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Revision Details

Rev No	Date	Section	Page	Revision Description	Prepared by	Reviewed by
1						
2						
3	01/11/2011			This document replaced DSTF OMS Manual Revision 2 prepared by AMEC in December 2007		
4	01/05/2014			Update documents including the information on new diversion ditch construction as built and DSTF closure study		
5	01/01/2017			Update with current 2017-2022 LOM Forecast.		
6	01/01/2018			Updated entire document for consistency with July 2018 Plan of Operations		
6.1	01/01/2019			Reformat to NSR template		
7	06/06/2019			Update with Northern Star name and logo, add DSTF density testing schedule, revise sections 6.0 and 7.0, add in annual diversion ditch walk and groin of the dam seepage inspection		
8	03/18/2020			Updated figures, added information from 2019 Geotechnical Investigation, added section on Low Grade Ore Storage Placement		

Approvals

Action	Name	Position	Signature	Date
Prepared by	Katie Schumacher	Environmental Engineer		3/18/2020
Reviewed by (if applicable)				
Reviewed by (if applicable)				
Reviewed / Approved by	Jill Ladegard	Environmental Manager		

Contents

1. INTRODUCTION

1.1 Objective

Northern Star (Pogo) LLC is the operator of the Pogo gold mine, located 38 miles northeast of Delta Junction, Alaska.

The Dry Stack Tailings Facility (DSTF) has been in operation since February 2006. As of December 2019, approximately 14.9 million tons (Mt) of material was placed on the DSTF. This amount is based on a WingtraOne drone survey completed April 1, 2019 and haul truck load counts. The DSTF was permitted and capacity expanded to 20 Mt by constructing new diversion ditch in September 2013. Currently the DSTF is at approximately 78% capacity.

The DSTF was originally designed by AMEC (AMEC, 2004a), and the Operating, Maintenance and Surveillance (OMS) Manual was issued in January 2006 as a guiding document for the construction of the DSTF. Subsequently, it was revised and issued as revision two in December 2007 (AMEC, 2007). Pogo updated the OMS Manual and issued it as the Construction and Maintenance Plan ("Plan") in November 2011, reflecting the information from DSTF Expansion Preliminary Study (SRK, 2011a) and the field compaction test conducted in March 2011 (SRK, 2011b). Pogo updated the Plan in June 2016, which still includes the as-built design of the diversion ditches (SRK, 2014a), updated stability evaluation (SRK, 2014b), and the DSTF year-by-year plan based on the draft life of mine plan as of end of year 2013. The 2020 Plan update includes information regarding the latest geotechnical investigation completed in October 2019, as well as operation updates related to low-grade ore storage on one of the DSTF shells.

This Plan provides the steps required to construct and maintain the DSTF as designed. It should be noted that the water quality, hydrology, and geochemical monitoring plans are omitted from this Plan and are described in the Pogo Mine Monitoring Plan (Pogo, 2020).

1.2 Document Control and Responsibility

The Environmental Manager is responsible for the preparation and administration of this Plan. Any revisions or updates to the Plan shall be submitted to and approved by Alaska Department of Natural Resources (ADNR).

The Maintenance Manager is responsible for the construction of the DSTF. The site-specific Safe Work Procedure (SWP) *DSTF Tailing and Rock Placement* provides best practices for the placement and management of rock tailing and rock in the DSTF.

The Environmental Manager is responsible for implementing the monitoring and inspection required by this Plan, and report any major changes to DSTF management, construction or maintenance to ADNR and ADEC.

1.3 Acronyms

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
APDES	Alaska Pollutant Discharge Elimination System
ARD	Acid rock drainage
ASTM	American Society for Testing and Materials
CIP	Carbon-in-Pulp
CFS	Cubic Feet per Second
CSP	Corrugated steel pipe
CSR	Cyclic Stress Ratio
CRR	Cyclic Resistance Ratio
DSTF	Dry Stack Tailings Facility
EDMS	Environmental Data Management System
FoS	Factor of Safety
GPA	General Placement Area
HDPE	High-density polyethylene

MDE	Maximum Design Earthquake
OMS	Operating, Maintenance and Surveillance
PGA	Peak Ground Acceleration
PPM	Parts per Million
SWP	Safe Work Procedure
SPT	Standard Penetration Test
RTP	Recycle Tailing Pond
VWP	Vibrating Wire Piezometer
USGS	United States Geological Survey

2. FACILITY DESCRIPTIONS

2.1 Major Components

The major components of the DSTF include:

- Flow-Through Drains,
- Starter Berm and Toe Berm,
- Shell Area,
- General Placement Area (GPA); and
- Diversion Ditch.

2.1.1 Flow-through Drains

All runoff in and around the DSTF is directed to the Recycle Tailings Pond (RTP) by means of a network of drains. Flow-through drains are constructed in the existing stream valleys within the DSTF area to augment the existing drainage courses and allow them to pass runoff under the stack. The drains are extended upstream of the existing stream as the elevation of GPA rises. **Figure 1** shows the general configuration of the DSTF, **Figure 2** shows aerial view of Flow-Through Drains, and **Figure 3** depicts the cross-section of the flow-through drains. The rock fill used in the flow-through drains is between 12 inch and 36 inch in size and covered with filter material to prevent fines from migrating into the dewatered flotation tailings. The flow-through drain filter consists of two layers: Filter 1 and Filter 2. The sand (0.04 inch to 0.2 inch in size) is used for Filter 1, and gravel (0.2 inch to 4 inch in size) is used for Filter 2. The corresponding flow capacity of the flow-through drains are calculated to be approximately 120 times the daily average flow of 0.47 cfs (200 gpm) measured at the Flume 1 on Liese Creek. The flow through drains are designed to the equivalent to a 1:10,000-year/24-hour storm event with no allowance for freeboard and without the diversion ditch (AMEC,2004a).

Figure 1: General Configuration of DSTF as of November 2019

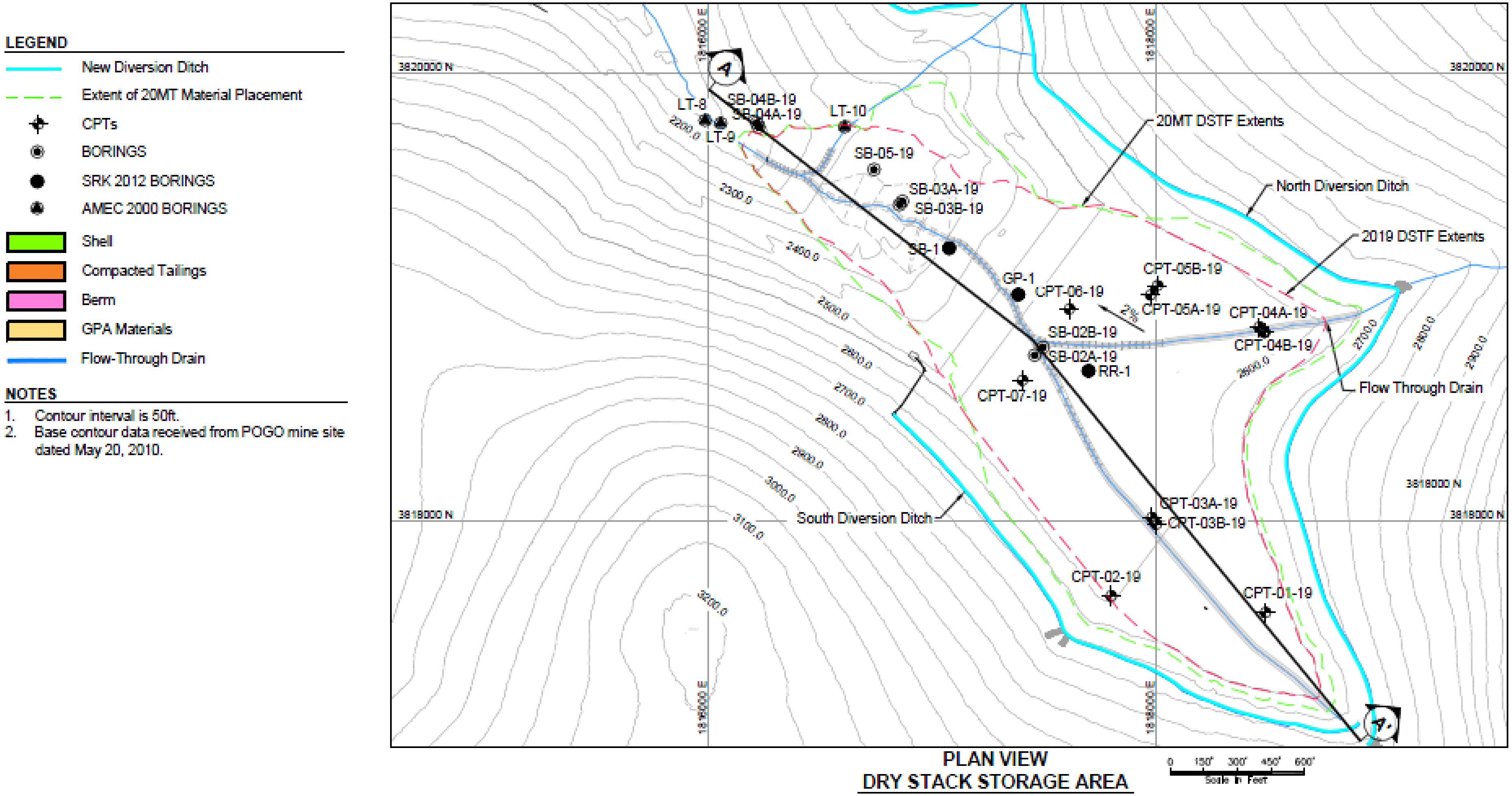

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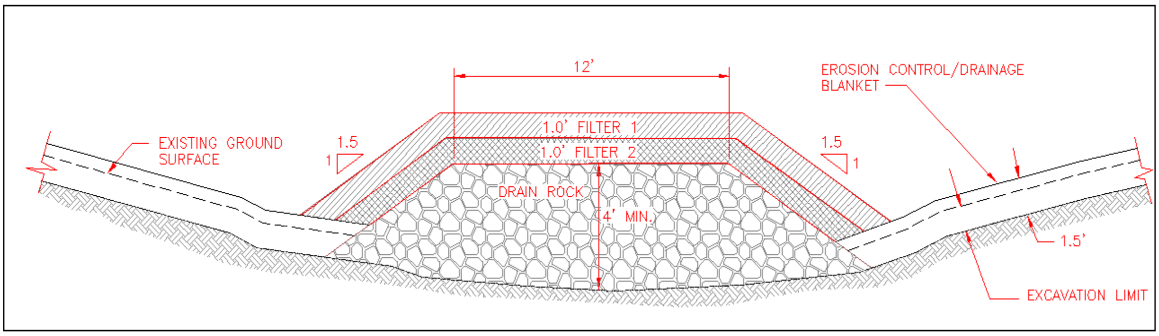
Figure 2: Flow-Through Drain Locations

