

State of Fluid Tailings Management for Mineable Oil Sands, 2023

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Alberta Energy Regulator

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Abbreviations

ACPN	Aurora centre pit north
AEP	Aurora east pit
AEPN-E	Aurora east pit north-east
AEPN-W	Aurora east pit north-west
AEPS	Aurora east pit south
AER	Alberta Energy Regulator
AFD	atmospheric fines drying
ARD	acid rock drainage
ASB	Aurora settling basin
BML	base mine lake (formerly west in-pit)
CC	centrifuge cake
CFFT	centrifuge fluid fine tailings
CNRL	Canadian Natural Resources Limited
CNUL	Canadian Natural Upgrading Limited
COSIA	Canada's Oil Sand Innovation Alliance
CST	coarse sand tailings
СТ	composite tailings
DDA	dedicated disposal area
EETA	east external tailings area
EIP	east in-pit
EPEA	Environmental Protection and Enhancement Act
EPO	environmental protection order
eNST	enhanced nonsegregating tailings

esNST	enhanced spiked nonsegregating tailings
ETA	external tailings area
ETF	external tailings facility
FC	fluid cell
FFT	fluid fine tailings
FTT	froth treatment tailings
ILF	in-line flocculation
IPA	integrated project amendment
IPC	in-pit cell
ITA	in-pit tailings area
KFTT	Kearl fine tailings treatment
LOMP	life-of-mine plan
LMCP	life-of-mine closure plan
MD9	mine dump 9
MD9S	mine dump 9 south
MLSB	Mildred Lake settling basin
Mm ³	million cubic metres
MSP	measurement system plan
NMCP-E	north mine centre pit-east
NMSP	north mine south pond
NMSPE	north mine south pond east
NPD	north pool deposit
NRU	naphtha recovery unit
NST	nonsegregating tailings
OES1	out-of-pit tailings area east stage 1

OPTA	out-of-pit tailings area
OSCA	Oil Sands Conservation Act
PAG material	potentially acid-generating material
PASS	permanent aquatic storage structure
RTR	ready to reclaim
SC	sand cell
SD	sand dump
SIR	supplemental information request
STP	south tailings pond
SWIP	south west in-pit
SWSS	south west sand storage
TMF	Tailings Management Framework
TMP	tailings management plan
TMR	tailings management report
TSRU	tailings solvent recovery unit
TT	thickened tailings
TZ	transition zone
WETA	west external tailings area
WT	whole tailings

Executive Summary

Alberta has eight operating oil sands mines, and each site has an approved tailings management plan (TMP). Under *Directive 085: Fluid Tailings Management for Oil Sands Mining Projects*, mine operators must annually submit tailings management reports (TMR) that show how they are implementing their TMPs.

This report summarizes the information for the 2023 reporting year and assesses the operators' progress in managing fluid tailings. Operators continue to report improvements in their tailings treatment technologies and the piloting and development of new technologies.

Directive 085 requires TMPs to be updated to build on existing approval conditions and provide assurance that the *Lower Athabasca Region: Tailings Management Framework for Mineable Oil Sands* (*TMF*) outcomes can be achieved. Seven of the eight operating oil sands mines submitted TMP amendments between January 2022 and December 2023. Four TMP amendments were approved, three are under review, and one will be submitted in 2025. The Alberta Energy Regulator (AER) reviews TMPs to ensure tailings profiles align with projections and reflect current technology, new knowledge, and continuous improvement.

For management purposes, fluid tailings are categorized as legacy fluid tailings (fluid tailings stored before January 1, 2015) and new fluid tailings. The total volume of fluid tailings (new and legacy tailings combined) on oil sands mine sites in the Athabasca oil sands region increased between 2014 and 2023. The increase in the total regional volume of fluid tailings is expected based on approved tailings profiles. Despite this trend, the total regional volume of fluid tailings for all operators remains below their combined profiles of new and legacy fluid tailings.

The total volume of water in fluid tailings ponds in the Athabasca oil sands region varied from 2014 to 2023. From 2014 to 2017, the total volume of water in the tailings ponds decreased, then increased between 2018 and 2020. Since 2020, the total volume of water in tailings ponds in the region has decreased, with the lowest reported volume in 2023.

From 2014 to 2019, bitumen production increased, as did the number of operating mines. This was followed by a decrease in production in 2020 during the COVID-19 pandemic and the associated drop in global oil demand. Bitumen production increased from 2021 to 2023.

TMPs include volume profiles for both legacy and new fluid tailings. All operators were below their approved new fluid tailings profiles, except for Syncrude Mildred Lake. All operators were below their total volume triggers and total volume limits. All operators were at or below their legacy fluid tailings profile in 2023 and below their 20% deviation triggers for new and legacy fluid tailings. Syncrude Mildred Lake exceeded its legacy fluid tailings profile from 2017 to 2022 and its new fluid tailings profile in 2023.

There has been no change in management level, as described in *Directive 085*, required for Syncrude Mildred Lake because their volume is within the total allowable volume trigger and limit. The AER is closely monitoring Syncrude Mildred Lake to ensure the reduction in its fluid tailings inventory accelerates to meet the profile target.

In 2023, the AER issued an environmental protection order to Imperial Oil Resources Limited (Imperial) under its *Environmental Protection and Enhancement Act* approval for Kearl. The AER initiated formal investigations related to the incidents. These investigations were ongoing as of December 2023, and the Regulatory Applications branch continues to review information gathered from the investigations to determine if treated tailings deposits are achieving subobjective 2 performance criteria. Should the review indicate Imperial has not met and maintained its approved subobjective 2 ready-to-reclaim (RTR) criteria, Regulatory Applications will determine the appropriate management level and management responses.

The tailings volumes presented in this report are as reported by the operators. The AER requested clarification or additional data from all operators relating to their 2023 TMRs. The AER has not received or completed reviews of all responses before finalizing this report. Requests for clarification or additional data are part of an ongoing iterative process between the AER and operators. Operators require time to collect data, complete analyses, or review calculations before submitting responses to the AER. This report only includes information that was available at the time of writing. Further review of those responses and the fluid tailings volumes, including assessing if they meet RTR criteria, may lead to changes in the reported data or analyses from previous years and will be reflected in the 2024 report.

Operators are required to submit measurement system plans (MSPs) showing how they measure and report fluid tailings volumes and the performance of their tailings deposits. The AER completed assessments of the MSPs submitted by the operators related to determining whether the physical properties of the tailings deposits are on a trajectory to support future stages of activity (subobjective 1 in *Directive 085*, fluid tailings volumetric calculations, laboratory testing).

The AER continues to assess MSPs to address the need to minimize the effect the tailings deposit has on the surrounding environment and ensure the deposit will not compromise the ability to reclaim the area to a locally common, diverse, and self-sustaining ecosystem (subobjective 2).

In 2022, the AER issued a notice to oil sands mining operators clarifying the *Directive 085* water quality characterization and reporting requirements for tailings surface water. Because of this guidance on reporting requirements, operators were required to submit updated MSPs, which were reviewed by the AER. The water quality parameters specified in the notice apply to water overlying treated tailings deposits and fluid tailings ponds. The sampling and characterization are included in the 2023 TMRs.

In 2023, the AER completed an initial audit to verify regional fluid tailings and water volumes and found the reported fluid tailings and water volumes are consistent with the AER's calculated volumes.

The AER may issue additional supplemental information requests in the future. The tailings MSPs are live documents that must be regularly updated with changes to reflect current best practices and operations. Operators must notify the AER of all MSP changes.

1 Introduction

The Alberta Energy Regulator (AER) regulates oil sands mines and the associated management of fluid tailings as part of its mandate to ensure the safe, efficient, orderly, and environmentally responsible development of energy resources over the entire development life cycle.

This report summarizes information submitted by oil sands mine operators in their annual <u>tailings</u> <u>management reports</u> (TMRs).

An approved tailings management plan (TMP) and a measurement system plan (MSP) are required for the AER to assess the data in an operator's annual TMR. Both are required for the AER to assess fluid tailings inventory data as they allow for the determination of what volumes are considered ready to reclaim (RTR) and can be removed from the operator's fluid tailings inventory. Operator reports for 2023 must adhere to all reporting requirements in *Directive 085: Fluid Tailings Management for Oil Sands Mining Projects* and to conditions in each operator's tailings approvals.

The AER completed assessments of the MSPs submitted by the operators related to determining whether the physical properties of the tailings deposits are on a trajectory to support future stages of activity (subobjective 1 in *Directive 085*, fluid tailings volumetric calculations, laboratory testing). In addition, the AER assessed the groundwater monitoring portion of subobjective 2 in *Directive 085*—the need to minimize the effect the tailings deposit has on the surrounding environment to ensure it will not compromise the ability to reclaim the area to a locally common, diverse, and self-sustaining ecosystem. The AER continues to assess MSPs to address water quality characterization and measurement of chemicals of potential concern, which are part of subobjective 2.

The tailings MSPs are live documents that must be regularly updated with changes to reflect current best practices and operations. Operators must notify the AER of all plan changes. Operator MSPs are posted on the AER's website under <u>By Topic, Tailings</u>.

The fluid tailings volumes described in this report are presented as reported by operators and are subject to change upon further review of fluid tailings volumes, including assessment of whether they meet RTR criteria.

Annual TMRs submitted by operators are reviewed by the AER. This review may lead the AER to request further clarification or additional information from an operator. In addition, potential compliance issues are referred to the AER's Compliance and Liability Management team. The AER may issue additional supplemental information requests (SIRs) in the future.

Information provided by the operators for 2023, upon further review by the AER after the publication of this report, may lead to changes in the data. Any changes will be incorporated into the 2024 edition of this report, which will be issued by October 30, 2025.

2 Purpose

The purpose of this report is to summarize information submitted by individual operators as required by *Directive 085*, including

- fluid tailings volumes for each operator and the region;
- water volumes stored in tailings facilities for each operator and the region;
- tailings volumes claimed as having reached RTR status;
- whether operators are within their approved fluid tailings profiles;
- site-wide fluid tailings management activities for each mine site;
- tailings treatment and developing treatment technologies;
- project-specific performance;
- progress made in managing fluid tailings; and
- alignment with the approved TMPs.

This report also includes a summary of the AER's regulatory and management actions taken in 2023 relating to fluid tailings.

This report does not address mine financial security, waterfowl protection, dam safety, or air emissions from tailings ponds. Information on these issues can be found on the AER website (<u>www.aer.ca</u>) or the Alberta Environment and Protected Areas oil sands information portal (<u>http://osip.alberta.ca/</u>). This report does not include information on audits or inspections conducted by the Compliance and Liability Management team or information reported on the <u>AER Compliance Dashboard</u>. However, it does include a summary of the 2023 tailings-related regulatory site inspections.

3 Regulatory and Operational Context

3.1 Regulatory Context

On March 13, 2015, the Government of Alberta released the *Lower Athabasca Region: Tailings Management Framework for Mineable Oil Sands* (*TMF*) to manage and decrease liability and environmental risk from the accumulation of fluid tailings on the landscape. The *TMF*'s goal is to "increase the rate of reclamation and enhance the reduction of tailings ponds" and establishes the following policy outcomes:

- land use must be returned to Albertans
- sustainable ecosystem (after reclamation)
- liability is minimized to Albertans
- environmental effects are managed

In support of the *Lower Athabasca Regional Plan*'s strategic direction of "encouraging timely and progressive reclamation," the *TMF* provides guidance and an objective for managing fluid tailings so that both new and legacy tailings can be reclaimed in a timely manner. The *TMF* objective states that fluid tailings accumulation be minimized by ensuring fluid tailings are progressively treated and reclaimed during the life of an oil sands mining project and by ensuring that all a project's fluid tailings are RTR within ten years of the project's end-of-mine life.

On July 14, 2016, the AER released *Directive 085* under the *Oil Sands Conservation Act (OSCA)*, replacing *Directive 074: Tailings Performance Criteria and Requirements for Oil Sands Mining Schemes. Directive 085* enables the implementation of the *TMF* and aligns with the *Lower Athabasca Regional Plan.* It also sets out application and performance reporting requirements for fluid tailings management. On October 12, 2017, the AER updated *Directive 085* to clarify compliance and enforcement, public education and awareness, and the review cycle. The AER updated *Directive 085* on May 19, 2022, to address the publication date for the annual performance report on the state of fluid tailings management.

3.2 Operational Context

Table 1 lists the eight oil sands mining projects operating in 2023. The locations of operating and approved oil sands mining projects and their tailings ponds are shown in figure 1.

Approval holder	Mine	Operator
Suncor Energy Incorporated	Base Plant (Millennium and North Steepbank)	Suncor
Syncrude Canada Limited	Mildred Lake	Syncrude
	Aurora North	Syncrude
Canadian Natural Upgrading Limited	Muskeg River	CNRL
	Jackpine	CNRL
Canadian Natural Resources Limited	Horizon	CNRL
Imperial Oil Resources Limited	Kearl	Imperial
Fort Hills Energy Corporation	Fort Hills	Suncor

Table 1. Oil sands mining projects operating in 2023



Base data contains information licensed under the Open Government License - Alberta

Figure 1. Operating oil sands mining projects and tailings ponds/deposits in 2023

4 2023 Reporting

The AER requires operators to report on the status of fluid tailings management at their sites by April 30 of each year in accordance with *Directive 085*. For most operators, 2023 marked the seventh year for submitting annual TMRs. It was also the fifth year where all operators were required to meet full reporting requirements under *Directive 085* and their conditions of approval. Operator submissions for 2023 were made available on the AER website on May 31, 2024, under <u>By Topic, Tailings</u>.

Tailings and fluid volumes in this report are as-measured volumes beginning in 2019 unless otherwise stated.

4.1 2023 Report Review

As part of its review of annual tailings reports submitted by operators, the AER assessed the reported progress in 2023 for fluid tailings management, including achieving RTR status, trends over time, consistency with previous annual TMRs, and compliance with approval conditions. The intent of the review is to ensure

- operators are implementing their approved TMP, including confirming that conditions related to fluid tailings management are being met and stated milestones are being achieved;
- fluid tailings performance is in accordance with their profiles;
- fluid tailings performance is in accordance with volume triggers and limits;
- fluid tailings management level for each operation is identified;
- fluid tailings deposits are meeting RTR criteria and are on the applicable trajectory; and
- initiated mitigation actions and contingency plans are effective in managing fluid tailings and treated tailings deposit performance.

All oil sands mining operators had an approved TMP by the end of 2019. Seven oil sands mines submitted TMP amendments in 2022 and 2023, of which four were approved (Table 2.)

Approval holder	Mine	TMP status
Suncor	Base Plant	Approved 2023
Syncrude	Mildred Lake	Submitted 2023, under review
	Aurora North	Submitted 2023, under review
CNUL	Muskeg River	Approved 2023
	Jackpine	Approved 2023
CNRL	Horizon	Approved 2021. TMP amendment submission expected 2025
Imperial	Kearl	Submitted 2022, under review
Fort Hills	Fort Hills	Approved 2024

Table 2. Oil sands mining projects TMP status in 2023

Amendment applications for oil sands mining are classified based on how the project modifications affect resource conservation, stakeholders, or the environment. Depending on the scope and scale of a proposed amendment, new or updated environmental information may be required under *Directive 023: Oil Sands Project Applications* or the specified enactment directions (e.g., *Environmental Protection and Enhancement Act [EPEA], Public Lands Act, Water Act*). The AER may request additional information to complete its technical review. Processing times vary between 20 and 565 business days.

4.2 Ready-to-Reclaim Criteria and Trajectory

Operators were required to identify volumes of treated fluid tailings that met RTR criteria in 2023. The *TMF* and *Directive 085* both require that the progress of fluid tailings and treated fluid tailings be tracked from the initial formation (accumulation) through to the initial RTR state and stay on a trajectory that remains in its approved RTR state. RTR criteria are used to track treated tailings during the operational stage of the deposit's trajectory to ensure the deposit can be reclaimed as predicted in the life-of-mine closure plan (see figure 2). Progress of fluid tailings to an RTR state includes processing with an accepted technology, placing tailings in their final position on the landscape, and achieving the approved RTR performance criteria.

In the 2023 reports, operators reported the treated tailings volumes that achieved RTR status during the reporting period and confirmed that treated tailings in deposits continued to meet the RTR trajectory approval conditions. Any deposits that operators could not confirm as continuing to meet the RTR criteria were returned to the fluid tailings inventory. Operators are required to identify any volumes returned to the fluid tailings inventory. The tailings volumes in this report are presented as reported by the operators and subject to change upon further review of fluid tailings volumes and performance related to meeting RTR criteria.

Under *Directive 085* and the *TMF*, the AER is tasked with evaluating regional performance against the *TMF*'s outcomes and objectives. Future AER reports on tailings management will incorporate a summary evaluation of environmental effects and reclamation performance reporting, which may include references to other required reports (e.g., *EPEA* reports) and links to *EPEA* and reclamation regulations.

Cleared	Disturbed	Soils Placed	Permanent Reclamation	Certified Reclaimed
	 Fluid tailings are treated and placed in final location Treated tailings meet ready-to-reclaim performance criteria 	Placement of reclamation material	Revegetation	

Figure 2. Reclamation stages

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4.3 Environmental Performance Monitoring

Directive 085 requires operators to summarize environmental performance monitoring reports and highlight the operator's management of environmental effects and the potential impacts of fluid tailings management activities.

The AER assesses the groundwater monitoring portion of subobjective 2 in *Directive 085*, which considers fluid tailings management activities and deposit performance concerning approved RTR criteria and alignment with the closure and reclamation trajectory.

The AER may allow operators to refer to other submitted reports (e.g., reclamation progress tracking report, groundwater monitoring report, industrial wastewater monitoring report) to avoid duplicate reporting of performance results for managing and minimizing environmental effects and the implications of fluid tailings management activities. Reporting under *Directive 085* does not relieve an operator from complying with other tailings-related environmental reporting requirements.

Some of the 2023 TMRs refer to other *EPEA* environmental reports or provide information from these reports. Consequently, the AER must complete further reviews to verify the additional reported data and information in the referenced reports. This review of the referenced reports is not part of the evaluation of volumetric measurements for fluid tailings and treated fluid tailings management activities in 2023.

For more information about surface water management, tailings seepage control, and groundwater monitoring concerning subobjective 2, see the operator 2023 TMRs.

Operators are required to report the characterization and quality of water for each treated tailings deposit and fluid tailings pond. In 2022, the AER clarified the *Directive 085* water quality characterization and reporting requirements for oil sands mining operators. The AER provided the following guidance on how operators are to characterize tailings surface water quality:

- The AER specified the chemical and physical water quality parameters to be reported for each treated tailings deposit and fluid tailings pond. Operators must report these parameters at environmentally relevant detection limits and at a frequency to appropriately capture seasonal and temporal variation.
- Each operator was to update and resubmit its MSPs with details of the water quality sampling methods, locations, and frequency.
- The sampling and characterization are to be included in the TMRs.

The water quality parameters specified in the notice apply to water overlying treated tailings deposits and fluid tailings ponds. The sampling and characterization were included in the 2023 TMRs to help the AER evaluate tailings surface water quality. Consistency in reporting across all sites will help the AER evaluate the quality of recycle water contained in tailings ponds.

