

Attachment A-4

Waste Management Facility – Environmental Management Plan



Norman Wells Operations

Waste Management Facility Environmental Management Plan

February 2020

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Plain Language Summary

Introduction

As part of the Interim Closure and Reclamation Plan (ICRP) for Imperial's Norman Wells Operations, a waste management facility (WMF) is needed for the long-term storage of impacted materials. Imperial is applying to the Sahtu Land and Water Board (SLWB) to include the WMF in Water Licence S13L-007. This document supports the Water Licence application and describes how the facility will be managed.

The WMF is an engineered structure designed to contain non-hazardous waste materials generated from closure and reclamation activities for an indefinite period of time. Material consolidated in the WMF will be isolated between a lower liner and an upper cover intended to prevent contact between impacted soils and the surrounding surface or subsurface environment.

The WMF is located on and adjacent to the closed mainland sumps area on the Operations mainland. The site is located within the Proven Area on the northern side of the Mainland ring road (Canol Drive), north of the Mainland Tank Farm and west of the airport area.

A collection system will be used to gather liquids (leachate) from the lower liner. Leachate will be disposed of through an injection well into the Norman Wells oilfield. The requirement an alternate leachate treatment facility, if and when the injection well is no longer available, will be assessed based on the leachate quantity and quality observed during facility operations.

WMF Environmental Management Plan

This management plan describes how the WMF will be monitored and maintained during construction and operation to meet the following objectives:

1. confirm the effectiveness of the containment system to prevent contact of impacted materials with the surrounding environment;
2. identify maintenance requirements to make sure the containment system is operating per the design standards;
3. identify any potential releases of contaminants to the surrounding environment;
4. define the appropriate response in the event of a contaminant release and
5. determine leachate management requirements.

The management plan will be updated as needed following detailed design and construction.

Surface Water

After construction, surface water will be monitored to confirm the separation between rain water and impacted materials in the WMF. Monitoring will also include inspections of drainage ditches and sampling and testing of surface waters. Water samples will be tested using the protocols defined in the Quality Assurance and Quality Control Manual.

Groundwater

Groundwater will be monitored by a series of wells installed around the edge of the WMF to ensure the containment system is in good working order and impacts are not leaching into the groundwater. Monitoring wells will target the groundwater table and the upper bedrock aquifer. Monitoring data will be collected in accordance with the sampling frequency and methodology outlined in the GMP.

Leachate Monitoring

Leachate will be monitored to figure out if a leachate treatment plant is needed and to validate the effectiveness of the cover and liner systems. The anticipated range of leachate volumes fall within the capacity of the on-site injection well, F-31X. Leachate volumes will be disposed of through the injection well until leachate volumes exceed the capacity of the well or the water quality of the leachate requires separate treatment, at which time a wastewater treatment facility will be installed to manage produced leachate. Leachate sampling will follow the GMP.

The cover will be monitored to check it is not damaged and/or leaking and to confirm that vegetation is in good condition. Inspections will identify issues and will be used to plan maintenance activities such as restoration of cover vegetation, repair of erosion, or repair of the cover itself.

Contingencies

Monitoring will be used to identify potential problems with the integrity of the cover and/or liner that may lead to contaminants coming in contact with surface water and/or groundwater. Indicator parameters will be monitored, and the containment system (cover/liner) will be repaired if it is found to be leaking.

Leachate volumes will be measured and tracked to figure out if a treatment plant is needed. Leachate may be trucked off-site for disposal if development of a treatment facility is deemed impractical.

Revision and Conformity Table

Date	Version	Rev	Details	Pages
February 2020	1	1	Created WMF-EMP for submission to SLWB	All pages were reviewed

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Glossary and Acronyms

Category 1 Well	Wells installed for the purposes of monitoring daily on-going operations intended for the identification of change near active work sites; data is submitted in the <i>Annual Water Use Report</i> .
Category A location	A source location not anticipated to have impacts.
Category B location	A source location anticipated to have impacts.
Category C location	A source location not anticipated to have impacts; further periodic monitoring is required to confirm this assumption.
Construction water	Water that accumulates in excavations, ditches or low spots during construction.
Cover	A physical barrier (cap) designed to prevent surface water contact with contaminated materials below.
Leachate	Liquids produced by contact with contaminated soil or materials.
Leachate collection system	A system of tubes placed above a liner designed to gather liquids from the bottom of the waste management facility.
Liner	A membrane designed to prevent the transfer of water.
Sentinel well	A groundwater well situated between a downgradient receptor and a potential source of impact; intended to detect contamination in areas unaffected by Imperial's operations.
Surveillance Network Program	Formal list of groundwater monitoring wells and surface water monitoring locations and sampling requirements.
Waste Management Facility	An earth-based structure, similar to a traditional landfill, engineered to provide for the containment of impacted materials over indefinite timeframes.