Figure 3: Typical Cross Section of Flow-Through Drain



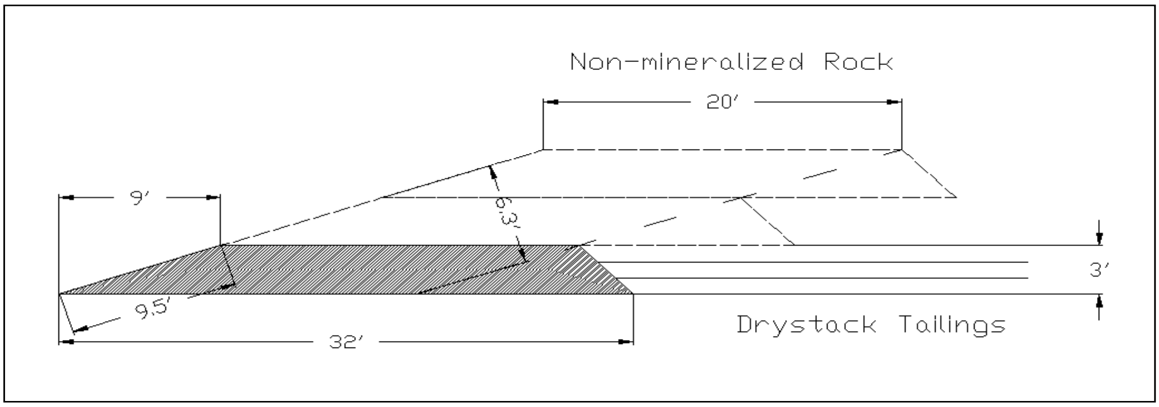
2.1.2 Starter Berm and Toe Berm

The starter berm was constructed as the initial containment for the GPA with the material from nearby colluvium excavations. The toe berm, downstream of the starter berm was constructed of non-mineralized rock and acts as a foundation of the shell area. The toe berm was extended to downstream before the construction of the second and third shell. The starter berm and toe berm are located directly upstream of the DRYTOE, shown in **Figure 2**.

2.1.3 Shell Area

There are three shells on the DSTF. The first shell (Shell 1) was constructed using non-mineralized rock to a width of 100 ft on the 3:1 slope. The haul road has been constructed on the Shell 1. The second shell (Shell 2) and third shell (Shell 3), which was constructed in 2010, and is a composite shell consisting of non-mineralized rock and dewatered flotation tailings. Non-mineralized rock is placed at the face slope to a width of 20 feet, and then the dewatered flotation tailings are placed inside of the non-mineralized rock and compacted (see **Figure 4**). The width of the Shell 2 and Shell 3 is about 180 ft and 150 ft, respectively. Both Shells 2 and 3 have not been completed. They are each approximately 100 feet below the design elevation. These shells will be completed prior to DSTF closure.

Figure 4: Typical Cross Section of Shell 2 and Shell 3



2.1.4 General Placement Area (GPA)

Dewatered flotation tailings and mineralized development rock is co-disposed in the General Placement Area (GPA). The mineralized rock is encapsulated in the tailings to minimize the oxidation of any sulfide minerals present. The mineralized rock may not be placed within 50 ft from the perimeter of DSTF. The non-mineralized waste rock is placed at the perimeter of DSTF to allow any runoff from precipitation that bypasses the diversion ditch above the site to flow into the flow-through drains. The GPA is managed per engineering designs and this Construction and Maintenance plan.

2.1.5 Diversion Ditch

A full description of the diversion ditch is provided in the RTP Operations and Maintenance Manual. The diversion ditch is designed to intercept a one in 200-year, 24-hour precipitation event (4.6 inches within 24 hours). Minimum one foot of freeboard was incorporated into the design. The estimated design flow (200-year, 24-hour precipitation event) for post-expanded conditions calculated by SRK is 78 cfs at Flume #2 (north diversion ditch), 24 cfs at the New South Flume, and 34 cfs at Flume #1 (south diversion ditch), respectively (SRK 2013b).

2.2 Environment Management

2.2.1 Waste Management

The diversion ditch was constructed around the DSTF to divert surface and near surface runoff around the DSTF. The Pogo RTP Dam serves as the impoundment where water can be stored prior to recycling or subsequent treatment and discharge to the environment. The Pogo RTP Dam impounds run off from the DSTF, captures natural flows from the catchment area below the limits of diversion ditch and the DSTF, and collects various plant site contact runoff water. Runoff down gradient of the diversion ditch and DSTF seepage are considered "mine-contacted."

A 20-inch HDPE pipe is connected to a concrete headwall of Flume #1 at the end of south diversion ditch. The 20-inch high-density polyethylene (HDPE) pipe transitions into a 10-foot long section of 24-inch corrugated steel pipe (CSP) with elbow that outfalls into the spillway CSP. The 6-foot diameter half spillway CSP then transitions to 8-foot in diameter. The channel is approximately 600 feet long and subsequently discharges into a rip rap outfall located in a channel that would return flows to Liese Creek in the event of spillway operation. Pogo's RTP Operating and Maintenance Manual further describes water management which enters the RTP from the DSTF.

2.2.2 Sedimentation Control

Flotation tailings erosion translates into a sediment load in the RTP, thus specific sedimentation control measures are used to keep erosion to a minimum:

- The slope of each shell is covered with non-mineralized rock, which minimizes the erosion of dewatered flotation tailings,
- The surface of GPA is designed to maintain a 2% slope to the nearest perimeter of GPA limiting tailings erosion; and
- The materials deposited on the DSTF are compacted as soon as possible.

2.2.3 Dust Control

Tailings have the potential to create dust, especially when they have been frozen or desiccated by the sun. Best management practices are used to control dust during dry stack operations such as; compacting the tailings, controlling traffic on the compacted flotation tailings, and limiting the use of equipment to active placement area(s) only. Summer moisture from rainfall assists in keeping the surface moisture content within an acceptable range although prolonged periods of warm weather with low humidity may require additional stormwater controls.

3. CONSTRUCTION DESIGN CRITERIA

3.1 Placement Schedule

Table 1 shows this placement schedule. However, drilling completed in 2018 and 2019 is expected to significantly increase reserves, leading to a life of mine in excess of 5 years. Major assumptions used for scheduling are as follows:

Assumed material dry densities for scheduling:

- Dewatered flotation tailings (compacted): 105 lb/ft^3 or 19.0 ft^3/ton; and
- Waste rock (compacted): 125 lb/ft^3 or 16.0 ft^3/ton; and
- Approximately 50,000 tons of non-mineralized waste rock (9% of total waste rock) is utilized annually for road construction, underground projects, and where practicable.

APPENDIX III - Drawings 1 - 7 depict projected year-by-year construction for the DSTF between September 2013 and 2019, as calculated in 2013. NSR Surveyors completed a site survey using a WingtraOne drone on April 1, 2019, which indicated that 13.6 M tons of material were contained in the DSTF. Based on truck load counts, a total of 14.9 M tons was placed in the DSTF through 2019, filling 74% of the available capacity. The projected volume for December 2019 is 14.5 Mt.

Table 1: Material Placement Schedule at the DSTF

Year		2006 - 2016	2017	2018	2019	2020	2021	2022	Total
Production									
Ore Milled	ton	-	904,540	901,533	892,451	802,793	751,124	415,196	4,667,637
Waste Rock Excavated	ton	-	711,232	675,720	673,253	683,954	614,593	89,025	3,447,777
Tailings Backfilled in Underground	ton	-	369,687	368,459	364,746	328,103	306,986	169,691	1,907,672
Material Placed at DSTF									
Drystack Tailings	ton	-	534,853	533,074	527,705	474,690	444,138	245,505	2,759,965
Waste Rock	ton	-	711,232	675,720	673,253	683,954	614,593	89,025	3,447,777
Total	ton	-	1,246,085	1,208,794	1,200,958	1,158,644	1,058,731	334,530	6,207,742
Cumulative Tonnage at DSTF									
Drystack Tailings	ton	6,899,750	7,434,603	7,967,678	8,495,383	8,970,073	9,414,211	9,659,716	-
Waste Rock	ton	3,977,831	4,689,063	5,364,783	6,038,036	6,721,990	7,336,583	7,425,608	-
Total	ton	10,877,582	12,123,667	13,332,461	14,533,419	15,692,063	16,750,794	17,085,324	-
Shell Area									
Drystack Tailings	ton	-	-	-	-	-	-	-	-
Waste Rock	ton	-	-	-	-	-	-	-	-
Total	ton	-	-	-	-	-	-	-	-
General Placement Area									
Drystack Tailings	ton	-	534,853	533,074	527,705	474,690	444,138	245,505	2,759,965
Waste Rock	ton	-	711,232	675,720	673,253	683,954	614,593	89,025	3,447,777
Total	ton	-	1,246,085	1,208,794	1,200,958	1,158,644	1,058,731	334,530	6,207,742
End of Year Crest Elevation of GPA	**ft**	**2,571**	**2,585**	**2,598**	**2,611**	**2,623**	**2,635**	**2,639**	

Note: As of 2017, the Pogo life of mine was projected to 2022. The updated life of mine estimate based on drilling completed in 2018-2019 is expected to be finalized in August 2019

Remaining DSTF volume and placement rates for tailings and waste rock were calculated in May 2019. The calculations were based on an aerial survey using a WingtraOne drone dated April 1^{st}, 2019, SRK's final design elevation of 2640 ft, average red rock placement from the past five years, and an assumed 3000 tons of ore milled per day. **Table 2** summarizes these calculations.

