instability	OMS Manual Section 5.5.2	Continue observation and evaluation of replacement fill placed in 2016 throughout 2018 monitoring period. Should be restored area indicate adequate performance, repair the remaining sections of observed erosion in 2019 with the same fill material used in the trial. Should significant erosion occur within the test section during 2018, complete a new test restoration using coarser fill in 2019, or evaluate alternative approaches such as periodic repair work of the fill.	3	Closed
south dyke	2018-1	Vegetation encroaching on downstream face of south dyke	OMS Manual Section 5.5.2	Remove vegetation at west end of south dyke as per OMS manual. The south dyke is outside the Teck lease boundary and permission from land owner will be required to complete vegetation removal.	3	2019
polishing pond	2018-2	No written procedure for sludge removal	none	Update water treatment manual to include written maintenance procedure for removal of sludge from polishing pond including dewatering operations.	4	2019
TIA	2018-3	Inaccurate storage curve for facility	OMS Manual Section 4.3.3	Complete bathymetry and tailings topographic survey to define the facility storage curve, review flood storage capacity and water handling practices, determine capacity of spillway and update freeboard limits. Incorporate these changes in the OMS manual. Consider preparing for high water levels in spring 2019 and requirement to treat water at the freshet.	2	Survey by Q1 2019

Priority[a]	Description
1	High probability or dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected/implemented could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
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.

a) Source: Teck 2014.

ID = identification; OMS = operation, maintenance, and surveillance; DSR = dam safety review; CDA = Canadian Dam Association.

6.6 Ongoing/Planned Work

Ongoing and planned work at the Pine Point TIA includes a topographic and bathymetric survey of the TIA.

7.0 CLOSURE

The reader is referred to the Study Limitations section, which precedes the text and forms an integral part of this report.

We trust that the factual information provided in this report is sufficient for your present needs. Should you have any questions regarding the above information or require additional information please contact the undersigned.

Golder Associates Ltd.

Martyn Willan, M.Sc., P.Eng.
Geotechnical Engineer

Ben Wickland, Ph.D., P.Eng.
Associate, Senior Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
22.02.2019
B. WEEKS
LICENSEE
NT/NU

Björn Weeks, Ph.D., P.Eng.
Principal, Geo-Environmental Engineer

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 22 Feb 2019
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

MBW/BEW/BW/cr/ah/cmm

https://golderassociates.sharepoint.com/sites/19510g/deliverables/issued/117-r-rev2-5000-2018 dsi pine point/1788880-117-r-rev2-5000-2018 dsi pine point 22feb_19.docx

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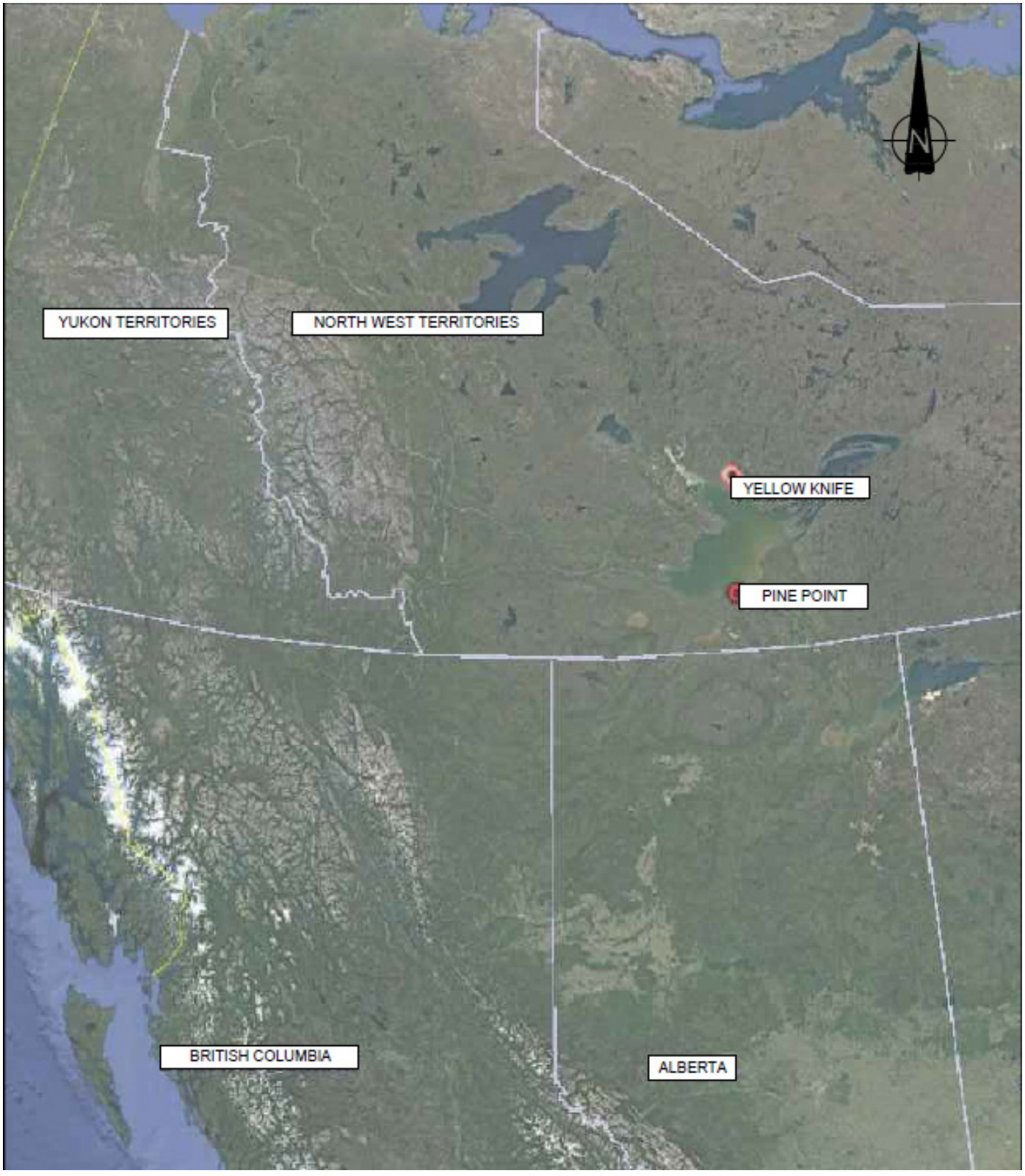


CLIENT
TECK METALS LTD.