AER	Alberta Energy Regulator
EPP	Environmental Protection Plan
GMP	Groundwater Management Plan
IRCP	Interim Closure and Reclamation Plan
KB/RT	Kelly bushing / rotary table
NT	Northwest Territories
QAQCM	Quality Assurance Quality Control Manual
SLWB	Sahtu Land and Water Board
UWI	Unique well identifier
WID	Well identifier
WMF	Waste Management Facility
WMF-EMP	Waste Management Facility – Environmental Management Plan
WMP	Waste Management Plan

Introduction

Background

The Norman Wells Operations, owned and operated by Imperial Oil Resources N.W.T. Limited (Imperial), is an upstream oil and gas facility located approximately 700 km northwest of Yellowknife, Northwest Territories (NT). Operations include a central processing facility, which receives production from wells on the mainland along the northeastern shore of the Mackenzie River, natural islands (Goose Island, Bear Island, and Frenchy's Island), and six artificial islands.

As part of the Interim Closure and Reclamation Plan (ICRP) for the Norman Wells Operations, a waste management facility (WMF) is required for the long-term storage of impacted materials. Imperial is applying to the Sahtu Land and Water Board (SLWB) to amend applicable components of Water Licence S13L-007 to include the WMF.

Under conditions of Water Licence S13L-007, Imperial maintains and updates several management plans. In most cases, the proposed WMF can be easily incorporated into overarching plans developed for the Norman Well Operations. However, because of differences between ongoing operational activities and the static nature of the WMF, some aspects of the WMF are better captured in a dedicated plan.

A separate Waste Management Facility Environmental Management Plan (WMF- EMP) is required to ensure that the facility is functioning as designed to prevent the release of materials contained within the structure to the surrounding environment. The elements of the plan focus on the WMF as a specific, discreet source of potential impact, in contrast to Imperial's other management plans under the Water License, which tend to consider the collective impacts of the Operations broadly. The WMF-EMP describes monitoring of the physical integrity of the facility, the nature and volume of any liquids (i.e., leachate) contained within it, and its impact on the quality of local groundwater and surface water.

Plan Objectives

Throughout construction and operation of the WMF, both its first stage of development and the expanded configuration at final build-out, ongoing monitoring is required to meet the following objectives:

1. confirm the effectiveness of the containment system to prevent contact of impacted materials with the surrounding environment;
2. identify any maintenance requirements to ensure the containment system is operating per the design standards;
3. identify any potential releases of contaminants to the surrounding environment;
4. define the appropriate response in the event of a contaminant releases; and
5. determine leachate management requirements.

This plan outlines future monitoring of the following elements of the WMF and/or its local environments including:

- surface water;
- groundwater;
- leachate; and
- cover integrity.

Plan Linkages

In addition to the WMF-EMP, Imperial maintains other management plans for the Norman Wells Operations. Imperial will leverage established site protocols from other management plans for the WMP-EMP as described in Table 1.

Table 1: Operations Management Plans

Plan	Description	Linkage to WMF-EMP
Groundwater Management Plan (GMP)	The GMP describes monitoring of groundwater in and around on-going active operations and is intended to act as an early detection system for changes to groundwater.	Protocols established in the GMP (i.e., measurement techniques and excursion responses) will be used for groundwater monitoring at the WMF.
Quality Assurance and Quality Control Manual (QAQCM)	The QAQCM outlines steps and procedures for surface water management.	Protocols for surface water established in the Quality Assurance and Quality Control Manual (i.e., measurement and water release procedures) will be used for surface water monitoring at the WMF.
Waste Management Facility Environmental Management Plan (WMF-EMP)	The WMF-EMP describes operations, monitoring, and maintenance activities for the WMF including management of surface water, groundwater, leachate and cover integrity.	
Environmental Protection Plan (EPP)	The EPP outlines environmental management and protection practices and defines actions and responsibilities of employees and contractors to meet the intent of Imperial's Environmental Policy.	Environmental impacts and mitigations associated with the WMF are included in the EPP.
Waste Management Plan (WMP)	The WMP identifies waste streams generated by Imperial and outlines overall on-site waste management including processes, standards, and storage and treatment locations.	The WMF is listed as an on-site storage location in the WMP. Waste materials that may be disposed in the WMF are summarized in the WMP Waste Information Table (Appendix B).

