Five-Year Operations Plan
Years 2019-2023

Milepost 7 Tailings Basin

Prepared for
Northshore Mining Company
Silver Bay, Minnesota

January 2019

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

Five-Year Operations Plan
Years 2019-2023
Milepost 7 Tailings Basin

January 2019

Contents

List of Tables

List of Figures

List of Appendices

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.

January 4, 2019

Aaron T. Grosser, P.E.
PE #: 25997

Date

1.0 Introduction

1.1 Introduction

Northshore Mining Company (Northshore) operates a tailings storage facility west of Silver Bay, Minnesota, where it transports fine tailings and plant aggregate/filter tailings from its processing plant for long-term storage. This Northshore Mining Company Milepost 7 Tailings Basin Five-Year Operations Plan, Years 2019-2023 includes a discussion of relevant information, recent construction activities, and then describes the tailings storage facility operations for the Basin. The design and engineering and basin closure sections of this Plan address the design of the basin through the life of operations.

1.2 Background

The previous five-year operations plan for Northshore's Milepost 7 tailings storage facility was presented in a document entitled "Northshore Mining Company, Milepost 7 Tailings Basin, Five-Year Operations Plan Years 2014-2018, by Barr Engineering Co. (Barr). For the 2019-2023 Operations Plan (Operations Plan), Northshore Mining Company also requested Barr assist with preparing the plan. The Design and Engineering section and Appendices of this plan present the details of the construction plans, dam safety, instrumentation, dam stability, and site control. The operations and deposition of tailings continue to follow the direction established in the 2004 operations plan.

1.3 Summary

Northshore's Operations Plan is a five-year plan for 2019-2023 It is a continuation of the overall plan for operations through the life of the facility as presented in the previous five-year operations plan. The implementation process of this Operations Plan is provided in the Summary section at the end of this report which presents the action items required for 2018-2023. Northshore is providing this Operations Plan to the Agencies for approval so that the operational objectives of the tailings storage facility can continue.

2.0 Recent Accomplishments

- Development of the West Ridge Railroad project
- Evaluate East Ridge Railroad concept
- Long- and short-range basin planning
- Bear Lake Outlet construction
- Review of impacts to landfill from future basin construction
- Dam 1W design and investigations
- Dam 1E investigation
- Dam 1E seepage cutoff
- Dam 1 and 2 relief well study
- Reclaim dam raises and weir relocation
- Dam instrumentation and monitoring upgrades
- NSM tailings deposition tests
- NSM-termed "super cell beach" concept development
- Seepage Recovery Dam investigations and studies
- Alternative seepage cutoff studies for Dam 5

Consistent with ongoing operations and long range goals developed over the last 15 years of engineering and construction, significant projects have been completed at the tailings basin to maintain a safe, stable storage facility. Dams 1, 2, and 5 have been raised using plant aggregate and filter sand, to meet dam freeboard requirements. Fine tailings have been nearly continuously discharged into the basin on the beaches upstream of the dams and splitter dike to seal the bottom of the pond. The seepage collection ditches on Dams 1 and 2 just upstream of the glacial till cutoff continue to collect and route seepage around the glacial till cutoff and to the toe of the dam where ponds are located to store the seepage water. The seepage collection ditch flow is monitored by weirs located at each end of the ditches. These features are shown on Figure 1.

Dams 1 and 2 have been raised using the offset upstream construction method to minimum elevations of 1,241 feet and 1,243.9 feet, respectively.

The current minimum elevation of Dam 5 is 1,235 feet, although the dam is currently under construction to be raised to a crest elevation of 1,245 feet. The dam construction method was originally by the downstream method using a downstream sloping glacial till cutoff. In 2004, the dam construction method was changed to the centerline method and the cutoff was changed to a wider vertical glacial till cutoff in 2005. In 2010, unsuitable foundation soils (organic soils and very soft clays) were removed from the ultimate plan foundation area at Dam 5. The soils were replaced with filter sands over the exposed lacustrine clays and glacial till. A plant aggregate layer was placed over the top of the filter to protect the filter until the remained of the dam is constructed and increase resistance to potential uplift that could occur.

The Reclaim Dam was raised to elevation 1,235 feet and a new weir with a chemical addition structure constructed on the north end of the dam near Dam 5. The location increases the detention time for the

water passing over the weir and flowing to the reclaim pumphouse allowing flocculation and settling of fine particles before the water is pumped back to the plant or the water treatment plant (WTP). An additional benefit may be seen as well in regard to minimized resuspension of tailings in the main pond because the fetch is greatly reduced in this area from the prevailing wind direction. The Reclaim Dam slopes were flattened and the crest was widened for vehicle traffic and raised to provide suitable freeboard to preclude overtopping due to waves and a normal frequency storm event. A new silt curtain was installed in 2014 downstream of the weir discharge pipes to further promote sedimentation of fines and improve water clarity and has been functioning well.

Construction at the WTP has not occurred since it was upgraded in 2007 and its design flow capacity was reached in 2008. Overall the operation of the plant has been successful and benefits have been seen from the increased flow through the plant. Northshore has been able to control pond water better through these improvements. To further improve on the water treatment capabilities of the plant, a pipeline has been constructed from Seepage Collection Pond 1A to the water treatment plant to supply water with less turbidity to the plant. This improvement has reduced the downtime at the WTP thus improving capacity.

Railroad grades were raised on Dams 1, 2, and 5 in the last 5 years to facilitate transporting plant aggregate and filter materials to each of the dams for construction. The splitter dike has been extended entirely across the basin. It was also extended to the north and south on the west side of the basin to allow for tailings deposition into the deeper portions of the pond. This work has largely been completed with the majority of the deeper portions of the basin filled with tailings and has been documented by bathymetry. Because of this method of deposition the amount of water stored within the basin has decreased over time.

An Emergency Action Plan (EAP) including dam break analyses had been completed previously and is in the process of being updated and includes many of the changes that have occurred at the basin since the original development of the plan. The updated plan will be completed in late 2018 or early 2019 as part of Northshore's ongoing commitment to safe operation of the tailings basin. Northshore will be submitting the updated EAP to the Minnesota Department of Natural Resources.

Supplemental information supporting this document is also found in the following reports:

- Stability Evaluation of Dams 1, 2, and 5, Milepost 7 Tailings Basin, Northshore Mining Company, Silver Bay, Minnesota, 2009 (identified as Barr, 2009)
- Dam 1 Stability Evaluation, Dam Crest Elevation 1,245 feet, Northshore Mining Company, Silver Bay, Minnesota, June 2013 (identified as Barr, 2013)
- Reclaim Dam Stability Analysis, October 9, 2015 (identified as Barr 2015)
- Dam 2 Stability Evaluation – Dam Elevation 1,248 feet, Northshore Mining Company, Silver Bay, MN, June 2016 (identified as Barr, 2016)

- Dam 5 Raise to Elevation 1,245 feet – Alternate Configuration Revised Analysis, June 19, 2018 (identified as Barr, 2018a)
- 2019-2023 Water Balance Report, Milepost 7 Tailings Basin, Northshore Mining Company, Silver Bay, Minnesota, 2018 (Barr Engineering Co.) (identified as Barr, 2018b)

3.0 Relevant Information

3.1 Introduction

This section presents information on the current status of the tailings storage facility and anticipated future production levels that are relevant for this Operations Plan.

3.2 Current Status

- Figure 1 shows the general arrangement of the basin in 2018.
- The pond levels in the main pond and reclaim pond were about elevation 1,221.5 and 1,205.7 feet, respectively as of November 3, 2018.
- The pond free water volume of both basin cells, based on the results of a bathymetric survey performed in June 2018 was approximately 13,262 acre-feet. The free water volume of the reclaim pond based on the results of the bathymetric survey was approximately 2,136 acre-feet.
- Fine tailings are being discharged from Dams 1 and 2 to maintain the beaches as needed and seal the bottom of the pond. The tailings are also being discharged along the Splitter Dike and west side of the basin to more uniformly fill the deeper portions of the basin and provide a seal over the existing natural soils.
- The crests of Dams 1 and 2, as defined by the minimum elevation of the filter berms where fine tailings are discharged, have been completed to a minimum elevation of 1,241 feet on Dam 1 and 1,243.9 feet on Dam 2 as of June 2018.
- The Dam 5 minimum crest elevation was 1,235 feet as of October 2018. It has been constructed using a compacted glacial till cutoff and centerline construction methods with a 6H:1V downstream slope. In 2018, lean to fat clay will be used as a cutoff material due to the lack of glacial till that meets the previously defined specification for the seepage cutoff material. Dam stability analyses, construction plans, and specifications have been developed for Dam 5 which will be completed to elevation 1,245 feet in 2018 by Northshore's own crews.
- Since 2003, Dams 1, 2, and 5 were constructed as shown in the latest dam raise construction drawings attached in Appendix A. No significant changes to dam construction have been made.
- Dam 5 seepage collection pond is maintained below the outlet of Bear Lake allowing drainage from Bear Lake to enter the seepage collection pond. The resulting Dam 5 seepage and Bear Lake runoff is pumped to the Reclaim Pond by submersible pump and pipeline. In 2019, the Bear Lake Outlet will be completed and water flow into the Dam 5 pond will cease. A screen berm will be constructed and all flow from Bear Lake will be directed through the Bear Lake outlet to the Beaver River.

- The latest instrumentation readings and 2018 dam safety inspection have been completed and the details are included in Appendix B. The dam performance was found to be acceptable for continued operation.

- The fine tailings handling system (including clarifier and pipelines) from the beneficiation plant to the basin is acceptable as reported by Northshore for continued operation as reported in the previous operations plan. The verification program includes fine tailings pipeline testing, a maintenance and replacement plan, and semiannual tailings pipeline inspection report.

- The Reclaim Dam was raised and flatter slopes constructed along portions of the alignment to stabilize the interior dam. The previous weir structure was abandoned in place and a new weir constructed. The dam crest elevation was 1,235 feet as of June 2018.

- Instrumentation was updated on Dam 1, Dam 2, Dam 5, and Reclaim in 2016, 2017, and 2018. Plans have been developed and will be implemented to replace malfunctioning instrumentation and install new instrumentation on all the dams.

3.3 Anticipated Production Levels

Northshore expects to continue to operate at a four furnace level throughout the 5-year period of this plan. Expected annual operating rates for the Operations Plan and the Water Balance are presented in Table 1.

Table 1 Estimated Annual Operating Rates

Concentrate	5.5 MLT including concentrate sales
Crude Ore	15 MLT
Dry Cobb Aggregate	2.2 MLT
Filter Sands	1.1 MLT
Plant Aggregate	3.3 MLT (dry cobb + filters)
Fine Tailings	7 MLT

* MLT = Million Dry Long Tons Data provided by Northshore Mining Company on 7/10/18

Actual production rates for the plant aggregate and fine tailings may vary depending on ore grade and plant performance. These normal variations are small, however, and will not affect the overall 2019-2023 Operations Plan. Annual updated production schedules and alterations to the operations plan will be provided as necessary. The Agencies will be notified in the event of major production changes and the proposed operations plan will be adjusted as necessary.

3.4 Anticipated Pond Levels and Dam Raising Schedule

The historical water level within the basin is shown in Figure 2. The predictive water balance analysis discussed in Section 4.5 of this report. The anticipated basin pond levels for the period of this plan are listed in Table 2. These water levels are based on a pond water surface elevation of 1221.5 feet at the end of 2017 and an estimate of pond level rise of about 2.3 feet which has been used for long range planning

purposes. It should be noted that the actual pond level at the end of the 2017-2018 water year was about 1221.5 feet which is less than that projected and similar to the value for the end of 2017. This means there has been no water level gain within the basin for a period of about one year. The dam raise schedule was developed to maintain at least the minimum required freeboard.

Table 2 Milepost 7 Anticipated Dam Construction

Year	Anticipated year-end Water Elevation[a]	Dam 1 Elevation/ Freeboard	Dam 2 Elevation/ Freeboard	Dam 5 Elevation/ Freeboard	Comments
2018	1,223.8[b]	1,241/17.2	1,243.9/20.1	1,245/21.2	Construct Dam 1 -1,243 Construct Dam 5 – 1,245 Backfill Dams: Dam 1, Dam 2, Dam 5
2019	1226.1	1,241/14.9	1,243.9/17.8	1,263/36.9	Construct Dam 5 – 1,263 Construct RR on Dam 2 Backfill Dams: Dam 1, Dam 2 and Dam 5
2020	1228.4	1,243/12.6	1,243.9/15.5	1,265/36.6	Construct Dam 5 – 1,265 Construct RR on Dam 2 Construct RR on East Ridge Backfill Dams: Dam 1, Dam 5
2021	1230.7	1,250/19.3	1,243.9/13.2	1,265/34.3	Construct Dam 1 -1,250 Construct Dam 2 RR Construct RR on East Ridge Construct Reclaim Dike - 1260 Backfill Dams: Dam 1, Dam 2, Reclaim
2022	1233	1,250/17	1,260/27.0	1,265/32	Construct Dam 2 -1,260 Construct Reclaim Dike - 1260 Backfill Dams: Dam 1, Dam 2, Reclaim
2023	1235.3	1,250/14.7	1,260/24.7	1,265/29.7	Construct Reclaim Dike – 1260 Backfill Dams: Dam 1, Dam 2, Reclaim

a For long-range planning purposes, a pond level rise based on historical rate of 2.3 feet per year was used
b Actual water level as of November 2018 is about 1,221.5 feet.

4.0 Tailings Basin Operations

The Milepost 7 tailings basin facility operations follow the general philosophy developed in the Closure Consensus Plan (Klohn, 1988) and the 2004 Milepost 7 Tailings Basin Five-Year Operations Plan. This philosophy has been carried forth in subsequent operating plans. The Disposal System Operations section of the 2004 Operations Plan described basin operations as required by the permits. It includes the handling and storage of plant aggregate and fine tailings, water management, and requirements for the dams related to flood storage and monitoring. The tailing clarifiers, tailings pipeline, tailings pipeline testing, maintenance and replacement plan are not addressed in this report as the schedule and processes have not changed. This reports represents the updates in operations.

4.1 Proposed Operation Plan

The proposed plan follows the previous operations plan in the way dams are constructed, material is stored for closure, and dust emissions are suppressed. Section 4.4 describes the current dust suppression plans. The dams will be continually constructed with plant aggregate and filter tailings. A centrally-located glacial till cutoff will also be constructed on Dam 5 to control seepage. Dams 1 and 2 were most recently raised to elevation minimum elevations of 1,241 feet for Dam 1 and elevation 1,243.9 feet for Dam 2. Although the filter tailings elevation is considered the dam crest, for purposes of long-term seepage control, Dams 1 and 2 have surface elevations that exceed the filter tailings elevation. The higher elevation is due to the construction of railroad grades downstream of the dam crests which allow material to be transported to each dam for use in construction. Therefore the dam crests actually exceed those elevations (along most of the dam alignment) presented as the top of the filter tailings. The current minimum Dam 5 crest elevation is 1,235 feet and will be completed to elevation 1,245 feet in the spring of 2019 and 1,263 at the end of 2019.

Ongoing construction will involve leveling of the crest of the dams, stockpiling plant aggregate or placing the remaining aggregate on the dams, and working on the Splitter Dike. The Splitter Dike is used to support the pipeline so fine tailings can be placed into the interior of the basin. Figure 3 shows the planned activities during this proposed Operations Plan.

The upper dam slopes for Dams 1 and 2 will be graded so the overall downstream slope is roughly 6H:1V above the crest of the current seepage collection ditch. Dam 5, constructed as a glacial till cutoff dam, will also be graded to an overall downstream slope of at least 6H:1V. Figure 4 shows the proposed long-term dam configurations subject to ongoing instrumentation and performance monitoring, analyses, and design. The following sections describe the features of the Operations Plan.

4.2 Handling and Storage of Plant Aggregate

Plant aggregate is a portion of the tailings stream produced from the concentrating process, defined as the combined dry cobb aggregate (approximately 60% to 80%) and filter sands (approximately 20% to 40%). For purposes of clarification in this report, plant aggregate is used in general terms to describe all tailing except fine tailing except in the instances where specific materials are discussed, such as filter sands for the filter berms.

The plant aggregate is hauled by rail from the plant to the basin and used to construct the containment dams (Dams 1, 2 and 5) and other structures. When required, the dry cobb aggregate and filter sands are kept separate at the plant and hauled separately to the basin for special needs such as the filter berm in the dams. At the basin, the plant aggregate is unloaded from railcars and placed by dozers, loaders, trucks, or scrapers to meet planned needs. Excess plant aggregate not used for the dams is placed within the basin limits to build roads, dikes, and railroad grades, or stored for future use to provide material for closure-related activities as defined herein, in Section 5.0, Basin Closure, and in general accordance with the Closure Consensus Plan. About 0.3 to 0.4 MLT of plant aggregate is returned to the mine each year for use as road covering and blast hole stemming.

4.2.1 Schedule for Plant Aggregate Storage

Plant aggregate is delivered to the planned construction areas for the dams, dikes, roads, railroads, and stockpiles. The Basin Supervisor or his designee works with the Railroad Dispatcher and Concentrating Department to schedule the daily delivery of the plant aggregate. The amount of material delivered to the basin depends on the operation of the processing plant and could vary significantly depending on ore grade.

4.2.2 Plant Aggregate for Exterior Dam Construction

Construction of Dams 1 and 2 will continue utilizing plant aggregate for dam construction. Filter sands will be used for the filter berm construction on Dams 1 and 2 and plant aggregate (dry cobb aggregate and filter sands) will be used downstream of the filter berms. Dam 5 will be raised using centerline construction methods and filter sands will be used on the downstream side of the seepage cutoff. Plant aggregate is placed downstream and upstream of the glacial till cutoff.

Normally dam construction takes place in the summer months. However, a single lift less than about 4 feet thick may be placed on the dams in the winter (freezing conditions), provided all snow has been removed from the area being covered and the layer is compacted after thawing and before any further lifts are placed.

The placement of plant aggregate in the dams and any associated foundation work within the dams will be monitored. Adequate testing for quality assurance and control (QA/QC) will continue to be performed.

4.2.3 Plant Aggregate for Railroads and Roads

The railroad tracks on Dam 1, Dam 2, and Dam 5 were completed to facilitate hauling plant aggregate to stockpile areas and then for use in dam construction. It is anticipated that a new railroad alignment will be constructed on the east side of the basin on top of the existing access roads and connecting to Dam 2 and plans are being developed to address the appropriate alignment. A new alignment called the West Ridge Railroad, for the ultimate basin configuration, has been develop along the west side of the tailings basins. Permitting is currently underway and this alignment will set the western boundary of the tailings basin.

Small amounts of plant aggregate will also be required each year to build and maintain roads for access within the basin. Plant aggregate will not be used for roads outside of the basin, except within the plant area in a covered or bonded state or as otherwise allowed by the Agencies.

4.2.4 Plant Aggregate for Splitter Dike and the Reclaim Dam

Plant aggregate material will be used for Reclaim Dam construction. The Reclaim Dam is raised as the water level rises in the basin to maintain freeboard. The dam is configured with a 4H:1V slope downstream with a wide centerline (greater than 50 feet) for access by the haul trucks. Material is frequently placed along the upstream face of the dam due to material loss due to erosion from wave action within the main pond. This interior dam has been reconfigured in the near-term using plant aggregate and constructing a raise over the upstream fine tailings beach. This change widens the dam and increases the global stability by flattening the overall downstream slope. Alternatives are being assessed for the reclaim pond and adjustments to this interior dam may be incorporated in the future.

In the past, he Splitter Dike was raised using plant aggregate as the center portion of the dikes. There are no plans within this operating plan to maintain construction of the splitter dikes however at times, a thin layer of plant aggregate may be added to allow limited access to central portions of the basin.

4.2.5 Plant Aggregate Stockpiles

Excess plant aggregate not required at the basin (for dams, railroads, roads, or dikes) or at the mine will be stockpiled within the ultimate basin limits for future closure activities. Records will be kept of stockpiled plant aggregate. Significant stockpiles of plant aggregate have already been placed along the western side of the basin within the West Ridge Railroad and could be used for basin closure within this five year plan. Additionally, the railroad grades on both Dams 1 and 2 have been constructed to elevations greater than the filter berms and represent a significant amount of potential material for closure activities.

4.2.6 Contingencies

The projected yearly plant aggregate volumes for 2019 through 2023 are listed in Section 3.3. Variations in ore grade and plant performance will cause the actual amounts delivered to the basin to vary. Such normal variations average out in the long term, and no alterations to the Operations Plan are required.

In the case of a major disruption or reduction in operations due to reduced plant operating levels, outages, or other causes, the following steps will be taken:

1. The DNR will be notified of the disruption.
2. Plant aggregate deliveries to the mine may be temporarily curtailed or suspended as required to provide material to raise the dams or otherwise protect the integrity and safety of the basin.
3. Plant aggregate will be utilized as required from the plant aggregate stockpiles at the basin to provide material to raise the dams or to otherwise protect the integrity and safety of the basin.

4. Detailed contingency plans will be developed to deal with the duration and extent of the situation.

Increases in plant production due to expanded production will include notification to the Agencies and alterations to the Operations Plan, if necessary, to handle the added production.

4.3 Handling and Storage of Fine Tailings

Fine tailings are defined by Northshore as the -#200 mesh (75 micron size) product of the concentrating process. With the upstream method of raising Dams 1 and 2, the fine tailings provide a seal for the dams and are an integral part of the dam and basin design. During the period of this Operations Plan, the fine tailings will continue to be discharged upstream of Dams 1 and 2 to create beaches to provide a seal for limiting seepage through the dams. Fine tailings not required to seal the dams will continue to be discharged from the Splitter Dike.

The fine tailings handling and storage facility consists of clarifying equipment at the plant, fine tailings storage at the basin system, and the tailings pipeline system between the two. Operation of the tailings clarifier and the pipeline system between the plant and the tailings storage facility is the responsibility of the Concentrating Section Manager. Fine tailings storage at the basin is the responsibility of the Basin Supervisor.

Clarifying equipment at the plant consists of two launder systems and four, 400-foot-diameter clarifiers. The fine tailings pipeline system consists of two parallel pumping/piping systems. One system serves as a standby. The pipeline is inspected and tested yearly and the results summarized in a report.

4.3.1 Fine Tailings Operations and Monitoring

The fine tailings system, including the fine tailings clarifiers, pumphouses, and pipeline, will be operated and monitored consistent with the criteria identified in the following documents held by Northshore:

- The Revised Plan for Operation and Monitoring of the Fine Tailings Handling System (dated January 25, 2002)
- The Pipeline Testing, Maintenance and Replacement Plan – Final Report (July 19, 2002)

4.3.2 Schedule for Fine Tailings Storage

Fine tailings will be discharged at Dam 1 and Dam 2 to further establish the relatively impervious blanket upstream of the filter berm creating a seepage cutoff. Coordination of future fine tailings discharge on the ends of the dams will be required to provide a direct cutoff of seepage water between the interface of the filter berm and plant aggregate and the pond water. There are two critical points in the development of the basin. The first is when the pond reaches elevation 1,232 feet. This elevation represents the invert of the diversion ditch on the north end of the alignment near Dam 2. The pond could potentially flow into the diversion ditch and basin water would be released from the basin limits. The second point is when the pond reaches elevation 1,238 feet back into Murphy's Pond located on the west side of the current West Ridge Railroad. At this point, the co-mingled water could not be discharged through the diversion ditch

and Murphy's pond would be considered basin or contact water (water that has touched tailings). The diversion ditch would have to be closed to the north of Murphy's Pond to prevent release of the contact water. As a result of the two situations, a plan has been developed for the new West Ridge Railroad which sets the western limit of the ultimate tailings basin. A revised water management plan is being developed during the permitting process to account for future small diversions and wetlands impacts.

4.4 Fugitive Dust Emissions

It is Northshore's intent to control dust emissions to the extent practical with existing operations. Dust emissions are generally from the fine tailings beaches, filter sand, and plant aggregate surfaces of the tailings basin. The following sections describe the Best Management Practices implemented at the tailings basin to control fugitive dust emissions. Northshore is experimenting with alternative storage practices that create elevated platforms or beaches. These "super cell beaches" (elevated or plateau-type beaches) can be vegetated for longer periods of time due to their elevation above the basin water surface thereby reducing the potential for dust generation that is common with beaches where tailings are frequently discharged and creating wind generated dust. The super cell beaches also act as a barrier or improved seepage cutoff by keeping the pond water further from the crest of the dam.

4.4.1 Dust Control on Plant Aggregate Surfaces

All plant aggregate surfaces at the basin will be vegetated, covered, or otherwise treated as described below.

1. Total plant aggregate surfaces at the basin will be limited as much as practical and consistent with current designs.
2. Plant aggregate used for road construction will be adequately covered with native soils or other suitable natural or artificial barriers.
3. Untreated plant aggregate surfaces will be limited to 300 acres (treatment includes precipitation and other methods).
4. Untreated plant aggregate surfaces will be limited to 400-foot widths on splitter dikes and 200-foot widths on railroad grades.

These treatments and operating constraints are intended to maintain essentially zero visible dust emissions, except under extreme meteorological conditions.

4.4.2 Dust Control on Fine Tailing Beaches (above Pond)

Exposed fine tailings beaches will be vegetated, mulched, and/or otherwise treated to the maximum extent possible under the conditions at the time to control fugitive dust. The use of the super cell beach will limit the pond water from encroaching on the beach for longer periods of time which limits resaturation of the tailings and killing the vegetation leading to dust generation when the beaches are dry.

4.5 Water Management (including Water Quality and Quantity)

The Silver Bay plant and Milepost 7 tailings basin operates as a closed water system with no direct discharge of water except through the WTP or as otherwise authorized by the Agencies. Because the basin is a closed system, it is necessary to recycle treated water back to the Concentrator Plant, treat and discharge water to the Beaver River, and build dams to contain the excess water in the pond at the basin.

A key goal of this Operations Plan is to control the pond water level and provide for safe, efficient storage of tailings. Controlling the pond water level will minimize the need to raise dams and provide more construction material for closure. As requested by the Agencies in the early 2000s, the reduction of water volume was a prior goal that has been achieved during the previous five year plan.

In general, Northshore controls the water within the basin by the following:

1. Net inflow—Controlling the net inflow to the pond from the plant;
2. Basin diversions—Diverting surface runoff away from the basin;
3. WTP—Discharging treated water from the basin through the WTP;
4. Upstream seepage control blanket (super cell beach)—Reducing seepage by sealing the pond with fine tailings.

These methods of water control and contingencies are discussed in the following sections.

4.5.1 Net Inflow and Revised Watersheds

The net water flow from the plant is tracked and recorded daily. All the process water from plant operations and runoff from within the plant area is collected and pumped to the basin with the fine tailings. The tailings settle or are filtered out at the basin and clearer water is reclaimed and pumped back to the plant for process needs.

Under normal conditions, makeup water for process water at the plant is not required. Under certain conditions such as starting a tailings pipeline, makeup water is required and an automatic valve opens to add makeup water to the system. Makeup water is also added to the system through other plant uses, such as dust control and cleaning processes. The Concentrator Section Manager is responsible for monitoring the net water pumped to the basin and makeup water additions and is responsible for taking corrective action as needed to keep net water flow within normal ranges.

4.5.2 Basin Diversions

The basin diversions consist of the headwaters diversions for Big Thirty-Nine Creek, Little Thirty-Nine Creek, and the west diversions, which are west of Dams 1 and 2. The basin diversions reduce the volume of water due to surface runoff reaching the pond and are monitored periodically by the Basin Supervisor.

4.5.3 Water Treatment Plant

In 1985, the water treatment plant was completed at the basin to allow water to be treated and discharged to the Beaver River. This discharge reduces the need for storing water in the pond. The water treatment plant discharged an average of 2,584 gallons per minutes (gpm) from startup through June 2018, although annual average discharge rates as high as 3,627 gpm had been achieved. The water treatment plant reduces the volume of free water accumulating in the basin, minimizes the pond level rises, and limits the need to raise the dams.

In 2007, the water treatment plant was upgraded for higher capacity through the addition of additional treatment lines. The updated normal water treatment rate ranges from 2,500 to 3,500 gpm; however, rates as high as 4,200 have been measured over extended periods of time. For 2019-2023, it is anticipated that the water treatment plant will be operated within the normal operating range. According to the water balance report, under normal meteorological conditions and at current plant operating rates, the water in the tailings pond will be reduced. However, it is expected the pond will still rise about 0.7 feet per year through 2020 because of fine tailings displacing the water and the creation of Dam 1 and Dam 2 super cell beaches. In 2021, the drainage area to the Dams will increase from 3,525 acres to 5,021 acres with the addition of 1,701 acres of drainage area to the west and exclusion of the 205 acres drainage to Bear Lake. With this increase in drainage area, the pond is expected to rise about 3.0 feet per year under current operating conditions and revised pond area caused by the creation of super cell beaches.

The Concentrator Section Manager is responsible for operation and control of the water treatment plant.

4.5.4 Water Quality Control at Water Treatment Plant

Based on historical data, the turbidity of the influent water to the treatment plant should be targeted to be less than 50 NTUs to meet plant operational requirements. As originally constructed, the basin water was previously filtered through splitter dikes and the Reclaim Dam surrounding the reclaim pond before being pumped to the processing plant and water treatment plant. As anticipated in the 1997 operating plan, the splitter dikes are now underwater with the exception of the current Splitter Dike. The Reclaim Dam has also become plugged with fine tailings and ineffective to filter the water as originally intended, requiring an overflow weir to allow water to flow from the basin pond into the reclaim pond. The water is no longer filtered by flowing through the dikes and a higher turbidity (suspended solids) exists in the reclaim water for the concentrator processing facilities and the water treatment plant. During previous operating plans, methods have been refined for the use of flocculants and coagulants to maintain basin discharge rates and minimize the influent turbidity (suspended solids) to the concentrator processing facilities and the water treatment plant.

One method to reduce the turbidity of the water at the water treatment plant has been the construction of a pipeline from Seepage Collection Pond 1A to the water treatment plant. This water is visibly clearer and tests show reduced turbidity. This cleaner water is being piped into the Seepage Recovery Pond 1B to improve the overall process. Through this betterment of the treatment process, higher throughput was expected and achieved allowing better control of the basin water volumes.

4.5.5 Seepage Cutoff/Upstream Blanket

Seepage from the pond will continue to be managed with the fine tailing blanket in the pond upstream of the major containment dams. As discussed in a previous section, a new methodology for tailings discharge and beach development has been used recently. The approach creates a beach to a higher elevation so that pond water has less impact (rewetting and killing vegetation) over a long period of time. This configuration will allow the beach to be reclaimed with vegetation for a longer period of time reducing the potential for wind generated dust.

Seepage flowing through the fine tailings and dam cross section is collected in the seepage recovery facilities and returned to the basin as described in the following section.

4.5.6 Seepage Recovery Facilities

Each of the three major containment structures (Dams 1, 2, and 5) has its own downstream seepage recovery facility. In the case of Dam 1, there are two seepage collection ponds identified as 1A and 1B. These consist of a pond, an emergency spillway, pumping facilities, and a pipeline. The seepage recovery systems collect any seepage through the dam and collected by the seepage collection ditches or under the dams plus any runoff from the dams and adjacent direct watershed. The seepage water is rerouted back to the tailings pond to complete the closed water system at the basin. The seepage recovery systems are operated and maintained as described in the August 1976 Klohn Leonoff Consultants Ltd. report "Volume I Engineering Report On Geotechnical, Hydrologic, and Hydraulic Design For Tailings Disposal Milepost No. 7 Site" including Drawing 292-069, "Seepage Recovery Dams – Reservoir Volume Curves & Mass Curves." The seepage collection pond water levels are monitored with remote sensors which report to the Concentrator Control Room.

The Basin Supervisor is responsible for the operation and control of the seepage recovery systems.

4.6 Requirements for the Dams for Flood Storage Freeboard and Dam Monitoring

Basin operations monitoring and reporting will be conducted as required by the permits to provide adequate information to measure the performance of the dams. The primary reporting and monitoring requirements relevant to the dams are flood storage and freeboard requirements, and dam instrumentation as discussed in the following sections. An updated water balance was completed in 2018 (Barr, 2018b) to address the issues regarding basin pond level rise. The water balance completed in 2008 addressed issues regarding Probable Maximum Precipitation (PMP), updates to the watersheds, and to evaluate precipitation monitoring stations.

4.6.1 Flood Storage and Freeboard Requirements

The determination of the appropriate freeboard for the tailings basin is not only dictated by the results of the normal operating and average hydrologic conditions, but primarily by a combination of upset operating conditions and hydrologic events of infrequent recurrence, such as a PMP event. The freeboard requirement for the MP7 Tailings Basin is 10 feet (based on Barr's 1997 report *Probable Maximum Flood*

Analysis for the MP7 Tailings Basin). Although a revised analysis performed during the development of the 2009–2013 Operating Plan suggested 8 feet would be sufficiently conservative the MnDNR has requested Northshore to maintain a freeboard of 10 feet as measured at the end of the year.

The following scenarios are intended to present a range of possible annual rise in water surface elevation of the basin for a variety of operating and hydrologic conditions for the period 2019-2023. Rise in water surface elevation of the basin is calculated based on:

- Discharges to and from the basin that Northshore controls (tailings slurry water, water reclaimed to the concentrator, water discharged through the water treatment plant).
- Volume of water displaced by tailings deposition and voids losses from tailing settling and consolidation (water trapped between tailings particles).
- The combined effect of the following hydrological variables which is called watershed net yield: surface runoff from the upstream watershed, direct precipitation onto and evaporation from the tailings basin, and groundwater inflows to and outflows from the basin.
- It was estimated from available mapping that the total watershed area is 3,525 acres and the tailings basin pond water surface area is about 1,300 acres for water years 2019 and 2020. In 2021, the drainage area is proposed to increase to 5,021 acres, and the creation of Dam 1 and Dam 2 super cell beaches will reduce the pond area by approximately 10 acres.

The scenarios of possible pond water rise use Northshore's expected annual operating rates for 2019-2023 and present some worst-case scenarios in terms of pond rise for wet years assuming Northshore does not deviate from the planned production values. It is anticipated that a four-furnace operation will be occurring in 2019-2023. There are many ways Northshore can control the pond level even during wet years—by reducing production and the amount of fine tailings placed in the basin, or increasing and decreasing reclaim, slurry pipeline, and WTP discharge rates. The scenarios considered included:

1. The predicted annual rise in water surface elevation assuming average hydrologic conditions is:
    - 0.7 feet for 2019 and 2020, which accounts for the creation of super cell beaches along Dam 1 and Dam 2, assuming only 5% of fine tailings are placed under water
    - 3.0 feet for 2021–2023, which accounts for the increase in drainage area to the pond and the continued use of the super cell beach concept
2. The annual watershed net yield with a 10% probability of exceedance (i.e., the event with a return period of 10 years) is 19.5 inches, or 8.6 inches more than the annual average watershed net yield observed from 2013–2017. This extra yield is equal to a 2.3-foot additional rise in the pond level with respect to average hydrologic conditions. Therefore, the total pond rise for a year with a 10% probability of exceedance for the conditions assumed in:
    - 2019 –2020 is 3.0 feet, and
    - 2021–2023 is 6.3 feet.

3. The 5-year wet annual watershed net yield with a 1% probability of exceedance (i.e., the event with a return period of 100 years, which will likely include annual events with probability of exceedance greater than 1%) is 17.5 inches, or 6.6 inches more than the annual average watershed net yield observed in 2013–2017 over a period of five years. This extra yield is equal to a 1.8 foot additional annual rise in the pond level over a period of five years with respect to average hydrologic conditions. Therefore, the total pond rise for a year with a 5-year watershed net yield with a 1% probability of exceedance for the conditions assumed in:

    - 2019–2020 is 2.5 feet, and
    - 2021 – 2023 is 5.6 feet.

4. For a period of 2 months in a given year, the water treatment plant (WTP) discharge system is shut down for major unanticipated maintenance work, or the discharge to the Beaver River is not allowed due to water quality issues. This would result in a 0.7-foot additional annual rise in the pond level with respect to average hydrologic conditions. Therefore, the total pond rise for a year when the WTP is shut down for a 2-month period for the conditions assumed in:

    - 2019 – 2020 is 1.4 feet, and
    - 2021–2023 is 3.7 feet.

The basin water balance affects the required rate of dam raise to contain the pond water and, to some degree, the seepage from the pond. The pond level also affects the minimum dam elevation required for containing infrequent precipitation events such as a PMP, possible wave run-up, and the amount of beach above surface water that may require mitigation to minimize fugitive emissions. The water balance analysis (Barr, 2018b) shows that:

> For the period 2019-2023, the dams will be raised to meet freeboard requirements. If average conditions occur until 2023, pond levels would be expected to rise approximately 0.7 feet per year through 2020, and up to 3.0 feet per year through 2023. The rise in water level at the end of water year 2023 could be up to 10.4 feet, reducing the available freeboard if planned dam construction does not occur for some reason.

4.6.2 Contingencies

Water management contingencies are needed for two scenarios:

1. Significantly less direct precipitation (and resulting runoff) or plant production (fine tailings and/or water) occurs than assumed in the Operations Plan.

2. Significantly more direct precipitation (and resulting runoff) or plant production (fine tailings and/or water) occurs than assumed in the Operations Plan.

If less water than assumed is available at the basin, the discharge of water through the water treatment plant will be reduced and the additional beach that becomes exposed will be mulched, vegetated, or otherwise treated to control dust emissions.

If more water than assumed is available at the basin, the crest heights of the containment dams (Dams 1, 2, and 5) will be increased to provide adequate flood storage, and the water level will be drawn down over time through increased flow at the water treatment plant and reduced or minimized augmentation at the plant until conditions return to normal. Northshore has planned for these events and can quickly raise the freeboard on the dams by placing additional plant aggregate along the downstream portion of the filter berms thus increasing the elevation of the dam to protect for wave run up, etc. However it should be noted and was discussed previously that a railroad grade exists on the top of each dam at an elevation far above the pond elevation also providing a level of protection against complete overtopping. Furthermore Northshore has provided another level of protection with the significant seepage collection ditches along Dams 1 and 2 to collection any increased seepage in the unlikely event that pond levels exceed the top of the filter berms which represents the worst upset condition. With the significant availability of plant aggregate along the dams, Northshore could also place plant aggregate immediately adjacent or on top of the filter berms, further limiting the advance of water across to the elevated portions of the dam constructed for rail access.

4.7 Design and Engineering

As discussed previously, Northshore has retained Barr to provide ongoing engineering assistance at the tailings facility. Projects recently completed were dam raises, dam stability evaluations, seepage cutoff construction, and railroad grades on each dam. These are addressed in the following sections.

4.7.1 Dam Performance

A yearly dam safety inspection has been completed to evaluate dam performance since 2003. The dam safety inspection was performed as required by permit. Appendix B provides the details of the most recent inspection.

The dams and diversions along the tailings basin were inspected in October 2018. The inspection included Dam 1, Dam 2, Dam 5, Seepage Recovery Dams (SRD) 1A, 1B, and 2-3, the Reclaim Dam, and diversion dams. Observations made during the inspection indicate each of the dams is stable, well maintained, and acceptable for continued operation. The tailings dam inspection did not identify any unresolved issues with the condition or integrity of the dams.

Dam construction during 2014 to 2018 included placing plant aggregate on Dam 1, Dam 2, Dam 5, and the Reclaim Dam. Fine tailings were deposited upstream of Dam 1, Dam 2, the reclaim dam, and the Splitter Dike. Foundation preparation was started along the western portion of Dam 1 in anticipation for the next dam raise. Super cell beaches were constructed on Dam 1.

A plan for the maintenance and continued operations of the dams for 2018 follows:

- Continue monitoring the instrumentation on Dams 1, 2, and 5 at least two times a year and replace defective or non-functional devices.
- Continue installing data loggers and create an instrumentation upgrade plan for the next 5 years to replace malfunctioning equipment and incorporate near real-time monitoring.

- Raise Dams 1, 2, and 5 as necessary to maintain freeboard according to permitted requirements. Based on current freeboard measurements and anticipated pond elevations, Dam 1, Dam 2, and Dam 5 will be raised under the current operations plan.
- Monitor pond and beach elevations to prevent pond water from coming in direct contact with upstream filter berms for Dam 1 and Dam 2. This will likely be easily accomplished with the implementation of the super cell beach concept.
- Continue vegetating exposed areas of the dams as they are regraded or raised. In areas where there is no vegetation and erosion has occurred previously, regrade by placing new material into the eroded areas and revegetate. This process will reduce damage from regrading by larger equipment.
- Monitor any wet areas that appear at the toes of the dams for evidence of seepage.
- Remove brush along glacial till cutoff on dams, and any larger brush present, such as along the core for the eastern end of Dam 1 and the diversion dam slopes.
- Remove algae/cattail build-up from the seepage collection ditches and areas surrounding the weirs to promote better flow.
- Fill in animal burrows, such as the few observed along the seepage collection ditch at Dam 2, per the FEMA Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams (2005).
- Periodically inspect areas where beaver dams have been present in the past and remove any newly constructed beaver dams.

4.7.2 Dam Raises

An evaluation of Dams 1, 2, and 5 was performed in 2009 to confirm the revised design developed in 2004 is adequate for further use in containing tailings at the storage facility. The evaluation involved an assessment of the existing, near-term, and ultimate dam configuration conditions. The objective of the assessment was to identify potential critical design issues with the 2003 proposed changes to the dam construction to provide a basis for the design of the anticipated next two raises on each dam to elevation 1,245 feet. The study also evaluated the dams at their ultimate elevation, 1,315 feet. The stability analyses combined the results from the geotechnical evaluation used average and lower bound parameters for strength with realistic permeability parameters developed from observational data to evaluate the anticipated condition of the dams over time. The analyses were performed at dam elevations 1,230, 1,245, and 1,315 feet.

Updated analyses have been performed for Dams 1, 2, 5, and the Reclaim since 2013. The results represent the current design at the elevation analyzed and supersede the preliminary analyses performed previously because additional information had been collected. The results of the stability analyses are summarized in the evaluation report in terms of the factor of safety for the limit-equilibrium method.

Typical (consistent with the current standard of practice) minimum required safety factors chosen for the project were 1.5 for the drained shear strength analysis and 1.3 for the undrained shear strength analysis. A safety factor of 1.05 was used for the liquefied strength analysis, assuming all fine tailings liquefied from some unknown triggering event.

The minimum safety factors used for design were based on confidence in the strength parameters due to years of testing and studies performed by several consultants. The average strength parameters were used for liquefied strengths of the fine tailings and the 33rd percentile strength parameters for all other materials evaluated in the studies. In 2009, the preliminary analysis of subsequent raises and the ultimate dam configuration considered lower bound strengths to determine if there were any conditions that could occur that would require further investigation and study. For example, if a lower bound strength analysis indicated that the factors of safety would be less than required, further investigations and testing would be planned. As a result of these analyses an investigation and instrumentation program was developed and conducted in 2013, 2014, 2017, and 2018. The conclusions of the stability evaluations performed for basin operations for the 2019-2023 Operations Plan are discussed in the following sections.

4.7.2.1 Dam 1 Stability Analyses

The stability of Dam 1 was updated and analyzed in 2013 and are reported in Barr (2013) using recent observations from instrumentation information and the existing and proposed dam geometry shown on Figure 5. Similar to analyses performed in 2009, updated analyses were performed for the short-term undrained conditions (undrained strength stability analysis, $USSA_{yield}$ and $USSA_{liquefied}$) and long-term conditions (effective stress stability analysis, ESSA). The results of the stability analyses presented in Table 3 the computed factors of safety are adequate for the conditions analyzed. While the long-term condition with a crest elevation at 1,245 feet and a maximum normal pond at elevation 1,235 feet is also considered stable. Careful management, ongoing evaluation, and monitoring will allow changes to be made to the dam configuration or updates to the geotechnical properties of the tailings prior to reaching this elevation. As discussed previously, a geotechnical investigation along the toe of Dam 1 was carried out in 2013 and others in 2017 and 2018. The intent of the plan was to install updated instrumentation and replace other instruments necessary for evaluation of the dam. Samples were also obtained of foundation materials for laboratory testing as part of an ongoing process to update the design strengths of materials found within the basin area.

Table 3 Computed Factors of Safety for Various Scenarios

Slope Location and Material Configuration (Dam Crest - 1,245 feet)	Factor of Safety for Pond Scenarios				Minimum Acceptable FOS
	Tailings Pond at 1,212.8 ft (Existing)	Tailings Pond at 1,235 ft, Above Existing Beach	Tailings Pond at 1,235 ft, Future Beach	Tailings Pond at 1,242 ft, Above Future Beach	
ESSA	2.45	2.42	2.43	2.42	**1.5**
ESSA Block Failure	2.26	2.21	2.22	2.19	**1.5**
USSA, Fine Tailings Yield Strength	1.60	1.58	1.58	1.58	**1.3**
USSA, Fine Tailings Yield Strength, Block Failure	1.52	1.47	1.47	1.45	**1.3**
USSA, Fine Tailings Liquefied Strength	1.57	1.53	1.53	1.51	**1.05**
USSA, Fine Tailings Liquefied Strength, Block Failure	1.41	1.36	1.37	1.35	**1.05**

4.7.2.2 Dam 2 Stability Analyses

The stability of Dam 2 was previously analyzed in Barr (2009) with preliminary analyses using the existing and proposed geometry shown on Figure 6 and used the strength parameters developed under the methodology used at the time of preparation of Barr (2009). The results of the preliminary stability analyses have shown the computed factors of safety are adequate for both existing and long-term conditions where the pond level was assumed 10 feet below the crest of the dam at elevation 1,305 feet. The ultimate elevation is stable and meets the required minimum safety factors.

Updated analyses were performed in 2016 in preparation for a future dam raise to elevation 1,248 feet using revised methodologies to evaluate strength and seepage parameters from field and lab testing. The results of the slope stability modeling are reported in Table 4 and show that the dam is stable under this configuration.

Table 4 Computed Stability Factors of Safety for Various Scenarios

Slope Location and Material Configuration	Factors of Safety for Dam 2 Crest Elevation 1,248 feet				Minimum Acceptable FOS
	Tailings Pond at 1,215.3 feet (Existing Spring 2014)	Tailings Pond at 1,238 feet, Existing Beach (10-foot freeboard)	Tailings Pond at 1,238 feet, Future Beach at 1238 feet (10-foot freeboard)	Tailings Pond at 1,245 feet, Future Beach at 1238 feet (3-foot freeboard)	
Downstream Slope, ESSA	2.85	2.84	2.85	2.84	**1.5**
Downstream Slope, ESSA Block Failure	2.91	2.91	2.91	2.91	**1.5**
Downstream Slope, Operational Conditions	1.75	1.74	1.74	1.74	**1.3**
Downstream Slope, Operational Conditions, Block Failure	1.77	1.76	1.76	1.76	**1.3**
Downstream Slope, USSA	1.77	1.76	1.77	1.76	**1.3**
Downstream Slope, USSA, Block Failure	1.75	1.75	1.75	1.75	**1.3**
Downstream Slope, USSA, Fine Tailings Liquefied Strength	1.76	1.75	1.76	1.75	**1.05**
Downstream Slope, USSA, Fine Tailings Liquefied Strength, Block Failure	1.76	1.76	1.76	1.76	**1.05**

4.7.2.3 Dam 5 Stability Analyses

Similar to Dams 1 and 2, preliminary analyses were performed in 2009 to assess the ultimate dam configuration at crest elevation 1,315 feet. The analyses indicate stable conditions for the configurations described and presented in Barr (2009). While the dam conditions or scenarios analyzed at the time are not entirely similar to the most recent analysis, the preliminary analyses are adequate for long range planning and will be updated during the design of each dam raise. Figure 7 shows the configuration for Dam 5.

A stability analysis and design for raising the Dam 5 crest to an elevation of 1,245 feet with downstream slopes matching the 1,260 feet design was completed in 2018 (Barr, 2018). Construction of the dam raise to elevation 1,245 feet was started in 2018 ending at elevation 1,236 feet in 2018. The dam will be constructed in to a crest elevation of 1,245 feet in 2019. The analysis included a review of seepage and slope stability using the proposed dam configuration and anticipated adjacent tailings pond levels.

The results of the analyses for a dam crest elevation of 1,245 feet are presented in Table 5 and indicate acceptable conditions under the current operating criteria. This analysis includes maintaining a toe pond elevation at 1,181 feet.

Table 5 Computed Factors of Safety for the Downstream Slope of Dam 5

Slope Location and Material Configuration	Minimum Acceptable Factor of Safety	Resulting Model Factor of Safety	
		Mid-Slope Failure	Large Failure
Normal Operating Pool (10 feet below crest)			
Downstream Slope, ESSA	**1.5**	2.14	2.44
Downstream Slope, ESSA Block Failure	**1.5**	2.32	2.37
Downstream Slope, USSA	**1.3**	1.39	1.68
Downstream Slope, USSA, Block Failure	**1.3**	1.41	1.66
Flood Pool			
Downstream Slope, ESSA	**1.5**	2.10	2.38
Downstream Slope, ESSA Block Failure	**1.5**	2.28	2.35
Downstream Slope, USSA	**1.3**	1.30	1.63
Downstream Slope, USSA, Block Failure	**1.3**	1.31	1.46

4.7.2.4 Reclaim Dam Stability Analyses

The Reclaim Dam is an interior dam that creates a ring dike around a historical low area within the basin which allows water to be ponded where floating pump stations return water to the plant or the water treatment plant. Updated stability analyses were prepared in 2015 to address planned dam raises and development of potential configuration changes to the Reclaim Pond. The dam configuration varies along the alignment and therefore three cross sections were evaluated for crest elevation 1,235 feet and the next dam raise to elevation 1,245 feet. Both shallow failures which affect the outside slopes of the dams and deep-seated failures which could compromise the dam integrity and likely lead to failure of the dam cross section were evaluated. Table 6 to Table 9 present the results of the stability analyses.

As can be seen in the tables, the upstream stability analyses indicate factors of safety less than minimal accepted values. This is the result of the fill placement over ground created by discharging tailings from the emergency line from the valve house. For this analysis it was assumed that the plant aggregate was placed over "fresh" tailings which had not dried/dessicated or gained strength. This is a conservative assessment because the beaches in this area have been shown to adequately support farm tractors, pickup trucks and some heavy equipment like excavators. In addition, Barr completed a limited field investigation in the area in 2018 and found that much of the tailings tested and obtained with thin-wall sampling methods within the depths explored were identified more as sands to silts in a dry condition. These materials are different from those evaluated within deeper deposits further from the discharge

point when developing the strengths of the fine tailings in both the yield and liquefied strengths. Since this study, construction observations have shown that even minimal fill heights of plant aggregate (2 feet or so) observed around the reclaim dam area can support heavier mining equipment and therefore the strengths of the tailings in this area are higher than the strengths used in the analyses.

Table 6 Computed Factors of Safety for Station 15+00

Model Scenario	Slope	Factor of Safety					
		Shallow/Slough Failure			Deep-Seated Failure		
		ESSA (1.5)	USSA		ESSA (1.5)	USSA	
			Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)		Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)
Crest at Elevation 1,230-1,232 ft	Downstream	1.54	1.44		1.86	1.86	
	Upstream	***1.13*** [1,3]	***0.90*** [2]	***0.44*** [1,2]	1.86	1.32	***0.54*** [1,3]
Crest at Elevation 1,245 ft	Downstream	***1.01*** [3]	***1.01*** [3]		1.54	1.54	
	Upstream	***1.13*** [2]	***0.88*** [2]	***0.44*** [1,2,5]	***1.40*** [1,2]	***1.04*** [1,2]	***0.44*** [1,2,5]

Table 7 Computed Factors of Safety for Station 27+00

Model Scenario	Slope	Factor of Safety					
		Shallow/Slough Failure			Deep-Seated Failure		
		ESSA (1.5)	USSA		ESSA (1.5)	USSA	
			Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)		Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)
Crest at Elevation 1,230-1,232 ft	Downstream	***1.13*** [3]	***1.20*** [3]		1.51	1.54	
	Upstream	***1.42*** [3]	1.42	***0.91*** [1,2]	1.88	1.50	***0.99*** [1,2]
Crest at Elevation 1,245 ft	Downstream	***1.14*** [3]	***1.11*** [3]		***1.31*** [1]	1.31	
	Upstream	***1.12*** [3]	***1.12*** [3]	***0.80*** [1,2]	***1.46*** [1,2]	***1.21*** [1,2]	***0.85*** [1,2]

Table 8 Computed Factors of Safety for Station 37+00

Model	Scenario	Factor of Safety					
		Shallow/Slough Failure			Deep-Seated Failure		
		ESSA (1.5)	USSA		ESSA (1.5)	USSA	
			Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)		Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)
Crest at Elevation 1,230-1,232 ft	Downstream	1.50	1.32		2.57	1.57	
	Upstream	***1.48***[3]	***1.00***[2]	***0.90***[2]	2.18	1.73	1.18
Crest at Elevation 1,245 ft	Downstream	***0.91***[3]	***0.92***[3]		2.18	1.92	
	Upstream	***0.84***[3]	***1.00***[2]	***0.85***[3]	1.57	1.39	***1.01***[4]

Table 9 Computed Factors of Safety for Station 37+00 Considering Block Failure Conditions

Model	Scenario	Factor of Safety Considering Block Failure Conditions					
		Shallow/Slough Failure			Deep-Seated Failure		
		ESSA (1.5)	USSA		ESSA (1.5)	USSA	
			Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)		Fine Tailings Yield Strength (1.3)	Fine Tailings Liquefied Strength (1.05)
Crest at Elevation 1,230-1,232 ft, Block Failure Conditions	Downstream	1.50	1.32		2.61	2.20	
	Upstream	***1.48***[3]	***1.00***[2]	***0.90***[2]	2.18	1.74	1.18
Crest at Elevation 1,245 ft, Block Failure Conditions	Downstream	***0.91***[3]	***0.92***[3]		2.12	1.36	
	Upstream	***0.84***[3]	***1.00***[2]	***0.85***[3]	1.57	1.35	***1.01***[4]

For the shallow/slough failure scenarios, representing maintenance concerns, some of the reported FOSs are less than the corresponding minimum FOSs. Those values less than the minimum FOS for the geometry at crest elevations at 1,230-1,232 feet are greater than 1.0 except for the upstream slope USSA scenario including liquefied fine tailings. The resulting failure surfaces are near the dam face through the sloughed plant aggregate, except for the upstream USSA scenarios where shallow bearing capacity failures occur near the upstream toe. It should be noted that placement of plant aggregate has occurred in this area since these analyses were performed and undesirable performance has not been observed.

For scenarios including the geometry for the dam raise to 1,245 feet, all of the FOSs are less than 1.0 for shallow/slough failures except for the USSA upstream scenario with fine tailings yield strength, which is at

1.0. Models indicate these failures are mainly thin and occur at the surface of the steep slopes of plant aggregate placed to raise the dam except for the upstream USSA scenarios, where shallow bearing capacity failures occur at the upstream toe on "fresh" tailings.

For the deep-seated failure scenarios, representing deeper failures that could affect the core zone of the dam, all the FOSs are greater than corresponding minimum FOSs for the existing dam configuration, with the exception of the scenarios for the undrained, liquefied tailings on the upstream slope for all the stations and the undrained tailings with the yield strength for station 15+00. The FOS for the upstream side of the dam at station 15+00 for the yield strength tailings was greater than 1, but the FOSs for the liquefied tailings scenarios were again less than 1.0. Although the liquefied strength analysis indicates a low factor of safety less than 1.0, this scenario requires a triggering condition which rapidly changes the stress within the embankment. This change in stress could be a rapid loading or unloading, change in water level, etc.

For the deep seated failure scenarios including the future dam configuration with the crest at elevation 1,245 feet, the modeled factor of safety for some upstream and downstream ESSA scenarios, as well as most of the upstream USSA scenarios was less than 1.0. These failure surfaces extend through the dam crest near the interface of the sloughed and compacted plant aggregate.

The configuration and future use of the Reclaim Dam is being evaluated and options developed for future dam raises. At this time, the dam crest has been constructed at a reduced width to limit traffic across the top as options are being evaluated.

4.7.2.5 Dam Stability Related Objectives

The following presents the objectives that Northshore will follow based on the conclusions of the recent dam evaluations. Northshore will:

- Continue the monitoring program at each of the dams to provide background information and compare to the stability models.
- Monitor more closely the groundwater pressures at the toe of all the dams. Additional piezometers have been installed at the toe of Dam for Dams 1, 2, SRD 1A, SRD 1B, and SRD 2-3 at the toe of the dams will occur to monitor seepage pressures. The instrumentation includes data loggers to evaluate to more closely monitor the changes over time. Compare the monitoring data to the calculated model values to evaluate the effects of changes.
- Continue to measure the shear strength of the fine tailings. This includes characterization of dilative or contractive behavior of the fine tailings relevant to liquefaction assessment in an ongoing process. This will allow the evaluation of the tailings' liquefied strength to continue over time.
- Increase the knowledge and understanding of the current physical properties now and the potential future changes within the lacustrine clays under the dam footprints.

4.7.3 Instrumentation Monitoring

Instruments have been installed within Dams 1, 2, and 5, including settlement plates (most of which have been damaged and no longer used), inclinometers, seepage weirs, and piezometers. The seepage weirs, piezometers, and inclinometers are monitored and data reported biannually by Barr. The monitoring instruments are used to measure the performance of the dams and their foundations as the dams are raised and the elevation of adjacent ponds increases. The two major geologic features monitored for the dams that significantly affect stability are the lacustrine clay and glacial till layers that comprise the dam foundations.

The lacustrine clay is characteristically "soft," and when load is applied deforms and develops increased pore pressures. The lacustrine clay is also varved, allowing pore pressures to easily be transferred horizontally. The clayey to sandy glacial till is characteristically very "hard" or dense but relatively pervious. Water within the till is pressurized from tailings pond head and adjacent groundwater flow and contained by the relatively impervious lacustrine clay above it. This creates potential uplift pressure downstream of the dams along the toe. This condition is being managed using relief wells and drains along the downstream toe of Dam 1 and Dam 2. Uplift of dam construction materials along the toe of Dam 5 is presently being managed by a plant aggregate buttress, which will also be incorporated into the downstream dam slope as part of future raises. For all dams, the water pressure in the glacial till is being measured with piezometers.

The most recent biannual monitoring event was completed in the fall of 2018. Data collected from piezometers, relief wells and inclinometers previously installed on Dams 1, 2, 5, and the Reclaim Dam are summarized in the monitoring report.

The data collected from instrumentation in the fall of 2018 does not indicate any significant changes have occurred since the spring of 2018 for Dam 1, Dam 2, or Dam 5. New instruments were installed in 2015 on the crest and at the toe of Dam 2 to replace older instruments and to provide additional insight into porewater pressure conditions within the dam where no instruments previously existed. New instruments were also installed in 2018 to replace damaged instruments at Dam 5 and to augment porewater pressure monitoring downstream of the clay core. Additionally, three nests of piezometers were installed in 2018 along a cross-section within the east end of Dam 1 where no instruments have previously been present. A nest of VW piezometers was also installed at the toe of each of the seepage recovery dams after the fall monitoring event, and will be incorporated into the biannual monitoring events in 2019.

Inclinometers are used to evaluate deformation of the dams. Apparent surficial movement is attributed to surface creep and casing movement possibly through freeze-thaw. Although slight creep has been observed in some deeper zones of inclinometers within Dam 1 and Dam 5, more significant deformations have not been observed in recent years. Inclinometers have been assessed using a downhole camera over the last several monitoring events, and based on these observations, a general plan has been developed for replacement of some of the damaged and/or older inclinometers.

In 2017 and 2018 Northshore installed data loggers at all the vibrating wire piezometer locations. The intent is to more closely monitor porewater pressures during construction and changes to the basin such

as pond water levels. In 2017, Northshore installed pond level monitoring devices in each of the seepage collection ponds to more closely track the water levels in the control room.

Other instruments that are damaged or have become inoperative may be replaced or abandoned and new instruments added as required at the direction of the Basin Engineer. The ongoing investigation program was developed based on this requirement.

4.7.4 Railroad Construction

Plant aggregate is a necessary component for dam construction and other projects at the tailings basin. As part of the storage practices, the plant aggregate is hauled by rail to both Dams 1 and 2 every day of production. In order to adequately place the material with limited additional handling, the rail lines cross both of the dams. As the dams are raised, the railroad grades are also raised in advance or higher elevation than the upstream portion of the actual dam. This results in dam grades higher than the filter berms, which are considered the "dam crest." Dam 1 was raised in 2017 and 2018 to an elevation of 1,265 feet. In 2010, Dam 2 railroad grade was raised to about elevation 1,245 feet and the extension from Dam 2 to Dam 5 was completed in 2012 at elevation 1,245 feet. Future railroad grade changes will consist of a raise and an extension of the Dam 2 rail down to Dam 5 to about elevation 1,270 feet, the new West Ridge Road alignment that will be the final railroad grade and will allow access to both Dam 1 and Dam 2 at their ultimate design at elevation 1,315 feet, and an extension of the Dam 1 rail to Dam 5. The design process has begun and will continue for the next several years as alignment alternatives and construction plans, specifications, and permits are completed. It is anticipated that the new rail grade will be needed in about 3 to 4 years and will require a several year construction period.

4.7.5 Bear Lake Outlet

The existing natural outlet for Bear Lake drains into a seepage collection pond at the toe of Dam 5 and is pumped periodically to the basin reclaim pond. The location of this drainage path is historical as Bear Lake has always flowed in this direction before the tailings basin was constructed. Currently, if the water is not pumped out of the seepage collection pond, the seepage and runoff water level will rise and could overflow into Bear Lake. Since 2016, Northshore has been working to construct the final Bear Lake Outlet down towards the east and south down the hillside. The remaining portion of work will be completed in 2019 which included a tunnel under the pipeline road and the channel and structure at the lake. Once the vegetation and channel have been stabilized, the outlet into Dam 5 seepage collection pond will be closed and water will flow out through the new channel. This is expected to take place in 2019 when a screen berm is constructed as the final phase of the project.

4.7.6 Site Survey Control

The tailings basin has been surveyed historically as part of the permit requirements, and site survey control is available within the basin. The site survey monuments are shown on Figure 1. The control is checked intermittently against points used frequently for survey and layout. The control is used for the construction of the basin only and not for long-term deformation monitoring. I Quantum Spatial of Lexington, Kentucky completed an aerial survey based on May 4, 2017. The results of the survey were

used for design work in 2017 and 2018. Northshore generally performs its own construction staking using GPS with a base station located on a control point at the landfill.

5.0 Basin Closure

5.1 Introduction

A basin closure plan has been developed and implemented to address current needs and configuration of the facility; it was based on conditions present since 2003, when the 2004-2008 Five Year Operating Plan was developed introducing significant changes to the operations and construction of the tailings basin. The planned closure approach, presented in the 2004-2008 Five Year Operating plan was consistent with the spirit of the Closure Consensus Plan (CCP) developed when Reserve Mining Company closed in 1986. At that time, the tailings basin was left with a significant amount of excess stored water, minimal plant aggregate to construct any additional required features, and threatening the long-term stability of the containment dams (Dams 1, 2, and 5). The facility also had limited means for treating and discharging basin water and, therefore, an inability to control the overall water balance of the basin in the event of storms or wet years. Particular issues related to the need for a closure plan that were addressed in the CCP were the needs for maintenance or improvement 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. Since the development of the 2004-2008 Five Year Operating plan, NSM has made significant progress to limit the risks and liabilities associated with any future basin closure.

In general, a basin closure plans should include the following items:

- General descriptions of plans (both planned and unplanned closures)
- Programs for perpetual maintenance and safety of the basin including adequate monitoring
- Management of ponded waters
- Monitoring and mitigation of surface and groundwater pollution
- Vegetation and landscaping plans

This five-year operating plan encompasses these objectives which were also embodied in the 1988 Closure Consensus Plan with details updated as noted to reflect existing conditions and information. This issuance of this updated plan supersedes in full the CCP and all obligations contained therein.

5.2 Recent Initiatives (2003 to Current)

Beginning in 2003, NSM developed initiatives to meet the overall objective of being prepared for closure activities while also reducing costs in the event of closure. One of the major concerns of the regulatory agencies was the amount of stored water in the basin in the 1980s and 1990s. This was seen as a risk in the event of closure, and NSM developed a plan to reconstruct splitter dike 2 and to discharge tailings into the deeper portions of the basin. The CCP required that fine tailings be used as bulk fill and, therefore, tailings were discharged on the dams and off the splitter dike, effectively reducing the depth of water from more than 70 feet to 20 feet or less in the north and south ponds. As a result of filling the basin from splitter dike 2 and both the Dam 1 and 2 beaches, the segments of cells 1 and 4 nearest the dam are filled eliminating two of the chief concerns that the CCP sought to resolve; a larger than desired

pond size and lower factors of safety on dam stability. The pond is now two smaller ponds connected by culverts through splitter dike 2.

A plan was also developed to discharge tailings onto the beach within a "training" or sacrificial upstream dike enclosure to create "super cell beaches." These beaches are raised 10 to 20 feet above the pond, depending on the height of the filter berm above the pond surface, and are 200 to 400 feet wide. The configuration has been created so the tailings can dewater after discharge on the beach and within the dikes and support equipment for grading and vegetation that can develop, grow, and stabilize the tailings over a number of years until it is necessary to discharge over the beach again. This process addressed the concern in the CCP that the beaches would stay wet and were undulating, thereby trapping water on the surface. In fact, the approach to long-term stabilization of fine tailings is very similar to practices at other tailings storage facilities in the area and was used in effectively stabilizing the Cell 2W surface at the LTV Steel Mining Company project. This approach will also not require plant aggregate cover, use of which has proven to make it more difficult to achieve a stabilized surface in short periods of time. The use of super cell beaches in all modes of closure described below minimizes resuspension of tailings due to additional water depth over the wave zone; maximizes the use of vegetation on the fine tailings surfaces, which is the current successful practice for achieving interim and final cover at NSM (and other northern Minnesota mining facilities); minimizes the demand on plant aggregate resource at the basin, which could be used for other construction and mining activities; maintains adequate distance of the tailings basin pool away from the crest of the dam, and minimizes overall dust generation during closure from hauling aggregate and placing it over fine tailings beaches.

The CCP stated that the water treatment plant would be used to treat and release water until such time that direct release could occur and an increase in capacity would be required. In 2007, the water treatment plant was updated by adding rapid-mix, flocculation and filtration treatment capacity. In recent years flow rates have been achieved up to about 4,200 gpm, achieving the long-term design consideration envisioned in the CCP for improving control over the water balance. The water treatment plant has been shown to effectively manage the basin water volume over time, keeping water levels below the elevations required for the design and flood conditions. As a result of the upgrades to the water treatment plant, the current state of minimized water pond, and stable dams described previously, the plan updates proposed in the following sections align with the limited wet closure goals of smaller, less voluminous ponds and eliminate the need for a substantial overflow channel unless otherwise deemed necessary by further water balance studies.

5.3 Closure Conditions

Closure is defined as the cessation of operations of the concentrating plant in Silver Bay and the resulting cessation of tailings deposition at the basin. Closure can occur in several forms, including:

- Temporary closure, defined as a short-term shutdown of the plant and basin operations for a time period that may last several years, as experienced between 1986 and 1990. A temporary closure becomes a permanent closure when the plant in Silver Bay is no longer maintained in a condition to restart operations.

- Premature closure, defined as an unplanned permanent cessation of operations with little or no prior notice.
- Planned final closure, defined as permanent cessation of operations with sufficient prior notice to accomplish much of the basin closure construction during the last years of plant operation.

In all three cases, the closure would follow the concepts established in this plan, with the main differences related to timing and the source and placement of the materials.

As defined by Minnesota state law, the planned final closure and demolition of a taconite plant must include a 2-year holding period, during which the facilities are sufficiently maintained to allow operations to restart. Any final closure can only proceed after this holding period. The effect is that any planned final closure is treated as a temporary closure for at least 2 years.

The following sections contain general closure plans for each of the scenarios listed above. In all cases, detailed plans including the final pond level to be achieved, the location and design of spillways, perpetual maintenance requirements, and other details would be finalized at the time of closure.

5.3.1 Temporary Closure

In the event of a temporary cessation of operations at Milepost 7, the following steps will be taken:

1. The Basin Operations Plan will be adjusted to reflect the cessation of operations and detailed plans developed to hold the basin for the required 2-year period.
2. The freeboard and stability of the containment dams (Dams 1, 2, and 5) will be evaluated and corrective action will be taken as required to protect public health and safety.
3. Water treatment plant operations will continue as required to control the pond level and maintain adequate freeboard for the dams.
4. Areas of exposed, untreated plant aggregate and fine tailings will be treated or covered with mulch minimizing dust emissions.
5. Monitoring and instrumentation of air and water quality will continue, as required.
6. Operation of the seepage recovery facilities will continue as designed.
7. Stream diversions will continue to be inspected and maintained.
8. The basin facilities will be maintained and kept in a condition to allow operations to resume when appropriate.

5.3.2 Premature Closure

In the event of a premature closure of the basin, the following steps will be taken:

1. The basin will be held, following the steps listed in the temporary closure section, for a period as defined by Minnesota State Law (2 years) to allow operations to resume if appropriate.

2. A detailed closure plan will be developed to define the final closed configuration of the basin including updated water balance, spillway design, water treatment operation, a vegetation plan, perpetual maintenance requirements, and a closure schedule.

3. Although the dams are currently stable under a variety of conditions, steps will be taken to evaluate the final stability for the proposed conditions for the containment dams (Dams 1, 2, and 5) and adjust the configurations if needed to meet the goals of the closure plan. There is currently about 1,412,851 cubic yards of plant aggregate available that can be used for the construction activities such as raising freeboard of the dams.

4. At the end of the temporary closure period, based on a schedule developed by Northshore and approved by the agencies, the following will occur:

    a. Remaining exposed fine tailings will be vegetated to prevent erosion and dust emissions similar to other basins that have undergone closure in Minnesota.

    b. Wave erosion zones on the fine tailings will be addressed to minimize re-disturbance; this could be achieved through cover with plant aggregate or other suitable materials to produce a reclaimable surface.

    c. Buildings, pipelines, and other structures not required for future maintenance will be removed.

    d. All roads, railroad grades, dikes, borrow pits, building sites, or other disturbed areas not required for future maintenance will be contoured and vegetated.

    e. An emergency spillway will be designed and constructed to handle runoff and protect the integrity of the containment dams (Dams 1, 2, and 5).

5. NSM will continue to operate the water treatment plant to control the pond level until such time as the pond water quality allows direct discharge of pond water outside of the basin.

6. With the improvement in water quality, direct discharge will be used to control the pond level in the following manner:

    a. An operating spillway will be excavated to control the basin surface-water level.

    b. The stream diversions and seepage recovery dams will be breached.

c. The water treatment plant will be shut down.

d. All remaining structures and roads not required for future access will be reclaimed.

7. Periodic monitoring and inspections will continue until the basin is deemed to be reclaimed to a natural self-sustaining condition.

5.3.3 Planned Final Closure

For a planned closure of the basin, the following steps will be taken:

1. Upon cessation of operations, closure will continue, following the steps listed for temporary and premature closures.

2. Prior to final closure:

   a. The basin will be managed to minimize the pond water volume and the pond will be filled with fine tailings in a manner that will force the water to the west shore of the basin.

   b. Exposed beaches will be shaped to form a surface capable of reclamation and vegetated. Plant aggregate will be placed in wave erosion zones to minimize erosion and wave resuspension of fine tailings.

   c. The water treatment plant will operate as required to control the pond level and minimize the pond water volume.

One difference between the current closure plans detailed above and the Closure Consensus Plan is that, in the current plan developed in 2004, the fine tailings stored underwater below wave erosion zones will not be covered with plant aggregate. At the time of the Closure Consensus Plan, it was thought that the fine tailings covering the pond bottom would be continually re-suspended and not allow the pond to clarify. To cover and contain all fine tailings, a 1-foot layer of plant aggregate was to be placed over the entire pond bottom. However, observations during the temporary plant closure (1986 to 1990) showed that basin water clarity improved dramatically during the first few months after operations ceased, indicating that a layer of plant aggregate over the underwater fine tailings is unnecessary. Studies and experience since 1988 have corroborated this finding.

The uncompacted plant aggregate unit weight is about 134 pounds per cubic foot and the fine tailings in the center of the basin can weigh as little as 75 pounds per cubic foot. Because the plant aggregate is much heavier than the fine tailings, it would be difficult to place a layer of plant aggregate under water on top of the soft, fine tailings without displacing, disrupting, or co-mingling the two, resulting in inefficient stabilization. The difficulty of placing aggregate would be compounded by the long-term differential settlement of fine tailings (and slimes) that would occur with the added weight of the aggregate. Even if a thin layer of plant aggregate could be established on the fine tailings, the differential settlement would likely expose other fine tailings, rendering the cover ineffective. Based on this scenario, placing plant aggregate cover over the entire pond bottom is not part of the current plan.

6.0 Summary

6.1 Objectives of Operations Plan

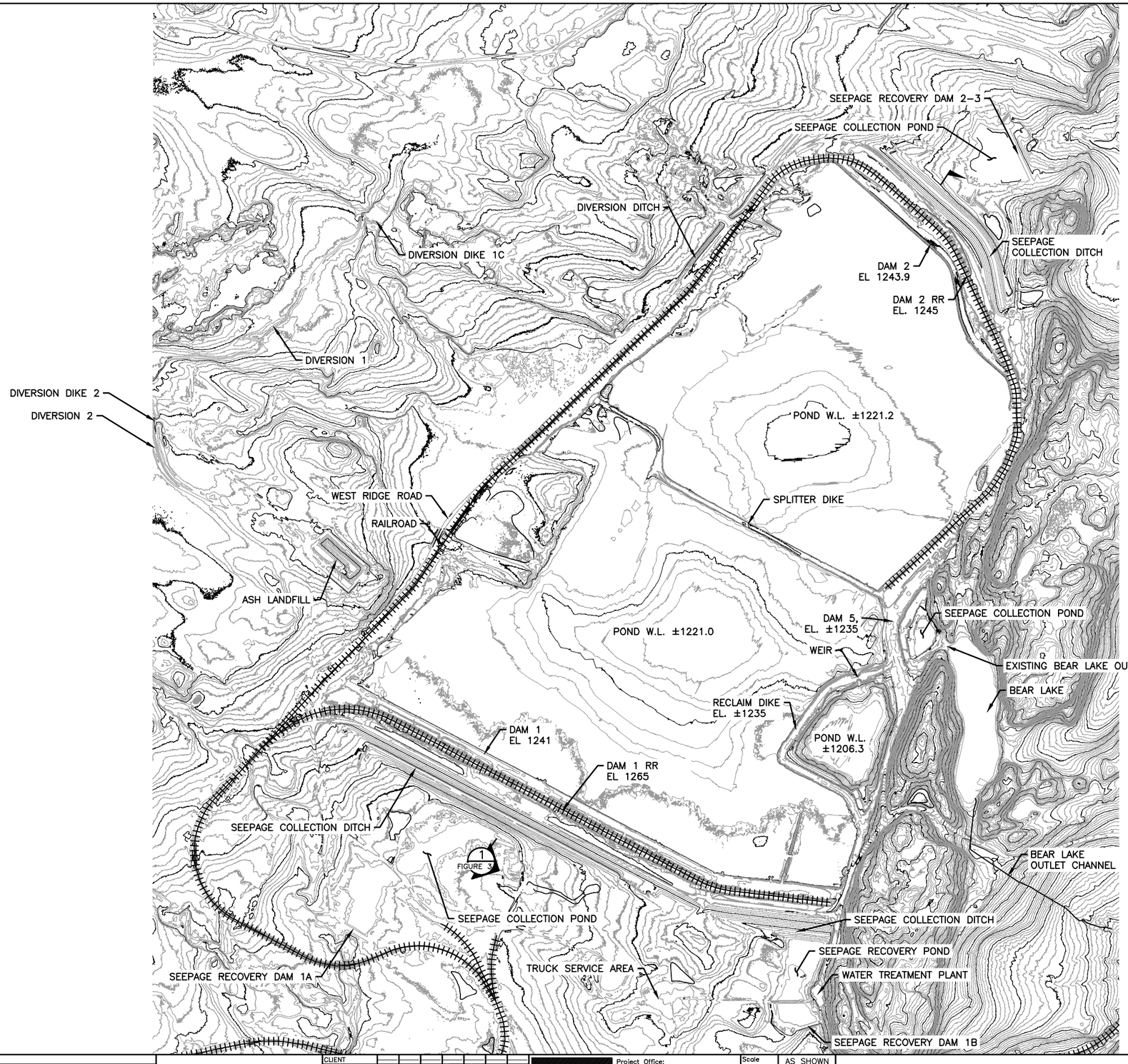
The proposed operations plan is intended to meet the following major objectives:

1. Providing storage of all fine tailings in the basin with special emphasis on supplementing the fine tailings blankets upstream of Dams 1 and 2 as a normal, ongoing practice of tailings discharge for sealing the dams and the bottom of the pond. Raising all dams, as necessary, to maintain adequate freeboard to contain the PMP. Dam construction will include dam stability and safety considerations addressed during the design process.
2. Managing plant aggregate material for dam construction and stockpiling for basin closure.
3. Controlling the basin water level and volume by diverting runoff away from the basin, discharging water from the basin (via water treatment plant and discharge to the Beaver River), and managing net plant water.
4. Controlling dust from the fine tailing beaches in the basin through the use of super cell beaches and vegetation.
5. Raising and/or relocating the railroad grades on Dams 1, 2, and 5.
6. Planning for the ultimate railroad configuration along the western side of the basin.
7. Performing basin reclamation as appropriate during operations to minimize activities required for closure.

6.2 General Considerations, 2019 through 2023

The analyses show that the dams, if constructed as proposed and shown in Table 2 will provide adequate freeboard for normal variations in precipitation and the PMP flood event. The dam safety inspection, along with the ongoing testing, instrumentation, and stability analyses, will continue to demonstrate reliable dam design. The ongoing approach for the dams is to prepare plans and specifications for construction along with construction inspection to verify that the dams are constructed as designed and within acceptable margins of safety. The ongoing evaluations of the long-range plan for dam construction including slopes, access routes and West Ridge Railroad alignments, material delivery, and material stockpiling, will occur during this Operations Plan to provide long-term guidance for operations of the facility. The plans presented in this report will provide the basis for the final details of the plan. Treated water will continue to be discharged from the basin to Beaver River to allow for control of water levels within the basin.

