Technical Memorandum

To: **Northshore Mining Company**
From: Aaron T. Grosser, BC.GE, PE, Sara Leow, PE, Jason Harvey, PE (Barr Engineering Co.)
Subject: Geotechnical Dam Safety Appendix
Date: April 14, 2026

Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Minnesota

Aaron T. Grosser, P.E. 04/14/2026
PE #: 25997 Date

The Minnesota Department of Natural Resources (MDNR) is in the process of redetermining whether the Proposed Project for the Northshore Mining Company (Northshore) Milepost 7 (MP7) Tailings Storage Facility (TSF) triggers an Environmental Impact Statement (EIS). MDNR had previously determined that an EIS was not required for the Project Proposed. However, the Minnesota Court of Appeals has directed MDNR to consider the Ongoing Tailings Basin Operations as a connected action to the Proposed Project for the limited purpose of determining whether an EIS is required. See *In re the Determination of Need for an Environmental Impact Statement for the Mile Post 7 West Ridge Railroad Relocatio*n, 2025 WL 368515 (Minn. Ct. App. Feb. 3, 2025). The entirety of the project, including a combination of the Ongoing Tailings Basin Operations and the Proposed Project, shall be referred to as the Tailings Basin Project. A necessary component of this review is Northshore's resubmission of the Environmental Assessment Worksheet (EAW) with updates to account for the TSF as a connected action. Northshore has retained Barr Engineering Co. (Barr), as qualified Professional Engineers, to assist by providing this Geotechnical Dam Safety Appendix to address dam structure and stability questions raised during prior public comments and in the litigation to offer MDNR the information it may need to consider any cumulative effects of the TSF as a connected action with the Proposed Project. While this added information is not a required section of the EAW, Barr, as the Engineer of Record (EOR), has prepared the following summary of its technical evaluation of the dam structures and stability to facilitate MDNR's analysis of the EAW.

1 Engineering Team Credentials

Barr's engineering team includes the following individuals who are educated and proficient in the design of TSFs and provide their engineering experience and judgment to many other TSFs within Barr's portfolio. A brief resume for each of the engineering team members follows:

Cleveland-Cliffs, Inc. – Tailings Management and Operations Team

Dean Korri, PE – Director: Civil and Tailings Engineering (Responsible Tailings Facility Executive)

- Professional Engineer: Board Licensed in Minnesota, Michigan
- Years of tailings engineering and dam construction experience – 36 years
- Member - Association of State Dam Safety Officials, (ASDSO) *Tailings Committee
- United States Society on Dams, (USSD/ICOLD) *Tailings Dams Committee Member

- Society of Mining Engineers (SME) *Tailings & Mine Waste Committee Member
- Canadian Dam Association, (CDA) *Mining Dams Committee
- BS, Civil Engineering, Michigan Technological University, 1989

Sarah Carlson – Senior Tailings Engineer

- Society of Mining Engineers (SME)
- BS, Civil Engineering, Montana Technological University, 2011
- Years of experience – 13 years

Barr Engineering Co. – Engineering Team

Aaron T. Grosser, PE, BC.GE – Engineering Oversight

- AusIMM Professional Certificate in Tailings Management
- Board Certified, Geotechnical Engineering (BC.GE), Academy of Geo-Professionals
- Member - Association of State Dam Safety Officials
- Years of experience – over 30 years
- Professional Engineer: Iowa, Michigan, Minnesota, North Dakota, Nevada, Wisconsin
- MS, Civil Engineering, Michigan Technological University, 1996 (emphasis: geotechnical engineering)
- BS, Civil Engineering, Michigan Technological University, 1993 (emphasis: geotechnical and structural engineering)

Sara Leow, PE – Lead Design Engineer

- AusIMM Professional Certificate in Tailings Management
- Years of Experience – over 20 years
- Professional Engineer: Minnesota, Ohio, Wisconsin
- MS, Civil Engineering, Michigan Technological University, 2005 (emphasis: geotechnical engineering)
- BS, Civil Engineering, Michigan Technological University, 2003 (emphasis: geotechnical engineering)

Jason Harvey, PE – Sr. Geotechnical Engineer

- United States Society on Dams, Tailings Dams Committee Member

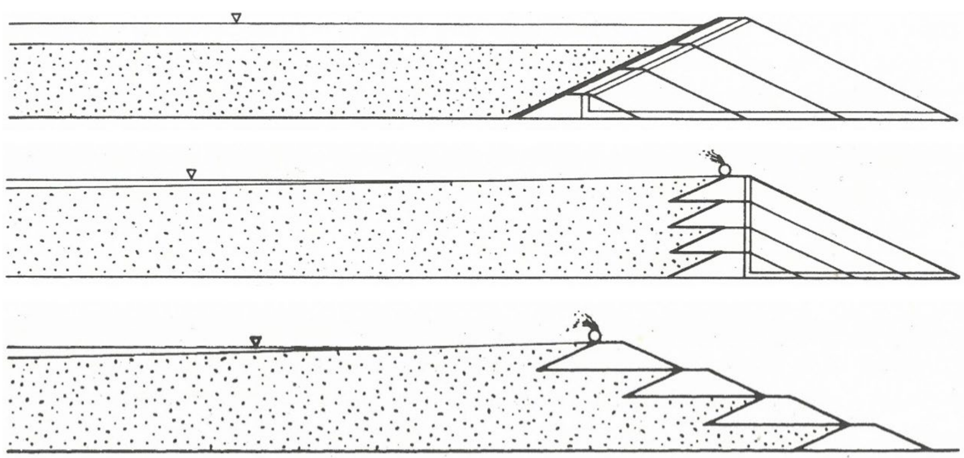
- Years of experience – 13 years
- Professional Engineer: Minnesota
- MS, Civil Engineering, University of Illinois at Urbana-Champaign, 2012 (emphasis: geotechnical engineering)
- BS, Civil Engineering, University of Illinois at Urbana-Champaign, 2011

2 Dam Configuration

Tailings dams have historically been categorized into three general configurations (upstream, centerline, and downstream), and the International Commission on Large Dams (ICOLD) states that selection of dam configurations are often “in response to site-specific conditions and are often modifications of historical designs” (ICOLD, 2023).

- Downstream dam construction involves placement of new fill over the downstream slope of the previous dam raise and native ground, such that the crest moves downstream with each raise.
- Centerline dam construction involves placement of new fill vertically over the previous dam raise, such that the crest remains fixed in the lateral direction with each raise.
- Upstream dam construction involves placement of new fill over the upstream slope of the previous dam raise and tailings beach, such that the crest moves upstream with each raise.

Textbook examples of downstream, centerline, and upstream dam configurations are shown in Figure 1; however, modifications are common in practice, as described in ICOLD (2023).



(Vick, 1990)

Figure 1 Typical Downstream, Centerline, and Upstream Dam Configurations

Upstream tailings basin construction includes dam construction over fine tailings that have been hydraulically placed from a discharge pipe. These hydraulically deposited fine tailings are initially saturated and deposited in a loose, or contractive, state, meaning that they have a lower initial strength than soils/tailings that are placed in lifts and mechanically compacted.

A one-time modified centerline dam configuration was implemented in the 1990s following initial implementation of a closure plan under different TSF ownership and subsequent re-start of plant operations by NSM. This configuration included depositing fine tailings upstream of the Dam 1 and Dam 2 starter dams and placement of coarse aggregate over the fine tailings beach to reduce the size of the TSF footprint, reduce the amount of water stored in the TSF, and reduce the amount of coarse tailings required to construct the perimeter dams.

Dam 1 and Dam 2 at the MP7 TSF use a modified centerline dam configuration that is customized to site-specific conditions. This approach is quite different from conventional upstream dam construction. As shown in Figure 2 and Figure 4, after construction of the starter dams, the dam crest alignments were modified only once to offset the dams partially over existing fine tailings. Since then, centerline dam construction has been used and is proposed to continue, whereby successive dam raises are founded on engineered fill (plant aggregate) of the previous lift, not fine tailings. Furthermore, and in stark contrast, the future progressions of Dam 1 and Dam 2 to the west (Dam 1W and Dam 2W) in the Proposed Project will be entirely founded on native soils and constructed in the conventional centerline manner with each subsequent dam raise placed on engineered fill as shown in Figure 3 and Figure 5. Dam 5 was founded on native soils since its initial construction and will continue to be raised using centerline and downstream construction methods, as shown in Figure 6.

