Groundwater Management Plan Framework

for the

Confirmation and Exploration Program

Pine Point District, Northwest Territories

This document is provided in support of the Mackenzie Valley Land and Water Board (MVLWB) Type A Land Use Permit and Type A Water Licence Application for the Pine Point Mining Limited Confirmation and Exploration Program. The intent of this document is to describe how this environmental management and monitoring plan relates to the Project and to list applicable guidelines and standards. It was developed with the available Project information. This document is not intended for approval but is provided for review purposes and will be further developed and refined as the regulatory process proceeds.

Version History

Pine Point Mining Limited is responsible for the distribution, maintenance, and updating of this document. Changes that do not affect the intent of the document will be made as required (e.g., phone numbers, names of individuals). The table below indicates the version of this document, and a summary of revisions made.

Revision #	Section(s) Revised	Description of Revision	Issue Date
0	-	Version for Type A Water Licence and Type A Land Use Permit Applications	25 November 2020

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Abbreviations and Definition

Abbreviation	Definition
MVLWB	Mackenzie Valley Land and Water Board
NWT	Northwest Territories
PPML	Pine Point Mining Limited
Project	Pine Point Project

Units and Definition

Unit	Definition
%	percent
°C	degrees Celsius
km	kilometre
m	metre
m/km	metres per kilometre
m^2/s	square metres per second

1.0 Introduction

1.1 Purpose

Pine Point Mining Limited (PPML) is the sole proponent for the Pine Point Project (Project) and is a wholly owned subsidiary of Osisko Metals Incorporated. The Pine Point District contains approximately 100 known zinc and lead deposits, distributed along three trends, which extend in aggregate along 65 km of strike and 7 km of width. The Project is located on a brownfield site resulting from the historical Pine Point Mine in the Northwest Territories (NWT) within the South Slave Mining District, south of Great Slave Lake, approximately 175 km directly south of Yellowknife, 75 km east of Hay River, and 53 km southwest of Fort Resolution. The closest major transportation hubs are Edmonton, Yellowknife, and Hay River. Access to the Project is presently via all-weather Highways 5 and 6 (Figure 1).

PPML is investigating the historical Pine Point Mine area with the objective of recommencing mining of lead and zinc deposits in the area (the Project). A Confirmation and Exploration Program is proposed at the Pine Point property.

Historical mining in the Pine Point area encountered groundwater during mining of the deposits that flowed into the open pits unless mitigated. The purpose of the planned aquifer testing is to obtain hydrogeological data and parameters that will enable the development of quantitative models of groundwater movement and flow rates for the aquifers to support future groundwater management planning. This is an exploratory data collection program to fill data gaps and further the understanding for future development of the Pine Point Project. This information will be used in the development of the water management plan for the Project.