For details of sampling and analytical methods, the parameters analyzed, and the sample test results for each treated tailings deposit and fluid tailings pond, see the operator 2023 <u>TMRs</u>.

4.4 Next Steps

Where the AER identified gaps or areas requiring clarification in the submitted 2023 TMRs, the AER followed up with the operators, requesting clarification or more information. These follow-ups may lead to data corrections, changes in the RTR status of treated tailings in a deposit, or changes in the fluid tailings inventory. Requests for clarification, SIRs, or additional data are part of an ongoing iterative process between the AER and operators. This report only includes information that was available at the time of writing.

The 2024 report will include any changes to individual company statuses resulting from responses to requests for clarification or information that was unavailable at the time of writing this report.

Changes in the RTR status of a deposit may warrant mitigation or corrective action, and changes in the fluid tailings inventory may warrant additional fluid tailings management responses.

MSPs are live documents that operators must regularly update to reflect current best practices and operations. Operators are required to notify the AER of all plan changes. All operator MSPs are posted on the AER's website under <u>By Topic, Tailings</u>.

A process and schedule are being prepared for audits of the tailings reports in upcoming years. The AER will audit the measurement systems for each mine and include the results in the annual *State of Fluid Tailings Management for Oil Sands* report. Details of the 2023 regional MSP audit are included in section 7.3

5 Tailings Description

About 20% of Alberta's oil sands reserves are recoverable by surface mining using trucks and shovels to excavate oil sands. The oil sands are transported to an extraction plant, where bitumen is separated from the sand. In 2023, mined bitumen accounted for 48% of total bitumen production in Alberta. This bitumen can be sold as a product or upgraded to synthetic crude oil or other products, which are either used on site or sold.

Tailings are a by-product of the process used to extract bitumen from mined oil sands. Tailings are a mixture of sand, clay, water, silt, residual bitumen and other hydrocarbons, salts, and trace metals. During the early stages of mine operations, tailings are deposited into constructed aboveground (out-of-pit) structures called external tailings ponds. Once a mined-out area (pit) becomes available, tailings are stored in these mined-out areas (in-pit tailings ponds). Tailings ponds act as a settling basin to separate the water from tailings and a holding area from which water can be removed and recycled to the bitumen extraction process.

Directive 085 defines fluid tailings as any fluid discard from bitumen extraction facilities containing more than five mass per cent suspended solids and having less than an undrained shear strength of five kilopascals. Any liquid containing less than 5% solids is considered ponded water. See *Directive 085*, appendix 1, for definitions of tailings management terminology.

The particles in a tailings pond settle out of the water at different rates. Sand particles tend to settle quickly. However, smaller particles of clay and silt (i.e., fines), 44 micrometres in diameter or less, tend to remain suspended in the water for long periods, forming fluid tailings. Without intervention, fluid tailings can take decades to settle, which makes managing fluid tailings an ongoing challenge for the oil sands mining industry.

Tailings generated as part of the mining and bitumen extraction process must be managed in accordance with *Directive 085* and the conditions in the operators' approvals.

6 Fluid Tailings Treatment and Deposition

Oil sands mine operators use various technologies to treat fluid tailings, with some operations using multiple technologies. Development and implementation of new technologies and continuous improvement of existing technologies are very important for the successful management of fluid tailings in the oil sands mining industry. The ability to successfully reclaim to target ecosites is also affected by the deposit design and operation, including the size and depth of the deposit, and the capping design, both of which are reflected in the RTR trajectory. A summary of the treatment technologies and typical treated tailings deposits from the TMPs is included in appendix 1.

The initial uncertainties and risks associated with the in-deposit performance of demonstration technologies, including treated fluid tailings deposit capping, are described in the *Directive 085* decision reports on the AER website. Operators must obtain regulatory authorization before implementing a new tailings treatment technology or constructing a deposit not already included in the current approval.

7 Regional Fluid Tailings Status

Data in this report are from the site-wide fluid tailings inventory table (appendix 3 of *Directive 085*) submitted by the operators. The tailings volumes are subject to change upon further review of fluid tailings volumes, including assessing whether they meet RTR criteria.

The total volume of fluid tailings in the Athabasca oil sands region, including new and legacy fluid tailings, increased between 2014 and 2023. This overall increase is expected based on the new and legacy profiles in the operator TMPs approved by the AER.

Total fluid tailings volumes increased from 1075 million cubic metres (Mm³) in 2014 to 1486 Mm³ in 2023 (see figure 3 and appendix 3). An aggregate of new and legacy profiles for all operators in each year is included in figure 3. The aggregate of approved fluid tailings volume profiles for all operators by year

is shown for comparison. From 2015 to 2023, the reported total volume of fluid tailings in the Athabasca oil sands region was below the aggregate of approved tailings profiles.

Figure 3, figure 4, and figure 5 present fluid tailings inventory volumes as reported by the operators. Treated fluid tailings volumes identified by the operators as having met RTR status are included in figure 4.

The annual change in fluid tailings volume is the volume of fluid tailings for that reporting year minus the previous year's fluid tailings volume. Each bar in figure 5 represents the volume of fluid tailings added or removed from the regional inventory in a reporting year. The volume of fluid tailings produced exceeded the volume of tailings reported as achieving RTR status from 2015 to 2023, apart from 2021.

In 2021, the volume of tailings reported by industry as achieving RTR status (i.e., tailings which could be removed from the fluid tailings inventory) exceeded the volume of fluid tailings produced.

The reported annual change in volume of fluid tailings in the Athabasca oil sands region decreased from 78.4 Mm³ in 2022 to 44.5 Mm³ in 2023 (see figure 5). The highest annual change in the regional fluid tailings volume was 87.2 Mm³ in 2020.

Bitumen production increased from 60.2 Mm³ in 2014 to 95.6 Mm³ in 2023.

Regional fluid tailings volumes were expected to increase in 2023 based on the new and legacy profiles in the TMPs approved by the AER.



- CNRL Horizon
- CNUL Jackpine Mine
- CNUL Muskeg River Mine
- Suncor Base Plant
- Syncrude Aurora North
- Syncrude Mildred Lake

Aggregate of new and legacy fluid tailings profiles for all operators

Note: Fluid tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

In 2018, Syncrude Aurora North and Mildred Lake data are as-measured values, not projected to year-end. Data are as-measured values starting in 2019, except for Imperial Kearl, which provided year-end predicted values for 2019.

Figure 3. Regional fluid tailings volumes and approved aggregate profiles, 2014 to 2023



Suncor Fort Hills Syncrude Aurora North Syncrude Mildred Lake

Figure 4. Regional claimed RTR volumes, 2014 to 2023



Annual fluid tailings volume change

Note: Fluid tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

In 2018, Syncrude Aurora North and Mildred Lake data are as-measured values, not projected to year-end. Data are as-measured values starting in 2019, except for Imperial Kearl, which provided year-end predicted values for 2019.

Figure 5. Change in annual fluid tailings volume in the Athabasca oil sands region, 2015 to 2023

7.1 Fluid Tailings Treatment and Deposition

Table 3 shows the treated fluid tailings volumes by operator from 2014 to 2023.

		-		-							
Project	Technology	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Suncor Base	Thin-lift drying	11.7	14.8	9.9	18.5	14.0	0.0	0.0	0.0	0.0	0.0
Plant	Permanent aquatic storage structure	0.0	0.0	0.0	0.0	14.0	26.7	25.0	21.2	22.0	23.0
	Coke capping mitigation	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Suncor Fort Hills	To be determined						0.0	0.0	0.0	0.0	0.0
	СТ	5.7	4.9	0.3	2.4	2.1	5.0	0.6	0.0	0.0	0.0

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Syncrude Mildred Lake	Centrifuge	2.7	4.1	6.0	6.7	6.4	3.8	3.4	5.0	2.6	3.1
	Floc-T plant									1.1	7.2
Syncrude Aurora North	СТ	5.0	10.9	11.8	13.7ª	16.3ª	23.9	4.7	0.0	2.2	6.2
CNUL	AFD	3.9	0.9	0.1	0.0	0.0	1.3	3.6	6.2	5.9	2.2
Muskeg River mine ^b	Fluid fine tailings drying at mine advance area	0.2	0.3	n/a	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	СТ	0.3	1.3	n/a	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	ТТ	15.1 ^{c,d}	13.6 ^{c,d}	19.4 ^d	22.5 ^e	22.9	13.0	27.0	24.4	21.7	4.5
CNUL	Centrifuge	1.1	3.9	3.9	2.3	2.2	2.1	1.4	2.6	2.2	1.8
Jackpine mine	ТТ	16.4 ^{c,f}	12.6 ^{c,f}	17.5 ^f	19.7 ^g	16.4	16.3	15.8	12.5	12.9	1.8
	CST/WT										31.3
CNRL Horizon	NST	0.0	7.7 ^h	48.7 ^h	62.7 ^h	131.8	156.3 ^h	139.3	125.8	149.9	151.6
	Naphtha recovery unit	0.0	0.0	0.0	0.0	17.2	20.8	18.6	16.5	17.8	20.5
	esNST	0.0	0.0	0.0	0.0	0.0	1.1	1.5	2.6	4.5	7.0
Imperial Kearl	TT	0.0	0.0	2.4 ⁱ	8.5	8.7 ⁱ	13.6	19.0	26.0	28.0	30.5

Note: Volumes cannot be added together between technologies or sites because of the differences in technologies and differences in performance of similar technologies at different sites.

^a Volume of CT slurry volume and CT beach deposit. Revised from CT beach deposit only reported in 2017.

^b TT combined with CST, WT, and tailings solvent recovery unit material in a single deposit forms NPD type.

^c Updated in April 2017 submission.

^d Volume of TT slurry at solids content of average 23.6% from 2014 to 2016.

^e Volume of TT slurry at solids content of 21.9% in 2017.

^f Volume of TT slurry at solids content of average 15% from 2014 to 2016.

^g Volume of TT slurry at solids content of 13.7% in 2017.

^h Volume of NST.

AFD = atmospheric fines drying

esNST = Enhanced spiked nonsegregating tailings

CST = coarse sand tailings

CT = composite tailings

NST = nonsegregating tailings

TT = thickened tailings

WT = whole tailings

7.2 Water Volumes

Based on the data reported by operators from 2014 to 2023, the volume of water contained in tailings ponds and deposits in the Athabasca oil sands region ranged from a high of 479.3 Mm³ (2020) to a low of 391.1 Mm³ in 2023 (see figure 6 and appendix 4). The increased ponded water volumes in 2020 compared with other years may have resulted from increased precipitation in the Athabasca oil sands region falling on the mine sites and ending up in the recycle water ponds. The 2023 pond water volume appears

consistent with those from 2014 to 2019, likely resulting from using recycle water and the average regional rainfall for 2022 and 2023.



Note: Water volumes are presented as reported by operators and are subject to change upon further review by the AER.

The water volumes are subject to change upon further review of pond and deposit volumes by the AER.

Figure 6. Ponded water volume in tailings ponds, 2014 to 2023

7.3 Regional Measurement System Audit

The AER has continued its development of an auditing system for fluid tailings.

In 2023, the AER requested fluid tailings and clear water zone surface data from mining operators and completed an initial audit to verify the regional fluid tailings and water volumes. The AER found the reported fluid tailings and water volumes are consistent with the AER's calculated volumes (see table 4).

Mine	Reported fluid tailings volumes (Mm³)	AER estimated fluid tailings volumes (Mm ³)	Reported ponded water volumes (Mm ³)	AER estimated water volumes (Mm ³)
Base Plant	270.1	260.2	83.2	86.1
Mildred Lake	598.7	584.1	121.7	118.3
Aurora North	148.8	148.9	90.8	78.9
Muskeg River mine	144.7	144.7	23.4	24.0
Jackpine mine	25.9	25.9	23.4	23.4
Horizon	148.3	145.0	19.1	18.7
Kearl	104.4	102.7	18.5	12.6
Fort Hills	63.6	63.4	7.5	6.3
Total	1504.5	1474.9	387.6	368.3
% Difference		2.0		5.2

Table 4. Regional reported fluid tailings volumetric audit results

Note: Tailings volume totals in this table may not match the company reports due to rounding. Data provided by operators in their TMRs were only to one decimal place.

Some of the volumes above include RTR volumes.

In general, it appeared that operators were more likely to overestimate volumes. The AER will follow up with questions for three mines. RTR volumes were not validated as part of the 2023 validation exercise.

Lessons learned from the initial validation audit will be applied to refine the design of the audit program and optimize submission data. The AER will be advancing its fluid tailings auditing program in the coming years and plans to provide information on the audits of individual companies, containment requirements, and RTR volumes in future reports.

8 Fluid Tailings Status

8.1 Suncor – Base Plant

In 2023, 11 tailings facilities were operating at Suncor Base Plant (see table 5). The tailings facilities vary in their primary function, contents, and size.

Facility	Function	Contents
Pond 1A	 fluid and solid tailings storage water recycle	CSTfluid tailings
Pond 2/3	 fluid and solid tailings storage water recycle FTT deposition	FTTfluid tailings
Pond 5	 fluid and solid tailings storage 	fluid tailingsCSTCTcoke
Pond 6	 fluid and solid tailings storage 	 fluid tailings CST CT
Pond 7	 fluid and solid tailings storage water recycle FTT deposition	FTTfluid tailingsCSTCT
Pond 8B	 fluid and solid tailings storage 	 fluid tailings CST
Dedicated disposal area 1 (DDA1)	 fluid and solid tailings storage 	 fluid tailings CST
DDA3	 fluid and solid tailings storage and treatment 	 fluid tailings CST
South tailings pond (STP)	ongoing tailings depositionwater recycle	 fluid tailings CST
Sand dump 8 (SD8)	ongoing tailings deposition	 fluid tailings CST
Mine dump 9 / mine dump 9 south (MD9/MD9S)	 solid tailings deposition and treatment 	overburdentreated fluid tailings

Table 5. Tailings facilities operating at Suncor Base Plant

Suncor Base Plant reported using its permanent aquatic storage structure (PASS) technology in which fluid tailings from the STP are treated with a coagulant and flocculant before placement in dedicated disposal area 3 (DDA3). In 2023, mine dump 9 south (MD9 south) received treated tailings from DDA1 and remnant mature fine tailings from pond 8B that were co-disposed with overburden from mining operations.

Suncor Base Plant treated 23 Mm³ of fluid tailings as per its treatment commitments in its TMP.

Suncor Base Plant reported that its new and legacy fluid tailings inventories for 2023 were within the approved fluid tailings profiles.

8.1.1 Fluid Tailings

For 2023, Suncor Base Plant reported a total fluid tailings inventory (new and legacy fluid tailings combined) of 270 Mm³, up from 267 Mm³ in 2022.

Volumes reported for 2023 fall within currently approved profiles for new and legacy fluid tailings inventories.

For 2023, Suncor Base Plant reported that 112.7 Mm³ of fluid tailings met its approved RTR criteria, up from 95.6 Mm³ in 2022.

The RTR status requires Suncor Base Plant to meet the approved subobjective 1 and 2 criteria (see table 6), which are included in appendix C to *OSCA* approval 8535T, approved December 12, 2023.

Deposit	Subobjective	RTR Criteria
Pond 5	subobjective 1	Capping with coke and the installation of vertical strip drains is complete in 2019.
	subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 94-03-00, as amended or renewed.
Pond 6	subobjective 1	Pond 6 mitigation is complete by December 31, 2028.
	subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 94-03-00, as amended or renewed.
Pond 7	subobjective 1	Pond 7 mitigation is complete by December 31, 2033.
	subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 94-03-00, as amended or renewed.
MD9 co-disposal	subobjective 1	Clay-to-water ratio >0.5 in DDA1 based on deposit sampling. Annual overburden to tailings volume ratio >1.
	subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 94-03-00, as amended or renewed.
MD9 south co-disposal	subobjective 1	Clay-to-water ratio >0.5 in DDA1 based on deposit sampling. Annual overburden to tailings volume ratio >1.
	subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by EPEA approval 94-03-00, as amended or renewed.
DDA3	subobjective 1	Clay-to-water ratio >0.3 threshold based on deposit sampling.

 Table 6.
 RTR criteria for Suncor Base Plant

	An annual average total suspended solids ≤500 parts per million for expressed water from DDA3 treated tailings.
subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 94-03-00, as amended or renewed.

8.1.1.1 New Fluid Tailings

For 2023, Suncor Base Plant reported a new fluid tailings inventory of 240 Mm³ (see figure 7), up from 200 Mm³ in 2022. The approved new fluid tailings inventory for 2023 was 240 Mm³.

Suncor Base Plant has a total volume trigger for new fluid tailings inventory of 272.0 Mm³ and a total volume limit of 380.8 Mm³. Based on data reported in its 2023 TMR, Suncor Base Plant was within its approved new fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 7. New fluid tailings for Suncor Base Plant, 2014 to 2023

8.1.1.2 Legacy Fluid Tailings

For 2023, Suncor Base Plant reported a legacy fluid tailings inventory of 30 Mm³ (see figure 8), down from 67 Mm³ in 2022. The approved legacy fluid tailings inventory for 2023 was 45 Mm³.

Based on data reported in its 2023 TMR, Suncor Base Plant was within its approved legacy fluid tailings profile and did not exceed its profile deviation trigger for legacy fluid tailings in 2023.



Approved profile: legacy fluid tailings inventory
 Legacy fluid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 8. Legacy fluid tailings for Suncor Base Plant, 2014 to 2023

8.1.2 Volume of Treated Fluid Tailings by Technology

For 2023, Suncor Base Plant reported that 23 Mm³ of fluid tailings were treated with PASS in DDA3. A SIR was issued regarding treated fluid tailings volumes in MD9S.

As of 2023, Suncor Base Plant reported that 112.7 Mm³ of fluid tailings had achieved RTR status:

- 30.4 Mm³ in pond 5
- 82.0 Mm³ in DDA3
- 0.3 Mm³ in MD9
The RTR volume increased from 95.6 Mm³ reported in 2022.

8.1.3 Treatment Options and Continuous Improvement

Suncor Base Plant reported that its tailings treatment technologies are operating as predicted and are meeting key milestones. Suncor Base Plant reported no issues with its tailings treatment technology in 2023 and that DDA3 operations met expectations.

Suncor Base Plant reported the following improvements in 2023:

- Data on the flocculent size of coagulated flocculated fluid tailings from a focused beam reflectance measurement analyzer was successfully used for online process monitoring.
- Near-infrared analyzers were used for online clay measurement in coagulated fluid tailings.
- A higher flow rate of coagulated fluid tailings through the polymer injectors resulted in increased mixing energy and better quality coagulated flocculated fluid tailings.
- The external structure of a second dredge was modified over the off-season to improve asset reliability and throughput when operating in the presence of debris in the fluid tailings source pond.

Near infrared and focused beam reflectance measurement analyzers were used to develop advanced process control logic to optimize the dosing of fluid tailings; however, Suncor Base Plant reported no change to the expected treatment capacity based on the improvements.

8.1.4 Technological Innovation in Fluid Tailings Treatment

Suncor Base Plant reported no 2023 field activities for pilots, prototypes, or demonstrations of fluid tailings technologies.