Figures



TAILING BASIN CONTROL DATA

BASIN CONTROL

NUMBER	NAME	NORTHING	EASTING	ELEVATION
9	HV-9	621587.4510	3048856.4250	1308.69
11	HV-11	620725.2580	3059623.2150	1201.82
16	HV-16	615676.6820	3054865.0750	1214.85

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY QUANTUM SPATIAL OF LEXINGTON KENTUCKY COMBINED WITH BATHYMETRY BY BARR ENGINEERING. LIDAR COMPLETED APRIL 21, 2017. BATHYMETRY COMPLETED JUNE 6, 2018. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

0 1000 2000
SCALE IN FEET

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

CLIENT
BID
CONSTRUCTION
RELEASED TO/FOR: A B C 0 1 2 3
DATE RELEASED

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	8/21/2018
Drawn	GSJ
Checked	ATG
Designed	
Approved	

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

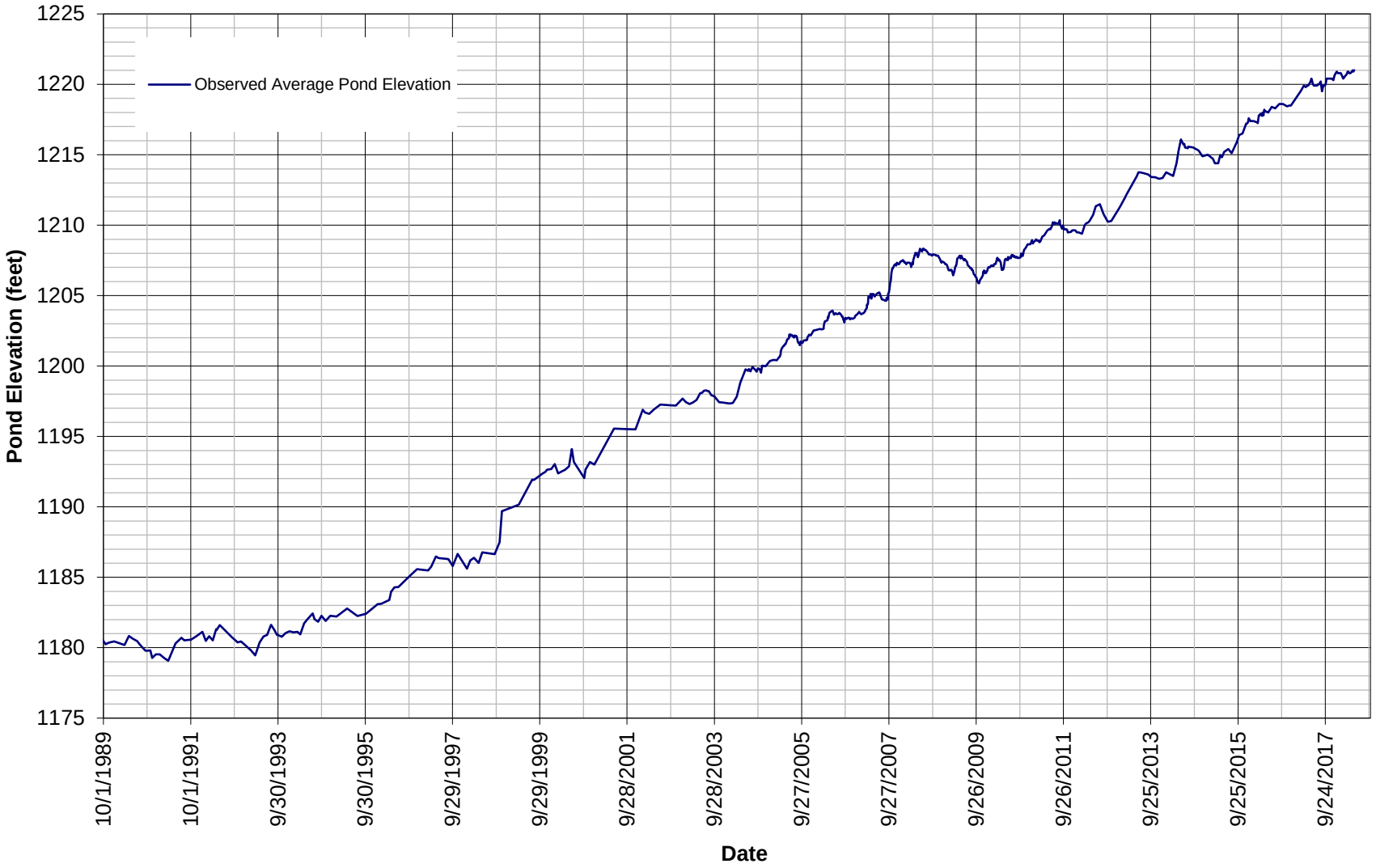
MP-7 TAILINGS BASIN
SILVER BAY, MINNESOTA

FIVE YEAR OPERATING PLAN
2018 BASIN CONDITIONS

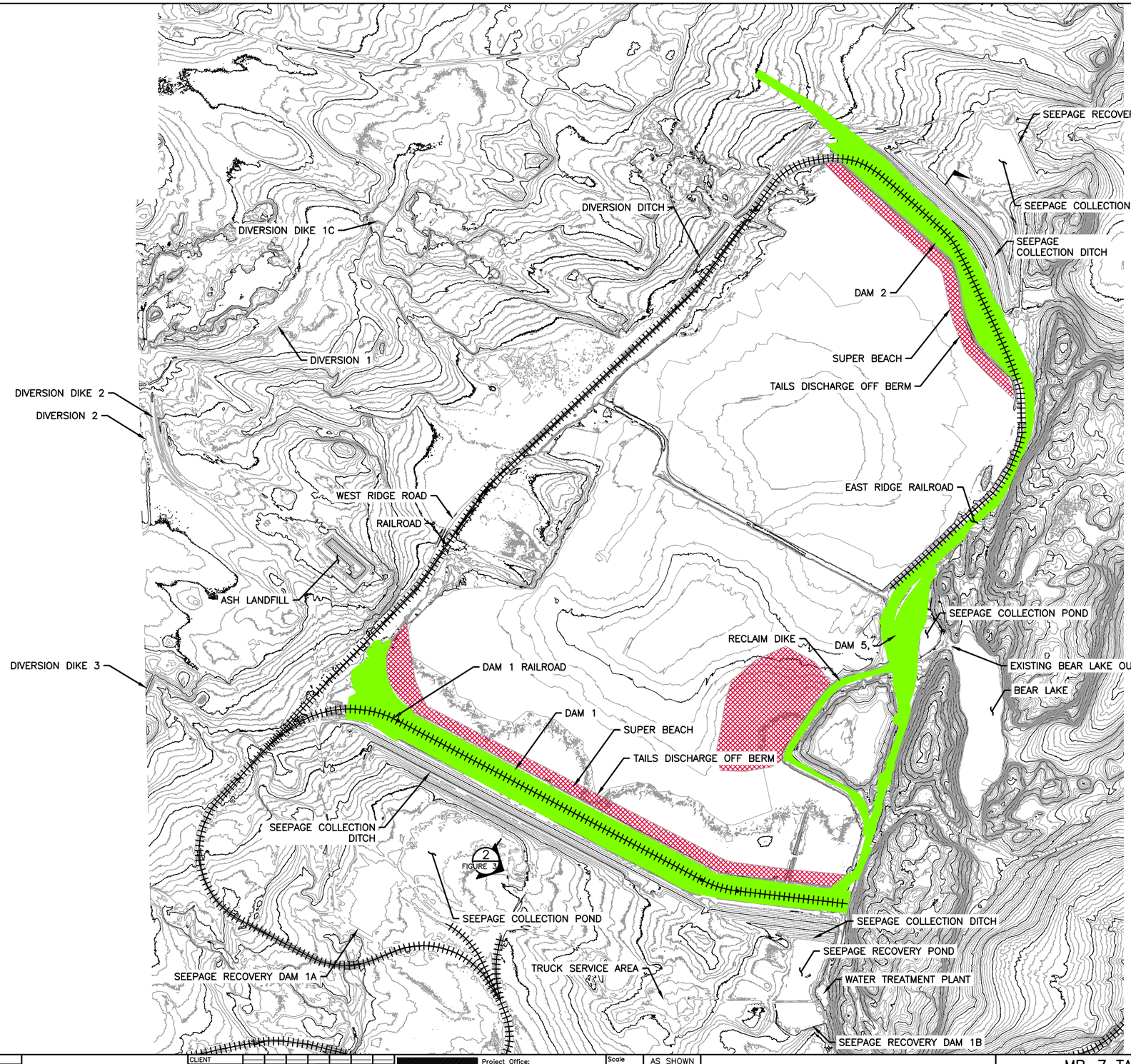
BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. FIGURE 1
REV. No. A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086 5YR_2018 OP_FIGURE 1.DWG PLOT SCALE: 1:2 PLOT DATE: 1/2/2019 7:48 AM
Images In Drawing - K:\Design\23380086.00\NORTH_SHORE_APRIL12.tif 12/03/2013 14:25:41
GSJ K:\Design\23380086.00\23380086 5YR_OP_Figure 1.dwg Plot at 100

Figure 2: MP7 Tailings Basin Pond Elevation
1989-2018 Historical Data



P:\Mpls\23 MN\38\2338086\WorkFiles\2018_Work\5Y18\5YOP\pond levels.xlsx



2019–2023 CONSTRUCTION

1. RAISE DAMS 1, 1W, 2, AND 5.
2. CONSTRUCT RAILROAD GRADES ON DAM 1, 2, 5, AND EAST RIDGE ROAD.
3. RAISE RECLAIM DAM.

0 1000 2000
SCALE IN FEET

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

	A	B	C	0	1	2	3
CLIENT							
BID							
CONSTRUCTION							
RELEASED TO/FOR							
DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	9/04/2018
Drawn	GSJ
Checked	ATG
Designed	
Approved	

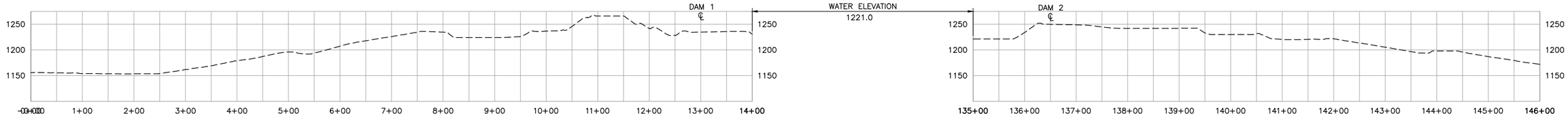
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MP-7 TAILINGS BASIN
SILVER BAY, MINNESOTA

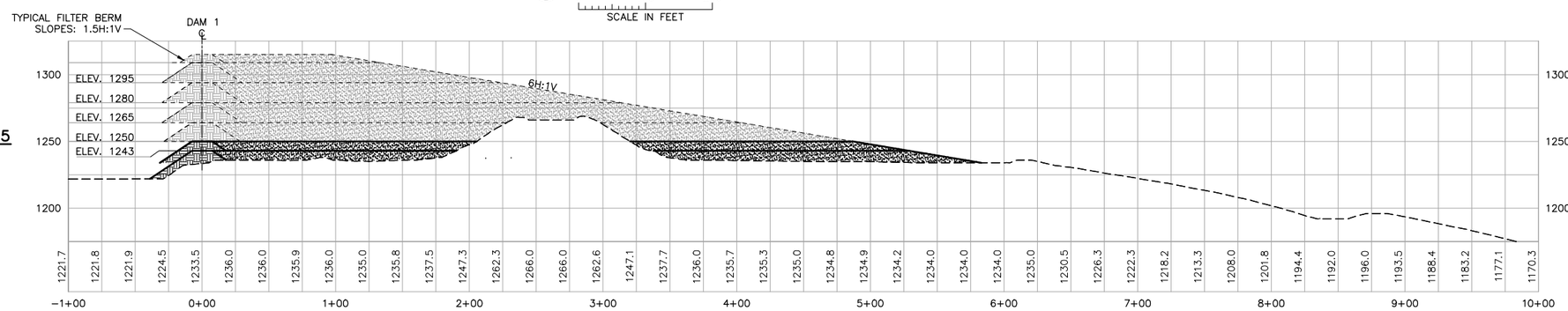
FIVE YEAR OPERATING PLAN
PROPOSED CONSTRUCTION 2019–2023

BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. FIGURE 3
REV. No. A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086 5YR_2018 OP_FIGURE 3.DWG PLOT SCALE: 1:2 PLOT DATE: 12/11/2018 9:00 AM
BAR M:\AutoCAD 2011\AutoCAD 2011 Support\enu\Template\Barr_2011_Template.dwt Plot at 1 10/05/2010 14:03:50



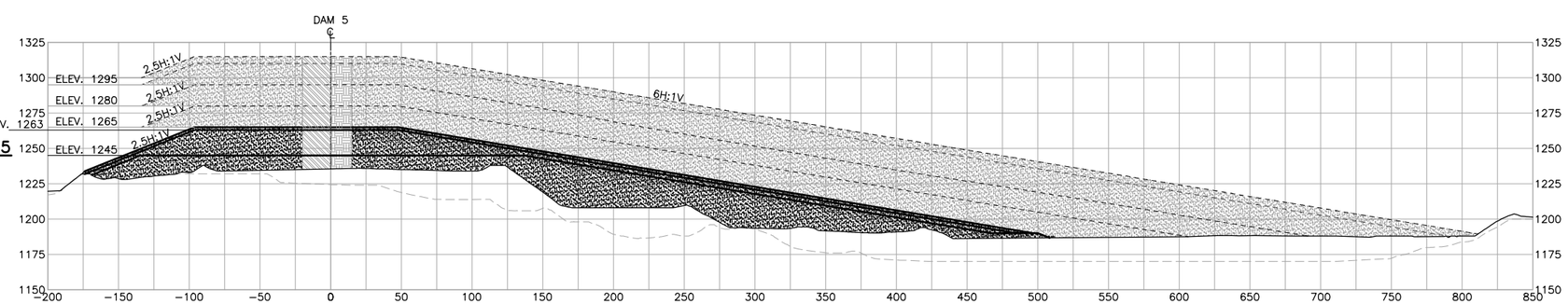
1 SECTION: EXISTING BASIN
FIGURE 1
0 100 200
SCALE IN FEET



2 SECTION: DAM 1 RAISE TO EL. 1315
FIGURE 2
0 50 100
SCALE IN FEET

3 SECTION: DAM 2 RAISE TO EL. 1315
FIGURE 2
0 50 100
SCALE IN FEET

LEGEND:
- PLANT AGGREGATE
- FILTER
- GLACIAL TILL CORE



4 SECTION: DAM 5 RAISE TO EL. 1315
FIGURE 2
0 50 100
SCALE IN FEET

DAM RAISES SHOWN ARE CONCEPTUAL. ACTUAL RAISE HEIGHT MAY VARY AND WILL BE ADDRESSED DURING DESIGN PHASE.

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

CLIENT / BID / CONSTRUCTION

RELEASED TO/FOR: A B C 0 1 2 3

DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1−800−632−2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1−800−225−1966
Fax: (218) 262−3460
www.barr.com

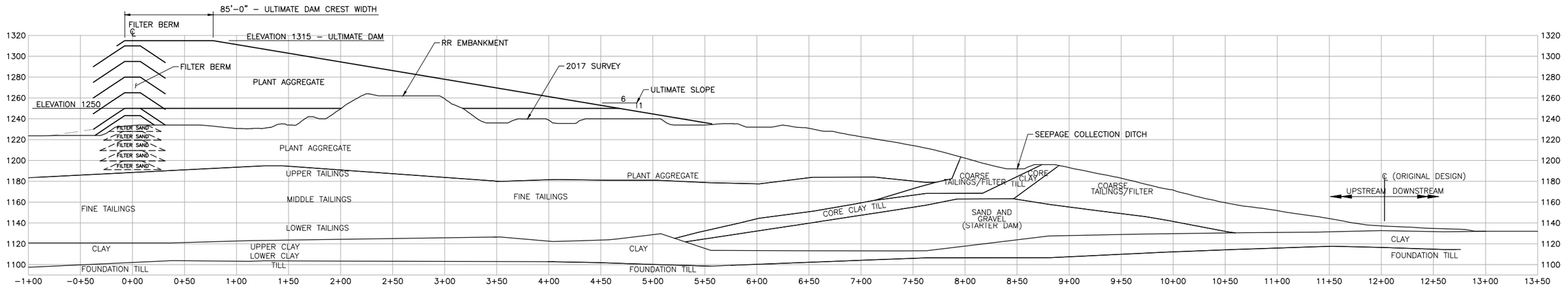
Scale	AS SHOWN
Date	9/04/2018
Drawn	GSJ
Checked	ATG
Designed	
Approved	

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MP−7 TAILINGS BASIN
SILVER BAY, MINNESOTA

FIVE YEAR OPERATING PLAN
TYPICAL CROSS−SECTIONS

BARR PROJECT No. 23/38−086
CLIENT PROJECT No.
DWG. No. FIGURE 4
REV. No. A



1 SECTION: DAM 1 TYPICAL STRATIGRAPHY STATION 35+00

0 50 100
SCALE IN FEET

DAM RAISES SHOWN ARE CONCEPTUAL. ACTUAL RAISE HEIGHT MAY VARY AND WILL BE ADDRESSED DURIND DESIGN PHASE.

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

CLIENT / BID / CONSTRUCTION

RELEASED TO/FOR: A B C 0 1 2 3

DATE RELEASED

BARR

Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/19/2013
Drawn	GSJ
Checked	ATG
Designed	
Approved	

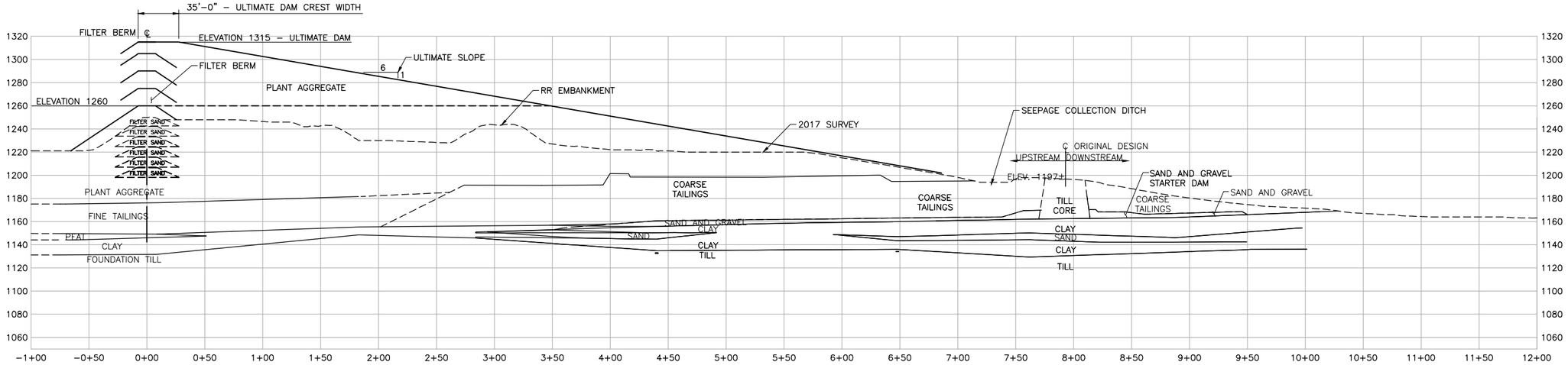
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MP-7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 1 CONCEPTUAL DAM RAISES
TYPICAL CROSS-SECTION

BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. FIGURE 5
REV. No. A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086 5YR_2018 OP_FIGURE 5.DWG PLOT SCALE: 1:2 PLOT DATE: 12/10/2018 10:10 AM
BAR M:\autocad 2006\template\barr_2006_template.dwt Plot at 0 07/27/2007 09:19:39



1 SECTION: DAM 2 TYPICAL STRATIGRAPHY STATION 41+95

0 50 100
SCALE IN FEET

DAM RAISES SHOWN ARE CONCEPTUAL. ACTUAL RAISE HEIGHT MAY VARY AND WILL BE ADDRESSED DURIND DESIGN PHASE.

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

CLIENT
BID
CONSTRUCTION
RELEASED TO/FOR: A B C 0 1 2 3
DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/19/2013
Drawn	GSJ
Checked	ATG
Designed	
Approved	

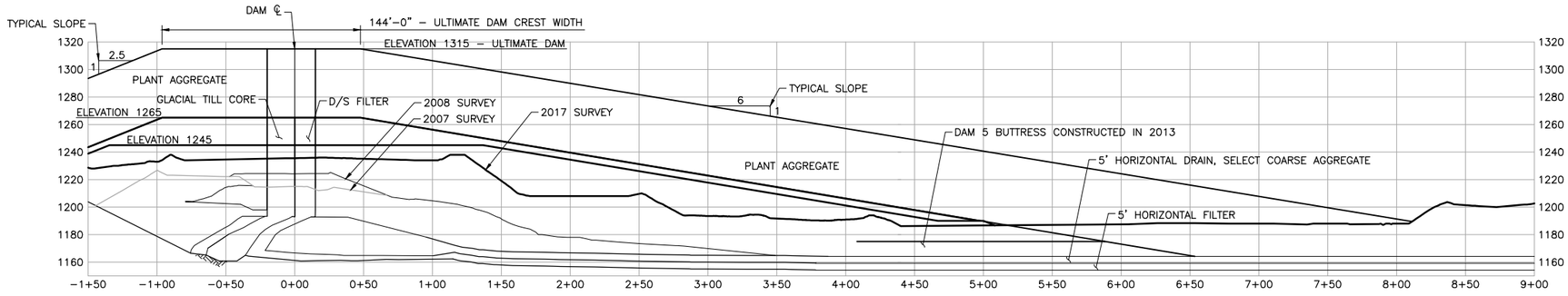
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MP-7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 2 CONCEPTUAL DAM RAISES
TYPICAL CROSS-SECTION

BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. FIGURE 6
REV. No. A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086 SYR_2018 OP_FIGURE 6.DWG PLOT SCALE: 1:2 PLOT DATE: 12/10/2018 10:19 AM
BAR M:\autocad 2006\template\barr_2006_template.dwt Plot at 0 07/27/2007 09:19:39



1 SECTION: DAM 5 TYPICAL STRATIGRAPHY STATION 14+00

0 50 100
SCALE IN FEET

DAM RAISES SHOWN ARE CONCEPTUAL. ACTUAL RAISE HEIGHT MAY VARY AND WILL BE ADDRESSED DURIND DESIGN PHASE.

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

CLIENT	12/12							
BID								
CONSTRUCTION								
RELEASED TO/FOR	A	B	C	0	1	2	3	
DATE RELEASED								

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1–800–632–2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

Scale	AS SHOWN
Date	6/19/2013
Drawn	GSJ
Checked	ATG
Designed	
Approved	

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MP–7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 5 CONCEPTUAL DAM RAISES
TYPICAL CROSS–SECTION

BARR PROJECT No. 23/38–086
CLIENT PROJECT No.
DWG. No. FIGURE 7
REV. No. A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086 5YR_2018 OP_FIGURE 7.DWG PLOT SCALE: 1:2 PLOT DATE: 12/10/2018 10:35 AM
BAR M:\autocad 2006\template\barr_2006_template.dwt Plot at 0 07/27/2007 09:19:39

Appendices

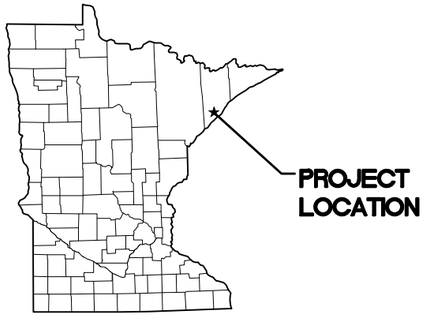
Appendix A

Recent Construction Plans

Dam 1
Dam 2
Dam 5
Reclaim Dam

Dam 1

NORTHSHORE MINING COMPANY
DAM 1 RAISE - ELEVATION 1246



LOCATION MAP

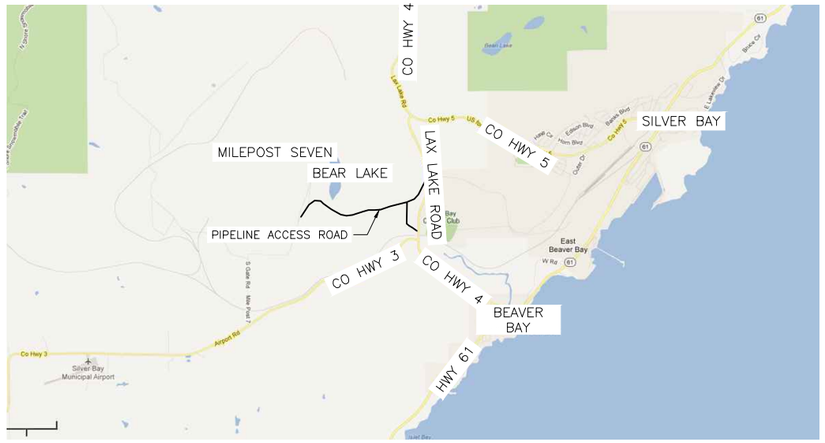
TAILING BASIN CONTROL DATA

BASIN CONTROL

NUMBER	NAME	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	~~HV-1~~	~~633317.4670~~	~~3058535.4610~~	~~1260.50~~	ELEVATION SHOT (NOT SHOWN)
2	~~HV-2~~	~~630988.2460~~	~~3062756.9580~~		LOST
3	~~HV-3~~	~~629237.6030~~	~~3059025.7570~~	~~1279.45~~	
4	~~HV-4~~	~~628860.3920~~	~~3065021.5920~~	~~1074.08~~	RESET
5	~~HV-5~~	~~627118.3550~~	~~3053032.4500~~	~~1282.36~~	
6	~~HV-6~~	~~626869.8220~~	~~3056117.4250~~	~~1203.84~~	1203.45
7	~~HV-7~~	~~626556.9590~~	~~3063987.7860~~		
8	~~HV-8~~	~~624210.9990~~	~~3060731.2050~~		LOST
9	HV-9	621587.4510	3048856.4250	1308.69	
10	~~HV-10~~	~~622144.3200~~	~~3052628.5600~~	~~1203.48~~	
11	HV-11	620725.2580	3059623.2150	1201.82	
12	~~HV-12~~	~~623264.1010~~	~~3066683.2400~~		
13	~~HV-13~~	~~621973.5000~~	~~3064939.1690~~		
14	~~HV-14~~	~~618769.1630~~	~~3047140.9480~~	~~1236.61~~	
15	~~HV-15~~	~~617984.6850~~	~~3051180.5900~~	~~1217.50~~	
16	HV-16	615676.6820	3054865.0750	1214.85	
17	~~HV-17~~	~~616947.0370~~	~~3061729.9260~~		
18	~~HV-18~~	~~613041.6280~~	~~3048880.1880~~		
19	~~HV-19~~	~~613756.3770~~	~~3057456.3040~~	~~1180.18~~	REVISED COORDS
20	~~HV-20~~	~~607757.4790~~	~~3039041.8880~~		
21	~~HV-21~~	~~607307.4110~~	~~3042001.3040~~		
22	~~HV-22~~	~~611828.6780~~	~~3051567.0600~~		
23	~~HV-23~~	~~611930.4590~~	~~3051899.1130~~		
24	~~HV-24~~	~~609360.0970~~	~~3054733.1200~~		
25	~~HV-25~~	~~616650.4460~~	~~3055689.9480~~	~~1214.00~~	
26	~~HV-26~~	~~619946.4520~~	~~3049228.7120~~	~~1215.50~~	
27	~~HV-27~~	~~628900.5960~~	~~3058511.1370~~	~~1206.44~~	LOST
28	~~HV-28~~	~~625548.7060~~	~~3061033.2610~~	~~1209.95~~	LOST
29	~~HV-29~~	~~621441.3880~~	~~3058790.1490~~		LOST
30	~~MON #1~~	~~615561.7414~~	~~3049384.3056~~	~~1137.13~~	MON #1=BM 109
31	~~M1A~~	~~615029.2024~~	~~3049048.4111~~	~~1134.05~~	
32	~~M1B~~	~~615035.1445~~	~~3049035.4817~~	~~1134.20~~	
33	~~M13A~~	~~615183.2566~~	~~3048762.1013~~	~~1119.42~~	
34	~~M13~~	~~615178.2094~~	~~3048749.5361~~	~~1119.37~~	
35	~~M2~~	~~617991.2396~~	~~3048112.8961~~	~~1194.44~~	
36	~~MON #2~~	~~619103.5816~~	~~3047292.2067~~	~~1246.02~~	MON #2=BM 113
37	~~M10~~	~~619447.1477~~	~~3047003.5273~~	~~1268.41~~	
38	~~M10A~~	~~619438.8907~~	~~3046983.8117~~	~~1268.50~~	
39	~~HV-39~~	~~624916.4170~~	~~3061133.3300~~	~~1221.53~~	
40	~~HV-40~~	~~631187.5960~~	~~3062978.2150~~	~~1156.20~~	PIN MARKED 302
41	~~HV-41~~	~~630131.8310~~	~~3061017.3930~~	~~1157.87~~	
42	~~HV-42~~	~~630093.3420~~	~~3058663.2790~~	~~1215.48~~	
43	~~HV-43~~	~~632342.8920~~	~~3045529.2660~~	~~1436.99~~	WEST ACCESS ROAD (NOT SHOWN)

NOTE:
NOT ALL CONTROL POINTS ARE SHOWN ON SITE PLAN

INDEX OF SHEETS



0 1000 2000
SCALE IN FEET

ISSUED FOR CONSTRUCTION 5/28/2014

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 5/28/2014 REG. NO. 47103

	A	B	C	0	1	2	3
CLIENT				5/28/14			
BID							
CONSTRUCTION				5/28/14			

RELEASED TO/FOR — DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	04/01/2013
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

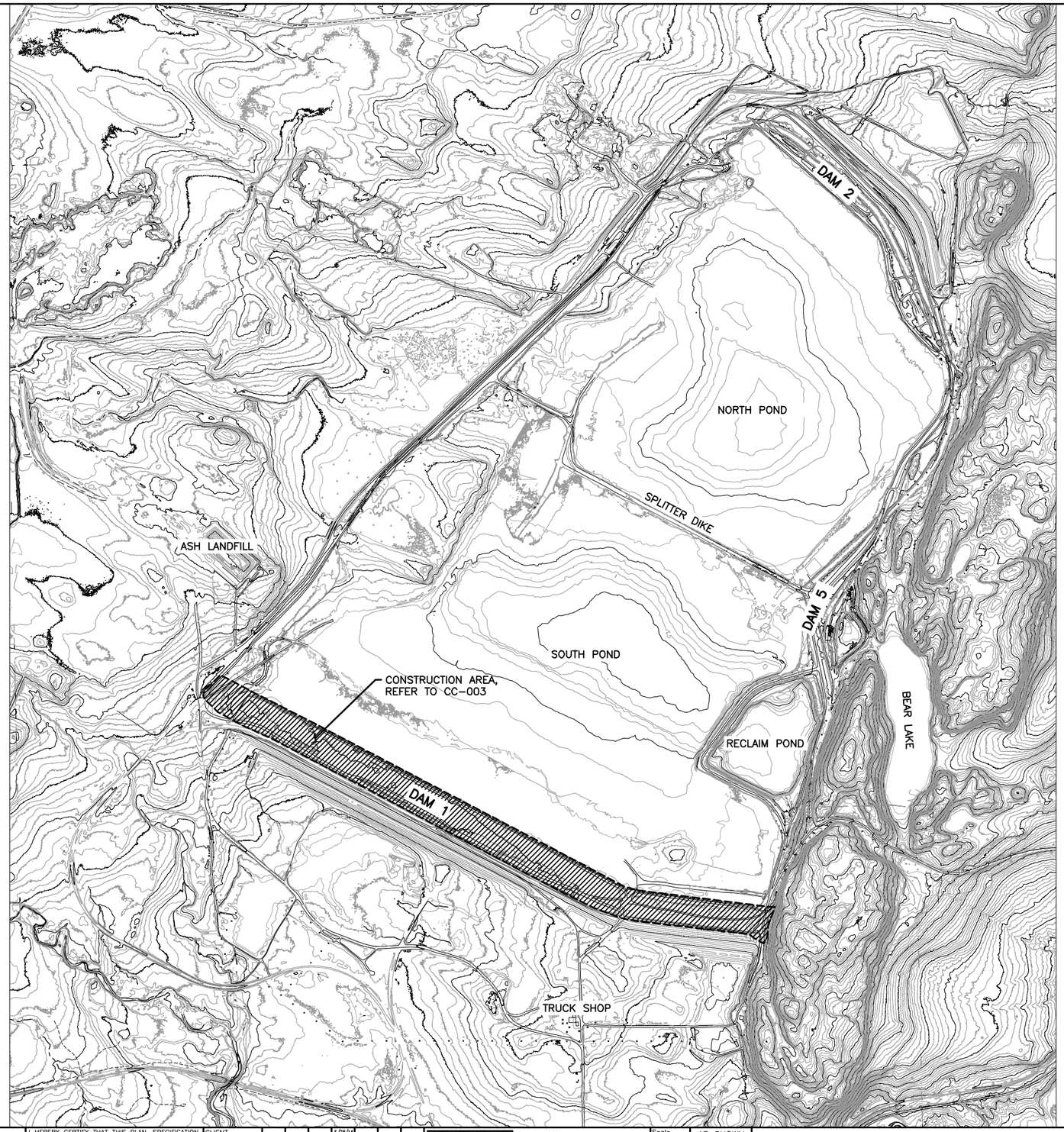
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2014 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

DAM 1 RAISE – ELEVATION 1246
TITLE SHEET, SITE PLAN, AND SHEET INDEX

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-001
REV. No. 0

CADD USER: Randy Wilson FILE: D-SIZE-BARR_2011_TEMPLATE.DWG PLOT SCALE: 1:1 PLOT DATE: 6/12/2008 3:47 PM
Images in Drawing - K:\Design\23380086.00\local map.tif C:\Users\grs\Desktop\SLL Signature.jpg
GSJ K:\Design\23380086.00\23380086 Dam 1_CC-001.dwg Plot at 20 05/28/2014 14:59:04



LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM AERIAL SURVEY BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 12, 2012. AERO-METRIC MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.

1 PLAN: VICINITY MAP

ISSUED FOR CONSTRUCTION 5/28/2014

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 5/28/2014 REG. NO. 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT				5/28/14			
BID							
CONSTRUCTION				5/28/14			
DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	04/01/2013
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

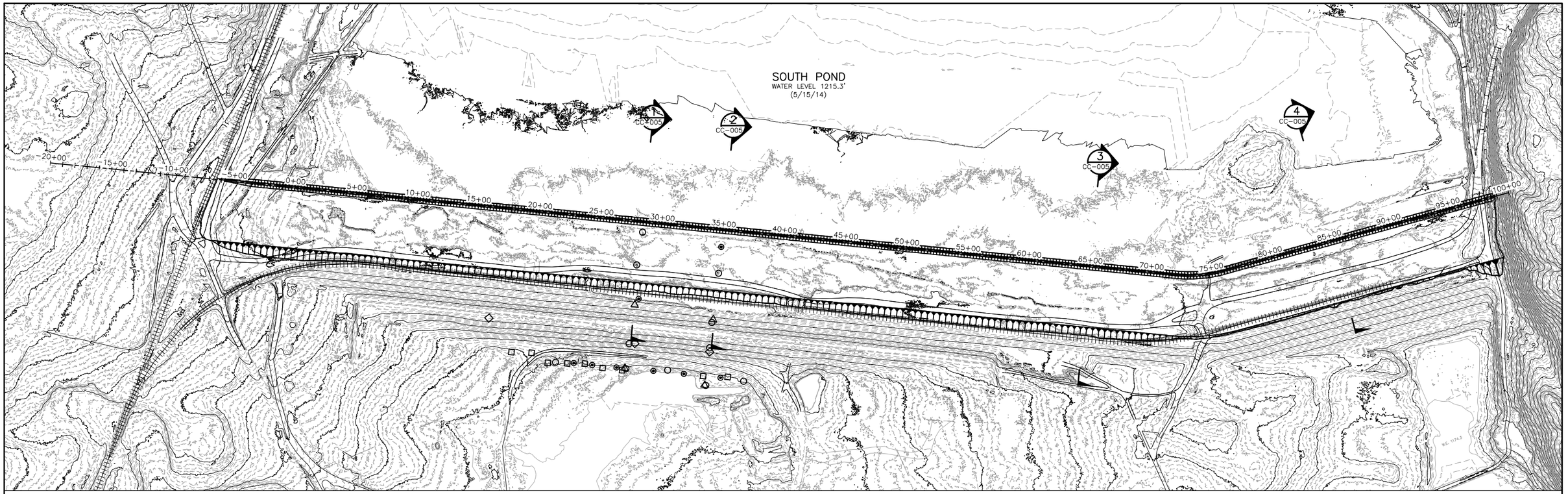
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2014 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN
DAM 1 RAISE – ELEVATION 1246
CONSTRUCTION LOCATION MAP

BARR PROJECT No.	CLIENT PROJECT No.
23380086	

DWG. No.	REV. No.
CC-002	0

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086 DAM 1_CC-002.DWG PLOT SCALE: 1:2 PLOT DATE: 5/28/2014 2:52 PM
GSJ K:\Design\23380086.00\23380086 Dam 1_CC-002.dwg Plot at 10 02/17/2014 09:38:01



LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM AERIAL LIDAR SURVEY BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN. DATE OF AERIAL LIDAR SURVEY APRIL 12, 2012. MAPPING BASED ON THE FOLLOWING DATUM:

-VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.

-HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

1 PLAN: DAM 1

0 400 800
SCALE IN FEET

LEGEND:

- CASAGRANDE PIEZOMETER
- PNEUMATIC PIEZOMETER
- VIBRATING WIRE PIEZOMETER
- INCLINOMETER
- RELIEF WELL

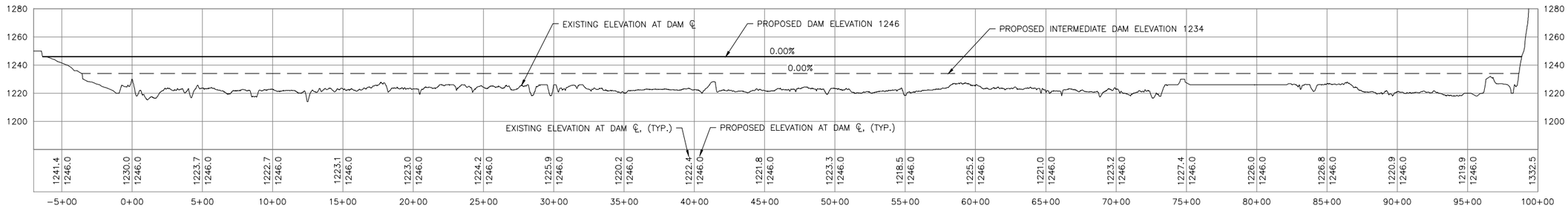
GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.

2. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF THE SURVEY.

3. PROTECT TAILINGS PIPE DURING CONSTRUCTION ACTIVITIES.

4. PROVIDE, PLACE, AND COMPACT MATERIALS IN DAMS IN GENERAL ACCORDANCE WITH MATERIALS AND METHODOLOGIES DESCRIBED IN UPDATE OF ENGINEERING DESIGN FOR THE RESERVE MINING COMPANY ON-LAND TAILINGS DISPOSAL, MAY 1985, AND DISCUSSED IN THE MEMO TITLED "2014 DAM 1 RAISE CONSTRUCTION RECOMMENDATIONS" DATED 5/28/2014 AND DESCRIBED IN BARR REPORT TITLED "DAM 1 STABILITY EVALUATION, DAM 1 CREST ELEVATION 1245 FEET" DATED SEPTEMBER 2013.



1 PROFILE: DAM 1

HORIZONTAL SCALE: 0 400 800 SCALE IN FEET

VERTICAL SCALE: 0 40 80 SCALE IN FEET

ISSUED FOR CONSTRUCTION 5/28/2014

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 5/28/2014 REG. NO. 47103

RELEASED TO/FOR: CLIENT, BID, CONSTRUCTION

DATE RELEASED: A 5/28/14; B; C; 0; 1; 2; 3 5/28/2014

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

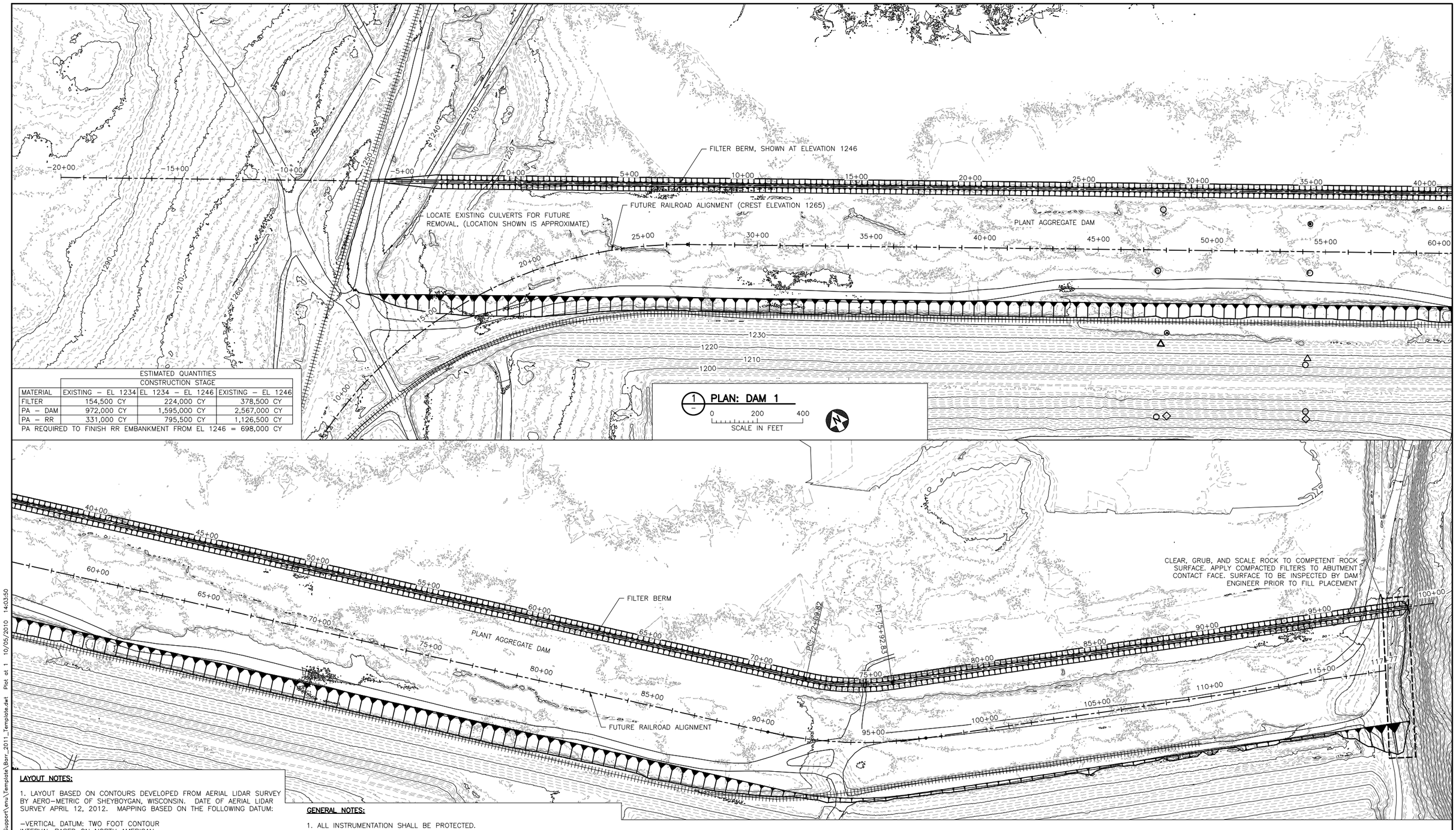
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	04/01/2013
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2014 PROPOSED DAM CONTRUCTION
MILEPOST SEVEN TAILINGS BASIN, DAM 1
DAM 1 RAISE – ELEVATION 1246
EXISTING CONDITIONS PLAN AND PROFILE

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-003
REV. No. 0



ESTIMATED QUANTITIES			
	CONSTRUCTION STAGE		
MATERIAL	EXISTING – EL 1234	EL 1234 – EL 1246	EXISTING – EL 1246
FILTER	154,500 CY	224,000 CY	378,500 CY
PA – DAM	972,000 CY	1,595,000 CY	2,567,000 CY
PA – RR	331,000 CY	795,500 CY	1,126,500 CY

PA REQUIRED TO FINISH RR EMBANKMENT FROM EL 1246 = 698,000 CY

1 PLAN: DAM 1
0 200 400
SCALE IN FEET

2 PLAN: DAM 1
0 200 400
SCALE IN FEET

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM AERIAL LIDAR SURVEY BY AERO–METRIC OF SHEYBOYGAN, WISCONSIN. DATE OF AERIAL LIDAR SURVEY APRIL 12, 2012. MAPPING BASED ON THE FOLLOWING DATUM:

–VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.

–HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.

2. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF THE SURVEY. ESTIMATED CONSTRUCTION VOLUMES HAVE BEEN CALCULATED AGAINST 2012 CONDITIONS.

3. PROTECT TAILINGS PIPE DURING CONSTRUCTION ACTIVITIES.

ISSUED FOR CONSTRUCTION 5/28/2014

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 5/28/2014 REG. NO. 47103

CLIENT	5/28/14
BID	
CONSTRUCTION	5/28/14

RELEASED TO/FOR: A B C 0 1 2 3 — DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1–800–632–2277

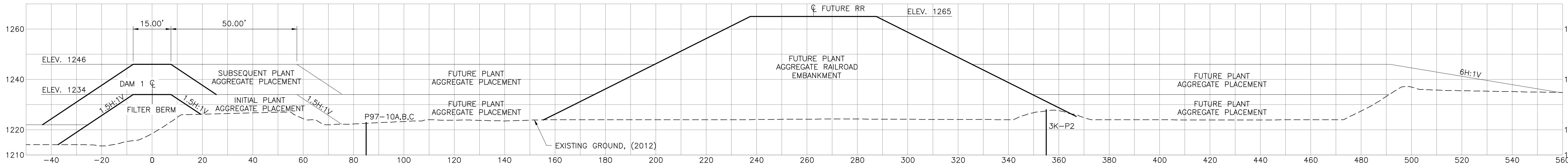
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

Scale	AS SHOWN
Date	04/01/2013
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

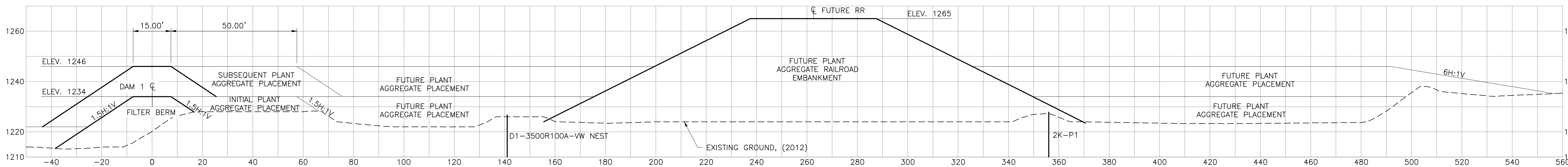
2014 PROPOSED DAM CONTRUCTION
MILEPOST SEVEN TAILINGS BASIN, DAM 1
DAM 1 RAISE – ELEVATION 1246 CONSTRUCTION PLAN

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC–004
REV. No. 0



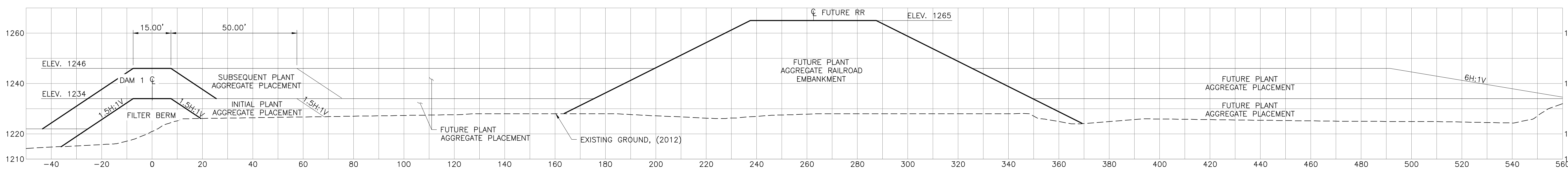
1 CC-003 **SECTION: STA 28+40**

0 20 40
SCALE IN FEET



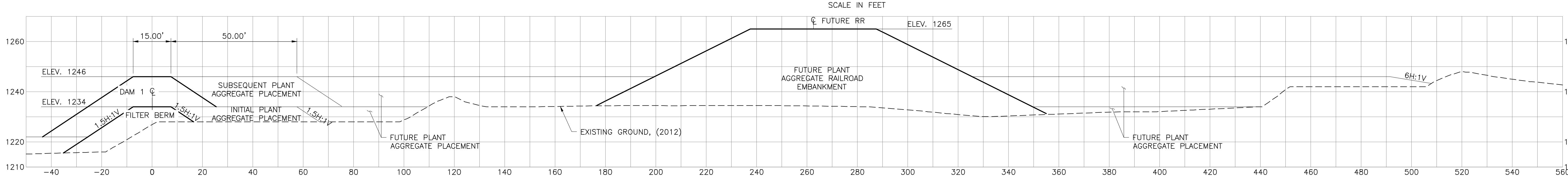
2 CC-003 **SECTION: STA 35+00**

0 20 40
SCALE IN FEET



3 CC-003 **SECTION: STA 65+00**

0 20 40
SCALE IN FEET



4 CC-003 **SECTION: STA 85+00**

0 20 40
SCALE IN FEET

GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.
2. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF THE SURVEY.
3. PROTECT TAILINGS PIPE DURING CONSTRUCTION ACTIVITIES.

ISSUED FOR CONSTRUCTION 5/28/2014

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 5/28/2014 REG. NO. 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT				5/28/14			
BID							
CONSTRUCTION				5/28/14			
	DATE RELEASED						

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	06/26/2013
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2014 PROPOSED DAM CONTRUCTION
MILEPOST SEVEN TAILINGS BASIN, DAM 1

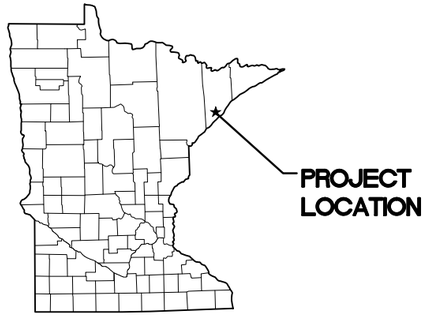
DAM 1 RAISE – ELEVATION 1246 SECTIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-005
REV. No. 0

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086 DAM 1_CC-005.DWG PLOT SCALE: 1:2 PLOT DATE: 5/28/2014 3:20 PM
Xrefs in Drawing – K:\Design\23380086.00\23380086 MP7 Existing Planimetric.dwg K:\Design\23380086.00\20276_1.dwg
Images in Drawing – C:\Users\gsj\Desktop\SLL Signature.jpg
OSL K:\Design\23380086.00\23380086 Dam 1_CC-005.dwg Plot at 0 05/28/2014 14:33:16

Dam 2

NORTHSHORE MINING COMPANY
DAM 2 RAISE - ELEVATION 1248



LOCATION MAP

TAILING BASIN CONTROL DATA

BASIN CONTROL

NUMBER	NAME	NORTHING	EASTING	ELEVATION
1	HV-9	621587.4510	3048856.4250	1308.69
2	HV-11	620725.2580	3059623.2150	1201.82
3	HV-16	615676.6820	3054865.0750	1214.85

INDEX OF SHEETS

0 1000 2000
SCALE IN FEET

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

	A	B	C	0	1	2	3
CLIENT					12/23	6/30	
BID							
CONSTRUCTION					12/23		

RELEASED TO/FOR — DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

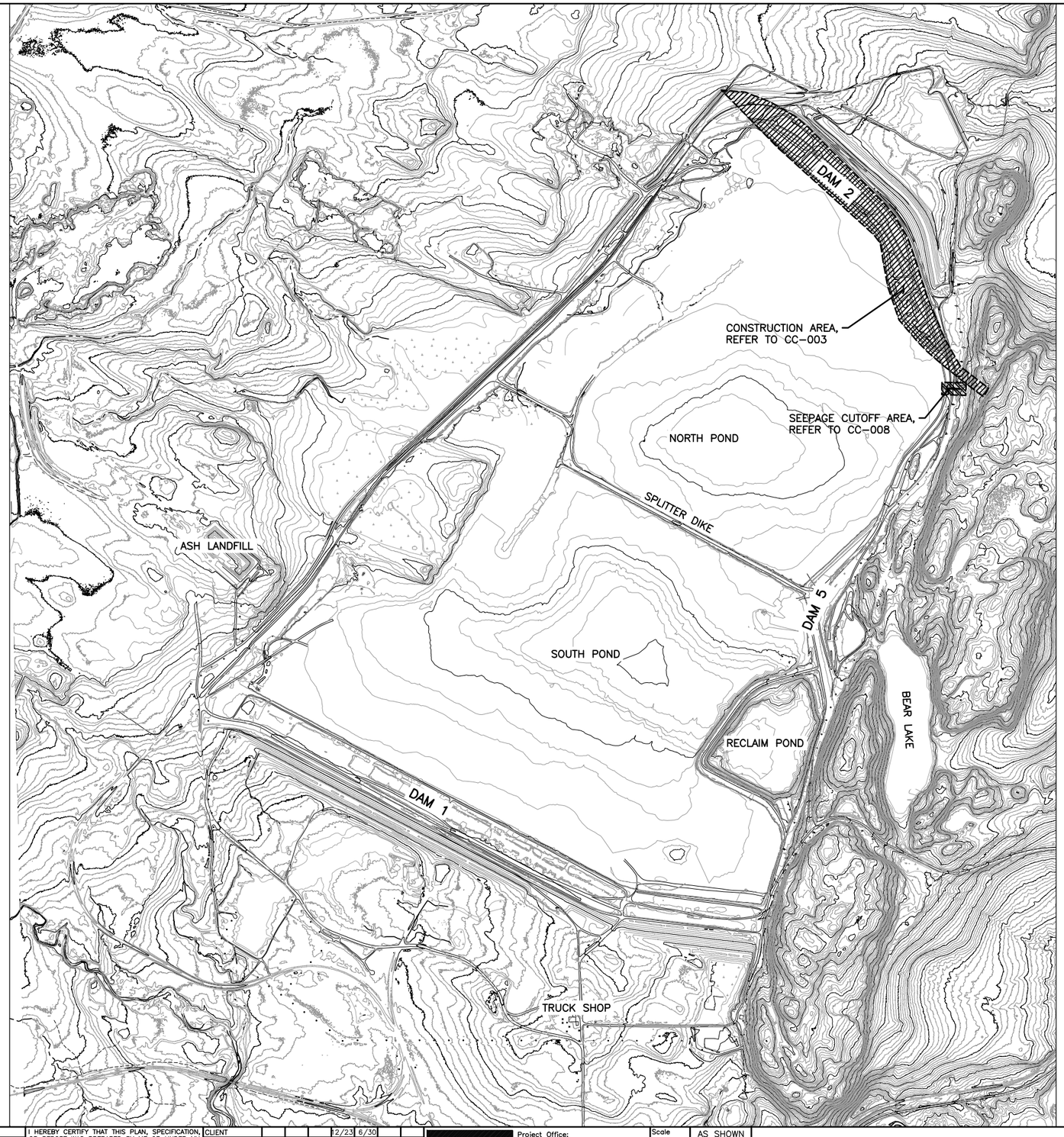
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

DAM 2 RAISE – ELEVATION 1248
TITLE SHEET, SITE PLAN, AND SHEET INDEX

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-001
REV. No. 1

Images in Drawing – K:\Design\23380086.00\local map.tif
gsj K:\Design\23380086.00\23380086 Dam 2_CC-001.dwg Plot at 20 12/03/2015 14:52:51



LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN COMBINED WITH BATHYMETRY BY BARR ENGINEERING. DATE OF LIDAR MAY, 2014. DATE OF BATHYMETRY MAY 15, 2015. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

1 PLAN: VICINITY MAP

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

	A	B	C	0	1	2	3
CLIENT				12/23	6/30		
BID							
CONSTRUCTION				12/23			
RELEASED TO/FOR	DATE RELEASED						

BARR

Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

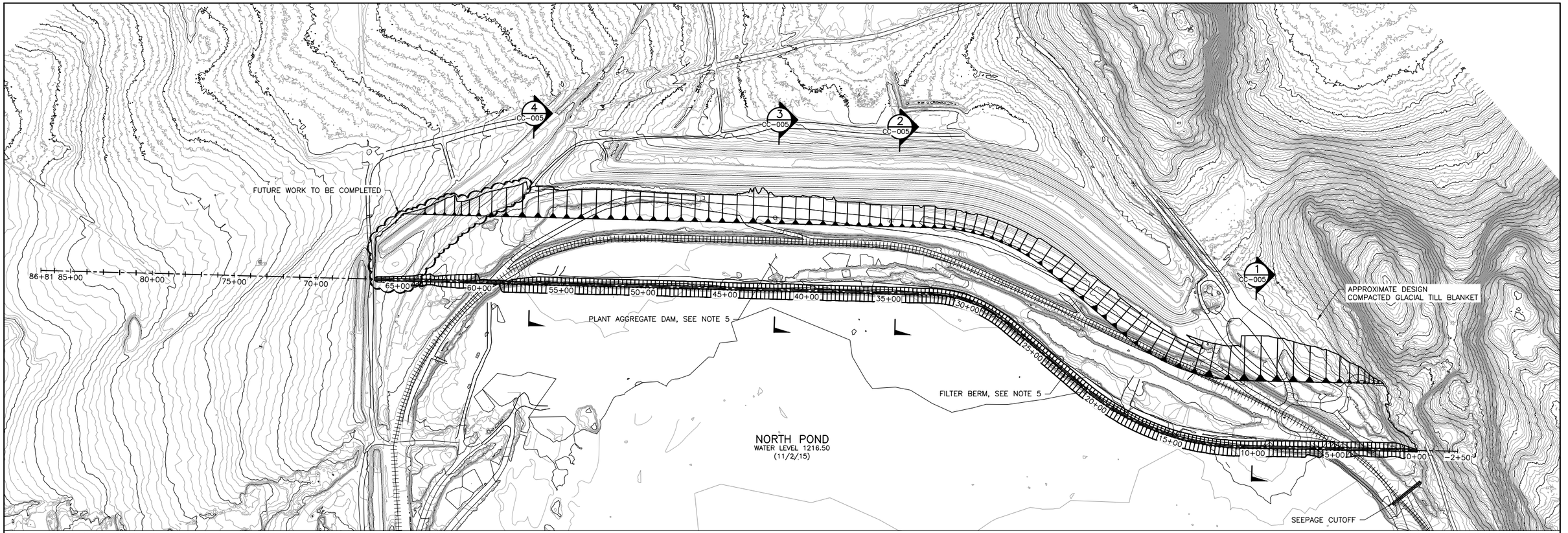
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

DAM 2 RAISE – ELEVATION 1248
CONSTRUCTION LOCATION MAP

BARR PROJECT No.	23380086
CLIENT PROJECT No.	
DWG. No.	CC-002
REV. No.	1

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086 DAM 2_CC-002.DWG PLOT SCALE: 1:2 PLOT DATE: 6/30/2016 12:15 PM
GSJ K:\Design\23380086.00\23380086 Dam 2_CC-002.dwg Plot at 10 05/06/2014 10:28:10



LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN COMBINED WITH BATHYMETRY BY BARR ENGINEERING. DATE OF LIDAR MAY, 2014. DATE OF BATHYMETRY MAY 15, 2015. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

1 PLAN: DAM 2

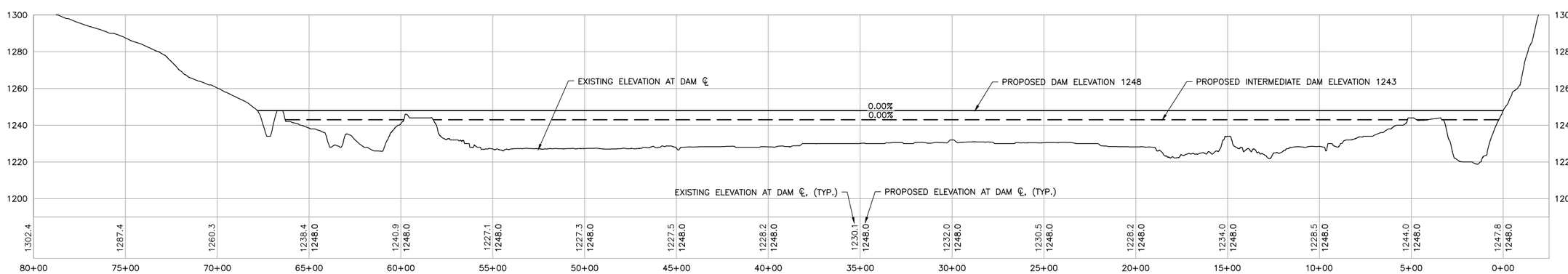
0 300 600
SCALE IN FEET

LEGEND:

- CASAGRANDE PIEZOMETER
- PNEUMATIC PIEZOMETER
- VIBRATING WIRE PIEZOMETER
- INCLINOMETER
- RELIEF WELL

GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.
2. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF THE SURVEY.
3. PROTECT TAILINGS PIPE DURING CONSTRUCTION ACTIVITIES.
4. PROVIDE, PLACE, AND COMPACT MATERIALS IN DAMS IN GENERAL ACCORDANCE WITH MATERIALS AND METHODOLOGIES DESCRIBED IN UPDATE OF ENGINEERING DESIGN FOR THE RESERVE MINING COMPANY ON-LAND TAILINGS DISPOSAL FACILITY, MAY 1985, DISCUSSED IN THE MEMO TITLED "DAM 2 RAISE CONSTRUCTION RECOMMENDATIONS," AND DESCRIBED IN THE BARR REPORT TITLED "DAM 2 STABILITY EVALUATION, DAM 2 CREST ELEVATION 1248 FEET."
5. DAM CONSTRUCTION SHOWN DEPICTS FULL DAM CONSTRUCTION EXTENTS TO ELEVATION 1248



1 PROFILE: DAM 2

HORIZONTAL SCALE: 0 300 600 SCALE IN FEET
VERTICAL SCALE: 0 30 60 SCALE IN FEET

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

	A	B	C	0	1	2	3
CLIENT				12/23	6/30		
BID							
CONSTRUCTION				12/23			
RELEASED TO/FOR	DATE RELEASED						

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

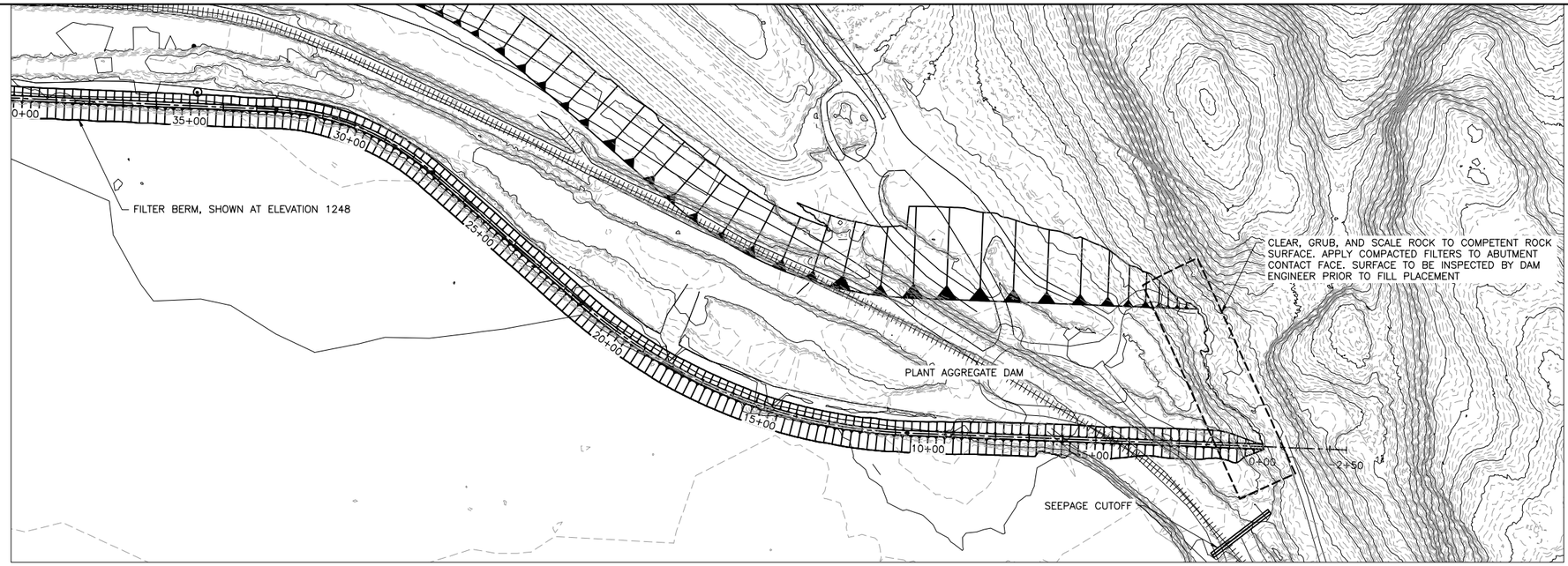
Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN, DAM 2
DAM 2 RAISE – ELEVATION 1248
EXISTING CONDITIONS PLAN AND PROFILE

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-003
REV. No. 1

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086 DAM 2_CC-003.DWG PLOT SCALE: 1:2 PLOT DATE: 6/30/2016 12:18 PM
Xrefs in Drawing - K:\Design\23380086.00\23380086 WP7 Existing Planimetric.dwg K:\Design\23380086.00\23380086_Dam 2 Elev 1248 Planimetric.dwg
GSJ K:\Design\23380086.00\23380086 Dam 2_CC-003.dwg Plot at 0 05/06/2014 10:19:05



1 PLAN: DAM 2

0 200 400

SCALE IN FEET

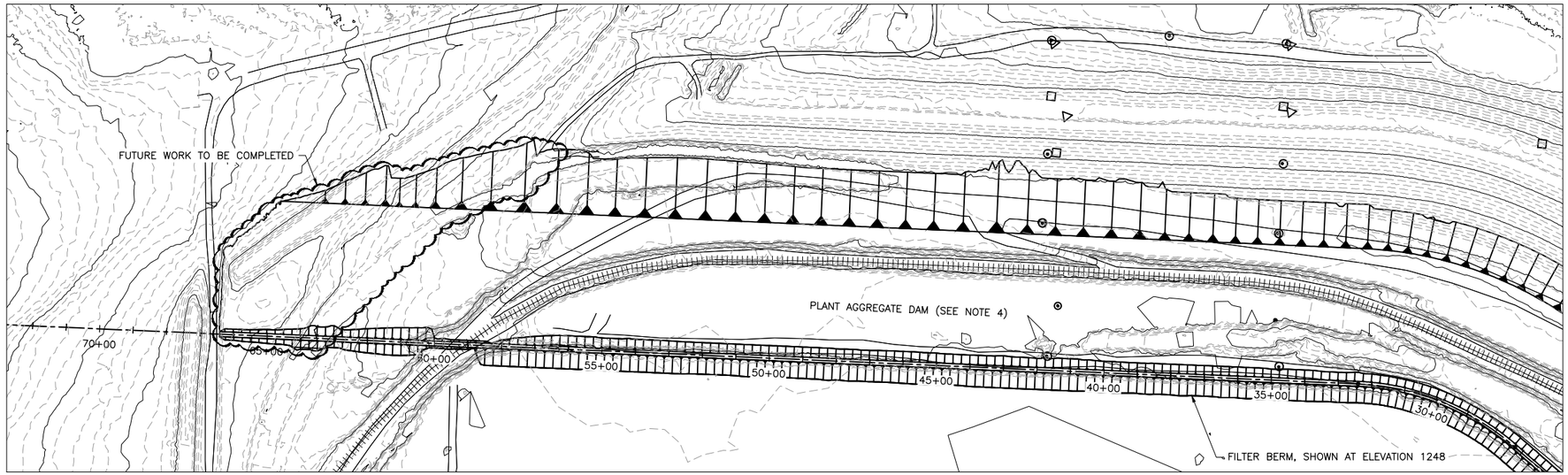
LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN COMBINED WITH BATHYMETRY BY BARR ENGINEERING. DATE OF LIDAR MAY, 2014. DATE OF BATHYMETRY MAY 15, 2015. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.
2. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF THE SURVEY. ESTIMATED CONSTRUCTION VOLUMES HAVE BEEN CALCULATED AGAINST 2014 CONDITIONS.
3. PROTECT TAILINGS PIPE DURING CONSTRUCTION ACTIVITIES.



2 PLAN: DAM 2

0 200 400

SCALE IN FEET

	ESTIMATED QUANTITIES	ESTIMATED QUANTITIES
MATERIAL	EXISTING – EL 1243	EL 1243 – EL 1248
FILTER	171,200 CY	105,000 CY
PA – DAM	1,900,000 CY	460,000 CY

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

	A	B	C	0	1	2	3
CLIENT				12/23	6/30		
BID							
CONSTRUCTION				12/23			

RELEASED TO/FOR — DATE RELEASED

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

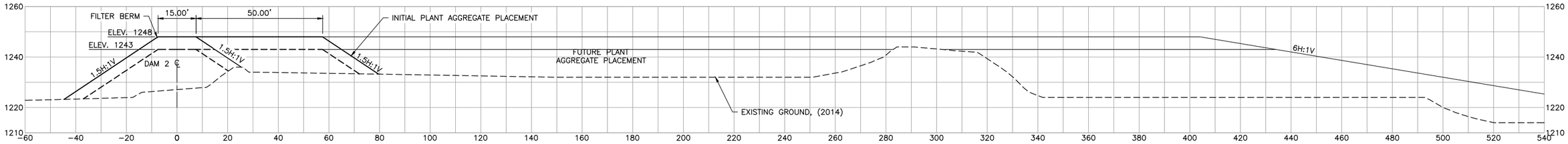
Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	ATG
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN, DAM 2
DAM 2 RAISE – ELEVATION 1248 CONSTRUCTION PLAN

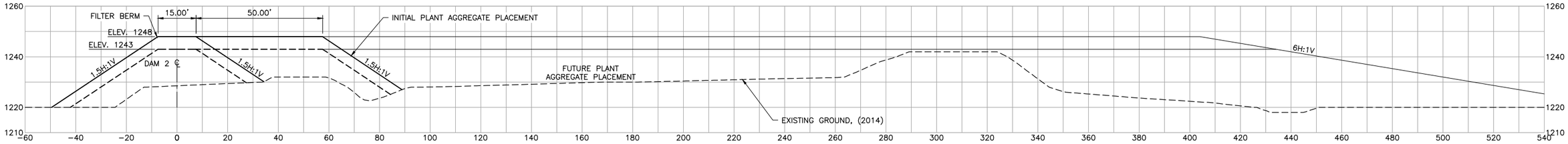
BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-004
REV. No. 1

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086 DAM 2_CC-004.DWG PLOT SCALE: 1:2 PLOT DATE: 6/30/2016 12:20 PM
Xrefs in Drawing – K:\Design\23380086.00\23380086 MP7 Existing Plan\metric.dwg K:\Design\23380086.00\20276_1.dwg K:\Design\23380086.00\23380086_Dam 2 Elev 1248 Planimetric.dwg
gsj K:\Design\23380086.00\23380086_Dam 2_CC-004.dwg Plot at 0 12/08/2015 10:21:02



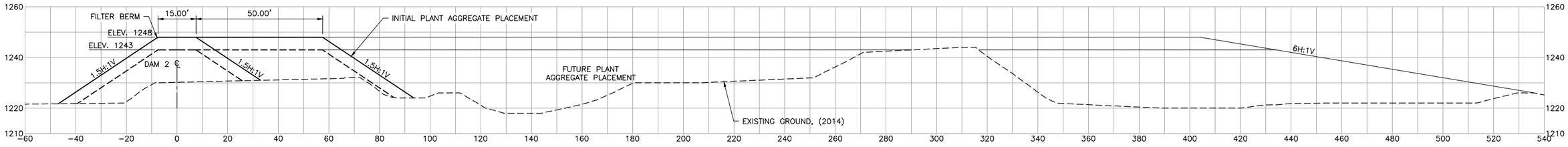
4 CC−003 **SECTION: STA 52+00**

0 20 40
SCALE IN FEET



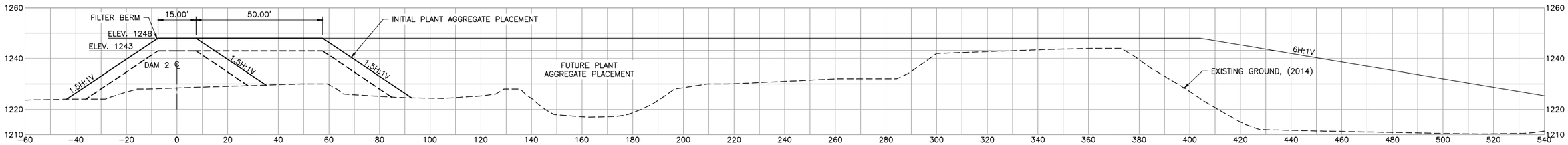
3 CC−003 **SECTION: STA 42+00**

0 20 40
SCALE IN FEET



2 CC−003 **SECTION: STA 34+75**

0 20 40
SCALE IN FEET



1 CC−003 **SECTION: STA 10+00**

0 20 40
SCALE IN FEET

GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.

2. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF THE SURVEY. ESTIMATED CONSTRUCTION VOLUMES SHOWN ON CC−004 HAVE BEEN CALCULATED AGAINST 2014 CONDITIONS.

3. PROTECT TAILINGS PIPE DURING CONSTRUCTION ACTIVITIES.

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

	A	B	C	0	1	2	3
CLIENT				12/23	6/30		
BID							
CONSTRUCTION				12/23			

RELEASED TO/FOR — DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1−800−632−2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1−800−225−1966
Fax: (218) 262−3460
www.barr.com

Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	SLL
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONTRUCTION
MILEPOST SEVEN TAILINGS BASIN, DAM 2
DAM 2 RAISE − ELEVATION 1248 SECTIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC−005
REV. No. 1

FUTURE WORK TO BE COMPLETED,
DITCH CONFIGURATION SHOWN IN CLOUDED AREA IS
PRELIMINARY AND CONCEPTUAL TO BE FINALIZED IN
CONJUCTION WITH WEST RIDGE RAILROAD DESIGN

REROUTED DIVERSION DITCH

EXISTING DIVERSION DITCH

BLOCK EXISTING DIVERSION DITCH

EXTEND SEEPAGE
COLLECTION DITCH

FUTURE DAM CONSTRUCTION
TO FULL WIDTH

WESTERN EXTENT OF
INTERMEDIATE DAM RAISE

EXISTING DIVERSION DITCH

EXISTING SEEPAGE
COLLECTION DITCH

DAM 2 ℄

1243 DAM 2 RAISE PROJECTION
(TO BE BUILT IN 2015)

1 PLAN: DAM 2 DIVERSION DITCH/DAM CONSTRUCTION

0 100 200
SCALE IN FEET

NOTE: "FUTURE WORK TO BE COMPLETED" SHALL BE REQUIRED TO BE COMPLETED WHEN THE WATER LEVEL IS WITHIN 10' OF THE DAM CREST, WHEN RUNOFF FROM THE WEST RIDGE RAILROAD WOULD ENTER THE DIVERSION DITCH, OR WHEN RUNOFF FROM THE DAM WOULD ENTER THE DIVERSION DITCH – WHICHEVER OCCURS FIRST.

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME SARA L. LEOW

SIGNATURE

DATE 6/30/2016 LICENSE # 47103

CLIENT						12/23	6/30		
BID									
CONSTRUCTION						12/23			
RELEASED TO/FOR	A	B	C	0	1	2	3		
DATE RELEASED									

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	11/19/2014
Drawn	GSJ
Checked	SLL
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

PLAN
DAM 2 – INTERMEDIATE ELEV 1243

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
CC-006	1

FUTURE WORK TO BEGIN AFTER COMPLETION OF WEST RIDGE RAILROAD/DIVERSION DITCH WORK, OR UNTIL MURPHY'S POND REACHES ELEVATION 1238, WHICHEVER OCCURS FIRST. PRELIMINARY DITCH CONFIGURATION CONCEPT IS SHOWN AND IS TO BE FURTHER DESIGNED IN CONJUNCTION WITH WEST RIDGE RAILROAD DESIGN.

REROUTED DIVERSION DITCH

EXISTING DIVERSION DITCH

BLOCK EXISTING DIVERSION DITCH

EXTEND SEEPAGE COLLECTION DITCH

EXISTING DIVERSION DITCH

EXISTING SEEPAGE COLLECTION DITCH

DAM 2 ℄

1248 DAM 2 RAISE PROJECTION

1250

1248

0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00 14+00 15+00 16+00 17+00 18+00 19+00 20+00 21+03

54+00 55+00 56+00 57+00 58+00 59+00 60+00 61+00 62+00 63+00 64+00 65+00 66+00 67+00 68+00 69+00 70+00 71+00 72+00 73+00 74+00 75+00 76+00 77+00 78+00 79+00

1 — PLAN: DAM 2 DIVERSION DITCH/DAM CONSTRUCTION

0 100 200

SCALE IN FEET

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME SARA L. LEOW

SIGNATURE

DATE 6/30/2016 LICENSE # 47103

	A	B	C	0	1	2	3
CLIENT					12/23	6/30	
BID							
CONSTRUCTION					12/23		
RELEASED TO/FOR	DATE RELEASED						

BARR

Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	11/19/2014
Drawn	GSJ
Checked	SLL
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

PLAN
DAM 2 – ELEV 1248

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
CC-007	1

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086 DAM 2_CC-007.DWG PLOT SCALE: 1:2 PLOT DATE: 6/30/2016 12:50 PM
Images in Drawing - C:\Users\gsj\Desktop\SLL Signature.jpg
gsj K:\Design\23380086.00\23380086 Dam 2_CC-007.dwg Plot at 0 12/22/2015 13:35:44

DAM 2 ℄

8+00

6+00

4+00

2+00

0+00

DAM 2 SEEPAGE RECLAIM PIPELINE

DISCHARGE TAILINGS TO CREATE BEACH AND FINES CUTOFF (BY OWNER)

DOWNSTREAM FILTER

100.00'

2+55

2+00

1+00

0+40

0+00

WORK ZONE

PROPOSED LOW PERMEABILITY COMPACTED FILL AND DOWNSTREAM FILTER

COMPLETED SEEPAGE CUTOFF

1
CC–009

RAILROAD ℄

FUTURE SPIGOT LINE (APPROXIMATE)

CONSTRUCTION COORDINATES

STATION	NORTHING	EASTING	DESCRIPTION
STA. 0+40	625143.76	3061057.34	LOW PERMEABILITY COMPACTED FILL
STA. 2+55	625138.34	3061272.27	(FIELD VERIFY)

1
CC–002
PLAN: DAM 2 – SEEPAGE CUTOFF

0 50 100
SCALE IN FEET

ISSUED FOR CONSTRUCITON 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

CLIENT				6/30				
BID								
CONSTRUCTION								
RELEASED TO/FOR	A	B	C	0	1	2	3	
	DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1–800–632–2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

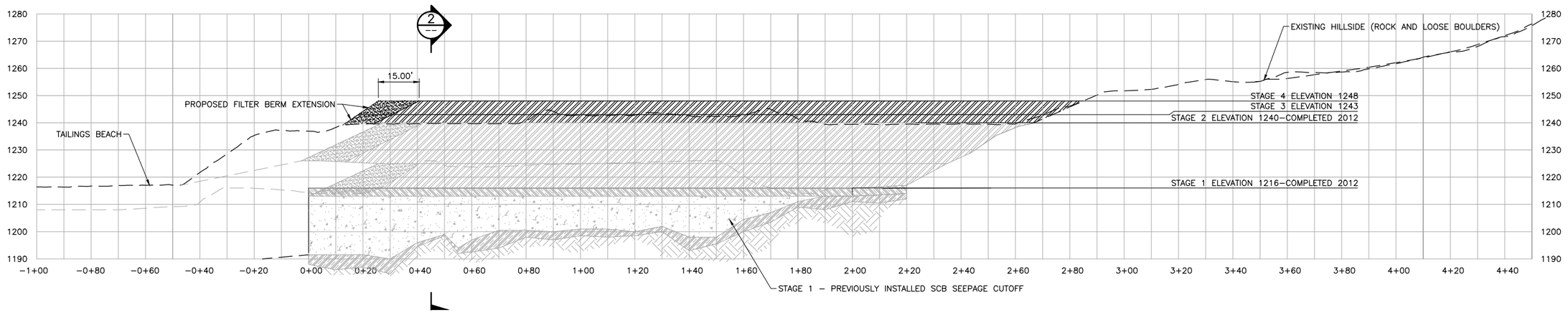
Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	ATG
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

DAM 2 RAISE – ELEVATION 1248
SEEPAGE CUTOFF

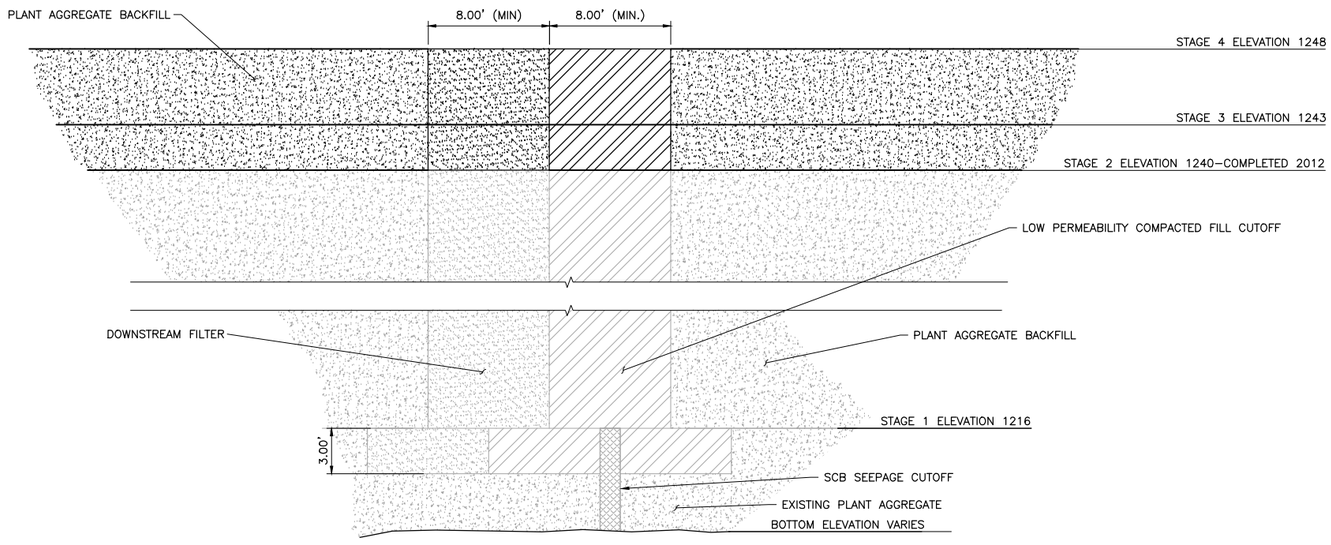
BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC–008
REV. No. 0



1 SECTION: SEEPAGE CUTOFF

0 20 40

SCALE IN FEET



2 SECTION: SEEPAGE CUTOFF

NOT TO SCALE

ISSUED FOR CONSTRUCTION 6/30/2016

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/30/2016 REG. NO. 47103

CLIENT	
BID	
CONSTRUCTION	
RECORD	

RELEASED TO/FOR

6/30

A B C 0 1 2 3

DATE RELEASED

BARR

Corporate Headquarters: Minneapolis, Minnesota Ph: 1–800–632–2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

Scale	AS SHOWN
Date	05/05/2014
Drawn	GSJ
Checked	ATG
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

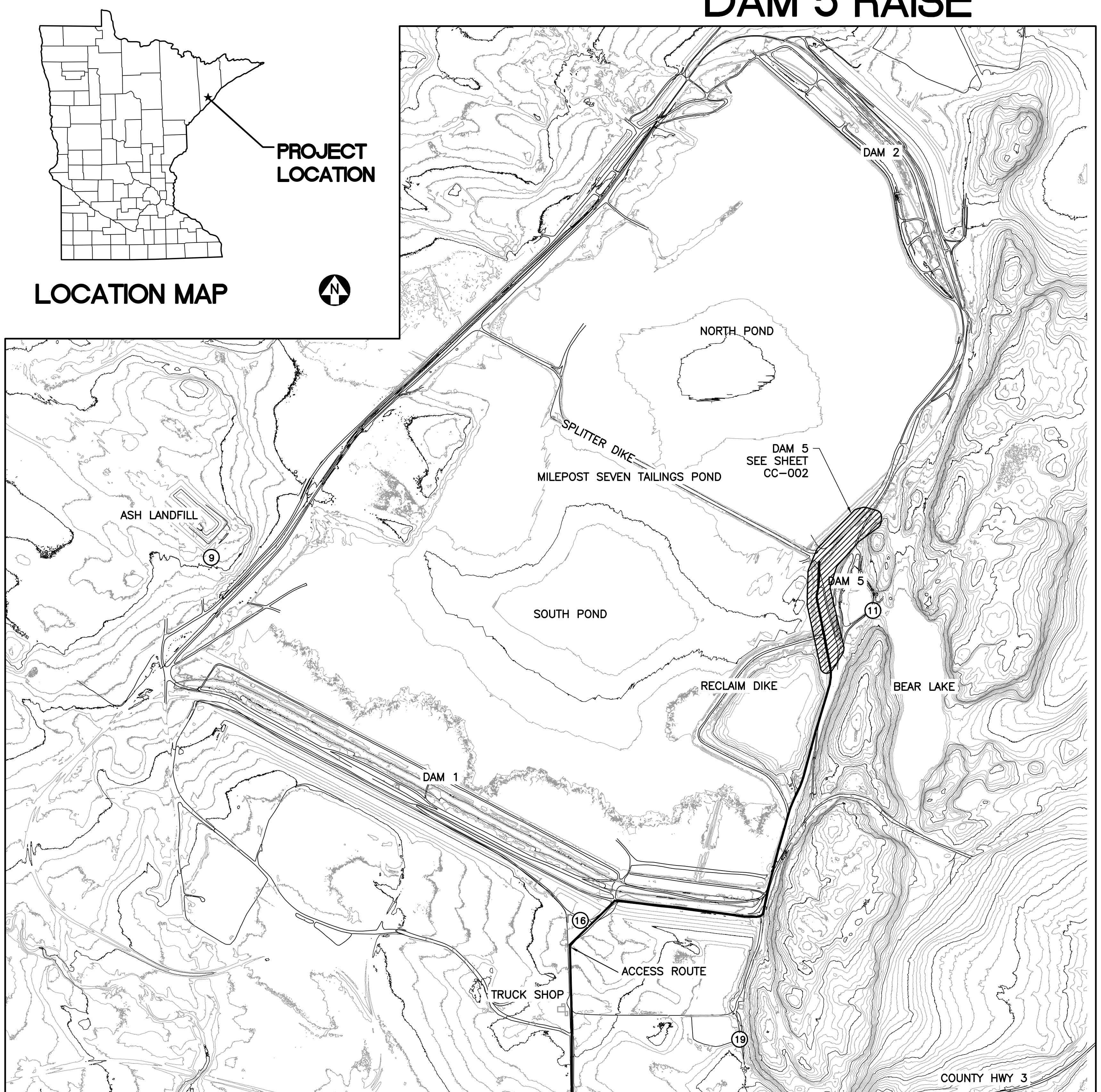
2016 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN

DAM 2 RAISE – ELEVATION 1248
SEEPAGE CUTOFF DETAILS

BARR PROJECT No.	23380086
CLIENT PROJECT No.	
DWG. No.	CC–009
REV. No.	0

Dam 5

NORTHSHORE MINING COMPANY
DAM 5 RAISE

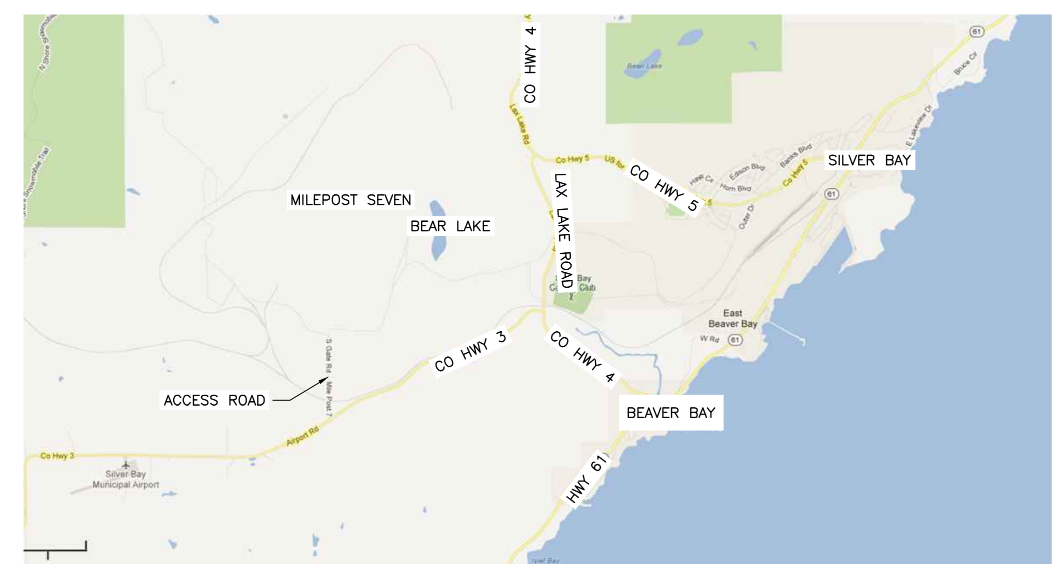


TAILING BASIN CONTROL DATA

BASIN CONTROL

NUMBER	NAME	NORTHING	EASTING	ELEVATION	DESCRIPTION
9	HV–9	621587.4510	3048856.4250	1308.69	
11	HV–11	620725.2580	3059623.2150	1201.82	
16	HV–16	615676.6820	3054865.0750	1214.85	
19	HV–19	613756.3770	3057456.3040	1180.18	REVISED COORDS

INDEX OF SHEETS



0 1000 2000
SCALE IN FEET

FOR CONSTRUCTION

CADD USER: Randy Wilson FILE: D–SIZE–BARR_2011_TEMPLATE.DWG PLOT SCALE: 1:1 PLOT DATE: 6/12/2008 3:47 PM
Xrefs in Drawing – M:\Design\23380086.00\2008 outer.dwg
Images in Drawing – M:\Design\23380086.00\Seepage Cut–off Wall Design\local map.tif
gsj M:\Design\23380086.00\23380086 Dam 5_TS–001.dwg Plot at 20 04/06/2012 10:39:37

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION
A	CMS2	ATG	SLL	06/12/18	ISSUED FOR CONSTRUCTION

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.