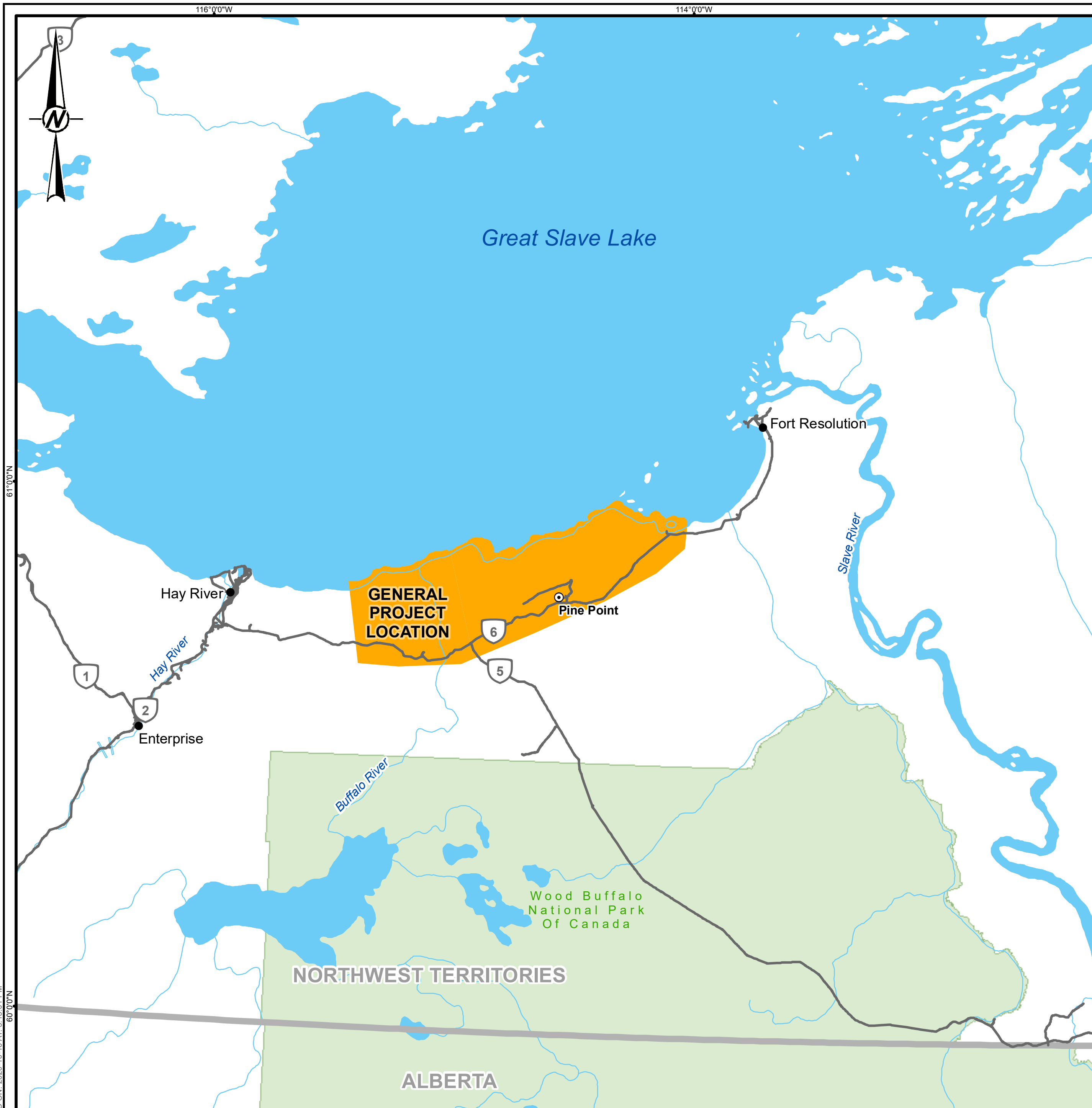
Potential mining resource areas will be characterized and investigated for the purposes of understanding and predicting the efforts needed for groundwater testing. There are two methods proposed to determine the aquifer characteristics depending on where the aquifer testing is located: extraction from an existing pit, and extraction from groundwater well.

This Groundwater Management Plan Framework is provided to the Mackenzie Valley Land and Water Board (MVLWB) in support of the Type A Land Use Permit and Water Licence applications for the Project. The intent of the Groundwater Management Plan Framework is to describe the approach to groundwater monitoring during the aquifer testing while acknowledging that the specific details of the aquifer testing and groundwater monitoring are still being determined. A final version of the groundwater management plan will be submitted to the MVLWB by PPML once these details are determined. Groundwater is not being consumed during the aquifer testing as all groundwater will be returned to the natural environment; however, groundwater monitoring during aquifer testing is recommended to further the understanding of the groundwater system.

1.2 Contacts

Primary Pine Point Mining Limited Contact:

Andrew Williams
Environment Manager
Pine Point Mining Ltd.
1100 Avenue des Canadien-de-Montréal
Bureau 300
Montréal, QC, H3B 2S2
awilliams@osiskometals.com



LEGEND

- FORMER PINE POINT TOWN SITE
- POPULATED PLACE
- ALL-SEASON ROAD
- PARK/PROTECTED AREA
- WATERBODY
- GENERAL PROJECT LOCATION

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1:1,250,000 KILOMETERS

REFERENCE(S)

1. BASE DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. PARKS AND PROTECTED AREAS OBTAINED FROM CONSERVATION AREAS REPORTING AND TRACKING SYSTEM (CARTS), CANADIAN COUNCIL ON ECOLOGICAL AREAS, 2017.

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CLIENT
PINE POINT MINING LTD.