On December 15, 2023, Suncor Base Plant submitted its *Tailings Environmental and Reclamation Research Report* as per its *EPEA* approval.

For more information about technological innovation, see Suncor Base Plant's pre-2023 TMRs.

8.1.5 Regulatory and Management Actions

Suncor Base Plant operates at management level 1 as described in the TMF and Directive 085.

Suncor Base Plant submitted its TMP amendment application (the application) in September 2022. The application updates components of the Base Plant's integrated mine, tailings, and closure plan, including

- updates to the froth treatment tailings (FTT) management plan, including extending FTT deposition in pond 7 to the end-of-mine life and removing a future tailings deposit;
- updates to pond 6 fluid tailings treatment timing to reduce operational fluid containment and air emissions risks;

Alberta Energy Regulator

- updates to the new fluid tailings profile, shifting it by three years to reflect an updated end-of-mine life date and resultant fluid tailings treatment timing for pond 6 and pond 7; and,
- updates to the life-of-mine closure plan (LMCP) to support changes to the mine and tailings plan.

The AER approved the application on December 12, 2023, including a modified new fluid tailings profile that aligns with the revised predicted fluid tailings generation rate and a corresponding change to the total volume trigger and total volume limit. The total volume trigger was lowered from 281 to 272 Mm³ and the total volume limit was lowered from 393.4 to 380.8 Mm³. The approval is subject to the following submission requirements:

- By July 11, 2025, an integrated site-wide life-of-mine plan (LOMP), LMCP and TMP for PASSbased fluid tailings treatment technology and closure to terrestrial outcomes of all treated and untreated tailings deposits.
- By October 31, 2025, updated pond 6 and pond 7 fluid tailings management plans that include
 - a description of the trajectory for the life of the deposits through to the end of closure, including
 - a defined schedule with multiple milestones,
 - objectives and performance indicators for each milestone,
 - material requirements for each milestone, and
 - a description of the state of the landform at the end of each milestone and
 - updated RTR criteria.
- By December 31, 2025, an updated plan for SD8 with timelines and milestones that transitions SD8 from operations to decommissioning, closure, and abandonment.

Modifications to annual fluid tailings management reporting requirements were also issued, including

- results from hydrogeochemical assessment testing conducted in the reports for each froth tailings deposit, including pore water quality analyses, static testing (acid-base accounting), kinematic modelling, and testing results for the froth tailings deposit;
- an updated risk assessment for acid rock drainage (ARD) potential from all facilities containing froth tailings; and
- additional reporting of surface water quality parameters.

On September 29, 2023, Suncor Base Plant submitted an updated TMP for extended use of pond 1A and pond 2/3 to fulfil *OSCA* conditions. The AER recognized Suncor's commitment to submit RTR criteria for the remnant fluid tailings in pond 1A and pond 2/3 (five years after the end-of-mine life), noting that until RTR criteria have been approved, all fluid tailings in ponds 1A and 2/3 will be included in Suncor's fluid tailings inventory.

8.1.6 Measurement System Audit Results

Suncor Base Plant did not submit MSP updates in 2023. The AER issued a SIR requiring the submission of an updated MSP for changes made in 2023.

The AER completed a desktop inspection of Suncor Base Plant's fluid tailings volumes to verify reported values. Fluid tailings volumes modelled by the AER were within an acceptable margin of error compared with the volumes reported by Suncor.

8.2 Syncrude – Mildred Lake

In 2023, six tailings facilities were operating at Mildred Lake (see table 7), and three facilities were either inactive or in the late stages of final reclamation. The tailings facilities vary in their primary function, contents, and size.

Facility	Function	Contents
Mildred Lake settling basin (MLSB)	 plant recycle water source fluid storage solids storage	 recycle water fluid tailings FTT flotation tailings petroleum coke CST centrifuge plant centrate
South west sand storage (SWSS)	solids storagefluid storage	recycle waterfluid tailingsCST
Base mine lake (BML) (demonstration)	water-capped tailings demonstrationtreated tailings deposits	fresh waterrecycle watersequestered fluid tailings
East in-pit (EIP) (final reclamation)	Solids storage	• CT • CST
South west in-pit (SWIP)	fluid storagesolids storageplant recycle water sourcetreated tailings storage	 recycle water CST CT fluid tailings CT cyclone overflow
North mine south pond (NMSP)	 fluid storage solids storage treated tailings storage plant recycle water source 	 CST CT fluid tailings recycle water
North mine south pond east (NMSPE) deep cake (NMSPE deep cake)	solids storagetreated tailings storage	centrifuged fluid tailings cakeoverburdenCST
North mine centre pit- east (NMCP-E)	fluid storagesolids storagetreated tailings storage	 CST fluid tailings flocculated tailings centrifuge fluid tailings cake

Table 7. Tailings facilities operating at Syncrude Mildred Lake

W1/SWSS cake	 solids storage 	 centrifuge fluid tailings cake
(inactive)	 treated tailings storage 	

The MLSB and SWSS are the only out-of-pit tailings facilities at the site. The MLSB, SWSS, SWIP, NMSP, NMSPE deep cake, and NMCP-E are currently operating, providing fluid and solid tailings storage for the site. EIP is in the final stages of reclamation and land forming for closure purposes. BML is a demonstration pit lake within the former west in-pit tailings facility, having water-capped tailings. SWSS was initially used to place thin cake lifts from the commercial demonstration plant.

The fluid tailings treatment technologies approved for commercial operation at Mildred Lake are composite tailings (CT), centrifuge cake (CC), and in-line flocculation (ILF).

Mildred Lake treated 3.1 Mm³ of fluid tailings through the CC plant and 7.2 Mm³ of fluid tailings through the ILF floc-T plant.

Mildred Lake reported that its new fluid tailings inventory for 2023 was above the approved new fluid tailings profile but below the 20% deviation trigger, and the legacy fluid tailings inventory was equal to the approved limit.

8.2.1 Fluid Tailings

For 2023, Mildred Lake reported a total fluid tailings inventory (new and legacy fluid tailings combined) of 551.7 Mm³, up from 530.0 Mm³ in 2022.

The total volumes of fluid tailings reported for 2023 exceed the currently approved profiles for new and legacy fluid tailings inventories.

For 2023, Mildred Lake reported that 47.2 Mm³ of fluid tailings met its approved RTR criteria, up from 45.9 Mm³ in 2022.

The RTR status requires Syncrude Mildred Lake to meet the approved subobjective 1 and 2 criteria (see table 8), which are included in appendix C to *OSCA* approval 8573S.

Mildred Lake applied for RTR criteria for densified fluid tailings in its 2023 TMP, which is still under review.

Deposit	Subobjective	RTR Criteria
СТ	subobjective 1	65% solids content by weight within one year of tailings placement based on deposit sampling. 75% solids content by weight within one year after sand capping of deposit based on deposit sampling.
	subobjective 2	Groundwater is monitored as required by <i>EPEA</i> approval 26-03-00, as amended or renewed.
Centrifuge cake deep deposits	subobjective 1	50% solids content by weight within one year of tailings placement based on deposit sampling.

 Table 8.
 RTR criteria for Syncrude Mildred Lake

	subobjective 2	Groundwater is monitored as required by <i>EPEA</i> approval 26-03-00, as amended or renewed.
Flocculated tailings deposits	subobjective 1	50% solids content by weight within one year of tailings placement based on deposit sampling.
	subobjective 2	Groundwater is monitored as required by <i>EPEA</i> approval 26-03-00, as amended or renewed.

8.2.1.1 New Fluid Tailings

For 2023, Mildred Lake reported a new fluid tailings inventory of 153.7 Mm³ (see figure 9), up from 127.3 Mm³ in 2022. The new fluid tailings inventory for 2023 includes fluid tailings as measured for the first time from the NMCP-E. The approved new fluid tailings inventory for 2023 was 147.4 Mm³.

Mildred Lake has a total volume trigger for new fluid tailings inventory of 179.4 Mm³ and a total volume limit of 251.2 Mm³. Based on data reported in its 2023 TMR, Mildred Lake exceeded its approved new fluid tailings profile but did not exceed its 20% deviation trigger or its total volume trigger or total volume limit for new fluid tailings in 2023.

In 2023, the AER approved an extension to the new fluid tailings profile until the end of 2025 to cover the review period of the 2023 TMP. See section 8.2.5 for details.



New huid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 9. New fluid tailings for Syncrude Mildred Lake, 2014 to 2023

8.2.1.2 Legacy Fluid Tailings

For 2023, Mildred Lake reported a legacy fluid tailings inventory of 397.9 Mm³ (see figure 10), down from 402.7 Mm³ in 2022. The approved legacy fluid tailings inventory for 2023 was 398.0 Mm³.

Based on data reported in its 2023 TMR, Mildred Lake was within its approved legacy fluid tailings profile and did not exceed its profile deviation trigger for legacy fluid tailings in 2023.

In 2023, the AER approved an extension of the legacy fluid tailings profile until the end of 2025 to cover the review period for the 2023 TMP. See section 8.2.5 for details.



Approved profile: legacy fluid tailings inventory

Legacy fluid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 10. Legacy fluid tailings for Syncrude Mildred Lake, 2014 to 2023

8.2.2 Volume of Treated Fluid Tailings by Technology

For 2023, Mildred Lake reported that 3.1 Mm³ of fluid tailings were treated through the CC plant, creating 2.6 Mm³ of deposit in NMSPE and 7.2 Mm³ of fluid tailings through the floc-T plant, creating 3.2 Mm³ of deposit in NMCP-E.

Mildred Lake did not process any CT in 2023.

As of 2023, Mildred Lake reported that 47.2 Mm³ of fluid tailings had achieved RTR status:

- 0.8 Mm³ of CT in SWIP Major
- 6.4 Mm³ of CT in NMSP
- 36.5 Mm³ of cake in NMSPE deep cake
- 3.5 Mm³ of flocculated tailings and cake in NMCP-E

The RTR volume increased from 45.9 Mm³ reported in 2022.

8.2.3 Treatment Options and Continuous Improvement

Mildred Lake reported that its tailings treatment technologies are operating as expected, and deposits are meeting performance criteria and remain aligned with long-term closure and reclamation objectives.

In 2023,

- the fluid tailings source for the CC and floc-T plants was changed from the MLSB to the NMSP to improve fluid tailings flow and quality, and
- a block model of the NMSP was developed to locate and optimize fluid tailings quality in the pond for the dredges to target and deliver to the CC and floc-T plants.

Mildred Lake reported no issues with either CC or floc-T tailings treatment technology in 2023.

Based on conversations held with operating personnel during the 2023 tailings site inspection, the change in the fluid tailings source made a significant improvement in fluid tailings supply and fluid tailings treatment volumes.

8.2.4 Technological Innovation in Fluid Tailings Treatment

Mildred Lake reported the following technology research and development efforts for 2023:

- BML demonstration
- flocculated tailings
- tailings co-deposition
- co-processing

- tailings equipment and process optimization (methods to visually monitoring polymer usage optimization)
- geochemical characterization of FTT

Mildred Lake submitted a tailings research report as per its *EPEA* approval and continued its industry collaboration through external forums such as Canada's Oil Sand Innovation Alliance (COSIA).

For more information about technological innovation, see the Mildred Lake 2023 TMR.

8.2.5 Regulatory and Management Actions

Mildred Lake operates at management level 1 as described in the *TMF* and *Directive 085*, wherein projects operate in line with approved fluid tailings volume profiles. The measured new fluid tailings inventory for 2023 is above the approved new fluid tailings profile but below the 20% deviation trigger. The legacy fluid tailings inventory is at or slightly below the legacy fluid tailings profile and below the 20% legacy fluid tailings profile deviation trigger.

Syncrude submitted an update to the TMP for Mildred Lake in May 2023. To facilitate continued operations through the regulatory review period for the TMP, the AER granted an extension of the approved new and legacy fluid tailings profiles to the end of 2025.

The extension to the profiles approved under *OSCA* 8573S was based on the current fluid tailings inventory, expected fluid tailings generation based on production, and existing treatment capacity with approved technologies, recognizing that MLSB and BML have not been removed from the fluid tailings inventory. Table 9 shows the approved changes.

Year	New fluid tailings	Legacy fluid tailings	Total fluid tailings
2023	147.4	398.0	545.4
2024	162.0	389.9	551.9
2025	179.4	382.7	562.1

Table 9. Interim approved fluid tailings profiles for Syncrude Mildred Lake

As part of the review of the TMP, the AER communicated to Syncrude that it could not approve the proposed RTR criteria for water-capped tailings technology (WCTT) because the Government of Alberta had not yet indicated acceptance of this technology. Consequently, Syncrude requested an extension to the fluid tailings profile until the end of 2028 to facilitate a reassessment of the integrated mine, tailings, and closure plan for Mildred Lake. The revised plans would incorporate required terrestrial treatment and placement plans for tailings deposits previously planned as capped with water and assumed to meet RTR criteria.

The AER has requested an update to the TMP and LMCP to understand the effects on the TMP for the proposed interim period.

No management actions were taken during the reporting period for tailings management operations at Mildred Lake.

The AER initiated an on-site tailings inspection of Mildred Lake tailings operations in 2023 and found no issues of concern.

8.2.6 Measurement System Audit Results

Mildred Lake did not submit MSP updates in 2023 and complied with all tailings pond deposit and surface water sampling requirements.

The AER did not audit Syncrude's Mildred Lake MSP in 2023.

8.3 Syncrude – Aurora North

In 2023, three tailings facilities were operating at Aurora North (see table 10).

The Aurora settling basin (ASB) is the only out-of-pit tailings facility at the site. The Aurora east pit (AEP) and the Aurora centre pit north (ACPN) are both in-pit tailings facilities. The AEP comprises the former Aurora east pit north-east (AEPN-E) and the Aurora east pit south (AEPS). Water transfer from AEP to ACPN began in November 2023 as planned. Deposition of straight coarse tailings into ACPN is not planned until August 2024.

The tailings facilities vary in their primary function, contents, and size.

Facility	Function	Contents
ASB	plant recycle water source fluid storage solids storage fluid fine tailings (FFT) source for CT plant	recycle water CST flotation tailings FFT CT cyclone overflow
AEP	fluid storage solids storage treated tailings deposit filter sand source Plant recycle water source	CT CST recycle water FFT
ACPN	fluid storage treated tailings deposit	CT CST flotation tailings FFT recycle water

Table 10. Tailings facilities operating at Syncrude Aurora North

The fluid tailings treatment technology approved for commercial operation at Aurora North is CT.

Aurora North treated 6.2 Mm³ of fluid tailings, producing 25.3 Mm³ of CT in 2023 compared with 2.2 Mm³ of fluid tailings and 8.3 Mm³ of CT in 2022.

Aurora North reported that its new and legacy fluid tailings inventories for 2023 were within the approved fluid tailings profiles.

8.3.1 Fluid Tailings

For 2023, Aurora North reported a total fluid tailings inventory (new and legacy fluid tailings combined) of 144 Mm³, up from 137 Mm³ in 2022.

Volumes reported for 2023 fall within currently approved profiles for new and legacy fluid tailings inventories.

For 2023, Aurora North reported that 4.8 Mm³ of fluid tailings met its approved RTR criteria, up from 4.0 Mm³ in 2022.

The RTR status requires Aurora North to meet the approved subobjective 1 and 2 criteria (see table 11), which are included in appendix C to *OSCA* approval 10781P.

Deposit	Subobjective	RTR Criteria
CT deposits	subobjective 1	65% solids by weight within one year of tailings placement based on deposit sampling.
		75% solids by weight within one year after sand capping of deposit based on deposit sampling.
	subobjective 2	Groundwater is monitored as required by <i>EPEA</i> approval 26-02-00, as amended or renewed.

Table 11. RTR criteria for Syncrude Aurora North

8.3.1.1 New Fluid Tailings

For 2023, Aurora North reported a new fluid tailings inventory of 66.8 Mm³ (see figure 11), up from 59.0 Mm³ in 2022. The approved new fluid tailings inventory for 2023 was 81.0 Mm³.

Aurora North has a total volume trigger for new fluid tailings inventory of 113 Mm³ and a total volume limit of 158 Mm³. Based on data reported in its 2023 TMR, Aurora North was within its approved new fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 11. New fluid tailings for Syncrude Aurora North, 2014 to 2023

8.3.1.2 Legacy Fluid Tailings

For 2023, Aurora North reported a legacy fluid tailings inventory of 77.2 Mm³ (see figure 12), down from 78.0 Mm³ in 2022. The approved legacy fluid tailings inventory for 2023 was 90.0 Mm³.

Based on data reported in its 2023 TMR, Aurora North was within its approved legacy fluid tailings profile and did not exceed its profile deviation trigger for legacy fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 12. Legacy fluid tailings for Syncrude Aurora North, 2014 to 2023

8.3.2 Volume of Treated Fluid Tailings by Technology

For 2023, Aurora North reported that 6.2 Mm³ of fluid tailings were treated with CT technology, producing 17.7 Mm³ of CT beach in the AEP, in comparison to 2022 with 2.2 Mm³ of fluid tailings processed and 5.6 Mm³ of CT beach produced.

Throughout 2023, the AER and Syncrude met quarterly to monitor CT performance at Aurora North. In March 2024, the AER was satisfied that CT performance was back on plan and discontinued further quarterly reporting.

As of year-end 2023, Aurora North reported that 4.8 Mm³ of fluid tailings had achieved RTR status in the AEP. The RTR volume increased from 4.0 Mm³ reported in 2022.

8.3.3 Treatment Options and Continuous Improvement

Aurora North reported that its CT tailings treatment technology is operating as expected, and deposits are meeting performance criteria and remain aligned with long-term closure and reclamation objectives.

Syncrude reported the following improvements in 2023:

- Added a trommel screen to the CT gypsum system to reduce plugging and improve system uptime.
- Added a shelf in the CT mix box to reduce slurry aeration and system pipe wear.

8.3.4 Technological Innovation in Fluid Tailings Treatment

Aurora North reported the following technology research and development efforts for 2023:

- BML demonstration
- flocculated tailings
- tailings co-deposition
- co-processing
- tailings equipment and process optimization
- geochemical characterization of FTT

Aurora North submitted a tailings research report as per its *EPEA* approval and continued its industry collaboration through external forums, such as COSIA.

For more information about technological innovation, see Aurora North's 2023 TMR.

8.3.5 Regulatory and Management Actions

Aurora North operates at management level 1 as described in the TMF and Directive 085.

Aurora North submitted an updated integrated mine, tailings, and closure plan on May 31, 2023, which is currently under review by the AER.

The AER met quarterly with Syncrude throughout 2023 to ensure CT was operating according to plan. In 2021, Syncrude did not produce any CT at Aurora North. In 2022, CT operations had resumed and only processed 2.2 Mm³ of fluid tailings, and in 2023, Syncrude processed 6.2 Mm³ of fluid tailings into CT deposits. The AER recognizes the significant effort Syncrude has put into CT operations over the past year.

By early 2024, the AER was satisfied that CT operations were operating according to plan and discontinued quarterly performance reporting.

The AER initiated an on-site tailings inspection in June 2023 and found no issues of concern.