SIGNATURE [signature]
PRINTED NAME SARA L. LEOW
DATE 6/12/18 REG. NO. 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT	6/12/18						
BID							
CONSTRUCTION	6/12/18						

DATE RELEASED

BARR
Corporate Headquarters: Minneapolis, Minnesota Ph: 1–800–632–2277
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

Scale	AS SHOWN
Date	6/8/2018
Drawn	CMS2
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
SILVER BAY, MINNESOTA
DAM 5 RAISE – ELEVATION 1245
TITLE SHEET, SITE PLAN, AND SHEET INDEX

BARR PROJECT No. 23/38–086
CLIENT PROJECT No.
DWG. No. CC–001
REV. No. A

LAYOUT NOTES:

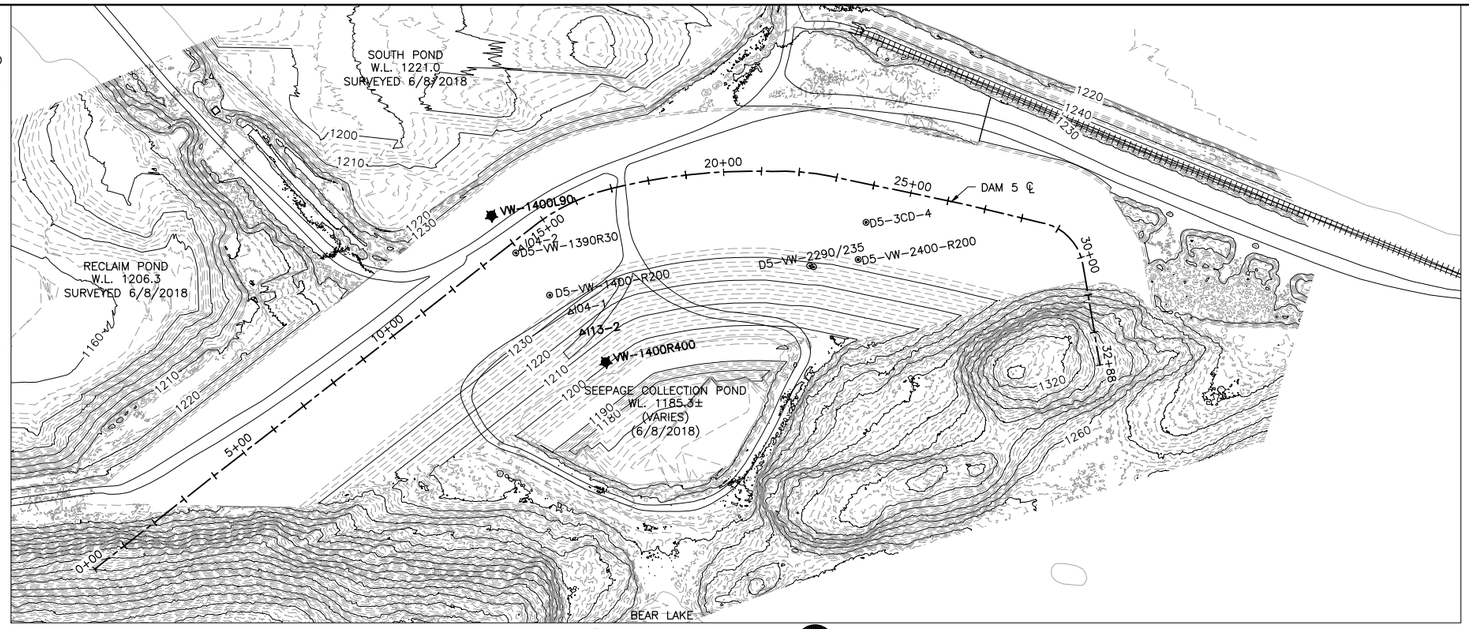
1. LAYOUT BEYOND DAM 5 FOOTPRINT BASED ON CONTOURS DEVELOPED FROM AERIAL SURVEY BY QUANTUM SPATIAL OF LEXINGTON, KENTUCKY. DATE OF PHOTOGRAPHY MAY 4, 2017. MAPPING BASED ON THE FOLLOWING DATUM:
   - VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
   - HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.
2. DEPICTED EXISTING CONDITIONS SURFACE OF DAM 5 ARE ESTIMATED BASED ON REGRADING RECOMMENDATIONS SENT BY BARR TO NSM 3/9/2018. NSM INDICATED THE RECOMMENDED REGRADED SURFACE WAS SUBSEQUENTLY CONSTRUCTED.

GENERAL NOTES:

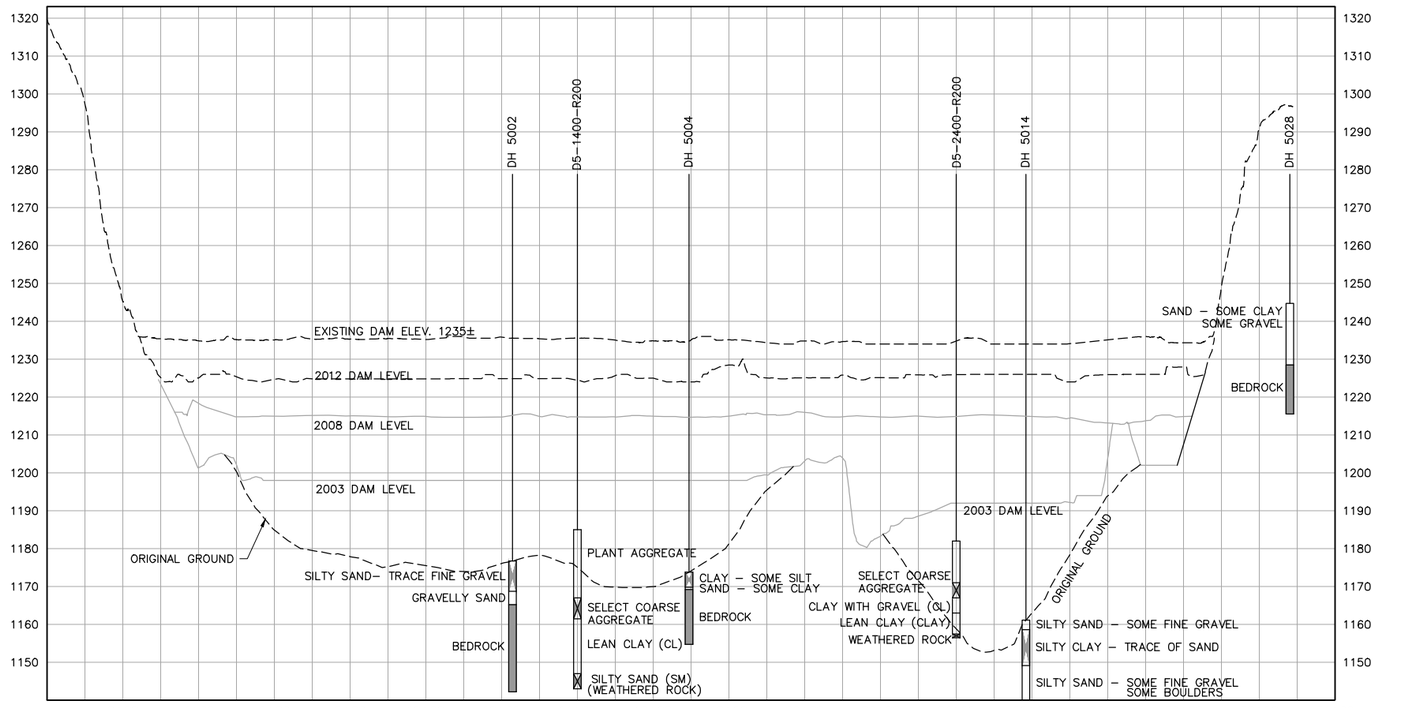
1. ALL INSTRUMENTATION SHALL BE PROTECTED.
2. PROPOSED DESIGN BASELINE DETERMINED FROM FIELD INVESTIGATION AND SHALL BE MODIFIED IN FIELD BASED ON ACTUAL CONDITIONS.
3. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF SURVEY.

LEGEND:

- EXISTING 10' MAJOR CONTOUR
- EXISTING 2' MINOR CONTOUR
- DAM CENTERLINE
- EXISTING RR
- INCLINOMETER
- HISTORIC BORING LOCATION
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER



1 PLAN: DAM 5
0 200 400
SCALE IN FEET



2 PROFILE: DAM 5
HORIZONTAL SCALE: 0 200 400 SCALE IN FEET
VERTICAL SCALE: 0 20 40 SCALE IN FEET

FOR CONSTRUCTION

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION
A	CMS2	ATG	SLL	06/12/18	ISSUED FOR CONSTRUCTION

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.
SIGNATURE
PRINTED NAME SARA L. LEOW
DATE 6/12/18 REG. NO. 47103

CLIENT	6/12/18
BID	
CONSTRUCTION	6/12/18

RELEASED TO/FOR

A	B	C	0	1	2	3

DATE RELEASED

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

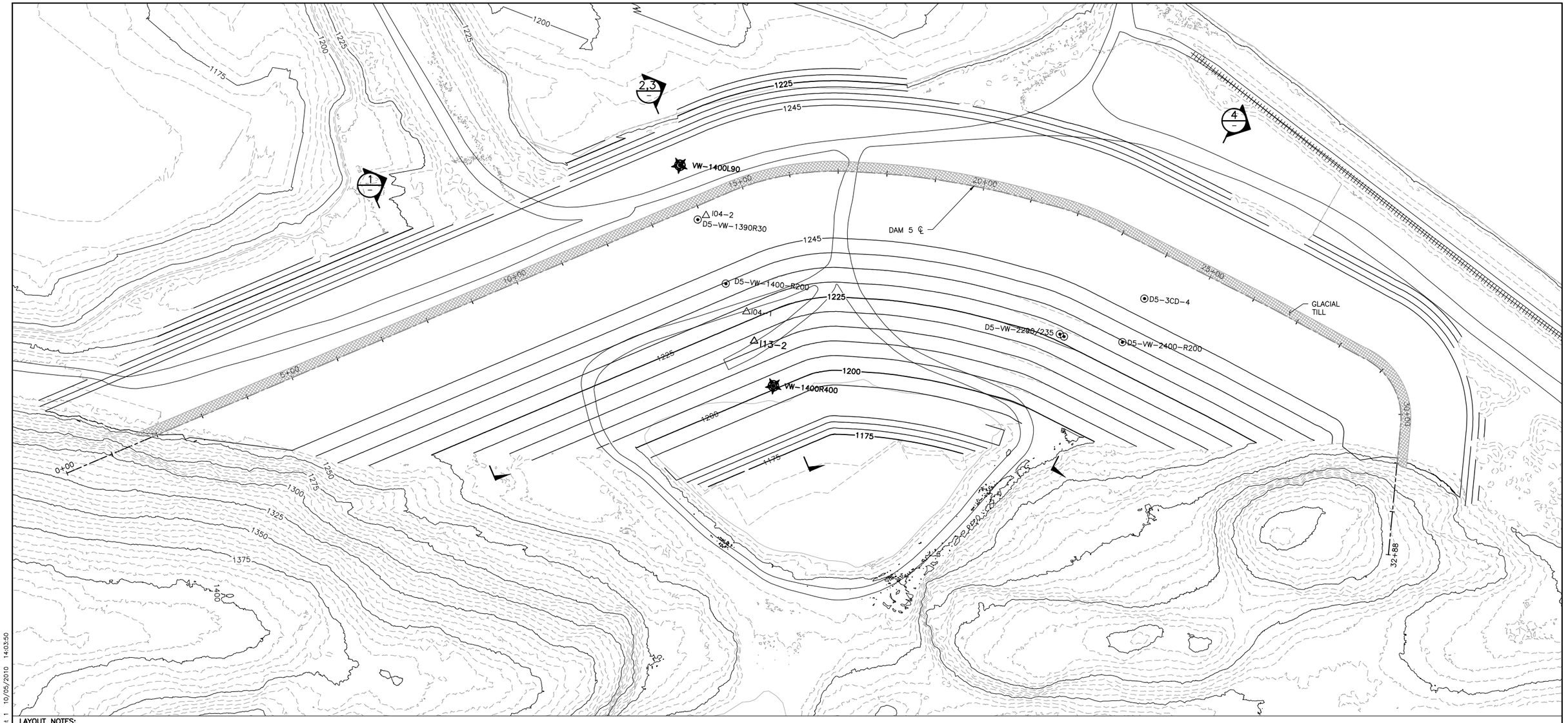
Scale	AS SHOWN
Date	6/8/2018
Drawn	CMS2
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 5 RAISE – ELEVATION 1245
EXISTING CONDITIONS PLAN/PROFILE

BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. CC-002
REV. No. A



1 PLAN: DAM 5
0 100 200
SCALE IN FEET

LAYOUT NOTES:

1. LAYOUT BEYOND DAM 5 FOOTPRINT BASED ON CONTOURS DEVELOPED FROM AERIAL SURVEY BY QUANTUM SPATIAL OF LEXINGTON, KENTUCKY. DATE OF PHOTOGRAPHY MAY 4, 2017. MAPPING BASED ON THE FOLLOWING DATUM:
   - VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
   - HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.
2. EXISTING CONDITIONS OF DAM 5 BASED ON CAD REGRADING SURFACE SENT BY BARR TO NSM 3/9/2018. WHICH WE UNDERSTAND HAVE BEEN SUBSEQUENTLY CONSTRUCTED.

GENERAL NOTES:

1. ALL INSTRUMENTATION SHALL BE PROTECTED.
2. PROPOSED DESIGN BASELINE DETERMINED FROM FIELD INVESTIGATION AND SHALL BE MODIFIED IN FIELD BASED ON ACTUAL CONDITIONS.
3. CONSTRUCTION OF THE DAM HAS BEEN ONGOING BY NSM. CONDITIONS HAVE CHANGED FROM THE TIME OF SURVEY.

APPROXIMATE FILL QUANTITIES (CY IN-PLACE)

D/S FILTER	GLACIAL TILL	SELECT COARSE AGGREGATE	PLANT AGGREGATE
16,000	22,000	102,000	201,000

NOTE: QUANTITY OF FILL SHOWN REFLECTS AMOUNT OF FILL REQUIRED TO CONSTRUCT DAM TO DESIGN CREST ELEVATION AND ASSOCIATED SLOPES ABOVE ESTIMATED EXISTING CONDITION.

LEGEND:

- EXISTING 25' MAJOR CONTOUR
- EXISTING 5' MINOR CONTOUR
- DAM CENTERLINE
- CLAY CORE
- EXISTING RR
- INCLINOMETER
- HISTORIC BORING LOCATION
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER

STATIONING COORDINATES: DAM 5 AS-BUILT ALIGNMENT

STATION	NORTHING	EASTING
0+00	619352.39	3059138.00
PC14+52.81	620768.09	3058811.75
PCC17+33.63	621045.94	3058811.14
PCC21+26.54	621415.38	3058941.86
PT22+80.63	621549.03	3059017.81
PC28+49.84	622001.20	3059363.74
PT30+22.54	622055.70	3059515.38
32+88.38	621984.99	3059771.65

FOR CONSTRUCTION

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION
A	CMS2	ATG	SLL	06/12/18	ISSUED FOR CONSTRUCTION

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.
SIGNATURE
PRINTED NAME SARA L. LEOW
DATE 6/12/18 REG. NO. 47103

CLIENT	6/12/18
BID	
CONSTRUCTION	6/12/18

RELEASED TO/FOR: A B C 0 1 2 3 — DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

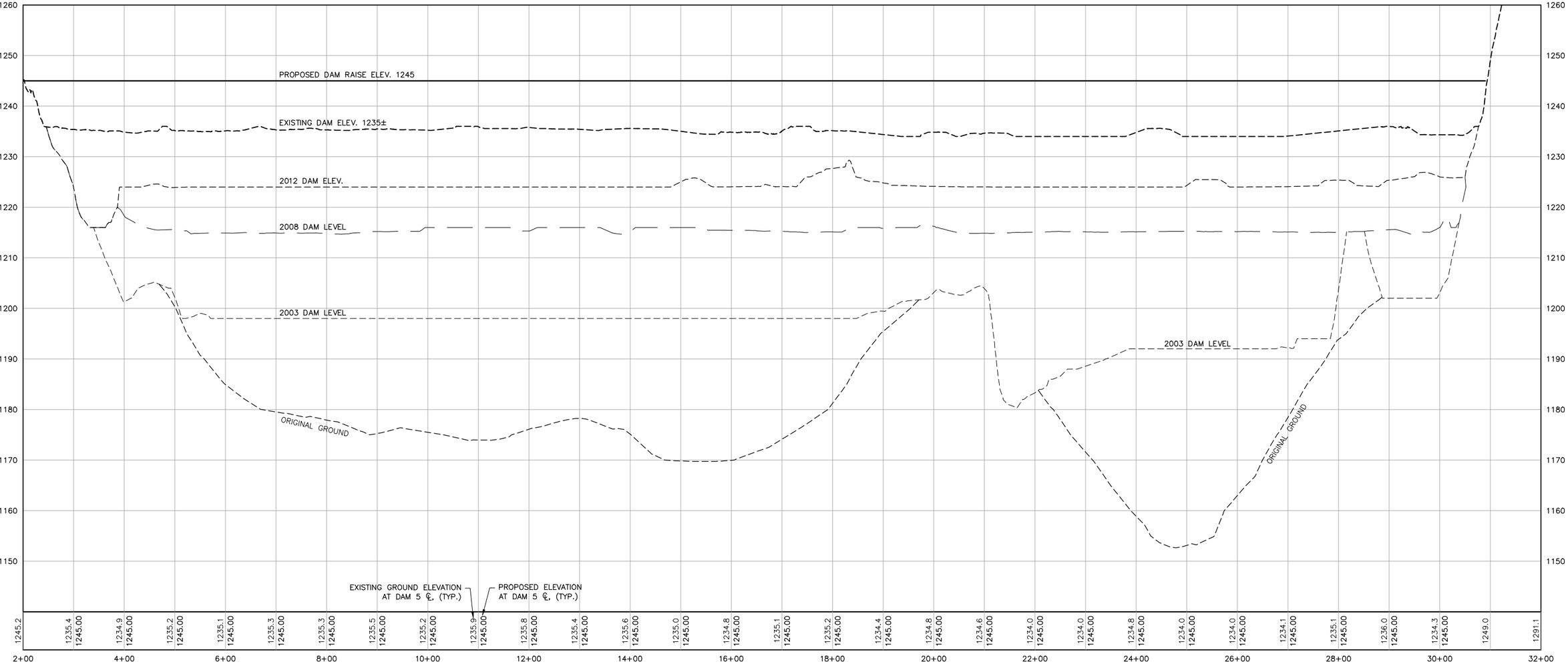
Scale	AS SHOWN
Date	6/8/2018
Drawn	CMS2
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 5 RAISE – ELEVATION 1245
CONSTRUCTION PLAN

BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. CC-003
REV. No. A



1 PROFILE: DAM 5
CC–004

HORIZONTAL: 0 100 200 SCALE IN FEET

VERTICAL: 0 10 20 SCALE IN FEET

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM AERIAL SURVEY BY QUANTUM SPATIAL OF LEXINGTON, KENTUCKY. DATE OF PHOTOGRAPHY MAY 4, 2017. MAPPING BASED ON THE FOLLOWING DATUM:
   - VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
   - HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.
2. ESTIMATED EXISTING CREST ELEVATION IS 1,235 FT, SIMILAR TO CREST ELEVATION FROM 2017 AERIAL SURVEY.

LEGEND

- ORIGINAL GROUND – ADAPTED FROM DIGITIZED 1976 DRAWING TEST HOLE LOCATION PLAN BY KLOHN LEONOFF CONSULTANTS LTD.
- EXISTING GROUND 2017 CONTOURS FROM QUANTUM SPATIAL, SEE LAYOUT NOTES
- PROPOSED DAM RAISE

FOR CONSTRUCTION

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION
A	CMS2	ATG	SLL	06/12/18	ISSUED FOR CONSTRUCTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/12/18 REG. NO. 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
	DATE RELEASED						

CLIENT	6/12/18
BID	
CONSTRUCTION	6/12/18

BARR

Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1–800–632–2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

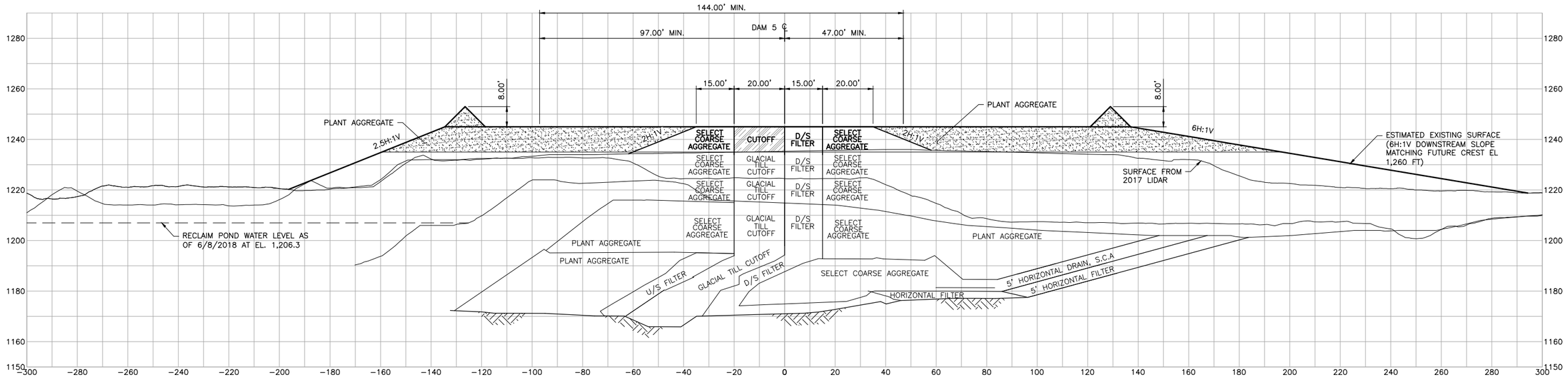
Scale	AS SHOWN
Date	6/8/2018
Drawn	CMS2
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 5 RAISE – ELEVATION 1245
DAM PROFILE

BARR PROJECT No. 23/38–086
CLIENT PROJECT No.
DWG. No. CC–004
REV. No. A

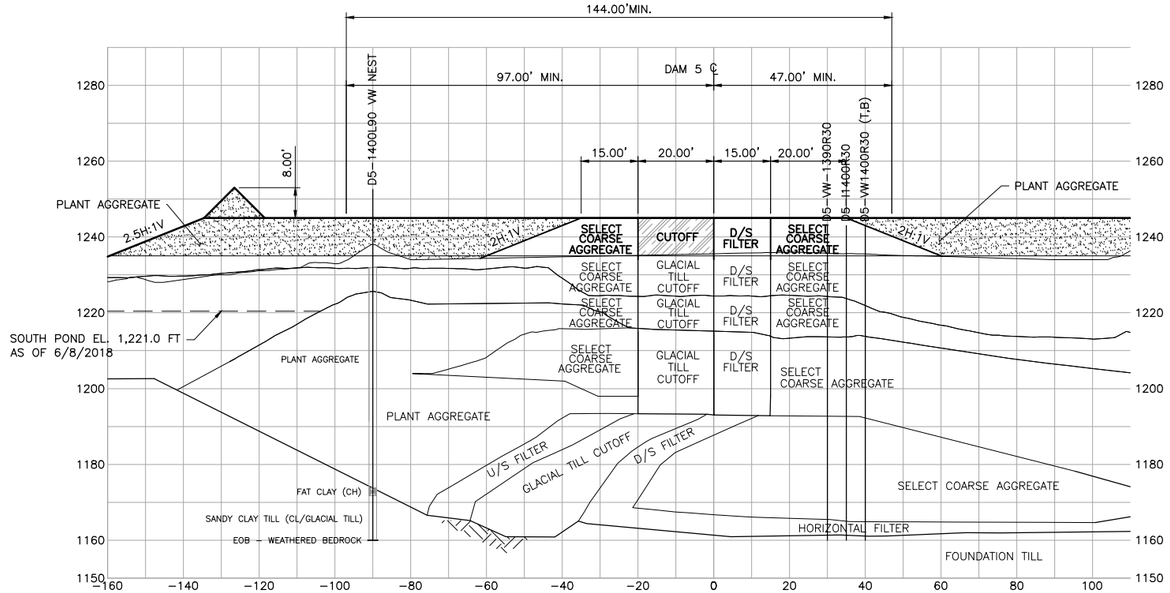


1 CC–003 **SECTION: STATION 8+00**

0 20 40
SCALE IN FEET

CONSTRUCTION NOTES:

1. SCARIFY, MOISTURE CONDITION, AND RE–COMPACT SURFACE OF EXISTING SEEPAGE CUTOFF PRIOR TO PLACEMENT OF NEW LAYER.
2. COMPACT ALL FILL MATERIALS FOR RAISE TO A MINIMUM 95% STANDARD PROCTOR (ASTM D698)
3. REFER TO ASSOCIATED CONSTRUCTION MEMO FOR MORE MATERIALS INFORMATION.



2 CC–003 **SECTION: UPSTREAM STATION 14+00**

0 20 40
SCALE IN FEET

FOR CONSTRUCTION

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION
A	CMS2	ATG	SLL	06/12/18	ISSUED FOR CONSTRUCTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/12/18 REG. NO. 47103

RELEASED TO/FOR								
CLIENT	6/12/18							
BID								
CONSTRUCTION	6/12/18							
DATE RELEASED		A	B	C	0	1	2	3

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1–800–632–2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1–800–225–1966
Fax: (218) 262–3460
www.barr.com

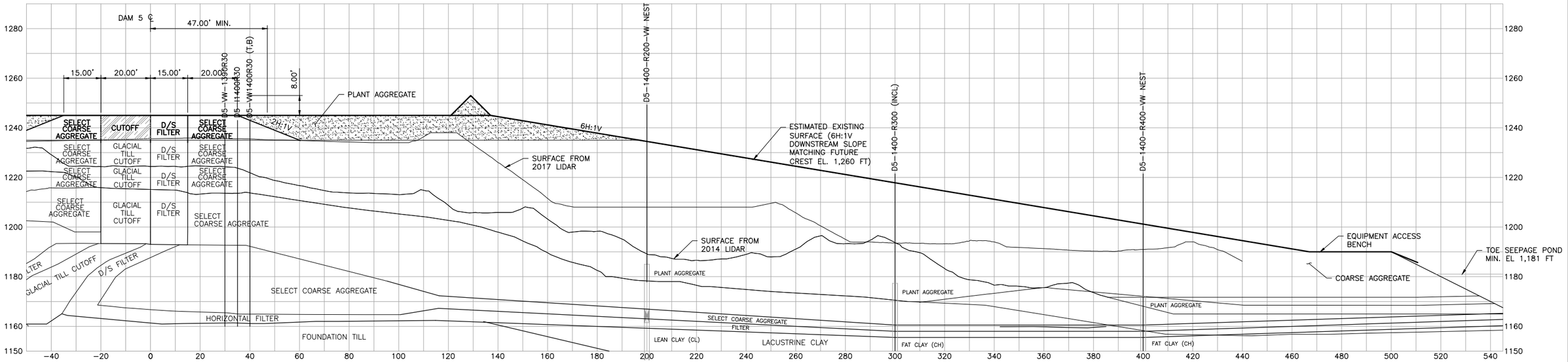
Scale	AS SHOWN
Date	6/8/2018
Drawn	CMS2
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS
SILVER BAY, MINNESOTA

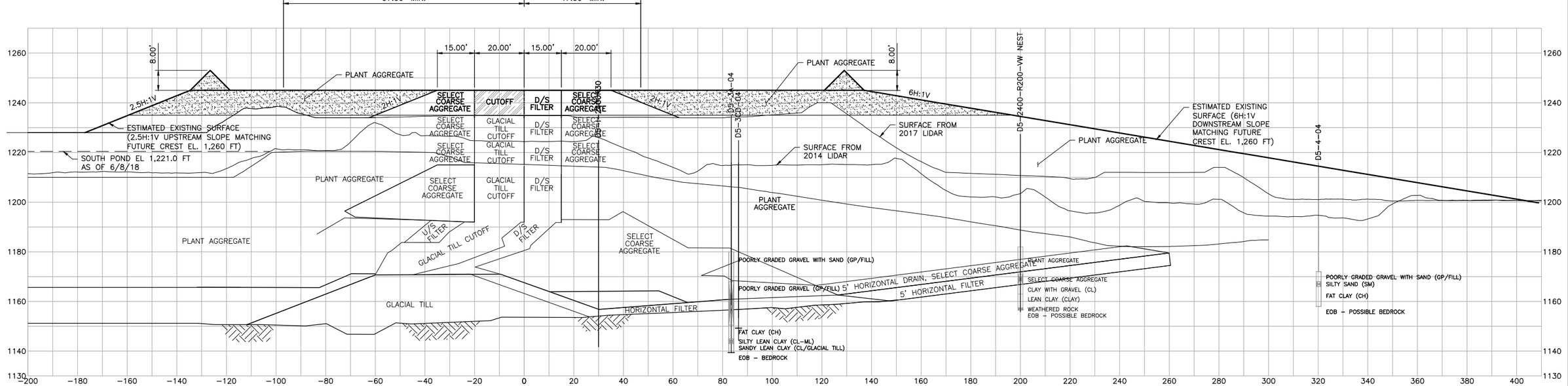
DAM 5 RAISE – ELEVATION 1245
SECTIONS – STATION 8+00 AND 14+00

BARR PROJECT No. 23/38–086
CLIENT PROJECT No.
DWG. No. CC–005
REV. No. A



3 CC-003 **SECTION: DOWNSTREAM STATION 14+00**

SCALE IN FEET (0, 20, 40)



4 CC-003 **SECTION: STATION 24+00**

SCALE IN FEET (0, 20, 40)

FOR CONSTRUCTION

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION
A	CMS2	ATG	SLL	06/12/18	ISSUED FOR CONSTRUCTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 6/12/18 REG. NO. 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT 6/12/18							
BID							
CONSTRUCTION 6/12/18							
DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/8/2018
Drawn	CMS2
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

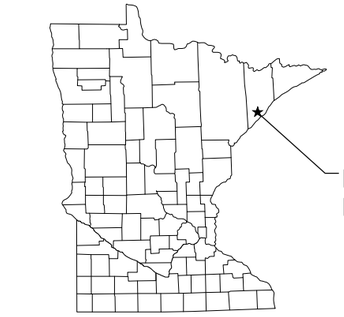
MILEPOST 7 TAILINGS BASIN
SILVER BAY, MINNESOTA

DAM 5 RAISE – ELEVATION 1245
SECTIONS – STATION 14+00 AND 24+00

BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. CC-006
REV. No. A

Reclaim Dam

NORTHSHORE MINING COMPANY
RECLAIM DAM RAISE - ELEVATION 1245



LOCATION MAP

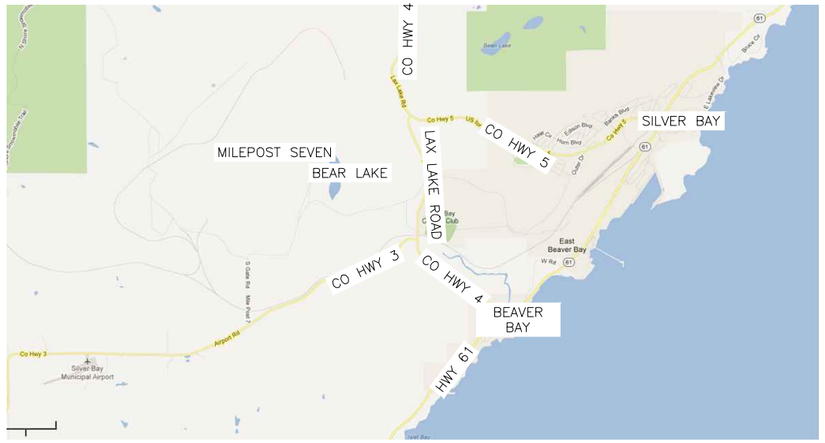
TAILING BASIN CONTROL DATA

BASIN CONTROL

NUMBER	NAME	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	HV-9	621587.4510	3048856.4250	1308.69	
2	HV-11	620725.2580	3059623.2150	1201.82	
3	HV-16	615676.6820	3054865.0750	1214.85	

NOTE:
NOT ALL CONTROL POINTS ARE SHOWN ON SITE PLAN

INDEX OF SHEETS



0 1000 2000
SCALE IN FEET

ISSUED FOR CONSTRUCTION 12/02/2015

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 12/02/2015 REG. NO. 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT				12/02			
BID							
CONSTRUCTION				12/02			
DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	10/12/2015
Drawn	JDH2
Checked	GSJ
Designed	GSJ
Approved	SLL

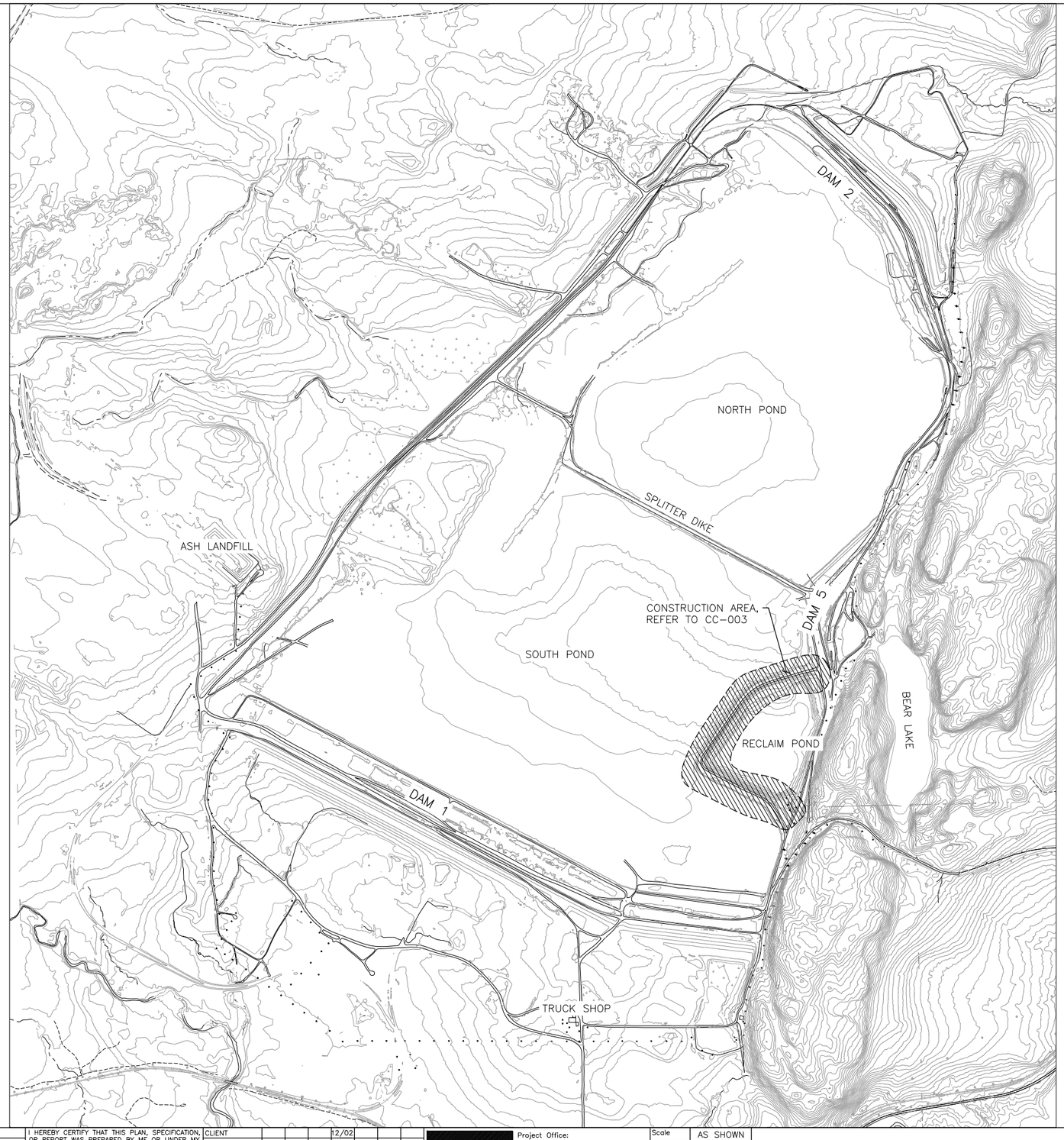
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2015 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN, RECLAIM DAM

RECLAIM DAM RAISE TO ELEVATION 1245
TITLE SHEET, SITE PLAN, AND SHEET INDEX

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
CC-001	0

Images in Drawing - K:\Design\23380086.00\local_map.tif C:\Users\gsj\Desktop\SLL_Signature.jpg gsj K:\Design\23380086.00\23380086_ReclaimDam_EL1245_CC-001.dwg Plot at 20 12/02/2015 11:55:37



LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN COMBINED WITH BATHYMETRY BY BARR ENGINEERING. DATE OF LIDAR MAY 23, 2014. DATE OF BATHYMETRY MAY 15, 2015. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.

1 PLAN: VICINITY MAP

ISSUED FOR CONSTRUCTION 12/02/2015

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE

PRINTED NAME SARA L. LEOW

DATE 12/02/2015 REG. NO. 47103

CLIENT				12/02				
BID								
CONSTRUCTION				12/02				
RELEASED TO/FOR	A	B	C	0	1	2	3	
	DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	10/12/2015
Drawn	JDH2
Checked	GSJ
Designed	GSJ
Approved	SLL

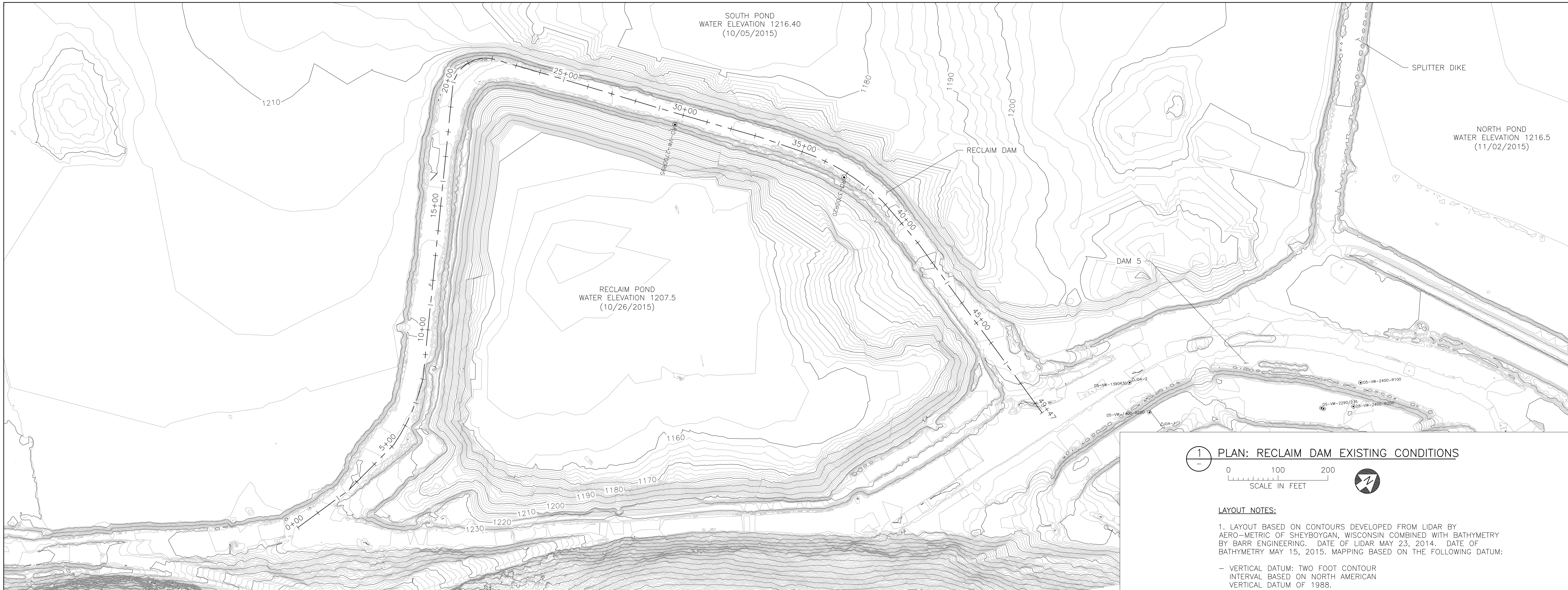
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2015 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS POND, RECLAIM DAM

RECLAIM DAM RAISE TO ELEVATION 1245
CONSTRUCTION LOCATION MAP

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-002
REV. No. 0

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086_RECLAIMDAM_EL1245_CC-002.DWG PLOT SCALE: 1:2 PLOT DATE: 12/2/2015 10:27 AM
Images in Drawing - C:\Users\gsj\Desktop\SLL Signature.jpg
gsj K:\Design\23380086.00\23380086_ReclaimDam_EL1245_CC-002.dwg Plot at 10 12/02/2015 10:26:53



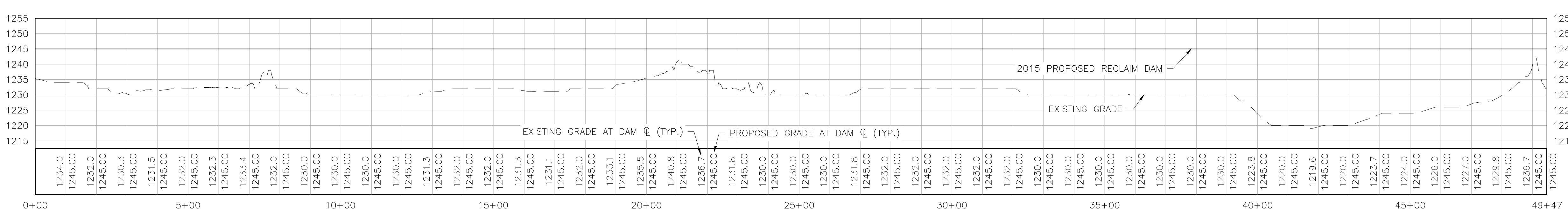
1 PLAN: RECLAIM DAM EXISTING CONDITIONS

0 100 200
SCALE IN FEET

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN COMBINED WITH BATHYMETRY BY BARR ENGINEERING. DATE OF LIDAR MAY 23, 2014. DATE OF BATHYMETRY MAY 15, 2015. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.



2 PROFILE: PROPOSED RECLAIM DAM EL 1245

0 200 400
HORIZONTAL SCALE IN FEET

0 20 40
VERTICAL SCALE IN FEET

ISSUED FOR CONSTRUCTION 12/02/2015

CADD USER: Greg Johnson FILE: K:\DESIGN\23380086.00\23380086_RECLAIMDAM_EL1245_CC-003.DWG PLOT SCALE: 1:2 PLOT DATE: 12/2/2015 10:28 AM
Xrefs in Drawing – K:\Design\23380086.00\20276_1.dwg
Images in Drawing – C:\Users\gsj\Desktop\SLL Signature.jpg
gsj K:\Design\23380086.00\23380086_ReclaimDam_EL1245_CC-003.dwg Plot at 0 12/02/2015 10:28:26

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME SARA L. LEOW
SIGNATURE
DATE 12/02/2015 LICENSE # 47103

RELEASED TO/FOR	A	B	C	0	1	2	3
CLIENT			12/02				
BID							
CONSTRUCTION			12/02				
	DATE RELEASED						

BARR
Corporate Headquarters: Minneapolis, Minnesota Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

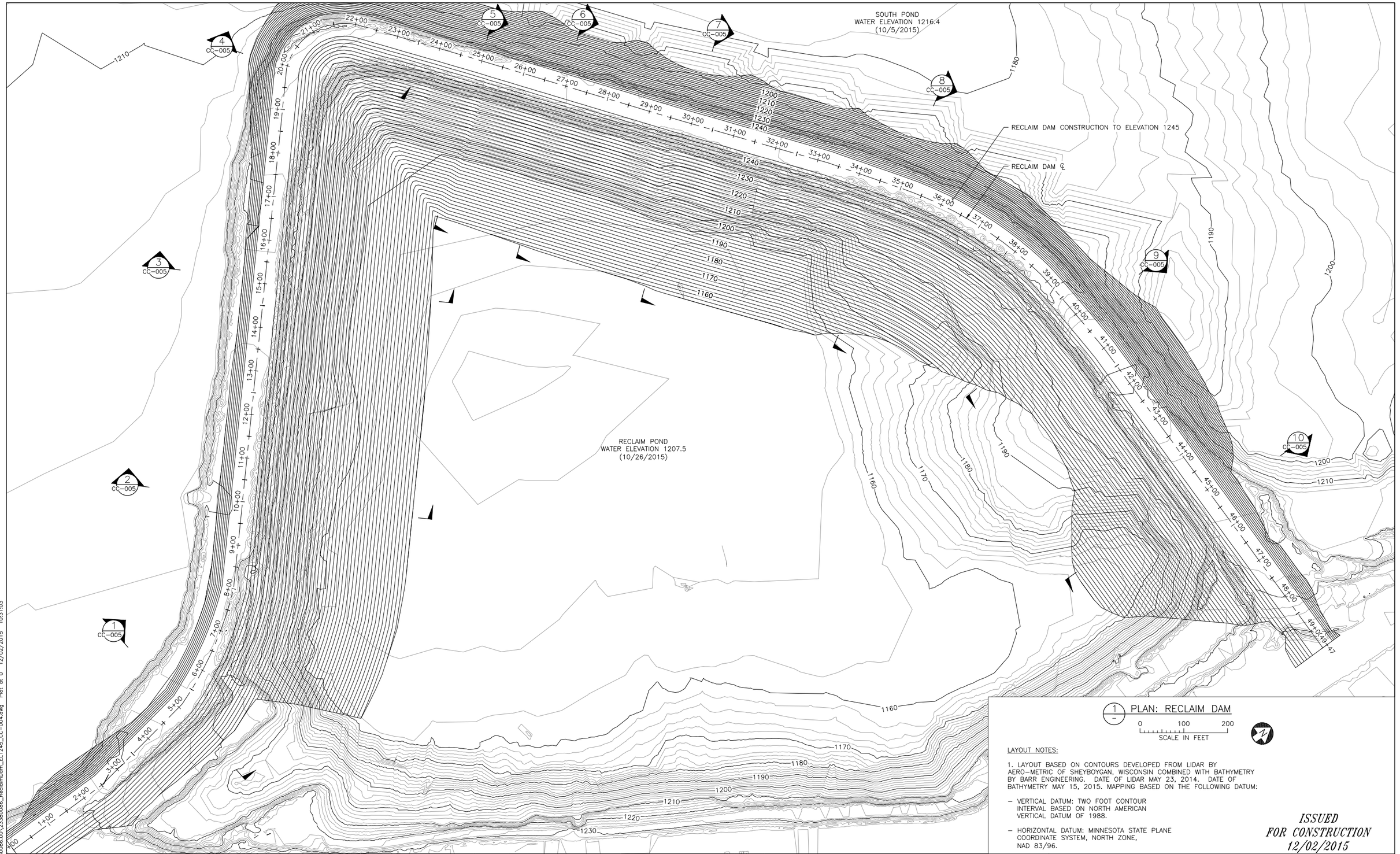
Scale	AS SHOWN
Date	10/12/2015
Drawn	JDH2
Checked	GSJ
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2015 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS BASIN, RECLAIM DAM

RECLAIM DAM RAISE TO ELEVATION 1245
EXISTING CONDITIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-003
REV. No. 0



1 PLAN: RECLAIM DAM

0 100 200
SCALE IN FEET

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY AERO-METRIC OF SHEYBOYGAN, WISCONSIN COMBINED WITH BATHYMETRY BY BARR ENGINEERING. DATE OF LIDAR MAY 23, 2014. DATE OF BATHYMETRY MAY 15, 2015. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96.

ISSUED FOR CONSTRUCTION 12/02/2015

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME SARA L. LEOW

SIGNATURE

DATE 12/02/2015 LICENSE # 47103

	A	B	C	0	1	2	3
CLIENT				12/02			
BID							
CONSTRUCTION				12/02			

RELEASED TO/FOR — DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	10/12/2015
Drawn	JDH2
Checked	GSJ
Designed	GSJ
Approved	

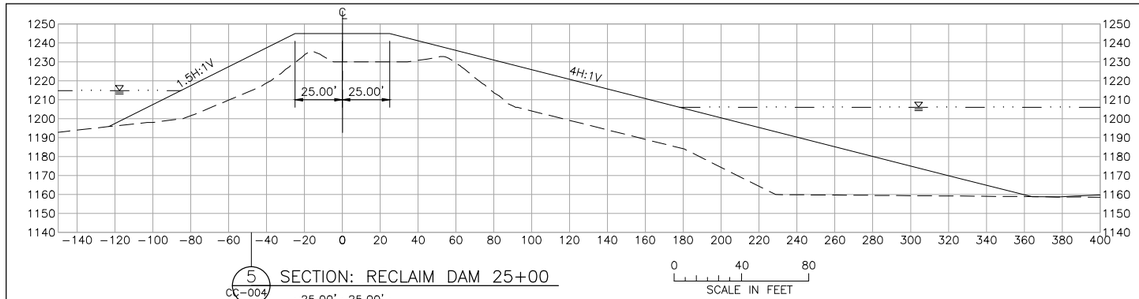
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2015 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS POND, RECLAIM DAM

RECLAIM DAM RAISE TO ELEVATION 1245
PROPOSED GRADING PLAN

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-004
REV. No. 0

CADD USER: Greg Johnson FILE: K:\Design\23380086.00\23380086_RECLAIMDAM_EL1245_CC-004.DWG PLOT SCALE: 1:2 PLOT DATE: 12/2/2015 10:32 AM
Xrefs: Design\23380086.00_GIS\Existing Trucks and Roads.dwg
Design\23380086.00_GIS\Shoreline.dwg
Design\23380086.00_GIS\Buildings.dwg
K:\Design\23380086.00\23380086_ReclaimDam_EL1245_CC-004.dwg Plot at 0 12/02/2015 10:31:03
gsj



5 CC-004 SECTION: RECLAIM DAM 25+00

4 CC-004 SECTION: RECLAIM DAM 20+00

3 CC-004 SECTION: RECLAIM DAM 15+00

2 CC-004 SECTION: RECLAIM DAM 10+00

1 CC-004 SECTION: RECLAIM DAM STA 5+00

10 CC-004 SECTION: RECLAIM DAM 45+00

9 CC-004 SECTION: RECLAIM DAM 40+00

8 CC-004 SECTION: RECLAIM DAM 35+00

7 CC-004 SECTION: RECLAIM DAM 30+00

6 CC-004 SECTION: RECLAIM DAM 27+00

0 40 80
SCALE IN FEET

ISSUED FOR CONSTRUCTION 12/02/2015

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME SARA L. LEOW

SIGNATURE

DATE 12/02/2015 LICENSE # 47103

CLIENT				12/02				
BID								
CONSTRUCTION				12/02				
RELEASED TO/FOR	A	B	C	0	1	2	3	
	DATE RELEASED							

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	10/12/2015
Drawn	JDH2
Checked	GSJ
Designed	GSJ
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

2015 PROPOSED DAM CONSTRUCTION
MILEPOST SEVEN TAILINGS POND, RECLAIM DAM

RECLAIM DAM RAISE TO ELEVATION 1245
SECTIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. CC-005
REV. No. 0

Appendix B

2018 Dam Inspection Report

Milepost 7 Tailing Basin
Dam Safety Inspection Report
Fall 2018

Prepared for
Northshore Mining Company

December 2018

Milepost 7 Tailing Basin
Dam Safety Inspection Report
Fall 2018

Prepared for
Northshore Mining Company

December 2018

4700 West 77th Street
Minneapolis, MN 55435-4803
Phone: 952.832.2600
Fax: 952.832.2601

Milepost 7 Tailing Basin
Dam Safety Inspection Report
Fall 2018

December 2018

Contents

List of Tables

List of Appendices, Attachments, or Exhibits

Certifications

I hereby certify that this 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.

Sara L. Leow, PE
PE #: 47103

December 31, 2018
Date

Executive Summary

The Northshore Mining Company Milepost 7 tailing basin was inspected as part of the dam safety review in October 2018. Each tailing dam was reviewed for evidence of instability, excess seepage, sloughing, erosion, or any other signs of structural deficiencies, and the results of the inspection are contained in this report. All tailing basin dams appear stable and do not exhibit excess seepage, sloughing, unusual erosion, or any other signs of structural deficiencies.

Several significant events or achievements occurred at the tailing basin this year under the direction of Mr. Daniel Scamehorn, Mr. Bryan Rusco, and Mr. William Panetti:

- In the winter and spring of 2018, the downstream slope of Dam 5 was regraded to match a future crest elevation of 1,260 feet following placement of a significant amount of fill beyond the design downstream slope face matching the crest elevation of 1,235 feet. Construction also occurred at Dam 5 in the summer of 2018 for the first phase of the crest raise to 1,245 feet.
- The area called the "Super Cell Beach" was created in 2017 between the reclaim dam and the eastern end of Dam 1 to store an elevated zone of fine tailings in an effort to better facilitate vegetation growth an increase dust control continued to be maintained. A new super cell beach was also started by constructing a containment berm parallel to the Dam 1 filter berm approximately 200 feet upstream of the Dam 1 centerline and spigotting fine tailings within this zone.
- Replacement of the weir in the northwestern corner of the reclaim dam continues to be in progress. The new weir box was installed just southwest of the existing weir, but is not yet in service due to a minimal rise of the tailings basin pond in 2018.
- Ongoing slope maintenance and repairs, such as regrading and erosion protection/vegetation, were performed.
- Instrumentation was monitored in May and November as part of the long-term monitoring program. Data loggers were installed on almost all of the remaining vibrating wire piezometers as well as newly installed piezometers. The fall instrumentation report is included in Appendix D.

1.0 Introduction

More than 3.5 miles of perimeter dams are currently maintained by Northshore Mining Company (NSM) to retain tailings produced as part of the ore extraction process as well as provide a suitable water source for mineral processing. The tailing basin currently encompasses nearly 2,100 acres of land and a 3,500 acre watershed. Annual inspections are completed to evaluate the conditions of the dam sections. This report discusses a review of the present tailing dam conditions at NSM's Milepost 7 (MP7) tailing basin. The review includes a summary of the existing structural conditions of each dam and, if necessary, a recommended action plan to remedy situations observed and identified during the review.

The dam safety review was performed on October 15 and 16, 2018 as part of NSM's engineering and design of the tailing basin. Sara Leow, P.E. and Aaron Grosser, P.E. of Barr Engineering Co. (Barr) performed the dam safety review.

The purpose of an annual inspection is to review the performance and condition of the dams. Observations consist of viewing the downstream toe through the crest of each dam section, the visible portion of the upstream slope, and basin shoreline. Visible deficient aspects of each structure are identified during these observations. A field inspection report, which includes dam observations, was created to document the conditions of the dam and is included in Appendix A. Photographs taken during the site visit are located in Appendix B. The most recent drawings of tailing basin conditions are included in Appendix C. The most recent instrumentation monitoring data was submitted separately, but is also included as Appendix D.

Seepage recovery dams are present north and south of the basin to impound seepage water from the perimeter dams. Surface water runoff is also diverted from entering the basin by diversion dams. A separate diversion ditch is located upstream of the West Ridge Railroad grade which diverts surface water from between the original diversion ditches and the current railroad to locations outside of the basin.

2.0 General Dam Information

Table 1 below offers pertinent data for the tailing basin and each dam section. Mr. William Panetti provided data that was not available from surveys due to ongoing construction.

Table 1 2018 Dam Information

Dam Section	Station Range of Dam	Minimum Toe Elevation	Filter Berm or Crest Elevations*	Adjacent Pond Elevation**
Dam 1	0+00 to 100+00 (final dimension)	1,132 feet	1,241 feet (as constructed)	1,221.2 feet (US) (10/13/2018)
Dam 2	0+00 to 60+00 (final dimension)	Approx. 1,160 feet	1,243.9 feet (lowest point in filter berm, as constructed)	1,221.2 feet (US) (10/13/2018)
Dam 5	0+00 to 41+36	Approx. 1,165 feet	1,235 feet (lowest point on crest, currently under construction)	North and South – 1,221.2 feet (US) (10/13/2018), 1,184.0 feet (DS) (10/13/2018)
Reclaim	0+00 to 51+50	Submerged downstream (approximately 1,155 feet from bathymetry in 2015)	1,235 feet (as constructed)	1,221.2 feet (US) (10/13/2017), 1,206 feet (DS) (10/13/2018)
Seepage Recovery Dam 1A	Not established	1,120 feet	1,139.3 feet	N/A
Seepage Recovery Dam 1B	Not established	1,150 feet	1,178.9 feet	N/A
Seepage Recovery Dam 2-3	Not established	1,130 feet	1,153.7 feet	N/A

*Provided by NSM
**US= upstream pond level, DS= downstream pond level

3.0 Dam Inspection

3.1 General Overview

On October 15 and 16, 2018, a detailed visual inspection of each of the perimeter (tailings) and seepage collection pond dams was performed. A less detailed review of the diversion dams was also performed. The inspection covered the tailings dams at the toe, mid-slope, and crests. The conditions encountered were noted, and observations entered into a set of field notes that are presented in Appendix A.

3.2 Dam 1

3.2.1 Description of Dam

As shown on sheet G-01 and G-03 (Appendix C), Dam 1 is located on the southern end of the tailings basin. The dam is approximately 10,000 feet long, and the crest of the dam is approximately 700 to 800 feet wide. Dam 1 and Dam 1E, located east of Dam 1, were two separate dams prior to 2004, with Dam 1E being constructed on the east side of a high point, the previous eastern abutment on Dam 1. Dam 1E was located east of the highpoint and west of another natural high ground area. Because the crest is wide in this area, the dams share the same alignment, although it changes direction at the location of the underlying natural high ground point between the two dams. Although the inspection table in Appendix A has separate sections for Dam 1 and Dam 1E, the dams are typically collectively considered Dam 1.

The general stratigraphy of native soils beneath the dam consists of lacustrine clay deposits 10 to 20 feet thick and glacial till of varying thickness, with bedrock below the till. Glacial till outwash is also present in some areas at the toe of the dam. Initial construction consisted of a sand and gravel starter dam with an upstream clay face. Downstream construction methods were originally intended to be employed; however, upstream construction methods were alternatively implemented during the early years of operation. In about 2003, dam construction was changed to an offset upstream method, in which a filter berm is constructed approximately 800 feet upstream of the starter dam and tailings are discharged upstream, creating a beach. The area downstream of the filter berm is constructed with plant aggregate overlying fine tailings; this plant aggregate was placed directly over the fine tailings in accordance with the Consensus Closure Plan. Fine tailings previously deposited by pipeline prior to the shift to offset upstream construction exist from near the old dam crest and extend into the basin. The plant aggregate zones are approximately 50 to 60 feet thick and the fine tailings are generally about 40 to 55 feet thick. The lowest point in the filter berm is presently at approximate elevation 1,241 feet. Plant aggregate was also placed on the dam crest to construct the new railroad grade. Some plant aggregate has been placed between the plant aggregate backer and the railroad grade, as well. The lower dam crest (immediately downstream of the seepage collection ditch) for the western part of the dam is about elevation 1,195 feet. The proposed overall upper dam slope as shown is about 6H:1V for an upper dam height of about 120 feet, ending at the currently permitted ultimate crest elevation of 1,315 feet.

Seepage collection ditches are present to control seepage for Dam 1. A seepage collection ditch was excavated upstream of the glacial till core for both the western and eastern portions of Dam 1 within the plant aggregate zone in 2003 and 2004. The seepage is routed to the ends of the dam, where it flows over

weirs into ditches leading into the seepage collection ponds downstream of the dam. The seepage flow is currently monitored at three locations on the dam. The upstream face of the ditch was regraded to flatten the slope and maintain local stability of the ditch slope as part of the seepage collection ditch project. The resulting slope was mulched and vegetation has been established.

Two cross sections (identified as 28+40 and 35+00) have historically been identified as critical areas of study during the initial phases of design and cross section at Dam 1. These cross sections are near the middle of the western portion of the dam in the area of the highest potential dam raise, also identified as the lowest natural ground foundation area where soft lacustrine clay deposits are present. The cross sections for stations 28+40 and 35+00 are shown as sheets G-04 and G-05 (Appendix C). As investigation and instrumentation installation also occurred over the past year, a cross section has also been developed for the eastern end of Dam 1 at station 90+50 and is shown in sheet G-06.

With a current lowest point of the dam filter berm crest at an approximate elevation of 1,241 feet, plant aggregate railroad grade higher than the filter berm, and an adjacent tailing pond level of 1,221.2 feet as of October 13, 2018, about 19.8 feet of freeboard exists, which is greater than the 10 feet required.

3.2.2 Site Observations

During the site review, the downstream slope and toe were observed by walking the length of the dam. The glacial till core was observed to be firm, dry, and intact. The weirs located at the ends of the seepage collection ditches normally flow about 150 to 800 $\pm$ gallons per minute depending on recent precipitation or the relative location of the pond to the filter berm. Due to the location, elevation of the weirs, and the grading of the seepage collection ditch, flows over the weirs have usually varied. The west weir was observed to be almost completely plugged by vegetation and algae debris; it appears cleanout of algae and vegetation from the seepage collection ditch may have occurred to the east and this material then washed into the weir. The east weir notch was observed to contain an abundance of algae. The weir at Dam 1E was functional, though quite a bit of algae and cattails were observed to be present upstream and downstream of the weir. The weirs and areas upstream and downstream of the weirs should be cleaned out to prevent backup of seepage water from the ditches and to allow representative monitoring readings. The removed material should be disposed in an area where it will not wash back into the seepage collection ditch. Algae and cattails were also observed to be prolific in the seepage collection ditch at Dam 1E, and the seepage collection ditch should be cleaned out.

A visible phreatic line was observed on the upstream side of the seepage collection ditches about one foot above the ditch water level along the entire ditch alignment. The core and filter were observed to generally be relatively clear of brush, though some tall brush was observed to be present near the east end of the main portion of Dam 1, which should be removed. It appeared as though some work had been performed to remove some of the brush on the core at Dam 1E, though large brush is still present to the west of approximate station 92+00. A notch appeared to have been cut out of the core as part of the previous brush clearing activities. This notch should be regraded to prevent collection of water from precipitation at this location.

As was noted in previous dam inspection reports, a seepage cutoff was constructed at the eastern abutment of the eastern extension of Dam 1 (old Dam 1E) in late August 2015 up to an approximate elevation of 1,236 feet. Even with inclusion of this cutoff, seepage was observed to be flowing into the seepage collection ditch from the upstream side at the east abutment of the east end of Dam 1 during both the 2016 and 2017 dam inspections. A similar condition was observed during the 2018 dam inspection. Soil particles were not observed to be carried in the seepage. This seepage may be from precipitation events and subsequent water draining through the plant aggregate, or could be seepage water from the basin. One option for further review of the seepage could be to test water samples to help determine if the water is from precipitation or the tailings pond.

As was observed starting in 2016, it appeared that some minor, shallow sloughing may have occurred in a few zones of filter material along the downstream side of the seepage collection ditch in the middle of the western portion of the dam. Conditions of these areas in 2018 looked the same as observed in 2016 and 2017. These areas should be regraded to protect the cutoff downstream of the filter.

A few apparent animal burrows approximately 3 inches in diameter and partially obscured by vegetation were observed to be present on the west edge of the core near the west weir. These animal burrows should be filled in accordance with FEMA *Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams* (2005) to help prevent creation of preferential drainage paths in the dam.

Along the toe of the dam (below the seepage collection ditch) there was no visible evidence of piping or internal erosion, as no seepage was observed to be exiting the face of the slope and seepage observed at the toe of the slope did not contain fines. Visible or apparent seepage was limited to the flow from the relief wells. No sand boils were observed, and the toe was firm. As has been observed since 2015, one relief well on the eastern edge of the pond, R-11, is broken off at the ground surface and should be repaired. The ditch supporting the flow from the R-11 well should be cleaned to promote drainage and the general area beyond the toe cleared so the relief wells are more visible. Additionally, it would be advantageous if one approximate excavator bucket of material was removed from beneath each relief well to allow use of a larger container for flow measurement during monitoring events.

No relief wells or piezometers currently exist on the eastern part of the main section of Dam 1. To gain a better understanding of seepage conditions near a smaller pond just east of seepage recovery pond 1A, the instrumentation plan for the next few years should include installation of piezometers at the toe of the dam near approximate station 43+00.

Although erosion on the slope face, particularly near the toe of the western section of the dam, has typically been observed during dam inspections and throughout the year, the erosional areas have not changed, worsened, or broadened over time based on comparisons with past dam inspection information. They do appear out of the ordinary in that minimal to no vegetation has regrown in the areas on its own. It is recommended to not use large equipment to repair the areas, rather material could be delivered and spread over the site, mulched, and seeded to promote future growth, thereby limiting further disturbance of adjacent areas by equipment. Vegetation in the area in the western section of the dam near station

20+00 where an old equipment shed was removed in 2015 continues to appear to have generally blended in with vegetation on the rest of the downstream slope face.

Starting in April 2017, NSM constructed a berm between the eastern end of Dam 1 and the reclaim dam to contain a raised area of fine tailings between the east side of the basin and the berm. This area is referred to as the "Super Cell Beach" (SCB). A weir was installed in the berm to decant water into the main tailings pond. Fine tailings were spitgotted into the cell, and the surface of the cell is now at an approximate elevation of 1,235 feet. The SCB configuration results in the elevated beach surface remaining above tailings pond level for a longer period of time than typical durations between spigotting operations. The beach surface is subsequently mulched and the longer time periods between spigotting can better facilitate vegetation growth, which could lead to a reduction in dust dispersion and related air quality issues. In the summer of 2018, NSM began another section of SCB consisting of a berm constructed of fine tailings placed parallel to and offset approximately 200 feet from the dam centerline along the entire length of the dam west of the original SCB. Fine tailings were subsequently spigotted into this new cell with the most recent spigotting occurring at the west end of the dam. A couple areas of the fine tailings berm in the west-central portion appeared to have been overtopped, and we understand NSM intends to reconstruct these areas to continue SCB construction. In general, the exposed tailings beach was observed to have been stabilized using mulch except for zones of recent spigotting activity and areas partially submerged further into the tailings basin, beyond the SCB.

The crest of the dam was reviewed and found to be generally level across the alignment with the exception of grading between the new railroad embankment and the filter berm/backer on the upstream side and the old railroad embankment one the downstream side. There appeared to be a narrow point in the filter berm at an access ramp location for the SCB near approximately station 25+00; however, the filter berm is typically constructed wider than plan. The minimum filter berm width should be maintained per plans.

3.3 Seepage Recovery Dam 1A

Seepage recovery dam 1A, which impounds seepage water from the western section of Dam 1 and local surface runoff, was originally constructed with sand and gravel including an upstream glacial till face. No indications of tension cracks or sloughing were observed along the dam alignment. The crest of the dam appeared level and was covered with grass and gravel.

The downstream slope was observed to be relatively dry with no seepage along the face. There were some wet areas along the toe, especially in clayey areas, consistent with historical observations. The ground was generally firm.

The area where monitoring wells are located about 100 feet off of the west end of the toe was observed to be flooded. NSM informed Barr that the culvert beneath the railroad grade downstream of this area was plugged by beaver activity and the culvert was cleared soon after the dam inspection.

Water levels in the monitoring wells have been high and water has been observed to flow from the top of these wells during past dam inspections, though was not observed during the 2018 inspection. The top of

the monitoring wells were observed to have caps with locks; these caps should be replaced with vented caps to allow water flow and prevent pressure build up.

In addition to the high monitoring well water levels, piezometric heads in some of the Casagrande piezometers at this dam have also been similar to the seepage recovery pond surface elevation. As noted in the monitoring report, new piezometers were recently installed at the toe of this dam and an evaluation of dam seepage underflow and its effect to stability of the seepage recovery dam using data from the new piezometers is planned to take place in 2019.

3.4 Seepage Recovery Dam 1B

Seepage Recovery Dam 1B acts in the same manner as Seepage Recovery Dam 1A, impounding seepage water originating from the east end of Dam 1 and local surface runoff. This dam was also originally constructed of sand and gravel with an upstream glacial till face. No indications of tension cracks or sloughing along the dam alignment were observed. The crest of the dam appears to be level and covered with grass and gravel. Although the majority of brush was observed to have been cleared out in 2017, some brush that should be cleared was observed near the west end of the dam. The water level in the associated seepage pond appeared normal. A few large ant hills were observed at the edge of the crest on the eastern end of the upstream side of the dam. The presence of several of these large ant hills could potentially create a preferential pathway for drainage, which may affect dam stability.

The downstream slope was observed to be dry with no seepage along the face. Wet areas and were observed at the toe of the dam. Consistent with past observations at this dam site, wet areas were somewhat soft, but the ground was otherwise observed to be firm. Old equipment sheds that housed two of the three monitoring wells at the toe were observed to have been removed and two replacement monitoring wells, M12 and M12A, installed. Seepage less than about 1 gallon per minute was observed adjacent to replacement monitoring well M12. The observed seepage was clear and did not appear to contain soil particles. Seepage of similar magnitude has been observed in the past at the toe of this dam, though it is unknown as to whether the recently observed seepage is related to the installation conditions of the replacement monitoring well. A new piezometer nest was installed near the monitoring wells after the dam inspection, and this data is planned to be used to assess seepage and stability conditions of seepage recovery dam 1B in 2019.

3.5 Dam 2

3.5.1 Description of Dam

As shown on sheets G-01 and G-07 (Appendix C), Dam 2 is located on the northern end of the tailing basin and is approximately 5,700 feet long. A glacial till cutoff was constructed as a central core in the starter dam for Dam 2. The fill material placed on natural ground to the existing dam elevation consists of plant aggregate, which extends upstream of the starter dam about 500 to 600 feet. After completion of the plant aggregate placement, fine tailings were discharged into the basin creating beaches. Similar to Dam 1, the offset upstream method was also used for Dam 2 beginning in about 2003, with a filter berm constructed about 800 feet upstream of the starter dam. Tailings were discharged into the basin to create

a beach adjacent to the starter dam prior to construction of the offset and associated filter berm. At Dam 2, about 20 feet of plant aggregate was used to cover the previously deposited approximate 30 foot thick layer of fine tailings, in accordance with the Closure Consensus Plan. The area downstream of the filter berm is currently raised using only plant aggregate. Presently, approximately 40 to 50 feet of plant aggregate exists over the fine tailings. The downstream dam slope for Dam 2 (above about elevation 1,200 feet) will be 6H:1V up to the currently permitted ultimate height of the dam at elevation 1,315 feet using the existing cross section. Cross sections of Dam 2 are shown on sheets G-08 and G-09 (Appendix C).

A peat deposit overlying the lacustrine clay and glacial till exists in the approximate middle portion of the dam cross section. The peat has been compressed from its original 10 foot thickness to a thickness of about 3 to 5 feet. Previous investigations identify an alluvial channel cut into the glacial till in the center of the dam site near the middle of the dam cross section. A plant aggregate buttress was constructed in 1997 along the downstream toe of Dam 2 in the area of the lowest natural ground and where the dam section will be highest. The toe berm increased the dam's stability by providing a means for drainage of seepage and additional weight along the toe of the dam.

A seepage cutoff was constructed in the northeastern corner of Dam 2 in May 2012. The seepage cutoff was constructed beyond the eastern extent of the clay core to significantly reduce the amount of seepage flowing along the hillside, through more permeable plant aggregate zones located in this area of the dam. The first stage consisted of a soil-cement-bentonite cutoff to elevation 1,216 feet, with the second stage consisting of compacted clay till to a present surface elevation of 1,240 feet. The cutoff will be extended vertically with glacial till as part of subsequent dam raises to the ultimate dam height.

The current minimum dam crest elevation at the filter berm is approximately 1,243.9 feet. The adjacent tailing pond level is 1,221.2 feet, resulting in a freeboard of about 22.7 feet, which is greater than the 10 feet required.

3.5.2 Site Observations

Consistent with previous inspections, the downstream slope below the seepage collection ditch was observed to be uniform and grass-covered, except near the toe where the plant aggregate buttress was previously constructed. Seepage was visible on the upstream face of the seepage collection ditch a few inches to a foot above the water surface, as evident by vegetation changes. The water in a few areas of the seepage collection ditch appeared cloudy, as has been observed in the past, which is likely related to the algae in the channel. An abundance of algae and cattails were observed to be present in the seepage collection ditch, in some locations creating little 'islands' of vegetation growth. Some algae and cattails were observed around the east weir, while prolific algae/cattail build-up was observed at, upstream, and downstream of the west weir. Algae and cattails should be cleaned out of the seepage recovery ditch, the areas surrounding the weirs, and the channels downstream of the weirs to promote the free flow of drainage.

The downstream slope has been filled and graded to its final design condition downstream of the railroad embankment, and this final dam slope is covered with vegetation. A few piles of cut woody brush were

observed on the clay core from clearing, consistent with recommendations to clear brush off the core, though some intermittent remaining brush was present. Several animal burrows approximately 2 to 3 inches in diameter were observed on the west end of the core, near the weir. Although in the generally same overall area near the west end of the core as last year, these animal burrows are not in the exact same locations. These animal burrows should be filled in accordance with FEMA *Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams* (2005) to help prevent creation of preferential drainage paths in the dam. An area of filter erosion was observed on the downstream side of the seepage collection ditch just west of station 42+00, although this same erosion area was observed in 2017 and the condition does not appear to have changed between the 2017 and 2018 dam inspections. This erosion area should be regraded to prevent additional erosion.

No seepage was observed on the downstream slope above the toe of the dam. The toe seepage collection ditch was observed to contain water. Water was flowing in ditches at the toe of the dam near the west and east ends; however, the channel on the east end of the dam is not well defined and is difficult to observe due to being obscured by vegetation. Several ponded areas were also observed to be present along the east toe of the dam. Vegetation should be cleared out beyond the buttress toe to allow for better observation of channel conditions and to plan for better diversion of this water to the seepage recovery pond.

Some remnant soil with grass growth appeared to still partially block the outlet channel for the toe drain near station 34+75 and should be removed. Beaver dams observed during the 2017 inspection at the south end of the outlet channel for the toe drain, just before the channel empties into the seepage recovery pond, as well as just east of the toe drain were observed during the 2018 inspection to have been cleared out to allow water to flow into the into the seepage collection pond.

Ponded water was observed in an area at the toe of the northeastern corner of the dam. This water appears to likely consist of runoff that has collected in a low area between existing topography and dam fill. This area should be considered during development of the toe ditching plan at the east end of the dam to better route water to the seepage collection pond.

Most recent construction of the filter berm occurred in 2015, with some minimal regrading at the west end in 2018. Some grading and backer placement was also performed in the spring of 2018. The upstream beach was observed to be mulched except for areas of recent spigotting near the west end of the dam on the date of inspection.

An area of eroded filter berm was observed near approximate station 40+00. Although the filter berm is overbuilt compared to plan, the area should be regraded to prevent continued erosion that infringes upon the minimum filter berm width.

3.6 Seepage Recovery Dam 2-3

Seepage recovery dam 2-3 is located downstream of Dam 2 on the north side of seepage recovery pond 2-3. This dam was originally constructed of sand and gravel with a glacial till face to impound seepage water from Dam 2 and local runoff.

The crest of the dam appears to be horizontal and is covered with tall grass, some brush, and gravel. No signs of tension cracks or movement were observed. The upstream slope is uniform and grass-covered. The pond surface elevation appeared normal.

The downstream slope was observed to be uniform and vegetated with brush and grasses; removal of taller vegetation at the toe would help facilitate observations. Wetland type vegetation was observed to be present at the downstream toe of the slope. Wet areas with cattail vegetation were found throughout the area along the toe where the relief wells are located, and the two relief wells were observed to be flowing, similar to past observations. A new piezometer was installed at the toe of this dam after the dam inspection.

