FORT HILLS ENERGY CORPORATION
FORT HILLS OIL SANDS PROJECT

MCCLELLAND LAKE WETLAND COMPLEX OPERATIONAL PLAN OBJECTIVE 4

December 2021

Operated by SUNCOR ENERGY

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McClelland Lake Wetland Complex Operational Plan

Executive Summary / Introduction / Supporting Attachments

Objective 1 – Define Baseline Conditions

Objective 2 – Define Functionality

Objective 3 – Assess Potential Impacts of Mine Development

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5. OBJECTIVE 4: ESTABLISH NECESSARY DESIGN FEATURES AND CONTINGENCY MITIGATION MEASURES

5.1. Introduction

5.1.1. Approach to Development and Execution

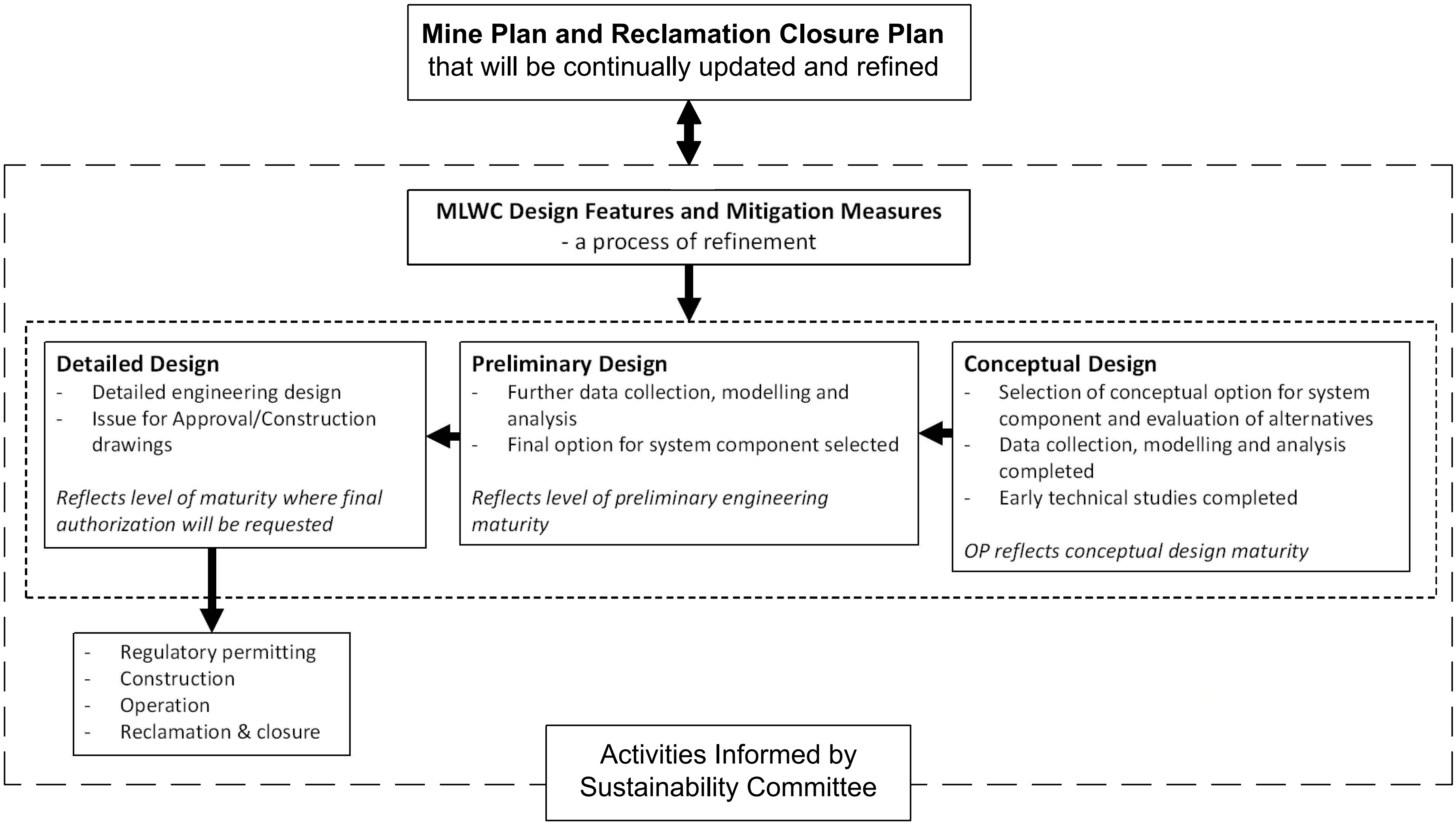
The purpose of the proposed design features and contingency mitigation measures is to maintain ecosystem diversity and function of the non-mined portions of the McClelland Lake Wetland Complex (MLWC), by managing and controlling future changes to the water quantity and quality in the non-mined portion of the MLWC during the operational and reclamation periods, as well as post-closure (i.e., after reclamation is complete and when runoff from the reclaimed areas starts to release to the receiving environment). The design features also consider the operational needs to hydrologically isolate the active mining areas from the non-mined portion of the MLWC.

The proposed MLWC design features include operational water management and closure drainage facilities. The overall framework for the ongoing design and construction of the MLWC design features and contingency mitigation measures is shown in Figure 5.1-1. The Fort Hills Project mine plan, as well as the Life of Mine Closure Plan (LMCP) will be regularly updated and refined as the mine progresses. Concurrently, the MLWC design features and contingency mitigation measures will be updated and refined to integrate with the Fort Hills Project mine, reclamation, and closure plan updates and will incorporate the results of future monitoring data analysis and modelling simulations.

For the MLWC Operational Plan (OP), Fort Hills Energy Corporation (FHEC) has selected a conceptual option for the system components to be constructed throughout the life of the mine. This work has included identification and evaluation of options, design concept selection supported by monitoring data collection, analysis, and modelling simulations. Progression of further design development and execution of the necessary MLWC design features and contingency mitigations measures is dependent on their respective timing for field activities and the results of future monitoring data analysis and modelling simulations. FHEC will initiate further stages of design and execution as follows:

- Preliminary engineering design will be initiated for each system components two to five years prior to commencement of the associated construction activities. Preliminary engineering will include design updates that incorporate monitoring data analysis and modelling simulations, as required.
- Detailed engineering designs will be prepared for each of the system components one to two years prior to commencement of the respective construction activities. Detailed engineering will include design updates, and the final design drawings. The detailed design drawings support regulatory permitting and construction. FHEC will submit detailed engineering designs pursuant to *Water Act* Approval 151636-01-00 (as amended), at least six months prior to the start of associated construction activities for a design feature.

Mitigation of the effects related to social, cultural, and traditional economic values and functions are discussed in Section 5.6 (Access and Security Management) and Section 5.7 (Cultural, Education, and Learning).



CLIENT
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PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

YYYY-MM-DD	2021-12-10
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TITLE
OVERALL FRAMEWORK FOR DEVELOPMENT AND EXECUTION OF McCLELLAND LAKE WETLAND COMPLEX DESIGN FEATURES

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0014	0	5.1-1

5.1.2. Sustainability Committee Input

Local Indigenous community members understand the complex connections and relationships between wetlands and water bodies in the McClelland Lake watershed because they have spent their lifetime living and travelling through the area, and because their parents and grandparents, friends and relations shared knowledge of McClelland Lake and the fen. The Indigenous communities have shared with FHEC their understanding of these connections and the importance of the supply of appropriate water to the non-mined portion of the MLWC to maintain its functionality. The mitigation and engineering plans have been iteratively developed, shared and reviewed by the Sustainability Committee (SC) over the past decade. Some examples of the direct input from the SC and how it has influenced the engineering and mitigations measures are discussed below.

Through a series of meetings, discussions and recommendations, the Indigenous Traditional Knowledge holders and the Technical Advisory Group (TAG) [illegible]

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cultural and habitation, education and learning and hence health and wellbeing of community members. These recommendations are summarized in Sections 5.7 and 5.8.

5.2. Evaluation of Water Resupply to the Fen

5.2.1. Water Resupply Objectives

Traditional land users have guided that the continued supply of the appropriate water is imperative to sustain the non-mined portion of the MLWC. The specific objectives of water resupply to the fen are as follows:

- Make up for the reduced surface water and groundwater inflows to the fen due to future mine development and reclamation.
- Route runoff from reclaimed overburden disposal areas to the fen post closure.
- Provide sufficient quantity and adequate quality of water for resupply to the fen.

The assessment of quantity and quality of water inflows to the fen from the closure landscape and drainage system, as well as the resulting characteristics of the water balances of the fen and McClelland Lake, are described in Section 5.4.2.3.

During the operational and reclamation phases, the water resupply to the fen will need to be provided by the operational water management facilities. The planning and design parameters of these facilities are influenced by the water resupply requirement as well as source water availability and quality, which are addressed in the following two sections.

5.2.2. Operational Water Resupply Requirements

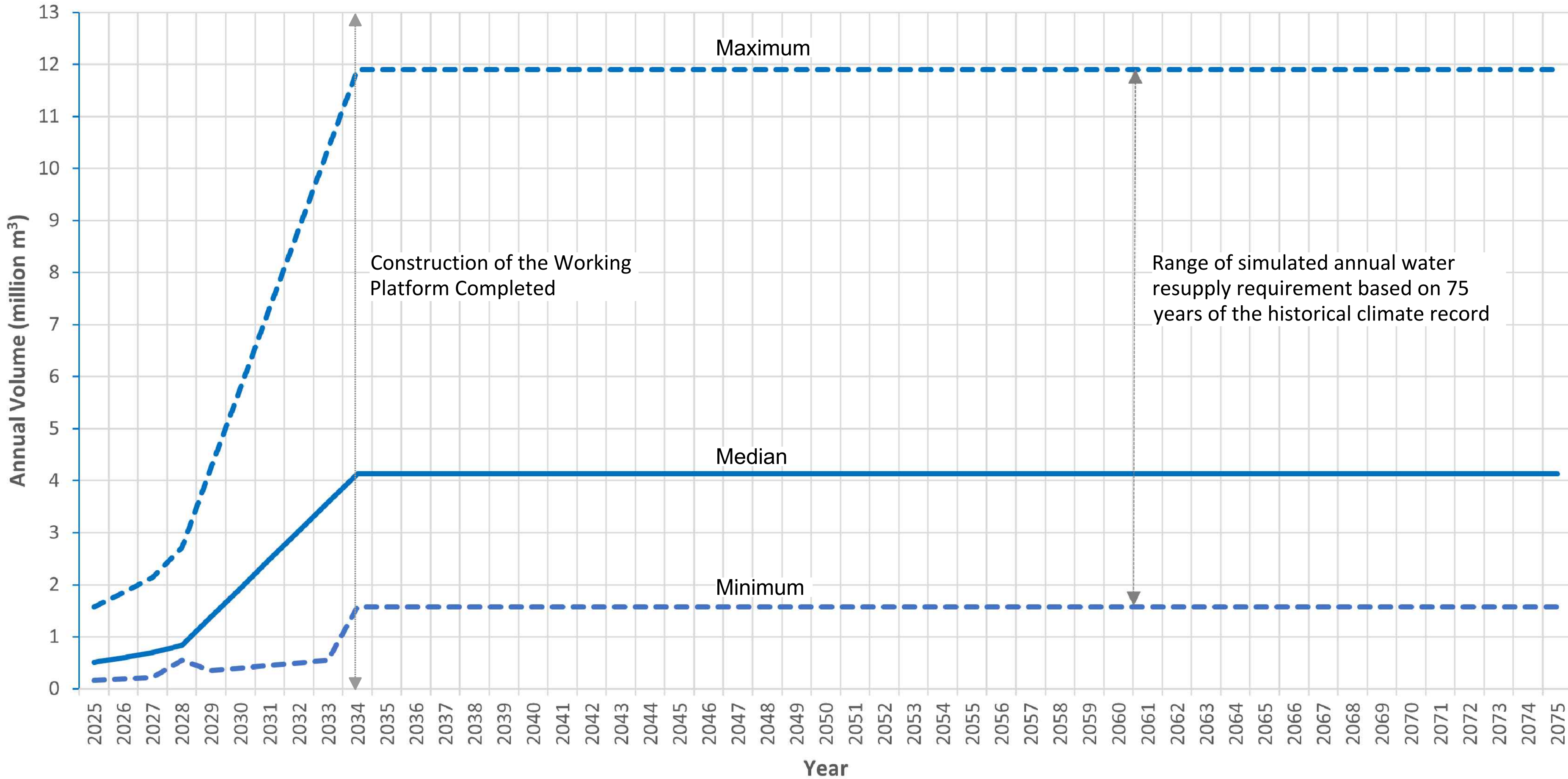
The required quantity of water resupply to the fen and McClelland Lake during the remaining operational phase (i.e., 2022 to 2063) and reclamation phase (i.e., 2064 to 2075) was analyzed using the results of simulated flows using 2020 MLWC HGS model, which are described in Appendix D. This analysis included the following:

- Simulated the inflows and water balances of the fen and McClelland Lake under pre-mining condition (i.e., baseline case).
- Simulated the inflows and water balances of the fen and McClelland Lake due to mine development without any water resupply to the fen (i.e., no mitigation case).
- Compared the simulation results of the baseline and no mitigation cases for determining the water inflow deficits and makeup water requirements to maintain the pre-mining range of hydrologic variability at the fen and McClelland Lake.

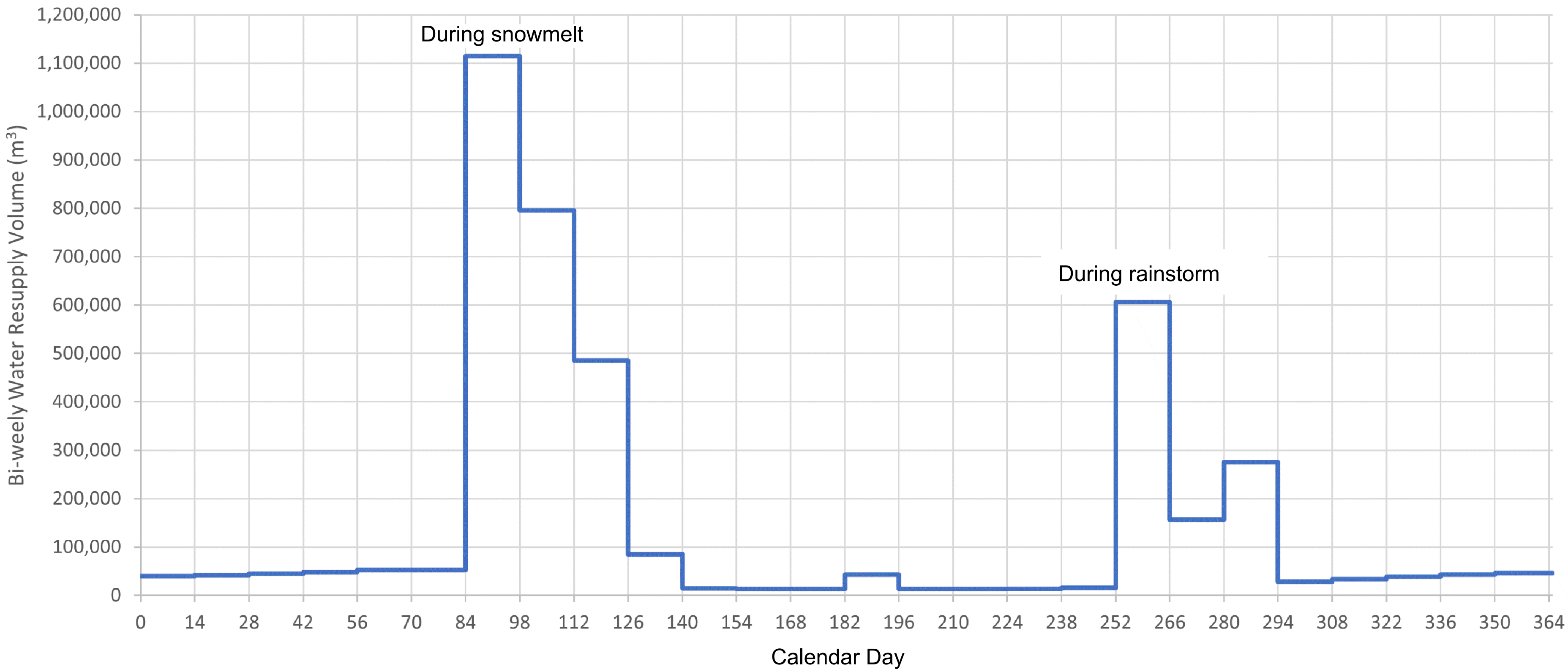
The results of the above-mentioned analysis are illustrated in Figure 5.2-1 and Figure 5.2-2 and summarized below:

- As shown in Figure 5.2-1, the water resupply to the fen and McClelland Lake will be required to start in 2025 as a result of muskeg drainage and overburden activities planned to occur within the McClelland Lake watershed.
- As shown in Figure 5.2-1, the water resupply requirement will gradually increase to the maximum requirement in and after 2034 when the working platform construction will be completed, and when the pre-mining surface water and groundwater inflows upstream of the working platform will be completely cut off.
- As illustrated by the bi-weekly water resupply requirement in Figure 5.2-2, there will be seasonal variation in water volume resupplied to the fen within a calendar year, reflecting the relatively large volume of pre-mining water inflow to the fen during snowmelt period and rainstorm runoff events during summer and fall.
- As illustrated in Figure 5.2-3, the annual water resupply volume to the fen and McClelland Lake will vary, likely within the range of 1.6 to 11.9 million cubic meters (Mm^3) with a median value of 4.2 Mm^3 during the period of maximum water resupply requirement (i.e., from 2034 to 2075).
- The operational water resupply will be needed until 2075 after which the runoff from the reclaimed areas is planned to be released to the fen and McClelland Lake to support the water balances of the fen and McClelland Lake post closure. If the quality of runoff from the reclaimed areas during the reclamation period is assessed to be suitable for release to the fen prior to 2075, the operational water resupply operation may be terminated prior to 2075.

The above-mentioned results provided a basis for supporting the conceptual planning and design of the proposed water resupply facilities. FHEC plans to continue to refine the MLWC HGS model and use the modelling results to confirm the water resupply requirements and to support the detailed design of the water resupply facilities, including selection of the design basis and parameters for sizing the capacities of the facilities.



CLIENT FORT HILLS ENERGY CORPORATION	PROJECT McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN
YYYY-MM-DD 2021-12-10 DESIGNED DL PREPARED RFM REVIEWED ZG APPROVED JH	TITLE **SIMULATED ANNUAL WATER RESUPPLY REQUIREMENT**
FORT HILLS Operated by Suncor Energy	PROJECT NO. 20140450 · CONTROL 400-CL-0020 · REV. 0 · FIGURE 5.2-1



CLIENT		PROJECT
FORT HILLS ENERGY CORPORATION		McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

YYYY-MM-DD	2021-12-10	
DESIGNED	DL	
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REVIEWED	ZG	
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TITLE
BI-WEEKLY WATER RESUPPLY VOLUMES - MEDIAN HYDROLOGIC CONDITION DURING THE PERIOD OF MAXIMUM REQUIREMENT

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0021	0	5.2-2

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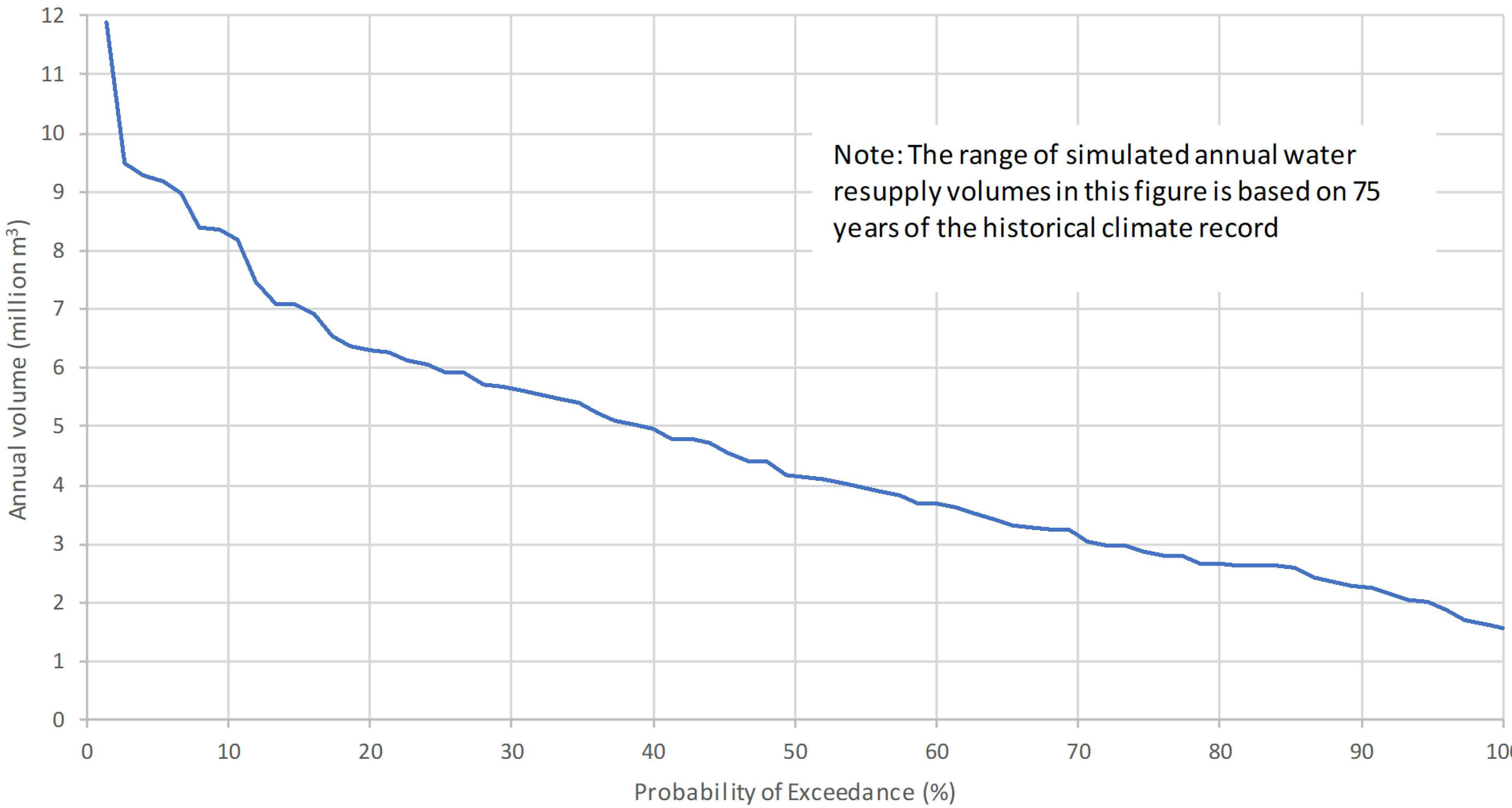

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FORTHILLS
Operated by Suncor Energy

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TITLE
EXCEEDANCE CURVE OF ANNUAL WATER RESUPPLY VOLUMES DURING THE PERIOD OF MAXIMUM REQUIREMENT

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0022	0	5.2-3

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5.2.3. Water Resupply Sources

The alternative water sources potentially available for providing water resupply to the fen were identified as follows:

1. Muskeg drainage and overburden dewatering activities prior to stripping of the overburden materials in preparation for mining.
2. Athabasca River.
3. Quaternary aquifer in the Fort Hills Upland Complex (FHUC).
4. Basal aquifer depressurization.

A summary of the evaluation of these water sources is provided in Table 5.2-1. This evaluation provided a basis for selecting the following reliable water sources for preparation of the conceptual water resupply plan and design (Sections 5.3 and 5.4):

- Water from the muskeg drainage and overburden dewatering activities for the period from 2025 to 2059 after which the dewatering activities would likely cease.
- Athabasca River water for the period from 2060 when dewatering volume is unlikely to be available, to 2075 when reclamation is planned to be completed and water from the reclaimed areas would be released to the environment including the fen.
- Water from the FHUC Quaternary aquifer pumping wells as a supplemental water source for the period from 2042 to 2075.

The remaining water sources listed above were not selected for preparation of the conceptual plan as explained below:

- It is unlikely that the FHUC Quaternary aquifer will be able to meet fen water resupply requirement in the later operational period, so using this source alone is not considered reliable. The FHUC Quaternary aquifer water can also be used during the initial operational period, but such opportunity will be further evaluated during the detailed system design.
- The Basal aquifer water is likely to be less reliable as a main water supply source than the muskeg drainage and overburden dewatering and Athabasca River water because the depressurized Basal water volume is unlikely to meet all the resupply requirement. In addition, the Basal aquifer water will likely require the most treatment before it can be used for water resupply to the fen, although there are pockets of Basal aquifer water within the development area with relatively low total dissolved solid (TDS) concentration and less treatment requirement.

