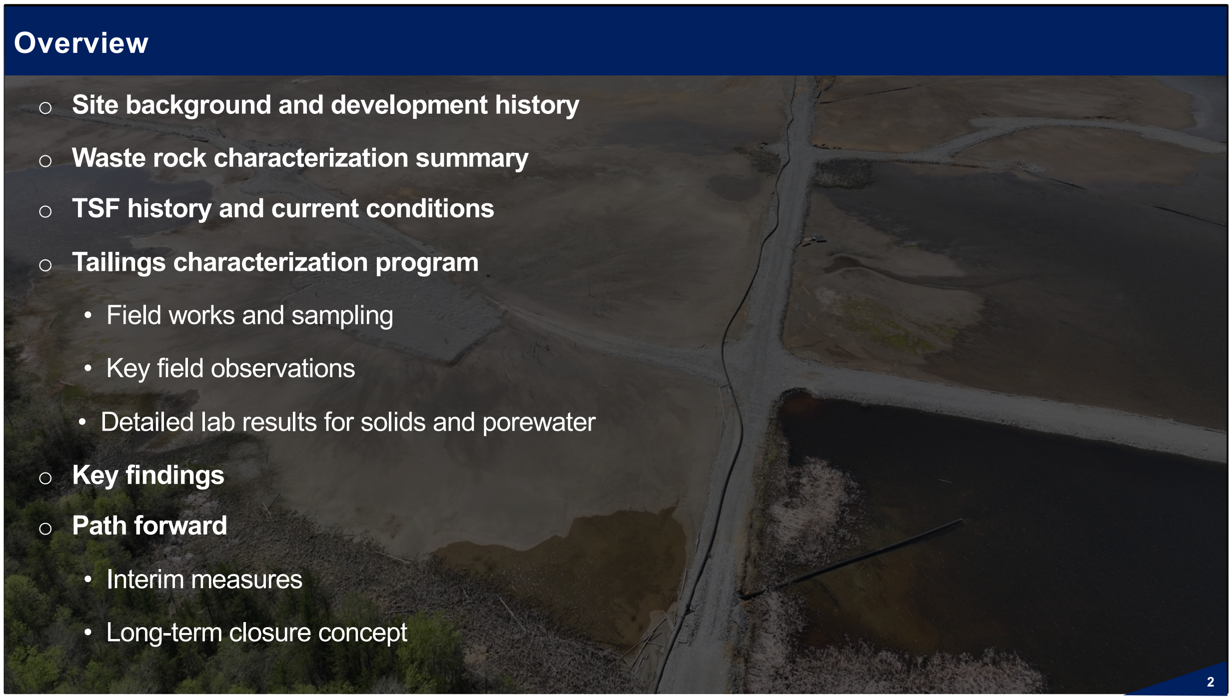
Good afternoon everyone, and thanks for staying through to the end of conference.

Over the next 25 minutes, I'll walk you through the work our team at RGC has done in recent years on the geochemical characterization of tailings and waste rock at Langlois Mine.

Before diving in, I'd like to acknowledge the contributions of my co-authors at RGC and beyond. So, this work is really result of a team effort.

The focus of today's talk will be on the tailings characterization, but I'll go through the key outcomes of the waste rock characterization as well, to provide some context for the site restoration concept.



As for the outlines, I'll start with introducing the site and its layout, then I'll go through a summary of the waste rock characterization work and what we learned from it.

Then, I'll move to the tailings characterization program, including the field work, on-site analyses, and the detailed lab results.

I'll then highlight the key findings and wrap up with the path forward, for both, the interim measures and the long-term closure concept.

Site Location

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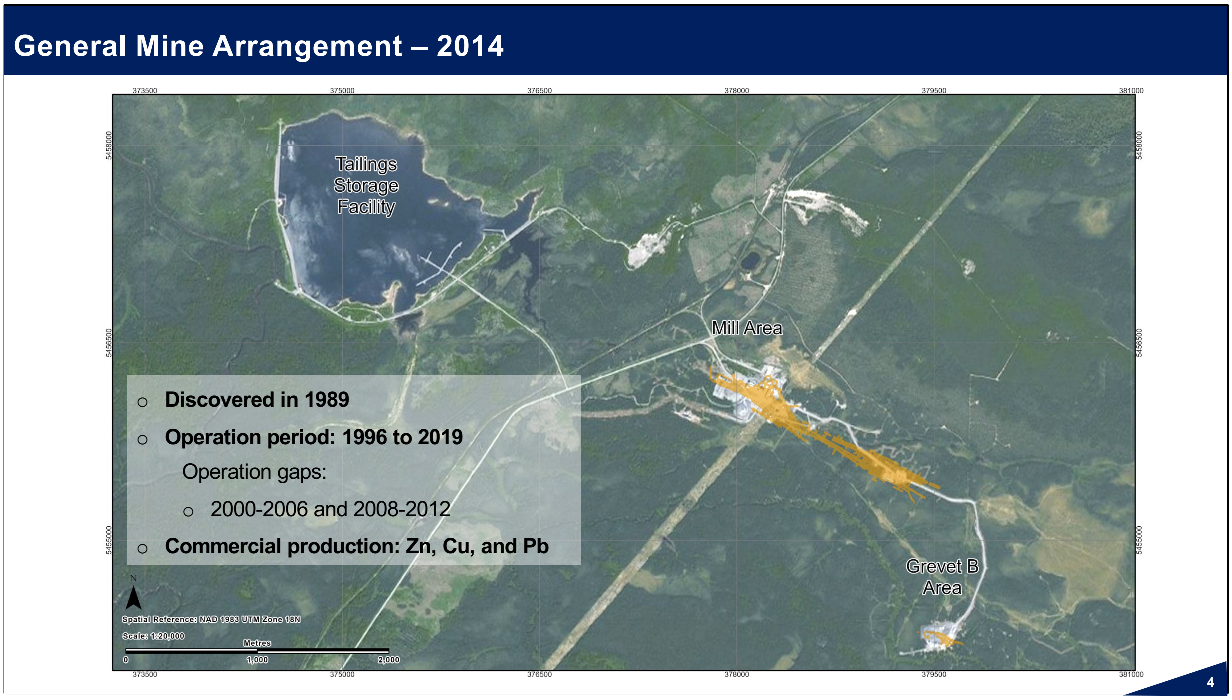
Here’s where the site is located. Langlois Mine is in western Quebec, nearly 700 km NW of Montreal.



Langlois Mine is a volcanogenic massive sulphide deposit which was discovered back in 1989, with commercial production of Zn and Cu, and Pb which was a by-product. The operation period was from 1996 to 2019 with two major gaps, for a total of 10 years bringing the total operating time to about 13 years.

This map shows the site layout along with the extent of underground workings projected on surface. So, the entire deposit in Langlois was mined underground with cut-and-fill mining technique, so there is no open pit for this site.

The main components of the site are the Mill Area, the Tailings Storage Facility, and the Grevet B area, which is a smaller deposit in association with Langlois Mine, sitting at about 2km to the east of the Mill area.

Mill Area

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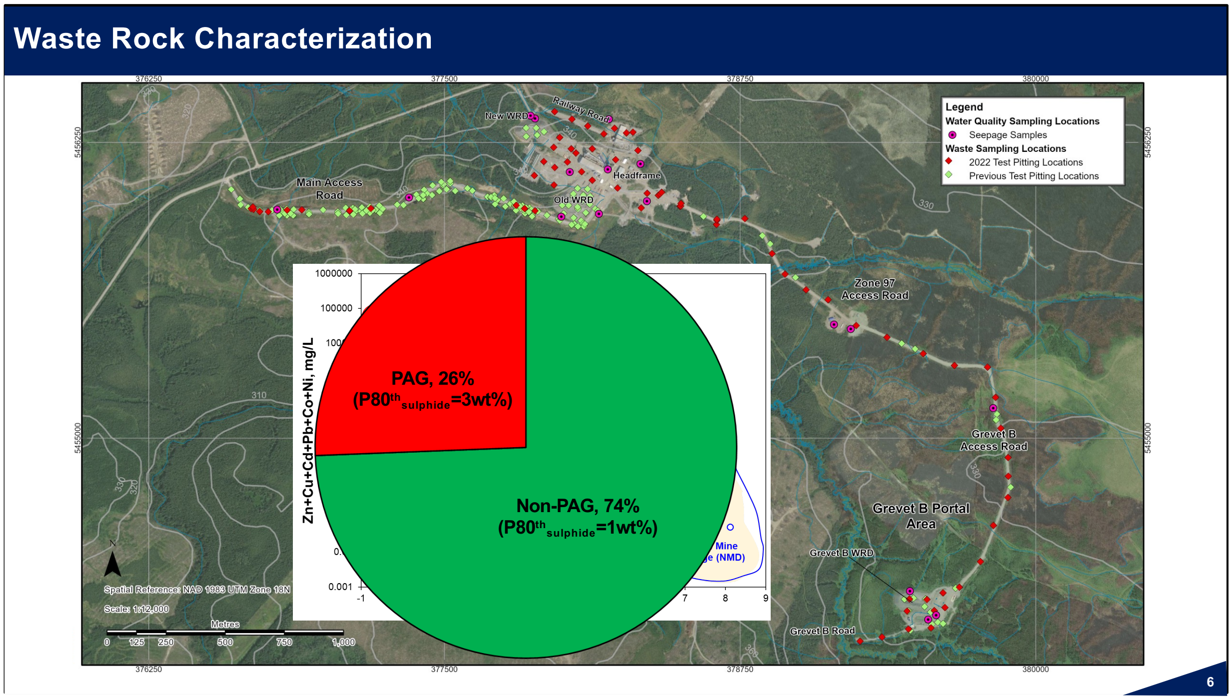
Here's a close-up of the Mill Area, where the headframe and the other main buildings are located. This was really the heart of the site during operations.

Ore came up through the shaft, and straight into the processing plant, which processed roughly over 6 Mt of ore, over the life of the mine.

About 40% of the tailings produced here were thickened, filtered, and mixed with cement and used as backfill for the underground workings, and the rest was mixed with lime and was sent to the TSF.

And regarding waste rock, any material that couldn't be used underground also came up and stored in these two surface dumps. The Old WRD and the New WRD. The New WRD is a lined facility with a geomembrane liner underneath. Aside from these two WRDs, Waste rocks were also used to build the mill area and all the access roads to different areas of the site.



In 2022, we completed a comprehensive waste rock characterization program by excavating 66 test pits across the site, which are shown here with red diamonds.

All test pits were excavated all the way to the natural ground and sampled systematically,,,, we collected over 100 waste rock samples from the depth profiles which were processed on site and subjected to in-situ rinse analysis and also sent to the lab for ABA analysis, XRD, and leach tests.

Aside from waste rocks, we also collected seepage samples, mostly from the toes of WRDs and also from the bottoms of some test pits, which are shown here with pink circles.

(Click)
From this work,,,as shown on this pie chart, we found that roughly 75% of the total waste rock volume are not acid generating, and the 25% **which is** acid generating,, is generally low in sulphide, with sulphide sulphur concentration less than 3wt% for majority of samples. The acid-potential of these PAG samples exceeded their neutralization-potential by only about 10%.

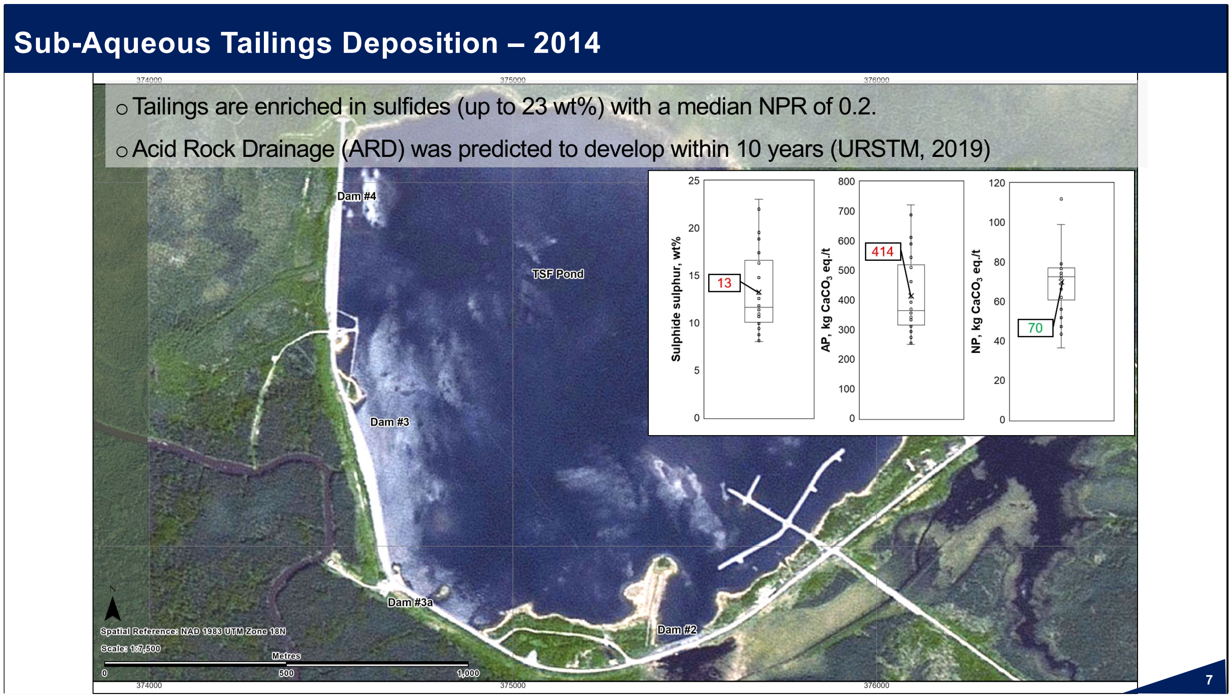
(Click)
This, low sulphide/high NP nature of the waste rock is reflected on their seepage chemistry.

Here the cumulative concentration of contaminants in seepage samples are mapped on a Ficklin diagram, which helps to see where our site falls within the world of ARD.

As we can see majority of the collected seepage samples have circum-neutral to alkaline pH, with cumulative contaminant concentrations mostly below 100 mg/L, with some localized seepage with elevated metal concentrations and lower pH.

For comparison, at other RGC sites like Bouchard Hébert, Myra Falls, and the legacy sites in Australia such as Rum Jungle and Sandy Flat Pit, the waste-rock impacted seepage mostly falls in the ARD region. So, Langlois, kind of stands out by falling in NMD region.