8.3.6 Measurement System Audit Results

Aurora North did not submit MSP updates in 2023 and complied with all tailings pond deposit and surface water reporting requirements.

Aurora North submitted the required surfaces for the AER to confirm the fluid tailings inventory. The AER did not audit Aurora North's MSP in 2023.

8.4 Canadian Natural Upgrading Limited – Muskeg River Mine

In 2023, six tailings facilities were operating at the Muskeg River mine (see table 12). The tailings facilities vary in their primary function, contents, and size. The external tailings facility (ETF) is the only out-of-pit tailings facility at the site.

The fluid tailings treatment technologies approved for commercial operation at Muskeg River mine are centrifuge fluid fine tailings (CFFT), thickened tailings (TT), north pool deposit (NPD) type, and atmospheric fines drying (AFD). Muskeg River mine is authorized to deposit ILF tailings for demonstration purposes. See section 8.4.4 for further details.

Facility	Function	Contents
External tailings facility	 fluid and solid tailings storage 	 tailings solvent recovery unit (TSRU) NPD type (TT, CST, TSRU) AFD CST TT
In-pit cell 1 (IPC1)	 fluid and solid tailings storage recycle water source	CSTTSRUrecycle water
IPC2	• fluid and solid tailings storage	 fluid tailings TT
IPC3	 fluid and solid tailings storage 	NPD type
IPC4	• fluid and solid tailings storage	TT and CST mixed depositCFFTAFD
IPC6	• fluid and solid tailings storage	AFDTSRU/CST

Table 12. Tailings facilities operating at CNUL Muskeg River mine

Muskeg River mine treated 6.7 Mm³ of fluid tailings, exceeding its treatment commitment of 4.7 Mm³ in its TMP.

Muskeg River mine reported that its new and legacy fluid tailings inventories for 2023 were within the approved fluid tailings profiles.

8.4.1 Fluid Tailings

For 2023, Muskeg River mine reported a total fluid tailings inventory (new and legacy fluid tailings combined) of 144.7 Mm³, down from 145.3 Mm³ in 2022.

Volumes reported for 2023 fall within currently approved profiles for new and legacy fluid tailings inventories.

For 2023, Muskeg River mine reported that 6.7 Mm³ of fluid tailings met its approved RTR criteria, down from 15.9 Mm³ in 2022.

The RTR status requires Muskeg River mine to meet the approved subobjective 1 and 2 criteria (see table 13), which are included in appendix C to *OSCA* approval 8512O.

There are no approved RTR criteria for ILF.

Table 13. RTR criteria for CNUL Muskeg River mine

Deposit	Subobjective	RTR Criteria
NPD type (co-deposition of TT with	subobjective 1	70% solids by weight within five years of tailings placement based on deposit sampling.
TSRU tailings, WT, and CST)	subobjective 2	Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 00020809-02-00, as amended or renewed.
AFD	subobjective 1	50% solids by weight within one year of tailings placement based on deposit sampling. 75% solids by weight within five years of final tailings placement based on deposit sampling.
	subobjective 2	Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 00020809-02-00, as amended or renewed.
TT/CST mixed deposit	subobjective 1	60% solids by weight within three years of tailings placement based on deposit sampling.70% solids by weight within five years of tailings placement based on deposit sampling.
	subobjective 2	Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 00020809-02-00, as amended or renewed.
TSRU/CST mixed deposit	subobjective 1	60% solids by weight within three years of tailings placement based on deposit sampling.70% solids by weight within five years of tailings placement based on deposit sampling.
	subobjective 2	Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 00020809-02-00, as amended or renewed.
CFFT/CST mixed deposit	subobjective 1	60% solids by weight within three years of tailings placement based on deposit sampling.70% solids by weight within five years of tailings placement based on deposit sampling.

subobjective 2	Groundwater adjacent or in communication with fluid tailings
	deposits is effectively monitored, reported, managed, and
	mitigated as required by EPEA approval 00020809-02-00, as
	amended or renewed.

8.4.1.1 New Fluid Tailings

For 2023, Muskeg River mine reported a new fluid tailings inventory of 56.7 Mm³ (see figure 13), down from 57.3 Mm³ in 2022. The approved new fluid tailings inventory for 2023 was 76 Mm³.

Muskeg River mine has a total volume trigger for new fluid tailings inventory of 110 Mm³ and a total volume limit of 154 Mm³. Based on data reported in its 2023 TMR, Muskeg River mine was within its approved new fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 13. New fluid tailings for CNUL Muskeg River mine, 2014 to 2023

8.4.1.2 Legacy Fluid Tailings

For 2023, Muskeg River mine reported a legacy fluid tailings inventory of 88 Mm³ (see figure 14), unchanged from 2022. The approved legacy fluid tailings inventory for 2023 was 92 Mm³.

Based on data reported in its 2023 TMR, Muskeg River mine was within its approved legacy fluid tailings profile and did not exceed its profile deviation trigger for legacy fluid tailings in 2023.



Legacy fluid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 14. Legacy fluid tailings for CNUL Muskeg River mine, 2014 to 2023

8.4.2 Volume of Treated Fluid Tailings by Technology

For 2023, Muskeg River mine reported that fluid tailings were treated with CFFT, TT, CST/TSRU, and AFD and placed in ETF, IPC1, IPC3, IPC4 and IPC6. In 2023, the report format changed following the approval of the 2022 Muskeg River mine TMP. Treated fluid tailings volumes were converted to treated deposit volumes and reported to allow using TMP targets as performance indicators. The AER issued a SIR to obtain the annual fluid tailings consumed from the production of tailings treatment technologies, as stipulated in section 6.2 of *Directive 085*, in addition to the new performance indicators.

Muskeg River mine is authorized to deposit ILF tailings for demonstration purposes. See sections 8.4.4 and 8.4.5 for details.

As of 2023, Muskeg River mine reported that 6.7 Mm³ of fluid tailings had achieved RTR status:

- 4.5 Mm³ of TT/CST in IPC4
- 2.2 Mm³ of AFD in ETF

The RTR volume increased from 15.9 Mm³ reported in 2022.

8.4.3 Treatment Options and Continuous Improvement

Muskeg River mine reported that its tailings treatment technologies are operating as expected, and deposits are meeting performance criteria and remain aligned with long-term closure and reclamation objectives.

Muskeg River mine reported it intends to expand the AFD cells in the ETF to add flexibility and contingency to the execution plan for meeting closure and reclamation milestones.

Muskeg River mine reported that the portion of the TSRU deposit in IPC1 capped with CST shows displacement or capture of fluid tailings underlying the deposit, which CNUL claimed as a reduction of the fluid tailings inventory. The AER is concerned that these fluid tailings volumes were deducted from the fluid tailings inventory without meeting approved RTR criteria. The AER issued a SIR to understand the applicability and how this may affect the 2023 fluid tailings volume calculation.

Muskeg River mine reported a suspended TSRU mat on top of the fluid tailings in IPC3. The AER issued a SIR to understand the characteristics of the deposit and how this may affect its development.

Muskeg River mine reported no change to the expected treatment capacity based on the improvements.

The AER noted Muskeg River mine reported new RTR material produced in the ETF and IPC3 in 2022. A TT source is a required component of NPD type as defined in appendix C of *OSCA* scheme approval 8512O. Since the TT and TSRU tailings streams were removed from the ETF, this deposit is created by material from the transition zone (TZ) mixing with beached CST. In IPC3, the Muskeg River mine reported "insignificant" TZ development and the removal of the TT stream from IPC3 in November 2021.

The AER based the RTR volume on the 2022 TMR round 1 SIR response. The AER has adjusted the reported volumes to reflect the lack of the TT source and the absence of a TZ. CNUL reported the same error in 2023, and the AER has requested CNUL issue an errata.

8.4.4 Technological Innovation in Fluid Tailings Treatment

Muskeg River mine reported the following technology research and development efforts for 2023:

- Fluid tailings consolidation casing project: Instrumentation monitoring continued in 2023 as part of this multiyear performance evaluation. In 2023, consolidation properties interpreted from casing data were used to compare the interpolated properties from various consolidation tests to evaluate the effectiveness of these consolidation tests. The consolidation test evaluation analysis will continue in 2024. Tailings material in all casings continues to settle, and the data and analysis results may be used to calibrate predictive consolidation models for the specific tailings materials in the future.
- Soft deposit capping (centrifuge cake test cell capping): Instrumentation monitoring to collect data on the long-term performance of CFFT within the test cell continued in 2023.
- Geobag pilot program: A final report summarized the evaluation of geobags as a technology to treat fluid tailings. The pilot showed that geobags are a viable technique for drying fluid tailings. Geobags are not included in the TMP; however, CNUL will provide additional information if it intends to pursue the use of geobags in the future. No further work is planned for this pilot.
- Fluid tailings pressure filtration pilot: In 2023, the final deposit investigation was conducted. A final report summarized the work completed evaluating filter press as a technology to treat fluid tailings. This pilot showed that filter press is a viable technique for drying fluid tailings. Filter press is not currently in the TMP; however, CNUL will provide additional information if it intends to pursue filter press in the future. No further work is planned for this pilot.
- **ILF fluid tailings and CST mixed deposit field trial**: Following the conclusion of the 2022 pilot, 1.7 Mm³ of CST slurry was deposited in Jackpine mine fluid cell 1 (FC1). Over 90% of the unmixed ILF fluid tailings from the 2022 pilot was mixed with CST, forming an ILF fluid tailings/CST mixed deposit. CNUL obtained approval for the 2023 ILF fluid tailings/CST mixing pilot. The objectives of the 2023 pilot focused on continued evaluation of the mixing process, deposition strategy, and mixed deposit performance. A redesigned ILF treatment facility was implemented for May to September 2023 for the pilot.

Key learnings in 2023 include the following:

- The deposits formed during the 2023 ILF fluid tailings/CST mixing pilot were compositionally similar to those formed during the 2022 pilot and the CFFT/CST mixed deposits formed in Jackpine mine DDA1 since 2014.
- The single CST discharge location configuration provided a two-dimensional sand-fines mixing scenario that helped understand the mixing mechanism, considering inputs from all ILF fluid tailings properties, cell geometry, and deposition conditions. The 2022 and 2023 pilots demonstrated how mixing efficiencies could be improved by deposition planning and operation.

- The 2023 pilot demonstrated the feasibility of forming an ILF fluid tailings/CST mixed deposit on top of the mixed deposit formed in the 2022 pilot and deposits between the 2022 and 2023 pilots.
- Preliminary consolidation test results showed the ILF fluid tailings/CST mixed deposit had similar consolidation properties to the CFFT/CST mixed deposits in DDA1.
- The estimated volume of the mixed deposit produced in the 2023 pilot was 0.9 Mm³, not including clean CST on top of the mixed deposits. The modelled average solids content was 72.3%, and the modelled average sand-to-fines ratio was 4.3.
- Centrifuged FFT and CST mixed deposit continuous improvement: The 2021 CFFT/CST mixed deposit will continue to be investigated and analyzed as part of the annual tailings investigation, and the data will continue to be published in the Jackpine mine TMR. The results will inform the Jackpine mine ETF closure design and optimize the formation of mixed deposits.

For more information about technological innovation, see Muskeg River mine's 2023 TMR.

8.4.5 Regulatory and Management Actions

Muskeg River mine operates at management level 1 as described in the TMF and Directive 085.

Muskeg River mine submitted its TMP amendment application in April 2022. The AER approved the amendment application on December 12, 2023, with conditions. The following is a summary of the changes to the *OSCA* approval:

- Reworded subobjective 2.
- Added appendix D incorporating infilling milestones.
- Additional requirements for demonstrating feasibility of alternative (i.e., terrestrial-based closure) fluid tailings management plans with an integrated mine, tailings, and closure plan.
- Provided a timeline for the submission of an integrated plan demonstrating feasibility of an alternative (i.e., terrestrial-based) closure.
- Standardized consolidation modelling criteria.
- Modified future TMP amendment application criteria.
 - Future TMPs will require proof of alignment with the LMCP and LOMP or provide an updated LMCP and LOMP.
- Added a requirement to include a froth tailings management plan in future TMPs and facility commissioning plans.
- Modified the TMR reporting criteria.

- Added a requirement to provide modelling surfaces to facilitate the volumetric verification process and development of the auditing process.
- Added performance reporting on the execution of the froth tailings management plan.
- Added a requirement to report actual treatment production rates versus planned.
- Added a requirement to report surface water quality parameters in the TMR.
- Approval of the CST/TSRU RTR criteria.
- Eliminated expired OSCA approval conditions.
- Addressed duplicate conditions with *EPEA* approval amendments.

See OSCA approval 8512O for details.

In 2023, Muskeg River mine provided an updated plan for IPC6. The AER authorized the updated IPC6 plan with conditions, noting the TMP application amendment was still under review. The final approval conditions will supersede the authorization.

On November 3, 2023, Muskeg River mine received approval to continue the tailings technology pilot: mixing of ILF fluid tailings/CST tailings. The mixing pilot will proceed at the mine in 2024 and 2025, with the construction and operation of a new pilot facility located in IPC4. The pilot will test mixing performance and the feasibility of year-round operations and study the mixed deposit performance with different operational conditions. The AER authorized the pilot with the conditions that the Muskeg River mine will

- provide the AER with an update in the TMR starting April 30, 2024, unless another date is authorized;
- execute the pilot in accordance with the submission and the SIR responses;
- collect pore water samples from the bottom and the top of the mixed deposit to characterize vertical variability of pore water chemistry at two laterally separate locations;
- notify the AER if there are changes to the total treated tailings slurry and dewatered deposit estimates as presented in the submission;
- notify the AER if there is a change to the final estimated milestone for the pilot;
- provide the AER with advance notice of the start of the pilot; and
- conduct the pilot activities aligned with the commitments and the associated monitoring activities detailed in their submissions.

During the 2023 annual tailings inspection, the AER observed that the beach above water slopes in IPC1 and IPC3 had an orange and yellow discolouration. CNUL confirmed that it had not yet tested to

determine the source of the discolouration. The AER required inspection follow-up under the *EPEA* approval.

8.4.6 Measurement System Audit Results

Muskeg River mine did not submit an updated MSP in 2023. However, due to the modifications required for the RTR criteria, the AER reviewed the 2022 MSP submission and issued SIRs during the review of the 2023 TMR. The SIRs will be addressed with the 2024 MSP update due by December 31, 2024.

The AER completed a desktop inspection of Muskeg River mine's fluid tailings volumes to verify reported values. Fluid tailings volumes modelled by the AER were within an acceptable margin of error compared with the volumes reported by Muskeg River mine.

8.5 Canadian Natural Upgrading Limited – Jackpine Mine

In 2023, five tailings facilities were operating at the Jackpine mine (see table 14). The tailings facilities vary in their primary function, contents, and size. ETF-western (ETF-W), ETF-eastern (ETF-E), and sand cell 2 (SC2) are the out-of-pit tailings facilities at the site.

The fluid tailings treatment technologies approved for commercial operation at Jackpine mine are CFFT, TT, and AFD. Jackpine mine is authorized to deposit ILF tailings for demonstration purposes. See section 8.5.5 for further details.

Facility	Function	Contents
External tailings facility-western (ETF-W)	 treated tailings (TT/CST, and CFFT/CST) storage recycle water storage 	 TT/CST CFFT/CST centrate recycle water
External tailings facility-eastern (ETF-E)	 fluid and solid tailings storage CST deposited for cell construction and beaching activities to build containment recycle water source 	fluid tailingsCSTrecycle water
Sand cell 2 (SC2)	 fluid and solid tailings storage CST deposited for cell construction and beaching activities to build containment recycle water transfer to ETF 	fluid tailingsCST
Fluid cell 1 (FC1)	 fluid and solid tailings storage CST deposited for cell construction and beaching activities to build containment ILF treated tailings storage for piloting purposes recycle water transfer to ETF 	 fluid tailings CST ILF recycle water
In-pit cell 1 (IPC1)	• fluid and solid tailings storage	• WT • CST

Table 14. Tailings facilities operating at CNUL Jackpine mine

 treated tailings (TT/CST, and
CFFT/CST) storage
 recycle water transfer to ETF

Jackpine mine treated fluid tailings as per its treatment commitments in its TMP.

Jackpine mine reported that its new and legacy fluid tailings inventories for 2023 were within the approved fluid tailings profiles.

8.5.1 Fluid Tailings

For 2023, Jackpine mine reported a total fluid tailings inventory (new and legacy fluid tailings combined) of 25.9 Mm³, up from 24.4 Mm³ in 2022.

Volumes reported for 2023 fall within currently approved profiles for new and legacy fluid tailings inventories.

For 2023, Jackpine mine reported that 4.9 Mm³ of fluid tailings met its approved RTR criteria, down from 5 Mm³ in 2022, but in alignment with TMP targets.

The RTR status requires Jackpine mine to meet the approved subobjective 1 and 2 criteria (see table 15), which are included in appendix C to *OSCA* approval 9756K.

As ILF is in the demonstration phase and there are no approved RTR criteria for ILF, treatment volumes are not included.

Table 15. RTR criteria for CNUL Jackpine mine

Deposit	Subobjective	RTR Criteria
ETF CFFT/CST mixed deposits	subobjective 1	60% solids by weight within three years of tailings placement based on deposit sampling. 70% solids by weight within five years of tailings placement based on deposit sampling.
	subobjective 2	Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 00020809-02-00, as amended or renewed.
ETF TT/CST mixed deposit	subobjective 1	70% solids by weight within five years of tailings placement based on deposit sampling.
	subobjective 2	Groundwater adjacent to or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 00020809-02-00, as amended or renewed.

8.5.1.1 New Fluid Tailings

For 2023, Jackpine mine reported a new fluid tailings inventory of 3.9 Mm³ (see figure 15), up from 2.4 Mm³ in 2022. The approved new fluid tailings inventory for 2023 was 27 Mm³.

Jackpine mine has a total volume trigger for new fluid tailings inventory of 41 Mm³ and a total volume limit of 57.4 Mm³. Based on data reported in its 2023 TMR, Jackpine mine was within its approved new

fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.



Approved profile: new fluid tailings inventory
 New fluid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 15. New fluid tailings for CNUL Jackpine mine, 2014 to 2023

8.5.1.2 Legacy Fluid Tailings

For 2023, Jackpine mine reported a legacy fluid tailings inventory of 21 Mm³ (see figure 16), down from 22 Mm³ in 2022. The approved legacy fluid tailings inventory for 2023 was 21 Mm³.

Based on data reported in its 2023 TMR, Jackpine mine was within its approved legacy fluid tailings profile and did not exceed its profile deviation trigger for legacy fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 16. Legacy fluid tailings for CNUL Jackpine mine, 2014 to 2023

8.5.2 Volume of Treated Fluid Tailings by Technology

For 2023, Jackpine mine reported that 3.6 Mm³ of fluid tailings were treated with CFFT/CST co-mixing and TT/CST co-mixing in ETF-E and ETF-W. In 2023, the report format change following the approval of the 2022 Jackpine mine TMP. Treated fluid tailings volumes were converted to treated deposit volumes and reported to allow using TMP targets as performance indicators. The AER issued a SIR to obtain the annual fluid tailings consumed from the production of tailings treatment technologies, as stipulated in section 6.2 of *Directive 085*, in addition to the new performance indicators.