Table 2: Dry Stack Placement Rate Estimates

Media	Remaining Volume to EL. 2640 (ft3)	Volume Per Day (ft3)	Tons Per Day (tons)	Annual Placement Quantity (tons)
Green Rock	14,377,874	8,101*	506	185,000
Tails	58,778,683	39,900	2,100	766,500
Red Rock	12,037,007	15,780*	986	360,000

*The green rock estimate is the amount required per day based on tails generated, whereas red rock estimate is based on historic data.

3.2 Tailings Characterization

Laboratory tests of the flotation tailings were carried out in 2009 by Golder Associates. In addition, a compaction test was carried out in March 2011 to evaluate the influence of the frozen flotation tailings on compaction. Compaction tests were completed in 2018 and 2019 by Mappa as an update to in-place density tests and standard proctor test. SRK (2013) and AECOM (2019) conducted additional geotechnical tests using Shelby Tube samples collected from piezometer drill holes. **Table 3** shows the geotechnical properties of flotation tailings obtained by these tests.

Table 3: Geotechnical Properties of Compacted Flotation Tailings

Parameters	Properties	Testing Method	Information Source
2018-2019 Flotation Tailings Compaction Test Results			
Maximum Dry Density	108.7 lb/ft^3	ASTM D6938 In Place Density and Water Content of Soil and Aggregate by Nuclear Methods (Shallow Depth)	2018 Compaction Test
Average Wet Density	119.1 b/ft^3	ASTM D6938 In Place Density and Water Content of Soil and Aggregate by Nuclear Methods (Shallow Depth)	2018 Compaction Test
Average Proctor Value	109.3	ASTM D6938 In Place Density and Water Content of Soil and Aggregate by Nuclear Methods (Shallow Depth)	2018 Compaction Test
Average Percent Density	91.0 %	ASTM D6938 In Place Density and Water Content of Soil and Aggregate by Nuclear Methods (Shallow Depth)	2018 Compaction Test
Maximum Dry Density	109 lb/ft^3	ASTM D698-12 Method A Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort	2019 Standard Proctor Test
Optimum moisture	17.0 %	ASTM D698-12 Method A Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort	2019 Standard Proctor Test
Shear Strength (Saturated)	Effective Friction Angle 34.4 degree(1) Cohesion - 63 psf	Triaxial Compression Test (CU- Test) (ASTM D-4767)	Golder Associates (2009)
Shear Strength (Saturated)	Effective Friction Angle 34.4 - 35 degree(2) Cohesion - 0.7 psf	Triaxial Compression Test (CU- Test) (ASTM D-4767)	SRK (2014)
Shear Strength (Undrained)	Effective Friction Angle 35 degree(3)	Triaxial Compression Test (CU-Test) (ASTM D-4767)	AECOM (2019)
Direct Shear Strength (90% Compaction)	Friction Angle - 37 degree Cohesion – 140 psf	Direct Shear Test (ASTM D-3080)	2011 Compaction Test
Direct Shear Strength (95% Compaction)	Friction Angle - 39 degree Cohesion – 90 psf		
Direct Shear Strength (100% Compaction)	Friction Angle - 41 degree Cohesion – 60 psf		

Hydraulic Conductivity (saturated)	1E-07 m/s	Tri-axial Saturated Hydraulic Conductivity (ASTM D-5084-90) Flexible Wall Permeability (ASTM D-5084-Method C)	Golder Associates in 2009 2011 Compaction Test
Specific Gravity	2.56	ASTM D854-06	2011 Compaction Test
Optimum Moisture Content	15% - 16%	Standard Proctor (ASTM D-698)	2011 Compaction Test

Notes:

1) Dry densities of specimens for triaxial tests were 101 – 102 pcf (93 – 94% of maximum dry density).
2) Triaxial testing indicated the following with respect to excess pore pressure generation in tailings (SRK, 2014b):
   i. For low confining pressures (near 5 psi) the samples under triaxial compression generally seemed to preserve volume with little to no contraction, dilation, or generation of excess pore pressure; and
   ii. At higher confining pressures (over 120 psi), the soil under triaxial compression generally showed an initial contractive behavior (i.e., increasing excess pore pressure) for axial deformations between 2% and 5%, with dilatant behavior (i.e., decreasing excess pore pressure) for higher deformations.
3) Drained friction angle from triaxial tests varied from 35 to 41 degrees. Used the lowest value (35 deg) for the analyses.

3.3 Development Rock Characterization

Development rock is classified as "mineralized" if it contains >600 parts per million (ppm) arsenic or >0.5% sulfur. Mineralized development rock is segregated for long-term storage because of the potential for generating acid rock drainage (ARD) and/or neutral arsenic leaching as a consequence of weathering. The 2019 Pogo Mine Monitoring Plan provides detailed information regarding development rock segregation and tracking procedures.

It is assumed that development rock placed and compacted will have a dry in-place density of approximately 125 lb/ft^3 (2.00 t/m^3). No geotechnical laboratory test was carried out using the development rock. The geotechnical characteristics of the development rock were estimated based on typical published values and engineering judgment for use in design.

3.4 Structural Stability Evaluations

The stability of the 20 Mt DSTF was previously studied by AMEC using the conceptual design (AMEC, 2004a). SRK updated the construction design for the 20 Mt DSTF (see APPENDIX III - Drawing 8), and evaluated its structural stability considering the variability of pseudo-static loadings, phreatic surfaces, and strength parameter (friction angle) of materials (SRK, 2011a). SRK updated slope stability evaluation as a part of DSTF Closure Study, considering the additional geotechnical tests and monitoring information on the phreatic surface obtained from piezometer holes (SRK, 2014b). AECOM updated the slope stability evaluation as part of a geotechnical investigation to determine the feasibility of storing low grade ore on Shell 2 of the DSTF. The geotechnical investigation included both SPT and CPT boreholes, soil sampling and analysis, and installation of two additional piezometers (AECOM, 2019). This section summarizes the results of stability evaluation.

3.4.1 Design Criteria

The design criteria used for the stability analysis were specified in the original design report (AMEC, 2004a). Stability analysis of embankment slopes requires assessment of the structure's ability to withstand the effects of self-weight (static) and earthquake induced (pseudo-static) loading conditions under both operating and closure conditions. In the original design report, it was considered the minimum allowable factor of safety (FoS) under static loading conditions during operations and closure conditions to be 1.5. During pseudo-static conditions, the minimum allowable FoS was selected as 1.1.

3.4.2 Seismic and Excess Pore Pressure Analysis Parameters

Seismic design criteria were developed for the Pogo site during completion of the project's Feasibility Study (Teck-Pogo, 2004) and reiterated in the RTP Dam Design Report (AMEC, 2004b). In summary, the peak ground acceleration (PGA) of 0.2 g (i.e., 20% of acceleration due to gravity) has a recurrence interval of 2,475 years at the site and represents the Maximum Design Earthquake (MDE) for the project (AMEC, 2004b). The PGA was reduced by half to 0.1 g for input to the slope stability model as a horizontal acceleration. The one-half reduction in PGA for slope stability analysis accounts for the duration of ground acceleration necessary to damage earth and rock structures (the PGA is an instantaneous acceleration) as well as the attenuation provided by earth and rock structures (AMEC, 2004b; SRK, 2014b).

Vertical acceleration can be a considerable component of earthquake ground motion, especially near a seismic source. The ratio of peak vertical to peak horizontal ground acceleration generally decreases with increasing distance from the seismic source. Based on engineering judgment and literature review, a vertical ground acceleration 0.7 times horizontal ground acceleration was selected for the sensitivity analysis (AMEC, 2014b).

SRK (SRK, 2014b) evaluated the sensitivity of the pseudo static stability model to excess pore pressure with the B-bar coefficient of the computer program SLIDE (Version 5.026), which can be varied from 0 (no excess pore pressure from vertical stress change) to 1 (excess pore pressure equals vertical stress change). B-bar coefficients of 1 were assumed for the compacted tailings, GPA, and interface materials. B-bar coefficients of 0 were assumed for rock shell and flow-through drain, starter berm and toe berm, overburden, and bedrock materials.

3.4.3 Material Strength Parameters

AMEC (AMEC, 2004a) modeled the shells with moderate shear strength and GPA with no shear strength, whereas SRK (SRK, 2011a; SRK, 2014b) modeled the shells and GPA with moderate shear strengths due to operational compaction of GPA.