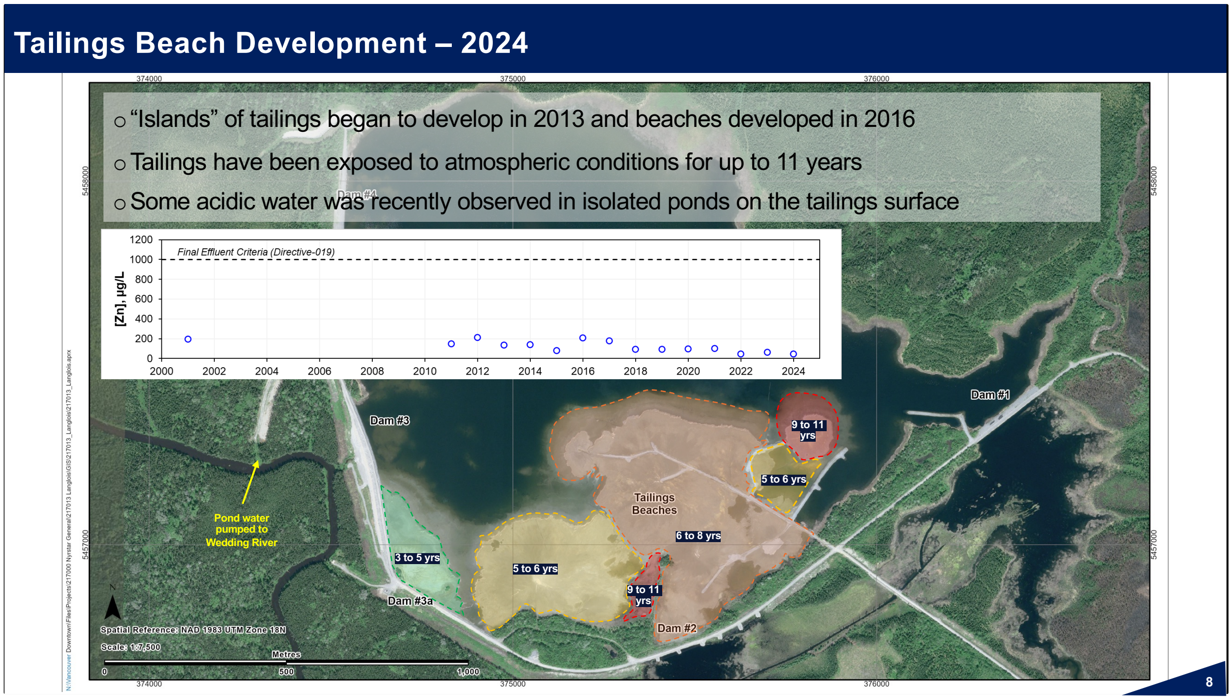
So, from this work, we concluded that waste rock in Langlois is yielding Neutral Mine drainage, which also has led to some localized elevated concentrations of Zn, Cu and Cd, in groundwater samples, specially at around Mill Area, where majority of waste rocks are located. So, removing these waste rock as part of the site closure program is expected to improve the groundwater quality.
(0.5 wt% Zn on average, 300 ppm Cu and 100 ppm Pb).



Moving on to the TSF, which is the focus of today's talk,, here we see a satellite image of the TSF from 2014. In contrast to the waste rocks, which are not enriched in sulphide, the tailings are.

The ABA analysis results of the fresh tailings show a sulphide concentration between 8 to 23 wt%, averaging to 13 wt% which translates to 414 kg/t of acid potential, while average of the neutralization potential is only about 70 kg/t, giving an NPR of about 0.2. So this imbalance between AP and NP means that, unlike the waste rock, these tailings could be highly acid generating, **if** exposed to oxidizing condition.

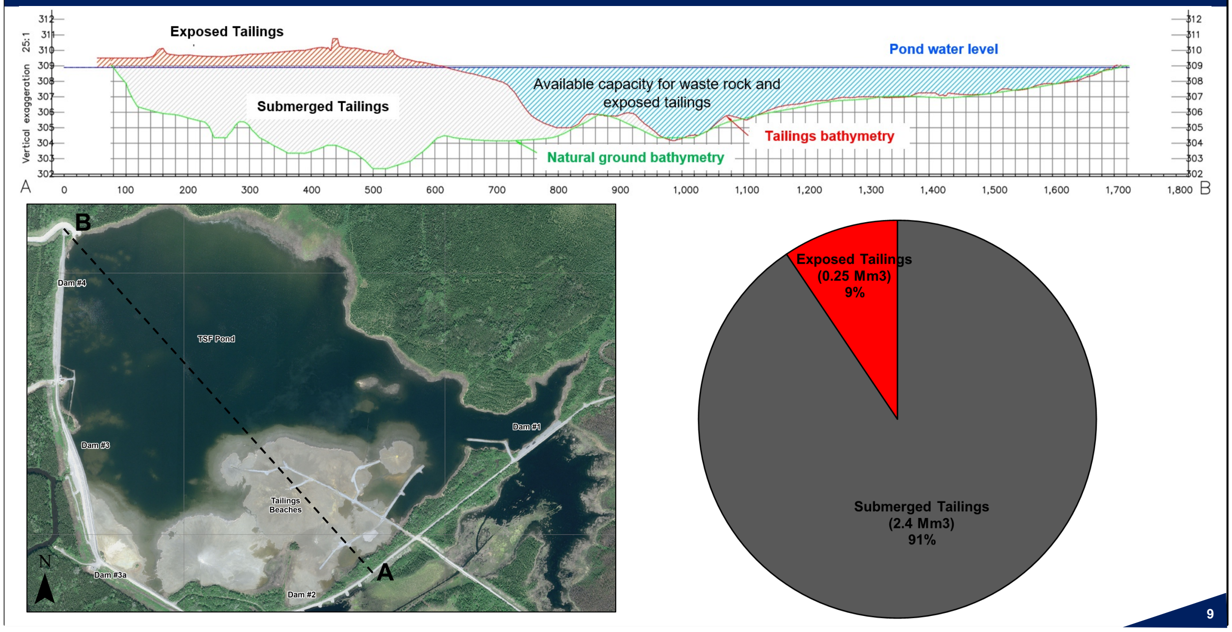
From a work by URSTM institution at Quebec, the oxygen consumption rate of fresh tailings were measured and this was predicted that if tailings become unsaturated, they could start producing ARD within about 10 years of exposure. Know that these tailings were required to be kept under 1 m of water cover during the operation and post closure. However, **it was the case** only up until 2013.



Unfortunately, tailings did not stay underwater, and tailings beaches started to emerge around 2013, when TSF was operating. This was mainly due to a lack of frequent movement of the discharge pipes during the winter-time when pipes were stuck in ice, and led to accumulation of tailings at discharge points. Based on the aerial photos of the TSF from 2011 to 2023, we identified the duration of exposure of different parts of the tailings beaches. As indicated on the map, the longest duration of exposure was about 10 years at eastern side of the tailings and about 4 years at the western side close to the dam #3 and 3a.

It should be noted that the excess pond water pumps into the nearby Wedding river, and so far, the routine monitoring of this pumped water has shown that water quality is compliant with the final effluent limits. For example, Zn concentration, as one of the main contaminants of concerns, shows an annual average concentrations way below the criteria for final effluent, nearly an order of magnitude lower. However,, some acidic water was observed in recent years in isolated ponds on the tailings surface, which were concerning and highlighted the need for a comprehensive geochemical analysis of the exposed tailings to understand their current condition.

Tailings Volume – Submerged vs. Exposed



We estimated the total volume of tailings within TSF, as well as the exposed parts vs. submerged portion. For that, we compared the tailings bathymetry which is shown with red line on this cross section, vs. the natural ground bathymetry which is the green line. We calculated the fill volume between these two surfaces which gave us roughly 2.65 Mm3 of tailings,,, and by applying the water level, we estimated that only about 10% of total tailings are exposed while the rest is underwater. We also estimated the TSF storage capacity below water level, at about 2.3 Mm3, which has implication for the closure concept and could be used for relocation of waste material.

Tailings Beaches – May 2024

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Here are some recent drone images from May 2024 showing the tailings beaches.

Study Objectives

- Characterize the geochemical properties of tailings in the tailings beaches to assess the degree to which tailings have been oxidized.
- Identify interim measures to reduce future ARD risk before final TSF restoration
- Establish routine pond water quality monitoring to track ARD-related impacts
- Provide a path forward for TSF closure planning, including future site work and modeling

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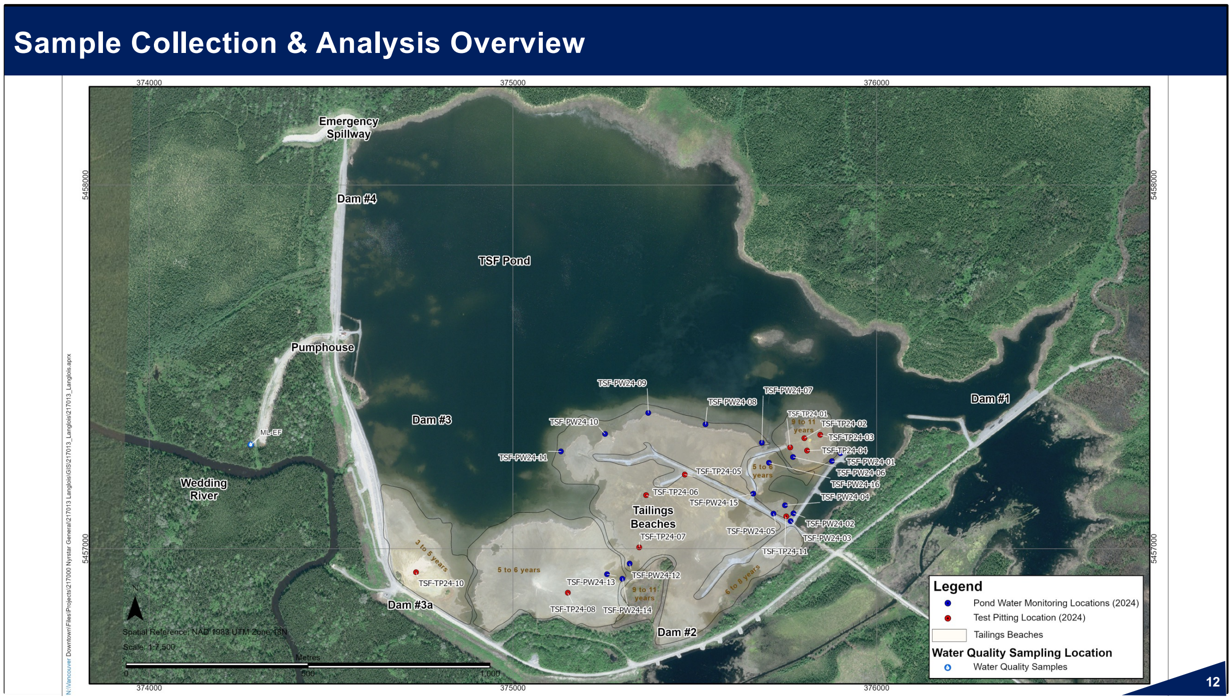
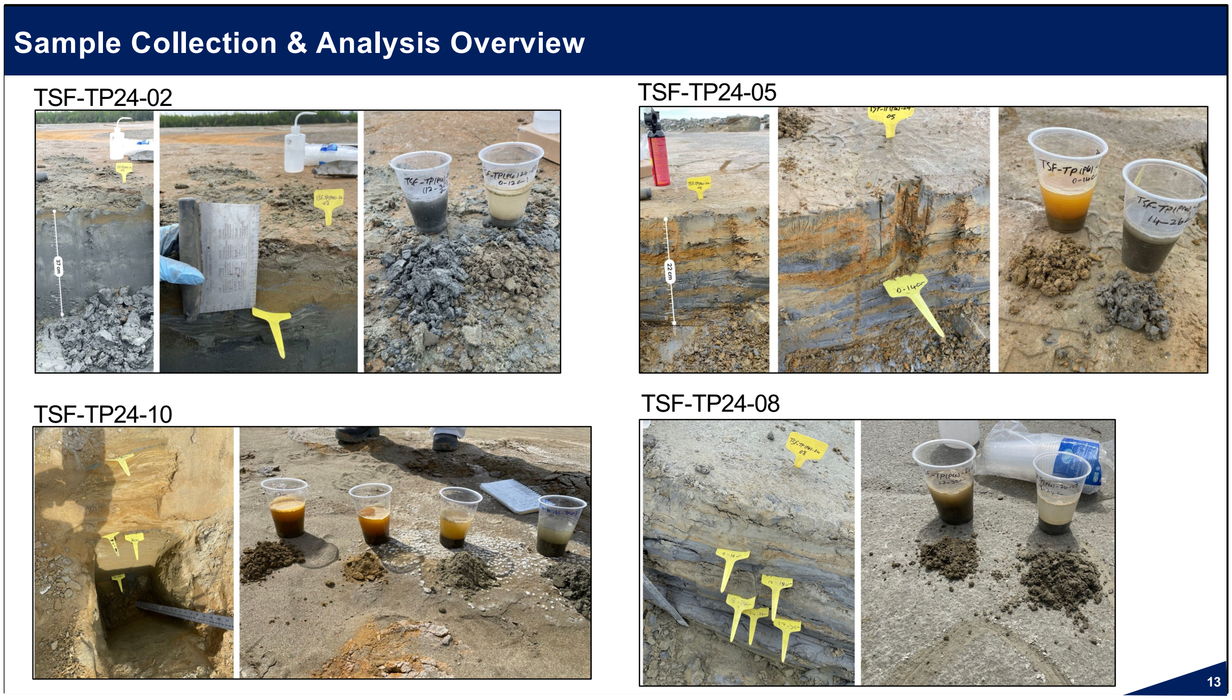
So, our objectives of the tailings study was first to update the onset of ARD, and conduct a systematic and comprehensive geochemical study of the tailings beaches to understand the current state of the exposed tailings, and to suggest interim measures to reduce the chance of ARD generation before final restoration of the TSF. And also to develop a routine pond-water quality monitoring program to identify any local water quality impacts, and finally, provide a path forward for TSF closure planning.



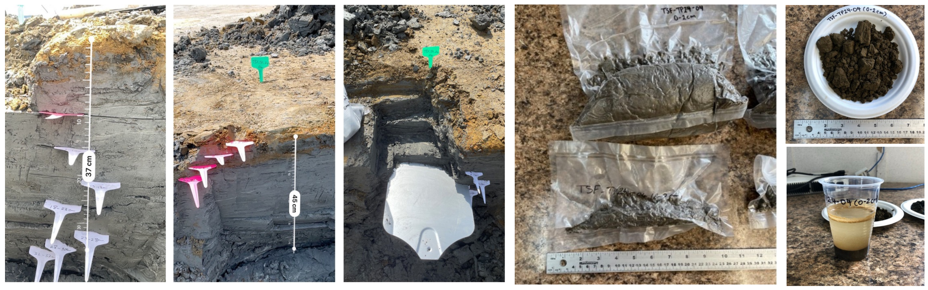
We conducted the tailings study in June 2024. We started with excavating test pits across the tailings beaches with variable duration of exposure, which are shown here with red circles. We were aiming to find locations with the worst oxidizing conditions to focus our detailed sampling and study on those fewer number of locations. Each test pit was excavated manually and to the fresh-looking material and bulk samples were taken from visually distinctive material which were used immediately for rinse tests. Aside from test pitting, we also surveyed the pond water quality along the shore of the tailings beaches, looking for any sign of the tailings impacted water. We collected water samples for lab analysis, in addition to measuring the in-situ physicochemical parameters using multi-probes.



Here are a few examples of the excavated test pits and in-situ rinse tests. As you can see, the extent of oxidation was quite variable from a few centimetres in some locations and to tens of centimetres in other locations.