Since no RTR criteria have yet to be approved, fluid tailings treated by the ILF pilot were placed in FC1 for demonstration purposes.

As of 2023, Jackpine mine reported that 4.9 Mm³ of fluid tailings had achieved RTR status:

- 1.7 Mm³ of TT in the ETF
- 3.2 Mm³ of CFFT in the ETF

The RTR volume decreased from 5.0 Mm³ reported in 2022.

8.5.3 Treatment Options and Continuous Improvement

Jackpine mine reported that its tailings treatment technologies are operating as expected, and deposits are meeting performance criteria and remain aligned with long-term closure and reclamation objectives.

Jackpine mine reported no issues with their suite of tailings treatment technologies in 2023. No concerns with treatment capacity were reported in 2023.

Jackpine mine reported no change to the expected treatment capacity based on improvements.

8.5.4 Technological Innovation in Fluid Tailings Treatment

CNUL pursues technological innovation in fluid tailings management at both the Muskeg River mine and Jackpine mine. The findings are applicable to both sites. See section 8.4.4 for details on the current technological research.

8.5.5 Regulatory and Management Actions

Jackpine mine operates at management level 1 as described in the TMF and Directive 085.

Jackpine mine submitted its TMP amendment application in April 2022. The AER approved the amendment application plan on December 15, 2023, with conditions. The following is a summary of the changes to the *OSCA* approval:

- Reworded subobjective 2.
- Added appendix D incorporating infilling milestones.
- Additional requirements for demonstrating feasibility of alternative (i.e., terrestrial-based closure) fluid tailings management plans with an integrated mine, tailings, and closure plan.
- Provided a timeline for the submission of an integrated plan demonstrating feasibility of an alternative (i.e., terrestrial-based) closure.
- Standardized consolidation modelling criteria.
- Modified future TMP amendment application criteria.
 - Future TMPs will require proof of alignment with the LMCP and LOMP or provide an updated LMCP and LOMP.
- Added a requirement to include a froth tailings management plan in future TMPs and facility commissioning plans.
- Modified the TMR reporting criteria.
- Added a requirement to provide modelling surfaces to facilitate the volumetric verification process and development of the auditing process.

- Added performance reporting on the execution of the froth tailings management plan.
- Added a requirement to report actual treatment production rates versus planned.
- Added a requirement to report surface water quality parameters in the TMR.
- Eliminated expired OSCA approval conditions.
- Addressed Jackpine mine expansion panel review clauses that were duplicated with *EPEA* approval amendments.

See OSCA approval 9756K for details.

In 2023, Jackpine mine provided an updated plan for IPC1. The AER authorized the updated IPC1 plan with conditions, noting the TMP application amendment was still under review. The final approval conditions will supersede the authorization.

In 2023, Jackpine mine applied for an extension of its ILF FT/CST mixing pilot. The AER authorized the pilot with the following conditions that the Jackpine mine will

- provide the AER with an update in the TMR starting April 30, 2024, unless another date is authorized;
- execute the pilot in accordance with the submission and the SIR responses;
- notify the AER before executing changes to the total treated tailings slurry and dewatered deposit estimates as presented in the submission;
- notify the AER before executing changes to the final estimated milestone for the pilot;
- provide the AER with advance notice of the start of the pilot; and
- conduct the pilot activities aligned with the commitments and the associated monitoring activities detailed in the submissions.

No management actions were taken during the 2023 reporting period for tailings management operations at Jackpine mine.

8.5.6 Measurement System Audit Results

Jackpine mine did not submit an updated MSP in 2023. However, due to the modifications required for the RTR criteria, the AER reviewed the 2022 MSP submission and issued SIRs during the review of the 2023 TMR. The SIRs will be addressed with the 2024 MSP update due by December 31, 2024.

The AER completed a desktop inspection of Jackpine mine's fluid tailings volumes to verify reported volumes. Fluid tailings volumes modelled by the AER were within an acceptable margin of error compared with the volumes reported by Jackpine mine.

8.6 Canadian Natural Resources Limited – Horizon Mine

In 2023, two tailings facilities were operating at the Horizon mine (see table 16). The tailings facilities vary in their primary function, contents, and size. ETF/DDA1 is the only out-of-pit tailings facility at the site.

The fluid tailings treatment technologies approved for commercial operation at Horizon mine are the suite of nonsegregating tailings (NST) technologies, including enhanced nonsegregating tailings (eNST) and enhanced spiked nonsegregating tailings (esNST). Although not an approved tailings treatment technology, naphtha recovery unit (NRU) tailings are also deposited in ETF/DDA1.

Facility	Function	Contents
External tailings facility (ETF) / DDA1	fluid and solid tailings storagerecycle water source	 NST (eNST, esNST) NRU recycle water
DDA2	 fluid and solid tailings storage 	• NST(eNST, esNST)

Table 16. Tailings facilities operating at CNRL Horizon mine

Horizon mine treated 158.6 Mm³ of fluid tailings as per its treatment commitments in its TMP.

Horizon mine reported that its new and legacy fluid tailings inventories for 2023 were within the approved fluid tailings profiles.

8.6.1 Fluid Tailings

For 2023, Horizon mine reported a total fluid tailings inventory (new and legacy fluid tailings combined) of 148.5 Mm³, down from 173.6 Mm³ in 2022. The total fluid tailings volume decrease is not directly comparable because the subobjective 1 RTR criteria for NST was modified to incorporate operational performance learnings. See section 8.6.5 for details.

Volumes reported for 2023 fall within currently approved profiles for new and legacy fluid tailings inventories.

For 2023, Horizon mine reported that 87.8 Mm³ of fluid tailings met its approved RTR criteria, up from 83.3 Mm³ in 2022.

The RTR status requires Horizon mine to meet the approved subobjective 1 and 2 criteria (see table 17), which are included in appendix C to *OSCA* approval 9752M.

In early 2024, Horizon mine submitted a proposal to modify the subobjective 2 criteria modification, which remains under review.

Deposit	Subobjective	RTR Criteria
ETF/DDA1, DDA2, DDA3, DDA4/5, DDA6, DDA7, DDA8 and DDA9	subobjective 1	70% solids by weight within one year of tailings placement. 75% solids by weight within five years of starting backfilling.
	subobjective 2	Groundwater is monitored as required by <i>EPEA</i> approval 149968, as amended or renewed; maintain the water table at a depth between 2 and 4 m.

Table 17. RTR criteria for CNRL Horizon mine

8.6.1.1 New Fluid Tailings

For 2023, Horizon mine reported a new fluid tailings inventory of 101.6 Mm³ (see figure 17), down from 121.3 Mm³ in 2022. The approved new fluid tailings inventory for 2023 was 130.3 Mm³.

Horizon mine has a total volume trigger for new fluid tailings inventory of 198 Mm³ and a total volume limit of 277 Mm³. Based on data reported in its 2023 TMR, Horizon mine was within its approved new fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 17. New fluid tailings for CNRL Horizon mine, 2014 to 2023

8.6.1.2 Legacy Fluid Tailings

For 2023, Horizon mine reported a legacy fluid tailings inventory of 46.9 Mm³ (see figure 18), down from 52.3 Mm³ in 2022. The approved legacy fluid tailings inventory for 2023 was 47.1 Mm³.

Based on data reported in its 2023 TMR, Horizon mine was within its approved legacy fluid tailings profile and did not exceed its profile deviation trigger for legacy fluid tailings in 2023.



Approved profile: legacy fluid tailings inventory
 Legacy fluid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of *Directive 085*) submitted annually by operators.

Figure 18. Legacy fluid tailings for CNRL Horizon mine, 2014 to 2023

8.6.2 Volume of Treated Fluid Tailings by Technology

For 2023, Horizon mine reported that 158.6 Mm³ of fluid tailings were treated with NST technology and deposited in ETF/DDA1 and DDA 2.

As of 2023, Horizon mine reported that 87.8 Mm³ of fluid tailings had achieved RTR status:

- 14.7 Mm³ of NST, eNST, and esNST in ETF/DDA1
- 73.1 Mm³ of NST, eNST, and esNST in DDA2

The RTR volume increased from 83.3 Mm³ reported in 2022.

8.6.3 Treatment Options and Continuous Improvement

Horizon mine reported that its tailings treatment technologies are operating as expected, and deposits are meeting performance criteria and remain aligned with long-term closure and reclamation objectives.

Horizon mine reported on continuous improvement, issues, and mitigations concerning operations in 2023 with thickener and eNST/esNST. The following improvements were addressed in 2023:

- maximizing underflow density
- optimizing polymer addition
- optimizing polymer addition to improve performance at deposition locations
- targeting higher-solids content fluid tailings in ETF/DDA1
- improving tailings performance monitoring

For more information, see the CNRL Horizon 2023 TMR.

The AER made the following observations during the annual tailings inspection in 2023:

- The exposed NRU beaches in ETF/DDA1 were yellow, resulting in the AER requesting follow-up information. Horizon mine presented current research, monitoring, results, and interpretations, indicating the presence of potentially acid-generating (PAG) material. Horizon has committed to providing the AER with an update by December 31, 2024.
- There are over-built NRU beaches, which raises concerns about alignment with the mine's LMCP. The beaches are at higher elevations than the closure elevation of the substrate of the final landform specified in the LMCP. The LMCP is over a longer timeframe, and the AER understands that Horizon mine would adjust the elevations and anticipated closure landscapes in upcoming *EPEA* submissions (i.e., *EPEA* renewal application or LMCP).

Horizon mine reported continued improvements in NST on-specification density performance in 2022 and 2023. Horizon mine reported an 89.8% on-specification NST rate, exceeding the 2023 to 2055 on-specification NST target year-end average of 83%. Horizon mine reported no change to the expected treatment capacity based on the improvements.

8.6.4 Technological Innovation in Fluid Tailings Treatment

In January 2022, Horizon mine submitted its *Tailings Research and Development Report*, as per its *EPEA* approval.

Horizon Mine reported the following technology research and development efforts for 2023:

• **2023 eNST / esNST Shear Cell Testing Program**: Conclusions from the 2023 program were that flocculation reduces the likelihood of segregation, and eNST and esNST are less prone to segregation

than NST. The laboratory data aligned with field data, showing a higher fines capture with increased eNST and esNST production than NST. The 2023 pilot findings support CNRL's shift towards a higher operational run time of eNST and esNST.

- **2023 Geo-Column and Large Strain Consolidation Test Program for esNST**: The results indicated that the infill settlement is predicted to be higher for esNST at a sand-to-fines ratio of 3.5 rather than 4.0.
- Fluid Tailings Thickener Pilot: CNUL evaluated the use of a commercial thickener to increase the fines captured. The average solids content of the thickened fluid tailings was higher than the feed.
- **Modified AFD**: In 2023, the AFD deposit was sampled to evaluate the effects of the freeze-thaw cycle on the 2022 deposits. The sampling results demonstrated strong performance repeatability after a single freeze-thaw cycle.
- **NRU Tailings Treatment**: CNRL completed the engineering design for a tailings treatment technology to recover residual naphtha and bitumen from the NRU tailings stream. Recovering additional naphtha and bitumen from the NRU tailings stream should benefit tailings consolidation and the environmental performance of the NRU tailings deposits.
- **Tailings Capping Studies**: CNRL developed a research plan to confirm or refine the existing conceptual DDA2 capping plan or to explore suitable alternatives that align with CNRL's LMCP. Components of the capping studies include
 - tailings consolidation assessments (NST samples collected in 2023 are being tested) and
 - the Horizon tailings biogeochemical evaluation project to evaluate risks for ARD and biogenic gas generation and the presence of naturally occurring radioactive materials.
- **NST Capping Pilot**: The objectives of this pilot are to characterize potential capping and reclamation materials, evaluate the effects of capping treatments on the short-term establishment of native boreal plant communities, and determine the effects of chemicals of potential concern on vegetation growth and soil microbial communities. The analyses showed coke had similar chemical properties to suitable sand and exhibited a higher water-holding capacity. After the first growing season, it was observed that plants could survive in weathered NST, although most did not thrive.
- NST Reclamation Field Trial Vegetation Research: This research addresses the suitability of capping materials for the reclamation of tailings deposits. A field trial will incorporate 20 cells, simulating upland and upland to wetland transition. The project will assess how boreal plants respond to the chemical and physical characteristics of capping treatments, the distribution of geochemical constituents in soil layers, and the influence of hydrological functions of capping materials on vertical and horizontal movement of geochemical constituents.

• **COSIA/Pathways End of Pit Lake Research**: CNRL actively participates in three COSIA/Pathways Projects concerning pit lake research. Research efforts continued towards creating sustainable end-pit lakes to safely sequester fluid tailings and effectively treat process-affected water in the closure landscape.

For more information about technological innovation, see Horizon mine's 2023 TMR.

8.6.5 Regulatory and Management Actions

Horizon mine operates at management level 1 as described in the TMF and Directive 085.

No management actions were taken during the 2023 reporting period for tailings management operations at Horizon mine.

Horizon mine requested a due date extension to submit an updated TMP. The AER authorized the extension request, changing the required submission date from June 30, 2024, to August 1, 2025.

Horizon mine applied to amend the NST RTR subobjective 1 performance criteria based on the assessment of performance data as follows:

- 70% solids by weight within one year of tailings placement
- 75% solids by weight within five years of starting backfilling (defined as the approximate final 5% of the planned NST deposition for each DDA).

The AER approved the proposed amendment to the NST RTR subobjective 1 performance criteria on June 7, 2023 (appendix C to *OSCA* approval 9752L).

During the annual tailings inspection (included in appendix 2), the AER identified concerns regarding construction milestones for dike 29 in DDA2, potentially affecting the mine's containment capacity. The AER issued the following information request:

• Horizon mine will provide a monthly construction update for dike 29 concerning construction milestones starting November 2023. In February 2024, the monthly update will include survey data to confirm the achievement of milestones.

During the 2022 tailings inspection, the AER identified concerns regarding discolouration of the ETF/DDA1 NRU beaches. The concerns focused on PAG materials and the implications for meeting *Directive 085* objectives, particularly subobjective 2. The AER issued the following information request:

• Horizon mine provided an update on November 16, 2023, concerning the composition of materials and other learnings obtained to address the presence of NRU beach discolouration. Due to the findings presented to the AER, there is a concern that PAG material is a risk. As such, Horizon mine is required to provide an annual update by December 31 of each year starting in 2024, unless otherwise specified, which includes the following:

- Development of monitoring, adaptive management, and mitigation plans for all aspects of PAG material sources.
- Test results and assessments, including how they are incorporated in future monitoring, mitigation, and reporting plans or programs.
- Development of a field monitoring program to inform an assessment that will identify optimum depositional environment conditions that reduce the risk of ARD.

The findings and outcome of the inspection follow-up will be reported in subsequent reports.

8.6.6 Measurement System Audit Results

Horizon did not submit an updated MSP in 2023. However, due to the recent modification of RTR criteria, the AER expects an updated MSP in 2024. The AER will issue SIRs to Horizon mine.

The AER completed a desktop inspection of Horizon mine's fluid tailings volumes to verify reported values. Fluid tailings volumes modelled by the AER were within an acceptable margin of error compared with the volumes reported by Horizon mine.

8.7 Imperial Oil Resources Limited – Kearl

In 2023, three tailings facilities were operating at the Kearl mine (see table 18). The east external tailings area (EETA) and the west external tailings area (WETA) continued to operate as in previous years. In May 2023, Kearl began placing tailings in in-pit tailings area 1 (ITA1).

The tailings facilities vary in their primary function, contents, and size. EETA and WETA are the only out-of-pit tailings facilities at the site, and ITA1 is the first in-pit tailings facility at the Kearl mine.

The fluid tailings treatment technology approved for commercial operation at Kearl is the Kearl fine tailings treatment (KFTT) process, wherein fluid tailings from the WETA and flotation tailings from the extraction plant are combined and flocculated in a thickener and later re-flocculated in-line before deposition in the EETA.

Facility	Function	Contents
EETA	 fluid storage solids storage	• TT • CST
WETA	fluid storagesolids storage	CSTflotation tailingsTSRU tailings
ITA1	 fluid storage solids storage	• CST • TSRU

Table 18. Tailings facilities operating at Imperial Kearl

In 2023, Kearl treated 1.58 Mm³ of fluid tailings through the KFTT process, down from 5.4 Mm³ in 2022. However, Kearl increased the proportion of flotation tailings in the KFTT process from 29.3 Mm³ in 2022 to 40.1 Mm³ in 2023, focusing fluid tailings consumption from WETA into proving the enhanced in-line flocculation (eILF) technology. Kearl reported that the fluid tailings inventory for 2023 was within the currently approved fluid tailings profile.

8.7.1 Fluid Tailings

For 2023, Kearl reported a total fluid tailings inventory (all new fluid tailings) of 138.0 Mm³, up from 67.0 Mm³ reported in 2022. The fluid tailings inventory includes all material made by the ILF pilots and accounts for the following:

- Returning all material previously considered as RTR (27.6 Mm³) to the fluid tailings inventory. Imperial voluntarily returned the volumes to their fluid tailings profile due to the uncertainty of having met the intention of *Directive 085* subobjective 2 requirements.
- Previously undefined fluid tailings deposits were found below the TSRU deposit in WETA. Additional sampling in WETA showed the potential for additional fluid tailings that were accumulating below the solid material over the last five years. Previous pond measurement programs since 2019 had not identified these deposit volumes. Imperial plans further testing to confirm and quantify the volume of the additional fluid tailings and will further amend its fluid tailings volumes in the 2024 TMR.

Volumes reported for 2023 fall within the currently approved profile for new fluid tailings.

For 2023, Kearl reported that 27.6 Mm³ of fluid tailings met its approved subobjective 1 RTR criteria, up from 25.0 Mm³ in 2022. Because of the environmental protection order (EPO) issued to Kearl in 2023, compliance with subobjective 2 has not yet been determined. Imperial voluntarily placed all previously designated RTR material back as fluid tailings on its profile.

The RTR status requires Kearl to meet the approved subobjective 1 and 2 criteria (see table 19) and are included in appendix C of *OSCA* approval 10829M.

Deposit	Subobjective	RTR Criteria	
EETA	subobjective 1	65% solids content by weight within one year of treated fluid tailings placement based on deposit sampling.	
	subobjective 2	Groundwater is monitored in accordance with <i>EPEA</i> approval 00046586-01-00, as amended or renewed.	

Table 19. RTR criteria for Imperial Kearl

8.7.1.1 New Fluid Tailings

For 2023, Kearl reported a new fluid tailings inventory of 138 Mm³ (see figure 19), up from 67.0 Mm³ reported in 2022. The significant increase in new fluid tailings volume is due in part to

- newly discovered fluid tailings found beneath the TSRU deposit in WETA (estimated 30 Mm³) and
- the voluntary return of all treated fluid tailings material in EETA, previously determined as RTR (measured at 27.6 Mm³), to the fluid tailings profile for failure to meet the intent of subobjective 2 in *Directive 085*.

The approved new fluid tailings inventory for 2023 was 170 Mm³.