The dam configuration selected does not dictate the safety and stability of the dam. Any of these configurations can be safe and stable with a rigorous approach based in sound engineering and industry standards. The industry has increased attention to proper design and implementation of upstream dam construction, and when performed properly, upstream dam construction can achieve fundamental design requirements and meet applicable factors of safety.[1] Improper utilization of the upstream construction method, when not grounded in sound engineering principles and rigorous methodology, led to high-profile tailings dam failures in recent years in Brazil and other parts of the world.

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[1] *See,* The Society for Mining, Metallurgy, and Exploration (SME) has stated that “no upstream dam has failed that has been rigorously designed using modern engineering principles.” Society for Mining, Metallurgy, and Exploration (2011). *SME Mining Engineering Handbook, Third Edition.* Ed. Darling, P.; ICOLD (2023) adds that, “Despite being less common in some regions, improved design methods and good construction control can result in upstream construction meeting design requirements. Upstream construction can be achieved in a variety of ways, but the fundamental requirements are no different to any other dam or earth structure, providing the factors of safety are achieved.” (ICOLD 2023); and *see also* Martin et al. (2002) states, “Upstream dams are not necessarily inherently unstable or dangerous. They can be as safe as other types of dams provided site conditions are favorable and that the rules for their safe design, construction and operation are followed.”

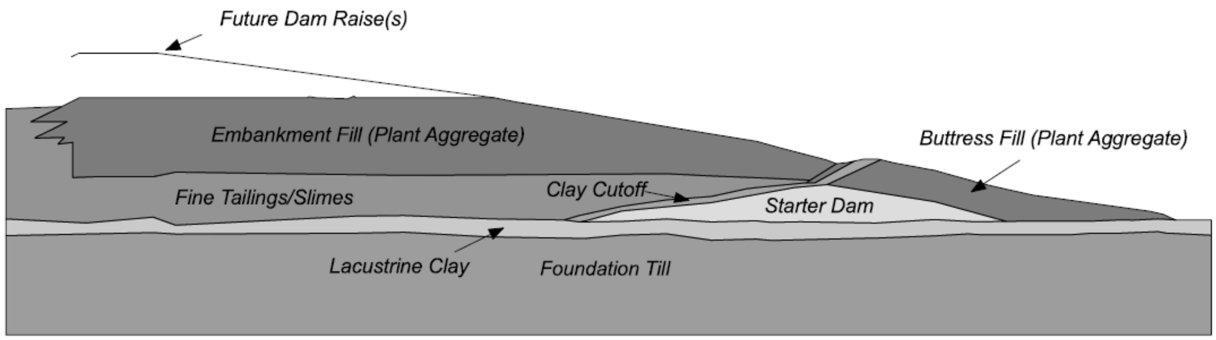


Figure 2 Typical Section of Dam 1

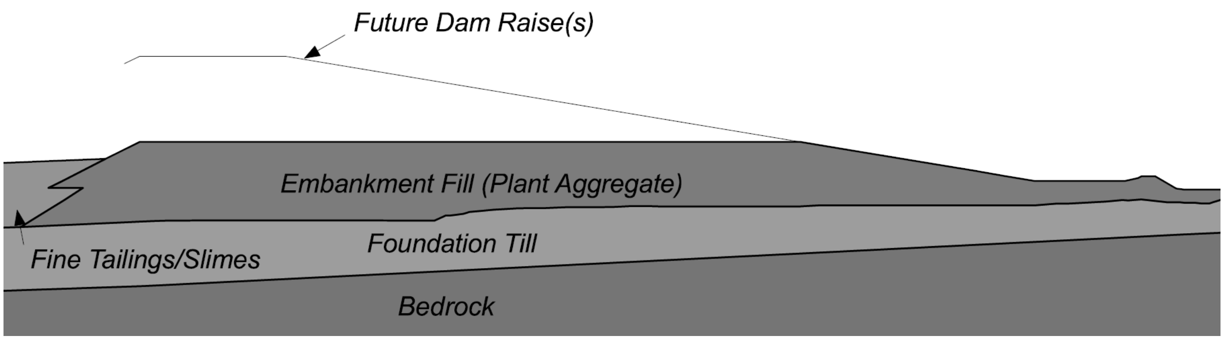


Figure 3 Typical Section of Dam 1 Progression

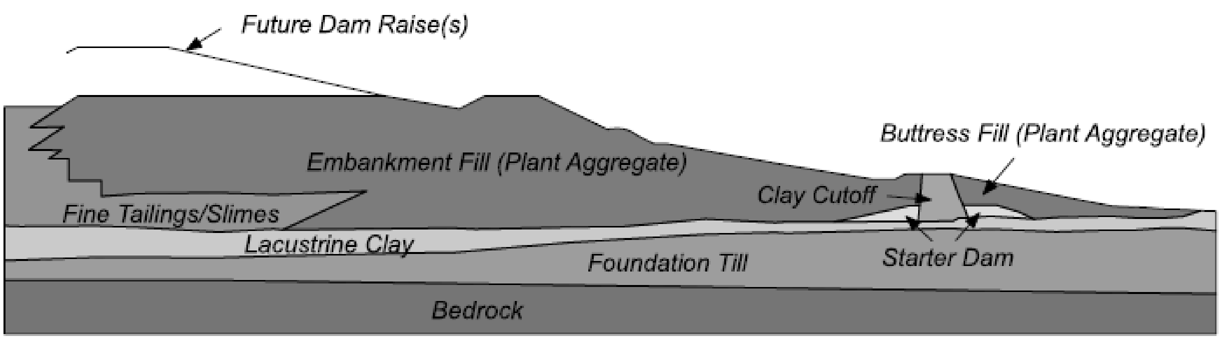


Figure 4 Typical Section of Dam 2

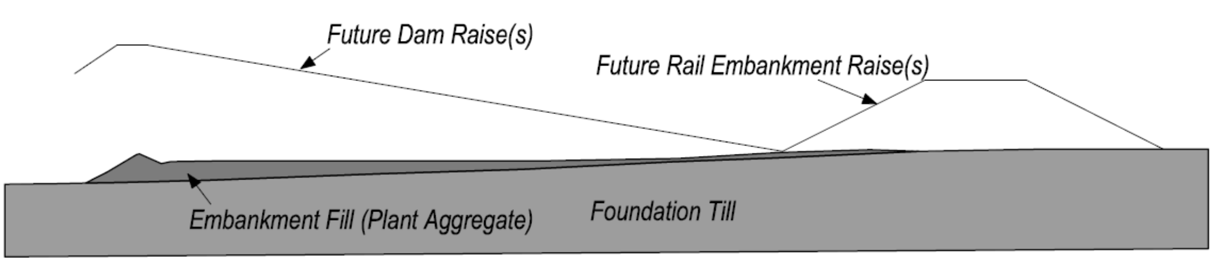


Figure 5 Typical Section of Dam 2 Progression

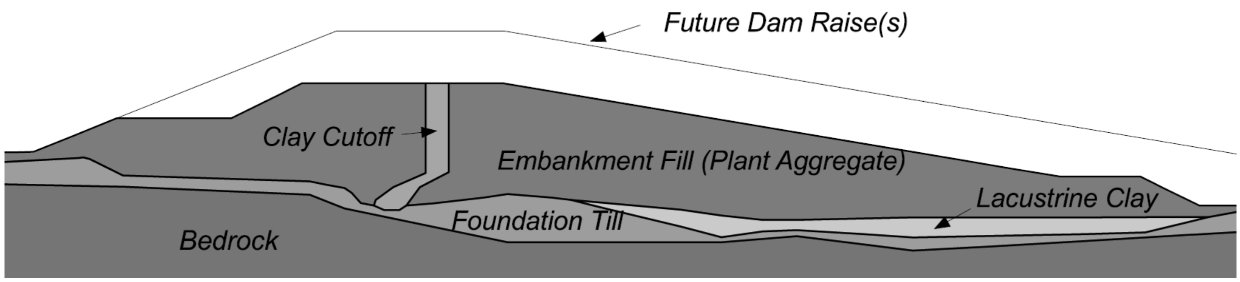


Figure 6 Typical Section of Dam 5

Depending on the site setting and conditions for any TSF, it is "not always practical or possible to eliminate contractive materials, and it is possible to design for these soils with appropriate techniques." ICOLD (2025). Northshore has a site setting and conditions that require but also allow for design techniques to accommodate contractive materials based on Barr's professional engineering judgment. As such, Northshore has accounted for the presence of contractive fine tailings beneath portions of the existing sections of Dam 1 and Dam 2 at the MP7 TSF with the following considerations:

- The robust downstream embankment of dilative (i.e., dense) plant aggregate provides significant resistance and buttressing of the impounded fine tailings, which concurs with recommendations of the International Council on Mining and Metals (ICMM) that such configurations "can be safely constructed, operated and closed provided they are supported at the downstream embankment zone by a dilative and/or unsaturated buttress that can be monitored and that provides adequate resistance if the upstream contents liquefy" (ICMM, 2025). The dams at the MP7 TSF do not have configurations with thin structural shells that ICOLD (2025) warns are "typically more vulnerable to slope failure" and responsible for many tailings dam failures.