AMEC (AMEC, 2004a) reduced the laboratory-obtained shear strength (tangent of effective friction angle) by 20% for use in the slope stability analysis to simulate a "direct shear stress path". SRK (SRK, 2011a) utilized a 20% reduction in effective friction angle to evaluate sensitivity of the slope stability analysis to shear strength.

ADNR questioned the methodology for the shear strength reduction of AMEC (AMEC, 2004a) and considered the effective friction angle reduction of SRK (SRK, 2011a) to be arbitrary. In response to these concerns, Pogo collected geotechnical parameters and samples from the sonic boreholes drilled in the DSTF for laboratory index and shear strength test. In 2019, AECOM performed geotechnical field test and laboratory tests on compacted tailings to provide up to date information on the bulk unit weight, saturated unit weight, and friction angle.

Table 4 summarizes the material parameters used in the stability analysis conducted by AECOM (AECOM, 2019) and SRK (SRK, 2014b).

Table 4: Material Properties Used for Stability Analysis (AECOM, 2019 & SRK, 2014b)

Material	**Bulk Unit Weight** (pcf)[4]	**Saturated Unit Weight** (pcf)[4]	**Friction Angle** (degrees)
Compacted Tailings[1]	125	135	35 (drained and undrained)
General Placement Area[1,2]	118/125	128/135	34
Rock Shell	125	135	38
Flow-through Drain	125	135	38
Starter Berm and Toe Berm	125	130	32
Overburden	125	130	32
Bedrock	156	156	40
Interface [3]	118	128	varies

Notes:

1) Total unit weight of compacted tailings obtained from 2019 geotechnical field tests and laboratory tests.
2) Unit weights were varied between tailings and waste rock values for general placement area (GPA) materials.
3) "Interface" material type created to facilitate analysis of non-circular failure surfaces at boundaries between material types (see Section 2.4). The bulk and saturated unit weights are minimum values for materials present at the interface. The shear strengths are assumed to be the same as the weaker material at the interface.
4) Pounds per cubic foot

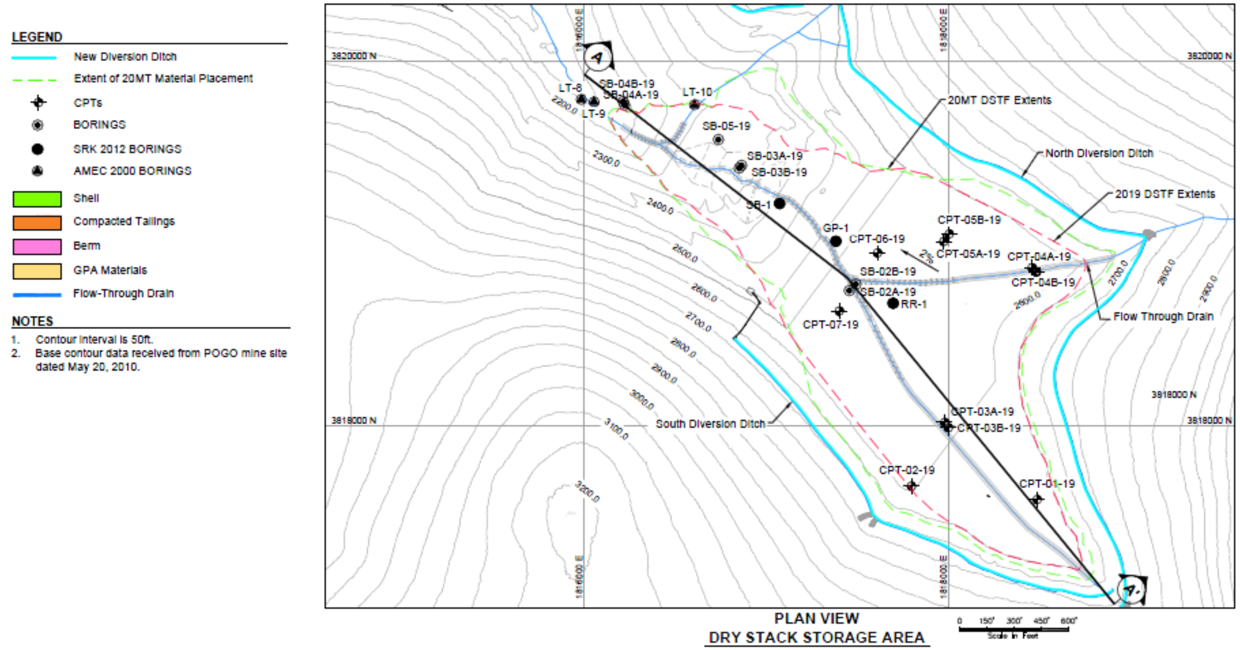
3.4.4 Phreatic Surface

One significant difference among three stability analyses conducted by AMEC and SRK was the assumed phreatic surface:

1) AMEC (AMEC, 2004a) assumed a phreatic surface 10 ft below the original ground surface;

2) SRK (SRK, 2011b) performed a sensitivity analysis, using the AMEC phreatic surface, a phreatic surface at the original ground surface, and a phreatic surface within the DSTF up to 50 ft above the original ground surface.
3) SRK (SRK, 2014b) assumed the phreatic surface presented in Figure 5 based on the following observations:
   i. The SB-1 deep vibrating wire piezometer (VWP) has consistently reported positive pore pressures since shortly after installation in October 2012; pore pressures measured through October 2013 have ranged up to 6 psi, indicating a maximum recorded phreatic surface elevation of 2,317.5 ft. In addition, wet material was encountered in the bottom 5 ft of the SB-1 borehole during drilling in October 2012.
   ii. Water discharges from the flow-through drain at the toe of the DSTF; therefore, the phreatic surface was assumed to project from the measured elevation in SB-1 (at the starter berm) downgradient to the top of the flow-through drain at the DSTF toe.
   iii. Water enters the flow-through drain upgradient of the DSTF. Furthermore, the deep VWP in GP-1 and RR-1 reported negative pore pressures or pore pressures near 1 psi. Therefore, the phreatic surface was assumed to project from the measured elevation in SB-1 upgradient to the flow-through drain and follow the top of the drain upgradient to the highest elevation on the DSTF section.
   iv. Given these observations, the phreatic surface at SB-1 was set to 2,330 ft for this analysis, which corresponds to the crest of the starter berm (from data supplied by Pogo) and is approximately 12 ft higher than the maximum measured pore pressure in SB-1, as of October 22, 2013.
4) AECOM (AECOM, 2019) used static water levels identified in the SRK (2012) investigation for the slope stability analyses during the 2019 geotechnical investigation. An updated plan view and cross section used for the 2019 stability analysis is shown in **Figure 5**.

Figure 5: Updated DSTF Configuration Used for Stability Analysis (AECOM, 2019)

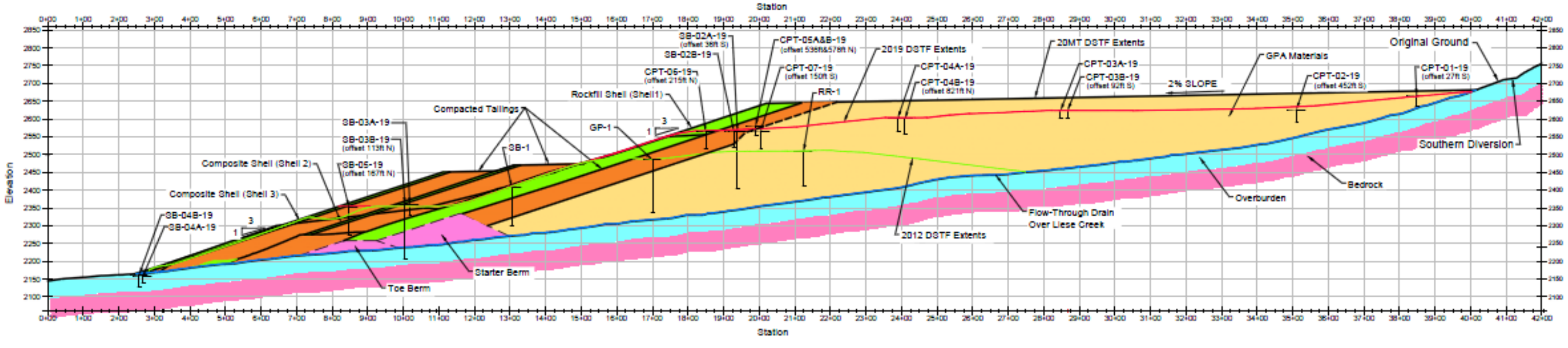


2019 AECOM GEOTECHNICAL CPT & BORING AS BUILT LOCATIONS					
CPT/Boring Id	Easting/X	Northing/Y	Ground Elevation (ft)	Boring/CPT Depth (ft)	Bottom Elevation (ft)
CPT-01-19	1818486.335	3817590.694	2663.5	40.0	2623.5
CPT-02-19	1817796.384	3817665.285	2627.9	35.0	2592.9
CPT-03A-19	1817988.325	3818002.223	2632.8	20.9	2612.0
CPT-03B-19	1817999.719	3817985.786	2632.8	20.6	2612.2
CPT-04A-19	1818470.647	3818857.074	2602.6	36.0	2566.6
CPT-04B-19	1818482.251	3818840.784	2602.6	57.0	2545.6
CPT-05A-19	1817973.776	3819008.832	2580.3	26.6	2553.7
CPT-05B-19	1818003.983	3819049.469	2576.7	27.0	2549.7
CPT-06-19	1817610.974	3818945.597	2563.2	49.3	2514.0
CPT-07-19	1817401.027	3818626.457	2563.2	49.6	2513.6
SB-02A-19	1817454.703	3818738.623	2564.1	161.5	2402.6
SB-02B-19 [1]	1817491.640	3818774.174	2564.2	45.0	2519.2
SB-03A-19	1816850.759	3819411.385	2359.1	29.0	2330.1
SB-03B-19	1816848.946	3819409.351	2359.1	151.0	2208.1
SB-04A-19	1816222.228	3819758.826	2194.2	12.5	2181.7
SB-04B-19	1816230.024	3819759.475	2204.2	33.0	2171.2
SB-05-19 [2]	1816736.496	3819568.109	2351.6	76.5	2275.1

NOTE(S):
1. PIEZOMETER INSTALLED IN SB-02B-19 AT 43 FEET BELOW EXISTING GROUND SURFACE (EL. 2521.2).
2. PIEZOMETER INSTALLED IN SB-05-19 AT 75 FEET BELOW EXISTING GROUND SURFACE (EL. 2276.6).