Kearl has a total volume trigger for new fluid tailings inventory of 180 Mm³ and a total volume limit of 252 Mm³. Based on data reported in its 2023 TMR, Kearl was within its approved new fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.

Imperial has provided an updated fluid tailings profile as part of the integrated application. However, considering the new fluid tailings findings in WETA and Imperial's application for RTR criteria for ILF technology submitted in June 2024, the AER would require Imperial to justify its need for an updated fluid tailings profile in 2024.



Approved profile: new fluid tailings inventory New fluid tailings inventory

Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 19. New fluid tailings for Imperial Kearl, 2014 to 2023
8.7.1.2 Legacy Fluid Tailings

Kearl does not have any legacy fluid tailings (i.e., fluid tailings in storage before January 1, 2015). The small amount of fluid tailings on the site in 2014 is considered new fluid tailings to simplify fluid tailings management and reporting.

8.7.2 Volume of Treated Fluid Tailings by Technology

For 2023, Kearl reported that a total of 30.5 Mm³ of fluid tailings were treated through the KFTT process since start-up, producing 27.6 Mm³ of material meeting subobjective 1 RTR criteria. This compares with 28 Mm³ of treated fluid tailings producing 25 Mm³ of material meeting subobjective 1 RTR criteria in 2022.

8.7.3 Treatment Options and Continuous Improvement

Kearl reported that its tailings treatment technology (thickening) is operating as expected, and deposits are meeting subobjective 1 performance criteria and remain aligned with long-term closure and reclamation objectives.

Throughout 2023, Kearl implemented several modifications to address various tailings system operating challenges and to improve performance:

- Implemented a control scheme to adjust flotation feed flow into the thickeners to optimize the TT recipe and fluid tailings consumption from WETA.
- Commissioned a new dredging system to enhance fluid tailings flow from WETA into the thickeners.
- Installed new thickener overflow water pumps.
- Installed thickener underflow pumps and piping reliability improvements to address gland water failures, piping wear rates, system turndown and capacity.
- Debottlenecked the eILF technology demonstration plant.
- Implemented co-deposition of CST with TT to enhance deposit strength.

For more detailed information about the above improvements, refer to the 2023 TMR.

8.7.4 Technological Innovation in Fluid Tailings Treatment

Throughout 2023, Kearl continued implementing the ILF pilot program phases 3, 4, and 5. Phase 3 focuses on the deposit characteristics of flocculated fluid tailings co-deposited with TT. Phases 4 and 5 focus on the co-deposition of flocculated fluid tailings combined with TT, CST, or both. Part of Phase 5 will test adding a three-chemical arrangement of a binder, a coagulant, and a flocculant with TT.

For more information about the above pilot programs refer to the 2023 TMR.

8.7.5 Regulatory and Management Actions

Kearl applied in June 2024 to the AER for an RTR criteria for ILF- and eILF-treated fluid tailings. The application remains open and under review.

Because of the active EPO issued to Imperial in February 2023 and the associated ongoing investigations, the AER cannot determine the management level for Kearl's tailings operation at this time. Once the AER concludes its formal investigations, Regulatory Applications will take the following actions:

- Review and decide on fluid tailings volumes that meet approved RTR criteria.
- Determine the appropriate management level classification to Kearl's tailings operation.
- Use any regulatory instruments, including regulatory tools and enforcement actions it deems appropriate, depending on the classification of the management level.
- Formally communicate to Imperial the decision regarding its RTR criteria compliance status, the classification of the management level of its tailings operation, and the applicable regulatory and enforcement actions.

For more information on management levels and potential management actions see section 10 of *Directive 85* on compliance and enforcement.

For more information regarding the EPO, see the <u>AER compliance dashboard</u> and <u>News and</u> <u>Announcements</u>.

8.7.6 Measurement System Audit Results

Kearl submitted a new MSP in January 2024 to account for the placement of tailings in ITA1 and to provide quality assurance and quality control documentation due to a change in third-party laboratory services. The AER has reviewed and accepted the updated MSP.

The AER did not audit Kearl's MSP in 2023 but has no concerns regarding the MSP at this time.

8.8 Suncor – Fort Hills

In 2023, two tailings facilities were operating at Suncor Fort Hills (see table 20).

The out-of-pit tailings area (OPTA) and out-of-pit tailings area east stage 1 (OES1) are the only tailings facilities at the site. The tailings facilities vary in their primary function, contents, and size. Fort Hills was managing all its fluid tailings in OPTA until March 2022. As of July 2023, Fort Hills reported prioritizing OPTA dike construction to manage fluid containment, resulting in minimal OES1 dike construction. The OES1 facility maintained minimal fluid to operate the fluid transfer barge. Runoff from the tailings sand, which forms fluid tailings, is pumped back to OPTA.

Facility	Function	Contents
Out-of-pit tailings area (OPTA)	 fluid and solid tailings storage recycle water source 	 CST TT TSRU fluid tailings recycle water tailings water
Out-of-pit tailings area east stage 1 (OES1)	 fluid and solid tailings storage 	 CST fluid tailings tailings water

 Table 20.
 Tailings facilities operating at Suncor Fort Hills

Suncor Fort Hills did not have an approved tailings treatment technology in 2023. The AER has authorized the continued use of existing infrastructure, specifically thickeners, which are expected to benefit tailings management as they can decrease the volume of fluid tailings generated. As part of Suncor Fort Hills' integrated project amendment (IPA) application submitted in 2022, Suncor Fort Hills proposed treating fluid tailings using the PASS technology. At the end of 2023, the AER was reviewing the application. In January 2024, Suncor Fort Hills submitted an addendum to the IPA application that further varied the mine and tailings plans. The AER issued a decision on the IPA and the addendum was issued on April 11, 2024. Findings and conditions will be reported on in the 2024 report.

Suncor Fort Hills reported that its new fluid tailings inventories for 2023 were within the approved fluid tailings profiles.

8.8.1 Fluid Tailings

For 2023, Suncor Fort Hills reported a total fluid tailings inventory (all new fluid tailings) of 64 Mm³, up from 48 Mm³ in 2022.

Volumes reported for 2023 fall within currently approved profiles for new fluid tailings. Suncor Fort Hills did not report any tailings meeting RTR criteria because it did not have approved RTR criteria in 2023. Suncor Fort Hills proposed RTR subobjective 1 and 2 criteria for all its fluid tailings deposits in its IPA. These were under review at the end of 2023.

8.8.1.1 New Fluid Tailings

For 2023, Suncor Fort Hills reported a new fluid tailings inventory of 64 Mm³ (see figure 20), up from 48 Mm³ in 2022. The approved new fluid tailings inventory for 2023 was 87 Mm³.

At the end of 2023, Suncor Fort Hills had a total volume trigger for new fluid tailings inventory of 125 Mm³ and a total volume limit of 175 Mm³. Based on data reported in its 2023 TMR, Suncor Fort Hills was within its approved new fluid tailings profile and did not exceed its total volume trigger or total volume limit for new fluid tailings in 2023.



Note: Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing whether volumes meet the RTR criteria.

Data are from the site-wide fluid tailings inventory table (appendix 3 of Directive 085) submitted annually by operators.

Figure 20. New fluid tailings for Suncor Fort Hills, 2016 to 2023

8.8.1.2 Legacy Fluid Tailings

Suncor Fort Hills does not have any legacy fluid tailings (i.e., fluid tailings in storage before January 1, 2015).

8.8.2 Volume of Treated Fluid Tailings by Technology

For 2023, Suncor Fort Hills did not report any volume of treated fluid tailings because it did not have an approved fluid tailings treatment technology. As part of Suncor Fort Hills' IPA application submitted in 2022, it proposed treating fluid tailings using the PASS technology with the RTR criteria shown in table 21. The application was under review at the end of 2023 and was approved April 11, 2024.

Deposit	Subobjective	RTR Criteria
All PASS deposits	subobjective 1	Clay-to-water ratio threshold >0.3 based on deposit sampling. An annual average total suspended solids <500 milligrams per litre (mg/L) for expressed water from DDA treated tailings
	subobjective 2	Surface water and seepage: The closed-circuit water management system is operating as designed. Groundwater adjacent or in communication with fluid tailings deposits is effectively monitored, reported, managed, and mitigated as required by <i>EPEA</i> approval 151469-01-00, as amended or renewed.

Table 21. RTR criteria for Suncor Fort Hills

8.8.3 Treatment Options and Continuous Improvement

Suncor Fort Hills reported that its fluid tailings treatment and placement in a dedicated disposal area has not started.

8.8.4 Technological Innovation in Fluid Tailings Treatment

Suncor Fort Hills reported the following technology research and development efforts for 2023:

- Application of PASS has been validated and improved through following laboratory scopes:
 - Continuous monitoring of 5 m columns to validate long-term stability, consolidation, and water quality of the deposit.
 - New injectors have been tested using the laboratory pilot setup.
 - A focused beam reflectance measurement probe has been tested for implementation as part of the PASS control system.

The Suncor Fort Hills TMR did not provide any additional information about technical innovation. Dissatisfied with this level of detail, the AER issued SIRs concerning technical innovation related to tailings based on the 2023 TMR submission.

For more information about technological innovation, see Fort Hills' 2019, 2020, and 2021 TMRs.

8.8.5 Regulatory and Management Actions

Suncor Fort Hills operates at management level 1 as described in the TMF and Directive 085.

On February 9, 2022, Suncor Fort Hills submitted the Fort Hills IPA amendment application, requesting to

- update the Suncor Fort Hills mine, tailings, and life-of-mine closure plans and
- adjust the project boundaries to accommodate infrastructure in support of mine development.

On September 30, 2023, Suncor Fort Hills submitted consolidation model results for the OPTA tailings. Suncor Fort Hills noted that the model is based on limited site data and publicly available literature and

focused on areas of OPTA where tailings from TSRU are being deposited. The AER was dissatisfied with the submission and issued SIRs to understand the predicted long-term performance of the OPTA tailings deposits. Suncor Fort Hills is required to submit additional information in 2024.

On September 30, 2023, Suncor Fort Hills also submitted an update on TSRU tailings management as required by conditions 34 and 35 of its *OSCA* approval. The AER accepted the submission as fulfilling the approval conditions. The AER notes that increased monitoring and reporting of PAG materials would be addressed under separate cover.

On December 4, 2023, Suncor Fort Hills requested a further deadline extension for the submission of a plan for demonstration of phase 1 of the PASS fluid tailings treatment process as required by *OSCA* approval 9241J and *EPEA* approval 151469-01-00 (as amended) from December 31, 2023, to June 30, 2024. The AER granted the extension. Suncor Fort Hills was required to submit a plan for a feasible alternative technology to PASS by December 31, 2023. Suncor Fort Hills indicated that the IPA amendment application included a proposal to treat fluid tailings using thin-lift drying and requested an extension of the submission date to June 30, 2024. The AER granted the extension.

On January 25, 2024, Suncor Fort Hills submitted an addendum to the amendment IPA application. The addendum proposes modification of the TMP associated with the south pit presented in the IPA application, including relocation of the dedicated disposal area and changes to seepage management elements along the shared boundary between Fort Hills south pit and Aurora west pit north.

No management actions were taken during the 2023 reporting period for tailings management operations at Suncor Fort Hills.

8.8.6 Measurement System Audit Results

Suncor Fort Hills did not submit a new or updated MSP in 2023. The AER issued a SIR requiring the submission of an MSP updated for changes made in 2023.

The AER completed a desktop inspection of Suncor Fort Hills' fluid tailings volumes to verify reported values. Fluid tailings volumes modelled by the AER were within an acceptable margin of error compared with the volumes reported by Suncor Fort Hills.

9 Summary

Tailings management under *Directive 085* continued in 2023. Operators were required to start full *Directive 085* reporting in the 2018 reporting year. All eight operating oil sands mines had approved TMPs in place by the end of 2019. Seven of the eight operating oil sands mines submitted TMP amendments in 2022 and 2023. Four TMP amendments were approved, three are under review, and one will be submitted in 2025.

The AER assessed the MSPs submitted by the operators related to determining whether the physical properties of the tailings deposits are on a trajectory to support future stages of activity (subobjective 1 in *Directive 085*, fluid tailings volumetric calculations, laboratory testing).

In addition, the AER assessed the groundwater monitoring portion of subobjective 2 in *Directive 085*. The AER continues to assess MSPs to address the need to minimize the effects the deposits have on the surrounding environment to ensure it will not compromise the ability to reclaim the area to a locally common, diverse, and self-sustaining ecosystem (subobjective 2)—related to water quality characterization and the measurement of chemicals of potential concern—and may issue additional SIRs in the future.

In 2022, the AER clarified the *Directive 085* water quality characterization and reporting requirements for tailings surface water. Operators submitted updated MSPs to reflect the changes, and the AER reviewed the updated MSPs. The operators included sampling and characterization of water overlying treated tailings deposits and fluid tailings ponds in their 2023 TMRs.

In 2023, the AER completed an initial audit to verify regional fluid tailings and water volumes and found the reported fluid tailings and water volumes are consistent with the AER's calculated volumes.

The tailings MSPs are live documents that must be regularly updated with changes to reflect current best practices and operations. Operators must notify the AER of all plan changes.

The tailings volumes in this report are presented as reported by operators and are subject to change upon further review of fluid tailings volumes, including assessment of whether they meet RTR criteria.

The total volume of fluid tailings (new and legacy tailings combined) on oil sands mine sites in the Athabasca oil sands region increased between 2014 and 2023. New and legacy fluid tailings inventories are projected to continue increasing based on the combined approved fluid tailings profiles. The total regional volume of fluid tailings remains below the new and legacy fluid tailings profiles for all operators combined.

The regional volume of water in tailings ponds decreased from 2014 to 2017, then increased until 2020. The maximum regional volume of water in tailings ponds was 479.3 Mm³ in 2020. The regional total volume of water in tailings ponds has since decreased to 391.1 Mm³ in 2023. The decrease may be because of water recycling and a return to average regional rainfall volumes.

Based on the fluid tailings volumes reported in the 2023 annual reports submitted by the operators, all operators other than Syncrude Mildred Lake were below their approved new fluid tailings profiles. All operators were below their total volume triggers and total volume limits and were at or below their legacy fluid tailings profiles. Syncrude Mildred Lake was above its legacy fluid tailings profile from 2017 to

2022 and its new fluid tailings profile in 2023. All operators, including Syncrude Mildred Lake, were below their 20% deviation triggers for new and legacy fluid tailings.

No change in management level (as described in *Directive 085*) was required for any operators, based on the 2023 TMR submissions, because their volumes were within the total allowable volume triggers and limits.

In 2023, the AER issued an EPO to Imperial Kearl under its *EPEA* approval due to a seepage event and a separate industrial wastewater storage pond overflow. The AER initiated formal investigations related to the incidents. As of the end of 2023, these investigations were ongoing, and the Regulatory Applications branch continues to review the information gathered. Should the review indicate Imperial has not met and maintained its approved subobjective 2 RTR criteria, Regulatory Applications will determine the appropriate management level and management responses.

Where information was insufficient for the AER to verify operator data or analyses, the AER issued requests for clarification or additional data. Reponses to requests that were not received or reviewed before finalizing this report were not included. Requests for clarification or additional data are part of an ongoing iterative process between the AER and operators. Operators require time to collect data, complete analyses, or review calculations before submitting responses to the AER. This report only includes information that was available at the time of writing. Responses may lead to changes in reported data or analyses from previous years, which will be reflected in the 2024 report.

Operators continue to develop and pilot new technologies to treat fluid tailings and report on improvements in tailings treatment technologies. The AER will review and evaluate technologies and deposit designs that show promise for treating and reducing fluid tailings volumes. The AER expects future submissions and applications regarding updated TMPs to include

- research and monitoring information that resolves outstanding risks and uncertainties about reclaiming treated fluid tailings deposits (including settlement, capping, and capping material availability);
- justification for RTR criteria and trajectories proposed for the demonstrated fluid tailings treatment technologies that will allow operators to achieve their targeted range of ecosites;
- justification that fluid tailings inventory profile requirements can be met; and
- a feasible alternative to water capping at sites wherever it has been proposed as a treatment.

The *TMF* states that the approved fluid TMPs must be reviewed by the AER every five years or as necessary over the course of the mine life. This review will ensure that the profiles and thresholds are in line with projections and reflect current technology, new knowledge, and continuous improvement.

10 Future Major Submissions

The AER will continue public reporting and will ensure the transparency of fluid tailings monitoring data received from operators. Future AER reports on tailings management will

- evaluate regional performance against the TMF's outcomes and objectives and
- identify operators that are performing well and those that need to make improvements (in accordance with *Directive 085*).

Future submissions from operators are required in the coming years that will inform evaluations of regional and individual operations' tailings management performance. These reports include the following:

- Syncrude Mildred Lake:
 - TMP and LMCP project update to cover the 2024–2026 period (submitted August 17, 2024)
 - Revised integrated mine, tailings, and closure plan to incorporate alternative treatment and placement plans for tailings deposits planned as water capped
- Suncor Base Plant:
 - September 30, 2024: A plan that updates pond 7 fluid tailings management
 - July 11, 2025: An integrated mine, tailings, and closure plan
 - October 31, 2025: updated pond 6 and pond 7 TMPs
 - December 31, 2025: an updated plan for SD8 that transitions from operations to decommissioning, closure, and abandonment
- CNUL Muskeg River Mine:
 - An updated TMP one year before fluid or treated tailings are placed in a tailings facility
 - June 12, 2025: A feasible alternative tailings treatment technology and implementation plan where the operator is proposing to create a water-capped deposit
 - April 30, 2027: An integrated mine, tailings, and closure plan
- CNUL Jackpine Mine:
 - An updated TMP one year before fluid or treated tailings are placed in a tailings facility
 - June 12, 2025: A feasible alternative tailings treatment technology and implementation plan where the operator is proposing to create a water-capped deposit
 - April 30, 2027: An integrated mine, tailings, and closure plan

• CNRL Horizon:

- August 1, 2025: An updated TMP
- Suncor Fort Hills:
 - September 30, 2026, or within 24 months of commencement of the PASS technology pilot, whichever date occurs first, application for an updated TMP.
 - June 30, 2024: A demonstration of phase 1 of PASS fluid tailings treatment process
 - June 30, 2024: A plan for a feasible alternative technology to PASS
 - September 30, 2024: An integrated site-wide mine plan and TMP
 - September 30, 2025: An integrated mine, tailings, and closure plan
 - September 30, 2030: An integrated mine, tailings, and closure plan

Appendix 1 Tailings Treatment Technologies

Thin-Lift Drying

Thin-lift drying is a process whereby fluid tailings are removed from tailings ponds and mixed with additives that bind the particles in the fluid tailings together. The fluid tailings with the additives are then thinly spread over a large area. Gravity and capillary action allow the water to drain away, and ambient conditions (evaporation and freeze-thaw cycles) facilitate the drying of fluid tailings within a few weeks. Once dry, another layer, or "lift," is added, and the process is repeated.

Suncor Base mine uses thin-lift drying technology before moving treated fluid tailings that meet the initial drying area ready-to-reclaim (RTR) criteria to the final placement location. This technology is referred to as a tailings reduction operation by Suncor and as atmospheric fines drying (AFD) by Canadian Natural Upgrading Limited (CNUL) Muskeg River mine. AFD is also approved for use at Jackpine mine. Operators are targeting a terrestrial closure with wetlands for their deposits.