- The robust downstream embankment of permeable plant aggregate provides significant drainage, and the elevated upstream tailings beach maintains the upstream pond 200 to 400 feet upstream of the dams, whereby maintaining the phreatic surface low in the embankment away from the downstream slope. Seepage control measures, including a sufficiently wide tailings beach and drainage elements, resulting in a relatively drained downstream shell, are critical aspects emphasized by many peer publications, including Martin et al. (2002) and ICOLD (2023).

- The designs of the dams account for both undrained strength stability analyses (USSA) and effective stress stability analyses (ESSA), including conservatively addressing the hypothetical scenario and underlying assumption that the entire fine tailings deposit will mobilize its undrained shear strength irrespective of the triggering mechanism. Martin et al. (2002) and ICOLD (2023) emphasize the importance of performing slope stability analyses using the undrained shear strength for contractive tailings. Undrained shear strength ratios used for the fine tailings at the MP7 TSF are also within typical value ranges provided in ICOLD (2023).

- The downstream slopes of the starter dams are constructed at relatively shallow 4 horizontal to 1 vertical (4H:1V) slopes and the subsequent raises are constructed at even shallower 6H:1V slopes, which impose lower static shear stresses on the fine tailings and foundation soils and improve overall stability. Martin et al. (2002) and Davies and Lupo (2024) recommended that dams be raised at slopes of 4H:1V or flatter when built over contractive materials.

- The MP7 TSF is located in northeastern Minnesota, which the U.S. Geological Survey identifies as within the lowest category of seismic hazard in the United States, as shown in Figure 7. Martin et al. (2002) explains that "Conventional upstream dams cannot be considered for areas of moderate to high seismicity. Improved upstream construction, involving a combination of compaction of the outer shell and good internal drainage, can be used in such areas."

- Strength conditions evaluated for each raise of the dam, including provisions for consideration of contractive fine tailings, are described in Section 3.3.

In summary, given that the dams at the MP7 TSF are designed, constructed, and operated based on accepted engineering principles guided by industry documents with consideration of the site-specific conditions and materials, the dam configurations employed have no inherent bearing on the safety of the facility, but rather it is the level of engineering that is the most significant factor. The remaining sections of this memorandum provide greater insight to the level of engineering applied to the dams at the MP7 TSF.

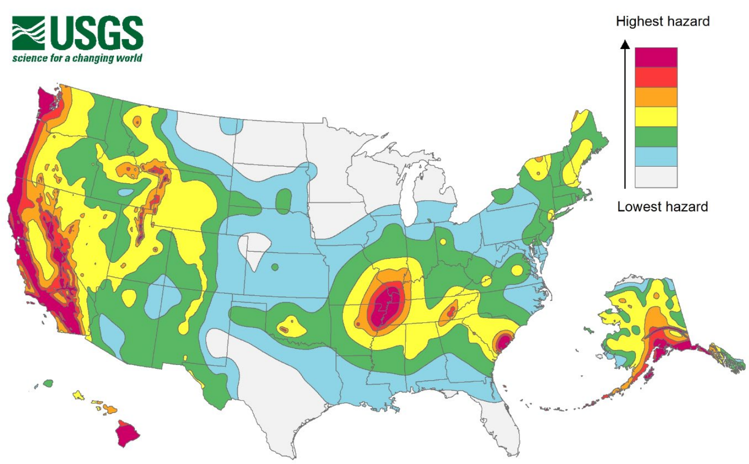


Figure 7 United States Geological Survey Seismic Hazard Map

3 Dam Safety Framework

The dam safety management system at the MP7 TSF utilizes a multi-faceted approach that incorporates understanding of the site conditions based on ongoing, modern methods of investigations, analyses and design, construction oversight, instrumentation monitoring, inspections, emergency action planning, and third-party review. In part, this facilitates utilization of the Observational Method (Peck, 1969), which ICOLD (2025) defines as "a process of verifying design assumptions and using additional data, knowledge and lessons-learned to revise, improve and optimize the design as a facility is constructed and/or operated." Additionally, these activities support a modern risk-based approach to dam safety at the MP7 TSF. ICOLD (2025) describes that, "Risk informed design supports the basic tenant of good engineering where risks are inherently considered in a design based on well-established engineering principles that incorporates all available theoretical and experiential knowledge of dam or TSF failures." In practice, this involves identifying potential (hypothetical) failure modes, evaluating their risks, establishing engineering or operations controls to limit these risks, monitoring measurable indicators, and planning for contingency.

To demonstrate this modern risk-based approach to dam safety at the MP7 TSF, the following sections of this memorandum highlight select potential failure modes or risks that have been identified, evaluated, and addressed through a multi-faceted engineering approach.

3.1 Instrumentation

The MP7 TSF incorporates a robust system of piezometers and inclinometers located at multiple cross sections on Dam 1, 2 and 5. Data from this instrumentation is incorporated into evaluations to inform analyses. Additional instrumentation information is available in the fall monitoring report included in the annual dam inspection report (Barr, 2025a)

3.2 Toe Uplift (Heave) of Confining Foundation Soil Layer

Foundation soil stratigraphy beneath limited portions of dams at the MP7 TSF consists of low-permeability lacustrine clay (i.e., confining layer) overlying relatively more permeable glacial till. Given this geologic condition, the United States Bureau of Reclamation (USBR) identifies that "at the downstream toe of an embankment, if the seepage pressures in the pervious layer are higher than the overburden pressure of the confining layer, uplift of the confining layer may occur" (USBR, 2014).

To evaluate the factor of safety against uplift (FOS_{uplift}) at the toe of dams at the MP7 TSF, Barr uses the *total stress method* explicitly recommended in the current design standards from the USBR (2014), which is the ratio of the downward soil pressure to the upward water pressure defined by the following equation.

$$FOS_{uplift} = \frac{\gamma_t * t}{\gamma_w * h_p}$$ **Equation 1**

Where

γ_t = total unit weight of the confining layer(s)

t = vertical thickness of the confined layer(s)

γ_w = unit weight of water (62.4 pcf)

h_p = pressure head at the base of the confining layer

With respect to both exit gradients (not applicable here) and uplift, the USBR (2014) design standard notes that "if foundation soil properties are well understood and a sufficient piezometer array is available to measure pressures, less uncertainty exists…" Accordingly, at the MP7 TSF, factors of safety against uplift are computed using actual measured water pressures from a series of piezometers along the toe of dams where this geology exists, as exemplified by those shown in the black box along the toe of Dam 1 (Figure 8). Moreover, to mitigate uncertainty from geologic variability, stratigraphic layer thicknesses (t) used in calculations are based on soil sampling at the actual piezometer location during its installation. Finally, extensive density testing data from across the site is used for selection of design unit weights.