2012 SRK GEOTECHNICAL BORING AS BUILT LOCATIONS					
CPT/Boring Id	Easting/X	Northing/Y	Ground Elevation (ft)	Boring/CPT Depth (ft)	Bottom Elevation (ft)
SB-1	3819217.00	1817073.00	2408.0	106.5	2301.5
GP-1	3819010.00	1817382.00	2486.0	147.0	2339.0
RR-1	3818669.00	1817696.00	2509.0	97.0	2412.0

2000 AMEC GEOTECHNICAL BORING LOCATIONS					
CPT/Boring Id	Easting/X	Northing/Y	Ground Elevation (ft)	Boring/CPT Depth (ft)	Bottom Elevation (ft)
LT-8	3819217.00	1817073.00	2305.0	14.5	2290.5
LT-9	3819776.00	1816054.00	2150.0	34.5	2115.5
LT-10	3819760.00	1816606.00	2283.0	24.5	2258.5



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FILE NAME: _DSTF GEOTECH BOREHOLE LOCATION.dwg

NORTHERN STAR

Dry Stack Tailings Facility
2019 Geotech Investigation

DATE: DEC 2019 | APPROVED: MS | DRAWING: 03

Prepared by:	Katie Schumacher	Document Status:	Uncontrolled
		Review Date:	06/06/2021
Approved by:	Environmental Manager	Approver's Signature:	Jill Ladegard

Document No:	PGO-ENV-005-PLA
Revision No:	7
Issue Date:	06/20/2020
Page No:	14 of 30

3.4.5 Stability Analysis

SRK performed a slope stability analysis in 2014 using the computer program SLIDE (Version 5.026).

The results of the slope stability analysis are summarized in Table 5 and show that the predicted stability of the critical cross-section satisfies the minimum allowable FoS for both static (1.5) and pseudo static (1.1) conditions. Table 5 shows the lowest FoS resulting from the different material parameters listed in Table 4, analyzed phreatic surfaces in Figure 5, and seismic/excess pore pressure parameters. Results of the analysis show minimal sensitivity of the pseudo static model to vertical acceleration or excess pore pressure, i.e., less than 5% difference in FoS relative to scenarios with horizontal acceleration only and drained conditions (SRK, 2014b).

Table 5: Results of DSTF Slope Stability Evaluations, SRK 2014

Section A-A'	Circular Failure Surface		Noncircular Failure Surface	
	FoS -Static	FoS - Seismic	FoS - Static	FoS -Seismic
Circular Failure	1.77	1.22	--	--
Block Failure Plane 1	--	--	2.40	1.72
Block Failure Plane 2	--	--	2.14	1.56
Block Failure Plane 3	--	--	2.02	1.47
Block Failure Plane 4	--	--	2.21	1.50

AECOM (AECOM, 2019) completed an updated stability analysis for the following configurations:

- Existing 2019 condition
- Existing 2019 condition on the bench and 20 MTon extents at the top of the DSTF
- Temporary Ore on Shell 2 and 2019 conditions at the top of the DSTF
- Temporary Ore on Shell 2 and 20 MTon extents at the top of the DSTF

Stability analyses show that the calculated FS meets or exceeds the required FS for static and pseudo-static. The approach was consistent with AMEC (2004a) and SRK (2014). Results of the slope stability analyses are provided in Table 6.

Table 6: Results of DSTF Slope Stability Evaluations, AECOM 2019

Analysis Case	FoS -Static	FoS – Pseudo-static
Existing 2019 condition	1.82	1.29
Existing 2019 condition on the bench and 20 Mt extents at the top of the DSTF	1.82	1.27
Temporary ore on Shell 2 and 2019 conditions on the top of the DSTF	1.82	1.28
Temporary ore on Shell 2 and 20 Mt on top of the DSTF	1.82	1.27

3.4.6 Liquefaction Analysis

SRK (SRK, 2014b) conducted the liquefaction analysis using a simplified procedure published by Youd *et al* (2001). The simplified procedure to evaluate the liquefaction resistance of soils requires two variables: (1) the seismic demand on a soil layer, termed the cyclic stress ratio (CSR); and (2) the capacity of the soil to resist liquefaction, termed the cyclic resistance ratio (CRR). The FoS against liquefaction can be obtained by dividing CRR by CSR. CSR is a function of peak horizontal acceleration at the ground surface, total vertical overburden stress, effective vertical overburden stress, and the sample depth.

The simplified procedure using standard penetrating test (SPT) data was adopted to determine CRR in the liquefaction analysis for the Pogo DSTF materials. The potential for liquefaction can exist only when loose, granular soil is saturated and subjected to vibration, e.g., earthquake ground motions. Among the soil samples collected from the three boreholes drilled in the 2012, only one sample, which was approximately 97 ft below ground surface (bgs) at SB-1, was below the established water table and was therefore used for liquefaction analysis. The result of the liquefaction analysis indicates the sampled soil from SB-1 has a FoS of 2.3 against liquefaction. Given the scope of observations in this study and the results of this analysis, liquefaction of the DSTF materials during the Maximum Design Earthquake (MDE) is considered unlikely.

AECOM (AECOM, 2019) conducted a liquefaction analysis for the DSTF tailings and overburden soils in 2019 using LiqSVs V.2.0.1.8 software. Seismic liquefaction of the DSTF tailings was performed on subsurface data from boring SB-1 and SB-03B-19, which was drilled in the 2019 geotechnical investigation. The subsurface data from SB-03B-19 between 75 and 100 ft bgs was used. Both seismic and static liquefaction of the DSTF tailings is considered unlikely. The potential for liquefaction of the underlying overburden soils was reviewed as part of evaluating the overall stability and safety of the DSTF. The overburden material information from SB-03B-19 below 110 feet bgs was used for static and seismic liquefaction review of the underlying overburden soils. Based on the available information, static liquefaction was deemed unlikely. Based on field observations, overburden samples are not likely prone to seismic liquefaction; however, AECOM recommended the seismic liquefaction analyses for the underlying overburden soils be updated with additional information.

4. COMPACTION TESTING

In order to evaluate the effectiveness of compaction and to establish appropriate compaction procedures, testing is routinely conducted. Additional details related to compaction testing methodology and results are available in Appendix V.

4.1 Major Findings from Compaction Test in March 2011

This section summarizes the major findings obtained from the compaction test conducted in March 2011.

- Dewatered flotation tailings can be placed in the DSTF within the limits of both GPA and Shell during winter conditions once the appropriate construction procedures are consistently followed.
- Adequate shear strength which exceeds the design criteria can be developed in the dewatered flotation tailings at 90% Standard Proctor compaction.
- To achieve 90% Standard Proctor compaction effort during winter/freezing conditions, dewatered flotation tailings should be spread within three days of placement and compacted with a minimum of four passes using a 12-ton compactor.

4.2 Compaction Test Results 2018

Mappa Inc. conducted an ASTM D6938 In-Place Density and Water Content of Soil and Soil Aggregate by Nuclear Methods (Shallow Depth) Test of the DSTF in June 2018. The results from the density and moisture content testing are found in **Appendix V**.

5. CONSTRUCTION PROCEDURES

5.1 General Placement Area

Materials are placed on the GPA year-round. This section describes the construction procedures for the GPA including Shell 1 and associated structures.

5.1.1 Shell 1 Construction

The first shell (Shell 1) has been constructed using non-mineralized rock since the commencement of operation. Shell 1 has a width of 100 ft on a 3:1 slope. Non-mineralized rock is dumped and spread into 3-ft loose lift. Then the lift is compacted with three passes of a D7 Dozer. A width of 100 ft of tailings is placed behind Shell 1 to encapsulate mineralized rock in the GPA.

A temporary single lane haul road may be constructed on the slope of Shell 1.

5.1.2 Flow-through Drain and Perimeter Preparation

The flow-through drain along the creek will be extended upward as necessary. The specifications of the flow-through drain are described in Section 2.1.1.

The trees, shrubs, and topsoil along the perimeter of DSTF are removed and non-mineralized rock is placed on the slope surface at a thickness of approx. 1 ft. This layer works as water drainage to route the run-off water on the GPA into the flow-through drain.

5.1.3 Dewatered Flotation Tailings Placement

The drystack tailings are dumped 15 ft apart, then spread into a maximum 12 in loose lift. To ensure workability of the surface, the GPA will be compacted with methods similar to those used on the shells.

Operation during Winter Conditions

During winter season (October to May), some additional work is required:

- Windrows of drystack tailings have to be dozed down and spread within three days; and
- The placement area needs to be regularly cleared to prevent build-up of snow and ice.