Thickened Tailings as an Initial Treatment

Tailings thickening is a process whereby fluid tailings from bitumen extraction plants are sent to a thickener where flocculants are added to bind the smaller particles together, creating thickened tailings (TT). The warm water released from the tailings is recycled back to the extraction plant. The process is an initial stage of fluid tailings treatment, and operators employ different secondary stages of treatment and placement of TT for treated fluid tailings deposits.

The Suncor Fort Hills mine, CNUL Muskeg River mine, CNUL Jackpine mine, and Imperial Kearl use conventional thickeners to produce a TT stream, with some variations. Operators use the following as a second stage of treatment:

- CNUL Muskeg River mine is co-depositing TT, tailings solvent recovery unit (TSRU) tailings, whole tailings (WT), and coarse sand tailings (CST) in a single deposit, creating a north-pool-deposit type.
- CNUL Jackpine mine is co-depositing TT, WT, and CST in a single deposit, creating a mixed deposit type.
- Imperial Kearl treats TT with a secondary polymer addition before placement in its tailings deposit.

Operators are targeting a terrestrial closure with wetlands for their deposits and are required to provide updated modelling for the deposits. Suncor Fort Hills does not have an approved closure plan for its TT.

Nonsegregating Tailings and Composite Tailings Deposits

Nonsegregating tailings (NST) technology requires the use of a thickener. The TT is mixed with sand from the extraction plant and a coagulant. The mixture is then placed into a tailings deposit.

Composite tailings (CT) are like NST, but instead of using TT, fluid tailings from ponds are mixed with sand from the extraction plant and a coagulant. The mixture is then placed in a tailings deposit.

Canadian Natural Resources Limited (CNRL) Horizon uses NST technology. CT is used by Syncrude Aurora North and at CNUL Muskeg River mine, with some variations. Although CT is approved for use at Syncrude Mildred Lake, it is no longer used.

CNRL Horizon, Syncrude, and CNUL are targeting a terrestrial closure with wetlands for their deposits and are required to provide updated modelling and RTR trajectory for the deposits.

Fluid Tailings Centrifugation

Fluid tailings centrifugation is a process whereby fluid tailings are removed from the tailings ponds and a flocculant is added to bind the small particles together. The mixture is pumped into a centrifuge where the water is spun out. The dewatered tailings are placed in a deposit.

Syncrude Mildred Lake and CNUL Jackpine mine use fluid tailings centrifugation at their sites.

CNUL has begun to co-mix centrifuge with CST, enhancing performance through improved consolidation. The RTR criteria have been modified to consist of centrifuge/CST mixed deposits.

Both operators are targeting a terrestrial closure with wetlands for their deposits.

In-Line Flocculation

In-line flocculation (ILF) is a process where a polymer flocculant is added to the tailings stream to bind clay particles into larger groupings (flocs or flocculent), which may settle more rapidly upon discharge. A coagulant is often added to neutralize the charge on clay particles before adding the flocculant.

The challenges using ILF include maintaining flocculant dosage for varying input properties, such as solids and clay content and flow rate, and in optimizing the level of mixing to blend the polymer with the tailings.

Syncrude uses ILF at Mildred Lake. ILF is operational in the demonstration phase at CNUL Jackpine and Muskeg River mines and Imperial Kearl.

ILF can be applied to terrestrial or aquatic closure scenarios.

Alberta Energy Regulator

Permanent Aquatic Storage Structure

Suncor is demonstrating performance of a new treatment technology in its commercial-scale implementation of the permanent aquatic storage structure (PASS) technology. Phase 1 is the initial treatment of fluid tailings with a coagulant and a flocculant with the treated mixture placed in a deposit. The AER has approved the implementation of phase 1 only, subject to approval conditions to manage uncertainties and long-term reclamation risks since performance assumptions have not been verified at the scale and complexity of Suncor's dedicated disposal area 3. Suncor is required to prove the efficacy of a unique capping technique to provide a terrestrial closure on PASS-treated fluid tailings.

Suncor is required to

- validate its RTR criteria and RTR trajectory performance for phase 1 at a large scale and
- submit research and implementation plans for terrestrial or aquatic closure options for phase 1 PASStreated tailings in DDA3 to support a decision for the proposed closure approach in 2023.

Water-Capped Tailings

Water-capped tailings is an unapproved technology currently in the demonstration and experimental phase at Syncrude and Suncor. Water capping involves placing water above untreated tailings (Syncrude Base Mine Lake at the Mildred Lake mine) or treated tailings (phase 1 PASS-treated tailings in Suncor demonstration pit lake at the Suncor Base mine) to create a water-capped deposit (e.g., a water-capped pit lake) as a landscape feature.

The proposed water capping of untreated or treated fluid tailings at oil sands mines is not authorized by the AER because the technology is subject to further assessment, research, and future policy. Except for the identified demonstrations, all tailings management plan approvals prohibit the creation of a water-capped pit lake. The AER's decision about water-capped pit lakes, including their prohibition and the need for feasible alternative tailings treatment technologies, is provided in the water-capping technology section of tailings management plan decision reports and in operator approvals.

Appendix 2 Tailings Field Inspection Summaries

Summary of the AER 2023 Tailings Field Inspection for Suncor Base Plant Summary of the AER 2023 Tailings Field Inspection for Syncrude Mildred Lake and Aurora North Summary of the AER 2023 Tailing Field Inspection for CNUL Muskeg River Mine Summary of the AER 2023 Tailings Field Inspection for CNUL Jackpine Mine Summary of the AER 2023 Tailings Field Inspection for CNRL Horizon Summary of the AER 2023 Tailings Field Inspection for Imperial Kearl Summary of the AER 2023 Tailings Field Inspection for Suncor Fort Hills Summary of the AER 2023 Tailings Site Inspection for Suncor Base Plant



TAILINGS FACILITIES INSPECTION Suncor Base Plant – MD9 South

Project	Base Plant	OSCA Approval	8535S	Inspection Date:	2023-09-13
Facility Owner	Suncor	Fluid Containment Types	Overburden; Tailings	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive / Annual	AER Inspector/Staff	

Observations

Component	Observations	Photos
Facility operation	No visible concerns. Material is trafficable, but wet.	Photo 1



Photo 01 – MD9 South overburden / treated tailings co-deposition dumping locations

Suncor Base Plant - South Tailings Pond

Project	Base Plant	OSCA Approvai	8535S	Inspection Date:	2023-09-13
Facility Owner	Suncor	Fluid Containment Types	Tailings; Process affected water	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Observations

Component	Observations	Photos
Facility operation	No visible concerns	Photo 2
Presence of hydrocarbon	Minimal hydrocarbon visible	
Containment	No visible concerns	
Exposed vegetation in pond	No visible concerns	



Photo 02 – South Tailings Pond beach and barge access

Suncor Base Plant - Pond 8B

Project	Base Plant	OSCA Approval	85355	Inspection Date:	2023-09-13
Facility Owner	Suncor	Fluid Containment Types	Tailings; Process affected water	Company staff	5
Life Cycle Phase	Operating / Decommissioning	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Facility operation	On-going dewatering / draining of facility Visible exposed vegetation in pond. No visible bitumen No visible containment concerns	Photo 3



Suncor Base Plant - Dedicated Disposal Area 3

Project	Base Plant	OSCA Approval	8535S	Inspection Date:	2023-09-13
Facility Owner	Suncor	Fluid Containment Types	Tailings; Process affected water	Company staff	
Life Cycle Phase	Operating	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Facility operation	No visible bitumen. No visible containment concerns. No visible concerns.	Photo 4



Photo 04 - DDA 3. No visible concerns

Suncor Base Plant – Sand Dump 8

Project	Base Plant	OSCA Approval	8535S	Inspection Date:	2023-09-13
Facility Owner	Suncor	Fluid Containment Types	Fluid tailings and process affected water	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Facility operation	No visible containment concerns Presence of bitumen mat	Photo 5



Summary of the AER 2023 Tailings Site Inspection for Syncrude Mildred Lake and Aurora North



TAILINGS FACILITY INSPECTION

Inspection Result Compliant

Centrifuge Cake and ILF Plants

Project	Mildred Lake	OSCA Approval	85735	Inspection Date:	2023-06-21
Facility Owner	Suncor Energy (Syncrude) Operating Inc (SESOI)	Fluid Containment Types	Centrifuge Cake Plant FT Treatment	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Centrifuge cake plant	 Observed centrifuge cake plant in operation from both the control room (CR) and field perspectives, Observed adjustments made in centrifuge operation that increased cake discharge density. Excellent discussion with CC CR operators and plant engineer about monitoring CC performance and reporting against plan; confirmed monthly comparisons of actual performance against plan is done and available 	CC Plant Product Conveyor
ILF plant	 ILF plant observed in operation, ILF plant now turned over to operations and is part of mainstream operation (no longer a pilot or demonstration plant) 	The plant mixing station
North Mine South Pond (NMSP) FT Supply	 Unable to travel to barge due to poor weather / road conditions Comments from CR operators indicated FT supply much more reliable than supply from MLSB 	
General Comments	 Extremely wet / rainy conditions prevented getting up close to many areas of the tailings areas, Rating of Compliant given for those areas inspected only, not possible to inspect all tailings facilities and deposits in one day 	

Findings: Observation, non-conformance, safety deficiency, or Critical safety deficiency

Type of finding	Description	Compliance
Observation	No visible concerns	Compliant



TAILINGS FACILITY INSPECTION

Inspection Result Compliant

CT Plant and Deposition Areas

Project	Aurora North	OSCA Approval	10781P	Inspection Date:	2023-06-22
Facility Owner	Suncor Energy (Syncrude) Operating Inc (SESOI)	Fluid Containment Types	Composite Tailings	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Composite Tailings (CT) plant inspection	 Observed CT plant in operation from both the control room (CR) and field perspectives, Excellent discussion with CT CR operators and plant engineer about monitoring CT performance and reporting against plan; confirmed monthly comparisons of actual CT performance against plan is done and available. 	



CT deposit areas		
General Comments	 Extremely wet / rainy conditions prevented getting up close to many areas of the tailings areas, Inspection result is "Compliant" based on the areas inspected 	

Findings: Observation, non-conformance, safety deficiency, or critical safety deficiency

Type of finding	Description	Compliance
Observation	No visible concerns	Compliant

Summary of the AER 2023 Tailings Site Inspection for CNUL Muskeg River Mine



TAILINGS FACILITY INSPECTION Canadian Natural Upgrading Ltd.

Muskeg River Mine

Project	Muskeg River Mine	OSCA Approval	8512 M	Inspection Date:	2023-07-18
Facility Owner	Canadian Upgrading Limited	Fluid Containment Types	Fluid tailings and process affected water	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Active deposition into facility	 IPC 1- CST is the main tailings stream being deposited, while only an 'emergency out' for TSRU is being placed (note: in 2022 only 11 days of TSRU deposition occurred in IPC 1, resulting in insignificant beach development). Lowest priority cell for deposition. IPC 3 - CST and TSRU currently depositing into IPC 3. IPC 4 - New TT / CST deposition location, a main deposition location. ETF - CST is the main tailings stream pouring into the ETF for the final infilling of ETF, scheduled to be completed by 2026. It was noted that the execution of infilling activities is going as planned, with little to no mitigation activities required. 	Photos 1-11
Active withdrawal from facility	• The ETF is the next facility identified to come to closure. The status is proposed completion by 2026.	Photos 6-11
Beach above water	 IPC 1 - Orange coloured beaches were observed in lower beach above water slopes and yellow in upper beach above water slopes. No testing has been conducted to date to determine the source of the colour. Required follow-up will be conducted through EPEA. IPC 3 - Yellow beaches were noted in this facility, for which required follow-up will be conducted through EPEA. 	Photos 1-4
Beach below water	 It was noted in 2021 that beach below water was being pushed up to surface. No change in coloration or vegetation was observed in/on the exposed material. No increase in pushed up volume from last year, suggesting the operational approach of utilizing the floating backhoe to maintain feed to the dredge to feed tailings treatment (i.e., AFD) is performing well. 	Photos 7,8, 10, 11 and 12
Tailings containment	No concerns regarding containment were noted.	Photos 4-6, 9, and 10
Potential wildlife attractants	 Islands in the ETF area were observed as noted in the 2022 Tailings Inspection, no significant change. Follow-up, if required, to be addressed via CLM and through EPEA. However, from an operational perspective no mitigation was identified as required that would impact tailings placement. IPC 3 – Islands were observed in the ponds. Follow-up required to determine if there is alignment between field observations and the bird protection plan. Follow-up to be led through EPEA. 	Photo 4, 7, 8, 10, 11 and 12
Presence of hydrocarbons / bitumen	• Was observed along the edges of the ponds. No significant change in visual presence noted.	Photos 12 and 13

Instrumentation / testing (condition of/access to)	 Existing: Consolidation on the ETF still being collected through settlement plates. Required: Investigation on the source for yellow / orange coloured beach above water in IPC 1 and IPC 3, to support if additional monitoring and mitigations are needed. 	Photo 1-2
ТМР	 IPC 1: Follow-up to address the potential impact to the closure plan final landform drainage required due to the over built beaches. Follow-up to be conducted via TMP SIR's and potentially LMCP SIRs. IPC 6: 1 year prior to plan is due. 	Photo 1-2
OSCA / OSCR / EPEA	 In IPC 1 and IPC 3 yellow and orange beaches have been observed during the 2023 inspection. Follow-up will be addressed through EPEA. IPC 1 beach over build requires follow-up to determine alignment impact between the execution of the approved TMP and LMCP. Follow-up to be conducted will be led by EPEA with the support of OSCA. IPC 3 – Islands were observed in the ponds. Follow-up required to determine if there is alignment between field observations and the bird protection plan. Follow-up to be led by EPEA. 	Photo 1-4

Findings: Observation, non-conformance, safety deficiency, or Critical safety deficiency

Type of finding	Description	Compliance
Observation	IPC 1 beach over build requires follow- up to determine alignment impact between the execution of the approved TMP and LMCP.	Follow-up Required
Observation	IPC 6: 1 year prior to plan is due.	Compliant
Observation	In IPC 1 and IPC 3 yellow and orange beaches have been observed during the 2023 inspection.	Follow-up Required
Observation	IPC 3 islands have been observed during the 2023 inspection. Alignment confirmation with Bird Protection Plan.	Follow-up Required



Photo 01 – IPC 1 TSRU deposit beach colouration (orange lowland areas)





Photo 03 - IPC 3 deposit BAW development yellow colouration (North Pool Deposit type consists of TSRU, TT, CST, WT)



Photo 04 – IPC 3 island development (potential bird habitat, identified for EPEA)



Photo 05 - IPC 4N TT / CST deposit beach development



Photo 05 – IPC 4S CST deposit beach development





Photo 07 –South end MRM ETF BBW material pushed above pond elevation





Photo 09. MRM ETF current AFD production (within drying cell)



Photo 10. MRM ETF north end view (potential bird habitat identified for EPEA)



Photo 11. North end of MRM ETF (ConeTech, potential bird habitat)



Photo 12. North end of MRM ETF fluid tailings transfer system (dredge feeding AFD tailings treatment)


Summary of the AER 2023 Tailing Site Inspection for CNUL Jackpine Mine



TAILINGS FACILITY INSPECTION Canadian Natural Upgrading Ltd.

Jackpine Mine

Project	Jackpine Mine	OSCA Approval	9756 K	Inspection Date:	2023-07-20
Facility Owner	Canadian Upgrading Limited	Fluid Containment Types	Fluid tailings and process affected water	Company staff	Ŧ
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
Active deposition into facility	• DDA 1 / ETF-West CFFT / CST deposition was not active during the inspection. However, beach development progressing as described.	Photos 1 - 5
Active withdrawal from facility	• N/A	Photos N/A
Beach above water	DDA 1 / ETF-West beach developing as reported.	Photos 1 – 5
Beach below water	No items identified during inspection.	Photos N/A
Tailings containment	 No concerns with tailings containment development as per depositional or planning purposes identified. 	Photos 1-13
Potential wildlife attractants	• No items of concern identified in the tailings facilities.	Photo N/A
Presence of hydrocarbons / bitumen	 The presence of bitumen in the pond seems to be more visually apparent in DDA 1/ ETF-West than in other operating facilities. Follow-up required via OSCA (Process Engineering SME) regarding bitumen content for CFFT / TT production. 	Photos 4-5
Instrumentation / testing (condition of/access to)	 Subobjective 2 observations via groundwater wells being followed- up through EPEA. FC1 ILF Pilot observations of flocculant production, beach development, and next steps are in alignment with pilot submission. The close to the end of pipe location of the in-line flocculation (ILF) addition has shown good flocculant formation. The toe of the ILF deposit slope held a shape like 'advancing lava' (Photo 11). Clear (low solids content) runoff was observed running down and away from the IPL deposit (Photos 10 and 12). The ILF material was deposited into itself created a volcano like mound shape. Note: End of pipe was not visible. Next step is to place CST into the area. 	Photo 6-13
ТМР	• One observation through slide presentation regarding a change to the DDA 1 / ETF-West final elevation. Follow-up to ensure alignment with LMCP to be addressed through EPEA.	Photo N/A
OSCR / EPEA	 Alignment with groundwater report to ensure alignment with subobjective 2. Alignment with LMCP landform and drainage plan specifically for DDA 1 / ETF-West. 	Photo N/A

Findings: Observation, non-conformance, safety deficiency, or Critical safety deficiency

Type of finding	Description	Compliance	
Observation	Alignment with groundwater report to ensure alignment with subobjective 2.	Follow-up Required	_
Observation	Alignment with LMCP landform and drainage plan specifically for DDA 1 / ETF- West.	Follow-up Required	-
Observation	The presence of bitumen in the pond seems to be more visually apparent in DDA 1/ ETF-West than in other operating facilities. Follow-up required via OSCA (Process Engineering SME) regarding Bitumen content for CFFT / TT production.	Follow-up Required	



Photo 01 – Northwest CFFT deposition line DDA 1/ETF-West





Photo 03 – DDA 1 / ETF-West north view - TT deposition line and beach development





Photo 05 – DDA 1 / ETF-West CFFT / CST beach development



Photo 06 - FC 1 ILF Pilot area



Photo 07 – FC 1 ILF Pilot area infrastructure layout and Beach Development





Photo 09 – FC 1 ILF Pilot area beach development at the end of pipe and injection location



Photo 10 - FC 1 ILF Pilot area beach development at the end of pipe (volcano appearance)



Photo 11 - FC 1 ILF pilot area beach development at the upstream edges of the deposit





Photo 13. FC 1 ILF Pilot area Phase 1 beach

Summary of the AER 2023 Tailings Site Inspection for CNRL Horizon



TAILINGS FACILITY INSPECTION Canadian Natural Resources Ltd.