Sample Collection & Analysis Overview

Challenge: Collecting and preserving enough material from fine intervals



Laboratory Analysis

Tailings Solids:

- Opened in nitrogen-filled glovebox (to prevent oxidation)
- Analysed for Moisture content, ABA, Near-total metals, PSD and Mineralogy via TIMA

Porewater & Pond Water:

- Porewater extracted by centrifugation
- Tested for pH, EC, acidity, alkalinity, major anions, dissolved metals
- ICP-MS used for dissolved metals analysis

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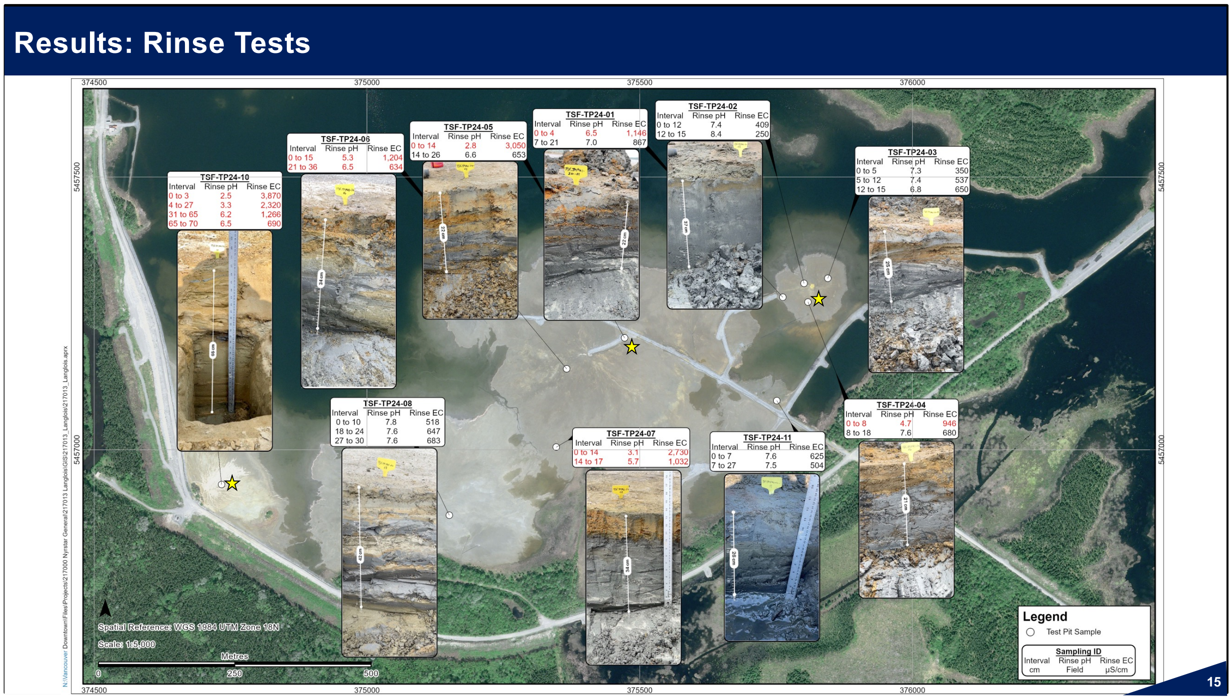
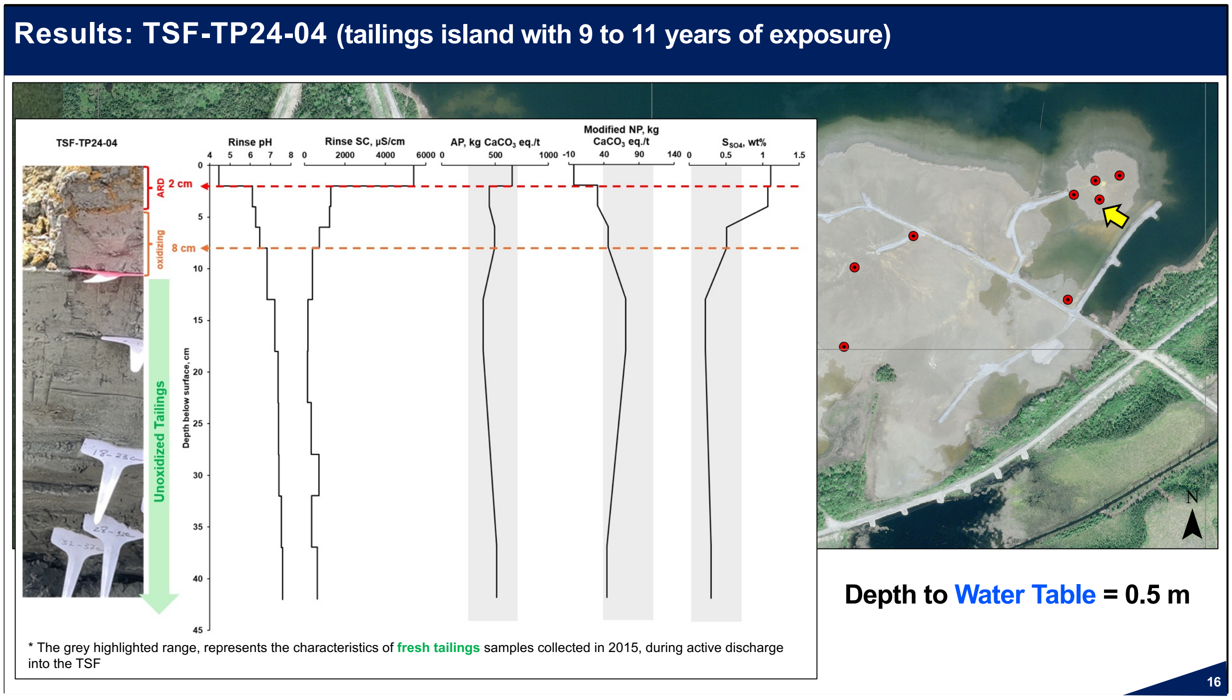
One of the challenges we were facing for detailed sampling from the test pits was collecting enough material for a comprehensive lab analysis and also preserving the collected samples to prevent further oxidation during the handling and transportation to the lab.To overcome these challenges, we collected blocks of samples from each sampling interval, which were sometimes as fine as only 2 cm, and we vacuum sealed samples immediately, as shown on this photo here. One split of samples was used for on-site rinse test and another sent to the lab for further analysis. We instructed the lab to open and prepare samples under nitrogen filled glovebox and submitted samples for a range of solids analysis including ABA, MC, near-total metals, PSD, and mineralogy and also porewater extraction which was done by centrifugation which further analyzed for physicochemical parameters and dissolved components.

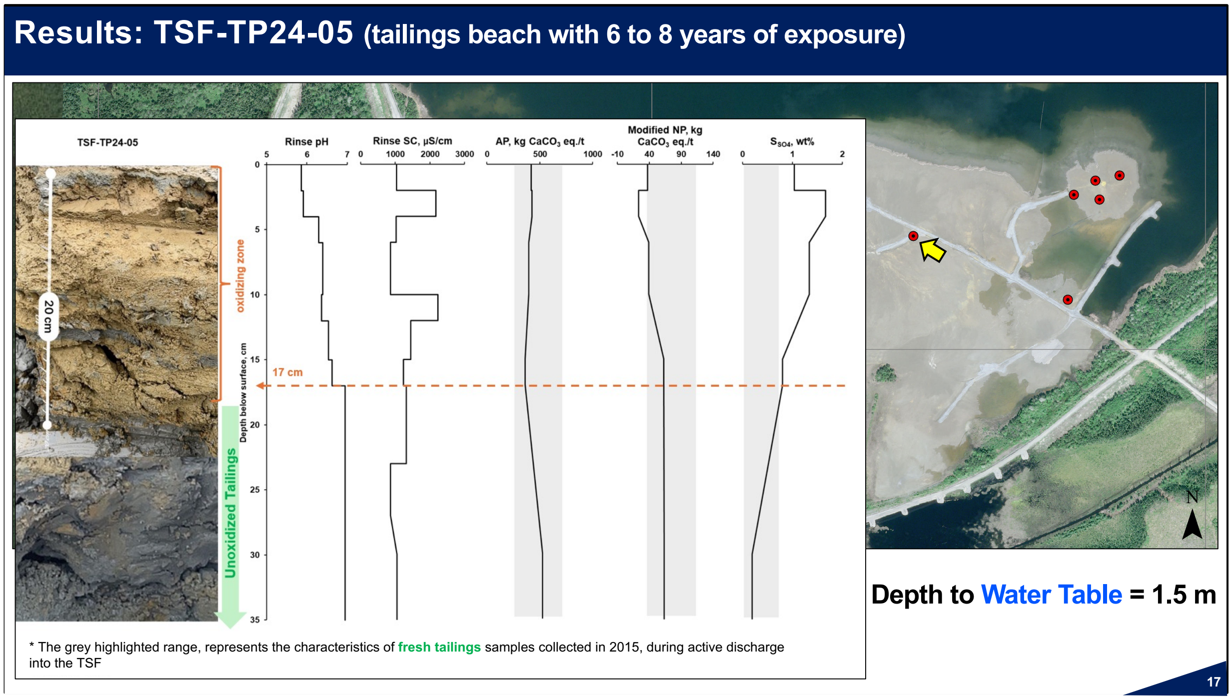


This map summarizes the results of our preliminary test pitting and the rinse test results. As you can see it here, this small island, which was in fact exposed the longest, for nearly 10 years, only shows localized signs of oxidation, such as here, with the least acidic rinse pH of 4.7 at the top 8 cm below surface. We saw worse conditions elsewhere, such as here, close to the access road where acidic pH was as low as 2.8 for up to 14 cm below surface with elevated rinse SC.

But the location that surprised us was here, close to the dam 3a, where we found tailings quite dry and rigid, **and not to mention**, very difficult to excavate. As you see, here, acidic rinse pH was quite profound, down to 70 cm, with pH as low as 2.5 in shallow tailings and rinse specific conductivity as high as nearly 4000 uS/cm. So, we ended up selecting these three locations for our detailed sampling and analysis.

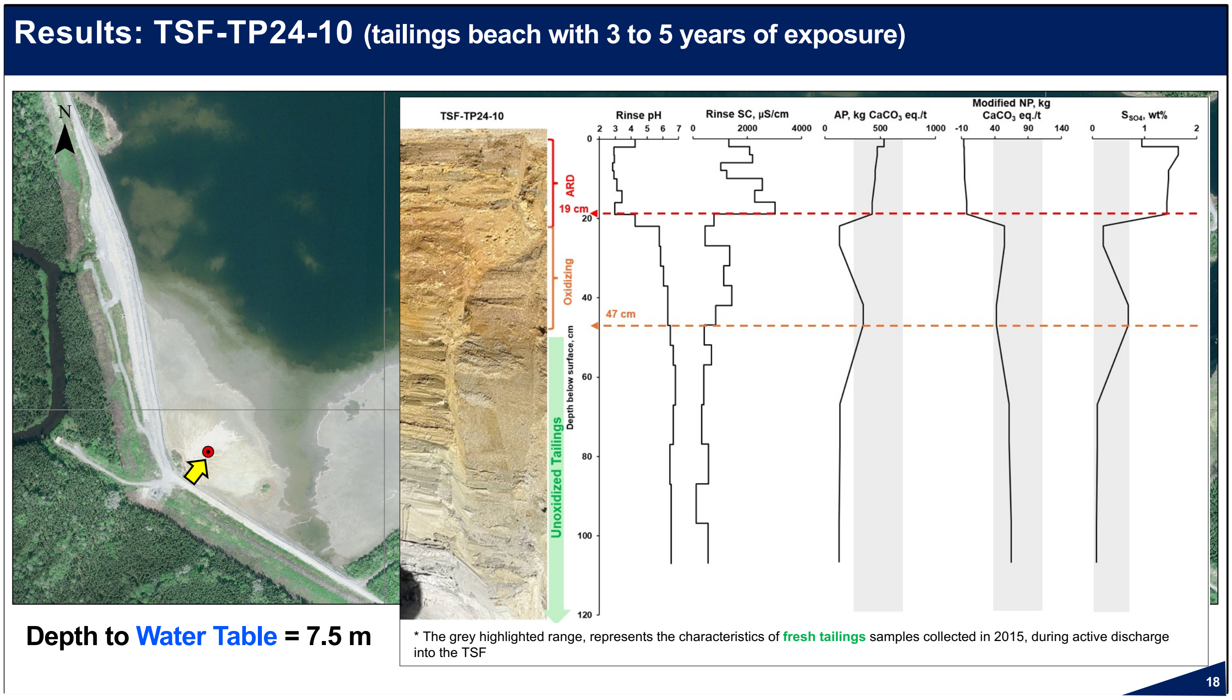


Here is the results of the detailed sampling in depth profiles for rinse pH, SC, acid potential, neutralization potential, and sulphate sulphur for tailings from this island with duration of exposure of nearly 10 years. As you can see the top 2cm, is characterized with highly acidic pH,, elevated SC,, and completely consumed NP,, and over 1wt% sulphate sulphur… These are all characteristics of highly oxidized tailings with potential for ARD generation. But as we go below 2 cm, the oxidizing condition gets milder, with NP increasing and sulphate sulphur decreasing. However, oxidation is still ongoing, and this is only below 8 cm, where the metrics falls within characteristics of unoxidized tailings. I should mention that the approximate depth to water table is quite shallow at this location and stands at approximately half a meter below the tailings surface.

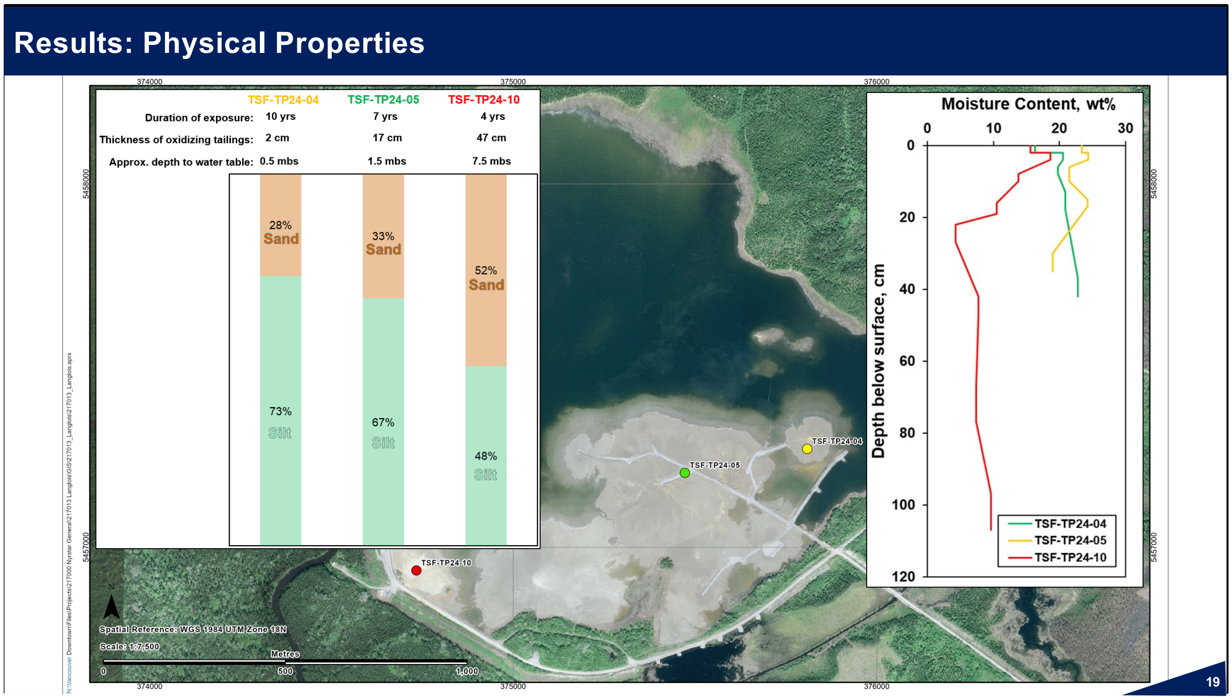


The same profiles are plotted here for the tailings close to the access road. The overall oxidizing condition was milder here, however it found to be more extended down to 17 cm below surface, which is consistent with deeper depth to water table of approximately 1.5 m here.