PROJECT
PINE POINT CONFIRMATION AND EXPLORATION PROGRAM

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-16
DESIGNED	DC
PREPARED	BW / MM / JE
REVIEWED	DP
APPROVED	DP

TITLE
PROJECT LOCATION

PROJECT NO.	CONTROL	REV.	FIGURE
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2.0 Background

2.1 Geological and Hydrogeological Setting

Geology

The topography of the regional area around the Pine Point site can be characterized as low relief, poor drainage, swampy muskeg, and shallow ponds. Glacial till makes up the near surface materials, consisting of sand, gravel, and clay, which produce a low-lying terrain that slopes gently towards the north and Great Slave Lake (Giroux 2004).

Sub-arctic winter conditions with a mean average temperature of –32 degrees Celsius (°C) extend from November to late April with relatively light snowfall, with a maximum snowpack of 1 to 1.5 m. The summers are hot and relatively dry with long daylight periods (Giroux 2004).

Giroux (2004) summarizes that the area around the Pine Point site lies within the northwestern part of the interior platform, an area consisting of gently west-dipping sedimentary strata between the Precambrian Shield to the east and the Foothills belt of the Cordilleran orogen to the west. It is the Middle Devonian Givetian barrier reef complex which hosts the mineralization at Pine Point. The barrier reef complex is approximately 10 km wide and 200 m thick, formed by a linear buildup of carbonate facies. The Givetian barrier complex outcrops on the eastern half of the Pine Point property and dips shallowly to the west (1.9 m/km) (Giroux 2004).

The Givetian barrier complex stratigraphy has been subdivided into numerous formations, but it is the Pine Point and Sulphur Point Formations which contain the lead-zinc mineralization. The mineralization is contained within the dolomitized units and within paleo-karstic openings of these formations and follows the trends established by prior karst development. Mineralization occurs within the karst networks as replacement material and generally consists of bodies of galena and sphalerite (Giroux 2004).

Hydrogeology

Regionally, shallow groundwater flows originate at topographic highs (recharge areas) such as the Caribou Mountains located 200 km south of the Pine Point area and are radially distributed in a northerly direction towards natural groundwater discharge areas, primarily to the Hay River valley to the northwest, Great Slave Lake to the north, and the Little Buffalo River and Slave River valleys to the northeast (JDS 2017). The area surrounding Great Slave Lake represents a lowland and is considered a major groundwater discharge area, evident by many springs in the area and high specific conductance in surface water (JDS 2017).

Local groundwater recharge to the bedrock is likely to be variable and largely controlled by the overburden geology. High rates of recharge are expected in areas where sinkholes are present, whereas recharge generally will be limited by the presence of till or lower permeability overburden materials (JDS 2017).

JDS Energy & Mining Inc. (JDS 2017) summarizes the most productive bedrock aquifer, known as the Presquile Aquifer, at the Pine Point site is the highly porous, well-fractured dolomite with paleo-karst cavity networks and described as ranging in thickness from 20 to 65 m. Groundwater within the saturated bedrock is expected to flow along dissolution channels, bedding planes, and fractured zones. The aquifer is confined by overlying clay till overburden and the Watt Mountain Formation low permeability limestones.

JDS (2017) reports the glacial till overburden has a shallow water table at depths between 7 to 30 m in the vicinity of the Pine Point site. The till unit has a relatively low permeability and negligible communication between the upper and lower water bearing zones. As a result, groundwater in the overburden is not expected to significantly influence testing requirements.

The permeability of the bedrock aquifer is very high with transmissivities in the order of 10^{-2} m^2/s (JDS 2017). JDS (2017) reports that lead-zinc deposits to the north may limit aquifer inflows to the open mine pits. Interpretation of the groundwater contours in relation to the topography indicates that the groundwater level is up to 30 m below ground along the northeastward trending ridge in the east-central part of the site. In the northwest portion of the site, the piezometric surface is higher than the ground surface (artesian) resulting in groundwater discharge as springs along the incised Buffalo River channel and other small tributary channels in the area, as well as conditions of leaky artesian flow from the bedrock units.

Limited data on groundwater quality are available; however, it is reported the quality of the near surface perched overburden aquifer is better than that of the bedrock Presquile Aquifer, but is still considered undesirable and is not used as a drinking source. Indigenous Traditional Knowledge holders confirmed the area's ground and surface waters are poor, describing the water as alkaline, sulphurous, and generally not drinkable (MVEIRB 2008). It is expected the bedrock aquifer may contain elevated metals if it is in contact with the lead-zinc deposits.