3.7 Dam 5

3.7.1 Description of Dam

As shown in plan view on sheets G-01 and G-10 (Appendix C), Dam 5 is located on the east side of the tailing basin and north of the Reclaim Pond. This dam was originally constructed as two dams, Dam 5A and Dam 5B, but the dams were joined as they were raised. The dam is constructed over a layer of clay on the south end, a rock knob in the middle, and a rock foundation on the north end. The northern rock foundation was improved using blanket grouting during initial construction, while the middle rock knob was covered by filter tailings as the dams were raised. A central glacial till cutoff was used in the initial design and has continued to be incorporated into recent raises as shown on cross sections on sheets G-11 and G-12 (Appendix C). Filter tailings have been placed over the downstream portion of the clay foundation and a plant aggregate drain has been constructed above the filter tailings along the entire downstream portion of the dam. The dam stratigraphy is shown on sheets G-11 and G-12 (Appendix C). A buttress was added along the toe of the dam starting in 2013 and is raised and extended for subsequent dam raises, depending on stability and uplift conditions.

In February 2018, Barr was performing data logger installation work at the basin and noticed that an extensive amount of fill had been placed on the downstream slope of Dam 5, including a significant amount of fill beyond the estimated 6H:1V slope matching the current dam crest elevation of 1,235 feet. To increase dam stability, Barr subsequently worked with NSM to develop a regrading plan with consideration for the anticipated future construction raises, typical NSM construction methods and equipment, winter weather conditions, and minimization of plant aggregate movement outside the Dam 5 area. The resulting plan included regrading of the dam slopes to match a crest elevation of 1,260 feet while maintaining the existing crest elevation of 1,235 feet. The regrading plan also included extension of the buttress originally planned as part of the dam raise to 1,245 feet. NSM performed the first phase of dam raise construction to a crest elevation of 1,245 feet during the summer and fall of 2018.

The current raise of the dam crest to 1,245 feet as well as future raises are planned to continue to use the centerline method to the approximate presently permitted ultimate elevation of 1,315 feet, although a final alignment has not been designed along the north side of the dam. Several alternatives have been proposed and will be evaluated in more detail prior to construction.

3.7.2 Site Observations

Over the past several years, the downstream slope of Dam 5 has consisted of overbuilt benches that have not been graded to the final slope. For the 2018 dam inspection, several areas of the downstream slope were observed to have been graded to the 6H:1V slope per plans while plant aggregate piles were present in other areas in preparation for grading to 6H:1V. The buttress at the toe of the dam was observed to have been extended across the majority of the dam. The southern end of the crest, filter berm, and core were observed to have been raised up to the raise elevation of 1,245 feet. Portions of the north end of the dam were raised while others remained at the previous elevation of 1,235 feet. NSM indicated the remainder of dam construction up to a crest elevation of 1,245 feet is planned to take place in the summer of 2019. Note that sheets G-11 and G-12 do not yet reflect the regraded condition of Dam 5 as construction is not yet complete and LiDAR data has not been collected since the spring of 2017.

Seepage was not observed through the dam, except for water observed in the seepage collection pond at the toe. A culvert from Bear Lake has sometimes been a source of water entering the seepage recovery pond in the past. This culvert was observed to have been removed and water was flowing in the remnant channel into to the seepage collection pond. NSM indicated the culvert was replaced after the dam inspection. The seepage collection pond was also observed at a higher level than the minimum recommended level in the spring 2017 monitoring report of 1,181 feet. NSM indicated that the toe pond water level on October 13, 2018 was 1,184 feet.

Since Dam 5 is frequently under construction and no part of the dam has reached the ultimate configuration, vegetation was not observed on the slopes. Minimal erosion was observed in most areas of the downstream slope.

A stockpile of clay was observed to have been placed on the filter near approximate station 15+00. This stockpile should be removed to prevent core material from mixing and migrating into the filter.

3.8 Reclaim Dike

The Reclaim Dike (Reclaim Dam) separates the south tailings basin pond from the Reclaim Pond. The Reclaim Pond supports two floating pump stations that supply water for plant operations and to the water treatment plant. Water from the south pond of the tailings basin flows over a steel decant structure (weir) and into pipes that discharge into the Reclaim Pond. A chemical treatment system is housed in a shed on top of the weir, which is used to treat the water by adding a flocculant as it enters the pond to reduce the total suspended solids. The dam was reportedly built over a former haul road, is constructed of plant aggregate, and uses the centerline construction method. A plan view of the Reclaim Dam is shown on sheet G-01 and G-13 (Appendix C).

In late 2005 and 2006, the dike was raised using plant aggregate. The tailings were hauled from the Dam 5 dumpsite and placed along the toe of the dam during the winter. Ice was broken in advance of the fill placement by an excavator reaching out into the Reclaim Pond in an effort to reduce any ice entrapment in the fill. Fill was pushed ahead by a dozer until a stable bench was constructed on top of the submerged toe and a bench that was constructed many years ago. After the material was placed along the toe, the

slopes were constructed until the crest was reached. The crest is now more than 50 feet wide, which allows haul truck traffic along the entire length of the dam. The crest along most of the dam is presently at an elevation of approximately 1,235 feet.

NSM plant operations were idled between approximately December 2015 and early April 2016. In mid-April 2016, cracking and sloughing were observed by NSM and Barr along the downstream slope. This sloughing and cracking appeared to have been the result of a reduction in the effective stress of the looser plant aggregate sloped near the angle of repose beyond the core areas of the dam due to a rise of the reclaim pond elevation. NSM subsequently regraded the entire downstream slope of the dam to approximately 4H:1V to match the dam design, and in some areas flatter. During the 2017 dam inspection, two areas of cracking were observed, including one on the upstream edge of the crest near approximate station 38+00 and a second on the downstream edge of the crest near approximate station 39+00; both of these areas are in the overbuilt area of the dam, beyond the core compacted zone.

To keep vehicle traffic near the center of the dam and prevent traffic in the overbuilt areas where cracking has been observed, NSM placed another set of berms interior to the berms typically placed along the crest edges. These berms were observed to be in place during the 2018 dam inspection. As has been the case for the last several inspections, erosion of the relatively steep upstream slope from wave action was observed. Piles of plant aggregate that have not yet been graded to 4H:1V were also observed on the downstream slope between approximate stations 24+00 and 33+00.

As mentioned in the summary of Dam 1 observations, a berm was constructed between the upstream faces of Dam 1 and the Reclaim Dam to create the Super Cell Beach. Fine tailings were also spigotted to create a beach on the upstream side of the reclaim dam along the remainder of the east-west section of the dam, as well as along the approximate southern half of the western section of the dam. An equipment causeway was constructed westward off the west end of the southwest corner of the reclaim dam to facilitate spigotting. The fine tailings beach was observed to be mulched.

In 2010, instrumentation was installed at two locations along the dam alignment to facilitate seepage and stability modeling, with three piezometers installed at station 27+00 and three installed at station 37+00. In 2015, piezometers were again installed at station 37+00 to replace the other piezometers at that station that became inoperative due to wire end submersion. Since the fall 2016 monitoring event, the wire ends for piezometers at station 27+00 could not be found and are assumed to have become buried during slope grading. These instruments should be replaced. Cross sections of the reclaim dam are shown on sheet G-14 (Appendix C).

The new weir was installed just southwest of the existing weir in 2017 was observed to still be present. The outlet pipes for the new weir were visible, but were not operational, during the dam inspection; the old weir was observed to still be operational. Equipment for a fine tailings treatment study was observed on the dam crest in the vicinity of the weir at the time of the dam inspection. The outlet pipes for the old weir should be grouted to prevent material migration between the south pond (Cell 1) and reclaim pond once the transition to the new weir is complete. The dam width in the area of the existing weir is also

narrower than the rest of the dam, and should be regraded and compacted to match the rest of the dam once the new weir is in service and the old weir sufficiently abandoned.

The intent of the weir is to limit the amount of finer material that flows into the reclaim pond by skimming surficial water and treating it as it flows through the weir house. The 1,000 foot long turbidity curtain installed in November 2014 was observed to be in service with none of the top floats submerged. Although the curtain appears to be functional, the turbidity curtain anchors could be repositioned to re-center the curtain around the weir outlet once the new weir is in service.

3.9 Diversion Dikes

Diversion Dikes 1C, 2, and 3 were also viewed during the dam inspection. These dams are located northwest and southwest of the landfill and function to divert water from the watershed away from the basin. Each dam appeared to be performing as intended. The dams are grass-covered with some trees or brush. Diversion Dam 2 includes an upstream riprap erosion control face. The dams were not observed to impound significant volumes of water except Diversion Dike 1C, which always impounds water and routes it into a low flow channel (Diversion 1) away from the tailings basin. Each of the dams was generally level and no sloughing or instability was observed. No seepage was observed on the dam faces or at the dam toes.

In the past, a beaver dam has been observed in the outlet to the pond upstream of Diversion Dike 1C. This channel was observed to be clear of debris and free flowing during the 2018 dam inspection. One larger coniferous tree as well as a larger deciduous tree were observed to be present on the upstream slope of Diversion Dike 1C, which should be removed. Some intermittent woody brush was also present on the upstream slope as well as the lower portion of the downstream slope, which should be removed.

Similar to the last couple years, some piles of trees and woody brush were present during the 2018 dam inspection that appeared to have been cut from the sideslopes of Diversion Dike 2. Some trees and woody brush are still present, and the remaining trees and woody brush should be removed from the dam slopes.

One larger tree was observed on the crest and a few medium-sized trees were observed to be present on the upstream slope of Diversion Dike 3, which should be removed.

4.0 Monitoring Data

The tailings basin is monitored on a regular basis, which includes the collection of monitoring data on a biannual basis. The monitoring program consists of recording data from all of the functioning piezometers and inclinometers that have been installed at the dams. Currently, there are many piezometers consisting of standpipe (in this case Casagrande-type), pneumatic, or vibrating wire construction. There are also ten inclinometers; four at Dam 1, four at Dam 2, and two at Dam 5. Additionally, there are 13 relief wells that are monitored. The data are collected in the field and entered into the piezometer spreadsheets or inclinometer database.

In general, the majority of pneumatic piezometers are functioning as intended. As has been noted in recent years, however, some reading issues have occurred and a few appear to have reached the end of their operable life. The majority of the pneumatic piezometers were placed in the dam during original construction in the late 1970s and 1980s. Additional pneumatic piezometers were installed in 1996 and 1997. Therefore, most of the instruments upon which significant reliance on the data for safety monitoring were installed 10 to 40 years ago. It is expected that many of these devices will eventually plug or become inoperable due to degradation of the supply tubing or other issues. In response to these equipment failures, vibrating wire (VW) piezometers have been installed at select locations to replace the pneumatic devices, such as the vibrating wire piezometers installed at Dam 2 in 2015. Some of the risers for the Casagrande piezometers have also become intermittently or completely blocked, which does not allow a water level indicator to be lowered into the standpipe to record the water level. These locations should be repaired or replaced as they are located on the midslope and/or near the toes of the dams and provide valuable information in this area. Pneumatic and Casagrande piezometers should be planned to be replaced with VW piezometers over the next several years to prevent data gaps.

VW piezometers were installed at Dam 1E for the first time at the toe in late 2017. Two additional nests were installed in the summer of 2018 along the same station alignment to facilitate analyses for this dam section.

Data loggers were installed at select locations to collect data from VW piezometers for the first time at the site in the 2017. In 2018, data loggers were installed on the majority of remaining VWs as well as newly installed VW piezometers. Data from these loggers has already been correlated to construction and/or pond change events with piezometer heads. Data loggers are planned to continue to be added to new VWs as they are installed. Setup of automated monitoring is also in progress.

The monitoring data and evaluation report is presented in detail within Appendix D. The report summarizes the fall 2018 monitoring event and discusses monitoring results. The piezometer data for Dam 1, Dam 2, Dam 5, the Reclaim Dam and the seepage recovery dams are relatively consistent with past readings and the data recorded during the fall monitoring event provides no indication of dam instability. The installation of more data loggers will allow additional data collection for use to set action levels for the piezometers on the downstream slopes and at the toe.

Piezometer readings from Casagrande piezometers at seepage recovery dam 1A and 2-3 appear generally consistent with past readings. The piezometric heads from some of the piezometers located at the toe of seepage recovery dam 1A are similar to the pond elevation for the adjacent seepage recovery pond and the environmental monitoring wells at the toe of the dam indicate artesian conditions. VW piezometers were installed in late 2018 at the toe of each of the seepage recovery dams and this data is planned to be used to perform updated seepage and stability analyses for these dams.

Inclinometer data generally shows no movement between the spring and fall of 2018. Several of the inclinometers at the basin were installed almost 20 years ago, while the rest of the inclinometers were installed 3 to 12 years ago. Although data from particularly the older piezometers does not appear to indicate movement, inclinometer casings can deteriorate over time which can potentially mask movement. Seven inclinometers were evaluated with a downhole camera in the fall of 2017 and the remaining two inclinometers were evaluated in the fall of 2018. This evaluation indicates that inclinometers are generally in acceptable condition, though some groove wear was observed in older instruments. Implementation of micro-electro-mechanical systems (MEMS) inclinometers is an option to upgrade these older instruments. The MEMS are permanent, can be installed in the existing inclinometer casing, and can be incorporated into a remote monitoring system. NSM and Barr have discussed incorporation of MEMS sensors at some initial select locations in 2019.

Discharge from the relief wells was also measured as part of the monitoring process. Relief well flows were measured to be higher than in the spring of 2018, but within the range of historical readings.

5.0 Summary and Action Plan

The tailings dam inspection performed on October 15 and 16, 2018 did not identify conditions immediately affecting the integrity of the basin. Each of the dams appears to be in acceptable condition for continued operation.

Dam construction during the year included regrading of Dam 5 and the initial phase of the raise of the Dam 5 crest to 1,245 feet. Filter material was also placed at the west end of Dam 1. Some backer material was also placed at Dam 1 and Dam 2. The SCB originally constructed in the southeast corner of the basin between Dam 1 and the Reclaim Dam in 2017 was raised up to the approximate elevation of 1,235 feet. A new SCB was constructed along the entire length of Dam 1 west of the original SCB, with the fine tailings containment berm parallel to the dam centerline and placed approximately 200 feet off of the filter berm toe. Fine tailings were also deposited upstream of Dam 1, Dam 2, and the Reclaim Dam. Beach mulching was conducted, as well.

Recommendations for the maintenance and continued operations of the dams for 2018 are as follows:

- Continue monitoring the instrumentation on Dam 1, Dam 2, Dam 5, the Reclaim Dam, and seepage recovery dams at least two times a year and repair/replace defective or non-functional devices. Perform interim site visits for construction observation and monitoring, as necessary. Develop action levels for piezometers on the downstream slope and at the toe of Dam 1 and Dam 2 relative to dam stability when sufficient data becomes available through use of data loggers.
- Raise Dams 1, 2, and 5 as necessary to maintain freeboard according to permitted requirements.
- Monitor pond and beach elevations to prevent pond water from coming in direct contact with upstream filter berms for Dam 1 and 2. Construct SCBs in a manner as to prevent fine tailings from overtopping the filter berm.
- Clear out vegetation and debris from the weirs and areas upstream and downstream of the weirs to prevent seepage backup and allow monitoring, especially for the west end of Dam 1. Clear out seepage collection ditches to maintain free flow.
- Clear vegetation from the area out beyond the toe of Dam 2 to allow better assessment of toe ditch conditions and creation of a toe ditching plan. Create channel to toe seepage ditch to route water from ponded area at northeastern corner of Dam 2.
- Continue to maintain traffic closer to the center of the Reclaim Dam.
- Remove the stockpiled clay placed on top of the filter berm at Dam 5 in a manner as to prevent mixing of clay and filter materials.
- Continue vegetating exposed areas of the dams as they are regraded or raised. In areas where there is no vegetation and erosion had occurred previously, regrade by placing new material into

the eroded areas and revegetate. This process will reduce damage from regrading by larger equipment.

- Regrade areas of plant aggregate and/or filter erosion on Dam 1, Dam 2, and the Reclaim Dam, as well as the area of minor, shallow sloughing on the downstream side of the seepage collection ditch near the middle of the eastern side of the western portion of Dam 1.
- Monitor any wet areas that appear at the toes of the dams for evidence of seepage.
- Remove brush along the core of the tailings dams, such as along the core of Dam 1E. Regrade any notches in the core created during brush clearing, such as observed at Dam 1E. Brush and trees should also be removed from the slopes of all the diversion dams.
- Fill in animal burrows observed at the west ends of Dam 1 and of Dam 2 per the FEMA *Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams* (2005).
- Periodically inspect areas where beaver dams have been observed in the past and remove any newly constructed beaver dams.
- Replace the caps on the monitoring wells with vented caps to prevent pressure build-up.
- Install data loggers on any remaining instruments and newly installed instruments where possible to collect data throughout the year, particularly over the duration of construction activities and during different seasons and weather conditions.
- Continue development of a plan to install MEMS based equipment in inclinometer casings.
- Continue to follow and update the instrumentation upgrade plan for the next 5 years to replace malfunctioning equipment and incorporate near real-time monitoring.

Appendices

Appendix A

Inspection Report

Northshore Mining Company
2018 Tailing Dam Inspection Forms
Inspection of Dam 1 Structure

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection		X	Not required due to beaches
1.2 Evidence of erosion		X	Some narrower sections of filter berm at ramp locations
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level		N/A	
1.7 Tailings adjacent to dam	X		Super cell beach under construction
1.8 Vegetation	X		Beaches have been mulched except where recent spigotting has taken place (west end of new super beach)
1.9 Slope visually uniform	X		
1.10 Other unusual conditions		X	Couple areas where super cell beach berm overtopped near west end
1.11 Evidence of repairs		X	Recent raise of filter berm, mainly at west end
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		Except in areas where fill being placed for railroad and dumpsites
2.8 Other unusual conditions		X	
2.9 Evidence of repairs		X	Backer fill material placed between RR grade and filter berm in several areas, filter berm construction at west end
3.0 Downstream Slope			
3.1 Erosion protection	X		Vegetation
3.2 Evidence of erosion		X	Seepage collection ditch is free of tailings or debris and flowing, although a significant amount of algae and cattails are present; no constrictions in width. Significant amount of algae upstream, downstream, and in weirs. Some minor erosion near 28+40 on downstream side of seepage collection ditch similar to that observed in 2017 and spring 2018
3.3 Evidence of movement		X	

Observed Features	Yes	No	Comment / Note No.
3.4 Evidence of sloughing		X	Potential minor, shallow areas of slough in filter on downslope side of seepage ditch between 28+40 and 35+00 – condition appears the same as observed in 2017 and spring 2018
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface	X		Inside, upstream side of seepage collection ditch about 1 foot up from water surface, defined by vegetation.
3.7 Evidence of seepage	X		Seepage flow inside seepage collection ditch, seepage visible at intermittent locations along dam on inside, upstream edge of seepage collection ditch.
3.8 Seepage clear	X		
3.9 Vegetation	X		Slopes are established with vegetation.
3.10 Slope visually uniform	X		
3.11 Other unusual conditions		X	Intermittent areas of brush along the filter as well as on the core near east end.
3.12 Evidence of repairs		X	
4.0 Left and Right Abutments			
4.1 Evidence of seepage	X		Seepage flow in ditch, routed to abutments, measured at weirs.
4.2 Seepage clear	X		Algae/cattails in seepage collection ditch
4.3 Evidence of erosion		X	
4.4 Evidence of cracks		X	
4.5 Evidence of movement		X	
4.6 Evidence of settlement		X	
4.7 Other unusual conditions		X	Abundance of algae, cattails, and branches in west weir. Abundance of algae in east weir. Animal burrows in core at west end, near weir.
4.8 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists	X		
5.2 Toe drain working well		N/A	Unknown, relief wells are flowing as shown in monitoring report.
5.3 Toe ditch exits	X		Seepage pond
5.4 Flow in toe ditch	X		Seepage pond recovers any flow
5.5 Evidence of seepage		X	
5.6 Seepage clear		N/A	
5.7 Soft toe condition		X	
5.8 Evidence of sloughing		X	
5.9 Evidence of boils		X	
5.10 Other unusual conditions		X	Relief wells are flowing
5.11 Evidence of repairs		X	

Observed Features	Yes	No	Comment / Note No.
6.0 General			
6.1 Associated tailings dam		N/A	
6.2 Decant structure at this dam		X	
6.3 Embedded/buried structures		X	
6.4 Spillway at/next to this dam		X	Designed at west end for ultimate dam elevation
6.5 Pipelines at this dam	X		Tailings discharge
6.6 Tailings next to dam inspected	X		
6.7 Crest accessible by truck	X		
6.8 Public access to dam		X	Gated facility
6.9 Any unusual conditions		X	

Inspection of Dam 1 (east end) Structure

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection		X	Not required, beach present
1.2 Evidence of erosion		X	
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level		X	
1.7 Tailings adjacent to dam	X		
1.8 Vegetation	X		Beach is mulched/vegetated except where tailings are being discharged
1.9 Slope visually uniform	X		
1.10 Other unusual conditions		X	Original super cell beach still in place. New super cell beach parallel to dam centerline.
1.11 Evidence of repairs		X	
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		Except where the railroad is being constructed and where dump sites are located for existing railroad
2.8 Other unusual conditions		X	
2.9 Evidence of repairs		X	
3.0 Downstream Slope			
3.1 Erosion protection	X		Uniform slope, graded and vegetated
3.2 Evidence of erosion		X	
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface		X	Upstream slope of seepage collection ditch is wet, especially at east end
3.7 Evidence of seepage	X		Seepage flow in collection channel, seepage into seepage collection ditch visible on upstream side at east end
3.8 Seepage clear	X		Abundance of algae and cattails in seepage collection ditch

Observed Features	Yes	No	Comment / Note No.
3.9 Vegetation	X		Slopes are established with vegetation. Though some has been removed, tall brush and trees remain in areas on clay core that should be removed. A lot of algae and cattails in seepage collection ditch
3.10 Slope visually uniform	X		
3.11 Other unusual conditions		X	Clay core notched in one location that appears to have occurred during vegetation clearing activities
3.12 Evidence of repairs		X	
4.0 Left and Right Abutments			
4.1 Evidence of seepage	X		Visible seepage on upstream side of seepage collection ditch at east end
4.2 Seepage clear	X		
4.3 Evidence of erosion		X	
4.4 Evidence of cracks		X	
4.5 Evidence of movement		X	
4.6 Evidence of settlement		X	
4.7 Other unusual conditions		X	
4.8 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists		X	
5.2 Toe drain working well		N/A	
5.3 Toe ditch exits	X		Seepage pond at toe of dam and diversion ditch
5.4 Flow in toe ditch	X		Trees/brush at toe obstruct view of some of the toe ditch – clear out trees
5.5 Evidence of seepage	X		Toe is moist to wet along pond shoreline.
5.6 Seepage clear		N/A	
5.7 Soft toe condition		X	
5.8 Evidence of sloughing		X	
5.9 Evidence of boils		X	
5.10 Other unusual conditions		X	
5.11 Evidence of repairs		X	
6.0 General			
6.1 Associated tailings dam		N/A	
6.2 Decant structure at this dam		X	
6.3 Embedded/buried structures		X	
6.4 Spillway at/next to this dam		X	
6.5 Pipelines at this dam	X		Tailings discharge
6.6 Tailings next to dam inspected	X		
6.7 Crest accessible by truck	X		
6.8 Public access to dam		X	Gated facility
6.9 Any unusual conditions		X	

Inspection of Seepage Recovery Dam 1A

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection	X		Grass covered
1.2 Evidence of erosion		X	
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level		X	
1.7 Tailings adjacent to dam		X	Seepage recovery pond
1.8 Vegetation	X		Well vegetated
1.9 Slope visually uniform	X		
1.10 Other unusual conditions		X	
1.11 Evidence of repairs		X	
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		
2.8 Other unusual conditions		X	
2.9 Evidence of repairs		X	
3.0 Downstream Slope			
3.1 Erosion protection	X		Sand and gravel construction, vegetation
3.2 Evidence of erosion		X	
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface		X	
3.7 Evidence of seepage	X		Wet toe, consistent with previous years
3.8 Seepage clear		N/A	
3.9 Vegetation	X		
3.10 Slope visually uniform	X		
3.11 Other unusual conditions		X	
3.12 Evidence of repairs		X	

Observed Features	Yes	No	Comment / Note No.
4.0 Left and Right Abutments			
4.1 Evidence of seepage		X	
4.2 Seepage clear		N/A	
4.3 Evidence of erosion		X	
4.4 Evidence of cracks		X	
4.5 Evidence of movement		X	
4.6 Evidence of settlement		X	
4.7 Other unusual conditions		X	
4.8 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists		X	
5.2 Toe drain working well		N/A	
5.3 Toe ditch exits	X		Wet toe and cattails. No well-designed ditch
5.4 Flow in toe ditch		X	
5.5 Evidence of seepage	X		No visible seeps but wet, cattails in wet areas
5.6 Seepage clear		N/A	
5.7 Soft toe condition		X	
5.8 Evidence of sloughing		X	
5.9 Evidence of boils		X	
5.10 Other unusual conditions		X	Flooded area downstream of dam toe due to culvert under RR grade blocked by beaver activity
5.11 Evidence of repairs		X	
6.0 General			
6.1 Associated tailings dam	X		Dam 1
6.2 SCF(s) at this dam		X	
6.3 Decant structure at this dam		X	Pump Station pumps upstream seepage recovery pond water back to basin
6.4 Embedded/buried structures		X	
6.5 Spillway at/next to this dam	X		Low area covered in vegetation off west end of dam
6.6 Pipelines at this dam		X	Pumps back to main pond over Dam 1
6.7 Tailings next to dam inspected		N/A	No tailings
6.8 Crest accessible by truck	X		
6.9 Public access to dam		X	Gated facility
6.10 Any unusual conditions		X	

Inspection of Seepage Recovery Dam 1B

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection	X		Vegetation and small boulders
1.2 Evidence of erosion		X	
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level		X	
1.7 Tailings adjacent to dam		X	
1.8 Vegetation	X		Some brush near west end of dam
1.9 Slope visually uniform	X		
1.10 Other unusual conditions		X	
1.11 Evidence of repairs		X	
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		
2.8 Other unusual conditions	X		Few ant hills, especially near east end
2.9 Evidence of repairs		X	
3.0 Downstream Slope			
3.1 Erosion protection		X	
3.2 Evidence of erosion		X	
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface		X	
3.7 Evidence of seepage	X		Wet toe, consistent with past conditions. Seepage observed adjacent to replacement monitoring wells installed at toe.
3.8 Seepage clear		N/A	
3.9 Vegetation	X		
3.10 Slope visually uniform	X		
3.11 Other unusual conditions		X	
3.12 Evidence of repairs		X	New monitoring wells at toe, old sheds removed.

Observed Features	Yes	No	Comment / Note No.
4.0 Left and Right Abutments			
4.1 Evidence of seepage		X	
4.2 Seepage clear		N/A	
4.3 Evidence of contamination		X	
4.4 Evidence of erosion		X	
4.5 Evidence of cracks		X	
4.6 Evidence of movement		X	
4.7 Evidence of settlement		X	
4.8 Other unusual conditions		X	
4.9 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists		X	Unknown
5.2 Toe drain working well		N/A	
5.3 Toe ditch exits		X	
5.4 Flow in toe ditch		X	
5.5 Evidence of seepage	X		Vegetation turns to tall grasses at toe; wet and mossy. Some seepage flowing <1 gpm in vicinity of old monitoring well that was recently replaced at the toe.
5.6 Seepage clear	X		Minimal standing water. Seepage in vicinity of replaced monitoring well appears clear.
5.7 Evidence of contamination		X	
5.8 Evidence of vegetation kills		X	
5.9 Soft toe condition		X	Soft in wet areas but typically firm
5.10 Evidence of sloughing		X	
5.11 Evidence of boils		X	
5.12 Other unusual conditions		X	
5.13 Evidence of repairs		X	
6.0 General			
6.1 Associated tailings dam	X		Dam 1 (old Dam 1E)
6.2 Decant structure at this dam		X	
6.3 Embedded/buried structures		X	
6.4 Spillway at/next to this dam	X		Low area covered in vegetation off west end of dam
6.5 Pipelines at this dam		X	
6.6 Tailings next to dam inspected		N/A	No tailings
6.7 Crest accessible by truck	X		
6.8 Public access to dam		X	Gated facility
6.9 Any unusual conditions		X	

Inspection of Dam 2 Structure

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection		X	
1.2 Evidence of erosion	X		Some erosion in a few spots
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level	X		Large beach
1.7 Tailings adjacent to dam	X		
1.8 Vegetation	X		Mulch on beaches to minimize dust issues
1.9 Slope visually uniform	X		
1.10 Other unusual conditions		X	
1.11 Evidence of repairs		X	
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		High at railroad grade and at filter berm, low in middle of dam, continuing to fill low areas to create 6H:1V slope downstream of railroad
2.8 Other unusual conditions		X	
2.9 Evidence of repairs		X	
3.0 Downstream Slope			
3.1 Erosion protection	X		Vegetation
3.2 Evidence of erosion	X		Some minor erosion of filter material adjacent to core, though same condition as observed in spring 2018.
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface	X		Generally present in seepage collection ditch a few inches above water flow on upstream side of ditch, vegetation changes in seepage collection ditch.
3.7 Evidence of seepage	X		Flow in seepage collection ditch. Quite a bit of algae and some cattails in seepage collection ditch
3.8 Seepage clear	X		Some murky areas in seepage collection ditch due to algae
3.9 Vegetation	X		
3.10 Slope visually uniform	X		
3.11 Other unusual conditions	X		A few animal burrows in core at west end, near west weir

Observed Features	Yes	No	Comment / Note No.
3.12 Evidence of repairs		X	
4.0 Left and Right Abutments			
4.1 Evidence of seepage		X	Seepage only at weirs from seepage collection ditch
4.2 Seepage clear		N/A	
4.3 Evidence of erosion		X	
4.4 Evidence of cracks		X	
4.5 Evidence of movement		X	
4.6 Evidence of settlement		X	
4.7 Other unusual conditions		X	Abundance of algae and cattails at, upstream, and downstream of weirs, especially west end.
4.8 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists	X		
5.2 Toe drain working well			Difficult to tell, optimize water flow away from toe with ditches
5.3 Toe ditch exits		X	Toe ditch contains water, limited flow in center and east areas. Difficult to see ditch condition due to abundance of trees, brush, and grass.
5.4 Flow in toe ditch	X		Water flowing in toe ditch at west end, standing water in some areas along east toe, east toe channel meanders
5.5 Evidence of seepage	X		Wet, swampy area beyond toe berm with water flow
5.6 Seepage clear	X		
5.7 Evidence of vegetation kills		X	
5.8 Soft toe condition	X		Swampy conditions, wet
5.9 Evidence of sloughing		X	
5.10 Evidence of boils		X	
5.11 Other unusual conditions	X		Beaver dams removed from area off toe, just upstream of seepage recovery dam 2-3. Remnants of old beaver dam in toe drain channel should be removed
5.12 Evidence of repairs		X	
6.0 General			
6.1 Decant structure at this dam		X	
6.2 Embedded/buried structures		X	
6.3 Spillway at/next to this dam		X	
6.4 Pipelines at this dam		X	
6.5 Tailings next to dam inspected	X		
6.6 Crest accessible by truck	X		
6.7 Public access to dam		X	Gated facility
6.8 Any unusual conditions		X	

Inspection of Dam 5 Structure

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope (currently under construction)			
1.1 Erosion protection		X	Not required, dam overbuilt in cross section so the pond is far upstream and crest is protected by plant aggregate
1.2 Evidence of erosion		X	
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level	X		Small plant aggregate beach at upstream toe
1.7 Tailings adjacent to dam		X	No fine tailings beach
1.8 Vegetation		X	
1.9 Slope visually uniform	X		Uniform yet varies along the alignment
1.10 Other unusual conditions		X	
1.11 Evidence of repairs		X	
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion	X		
2.6 Reduced width		X	Extra wide for trucks
2.7 Crest visually horizontal	X		
2.8 Other unusual conditions		X	
2.9 Evidence of repairs	X		Under construction for raise to 1,245 feet
3.0 Downstream Slope (currently under construction)			
3.1 Erosion protection		X	
3.2 Evidence of erosion		X	Minimal erosion
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface		X	
3.7 Evidence of seepage	X		Seepage pond at toe
3.8 Seepage clear	X		
3.9 Vegetation		X	
3.10 Slope visually uniform		X	Slope is under construction by NSM to 6H:1V slopes, so slope varies along alignment.
3.11 Other unusual conditions		X	
3.12 Evidence of repairs	X		Under construction to move excess fill on downstream slope and raise dam crest to 1,245 feet

Observed Features	Yes	No	Comment / Note No.
3.13 Other		X	
4.0 Left and Right Abutments			
4.1 Evidence of seepage		X	
4.2 Seepage clear		N/A	
4.3 Evidence of erosion		X	
4.4 Evidence of cracks		X	
4.5 Evidence of movement		X	
4.6 Evidence of settlement		X	
4.7 Other unusual conditions		X	
4.8 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists	X		
5.2 Toe drain working well	X		
5.3 Toe ditch exits		N/A	Pumping system to the main pond
5.4 Flow in toe ditch		N/A	
5.5 Evidence of seepage	X		Pond collects seepage and run off from Bear Lake
5.6 Seepage clear	X		
5.7 Soft toe condition		X	
5.8 Evidence of sloughing		X	
5.9 Evidence of boils		X	
5.10 Other unusual conditions		X	
5.11 Evidence of repairs		X	Buttress extension at toe per plans
6.0 General			
6.1 Associated tailings dam		X	
6.2 Decant structure at this dam		X	
6.3 Embedded/buried structures		X	
6.4 Spillway at/next to this dam		X	
6.5 Pipelines at this dam	X		Pipeline/culvert from Bear Lake removed; water flowing through remaining channel into seepage pond. Toe pond surface at 1,184 feet as of 10/13/18 as measured by NSM.
6.6 Tailings next to dam inspected		X	No fine tailings
6.7 Crest accessible by truck	X		
6.8 Public access to dam		X	Gated facility
6.9 Any unusual conditions		X	

Inspection of Reclaim Dam

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection		X	
1.2 Evidence of erosion		X	Erosion along slopes and from rain and wave action, especially north of station 37+00
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level		X	Small plant aggregate beach
1.7 Tailings adjacent to dam	X		'Super Cell Beach' on south side of dam. Fine tailings beach also on southern part of western leg of dam. Submerged fine tailings in vicinity of weir.
1.8 Vegetation		X	
1.9 Slope visually uniform		X	Some areas are near slope of angle of repose
1.10 Other unusual conditions		X	
1.11 Evidence of repairs	X		Under continual construction and grading
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		Sloped to drain into reclaim pond
2.8 Other unusual conditions		X	New weir at north end to replace old weir. Weir is in place, but flow has not yet been switched from old to new weir. Narrow area of dam crest at existing weir.
2.9 Evidence of repairs		X	
3.0 Downstream Slope			
3.1 Erosion protection		X	
3.2 Evidence of erosion	X		Some erosion in a few areas
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface		X	
3.7 Evidence of seepage		X	
3.8 Seepage clear		N/A	
3.9 Evidence of contamination		X	

Observed Features	Yes	No	Comment / Note No.
3.10 Vegetation		X	
3.11 Slope visually uniform	X		Slopes generally similar at about 4H:1V, but in some areas closer to 6H:1V, especially on east-west section of dam
3.12 Other unusual conditions		X	Activity in vicinity of weir for fine tailings treatment study
3.13 Evidence of repairs	X		Regrading has been ongoing to make slopes closer to design plans
4.0 Left and Right Abutments			
4.1 Evidence of seepage		X	
4.2 Seepage clear		N/A	
4.3 Evidence of contamination		X	
4.4 Evidence of erosion		X	
4.5 Evidence of cracks		X	
4.6 Evidence of movement		X	
4.7 Evidence of settlement		X	
4.8 Other unusual conditions	X		Fill material from elsewhere near basin dumped on upstream slope at far east end of east-west section of dam on south end of pond in fall 2016. Material is now covered in fine tailings, but NSM has recorded perimeter of fill material area.
4.9 Evidence of repairs		X	
5.0 Downstream Toe			
5.1 Toe drain exists		X	
5.2 Toe drain working well		N/A	
5.3 Toe ditch exits		N/A	
5.4 Flow in toe ditch		N/A	
5.5 Evidence of seepage		X	Reclaim pond at toe
5.6 Seepage clear		X	
5.7 Evidence of contamination		X	
5.8 Evidence of vegetation kills		X	
5.9 Soft toe condition		X	
5.10 Evidence of sloughing		X	
5.11 Evidence of boils		X	
5.12 Other unusual conditions		X	
5.13 Evidence of repairs		X	Regrading of downstream slope continues
6.0 General			
6.1 Associated tailings dam		N/A	
6.2 Decant structure at this dam	X		Weir
6.3 Embedded/buried structures	X		Pipes from new weir (not yet in service). Pipes from old weir also still present and will need to be removed/grouted once flow switched to new weir.

Observed Features	Yes	No	Comment / Note No.
6.4 Spillway at/next to this dam		X	
6.5 Pipelines at this dam	X		Pipeline for tailings discharge upstream
6.6 Tailings next to dam inspected	X		
6.7 Crest accessible by truck	X		
6.8 Public access to dam		X	Gated facility
6.9 Any unusual conditions		X	Turbidity curtain visible. May need some re-adjustment of anchors to maintain arc around outlet

Inspection of Seepage Recovery Dam 2-3

Observed Features	Yes	No	Comment / Note No.
1.0 (visible part of) Upstream Slope			
1.1 Erosion protection	X		Vegetation
1.2 Evidence of erosion		X	
1.3 Evidence of movement		X	
1.4 Evidence of sloughing		X	
1.5 Evidence of cracking		X	
1.6 Mark of high pond level		X	
1.7 Tailings adjacent to dam		X	
1.8 Vegetation	X		Tall grass, brush
1.9 Slope visually uniform	X		
1.10 Other unusual conditions		X	
1.11 Evidence of repairs		X	
2.0 Crest			
2.1 Breach / wash-out		X	
2.2 Lateral movement		X	
2.3 Evidence of settlement		X	
2.4 Evidence of cracking		X	
2.5 Shoulder erosion		X	
2.6 Reduced width		X	
2.7 Crest visually horizontal	X		
2.8 Other unusual conditions		X	
2.9 Evidence of repairs		X	
3.0 Downstream Slope			
3.1 Erosion protection	X		Vegetated
3.2 Evidence of erosion		X	
3.3 Evidence of movement		X	
3.4 Evidence of sloughing		X	
3.5 Evidence of cracking		X	
3.6 Signs of phreatic surface	X		Wet near toe, but no flow was observed except for flow at relief wells
3.7 Evidence of seepage		X	
3.8 Seepage clear		N/A	
3.9 Vegetation	X		
3.10 Slope visually uniform	X		
3.11 Other unusual conditions		X	
3.12 Evidence of repairs		X	

Observed Features	Yes	No	Comment / Note No.
4.0 Left and Right Abutments			
4.1 Evidence of seepage		X	
4.2 Seepage clear		N/A	
4.3 Evidence of erosion		X	
4.4 Evidence of cracks		X	
4.5 Evidence of movement		X	
4.6 Evidence of settlement		X	
4.7 Other unusual conditions		X	
4.8 Evidence of repairs		X	
5.0 Downstream Toe (Sand and Gravel Construction)			
5.1 Toe drain exists		N/A	
5.2 Toe drain working well		N/A	Relief wells flowing
5.3 Toe ditch exists	X		Small channel, difficult to see due to vegetation
5.4 Flow in toe ditch	X		Water in areas that are low, with cattails
5.5 Evidence of seepage	X		Relief well flow
5.6 Seepage clear	X		
5.7 Soft toe condition		X	
5.8 Evidence of sloughing		X	
5.9 Evidence of boils		X	
5.10 Other unusual conditions		X	
5.11 Evidence of repairs		X	
6.0 General			
6.1 Associated tailings dam	X		Dam 2
6.2 Decant structure at this dam		X	
6.3 Embedded/buried structures		X	
6.4 Spillway at/next to this dam		X	
6.5 Pipelines at this dam		X	
6.6 Tailings next to dam inspected		N/A	
6.7 Crest accessible by truck	X		
6.8 Public access to dam		X	Gated facility
6.9 Any unusual conditions		X	

Appendix B

Photographs

Dam 1 Photographs

Looking west along the toe of Dam 1

Looking east at toe of east end of Dam 1

Dam 1 Photographs

Looking east along the toe of Dam 1 from near west end

Upstream side of west weir at Dam 1

Dam 1 Photographs

Downstream side of west weir at Dam 1

Looking downstream at channel to divert seepage recovery ditch water away from west end of Dam 1

Dam 1 Photographs

Animal burrows in core at west end of Dam 1, near weir

Looking east along seepage recovery ditch with sporadic brush and abundance of algae at Dam 1

Dam 1 Photographs

Looking west along seepage recovery ditch at Dam 1

Looking west along seepage recovery ditch from near east weir at Dam 1

Dam 1 Photographs

Looking northwest at cattails in seepage recovery ditch near east weir at Dam 1

Weir at east end of seepage recovery ditch for main segment of Dam 1

Dam 1 Photographs

Looking west along crest of Dam 1

Looking west along the filter berm near intersection of Dam 1 and Dam 1E at new section of mulched super cell beach

Dam 1 Photographs

Looking east at area of new super cell beach where fine tailings were recently spigotted

Access ramp to new super cell beach through filter berm near west end of Dam 1

Dam 1 Photographs

Looking east at filter berm placement at the west end of Dam 1

Dam 1E Photographs

Looking west at the toe along the eastern end of Dam 1

Weir at the eastern end of Dam 1

Dam 1E Photographs

Looking east at seepage collection ditch at the east end of Dam 1

Looking west along upstream side of seepage collection ditch at eastern end of Dam 1

Dam 1E Photographs

Looking west along clay core at the east end of Dam 1

Looking east at brush on the core near the eastern end of the east part of Dam 1

Dam 1E Photographs

Looking east along clay core from the central area of the eastern portion of Dam 1

Looking west along downstream slope of eastern portion of Dam 1

Dam 1E Photographs

Looking west at downstream slope of the eastern end of Dam 1

Looking northeast at the filter berm and fine tailings in Super Cell Beach area north of the eastern end of Dam 1

Dam 1E Photographs

Looking east along filter berm at new super cell beach with original super cell beach in the distance at the eastern end of Dam 1

Looking west along the crest of the eastern end of Dam 1

Dam 2 Photographs

Looking southwest at buttress and downstream slope of Dam 2

Looking north along drainage ditch at toe of Dam 2

Dam 2 Photographs

Looking southeast at cattails off the eastern toe of Dam 2

Toe ditch just downstream of the east weir at Dam 2

Dam 2 Photographs

East weir for seepage collection ditch at Dam 2

Looking northwest along seepage collection ditch from near east end of Dam 2

Dam 2 Photographs

Brush on core near east end of Dam 2

Looking east along seepage collection ditch at Dam 2

Dam 2 Photographs

Looking west-southwest along seepage collection ditch at Dam 2

Looking east along core at downstream slope of Dam 2

Dam 2 Photographs

Looking west along core at downstream slope of Dam 2

Animal burrows in the filter berm near the weir at the west end of Dam 2

Dam 2 Photographs

Weir at the west end of Dam 2

Widened area of drainage ditch off the toe of Dam 2 just upstream of seepage recovery pond 2-3 where beaver dams were removed

Dam 2 Photographs

Another area off the toe of Dam 2 just upstream of seepage recovery pond 2-3 where a beaver dam was removed

Looking west along upstream slope of filter berm at Dam 2

Dam 2 Photographs

Looking east-southeast at upstream slope of the filter berm of Dam 2

Looking south at the beach along the upstream side of Dam 2

Dam 2 Photographs

Looking east at the crest of Dam 2

Looking west at some erosion on the filter berm at Dam 2 approximately near station 40+00

Dam 2 Photographs

Looking west at the crest of Dam 2

Recently spigotted beach area in northwest corner of Dam 2

Dam 2 Photographs

Looking east at the seepage cutoff on east side of Dam 2

Looking northwest at the eastern end of Dam 2

Dam 5 Photographs

Looking north at buttress extension at the toe of Dam 5

Looking southeast at downstream slope of Dam 5

Dam 5 Photographs

Looking north at downstream slope of Dam 5

Looking south at downstream slope of Dam 5

Dam 5 Photographs

Looking northwest at recently raised southern portion of the crest of Dam 5

Looking south at recently raised southern portion of Dam 5 near station 14+00

Dam 5 Photographs

Looking southwest at northern portion of the crest of Dam 5 under construction

Looking northwest at clay stockpiled on filter material at Dam 5

Reclaim Dam Photographs

Looking northwest at downstream slope of the reclaim dam

Looking west at crest along east-west portion of the reclaim dam

Reclaim Dam Photographs

Looking northwest at pump stations in the southeastern corner of the reclaim pond

Looking south along downstream slope of the reclaim dam

Reclaim Dam Photographs

Looking northeast at downstream slope of the reclaim dam and weir area

Looking northeast at the crest of the reclaim dam

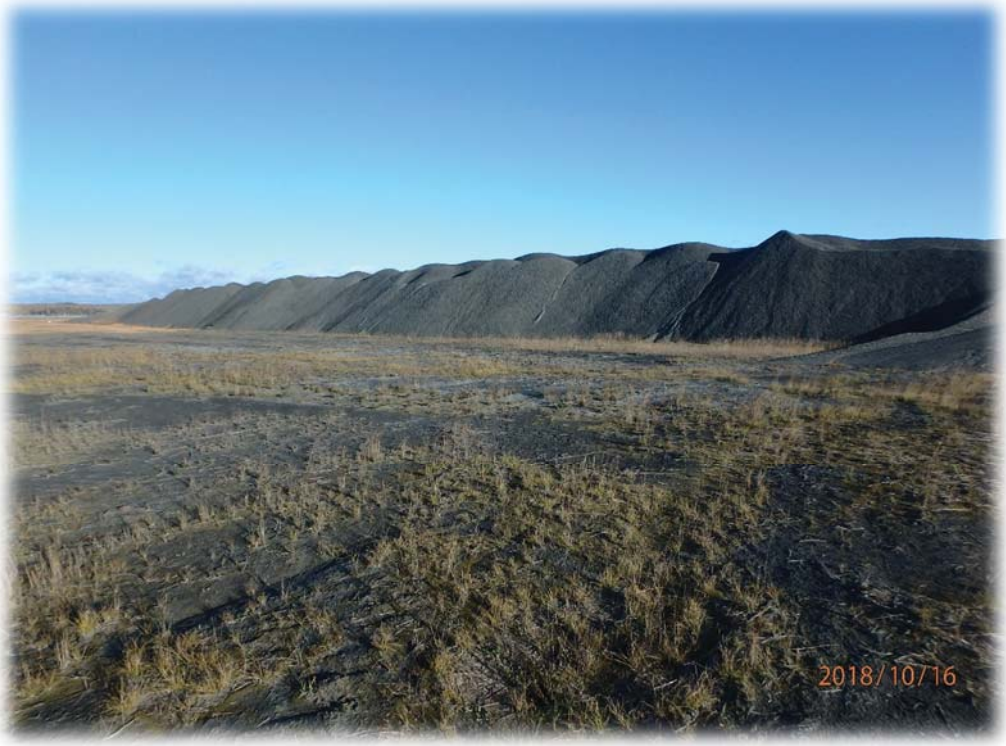
Reclaim Dam Photographs

Looking south at crest and upstream slope of the reclaim dam

Looking west-southwest at the fine tailings beach from near station 28+00

Reclaim Dam Photographs

Looking north at the crest and upstream slope of the reclaim dam from near the southwest corner of the dam



Looking northwest at the upstream slope of the reclaim dam from the adjacent beach approximately near station 17+00

Reclaim Dam Photographs

Looking southwest at super cell beach at upstream side of the reclaim dam from approximate station *13+00*

Seepage Recovery Dam 1A Photographs

Looking west at upstream slope of dam

Looking east at crest and upstream slope of dam

Seepage Recovery Dam 1A Photographs

Looking west at downstream slope of dam

Flooding at west end of the toe of the dam, by monitoring wells

Seepage Recovery Dam 1A Photographs

Monitoring well off the toe of the dam with locked cap

Seepage Recovery Dam 1B Photographs

Looking west at dam crest and downstream slope

Downstream slope of dam looking east

Seepage Recovery Dam 1B Photographs

New monitoring wells at the toe of the dam

Looking east at the downstream slope and crest of the dam

Seepage Recovery Dam 2-3 Photographs

Looking east at the upstream slope of the dam

Dam crest looking west

Seepage Recovery Dam 2-3 Photographs

Downstream slope of dam looking east

Downstream slope looking west

Seepage Recovery Dam 2-3 Photographs

Relief wells at the dam toe

Diversion Dike 1C Photographs

Looking east at crest of diversion dike

Looking east at downstream slope of diversion dike

Diversion Dike 1C Photographs

Looking east at upstream slope of diversion dike

Looking west at crest and tree on upstream slope of diversion dike

Diversion Dike 2 Photographs

Remnants of cut woody debris on upstream slope

Inlet structure from previous construction

Diversion Dike 2 Photographs

Dam crest

Downstream slope

Diversion Dike 3 Photographs

Diversion dike crest

Trees on the upstream slope

Appendix C

Milepost 7 Tailing Basin 2018 Conditions Drawings

LOCATION MAP

INDEX

0 1000 2000
SCALE IN FEET

PRELIMINARY DRAFT

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2017 INSTRUMENTATION G-01.DWG PLOT SCALE: 1:1 PLOT DATE: 3/4/2011 3:44 PM
Xrefs in Drawing – M:\Design\23380086.00\23380086 2017 X-Planimetric.dwg
gsj M:\Design\23380086.00\23380086_2017 Instrumentation G-01.DWG Plot at 96 09/17/2018 08:55:09

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

	A	B	C	0	1	2	3
CLIENT							
BID							
CONSTRUCTION							
RELEASED TO/FOR							

DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	9/26/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

BASIN SITE PLAN

BARR PROJECT No.	23380086
CLIENT PROJECT No.	
DWG. No.	G-01
REV. No.	A

SOUTH POND (CELL 1)
POND W.L. 1221.5
SURVEYED 11/03/2018

1 G-04

1 G-05

-13+00
-10+00
-5+00
-1+00
1+00
5+00
10+00
15+00

0+00 5+00 10+00 15+00 20+00 25+00 30+00 35+00 40+00 45+00 50+00 55+00 60+00

FILTER BERM

P97-10A
P97-10B
P97-10C
S97-1
S97-2
D1-3500R100A-VW NEST
3K-P2
2K-P1
D1-2840R650-VW NEST
I13-1
3A-S
I10-1
2H-P1
SEEPAGE COLLECTION DITCH
5A-S1
5A-S3
5A-S4
5A-P0
WEIR
1A-S4
1A-S2
3C-P1
3C-P2
3B-P1
3B-P2
3B-P3
2C-P1
2C-P2
2B-S
2B-P2
2B-P3
R-1
R-2
R-3
P97-7
R-4
D1-2400R1200-VW
R-6
D1-2550R1200-VW
D1-2750R1200-VW
I97-1
3F-P1,2
R-7
P97-1
D1-3050R1200-VW
P97-8
D1-3300R1200-VW
R-11
D1-3600R1200-VW
R-12
P97-9
I97-3
P97-4
2F-P2

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY QUANTUM SPATIAL OF LEXINGTON KENTUCKY COMBINED WITH BATHYMETRY BY BARR ENGINEERING. LIDAR COMPLETED APRIL 21, 2017. BATHYMETRY COMPLETED JUNE 6, 2018. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

2 PLAN: DAM 1

0 200 400
SCALE IN FEET

LEGEND:

- PNEUMATIC PIEZOMETER
- CASAGRANDE PIEZOMETER
- INCLINOMETER
- RELIEF WELL
- SETTLEMENT PLATE
- VIBRATING WIRE PIEZOMETER
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR: A B C 0 1 2 3 — DATE RELEASED

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/21/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 1 PLAN VIEW
INSTRUMENTATION PLAN

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. G-02
REV. No. A

Xrefs in Drawing – M:\Design\23380086.00\20276_1.dwg M:\Design\23380086.00\23380086 2017 X-Planimetric.dwg
gsj M:\Design\23380086.00\23380086_2018 Instrumentation G-02.DWG Plot at 400 09/17/2018 08:43:32

SOUTH POND (CELL 1)
POND W.L. 1221.5
SURVEYED 11/03/2018

1
G-06

60+00 65+00 70+00 75+00 80+00 85+00 90+00 95+00 100+00 -4+00 0+00 5+00 10+00 12+50

D1-9050R550
D1-9050R850
D1-9050R975
SRD18-1-18@

SEEPAGE COLLECTION DITCH

WEIR

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY QUANTUM SPATIAL OF LEXINGTON KENTUCKY COMBINED WITH BATHYMETRY BY BARR ENGINEERING. LIDAR COMPLETED APRIL 21, 2017. BATHYMETRY COMPLETED JUNE 6, 2018. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

2
G-03
PLAN: DAM 1E

0 200 400
SCALE IN FEET

LEGEND:

- PNEUMATIC PIEZOMETER
- CASAGRANDE PIEZOMETER
- INCLINOMETER
- RELIEF WELL
- SETTLEMENT PLATE
- VIBRATING WIRE PIEZOMETER
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3

DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/21/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

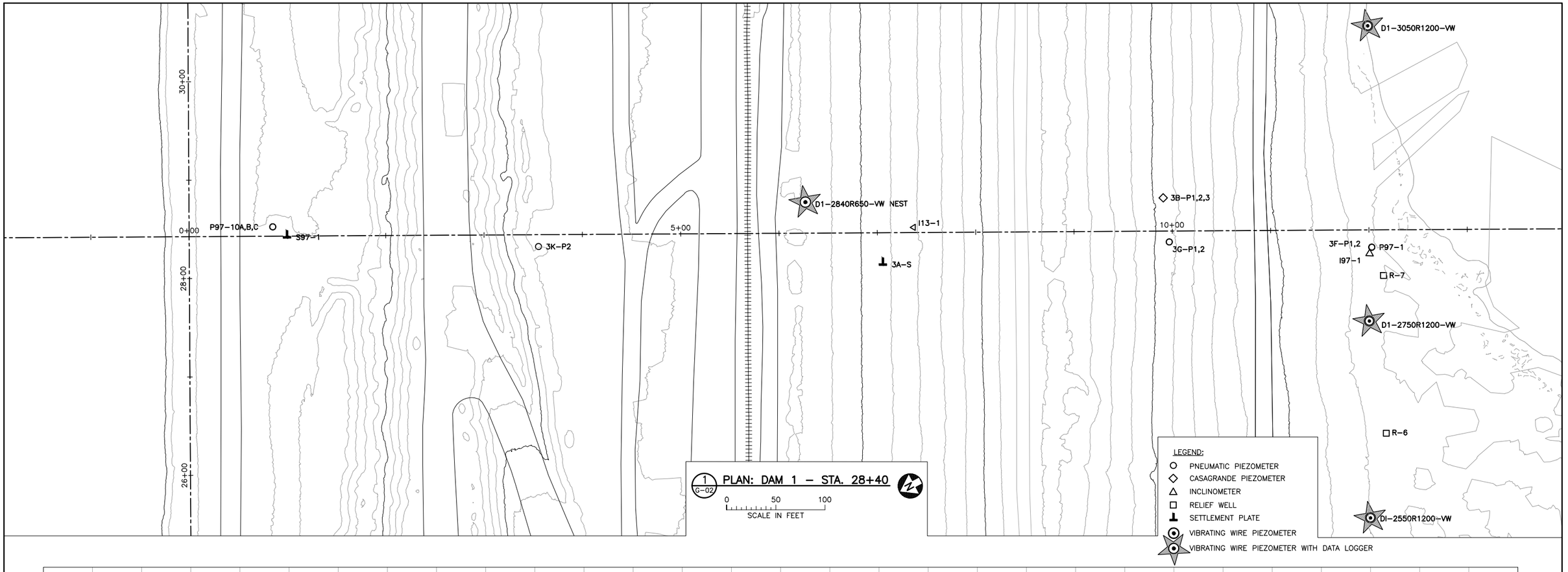
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 1E PLAN VIEW
INSTRUMENTATION PLAN

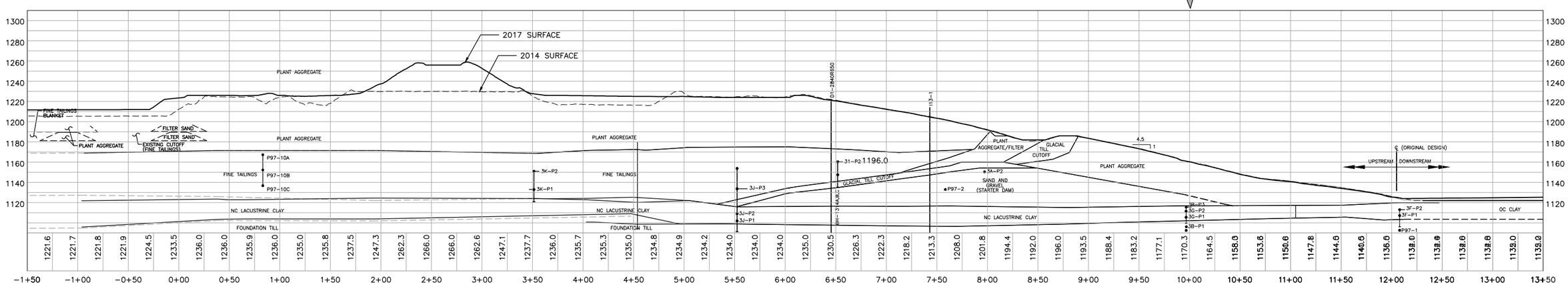
BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. G-03
REV. No. A

Xrefs in Drawing - M:\Design\23380086.00\20276_1.dwg M:\Design\23380086 2017 X-Planimetric.dwg
M:\Design\23380086.00\23380086_2018 Instrumentation G-02.DWG Plot at 400 09/17/2018 08:43:32
gsj



1 G-02 **PLAN: DAM 1 – STA. 28+40**

0 50 100
SCALE IN FEET



1 G-02 **SECTION: DAM 1 – STA. 28+40**

0 50 100
SCALE IN FEET

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER.

– – –?– – – UNAVAILABLE INFORMATION FOR ACCURATE CONTACT INTERPRETATION

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORING AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE.

LEGEND

INVESTIGATIVE BORING

3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR	A	B	C	0	1	2	3
	DATE RELEASED						

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

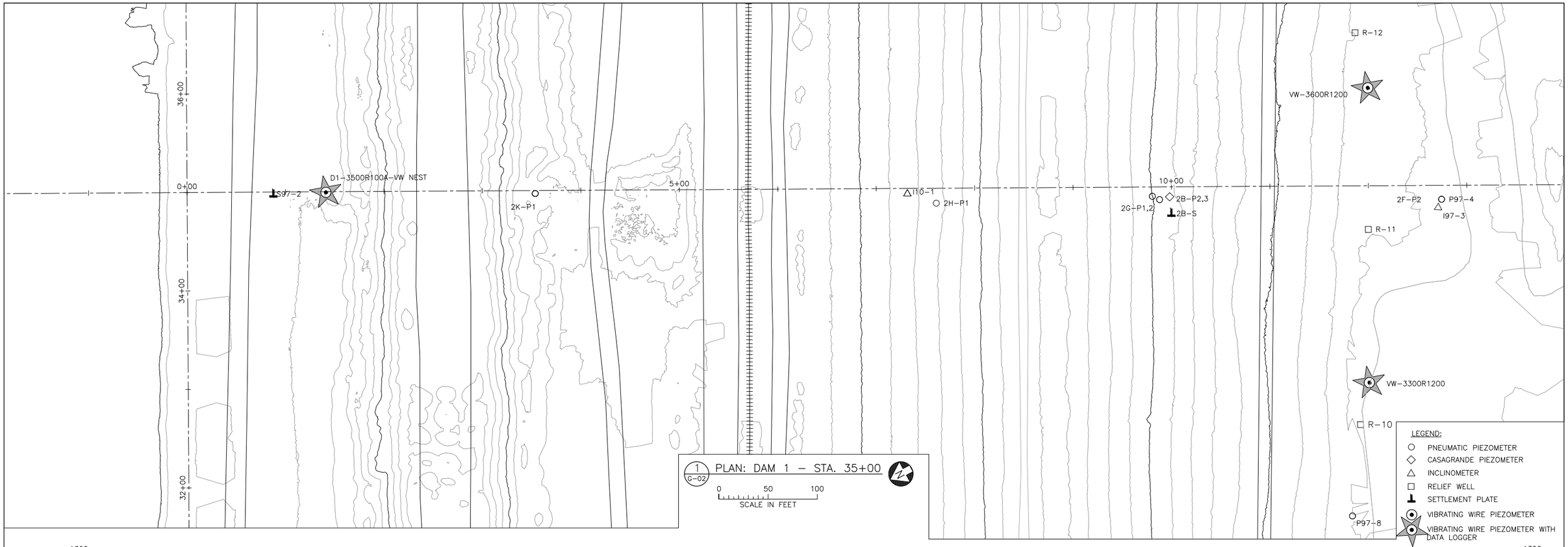
Scale	AS SHOWN
Date	6/21/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS
DAM 1 – STA. 28+40
CROSS SECTION OF EXISTING CONDITIONS

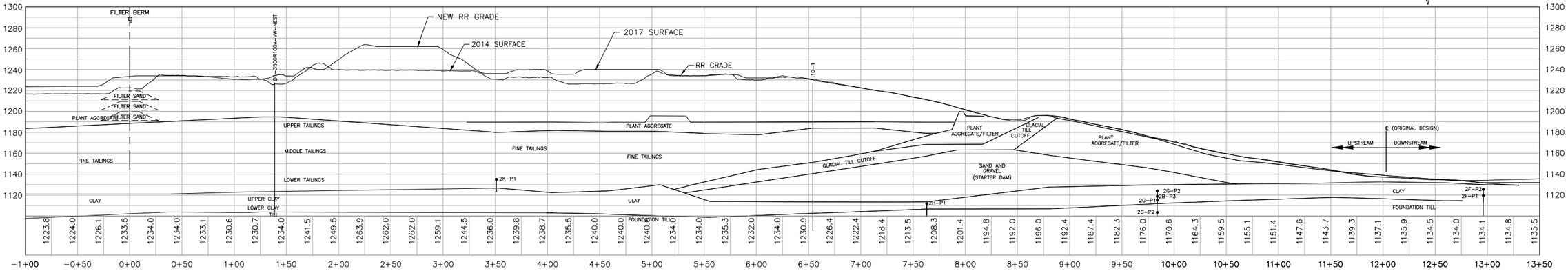
BARR PROJECT No. 23/38-086
CLIENT PROJECT No.
DWG. No. G-04
REV. No. A

M:\Design\23380086.00\23380086_2018 Instrumentation G-03.DWG Plot at 50 09/17/2018 09:46:52 gsj



1 / G-02 PLAN: DAM 1 – STA. 35+00

0 50 100
SCALE IN FEET



1 / G-02 SECTION: DAM 1 – STA. 35+00

0 50 100
SCALE IN FEET

LEGEND

– – –?– – – UNAVAILABLE INFORMATION FOR ACCURATE CONTACT INTERPRETATION

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORING AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE.

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER.

INVESTIGATIVE BORING

3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3

DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

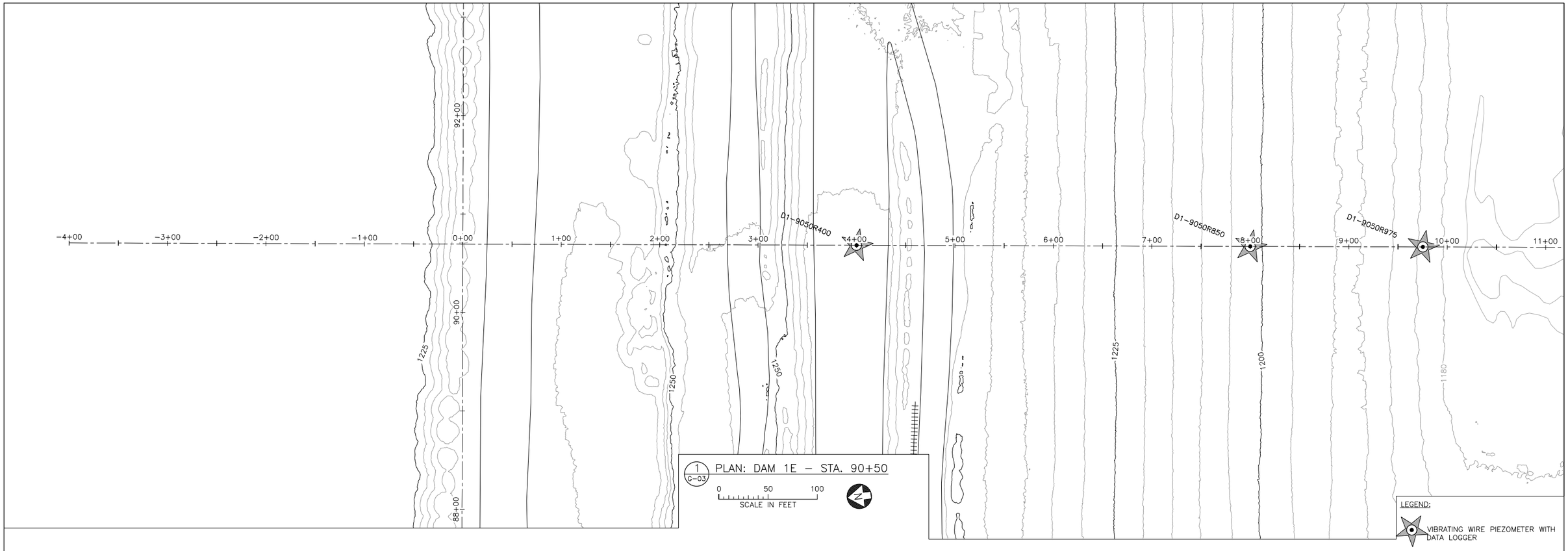
Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 1 – STA. 35+00
CROSS SECTION OF EXISTING CONDITIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. G-05
REV. No. A

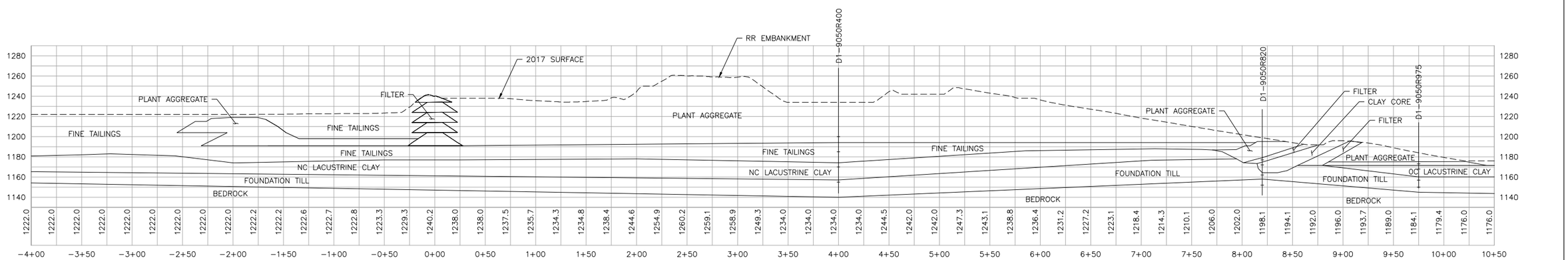


1 G-03 PLAN: DAM 1E – STA. 90+50

0 50 100
SCALE IN FEET

LEGEND:

VIBRATING WIRE PIEZOMETER WITH DATA LOGGER



1 G-03 SECTION: DAM 1E – STA. 90+50

0 50 100
SCALE IN FEET

LEGEND

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORING AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE.

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER.

INVESTIGATIVE BORING

3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME

SIGNATURE

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3
DATE RELEASED						

BARR
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Scale	AS SHOWN
Date	9/28/2018
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

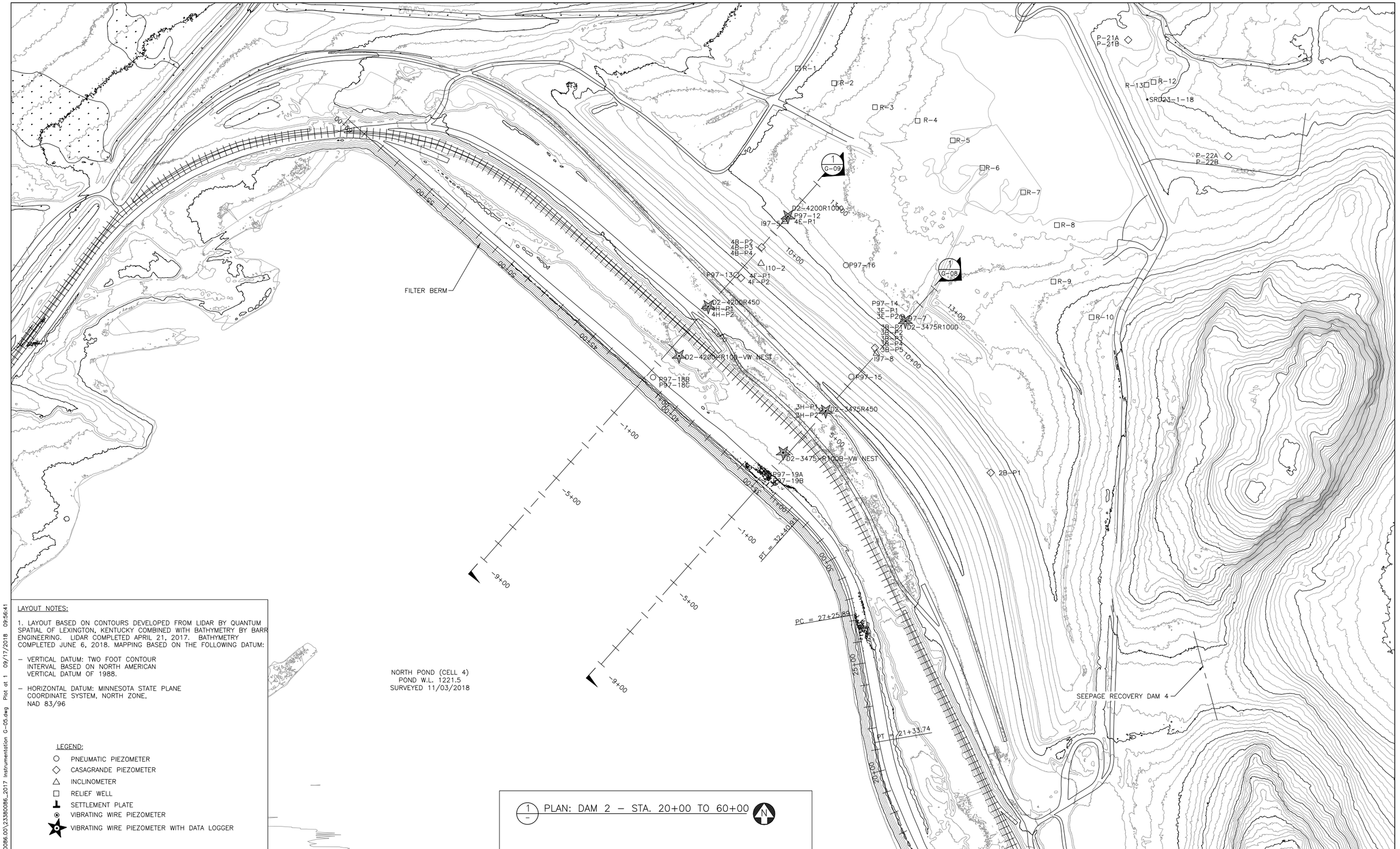
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 1E – STA. 90+50
CROSS SECTION OF EXISTING CONDITIONS

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
G-06	A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2018 INSTRUMENTATION G-06.DWG PLOT SCALE: 1:2 PLOT DATE: 10/31/2018 11:17 AM
gsj M:\Design\23380086.00\23380086_2018 Instrumentation G-04.DWG Plot at 50 09/17/2018 09:53:59



LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY QUANTUM SPATIAL OF LEXINGTON, KENTUCKY COMBINED WITH BATHYMETRY BY BARR ENGINEERING. LIDAR COMPLETED APRIL 21, 2017. BATHYMETRY COMPLETED JUNE 6, 2018. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

LEGEND:

- ○ PNEUMATIC PIEZOMETER
- ◇ CASAGRANDE PIEZOMETER
- △ INCLINOMETER
- □ RELIEF WELL
- ⊥ SETTLEMENT PLATE
- ◎ VIBRATING WIRE PIEZOMETER
- ✡ VIBRATING WIRE PIEZOMETER WITH DATA LOGGER

(1) – PLAN: DAM 2 – STA. 20+00 TO 60+00

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3

DATE RELEASED

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 2 PLAN VIEW
INSTRUMENTATION PLAN

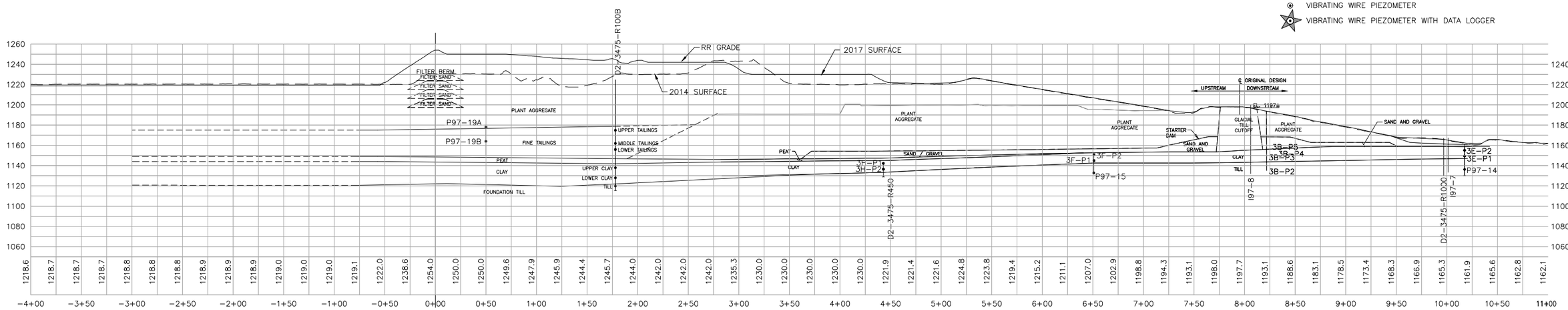
BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
G-07	A

Xrefs in Drawing - K:\Design\23380086.00\20276_1.dwg M:\Design\23380086.00\23380086 2017 X-Planimetric.dwg M:\Design\23380086.00\23380086_2017 Instrumentation G-05.dwg Plot at 1 09/17/2018 09:56:41 gsj

1 / G-07 PLAN: DAM 2 – STA. 34+75

0 50 100
SCALE IN FEET

LEGEND:
- PNEUMATIC PIEZOMETER
- CASAGRANDE PIEZOMETER
- INCLINOMETER
- RELIEF WELL
- SETTLEMENT PLATE
- VIBRATING WIRE PIEZOMETER
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER



1 / G-07 SECTION: DAM 2 – STA. 34+75

0 50 100
SCALE IN FEET

CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER.

– – –?– – – UNAVAILABLE INFORMATION FOR ACCURATE CONTACT INTERPRETATION

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORING AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE.

LEGEND
- INVESTIGATIVE BORING
- 3F-P2 — PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.
PRINTED NAME
SIGNATURE
DATE ____ LICENSE # ____

RELEASED TO/FOR

A	B	C	0	1	2	3
DATE RELEASED						

BARR
Corporate Headquarters: Minneapolis, Minnesota
Ph: 1-800-632-2277
Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 2 – STA. 34+75
CROSS SECTION OF EXISTING CONDITIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. G-08
REV. No. A

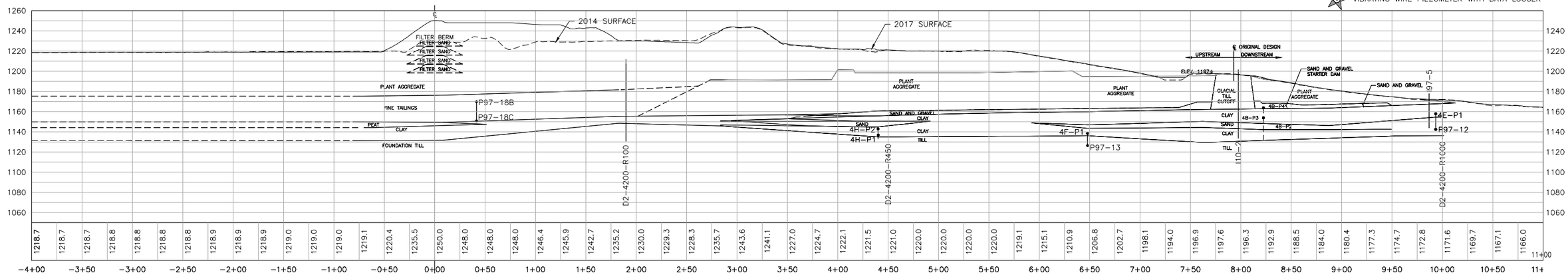
CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2018 INSTRUMENTATION G-08.DWG PLOT SCALE: 1:2 PLOT DATE: 12/19/2018 7:44 AM
gsj K:\Design\23380086.00\23380086_2015 Instrumentation G-08.dwg Plot at 50 11/30/2015 11:54:05

1 G-07 PLAN: DAM 2 – STA. 42+00

0 50 100
SCALE IN FEET

LEGEND:

- PNEUMATIC PIEZOMETER
- CASAGRANDE PIEZOMETER
- INCLINOMETER
- RELIEF WELL
- SETTLEMENT PLATE
- VIBRATING WIRE PIEZOMETER
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER



1 G-07 SECTION: DAM 2 – STA. 42+00

0 50 100
SCALE IN FEET

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER.