Horizon Mine

Project	Horizon Mine	OSCA Approval	9752 J	Inspection Date:	2023-07-17
Facility Owner	Canadian Resources Limited	Fluid Containment Types	Fluid tailings and process affected water	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	;

Component	Observations	Photos	
Active deposition into facility	 NST lines actively discharging in to DDA 2. Long beaches and small main pond are being maintained. This is as reported. NRU actively being deposited into the ETF to an elevation of 395.5m 	Photos 5-6	
Active withdrawal from facility	• N/A	Photos N/A	
Beach above water	 The NST beaches in DDA 2 were observed to be developing as expected. Long and shallow slopes. ETF uncapped NRU beach showing yellow colour for a second year in a row and now areas showing orange colour have appeared. It was noted that the yellow beaches have increased in surface area. 	Photos 1-4	
Beach below water	 Very little present in DDA 2 due to the long beaches. No concerns observed in ETF. 	Photos N/A	
Tailings containment	 It was reported that Dike 29 construction is on schedule for timing of required pouring benches for DDA 2. It was also stated that the schedule is very closely being monitored as there is not much flexibility at this time. ETF NRU beaches were being deposited to 395.5 m elevation, with the final dike elevation at 396 m. There is currently 1 m of sand capping required for closure, thus, follow-up to confirm alignment with the approved LMCP is required through EPEA. 	Photos 2-4 and 8-11	
Potential wildlife attractants	• During discussions, identified areas were reviewed. Follow-up, if required, will be through EPEA.	Photo N/A	
Presence of hydrocarbons / bitumen	 No concerns with the amount of bitumen present in tailings storage facilities. 	Photos 12	
Instrumentation / testing (condition of/access to)	 Horizon representatives presented on highlights of current investigation program regarding the yellow / orange NRU beaches. Follow-up will be conducted via EPEA and CLM, estimated reporting date on this matter is October 2023. 	Photo 1-4	
ТМР	• It was identified that construction of Dike 29 is on schedule but is a very tight. Follow-up via OSCA and CLM required to ensure alignment with containment development as per approved TMP. Construction reporting on a monthly basis is required to update the AER on Dike 29 construction milestones, to meet deposition	Photo 8-11	

	schedule to ensure risk management to the ability to execute the approved TMP.	
OSCR /EPEA	 Yellow and orange beach investigation follow-up, EPEA. Over built NRU beaches alignment /mitigation follow-up, EPEA. Dike 29 containment construction execution reporting, OSCA. 	Photo All

Findings: Observation, non-conformance, safety deficiency, or Critical safety deficiency

Type of finding	Description	Compliance
Observation	Yellow and orange beach investigation follow-up, EPEA.	Follow-up Required
Observation	Over built NRU beaches alignment /mitigation follow-up, EPEA.	Follow-up Required
Observation	Dike 29 containment construction execution reporting, OSCA.	Follow-up Required



Photo 01 -- ETF uncapped NRU beach yellow and orange colouration 1





Photo 04 – ETF yellow and orange colouration of uncapped NRU beach 4, and dike vs beach elevation



Photo 05 – DDA 2 NST 2 active deposition stream location



Photo 06 – DDA 2 NST 3 Active deposition stream location



Photo 07 – DDA 2 NST beach development



Photo 08 – DDA 2 Dike 29 containment construction development (distant view)





Photo 10 – DDA 2 long beaches and small pond





Summary of the AER 2023 Tailings Site Inspection for Imperial Kearl



TAILINGS FACILITY INSPECTION EETA, WETA, ITA1

Inspection Result Noncompliant

Project	Kearl	OSCA Approval	10829M	Inspection Date:	2023-06-20
Facility Owner	Imperial Oil Resources	Fluid Containment Types	Fluid tailings and process affected water	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive	AER Inspector/Staff	

Component	Observations	Photos
EETA	 Witnessed the following: TT line running south west corner of EETA Witnessed dry desiccated TT deposit adjacent TT line discharge Co-mixed TT with CST deposit west side of EETA, No changes from 2022 field visit 	CST Beach West side of EETA TT Beach
WETA	Witnessed the following: WETA appears mostly full No changes from 2022 field visit	



WB3 / off- lease PAW release sites (EPO)	• Observed WB3 and sites North of WETA where PAW was found outside of the ETA.	
General comments	 Extremely wet / rainy conditions prevented getting up close to many areas of the tailings areas, Inspection overall deemed noncompliant due to off lease PAW EPO; otherwise, remaining parts of inspection were compliant with approved plan 	

Findings: Observation, non-conformance, safety deficiency, or Critical safety deficiency

Description	Complianc	
No visible concerns		
	Description No visible concerns	

Summary of the AER 2023 Tailings Site Inspection for Suncor Fort Hills



TAILINGS FACILITY INSPECTION Fort Hills – OPTA and OPTA East

Project	Fort Hills Oil Sands Project	OSCA Approval	9241J	Inspection Date:	2027-09-12
Facility Owner	Suncor	Fluid Containment Types	Fluid tailings and process affected water	Company staff	
Life Cycle Phase	Operating / Construction	Inspection Type	Proactive / Annual	AER Inspector/Staff	

Component	Observations	Photos
Active deposition into facility	No active deposition. Froth treated tailings deposit. Coarse tailings construction in OPTA. Standard procedures.	Photo 1
Presence of hydrocarbons / bitumen	Visible hydrocarbon in OPTA	Photo 1
Beach above water	No visible concerns in OPTA or OPTA East	Photo 1
Beach below water	No visible concerns in OPTA or OPTA East	
Containment	No visible concerns in OPTA.	
Exposed vegetation in pond	No visible concerns in OPTA or OPTA East.	
Erosion Protection	Additional armouring below culverts and along ditches around OPTA	Photo 2 Photo 3
OPTA East Collection Pond with Secondary Clarification Facility	Presence of secondary facility not evident in approved design. Follow up required.	Photo 4 Photo 5









Project	Pond/Facilities										
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Pond 1A	10.1	10.1	10.1	10.1	10.4	10.4	10.4	10.4	10.4	10.4
	Pond 2/3	38.3	35.0	30.7	32.7	33.6	29.8	37.3	36.9	36.9	36.9
	Pond 5	18.4	18.4	20.2	-	-	-	-	-	-	-
	Pond 6	35.2	34.5	35.0	35.5	36.5	37.0	37.0	37.0	32.4	32.4
	Pond 7	68.9	69.9	74.5	74.2	73.8	79.3	77.4	75.1	76.9	75.8
Suncor Base Plant	DDA1 (Pond 8A)	0.3	0.3	0.0	-	-	-	-	-	-	-
- Idine	DDA3	-	-	-	-	-	-	21.1	1.3	0.5	0.3
	Pond 8B	38.5	38.9	36.8	38.9	20.9	14.5	12.5	12.6	11.9	12.0
	STP	101.0	105.0	105.4	105.7	95.8	90.7	95.9	93.5	97.1	101.5
	SD8	3.4	4.0	3.7	3.2	2.3	0.9	0.8	1.5	0.5	0.7
	Total	314.1	316.1	316.4	300.3	273.3	262.6	292.4	268.3	266.6	270.0
	MLSB	177.6	168.1	167.5	141.5	141.2	137.1	133.7	121.2	115.5	110.5
	SWSS	71.0	80.9	94.2	112.5	116.3	123.1	137.7	137.1	138.5	155.2
	BML	182.6	182.6	177.4	175.1	172.9	171.5	171.5	169.1	167.7	166.8
	EIP	3.3	1.7	1.4	2.0	1.3	0.8	0.1	0.1	0.0	0.0
	SWIP junior	N/A									
Syncrude Mildred	SWIP major	33.7	39.4	35.5	37.2	43.6	35.5	28.5	23.6	25.6	14.7
	NMSP / NMSPW major	1.4	3.6	16.0	16.2	18.1	37.8	51.5	73.9	91.4	98.5
	NMSPE	N/A	N/A	3.4	4.3	7.3	-	-	-	-	-
	NMSPE deep cake	N/A	N/A	5.8	13.3	13.9	19.7	25.6	28.7	37.3	37.0
	NMCP-E	N/A	16.0								
	Total	469.6	476.3	501.2	502.1	514.6	525.5	548.6	553.7	576.0	598.7
	ASB	83.1	77.6	74.7	72.3	70.4	75.6	86.0	79.1	93.9	89.8
	AEPN-E	27.5	38.7	43.5	51.1	50.2	42.5	34.0	24.7	6.8	N/A
Syncrude Aurora	AEPN-W	2.4	3.1	2.1	0.3	0.0	0.0	-	-	-	-
Horan	AEP (AEPS)	N/A	8.4	10.9	13.2	12.6	18.9	23.8	28.9	40.3	59.0
	ACPN	N/A									

Appendix 3 Fluid Tailings Volume Data

Project	Pond/Facilities					Fluid taili	ngs (Mm³)				
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Total	113.0	127.9	131.2	136.9	133.2	137.0	143.8	132.7	141.0	148.8
	ETF	62.4	63.7	58.3	57.9	51.7	50.4	43.1	36.3	31.0	19.9
	SEA	0.5	0.8	1.5	1.3	0.2	0.0	-	-	-	-
	IPC1	23.0	24.3	32.8	31.5	31.4	30.8	30.3	30.1	30.3	27.7
	IPC2	N/A	N/A	N/A	N/A	26.5	28.1	30.0	32.4	35.9	48.3
CNUL Muskeg	IPC2A	N/A	N/A	6.8	7.7	N/A	N/A	N/A	N/A	N/A	-
River mine	IPC2B	2.1	5.6	9.5	12.5	N/A	N/A	N/A	N/A	N/A	-
	IPC3	N/A	N/A	0.8	5.7	11.9	16.8	29.9	39.8	41.2	33.7
	IPC4N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.7	14.3
	IPC4S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.2	0.8
	Total	88.0	94.4	109.7	116.6	121.7	126.1	133.3	138.6	145.3	144.7
	ETF-W (DDA1)	6.8	12.0	7.8	11.7	12.8	12.5	11.0	N/A	N/A	N/A
	ETF-E (SC1)	12.8	10.6	11.2	9.4	8.6	8.1	10.3	N/A	N/A	N/A
	ETF (ETF-W and ETF-E)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.0	17.1	18.1
CNUL Jackpine	SC2	N/A	1.0	2.4	5.7	5.2	4.1	4.6	5.8	5.5	5.5
mino	FC1	N/A	N/A	2.8	1.6	1.4	1.2	1.1	1.2	1.8	2.3
	IPC1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0
	Total	19.6	23.6	24.2	28.4	28.0	25.9	27.0	26.0	24.4	25.9
	ETF/DDA1	66.2	82.1	99.5	114.5	131.8	146.7	146.4	155.3	162.9	144.0
CNRL Horizon	DDA2	-	-	-	-	-	-	3.5	2.3	7.1	4.3
	Total	66.2	82.1	99.5	114.5	131.8	146.7	149.9	157.6	170.0	148.3
	WETA	4.7	13.6	24.1	39.3	46.5	55.1	62.1	62.0	59.0	63.0
	EETA	N/A	-	-	0.4	1.0	2.5	3.0	2.0	2.0	3.0
Imporial Koarl	West TT panel	N/A	N/A	-	0.8	1.5	4.5	9.9	6.1	6.0	38.0
impenal Reali	East TT panel	N/A	N/A	-	0.5	1.1	-	-	-	-	-
	ITA1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.4
	Total	4.7	13.6	24.1	41.0	50.1	62.1	75.0	70.1	67.0	104.4
Suppor Fort Lillo	OPTA	-	-	-	-	6.0	17.0	30.0	36.0	48.0	63.3
Suncor Fort Hills	OES1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.0	0.3

Project	Pond/Facilities	Fluid tailings (Mm³)									
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Total	-	-	-	-	6.0	17.0	30.0	36.0	48.0	63.6
Industry total		1075. 2	1134.0	1206.3	1239.8	1258.7	1302.9	1400.0	1383.0	1438.3	1504.4

N/A: Not applicable

Tailings volume totals in this table may not match the company reports due to rounding. Data provided by operators in their TMRs were only to one decimal place.

Tailings volumes for 2017 year-end are estimates based on midyear survey data and estimates based on production from end of surveys to 2017 year-end, except for Suncor.

Syncrude Mildred Lake and Aurora North volumes for 2018 are as measured and not year-end projections, which the other operators provided.

Imperial Kearl volumes for 2019 are year-end projections and not as measured, which the other operators provided.

Some of the volumes above may include RTR volumes. Suncor Base Plant pond 5, DDA3, and MD9 data do not include RTR fluid tailings.

Variances for monitoring requirements were granted to operators in 2020 due to COVID-19. As a result, there was a mix of measured and estimated volumes for 2020. Pond surveys were not conducted for Imperial Kearl, Syncrude Mildred Lake, and Syncrude Aurora. Reduced pond surveys were completed for Suncor Base Plant, CNUL Muskeg River mine, CNUL Jackpine mine and CNRL Horizon.

Tailings volumes are presented as reported by operators and are subject to change upon further review by the AER, including assessing volumes that meet the RTR criteria.

Appendix 4 Water Volume Data

Project	Pond	Water (Mm ³)									
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Pond 1A	2.1	2.1	2.5	2.5	2.2	2.2	2.2	2.2	2.2	2.0
	Pond 2/3	5.0	2.6	4.8	1.9	2.1	5.8	3.8	4.0	4.0	4.0
	Pond 5	N/A	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pond 6	6.0	6.9	6.9	5.7	7.1	7.3	7.3	7.3	9.5	9.5
	Pond 7	49.3	40.4	41.7	37.1	42.7	33.5	36.9	35.8	32.1	28.5
Suncor Base Plant	DDA1 (Pond 8A)	N/A	N/A	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	DDA3	-	-	-	8.1	7.4	12.6	17.4	21.6	19.2	16.9
	Pond 8B	43.3	39.1	42.3	30.8	28.6	10.4	7.3	0.0	0.0	0.0
	STP	19.0	13.7	17.6	24.4	26.2	32.1	30.6	36.6	34.9	21.8
	SD8	1.5	1.5	3.4	0.9	1.7	0.7	0.9	1.1	0.5	0.5
	Total	126.2	106.3	119.3	111.4	118.0	104.6	106.4	108.6	102.4	83.2
	MLSB	5.6	10.8	3.4	7.5	8.3	10.0	8.1	10.8	10.8	8.3
	SWSS	34.0	42.6	47.5	48.4	43.9	48.4	33.0	29.5	29.5	19.0
	BML	57.4	55.7	60.2	63.6	67.1	70.5	69.5	71.6	71.6	71.3
	EIP	0.2	0.5	1.2	0.7	0.0	0.0	0.1	0.0	0.0	0.0
	SWIP junior	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Syncrude Mildred	SWIP major	14.0	13.9	20.9	19.2	14.6	14.9	19.5	14.6	14.6	8.6
	NMSP / NMSPW major	15.3	14.7	2.5	0.6	6.2	12.1	39.2	30.1	30.1	8.4
	NMSPE	N/A	N/A	1.7	4.1	7.4	-	-	-	-	-
	NMSPE deep cake	N/A	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	NMCP-E	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.1
	Total	126.5	138.2	137.4	144.1	147.5	155.9	169.4	156.6	156.6	121.7
	ASB	50.5	38.9	40.1	37.9	43.2	37.2	27.4	32.5	22.5	25.0
	AEPN-E	20.0	7.5	0.1	1.6	4.8	6.0	3.8	1.8	0.1	NA
Syncrude Aurora	AEPN-W	0.3	0.8	0.1	0.0	0.0	0.0	-	-	-	-
	AEP (AEPS)	1.0	28.3	27.7	21.4	27.4	35.1	61.9	62.8	75.0	65.8
	ACPN	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Project	Pond					Water	(Mm³)				
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	Total	71.8	75.5	68.0	60.9	75.4	78.3	93.1	97.1	97.6	90.8
	ETF	2.8	1.7	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0
	SEA	0.4	0.1	0.4	0.8	0.2	0.0	-	-	-	-
	IPC1	4.6	6.4	8.4	7.9	9.6	9.8	10.5	9.9	9.7	10.0
	IPC2	N/A	N/A	N/A	N/A	8.4	7.6	4.4	13.1	13.1	9.0
CNUL Muskeg	IPC2A	N/A	N/A	0.3	1.0	N/A	N/A	N/A	N/A	N/A	N/A
River mine	IPC2B	2.0	0.7	2.1	4.2	N/A	N/A	N/A	N/A	N/A	N/A
	IPC3	N/A	N/A	1.6	2.1	2.4	3.0	7.6	4.9	1.6	1.4
	IPC4N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.9	2.9
	IPC4S	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.3	0.1
	Total	9.8	8.9	13.3	16.3	20.6	20.4	22.5	27.9	34.6	23.4
	ETF-W (DDA1)	0.4	0.0	0.1	0.4	0.0	0.0	0.0	N/A	N/A	N/A
	ETF-E (SC1)	17.0	10.1	6.4	4.9	7.1	8.0	9.6	N/A	N/A	N/A
	ETF (ETF-W and ETF-E)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12.4	8.3	7.8
CNUL Jackpine	SC2	2.4	4.9	3.6	0.5	2.2	4.0	1.2	1.1	2.2	2.2
mino	FC1	N/A	N/A	0.7	6.4	6.7	7.8	7.6	9.2	10.0	7.1
	IPC1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.3
	Total	19.8	15.0	10.8	12.2	16.0	19.8	18.4	22.7	20.5	23.4
	ETF/DDA1	33.0	30.0	33.0	28.2	31.1	31.1	28.0	21.2	19.7	17.5
CNRL Horizon	DDA2	-	-	-	-	-	-	2.0	4.0	4.0	1.6
	Total	33.0	30.0	33.0	28.2	31.1	31.1	30.0	25.2	23.7	19.1
	WETA	21.3	27.4	18.4	17.3	18.0	20.1	23.8	16.0	14.0	14.0
	EETA	N/A	0.3	0.8	1.7	0.5	2.3	2.1	1.0	1.0	1.0
Imporial Koorl	West TT panel	N/A	N/A	0.5	0.4	0.1	0.3	0.9	0.0	0.0	-
	East TT panel	N/A	N/A	0.2	0.3	0.1	-	-	-	-	-
	ITA1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.0
	Total	21.3	27.7	19.9	19.7	18.7	22.7	26.8	17.0	15.0	22.0
Supeer Fort Hills	OPTA	-	-	-	-	3.0	5.7	12.7	16.6	13.0	7.2
Suncor Fort Hills	OES1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5	0.3

Project	Pond	Water (Mm ³)											
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023		
	Total	-	-	-	-	3.0	5.7	12.7	16.6	13.5	7.5		
Industry total		408.4	401.6	401.7	392.8	430.3	438.5	479.3	471.7	463.9	391.1		

N/A: Not applicable.

Water volume totals in this table may not match the company reports due to rounding. Data provided by operators in their TMRs were only to one decimal place.

Variances for monitoring requirements were granted to operators in 2020 due to COVID-19. As a result, there was a mix of measured and estimated volumes for 2020. Pond surveys were not conducted for Imperial Kearl, Syncrude Mildred Lake, and Syncrude Aurora. Reduced pond surveys were completed for Suncor Base Plant, CNUL Muskeg River mine, CNUL Jackpine mine and CNRL Horizon.

Water volumes are presented as reported by operators and are subject to change upon further review by the AER.