After detailed design, locations of the groundwater monitoring wells and surface water monitoring locations will be finalized and the WMF-EMP will be updated to confirm facility monitoring details. Anticipated reporting from the WMF is described in Table 2.

Table 2: Anticipated WMF reporting

Report	Timing	Comments
<i>Annual Water Use Report</i>	Yearly by March 31	WMF monitoring data will be included in the Annual Water Use Report.
<i>Annual Closure and Reclamation Plan Progress Report</i>	Yearly by May 31	Volume of material generated from conservation & reclamation activities that will be transferred to the WMF at Operations Closure.
<i>Annual Flowline Integrity and Mackenzie River Breakup Report</i>	Yearly by October 31	WMF out of scope for the report

Plan Ownership and Updates

The plan will be owned by Imperial Norman Wells Operations. The first update to this management plan is expected to occur following final design of the WMF. Thereafter, the plan will be reviewed on an annual basis and updated as required.

Baseline Setting

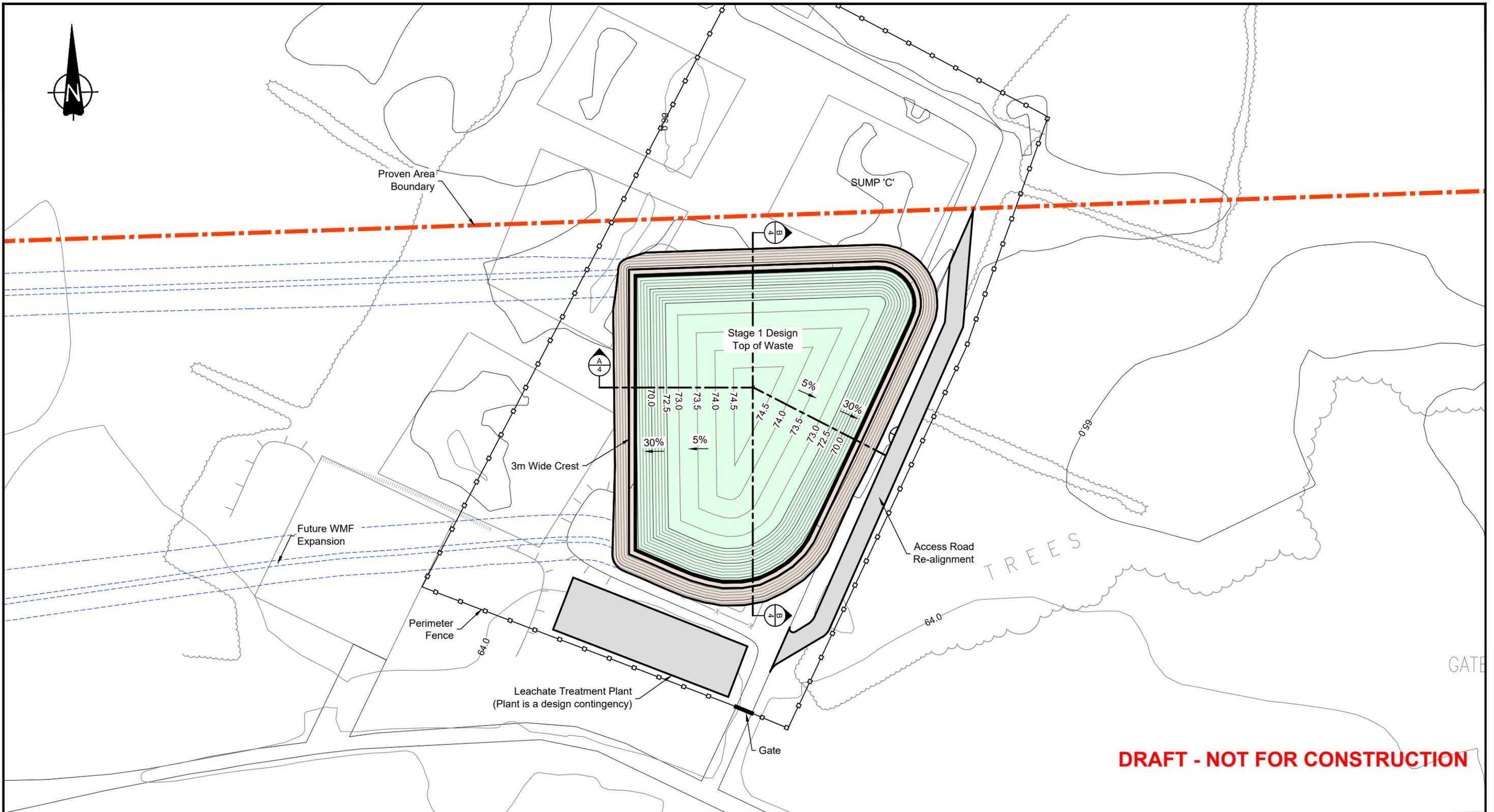
WMF Design Overview

The WMF is an engineered structure providing for the indefinite containment of impacted materials generated by Imperial's Norman Wells Operations. The WMF will be used to manage the proportion of the impacted non-hazardous soil inventory that is not treatable, and structure dismantling/ demolition debris produced during closure and reclamation activities. A general arrangement of the first stage of WMF development that is currently planned is shown on Figure 1.

The WMF is located on and adjacent to the closed mainland sumps on the Operations Mainland. The site is located on the northern side of the Mainland ring road (Canol Drive), north of the Mainland Tank Farm and west of the Norman Wells airport area.

Contaminated material in the WMF will be isolated between a lower liner and an upper cover to prevent release of leachate to groundwater and contact between contaminated materials and surface waters. The facility is designed to:

- prevent the release of contaminants to the environment; and
- prevent surface water from contacting contaminated materials.



DRAFT - NOT FOR CONSTRUCTION

LEGEND

- Future WMF Expansion
- WMF Base and Berms
- Contaminated Soil

1 : 2000

CLIENT:

IMPERIAL OIL LIMITED

Environment & Infrastructure Solutions
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 PHONE 403-387-1639

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:	NORMAN WELLS INTERIM CLOSURE AND RECLAMATION PLAN FDB UPDATE
TITLE:	WMF STAGE 1 TOP OF WASTE PLAN FOR 144,000 m³ STORAGE CAPACITY

DATE:	NOV. 2019
PROJECT No.:	CE4839.0020
REV. No.:	A
DWG. No.:	1