Looking at the neutralization potential, we see that it **was not** fully consumed anywhere within the depth profile, **meaning that while oxidation is ongoing, this location is probably still away from a full-blown ARD generation**.



As I mentioned before, we found the worst condition close to the dam 3a, where tailings were only exposed for nearly 4 years. As you see tailings were highly oxidized with very acidic condition and fully depleted NP, for up to 19 cm below surface, and the oxidizing condition which found to be ongoing down to at least 47 cm. This is also consistent with very deep depth to water table of approximately 7.5 m at this location. This result was sort of in contrast with what we expected from such short duration of exposure, **however, it highlighted the strong impact of physical properties** of tailings on the **kinetics of oxidation reactions.**



As plotted on these bar charts, we found that average fraction of sand sized tailings are higher for tailings close to Dam 3a with advanced oxidation front, than the other two locations. Therefore, these tailings are unable to retain the moisture content effectively and provide a barrier against oxygen diffusion to deeper layer.

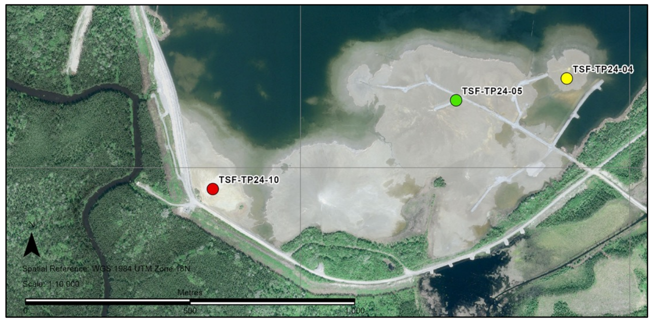
In addition, we also measured gravimetric moisture content in depth profile, showing lower values for the coarser tailings. So, the impact of grain size and moisture content and its retention are overpowering the duration of oxidation and **that's why the extent of oxidation got quite advanced in such a short time at this coarser grain area** compared to the other areas. We also looked at the mineralogy of tailings in detail, at TP24-10 in depth profile, and found out that pyrite crystals are very fine grain and they are highly exposed, compared to the carbonate grains,, which is another evidence for faster ARD generation here. I won't go through those mineralogy results today, given the limitation of time, but I'd be more than happy to discuss it afterward.

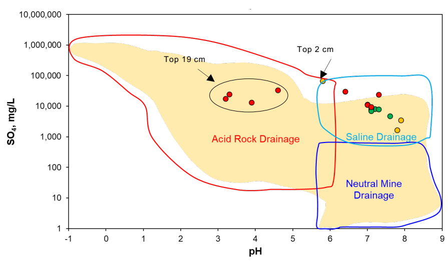
Results: Tailings Porewater

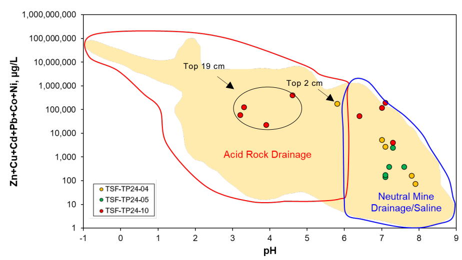
Porewater classified as ARD at:

- ✓ Top 2 cm of TSF-TP24-04
- ✓ Top 19 cm of TSF-TP24-10

- All porewater samples show elevated sulphate and base metal concentrations.
- Deeper samples, despite having circum-neutral to alkaline pH, are classified as Saline Drainage due to high solute content.







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Here is the porewater analysis results for samples from the three test pits, plotted on Ficklin diagrams, showing concentrations of sulphate, and trace metals vs. pH. These results are consistent with our solids analysis, showing that porewater from the top 19 cm of tailings at TP24-10 are classified as ARD, while only the top 2 cm at the tailings island are categorized as ARD,, and the rest fall within saline drainage class given their high solute content.

Key Findings

- Near-surface (exposed) tailings are actively oxidizing, while the extent of oxidation varies with physical properties:
- Older tailings beaches/islands (10 years of sub-aerial exposure):
  - Oxidation limited to top 2 cm
  - Fine grain size promote moisture retention, limiting oxygen diffusion
- Younger tailings (4 years of sub-aerial exposure):
  - Oxidation front extends to ~20 cm
  - Coarser grain size and reduced moisture retention lead to greater oxygen diffusion
- Shallow porewater (<50 cm) is enriched in SO_4, Fe, Mn, Pb, Zn.
- Despite the oxidation, sampling of pond water near the edges of the beaches in 2024 and 2025 has not identified any impacts on the quality of the pond water.
- Most Langlois waste rock produces NMD but elevated metals that can exceed groundwater standards. Placing this material under water in the TSF would prevent future contaminant loads to the local groundwater.

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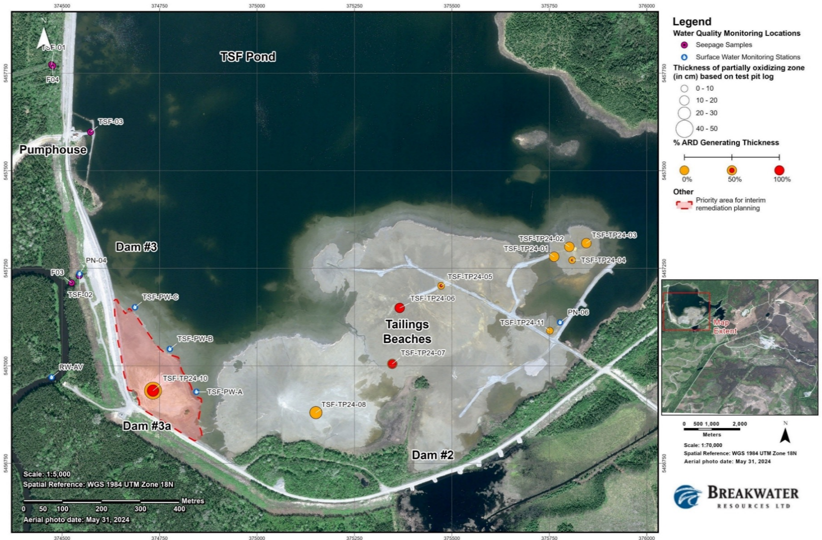
To summarize, we learnt from the tailings study that the exposed tailings are in fact oxidizing right now, but the extent and intensity of oxidation is variable across the tailings beaches, and it's mainly controlled by their grain size and moisture content. And we found that shallow porewater is enriched in sulphate and trace metals. However, I should mention that our pond water sampling at proximity to the tailings, could not identify any impact on the quality of the pond water.

And the waste rock characterization study showed that most of the waste rock at Langlois are Non-PAG and the potentially acid generating waste rocks are low in sulphide and they tend to yield neutral mine drainage, so relocating these waste rock to the TSF, would eliminate future NMD generation and prevent local groundwater contamination.

Path Forward

Recommended Interim Measures

- Apply crushed limestone over exposed tailings with an advanced state of oxidation to increase pH and slow down the rate of ARD generation.
- Routine pond water monitoring close to the tailings with an advanced state of oxidation.



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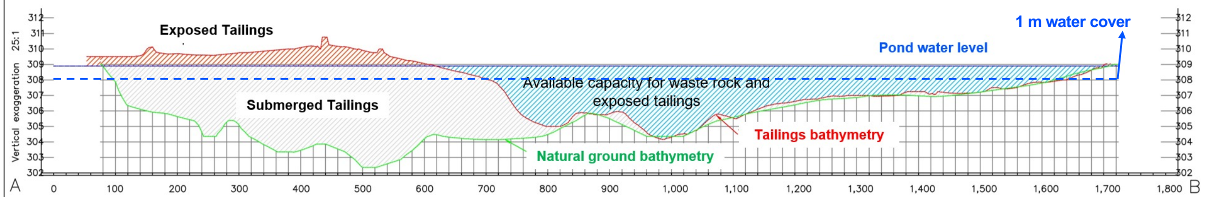
As for the path forward, we recommended to place an interim preventive treatment over this area with advanced oxidation, such as spreading of crushed limestone to bring up the pH and slow down the rate of oxidation, as well as routine pond water monitoring at close proximity to this area to capture any early sign of ML/ARD discharging into the pond.

This pond water monitoring was put in place in 2025 which as of today no impact of ML/ARD has identified yet.

Path Forward



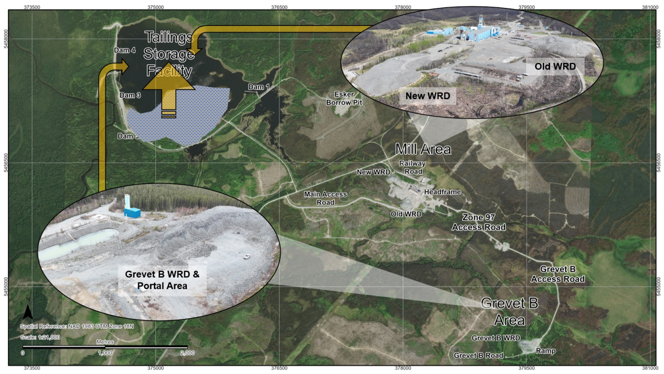
Long-term Closure Options

- Relocation of waste rock to TSF
- Dredging of tailings to underwater

- Total Waste Rock Volume = 610,000 m³
- Total Exposed Tailings Volume = 250,000 m³
- **Total Waste Volume = 860,000 m³**

TSF Capacity (below water level) = 2,300,000 m³

TSF Capacity (below 1 m water cover) =1,260,000 m³



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As for the long-term closure options, this is suggested to relocate all waste rock into the TSF, and for exposed tailings, dredging them into the deeper parts of the TSF is recommended.

Our volume estimates indicate about 0.6 Mm3 of waste rock and roughly 0.25 Mm3 of exposed tailings, so about 0.86 Mm3 would need to be placed underwater, which with an estimated 2.3 Mm3 of TSF capacity below the water level, this plan sounds feasible.

There are ongoing discussions about the minimum water cover needed on top of the tailings and waste rocks. For instance, one option is submerging waste material under 1 m of water cover (Click)

This would drop the TSF capacity by 45%, however, yet, it is enough to contain all waste volume.

However, aside from the capacity there are other considerations such as the dam stability and wind-induced erosion effect on relocated material etc, which all will be addressed in the closure options assessment which is in progress right now.

Also, a site-wide WLBM is underway, which would let us to predict pond water quality under various closure scenarios.
So, we'll soon have the framework needed to finalize a long-term closure strategy.

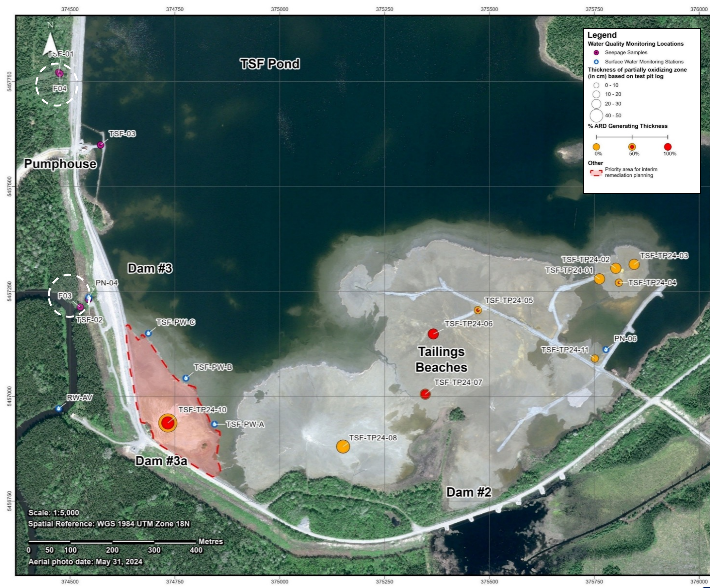
And with that, I'd like to thank again all my colleagues and co-authors at and outside RGC.

Thank you for your attention

Questions?