FHEC plans to continue its evaluation of the above-mentioned water resupply sources, including confirmation of any water treatment requirements, as well as potential use of FHUC Quaternary aquifer water particularly during the initial water resupply period. The water source selection, particularly for later years, will be made during the water resupply system design and be based on additional data collection, modelling and analysis, for optimizing the plan and design.

Table 5.2-1: Evaluation of Alternative Sources for Water Resupply to the Fen

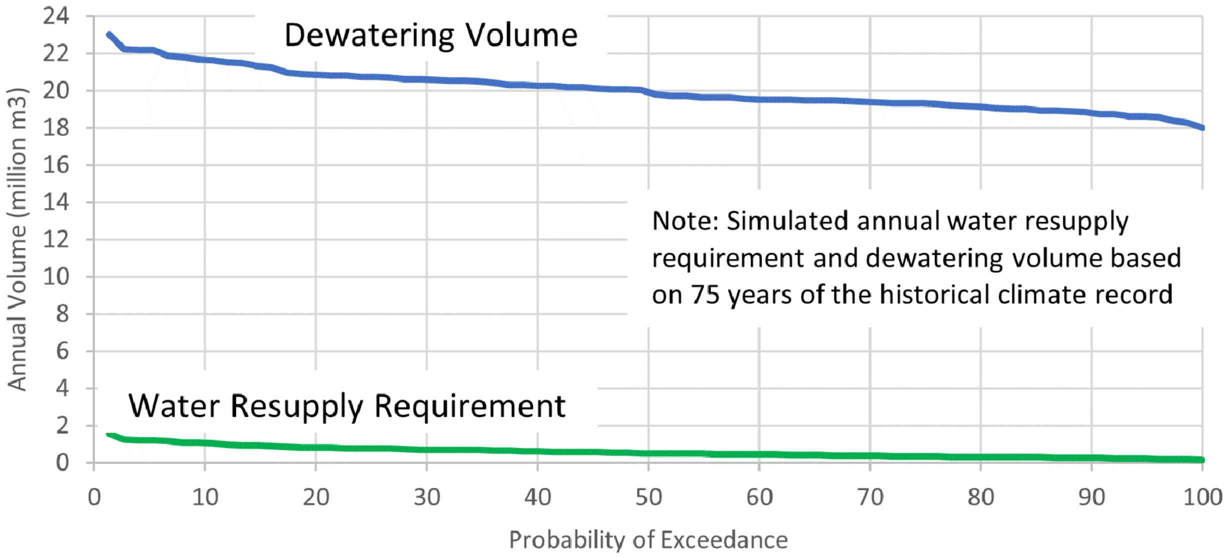
Water Source	Water Availability	Water Quality	Infrastructure Requirements
Muskeg drainage and overburden dewatering	• 2020 MLWC HGS modelling of the dewatering activities shows that the dewatering volumes will be much higher than the water resupply requirement during the period 2025 to 2059, as illustrated in Figure 5.2-4. • A reliable source for water resupply to the fen for the period 2025 to 2059.	• Sediment from the dewatering flow will need to be settled and removed before entering the fen. • Other water quality parameters are estimated to meet the discharge requirement before entering the fen, but this will be confirmed by additional data collection and investigation.	• Most of the dewatering activities and infrastructure including sedimentation ponds, will be located within the McClelland Lake watershed. • Minimum additional infrastructure requirement to use the dewatering water as water resupply to the fen.
Athabasca River	• The latest mine-site water balance analysis shows that the existing Athabasca River water licence would be sufficient to meet the makeup water requirement for processing and to support water resupply to the fen for the period 2060 to 2075. During this period, the maximum annual river water requirement would be less than 25 Mm^3 for processing use or can be controlled to be below that amount for pit lake filling if required at all. Therefore, more than 15 Mm^3 annual volume of river water allowed under the licence could be used for fen water resupply. This allowable limit would be higher than the maximum annual fen water resupply requirement of less than 12 Mm^3 (Figure 5.2-1). The water balance analysis has accounted for full compliance with the provincial Surface Water Quantity Management Framework (SWQMF) for managing the water withdrawal from the Athabasca River, including provision of sufficient on-site water storage for addressing potential river water withdrawal restriction due to implementation of the SWQMF. • A reliable source for water resupply to the fen for the period 2060 to 2075.	• Treatment requirements for the Athabasca River water are to be evaluated. • For example, sodium and chloride levels in the river water may be higher than the water quality requirements of the fen.	• A water treatment plant may be required. • Pump station(s) and a water supply pipeline would be required from the raw water pond near the plant site to the water treatment plant if required and the water storage pond near the fen.

Table 5.2-1: Evaluation of Alternative Sources for Water Resupply to the Fen

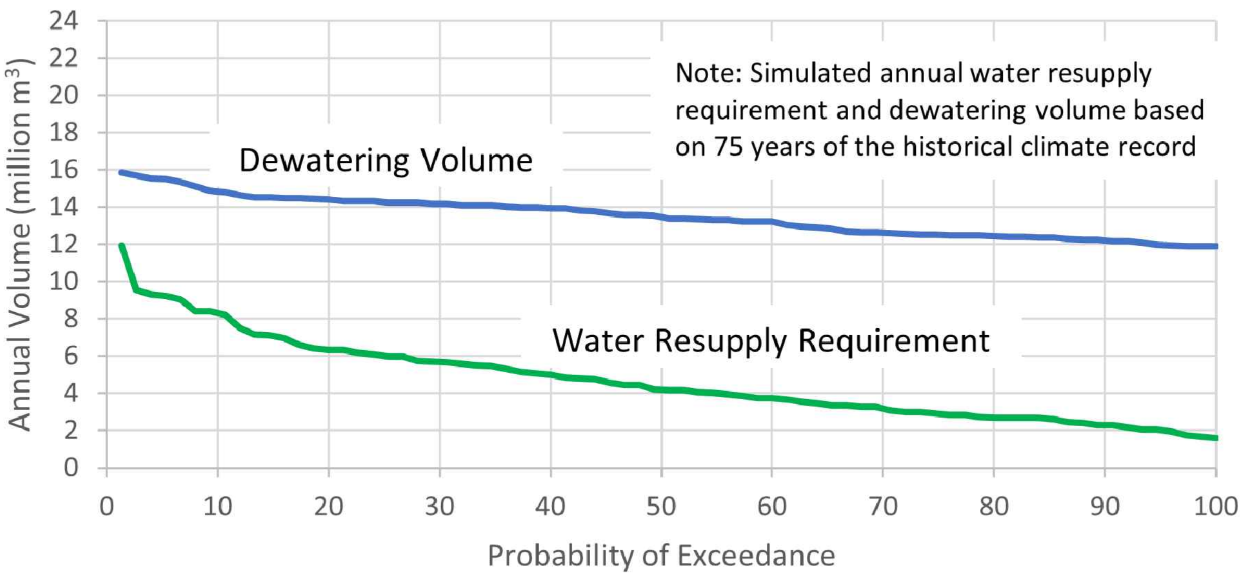
Water Source	Water Availability	Water Quality	Infrastructure Requirements
FHUC Quaternary aquifer	• Extracting the natural FHUC Quaternary aquifer storage for water resupply to the fen would be feasible during the initial operational period when the water supply requirement would be relatively low. • The FHUC Quaternary aquifer water would unlikely be a reliable, main water supply source during the later operational period when the fen water resupply requirement would be relatively large, but it could be used as a supplemental source.	• This water source is expected to meet the quality requirement for water resupply to the fen based on the available data. • It has the best quality among the four water sources.	• Close proximity to the fen. • Pumping wells and pipeline would be required.
Basal aquifer depressurization	• The annual Basal aquifer depressurization volume is estimated to be in a range of 0.7 to 2.9 Mm^3 throughout the Fort Hills mine life. This range is less than the range of annual fen water resupply requirement of up to 12 Mm^3 (Figure 5.2-1). • The Basal aquifer water would be an unreliable, main water supply source but could be used as a supplemental source.	• Treatment requirements for the Basal aquifer water need to be evaluated. • For example, the Basal water has higher sodium, potassium, fluoride, bicarbonate, alkalinity, and TDS concentrations than the fen water.	• A water treatment plant is likely required. • Additional booster pump station(s) and pipeline would be required to transport the Basal water to the water treatment plant and water storage pond near the fen.

FHUC = Fort Hills Upland Complex; Mm^3 = million cubic meters.

(a) 2025 - Low Water Resupply Requirement and High Dewatering Volume



(b) 2059 - High Water Resupply Requirement and Low Dewatering Volume



CLIENT FORT HILLS ENERGY CORPORATION	PROJECT McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

FORT HILLS
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TITLE
COMPARISON OF EXCEEDANCE CURVES OF ANNUAL DEWATERING AND WATER RESUPPLY VOLUMES

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0023	0	5.2-4

5.3. McClelland Lake Wetland Complex Water Management System Layout Plans

5.3.1. Introduction

The MLWC water management system will consist of various components that will be installed and operated during the operation and reclamation, and post closure phases. The system components included in the OP are summarized in Table 5.3-1 (for surface water management) and Table 5.3-2 (for groundwater management and control), as well as their general locations are shown in Figure 5.3-1.

The spatial layouts of the various system components and the operational sequencing are described in the following two sections (i.e., Sections 5.3.2 and 5.3.3). Identification and evaluation of alternative design concepts for each system component, as well as a detailed description of the selected design features shown in the system layout plans, are presented in Section 5.4.

Table 5.3-1: A Summary of Surface Water Management System Components

Phase	Purpose	System Component
Operation – Stage One (2025 to 2028)	Resupply surface water to the fen	• Sedimentation ponds with inflows routed by pumping from the muskeg drainage and overburden dewatering areas, as well as outflows routed by gravity and conveyed in natural drainage to the fen
Operation – Stage Two (2029 to 2033)		• Sedimentation ponds with inflows routed by pumping from the muskeg drainage and overburden dewatering areas, as well as outflows routed by gravity and conveyed in natural drainage to the areas upstream of the working platform • A water pumping system over the construction area of a working platform and a water distribution system for discharging to the fen
Operation – Stage Three (2034 to 2059)		• Sedimentation ponds with inflows routed by pumping from the muskeg drainage and overburden dewatering areas and outflows routed by pumping to a water storage pond which will allow for variable rates of water resupply • An overflow ditch with a water supply pipeline from the water storage pond and water discharging to the fen
Operation – Stage Four (2060 to 2063) & Reclamation (2064 to 2075)		• A river water supply pipeline from the raw water pond at the plant site to, a water treatment plant if required and then to, the water storage pond • An overflow ditch with a water supply pipeline from the water storage pond and water discharging to the fen
Post Closure (2076 to Far Future)	Route and sustain surface water inflows to the fen	• A network of closure drainage channels conveying runoff from the reclaimed areas to the fen

Table 5.3-2: A Summary of Groundwater Management and Control System Components

Phase	Purpose	System Component
Operation – Stage One (2028 to 2037)	Redirect and resupply groundwater to the North Outwash Plain Quaternary aquifer beneath the fen to maintain groundwater recharge to the fen and maintain pressures to prevent peat consolidation	• Vertical injection wells in the North Outwash Plain area which will be decommissioned after a low permeability cutoff wall is constructed and commences its operation • A working platform to be constructed during the period 2029 to 2033 to facilitate construction of the cutoff wall and overflow ditch
Operation – Stage Two (2037 to 2063) & Reclamation (2064 to 2075)	Control Quaternary groundwater from the fen and Fort Hills Upland Complex from reporting to the pit	• Pumping wells in the Fort Hills Upland Complex beyond the pit crest • The cutoff wall across the fen and between the North External Dump and the fen
Post Closure (2076 to Far Future)	Control and sustain Quaternary aquifer groundwater beneath the fen	• The cutoff wall between North External Dump and the fen to remain in-place after the working platform and a top layer of the cutoff wall across the fen are removed for closure

5.3.2. Operational Water Management System

The system layout plans for surface water and groundwater management during the operation and reclamation periods, are presented in Figure 5.3-2 to Figure 5.3-8. These plans are presented for select time snapshots to show the major changes of the system layout over time, as summarized below:

- 2025 (Figure 5.3-2): Commencement of operation of an early system for surface water resupply to the fen, which will involve pumping water from the muskeg drainage and overburden dewatering area to sedimentation pond(s) located within the McClelland Lake watershed, with gravity outflow ultimately routed by the natural drainage system to the fen.
- 2028 (Figure 5.3-3): Commencement of operation of injection wells in the NOP which will be decommissioned in 2037 after installation of a low permeability cutoff wall is completed.
- 2029 (Figure 5.3-4): Commencement of working platform construction as well as operation of a surface water pumping system over the construction area and a distribution system for water resupply to the fen.
- 2034 (Figure 5.3-5): Commencement of operation of a long-term system for surface water resupply to the fen, including a water storage pond and an overflow ditch, post installation of the working platform.
- 2037 (Figure 5.3-6): Commencement of operation of the completed low permeability cutoff wall. This operation will continue during the phase of Operation – Stage Two (2037 to 2063) & Reclamation (2064 to 2075) listed in Table 5.3-2.
- 2042 (Figure 5.3-7): Commencement of operation of FHUC pumping wells which outflows will be pumped to the water storage pond. This operation will continue in the phase of Operation – Stage Two (2037 to 2063) & Reclamation (2064 to 2075) listed in Table 5.3-2.

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- 2060 (Figure 5.3-8): Commencement of operation of a river water supply pipeline from the raw water pond near the plant site to (if required, a water treatment facility with outflow to) the water storage pond. The river water source will replace the muskeg drainage and overburden dewatering water source that will be used for water resupply to the fen during the period 2025 to 2059. The river water source will be used for the period 2060 to 2075 when runoff from the reclaimed areas will discharge to the fen. The water management system layout plan illustrated in this figure is applicable for the phase of Operation – Stage Four (2060 to 2063) & Reclamation (2064 to 2075) listed in Table 5.3-1.

The above-mentioned figures do not include all the site-wide water management system details (e.g., muskeg drainage ditches; overburden dewatering ditches, sumps and pipelines; FHUC runoff interception ditch; and industrial wastewater sumps and pipelines), because these figures focus on highlighting the main design features of the MLWC water management system, and the main linkages to the other water management activities on the Fort Hills Project site.

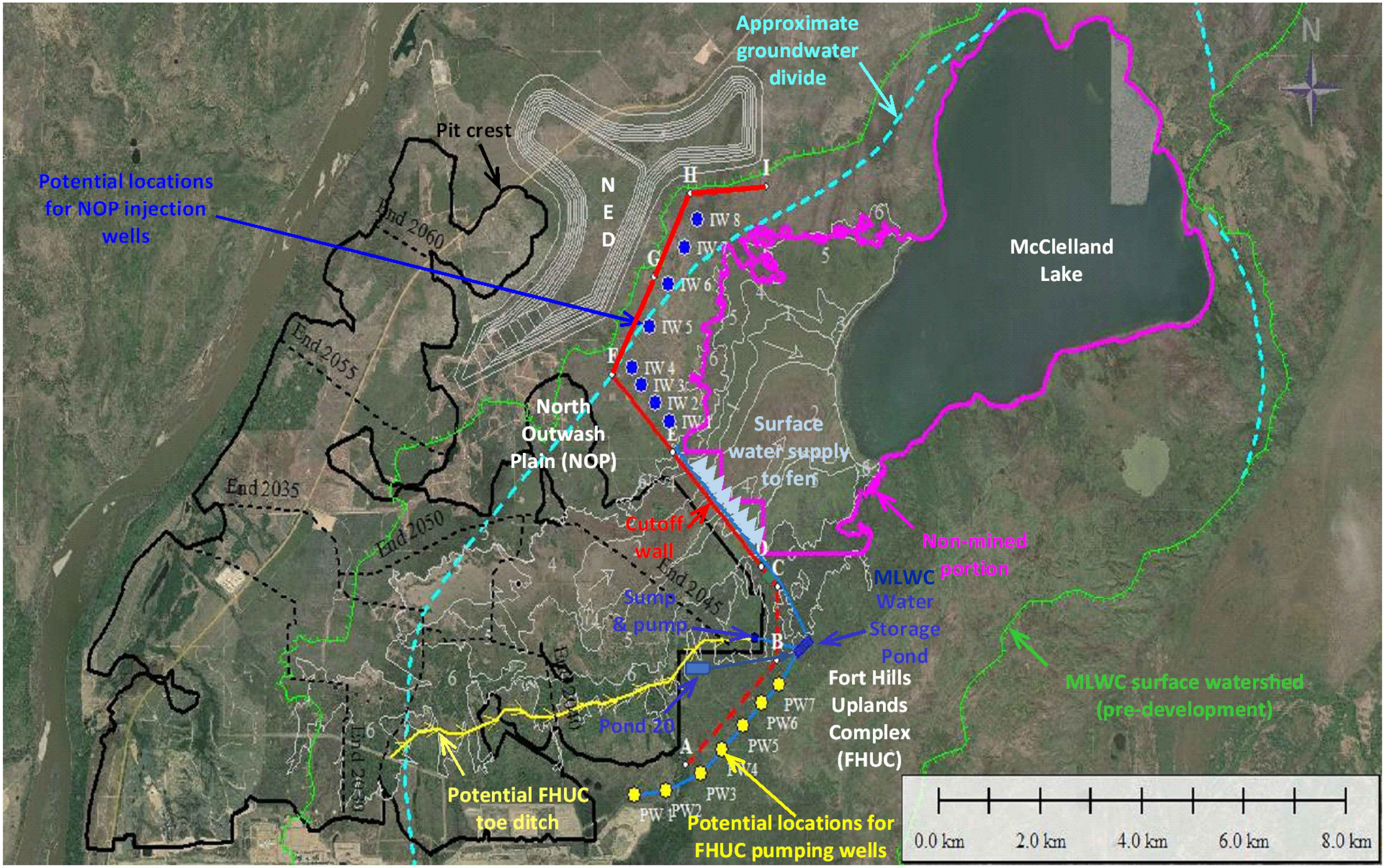
5.3.3. Closure Landscape Plan and Drainage System

The conceptual closure landscape and drainage layout plan for the McClelland Lake watershed area is shown in Figure 5.3-9 (with contour lines) and Figure 5.3-10 (without contour lines). The proposed closure drainage system within the McClelland Lake watershed, is summarized below:

- The eastern and northeastern parts of the North Pit are planned to be backfilled with overburden materials with a top layer of select overburden sands for restoring the pre-mining Quaternary aquifer in the pit area. Runoff from the reclaimed overburden backfill area in the eastern portion of the North Pit will drain to the constructed fen, which will discharge to the non-mined portion of the natural fen and ultimately to McClelland Lake.
- Runoff from most of the reclaimed NED area will be routed southward to a mineral wetland in the reclaimed overburden backfill area of the North Pit, which will outflow eastward towards the constructed fen just upstream of the non-mined portion of the natural fen.
- The natural drainage of the undisturbed upland area south of the North Pit will be integrated with the closure drainage in the North Pit to enable the natural runoff to be routed to the constructed fen.

The northwest extension of the cutoff wall is expected to remain in place in perpetuity to prevent groundwater losses from this region of the non-mined portion of the MLWC fen to the surrounding landscape. The remainder of the cutoff wall can be removed as soon as the reclaimed landscape is ready to be hydraulically reconnected to the surrounding landscape, or kept in place after the working platform and a top layer of the cutoff wall across the fen are removed for closure. The total catchment area at the McClelland Lake outlet post closure of Fort Hills Project will be approximately 183 square kilometres (km^2), which is approximately 9% less than the pre-mining catchment area of approximately 203 km^2. The change results from the western part of the pre-mining McClelland Lake watershed being configured and reclaimed with drainage toward the Center Pit Lake and then the North Pit Lake discharging to the Athabasca River at closure.

The proposed closure drainage system is intended to conceptually align with the LMCP included as part of the IPA Application (FHEC 2021). Through the LMCP, the Fort Hills Project will continue to manage catchment areas across the site to support long-term closure outcomes.



NOTES:

1. Ecohydrology Zones 1 to 6 are from Vitt and House (2020).
2. The red line (Point A to Point I) shows the potential maximum length and alignment of the cutoff wall.
3. The current concept is to build the initial cutoff wall from Point D to Point I (solid red line). The wall may need to extend further into the FHUC (dashed red line).
4. The numbers and locations of FHUC pumping wells (PW1 to PW7) and NOP injection wells (IW1 to IW8) are preliminary.
5. The conceptual plan and design information shown in this figure was based on the relevant information prepared by Wood and Suncor.

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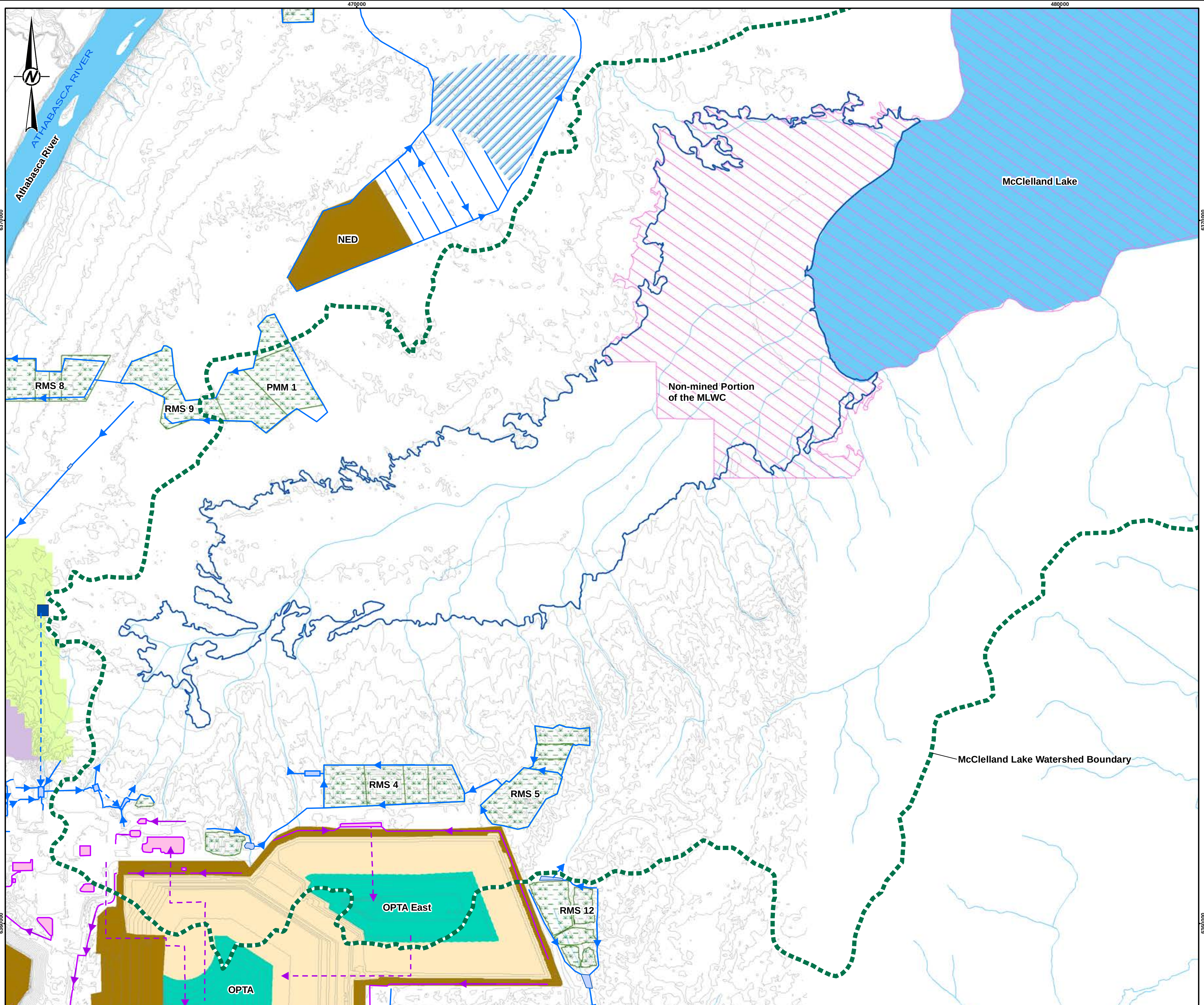
APPROVED	JH

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
McCLELLAND LAKE WETLAND COMPLEX WATER MANAGEMENT SYSTEM - COMPOSITE LAYOUT PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0003	0	5.3-1



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- INDUSTRIAL WASTEWATER
- READY FOR RECLAMATION
- RECLAMATION STOCKPILE
- INDUSTRIAL RUNOFF SUMP
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- INDUSTRIAL WASTEWATER PIPELINE
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- NATURAL STREAM
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- NATURAL WATERBODY
- NON-MINED PORTION OF THE MLWC
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
2. NED = NORTH EXTERNAL DUMP
3. OPTA = OUT-OF-PIT TAILINGS AREA
4. PMM = PEAT MINERAL MIX
5. RMS = RECLAMATION MATERIAL STOCKPILE
6. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
7. SUMP IS AN EXCAVATED POND FOR COLLECTING AND STORING RUNOFF.

CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2025

FORT HILLS
Operated by Suncor Energy

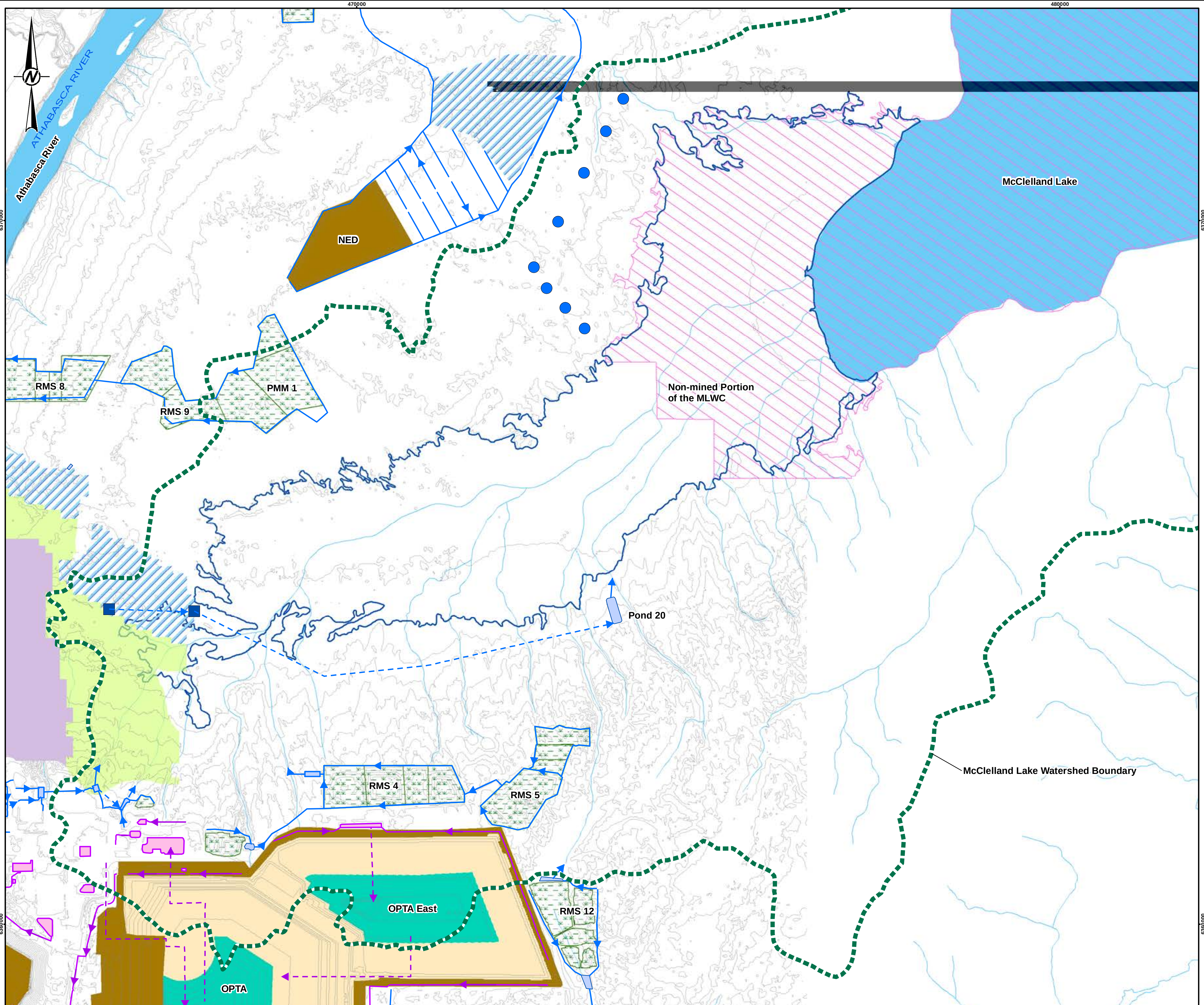
YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-2

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: I:\CLIENTS\SUNCOR\20140450\Mapping\Products\Hydrology\McLellandLakeWetlandComplex_WMP\20140450_Fig5_3_2_SurfaceWater_2025_Rev0.mxd PRINTED ON: 2021-12-10 AT: 2:40:41 PM



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- INDUSTRIAL WASTEWATER
- READY FOR RECLAMATION
- RECLAMATION STOCKPILE
- INDUSTRIAL RUNOFF SUMP
- POTENTIAL LOCATION FOR NOP INJECTION WELL
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- INDUSTRIAL WASTEWATER PIPELINE
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- NATURAL STREAM
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- NATURAL WATERBODY
- NON-MINED PORTION OF THE MLWC
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
2. NED = NORTH EXTERNAL DUMP
3. OPTA = OUT-OF-PIT TAILINGS AREA
4. PMM = PEAT MINERAL MIX
5. RMS = RECLAMATION MATERIAL STOCKPILE
6. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
7. SUMP IS AN EXCAVATED POND FOR COLLECTING AND STORING RUNOFF.
8. NOP = NORTH OUTWASH PLAIN

CLIENT
FORT HILLS ENERGY CORPORATION

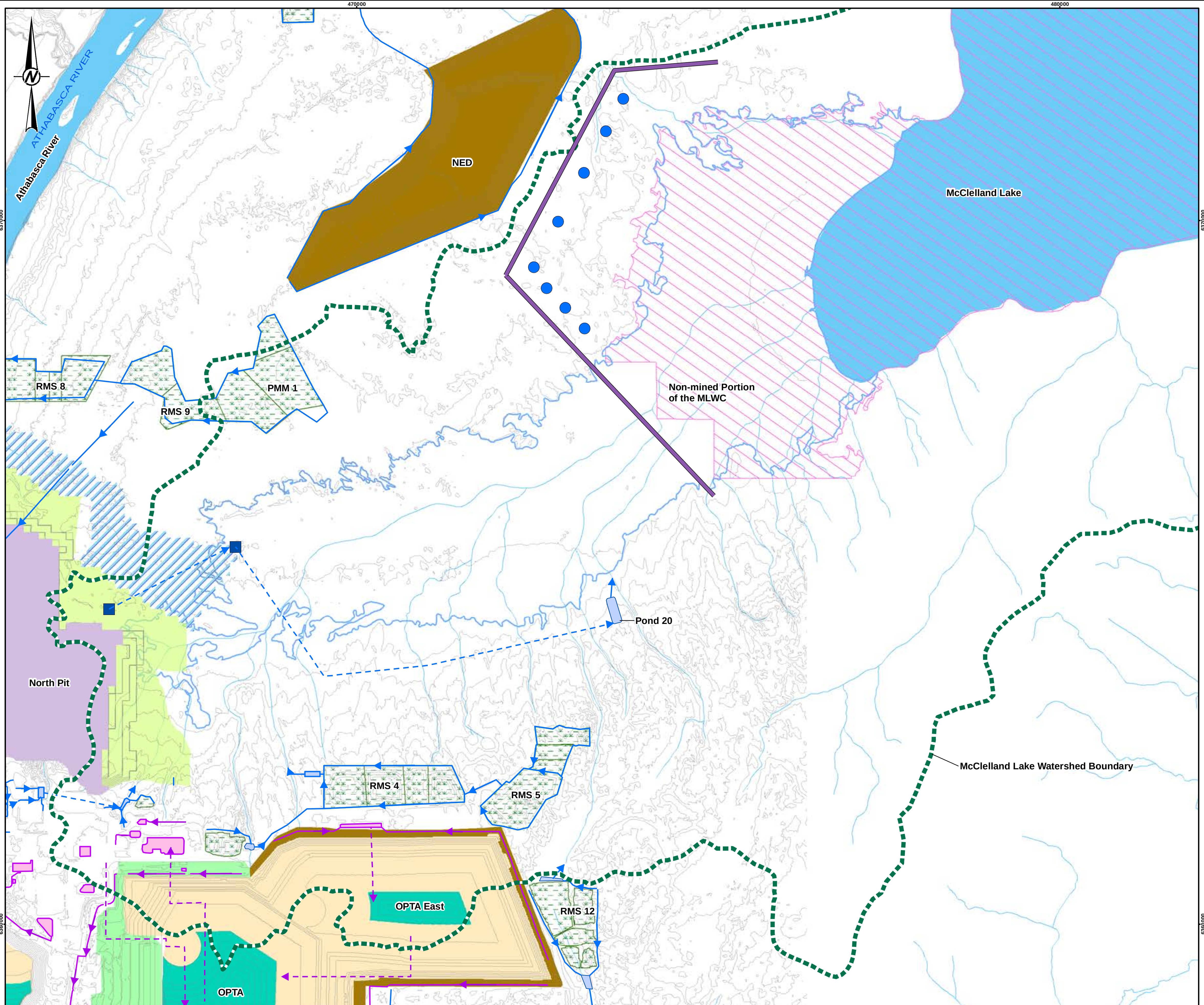
PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2028

FORTHILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-3



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- INDUSTRIAL WASTEWATER
- READY FOR RECLAMATION
- RECLAMATION STOCKPILE
- INDUSTRIAL RUNOFF SUMP
- POTENTIAL LOCATION FOR NOP INJECTION WELL
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- INDUSTRIAL WASTEWATER PIPELINE
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- NATURAL STREAM
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- WORKING PLATFORM
- NATURAL WATERBODY
- NON-MINED PORTION OF THE MLWC
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
2. NED = NORTH EXTERNAL DUMP
3. OPTA = OUT-OF-PIT TAILINGS AREA
4. PMM = PEAT MINERAL MIX
5. RMS = RECLAMATION MATERIAL STOCKPILE
6. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
7. SUMP IS AN EXCAVATED POND FOR COLLECTING AND STORING RUNOFF.
8. DETAILS OF THE WATER PUMPING SYSTEM OVER THE CONSTRUCTION AREA OF A WORKING PLATFORM AND THE WATER DISTRIBUTION SYSTEM FOR DISCHARGING TO THE FEN, NOT SHOWN IN THIS FIGURE, ARE YET TO BE DEVELOPED.
9. NOP = NORTH OUTWASH PLAIN

CLIENT

FORT HILLS ENERGY CORPORATION

PROJECT

McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE

MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2029

FORTHILLS

Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-4

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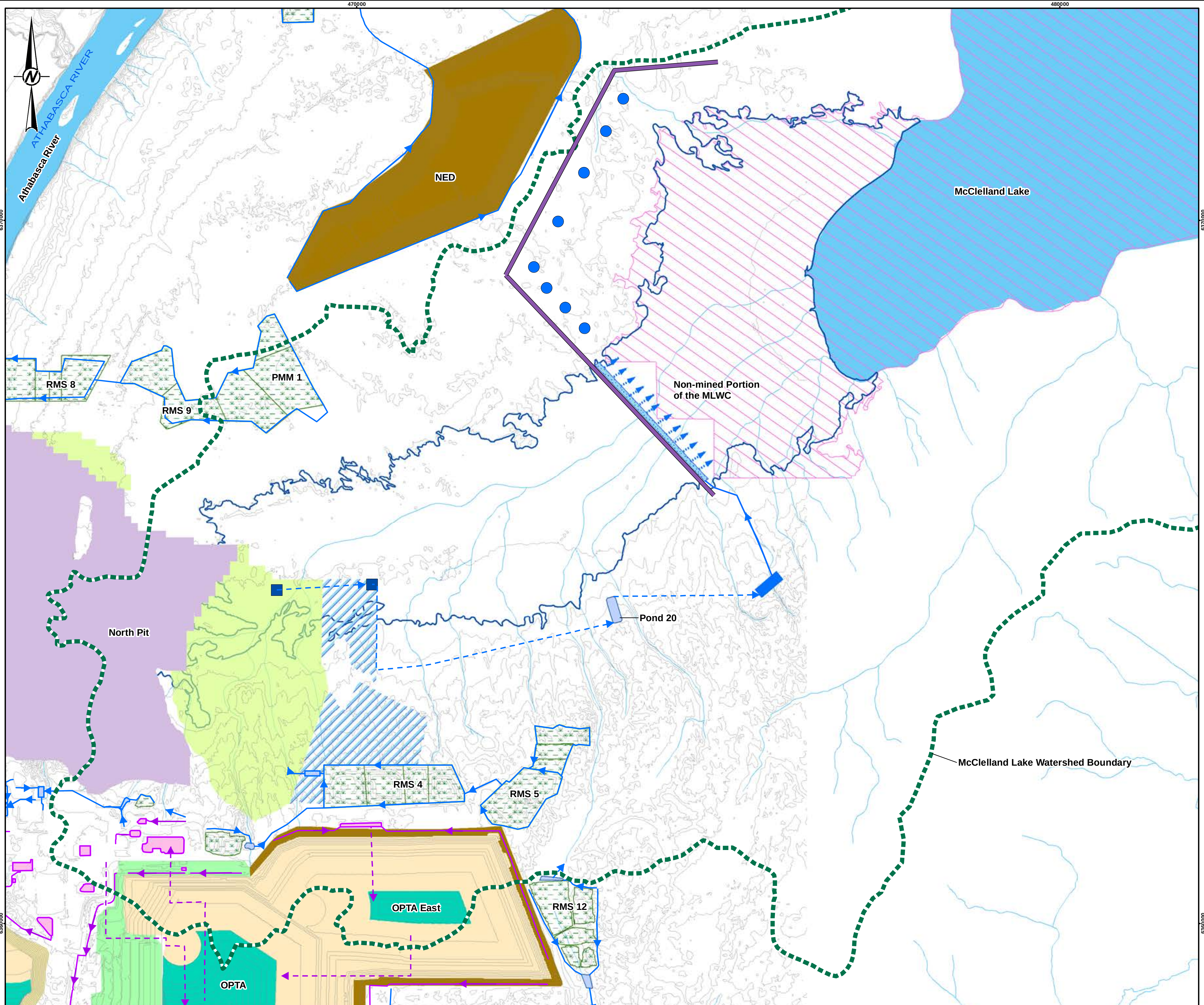
25mm



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- INDUSTRIAL WASTEWATER
- READY FOR RECLAMATION
- RECLAMATION MATERIAL STOCKPILE
- INDUSTRIAL RUNOFF SUMP
- POTENTIAL LOCATION FOR NOP INJECTION WELL
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- INDUSTRIAL WASTEWATER PIPELINE
- SURFACE WATER RESUPPLY
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- OVERFLOW DITCH
- MLWC WATER STORAGE POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- NATURAL STREAM
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- WORKING PLATFORM
- NATURAL WATERBODY
- NON-MINED PORTION OF THE MLWC
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
2. NED = NORTH EXTERNAL DUMP
3. OPTA = OUT-OF-PIT TAILINGS AREA
4. PMM = PEAT MINERAL MIX
5. RMS = RECLAMATION MATERIAL STOCKPILE
6. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
7. SUMP IS AN EXCAVATED POND FOR COLLECTING AND STORING RUNOFF.
8. NOP = NORTH OUTWASH PLAIN

CLIENT

FORT HILLS ENERGY CORPORATION

PROJECT

McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE

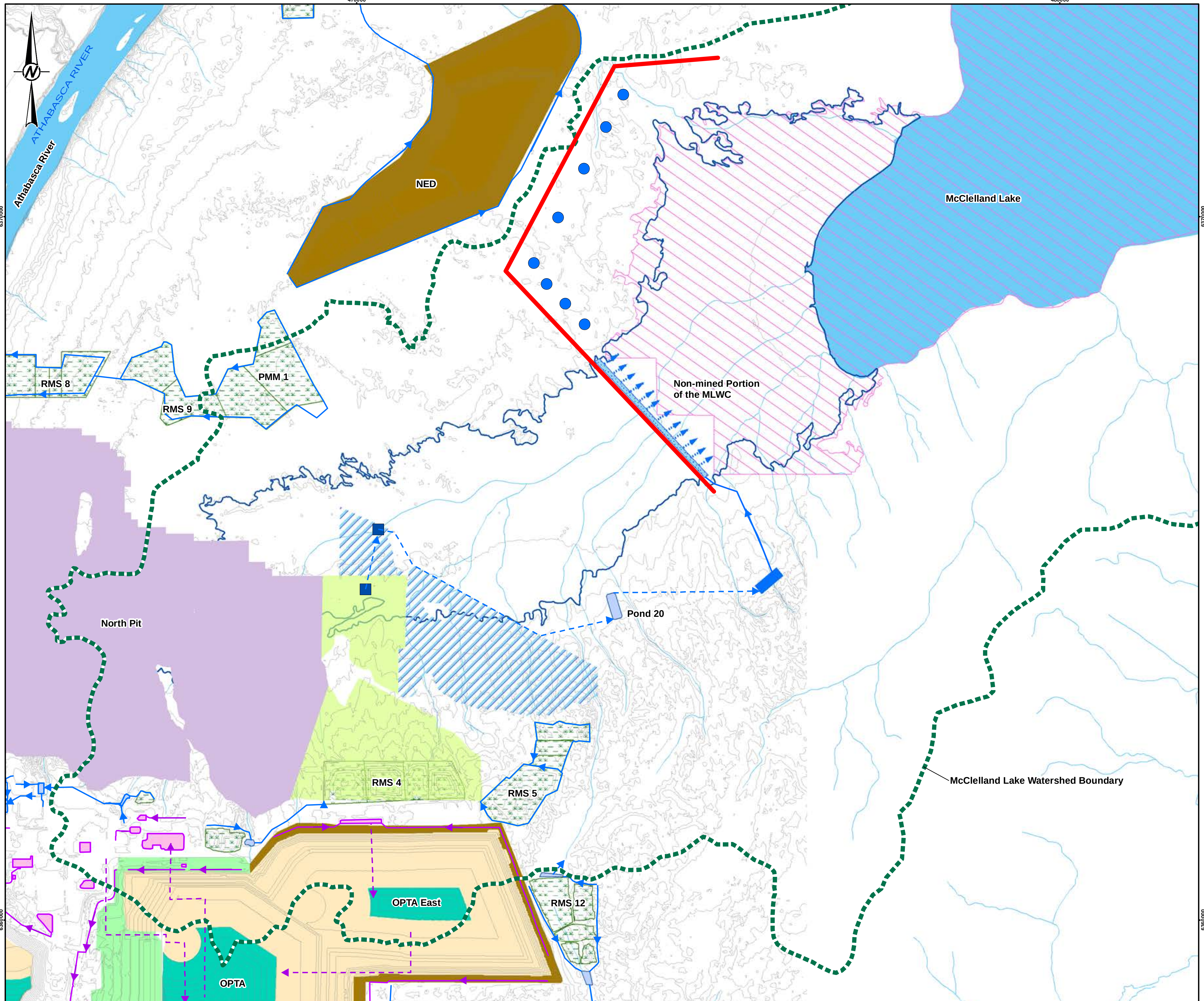
MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2034

FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-5

PATH: I:\CLIENTS\SUNCOR\20140450\Mapping\Products\Hydrology\McLellandLakeWetlandComplex_WMP\20140450_Fig5_3_5_SurfaceWater_2034_Rev0.mxd PRINTED ON: 2021-12-10 AT: 2:42:59 PM



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- INDUSTRIAL WASTEWATER
- READY FOR RECLAMATION
- RECLAMATION MATERIAL STOCKPILE
- INDUSTRIAL RUNOFF SUMP
- POTENTIAL LOCATION FOR NOP INJECTION WELL
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- INDUSTRIAL WASTEWATER PIPELINE
- SURFACE WATER RESUPPLY
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- OVERFLOW DITCH
- MLWC WATER STORAGE POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- NATURAL STREAM
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- CUTOFF WALL
- NATURAL WATERBODY
- NON-MINED PORTION OF THE MLWC
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
2. NED = NORTH EXTERNAL DUMP
3. OPTA = OUT-OF-PIT TAILINGS AREA
4. PMM = PEAT MINERAL MIX
5. RMS = RECLAMATION MATERIAL STOCKPILE
6. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
7. SUMP IS AN EXCAVATED POND FOR COLLECTING AND STORING RUNOFF.
8. NOP = NORTH OUTWASH PLAIN

CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2037

FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-6

PATH: I:\CLIENTS\SUNCOR\20140450\Mapping\Products\Hydrology\McClellandLakeWetlandComplex_WMP\20140450_Fig5_3_6_SurfaceWater_2037_Rev0.mxd PRINTED ON: 2021-12-10 AT: 2:46:07 PM

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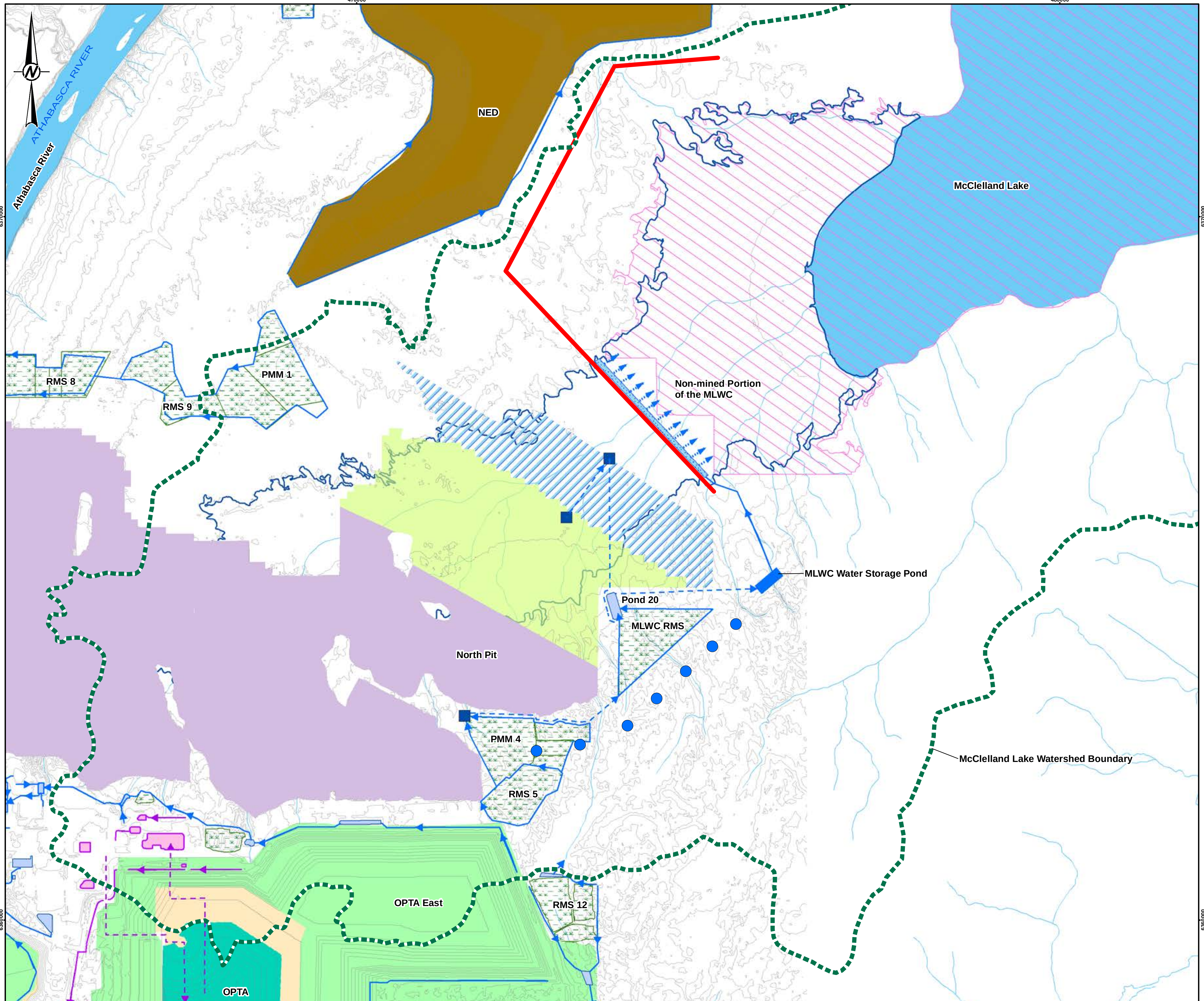
25mm