LEGEND

- UNAVAILABLE INFORMATION FOR ACCURATE CONTACT INTERPRETATION
- STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN BORINGS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN BORINGS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE.
- INVESTIGATIVE BORING
- 3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3

DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 2 – STA. 42+00
CROSS SECTION OF EXISTING CONDITIONS

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
G-09	A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2018 INSTRUMENTATION G-09.DWG PLOT SCALE: 1:2 PLOT DATE: 12/19/2018 7:42 AM
Xrefs in Drawing - M:\Design\23380086.00\20276_1.dwg M:\Design\23380086.00\23380086 2017 X-Planimetric.dwg
gsj M:\Design\23380086.00\23380086_2018 Instrumentation G-07.DWG Plot at 50 09/17/2018 10:47:46

RECLAIM POND
POND W.L. 1205.70
SURVEYED 11/03/2018

D5-1400L90-VW

I04-2
D5-1400R50-VW

D5-2400-R200-VW

I13-2

D5-1400R400-VW

SEEPAGE COLLECTION POND
POND W.L. 1187.1
11/03/2018

5+00
10+00
15+00
20+00
25+00
30+00
32+88

2
G-11

3
G-12

BEAR LAKE
OUTLET

LAYOUT NOTES:

1. LAYOUT BASED ON CONTOURS DEVELOPED FROM LIDAR BY QUATUM SPATIAL OF LEXINGTON, KENTUCKY COMBINED WITH BATHYMETRY BY BARR ENGINEERING. LIDAR COMPLETED APRIL 21, 2017 BATHYMETRY COMPLETED JUNE 6, 2018. MAPPING BASED ON THE FOLLOWING DATUM:

- VERTICAL DATUM: TWO FOOT CONTOUR INTERVAL BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.
- HORIZONTAL DATUM: MINNESOTA STATE PLANE COORDINATE SYSTEM, NORTH ZONE, NAD 83/96

1 -- PLAN: DAM 5

0 100 200
SCALE IN FEET

LEGEND:

- PNEUMATIC PIEZOMETER
- CASAGRANDE PIEZOMETER
- INCLINOMETER
- RELIEF WELL
- SETTLEMENT PLATE
- VIBRATING WIRE PIEZOMETER
- VIBRATING WIRE PIEZOMETER WITH DATA LOGGER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3
DATE RELEASED						

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	ATG
Approved	ATG

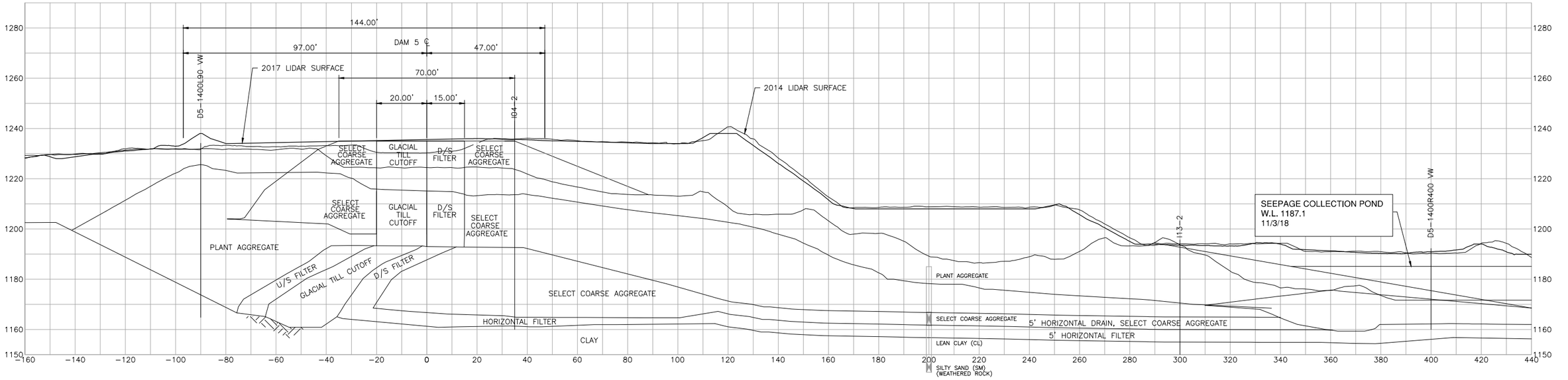
NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 5
PLAN VIEW

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
G-10	A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2018 INSTRUMENTATION G-10.DWG PLOT SCALE: 1:2 PLOT DATE: 12/19/2018 8:26 AM
Xrefs in Drawing - M:\Design\23380086.00\23380086 2017 X-Plan\metric.dwg
gsj M:\Design\23380086.00\23380086_2018 Instrumentation G-08.DWG Plot at 1000 09/17/2018 11:06:21



2 G-10 SECTION: STATION 14+00

0 20 40
SCALE IN FEET

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORINGS AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE

LEGEND:

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER

INVESTIGATIVE BORING

3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE _____

PRINTED NAME _____

DATE _____ REG. NO. _____

CLIENT
BID
CONSTRUCTION

RELEASED TO/FOR

A	B	C	0	1	2	3

DATE RELEASED

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

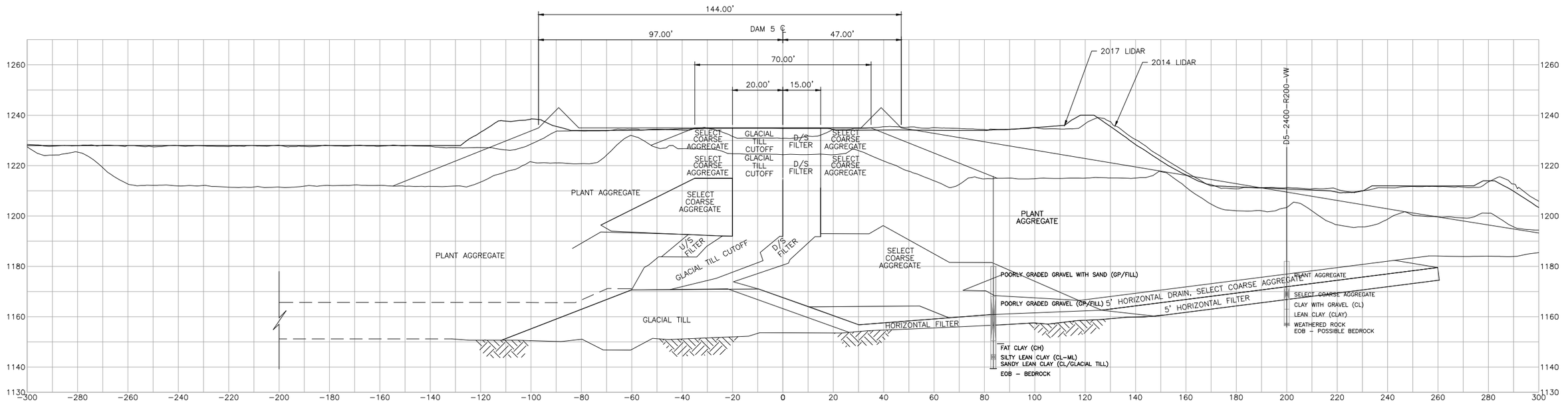
Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 5 – STA. 14+00
CROSS SECTION OF EXISTING CONDITIONS

BARR PROJECT No. 23380086
CLIENT PROJECT No.
DWG. No. G-11
REV. No. A



3 / G-10 SECTION: STATION 24+00

0 20 40
SCALE IN FEET

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORINGS AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE

LEGEND:

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER

INVESTIGATIVE BORING

3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

SIGNATURE _____

PRINTED NAME _____

DATE _____ REG. NO. _____

CLIENT								
BID								
CONSTRUCTION								
RELEASED TO/FOR	A	B	C	0	1	2	3	
DATE RELEASED								

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

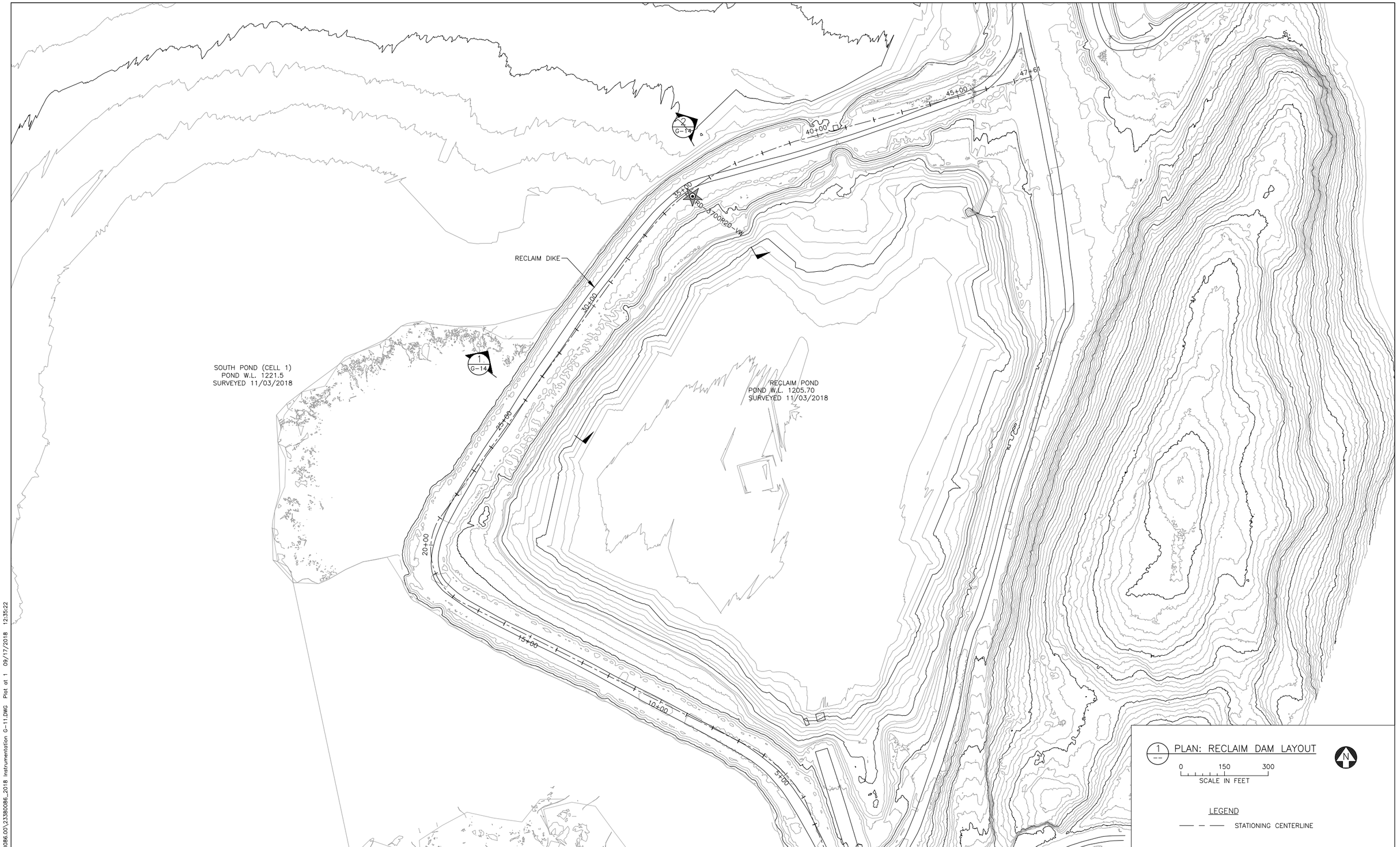
Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

DAM 5 – STA. 24+00
CROSS SECTION OF EXISTING CONDITIONS

BARR PROJECT No.	23380086
CLIENT PROJECT No.	
DWG. No.	G-12
REV. No.	A



CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2018 INSTRUMENTATION G-13.DWG PLOT SCALE: 1:2 PLOT DATE: 12/19/2018 8:18 AM
Xrefs in Drawing – M:\Design\23380086.00\20276_1.dwg M:\Design\23380086.00\23380086 2017 X-Planimetric.dwg
gsj M:\Design\23380086.00\23380086_2018 Instrumentation G-11.DWG Plot at 1 09/17/2018 12:35:22

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR	A	B	C	0	1	2	3
	DATE RELEASED						

BARR

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

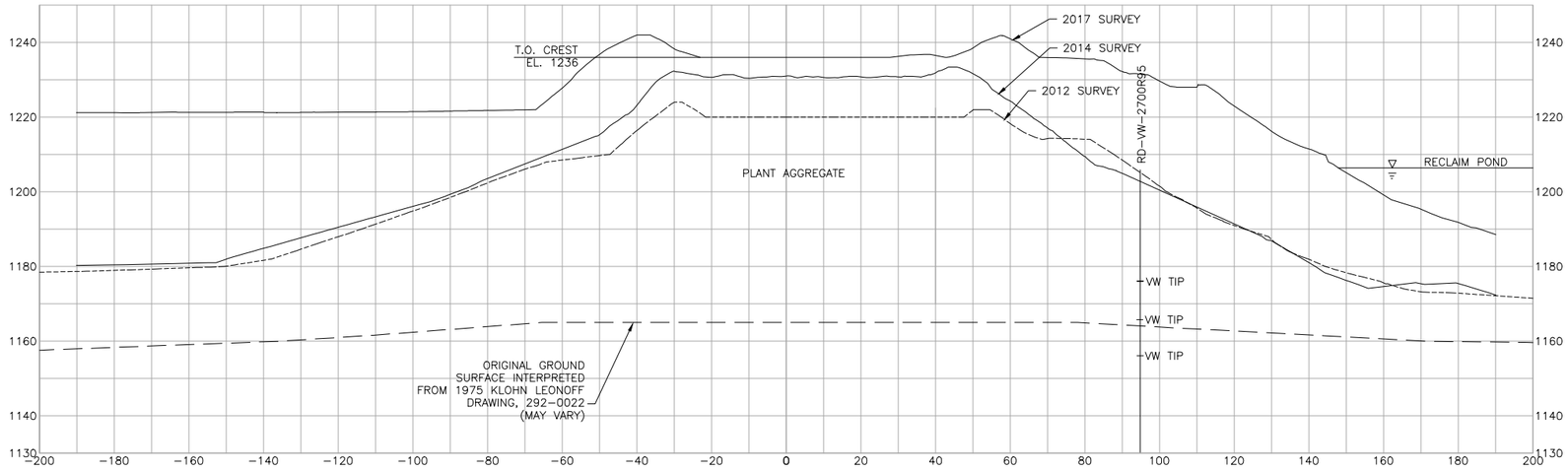
Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

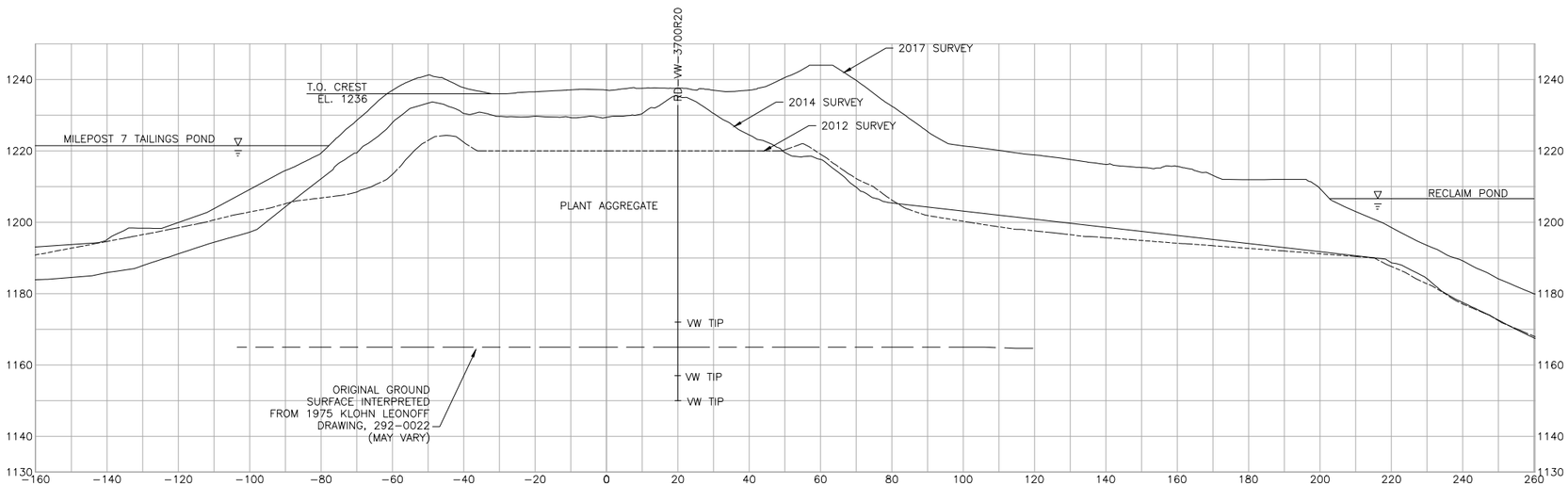
RECLAIM DAM
PLAN VIEW

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
G-13	A



1 G-13 SECTION: STATION 27+00

0 20 40
SCALE IN FEET



2 G-13 SECTION: STATION 37+25

0 20 40
SCALE IN FEET

LEGEND:

STRATIGRAPHIC CONTACTS BETWEEN FOUNDATION SOILS ARE BASED ON INTERPRETATION BETWEEN SOIL BORINGS AND CORE PENETRATION TESTS. CONTACTS BETWEEN INTERNAL DAM FILL ZONES ARE BASED ON INTERPRETATION BETWEEN INVESTIGATIVE METHODS AND CONSTRUCTION RECORDS INFORMATION, WHERE AVAILABLE

NOTE: CROSS SECTION SURFACE DEVELOPED FROM 2017 FLYOVER

INVESTIGATIVE BORING

3F-P2 PIEZOMETER IDENTIFIER

NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

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.

PRINTED NAME _____

SIGNATURE _____

DATE _____ LICENSE # _____

RELEASED TO/FOR

A	B	C	0	1	2	3
DATE RELEASED						

BARR
Corporate Headquarters:
Minneapolis, Minnesota
Ph: 1-800-632-2277

Project Office:
BARR ENGINEERING CO.
3128 14TH AVENUE EAST
HIBBING, MN 55746
Ph: 1-800-225-1966
Fax: (218) 262-3460
www.barr.com

Scale	AS SHOWN
Date	6/23/2017
Drawn	GSJ
Checked	GSJ
Designed	SLL
Approved	SLL

NORTHSHORE MINING COMPANY
SILVER BAY, MINNESOTA

MILEPOST 7 TAILINGS BASIN
FALL 2018 CONDITIONS

RECLAIM DAM
STATIONS 27+00 AND 37+25

BARR PROJECT No.	
23380086	
CLIENT PROJECT No.	
DWG. No.	REV. No.
G-14	A

CADD USER: Greg Johnson FILE: M:\DESIGN\23380086.00\23380086_2018 INSTRUMENTATION G-14.DWG PLOT SCALE: 1:2 PLOT DATE: 12/19/2018 8:31 AM

Appendix D

Instrumentation Monitoring Report

(report and data only)

resourceful. naturally.
engineering and environmental consultants

BARR

December 31, 2018

Mr. Dan Scamehorn
Northshore Mining Company
10 Outer Drive
Silver Bay, MN 55614

Re: Fall 2018 Milepost 7 Tailings Basin Instrumentation

Dear Mr. Scamehorn:

Fieldwork for the fall monitoring event was completed by Barr Engineering Co. (Barr) on November 5 and 6, 2018 for the Milepost 7 Tailings Basin at the Northshore Mining Company (NSM) facility in Silver Bay, Minnesota. This monitoring event is part of a bi-annual instrumentation monitoring program for the basin. This letter includes the field data, data analysis, and interpretation.

Field Data

Data was collected from piezometers, relief wells, and inclinometers located on Dam 1, Dam 2, Dam 5, and the Reclaim Dam as well as Seepage Recovery Dams 1A and 2-3. Data from seepage channel weirs on Dam 1 and Dam 2 were also collected. The attached charts depict the data collected during the monitoring event. NSM provided pond levels.

Analysis and Interpretation

Piezometers

Data Presentation

The attached figures graphically present measured piezometric levels versus the date. Graphs showing the recorded piezometric levels versus the adjacent tailing pond (cell) level for Dams 1, 2, and 5, as well as the Reclaim Dam are also attached. The piezometric levels from Dam 1 are compared to Cell 1 (south pond), Dam 2 levels are compared to Cell 4 (north pond), Dam 5 levels are compared to the average levels of Cells 1 and 4 as well as the reclaim pond, and the Reclaim Dam is compared to

Action Item Highlights:

- Maintain Dam 5 toe seepage pond at a minimum elevation of 1,181 feet.
- Continue review of VW piezometer connections to the data loggers at the crests of Dam 1 and Dam 2
- Lengthen and connect wire for D1-3300R1200 Upper Clay to data logger
- Replace inclinometers I04-2 and I13-2 at Dam 5
- Clean out weirs at Dam 1 to prevent seepage backup and allow representative monitoring
- Continue to install data loggers for remaining/new VW piezometers. Install remaining components for real-time monitoring system.
- Set action levels for downstream slope and toe piezometers for Dam 1, Dam 2, and Dam 5 relative to dam stability based on data logger information as available over the next couple years.
- Repair relief well R-11 at Dam 1.
- Install additional piezometers at/beyond toe of dam at Dam 2 to monitor uplift pressures.
- Use data from VW piezometers installed at the toes of the seepage recovery dams in the fall of 2018 for seepage/stability analyses.
- Update construction tracking log to document the reasons for fluctuations in instrumentation, such as pumping from seepage ponds, placement of aggregate, etc. (possible Hibtac-like monitoring systems)
- Install inclinometers (MEMS-based) with datalogging/automation capabilities within existing inclinometer casings over the next few years.
- Replace non-functional pneumatic piezometers with VW piezometers over the next several years.

levels for Cell 1 and the reclaim pond. The graphs note some distinction between Cells 1 and 4 since in the past slight variations between the ponds have existed; however, these cells are currently connected via culverts beneath the splitter dike, and for 2018 the Cell 4 pond elevation was assumed to be at the same elevation as Cell 1. Plots of field data for the instruments on seepage recovery dams 1A and 2-3 are also attached.

Data ranges for the graphs have been adjusted to increase viewing resolution, which resulted in presented graph data range variations between locations. In some cases, pond surface elevations recorded prior to installation of the instrument(s) are shown to illustrate historic variations in pond levels. Corresponding seepage recovery pond elevations, Dam 5 toe pond elevations, and/or reclaim pond elevations are also shown on select graphs as applicable for comparison. Pond elevation data recorded by NSM on the date closest to the instrument readings were used for comparison. Data from nearby VW piezometers is shown on select graphs for comparison to readings from pneumatic and Casagrande instruments, as well.

Dam 1

Data were recorded from Casagrande, pneumatic, and vibrating wire (VW) piezometers present on Dam 1, which are mainly located along dam centerline stations 28+40 and 35+00. As noted in the spring 2018 monitoring report, data loggers were connected to VW piezometers at Dam 1 in the fall of 2017 and spring of 2018.

Most of the readings from the instruments at Dam 1 are relatively consistent with past data. The fall 2018 reading for 2F-P2 (pneumatic), located at the toe of Dam 1, indicated a slightly lower reading than the spring of 2018, though was still higher than historical data. As mentioned in the spring 2018 report, however, readings from the recent past from this piezometer have been inconsistent while readings from nearby VW piezometer D1-3600R1200T have been relatively consistent, indicating 2F-P2 may be malfunctioning. This piezometer was installed in 1996 and may be nearing the end of its operational life.

Data from VW piezometers located at station 35+00 approximately 100 feet downstream of the dam centerline (D1-3500R100A) indicated a rise in piezometric elevations in the summer of 2018 followed by a reduction. This is consistent with filter material hauling and placement activities at the west end of Dam 1 along with placement of backer material between the railroad grade and filter berm in the summer of 2018 and associated subsequent porewater pressure dissipation after construction activities were completed for the year.

Two nests of new instruments were also installed in the summer of 2018 at the crest and mid-slope of the east end of Dam 1 along station 90+50 in line with the nest installed at the toe in the fall of 2017. Data loggers were also connected to these instruments. Readings for all three sets of instruments over the duration between the time of installation and the spring monitoring event indicate relatively consistent readings.

Dam 2

Data from Casagrande, pneumatic, and VW piezometers present at Dam 2 were recorded during the fall 2018 monitoring event, as well. These instruments are mainly located along dam centerline stations 34+75 and 42+00. Similar to Dam 1, data loggers were connected to VW piezometers on Dam 2 in 2017 and 2018. Readings for instruments located along both stations 34+75 and 42+00 mainly appeared consistent with past readings.

The fall 2018 reading for pneumatic piezometer 3E-P1 located in the lower part of the clay at the toe of the dam remained similar to past readings. A reading was again not able to be collected from 3E-P2, similar to the spring of 2018. A reading was able to be collected from 3E-P2 in 2017 after 3 years of not being able to record data; however, given the most recent reading attempts and history before 2017, this instrument may be no longer operable. A VW piezometer within the nest at D2-3475R1000 was installed in the clay in 2015 which is relatively close to 3E-P2 and at a similar elevation. This VW instrument is considered to have replaced 3E-P2.

Readings again were not able to be collected from 4H-P2, located in the lacustrine clay about 450 feet downstream of the dam centerline, during the fall 2018 monitoring event. Readings that have been able to be collected since the spring of 2014 have been significantly higher and erratic compared to the readings from adjacent VW piezometers, indicating this instrument is likely malfunctioning. The adjacent VW piezometer in the clay that is part of the nest installed in 2015 (D2-4200R450) has essentially replaced 4H-P1 (considered inoperable) and 4H-P2. The fall 2018 reading from pneumatic piezometer 4E-P1, in the lacustrine clay near the toe of the dam, continued to be similar to readings from an adjacent VW piezometer also installed in the clay in 2015.

Data from Casagrande piezometer 3B-P1 in the till along station 34+75 and just downstream of the clay core indicated a similar reading in the fall of 2018 to those in 2017 and the spring of 2018. Since the fall of 2016, the piezometric heads in this instrument have been a bit higher than historic data. One VW piezometer is included in the till in a nest located upstream of the clay core at nearby D2-3475R450. Although some stockpiling/hauling activities had appear to have caused temporary increases in the piezometric head in the 2017 and the spring of 2018, similar activities did not occur in the fall of 2018. This instrument may be deteriorating.

Dam 5

Data were recorded from two VW piezometer nests at Dam 5 along dam centerline station 14+00. At the time of the monitoring event, wires for VW piezometers along station 24+00 (D5-2400R200) were observed to be buried by dam fill. NSM informed Barr that the wires for D5-2400R200 were subsequently unearthed; however, these instruments were inaccessible and again partially buried in the fall of 2018. Barr will work with NSM to reach these piezometer for the spring 2019 monitoring event.

As discussed in the spring 2018 report, NSM placed a significant amount of fill material beyond the planned 6H:1V slope matching the dam crest elevation of 1,235 feet over the winter of 2017-2018. Barr subsequently performed stability analyses and worked with NSM to develop a plan to move this excess fill material to the crest of Dam 5 as part of the crest raise to 1,245 feet. Data recorded from the VW piezometers at station 14+00 at Dam 5 show responses to movement of this excess fill over the spring and summer as well as construction over the summer and fall of 2018 to raise the dam core and adjacent filter.

NSM is maintaining the toe seepage pond at an elevation of at least 1,181 feet as recommended in the spring 2017 monitoring report based on the provided seepage pond elevation data. Historically, readings from the VW piezometers at station 14+00 approximately 90 feet upstream of the centerline (D5-1400L90) follow the trends of the reclaim pond surface, while readings at the dam toe at the same station (D5-1400R400) follow the toe seepage pond. As was seen in the readings over the winter and spring, response to recent construction events overshadowed the response to pond fluctuations between the spring and fall monitoring events, especially for the VWs at D5-1400R400.

Reclaim Dam

Data were recorded from the nest of VW piezometers located approximately 20 feet downstream of the dam centerline at station 37+00. Consistent with historical readings, VW piezometer readings at station 37+00 generally appear to follow the trend of the elevation of the reclaim pond. As readings have not been able to be recorded since the spring of 2016 from VW piezometers located at station 27+00 due to apparent wire burial, these instruments should be replaced. Installation of piezometers at station 15+00, along the east-west section of the dam, within the next few years would also be advantageous to monitor piezometric heads during the next raise of the reclaim dam. An instrumentation plan will be developed in 2019.

Seepage Recovery Dams

Data were recorded from Casagrande piezometers present at seepage recovery dam 1A, located downstream of the western portion of Dam 1, and seepage recovery dam 2-3, located downstream of Dam 2. Piezometric heads from most of these instruments have typically fluctuated a few to several feet between monitoring events in the past. Readings from P19A and P20A, located at the toe of seepage recovery dam 1A, continue to be at a consistent elevation, with the piezometric head for P20A higher than the seepage recovery pond elevation and the piezometric head for P19A a few feet lower than the pond.

Piezometric elevations for Casagrande piezometers at seepage recovery dam 2-3 appear consistent with historical data with the exception of P22B. The reading from this instrument indicates the piezometer was dry during the monitoring event, which has not occurred in the past at this dam, though a similar situation was observed for the fall 2012 monitoring event at seepage recovery dam 1A. An attempt was made to check the reading on this instrument in December 2018; however,

measurement sensor could not be extended more than a few feet down the standpipe due to an apparent ice piece blockage. This instrument will be re-checked after the spring thaw.

As has been noted for the past several monitoring events, apparent artesian conditions have been observed in the monitoring wells at the toe of seepage recovery dam 1A and 1B and flowing relief wells are present at the toe of seepage recovery dam 2-3. To better assess conditions at the toe of all three seepage recovery dams, a nest of VW piezometers was installed at the toe of each of these three dams in the late fall of 2018. Information from these piezometers will be incorporated into the spring 2019 monitoring event.

Equipment

Difficulties were encountered reading several of the instruments at the site during the spring 2018 monitoring event. These instruments are discussed for each associated dam below.

Dam 1

The fall 2018 reading for Casagrande piezometer 3B-P1 on the downstream slope of Dam 1 is relatively similar to the 2017, 2016, 2015, and pre-2012 elevations and the recorded length of this instrument for the fall monitoring event is also consistent with measurements from the 2015, 2016, 2017, and spring 2018 readings. Depth measurements in 2014 indicated an apparent increase in length compared to historic data, and in 2012 and 2013, there were several instances of the water level indicator equipment becoming stuck in the standpipe at a depth of about 10 feet. These conditions may point to this instrument becoming deteriorated and/or a casing separation. Similarly, the depth and reading recorded for 2B-P3 increased starting in the spring of 2013, though has remained consistent since then. Due to an increase in length over the last several years, the accuracy of readings is still suspect. As previously recommended over the past few years, the role of both 3B-P1 and 2B-P3 piezometers should be evaluated during subsequent Dam 1 model updates to determine if these instruments should be replaced or abandoned.

A reading was again able to be recorded for Casagrande piezometer 5A-P0 on Dam 1. Although data has been recorded from this instrument for the last several monitoring events, data from this instrument was not able to be collected between the fall of 2011 and spring of 2014. As such, the trend of functionality of this instrument is suspect and this piezometer may be abandoned in the future.

As has been the case for the last several monitoring events, no readings were able to be collected from pneumatic piezometers 2H-P1, 2K-P1, 3K-P2, and P97-10B. Piezometers 2K-P1 and 3K-P2 are both located upstream of the dam core along stations 28+40 and 35+00, respectively, approximately 350 feet downstream of the filter berm centerline. Readings have not been able to be collected from these instruments for the last several monitoring events due to the pressure not releasing from the sensor during the reading process indicating these instruments are likely plugged and are considered

inoperable. Piezometer 2H-P1 is located along station 28+40 approximately 750 feet downstream of the filter berm centerline is broken and has not been operable for the past several monitoring events. Instrument P97-10B, located along station 28+40 about 80 feet downstream of the filter berm centerline and has had pressure release problems for the last several monitoring events. This instrument, along with two other instruments in the same nest, P97-10A and P97-10C, could not be found during the fall 2018 monitoring event and appear to have been buried during construction activities over the summer. The fitting for pneumatic piezometer 2F-P2 was replaced in the spring of 2017 and a reading was recorded for the fall 2017, spring 2018, and fall 2018 monitoring events; however, readings since the spring of 2013 have been inconsistent, making the readings suspect.

The role of instruments that have not been operable for the past several monitoring events, have had suspect past readings, such as 2H-P1 and 2H-P2, or appear to have been buried should be assessed during the next Dam 1 seepage analysis and subsequently replaced. Pneumatic instruments for which unsuccessful reading attempts have been made over the last several monitoring events are likely failing from corrosion based on discussions with the pneumatic piezometer manufacturer, Slope Indicator. To protect the instruments that are still functional, countermeasures such as tube caps and water proof boxes will need to be implemented. These should be implemented within the next year.

The VW piezometer in the upper lacustrine clay within the nest located approximately 100 feet downstream of the dam centerline (D1-3500R100A) has historically been functional when readings have been attempted during monitoring events, although a reading was not able to be collected from this instrument in the spring of 2016. As discussed in the spring 2018 report, readings for some of these piezometers could not be recorded following data logger installation and subsequent data logger shifting between locations in February 2018. Functionality review is currently underway to determine how to resume collection of readings from the piezometer in the upper portion of the fine tailings, though this variable functionality may be an initial indicator of instrument deterioration. Future investigation and instrumentation installation planning should include replacement of this instrument nest.

Readings were not collected from the piezometer installed in the clay at the toe of Dam 1 at station 33+00 (D1-3300R1200) due to the VW cable being disconnected. This instrument cable was lengthened and connected to the data logger box in December 2018 during some other instrument updates/repairs and data will be included in the spring 2019 monitoring report.

Dam 2

Data were not able to be collected from pneumatic piezometers 4H-P2, 3E-P2, and P97-19A due to the pressure not releasing during the reading process. The fitting for piezometer 4F-P1 was replaced as part of the fall monitoring event and a reading recorded. The fitting for pneumatic piezometer P97-13 was also replaced.

As for VW piezometers of the same vintage at the crest of Dam 1, data from some VW piezometers located approximately 100 feet downstream of the filter berm centerline along station 34+75 (D2-3475R100B) were not able to be recorded following installation of a data logger. These instruments will continue to be reviewed, though this variable functionality may be an initial indicator of instrument deterioration. Future investigation and instrumentation installation planning should include replacement of this instrument nest, as well.

Consistent with historical performance, data logger readings indicate the VW installed in the sand seam at the toe of Dam 2 at station 42+00 (D2-4200R1000) continues to be non-functional. The piezometric level for the nearby P97-12 within the same sand layer is similar to historic readings, and no functionality issues have been noted for this instrument. Although this instrument currently appears functional, the other pneumatic piezometers installed at the same time have deteriorated to the point of becoming nonfunctional over the past several years and this instrument may need to be replaced in the next few years.

Reclaim Dam

As the ends of the wires for the VW piezometer nest located at station 27+00 were buried during dam construction in 2016 and have not been able to be unearthered, this instrument could again not be read. A replacement nest of VW piezometers should be installed, and this new nest should consider future configuration plans for the reclaim dam.

Dam 5 and Seepage Recovery Dams

No piezometers appeared to be inoperable or damaged at Dam 5 and seepage recovery dam 1A during the fall 2018 monitoring event. As noted for the spring of 2018, the casing for Casagrande piezometer P-22A at seepage recovery dam 2-3 was observed to be bent. The reading for this instrument was also outside of the typical range. This instrument may need to be replaced in the future.

Equipment Summary

Table 1 below provides a summary of piezometers that are suspected to be malfunctioning or are no longer functional, as well as the recommended plan of action.

Table 1: Malfunctioning or Non-Functional Piezometer Summary

Instrument Name	Piezometer Type	Associated Dam	Station	Location	Approximate Distance from Dam Centerline (ft)	Comments
5A-P0	Casagrande	Dam 1	17+00	Mid Downstream Slope	900	Abandon piezometer
3B-P1	Casagrande	Dam 1	28+40	Mid Downstream Slope	1000	Evaluate role of piezometer during model updates then decide to abandon or replace
2B-P3	Casagrande	Dam 1	35+00	Toe	980	Evaluate role of piezometer during model updates then decide to abandon or replace
2F-P2	Pneumatic	Dam 1	35+00	Toe	1290	Evaluate role of piezometer during model updates then decide to abandon or replace
2H-P1	Pneumatic	Dam 1	35+00	Upstream of Cutoff	760	Piezometer buried; evaluate role of piezometer during model updates and decide whether to replace
2K-P1	Pneumatic	Dam 1	35+00	Upstream of Cutoff	350	Piezometer inoperable; evaluate role of piezometer during model updates and decide whether to abandon or replace
3K-P2	Pneumatic	Dam 1	28+40	Upstream of Cutoff	350	Piezometer inoperable; evaluate role of piezometer during model updates and decide whether to abandon or
P97-10B	Pneumatic	Dam 1	28+40	Upstream of Cutoff	80	Piezometer buried. Review piezometer status for future course of action
D1-3500R100 (Upper Fine Tailings)	VW	Dam 1	35+00	Upstream of Cutoff	100	Continue recording data with data logger to assess functionality. Plan for future replacement of entire nest
D1-3300R1200 (Upper Clay)	VW	Dam 1	33+00	Toe	1200	Splice on extra wire and connect to data logger
3E-P2	Pneumatic	Dam 2	34+75	Toe	1020	Evaluate role of piezometer during model updates for next raise then decide to abandon or replace
4H-P1	Pneumatic	Dam 2	42+00	Upstream of Cutoff	440	Abandon piezometer
4H-P2	Pneumatic	Dam 2	42+00	Upstream of Cutoff	440	Abandon piezometer
P97-19A	Pneumatic	Dam 2	34+75	Dam Crest	50	Attempt to read again in Spring 2019. Review piezometer status for further course of action
D2-3475R100 (nest of 6)	VW	Dam 2	34+75	Dam Crest	100	Continue recording data with data logger to assess functionality. Plan for future replacement of entire nest

Table 1 (cont.): Malfunctioning or Non-Functional Piezometer Summary

Instrument Name	Piezometer Type	Associated Dam	Station	Location	Approximate Distance from Dam Centerline (ft)	Comments
D2-4200R1000M1	VW	Dam 2	42+00	Toe	1000	Continue data collection with data logger, though likely will remain non-functional
RD-2700R95 (nest of 3)	VW	Reclaim Dam	27+00	Dam Crest	95	Replace instruments
P-22A	Casagrande	SRD 2-3	N/A	Downstream of Toe, East End	150	Continue to read instrument, assess role as part of dam stability analysis

Inclinometers

Readings

Data collection was attempted at ten inclinometers at the site for the spring 2018 monitoring event. Barr processed inclinometer data using DMM and Digipro software developed by the Slope Indicator Company. Systematic errors, such as sensor bias shift, rotation, and casing inclination are common in inclinometer readings, and it is critical to diagnose and correct such factors. Barr applied corrections to the data and produced graphs of cumulative displacement for each inclinometer, presented in the attached figures. Each figure includes two graphs: the left graph represents cumulative displacement along the A-axis perpendicular to the slope and the right graph shows incremental displacement along the A-axis perpendicular to the slope.

Inclinometer I10-1 is located on the mid-slope of Dam 1 near Station 35+00. Slight creep has historically been observed generally between 52 to 58 feet and 104 to 112 feet below the top of casing since its installation in 2010. Readings indicate no new movement between the spring and fall 2018. As has been noted previously, some casing drift appears to have occurred in the upper approximate 5 feet, likely due to freeze/thaw conditions or extension without grout support.

The historical readings collected from inclinometer I13-1, installed in the mid-slope of Dam 1 at station 28+40 in September 2013, appear to indicate casing settlement may have occurred within a zone generally between 38 and 60 feet below grade since installation. The rate of casing settlement appeared to have slowed significantly by early 2014. A comparison of the available readings to the original baseline reading just after installation appears to indicate depth position error (DPE). This error was corrected by changing the baseline reading for displacement to May 2014, after the majority of the settlement already occurred. Based on the data, no movement was observed between the spring and fall 2018.

No movement was observed for inclinometers I97-1 and I97-3 located at the toe of Dam 1. No movement was observed in Dam 2 toe inclinometers I97-5 and I97-7 along with Dam 2 midslope

inclinometer I97-8, as well. Casing disturbances have been indicated by the data at approximately 20' below the top of casing at I97-1 and at 50 feet below the top of casing at I97-8 that occasionally result in an inconsistent history of very slight movement. Actual movement of the dam does not contribute to this reading since movement is not observed during consecutive monitoring events and occurs at locations with high checksum values (indicating high potential for error in the raw data). The data for these inclinometers do indicate some casing joint disturbances from age and compression which do not yet appear to be affecting function. Inclinometer I10-2 is located on the midslope of Dam 2, in the core just downstream from the seepage collection ditch near station 42+00, and has indicated no significant movement since its installation in 2010. Apparent surface drift appears to have also occurred for I97-3, I97-5, I97-7, I97-8, and I10-2.

Two inclinometers are located at Dam 5, I04-2 and I13-2. Inclinometer I04-2 is located just downstream of the Dam 5 core at Station 14+00. An additional 10 feet of inclinometer casing was added to this instrument due to the raise of the dam crest. Readings continue to indicate a damaged joint at a depth of about 25 feet below the current top of casing and settlement from approximately 32 to 76 feet below the top of casing. Slight creep movement has been noted in the past between the depths of 72 and 76 feet below the top of casing, though no significant creep between the spring and fall of 2017. A comparison of the most recent readings and spring 2018 readings indicates very slight creep at a depth of approximately 72 feet. Replacement of this instrument is in progress.

Inclinometer I13-2, installed in September 2013, is located on the downstream slope at station 14+00. Slight creep movement had been intermittently indicated by this inclinometer from 42 to 46 and 50 to 58 feet, though negligible movement was indicated by data recorded in the fall of 2017. An attempt to read this inclinometer in the spring of 2018 indicated the casing was damaged. Subsequent use of a video camera to investigate the inclinometer casing condition in the summer of 2018 found the instrument was partially collapsed at depth of approximately 29 feet below grade and bent at about 37 feet below grade, rendering this instrument inoperable. Replacement of this instrument is in progress.

Increased frequency of inclinometer readings is recommended for instruments on dams where construction is taking place, especially for instruments where previous creep movement has been observed in the past, particularly Dam 1 and Dam 5. Construction at the basin many times is conducted discontinuously over the late spring, summer, and fall months due to weather, personnel, material, and operations restrictions, which can make it difficult to plan appropriate inclinometer reading events. To accommodate this construction situation, remove the need for raising inclinometer casing, and, though slight as it is, eliminate human error in readings, it is recommended future basin planning include the installation of micro-electro-mechanical systems (MEMS) inclinometers. The MEMS are permanent, can be installed in the existing inclinometer casing, and can be incorporated into a remote monitoring system. NSM and Barr have discussed incorporation of MEMS sensors at some initial select locations in 2019.

Equipment

Inclinometer I13-1, located at station 28+40 just north of the seepage collection ditch at Dam 1, is still functional despite grooves potentially being damaged at a few intervals. Extra care in consideration of this condition should continue to be exercised when recording readings.

As noted in several of the past monitoring reports, inclinometer I04-2 should be replaced. Provisions for a replacement inclinometer are currently underway and will be discussed in the spring 2019 monitoring report.

As mentioned above, the casing for I13-2 was rendered inoperable due to damage at approximately 29 and 37 feet below grade. Provisions for a replacement inclinometer are also underway at this location.

A video camera was used to assess the condition of I97-1 and I97-3, both located at the toe of Dam 1, during the fall 2018 monitoring event. Based on this footage, I97-1 appears to be in acceptable condition, though some groove wear is evident. The casing extensions for I97-1 appear to be completely extended, indicating consolidation has not been measured since installation. There also appears to be a small crack just above a casing connection near a depth of approximately 24 feet below grade. Although this crack doesn't appear to be affecting functionality, it is a sign of deterioration. In I97-3, it appears the extension nub near a depth of 9 feet may have become disconnected. Other casing extensions appear to be completely extended.

Review of inclinometers I97-5 and I97-7 in the fall of 2017 indicated I97-5 may be cracked and I97-7 has some groove wear and the casing extensions are completely extended. These instruments along with I97-1 are good candidates as some of the first older inclinometers to be replaced with an automated Shape Accelarray (SAA). Development of a plan for automating inclinometers is underway and initial installation is planned for 2019.

Reading and Equipment Summary

Table 2 provides a summary of the inclinometers at Milepost 7.

Table 2: Inclinometer Summary

Inclinometer	Location	Total Depth (feet)	Fall 2018 Observation
I97-1	Dam 1 toe, Sta. 28+40	38	No movement observed. Potential small cracks observed at about 24 feet. Groove wear and fully extended casing extensions also observed. Plan for future installation of MEMS equipment.
I13-1	Dam 1 mid-slope, Sta. 28+40	134	No movement observed.
I97-3	Dam 1 toe, Sta. 35+00	32	No movement observed. Apparent drift from freeze/thaw and/or extension without grout in upper portion. Groove wear and fully extended casing extensions observed. Plan for future installation of MEMS equipment
I10-1	Dam 1 mid-slope, Sta. 35+00	118	No movement observed. Apparent surface drift from freeze/thaw in upper portion.
I97-5	Dam 2 Toe, Sta. 42+00	34	No movement observed. Apparent drift from freeze/thaw and/or extension without grout in upper portion.
I10-2	Dam 2 mid-slope, Sta. 42+00	78	No movement observed. Apparent drift from freeze/thaw and/or extension without grout in upper portion.
I97-7	Dam 2 toe, Sta. 34+75	34	No movement observed. Apparent drift from freeze/thaw and/or extension without grout in upper portion.
I97-8	Dam 2 mid-slope, Sta. 34+75	68	No movement observed. Apparent drift from freeze/thaw and/or extension without grout in upper portion.
I13-2	Dam 5 toe, Sta. 14+00	73	Inclinometer damaged and no longer operational. Replacement in progress.
I04-2	Dam 5 crest, Sta. 14+00	98	Slight creep at 72 feet. 10 ft of casing added in summer 2018. Casing is damaged at joint 25 feet from top of casing. High curvature above 25 feet, but instrument still functioning. Replacement in progress.

Relief Wells

Following the methodology since the fall of 2015, the relief wells were not plugged to record water levels as part of the fall 2018 monitoring event to prevent increasing porewater pressures in dam

foundation soils. Flow rates were still documented where well outlets were accessible and/or above the adjacent pool level.

The flow rates for relief wells R-1, R-3, R-4, and R-5 were all higher than in the spring of 2018, though within the historic data range for the instrument. Flow rates could not be recorded for relief wells R-6, R-7, R-11, and R-12 at Dam 1 due to the outlets being below the water surface of the adjacent pool. The standpipe for R-11 is also disconnected/damaged and should be repaired.

At the toe of seepage recovery dam 2-3, the outlets for relief wells R-12 and R-13 were under the water surface of the adjacent pool. This scenario has been the case since 2009 for R-12 and 2010 for R-13.

Seepage Channel Weirs

Measurements of the flow over the seepage channel weirs were recorded and are depicted in the attached graphs. A measurement could not be made for the weir at the west end of the main portion of Dam 1 due to an abundance of algae, cattails, and branches that collected in and around the weir notch. A flow rate significantly higher than the spring of 2018 was recorded for the east weir; however, this reading was likely also affected by a large build-up of algae in the weir notch. The weirs as well as areas upstream and downstream should be cleared of algae, cattails, and any other debris to allow measurements to be recorded.

Weir measurements indicate total seepage flow in the channels was approximately 1,024 gpm at Dam 1, excluding flow for the west weir and including the apparent increased flow for the east weir. For Dam 2, weir flow in the channels indicate a total seepage flow of approximately 832 gpm, which falls within the typical range of historical seepage channel flow. Variations in flow are generally due to precipitation on the dam face and crest above the channel.

Summary and Recommendations

Data from all of the piezometers, inclinometers, relief wells, and weirs at the basin were recorded during the fall 2018 monitoring event conducted in early November. The majority of piezometer readings for Dam 1, Dam 2, Dam 5, the reclaim dam, and the seepage recovery dams are generally consistent with past readings.

Data recorded for VW piezometers at the crest of Dam 1 (D1-3500R100A) indicated higher piezometric elevations likely related to backer and filter berm material placement as well as associated material hauling between the spring and fall monitoring events. Increases in piezometric heads were also recorded over the summer and fall at Dam 5, especially for the VW piezometers in the nest approximately 400 feet downstream of the dam centerline. The response of these piezometers matches material placement and movement related to construction NSM indicated has occurred and/or Barr has observed at this dam over the summer and fall of 2018.

Nests of VW piezometers at the crest of Dam 1 and Dam 2 where some data reading problems have been encountered were installed in 2005. As these reading issues may be an early sign of deterioration, instrumentation planning should consider replacement of these instruments within the next several years.

As has been noted for previous monitoring events, pneumatic piezometers at both Dam 1 and Dam 2 appear to be deteriorating. Some of the pneumatic piezometers with non-functional and/or of suspect functionality were replaced with VW piezometers in 2015. Since the deterioration is likely caused by corrosion, countermeasures such as tube caps and water proof boxes will need to be implemented to protect instruments that are still functional. One of the VW piezometers installed in a sand layer at the toe of Dam 2 in 2015 remains non-functional and will need to be replaced if the adjacent pneumatic piezometer installed in the same sand layer starts showing signs of deterioration. A couple of the Casagrande piezometers also appear to potentially be deteriorating and their role for dam analyses should be assessed.

Readings from the VW piezometers at station 37+00 for the reclaim dam appear similar to previous readings. Since the wires for the VW piezometers at station 27+00 were lost in 2016, a new nest of VWs should be installed as a replacement in an acceptable location considering the potential future reconfiguration of the reclaim pond.

Piezometer readings from Casagrande piezometers at seepage recovery dam 1A and 2-3 appear generally consistent with past readings; the exception is P-22B at seepage recovery dam 2-3 in which no water was present. Readings from some of the piezometers located at the toe of seepage recovery dam 1A continue to be similar to the pond elevation for the adjacent seepage recovery pond. Fieldwork to install VW piezometers at the toes of the seepage recovery dams was completed in late fall 2018, and data will be reviewed and discussed as part of the spring 2019 monitoring event.

Bi-annual monitoring, including downloading of data from data loggers not connected to the near real-time monitoring system, should continue during bi-annual monitoring events unless instrumentation or observations indicate potential for instability, at which point more frequent monitoring should occur. Readings should be recorded monthly during material placement or other construction activities for instruments near construction locations. Reading frequency should be increased to weekly, or as otherwise recommended for observed conditions, for the duration of construction if movement is shown to increase during construction. These reading intervals could be achieved by using remote monitoring with data frequency adjusted from the office rather than site visits.

Data from the relief wells appeared similar to historic data. Several relief wells were not accessible or read due to water pooling at the well outlets. The standpipe for relief well R-11 at Dam 1 should be repaired.

Algae and cattails need to be cleared out of the weirs at Dam 1 to accommodate measurements and prevent water build-up in the seepage collection ditches. Total flow of seepage water over the weir

at the east end of Dam 1 and for Dam 2 varied as typically observed during past monitoring events. Excluding the apparent unrepresentative data from the weirs for the main part of Dam 1, seepage rates were within the general range of historic data.

No movement was recorded for the majority of inclinometers considering data compared between the spring and fall 2018 monitoring events. Slight creep was indicated at a depth of about 72 feet in I04-2 on the crest at Dam 5. The upper portion of inclinometer I04-2 is curved towards the dam core, and a replacement inclinometer is in progress. Inclinometer I13-2 has been damaged to the point where it is inoperable and a replacement is in progress. Apparent casing drift, likely due to freeze-thaw and/or absence of grout when instruments were raised for dam raises, was observed for the upper portion of several inclinometers, as well.

Table 4 provides a summary of action items.

Table 4: Action Items

#	Action Item	Action Timeframe
1	Maintain Dam 5 toe seepage pond surface at a minimum elevation of 1,181 feet.	Ongoing
2	Continue review of VW piezometer connections to the data loggers at the crests of Dam 1 and Dam 2	2019
3	Lengthen and connect wire for D1-3300R1200 Upper Clay to data logger	Late Fall 2018
4	Replace damaged inclinometer I13-2 at Dam 5	In Progress
5	Replace inclinometer I04-2 at Dam 5	In Progress
6	Continue to install data loggers for remaining/new VW piezometers. Install remaining components for real-time monitoring system.	~Late 2018-2020
7	Clean out weirs at Dam 1	Winter 2018-2019
8	Set action levels for downstream slope and toe piezometers for Dam 1, Dam 2, and Dam 5 relative to dam stability, using data logger information as available.	~2019-2020
9	Repair relief well R-11 at Dam 1	2018/2019

Table 4 (cont.): Action Items

#	Action Item	Action Timeframe
10	Install additional piezometers at/beyond the toe of Dam 2 to monitor uplift pressures.	2019/2020
11	Perform seepage and stability analyses for the seepage recovery dams incorporating information from new VW piezometers installed in the late fall of 2018	2018/2019
12	Update construction tracking log to allow documentation of reasons for instrumentation fluctuations, such as pumping from seepage ponds, placement of aggregate, etc.	Ongoing
13	Replace piezometers at station 27+00 and install a VW nest at station 15+00 at the reclaim dam	~2018-2020
14	Install inclinometers with datalogging/automation capabilities (MEMS) within existing inclinometer casings	~Early 2019-2023
15	Replace non-functional pneumatic piezometers with VW piezometers	~2019-2025
16	Attempt to read piezometers from which data could not be recorded as part of the fall 2018 monitoring event.	Spring 2019
17	Record data from pneumatic piezometers adjacent to newly installed vibrating wire piezometers to allow data comparison	Ongoing as pneumatic equipment is functional
18	Implement protective measures for functional pneumatic piezometers to reduce degradation rate	2019

Closing

This report represents findings based on the data collected during the fall 2018 monitoring event. If you have any questions, please contact me at 218-529-7125 and/or sleow@barr.com.

Sincerely,

Sara L. Leow, P.E.
Geotechnical Engineer

Attachments:

Instrumentation Maps
Piezometer Charts
Relief Well Charts
Weir Charts
Inclinometer Charts

Certification

I hereby certify that this 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.

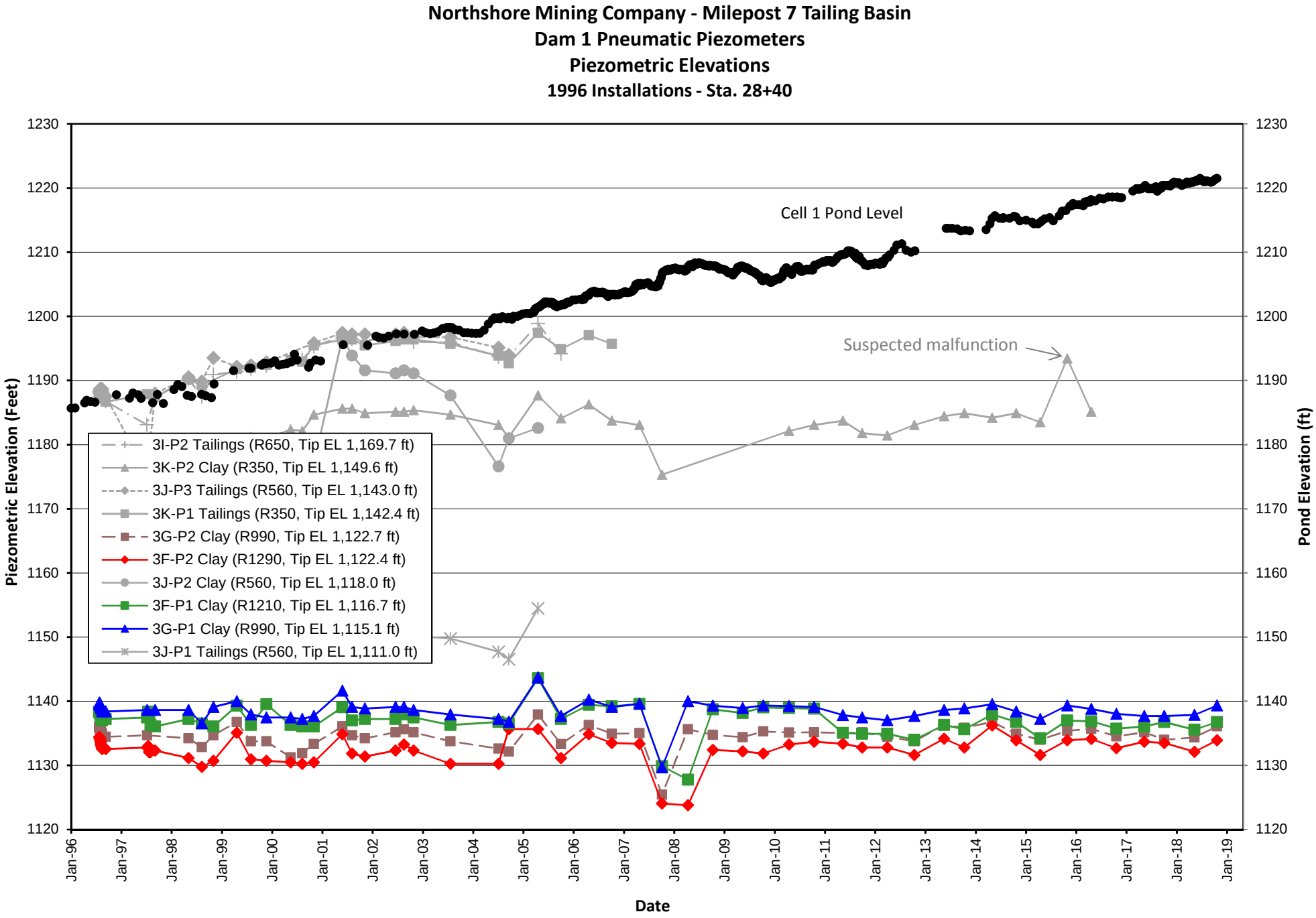
_____

Sara L. Leow, P.E.
License No.: 47103
Date: December 31, 2018

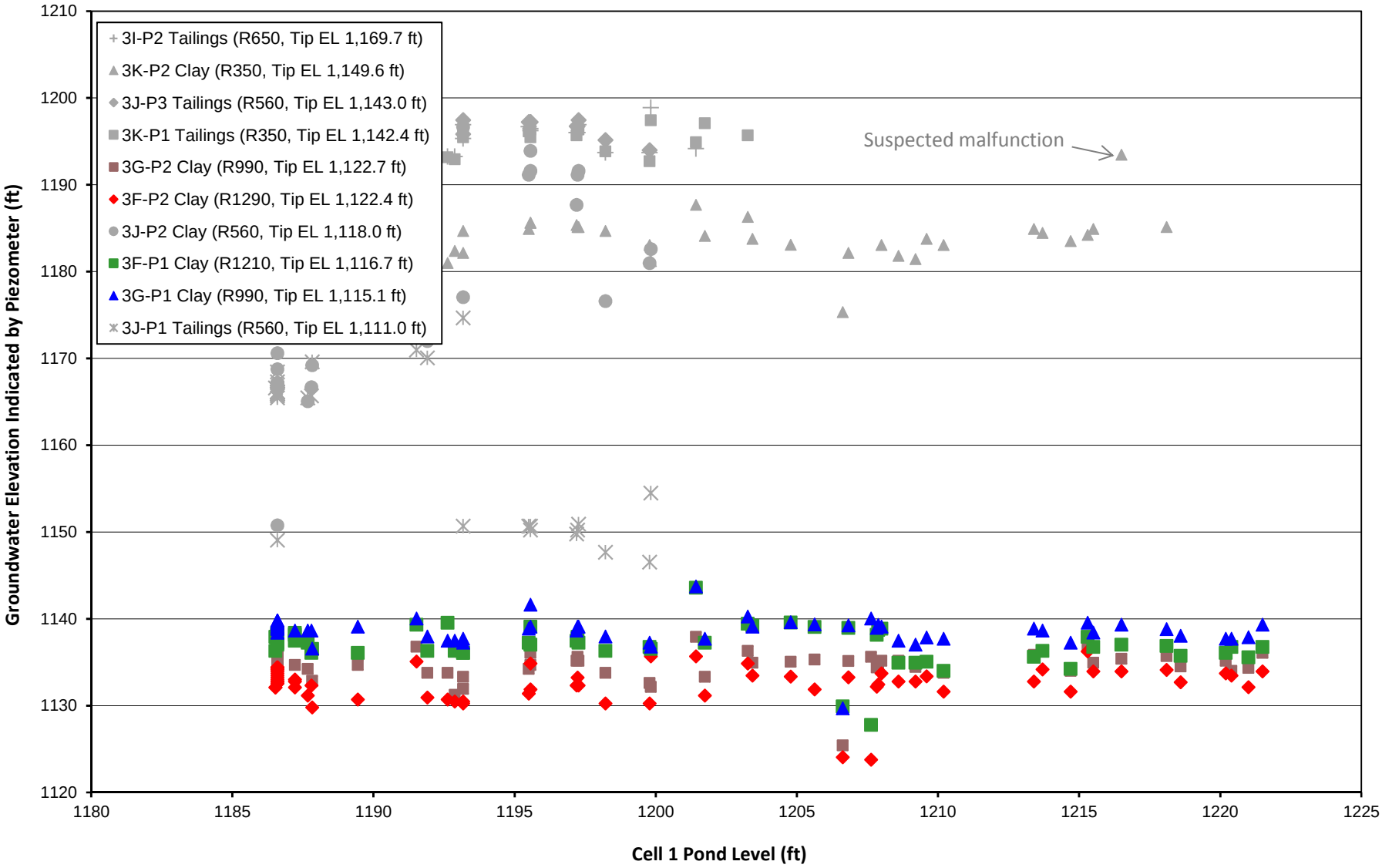
Instrumentation Maps

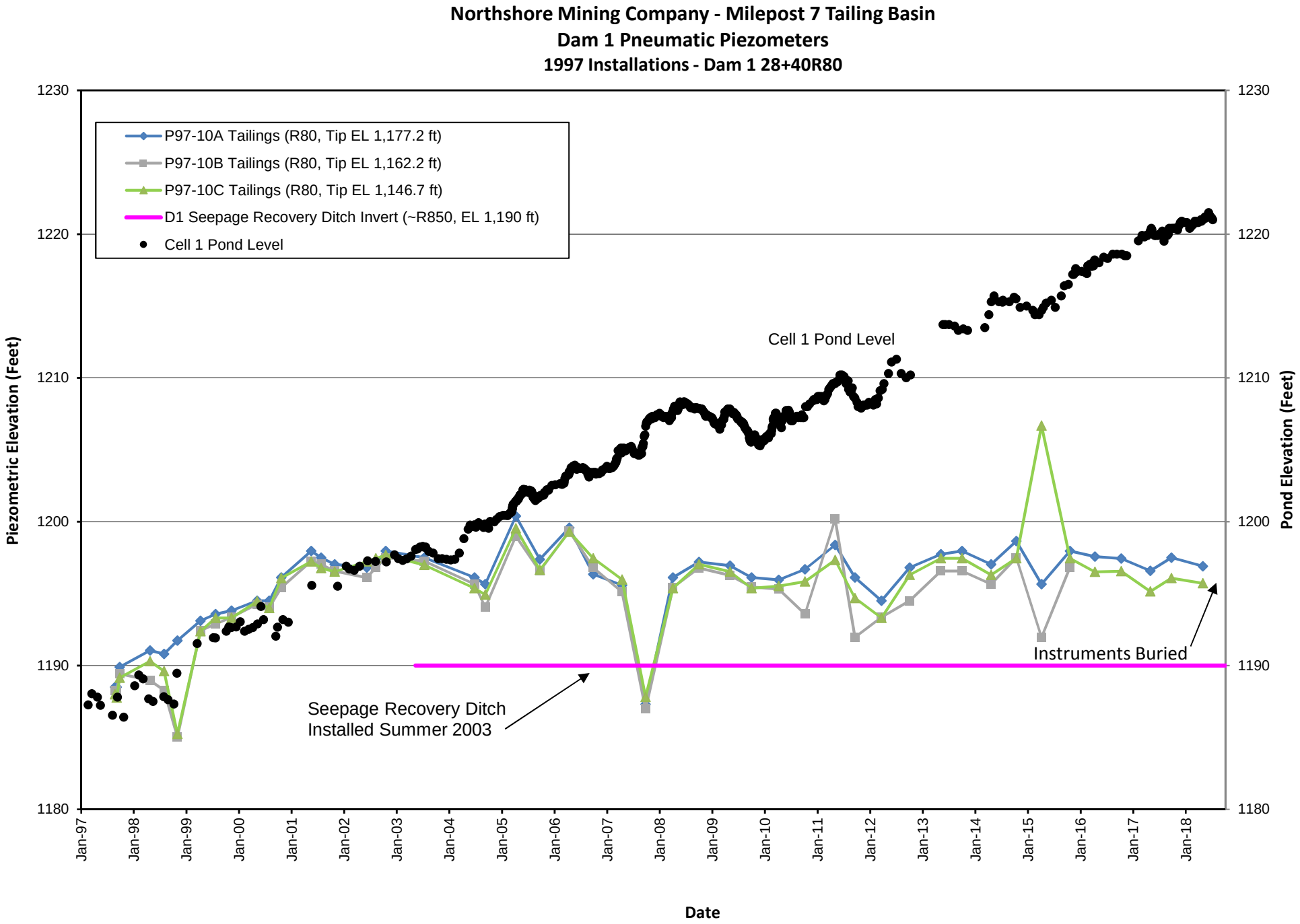
Piezometer Charts

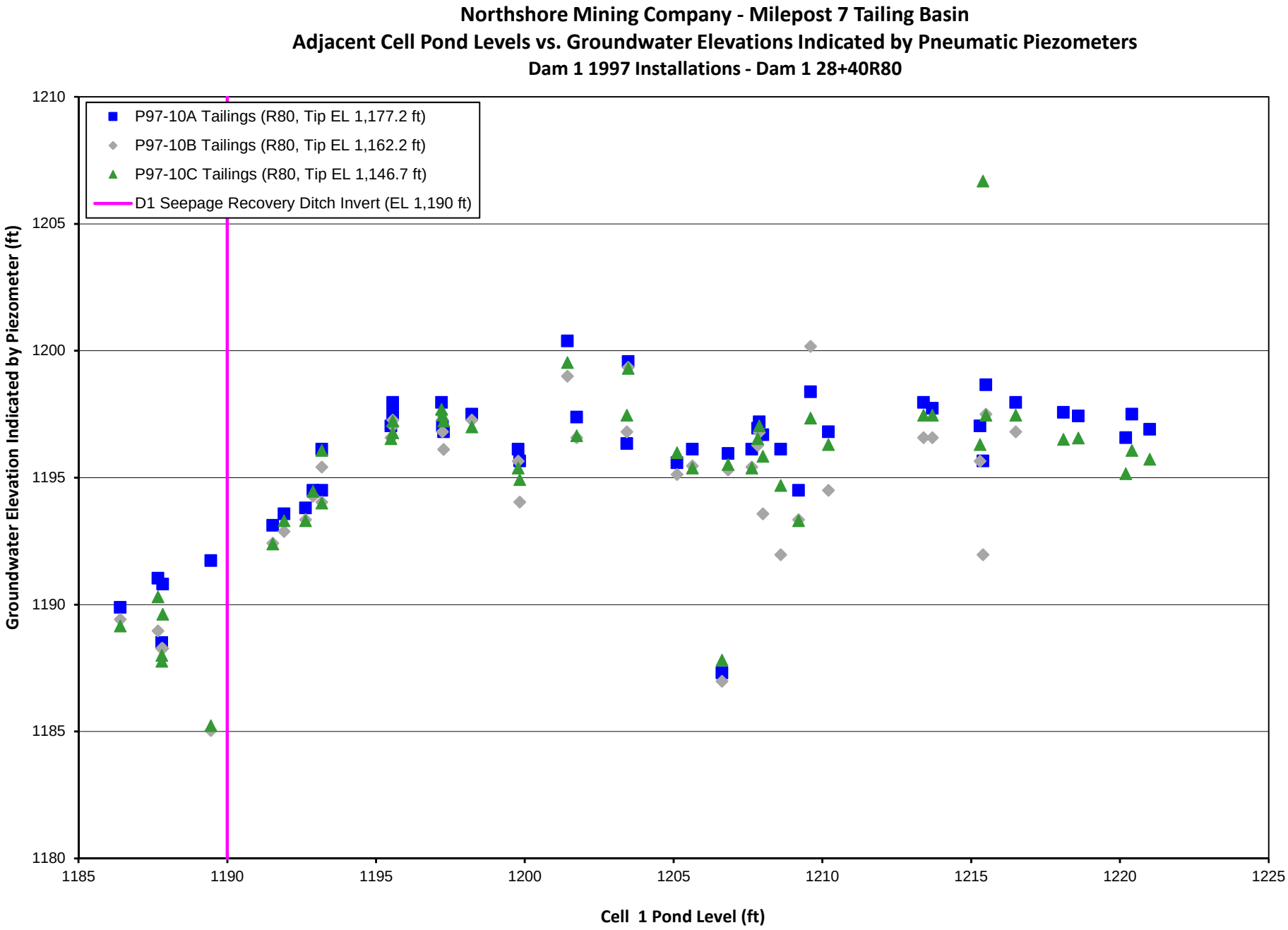
Dam 1 Piezometers


Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Pneumatic Piezometers
Piezometric Elevations
1996 Installations - Sta. 28+40
Cell 1 Pond Level
Suspected malfunction
3I-P2 Tailings (R650, Tip EL 1,169.7 ft)
3K-P2 Clay (R350, Tip EL 1,149.6 ft)
3J-P3 Tailings (R560, Tip EL 1,143.0 ft)
3K-P1 Tailings (R350, Tip EL 1,142.4 ft)
3G-P2 Clay (R990, Tip EL 1,122.7 ft)
3F-P2 Clay (R1290, Tip EL 1,122.4 ft)
3J-P2 Clay (R560, Tip EL 1,118.0 ft)
3F-P1 Clay (R1210, Tip EL 1,116.7 ft)
3G-P1 Clay (R990, Tip EL 1,115.1 ft)
3J-P1 Tailings (R560, Tip EL 1,111.0 ft)
Piezometric Elevation (Feet)
Pond Elevation (ft)
Date
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

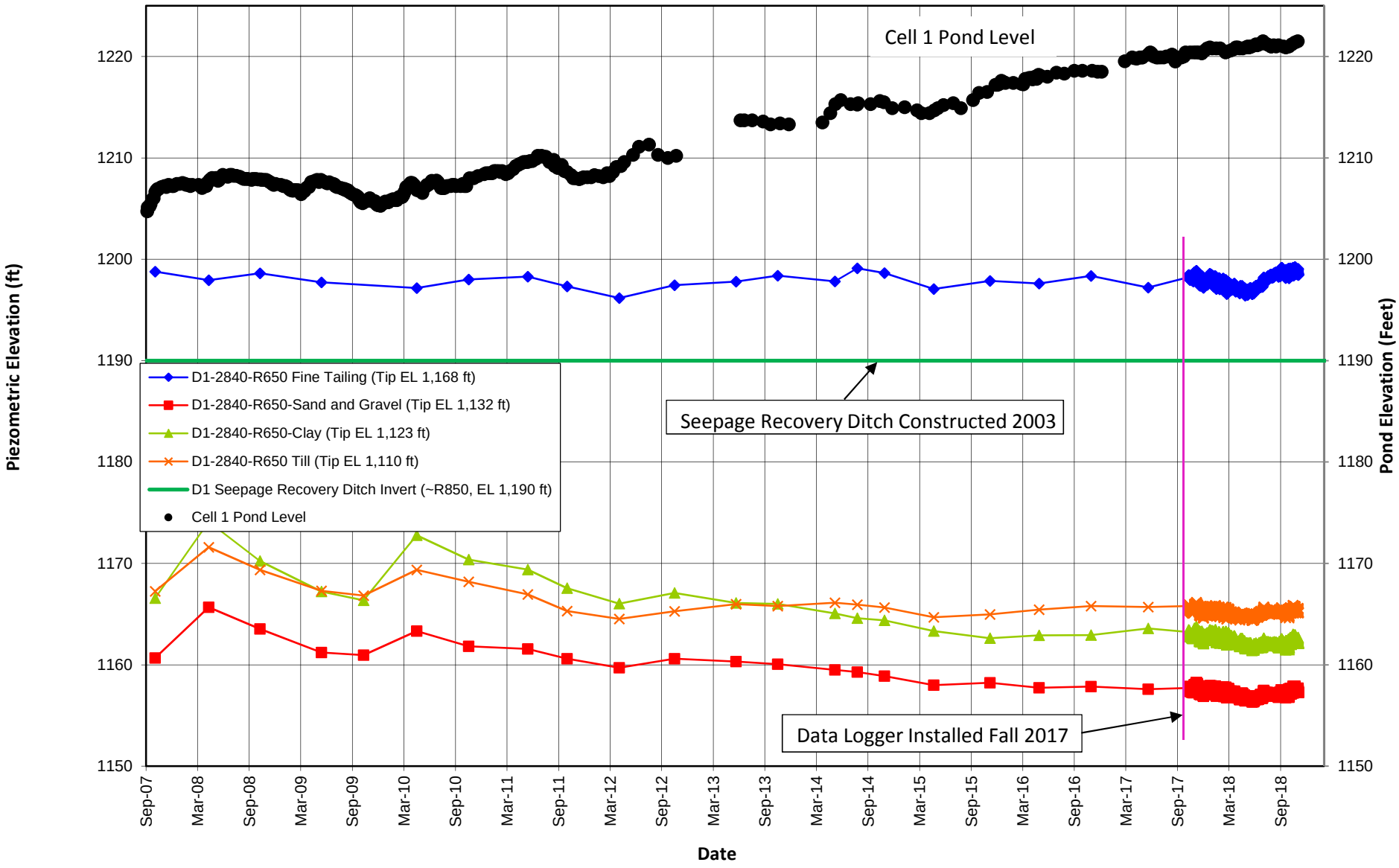
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 1 1996 Installations - Sta. 28+40



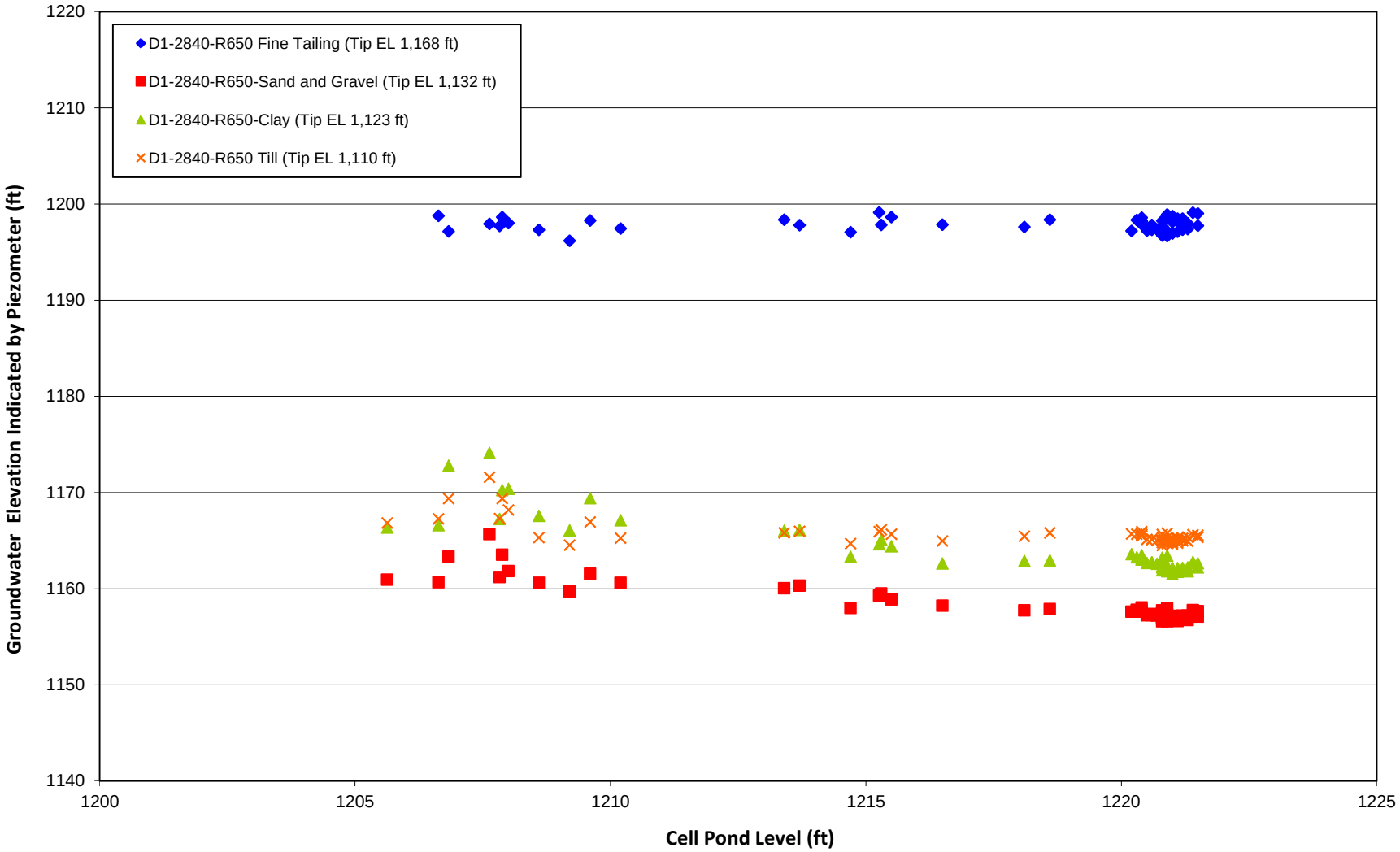

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Pneumatic Piezometers
1997 Installations - Dam 1 28+40R80
P97-10A Tailings (R80, Tip EL 1,177.2 ft)
P97-10B Tailings (R80, Tip EL 1,162.2 ft)
P97-10C Tailings (R80, Tip EL 1,146.7 ft)
D1 Seepage Recovery Ditch Invert (~R850, EL 1,190 ft)
Cell 1 Pond Level
Cell 1 Pond Level
Instruments Buried
Seepage Recovery Ditch
Installed Summer 2003
Piezometric Elevation (Feet)
Pond Elevation (Feet)
Date
1230
1220
1210
1200
1190
1180
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18


Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 1 1997 Installations - Dam 1 28+40R80
P97-10A Tailings (R80, Tip EL 1,177.2 ft)
P97-10B Tailings (R80, Tip EL 1,162.2 ft)
P97-10C Tailings (R80, Tip EL 1,146.7 ft)
D1 Seepage Recovery Ditch Invert (EL 1,190 ft)
Groundwater Elevation Indicated by Piezometer (ft)
1210
1205
1200
1195
1190
1185
1180
1185
1190
1195
1200
1205
1210
1215
1220
1225
Cell 1 Pond Level (ft)

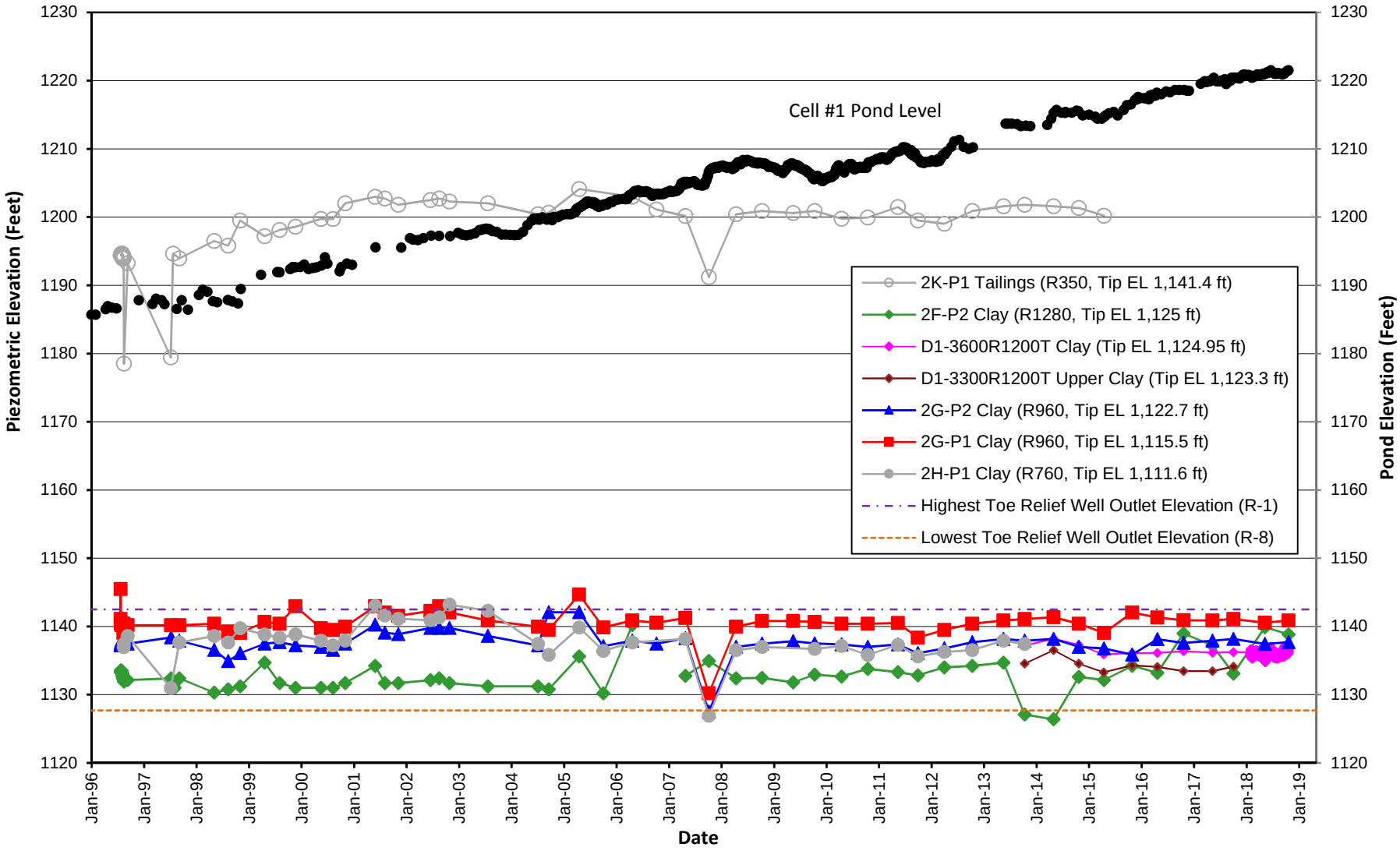
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Vibrating Wire Piezometers
Piezometric Elevations
Sta. 28+40R650



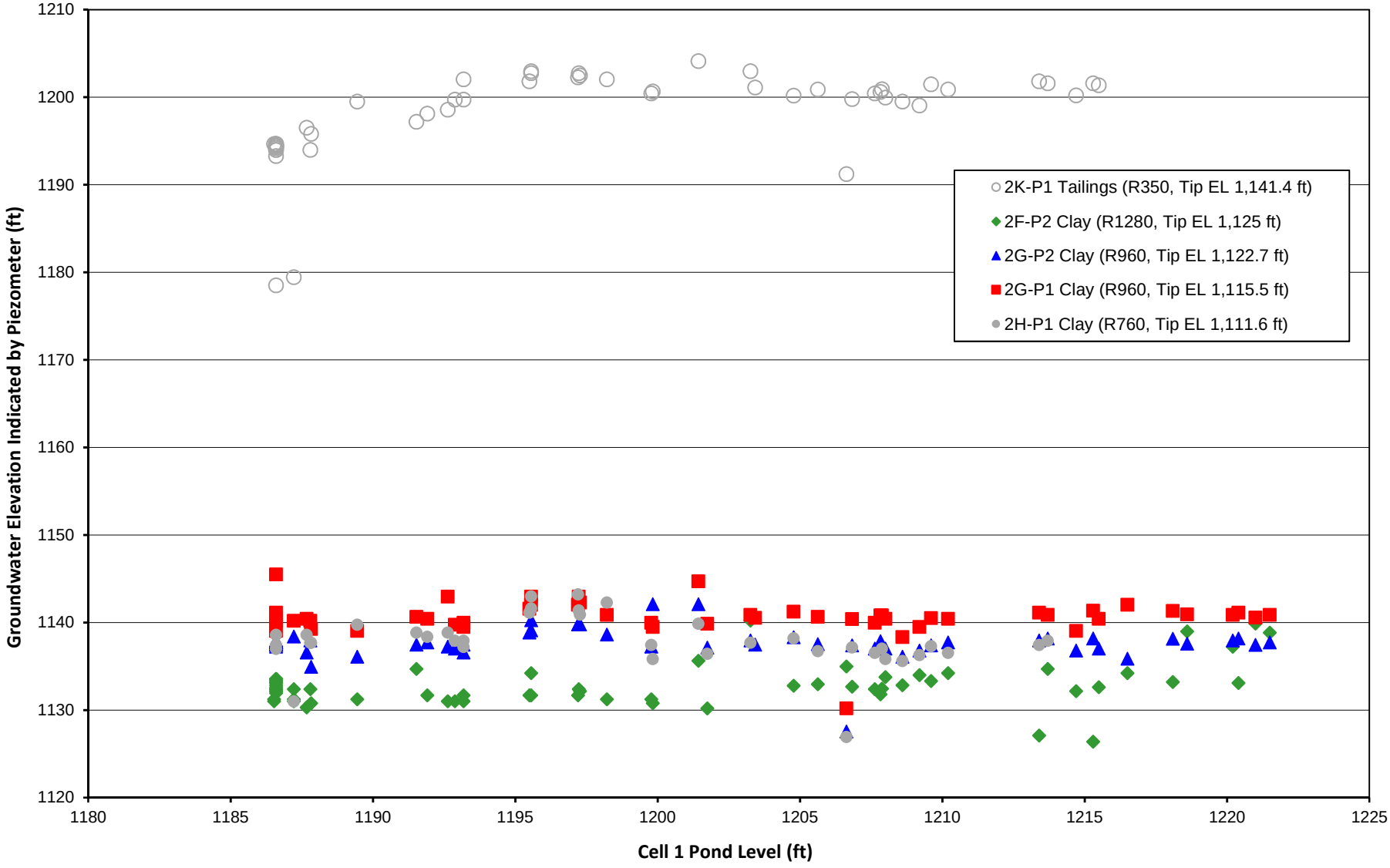
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 1 Sta. 28+40R650