A collection system will be used to gather leachate from the WMF. Collected leachate will be injected into the Norman Wells Proven Area oilfield reservoir, through an on-site injection well. The requirement for a treatment plant to manage leachate volumes after termination of oilfield production will be determined before final site closure and will depend on measured leachate volumes and qualities. The WMF design includes plot plan space should a future leachate treatment plant be required.

The maximum expected size and capacity of the WMF at final build out is provided in Table 3.

Table 3: WMF Size and Capacity

	WMF (at Maximum Potential Capacity)
Capacity	900,000 m ³
Maximum Height	14.2 m
Base Footprint	121,738 m ²
Base Perimeter	1,687 m

WMF Baseline Setting

A detailed description of baseline conditions at the WMF site is provided by way of a conceptual model of the mainland sumps area developed by Advisian (2019). Excerpts of this description follow.

The WMF area is typically comprised silty clay fill underlain by native silty clay till that was followed by the sedimentary bedrock. At many locations where the silty clay fill was absent, the surface was covered with topsoil or organic material (peat). Within the southwestern portion of the site, some sandy lenses were reported. Bedrock was encountered at many of the borehole locations. The depth to the bedrock was typically less than 3.0 metres below existing ground surface (mbgs). The bedrock typically consisted of siltstone/mudstone or shale. The upper zone was found to be weathered and could be misinterpreted as silty clay till in the historical boreholes.

Ground temperature data collected in 2013 and 2014 suggest mean annual ground temperatures in the order of -1.0°C to -0.5°C. Investigations at the proposed site to date confirm that permafrost distribution is highly variable across the Site. The proposed site was selected, in part, because it is set back from the Mackenzie River (approximately 1 km) and Bosworth Creek (approximately 800 m). The proposed facility is offset 300 m from the high water mark of the nearest surface water body.

Historical groundwater monitoring indicates saturated soil conditions present at depths ranging from 0.3 to 1.2 mbgs. Groundwater at the site was typically shallow and surface water was ponded in low areas. Standing surface water is known to exist in the northern parts of the site. Both the shallow and bedrock aquifers below and near the proposed site have little to no utility as resource and/or potable water aquifers.

Groundwater flow has been interpreted to be relatively stagnant in the vicinity of the Mainland Sumps, with no apparent or consistent pattern to hydraulic heads. There is some localized shallow flow towards the southwest in the area. The Mainland Sumps are interpreted to be surrounded by shallow permafrost to the east, west, and south, as well as permafrost under the sumps.