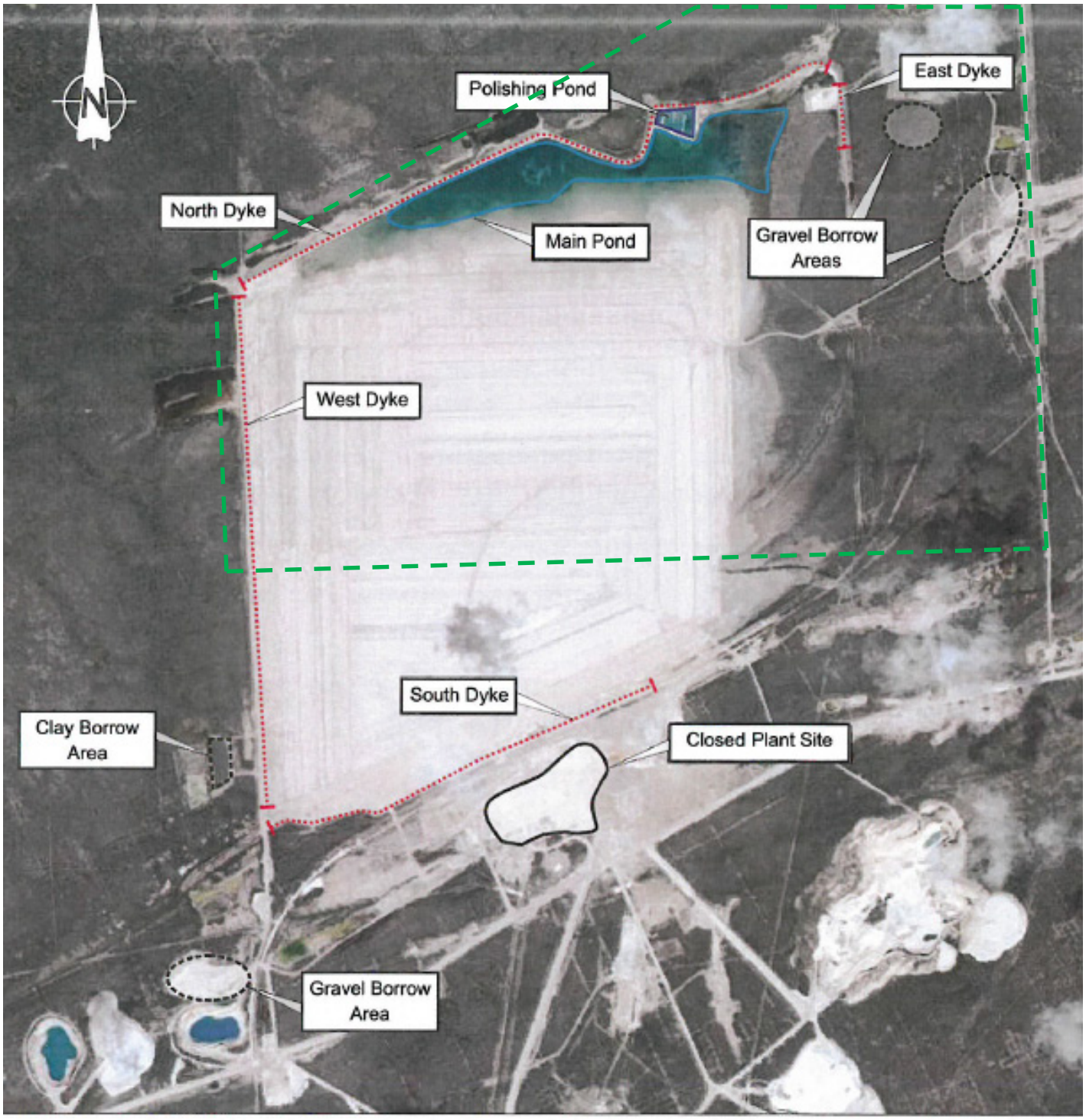
CONSULTANT
GOLDER

YYYY-MM-DD	2019-02-22
PREPARED	MBW
DESIGNED	MBW
REVIEWED	MBW
APPROVED	BEW

PROJECT
PINE POINT TAILINGS IMPOUNDMENT AREA
2018 DAM SAFETY INSPECTION
PINE POINT, NT

TITLE
GENERAL LOCATION OF PINE POINT MINE SITE

PROJECT NO.	TASK NO.	REV.	FIGURE
1788880	5000	2	**1**



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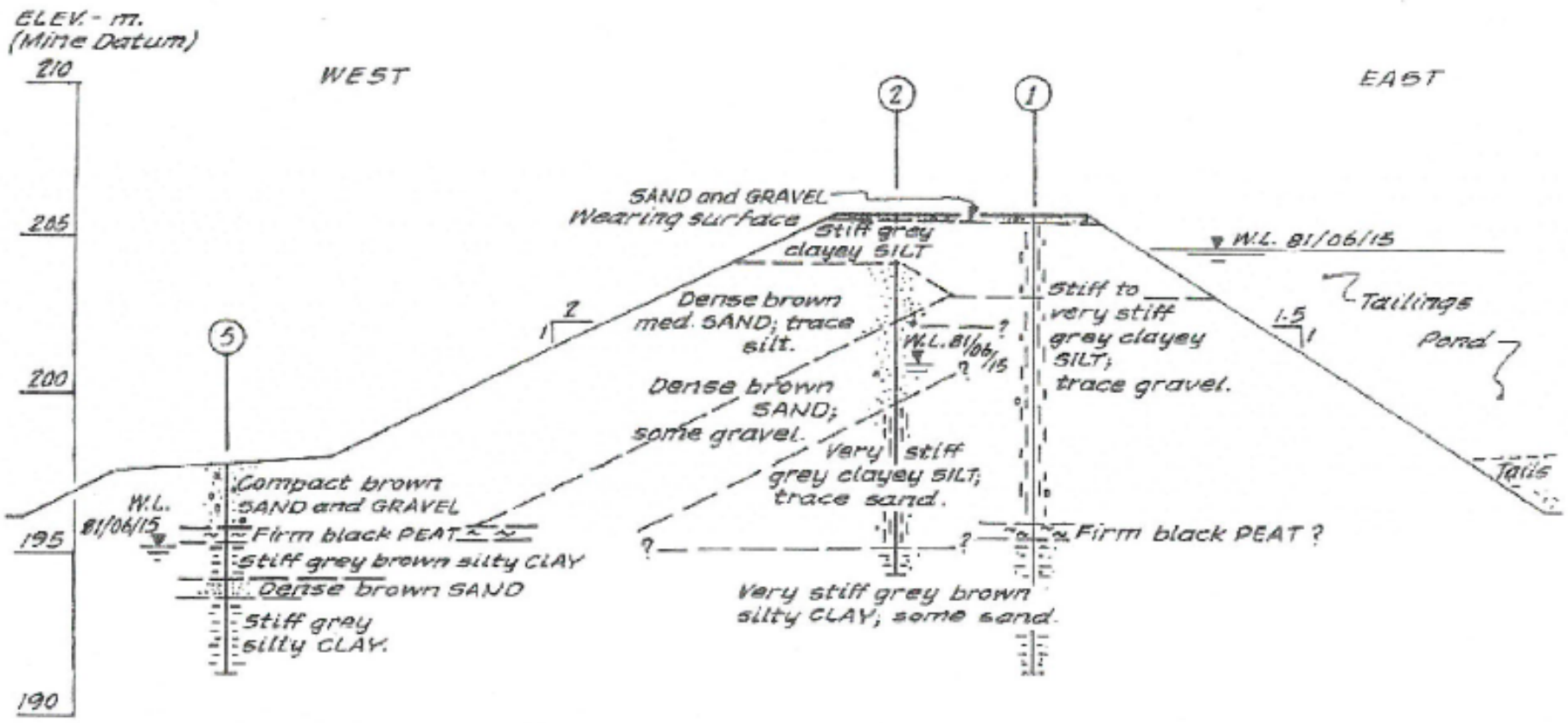
GOLDER

YYYY-MM-DD	2019-02-22
PREPARED	MBW
DESIGNED	MBW
REVIEWED	MBW
APPROVED	BEW

PROJECT
PINE POINT TAILINGS IMPOUNDMENT AREA
2018 DAM SAFETY INSPECTION
PINE POINT, NT

TITLE
TAILINGS IMPOUNDMENT AREA

PROJECT NO.	TASK NO.	REV.	FIGURE
1788880	5000	2	**2**



SCALE 1 : 200

LEGEND

(2) Location of Borehole

NOTE

1. Section partially inferred from construction records.
2. Black peat removed from under toe berm of west dyke south of Sta. 35+00.