2.2 Groundwater Monitoring During Aquifer Testing

For PPML to collect the data required to plan for potential future mining, both in respect to operations and environmental considerations, monitoring will need to be completed during the aquifer testing. The primary areas for groundwater monitoring consideration during aquifer testing would be considered as follows:

- drawdown or build-up to the bedrock or overburden aquifers in the surrounding area of extraction and injection
- hydraulic connectivity of the historical open pits to the surrounding aquifers and potential for influences on nearby surface water and groundwater chemistry and levels
- groundwater chemistry of the bedrock aquifer during production and groundwater placement in a pit or the aquifer via injection

These items are discussed further in sections below.

3.0 Approach to Aquifer Testing

There are two aquifer testing methods proposed to determine the aquifer characteristics depending on where the testing is located. Each of these methods is described below in each subsection.

3.1 Method 1: Extraction from an Existing Pit

The first aquifer test method involves extracting pit water from one existing open pit to another existing open pit or to an injection well. Many of the open pits in the Pine Point area have naturally filled with water since the end of mining (groundwater and surface water). These tests will provide:

- the source pit water levels response to water extraction and recovery of the aquifer through groundwater recharge
- the response of water levels in the destination pit and the rate of return to the pit water level present prior to the test
- the response of water levels in the destination injection wells

Water will be pumped directly from one pit either to the other open pits or injection wells using temporary piping.

3.2 Method 2: Extraction from a Groundwater Well

The second aquifer testing method will use wells installed near a mineral deposit to draw down the water table through conventional extraction pumping. The extracted groundwater from tests will either be deposited into a nearby existing open pit or be re-injected into another well located far enough away to not affect the extraction site. The exact locations and number of tests have not yet been determined and will be decided on based on the mine design. Once this has been determined, PPML will submit an updated Groundwater Management Plan for aquifer testing to the MVLWB for approval.

3.2.1 Approach to Method 2: Extraction from a Groundwater Well

Each aquifer test is planned to have an extraction phase and a recovery phase, each of equal duration. Typical test durations for each phase are 48 to 72 hours; however, longer test times may be deemed necessary based on aquifer characteristics. Pumping durations will be determined in advance of the program and modified as required. Drilling and testing will be performed at each Method 2 aquifer test location as follows (modifications to this method may be made based on field conditions and updated testing objectives):

- Extraction wells will require 18-inch boreholes with which a 15- to 16-inch casing installed to a depth of 150 to 200 m. Casing that is 20 inches in diameter will be installed in the overburden section of the borehole. Perforated well casing will be installed at the depth of the aquifer to be tested.
- Injection wells, if required (Section 3.2.2), it will be drilled and installed using the same method as the extraction well and will be installed at least 1 km from the extraction well and sufficiently far enough away to avoid effects on the source aquifer.
- Monitoring wells will be 8- to 10-inch diameter boreholes with a 4-inch monitoring wells installed to similar installation depths as were used for the associated extraction well. Each of the monitoring wells will be installed at different distances from the planned extraction well. The number and location of the monitoring wells will be finalized based on the objective of each well and test.
- All extraction, injection and monitoring wells will be developed following installation to improve the wells connection to the formation.

- The collection of data may be modified based on aquifer testing but it is currently suggested that:
    - the extraction well will be equipped with a back-up and direct read transducer for collection of aquifer testing data
    - the monitoring wells will be equipped with temporary transducers during aquifer testing and set to read at regular intervals
    - the injection well will be equipped with a transducer during aquifer testing and set to read at regular intervals
- Ideally the first part of the aquifer testing will consist of a step rate test in the extraction well using an electric submersible pump to determine an appropriate rate for a constant rate test. Following this, the well will be left to recover to 90% of the static water level or the length of time the step rate test occurred, whichever occurs first. The extraction well will then be pumped at a constant rate for the pumping period (to be determined). Recovery should be monitored for equal duration to pumping, or until the well recovers to 90% of the static water level, whichever occurs first.

3.2.2 Approach to Placement of Extracted Groundwater

For each aquifer test, the placement of the extracted water will vary depending on the extraction well location. For wells located within 2 km of a historical open pit, the extracted groundwater is planned to be piped to the nearest historical open pit via a temporary surface pipeline. For wells located greater than 2 km from a historical open pit, an injection well will be established for the re-injection of the groundwater into the aquifer. The injection well will be located at least 1 km from the extraction well via a temporary surface pipeline.