Monitoring and Maintenance

Surface Water Program

Surface water management for Imperial's Norman Wells Operations is described in the Quality Assurance Quality Control Manual (QAQCM). This manual defines sampling and water release protocols for source categories as defined in Table 4.

Table 4: QAQCM Source Categories and Protocols for Surface Water Management

Source Category	Description	Sampling	Release Protocol
A	No anticipated impacts	Field testing following Table E in Section 5.1.1	Release flowchart in Figure C
B	Anticipated impacts	Lab testing following Table F in Section 5.1.2	Release flowchart in Figure D
C	No anticipated impacts but periodic monitoring required to confirm barrier performance	Lab testing following Table F in Section 5.1.2	Release flowchart in Figure E

During construction, the WMF will be considered a category B location. Water accumulating in excavations will be sent to well F-31X for disposal or laboratory tested in accordance with Table F and released in accordance with the flowchart in Figure D of the QAQCM.

The WMF design includes perimeter ditches that will transfer surface water (precipitation falling on the WMF or water from melting snow) to a catch basin (Figure 2). Immediately following construction, the WMF will be considered a category B location and water will be impounded and tested in accordance with Table F and released in accordance with Figure D of the QAQCM. Testing of catch basin will continue until a baseline is established verifying the performance of the cover membrane.

After testing of the catch basin confirms the cover membrane successfully isolates contaminated materials from surface water, the WMF will be classified as a category C location and surface water will be allowed to drain naturally to the surrounding environment. Lab sampling of catch basin water will be conducted twice a year to confirm the integrity of the WMF containment system and will follow the sampling protocols outlined in Table F of the QAQCM. If changes in water quality trends are detected, the WMF will revert to a category B location and water will be impounded until cover repairs are undertaken and testing confirms reclassification as category C is appropriate.

Groundwater Program

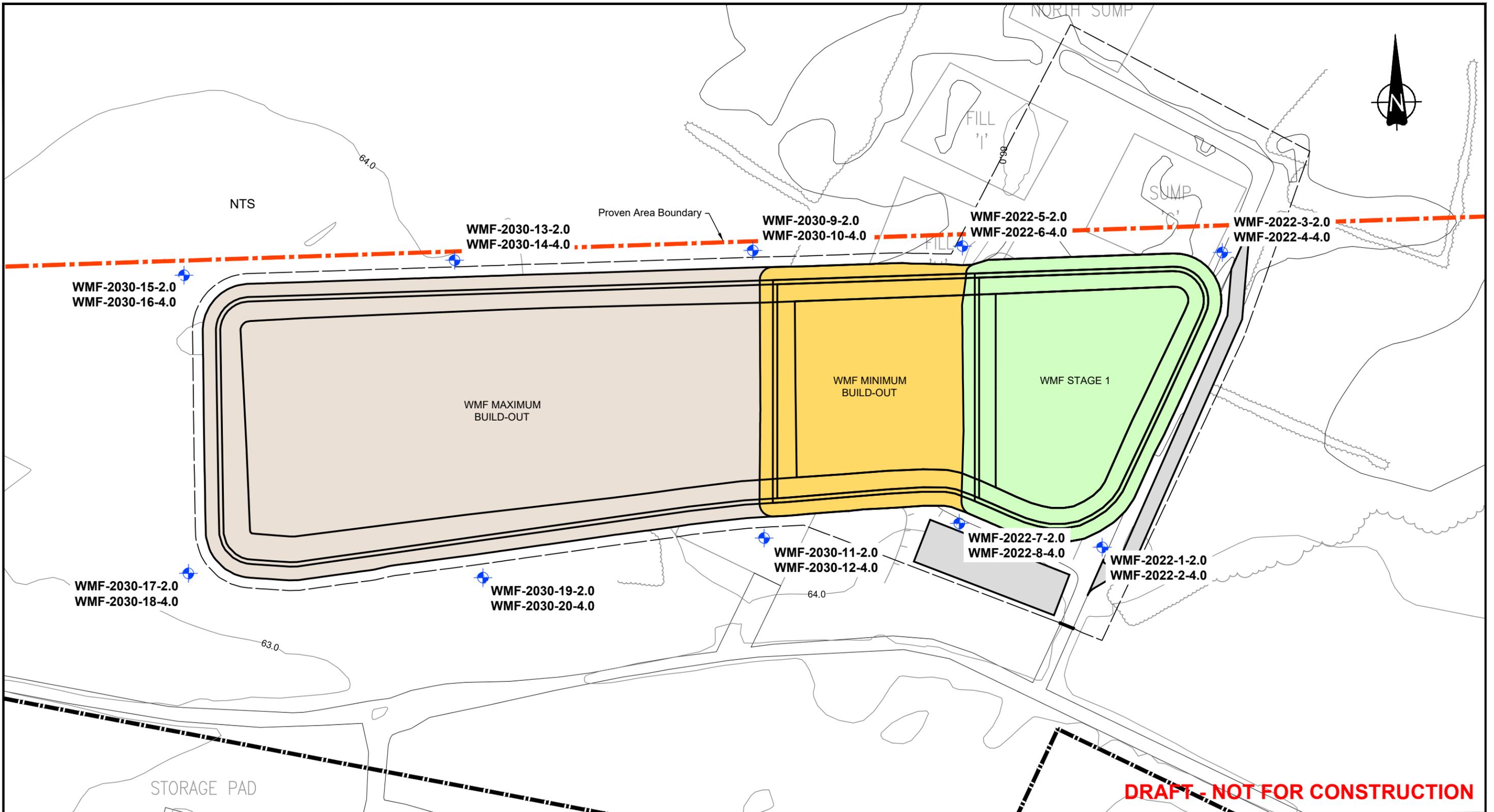
The containment performance of the WMF, and its influence on local groundwater regimes (i.e., groundwater quality and levels), will be monitored via a series of wells installed around the perimeter of the WMF. Preliminary locations are shown on Figure 2. Each monitoring location will have two separate wells targeting the groundwater table and the upper bedrock aquifer (i.e., there will be two completion intervals and two monitoring wells at each location). The number and locations of the WMF groundwater monitoring wells have been established based on criteria outlined in Western Canadian landfill design guidelines (specifically, AER (2006)), which call for wells spaced at about 200 m along a perimeter of the facility and extending between 10 m and 60 m from edge of the waste perimeter. The locations and completion details will be validated and adjusted appropriately as detailed design development for the WMF is completed. Note that wells in the WMF-2022 series (Figure 3) will be installed following the first stage of WMF development and an additional two to six wells (WMF-2030 series) will be installed at full WMF build out; the final number of monitoring wells will depend on the ultimate size of the WMF.