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YYYY-MM-DD	2019-02-22
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DESIGNED	MBW
REVIEWED	MBW
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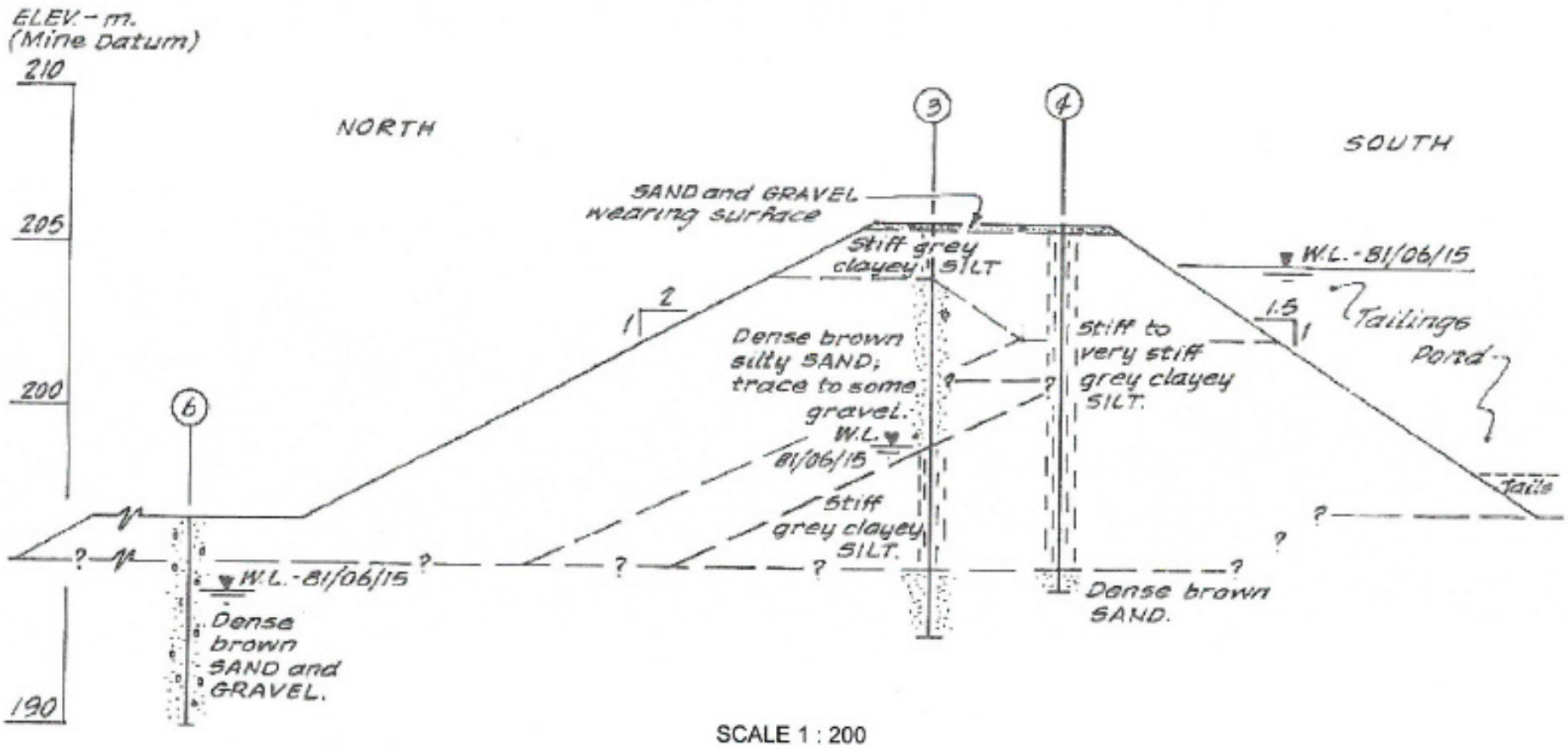
PROJECT
PINE POINT TAILINGS IMPOUNDMENT AREA
2018 DAM SAFETY INSPECTION
PINE POINT, NT

TITLE
TYPICAL SECTION
WEST DYKE

PROJECT NO.	TASK NO.	REV.	FIGURE
1788880	5000	2	**3**



SCALE 1 : 200

LEGEND

(6) Location of Borehole

NOTE

1. Section partially inferred from construction records.

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YYYY-MM-DD	2019-02-22
PREPARED	MBW
DESIGNED	MBW
REVIEWED	MBW
APPROVED	BEW

PROJECT
PINE POINT TAILINGS IMPOUNDMENT AREA
2018 DAM SAFETY INSPECTION
PINE POINT, NT

TITLE
TYPICAL SECTION
NORTH DYKE

PROJECT NO.	TASK NO.	REV.	FIGURE
1788880	5000	2	**4**

APPENDIX A

Facility Data Sheet

Appendix A

Facility Data Sheet

Physical Description

Pine Point Tailings Impoundment Area

Impoundment Area	~7,000,000 m^2
Volume of Tailings	~60,000,000 m^3
Reservoir Capacity	790,660 m^3 (to maximum operating water level of 201.8 m)
Inflow Design Flood (IDF)	between 1/100 and 1/1,000 year return period (CDA 2013)
Design Earthquake	between 1/100 and 1/1,000 year return period (CDA 2013)
Spillway Capacity	Unknown
Catchment Area	9 km^2 (6 km^2 internal and 3 km^2 external)

South Dyke

Dam Type	Downstream raised Earthfill Dam
Maximum Dam Height	~4 m
Dam Crest Width	~2.5 m
Consequence Classification	Low (CDA 2013)
Access to Dam	From southeast and southwest corners of facility

West Dyke

Dam Type	Downstream raised Earthfill Dam
Maximum Dam Height	~15 m
Dam Crest Width	~8 m
Consequence Classification	Significant (CDA 2013)
Access to Dam	From southwest corner of facility

North Dyke

Dam Type	Downstream raised Earthfill Dam
Maximum Dam Height	~15 m
Dam Crest Width	~7 m
Consequence Classification	Significant (CDA 2013)
Access to Dam	From northeast corner of facility

East Dyke

Dam Type	Downstream raised Earthfill Dam
Maximum Dam Height	~1 m
Dam Crest Width	~2.5 m
Consequence Classification	Low (CDA 2013)
Access to Dam	From northeast corner of facility

APPENDIX B

Dam Safety Inspection Visit Report

TECHNICAL MEMORANDUM

DATE 23 October 2018 **Reference No.** 1788880-108-TM-Rev0-3000

TO Michelle Unger, Manager, Environmental Compliance
Teck Metals Limited

CC Kathleen Willman, Stephen Parris, Morgan Lypka

FROM Ben Wickland and Bjorn Weeks **EMAIL Ben_Wickland@golder.com; Bjorn_Weeks@golder.com**

INSPECTION 23 JULY 2018 PINE POINT TAILINGS IMPOUNDMENT AREA, NT

1.0 SITE INSPECTION NOTES

Golder Associates: Bjorn Weeks (Engineer of Record), Ben Wickland

Maskwa Engineering: Clell Crook

Teck: Kathleen Willman, Morgan Dypka

Weather: Sunny to overcast, light cloud, light breeze and 20^{o} Celsius

Time: 9:25 am to 1:45 pm

1.1 South Dyke

East End

- Vegetation developing on upstream slope. No water observed on pond side (upstream of dyke). Clear standing water present in ditch on downstream side, consistent with observations in previous years. No indication that water presence is the result of seepage.