Results: Tailings Seepage

Tailings Seepage Station	Year	Annual Averages					
		Lab pH	Lab EC	Cu-t	Fe-t	Pb-t	Zn-t
			μS/cm	μg/L	μg/L	μg/L	μg/L
Criteria for Final Effluent (Directive 019)		*6.5 - 9.0*		*600*	*6,000*	*400*	*1,000*
ML-F3	2010	7.7	690	0.9	360	2.1	5.0
	2011	7.4	516	3.2	509	24	18
	2012	7.5	534	3.3	526	19	19
	2013	7.3	710	1.6	481	1.6	6.8
	2014	7.5	734	1.0	475	0.7	4.7
	2015	7.5	689	1.0	703	0.7	2.7
	2016	7.6	747	1.1	545	0.9	22
	2017	7.8	744	0.6	270	17	8.0
	2018	7.7	562	2.1	613	0.3	6.0
	2019	7.6	741	1.9	242	0.4	19
	2020	7.5	649	1.2	331	0.3	2.8
	2021	7.6	634	2.9	382	0.2	7.0
	2022	7.6	707	3.0	223	0.2	2.5
	2023	7.6	661	5.6	271	0.2	1.9
	2024	7.5	570	1.0	233	0.2	1.7
	2025	7.5	598	1.2	291	0.3	4.0
ML-F4	2010	7.6	409	3.6	433	1.8	6.9
	2011	7.5	433	3.8	1,237	25	13
	2012	7.6	443	2.1	343	3.5	13
	2013	7.6	446	2.2	204	2.1	9.1
	2014	7.7	379	1.1	630	1.6	2.4
	2015	7.6	383	5.0	389	2.4	17
	2016	7.8	502	1.1	238	0.6	1.9
	2017	7.7	451	1.4	265	0.6	1.7
	2018	7.8	410	1.2	249	0.3	1.9
	2019	7.7	423	4.2	533	7.5	10
	2020	7.7	448	1.2	191	0.3	1.8
	2021	7.7	425	2.0	198	0.2	1.4
	2022	7.7	363	2.9	193	0.2	3.3
	2023	7.7	376	1.1	298	0.2	1.8
	2024	7.7	370	1.3	324	0.2	4.3
	2025	7.5	300	1.0	208	0.2	2.5



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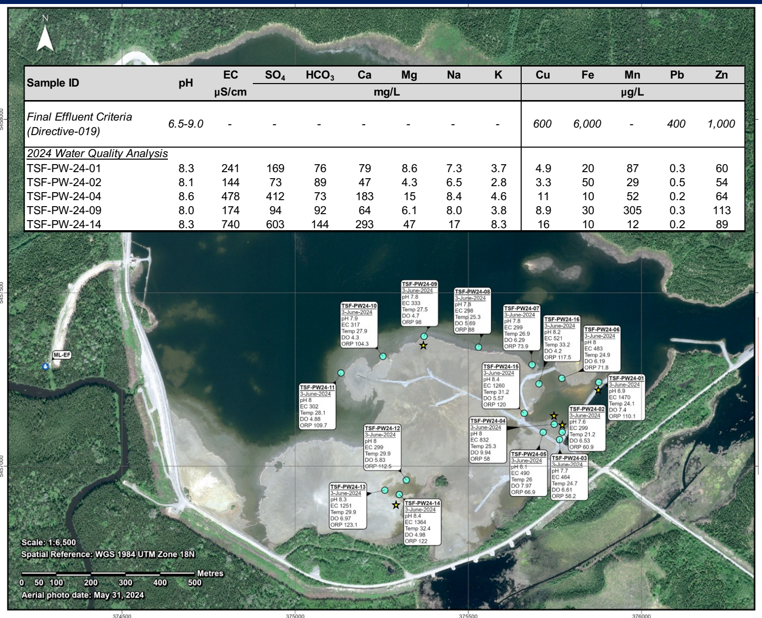
Results: TSF Pond Water



Sample ID	pH	EC	SO_4	HCO_3	Ca	Mg	Na	K	Cu	Fe	Mn	Pb	Zn
		µS/cm	mg/L						µg/L				
Final Effluent Criteria (Directive-019)	*6.5-9.0*	-	-	-	-	-	-	-	*600*	*6,000*	-	*400*	*1,000*
2024 Water Quality Analysis													
TSF-PW-24-01	8.3	241	169	76	79	8.6	7.3	3.7	4.9	20	87	0.3	60
TSF-PW-24-02	8.1	144	73	89	47	4.3	6.5	2.8	3.3	50	29	0.5	54
TSF-PW-24-04	8.6	478	412	73	183	15	8.4	4.6	11	10	52	0.2	64
TSF-PW-24-09	8.0	174	94	92	64	6.1	8.0	3.8	8.9	30	305	0.3	113
TSF-PW-24-14	8.3	740	603	144	293	47	17	8.3	16	10	12	0.2	89

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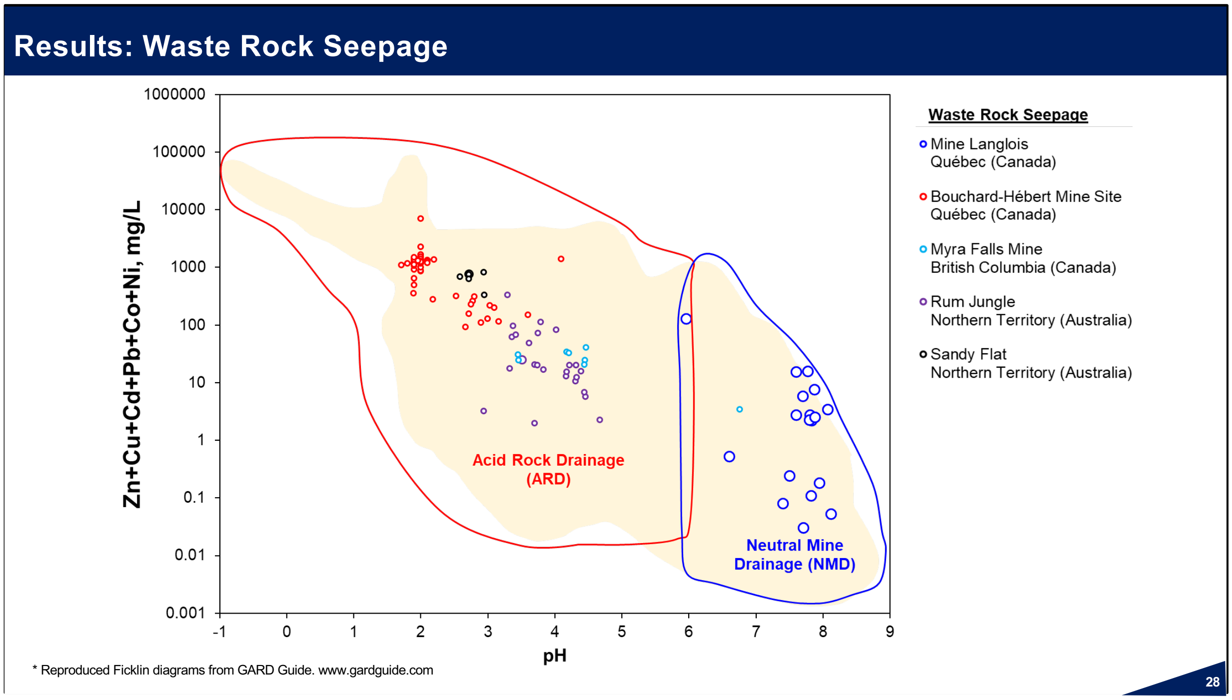
- 2024 samplings (targeted water at close contacts with tailings) assessed impact of shallow tailings on pond water.
- Field measurements showed: circum-neutral to slightly alkaline pH, EC ranging from 30-1,470 µS/cm, DO at near equilibrium with atmosphere oxygen, and oxidizing to sub-oxic ORP.
- Lab analysis of four samples showed slightly elevated SO_4, Zn, and Mn; still well below criteria.



We did a comprehensive study on waste rock geochemical characterization across Mine Langlois. We excavated ...66 test pits excavated to natural ground/bedrock, with 117 waste rock samples collected from the profiles.

All samples were sieved to -19 mm in the field; rinse tests were completed on -2 mm material on site.

About 1 kg of each -19 mm sample was sent to SGS. Lab analyses included ABA, and near-total metals by aqua regia digestion, XRD for mineralogy, and leach tests of SPLP, TCL, and CTEU-9 for selected number of samples

Static leaching tests (SPLP, TCEU-09, TCLP) revealed that 90% of waste rock samples are leachable and could release elevated concentrations of Zn, Cd, Pb, and Se. Relocating this material to the TSF would eliminate this source of NMD and improve groundwater quality across the rehabilitation footprint in the long term.

Seepage samples were also collected from bottom of test pits, toes of WRDs etc.

Most seepage samples collected in 2021 and 2022 show circum-neutral to slightly alkaline pH and low SO_4 and metal levels, so they fall in the NMD range. This includes seepage from the WRDs, Mill Area, and access roads. A few samples contain elevated Cd, Cu, Se, and Zn, and Zn can exceed Directive 019 limits, but their overall chemistry still aligns with NMD.

Results match the SFE patterns for waste rock. The only clear outlier is a ponded sample from TP22-59C with very high Zn, likely due to stagnant water; it classifies as SD but is not representative of flowing seepage.

Overall, seepage from non-PAG and most PAG materials at surface is predominantly NMD, with only minor groundwater impacts observed on site.

Overview

- Site background and development history
- Waste rock characterization summary
- TSF history and current conditions
- Tailings characterization program
  - Field works and sampling
  - Key field observations
  - Detailed lab results for solids and porewater
- Key findings
- Path forward
  - Interim measures under consideration
  - Long-term closure concept

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From Mine to Sustainable Landscape: What Does It Take?

The answer begins with understanding the chemistry of what's left behind.

Mine Langlois, Waste Rock Dump, 2025

Mine Langlois, Tailings Storage Facility, 2024

- Once sulphide minerals exposed at the surface, they become unstable and react with oxygen and water.
- Oxidation of sulphide minerals, especially pyrite (FeS_2), produces acidic drainage and releases toxic metals, known as Metal Leaching (ML) and/or Acid Rock Drainage (ARD).

$$4FeS_{2(s)}+15O_{2(g)}+8H_2O_{(l)}\rightarrow 4Fe^{3+}_{(aq)}+8SO_4^{2-}{}_{(aq)}+16H^+_{(aq)}$$

Generic ML/ARD image (for demo only)

Flyover – June 2025

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Here is a short video flying over the mine site. Starting from the Gerevt B Mine site. This Mine was a smaller deposit in association with Mine Langlois which has its own WRD. Then there is an access road to the Mill area. All access roads were partially constructed from waste rock.

There are two Waste Rock Dumps in the Mill Area that contain sulphide-bearing waste rock. The Old and New WRD. New WRD has a liner underneath. Waste rock was also placed as fill in the Mill Area in order to provide level working surfaces. And then we have the main access road and the road to the TSF. Tailings were mixed with lime and discharged to the TSF. All discharged tailings was under water prior to 2013 and they were required to be kept under 1 m of water cover during operation and post closure. However, as you see it did not stay as intended and tailings beaches started to emerge since 2013, when TSF was operating. Which was mainly due to lack of frequent moving of the discharge pipes during the winter-time when pipes were stuck in ice, led to deposition of tailings at discharge points.

It should be noted that the excess pond water discharges directly into the nearby Wedding river, and so far, the routine pond water monitoring has shown that water quality **is compliant with the final effluent limits.**

Grevet B Area

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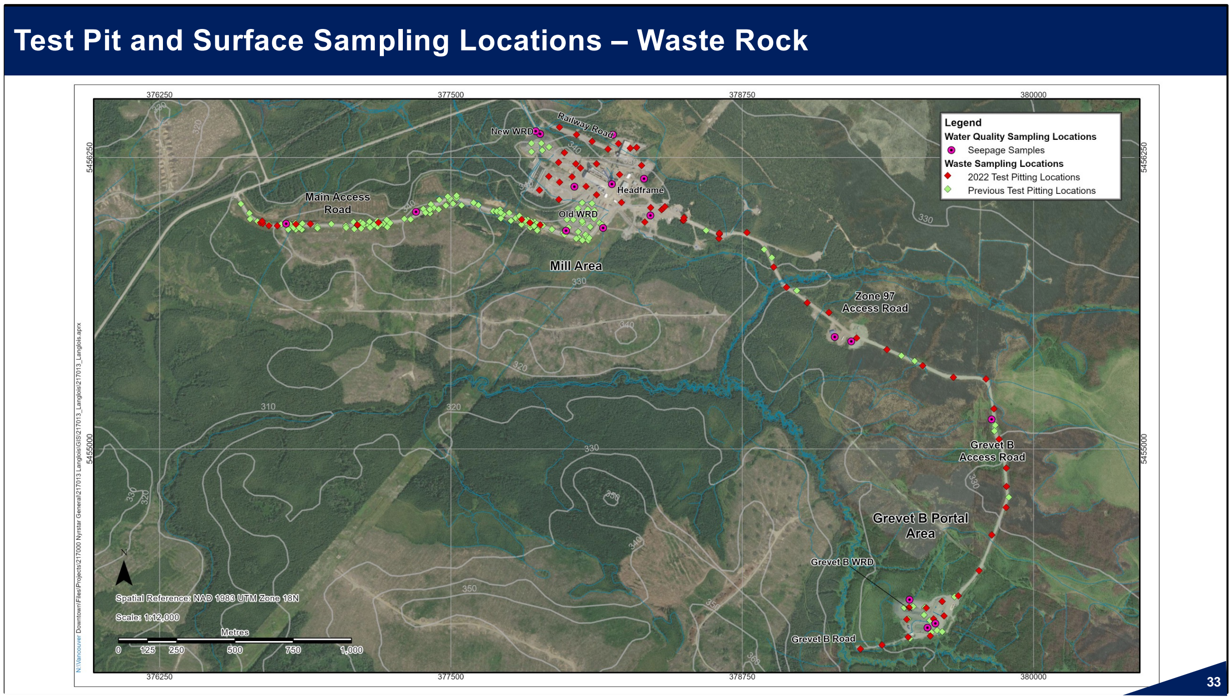
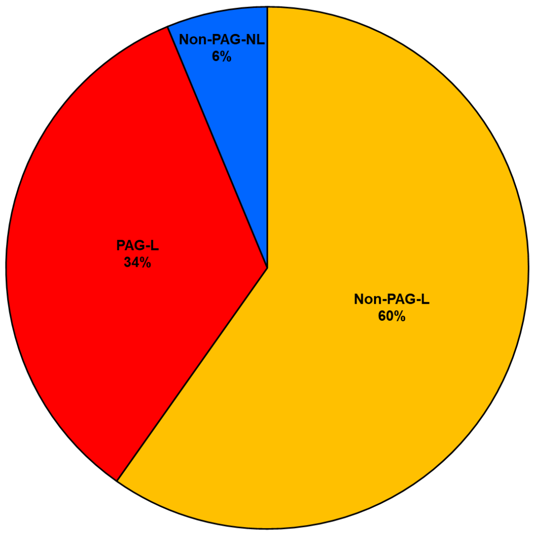
The TSF closure plan is still under option assessment stage. However, given the large 2.3 Mm3 capacity within the pit and underwater cover, a high potential option is to relocate all waste rocks from Grevet B, Mill Area, access roads and waste rock dumps into the TSF and also dredge the exposed tailings to the deeper parts of the TSF.



66 test pits excavated to natural ground/bedrock, with 117 waste rock samples collected from the profiles. All samples were sieved to -19 mm in the field; rinse tests were completed on -2 mm material on site. About 1 kg of each -19 mm sample was sent to SGS. Lab analyses included ABA, and near-total metals by aqua regia digestion, XRD for mineralogy, and leach tests of SPLP, TCL, and CTEU-9 for selected number of samples. Static leaching tests (SPLP, TCEU-09, TCLP) revealed that 90% of waste rock samples are leachable and could release elevated concentrations of Zn, Cd, Pb, and Se. Relocating this material to the TSF would eliminate this source of NMD and improve groundwater quality across the rehabilitation footprint in the long term. Seepage samples were also collected from bottom of test pits, toes of WRDs etc.