The WMF monitoring wells are classified as category 1 wells as defined in the GMP. However, they will not be added to the list of sentinel wells under the licence's Groundwater Surveillance Network Program because these sentinel wells are intended to reflect conditions in areas not impacted by the Operations. Existing monitoring well MLS 09-6-2 acts as a sentinel for the WMF area.

Most of the WMF wells will be installed in areas known to exhibit groundwater quality impacts from the sump materials. WMF performance will be monitored relative to the baseline conditions that will be established for the new wells following installation. Characterization of these baseline conditions will be initiated following placement of the WMF perimeter berms and prior to initial waste placements within the WMF. It will not be practical to install and monitor these wells prior to WMF development because their presence would create significant impediments to the efficiency of materials movements during construction.

The GMP includes protocols for defining indicator parameters, well sampling and testing, data evaluation, and parameter excursion (i.e., inconsistencies with prescribed quality criteria) response that will be applied to the WMF groundwater monitoring program. For example, the GMP defines:

- the sampling frequency, indicator parameters and analytical methods will follow Table D in Section 3.
- data evaluation will follow the protocols outlined in Section 4 and further investigation of anomalous results will follow flow chart provided in Figure D; and
- groundwater response will follow the protocols outlined in Section 5 and remedial action plans will be developed based on the risk to receptors.



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LEGEND

- Proven Area Boundary
- Proposed WMF Monitoring Well (Water Table & Bedrock Completions)

CLIENT:

IMPERIAL OIL LIMITED

DWN BY:	MDDS
CHK'D BY:	BG
DATUM:	-
PROJECTION:	-
SCALE:	AS SHOWN

PROJECT:	NORMAN WELLS INTERIM CLOSURE AND RECLAMATION PLAN FDB UPDATE
TITLE:	WMF GROUNDWATER MONITORING LOCATIONS

DATE:	FEB. 2020
PROJECT No.:	CE4839.0020
REV. No.:	A
FIGURE No.:	3

Leachate Program

Monitoring of leachate that accumulates in the WMF collection system will be undertaken to meet three objectives, specifically:

- to assess whether future volumes and/or qualities of leachate are likely to exceed the accommodative capabilities of on-site infrastructure and thus require alternate means of disposal such as the development of a local treatment system;
- to ensure the containment performance of the WMF is consistent with the objectives established for the facility; and
- to collect volume and water quality data to support potential future design of leachate treatment capabilities