Operation in Wet Conditions

During rainy periods, the drystack tailings may become difficult to compact if water is allowed to infiltrate. In order to minimize the adverse effect on compaction, the following actions may be taken:

- Keep tailings placement area as small as possible;
- Prior to placement of tailings in this small area, the saturated and softened surface will be scraped off;
- If the tailings cannot be compacted immediately, then they will not be spread at all, but left in a pile. If the tailings remain in a pile, the rain will generally only penetrate the outer shell of the pile; and
- Once drystack tailings placement in the area is complete, the tailings surface will be smooth, free of water traps, and graded to allow water to run off the surface.

5.1.4 Mineralized Rock Placement

The mineralized rock requires encapsulation in the dewatered flotation tailings with the following procedures applied:

- The mineralized rock may not be placed within 50 ft from the perimeter of the DSTF,
- The mineralized rock is placed in piles and spread into 3-foot loose lifts and compacted; and
- Once three lifts are placed, the mineralized rock will be covered with two one-foot dewatered flotation tailings layers before placing another lift of mineralized rock.

5.2 Shell Area

This section describes the construction procedures for Shell 2 and Shell 3 which consist of non-mineralized rock and dewatered flotation tailings.

5.2.1 Construction Period

The previous DSTF OMS Manual (AMEC, 2007) prescribed that the Shell would be constructed during a typical four-month summer construction period. However, a compaction test conducted in March 2011 confirmed that the dewatered flotation tailings can be compacted appropriately during winter / freezing conditions once the appropriate construction procedures are consistently followed. Therefore, shells are constructed year-round. Construction on Shells 2 and 3 is not presently occurring and will be completed to the design height prior to closure of the DSTF.

5.2.2 Flow-Through Drain and Toe Berm

The flow-through drain and toe berm for the Shell 2 and Shell 3 have already been constructed. In case an additional shell will be constructed, the flow-through drain and toe berm will be sufficiently advanced. The specifications of the flow-through drain are described in Section 2.1.1.

The toe berm is constructed using non-mineralized rock and acts as a foundation for the shell.

5.2.3 Shell Construction Procedures

Shell 2 and Shell 3 consist of compacted dewatered flotation tailings and non-mineralized rock placed on the slope surface of the shells. The construction procedures for these shells are as follows:

- Non-mineralized rock is used to form the crest of the shells. Non-mineralized rock is dumped on the slope side of the shells and then spread into 3-ft loose lift. Compaction then proceeds with a minimum of 4 passes of a compactor or three passes of a D7 dozer. The crest of non-mineralized rock will have a width of 20 ft on the 3:1 slope; and
- The dewatered flotation tailings are dumped 15-ft apart within the crest, and then spread into maximum 12-inch loose lift. Compaction then proceeds with a minimum of six passes of a smooth drum roller having a minimum 12-ton equivalent weight. Though adequate shear strength can be developed in the dewatered flotation tailings with a minimum of four passes compaction, six passes compaction is applied for Shell construction to minimize the variability of operation.

Shell construction will resume prior to closure of the DSTF.

Operation during Winter Conditions

During winter season (October to May), some additional work is required due to the effect of freezing temperatures on the efficacy of tailings and non-mineralized rock compaction. Current and forecasted temperatures should be considered when depositing windrows and scheduling dozing and compaction. Additionally, the placement area should be managed to clear snow and ice.

Operation in Wet Conditions

During rainy periods, the dewatered flotation tailings and non-mineralized rock may become difficult to compact to achieve the target density. In order to minimize the adverse effect on compaction, the following actions may be taken:

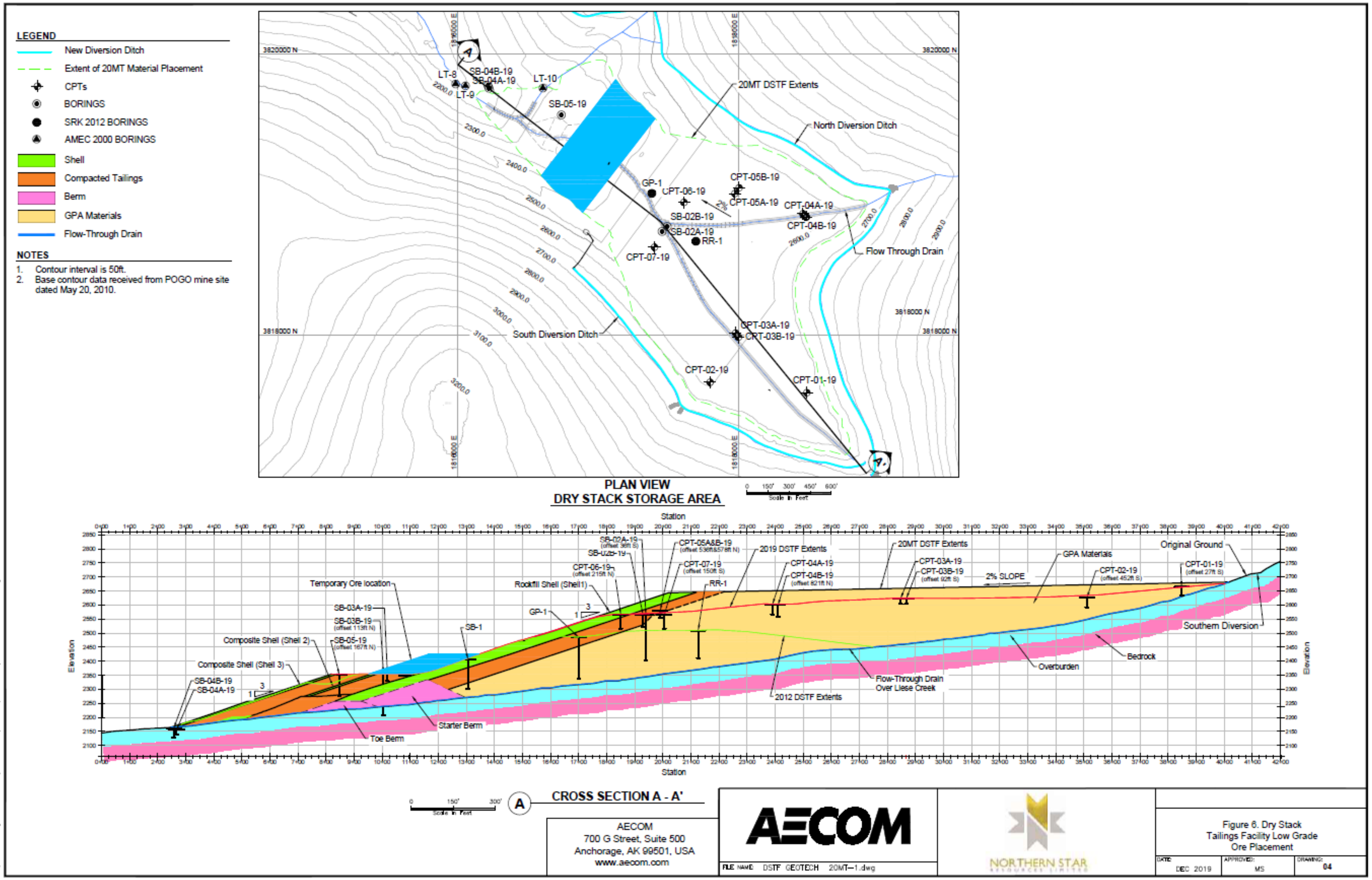
- Prior to placement of drystack tailings, the saturated and softened surface will be scraped off;
- Windrows of dewatered flotation tailings and non-mineralized rock have to be dozed down and compacted as soon as possible; and
- If the amount of rainfall begins to reach extreme levels (more than 0.5 inches in 24 hours), placement of dewatered flotation tailings in the shell area may be suspended.

5.3 Low Grade Ore Placement

Based on a geotechnical investigation in October of 2019 (AECOM, 2019), it was determined that low-grade (LG) ore can be safely placed on Shell 2 up to a total of 1.0 MTon, as shown in Figure 6.

The height and tonnage of ore placed will be monitored and reported daily by the Surface Department to ensure that the calculated safe capacity is not exceeded. Temporary ore should be end dumped off the haul trucks and spread by a bulldozer in three-foot maximum high lifts to eliminate the potential for large voids in the temporary ore. Slopes will mirror the existing slopes of Shell 1 (3H:1V). Surface drainage will be managed by excavating any wet or soft spots and monitoring for ponding. If ponding is occurring, any wet spots will be removed. The area will be sloped to collect water along the west down-slope edge. Accumulation will be reviewed during the daily facility inspections completed by the surface operators.

Figure 6: DSTF Low Grade Ore Placement (AECOM, 2019)



6. MONITORING

6.1 Geotechnical Monitoring

The compaction of dewatered flotation tailings at the shells is important for overall stability of the DSTF and to ensure volume capacity. The construction procedures for the GPA and Shells aim to compact the dewatered flotation tailings to achieve a nominal 90% Standard Proctor of the dry density to secure the designed shear strength.

6.1.1 Geotechnical Monitoring for Shell Construction

During construction of Shell 2 and Shell 3, the QA/QC program shown in Table 8 is implemented.

The location of densometer readings and grab samples were documented using handheld GPS, indicated on a site plan, and included with the data collected for the QC program. When QC testing was completed by an independent third-party technician and soils testing laboratory, only the sand cone testing indicated in the proposed QA plan was completed at a frequency of every 80,000 tons of placed and compacted tailings. When QC testing was completed by Pogo personnel, QA testing was carried out by an independent certified technician and soils testing laboratory. The results of geotechnical monitoring were recorded using the data sheet shown in Appendix I.

In case the average of in-situ dry densities was less than the target (90% of Standard Proctor), that layer of dewatered flotation tailings was re-compacted until the target dry density will be achieved.