3.3 Schedule and Location of Aquifer Testing

The schedule and location of aquifer testing is to be determined, and will be provided in a future version of this document.

4.0 Groundwater Management During Aquifer Testing

4.1 Approach to Groundwater Management

Groundwater sampling and monitoring will be conducted throughout the aquifer testing program, and it is important that groundwater management considers the following:

- the extraction location
- the injection location
- water quantity and the water level responses to testing
- water quality

Table 1 summarizes the recommended groundwater monitoring to be completed during aquifer testing. Details on how these groundwater management aspects will be monitored during testing (e.g., testing set-ups including flow meters) will be determined as part of the field planning phase and will be included in the updated Groundwater Management Plan.

Table 1: Preliminary Summary of Groundwater Management during Testing

<table>
<tr><th rowspan="2">Placement of Groundwater</th><th colspan="2">Groundwater Source</th></tr>
<tr><th>Historical Pit (Method 1)</th><th>Extraction Well (Method 2)</th></tr>
<tr><td rowspan="2">Historical pit</td><td>Water Quantity: Responses to testing (water levels) will be monitored in both the extraction pit and the pit receiving the water, as well as within observation wells adjacent to the pits in both the overburden and bedrock to provide the degree of connection of the pit to the surrounding aquifers.

Pumping and deposit rates will be monitored using flow meters both at the extraction and receiving pits and recorded at regular intervals. Water levels in the pits and monitoring wells will be recorded with electronic pressure transducers at regular intervals to evaluate for aquifer responses.</td><td>Water Quantity: Responses to testing (water levels) will be monitored in the extraction wells, monitoring wells, and the receiving pit to establish communication of the pit to the surrounding aquifers.

Pumping rates will be monitored using flow meters both at the extraction well and receiving pit and recorded at regular intervals. Water levels will be recorded with electronic pressure transducers at regular intervals to evaluate for aquifer responses.</td></tr>
<tr><td>Water Quality: Prior to the start of testing, a water sample will be collected from both the extraction pit and receiving pits and will be reviewed at a high level for compatibility.

Water quality samples will also be collected from the overburden and bedrock observation wells around the pits following well development to establish baseline aquifer conditions. If a pressure response to pumping or placement of water in a pit is noted, at a groundwater observation point, it is suggested a test sample be collected and compared to baseline for evaluation of change in chemistry.

Water quality samples will be collected from the extraction pit at regular intervals during testing during pumping and field water quality indicator parameters (pH, temperature, redox potential, and total dissolved solids) will be collected at regular intervals.

A review of nearby surface water sources to the receiving pit will be completed. If a potential hydraulic connection of the pit to the surface water source exists, a pre-test baseline surface water quality sample will be collected as well as an end of test sample for comparison of results and changes to surface water quality to evaluate for influence from the pit.</td><td>Water Quality: Prior to the start of testing, a water sample will be collected from both the pumping well and receiving pit; both will be reviewed at a high level for compatibility.

Samples will be collected from the monitoring wells around the receiving pit following well development. If a pressure response is noted at a monitoring well, it is suggested a post-test sample be collected and compared to baseline for evaluation of change in chemistry.

Water quality samples will be collected from the extraction well at regular intervals during testing and water quality indicator parameters (pH, temperature, redox potential, and total dissolved solids) will be collected at regular intervals.

A review of nearby surface water sources to the receiving pit will be completed. If a potential hydraulic connection of the pit to the surface water source exists, a pre-test baseline surface water quality sample will be collected in the open pit, as well as an end of test sample for comparison of results and changes to surface water quality to evaluate for influence from the pit.</td></tr>
</table>