Central

- Dyke continues to be in good shape with minor rilling – no evidence that rilling has increased significantly from previous years.
- No standing water observed on crest, upstream or downstream of the dyke.
- Minor rutting on crest due to light vehicle traffic.

West End

- Dyke crest narrow compared with dyke crests in all other areas of the facility, with vegetation encroaching from the downstream side. No change in dyke width.
- Crest slopes towards pond side and crest is in good condition, no erosion on crest.
- At west end the downstream slope is overgrown with vegetation.
- Permanent swamp area to the south of dyke at the west end.

1.2 West Dyke

South End

- Dyke in good shape with no new or noticeable erosion of crest or downstream slopes. No notable change from last year.
- Crest and upstream slope in good condition.
- Ponded water below downstream toe, outside impoundment. Water is clear. There are some sections with rust-colored staining near the pond that may be indicative of historic seepage, as per observations in past years. There is no evidence of new seepage.
- Minor vegetation on the upstream and downstream faces.
- No water on impoundment side.

Central

- Overall slopes and crest in good condition.
- Small swamp at toe appears to be natural ponding of water in zone with poor drainage.
- Woody vegetation on downstream face without leaves.
- No new erosion of downstream slope. Historic rills on downstream face are rounded.

North End

- Upstream, crest, and downstream slopes in good condition.
- Downstream toe area generally dry, with some soft ground near the permanently ponded areas.
- No significant new erosion of downstream slope noted. Old gullies on lower part of slope have not increased in size and appear stable, approximately 30 cm deep (maximum).
- Overall slopes and crest in good condition.

- Water to the west of the impoundment appears to be natural accumulation in low areas/ former borrow areas. As noted in previous years, there is a runoff drainage course between the dyke toe and the downstream pond, with some residual staining and salts. The drainage course was moist to wet, with minor seepage, and there was no free water in the tailings impoundment adjacent to this location.

1.3 North Dyke

West End

- Two large erosion rills on the lower portion of the downstream slope ~70 m from the northwest corner.
- Water north of downstream toe in old borrow area was clear with no visible movement or evidence of seepage.
- Minor rilling of upstream slope.
- No pond against dyke at west end.
- Crest and downstream slope otherwise in good condition.
- Several dead trees noted, presumable from herbicide application during the past years.

Central

- Larger erosion rills noted on downstream slope in 2016 have been repaired and are in good shape.
- Small ponds north of dyke in downstream toe area in old borrow pit. No visible seepage. Water in the ponds appears to be clear and still.
- Water in North Dyke pond is some 1.5 to 2 m below the crest, with a similar extent to previous years.
- As per observations noted in previous year, the upstream (tailings pond side) slope was flattened 9 years ago with a well graded sand with some gravel.
- Wave action or possibly ice action has eroded the upstream slope over 700 m west of dogleg, with erosion benches visible above the water line. The erosion has increased since the May 2018 inspection, with as much as a 1.0 m step in the upstream face, with exposed till in places. Erosion has not reached or reduced the dike crest width.
- Dyke width is currently adequate.
- Crest and downstream slope in good condition.

East End

- Similar to the central section, the upstream face has been repaired and has cobbles/coarse gravel sized material at the water line. The erosion protection appears effective east of the dogleg considering the high water levels in spring 2018.
- Repairs extend along the dogleg to the east around the polishing pond area.
- On the downstream side near the dogleg, there is a zone where a former ramp has been removed. The remnants of this ramp extend north. Several erosion features are now present on the remnants of this ramp (5 or 6 features, typically 2 to 3 m long, and up to 30 cm wide and 20 cm deep at their maximum extents). These erosion features do not impinge on dam structural material, nor are they likely to, even if they grow significantly. They should be monitored, and may be patched/repaired in the future as a part of housekeeping activities, but do not need to be addressed as a structural concern.
- Ponding in the dogleg area downstream of the dyke showed no visible seepage at two locations where seepage had been previously noted. The water in the pond was clear and showed no visible movement or accumulation of sediments.
- At the far east end of the dyke the natural ground is higher than the pond. Erosion gullies observed in 2015 have been repaired, and have not reappeared.

Polishing Pond Area

- North Dyke downstream slopes and crest in good condition.
- Spillway 1 – from main pond - seepage previously noted under spillway at the downstream end was not visible, should continue to be monitored. Permanent concrete closure wall in spillway. Soil placed in inlet area with vegetation in outlet area. Small pond downstream of weir. Water upstream below spillway level. Concrete in spillway generally in good shape although some minor spalling was visible on the downstream side (not known if spalling was damage at the time of construction or something that developed after construction. It has been unchanged since first registered in inspection notes in 2016).
- Spillway 2 – from polishing pond - syphons were in place. No seepage noted from soils around the spillway discharge side, where slight seepage had been noted in the past. Permanent concrete closure wall in place.
- Slopes in good shape at spillway with no evidence of seepage, outlet was clear.
- Culvert – Water level registered at culvert during inspection was 201.62 m (see photo 17).

1.4 East Dyke

- Dyke in good shape, minor rills on land side.
- More heavily vegetated on both sides and crest along section south of access road. The road is accessible, however vegetation continues to grow back after last clearing, and will eventually need to be cleared based as per requirements of the OMS manual.