Table 8: Geotechnical Monitoring Items

QA/ QC	Test Description	ASTM Method	Test Frequency	Test Procedures	Target
Quality Control Program	In-situ Nuclear Densometer	D6938-10	Quarterly (when above freezing)	Performed on material placed and compacted in all areas within 24 hours prior to test day. Maximum testing spacing of 30 ft to a target depth of 12 inches. Test density results should be reported in pcf and moisture content in %. Compare results to laboratory Standard Proctor test results.	Avg. Density of 98.1 pcf or 90% Standard Proctor
	Standard Proctor	D698-07		Completed for three equally spaced grab samples from each test area.	N/A
	Moisture Content	D2216		Completed for three equally spaced grab samples from each test area.	N/A
	Grain Size Distribution	D422		Completed for three equally spaced grab samples from each test area.	Verify tailings consistency
Quality Assurance Program (1)	In-situ Nuclear Densometer	D6938-10	Annual	Performed on material placed and compacted in all areas within 24 hours prior to test day. Maximum testing spacing of 30 ft to a target depth of 12 inches. Test density results should be reported in pcf and moisture content in %. Compare results to laboratory Standard Proctor test results.	As above
	Sand Cone Test	D1556-07		One test for every ten densometer tests completed.	Consistency with ASTM D6938-10 results
	Standard Proctor	D698-07		Completed for three equally spaced grab samples from each test area.	As above
	Moisture Content	D2216		Completed for the three samples collected for the Proctor test.	As above
	Grain Size Distribution	D422		Completed for the three samples collected for the Proctor test.	As above

(1) If QC is performed by a contractor, QA is not necessary

6.2 Annual Survey

A detailed survey of the DSTF will be conducted annually when temperatures are above freezing. The survey should document elevation and horizontal extent at each end of the front of the working area, as well as the intersection of the DSTF with the North and South forks of Liese Creek. The survey data will be compared with the year-by-year plan. If a significant discrepancy is identified, the plan may be updated accordingly.

6.3 Vibrating Wire Piezometers

In October of 2012, a subsurface investigation of the DSTF was performed to evaluate the geotechnical, thermal, hydrogeological, and geochemical characteristics of the facility (SRK, 2014c). Three sonic boreholes (SB-1, GP-1, and RR-1) were vertically drilled in the following locations:

- Immediately up-gradient of the starter berm (SB-1),

- In a portion of the GPA where tailings was expected to comprise a significant fraction of the stratigraphy (GP-1); and,
- In a portion of the GPA where mineralized red rock was expected to comprise a significant portion of the stratigraphy (RR-1).

In October of 2019, AECOM performed a geotechnical investigation on the DSTF that included installation of two more piezometers (AECOM, 2019). These piezometers are in the following locations:

- Immediately up-gradient of the green rock shell between GP-1 and RR-1 (SB-02A-19)
- In the center of Shell 2 (SB-05-19)

RST vibrating wire piezometers (VWP) are installed in each borehole to evaluate the presence and extent of saturated zones within the DSTF and to monitor changes in pore pressure. DSTF temperatures are also measured using thermistors located within each VWP sensor. The installation depth of each sensor is shown in Figure 7 and presented in Table 9, Summary of Vibrating Wire Piezometer Installation.

Piezometer data should be downloaded quarterly and datalogger batteries should be checked annually.

Table 9: Summary of Vibrating Wire Piezometer Installation

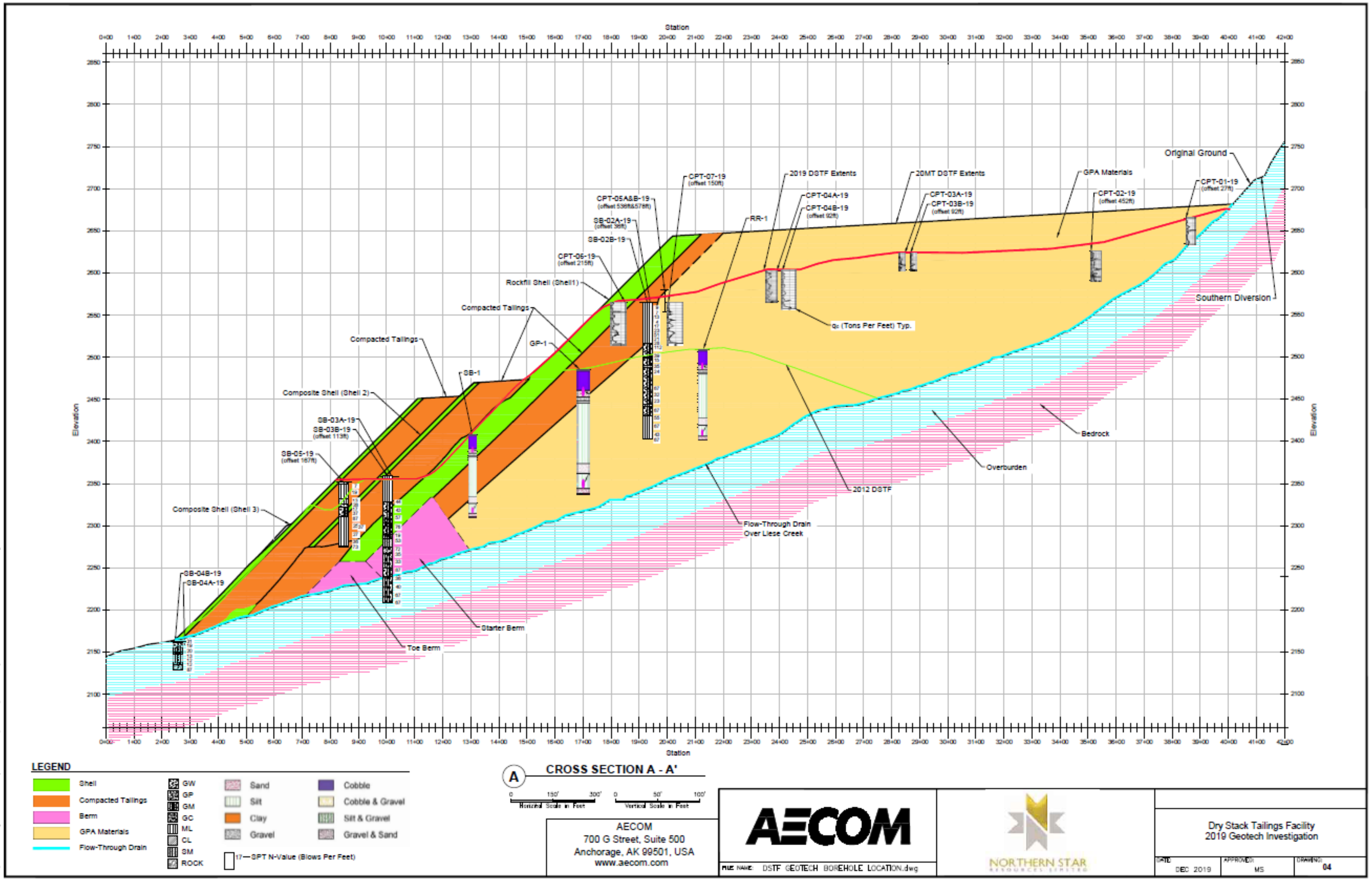
Drill hole	Drilled Depth (ft)	Details of Vibrating Wire Sensor		
SB-1	106.5	Depth: 25 fbgal* Elev. 2383 ft Range: 0.7 Mpa Vibe wire SN: VW22850 Datalogger SN: 2639 Logger channel: VW2, Therm 2	Depth: 104.5 fbgl Elev. 2303.5 ft Range: 0.6 Mpa Vibe wire SN: VW22851 Datalogger SN: 2639 Logger channel: VW1, Therm 1	
GP-1	147	Depth: 63 fbgl Elev. 2423 ft Range: 0.7 Mpa Vibe wire SN: VW22852 Datalogger SN: 2640 Logger channel: VW1, Therm 1	Depth: 137 fbgl Elev. 22349 ft Range: 0.7 Mpa Vibe wire SN: VW22853 Datalogger SN: 2640 Logger channel: VW2, Therm 2	
RR-1	97	Depth: 2 fbgl Elev. 2507 ft Range: 0.7 Mpa Vibe wire SN: VW23152 Datalogger SN: 2640 Logger channel: VW5, Therm 5	Depth: 61 fbgl Elev. 2448 ft Range: 0.7 Mpa Vibe wire SN: VW22854 Datalogger SN: 2640 Logger channel: VW3, Therm 3	Depth: 94 fbgl Elev. 2415 ft Range: 0.7 Mpa Vibe wire SN: VW22855 Datalogger SN: 2640 Logger channel: VW4, Therm 4
SB-02A-19	45	Depth: 43 fbgl Elev. 2521.2 ft Range: 0.7 Mpa Vibe wire SN: VW61721 Datalogger SN: 2639 Logger channel: VW3, Therm 3		
SB-05-19	76.5	Depth: 75 fbgl Elev. 2276.6 ft Range: 0.7 Mpa Vibe wire SN: VW61721 Datalogger SN: 10065 Logger channel: VW1, Therm 1		

Note: 1 *fbgl – feet below ground level.

6.4 Reporting

The results of the monitoring described in this section will be compiled and retained for future reviews and permitting as required.

Figure 7: As-Built Borehole and Vibrating Wire Piezometer Locations (AECOM, 2019)



7. INSPECTION

7.1 Weekly Inspection

Environmental personnel will conduct visual inspection of the DSTF on a weekly basis. Environmental personnel will look for any unusual physical conditions paying particular attention to:

- Any ponding of water on DSTF,
- Water flow into and out of the DSTF,
- Evidence of deformation on the slope of the shell; and
- Evidence of excessive erosion or seepage of the slope of the shell.