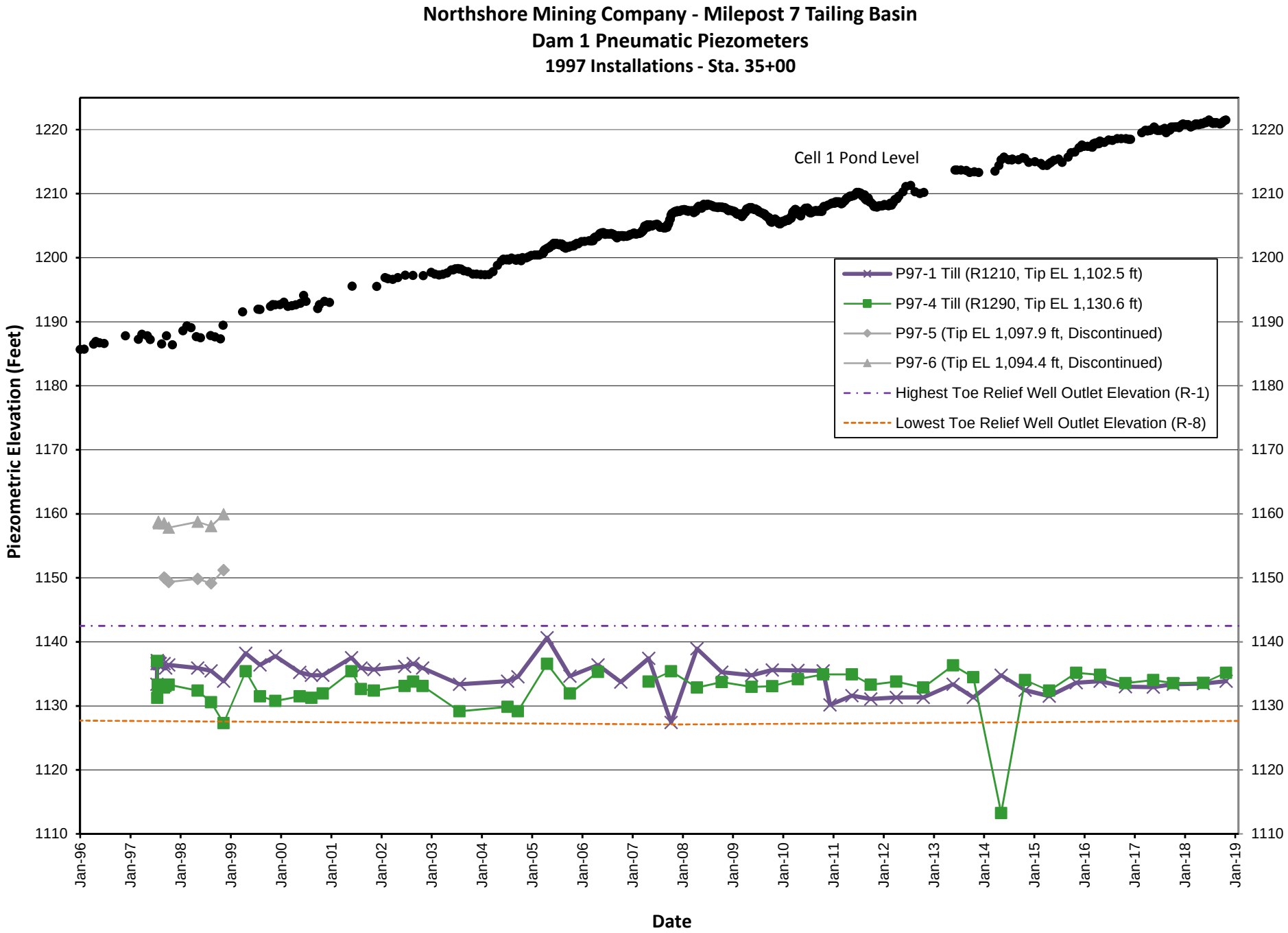


Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Pneumatic Piezometers
(with Select VW Data for Comparison)
Piezometric Elevations
1996 Installations - Sta. 35+00

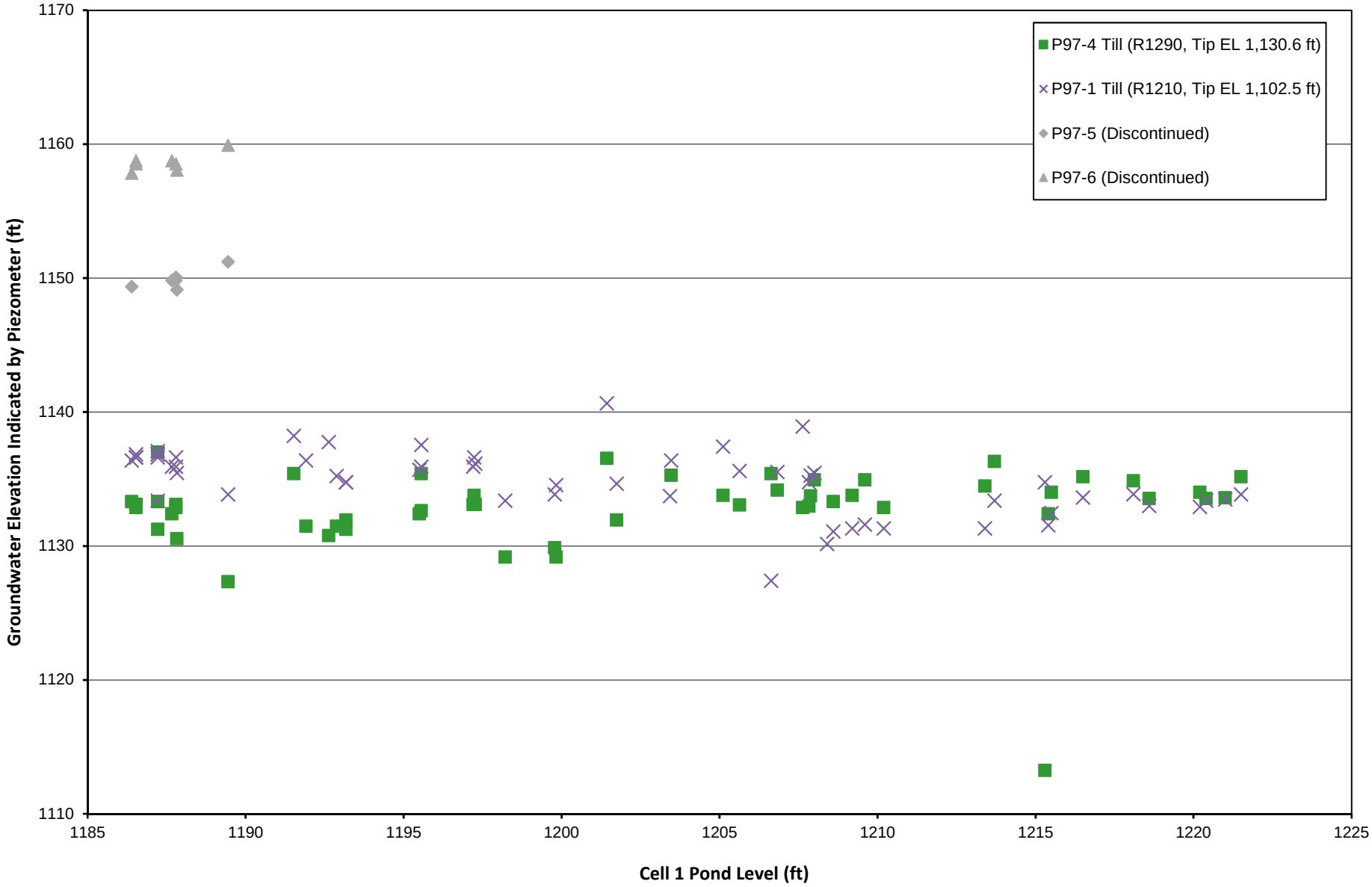


Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 1 1996 Installations - Sta. 35+00

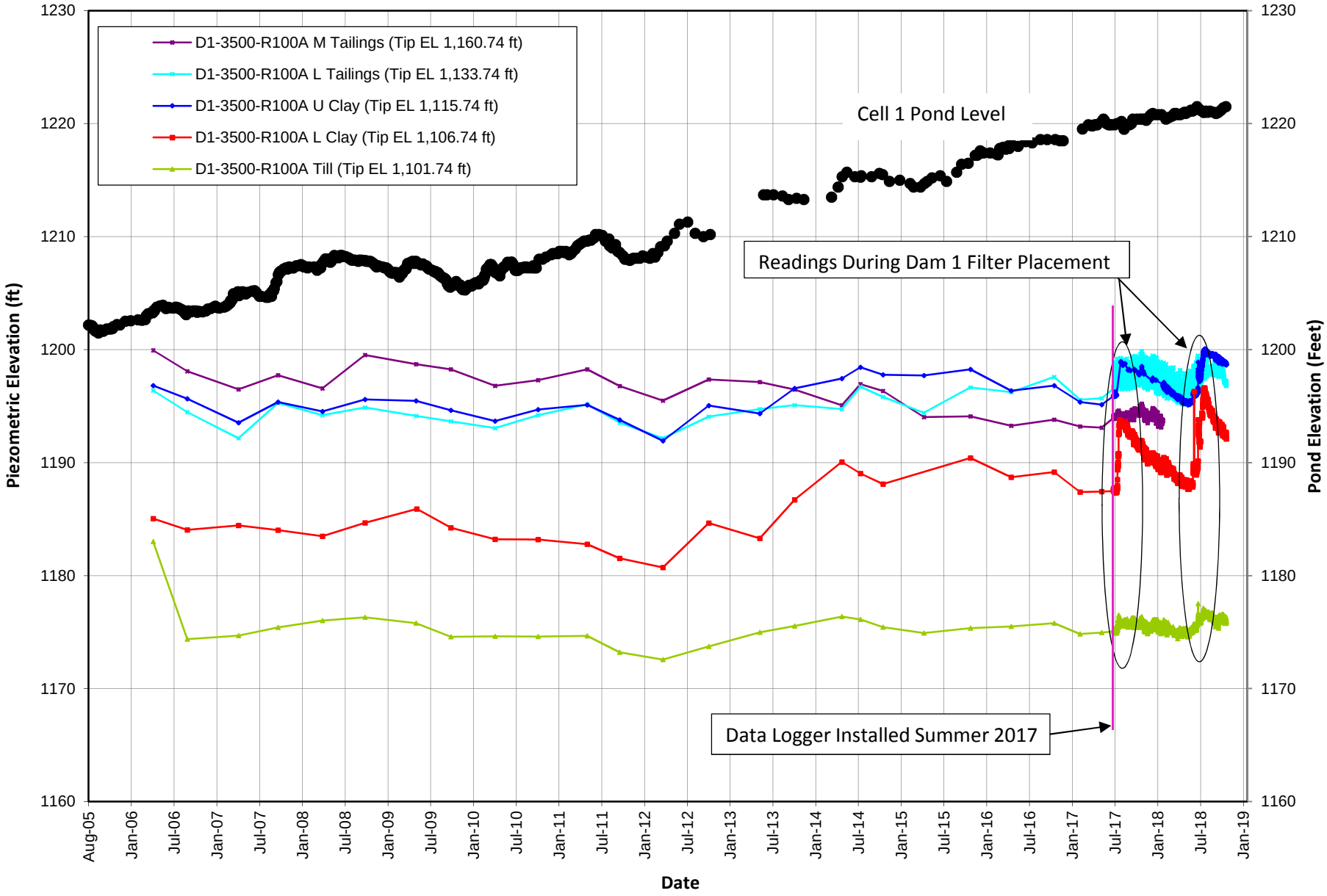



Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Pneumatic Piezometers
1997 Installations - Sta. 35+00
Cell 1 Pond Level
P97-1 Till (R1210, Tip EL 1,102.5 ft)
P97-4 Till (R1290, Tip EL 1,130.6 ft)
P97-5 (Tip EL 1,097.9 ft, Discontinued)
P97-6 (Tip EL 1,094.4 ft, Discontinued)
Highest Toe Relief Well Outlet Elevation (R-1)
Lowest Toe Relief Well Outlet Elevation (R-8)
Piezometric Elevation (Feet)
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Date

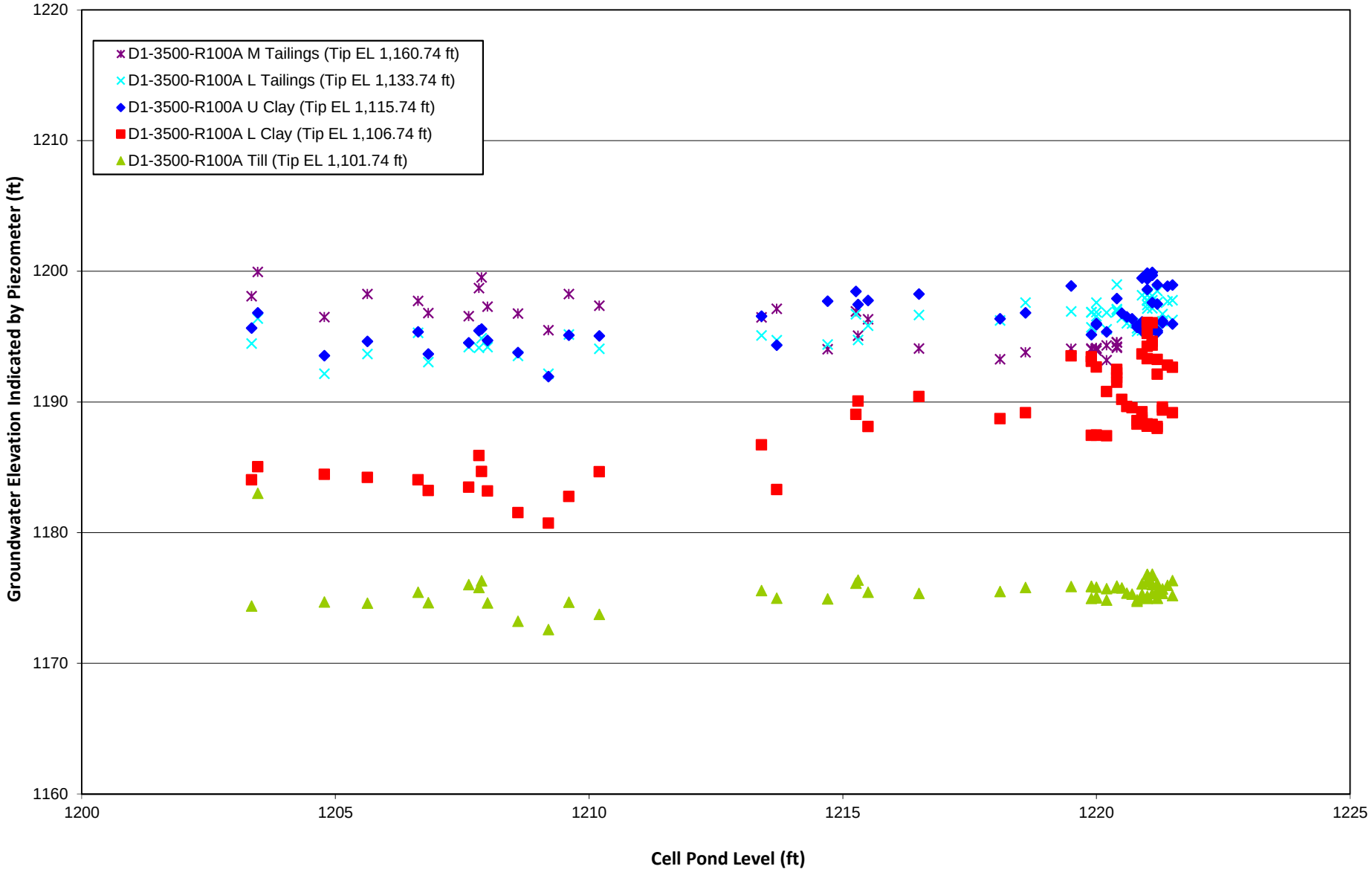
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 1 1997 Installations - Sta. 35+00

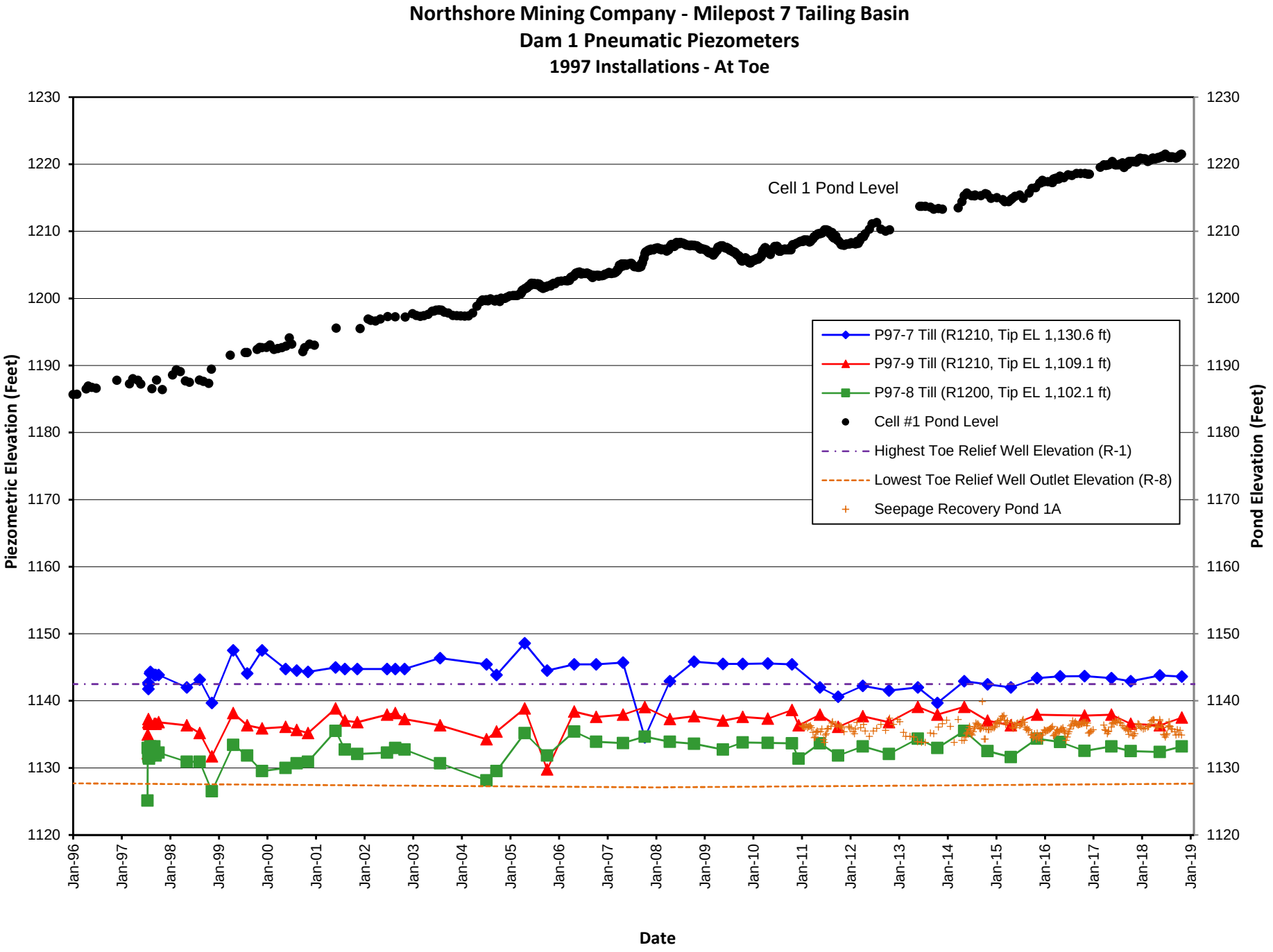


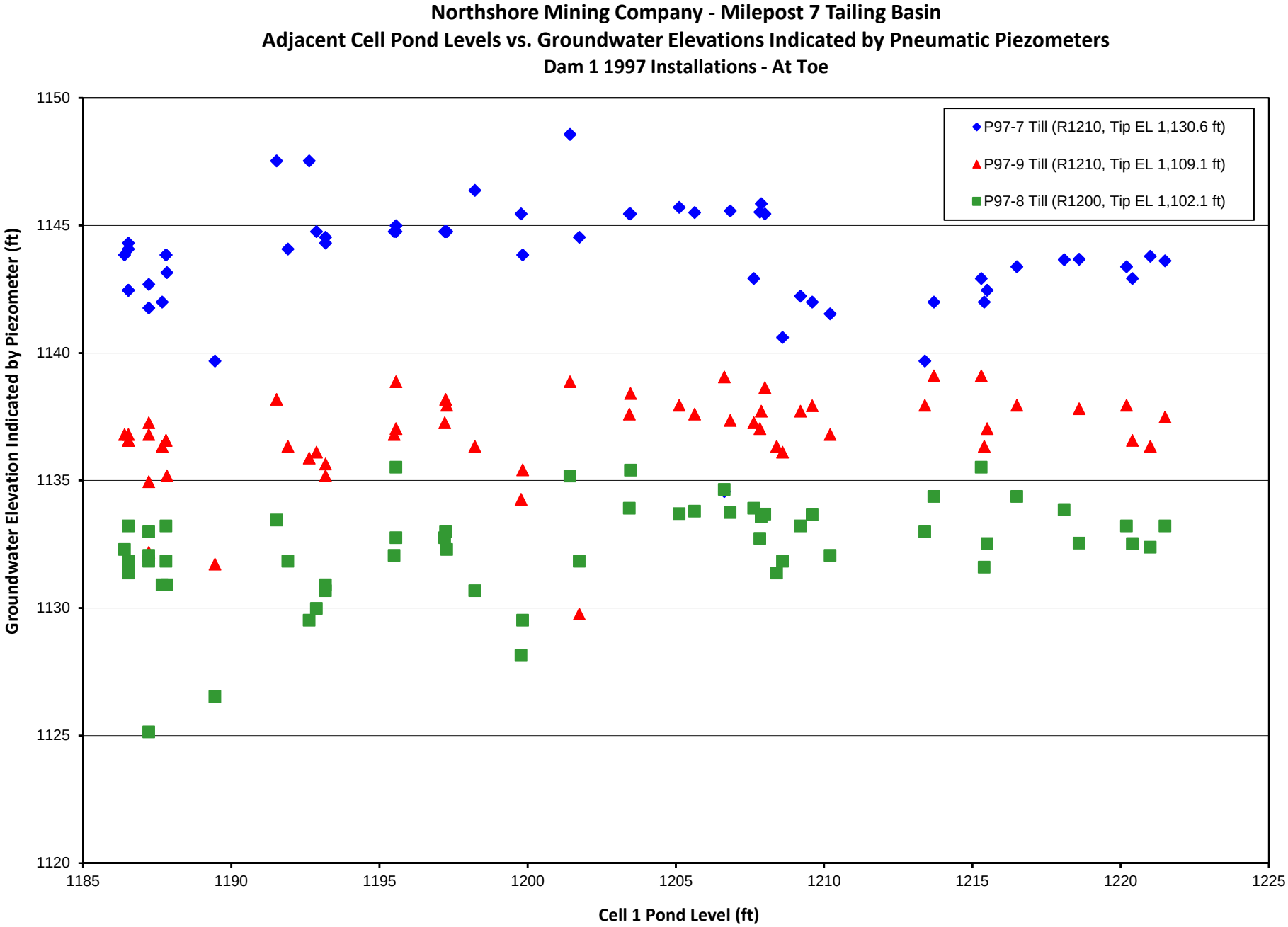
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Vibrating Wire Piezometers
Piezometric Elevations
Sta. 35+00R100



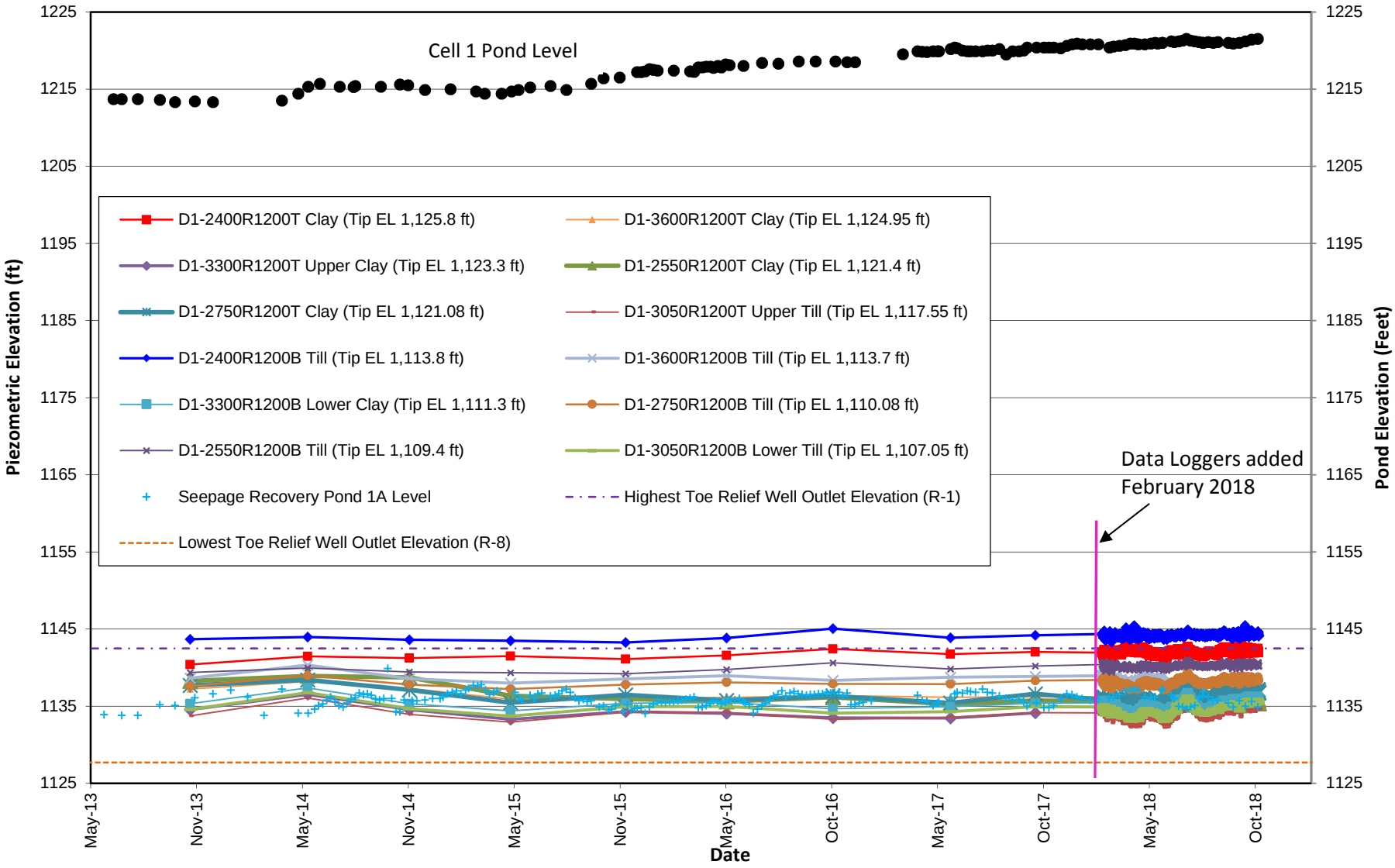
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 1 Sta. 35+00R100



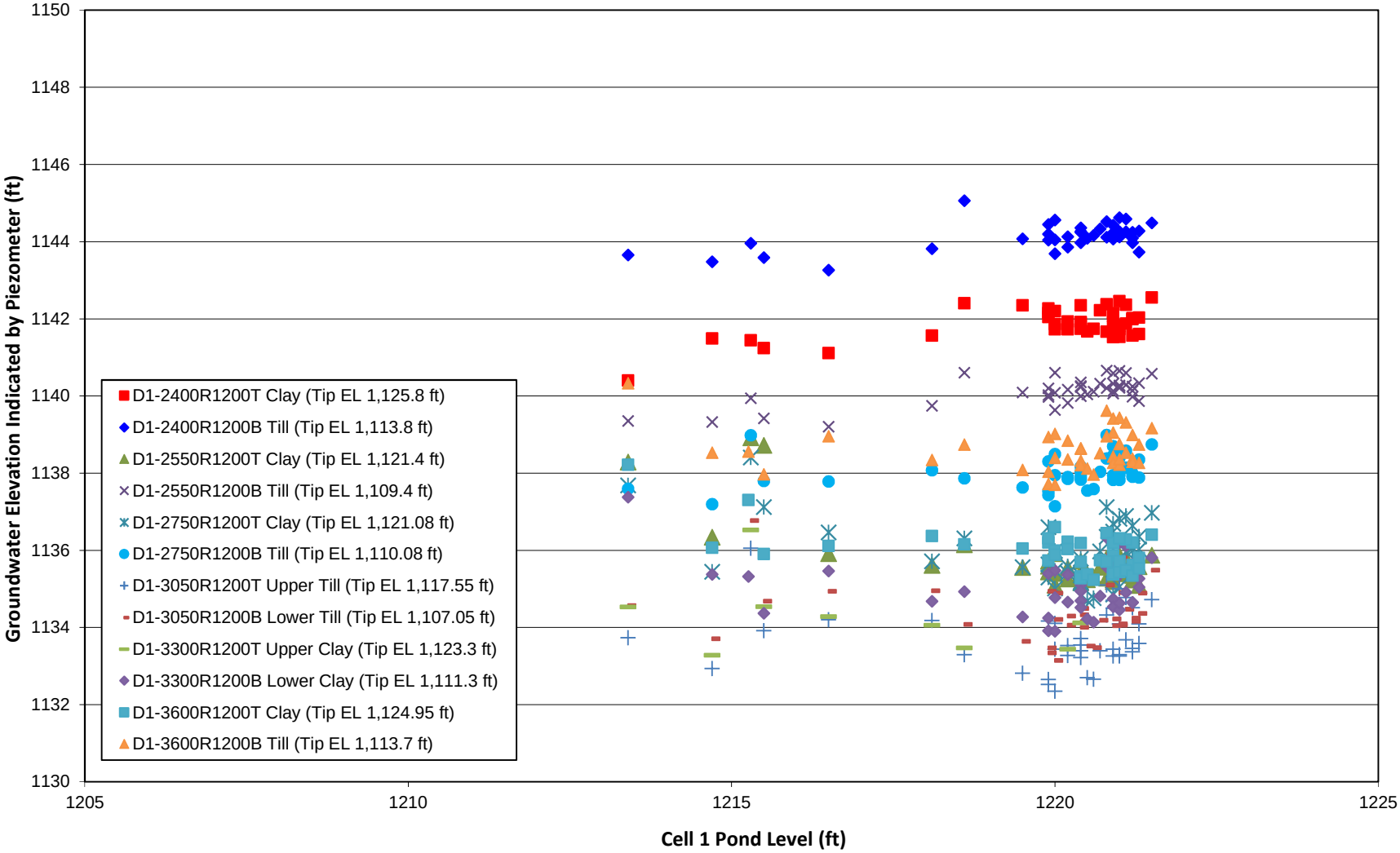

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Pneumatic Piezometers
1997 Installations - At Toe
Cell 1 Pond Level
P97-7 Till (R1210, Tip EL 1,130.6 ft)
P97-9 Till (R1210, Tip EL 1,109.1 ft)
P97-8 Till (R1200, Tip EL 1,102.1 ft)
Cell #1 Pond Level
Highest Toe Relief Well Elevation (R-1)
Lowest Toe Relief Well Outlet Elevation (R-8)
Seepage Recovery Pond 1A
Piezometric Elevation (Feet)
Pond Elevation (Feet)
Date
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

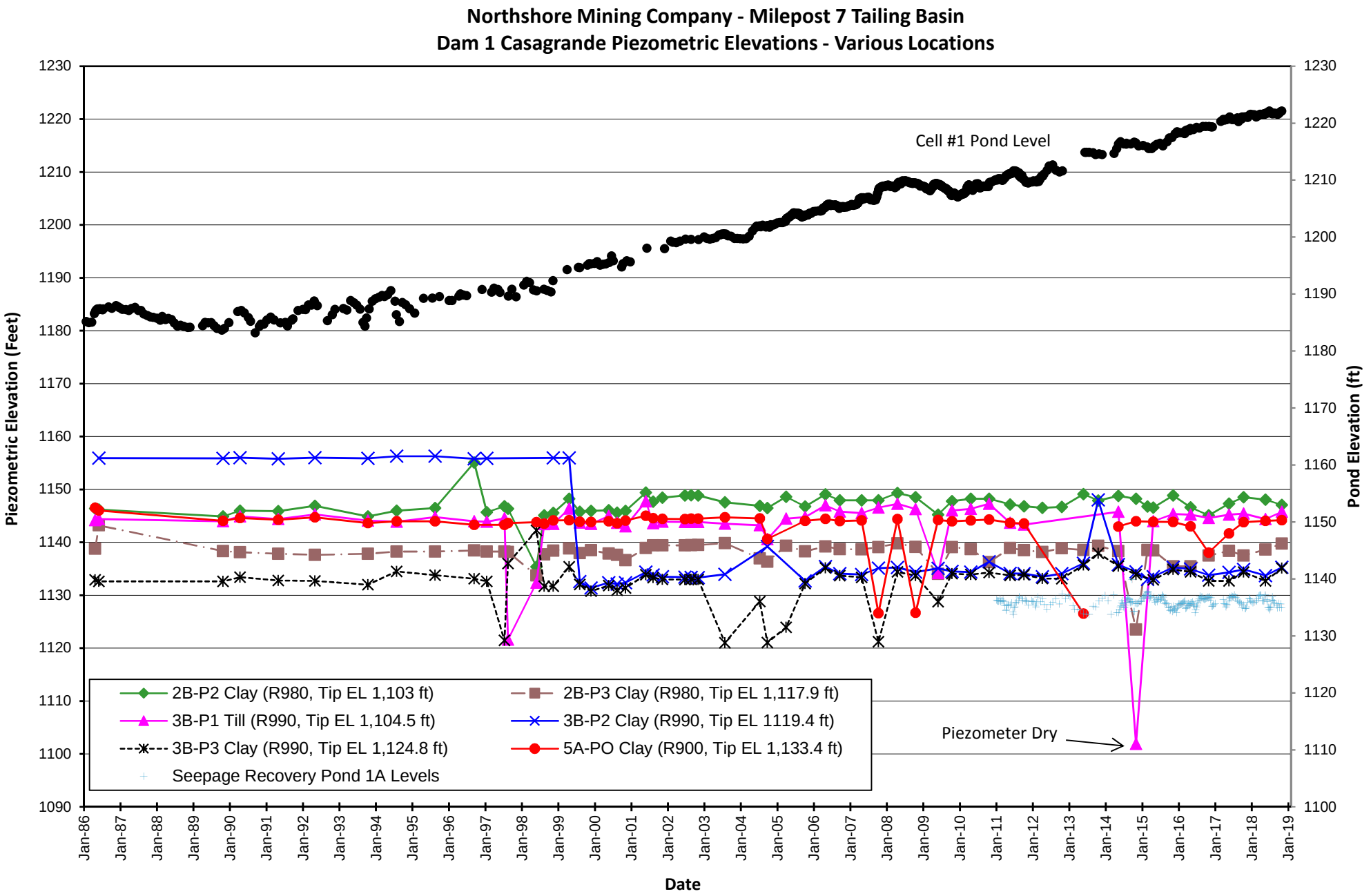

Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 1 1997 Installations - At Toe
P97-7 Till (R1210, Tip EL 1,130.6 ft)
P97-9 Till (R1210, Tip EL 1,109.1 ft)
P97-8 Till (R1200, Tip EL 1,102.1 ft)
Groundwater Elevation Indicated by Piezometer (ft)
1150
1145
1140
1135
1130
1125
1120
1185
1190
1195
1200
1205
1210
1215
1220
1225
Cell 1 Pond Level (ft)

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Vibrating Wire Piezometers
Piezometric Elevations
All Toe Piezometers

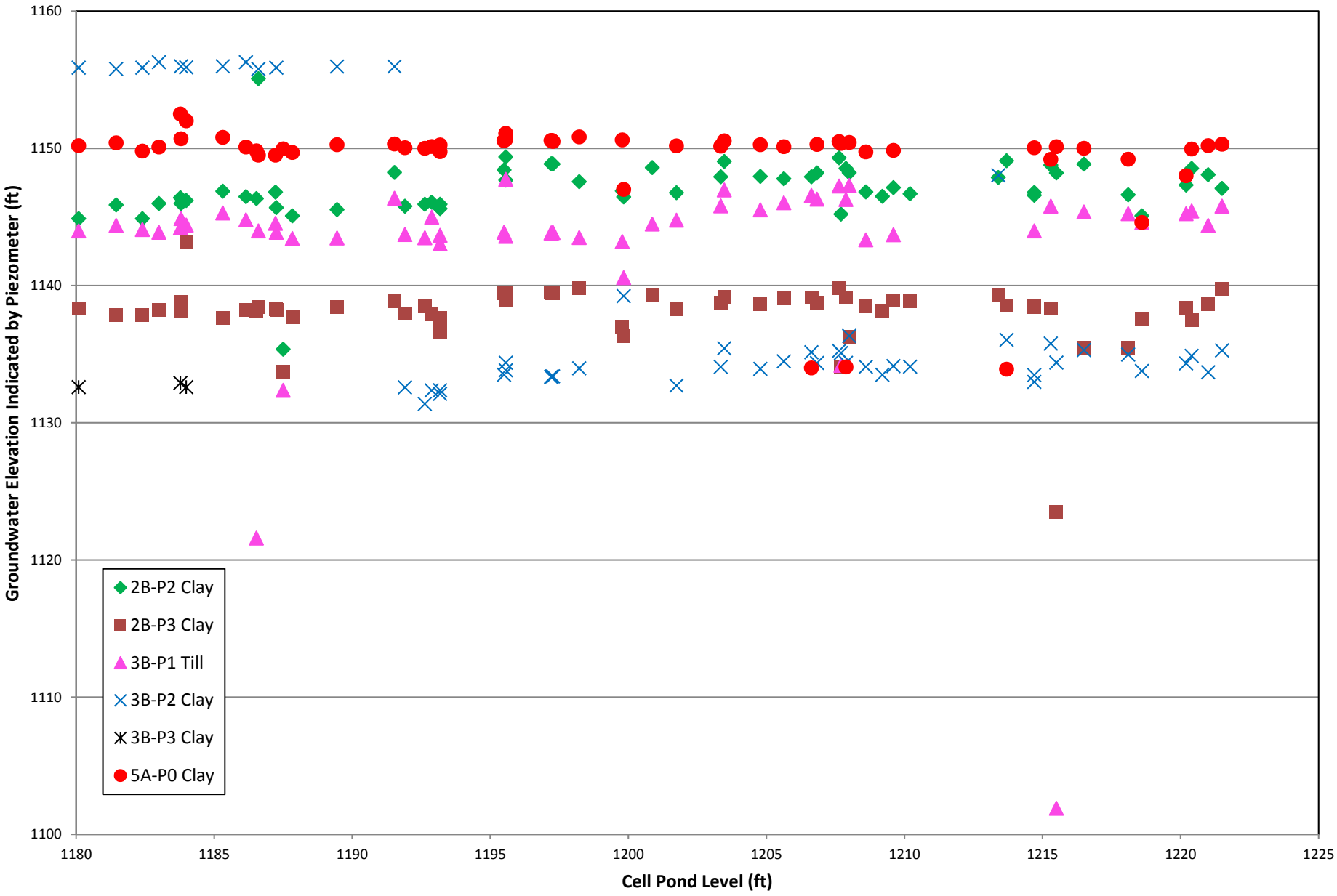


Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 1 All Toe Piezometers

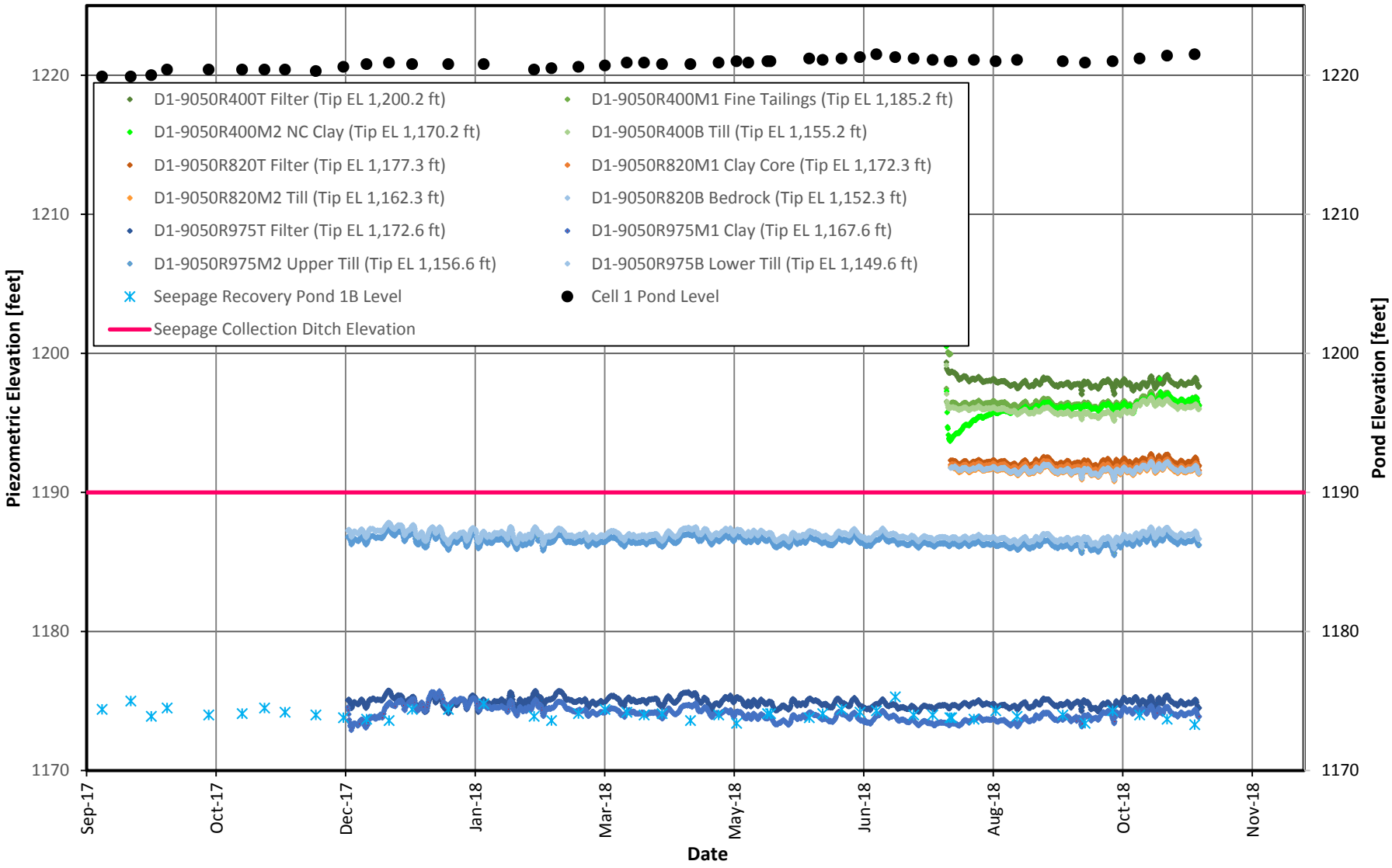



Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Casagrande Piezometric Elevations - Various Locations
Piezometric Elevation (Feet)
Pond Elevation (ft)
Date
Cell #1 Pond Level
Piezometer Dry
2B-P2 Clay (R980, Tip EL 1,103 ft)
2B-P3 Clay (R980, Tip EL 1,117.9 ft)
3B-P1 Till (R990, Tip EL 1,104.5 ft)
3B-P2 Clay (R990, Tip EL 1119.4 ft)
3B-P3 Clay (R990, Tip EL 1,124.8 ft)
5A-PO Clay (R900, Tip EL 1,133.4 ft)
Seepage Recovery Pond 1A Levels
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
1110
1100
1090
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

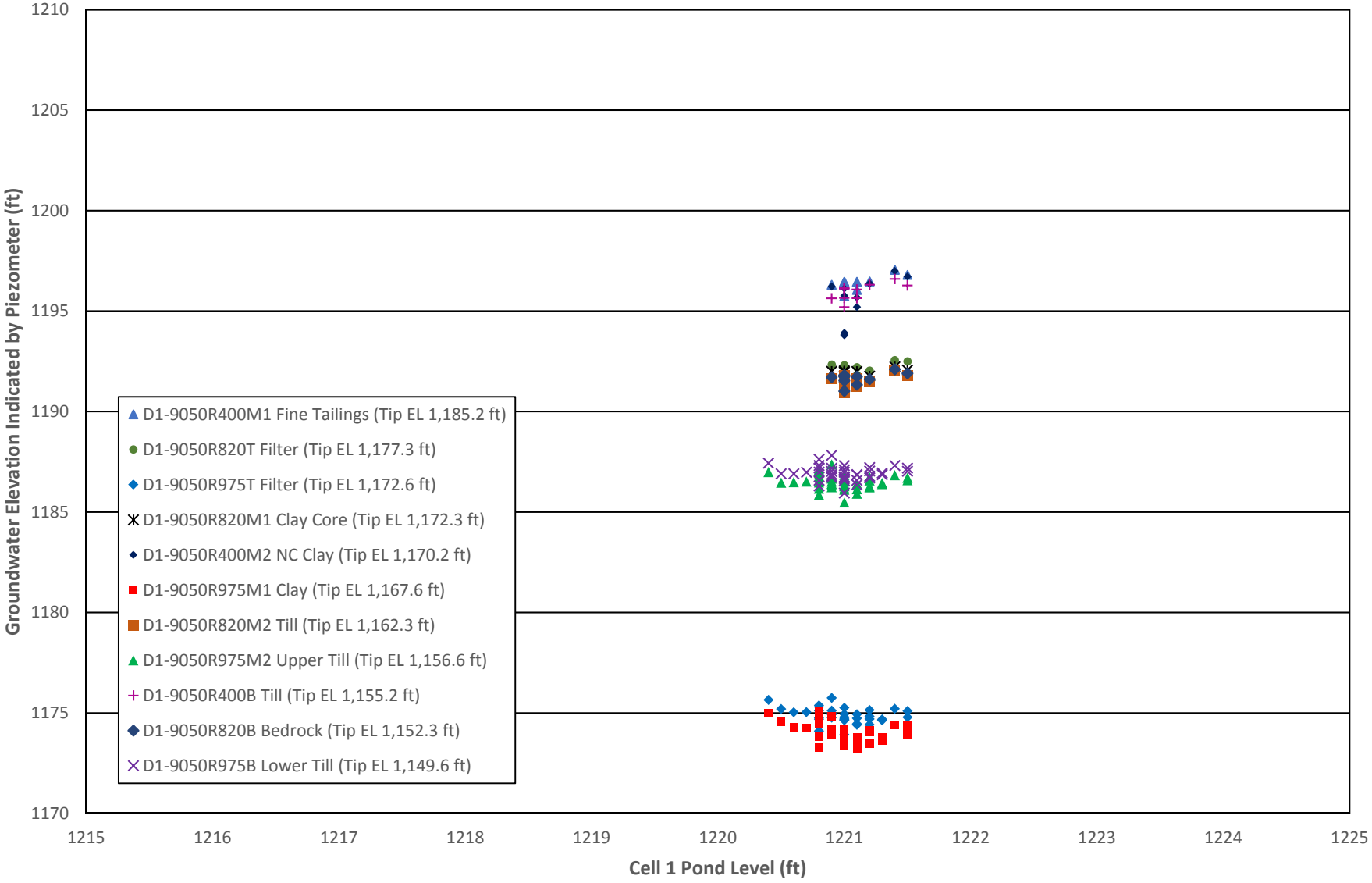
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Casagrande Piezometers - Dam 1, Various Locations



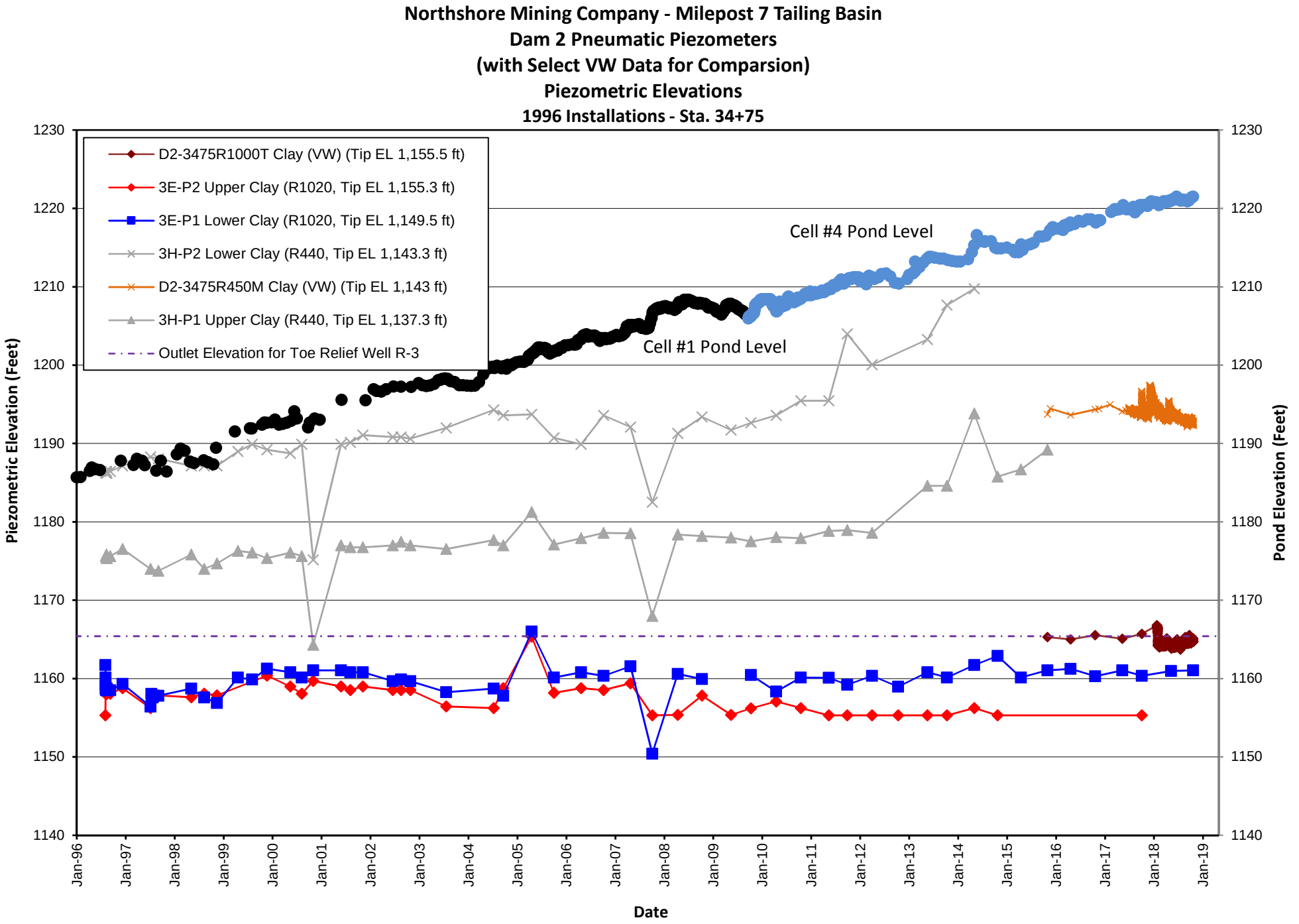
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 (East End) Vibrating Wire Piezometers
Piezometric Elevations
Sta. 90+50



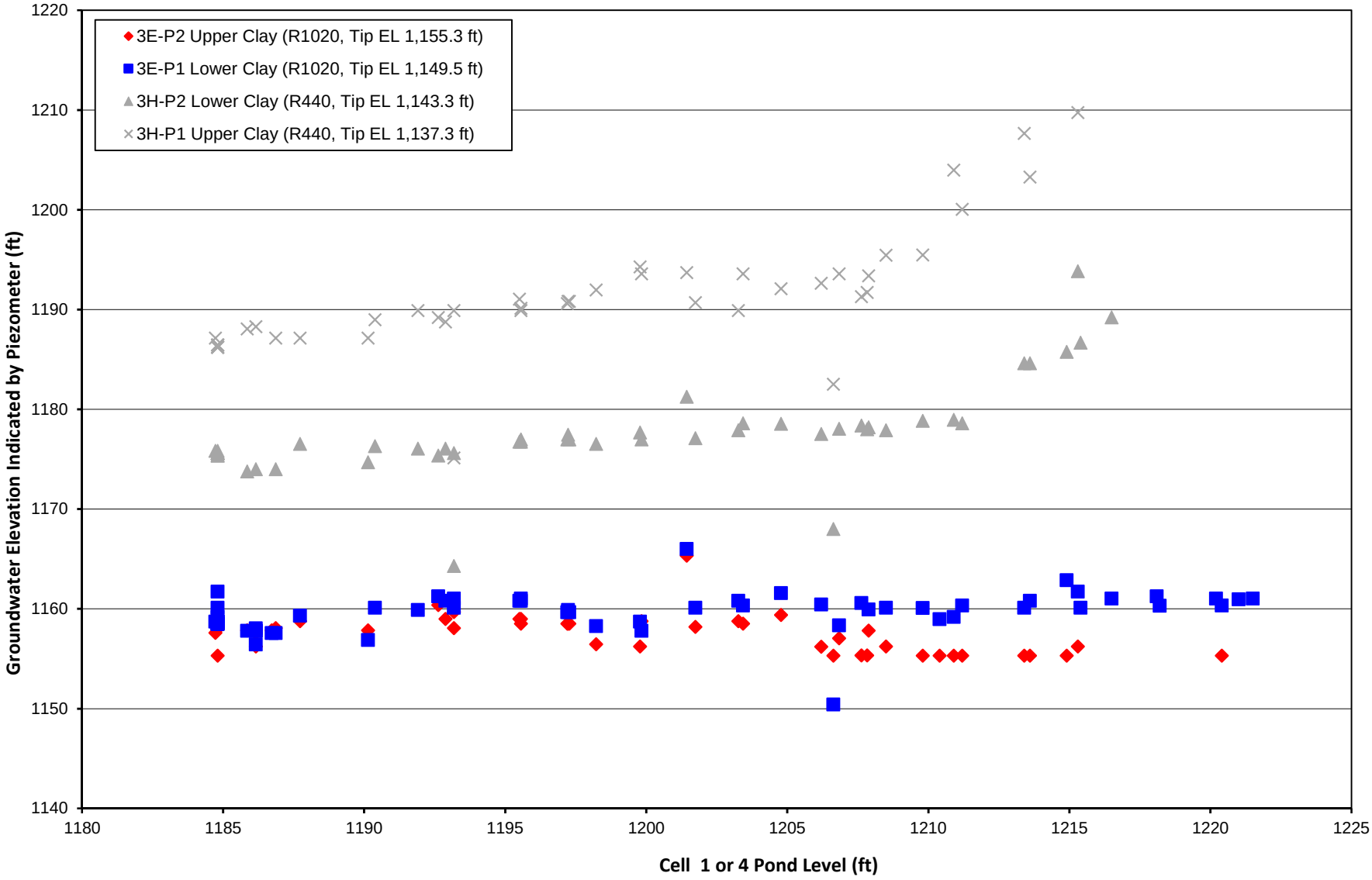
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 1 (East End) Sta. 90+50

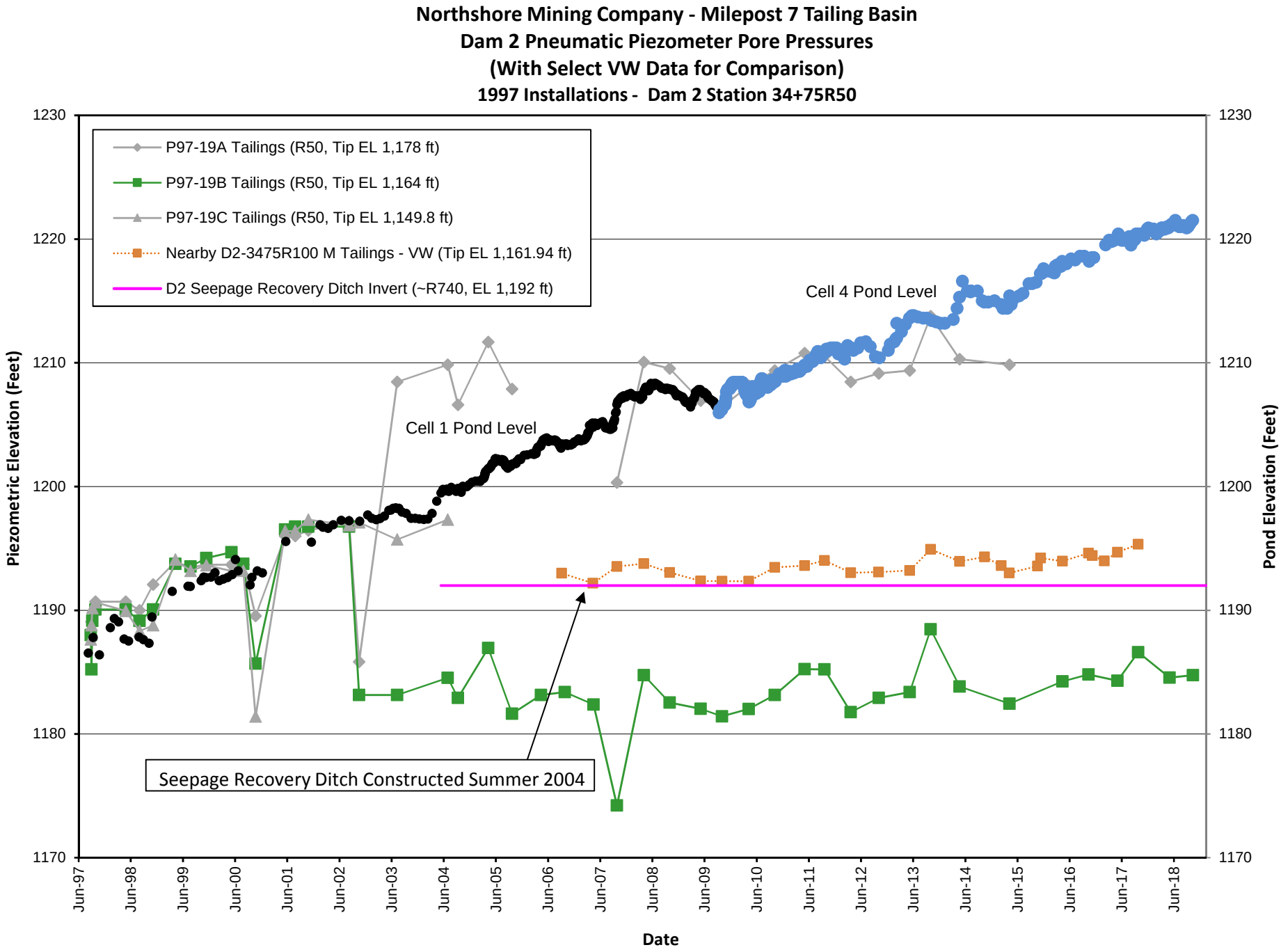


Dam 2 Piezometers

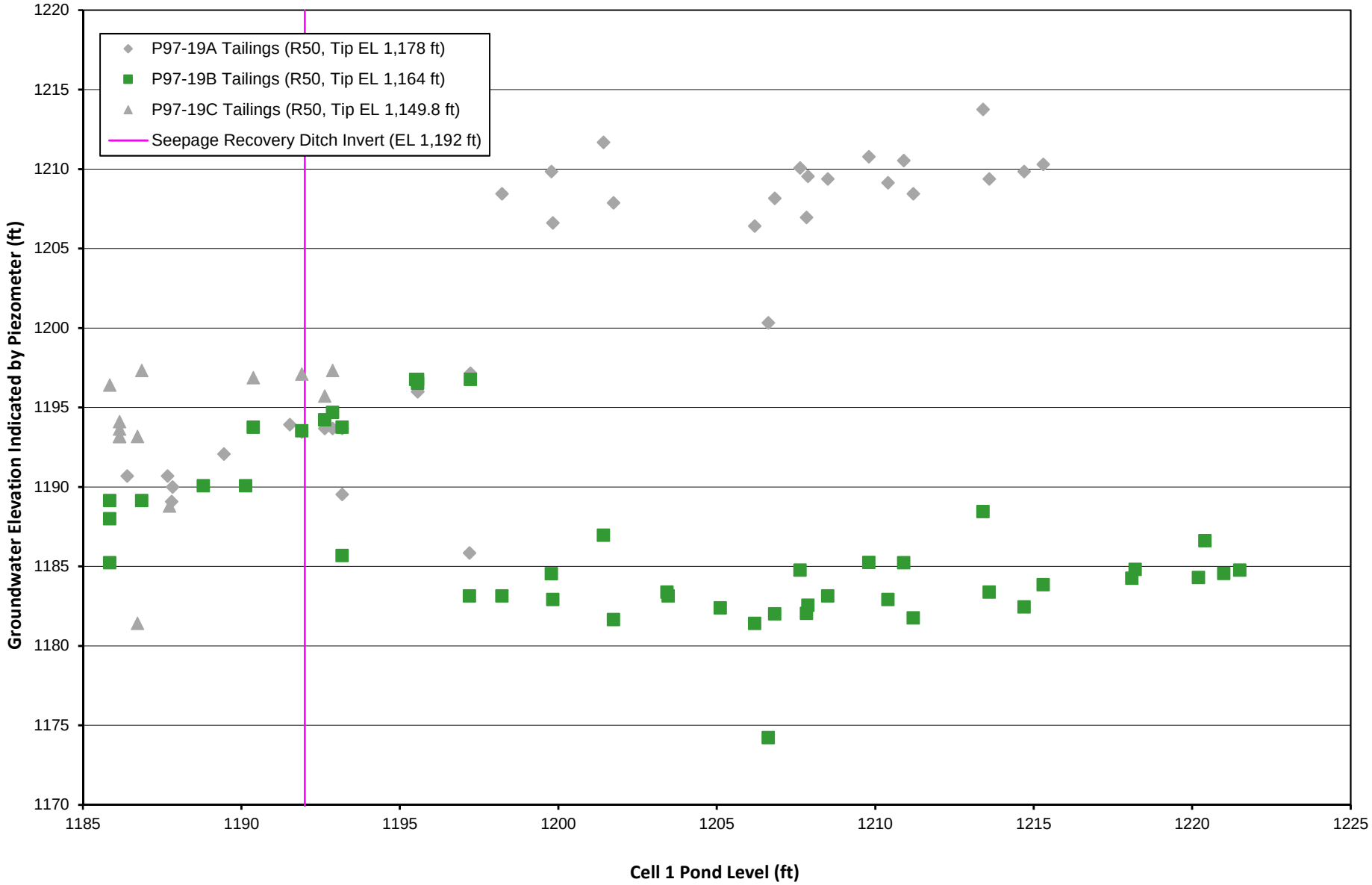

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Pneumatic Piezometers
(with Select VW Data for Comparsion)
Piezometric Elevations
1996 Installations - Sta. 34+75
D2-3475R1000T Clay (VW) (Tip EL 1,155.5 ft)
3E-P2 Upper Clay (R1020, Tip EL 1,155.3 ft)
3E-P1 Lower Clay (R1020, Tip EL 1,149.5 ft)
3H-P2 Lower Clay (R440, Tip EL 1,143.3 ft)
D2-3475R450M Clay (VW) (Tip EL 1,143 ft)
3H-P1 Upper Clay (R440, Tip EL 1,137.3 ft)
Outlet Elevation for Toe Relief Well R-3
Cell #4 Pond Level
Cell #1 Pond Level
Piezometric Elevation (Feet)
Pond Elevation (Feet)
Date
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 2 1996 Installations - Sta. 34+75

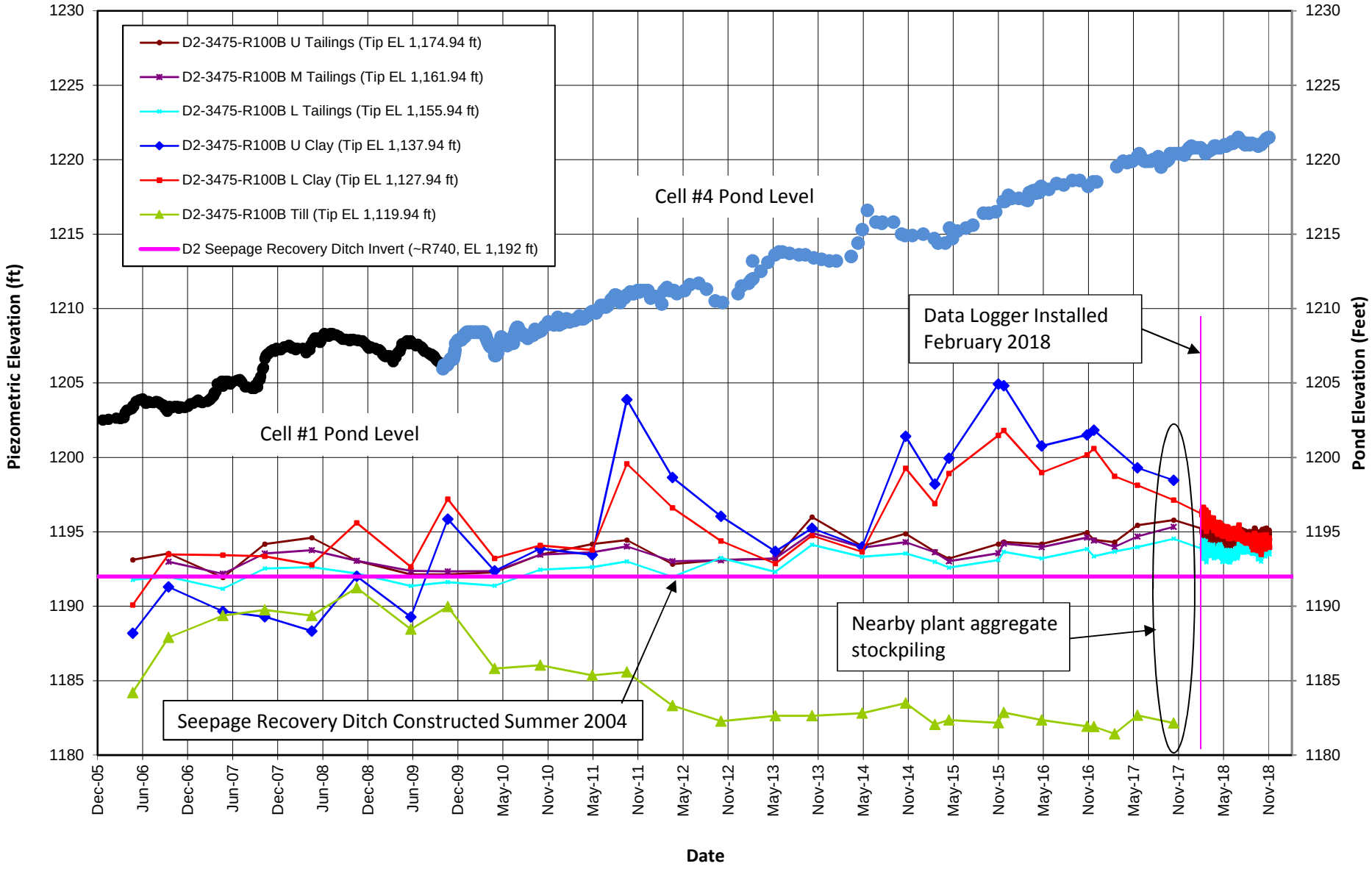



Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Pneumatic Piezometer Pore Pressures
(With Select VW Data for Comparison)
1997 Installations - Dam 2 Station 34+75R50
P97-19A Tailings (R50, Tip EL 1,178 ft)
P97-19B Tailings (R50, Tip EL 1,164 ft)
P97-19C Tailings (R50, Tip EL 1,149.8 ft)
Nearby D2-3475R100 M Tailings - VW (Tip EL 1,161.94 ft)
D2 Seepage Recovery Ditch Invert (~R740, EL 1,192 ft)
Cell 4 Pond Level
Cell 1 Pond Level
Seepage Recovery Ditch Constructed Summer 2004
Piezometric Elevation (Feet)
Pond Elevation (Feet)
Date
1230
1220
1210
1200
1190
1180
1170
Jun-97
Jun-98
Jun-99
Jun-00
Jun-01
Jun-02
Jun-03
Jun-04
Jun-05
Jun-06
Jun-07
Jun-08
Jun-09
Jun-10
Jun-11
Jun-12
Jun-13
Jun-14
Jun-15
Jun-16
Jun-17
Jun-18

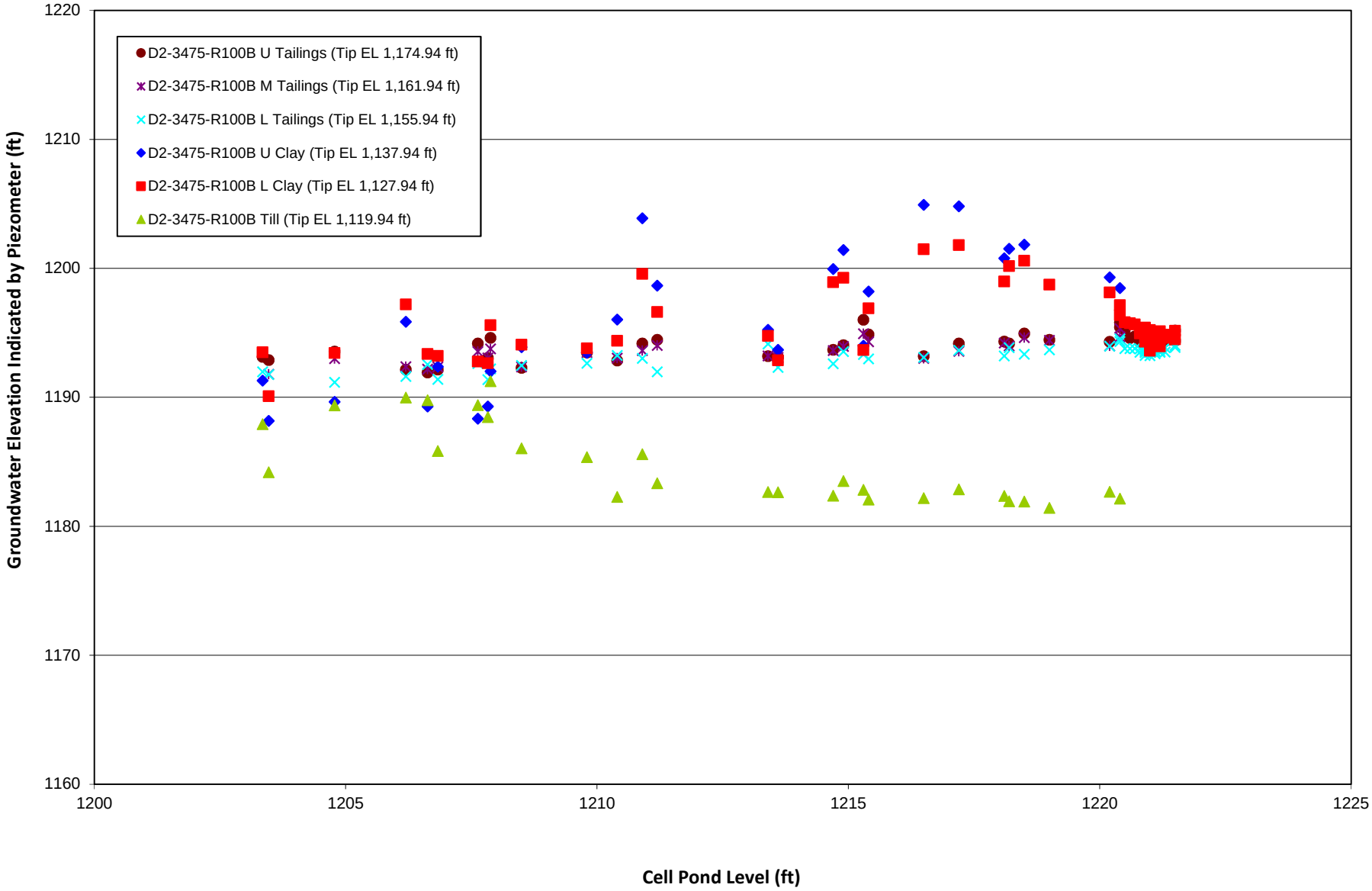
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 2 1997 Installations - Dam 2 Station 34+75R50



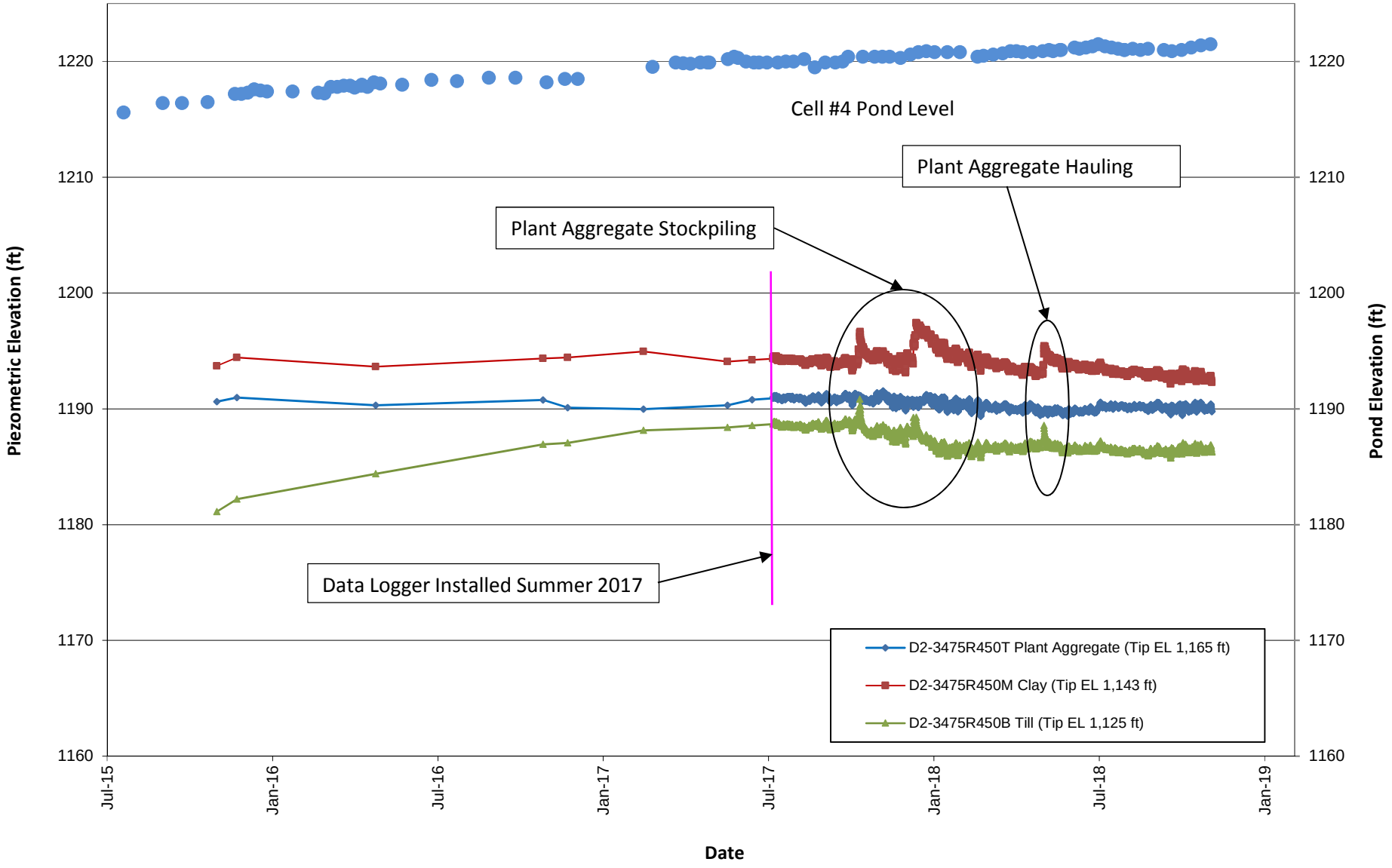
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Vibrating Wire Piezometers
Piezometric Elevations
Sta. 34+75R100



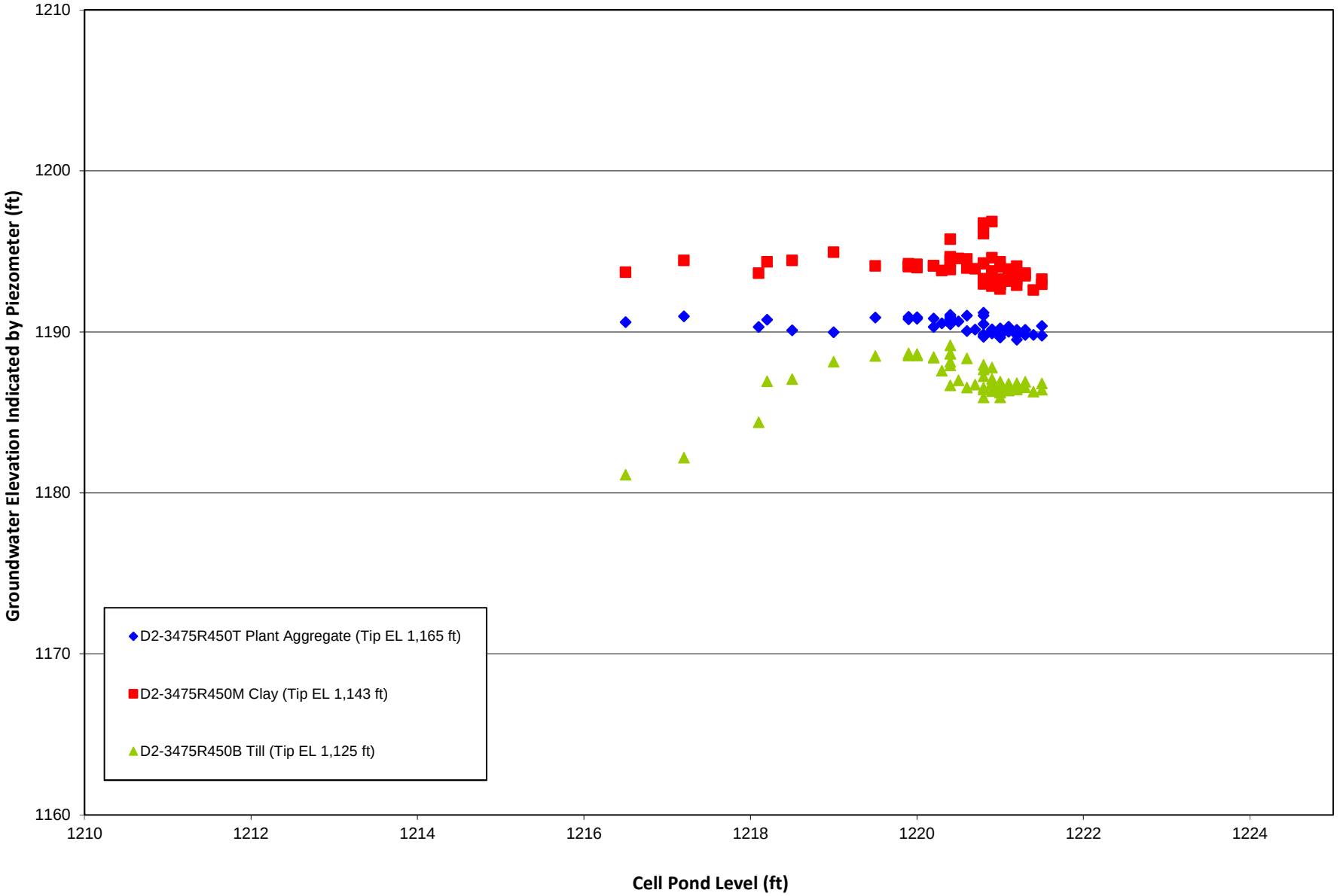
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 2 Sta. 34+75R100