Waste Rock Characterization



Parameters	S_{S2-}	AP	NP	NNP	NPR
Units	wt. %	kg $CaCO_3$ eq./t		kg $CaCO_3$ eq./t	
Non-PAG (n=213)					
Avg.	0.6	20	84	64	4.3
Max.	1.5	47	128	81	2.7
PAG (n=73)					
Avg.	2.1	64	62	-2.2	1.0
Max.	8.6	269	110	-159	0.4

Trace Metals		Ag	Cd	Cu	Mn	Pb	Se	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Groundwater Quality Standard		*0.1*	*0.4*	*3*	*1,000*	*10*	*62*	*31*
SPLP, TCLP, and CTEU-9								
Non-PAG	% exceeding GWQ-std	58%	39%	54%	0%	0%	15%	44%
PAG	% exceeding GWQ-std	100%	100%	100%	64%	61%	32%	100%

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66 test pits excavated to natural ground/bedrock, with 117 waste rock samples collected from the profiles. All samples were sieved to -19 mm in the field; rinse tests were completed on -2 mm material on site. About 1 kg of each -19 mm sample was sent to SGS. Lab analyses included ABA, and near-total metals by aqua regia digestion, XRD for mineralogy, and leach tests of SPLP, TCL, and CTEU-9 for selected number of samples

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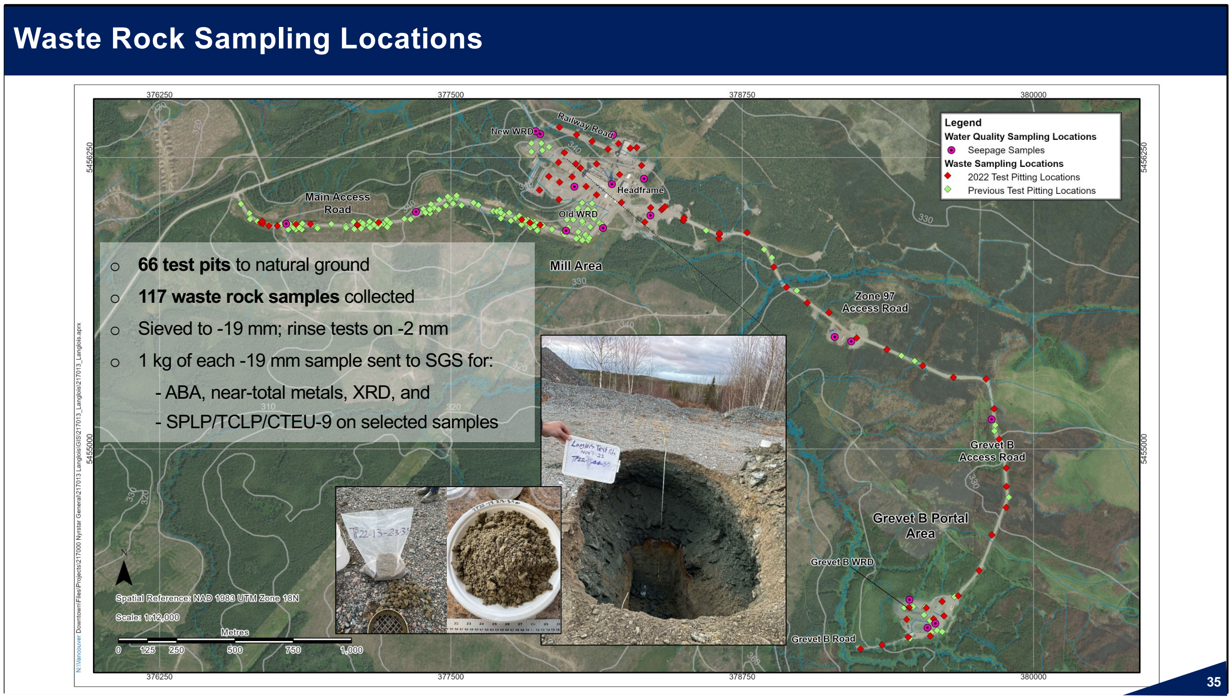

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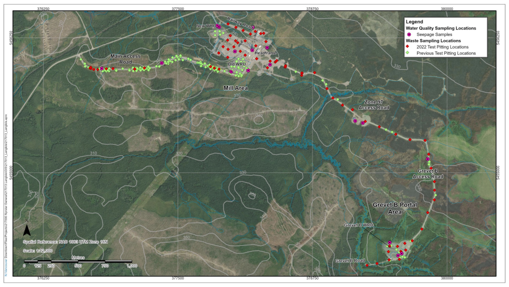
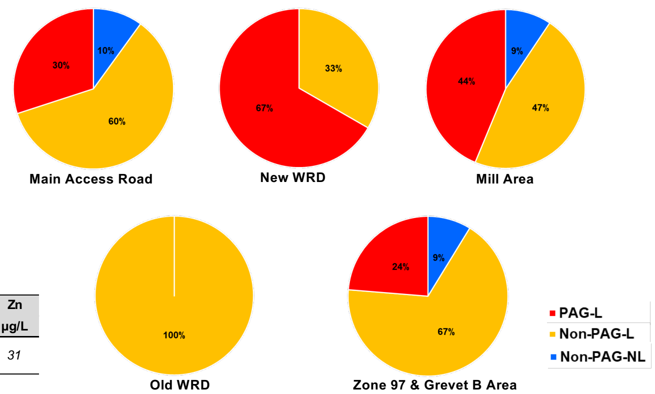
Waste Rock Characterization

Waste Type	ABA Criteria
PAG	0.04 wt. % < S_{total}, NPR < 2 and NNP < 20 kg $CaCO_3$ eq./t
Non-PAG	0.04 wt. % < S_{total} < 5 wt. %, NPR > 2 and NNP > 20 kg $CaCO_3$ eq./t

Waste Type	Mandated Leaching Tests by MELCC	Leachability Criteria
PAG	TCLP, SPLP, and CTEU-9	Any test result that exceeds the groundwater quality criteria of the Intervention Guide by MELCC.
Non-PAG	SPLP and CTEU-9	

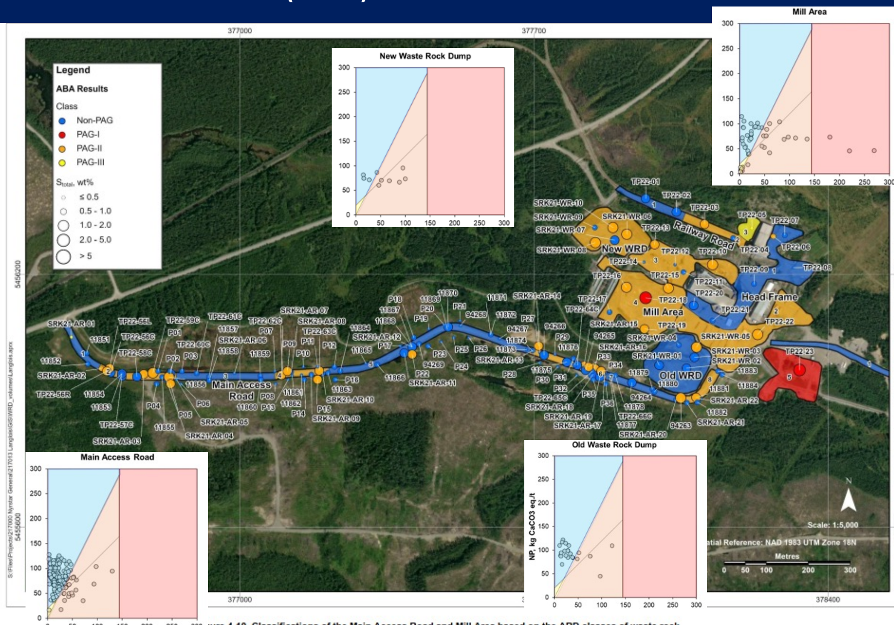




Trace Metals		Ag	Cd	Cu	Mn	Pb	Se	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Groundwater Quality Standard (resurgence in surfacewater)		*0.1*	*0.4*	*3*	*1,000*	*10*	*62*	*31*
SPLP, TCLP, and CTEU-9								
Non-PAG	% exceeding GWQ-std	58%	39%	54%	0%	0%	15%	44%
PAG	% exceeding GWQ-std	100%	100%	100%	64%	61%	32%	100%

36

Waste Rock Characterization (ABA)



ure 4-10. Classifications of the Main Access Road and Mill Area based on the ARD classes of waste rock

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Waste Rock Characterization (ABA)

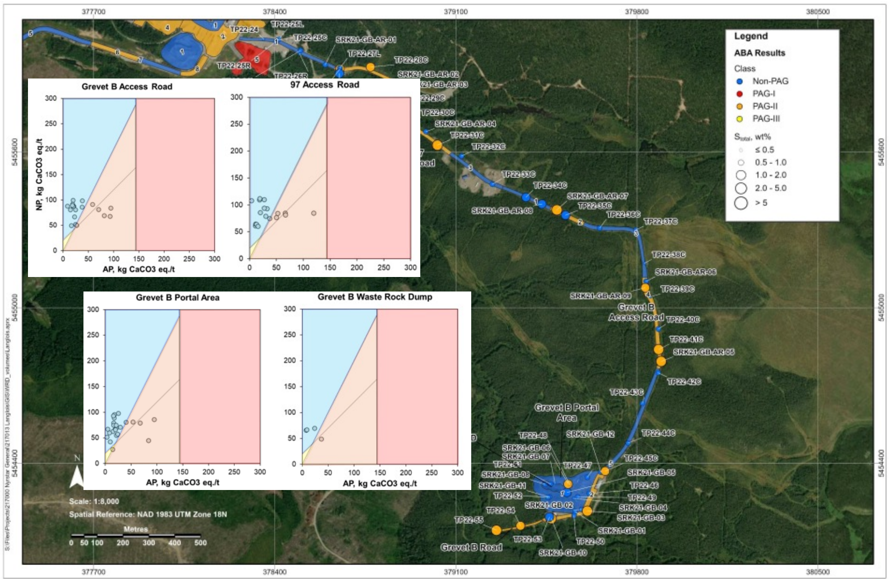

Figure 4-11. Classifications of the Zone 97, and Grevet B Access Road, and Grevet B Portal Area based on the ARD classes of waste rock

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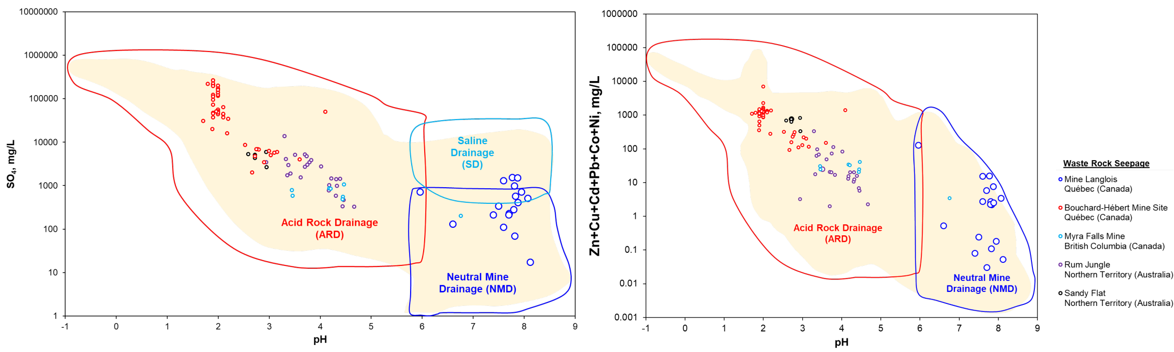
Waste Rock Characterization (Seepage)

- Circum-neutral to slightly alkaline pH in most seepage (avg 7.6)
- Low SO_4 (avg 550 mg/L) and low metals (avg 10 mg/L)
- Majority classify as NMD, with a few cases of SD



* Reproduced Ficklin diagrams from GARD Guide. www.gardguide.com

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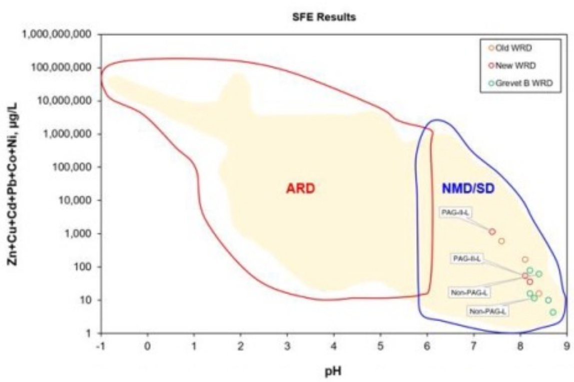
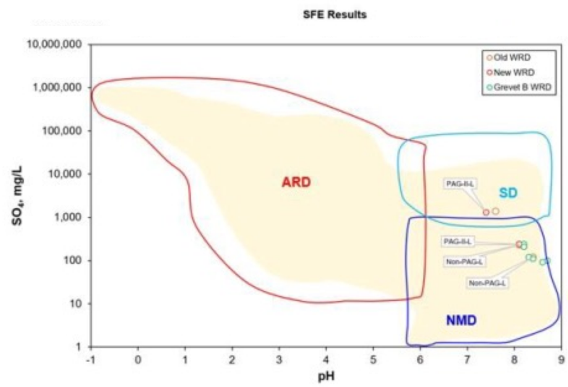
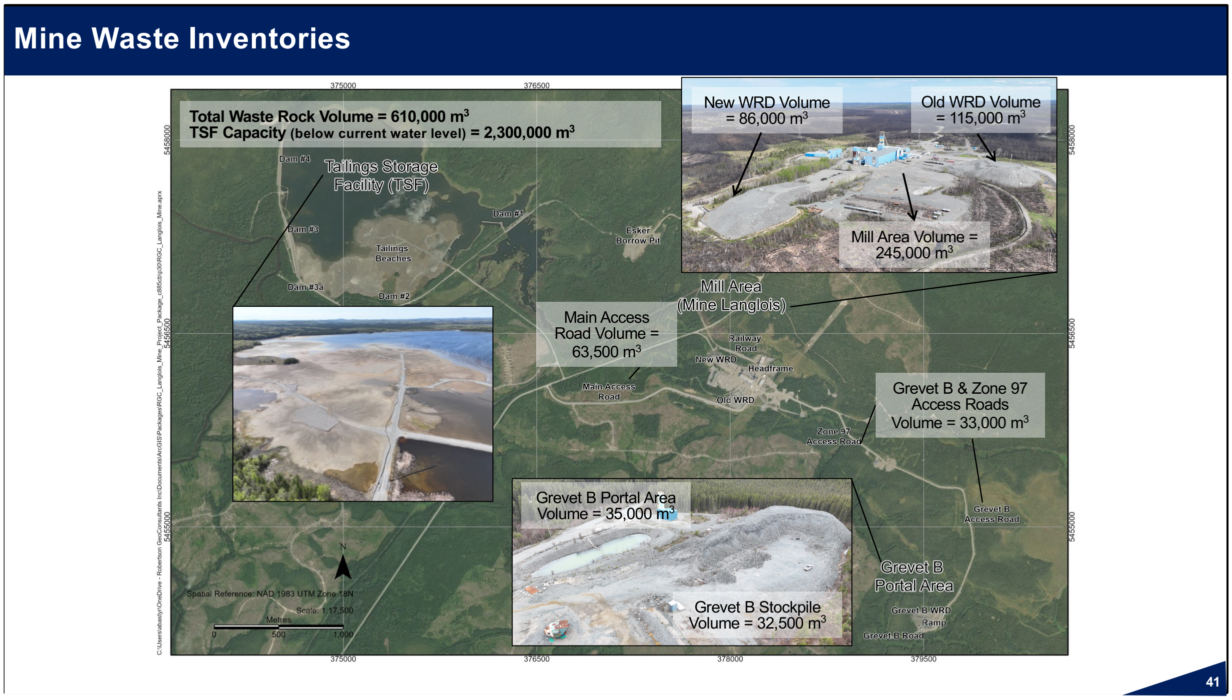
Most seepage samples collected in 2021 and 2022 show circum-neutral to slightly alkaline pH and low SO4 and metal levels, so they fall in the NMD range. This includes seepage from the WRDs, Mill Area, and access roads. A few samples contain elevated Cd, Cu, Se, and Zn, and Zn can exceed Directive 019 limits, but their overall chemistry still aligns with NMD. Results match the SFE patterns for waste rock. The only clear outlier is a ponded sample from TP22-59C with very high Zn, likely due to stagnant water; it classifies as SD but is not representative of flowing seepage. Overall, seepage from non-PAG and most PAG materials at surface is predominantly NMD, with only minor groundwater impacts observed on site.