The following leachate monitoring requirements will be common to meeting these objectives:

- starting after the initial placements of waste, monitoring of leachate levels in all collection sumps will be undertaken weekly;
- once leachate accumulation rates have stabilized, or are declining, the level monitoring frequency will be reduced to that required to confirm that the maximum allowable liner head will not be exceeded, but in no case, less frequent than monthly;
- prior to the stabilization of accumulation rates, leachate quality from each sump will be tested monthly; following stabilization, leachate quality will be tested in accordance with the groundwater sampling frequency specified in the GMP (twice annually in the current GMP; and
- leachate samples will be tested for the indicator parameters and using the protocols specified in the GMP for category 1 wells.

Treatment Assessments

The leachate monitoring data described above will trigger an assessment of the need for, and nature of, a local treatment capability if and when:

- it becomes evident that current on-site facilities (i.e., Operations injection well) will not be available, or able, to accommodate the anticipated volumes and/or qualities of leachate production; and
- the volumes and/or qualities of leachate anticipated are not compatible with batch removal and disposal (likely via truck) to available off-site disposal options.

Performance Monitoring

The leachate volume and quality data compiled as described above will be used as follows:

- **Volume Assessments:** the rates of leachate production will be compared to predictions generated during detailed WMF design development and the operational requirements/limitations of the site injection well. These assessments will be used to establish an operating maximum liner head level within the WMF that is keyed to a prescribed schedule of leachate withdrawals compatible with the injection well's operating constraints.
- **Quality Assessments:** a baseline leachate quality will be established using the data evaluation protocols outlined in the GMP. Any increasing trends from this baseline quality will be assessed thereafter to ensure compatibility with the characteristics and capabilities of the barrier materials that are selected in the final WMF liner design.

Injection Well Operations

As noted above, and in Section 7, the Operations' current injection well will be used for the disposal of impacted construction waters (see Section 10.5.1), and any leachate generated in the WMF, for at least a portion of WMF operations post construction. The injection well (F-31X) is located approximately 1,200 m southwest of the WMF in the Mainland Central portion of the Operations. Details for this well are as follows:

Unique Well Identifier (UWI)	305M376520126450
NEB Well Identifier (WID)	1227
Short Well Name	NORMAN WELLS F-31X
KB/RT	58.6
Formation Code	99999
Geological Name	Total Depth
Measured Depth (m)	740
True Vertical Depth (m)	525.6
Elevation (m) M	-681.4
Elevation (m) TV	-467
Region Code	9200
Strike Code	204
Strike Name	Mackenzie Plain

This well is used primarily to support Imperial's well workover requirements and general process maintenance operations and is part of the F-31X Treatment and Injection Facility, which is a solid/liquid system comprised of the following components:

- **Grizzly Tank (Tank 002):** a double walled tank with weirs that separate solids from liquids. It has a holding capacity of 53 m³.

- Tank 001: a single walled 445 m³ skim tank within a lined and bermed area.
- F-31X Injection Well: the water injection well which accepts water (from Tank 001) or produced water (from the central processing facility).

Operations materials typically directed to the facility include:

- hydrovaced material;
- impacted snow;
- well workover materials (diluted);
- surface water runoff that does not meet release requirements;
- biocell sump runoff; and
- excess chemicals (diluted).

Injection volumes vary considerably depending on the scheduling of these activities but can reach up to 300 m³/day when workovers and/or maintenance are ongoing. The well capacity is limited by a maximum tolerable injection pressure for the formation (Gillingham, pers. comm. 2019). The only operating constraints on the quality of injected waters relate to solids content, which is addressed by solids separation through the Grizzly Tank (i.e., injected waters typically require filtration prior to injection to minimize plugging or fouling of the reservoir).

WMF Injection Volumes

Waters impacted by the WMF will fall into one of two broad categories, namely:

- construction waters: surface runoff from active work areas that is, or is potentially, impacted by contaminated materials and therefore cannot be released directly to the local watershed; and
- leachate: waters that accumulate in the WMF's collection system during the facility's operating phase (i.e., post construction).

The volumes of construction water produced during storm events would be much greater than any ongoing leachate production following construction. A summer storm event would generate an estimated volume of 700 m³ over the WMF Stage 1 footprint during construction. However, this volume will be collected in a temporary construction water sump that will be sized to provide storage compatible with the capacity constraints of the injection well (i.e., peak storm requirements will be attenuated as needed via local storage). Storm volumes will be drawn down over relatively short periods after the event (e.g., a storm producing 700 m³ could be injected over about two weeks without requiring more than about 10% of the well's injection capacity).