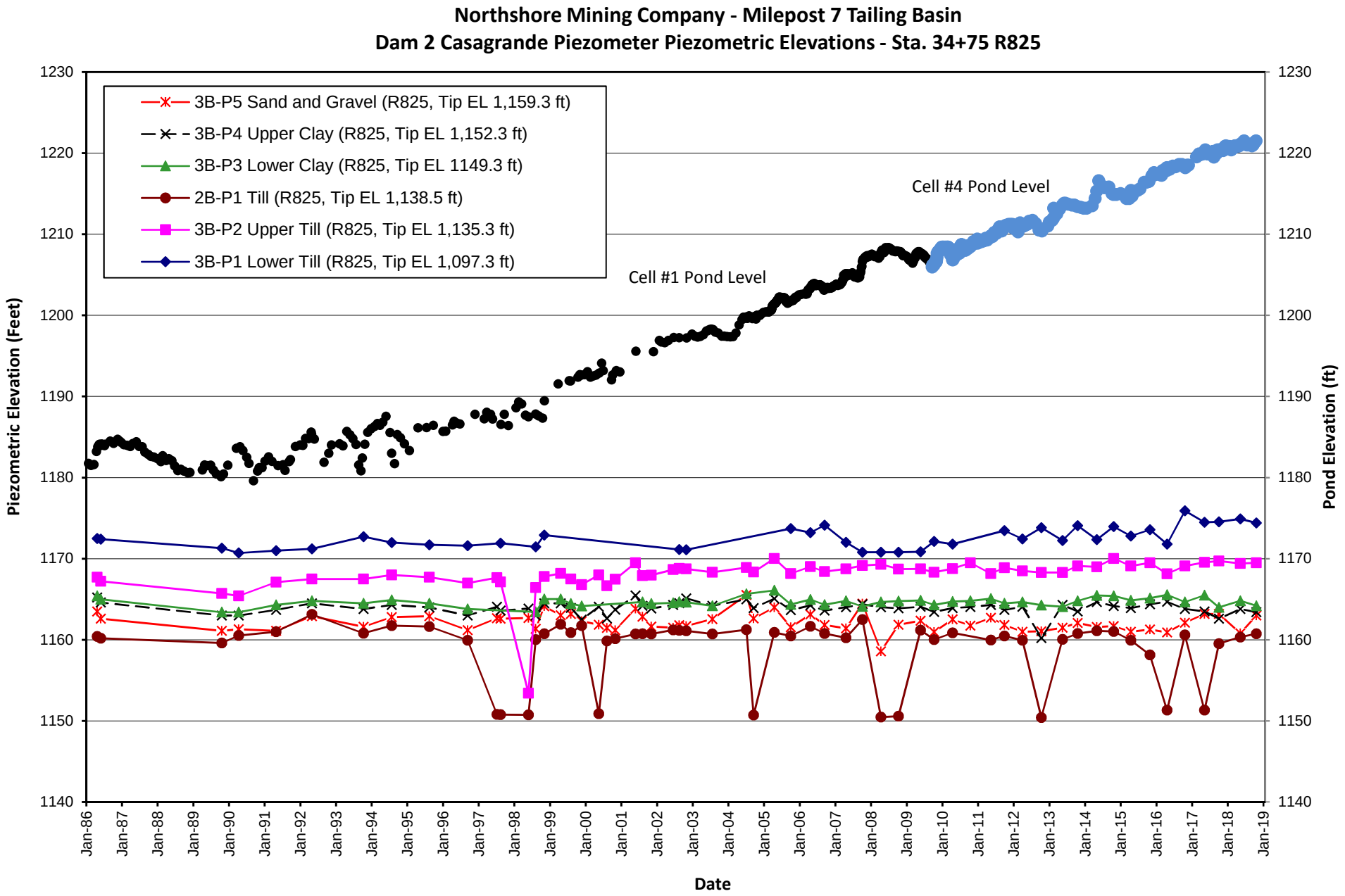


Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Vibrating Wire Piezometers
Piezometric Elevation
Sta. 34+75R450

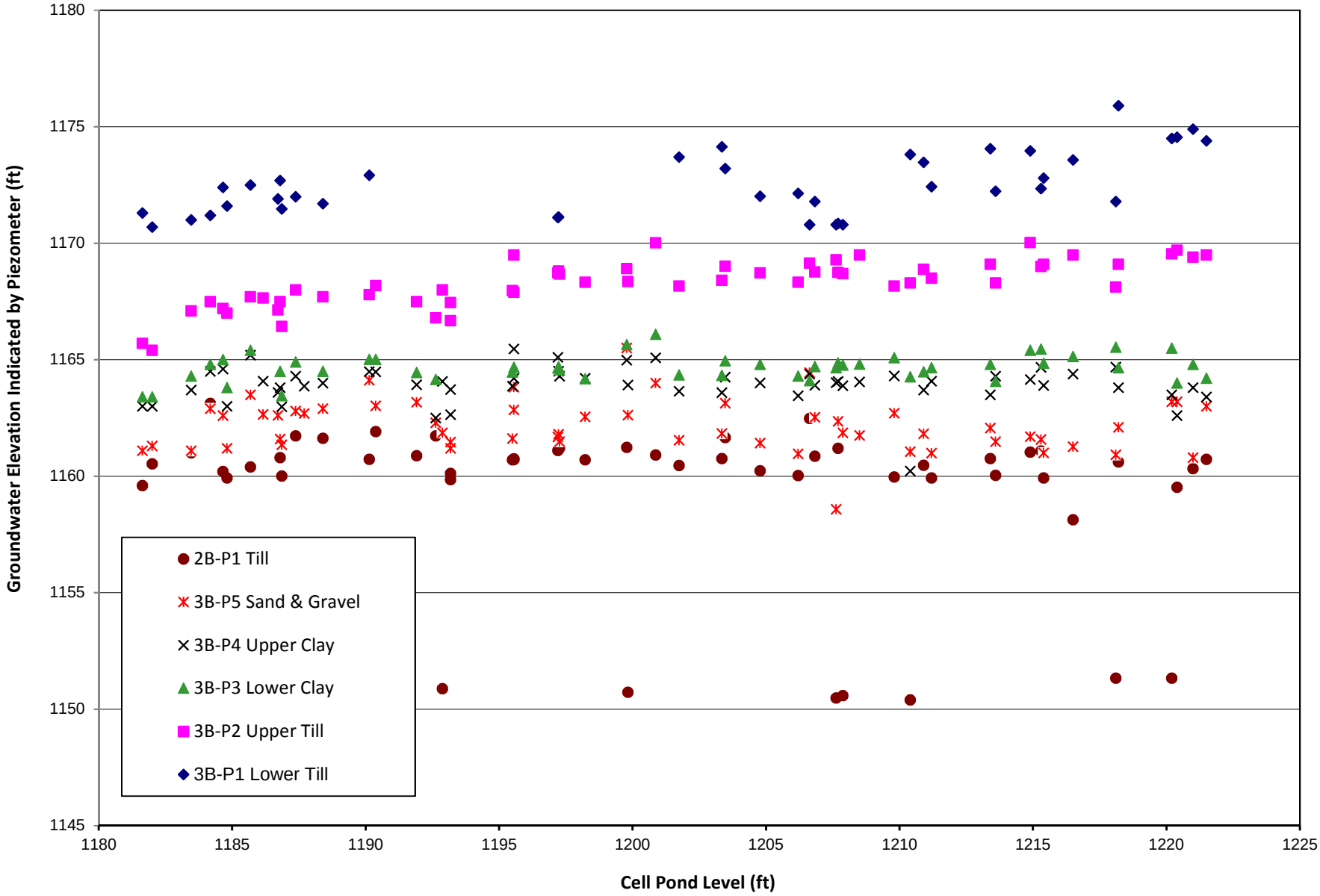


Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 2 Sta. 37+45R450

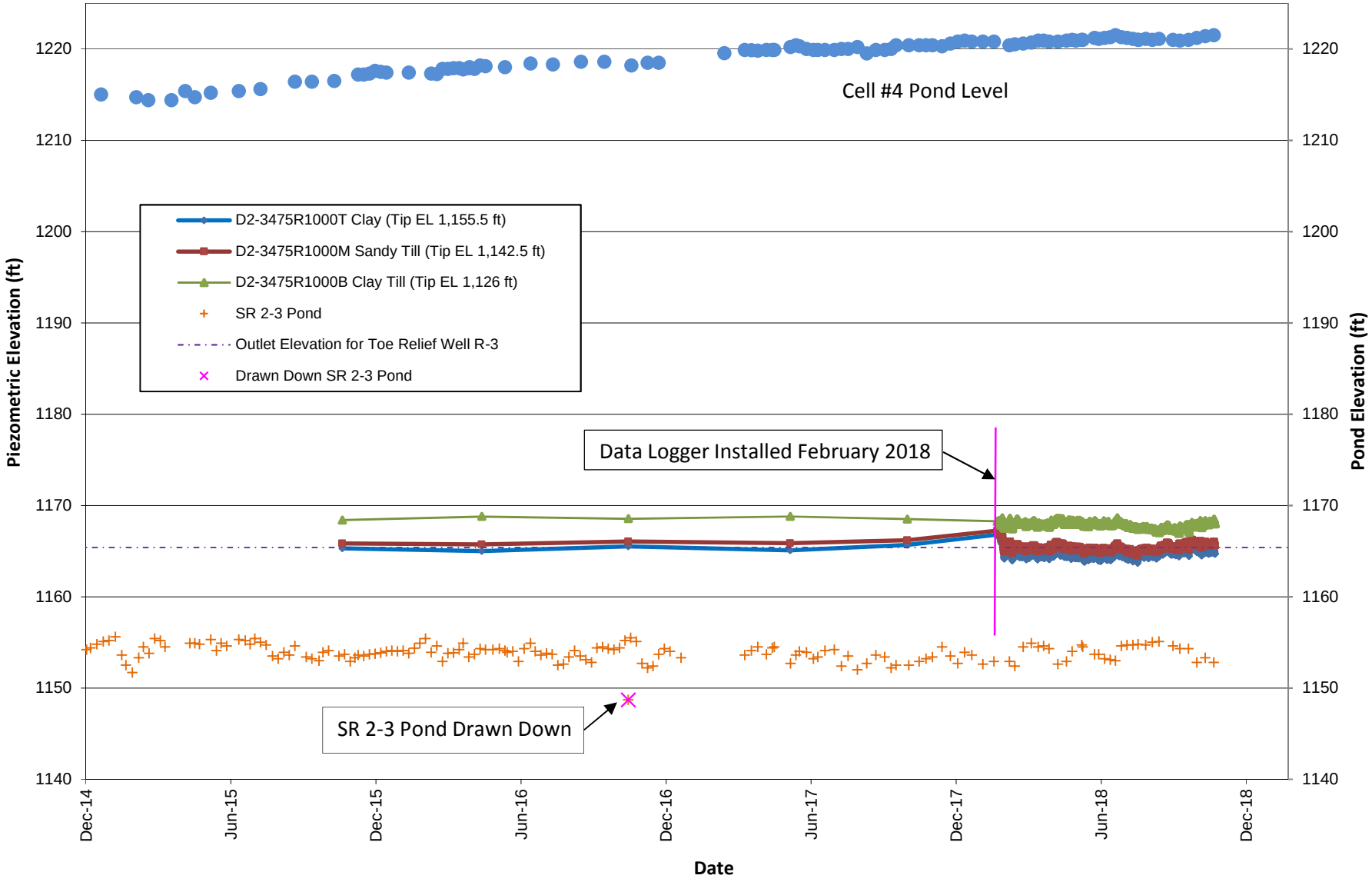



Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Casagrande Piezometer Piezometric Elevations - Sta. 34+75 R825
3B-P5 Sand and Gravel (R825, Tip EL 1,159.3 ft)
3B-P4 Upper Clay (R825, Tip EL 1,152.3 ft)
3B-P3 Lower Clay (R825, Tip EL 1149.3 ft)
2B-P1 Till (R825, Tip EL 1,138.5 ft)
3B-P2 Upper Till (R825, Tip EL 1,135.3 ft)
3B-P1 Lower Till (R825, Tip EL 1,097.3 ft)
Cell #1 Pond Level
Cell #4 Pond Level
Piezometric Elevation (Feet)
Pond Elevation (ft)
Date
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

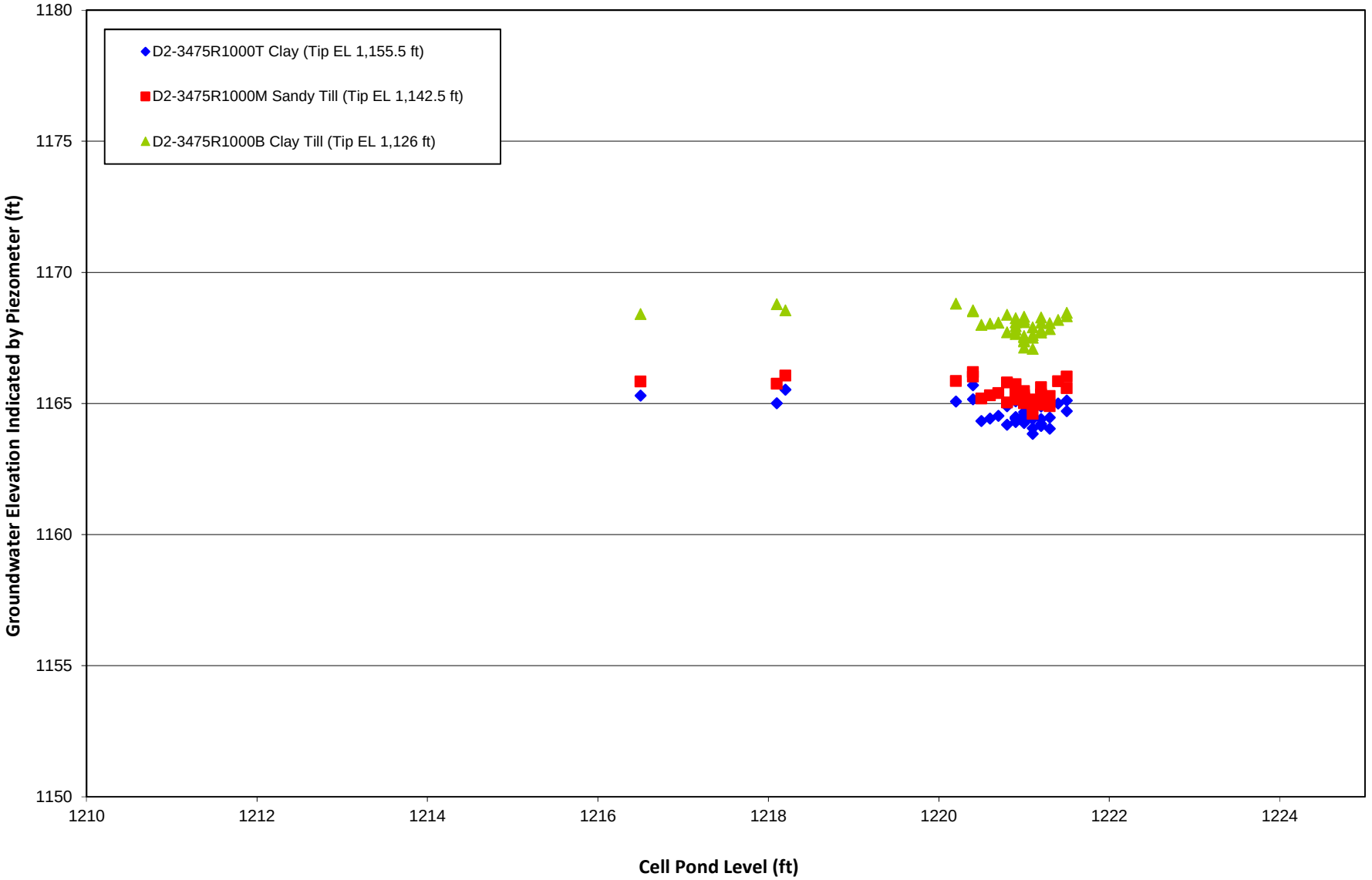
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Casagrande Piezometers
Dam 2 Sta. 34+75 R825



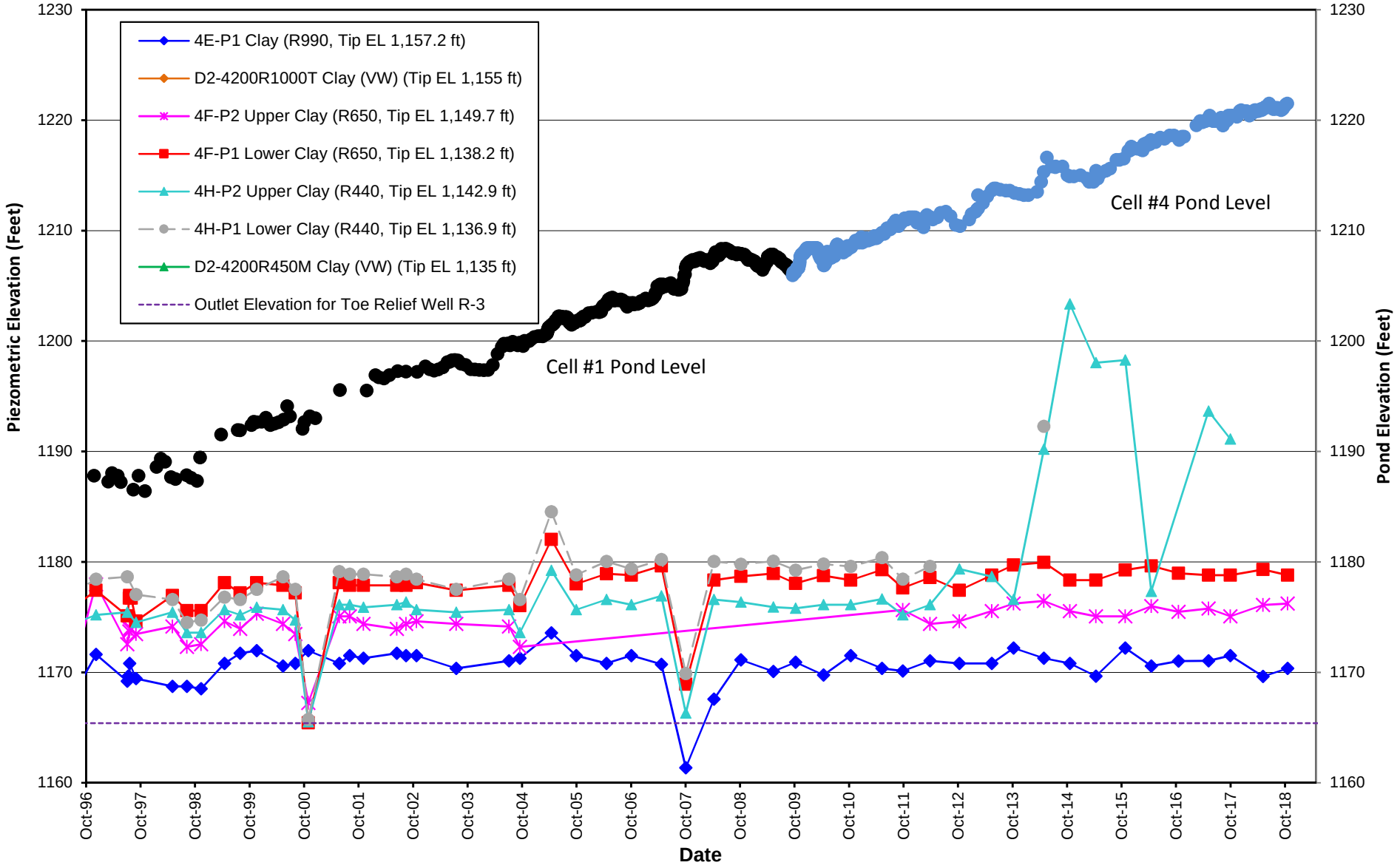
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Vibrating Wire Piezometers
Piezometric Elevation
Sta. 34+75R1000



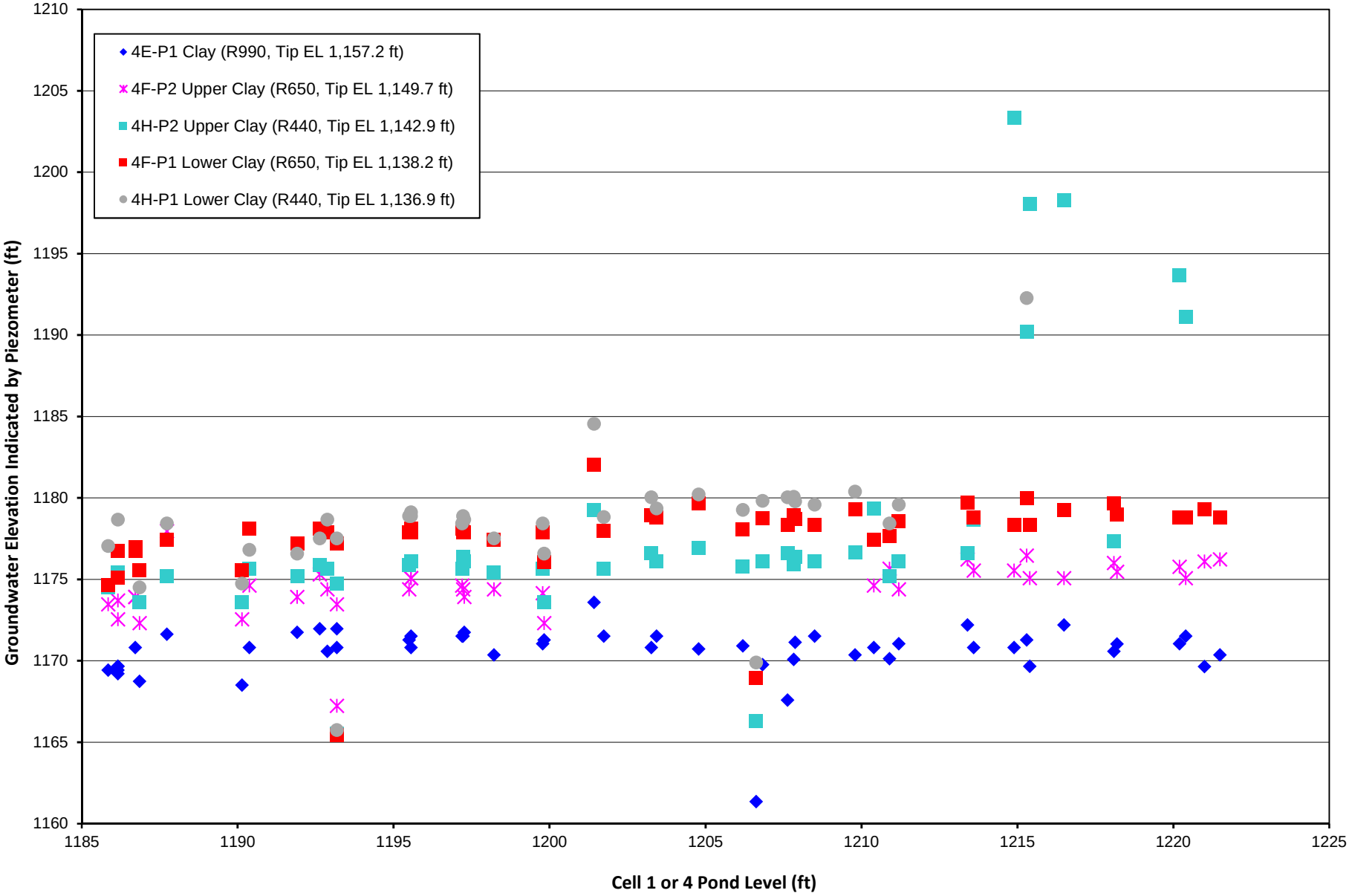
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 2 Sta. 37+45R1000



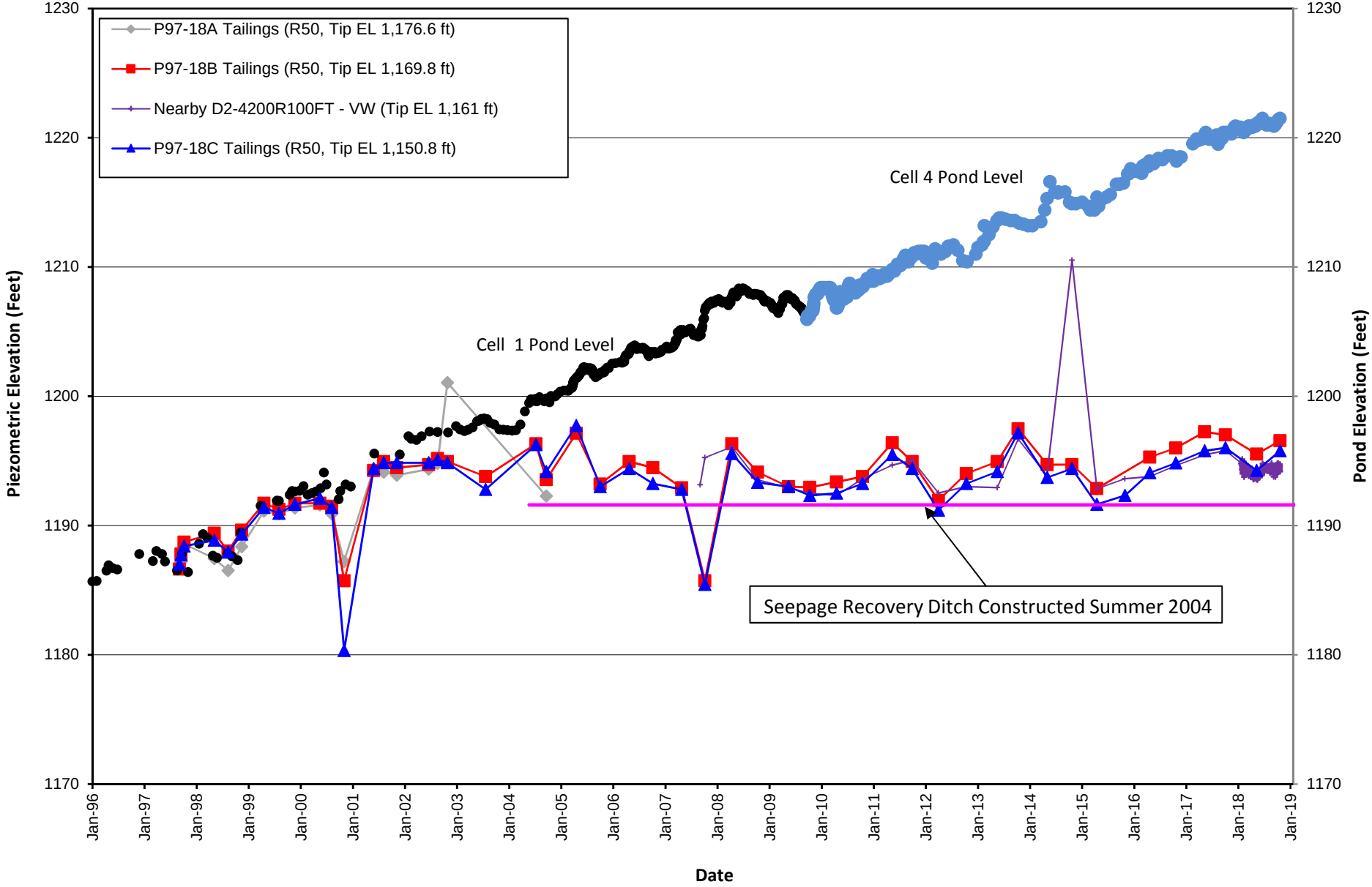
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Pneumatic Piezometers
(with Select VW Data for Comparsion)
Piezometric Elevations
1996 Installations - Sta. 42+00



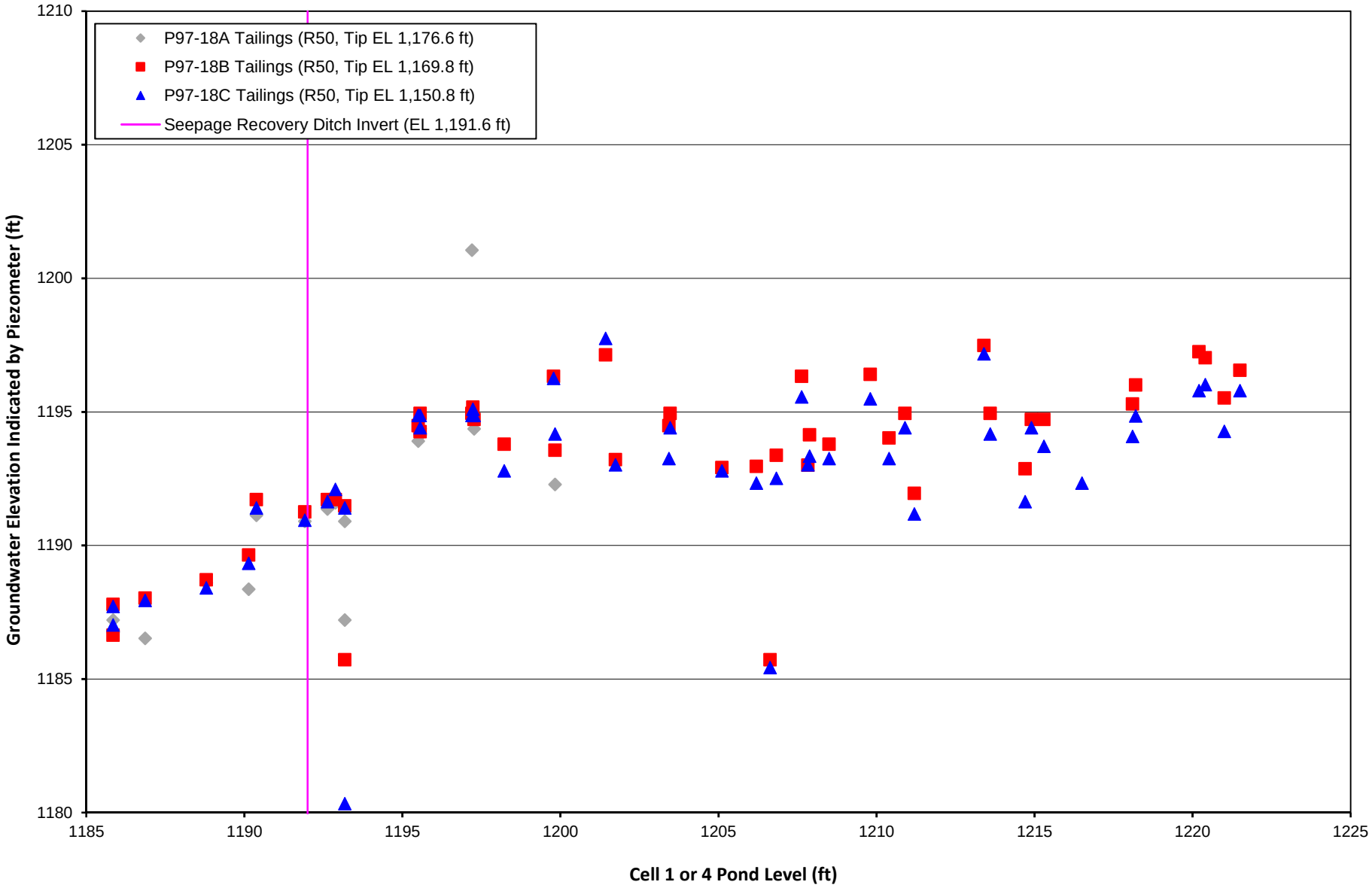
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 2 1996 Installations - Sta. 42+00



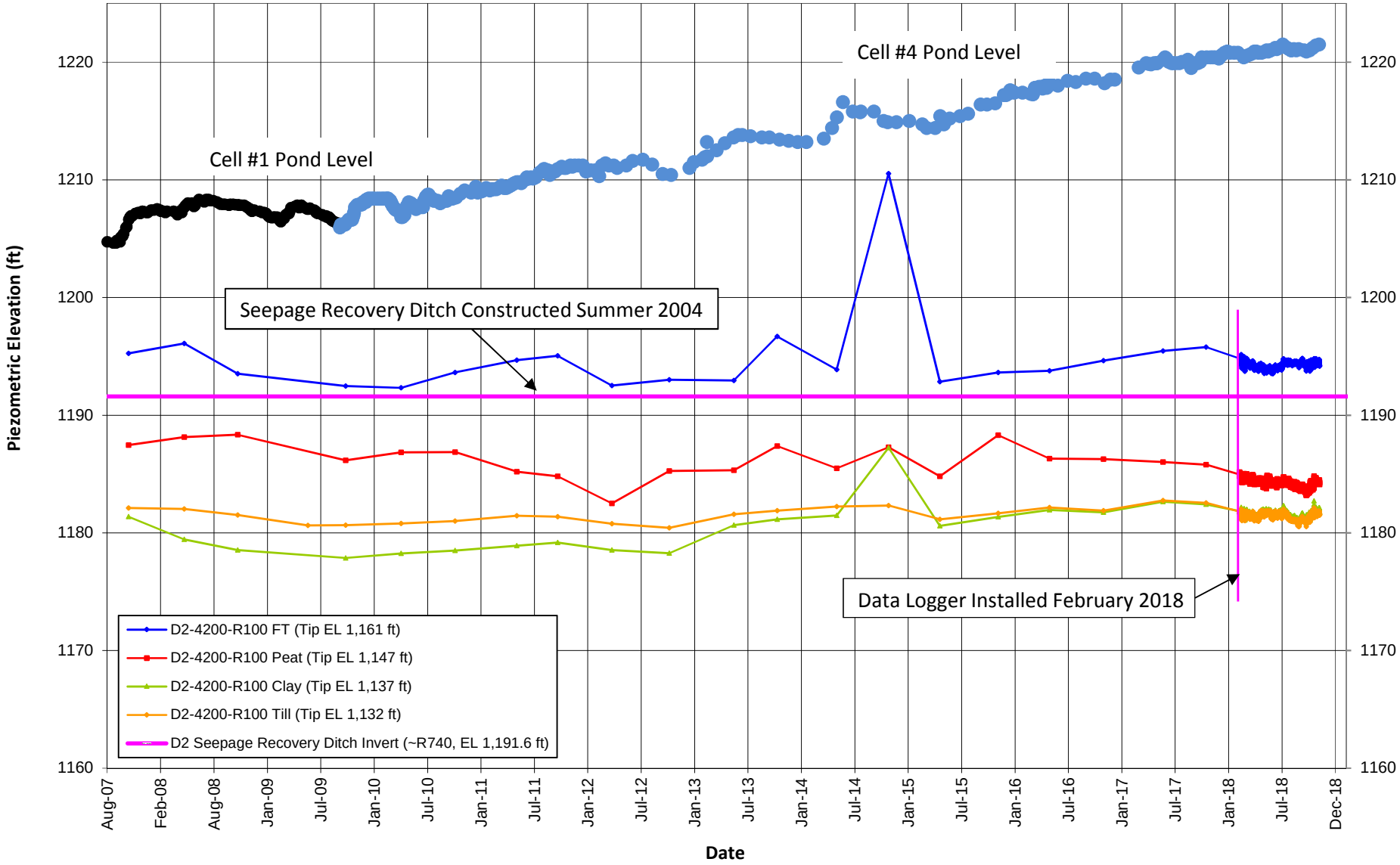
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Pneumatic Piezometers
(With Select VW Data for Comparison)
1997 Installations - Dam 2 Station 42+00R50



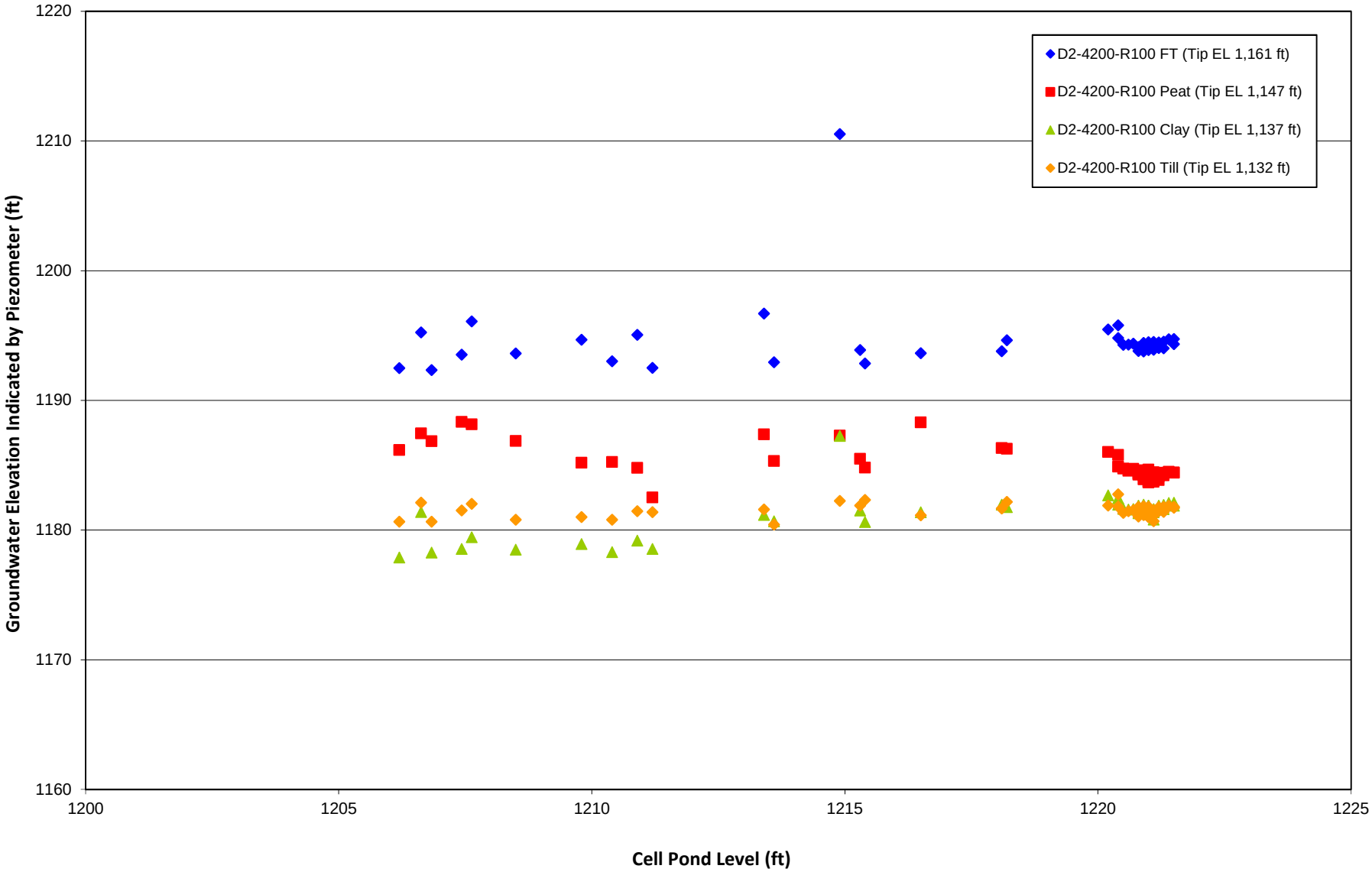
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 2 1997 Installations - Dam 2 Station 42+00R50



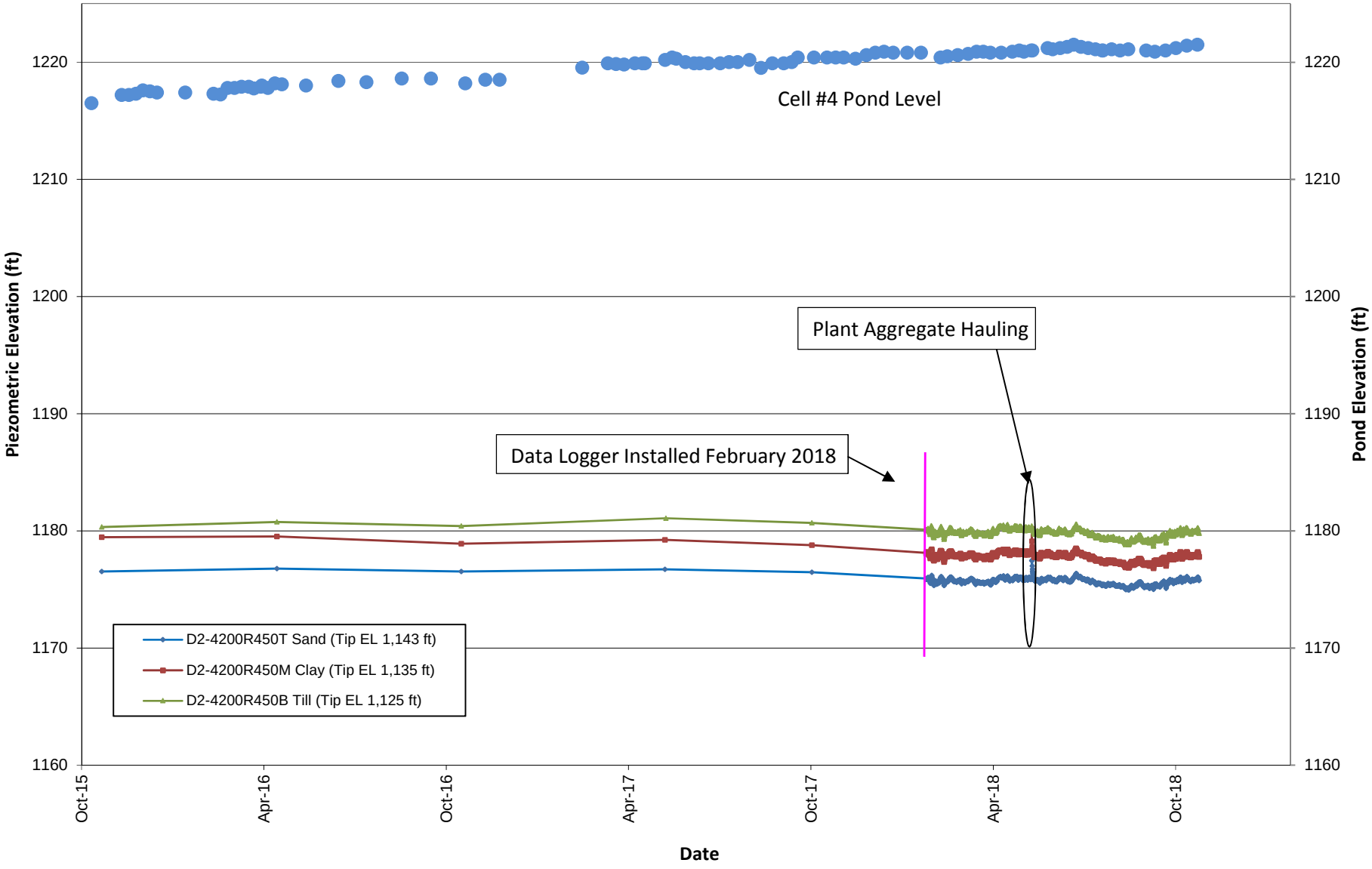
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Vibrating Wire Piezometers
Piezometric Elevation
Sta. 42+00R100



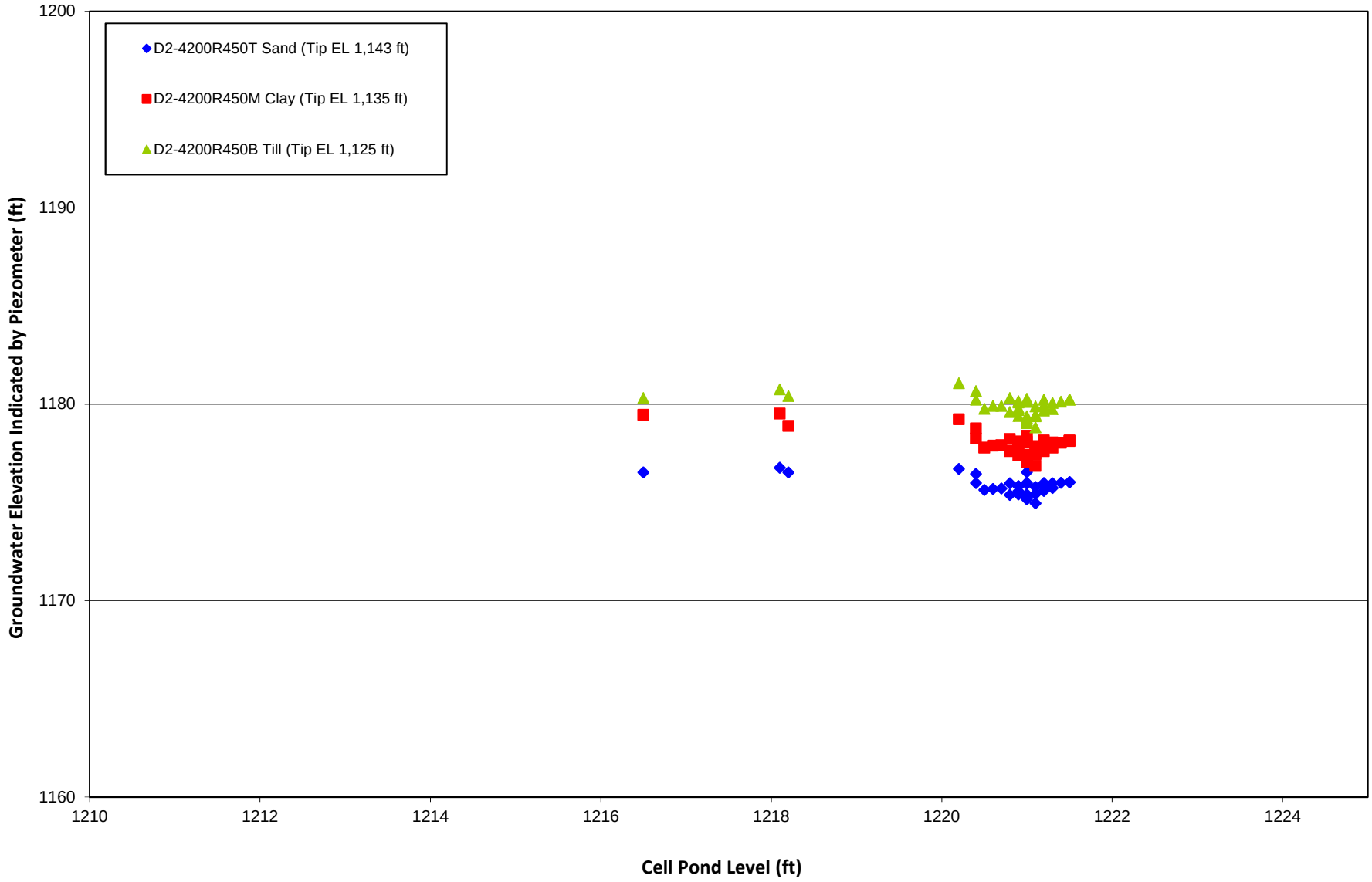
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 2 Sta. 42+00R100

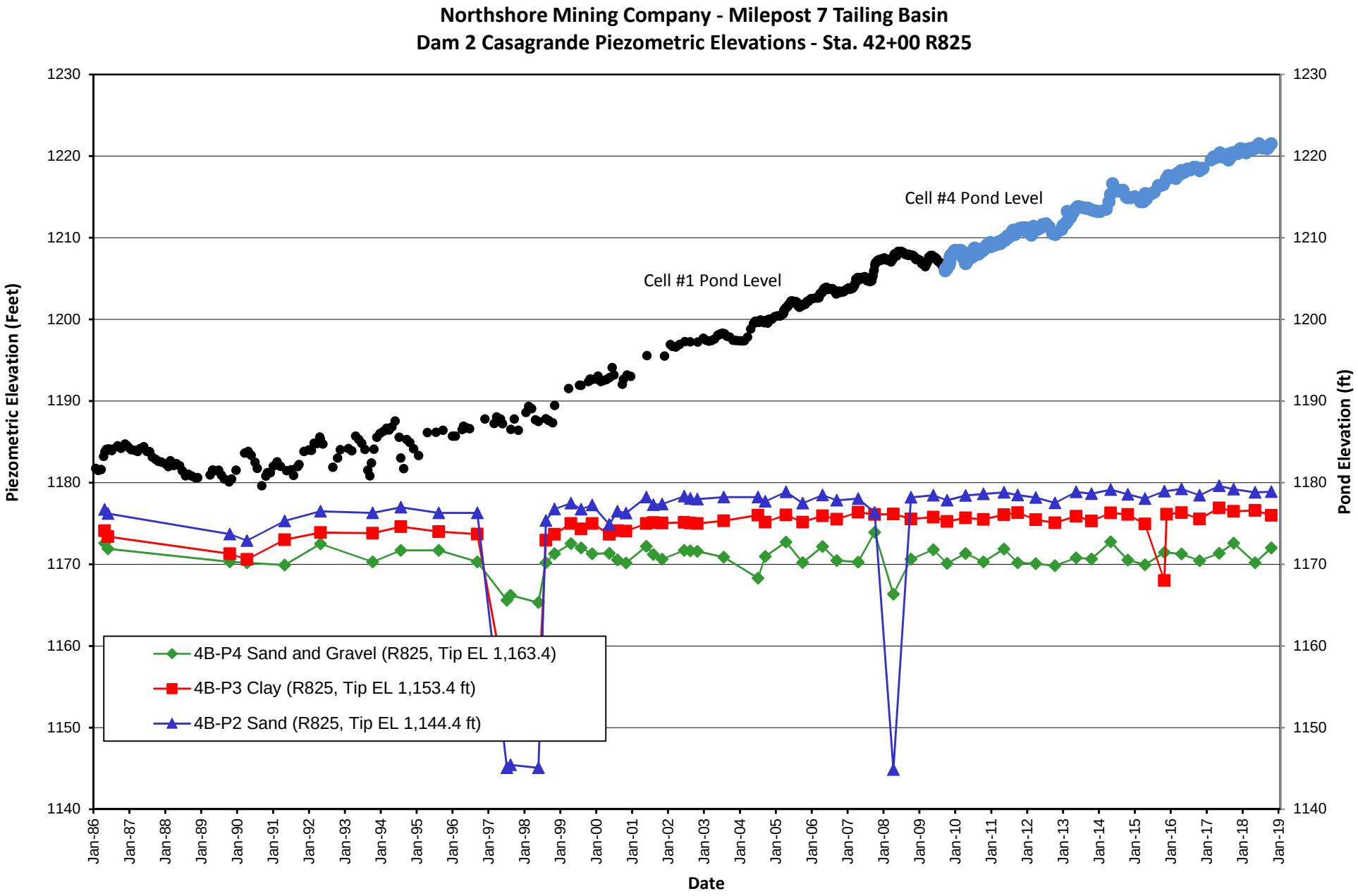


Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Vibrating Wire Piezometers
Piezometric Elevation
Sta. 42+00R450

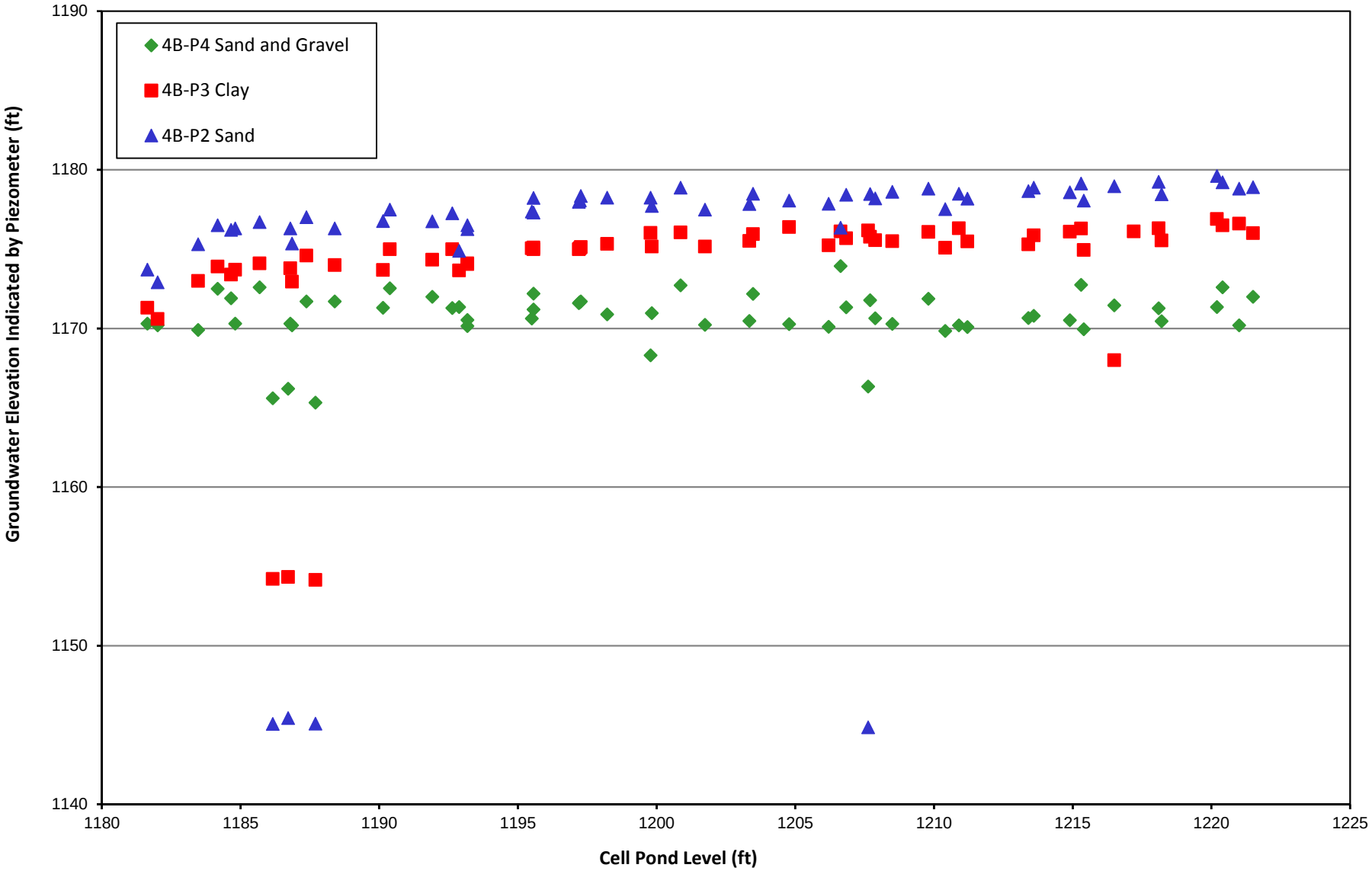


Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 2 Sta. 42+00R450

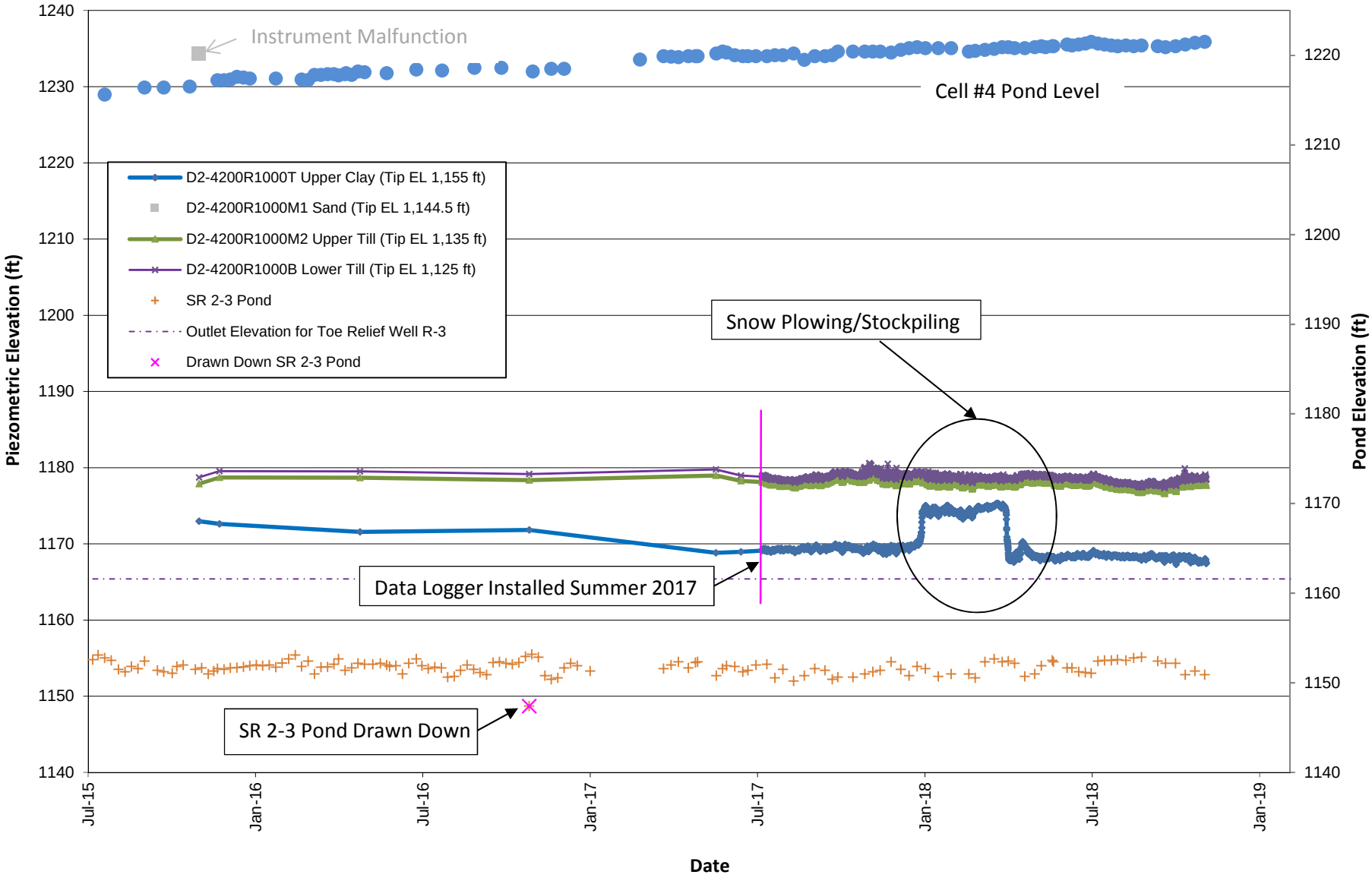



Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Casagrande Piezometric Elevations - Sta. 42+00 R825
Piezometric Elevation (Feet)
Pond Elevation (ft)
Date
Cell #4 Pond Level
Cell #1 Pond Level
4B-P4 Sand and Gravel (R825, Tip EL 1,163.4)
4B-P3 Clay (R825, Tip EL 1,153.4 ft)
4B-P2 Sand (R825, Tip EL 1,144.4 ft)
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

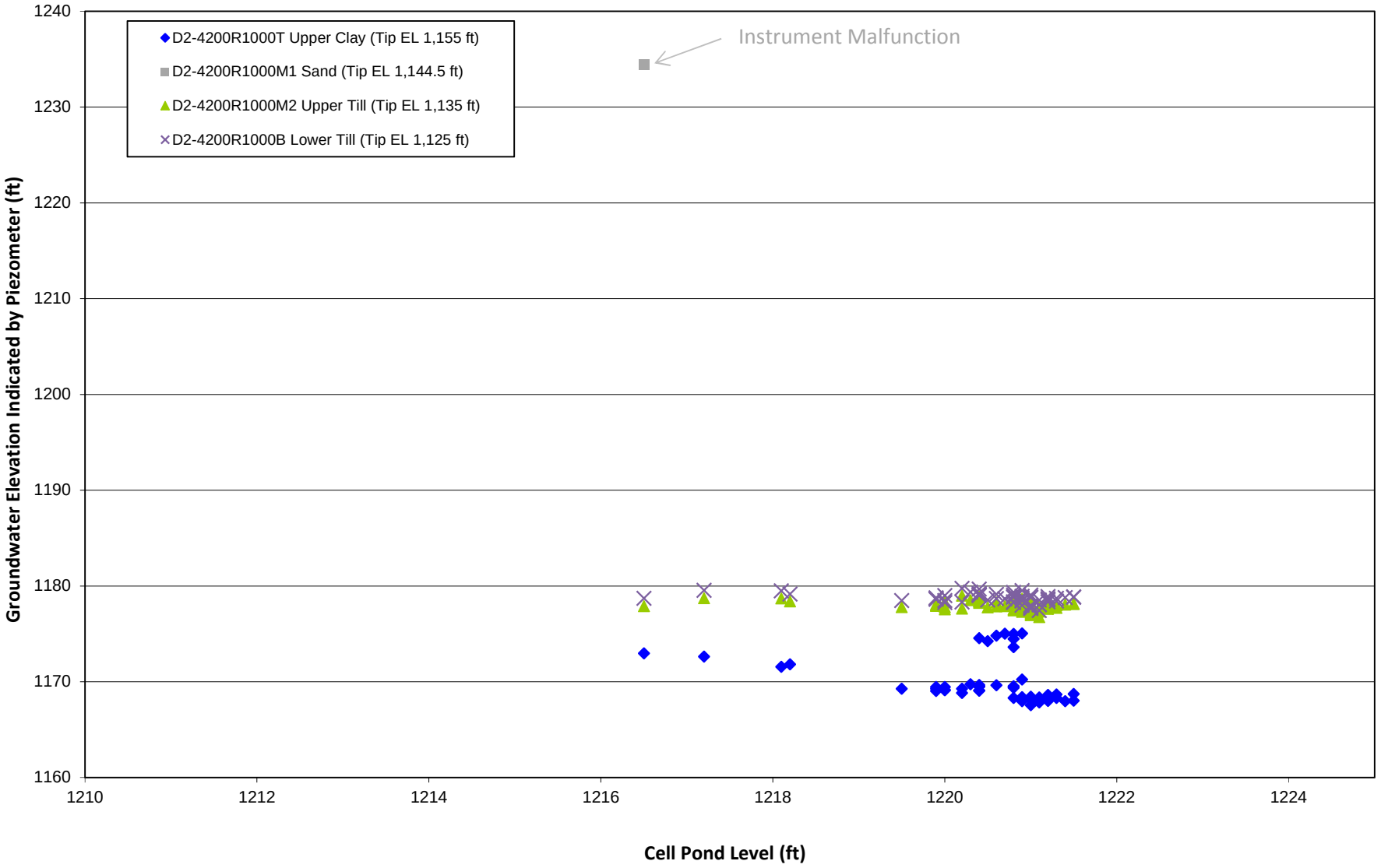
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Casagrande Piezometers
Dam 2 Sta. 42+00 R825

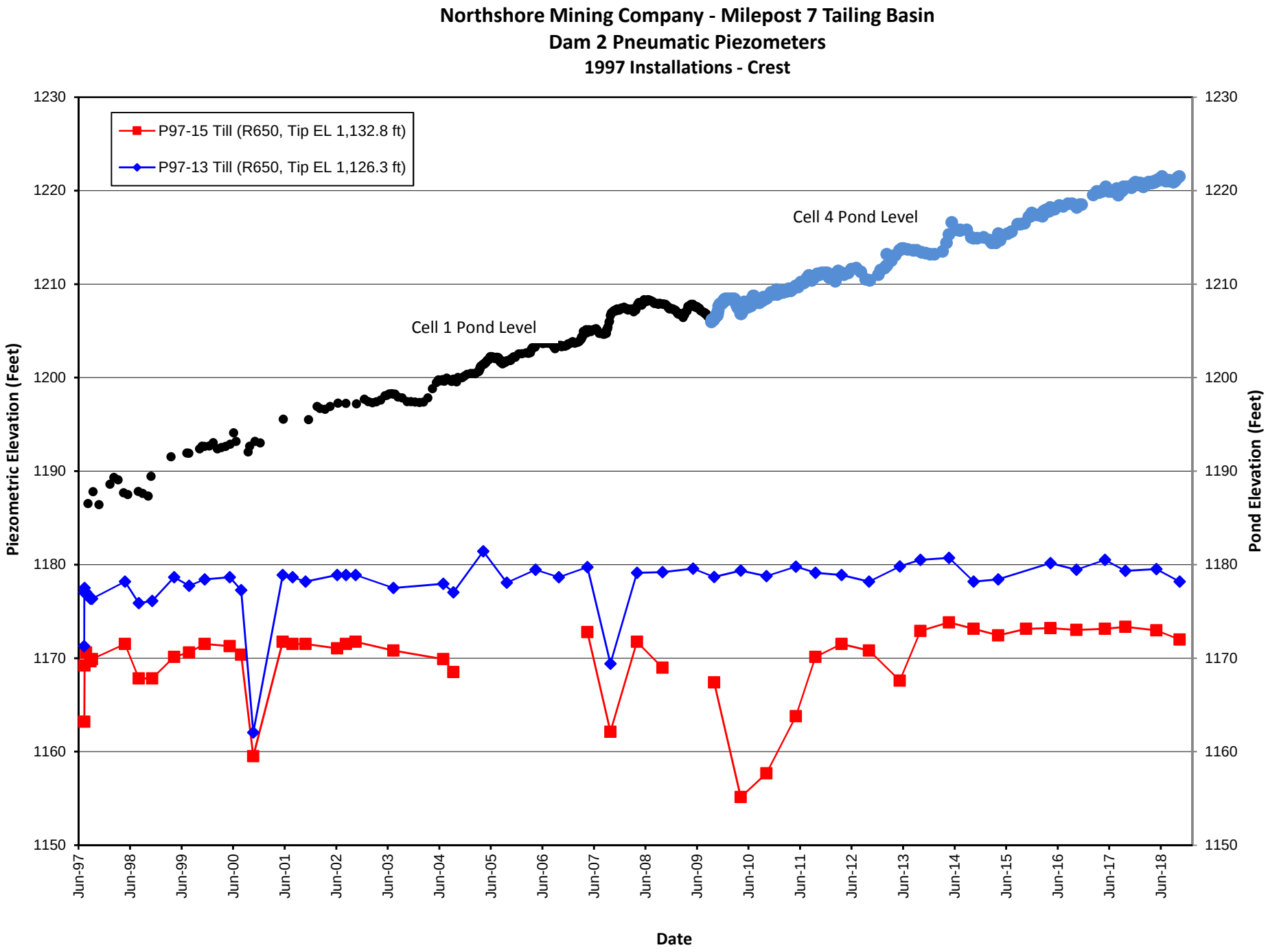


Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Vibrating Wire Piezometers
Piezometric Elevation
Sta. 42+00R1000

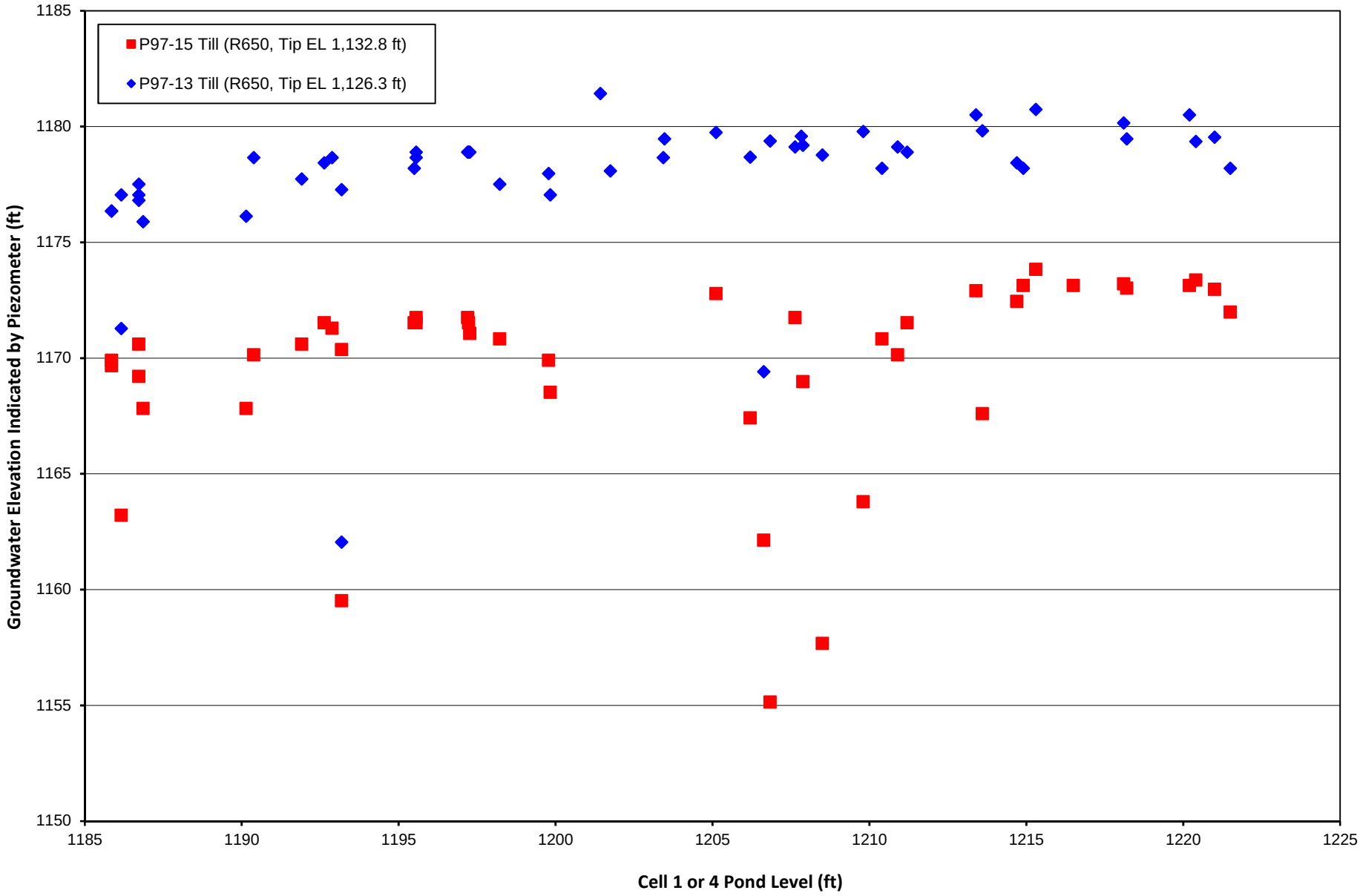


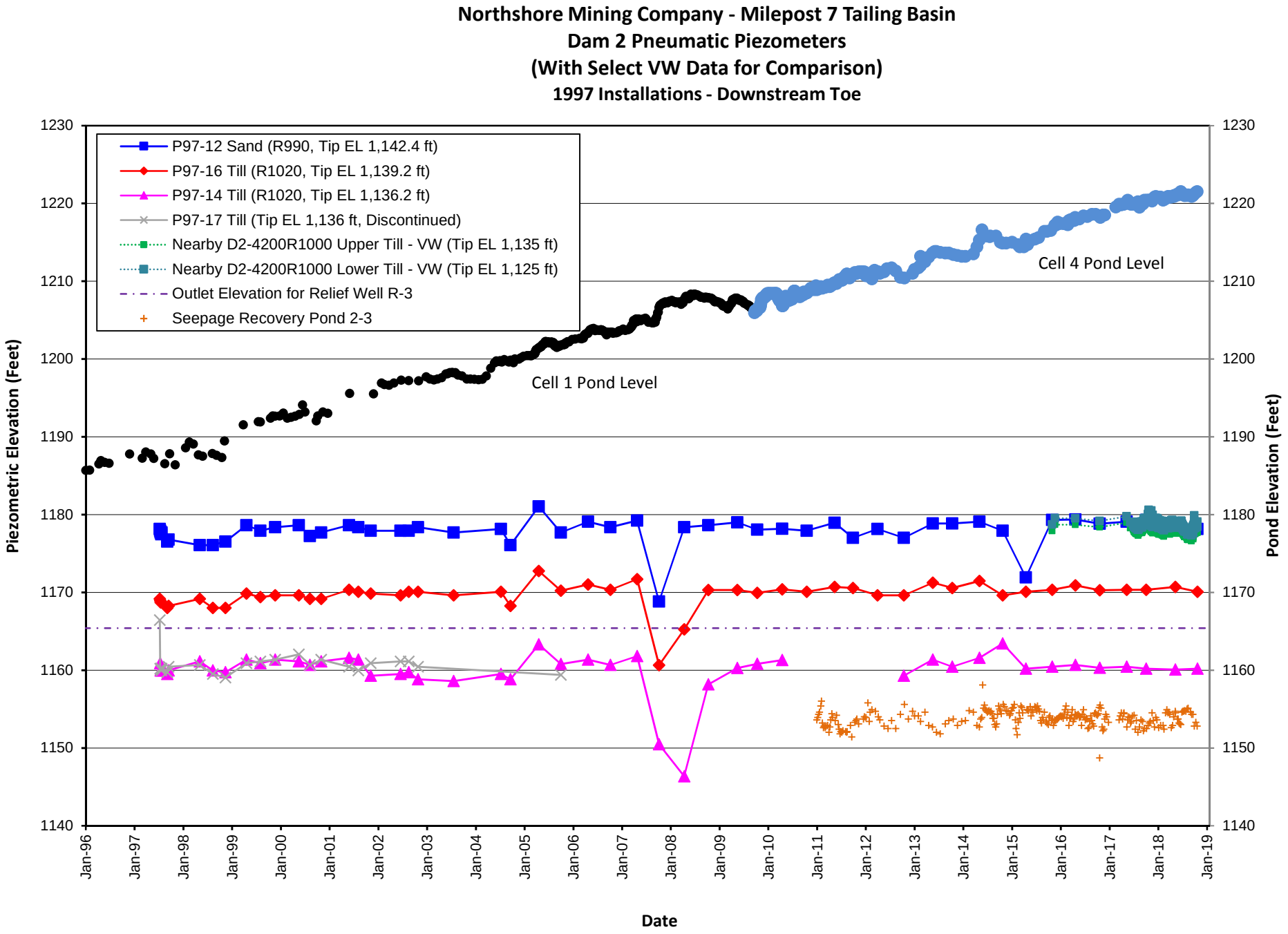
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 2 Sta. 42+00R1000



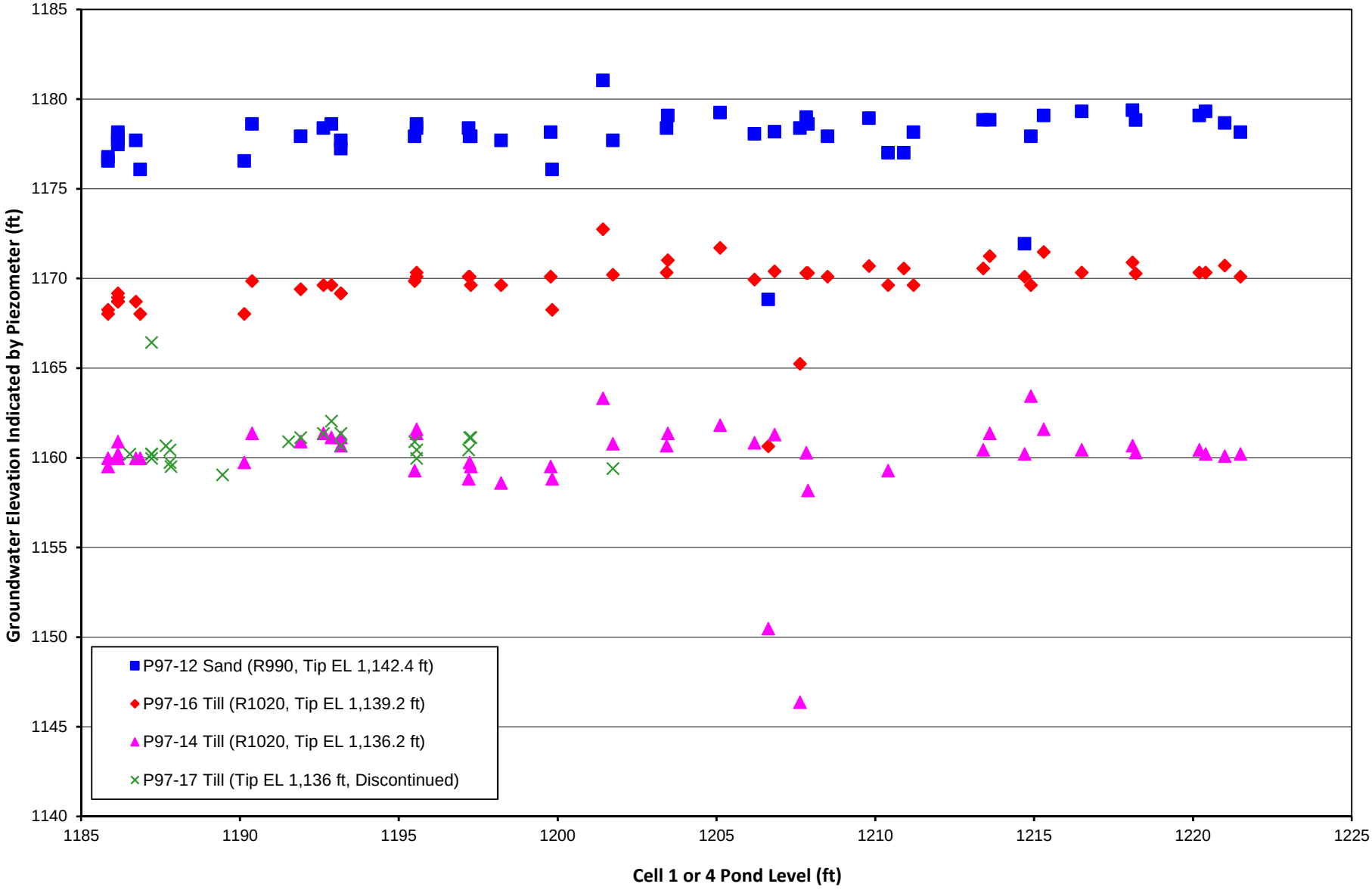

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Pneumatic Piezometers
1997 Installations - Crest
P97-15 Till (R650, Tip EL 1,132.8 ft)
P97-13 Till (R650, Tip EL 1,126.3 ft)
Cell 1 Pond Level
Cell 4 Pond Level
Piezometric Elevation (Feet)
Pond Elevation (Feet)
Date
1230
1220
1210
1200
1190
1180
1170
1160
1150
Jun-97
Jun-98
Jun-99
Jun-00
Jun-01
Jun-02
Jun-03
Jun-04
Jun-05
Jun-06
Jun-07
Jun-08
Jun-09
Jun-10
Jun-11
Jun-12
Jun-13
Jun-14
Jun-15
Jun-16
Jun-17
Jun-18

Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 2 1997 Installations - Crest



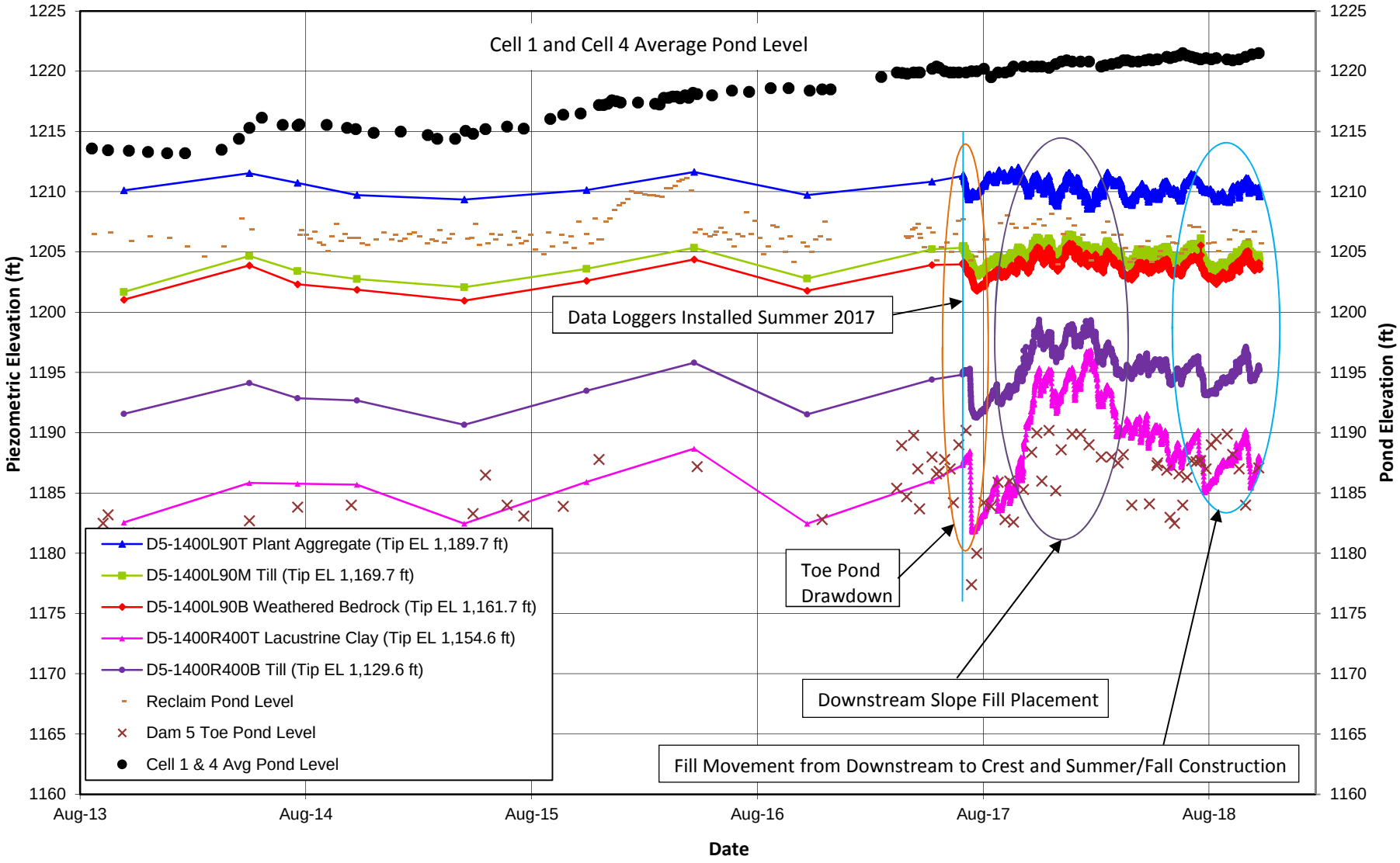

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Pneumatic Piezometers
(With Select VW Data for Comparison)
1997 Installations - Downstream Toe
P97-12 Sand (R990, Tip EL 1,142.4 ft)
P97-16 Till (R1020, Tip EL 1,139.2 ft)
P97-14 Till (R1020, Tip EL 1,136.2 ft)
P97-17 Till (Tip EL 1,136 ft, Discontinued)
Nearby D2-4200R1000 Upper Till - VW (Tip EL 1,135 ft)
Nearby D2-4200R1000 Lower Till - VW (Tip EL 1,125 ft)
Outlet Elevation for Relief Well R-3
Seepage Recovery Pond 2-3
Cell 1 Pond Level
Cell 4 Pond Level
Piezometric Elevation (Feet)
Pond Elevation (Feet)
Date
1230
1220
1210
1200
1190
1180
1170
1160
1150
1140
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