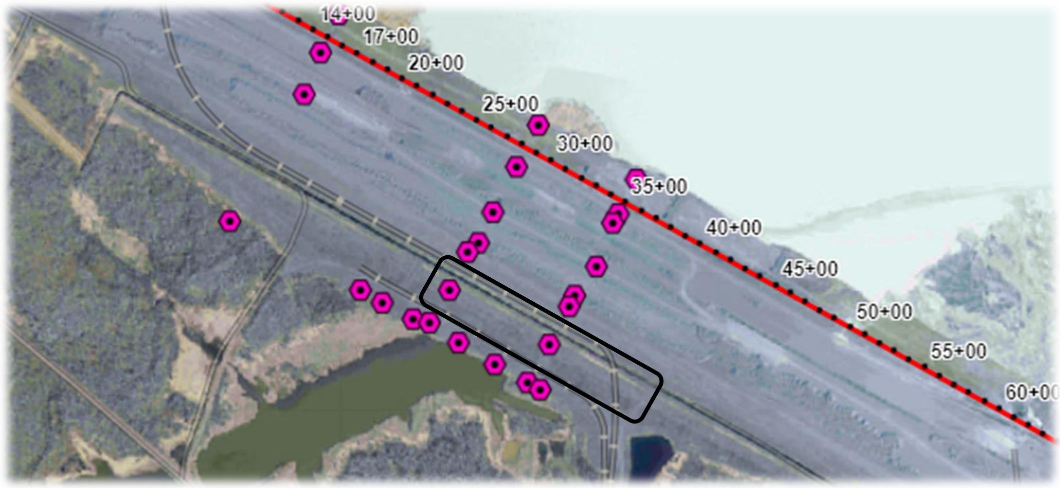


Figure 8 Piezometers Included in Uplift analysis for Dam 1

To reduce uncertainty and better reflect actual conditions, factors of safety against uplift at the MP7 TSF are calculated using piezometer data rather than estimated water pressures from numerical seepage models (e.g., GeoStudio SEEP/W), when available. USBR (2014) generally supports this approach, noting that seepage modeling of natural foundation soils involves significant uncertainty. In practice, the seepage models are often conservatively calibrated to overestimate water pressures (on average) for the primary purpose of exporting the results into slope stability analyses. However, this can lead to artificially low factors of safety against uplift, which explains lower factors of safety against uplift in some previous reporting prior to installation, monitoring, and analysis of additional piezometers. As more piezometer data became available, there was greater certainty and the factors of safety were updated accordingly. Further to this point, new dams generally require higher factors of safety against uplift because the analysis and design must rely solely on numerical seepage models and do not have a history of actual monitoring data, such as exists for MP7 TSF.

USBR (2014) also explains the simplified *total stress method* may discount benefits of various real-world factors and “may underpredict the actual factor of safety against uplift.” For example, the total stress method excludes the contribution of the shear strength of the overlying soil that would counteract at least some of the uplift pressures. Moreover, USBR (2014) strongly notes, “This is **not** a factor of safety against the initiation of internal erosion or the creation of an unfiltered exit. Even if the safety factor is low, or even below unity, there is no guarantee that an internal erosion failure mechanism will initiate or progress.”

Barr (2025b) shows that computed factors of safety against uplift at the toe of Dam 1, Dam 2, and Dam 5 of the MP7 TSF exceed the USBR (2014) recommended minimum of 1.5 for existing dams, with several locations having values of 2.0 or above. Furthermore, long-term monitoring of the existing piezometers at the toe of Dam 1 and Dam 2 generally suggests total heads are not increasing to any appreciable degree in response to upstream pond level raises. This behavior can be attributed to the presence of a mid-slope seepage collection ditch, relief wells and a functioning drain under the dam. As such, the associated minimum computed factors of safety against uplift are not decreasing.

In addition to adequate computed factors of safety against uplift, the toe of the dams at the MP7 TSF are subject to routine inspections by the owner, which are supplemented by an annual comprehensive dam safety inspection and other periodic inspections by the EOR. Water pressures at existing piezometer locations at the toe of the dams are collected multiple times a day by an automated instrumentation monitoring system with trigger alarms. As a contingency measure in the event of observed distress or elevated water pressures, granular filter material has been strategically stockpiled for placement at affected areas to mitigate initiation or progression of an internal erosion failure mechanism.

3.3 Slope Stability of Embankment Dams and their Foundations

Slope stability analyses are a critical element of dam safety for the MP7 TSF to check that the driving forces acting on the dams and their foundations are counteracted by sufficient resisting forces to maintain stability. These forces, referred to as static shear stresses develop within embankment dams and their foundations due to the sloping ground (e.g., downstream slope of embankment dam) and weight of the structure, among other smaller loads and external stresses. Effects of internal basin infrastructure, including the reclaim dam, are also taken into account. If the shear stresses exceed the shear strength of the materials within the embankment dam and/or its foundation, the dam may undergo unsatisfactory slope performance, such as shear failure, surficial sloughing, excessive deformation, and/or static liquefaction (USACE, 2003). The analyses performed for the dams at the MP7 TSF to account for this recognized potential dam safety risk are summarized below.

3.3.1 Analysis Methods

Slope stability analyses of the dams at the MP7 TSF are performed using two-dimensional, limit equilibrium methods (LEM) within the GeoStudio SLOPE/W computer software. USBR (2011) indicates that LEM is the preferred method of stability analysis for earth (and rockfill embankments). ICOLD (2025) states that the evaluation of tailings dams is most often based on LEM analyses, and that “because of its simplicity and generally favorable track record when appropriate input parameters are selected, the [LEM] is suitable for most design cases.” However, LEM analyses may be supplemented with more advanced non-linear deformation analyses (NDA) when more complex representations of shearing and deformation behavior are necessary, but “they are not necessarily superior to the more simplified [LEM] because of the range of uncertainties associated with the material parameters for an NDA model” (ICOLD, 2025). As a result, NDA is recommended when computed factors of safety are less than or near unity (1.0) as discussed in Appendix B of ICOLD (2025). Results of slope stability analyses performed to date using LEM have not indicated a need for NDA of the dams at the MP7 TSF.

3.3.2 Analysis Scenarios

Slope stability analyses of the dams at the MP7 TSF are performed for each of the primary scenarios recommended by USACE (2003), USBR (2011), and ICOLD (2025), which are:

- Normal Operation (i.e., long-term, steady-state pore-water pressures)
- Construction (i.e., short-term, excess pore-water pressures due to loading)
- Maximum Pool (i.e., temporary, elevated pond level due to extreme rainfall event or other)

3.3.2.1 Normal Operation

For evaluation of normal operating conditions, slope stability analyses apply “shear strength properties that reflect the range of loading conditions and behaviors expected” (ICOLD, 2025), meaning that several shear strengths are evaluated for long-term conditions. The fundamental attribute common to each condition is that shear strengths are based on end-of-primary (EOP) consolidation vertical effective stresses.

- Effective stress stability analyses (ESSA) are performed, whereby all materials are assumed to mobilize their peak drained shear strength whether contractive (loose) or dilative (dense). This is the shear strength generally recommended by USACE (2003) and USBR (2011) for this scenario.

- Undrained strength stability analyses (USSA) are performed, whereby all potentially contractive materials are assumed to mobilize their yield undrained shear strength and all dilative materials are assumed to mobilize their peak drained shear strength. Yield undrained shear strengths are applied to the fine tailings, lacustrine clay, and foundation till. USACE (2003) and USBR (2011) generally have not required this shear strength condition to be evaluated for a long-term scenario. However, for tailings dams, ICOLD (2025) acknowledges, "A common misconception is that after a dam is constructed and the excess pore pressures resulting from construction have dissipated, the contractive materials in the dam may be considered "drained" and effective-stress parameters are appropriate for future slope stability analysis. However, if an initiating event results in undrained loading and shearing, then the material can quickly transition from a drained to undrained condition as shear-induced excess pore pressures are generated… and the undrained strengths will control stability." Northshore accounts for this factor as integral in its design at the MP7 TSF.

- Undrained strength stability analyses (USSA) are also performed, whereby all brittle potentially contractive materials are assumed to mobilize their liquefied (post-peak) undrained shear strength, all non-brittle potentially contractive materials are assumed to mobilize their yield undrained shear strength, and all dilative materials are assumed to mobilize their drained shear strength. In this case, liquefied undrained shear strengths are applied to the fine tailings, and yield undrained shear strengths are applied to the lacustrine clay and foundation till per the material characterization (discussed subsequently). This shear strength condition addresses the post-liquefaction slope stability of the dams irrespective of the liquefaction triggering mechanism – static liquefaction, earthquake, railroad, and/or other vibrations. ICOLD (2025) notes that for dams located in low seismicity areas, such as the MP7 TSF, slope stability analyses using liquefied undrained shear strengths "will typically suffice for evaluating earthquake loading, since the residual undrained strength is the same whether 'triggered' by cyclic or monotonic loading."