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- INDUSTRIAL WASTEWATER
- READY TO RECLAIM
- RECLAMATION MATERIAL STOCKPILE
- INDUSTRIAL RUNOFF SUMP
- FHUC PUMPING WELL
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- INDUSTRIAL WASTEWATER PIPELINE
- SURFACE WATER RESUPPLY
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- OVERFLOW DITCH
- MLWC WATER STORAGE POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- NATURAL STREAM
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- CUT OFF WALL
- NATURAL WATERBODY
- NON-MINED PORTION OF THE FEN
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
2. NED = NORTH EXTERNAL DUMP
3. OPTA = OUT-OF-PIT TAILINGS AREA
4. PMM = PEAT MINERAL MIX
5. RMS = RECLAMATION MATERIAL STOCKPILE
6. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
7. SUMP IS AN EXCAVATED POND FOR COLLECTING AND STORING RUNOFF.
8. NOP = NORTH OUTWASH PLAIN

CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2042

FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-7

PATH: I:\CLIENTS\SUNCOR\20140450\Mapping\Products\Hydrology\McLellandLakeWetlandComplex_WMP\20140450_Fig5_3_7_SurfaceWater_2042_Rev0.mxd PRINTED ON: 2021-12-10 AT: 2:47:08 PM

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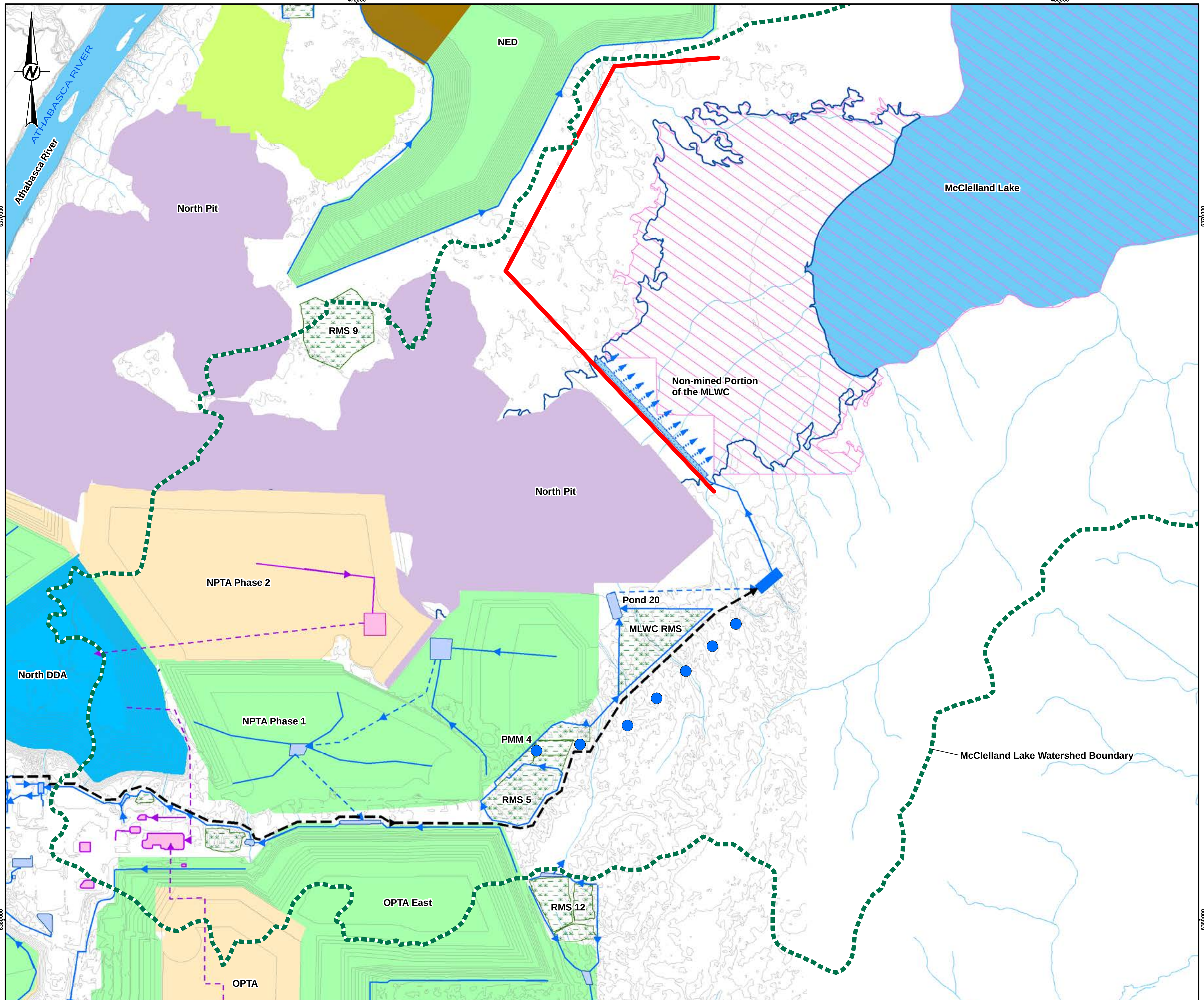
25mm



LEGEND

- AREA WITHIN ACTIVE MINE PIT LIMIT
- OVERBURDEN PLACEMENT
- TAILINGS SAND
- TREATED FT
- READY FOR RECLAMATION
- RECLAMATION MATERIAL STOCKPILE
- FHUC PUMPING WELL
- INDUSTRIAL RUNOFF PIPELINE
- INDUSTRIAL RUNOFF
- INDUSTRIAL WASTEWATER
- PIPELINE FROM RAW POND NEAR THE PLANT SITE
- INDUSTRIAL WASTEWATER PIPELINE
- SURFACE WATER RESUPPLY
- INDUSTRIAL RUNOFF SEDIMENTATION POND
- INDUSTRIAL WASTEWATER SEDIMENTATION POND
- MLWC WATER STORAGE POND
- OVERBURDEN DEWATERING
- MUSKEG DRAINAGE
- OVERFLOW DITCH
- NATURAL STREAMS
- CONTOUR ELEVATION INTERVAL 5 m
- FEN BOUNDARY
- CUTOFF WALL
- NATURAL WATERBODY
- NON-MINED PORTION OF THE MLWC
- WATERSHED BOUNDARY

0 1,000 2,000

1:55,000 METRES

NOTE(S)

1. FT = FLUID TAILINGS
2. MWLC = MCCLELLAND LAKE WETLAND COMPLEX
3. NED = NORTH EXTERNAL DUMP
4. OPTA = OUT-OF-PIT TAILINGS AREA
5. PMM = PEAT MINERAL MIX
6. RMS = RECLAMATION MATERIAL STOCKPILE
7. NON-MINED PORTION OF THE MLWC IS LOCATED BEYOND THE FOOTPRINTS OF ANY MINING AND WATER MANAGEMENT FACILITIES.
8. NOP = NORTH OUTWASH PLAIN
9. FHUC = FORT HILLS UPLAND COMPLEX
10. NPTA = NORTH PIT TAILINGS AREA
11. DDA = DEDICATED DISPOSAL AREA

CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

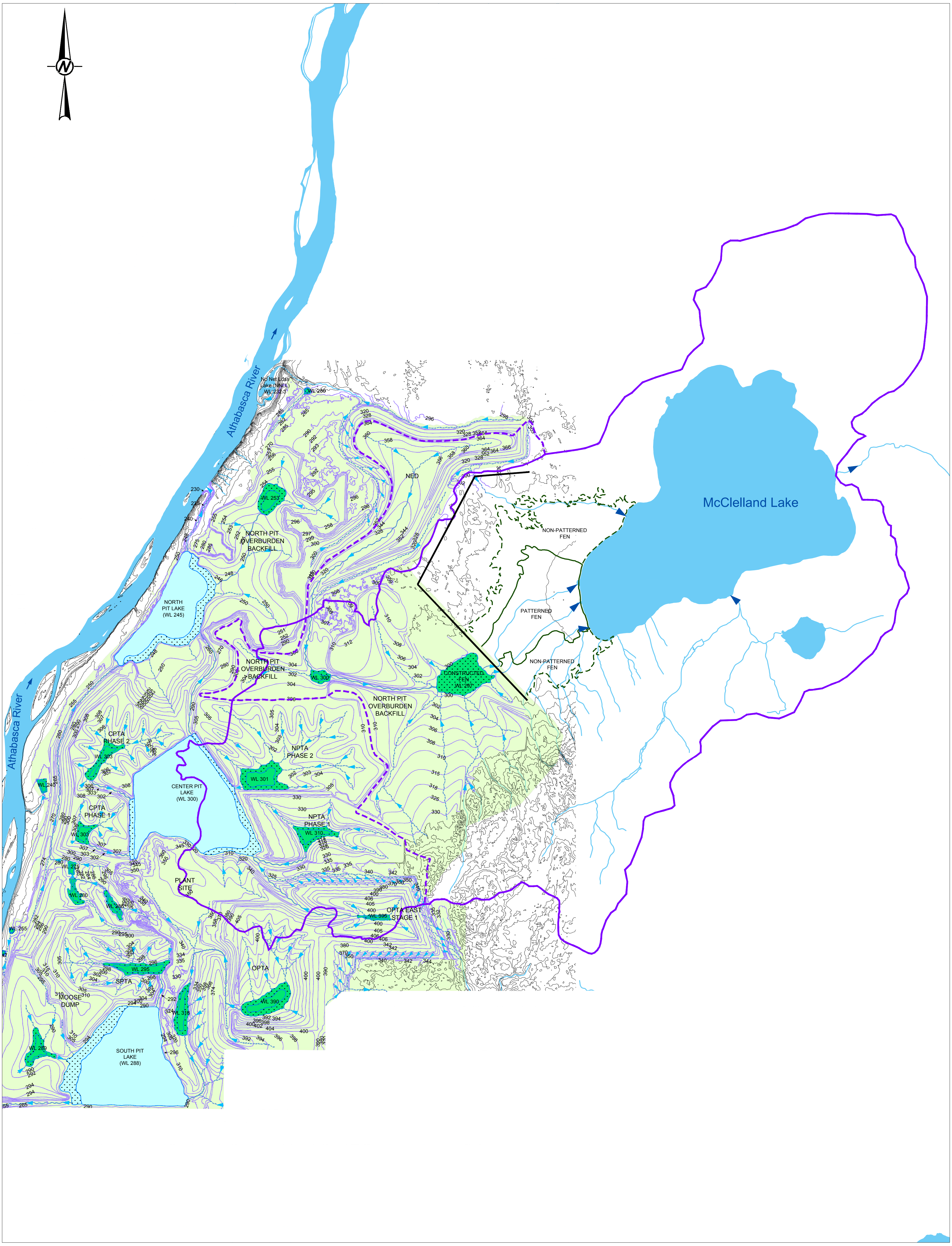
TITLE
MCCLELLAND LAKE WETLAND COMPLEX
WATER MANAGEMENT SYSTEM LAYOUT PLAN - END OF 2060

FORTHILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AA
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.3-8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm



LEGEND

- CONSTRUCTED CLOSURE CHANNEL
- SECONDARY OR INTERMITTENT CLOSURE CHANNEL
- NATURAL WATERCOURSE
- 320 — FINAL RECLAIMED SURFACE CONTOUR (masl) - CONTOUR INTERVAL (masl) VARIES
- EXISTING GROUND SURFACE CONTOUR (masl) - CONTOUR INTERVAL (masl) 5 m
- WL 310 — WATERBODY (ELEVATION masl)
- LITTORAL ZONE
- MINERAL WETLAND - SHALLOW OPEN WATER
- MINERAL WETLAND - MARSH
- PRE-DEVELOPMENT WATERSHED BOUNDARY
- CHANGED WATERSHED BOUNDARY AT CLOSURE
- CUTOFF WALL ALIGNMENT

DEFINITION(S)

masl - METRES ABOVE SEA LEVEL
OPTA = OUT-OF-PIT TAILINGS AREA
CPTA = CENTRE PIT TAILINGS AREA
NPTA = NORTH PIT TAILINGS AREA
NED = NORTH EXTERNAL DUMP
SPTA = SOUTH PIT TAILINGS AREA

0 2,500 5,000
1:100,000 METRES

REFERENCE(S)

1. END OF MINE TOPOGRAPHY FROM CLOSURE_TOPO_14B.DXF FEB. 2021
2. ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
3. DATUM: NAD 83 PROJECTION UTM ZONE 12

CLIENT
FORT HILLS ENERGY CORPORATION

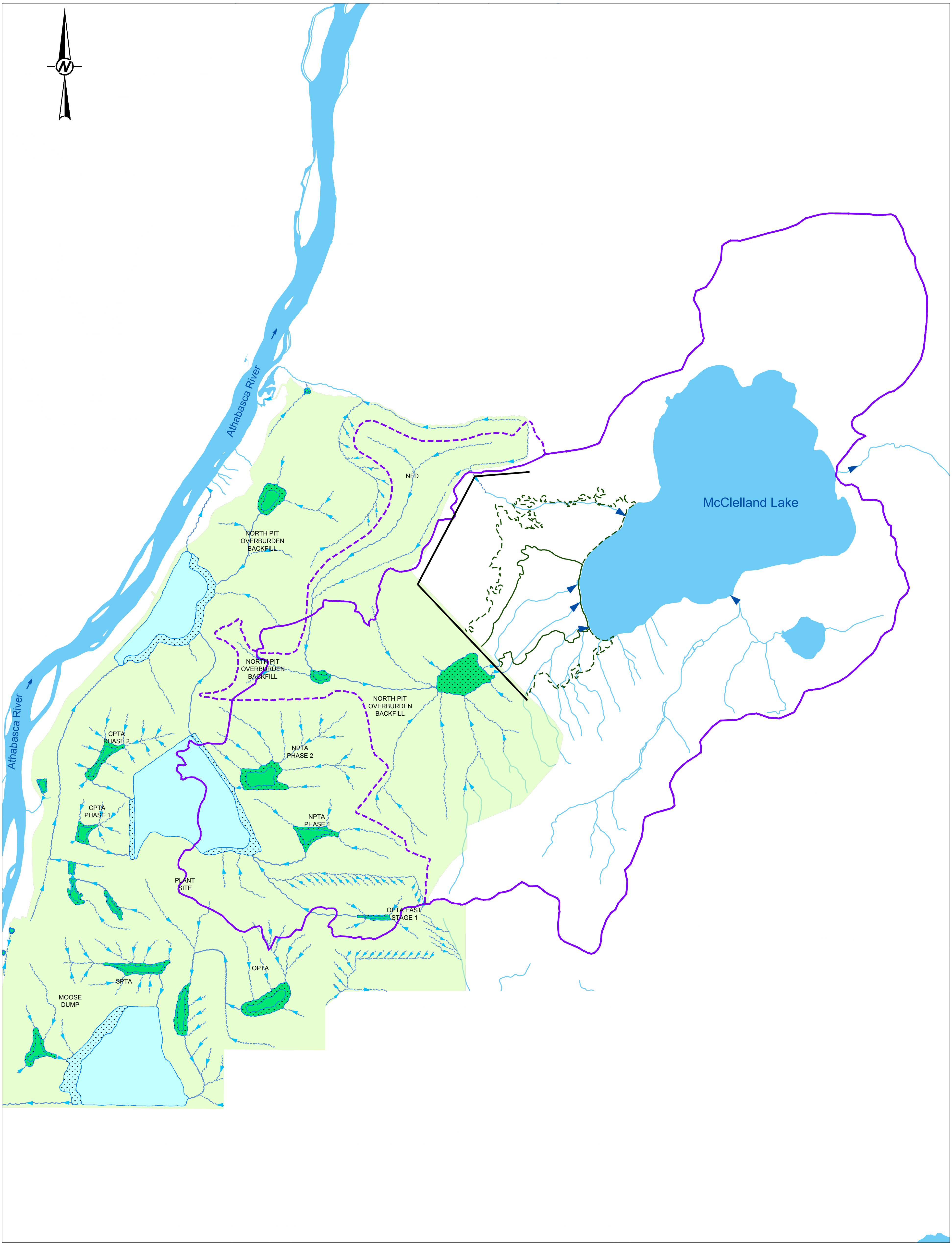
PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
CONCEPTUAL CLOSURE LANDSCAPE AND DRAINAGE PLAN FOR THE McCLELLAND LAKE WATERSHED AREA

CLIENT
FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	RFM
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	1000-CL-0001	0	5.3-9



LEGEND

- CONSTRUCTED CLOSURE CHANNEL
- SECONDARY OR INTERMITTENT CLOSURE CHANNEL
- NATURAL WATERCOURSE
- FINAL RECLAIMED SURFACE
- WL 310 — WATERBODY (ELEVATION masl)
- LITTORAL ZONE
- MINERAL WETLAND - SHALLOW OPEN WATER
- MINERAL WETLAND - MARSH
- PRE-DEVELOPMENT WATERSHED BOUNDARY
- CHANGED WATERSHED BOUNDARY AT CLOSURE
- CUTOFF WALL ALIGNMENT

DEFINITION(S)

masl - METRES ABOVE SEA LEVEL
OPTA = OUT-OF-PIT TAILINGS AREA
CPTA = CENTRE PIT TAILINGS AREA
NPTA = NORTH PIT TAILINGS AREA
NED = NORTH EXTERNAL DUMP
SPTA = SOUTH PIT TAILINGS AREA

REFERENCE(S)

1. END OF MINE TOPOGRAPHY FROM CLOSURE_TOPO_14B.DXF FEB. 2021
2. ALBERTA DIGITAL BASE DATA OBTAINED FROM ALTALIS LTD. © GOVERNMENT OF ALBERTA 2015. ALL RIGHTS RESERVED.
3. DATUM: NAD 83 PROJECTION UTM ZONE 12

0 2,500 5,000
1:100,000 METRES

CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
CONCEPTUAL CLOSURE DRAINAGE PLAN FOR THE McCLELLAND LAKE WATERSHED AREA

CLIENT
FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	RFM
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0017	0	5.3-10

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0

5.4. Design Features

5.4.1. Introduction

Description of the selected design concepts for the various system components as shown in the layout plans (Figure 5.3-1 to Figure 5.3-8) and summarized in Table 5.3-1 and Table 5.3-2, is described in the following sections (i.e., Sections 5.4.2 to 5.4.4), including the alternative design concepts considered and evaluated for each system component.

5.4.2. Surface Water Management Facilities

5.4.2.1. Sedimentation Ponds

5.4.2.1.1. Conceptual Layout Plan and Design

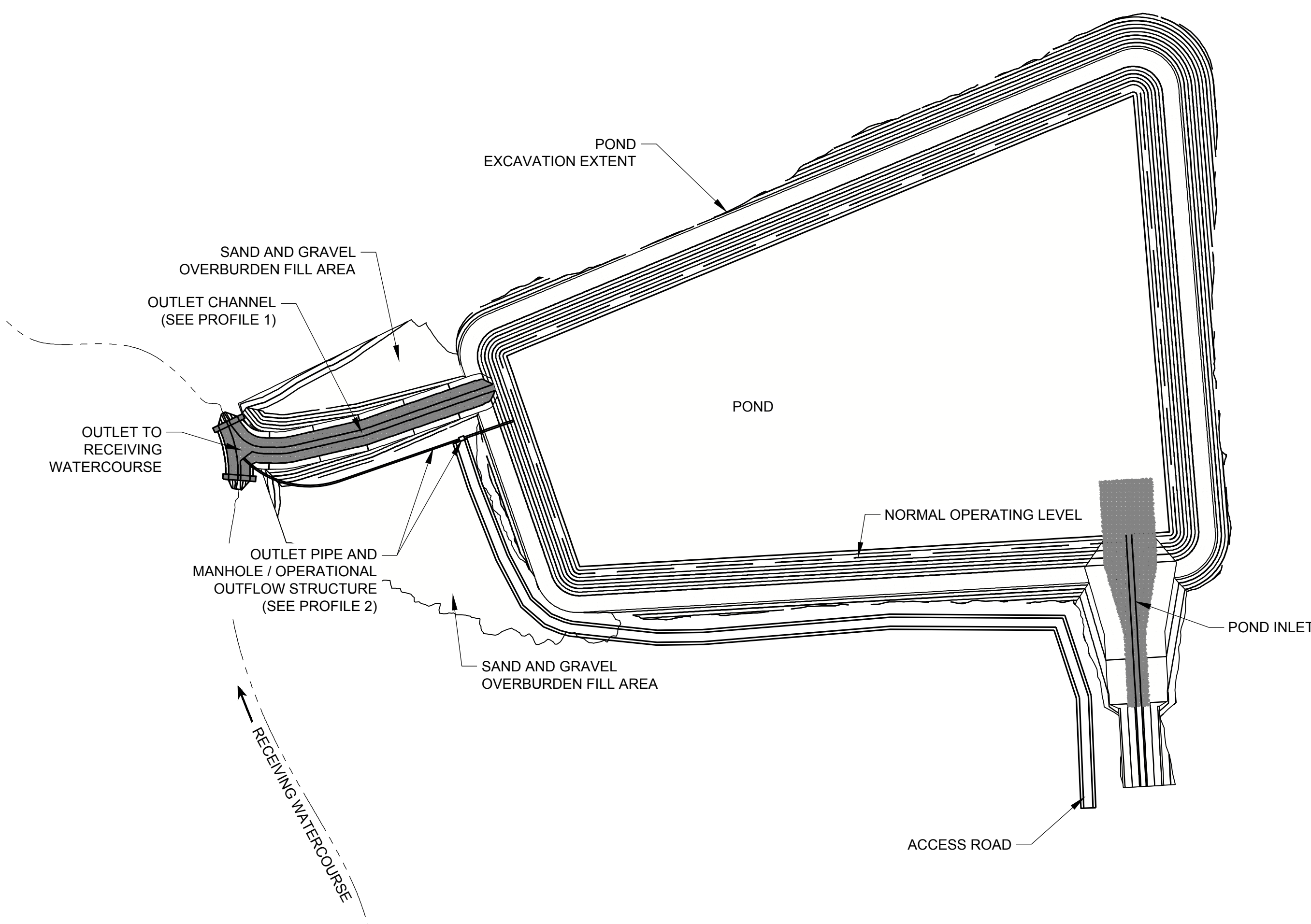
Multiple sedimentation ponds are planned in the McClelland Lake watershed to support sediment management and water resupply to the fen. These ponds will be used for managing the muskeg drainage and overburden dewatering water as well as runoff from NED.

The inflows to the sedimentation ponds will be pumped via pipelines from the sumps in the muskeg drainage and overburden dewatering areas or routed by gravity from the NED area. The primary function of these sedimentation ponds is to treat and settle the inflow sediments to meet the existing EPEA release criteria for Fort Hills. At this planning stage, no additional water treatment is anticipated before the outflow from the sedimentation ponds can be discharged to the downstream McClelland Lake watershed areas.

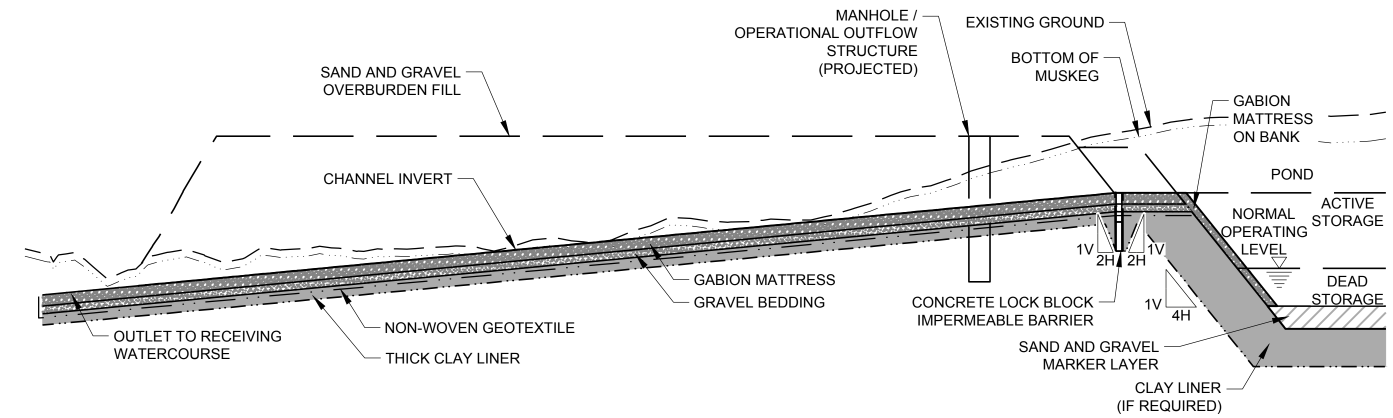
The sedimentation ponds will be sized to have sufficient active storage capacity to contain the 10-year, 24-hour design rainstorm runoff volume to meet the regulatory requirements and to store any additional water to enable relatively large release rates for water resupply to the fen during freshets. In addition to the active storage, the sedimentation ponds will have adequate sediment storage capacity (or dead storage) and freeboard allowance. The sedimentation ponds will be equipped with spillways which will be sized to manage and pass the 100-year, 24-hour design rainstorm runoff inflows. A conceptual design of typical sedimentation pond is shown in Figure 5.4-1.