2.0 RECOMMENDATIONS

Table 1: Preliminary Dam Safety Recommendations

No.	Recommendation	Priority
2018-1	Remove of vegetation at west end of South Dyke as per OMS manual. The Operations, Maintenance, and Surveillance (OMS) manual for the facility indicates any trees with a trunk diameter greater than 100 mm should be cut within 50 mm of ground surface. If herbicide is used to control vegetation, all trees with a diameter of greater than 20 mm are to be cut off prior to herbicide application.	3
2018-2	Repair two large erosion rills on downstream slope of North Dyke, ~70 m from northwest corner. Fill with granular material.	2
2018-3	Repair upstream face of North Dyke • 700 m of dyke face west of the dogleg • 200 g/m2 non-woven geotextile against exposed silty clay core • Rip rap placed in 2 layers o d_{50} 200 mm o 100% passing 250 mm o 0% passing 150 mm	2

Priority	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; or, a repetitive deficiency that demonstrates a systematic breakdown of procedures.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice is a suggestion for continuous improvement towards industry best practices that could further reduce potential risks. This typically includes ongoing construction items within the appropriate construction cycle.

3.0 CLOSURE

The reader is referred to the Study Limitations, which follow the text and form an integral part of this technical memorandum.

We trust the above meets your present requirements. If you have any questions or would like to discuss, please contact the undersigned.

Golder Associates Ltd.

REGISTERED PROFESSIONAL ENGINEER
B. WEEKS
LICENSEE
23 Oct 18
NT/NU

Ben Wickland, Ph.D., P.Eng.
Associate, Senior Geotechnical Engineer

Bjorn Weeks, Ph.D., P.Eng.
Principal, Senior Geo-Environmental Engineer

BEW/BW/jc/no/cr

Attachments: Study Limitations
Attachment 1: Inspection Photographs
Attachment 2: Dam Inspection Form

https://golderassociates.sharepoint.com/sites/19510g/deliverables/issued/108-tm-rev0-3000-july 2018 inspection tia/1788880-108-tm-rev0-3000-july 2018 inspection tia 23oct_18.docx

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 23 Oct 2018
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

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ATTACHMENT 1

Inspection Photographs

Photograph 1: South Dyke – Downstream Face at East End, Looking Southwest. 23 July 2018

Photograph 2: South Dyke – Upstream Face of Central Portion, Looking West. 23 July 2018

Photograph 3: South Dyke – Crest at West End with Vegetation on Downstream Face, Looking West. 23 July 2018

Photograph 4: West Dyke – Downstream Face Near South End, Looking North. 23 July 2018

Photograph 5: West Dyke – Downstream Toe at South End, Looking North. 23 July 2018

Photograph 6: West Dyke – Downstream Drainage Course near North End, Looking West, Staining Noted Near Seep. 23 July 2018

Photograph 7: West Dyke – Downstream Toe and Slope Near North End, Looking East, Minor Erosion Features. 23 July 2018

Photograph 8: North Dyke – Downstream Slope (left side of photo) Near West End, Looking East. 23 July 2018

Photograph 9: North Dyke – Erosion Feature on Downstream Slope Near West End, Looking South. 23 July 2018

Photograph 10: North Dyke – Erosion Feature on Downstream Slope Near West End, Looking South. 23 July 2018

Photograph 11: North Dyke - Close Up of Erosion Feature on Downstream Slope Near West End, Looking South. 23 July 2018

Photograph 12: North Dyke - Upstream Face, Gravel and Cobbles at Pond Waterline, at Dogleg Looking East. 23 July 2018

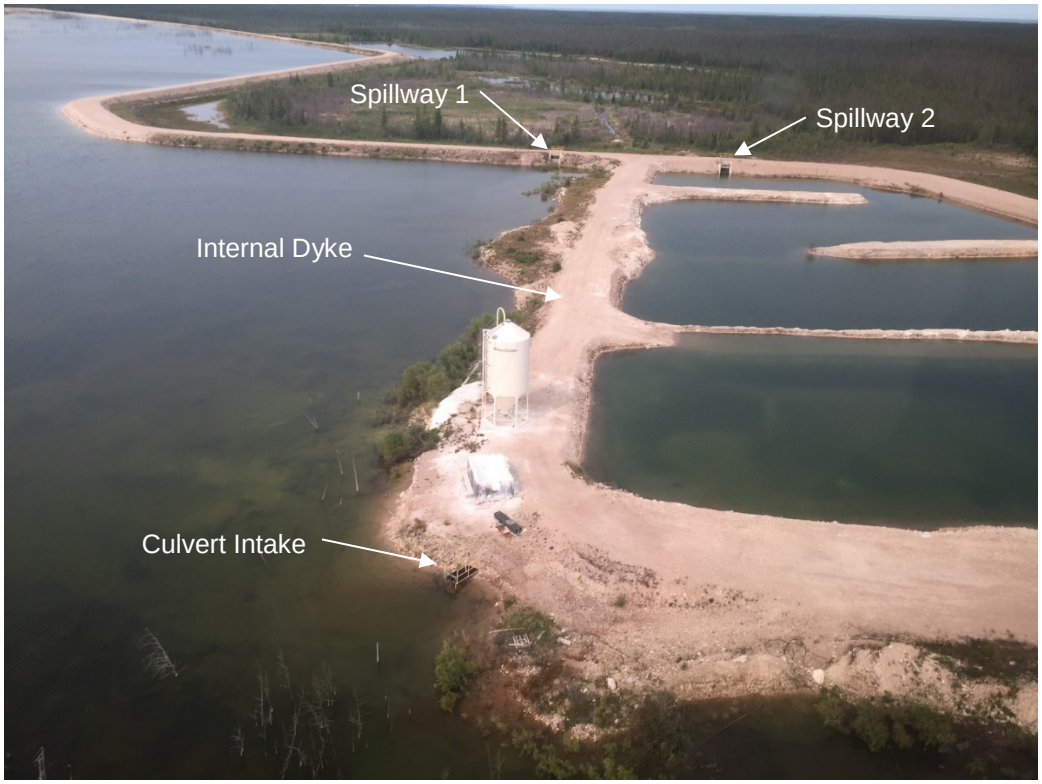
Photograph 13: North Dyke – Repair at Waterline on Upstream Face West of Dogleg, Erosion Approximately 1 m scarp, Looking West. 23 July 2018