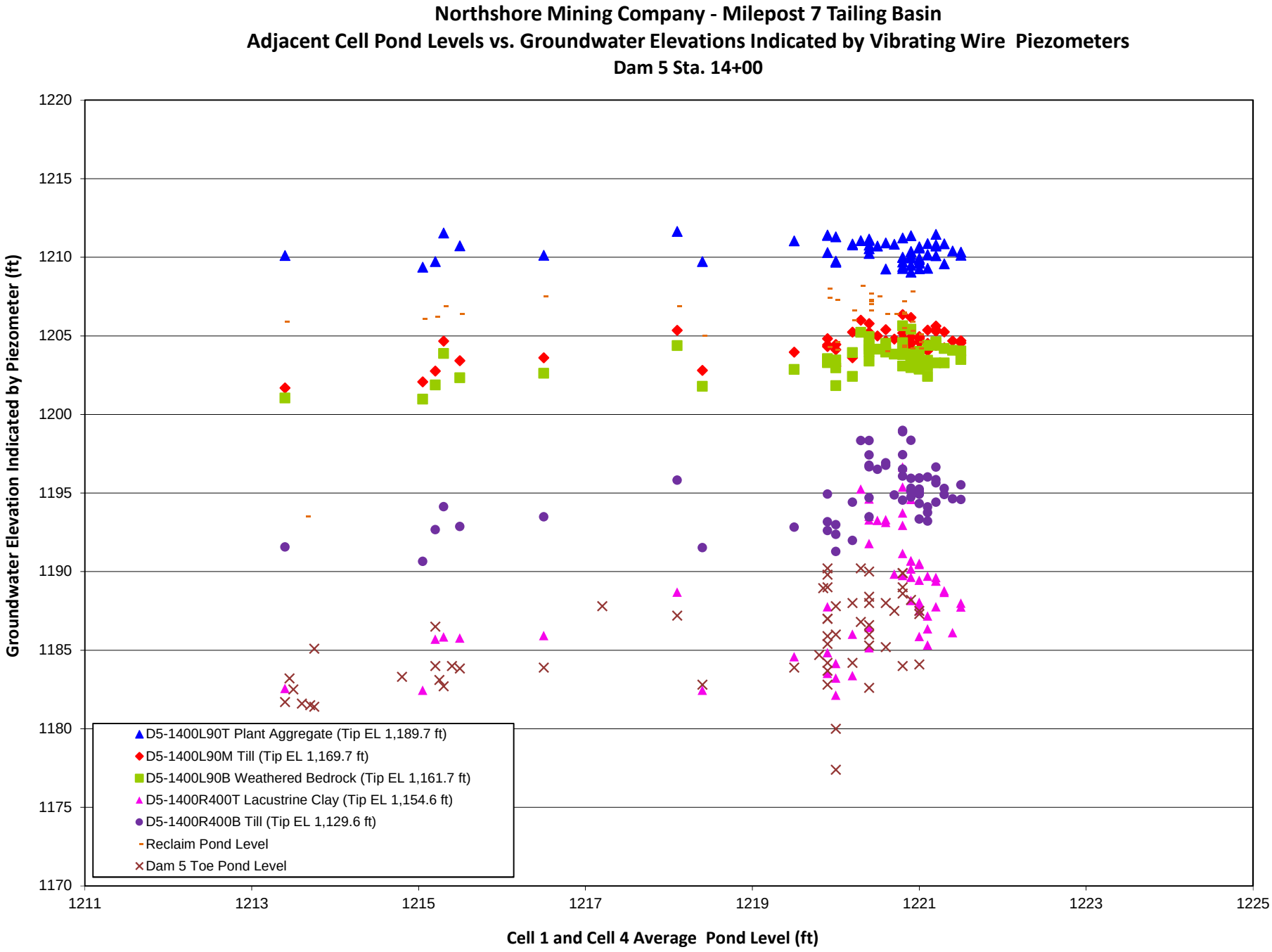
Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Pneumatic Piezometers
Dam 2 1997 Installations - Downstream Toe



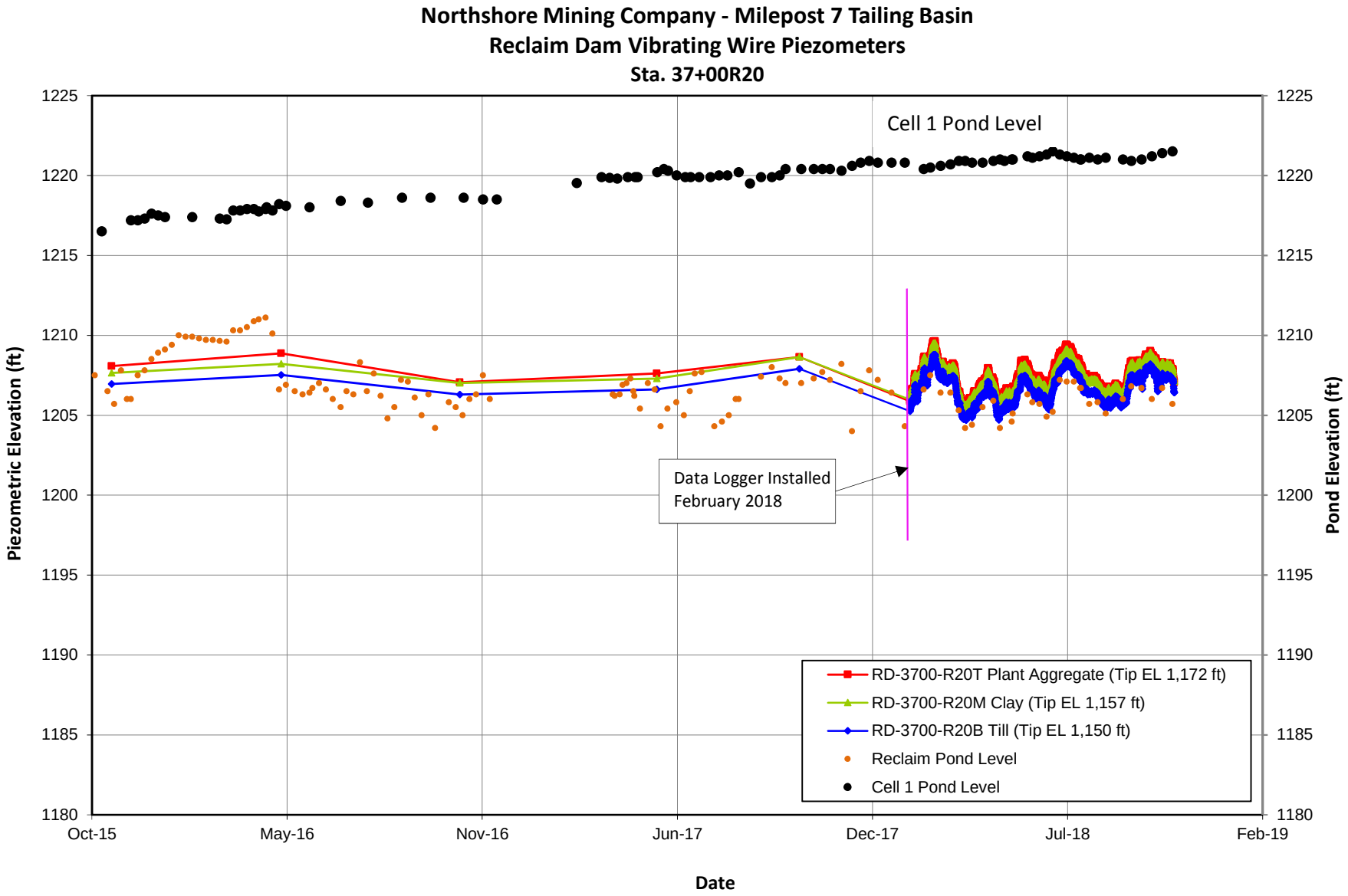
Dam 5 Piezometers

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 5 Vibrating Wire Piezometers
Piezometric Elevations
Sta. 14+00

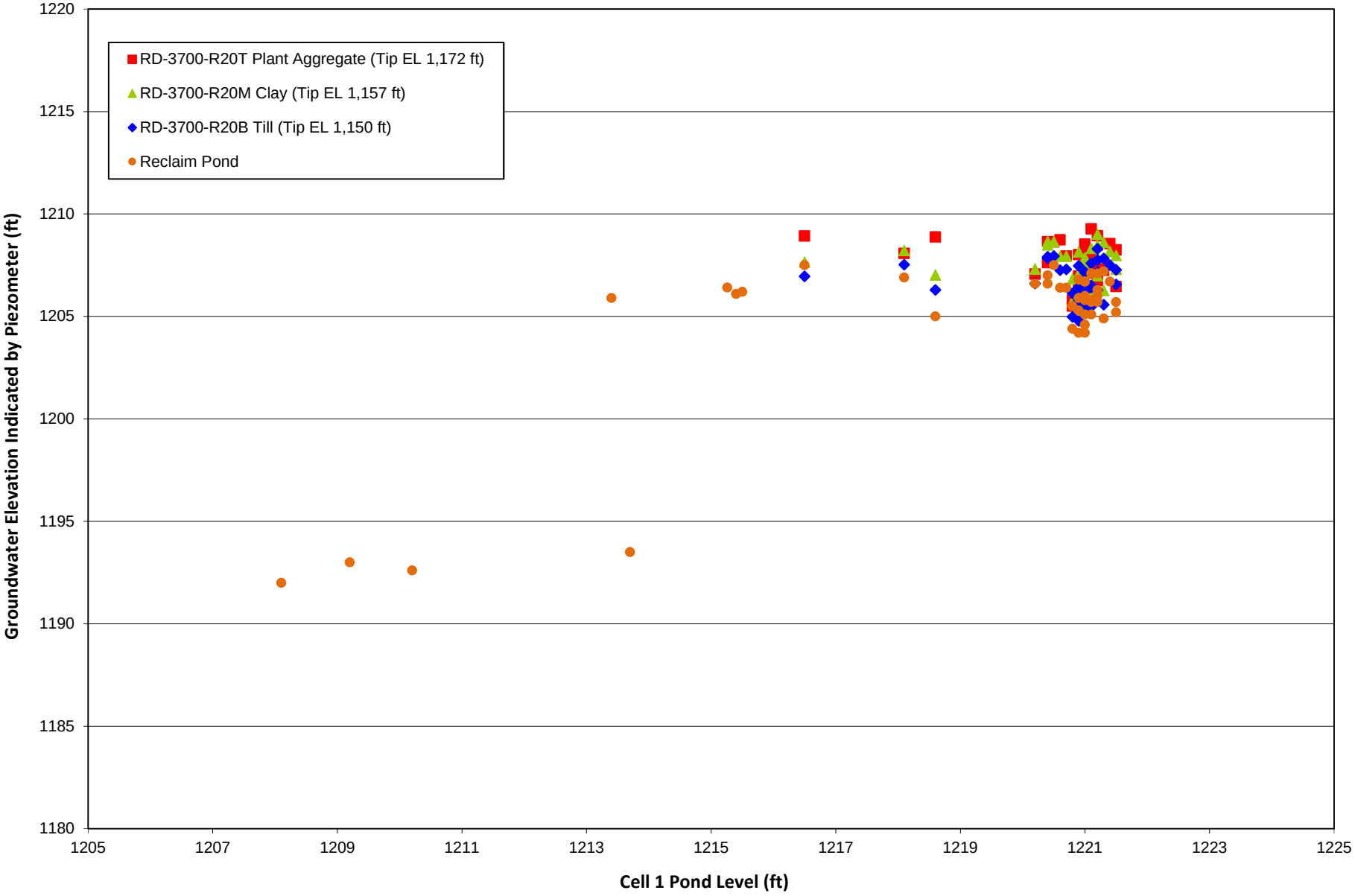



Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Dam 5 Sta. 14+00
Groundwater Elevation Indicated by Piezometer (ft)
Cell 1 and Cell 4 Average Pond Level (ft)
1220
1215
1210
1205
1200
1195
1190
1185
1180
1175
1170
1211
1213
1215
1217
1219
1221
1223
1225
D5-1400L90T Plant Aggregate (Tip EL 1,189.7 ft)
D5-1400L90M Till (Tip EL 1,169.7 ft)
D5-1400L90B Weathered Bedrock (Tip EL 1,161.7 ft)
D5-1400R400T Lacustrine Clay (Tip EL 1,154.6 ft)
D5-1400R400B Till (Tip EL 1,129.6 ft)
Reclaim Pond Level
Dam 5 Toe Pond Level

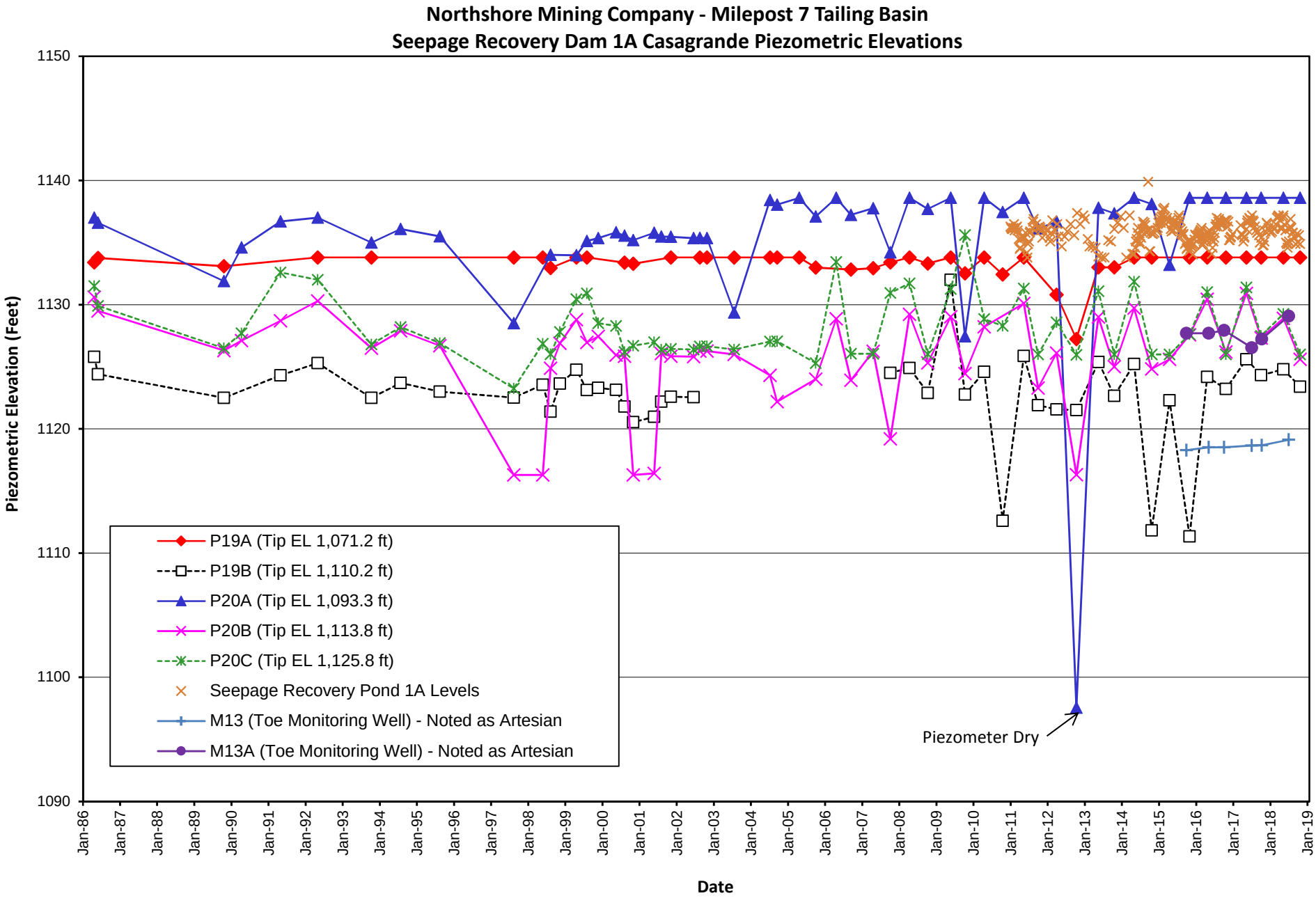
Reclaim Dam Piezometers

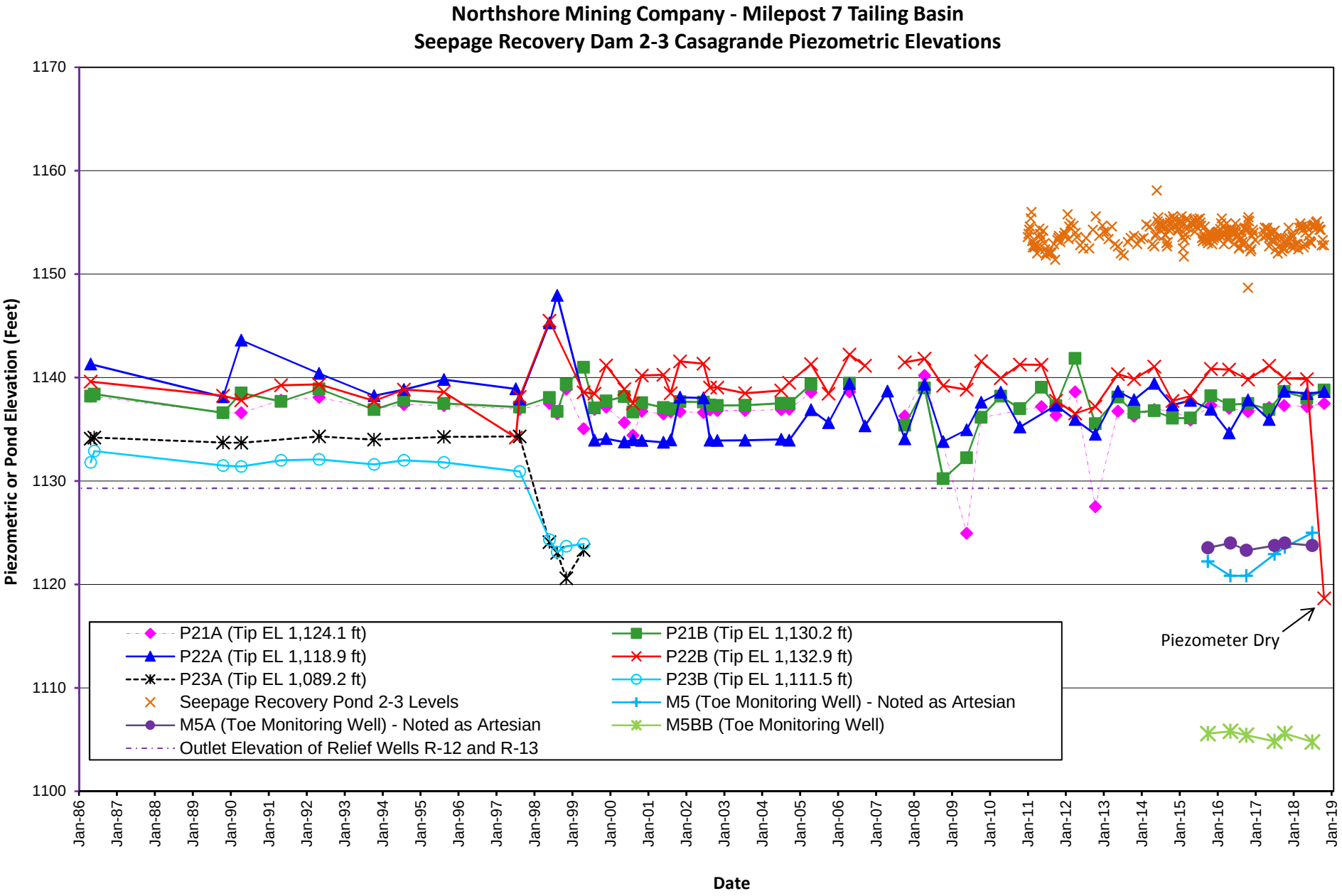

Northshore Mining Company - Milepost 7 Tailing Basin
Reclaim Dam Vibrating Wire Piezometers
Sta. 37+00R20
Cell 1 Pond Level
Data Logger Installed
February 2018
RD-3700-R20T Plant Aggregate (Tip EL 1,172 ft)
RD-3700-R20M Clay (Tip EL 1,157 ft)
RD-3700-R20B Till (Tip EL 1,150 ft)
Reclaim Pond Level
Cell 1 Pond Level
Piezometric Elevation (ft)
Pond Elevation (ft)
Date
1225
1220
1215
1210
1205
1200
1195
1190
1185
1180
Oct-15
May-16
Nov-16
Jun-17
Dec-17
Jul-18
Feb-19

Northshore Mining Company - Milepost 7 Tailing Basin
Adjacent Cell Pond Levels vs. Groundwater Elevations Indicated by Vibrating Wire Piezometers
Reclaim Dam Sta. 37+00R20



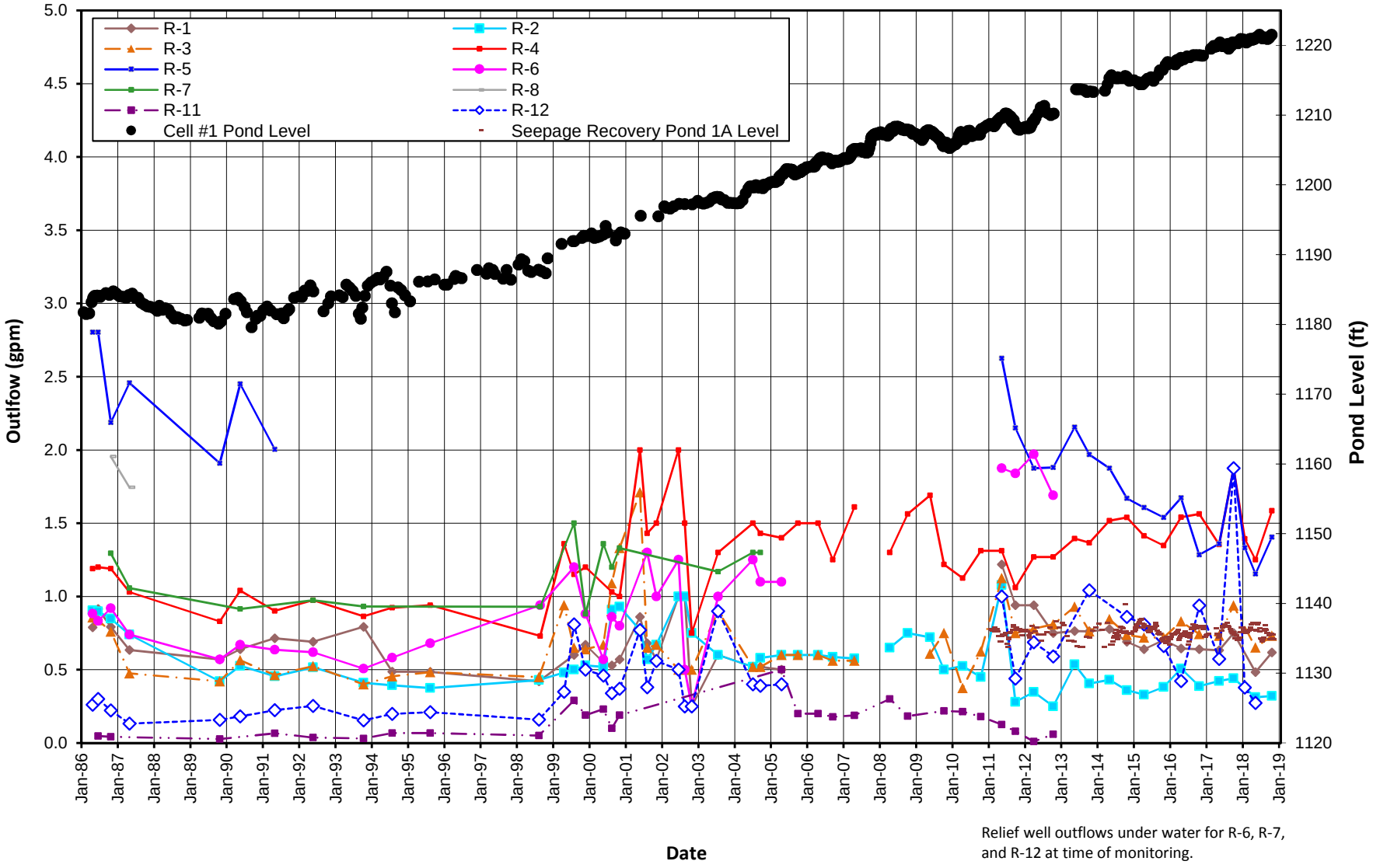
Seepage Recovery Dam Piezometers


Northshore Mining Company - Milepost 7 Tailing Basin
Seepage Recovery Dam 1A Casagrande Piezometric Elevations
Piezometric Elevation (Feet)
1150
1140
1130
1120
1110
1100
1090
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Date
P19A (Tip EL 1,071.2 ft)
P19B (Tip EL 1,110.2 ft)
P20A (Tip EL 1,093.3 ft)
P20B (Tip EL 1,113.8 ft)
P20C (Tip EL 1,125.8 ft)
Seepage Recovery Pond 1A Levels
M13 (Toe Monitoring Well) - Noted as Artesian
M13A (Toe Monitoring Well) - Noted as Artesian
Piezometer Dry

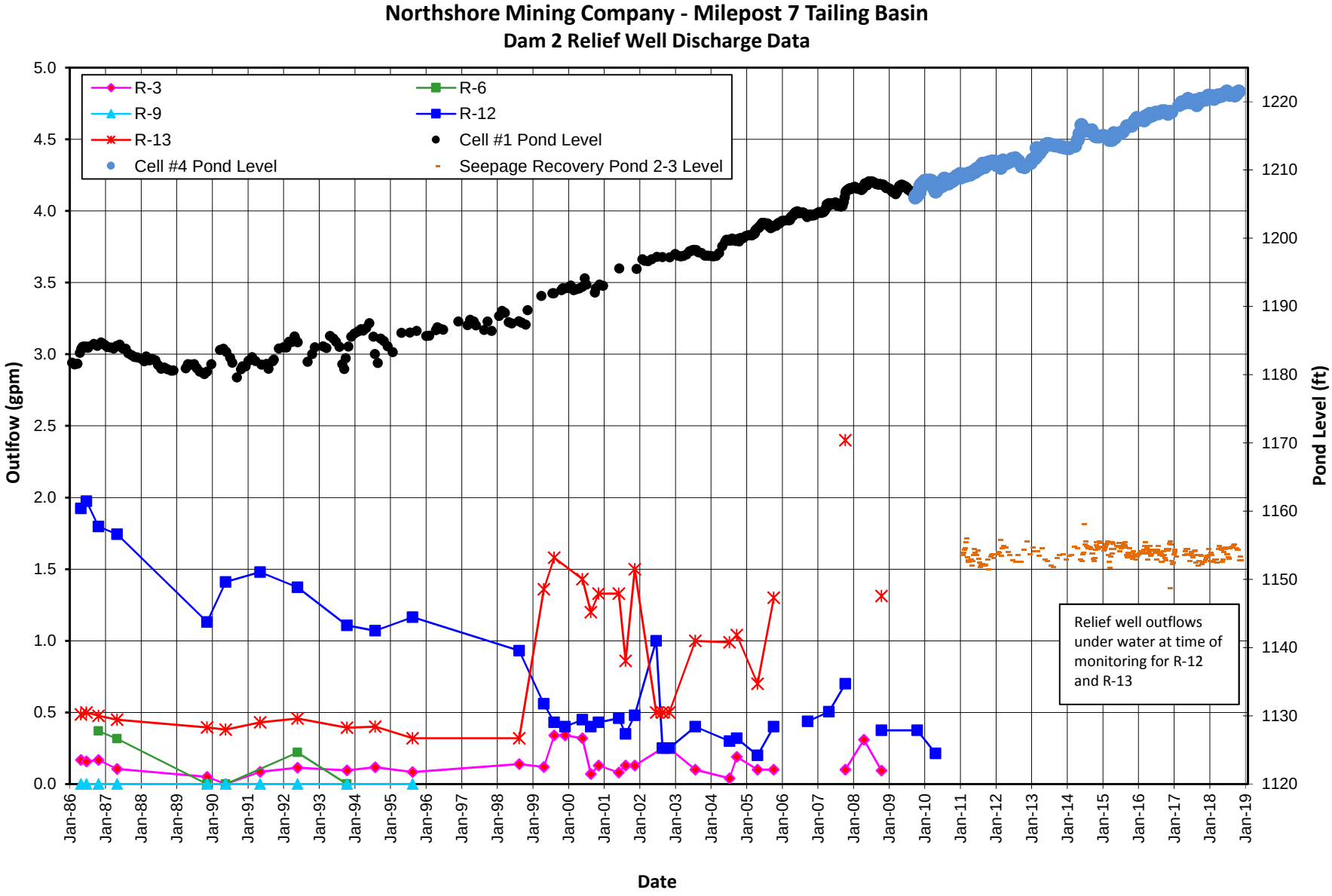

Northshore Mining Company - Milepost 7 Tailing Basin
Seepage Recovery Dam 2-3 Casagrande Piezometric Elevations
Piezometric or Pond Elevation (Feet)
1170
1160
1150
1140
1130
1120
1110
1100
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Date
P21A (Tip EL 1,124.1 ft)
P21B (Tip EL 1,130.2 ft)
P22A (Tip EL 1,118.9 ft)
P22B (Tip EL 1,132.9 ft)
P23A (Tip EL 1,089.2 ft)
P23B (Tip EL 1,111.5 ft)
Seepage Recovery Pond 2-3 Levels
M5 (Toe Monitoring Well) - Noted as Artesian
M5A (Toe Monitoring Well) - Noted as Artesian
M5BB (Toe Monitoring Well)
Outlet Elevation of Relief Wells R-12 and R-13
Piezometer Dry

Relief Well Charts

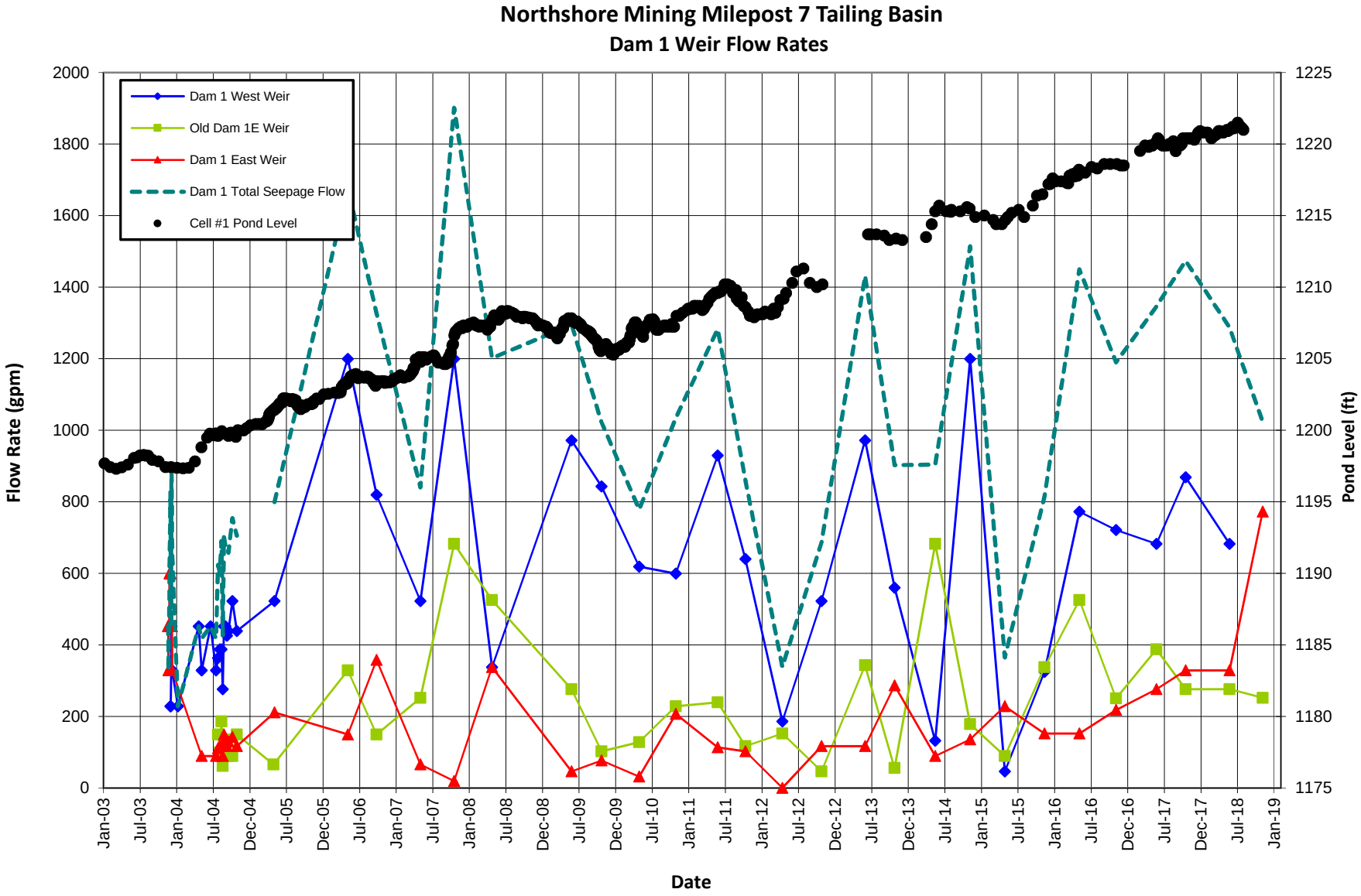
Northshore Mining Company - Milepost 7 Tailing Basin
Dam 1 Relief Well Discharge Data

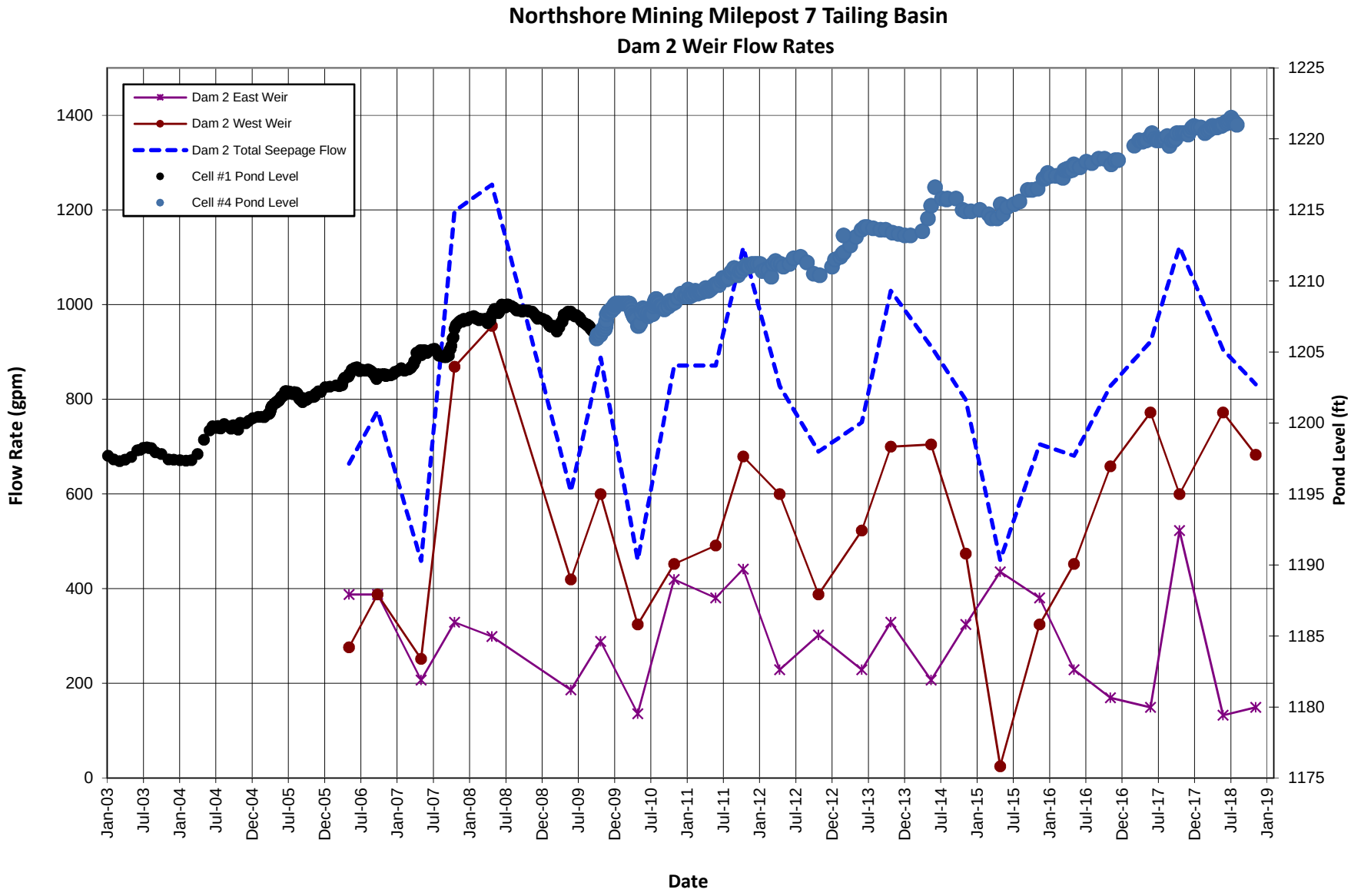


Relief well outflows under water for R-6, R-7, and R-12 at time of monitoring.

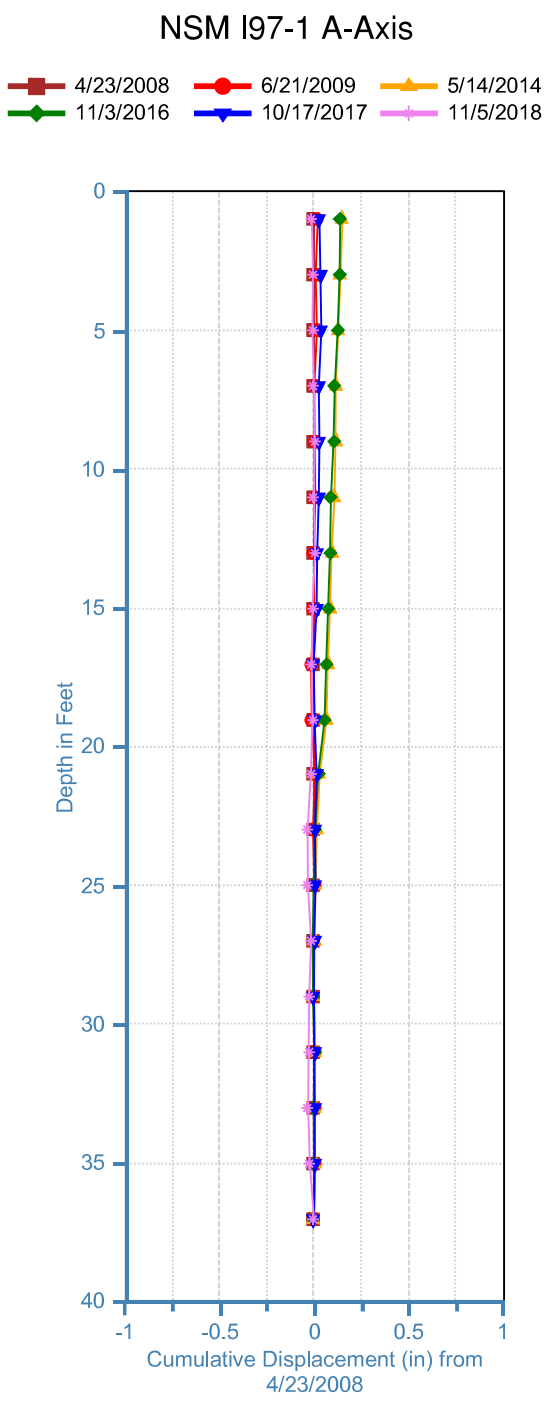

Northshore Mining Company - Milepost 7 Tailing Basin
Dam 2 Relief Well Discharge Data
R-3
R-6
R-9
R-12
R-13
Cell #1 Pond Level
Cell #4 Pond Level
Seepage Recovery Pond 2-3 Level
Relief well outflows under water at time of monitoring for R-12 and R-13
Outlfow (gpm)
Pond Level (ft)
Date
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1220
1210
1200
1190
1180
1170
1160
1150
1140
1130
1120
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19

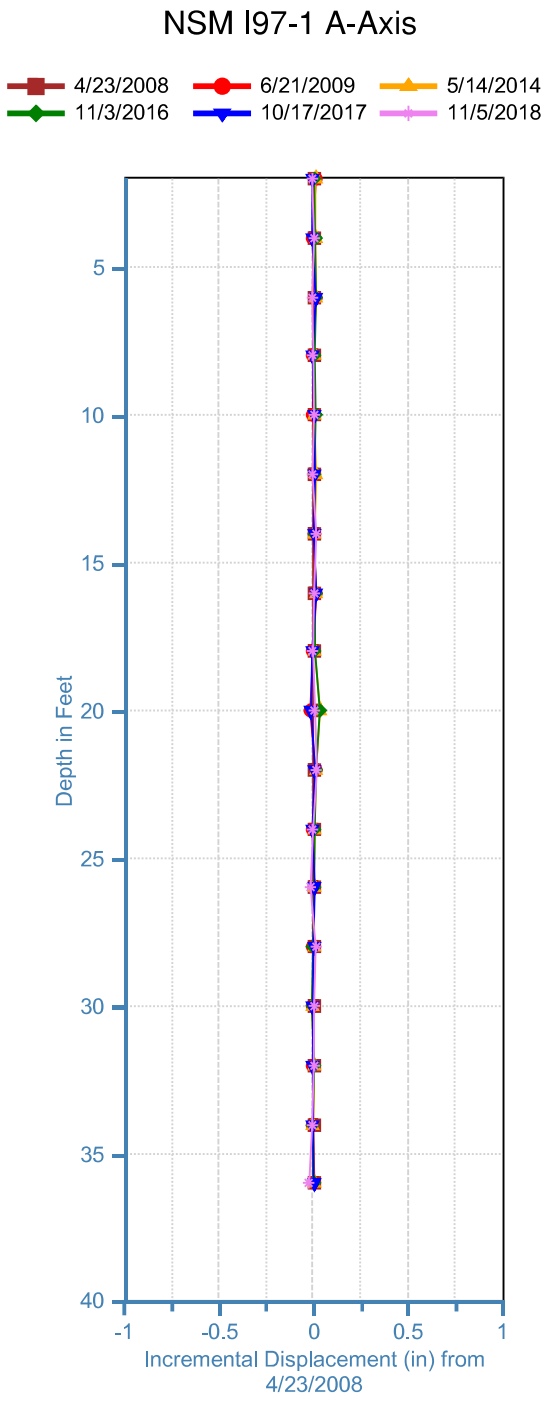
Weir Charts


Northshore Mining Milepost 7 Tailing Basin
Dam 1 Weir Flow Rates
Dam 1 West Weir
Old Dam 1E Weir
Dam 1 East Weir
Dam 1 Total Seepage Flow
Cell #1 Pond Level
Flow Rate (gpm)
Pond Level (ft)
Date
0
200
400
600
800
1000
1200
1400
1600
1800
2000
1175
1180
1185
1190
1195
1200
1205
1210
1215
1220
1225
Jan-03
Jul-03
Jan-04
Jul-04
Dec-04
Jul-05
Dec-05
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Dec-08
Jul-09
Dec-09
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Dec-12
Jul-13
Dec-13
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Dec-16
Jul-17
Dec-17
Jul-18
Jan-19

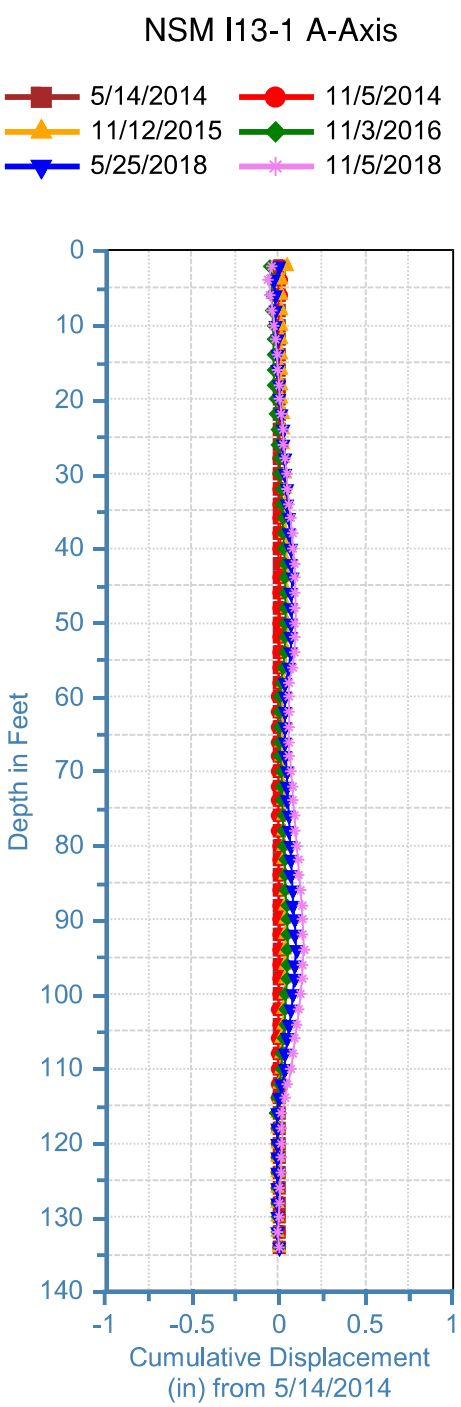

Northshore Mining Milepost 7 Tailing Basin
Dam 2 Weir Flow Rates
Dam 2 East Weir
Dam 2 West Weir
Dam 2 Total Seepage Flow
Cell #1 Pond Level
Cell #4 Pond Level
Flow Rate (gpm)
Pond Level (ft)
Date
0
200
400
600
800
1000
1200
1400
1175
1180
1185
1190
1195
1200
1205
1210
1215
1220
1225
Jan-03
Jul-03
Jan-04
Jul-04
Dec-04
Jul-05
Dec-05
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Dec-08
Jul-09
Dec-09
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
Dec-12
Jul-13
Dec-13
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Dec-16
Jul-17
Dec-17
Jul-18
Jan-19

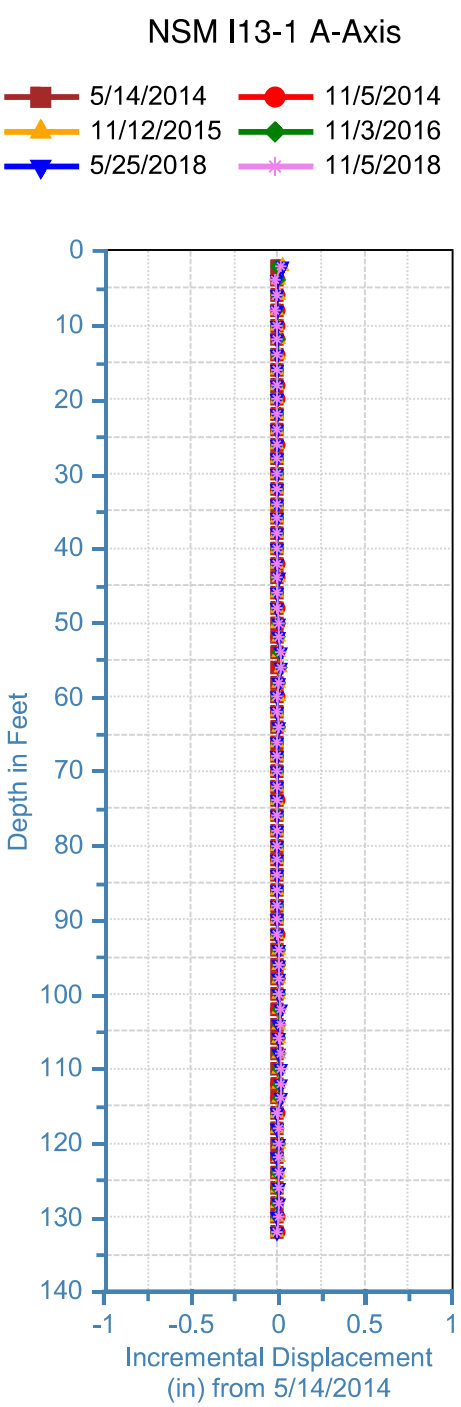
Inclinometer Charts



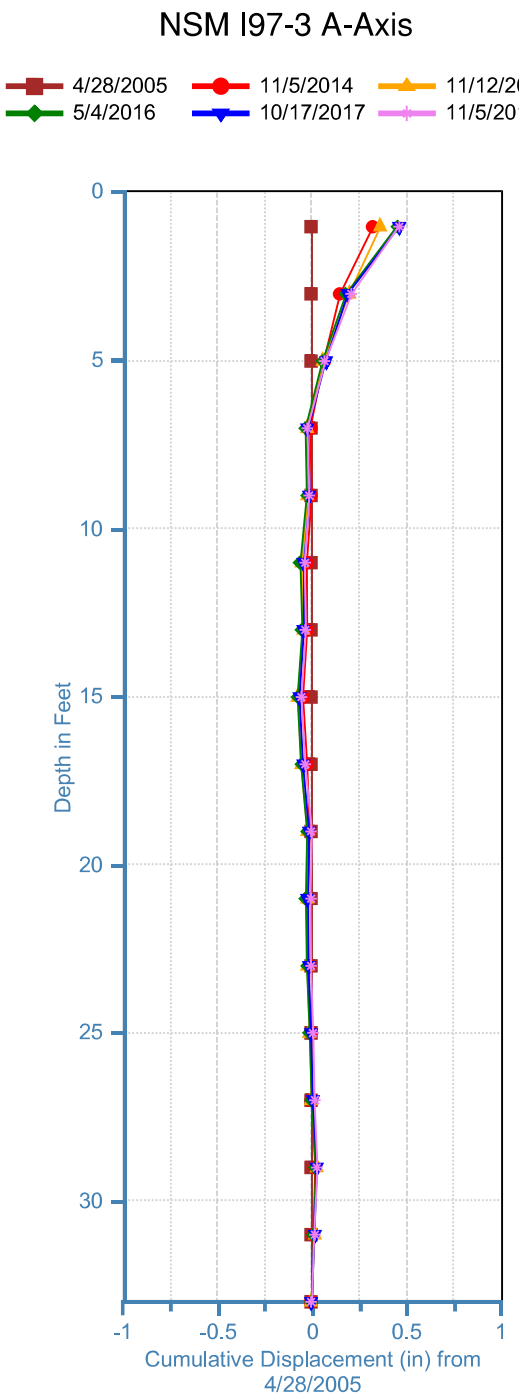


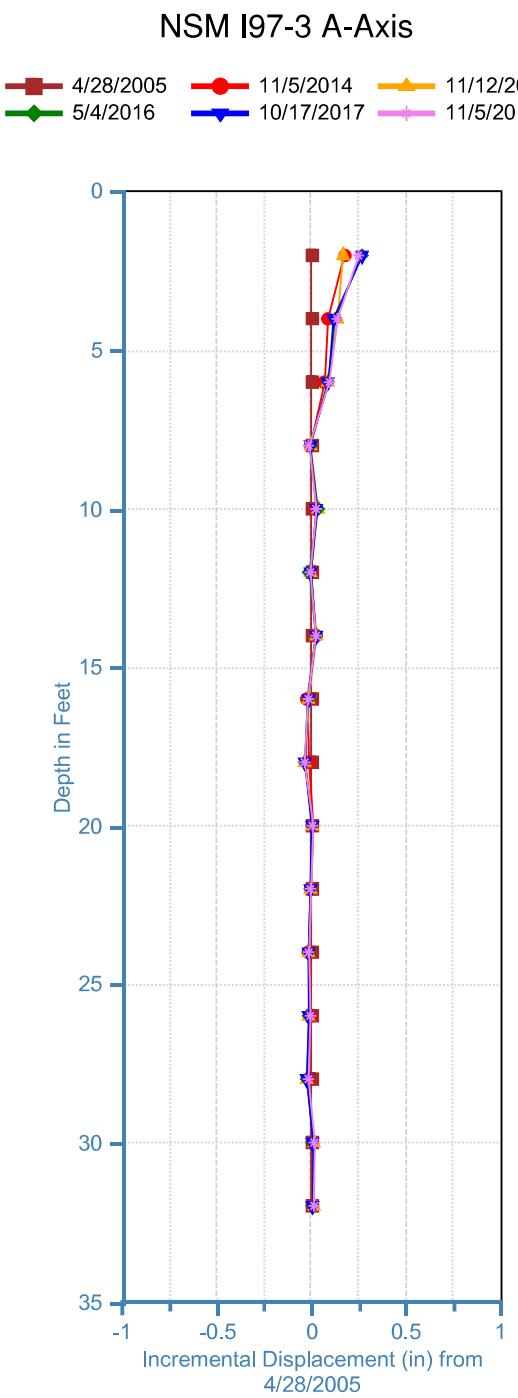
I97-1 - Dam 1 Toe, Sta 28+40
Milepost 7 Tailings Basin Monitoring
Northshore Mining
23\38-086
Fall 2018



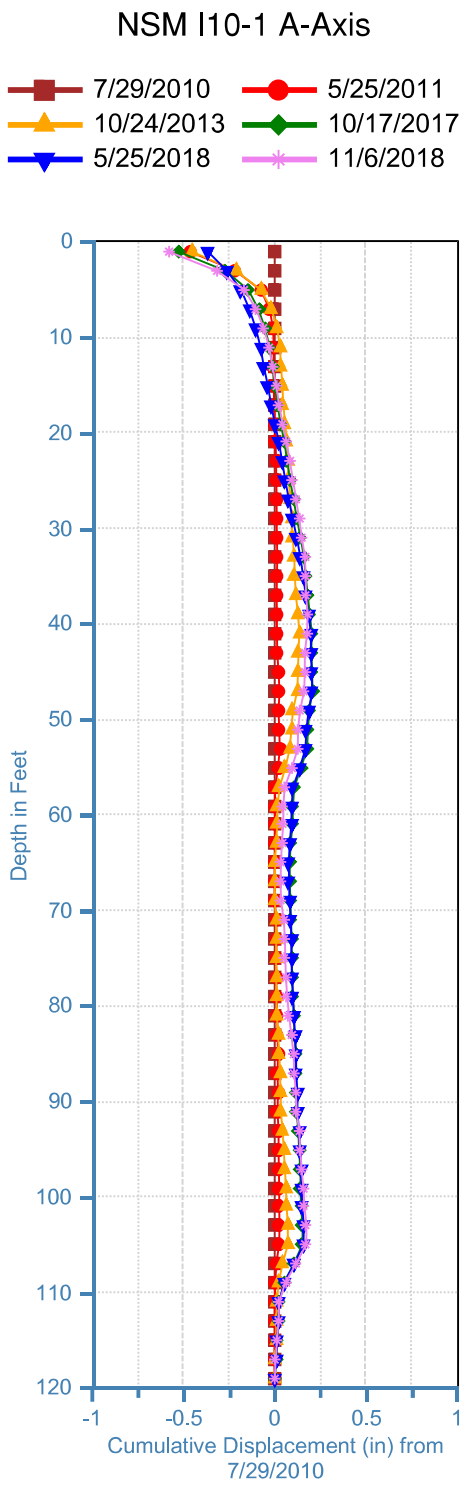


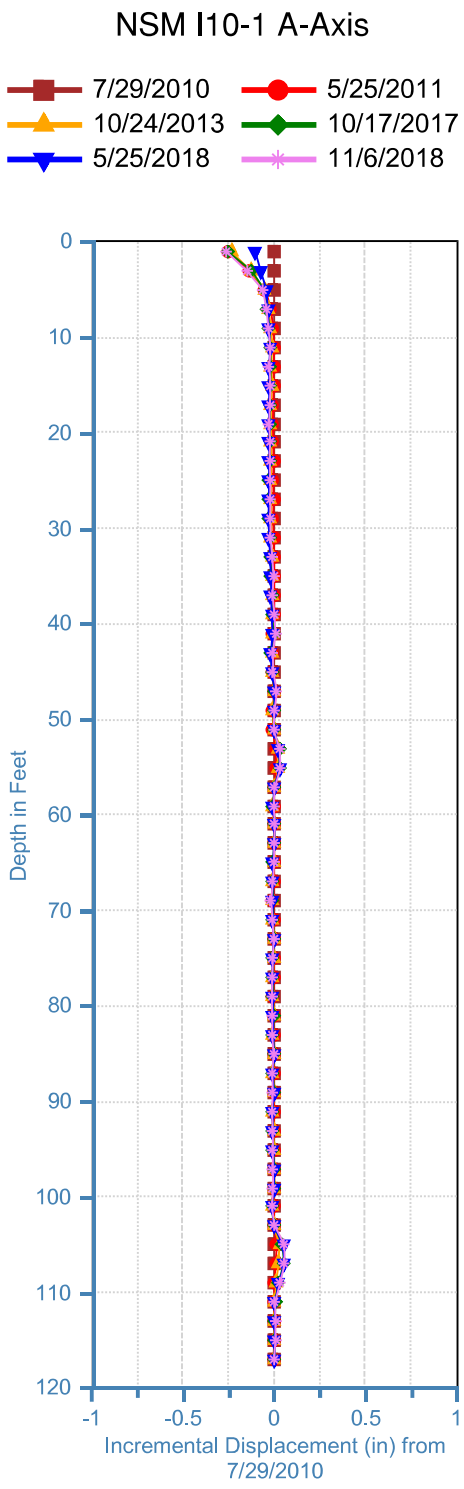
I13-1 - Dam 1 Mid-Slope, Sta. 28+40
Milepost 7 Tailings Basin Monitoring
Northshore Mining Company
23/38-0086
Fall 2018



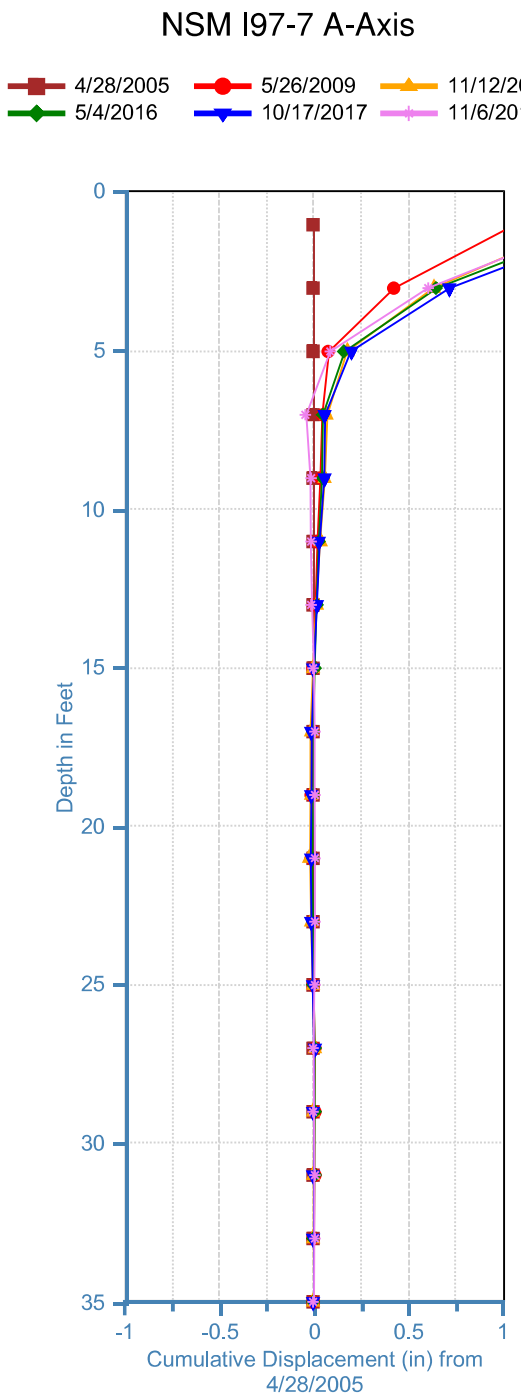


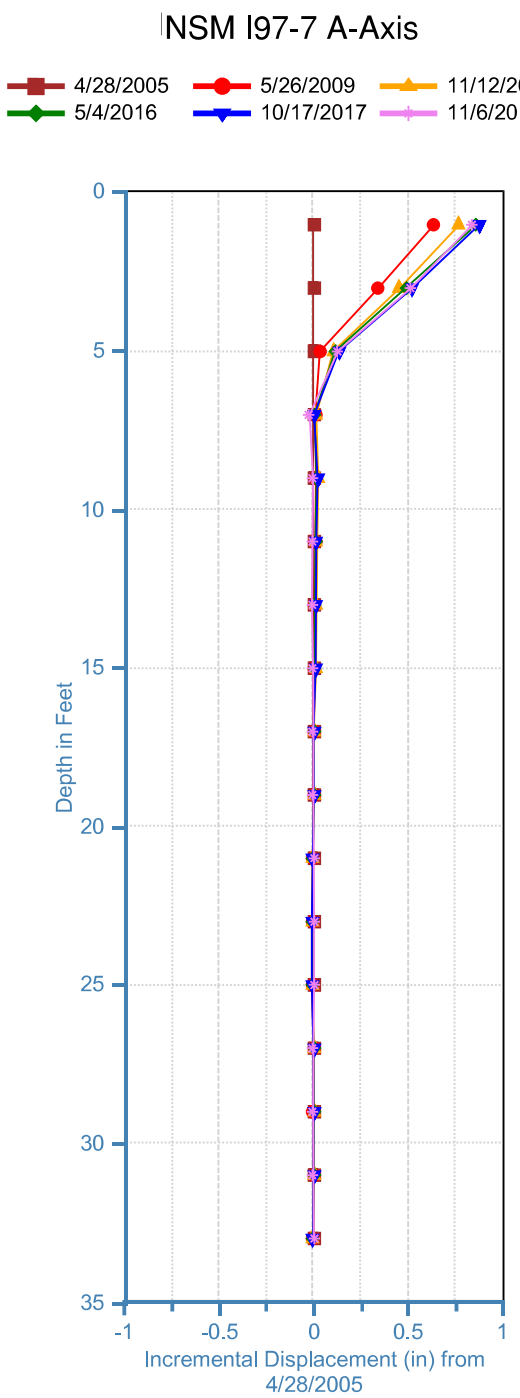
I97-3 - Dam 1 Toe, Sta 35+00
Milepost 7 Tailings Basin Monitoring
Northshore Mining Company
23\38-086
Fall 2018



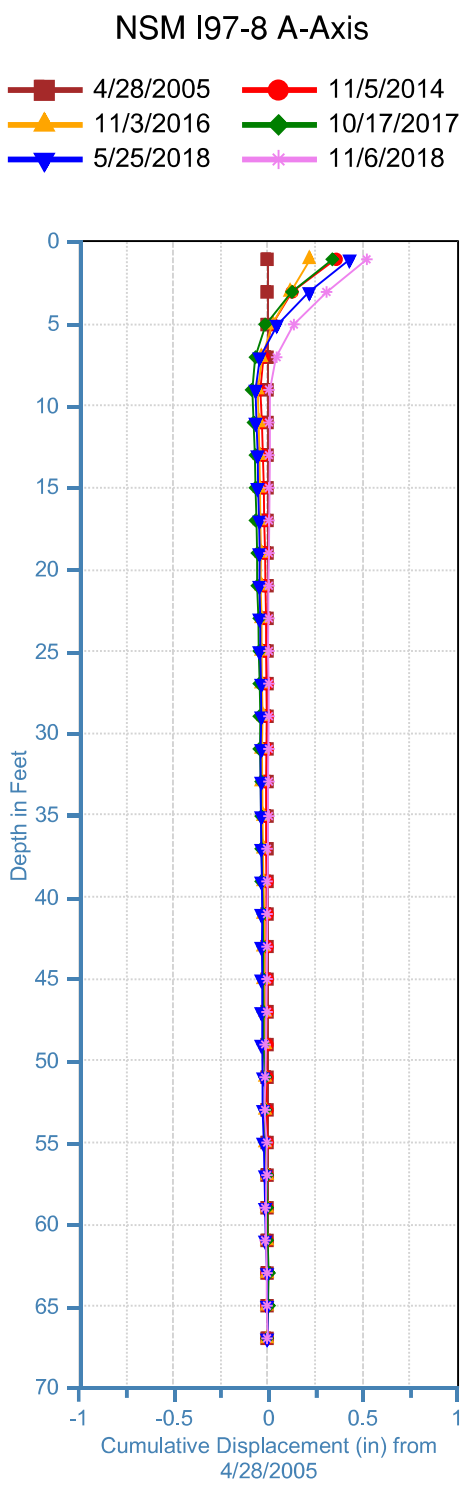


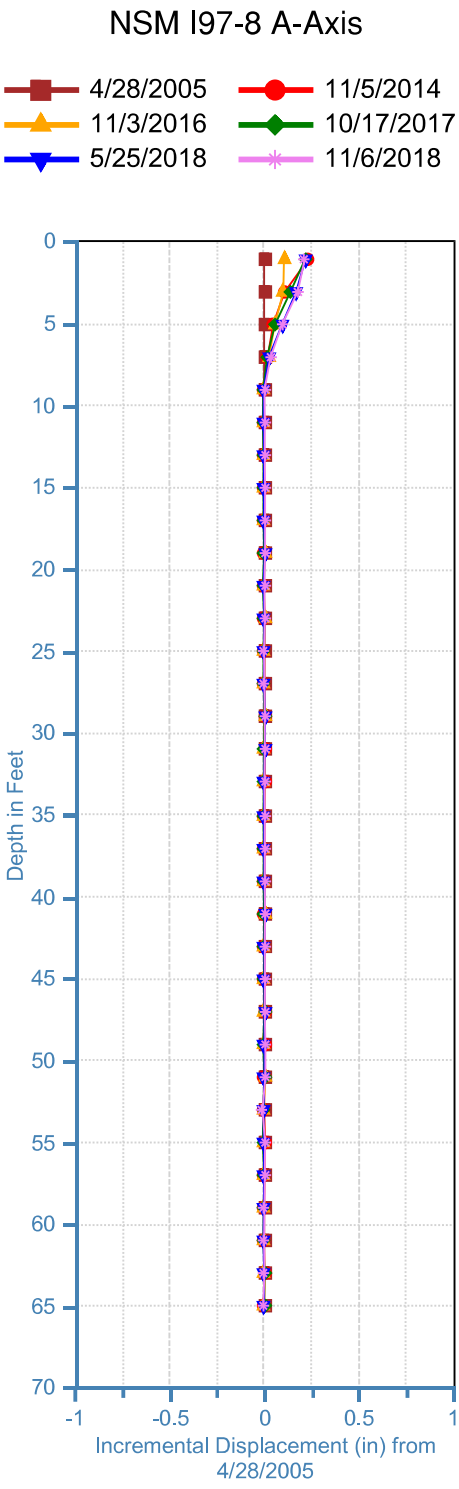
I10-1 Dam 1 Mid-Slope, Sta 35+00
Milepost 7 Tailings Basin Monitoring
Northshore Mining Company
23/38-086
Fall 2018



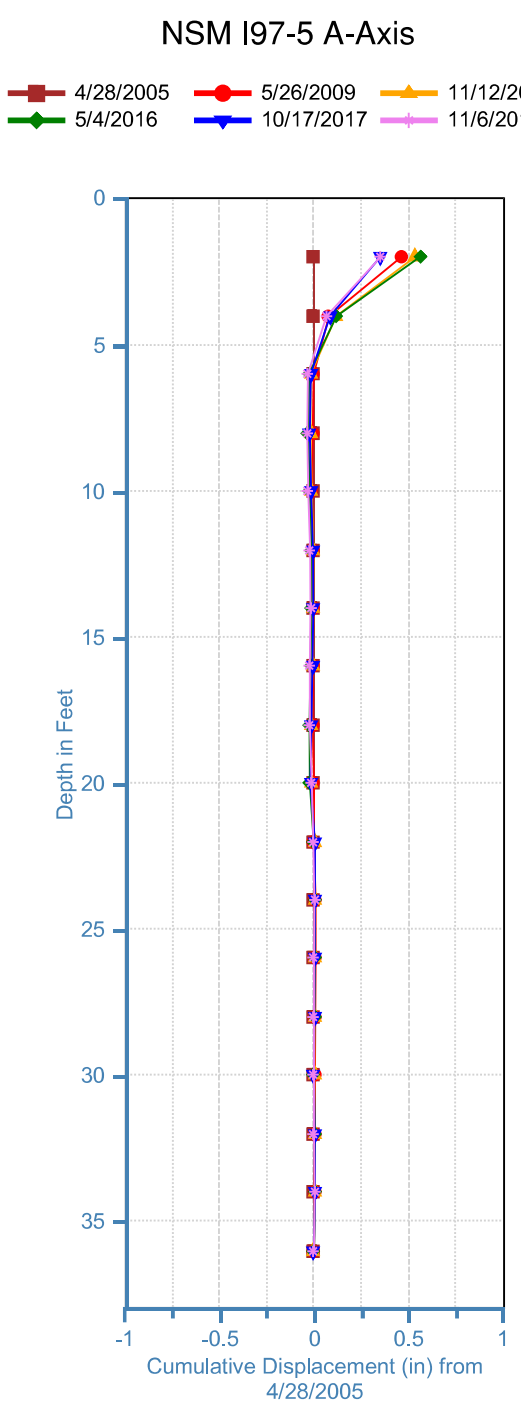


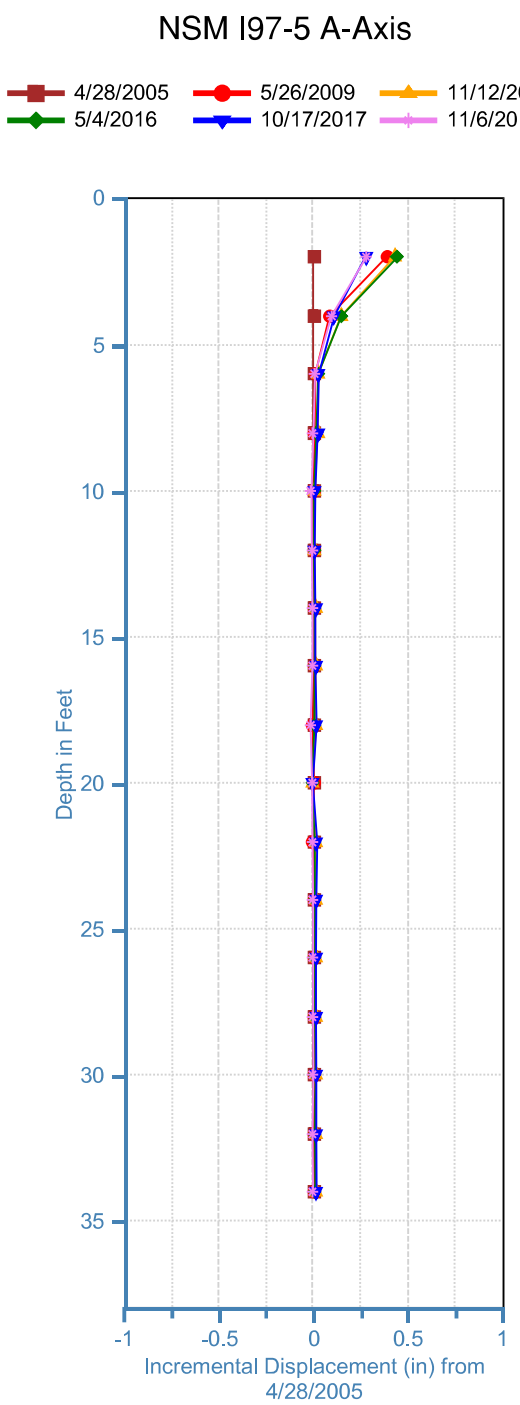
I97-7 - Dam 2 Toe, Sta 34+75
Milepost 7 Tailings Basin Monitoring
Northshore Mining
23/38-086
Fall 2018



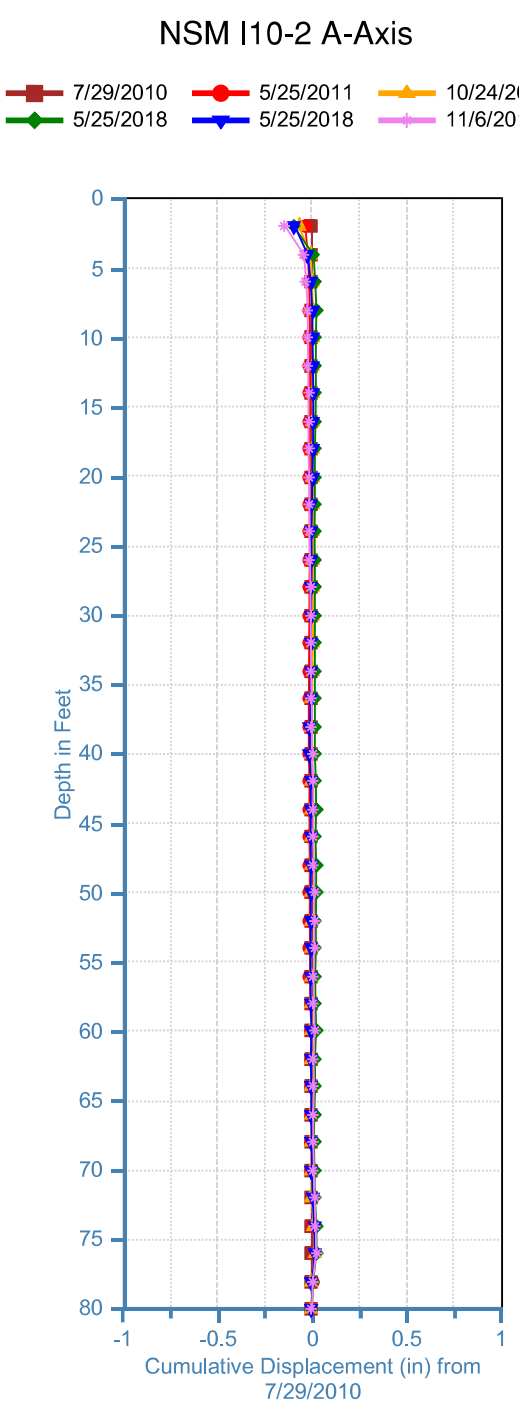


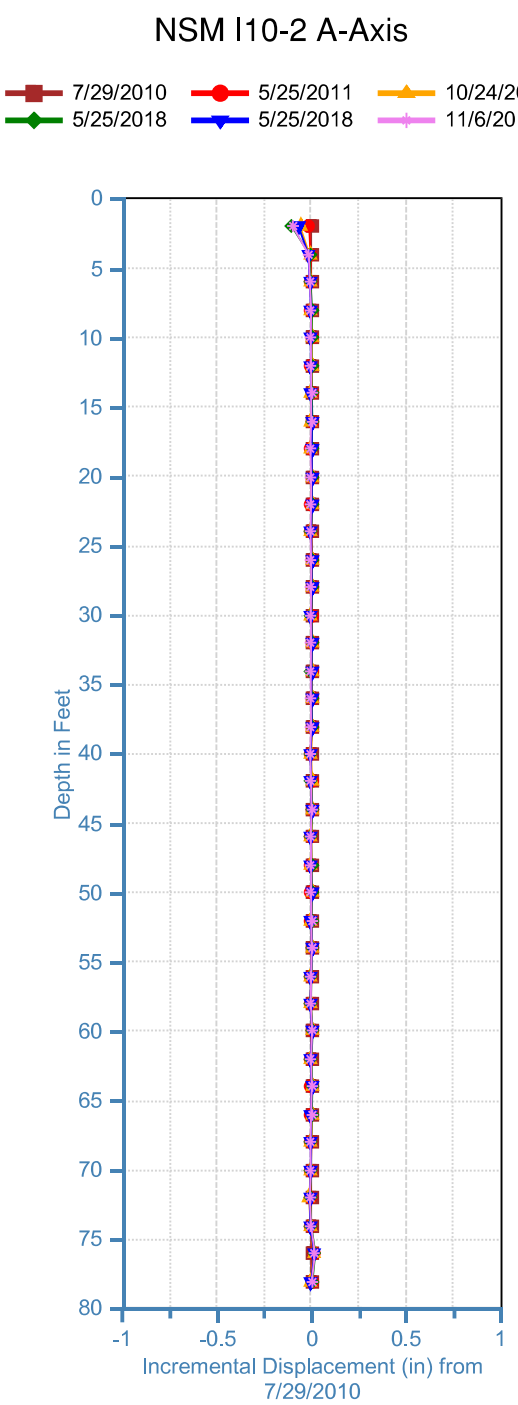
I97-8 - Dam 2 Mid-Slope, Sta 34+75
Milepost 7 Tailings Basin Monitoring
Northshore Mining Company
23/38-086
Fall 2018



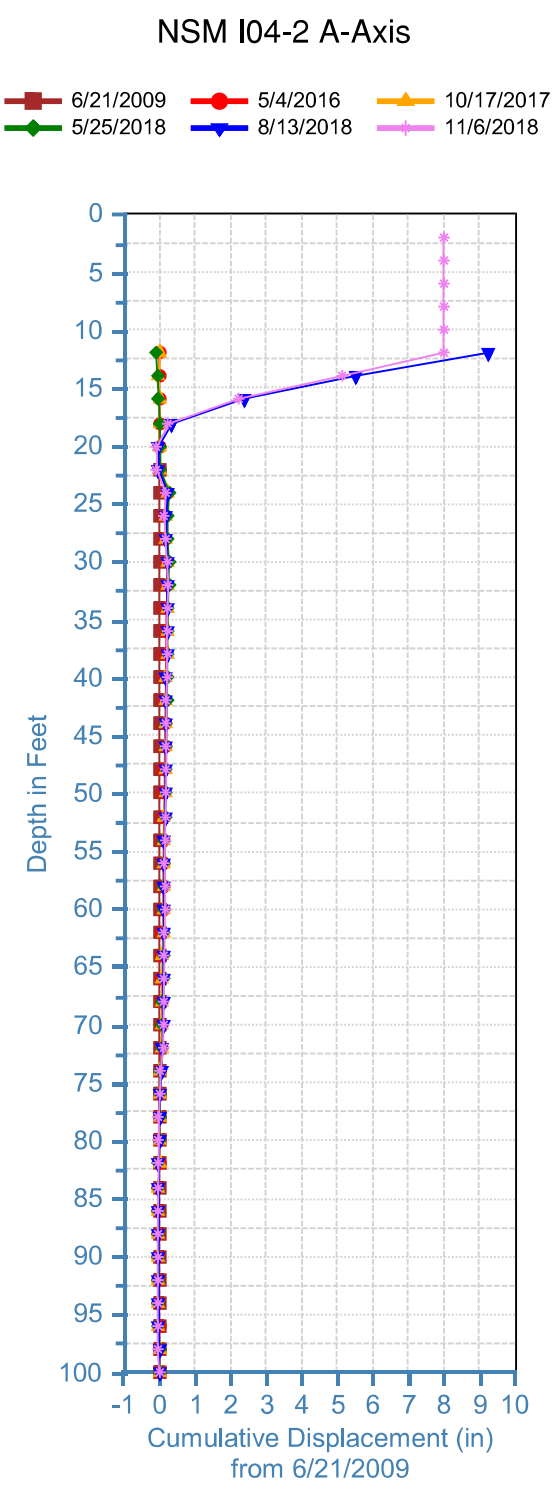


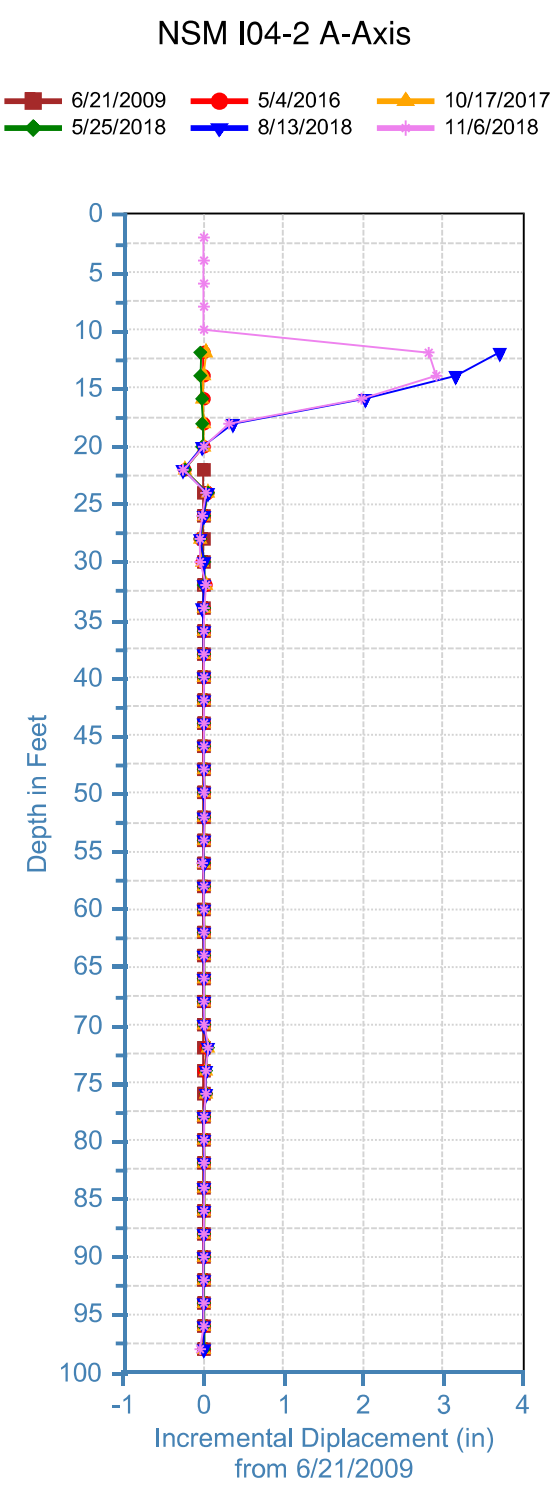
I97-5 - Dam 2 Toe, Sta 42+00
Milepost 7 Tailings Basin Monitoring
Northshore Mining Company
23/38-086
Fall 2018





I10-2 Dam 2 Mid Slope, Sta 42+00
Milepost 7 Tailings Basin Monitoring
Northshore Mining Company
23/38-086
Fall 2018





I04-2 - Dam Mid-Slope, Sta 14+00
Milepost 7 Tailngs Basin Monitoring
Northshore Mining Company
23/38-086
Fall 2018