Additional pond design considerations will include the following:

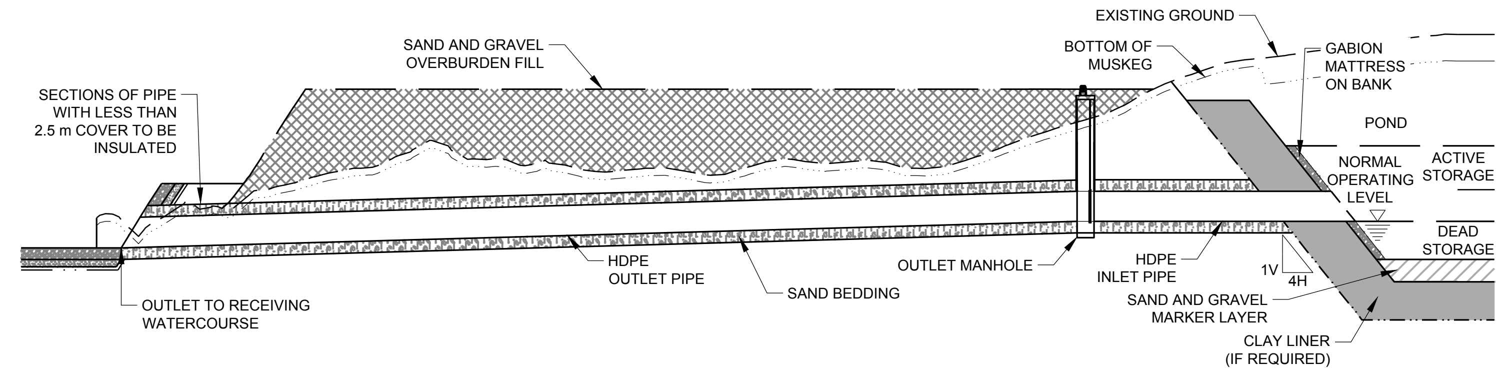
- potential requirement of pond liner
- provision of erosion protection at the pond inlet and outlet
- allowance for ice formation
- gated outlet control to enable gravity release when feasible
- wet well for outflow pipeline and control system when gravity outflow is not feasible
- geotechnical stability



PLAN



PROFILE 1 - OUTLET CHANNEL



PROFILE 2 - OUTLET PIPE

CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
CONCEPTUAL DESIGN OF TYPICAL SEDIMENTATION POND

CLIENT

FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	AS
REVIEWED	ZG
APPROVED	JH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400	0	5.4-1

5.4.2.1.2. Alternative Design Concepts

The water from the muskeg drainage and overburden dewatering areas within the McClelland Lake watershed could alternatively be routed by pumping to sedimentation ponds located outside of the McClelland Lake watershed (e.g., sedimentation ponds with outflows to the Athabasca River). Such alternatives were not selected, because of increased infrastructure and operational requirements for pumping, and because the dewatering water is a reliable and nearby source of water for resupply to the fen.

5.4.2.1.3. Further Investigation

Further design analysis will be conducted to finalize selection of the active design storage capacities of the sedimentation ponds during the next stage of engineering. Further evaluation of the gravity outflows from the sedimentation ponds to the McClelland Lake watershed will be conducted to confirm the resulting flow pattern in the fen areas will be similar to pre-mining conditions.

Sedimentation pond outflows are expected to meet regulatory criteria for release to the downstream McClelland Lake watershed areas. However, the potential influence and effect on the fen water quality will be assessed using water quality data collected from muskeg drainage and overburden dewatering operations as well as watershed scale water quality modelling, to confirm and validate that no additional treatment of the sedimentation pond outflows would be required to meet the quality of water for resupply to the fen.

A geotechnical investigation program will be conducted to determine the soil characteristics in the selected areas of the sedimentation ponds, the water retention or infiltration characteristics, and water table depth, and to collect the necessary information for designing the sedimentation pond side slopes.

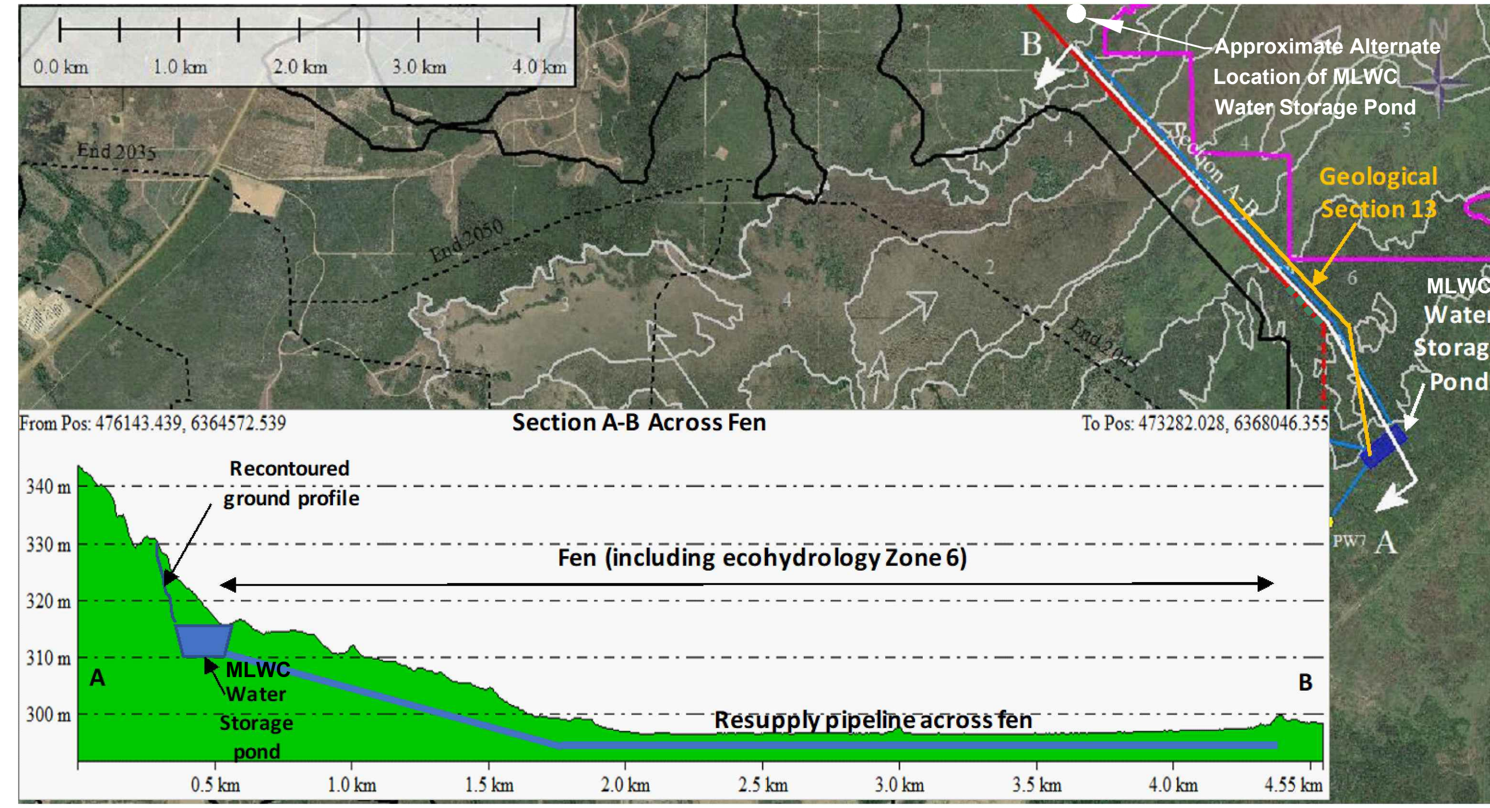
Potential use of snow cannons during stage one of the surface water resupply operation (i.e., from 2025 to 2028) to increase snowpack depth in select locations downstream of the dewatering area but upstream of the fen, will be further evaluated for its potential benefit as a supplemental measure to increase snowmelt runoff and to reduce the storage capacity requirements for the sedimentation ponds.

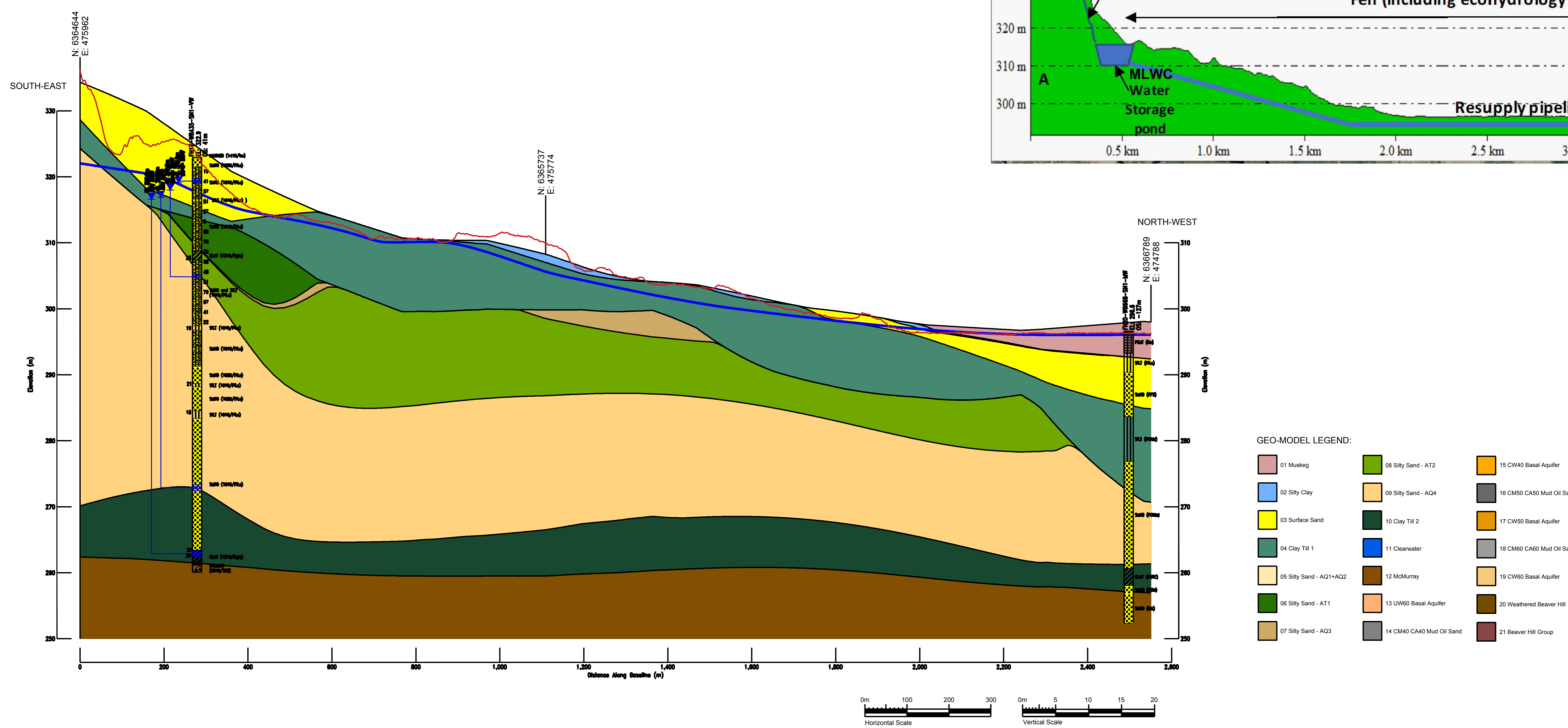
5.4.2.2. McClelland Lake Wetland Complex Water Storage Pond

5.4.2.2.1. Conceptual Layout Plan and Design

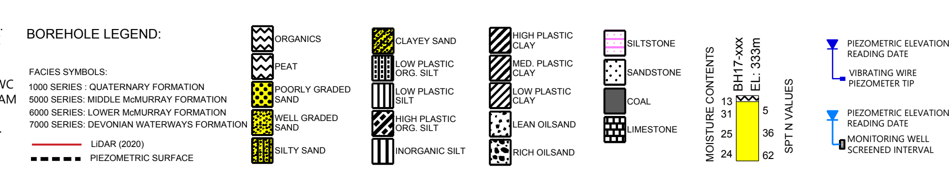
The water storage pond will be designed to enable provision of variable surface water resupply rates within a hydrologic year which will increase with time as the mine pit development advances. Water from a supply source (e.g., sedimentation ponds, pumping wells) will be piped to the storage pond when in operation. The pond water will be delivered to the fen via a water distribution system.

The selected pond location and a conceptual design are shown in Figure 5.4-2. The pond will be sized to provide the necessary storage volume and an allowance for ice formation in the winter. An outflow pipeline will provide sufficient head to a resupply pipeline along the alignment of the working platform across the fen. Pressurized water will be supplied to the pipeline and discharge system at regular intervals.





NOTES:
1. THE BACKGROUND STRATIGRAPHY WAS OBTAINED FROM THE FHELP 2020 UNIFIED GEO-MODEL.
2. FH20-WR668-SN1-MW BOREHOLE LOG WAS OBTAINED FROM A FIELD DATA REPORT BY MATRIX SOLUTIONS INC. THE OTHER BOREHOLE IS FROM WOOD DATA.
3. VIBRATING WIRE PIEZOMETER READINGS WERE PROVIDED BY FHELP.
4. PIEZOMETRIC SURFACE WAS CREATED BY WOOD BASED ON THE DATA FROM GOLDER 2018 MLWC DATA SYNTHESIS REPORT, WOOD 2017-2020 GEOTECHNICAL MLWC SYNERGY DRILLING PROGRAM DATA REPORTS AND MATRIX 2017-2020 MLWC FIELD REPORTS.
5. WOOD PROVIDED THE CONCEPTUAL PLAN AND DESIGN INFORMATION SHOWN IN THIS FIGURE.



CLIENT
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PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	RFM
REVIEWED	ZG
APPROVED	JH

TITLE
CONCEPTUAL LAYOUT PLAN AND DESIGN CROSS-SECTION OF THE MLWC WATER STORAGE POND

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0001	0	5.4-2

Although the pond was conceptually designed to be below ground surface, the interaction with the foundation conditions may require the pond to be raised by building berms around the pond to provide the necessary storage depth and capacity. The other pond design considerations will include the following:

- potential requirement of a pond liner
- provision of erosion protection at the pond inlet
- provision of sediment storage
- allowance for ice formation
- overflow spillway
- wet well for outflow pipeline and control system
- geotechnical stability

5.4.2.2.2. Alternative Location

The water storage pond could alternatively be located in the NOP on the north side of the fen as shown in Figure 5.4-2. This alternative location was not selected at the conceptual stage because it would require pumping and increase operational cost.

5.4.2.2.3. Further Investigation

Both water storage pond locations (i.e., north and south sides of the fen) will be further evaluated during the next stage of engineering design in consideration of site-specific conditions and proximity to selected water supply source(s). The option that both ponds may be needed will also be examined.

A geotechnical investigation program will be conducted to determine the soil characteristics in the selected area of the water storage pond, the water retention or infiltration characteristics, and water table depth, and to collect the necessary information for designing the pond side slopes.

5.4.2.3. Fen Water Resupply Distribution System

5.4.2.3.1. Short-Term Water Distribution System during Working Platform Construction

Conceptual Layout Plan and Design

As the working platform is being constructed, the natural surface water flow from west to east will begin to be blocked. During construction of the working platform, it is planned that surface water will be pumped over the platform at regular intervals. Distribution at the outlet of each pumping system would be a spray to not cause erosion.

The method of moving surface water to the non-mined fen side of the working platform during its construction is heavily dependent on the working platform construction method. The selected design concept for the working platform construction relies on staged loading of the muskeg, which is likely to take several years to complete. The selected pumping and spraying method for water distribution has the flexibility to accommodate the approach of staged construction over several years.

Alternative Design Concepts

If an alternative working platform construction method were selected, other options for surface water resupply could become viable. The following alternative concepts were considered, although not all combinations are feasible:

- Diversion of water around the edges of the working platform.
- Construction of the working platform in segments, with the long-term surface water resupply system being put into service prior to constructing the final segments.
- A series of temporary culverts that are abandoned in place as the peat compresses and the working platform construction progresses. This would be challenged by the magnitude of settling expected and trench wall stability in the areas where abandoned culverts are removed at the wall section.
- Segments of cut-off wall made from a permeable material that allows continued flow of water.

Further Investigation

While the selected pumping system concept is feasible, there will be practical issues for pumping over the working platform that must be solved through further design work. In addition, some of the alternative design concepts mentioned above will be investigated further.

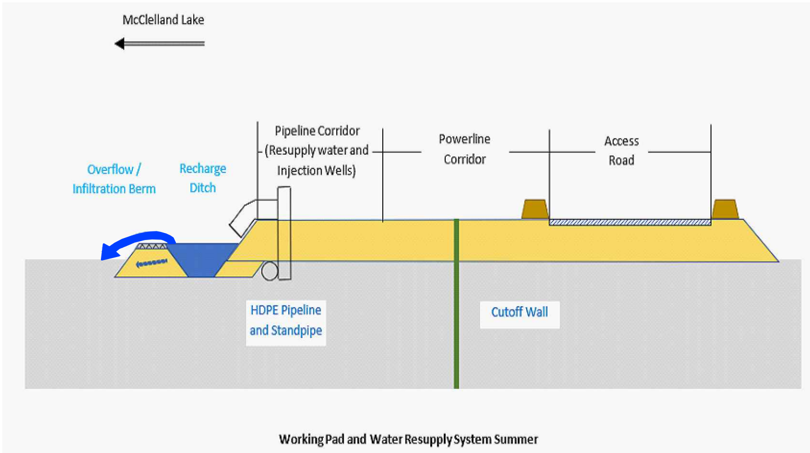
The non-mined portion of the MLWC will be separated from the working platform by a buffer of variable width. It will be necessary to control transport of clay-sized particles and floating organics into the non-mined portion of the MLWC to protect the natural surface water flow conveyance system from clogging.

Therefore, some form of silt curtain will likely be provided, especially during construction, but may be eliminated in the longer term. The interaction of sediment control and discharge of the water resupply to the fen will require further detailed consideration. Trials in the patterned fen well to the west of the non-mined portion of the MLWC for identifying an optimum sediment control method, will be considered.

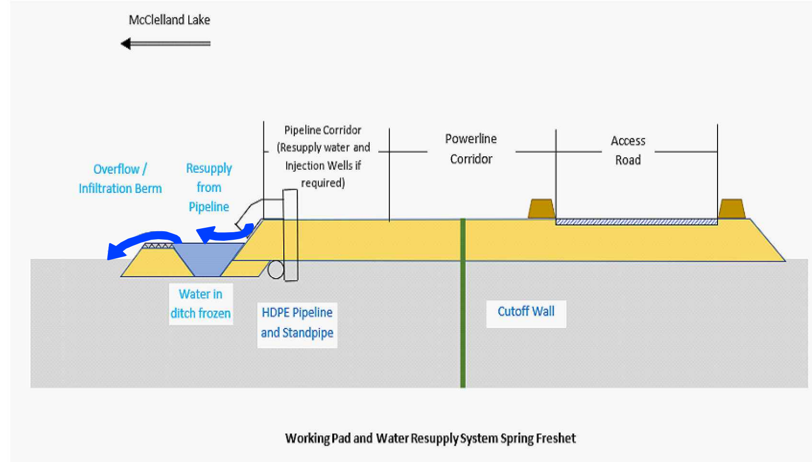
5.4.2.3.2. Long-Term Water Distribution System Installed on the Working Platform

Conceptual Layout Plan and Design

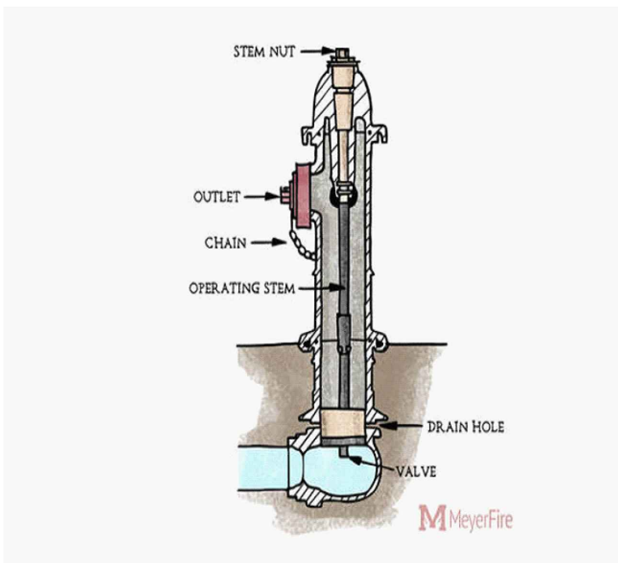
Once the working platform has been installed in preparation for construction of the cutoff wall, the natural surface water flow from west to east will be blocked, and a long-term water distribution system along the cutoff wall alignment (Figure 5.4-3) will be provided to deliver the water from the water storage pond to the fen. A possible design concept is an overflow ditch located on the east side of the working platform and connected to the pipeline buried below the frost line in the working platform, as shown in Figure 5.4-3.

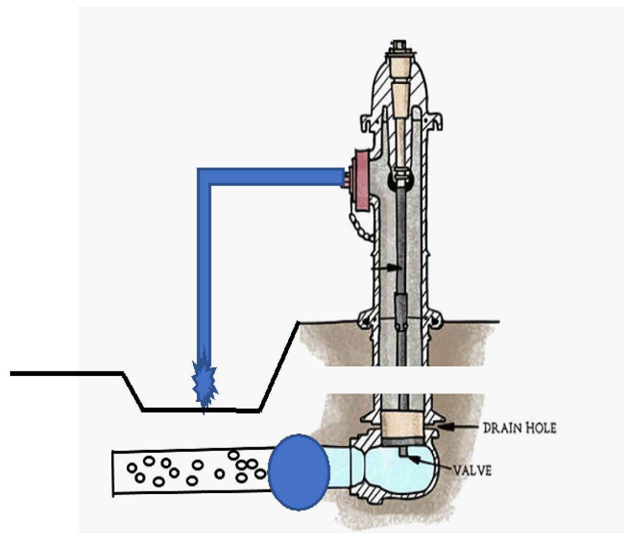


Working Pad and Water Resupply System Summer



Working Pad and Water Resupply System Spring Freshet





NOTES:

1. SCHEMATIC ONLY, NOT TO SCALE
2. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

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PROJECT
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FORT HILLS
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APPROVED	JH

TITLE
DESIGN CROSS-SECTION OF THE LONG-TERM WATER DISTRIBUTION SYSTEM INSTALLED ON THE WORKING PLATFORM

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0005	0	5.4-3

A standpipe system similar to a fire hydrant would be used to transfer water from the buried pipeline into the overflow ditch. The water in the ditch will be allowed to overflow into the fen and infiltrate into the shallow subsurface layer of the fen. The overflow side of the ditch embankment will be constructed to be semi-permeable, allowing water to infiltrate through it to the subsurface fen layer.

The pipe/standpipe system will allow resupply water to be introduced at multiple locations, allowing for even distribution along the ditch length. Heat tracing and/or internal drains on the standpipes will be provided to enable the water distribution system to stay free of ice blockage.

A high-density polyethylene (HDPE) pipeline is planned, as it offers the strength and flexibility characteristics needed for the system. Valving and controls at the upper end of the pipeline will be provided to vary the flow rate in the pipeline.

Alternative Design Concepts

An alternative concept of having an open channel to supply water from the resupply pond to the overflow ditch was considered and evaluated. This concept was not selected because ice buildup in the overflow ditch would prevent resupply water from reaching a large section of the fen and because resupply water would tend to short-circuit the ditch and oversupply the southern end of the fen. However, an open channel should still be used to connect the water storage pond overflow spillway to the overflow ditch to prevent erosion downstream of the pond if an emergency event were to occur.