Waste Rock Characterization (Seepage)



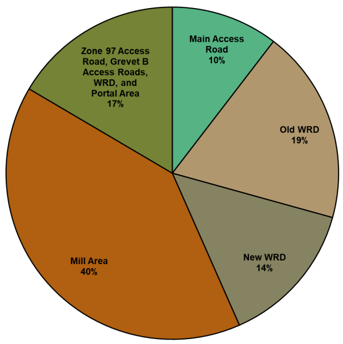




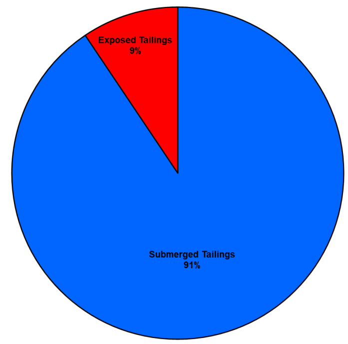
The site consists of the Mill Area, where the headframe and various mine-related buildings are located, the Tailings Storage Facility (TSF) to the west, and the associated Grevet B mine approximately 2 km east of the Mill Area. There are two Waste Rock Dumps (WRDs) in the Mill Area that contain sulphide-bearing waste rock and three access roads that were partially constructed from waste rock. Sulphide-bearing waste rock has also been deposited throughout the Mill Area and in the vicinity of the Grevet B portal and in the nearby Grevet B WRD (Breakwater, 2023a). Breakwater is updating the Restoration Plan for Mine Langlois (Breakwater, 2018) and revising the recent Restoration Plan for the Grevet B mine (see Breakwater, 2023a) in 2023 as part of site-wide restoration planning.

Mine Waste Inventory

Total Waste Rock Volume = 610,000 m^3



Total Tailings Volume = 2,600,000 m^3



- **Total Exposed Tailings Volume = 250,000 m^3**
- **Total Waste Rock Volume = 610,000 m^3**

Total Waste Volume = 860,000 m^3

TSF Capacity (below water level) = 2,300,000 m^3

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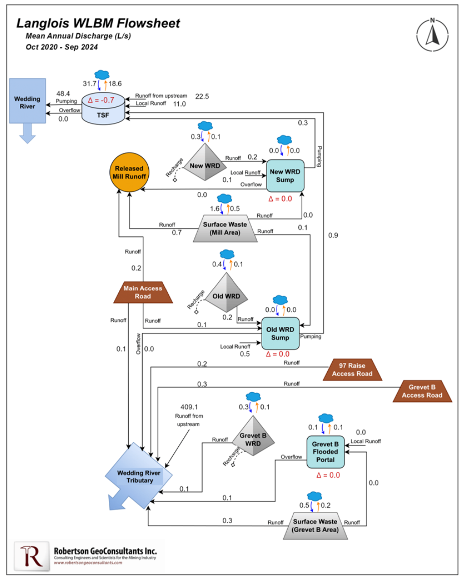
Water Management System



Impact on Groundwater Quality

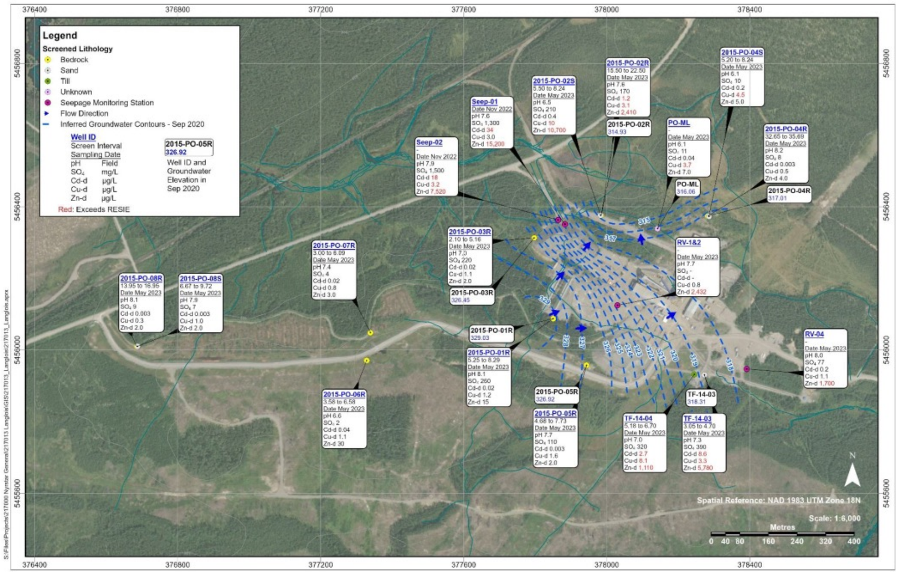
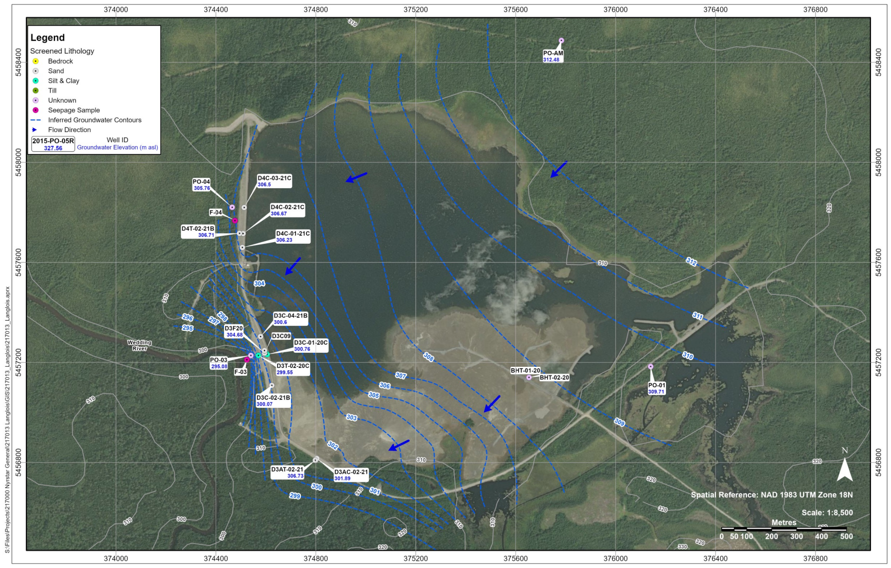


Table 4-13 summarizes groundwater quality results from a sampling campaign completed by RGC in May 2023. This table includes groundwater quality results for wells in the Mill Area, TSF Area, and the two wells (PO-06-05 and F06-11) that were sampleable in the Grevet B Area. Other wells in the Grevet B Area have either been destroyed or were not installed as planned (see Section 2). Also included in Table 4-13 are water quality results for waste rock seepage from the New WRD and water quality results for mine water that has flooded the Grevet B ramp and mine water that has recently expressed at ground surface near the Zone 97 Raise (MV-97 and RRF-97) and the Ventilation Raise (RV-04) in the Mill Area. Note, seepage from PAG waste rock in the lined New WRD is collected (and pumped to the TSF supernatant pond) but the data are representative of seepage that likely reports to groundwater from waste rock in the Mill Area and the access roads. Water quality results for the Mill Area and TSF Area are also plotted in Figure 4-17, Figure 4-18, and Figure 4-19 for reference. Preliminary groundwater level contours for the Mill Area and TSF Area based on water level data for September 2022 are included in the figures. Contours are not provided where there are insufficient water level data, e.g., near the Main Access Road. Also, the inferred flow fields do not consider the recent expression of underground mine water, which may affect the groundwater flow field locally near the Zone 97 Raise and the raised rockfill in the Mill Area. Also, there are too few water level data for wells in the Grevet B Area to delineate the local groundwater flow field, so contours are not provided for this area.

Flow Field - TSF



Flow Field - TSF

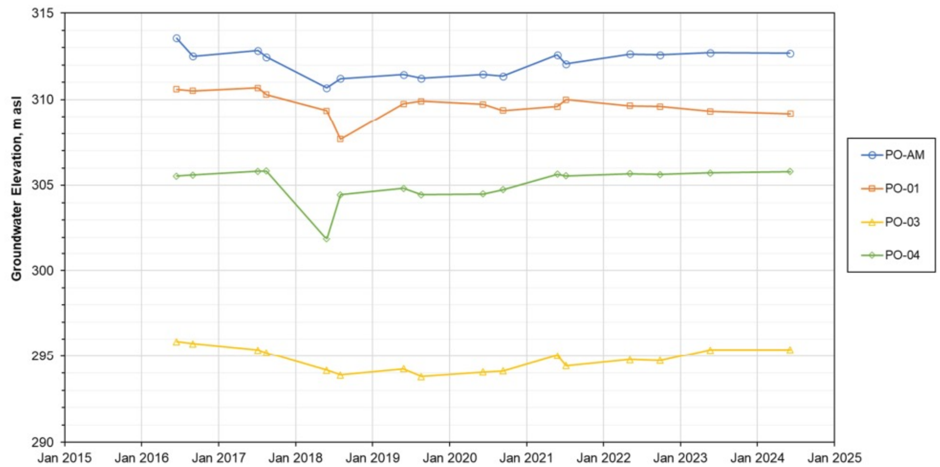
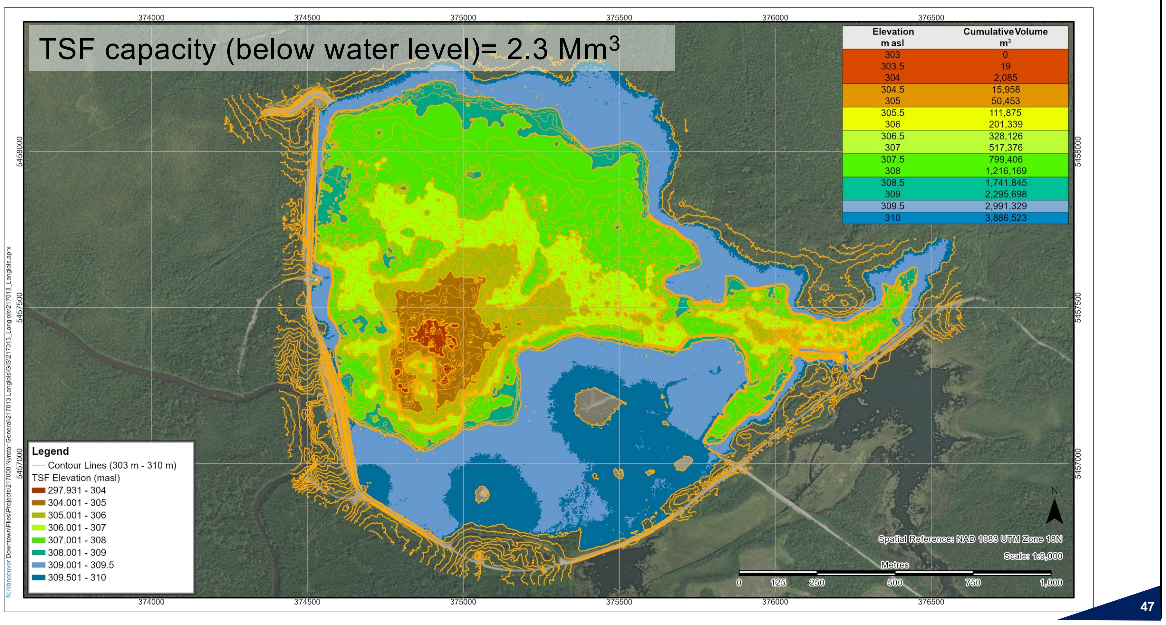


Figure 5-6 Observed Groundwater Level Time Trends at the TSF.

Pit Bathymetry



Elevation m asl	Cumulative Volume m^3
303	0
303.5	19
304	2,085
304.5	15,958
305	50,453
305.5	111,875
306	201,339
306.5	328,126
307	517,376
307.5	799,406
308	1,216,169
308.5	1,741,845
309	2,295,698
309.5	2,991,329
310	3,886,523

This map shows the current pit bathymetry. The TSF was built in a natural depression, and the pond sits directly on natural soils, underlain by varved clays, sand and silt, and then the bedrock. The current bathymetry indicate that there is around 7 m difference in elevation between the deepest parts of TSF and tailings beaches. Our volume calculations estimated approximately 2.3 Mm3 of space below current water level.

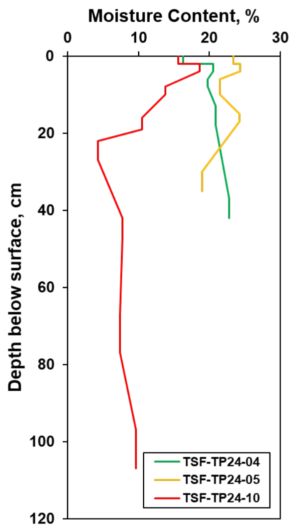
Background

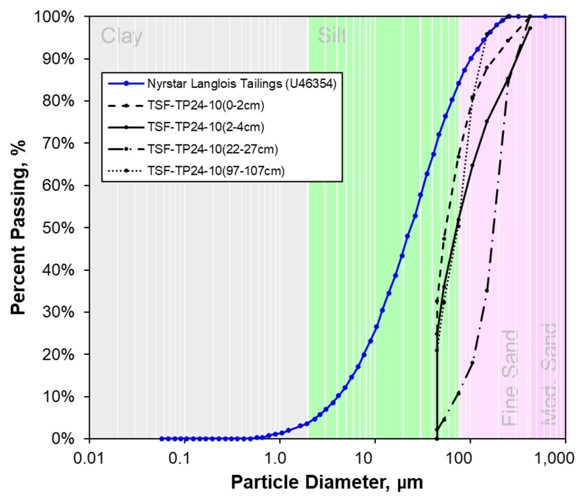
- TSF Operation Periods: Feb 1996 to Dec 1996, 1997 to 2000, 2007 to 2008, 2012 to 2019
- Tailings beach exposure durations were identified using aerial photo analysis from 2011 to 2023
- Routine monitoring at the discharge point to the Wedding River showed neutral to alkaline pH and low trace metals.
- 2021 porewater analysis showed neutral to alkaline pH and very low metal concentrations (<1 mg/L).
- No systematic characterization of the tailings beaches had been conducted prior to this study.