3.3.2.2 Construction

For evaluation of construction phases, undrained slope stability analyses (USSA) are performed using end-of-construction (EOC) yield undrained shear strengths for the potentially contractive materials, including the fine tailings, lacustrine clay, and foundation till. In this respect, "end-of-construction" does not specifically represent a time in the sequence of construction, but rather a short-term shear strength condition. The slope stability analyses are programmed to mobilize the yield undrained shear strength prior to construction, whereby no excess pore-water pressure dissipation, consolidation, or strength gain has occurred due to assumed instantaneous loading. In actuality, construction occurs slowly over time and material drainage properties are such that excess pore-water pressure dissipation, consolidation, and strength gain occur concurrently and/or within a short time after the end-of-construction. Especially in the fine tailings, instrumentation has shown that excess pore-water pressures, if any, dissipate very quickly (typically less than a day). Thus, this scenario represents short-term conditions with shear strengths likely less than available in the field.

In contrast to the construction scenario, the normal operation scenario described previously represents long-term conditions using yield undrained shear strengths based on end-of-primary (EOP) consolidation vertical effective stresses after excess pore-water pressure dissipation, consolidation, and strength gain occur due to loading from the construction fill placement.

3.3.2.3 Maximum Pool

For evaluation of construction phases and normal operating conditions, slope stability analyses utilize pore-water pressures based on steady-state seepage conditions with the upstream pond at the maximum normal operating pool level, which is 10 feet below the respective dam crest being analyzed. For evaluation of maximum pool conditions during a probable maximum flood (PMF) event, slope stability analyses use pore-water pressures based on steady-state seepage conditions with the upstream pond 3 feet below the respective dam crest. This approach conservatively assumes that higher upstream pond levels are sustained for a long duration, such that higher pore-water pressures develop throughout the model domain. In reality, the flood condition is a transient (i.e., temporary) condition unlikely to increase pore-water pressures or consequently decrease factors of safety to the degree simulated in the models.

3.3.2.4 Other Considerations

A critical assumption incorporated into the slope stability analyses performed for the dams at the MP7 TSF is that all potentially contractive fine tailings materials (a) will be triggered irrespective of scale, duration, and/or combination of mechanisms and (b) will mobilize their yield or liquefied undrained shear strength across the entire model domain, as supported by Silvas and de Groot (1995), Martin et al. (2002), Robertson (2010), and ICOLD (2025) among others. While triggering of all fine tailings at once is highly unlikely to occur at the MP7 TSF, this is the most robust and conservative way to perform the analysis.

Additionally, the effects of internal basin infrastructure have been taken into account in the analyses. The reclaim dam does not pose a credible failure mode and would have no effect on the stability of perimeter dams.

3.3.3 Design Criteria

The result of slope stability analyses for any given condition is a computed factor of safety "defined as the ratio of the total available shear strength of the soil to shear stress required to maintain equilibrium along a potential surface of sliding" (USBR, 2011). A "factor of safety greater than 1.0 indicates… that the slope will be stable with respect to sliding along the assumed particular slip surface analyzed. A value of factor of safety less than 1.0 indicates that the slope will be unstable" (USACE, 2003). Various guidance exists on recommended minimum factors of safety to be used for evaluation of dam safety. Northshore and the EOR monitor established industry standards and resources so that industry supportable factors of safety are employed as applicable across its dams.

The slope stability analyses and design of dams at the MP7 TSF are assessed for dam safety with respect to the minimum factors of safety shown in Table 2, which vary by scenario and shear strength condition being evaluated in the slope stability analyses. The basis for each design minimum factor of safety is discussed in detail below the table.

Table 1 Design Minimum Factors of Safety

Analysis Scenario	Design Minimum FOS	Shear Strength Condition
Construction	1.3	Undrained strength stability analyses (USSA) with yield undrained shear strengths for contractive materials and drained shear strengths for dilative materials based on short-term, end-of-construction (EOC) stresses
Normal Operation & Maximum Pool	1.5	Effective stress stability analyses (ESSA) with drained shear strengths for all materials based on long-term, end-of-primary (EOP) consolidation stresses
Normal Operation & Maximum Pool	1.3	Undrained strength stability analyses (USSA) with yield undrained shear strengths for contractive materials and drained shear strengths for dilative materials based on long-term, end-of-primary (EOP) consolidation stresses
Normal Operation & Maximum Pool	1.1	Undrained strength stability analyses (USSA) with liquefied undrained shear strengths for brittle contractive materials, yield undrained shear strengths for non-brittle contractive materials, and drained shear strengths for dilative materials based on long-term, end-of-primary (EOP) consolidation stresses

3.3.3.1 Normal Operation

For normal operating conditions, a minimum factor of safety of 1.5 is widely recommended by USACE (2003), USBR (2011), and ICOLD (2025) for effective stress stability analyses (ESSA), which is consistent with practice at the MP7 TSF. USACE (2003) and USBR (2011) do not provide a minimum factor of safety recommendation that is applicable to undrained strength stability analyses (USSA) of normal operating conditions. ICOLD (2025) provides a target minimum factor of safety of 1.5 for static conditions, which is intended to be inclusive of undrained strength stability analyses (USSA) with yield undrained shear strengths during normal operations. However, ICOLD (2025) says these values “should be considered as initial targets that may be adjusted” and provides direct guidance on “where adjustments may be made to these targets.” Specifically, for the dams at the MP7 TSF, many of the critical slip surfaces (i.e., those with the lowest computed factors of safety that govern design) extend in large part through the non-brittle lacustrine clay. For non-brittle materials with 20 percent or less post-peak strain softening, ICOLD (2025) states that a “minimum factor of safety of 1.3 may be acceptable so long as the [factor of safety] for the residual undrained strength case is greater than the target minimum.”

For post-liquefaction slope stability analyses during normal operating conditions, a target minimum factor of safety of 1.1 is recommended by ICOLD (2025), which is consistent with practice at the MP7 TSF. Note that there has historically been limited industry guidance on minimum factor of safety for this scenario and strength condition, particularly with respect to static liquefaction of tailings dams, and minimum factors of safety between 1.0 and 1.2 were commonly used in practice depending on the site setting, level of engineering exercised, and confidence in the post-peak shear strength. Only in recent years has industry guidance provided clarified and unified recommendations for a minimum factor of safety of 1.1, and design criteria for the dams at the MP7 TSF have been updated accordingly.

3.3.3.2 Construction

For undrained strength stability analyses (USSA) of construction conditions, and separately from normal operations previously described, a minimum factor of safety of 1.3 is generally recommended by USACE (2003) and USBR (2011). ICOLD provides a more customized site-specific approach, providing a target minimum factor of 1.5 be applied as an initial value (ICOLD, 2025), but qualifying that a minimum factor of safety of 1.3 may be acceptable when the critical slip surface is largely governed by a non-brittle material. Northshore fits squarely into this scenario given the non-brittle lacustrine clay beneath dams at the MP7 TSF. Additionally, the staged construction of the dams at the MP7 TSF occurs slowly relative to the rate of drainage and consolidation of the materials, particularly the fine tailings; thus, the end-of-construction (EOC) yield undrained shear strengths are truly a temporary condition, which is typically allowed a lower factor of safety.

3.3.3.3 Maximum TSF Pool

The extreme maximum TSF pool is considered a water elevation three feet below the crest of the dam and is the result of the probable maximum precipitation over the TSF watershed with steady state seepage. Both USACE (2003) and USBR (2011) allow for lower factors of safety for the maximum pool condition, although lower values have not been adopted for use at the MP7 TSF. ICOLD (2025) does not offer specific guidance on this matter.