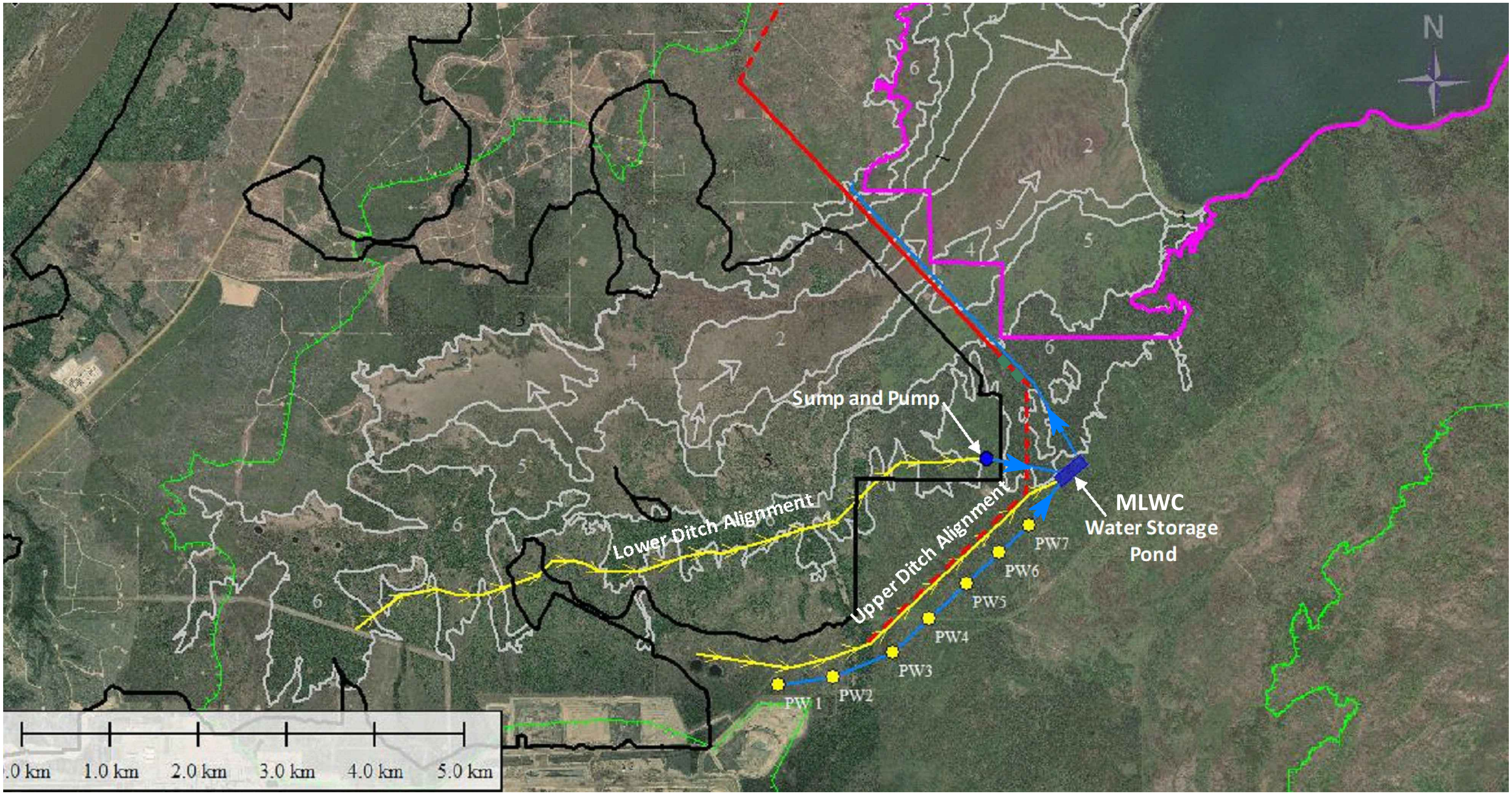
Another alternative concept would involve a pipeline built on piles across the fen that would include an array of spray outlets and an access platform, which is also an alternative for the short-term system.

5.4.2.4. Fort Hills Uplands Complex Water Interception Ditch

5.4.2.4.1. Conceptual Layout Plan and Design

A water interception ditch is planned along the toe of the FHUC to route the surface runoff and groundwater seepage collected from the FHUC catchment area of approximately 20 km^2 to a sump as shown in Figure 5.4-4. The main purpose of this toe ditch is to reduce the runoff from the FHUC from recharging the downstream area that will be dewatered in advance of mining. This ditch can also be used for conveying some of muskeg drainage and overburden dewatering water to the sump when practical. The water in the sump will be pumped to the water storage pond for water resupply to the fen. The conceptual design of the ditch has a length of approximately 9 km, a gradient of approximately 0.07%, a bottom width of 2 m, a maximum depth of approximately 7 m, and a side slope of 3H:1V.

This water interception ditch will be gradually removed as the mine pit development progresses eastward in the McClelland Lake watershed. The ditch will not be available beyond 2048, when the mine development will result in its complete removal.



Legend

- Toe Ditch Alignment
- Non-mined Portion
- Ultimate Pit Crest
- Resupply Pipeline
- Ecohydrology Zone
- Mine Advance
- Provisional Pumping Well Location
- Groundwater Divide
- Surface Water Divide

NOTE(S)

1. MAP IS SCHEMATIC ONLY, NOT TO SCALE
2. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

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APPROVED	JH

TITLE
CONCEPTUAL LAYOUT PLAN OF FORT HILLS UPLAND COMPLEX WATER INTERCEPTOR DITCH

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0004	0	5.4-4

5.4.2.4.2. Alternative Design Concept

An alternative upper ditch alignment south of the future mine pit limit, was considered and evaluated. The ditch would be offset approximately 50 m upgradient from the potential cutoff wall alignment at the FHUC to allow for construction of the wall in the future, if necessary. The main benefit of this ditch alignment would be to intercept most of the surface runoff from the undisturbed FHUC catchment area of approximately 7.4 km^2, to prevent it from entering the active mining area, and to capture it for use as a source of water for resupply to the fen. However, this alignment concept was not selected for the current plan because of the main shortcomings listed below:

- This upper ditch alignment would require deep cuts (up to about 25 m) in sandy soils with piezometric elevations much higher than the ditch invert. This would result in geotechnical instability and operational issues with water draining into the ditch creating slumping, internal erosion and silting of the ditch, and potentially icings in the winter.
- Raising the ditch invert to reduce the cut depth would result in the need to place fill where the alignment crosses ravines on the FHUC slope, and these fill areas could require dam structures. The fill would cause a pool of water to form in the ravine upstream of the fill and require pumps to lift the water into the ditch.

5.4.2.4.3. Further Evaluation

The current plan does not include any water handling facility to intercept the surface water runoff from the FHUC for preventing it from entering the mine pit particularly during spring freshet, once part or all of the ditch along the toe of the FHUC is removed. Although the upper ditch alignment would have challenges as described above, an alignment alternative with shallow ditch and mild slope as well as other potential surface runoff management measures will be further evaluated during the next stage of engineering design.

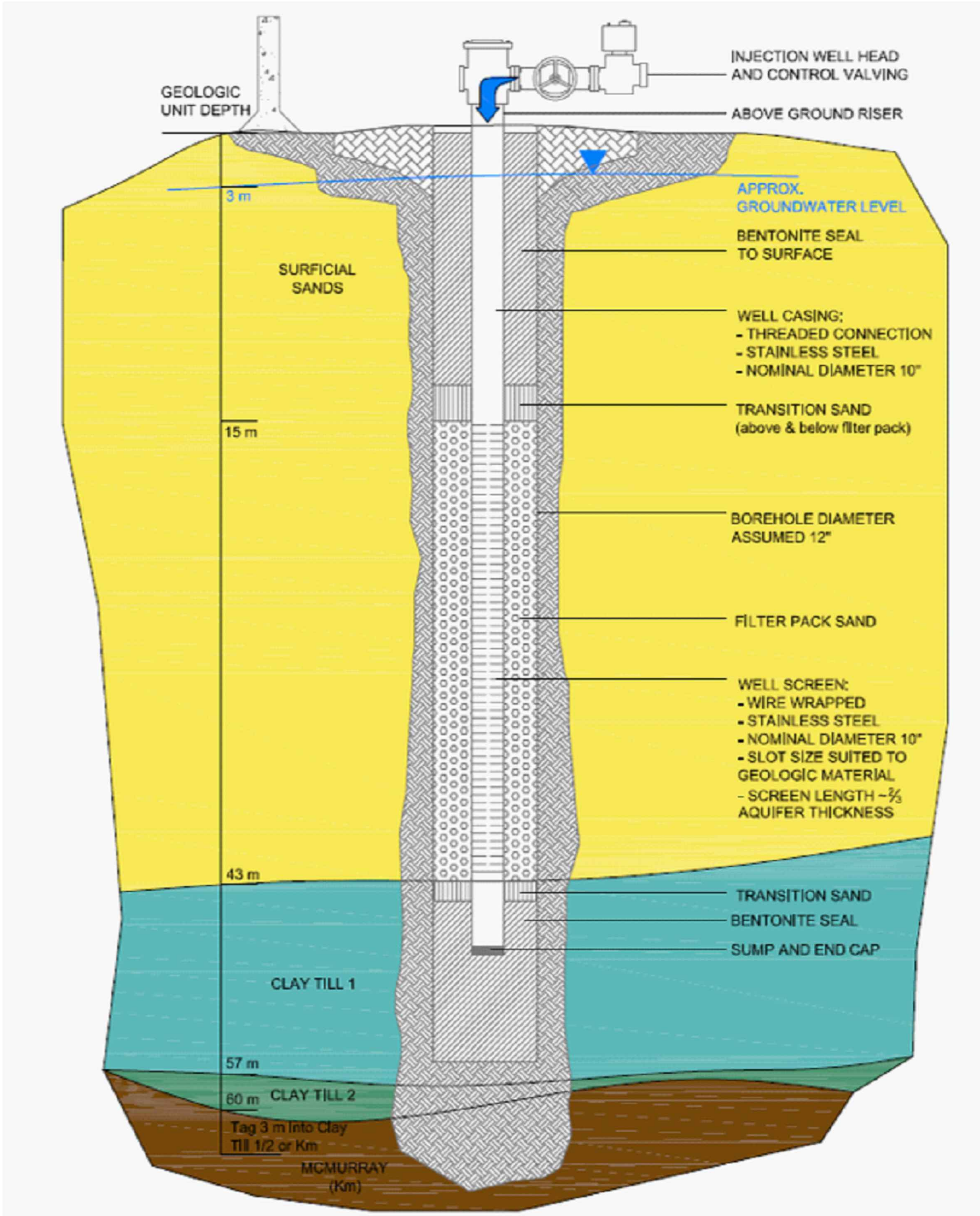
5.4.3. Groundwater Management Facilities

5.4.3.1. North Outwash Plain Injection Wells

5.4.3.1.1. Conceptual Layout Plan and Design

Injection wells in the NOP will be installed to recharge the groundwater in the NOP Quaternary aquifer which extends under the fen, and to maintain groundwater levels in this aquifer, prior to installation of the cutoff wall. A maximum of eight (8) vertical injection wells would be installed in the NOP. The potential locations of these wells are shown in Figure 5.3-3 (i.e., IW1 to IW8). Results of groundwater modelling analysis completed indicate that these wells can be used to inject up to 4,800 cubic meters per day (m^3/day).

A design of a typical injection well is shown in Figure 5.4-5. The total drilling depth of 25 to 45 m below ground surface was estimated with completion into clay till or McMurray Formation below the outwash sand aquifer. The injection wells will be operated at low pressure and the rate of injection will be highly dependent on the hydraulic conductivity of the injected zone and the available thickness of the unsaturated zone, which is up to approximately 15 m below ground surface near the groundwater divide and the NED.



NOTE(S)

1. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

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PROJECT
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FORT HILLS
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PREPARED	RFM
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TITLE
CONCEPTUAL DESIGN OF A TYPICAL INJECTION WELL

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0011	0	5.4-5

The injection wells will be operated on a year-round basis and will require winterization. The wellhead infrastructure may include the following:

- electrical power supply
- piping and valves
- pump controls for rate and on/off record
- water level controls
- sampling and monitoring ports
- weather protection such as insulation and heat wrap or heated shack
- physical protection
- communication or automation (as appropriate)

Well installation and operation will require road access and preparation of a drilling platform.

5.4.3.1.2. Alternative Design Concept

A number of potential injection well layout scenarios were considered and evaluated for three cases of mine development conditions (i.e., pre-mining conditions, addition of cutoff wall, and fully developed mine conditions). The results of the evaluation provided a basis for selecting a design concept of a potential maximum number of eight (8) vertical injection wells.

5.4.3.1.3. Further Investigations

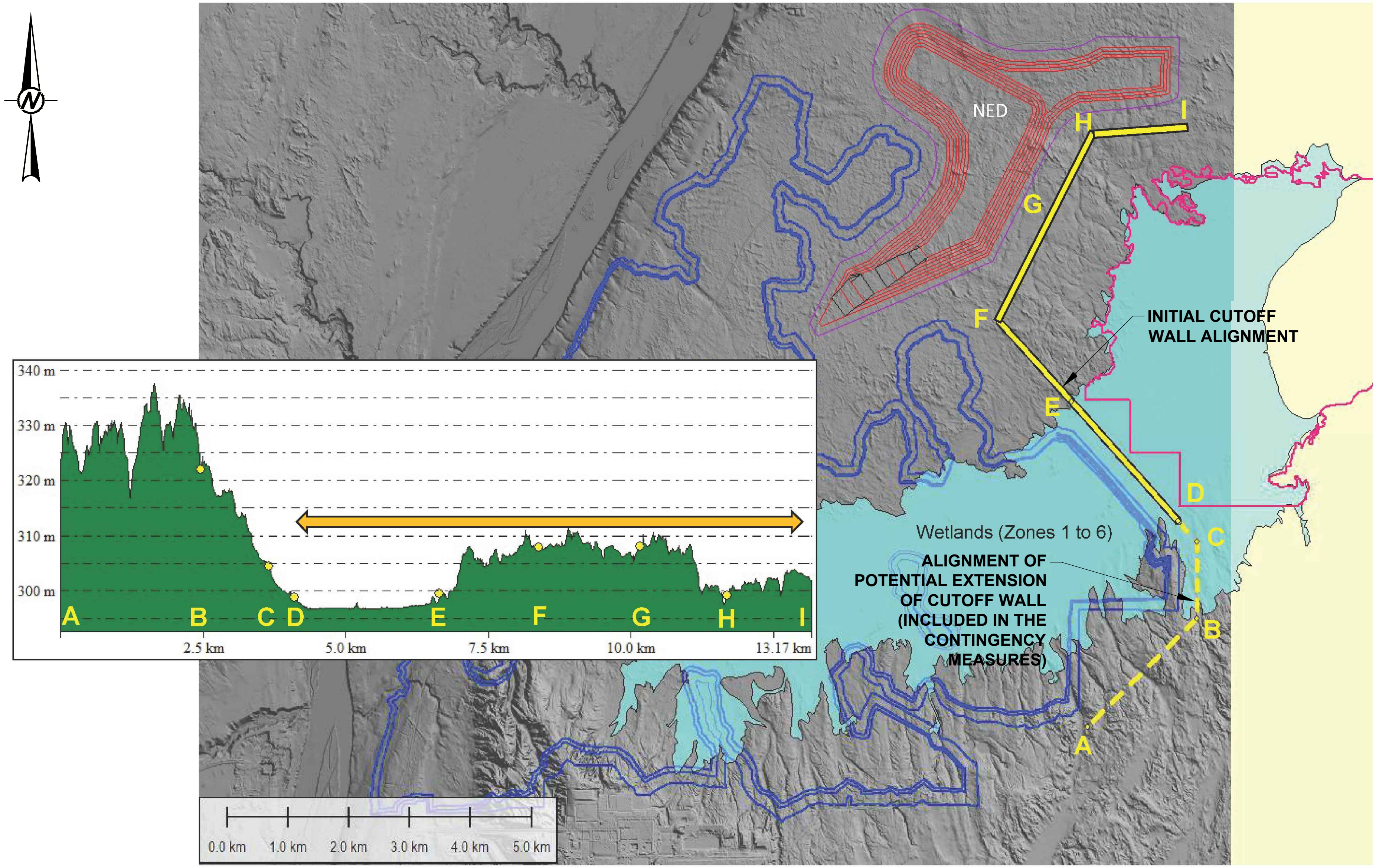
Additional hydrogeologic characterization of subsurface conditions and determination of aquifer hydraulic properties in the areas where injection wells would be installed, injection well testing, and further numerical modelling, will be conducted to support design of the injection wells to be installed in the NOP in conjunction with the cutoff wall design. An observational approach to the design will be adopted for achieving the system performance goals.

5.4.3.2. Cutoff Wall

5.4.3.2.1. Conceptual Layout Plan and Design

A low permeability, Graded Soil Bentonite (GSB) cutoff wall will be installed across the fen and beyond to prevent Quaternary aquifer groundwater under the fen (currently flowing towards McClelland Lake) from reversing direction and flowing toward the mine pit. The composition of the GSB mixture will be determined based on the results of future mix design testing, but it was estimated to be composed of approximately 2% bentonite, 75% sand, and 23% clay till borrow material.

The potential maximum extents of the wall alignment are shown in Figure 5.4-6 (i.e., from Points A to I). This maximum alignment involves a total wall length of 13.6 km and a wall depth ranging from approximately 20 to 70 m. The cutoff wall will have a minimum setback of 300 m from the pit crest and a minimum setback of 200 m from the toe of NED to control wall deformation. A geological cross section along the maximum cutoff wall alignment is shown in Figure 5.4-7. A typical cutoff wall design profile is shown in Figure 5.4-8.



NOTE(S)

1. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE.
2. THE INITIAL CUTOFF WALL IS PLANNED TO EXTEND FROM "D" TO "I" (9.1 km).

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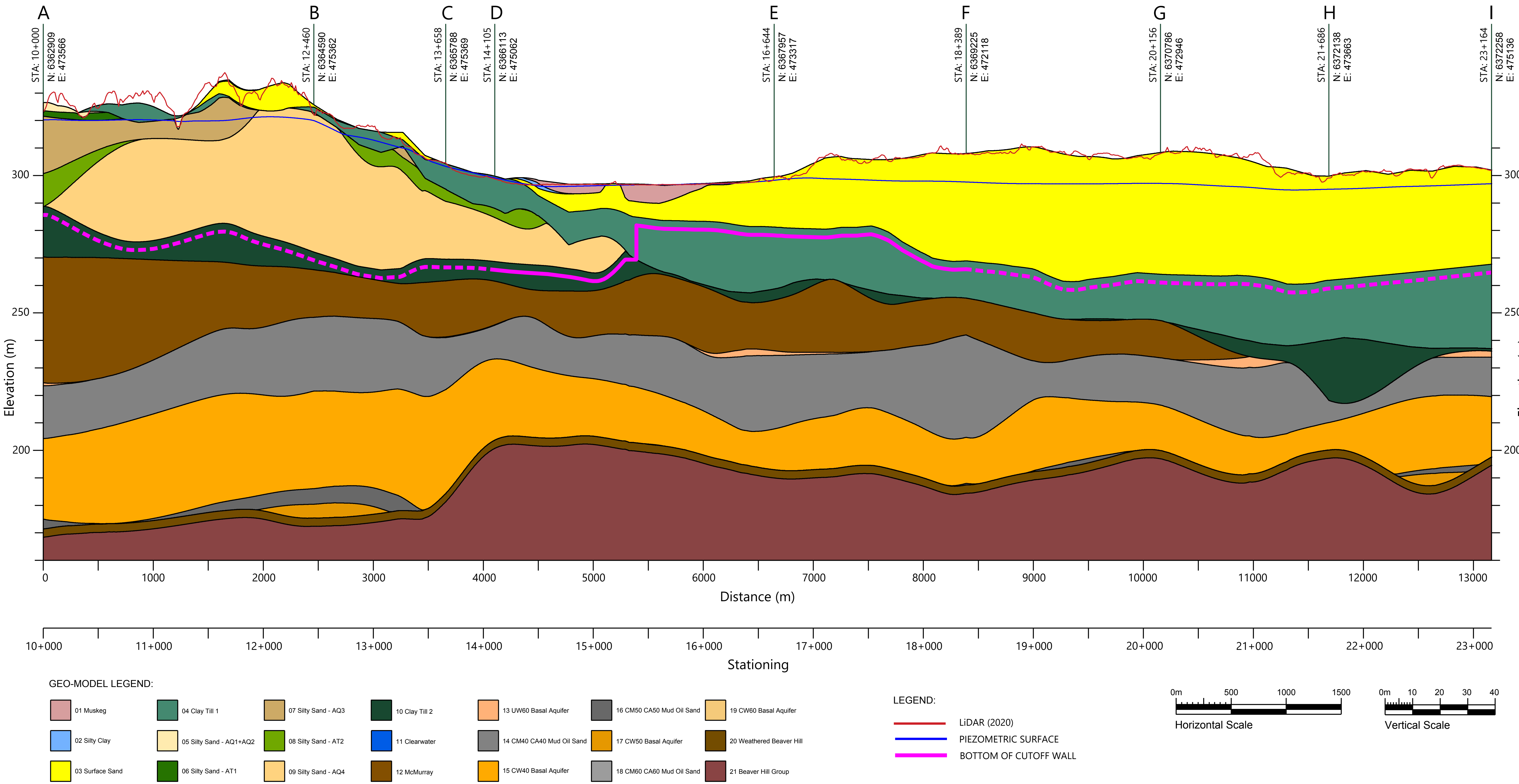
TITLE
ALIGNMENT OF THE PLANNED CUTOFF WALL

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0009	0	5.4-6

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



NOTES: 1. THE BACKGROUND STRATIGRAPHY WAS OBTAINED FROM THE FHELP 2020 UNIFIED GEO-MODEL.
2. PIEZOMETRIC SURFACE WAS CREATED BY WOOD BASED ON THE DATA FROM GOLDER 2018 MLWC DATA SYNTHESIS REPORT, WOOD 2017-2020 GEOTECHNICAL MLWC SYNERGY DRILLING PROGRAM DATA REPORTS AND MATRIX 2017-2020 MLWC FIELD REPORTS.
3. VERTICAL SCALE EXAGGERATION: 25 TIMES.
4. WOOD PROVIDED THE CROSS-SECTIONAL INFORMATION SHOWN IN THIS FIGURE.

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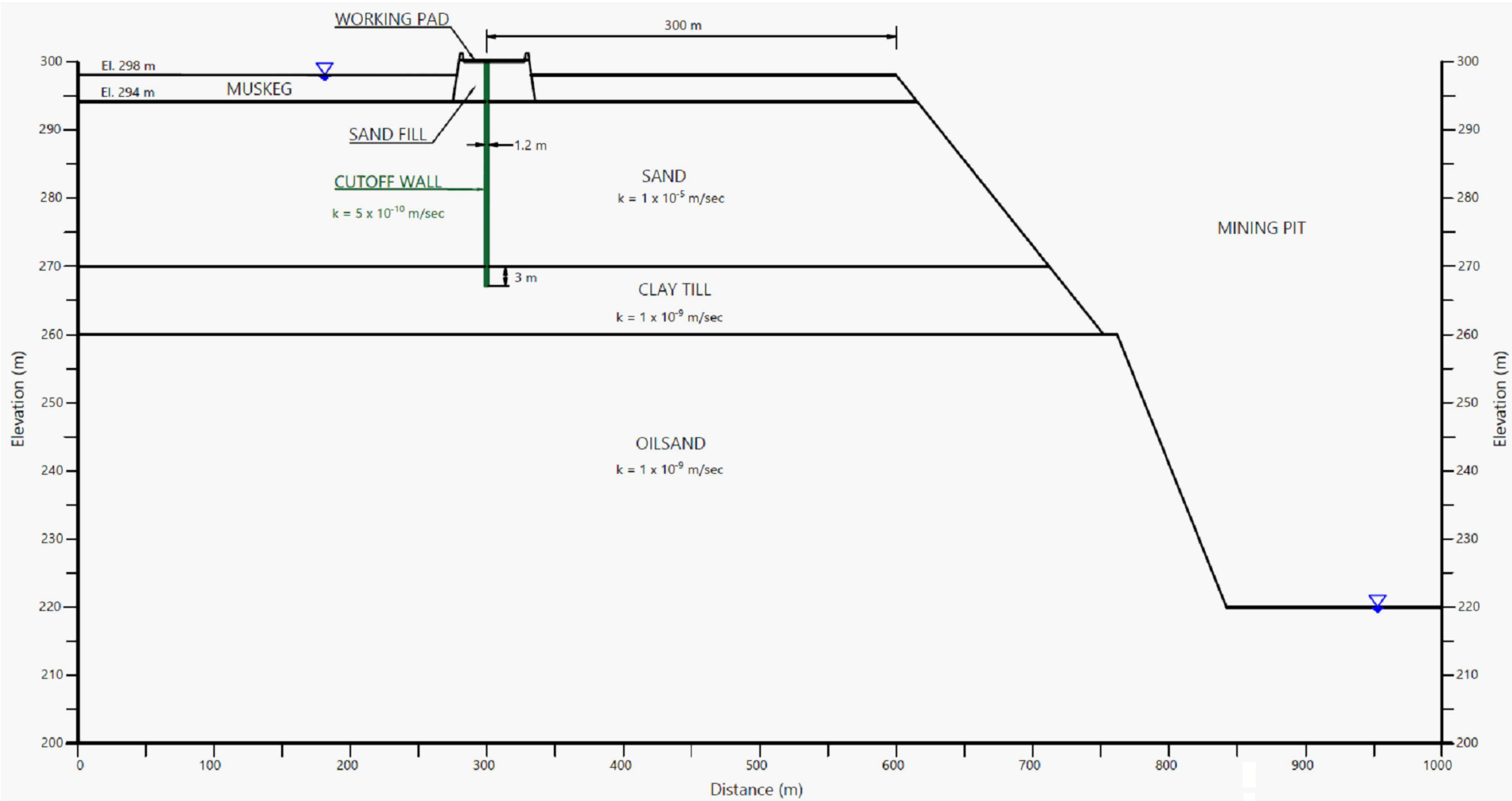
TITLE
GEOLOGICAL CROSS-SECTION ALONG THE CUTOFF WALL ALIGNMENT

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0002	0	5.4-7



NOTE(S)

1. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

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PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

TITLE
TYPICAL CUTOFF WALL DESIGN PROFILE

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0010	0	5.4-8

The initial cutoff wall is currently planned to extend a relatively short distance into the FHUC to the south (i.e., Point D), and a relatively long distance into the NOP to the north (i.e., Point I) between NED and the fen.