Photograph 14: Main Pond Spillway – Upstream Entry (Spillway No. 1), Looking South. 23 July 2018

Photograph 15: Polishing Pond Spillway (Spillway No.2) Outlet, Looking East. 23 July 2018

Photograph 16: North Dyke – Crest at Polishing Pond Spillway (Spillway No.2), Polishing Pond on Right, Looking North. 23 July 2018

Photograph 17: Main Pond Water Level at Culvert Intake to Polishing Pond (201.62 m). 23 July 2018



Photograph 18: Aerial view of Main and Polishing Ponds, Looking West. 23 July 2018

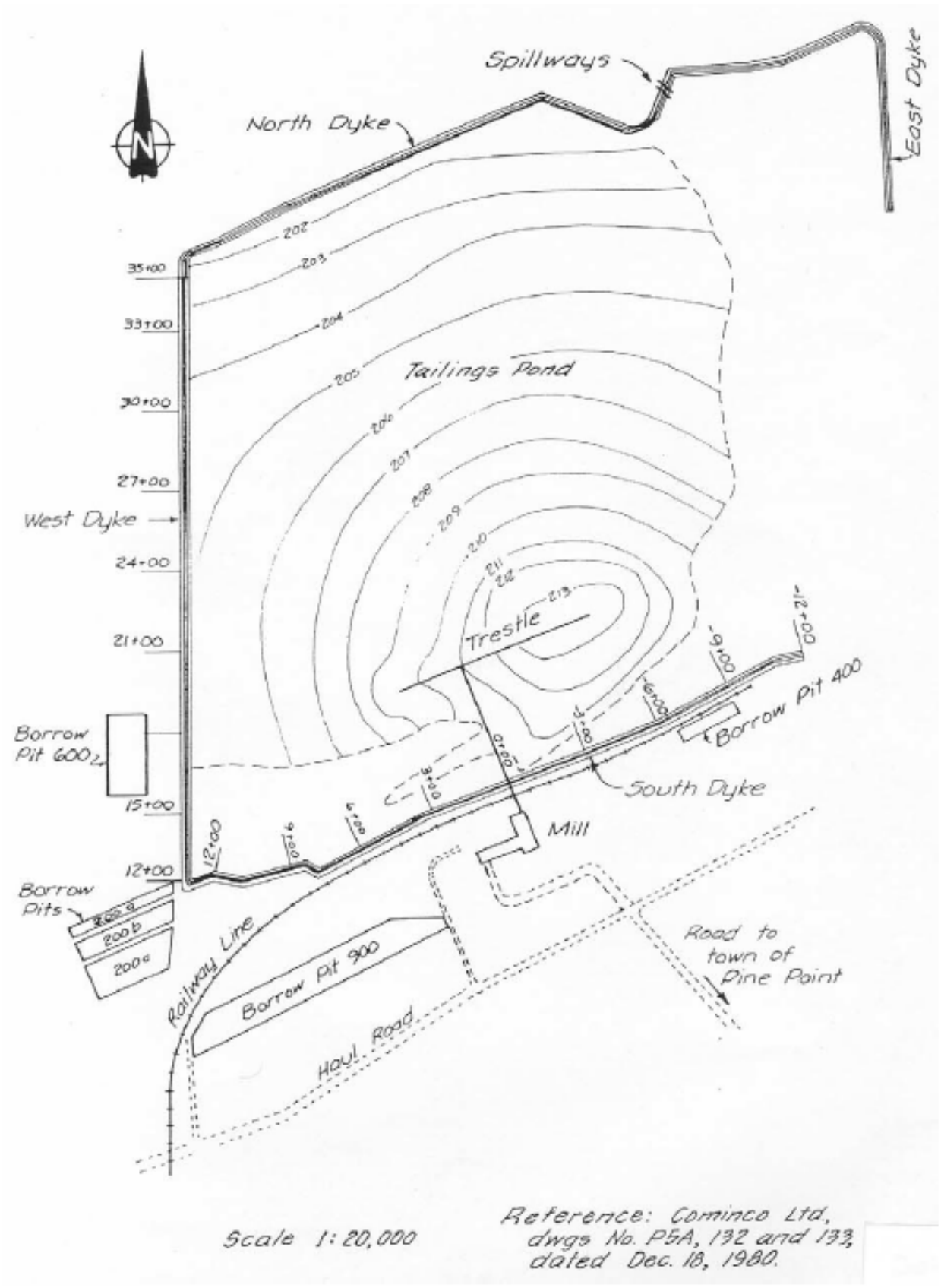
ATTACHMENT 2

Dam Inspection Form

Tailings Impoundment Inspection Form
Pine Point Tailings Impoundment

Date: 23 July 2018		Inspected By: Björn Weeks and Ben Wickland
Weather: Sunny 23°C		
Tailings Pond Information:		
Pond Elevation: 201.62 m		Operating Limits:
Crest Elevation: -note for each area.		Freeboard: 1.5 to 2 m
Dyke Inspection Check List (☑ = checked and no problems; X = not checked)		
Check: Upstream Slope of Dyke, Crest and Downstream Slope of Dyke		
South Dyke	**Checked**	**Comment**
Ponded Water	☑	
Erosion	☑	
Settlement/Depressions	☑	
Cracks/Movement	☑	
Debris		On upstream side.
Vegetation		Vegetation at east end requires clearing
Other -(photos)		
Notes:		Water ponded on outside.
West Dyke		
Ponded Water	☑	Water not at dam.
Erosion	☑	Downstream Slope. Rills are stable.
Settlement/Depressions (on dam crest)	☑	
Sinkholes	☑	
Cracks/Movement	☑	
Debris	☑	Trees/branches on pond side
Vegetation	☑	
Other -(photos)		
Notes:		Seepage at north end.