3.3.3.4 General Considerations

Finally, ICOLD (2025) states, “Lower [factors of safety] for static conditions can be adopted through comprehensive implementation of the Observational Method… supported by a detailed [geotechnical design model]” and “statistical methods and reliability approaches.” In this regard, the dams at the MP7 TSF undergo rigorous level of engineering generally consistent with Category I (Best) and Category II (Above Average) practices per characteristics outlined by Silva et al. (2008), including but not limited to use of advanced in-situ and laboratory testing, measured data for calculation of factors of safety, construction control testing, instrumentation for performance monitoring, and independent technical review. Silva et al. (2008) was concisely summarized by the Alaska Department of Natural Resources in their guidance that “the level of detail in the engineering work, has a greater influence on the probability of failure than increasing the factor of safety” (ADNR, 2017). Designing to the industry standard minimum factor of safety with a Category I or II level of engineering, as is the case at the MP7 TSF, actually results in an annual probability of failure that is several orders of magnitude lower than a facility designed to the same factor of safety with average (Category III) level of engineering.

3.3.4 Computed Factors of Safety

The computed factors of safety for multiple sections of the dams at the MP7 TSF, as well as details of the model geometry, material parameters, loading conditions, and model scenarios used in the slope stability analyses, are provided in Barr (2025b). Barr (2025b) addresses stability analyses that were performed for Dam 1 configuration with a crest elevation of 1,265 feet at dam stations -17+00, -10+00, 0+00, 28+40, 35+00, and 90+50, Dam 2 configuration with a crest elevation of 1,270 feet at dam stations 34+75, and 42+00, and Dam 5 configuration with a crest elevation of 1,270 at dam station 14+00. All are considered current design conditions.

For the purposes of this memorandum, only the range of computed factors of safety reported in Barr (2025) for each dam and model scenario are summarized in Table 2.

Table 2 Computed Factors of Safety from *Perimeter Dam Stability Evaluations*

Analysis Scenario	Shear Strength Condition	Slip Surface	Dam 1 Normal Pool	Dam 1 Maximum Pool	Dam 2 Normal Pool	Dam 2 Maximum Pool	Dam 5 Normal Pool	Dam 5 Maximum Pool	Design Minimum FOS
Construction	USSA (Yield)	Circular	1.4 to 2.8	N/A	1.7 to 1.9	N/A	1.9	N/A	1.3
Construction	USSA (Yield)	Block	1.3 to 3.9	N/A	1.7 to 1.8	N/A	1.5	N/A	1.3
Normal Operation & Maximum Pool	ESSA (peak)	Circular	2.3 to 5.3	2.2 to 3.7	2.8 to 3.0	2.8 to 3.0	2.6	2.5	1.5
Normal Operation & Maximum Pool	ESSA (peak)	Block	1.9 to 6.0	1.9 to 4.4	2.9 to 3.2	2.9 to 3.3	2.3	2.2	1.5
Normal Operation & Maximum Pool	USSA (Yield)	Circular	1.4 to 4.2	1.4 to 2.9	1.8 to 1.9	2.8 to 1.9	1.7	1.7	1.3
Normal Operation & Maximum Pool	USSA (Yield)	Block	1.4 to 2.5	1.4 to 2.4	1.7 to 1.8	1.7 to 1.8	1.5	1.5	1.3
Normal Operation & Maximum Pool	USSA (Post-Liq)	Circular	1.3 to 4.2	1.3 to 2.9	1.8 to 1.9	1.8 to 1.9	N/A	N/A	1.1
Normal Operation & Maximum Pool	USSA (Post-Liq)	Block	1.3 to 2.3	1.3 to 2.3	1.7 to 1.8	1.7 to 1.8	N/A	N/A	1.1

Source: Barr, 2025b
N/A – not applicable

3.3.4.1 Effective Stress Stability Analyses (ESSA)

For effective stress stability analyses (ESSA) during normal operation and maximum pool conditions, the computed factors of safety for each dam significantly exceed the minimum factor of safety of 1.5 recommended by USACE (2003), USBR (2011), and ICOLD (2025).

3.3.4.2 Yield Undrained Strength Stability Analyses (USSA)

For yield undrained strength stability analyses (USSA) during construction, normal operation, and maximum pool conditions, the computed factors of safety at Dam 1 and Dam 2 exceed the minimum factor of safety of 1.3 recommended by USACE (2003) and USBR (2011) with most analysis sections significantly exceeding this minimum requirement. In fact, most of the analysis sections at Dam 1 and Dam 2 exceed the more general target minimum factor of safety of 1.5 suggested by ICOLD (2025).

Only one of the six analysis sections at Dam 1 had computed factors of safety greater than accepted 1.3 but less than 1.5 for the yield undrained strength stability analyses (USSA). However, the critical slip surfaces with computed factors of safety less than 1.5 were predominantly through the non-brittle lacustrine clay, which as discussed earlier in Section 3.3.3.1 is justification for use of a lower minimum factor of safety of 1.3. Non-critical slip surfaces that were predominantly within potentially brittle fine tailings had computed factors of safety significantly exceeding the more general target minimum factor of safety of 1.5 proposed by ICOLD (2025).

3.3.4.3 Post-Liquefaction Undrained Strength Stability Analyses (USSA)

For post-liquefaction undrained strength stability analyses (USSA) during normal operation and maximum pool conditions, the computed factors of safety for Dam 1 and Dam 2 significantly exceed the minimum factor of safety of 1.1 recommended by ICOLD (2025). No materials susceptible to liquefaction exist within Dam 5 or its foundation, thus no slope stability analyses for this scenario were performed for this dam.

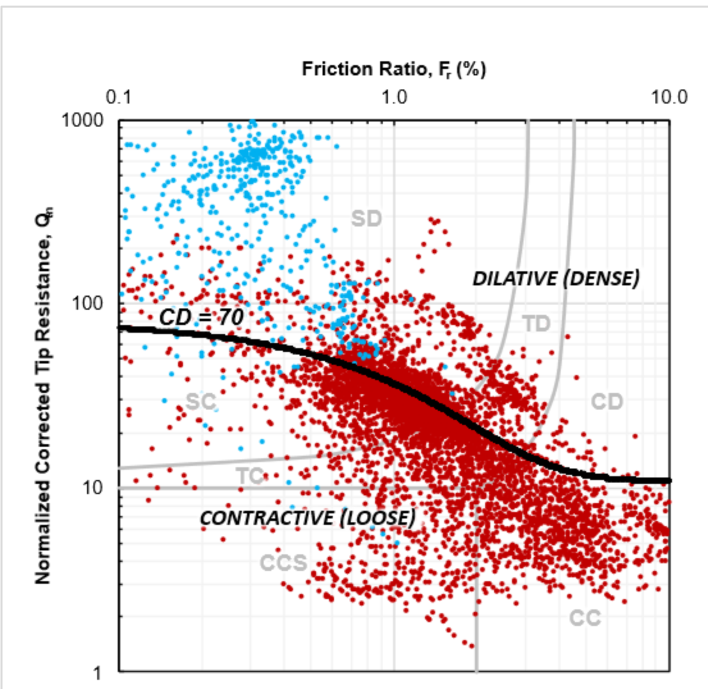
3.4 Material Characterization for Slope Stability Analyses

As part of ongoing design, construction, and operation of the MP7 TSF, dam performance assessments are conducted to evaluate the material characterization, engineering parameters, and expected behavior of the various materials within the dams and their foundations. The material characterization assessments are supported by extensive in-situ and laboratory testing, instrumentation monitoring, data processing and analyses, and engineering interpretation of the data. As alluded to previously, ICOLD (2025) emphasizes that the execution of slope stability analyses and selection of design minimum factors of safety should include “recognition of whether the soils will be contractive or dilative during shearing, if the soils could be brittle or ductile, and other considerations.” These aspects of the material characterization will be briefly reviewed subsequently for the plant aggregate, fine tailings, and lacustrine clay at the MP7 TSF.

3.4.1 Background

Detailed discussion of the complex soil mechanics that govern undrained versus drained conditions, contractive versus dilative behavior, strain-hardening versus strain-softening at large strains, and brittle versus ductile responses are beyond the scope of this memorandum; however, these topics are covered at length in ICOLD (2025). In short, ICOLD (2025) explains that a “soil experiencing reduction of volume (i.e., changing from loose to dense) during shearing is referred to as being contractive, and a soil that experiences increase in volume during shearing is referred to as being dilative.” If subjected to undrained loading, contractive soils tend to mobilize their undrained shear strength, which is typically less than their drained shear strength, and exhibit either gradual or rapid strain-softening (i.e., brittleness) after reaching an initial peak shear resistance. If this post-peak shear strength loss occurs rapidly, it is often referred to as static liquefaction. Conversely, dilative soils tend to be governed by drained shear strengths, exhibit strain-hardening responses, and not be susceptible to liquefaction.