Installation of the cutoff wall will require prior construction of a working platform along the entire alignment of the cutoff wall, including the fen crossing with muskeg deposits up to 8 m thick and possibly thicker locally. A conceptual design of typical working platform cross section is shown in Figure 5.4-9. The working platform will support heavy construction equipment requiring strict tolerance on maintaining verticality of the crane mast during excavation of the wall slot. The working platform will also provide a suitable platform for installing the permanent operational system for surface water resupply to the fen.

Constructing the working platform is planned to involve stage loading of the muskeg where required, including a pre-load that is later removed. Pressure berms would be constructed on either side of the central portion of the working platform, to keep the working platform stable. In addition, pressure in the NOP sands will be maintained with the injection wells to prevent subsidence of the peat.

The working platform would be 55 m wide plus a pressure berm on either side which would be in the order of 30 m wide - for a total width of 115 m.

5.4.3.2.2. Alternative Design Concepts

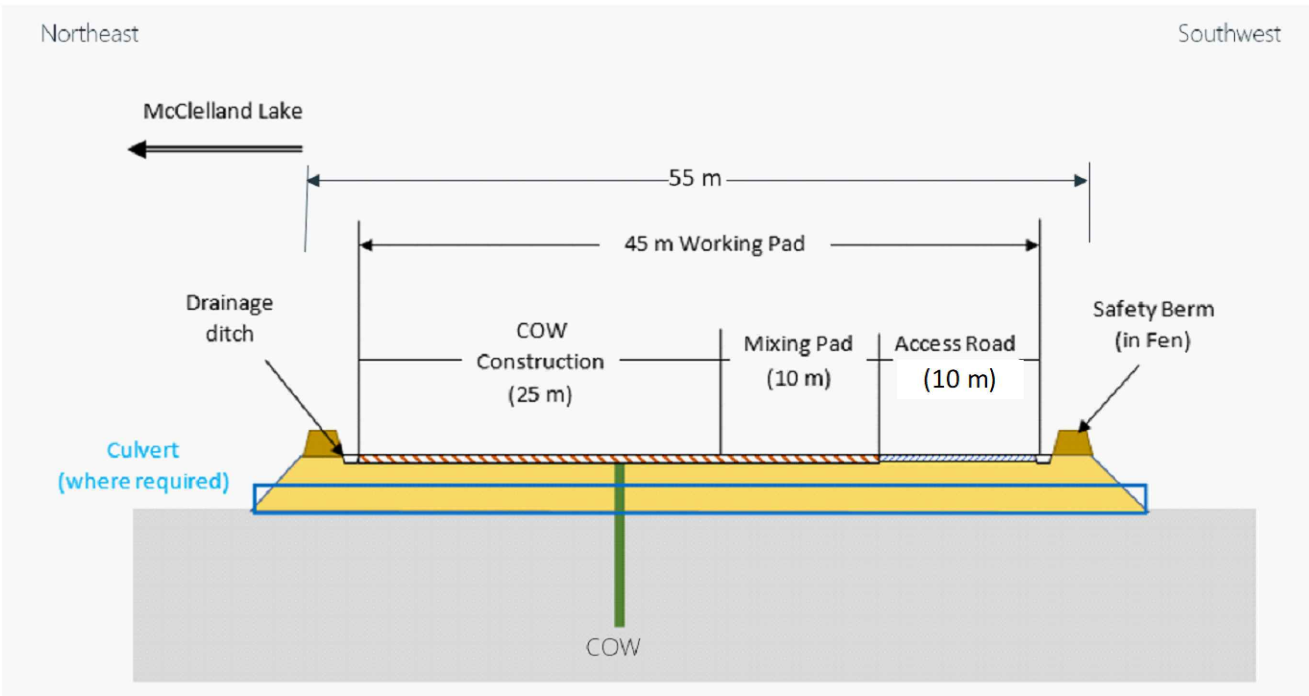
Soil Bentonite (SB) and GSB walls have low permeability. Bentonite is composed of clay minerals and contains no chemical additives, which is appropriate for maintaining water quality in the fen. A GSB wall was preferred over a SB wall, because the GSB wall has the lowest permeability and includes additional fines (silt and clay) to the backfill mixture to achieve a permeability in the 10^{-10} metres per second (m/s) range.

5.4.3.2.3. Further Investigations

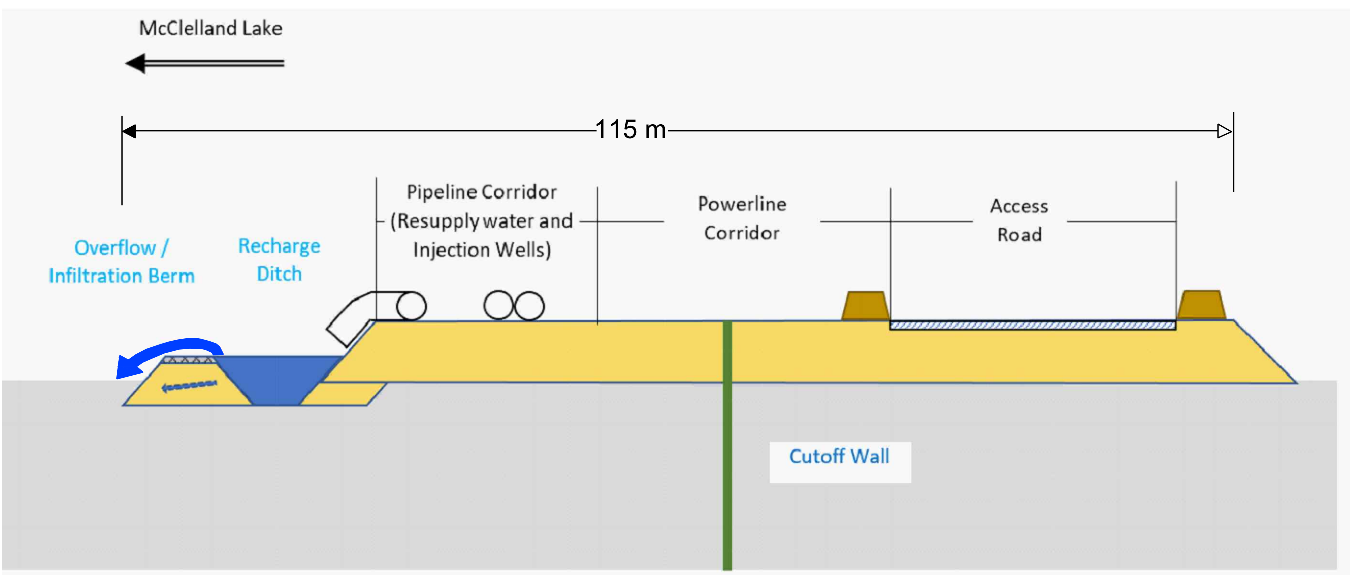
Future results of model refinement will be used to evaluate the potential benefits of modifying the cutoff wall extents north into the NOP and/or south into the FHUC. There will be a trade-off between the length of the wall into the NOP and the number of NOP injection wells. Any extensions to the planned length of the cutoff wall will be evaluated on an observational basis, depending on actual observed performance in the field, upon installation of the planned cutoff wall and NOP injection wells.

Additional geotechnical and hydrogeological site investigations will be conducted for advancing the design of the cutoff wall and the working platform. These investigations will include additional geotechnical borings to provide soil profiles and geotechnical engineering properties along the wall alignment at a reduced spacing, in-situ Cone Penetration Tests (CPTs) to provide engineering properties of the potentially loose surficial sands, further assessment of the liquefaction potential of these sands, and additional data regarding the geotechnical properties and extent of the muskeg.

Bench scale mix design testing will be conducted to determine the quantities of the materials that constitute the GSB backfill. The optimum graded mixture of silt and clay fines available for wall construction will be evaluated by particle size analyses as well as by using variations of the size distribution in the mix design tests to ascertain the lowest practical permeability for the wall.



(a) Working Platform Configuration for Cutoff Wall Construction Phase



(b) Long-Term Configuration after Cutoff Wall Construction for Operation and Monitoring Phase

NOTE(S)

1. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

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PROJECT
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TITLE
CONCEPTUAL DESIGN OF TYPICAL WORKING PLATFORM CROSS-SECTION

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0008	0	5.4-9

Field trials may be conducted for the working platform construction in the fen to provide a proof of concept, and to confirm the design parameters, production rates, and constructability issues to be managed prior to detailed design and full-scale construction.

A detailed assessment of potential borrow sources will be undertaken. This would allow for an assessment beyond the areas covered by the geotechnical boreholes and may provide a better understanding of the extents and continuity of the borrow materials. Available laboratory data for material being considered as potential borrow would be reviewed to assess the suitability of the material. The potential of utilizing overburden material from mining operations would also be considered. A field investigation consisting of boreholes or test pits will be considered to determine extents and continuity of potential borrow sources and allow for laboratory testing to determine the suitability of the materials and water sources.

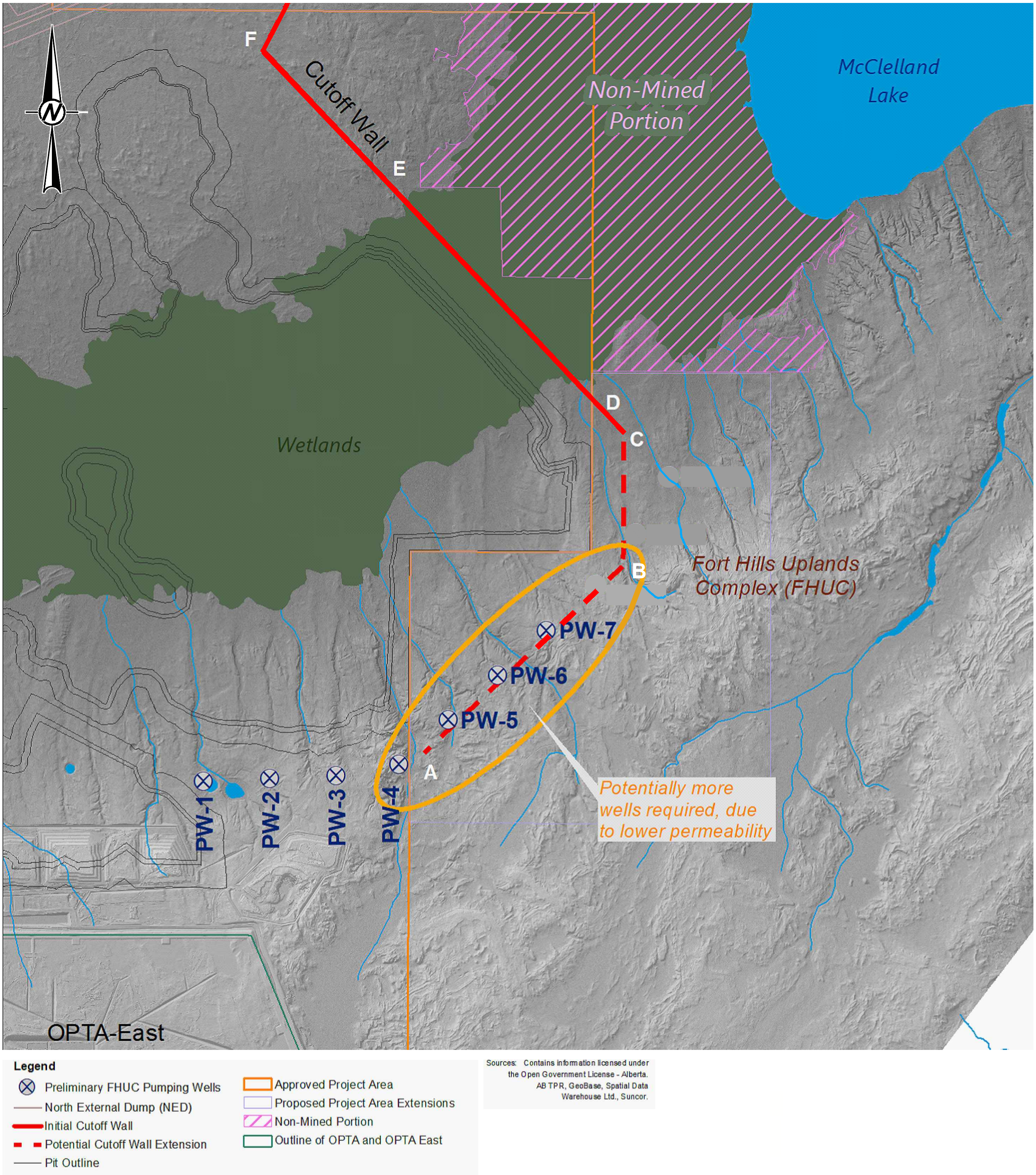
5.4.3.3. Fort Hills Groundwater Pumping Wells

5.4.3.3.1. Conceptual Layout Plan and Design

Pumping wells are planned for intercepting and limiting groundwater seepage from the FHUC to the mine pit as it expands eastward. The water produced by these pumping wells is planned to be used as one of the water sources for resupply to the fen and will be directed via a pipeline to the MLWC water storage pond. A layout plan of the proposed system of evenly spaced pumping wells is shown in Figure 5.4-10. A conceptual design of the pumping well installation is shown in Figure 5.4-11.

These dewatering wells will be drilled to depths of approximately 70 m below ground surface through the Quaternary materials, to terminate in the top of the Quaternary clay till or McMurray Formation. The wells will be installed to be fully penetrating and screened across the silty sand aquifer, with some unscreened segments across larger clay/silt intervals (greater than 1 m thick). The diameters of the wells were estimated to be between 6 and 12 inches. Filter pack sand, screen slot sizes and well diameter will be determined based on particle size data obtained from drilling samples. It is expected that wells will be equipped with a bottom sump to allow placement of the well pump to maximize available drawdown.

Wellhead infrastructure will include a power supply for the pumps, piping and valves, automated pump and water level controls, sampling and monitoring ports, protective coverings and insulation, and a radio telemetry system for data acquisition and programming.



NOTE(S)

1. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

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APPROVED	JH

TITLE
CONCEPTUAL LAYOUT PLAN OF THE FORT HILLS GROUNDWATER PUMPING WELLS

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0007	0	5.4-10

25 mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

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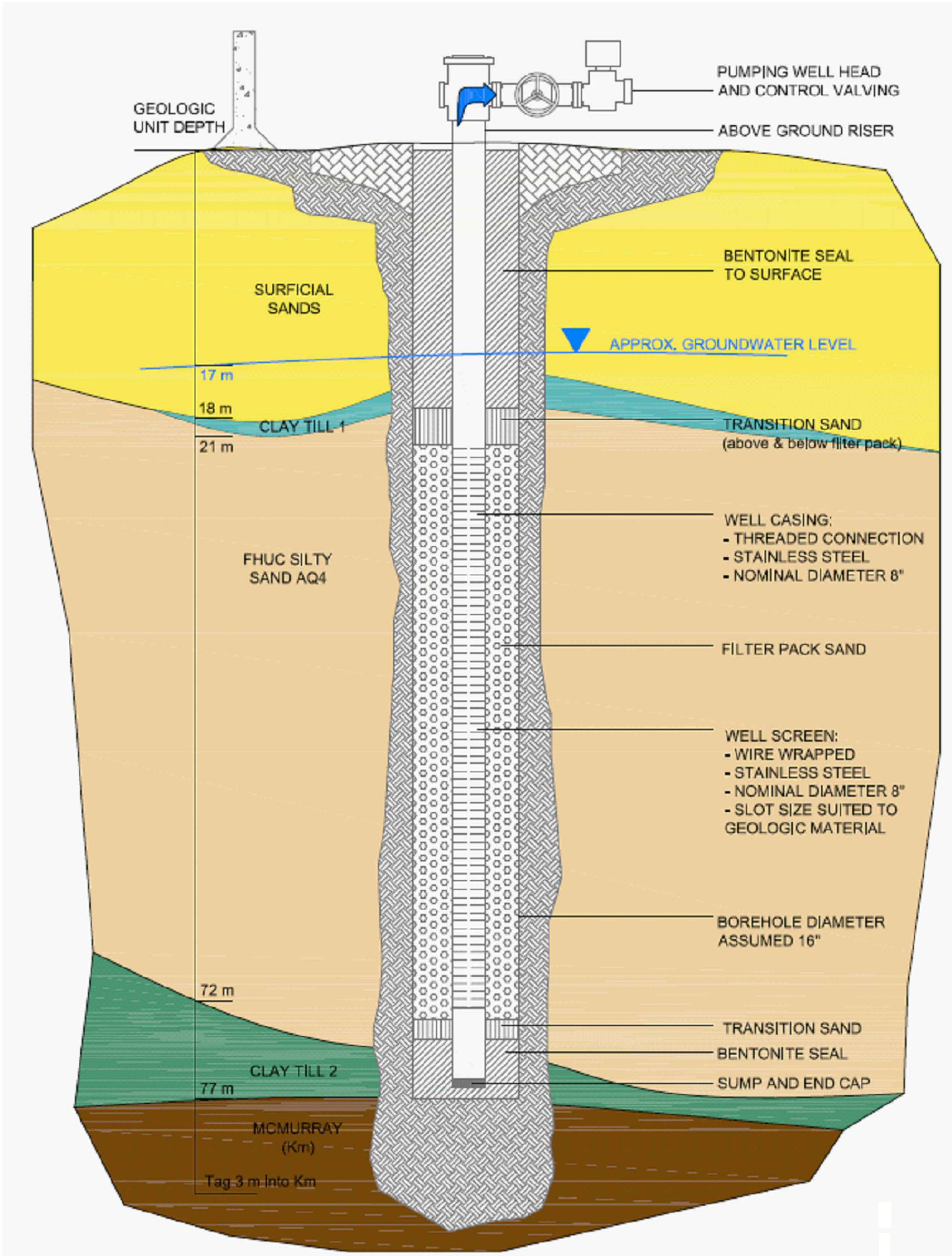

NOTE(S)

1. WOOD PROVIDED THE CONCEPTUAL DESIGN INFORMATION SHOWN IN THIS FIGURE..

CLIENT	FORT HILLS ENERGY CORPORATION
PROJECT	McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN
YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	RFM
REVIEWED	ZG
APPROVED	JH
TITLE	**CONCEPTUAL DESIGN OF PUMPING WELL**
PROJECT NO.	20140450
CONTROL	400-CL-0006
REV.	0
FIGURE	5.4-11

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5.4.3.3.2. Alternative Design Concept

Two alternative methods for controlling the FHUC groundwater seepage to the pit were evaluated but not selected as explained below:

- Horizontal wells or passive drains could be advanced directly into the northwestern slopes of the FHUC or the side slopes of the ravines; however, it may prove difficult to accurately target the more permeable intervals of the Fort Hills aquifer with this method. Maintenance and instrumentation integrity along the long distances that are involved with horizontal completions would also be a challenge. Additionally, the phreatic surface could only be lowered to close to the elevation of the horizontal drain or well. The base of the FHUC is between 295 and 300 metres above sea level (masl), so horizontal completions would not intercept seepage from lower elevations in the aquifer (to approximately elevation of 270 masl).
- Similarly, passive drains or ditches along the toes of the slopes would only intercept seepage from above those toe elevations and not deeper portions of the aquifer. Construction of ditches or drains at the toe of the pit wall would likely have to be preceded by other groundwater control methods to facilitate excavation, which are not preferred.

5.4.3.3.3. Further Investigations

Based on calculations of theoretical additive drawdowns for conceptual well configurations and consistent aquifer properties, a minimum of approximately 10 wells will be required for the groundwater seepage control system. If lower permeability materials are encountered in exploratory boreholes over a wide area, additional wells might be required.

Additional field investigation and testing will be considered to address the uncertainty in the estimation of hydraulic parameters as well as distribution of low hydraulic conductivity and high hydraulic conductivity deposits. Additional pumping wells may be installed and tested to evaluate observed drawdown behaviour. After each test or series of tests, the well configuration and design (depths, spacing from adjacent wells, pump sizes) would be re-evaluated and adjusted to meet the objective of effectively intercepting the groundwater seepage.

There is some uncertainty with regards to the continuity of the FHUC geological stratigraphy adjacent to the fen. At this time, the subsurface information at the FHUC/fen interface is limited and the depositional processes are not certain. There may be data gaps or windows in the low hydraulic conductivity silt/clay deposits beneath the northwestern slopes of the FHUC that allow for connectivity and continuity of more permeable zones, hence allowing groundwater flow between the silty sand aquifer and the surficial sand unit beneath the fen. Ground truthing will be considered for identifying any potential groundwater seeps or groundwater discharges adjacent to the fen so that the proposed dewatering plan can be adjusted as necessary.

5.4.4. Water Treatment

5.4.4.1. Conceptual Layout Plan and Design

In addition to resupplying sufficient quantity of water to the fen (Section 5.2), the quality of the resupply water will need to be suitable so that the resulting water quality in the fen will be within the measured range of variation (Objective 1, Section 2.5.6). Some form of treatment of the source water before delivery of the water to the fen may be required to meet the resupply water quality requirements. The means of treatment will likely vary over time with each stage of water resupply.

The main source of water for resupply will be from muskeg drainage and overburden dewatering, as well as operation of the pumping wells in the FHUC. The required level of treatment for these water sources will be low (e.g., sedimentation ponds for solid settling only as described in Section 5.4.2.1). In addition, the water mixing, dilution and interaction of the sedimentation pond outflows with the natural runoff in the lowland and wetland areas upstream of the fen, will provide additional natural treatment of the sedimentation pond outflows before they reach the fen.

The Athabasca River water is planned to be used as the resupply water source in late mine life and during the reclamation period. A water treatment plant may be required for the river water before discharging to the fen, because the concentrations of some of the river water quality parameters (e.g., sodium and chloride) may be higher than the water quality requirements of the fen.

The water treatment plant, if required, may be located near the injection wells or the water storage pond. The treatment plant may involve raw water pre-treatment (i.e., removal of total suspended solids [TSS], turbidity, dissolved iron), parameters of concern (POC) treatment (e.g., Sodium), and post-treatment to meet the appropriate criteria before delivery for resupply (e.g., through blending, pH adjustment, chemical addition).

5.4.4.2. Alternative Design Concepts

Alternative design concepts for pre-treatment, POC treatment, and post treatment within the water treatment plant were identified and conceptually evaluated as summarized below:

Options for Pre-Treatment:

1. Multimedia filtration
2. Microfiltration/ultrafiltration membranes
3. Greensand filtration

Options for POC Treatment:

1. Ion exchange
2. Reverse osmosis membranes
3. Electrodialysis reversal

Options for Post-Treatment:

1. Blending
2. pH or alkalinity adjustment
3. Chemical addition

5.4.4.3. Further Investigations

The requirements for treatment of the various sources for water resupply to the fen will be further evaluated before any selected water source is used for the resupply operation. If a water treatment plant would be required, further design studies would be conducted to develop the water treatment plant design basis, evaluate the various design options based on pertinent criteria supported by modelling, select the preferred design solution, and prepare preliminary and detailed designs.