Table 1: Preliminary Summary of Groundwater Management during Testing

Placement of Groundwater	Groundwater Source	
	Historical Pit (Method 1)	**Extraction Well (Method 2)**
Injection well	**Water Quantity**: Water levels will be monitored in the extraction pit, monitoring wells and receiving well to provide the degree of connection of the extraction pit and injection well to the surrounding aquifers. The injection well will also be monitored for pressure build-up at the well head and the injection rate would be managed accordingly. Extraction and injection rates will be monitored and recorded at regular intervals. Water levels in the extraction pits, injection wells and monitoring wells will be recorded with electronic pressure transducers at regular intervals to evaluate for aquifer responses.	**Water Quantity**: Water levels will be monitored in the extraction well, monitoring wells and receiving well. The injection well will also be monitored for pressure build-up at the well head and the injection rate would be managed accordingly. Overburden observation wells are also recommended to evaluate the connectivity to the deeper injection zone. Pumping rates will be monitored using flow meters both at the extraction well and injection well and recorded at regular intervals. Water levels will be recorded with electronic pressure transducers at regular intervals to evaluate for aquifer responses.
	Water Quality: Prior to the start of testing, a water sample will be collected from both the extraction pits and injection wells and will be reviewed for compatibility. Water quality samples will be collected from the overburden and bedrock observation wells around the injection wells following well development to establish baseline aquifer conditions. If a pressure response to injection of water in a well is noted at a groundwater observation point, it is suggested a post-test sample be collected and compared to baseline for evaluation of changes in chemistry. Water quality samples will be collected from the extraction pit at regular intervals during testing and field water quality indicator parameters (pH, temperature, redox potential, and total dissolved solids) will be collected at regular intervals. A review of nearby surface water sources to the receiving pit will be completed. If a potential hydraulic connection of the pit to the surface water source exists, a pre-test baseline surface water quality sample will be collected as well as an end of test sample for comparison of results and changes to surface water quality to evaluate for influence from the pit.	**Water Quality**: Assuming that the extracted groundwater is planned to be injected into its source aquifer, concerns about compatibility are relatively low. Water quality samples will be collected from the extraction well at regular intervals during testing and field water quality indicator parameters (pH, temperature, redox potential, and total dissolved solids) will be collected at regular intervals. If the injection well is in a different aquifer, additional water quality sampling and compatibility studies would be recommended. This may include a mixing model of chemistry and adverse groundwater quality changes. A baseline sample from the injection well following well development is recommended for later compatibility studies.

NA = not applicable

Initially, a single observation well will be drilled with the purpose of penetrating the carbonates and targeting the underlying Chinchaga Formation, a sequence of evaporite-based stratigraphy. It will ideally be installed in close proximity to the site access road, 2 to 5 km east of where it crosses the Buffalo River. This groundwater has been identified in literature as having higher salinity and may have the potential to negatively influence the quality of water extracted for mining purposes. This observation well will have the groundwater levels monitored during all of the aquifer testing to see if it responds to any of the testing activities and groundwater samples will be collected from the well for laboratory analysis. Depending on results, additional wells may be drilled into the Chinchaga formation.

4.2 Sampling Parameters

Groundwater will be sampled both prior to and during the testing, from both the extraction and receiving sites. Sampling parameters will include pH, temperature, redox potential, and total dissolved solids. If the injection well is in a different aquifer, additional water quality sampling and compatibility studies would be recommended. This may include a mixing model of chemistry and adverse groundwater quality changes. Criteria to determine if groundwater testing can proceed based on the sample parameters will be developed. Further details, including quality assurance procedures, will be provided in a future version of this document.

4.3 Sampling Frequency

Sampling frequency will be provided in a future version of this document. Sampling will be completed within a defined time prior to the groundwater test. Further details will be provided in a future version of this document.

5.0 Closure

The intent of this document is to describe the approach to groundwater monitoring during the groundwater testing while acknowledging that the specific details of the testing and groundwater monitoring are still being determined. PPML welcomes feedback on the outlined approach so that future versions of this document provide the information necessary for approval. If you have any questions, please do not hesitate to contact Andrew Williams, Environment Manager, PPML. This exploratory data collection program is intended to close data gaps and further the understanding of the Pine Point Project.

6.0 REFERENCES

Giroux (Giroux Consultants Ltd.). 2004. Report on The Great Slave Reed Lead-Zinc Deposits Pine Point N.W.T. Produced for: Tamerlane Ventures Inc. Vancouver, Canada.

JDS (JDS Energy & Mining Inc.). 2017. NI 43-101 Preliminary Economic Assessment Technical Report on the Pine Point Zinc Project, Northwest Territories, Canada. Prepared for Darnley Bay Resources Limited. Toronto, Canada. June 1, 2017.

MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2008. Report on Environmental Assessment and Reasons for Decision on Tamerlane Ventures Inc.'s Pine Point Pilot Project EA0607-002. February 22, 2008.