Post construction leachate volumes are uncertain, but they will be much lower than the storm volumes referenced above. The maximum leachate production rate of 10 L/min. described in the analysis in Appendix A of the Facility Design Basis Update Report (Wood 2020) amounts to about 15 m³/day, a figure well below injection capacities available over most of the year. Detailed design of the leachate management system will include identifying any supplemental storage requirements (i.e., tank capacities) needed to attenuate any peaks in leachate production that might temporarily exceed injection capacities.

WMF Injection Quality

Reliable predictions of leachate quality are not available at this point. However, the most conservative (i.e., most impacted) representations of leachate quality is provided in Appendix A of the Facility Design Basis Update Report (Wood 2020) (see Table A-1). These predictions do not include parameters or concentrations that are likely to be a constraint for injection. Detailed management system design will need to consider any supplementary requirements needed to maintain leachate solids levels below injection well constraints.

After reliable predictions of leachate quality are available, they will be included in updates to the WMF-EMP.

WMF Water Transport

Construction waters will be moved from the WMF site to the injection well via a temporary pumping system or water truck. Methods for moving produced leachate post-construction will depend on the volume of leachate generated. Leachate will be initially transported using a water truck; installation of a permanent pipeline system will be considered if leachate volumes exceed the expected ranges and it is deemed impractical to transport by truck.

Cover Integrity Program

Monitoring

The physical integrity and performance of the WMF cover will be regularly and systematically assessed. Currently, it is expected that annual inspections will be undertaken. After detailed design is complete and final cap details are defined, the WMF-EMP will be updated with monitoring details and inspection frequencies. The cover assessments would involve physical inspections to identify:

- any evidence of unanticipated differential settlements that have, or have the potential to, compromise cover integrity;
- any evidence of deep-seated soil movements impacting cover integrity;
- the performance of drainage structures that are incorporated into the cover landforms;
- the vigour and percent cover of any vegetation that is part of the final cover design;

- any evidence of shallow soil movements or displacements above cover barrier drainage systems;
- any evidence of near surface soil erosion or displacement generated by precipitation running off the cover; and
- the condition of any fencing around the cover, or any vents or surface infrastructure associated with the cover.

Maintenance

The cover inspections will identify any cover maintenance issues that may emerge from time to time and resulting action to resolve the issue and ensure continued integrity of the cover system. Potential requirements may include:

- restoration of gaps in the cover vegetation;
- removal of invasive, deep rooting trees or shrubs that could damage the cover;
- repair of erosional rills or other soil displacements above the cover geosynthetics; and
- repair of damage to geosynthetic layers caused by unanticipated soil displacements.

Contingencies

This section outlines the responses to monitoring outcomes that indicate assessment, maintenance and/or mitigation is required to ensure the WMF continues to function as intended.

- **Groundwater**: the GMP describes a response hierarchy for groundwater monitoring excursions that will be applied to the WMF groundwater monitoring wells (described in Section 5 of the GMP);
- **Surface Water**: similarly, evaluation of the surface water monitoring data will be undertaken using the protocols established in the QAQCM; if monitoring data identifies changes in water quality trends that could be associated with breaches in the WMF cover system, the WMF will be reclassified as a category B site and natural release of surface water will be suspended until repairs are completed and water quality returns to baseline conditions.
- **Leachate**: the leachate monitoring data described in Section 4.3 would trigger an assessment of the need for, and nature of, a local treatment capability if and when:
 - *it becomes evident that the current injection well that Imperial maintains for the Operations will not be available, or able, to accommodate the anticipated volumes and/or qualities of leachate production; and*

- *the volumes and/or qualities of leachate anticipated are not compatible with batch removal and disposition (likely via truck) to available off-site disposition options.*
- **Cover Integrity:** the cover inspections will identify any cover maintenance issues that may emerge from time to time. Potential requirements would be as described previously in Section 4.4.2.

Reporting

Results of WMF operation and monitoring will be reported in the *Annual Water Use Report*. In the event a groundwater or surface water response plan was initiated, reporting will follow the protocols outlined in the Operations Groundwater Monitoring Plan and Quality Assurance and Quality Control Manual.

REFERENCES

- Advisian. 2019. *2018 Annual Closure and Reclamation Progress Report, Norman Wells, NT*. Submitted to Imperial Oil. 30 May 2019.
- Alberta Energy Regulator (AER). 2006. Directive 058: *Oilfield Waste Management Requirements for the Upstream Petroleum Industry*.
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