North Dyke	**Checked**	**Comment**
Ponded Water	☑	
Erosion		Upstream slope– 700 m requires repair and armoring Downstream slope – two large rills at 70 m from west end require repair
Settlement/Depressions	☑	
Sinkholes	☑	
Cracks/Movement	☑	
Debris	☑	
Vegetation	☑	
Main Pond Spillway	☑	
Treatment Spillway	☑	
Other -(photos)		
Notes:		
East Dyke		
Ponded Water		Water near in impoundment at north end.
Erosion	X	
Settlement/Depressions	X	
Sinkholes	X	
Cracks/Movement	X	
Debris	X	
Vegetation		Becoming undrivable.
Other -(photos)		
Notes:		


Spillways
East Dyke
North Dyke
N
202
203
204
205
Tailings Pond
206
207
208
209
210
211
212
213
Trestle
35+00
33+00
30+00
27+00
West Dyke
24+00
21+00
18+00
15+00
12+00
9+00
6+00
3+40
0+00
-2+00
Borrow Pit 600
Borrow Pit 400
South Dyke
Mill
Borrow Pits
200a
200b
200c
Railway Line
Borrow Pit 900
Haul Road
Road to town of Pine Point
Scale 1:20,000
Reference: Cominco Ltd, dwgs No. P5A, 132 and 133, dated Dec. 18, 1980.

Tailings Impoundment Inspection
Explanation of Details

Ponded Water:

Look for pools of water against the inside or outside slopes of the Dyke structure. The pooled water is a potential source of water to erode the dyke and therefore the presence of any water must be recorded. Ideally the GPS location should be noted in the comments area.

Another aspect of pooled water is that it may be a source of seepage water at the outside toe of the dyke therefore where pooled water is observed look for increased seepage at the toe. The presence of water at the dyke face can be an indication of increased water levels within the dyke which can decrease Dyke stability.

Erosion:

The presence of small rills, up to 0.3m deep, on the downstream face of the dyke are normal and of no concern. If the rills start eroding into channels greater than 0.3 m and are cutting into the crest more than 0.5 m then the rills must be filled to prevent further progress.

Erosion can also be caused by wave action on the pooled water. Erosion has been occurring on the inside slope of the North Dyke and will soon require placement of material to armor the dyke face. Erosion into the till core must be prevented therefore any excessive erosion must be reported. Ideally record the GPS location so the area can be found on future inspections.

Settlement/Depressions:

Settlement or depressions in the crest or slopes indicate groundwater erosion of the interior of the dyke. Look for any visible seepage at the toe of the dyke. This is a very serious problem and it must be investigated by a professional.

Ideally record the GPS location so the depression can be easily found.

Sinkholes:

Sinkholes are localized deep depressions and are another indication of interior erosion of the dyke. This is a very serious problem and it must be investigated by a professional.

Ideally record the GPS location so the depression can be easily found.

Cracks/Movement:

Cracks accompanied by movement are an indication of a dyke failure and material would probably be seen flowing from the toe of the dyke. This is a very serious situation which must be reported immediately and be investigated by a professional. Ideally record the GPS location so the area can be easily found.

Debris:

Accumulation of debris on the dyke can prevent inspection of the dyke and should be removed.

Vegetation:

Small vegetation on the slopes of the dykes is good to minimize surface erosion. Larger vegetation hinders inspections of the dyke and can damage the dyke if root systems penetrate the till core or large root systems are ripped out by the wind. Therefore any trees on the dyke slopes over 1" diameter should be removed.

Photos:

A log of photos should be maintained.

Locations of key photos should be noted so future photos are taken from the same spot of area looking at the same feature.

APPENDIX C

Tailings Pond Water Levels

Date	Water Elevation (metres)	Date	Water Elevation (metres)
May 2009	201.45	July 2017	201.03
October 2009	200.20	October 2017	200.39
May 2010	201.49	3 May 2018	201.82
July 2010	200.65	9 May 2018	202.02
October 2010	200.17	11 May 2018	202.04
May 2011	201.31	12 May 2018	202.04
July 2011	201.16	13 May 2018	202.05
October 2011	200.15	14 May 2018	202.05
May 2012	201.21	15 May 2018	202.05
August 2012	201.00	16 May 2018	202.05
October 2012	200.02	17 May 2018	202.03
May 2013	201.22	18 May 2018	202.00
July 2013	201.03	19 May 2018	201.98
October 2013	200.19	20 May 2018	201.95
May 2014	201.20	21 May 2018	201.92
July 2014	201.00	22 May 2018	201.89
October 2014	199.73	23 May 2018	201.87
May 2015	201.00	24 May 2018	201.84
October 2015	200.37	25 May 2018	201.82
May 2016	201.43	26 May 2018	201.79
October 2016	200.39	27 May 2018	201.77
May 2017	201.67	5 July 2018	201.71
28 May 2018	201.74	12 July 2018	201.65
29 May 2019	201.72	19 July 2018	201.65
30 May 2018	201.69	23 July 2018	201.62
31 May 2018	201.68	26 July 2018	201.62
7 June 2018	201.66	3 August 2018	201.60
14 June 2018	201.72	10 August 2018	201.51
28 June 2018	201.71	20 October 2018	200.48
June 2017	201.62		

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