Sample ID	pH	EC	Cu	Fe	Mn	Pb	Zn
		µS/cm	µg/L				
Final Effluent Criteria	*6.5-9.0*	*-*	*600*	*6,000*	*-*	*400*	*1,000*
Yearly Average Water Quality at Station ML-EF							
2001	7.4	734	16	151	-	5	196
2011	7.7	451	3	223	10	18	151
2012	7.7	566	10	171	16	2	172
2013	7.4	827	12	233	17	6	143
2014	7.1	736	10	113	47	1	139
2015	7.3	896	5	78	78	3	165
2016	7.1	812	9	170	102	2	209
2017	7.4	894	29	68	31	1	178
2018	7.8	957	8	90	67	1	35
2019	7.5	800	10	230	55	4	95
2020	7.5	583	4	125	40	1	171
2021	7.6	543	3	120	32	1	100
2022	7.9	396	2	60	23	0	45
2023	7.9	330	4	143	33	1	62
2024	7.5	250	3	75	22	1	48

Results: Moisture Content and PSD

Why is the oxidation front more advanced in tailings with shorter exposure durations compared to locations that have been exposed to subaerial conditions for longer?

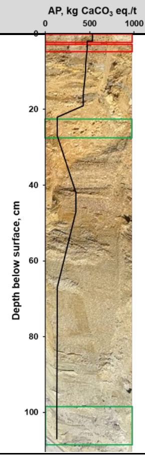




Results: Mineralogy of Tailings at TSF-TP24-10

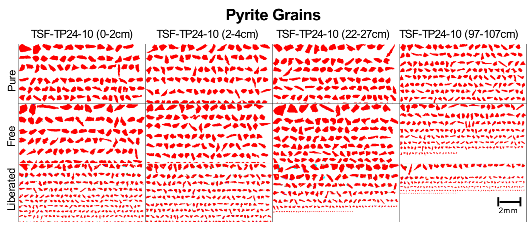
- Carbonates are depleted in shallow tailings versus deeper layers.
- Oxidation is evident in the higher abundance of iron oxides/hydroxides and gypsum in the top 4 cm, compared to those at depth.

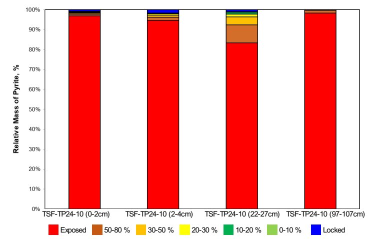
Mineral Group	Sulphide	Carbonate		Sulphate		Oxide	Silicate
Phase	Py, Ccp, Sph	Cal, Dol	Ank	Gyp	Fe-sul	Fe-ox/hydr	Qz, Ms/Ill, Pl, Chl,
Sample ID	wt%	wt%	wt%	wt%	wt%	wt%	wt%
TSF-TP24-10 (0-2cm)	36	0.04	0.1	3.6	0.2	4.7	55
TSF-TP24-10 (2-4cm)	32	0.03	0.02	6.7	0.1	2.9	57
TSF-TP24-10 (22-27cm)	8.6	3.9	2.4	1.0	0.03	0.6	82
TSF-TP24-10 (97-107cm)	9.9	2.7	4.5	0.2	0.005	0.8	81

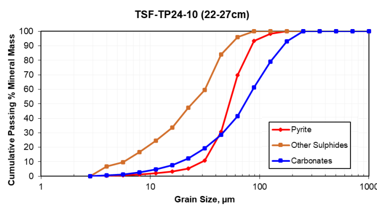


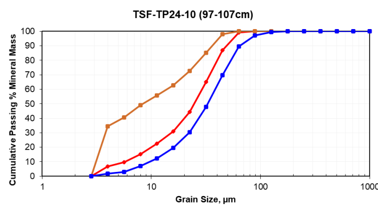
Results: Mineralogy of Tailings at TSF-TP24-10

- Over 85% of pyrite grains in all analyzed samples are present as pure, free, and liberated grains.
- More than 80% of pyrite grains are fully exposed to their surrounding environment.





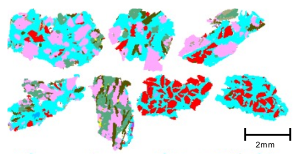




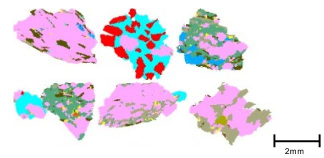
- Sulphide minerals have finer grain sizes compared to associated carbonates.

Results: Mineralogy of Tailings at TSF-TP24-10

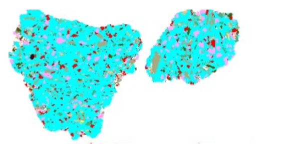
- Between 50% and 70% of gypsum occurrences are associated with complex mineral assemblages, indicating gypsum cementation of tailings grains, while most of the remainder occurs as free gypsum grains.



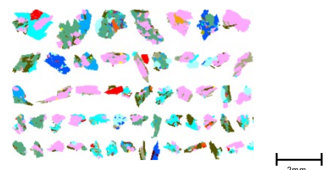
TSF-TP24-10 (0-2 cm)
Gypsum content= 3.6 wt%



TSF-TP24-10 (22-27 cm)
Gypsum content= 1.0 wt%



TSF-TP24-10 (2-4 cm)
Gypsum content= 6.7 wt%



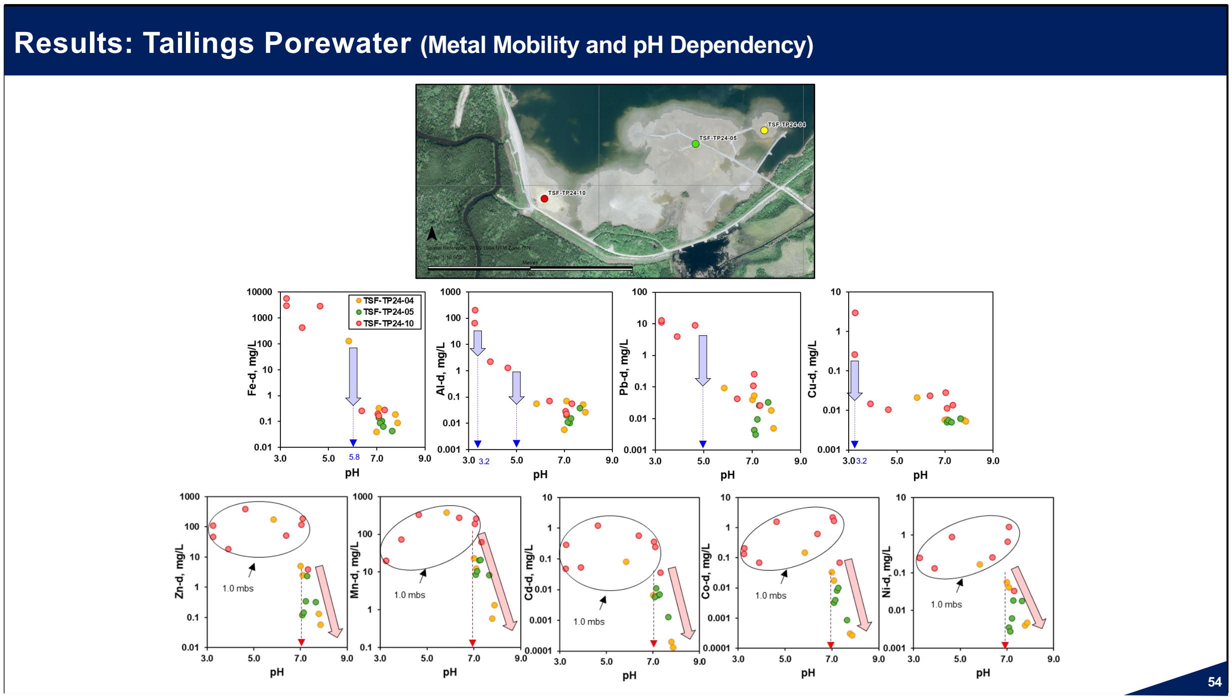
TSF-TP24-10 (97-107 cm)
Gypsum content= 0.2 wt%

Gypsum | Pyrite | Quartz | Plagioclase | Sphalerite | Calcite | Dolomite | Ankerite

Results: Testing of the Preservation Method

Sampling Interval						S_{total}	S_{SO4}	$S_{sulphide}$	$S_{insoluble}$	AP*	TIC	$CaCO_3$ NP	Modified NP	NNP**	NPR**	
From	To	Fizz Test	Moisture Content	Paste pH	Rinse pH	Meas.	Meas.	Meas.	Calc.	Calc.	Meas.	Calc.	Meas.	Calc.	Calc.	Tailings Class
cm	cm		%			wt. %	wt. %	wt. %	wt. %	kg $CaCO_3$ eq./t	%	kg $CaCO_3$ eq./t	kg $CaCO_3$ eq./t	kg $CaCO_3$ eq./t		
Average Composition of Fresh Tailings (2015)																
-	-	-	25	9.0	-	13	0.1	13	0.0	414	-	-	70	-	0.2	PAG
TSF-TP24-04																
0	2	None	16	5.1	4.5	24	1.1	21	1.7	660	0.02	1.7	-2.9	-663	-0.004	PAG
2	4	None	21	5.9	6.1	17	1.1	14	1.3	444	0.5	40	31	-413	0.07	PAG
6	8	Slight	20	6.3	6.5	18	0.5	16	1.4	494	0.7	55	46	-448	0.09	PAG
13	18	Slight	21	7.6	7.2	14	0.2	12	1.5	386	1.0	82	71	-315	0.2	PAG
18	23	-	-	-	7.4	17	0.1	17	0.0	544	1.0	82	82	-462	0.2	PAG
37	42	Slight	23	6.7	7.6	18	0.3	16	1.6	515	0.6	48	44	-470	0.09	PAG
TSF-TP24-05																
0	2	Slight	23	6.9	5.9	15	1.0	13	0.7	417	0.5	43	37	-380	0.09	PAG
2	4	None	24	6.4	5.9	16	1.7	14	0.7	427	0.4	31	23	-403	0.05	PAG
6	10	None	21	6.9	6.4	15	1.3	13	0.6	394	0.6	47	39	-355	0.1	PAG
15	17	Slight	24	7.4	6.6	13	0.8	12	0.5	360	0.9	72	63	-298	0.2	PAG
30	35	Slight	19	7.7	7.0	18	0.2	17	1.1	525	0.9	72	63	-461	0.1	PAG
TSF-TP24-10																
0	2	None	16	3.9	4.3	19	1.0	17	0.6	533	0.01	0.8	-6.2	-539	-0.01	PAG
2	4	None	19	3.4	2.9	18	1.7	15	0.8	472	0.01	0.8	-5.8	-478	-0.01	PAG
8	10	None	14	3.7	2.9	17	1.5	14	0.9	453	0.01	0.8	-5.0	-457	-0.01	PAG
16	19	None	10	4.1	3.0	16	1.4	14	0.9	428	0.04	3.3	-2.1	-430	-0.005	PAG
22	27	Slight	4.3	8.1	5.8	4.7	0.2	4.2	0.3	133	0.7	59	54	-78	0.4	PAG
42	47	Slight	7.8	7.5	6.3	12	0.7	11	0.1	345	0.6	48	42	-303	0.1	PAG
67	77	Slight	7.4	7.9	6.7	4.5	0.1	4.3	0.1	133	0.9	73	61	-72	0.5	PAG
87	97	-	-	-	6.5	4.9	0.1	4.8	0.0	150	0.9	75	75	-75	0.5	PAG
97	107	Slight	9.6	7.9	6.5	4.4	0.1	4.1	0.3	128	0.9	76	65	-63	0.5	PAG

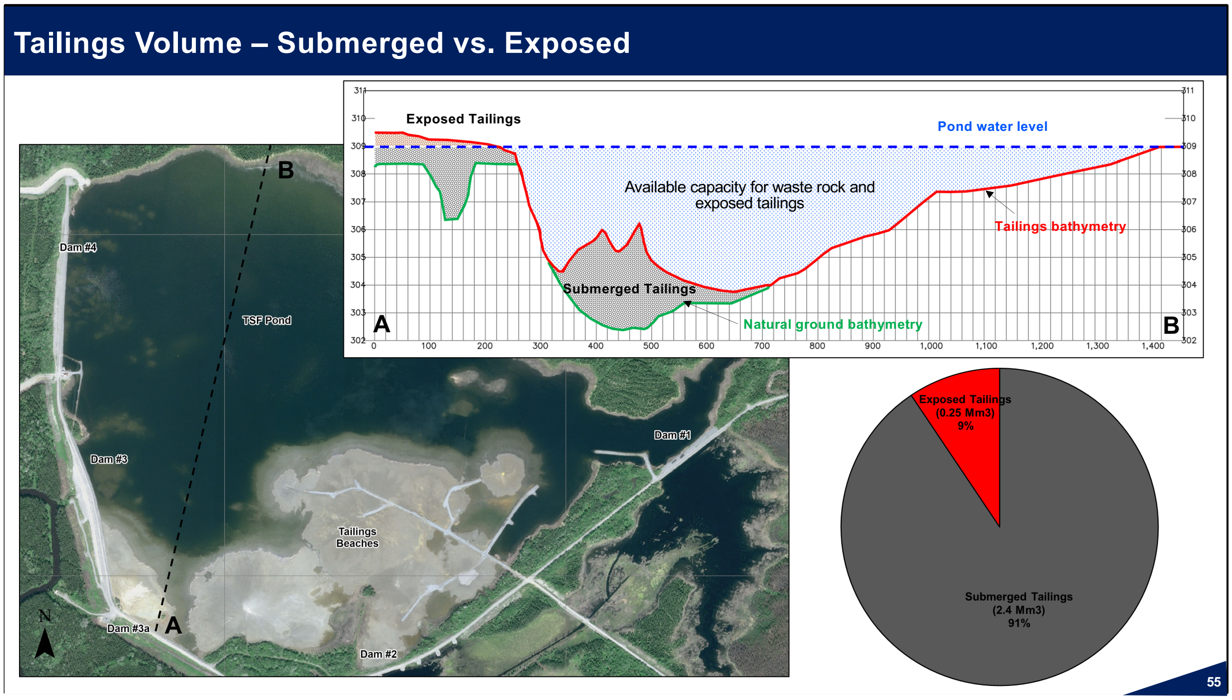
Notes:
* AP is calculated by multiplying the weight percent of sulfide sulfur concentration by a conversion factor of 31.25 to obtain the potential acidity in kg $CaCO_3$ equivalent per ton.
**Calculated based on measured Modified NP.
Red cells denote values below the detection limit.



Another interesting aspect of the porewater analysis results is looking at mobility of trace metals and its dependency on the pH. We know that mobility of trace metals decrease by increasing of pH.

But if we look at concentrations of Fe and Al, we see that it drops significantly at pH above 5 and 6, and for Al and Cu, the mobility drops significantly at pH above 3. **So it means that these trace metals were only mobile at acidic condition which was limited to the top 19 cm at TP24-10 and top 2 cm at TP24-04.**

However, trace metals such as Zn, Mn, Cd, Co, and Ni, become immobile only when pH goes above 7.0, **Therefore, these trace metals stayed mobile almost all the way through TP24-10, for nearly 1 m below surface.**



We estimated the total volume of tailings within TSF, as well as the exposed and submerged portions.

For that, as shown on this cross-section, we compared the tailings bathymetry vs. the natural ground bathymetry, so, the fill volume between these two surfaces gave us roughly 2.6 Mm3 of tailings which compared to the current water level, we found that only about 10% of it is exposed while the rest is underwater.

We also estimated the TSF storage capacity below water level, at about 2.3 Mm3, which has implication for the closure concept and could be used for relocation of waste material.