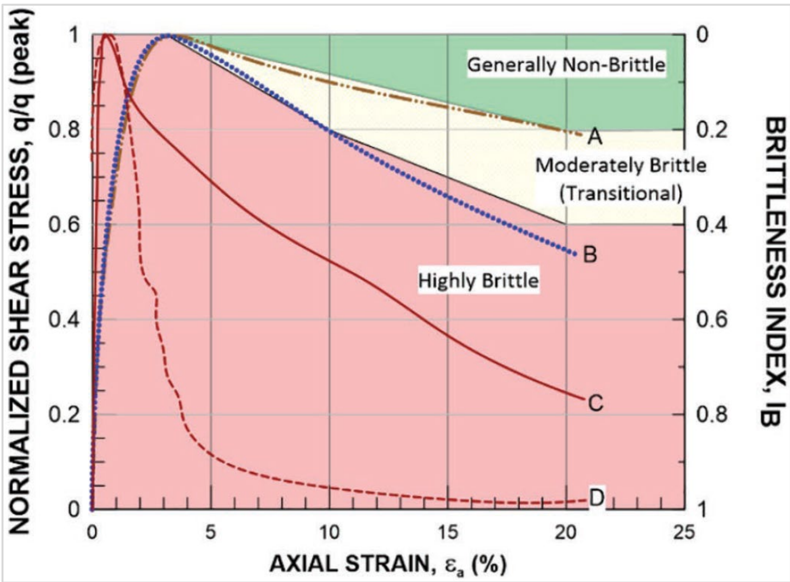
Determining whether materials are contractive or dilative "is dependent on the actual void ratio occurring in the field setting, which must be based on a measurement of the soil conditions *in situ*… The CPTu currently provides the most practical means to infer the in situ state of many soils, especially tailings" (ICOLD, 2025). Based on case histories of actual failures, Robertson (2016) developed an updated soil behavior type (SBTn) chart that with CPT "can be used to reliably identify contractive soils" and "forms a basis for identifying whether the materials will behave in a contractive or dilative manner and whether the potential for strain-softening and/or brittle behavior is indicated" (ICOLD, 2025). Figure 9 illustrates the Robertson (2016) SBTn chart, whereby data above the contractive-dilative boundary (solid black line labelled as CD = 70) are likely dilative and those below are likely contractive. Robertson (2016) also acknowledges that case histories suggest that the CD = 70 boundary is slightly conservative.



Source: Robertson (2016)
Plant Aggregate Shown in Blue & Fine Tailings Shown in Red

Figure 9 SBTn Chart Annotated with CPT Data from MP7 TSF

Because it is possible for contractive soils to strain-soften during undrained shearing, ICOLD (2025) states that "caution is needed if the contractive soils have the potential to fail in a brittle manner" while acknowledging that "not all contractive soils are strain-softening and not all soils that are strain-softening have high brittleness" (Robertson, 2017). Brittleness is a measure of a soil's tendency to suddenly lose strength after relatively little strain, and high brittleness is associated with static liquefaction. In addition to consideration of insitu- testing (e.g., CPT), case histories, and professional judgement, ICOLD (2025) proposed the chart shown in Figure 10 for assessment of brittleness based on laboratory testing, whereby highly brittle materials exhibit more than 40 percent strength loss within 20 percent strain and non-brittle materials exhibit less than 20 percent strength loss. Note that Figure 10 depicts the proposed brittleness criteria chart with example case history data (labeled as lines A, B, C, and D) from other sites that are not the MP7 TSF.



Source: ICOLD, 2025

Figure 10 Brittleness Criteria Based on Laboratory Testing Data

3.4.2 Plant Aggregate

Plant aggregate is the site-specific name for non-plastic, sandy gravel tailings that are much coarser and have fewer fines than “coarse tailings” as defined by industry guidance (ICOLD, 2023) and thus offer better drainage and strength characteristics. Plant aggregate is used for dam construction at the MP7 TSF and is considered engineered fill with specified construction control requirements, including that lifts be placed and compacted to a specified density. Construction materials testing by independent technicians has demonstrated that in-place compacted plant aggregate sufficiently exceeds 95 percent of the maximum standard Proctor density, as required. Kramer (1996) states, “Liquefaction susceptibility depends strongly on the initial state of the soil” and that well-compacted fill is unlikely to be susceptible to liquefaction, as in the case for the plant aggregate used for dam construction at the MP7 TSF. ICOLD (2025) concurs with this by explicitly stating that compaction is a design measure to achieve dilative behavior.

Geotechnical investigations conducted at the MP7 TSF provide strong evidence of the density of the plant aggregate within the dams. First, common borehole drilling methods (e.g., hollow-stem auger and rotary tri-cone bit drilling) frequently refuse due to the density of the plant aggregate. Secondly, cone penetration testing (CPT) data of the plant aggregate plots well-above the contractive-dilative boundary, as shown in Figure 10, demonstrating actual measurements that the in-situ material is strongly dilative (i.e., very dense) and not susceptible to liquefaction.

Additionally, instrumentation monitoring shows that large portions of the plant aggregate are unsaturated due to the relatively low phreatic surface within the dams. It is widely understood that sufficient saturation (greater than 70 to 85 percent) of the material is a prerequisite for undrained shearing and/or liquefaction to occur, regardless of whether it is contractive or dilative. Therefore, much of the plant aggregate is not susceptible to undrained shearing and/or liquefaction simply because it is unsaturated.

While also a resource, Northshore does not rely solely on rudimentary guidance (*i.e.,* methods such as particle-size distribution/gradation, which is an example of a Category III analysis discussed in Section 2.3.3.4 and not used at this facility) as basis for its analysis of susceptibility to liquefaction. This because sources such as Fell et al. (2015) directly state that "it should be recognized that particle size distribution alone is not able to identify soils which are susceptible to liquefaction." This is reiterated by Kramer (1996), and the fact that ICOLD (2025) stresses the importance of the insitu state with little to no discussion of the gradational composition of materials.

For these reasons, the plant aggregate is considered dilative (i.e., dense) and analyses incorporate drained shear strength parameters of the plant aggregate for slope stability evaluation of the dams at the MP7 TSF.

3.4.3 Fine Tailings

Fine tailings refers to non-plastic to low plasticity, sandy silt tailings that are hydraulically discharged and stored upstream of the dams at the MP7 TSF. Only a small portion of the tailings discharged into the TSF are considered "ultra fine tailings" as defined by industry guidance (ICOLD, 2023), and those that do exist are generally within the interior of the MP7 TSF far upstream of the perimeter dams. With the exception of the near-surface upstream beach deposits, the fine tailings are generally assumed to be fully saturated due to the location and elevation of the fine tailings below the pond surface.

As shown in Figure 9, actual measurements from CPT soundings demonstrate that the in-situ fine tailings are somewhat heterogeneous varying from sand-like to clay-like behavior. Most of the data points are below the contractive-dilative boundary indicating that those materials are likely to behave in a contractive manner, which is typical for hydraulically deposited tailings as noted by ICOLD (2025). However, Figure 9 illustrates that the highest density of fine tailings data points is near the contractive-dilative boundary with some data points above the contractive-dilative boundary. This suggests that there are a significant portion of the fine tailings that are only marginally contractive or in some cases marginally dilative.

Nevertheless, slope stability analyses of the dams at the MP7 TSF conservatively assume that the entire fine tailings deposit is contractive and susceptible to liquefaction with brittle strain-softening while knowing this is not fully the case. Consistent with ICOLD (2025) recommendations, yield and liquefied undrained shear strengths are applied for their respective slope stability analyses scenarios. Further, the selected yield and liquefied undrained shear strengths are based on the weighted combination of in-situ testing (e.g., CPT, FVT) and laboratory testing (e.g., triaxial compression, direct simple shear), including approaches discussed in ICOLD (2025).

3.4.4 Lacustrine Clay

Lacustrine clay refers to a medium to high plasticity, native clay that exists within the foundation beneath portions of some of the dams at the MP7 TSF. The lacustrine clay is overconsolidated due to past glacial loading and unloading. As explained in ICOLD (2025), as the dam is raised over time and effective stress acting on the clay increases, the overconsolidation ratio (OCR) and undrained shear strength ratio (USSR) will decrease. With enough loading, the clay may become normally consolidated under parts of the dam. These effects have been investigated at the MP7 TSF through extensive laboratory testing on lacustrine clay using the SHANSEP method (Ladd and Foott, 1974) recommended by ICOLD (2025).