5.4.5. Operating Philosophy

- FHEC recognizes the need for an operating philosophy accounting for approximate hydrologic forecasts influenced by future climate conditions that are unknown in advance. A notional plan is described below. FHEC would like the opportunity to hold workshop(s) on this plan with TAG and the SC in 2022. The water resupply system will be operated based on the operating rules that will be developed for specific time intervals (e.g., 4 weeks for ice-cover season and 2 weeks for open-water season) by setting water resupply targets (e.g. median historical inflows to the fen and McClelland Lake) based on measured and simulated historical hydrologic information.
- The water resupply flow delivered in the current time period based on the targets may either exceed or fall below the natural conditions associated with the actual climate occurring during this period. The flow deviation from the natural conditions in the current time period will be accounted for by adjusting the water resupply target in the subsequent time period. A combination of effects monitoring data (e.g., water levels), operational climate and hydrologic monitoring data (e.g., precipitation), and simulated historical hydrologic information (e.g., inflow rate to the fen) will be considered and assessed for adjusting the water resupply target if necessary for the subsequent time period.
- It is anticipated that computer modelling will be conducted to derive the water resupply targets and validate/assist hindcasting efforts in the early stages of operation. The modelling effort is expected to be reduced and replaced by an improved approach with time (e.g., machine learning).
- In addition to ongoing precipitation monitoring, snowpack measurements will be conducted to help increase hydrologic hindcasting accuracy and water resupply reliability during the spring, when the highest water flow rates are introduced to the fen and McClelland Lake.

It is important to note that operating plans will continue to mature as engineering progresses on individual design features. Water modelling presented in Objective 3 is focused on design sizing requirements for the mitigations as opposed to operation.

5.4.6. Closure Landforms and Drainage Facilities

5.4.6.1. Design Objectives

As discussed in Section 5.3.3, the closure drainage systems as described in the OP, are intended to be conceptually aligned with the Fort Hills LMCP included as part of the IPA Application (FHEC 2021).The conceptual closure landscape and drainage systems for Fort Hills Project (including MLWC) were designed with the following general objective:

> *Developed lands shall be reclaimed to a self-sustaining, locally common boreal forest ecosystem, compatible with pre-development, including forested areas, wetlands, and streams. The reclaimed lands will provide a range of end land uses, including forestry, wildlife habitat, traditional use, and recreation.*

As discussed in Section 5.1.1, the LMCP will continue to be updated over time, and will present the current closure concept for the Fort Hills Project including MLWC.

5.4.6.2. Design Approach

A geomorphic approach was used to design the conceptual closure landscape and drainage systems. This design approach aims to provide sustainable, dynamic landforms and drainage facilities capable of accommodating evolutionary changes without accelerated erosion or unacceptable environmental effects and risks.

The geomorphic approach is based on the recognition that natural systems are in regimes and that they exhibit sediment equilibrium and dynamic stability. It recognizes that natural landforms and drainage features change over time because of climatic, hydrologic, and biologic processes. Anticipating such evolutionary changes enables the design of robust landscape and drainage systems with multiple lines of defence.

Natural channels are capable of accommodating extreme flood events because flow velocities are reduced by the presence of wide valleys (or 'floodplains'). Accordingly, the closure drainage plan for Fort Hills Project incorporates drainage features such as floodplains, shallow wetlands, and lakes to attenuate flood flows and provide the capability to accommodate extreme hydrologic events without large damage.

The existing literature and geomorphic studies for the oil sands region include extensive data that correlate channel regimes with hydrologic, topographic, and soil conditions. This information provides a foundation for channel design that mimics the dynamic character of natural channels, avoids rapid channel degradation or aggradation, and exhibits the following characteristics:

- dynamic stability
- robustness
- longevity
- self-repairing mechanisms

The objective of providing an ecologically productive boreal landscape supporting diverse fish and wildlife habitats is accomplished by providing a diverse landscape of upland and lowland areas and by incorporating shallow wetlands and pit lakes with littoral zones.

5.4.6.3. Design of Closure Landforms

The closure landscape plan, including the various closure landforms, is presented in Figure 5.3-9. Design of the major closure landforms within the McClelland Lake watershed is described below.

5.4.6.3.1. Reclaimed North External Dump

The NED will be an ex-pit overburden dump. The total area of NED with drainage included in the McClelland Lake watershed will be approximately 8.2 km^2. The maximum surface elevation of NED will be approximately 366 masl, and the minimum toe elevation of NED approximately 306 masl. The drainage system at NED will consist of the following intermittent watercourses:

- Main drainage channels conveying the runoff from the top surface of the dump with routing in a general direction from north to south.
- Perimeter drainage channels conveying the runoff from the side slopes of the dump with routing, also in a general direction from north to south.

The alternative drainage concept of routing the runoff from the top surface of NED toward the No Net Loss Lake was evaluated but not selected for the closure plan. Including the NED drainage in the McClelland Lake watershed will help reduce the Fort Hills Project's effect on the water balances of the fen and McClelland Lake post closure.

5.4.6.3.2. Reclaimed North Pit

The northeastern part of the North Pit will be backfilled with overburden materials with a top layer of select overburden sands to restore the pre-mining Quaternary aquifer in the pit area. The reclaimed North Pit area included in the McClelland Lake watershed will be approximately 24.5 km^2, with an elevation range of approximately 300 to 297 masl. The reclaimed area will have relatively small overland slopes ranging from approximately 0.5% to 1%. The drainage channels in the reclaimed North Pit area will route the runoff toward the constructed fen area.

The alternative drainage design concept of including the North Pit Tailings Areas (NPTA) Phase 1 and Phase 2 as well as the Out-of-Pit Tailings Area (OPTA) East Phase 1 area in the McClelland Lake watershed was evaluated but not selected, because these two areas will contain tailings and the runoff water quality following initial reclamation activities may not be suitable for routing the runoff toward the non-mined portion of MLWC. Routing the runoff from these reclaimed tailings areas to the Center Pit Lake is the preferred solution. Additional passive water treatment is expected to occur within the pit lake and pit lake outflow quality will be suitable for release to the downstream receiving environment.

5.4.6.3.3. Constructed Fen

A fen wetland will be constructed in the North Pit to function as a buffer between the non-mined portion of the natural fen and the upstream reclaimed areas. The constructed fen will have a surface area of approximately 1.1 km^2, and an average elevation of approximately 297 masl. The fen will consist of a 1.5 m thick layer of peat salvaged from the Fort Hills Project footprint on top of backfilled overburden. Fen revegetation may be initiated through a combination of seedling planting, spreading of locally collected clippings, natural ingress, and seeding. It is expected that the constructed fen will perform as a graminoid fen once established.

The alternative design concepts of creating a mineral wetland or a pit lake were evaluated but not selected, because the constructed fen will mimic the pre-mining condition in the area while accommodating the overburden backfill plan for the pit.

5.4.6.4. Design of Closure Drainage Channels

The closure drainage channels, which are labelled as "Constructed Closure Channels" in Figure 5.3-9 and Figure 5.3-10, were designed as alluvial channels. The term "alluvial channel" refers to a stream in which the channel bed is comprised of loose sediments, known as "alluvium", that is deposited by flowing water. Alluvial channels have bed materials ranging in size from clay, to sands, gravels, and boulders, and contain either aquatic vegetation or no vegetation. Alluvial channels have the capability to adjust and change gradually over time. Anticipated changes that may occur include the following:

- Deposition of sediment resulting in a gradual raising of the channel bed and a reduction in the channel conveyance capacity (i.e., channel aggradation).
- Erosion of the channel bed resulting in a gradual lowering of the channel bed (i.e., channel degradation).

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- Vegetation growth on the channel beds and banks resulting in an increase in channel roughness, a decrease in channel flow velocities and conveyance capacity, and protection against erosion.
- Reduction of the channel width due to sedimentation along the banks.
- Overtopping and consequent relocation of drainage channels within the floodplain because of excessive sedimentation, beaver dams, or icing.
- Bank erosion and subsequent failure because of slope instability and/or slumping.

Constructed alluvial closure channels are expected to mimic the form and function of natural alluvial channels when they are properly designed, and to evolve over time without accelerated erosion or unacceptable environmental effects. Typical cross-sections of alluvial closure drainage channels are provided in Figure 5.4-12. The main drainage channels will be designed to convey the bankfull discharges and floodplains are designed to contain the Probable Maximum Flood and to allow for potential channel meandering.

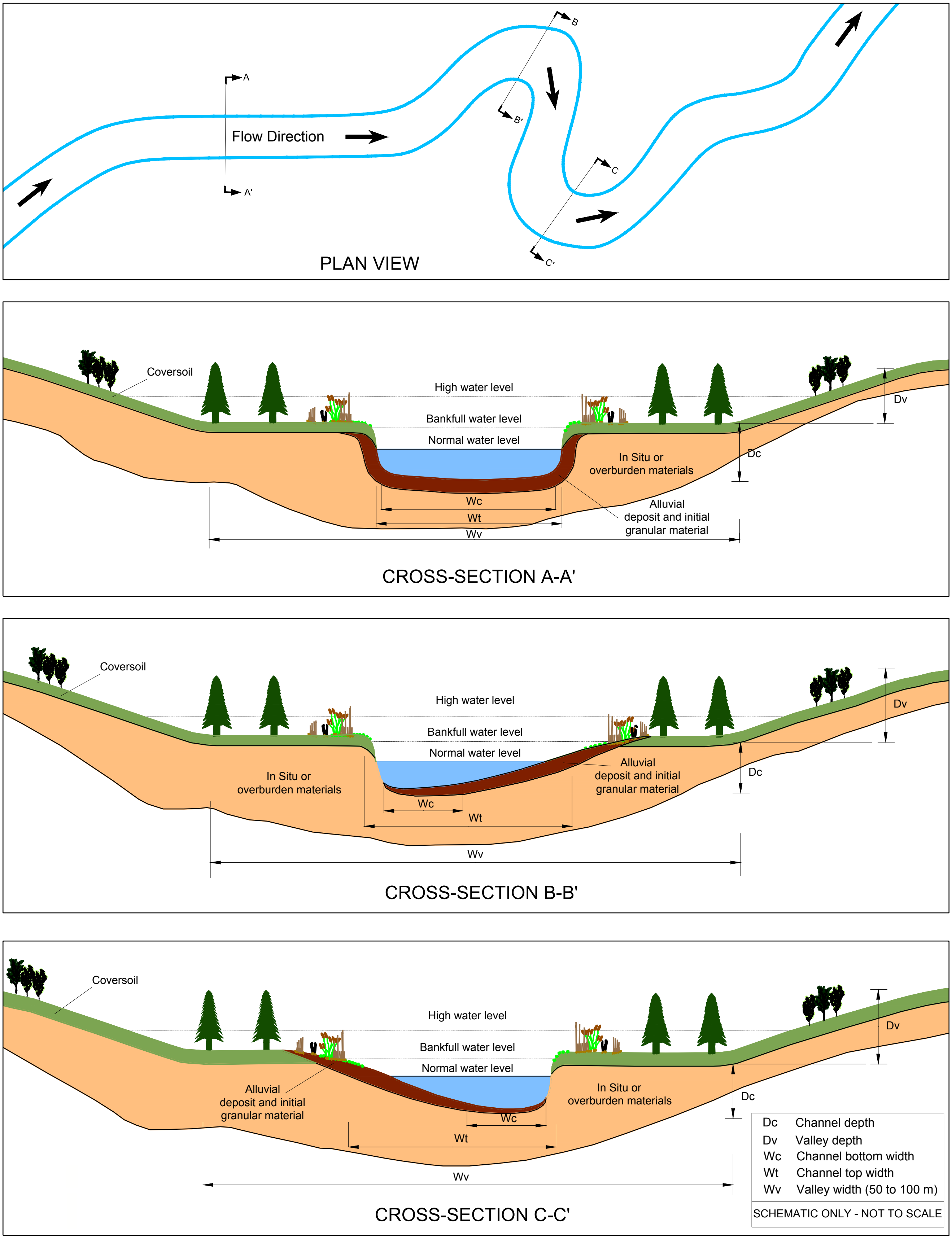
Regime relationships governing channel width, depth, sinuosity, channel slope, and meander wavelength were developed for the oil sands region (Golder 2008a,b). The Alluvial Channel Design Manual (Golder 2008b) was developed based on these relationships. This manual and the applicable regime relationships will be used as a primary guide in the selection of the channel design parameters for designing the closure alluvial channels.

Channels on steep slopes will be constructed with bouldery ground materials with a supply of larger granular material for self-armouring over time. Materials consisting of large rocks, gravel, sand, silt, and clay will be placed below the channel and across the floodplain. To reduce the quantity of granular material required for steep sloped channels, ‘sacrificial armouring cells’ can be incorporated as an alternative design. This design provides the channels with a self-repairing capability and gives them the ability to dynamically adapt within the entire floodplain.

5.4.6.5. Cutoff Wall

The current plan is to leave the low permeability cutoff wall in place post closure for sustaining groundwater levels in the fen, but the working platform and top portion of the cutoff wall across the fen will be removed to facilitate surface water flow from the reclaimed areas to the fen. The platform and cutoff wall are planned to be left in place until water quality is suitable for release to the non-mined portion of MLWC.

There may be a potential need to establish an efficient hydraulic connection of the Quaternary aquifer beneath the fen with the surficial aquifer in the backfilled and reclaimed North Pit areas, for mimicking pre-mining groundwater flux to the fen. This potential need is addressed in the contingency mitigation plan (Section 5.5).



CLIENT
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PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

CLIENT
FORT HILLS
Operated by Suncor Energy

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	RFM
REVIEWED	ZG
APPROVED	JH

TITLE
CONCEPTUAL DESIGN OF TYPICAL ALLUVIAL CHANNELS

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0013	0	5.4-12

5.5. Contingency Mitigation Measures

The proposed design features and water management system are expected to function as planned to help achieve the mitigation objectives of maintaining ecosystem diversity and function of the non-mined portion of the MLWC. However, the following contingency mitigation measures to address potential functional gaps of the proposed water management system, were identified during development of this operational plan:

- Depending on the actual observed performance of the cutoff wall, a longer wall into the NOP (i.e., beyond I shown in Figure 5.4-6) and/or the FHUC (i.e., from Points A to C shown in Figure 5.4-6) may be required. Extending the cutoff wall further into these areas would also require deeper walls.
- Sand fracturing or removal of the low permeability cutoff wall across the fen may be required for closure to enable efficient hydraulic connection of the Quaternary aquifer beneath the fen with the surficial aquifer in the backfilled and reclaimed North Pit areas. The potential need for this mitigation measure will be further evaluated based on future investigation and performance monitoring of the mitigation system during the operational phase.

5.6. Access and Security Management

The SC has shared the importance of mitigating some of the current and future potential effects on land users in the McClelland Lake area by providing safe, reliable access to areas important to local Indigenous community members while deterring access by non-local, non-Indigenous users. The SC has shared some ideas and recommendations around access and security including:

- notifying community members and trappers about change in access routes
- providing maps of access routes and points (either via a printed map, a website or a mobile phone application)
- installing signs (such as no access or no hunting) to discourage entry into access routes around the fen and lake
- supporting site safety programs (examples include guardian or ranger programs)
- creating alternate access routes so that land users can avoid active development areas; and
- providing orientation and awareness training for new staff, security personnel and contractors working in the area

While Fort Hills Operations does not manage access to lands outside of its active development areas, Fort Hills Operations can work with the SC to share maps of recent drilling programs and any modifications to access routes created by Fort Hills Operations activities.

5.7. Culture, Education, and Learning

McClelland Lake provides local Indigenous land users with an important area for cultural, spiritual, education and wellness practices. These critical cultural activities link to the MLWC wetland functions from Objective 2 and can include (but are not limited to) hunting and trapping, plant gathering (consumption, medicinal and ceremonial purposes), water use, experience on the land related to culture and habituation, education, and learning, as well as health and wellbeing of community members.

The SC has provided recommendations around cultural mitigations including:

- mapping access areas (as Section 5.4.1 above)
- providing for a spiritual gathering and ceremony at McClelland Lake (prior to development at the site)
- supporting community driven initiatives aimed at supporting cultural retention such as harvest camps and student training/learning programs
- supporting use by building restricted access and camping areas around the north side of the lake
- supporting mentoring relationships between elders and youth
- supporting learning and e-learning initiatives
- signage and displays to recognize the important Indigenous history in the area, indicating these are sacred grounds and to encourage respectful and proper use of the area.

FHEC will work with the SC to find opportunities to promote cultural, spiritual, education and wellness practice in the McClelland Lake area.

5.8. Implementation Schedule

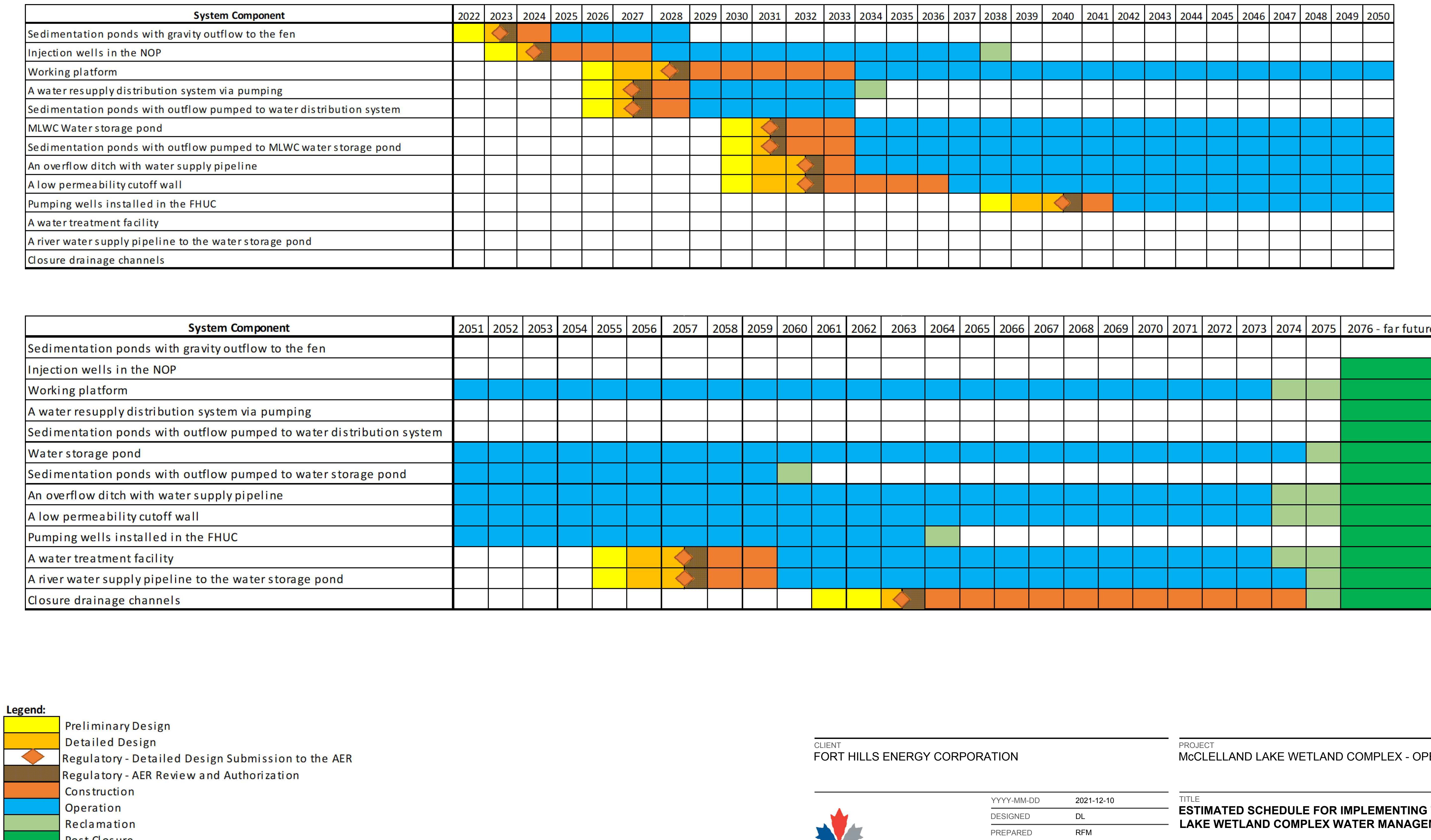
The estimated periods of operation of the various water management system components are summarized in Table 5.8-1. The estimated schedule for next stage of engineering design, construction, operation, reclamation, and closure of the various system components is presented in Figure 5.8-1. This implementation schedule is also graphically reflected in the conceptual system layout plans (Figure 5.3-2 to Figure 5.3-9).

Also shown in Figure 5.8-1 is the regulatory schedule, FHEC will submit detailed engineering designs pursuant to *Water Act* Approval 151636-01-00 (as amended), at least six months prior to the start of associated construction activities for a design feature. FHEC plans to continue to refine and update this implementation schedule as the mine development plan and schedule continue to be refined and updated, and as further data collection, studies, investigations, and planning and design works are completed. FHEC will work in collaboration with the SC and its Advisory Groups to share information and review mitigation plans.

Table 5.8-1: Operational Periods of the Various Water Management System Components

Phase	Category	System Component	Period of Operation
Operation and Reclamation	Surface Water Management	Sedimentation ponds with gravity outflow to the fen	2025 - 2028
		Sedimentation ponds with outflow pumped to the water storage pond	2029 - 2059
		A water resupply distribution system via pumping	2029 - 2033
		Water storage pond	2034 - 2075
		An overflow ditch with water supply pipeline	2037 - 2075
		A river water supply pipeline to the water storage pond	2060 - 2075
	Groundwater Management	Injection wells in the NOP	2028 - 2037
		Working platform	2034 - 2075
		A low permeability cutoff wall across the fen as well as between NED and the fen	2037 - 2075
		Pumping wells installed in the FHUC	2042 - 2063
	Water Treatment	A water treatment plant (if required)	2060 - 2075
Post Closure	Surface Water Drainage	Closure drainage channels conveying runoff	2076 - far future
	Groundwater Control	The low permeability cutoff wall to remain partially in place	2076 - far future

FHUC = Fort Hills Upland Complex; NED = North External Dump; NOP = North Outwash Plain.



CLIENT
FORT HILLS ENERGY CORPORATION

PROJECT
McCLELLAND LAKE WETLAND COMPLEX - OPERATIONAL PLAN

YYYY-MM-DD	2021-12-10
DESIGNED	DL
PREPARED	RFM
REVIEWED	ZG
APPROVED	JH

TITLE
ESTIMATED SCHEDULE FOR IMPLEMENTING THE McCLELLAND LAKE WETLAND COMPLEX WATER MANAGEMENT SYSTEM

PROJECT NO.	CONTROL	REV.	FIGURE
20140450	400-CL-0016	0	5.8-1

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FHEC (Fort Hills Energy Corporation). 2021. *Fort Hills Oil Sands Project – Integrated Plan Amendment Application*. Submitted to the Alberta Energy Regulator on December 9, 2021.

Golder (Golder Associates Ltd.). 2008a. *Geomorphic Characterization and Design Alluvial Channels in the Athabasca Oil Sands Region*. Prepared for the Canadian Oil Sands Network for Research and Development, and Fisheries and Oceans Canada.

Golder. 2008b. *Alluvial Channel Design Manual Procedures for the Athabasca Oil Sands Region*. Prepared for the Canadian Oil Sands Network for Research and Development and the Department of Fisheries and Oceans Canada.

ABBREVIATIONS, ACRONYMS, AND UNITS

Abbreviations and Acronyms

Abbreviation / Acronym	Definition
CPT	Cone Penetration Test
e.g.,	for example
FHEC	Fort Hills Energy Corporation
FHUC	Fort Hills Upland Complex
Fort Hills Project	Fort Hills Oil Sands Project
Golder	Golder Associates Ltd.
GSB	Graded Soil Bentonite
HDPE	high-density polyethylene
2020 MLWC HGS model	HydroGeoSphere Model
H:V	Horizontal:Vertical
i.e.	that is
IPA	Fort Hills Integrated Plan Amendment Application
LMCP	Life of Mine Closure Plan
MLWC	McClelland Lake Wetland Complex
NED	North External Dump
NOP	North Outwash Plain
NPTA	North Pit Tailings Area
OP	Operational Plan
OPTA	Out-of-Pit Tailings Area
POC	parameters of concern
SB	Soil Bentonite
TDS	total dissolved solid
TSS	total suspended solids

Units

Unit	Definition
%	percent
km	kilometre
km^2	square kilometre
m	metre
m/s	metres per second
m^3/day	cubic metres per day
masl	metres above sea level
Mm^3	million cubic meters