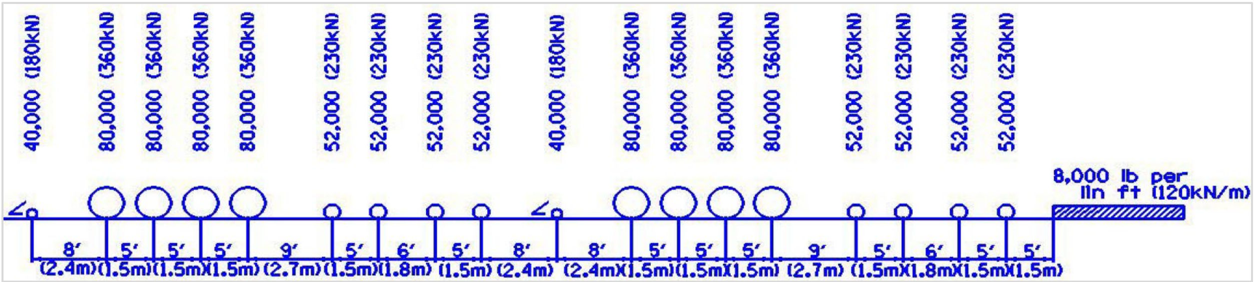
From that, the yield undrained shear strengths used for the lacustrine clay in the slope stability analyses account for the variable overconsolidation ratio (OCR) beneath the dam and possible transition to normal consolidation.

Additionally, a combined total of nearly a hundred triaxial compression and direct simple shear tests performed on lacustrine clay specimens from the MP7 TSF were evaluated to assess their brittleness with respect to the ICOLD (2025) criteria shown in Figure 10. The findings suggest that the lacustrine clay was largely nonbrittle (i.e., less than 20 percent strain softening) with only a few specimens being moderately brittle (i.e., between 20 and 40 percent strain softening) when vertical effective stresses are such that the lacustrine clay is overconsolidated (OCR > 1.5). Only when vertical effective stresses were high enough that the lacustrine clay became normally consolidated did some of the specimens exhibit highly brittle behavior (i.e., greater than 40 percent strain softening). Given that lacustrine clay may only be subjected to insitu vertical effective stresses high enough to result in normally consolidated conditions beneath the far upstream portions of the dams and that critical slip surfaces from slope stability analyses largely pass through the lacustrine clay beneath the downstream slopes and starter dam where it is over consolidated, it is justified to treat the lacustrine clay as non-brittle for the purposes of the slope stability analyses.

3.5 Railroad Loading

Plant aggregate has been transported from the plant to the MP7 TSF by rail for nearly fifty years, and rail operations provide an effective solution for delivery to the perimeter dams for later unloading and placement as part of the dam construction sequence. Rail operations allow for the plant aggregate to be transported in a relatively dry state supporting mechanical dam construction practices, including uniform fill placement, controlled compaction, and systematic construction oversight, resulting in a more predictable engineered fill and enhanced overall dam safety. For example, the quality control achievable through mechanical dam construction and rail operations directly mitigates factors contributing to liquefaction potential of the plant aggregate. Compared to conventional haul truck delivery of tailings, rail operations at the MP7 TSF also offer secondary benefits, including reduced environmental impacts (e.g., improved dust control, lower carbon emissions) and operational safety (e.g., reduced collision risk, less human exposure to hazards).

With that said, USACE (2003) guidelines indicate, “All external loads imposed on the slope or ground surface should be represented in slope stability analyses.” Accordingly, a surcharge load representative of the railroad loading is applied for all slope stability analysis scenarios at the MP7 TSF, even though the railroad loading is temporary and intermittent. The slope stability analyses reported in Barr (2025b) applied an infinite strip surcharge load of 1,300 psf over an 8.5-foot wide railroad tie based on the distributed total weight of the Cooper E-80 loading configuration (Figure 11), which is a standard live load used for railroad design in the United States (AREMA, 2025). For the purpose of global slope stability analyses using LEM, the distributed total weight is more applicable given the stress redistribution expected at the depth of the potential slip surfaces. Nevertheless, sensitivity analyses not reported in Barr (2025b) were performed with an infinite strip surcharge load of 2,800 psf over an 8.5-foot wide railroad tie to verify that the computed factor of safety did not change any appreciable amount ($\Delta FOS \leq 0.01$). This higher surcharge load very conservatively assumes that the single heaviest axle load of the locomotive per Cooper E-80 loading with additional load factor for dynamic/impact effects are present infinitely along the dam. Finally, the 1,300 psf surcharge load is more consistent with the actual loading of the EMD SD40 locomotives used at the MP7 TSF (compared to the heavier Cooper E-80 loading), and guidelines indicate that live loads may be reduced by the Engineer for branch lines or when using lighter equipment (AREMA, 2025).



Source: AREMA, 2025

Figure 11 Cooper E-80 Axle Load Diagram

For further context, given the thickness of existing plant aggregate and other fill overlying compressible materials, only 5 to 10 percent of the surcharge load would be transferred to the compressible materials based on Boussinesq's solution for stress redistribution beneath an infinite strip load. Therefore, there is expected to be minimal effect on the consolidation (i.e., settlement) or shear strength response of the compressible materials as a result of railroad loading.

Many engineering and operational controls have been established for rail operations at the MP7 TSF that are related to track and infrastructure design, maintenance, and inspection; equipment operating protocol; safety; and other areas that are beyond the scope of dam safety. However, operational controls imposed at the MP7 TSF like reduced speed limits (10 miles per hour or less) on the dams have beneficial effects on dam safety, specifically substantially reducing dynamic and impact loads such that their effects are not much greater than those imposed by static loads. Further, soil provides a significant damping effect that attenuates vibrations and mitigates dynamic and impact loads (AREMA, 2025).

In summary, Northshore's stability analysis appropriately accounts for the utilization of the railroad and its minimal additional load on the dams.

4 Closure

The dam stability analysis includes both operating conditions and future closure conditions. Northshore has operated the MP7 TSF consistent with the major overarching themes of the 1988 Closure Consensus Plan. Relevant changes to future closure planning concepts, criteria, and additional goals have been implemented in response to the restart of operations, operational improvements, insight gained from studies, opportunities to mitigate risk, and optimization of long-term environmental and financial outcomes.

The TSF closure procedures since 2004 have been included in the TSF Five-Year Operations Plans (5YOP). With the introduction of significant changes to the operations and construction of the tailings basin, the 2004-2008 5YOP included a closure approach consistent with the spirit of the superseded CCP. Aspects of the closure plan addressed in the CCP were maintenance or assurance of dam stability, provisions for flood storage, treatment of water for release until direct release is authorized, ongoing dust control, revegetation of reclaimed surfaces, and long-term erosion control. These closure procedures have been carried through each subsequent 5YOP.

Northshore has additionally made significant progress to limit the risks and liabilities associated with future basin closure by integrating the following items:

- Maintenance and Safety of the Tailings Disposal System, including Adequate Monitoring System
- Disposal and Treatment of Ponded and Channeled Waters
- Monitoring and Mitigation of Surface and Groundwater Pollution
- Sedimentation and Erosion Control
- Vegetation and Landscaping

The current closure framework encompasses these objectives with details updated as noted to reflect existing conditions and information.

5 Summary

In closing, Northshore and its EOR team, consisting of licensed professional engineers, hold the safety of the public paramount along with the environment in their industrious efforts to properly analyze and design safe dams. This greater team of subject matter experts has conducted and continues to conduct extensive geotechnical investigations, laboratory and in-situ testing, data interpretation and analysis of geotechnical conditions. Furthermore, they have performed significant analyses including seepage and stability that account for the actual materials and geotechnical conditions on the site to demonstrate that the dams supporting this TSF meet the published guidelines for safety and stability. As the Engineer of Record, Barr has worked with Northshore to establish an advanced instrumentation monitoring network to provide the data required to sustain Category I and Category II level engineering for dam safety and stability at MP7 throughout its operating life and its ultimate closure.

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