The results of inspections will be documented using the designated form (see **Appendix II**) and recorded into the INX Database. If any unusual situation is found, it will be reported to the Maintenance and Environmental Managers. The Environmental Department retains records for monitoring activities described in this document. Data are retained in the environmental G:/ drive under the monitoring subfolders, or in Pogo's INX InControl database.

7.2 Daily Inspection

Surface personnel conduct a visual inspection of the DSTF on a daily basis. Surface operators check for unusual cracks, bulging, signs of settlement, seepage, erosion, and wildlife interaction. The results of these inspections are recorded in the Dry Stack Daily Inspection Log, located on NSR's server.

7.3 Upset Condition Inspection

The DSTF will be inspected by Environmental personnel after extreme rainfall (recommended two inches within 24 hours) or an appreciable earthquake (reported in the area or felt by site personnel).

7.4 Annual Ditch and Dam Groin Inspection

The North and South Diversion ditches are included in the weekly inspection. In addition to the weekly inspection, Environmental personnel will walk the ditches to look for failures. This inspection will take place in early summer.

Once a year, the groin of the dam will be evaluated for seepage. This inspection will occur during summer months.

8. REFERENCES

- AMEC, 2004a, Drystack Tailings Facility Geotechnical Design Report.
- AMEC, 2004b, RTP Dam Design Report.
- Teck-Pogo, 2004, Pogo Project Final Feasibility Study
- AMEC, 2006, RTP Dam 2004-2005 As-built Report
- AMEC, 2007, Pogo Mine Drystack Tailings Facility OMS Manual – Revision Two.
- SRK, 2011a, Pogo Drystack Tailings Facility Expansion Preliminary Study.
- SRK, 2011b, Pogo Mine – Findings of Winter Field Program and Preliminary Recommendations for Dry Stack Storage Facility Construction and QA/QC Procedures.
- Pogo, 2018, Pogo Mine Monitoring Plan.
- SRK, 2013a, South Diversion Flume, As-Built Hydraulic Capacity.
- SRK, 2013b, DSTF Diversion Ditches Design Calculations
- SRK, 2014a, Dry Stack Tailings Facility Expansion – Final As-Built Report for Diversion Channels.
- SRK, 2014b, DSTF Closure Study – Slope Stability Analysis.
- SRK, 2014c, DSTF Closure Study – DSTF Vibrating Wire Piezometers.
- AECOM, 2019, 2019 Geotechnical Investigation Temporary Ore Storage and Future Expansion Dry Stack Tailings Facility, Pogo Mine, Alaska

9. RELATED DOCUMENTS

Document Name	Document Number
DSTF Density Testing	PGO-ENV-003-SWP
DSTF Tailing and Rock Placement	PGO-ENV-025-SWP
DSTF Piezometer Data Downloading and Compiling Manual	PGO-ENV-002-SWP
Pogo Mine Monitoring Plan	PGO-ENV-011-PLA

10. APPENDICES

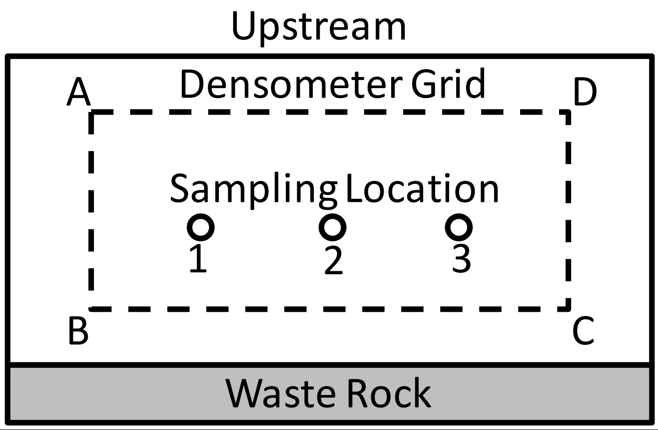
APPENDIX I – DSTF Shell Geotechnical Monitoring Data Sheet
APPENDIX II – Weekly Inspection Form
APPENDIX III – Drawings
APPENDIX IV – Compaction Test March 2011

10.1 APPENDIX I – DSTF Shell Geotechnical Monitoring Data Sheet

Date Tested		Reported by	
Shell No.		Elevation (ft)	
Date Compacted			

GPS Coordinates (degree)		
Nuclear Densometer Grid		
A	N:	W:
B	N:	W:
C	N:	W:
D	N:	W:
Sampling Location		
1	N:	W:
2	N:	W:
3	N:	W:

Map



Moisture Content / Standard Proctor Test (Three samples per monitoring)				
Sample No.	**1**	**2**	**3**	**Average**
Moisture Content (%)				
Maximum Dry Density (pcf)				
Optimum Moisture Content (%)				

Nuclear Densometer (30 ft grid, Target Depth: 12 inch)			
Number of measurements			
Items	**Minimum**	**Maximum**	**Average**
Moisture Content (%)			
Dry Density (pcf)			
% of Standard Proctor			

Sand Cone Test (One test for every ten densometer measurements) (QA Program)							
Test Hole No.	**1**	**2**	**3**	**4**	**5**	**6**	**Average**
Moisture Content (%)							
Dry Density (pcf)							

10.2 APPENDIX II – Weekly Inspection Form (INX)

Reference No: 80285

Inspections - Pogo Checklist

PGO - ENV - RTP Dam & Dry Stack Weekly Inspection - PGO - ENV - RTP Dam & Dry Stack Weekly Inspection

Prompt	Yes	No	N/A	Explanation	Comments
Seepage Collection Wells	☐	☐	☐	Are all pumps running in Auto Mode? Do the well motor speeds and water levels indicate that the wells are working properly?	
RTP Dam	☐	☐	☐	Are dam faces free of vegetation, erosion, collapse, subsidence? Is downstream dam free of seepage? Is dam crest free of subsidence and damage to facilities? Are reservoir walls free of erosion and collapse?	
Spillway Inlet (Concrete) and Outfall (Flume)	☐	☐	☐	Is spillway inlet (concrete) free of cracks and properly connected to flume (culvert)? Is spillway outfall (flume) free of damage, obstacles and erosion on the ground?	
Drystack	☐	☐	☐	is the dry stack free of unusual cracks and signs of settlement? is the dry stack free of bulging and seepage? Is the dry stack free of erosion, rills, and gullies? Are 2% slopes being maintained?	
Diversion Ditches - North, South (Upper), South (Lower) – to be completed monthly	☐	☐	☐	Are Diversion ditch flumes free of obstacles and damage? Are diversion ditches free of erosion, sediment accumulation, aufeis, obstacles, and damage?	

30/09/2019 12:57:18AM *inControl - Event Checklist* *Page 1 of 1*

10.3 APPENDIX III – Drawings

Drawing 1: DSTF Plan and Section September 2013 As-built

Drawing 2: DSTF Plan and Section End of 2014

Drawing 3: DSTF Plan and Section End of 2015

Drawing 4: DSTF Plan and Section End of 2016

Drawing 5: DSTF Plan and Section End of 2017

Drawing 6: DSTF Plan and Section End of 2018

Drawing 7: DSTF Plan and Section End of 2019

Drawing 8: DSTF 20Mt Facility

10.4 APPENDIX IV – Compaction Test March 2011

The previous DSTF OMS Manual describes that "windrows of tailings have to be dozed down and spread within 1 hour" during winter conditions. However, it is not practical to implement this rule.

In order to evaluate the influence of frozen dewatered flotation tailings on the compaction and to establish appropriate compaction procedures during winter season, a compaction test was conducted in March 2011. A technical memorandum was provided by SRK (SRK, 2011b). This section summarizes the results of this test.

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Methodology

Four different scenarios were tested on site to assess the potential impact of time lags between the dumping of tailings material into heaps on the surface of the DSTF and subsequent spreading of that material under freezing conditions. The four-time lags tested were 1, 2, 3, and 7 days between the time tailings were dumped on the surface of the DSTF and when material was spread into one-foot thick lifts and then compacted with a vibratory roller. Air temperature measured during the test period was between -9- and 27-degrees F.

At each site when the specified time had elapsed dumped materials were spread using a CAT D7 track type dozer to create a one-foot thick lift that was approximately 30 ft by 60 ft. Each pad was then subjected to three different of compaction passes (four, six and eight passes) with a CAT CS 563 vibratory compactor (approximately 12 tons operating weight).

The following field measurements and laboratory tests were conducted:

- Soil temperature measurements using a handheld infrared gauge;
- In-situ density and water content measurements using nuclear densometer (ASTM D6938-10),
- Sand cone test (ASTM D1556-07),
- Standard Proctor (ASTM D698-07),
- Moisture content (ASTM D2216); and
- Direct shear test (ASTM D3080).

Results

Soil Temperatures and Frost Penetration

Table 10, Summary of Soil Temperatures of Dumped Tailings Piles summarizes the soil temperature recorded on site. Measured soil temperatures indicate increased frost penetration depth with increased exposure time to freezing conditions. Frost penetration depth ranged from approximately 3 inches from the surface of dumped tailings piles after one day exposure to depths in excess of 3 ft in material heaped for the seven-day test. After seven days it is estimated that up to two-thirds (by volume) of tailings material dumped is frozen.

Table 10: Summary of Soil Temperature of Dumped Tailings Piles

Trial	Surface Temp (°F)	3' Depth Temp (°F)	5' Depth Temp (°F)
1 Day Trial	31	72	n/a
2 Day Trial	15	36	n/a
3 Day Trial	10	35	42
7 Day Trial	7	30	n/a(1)

Note: *(1) Completely frozen at depth and unable to excavate for temperature measurement.*

Material Properties and Field Density Measurements

Table 11, Laboratory Test Results-Material Properties, summarizes the material properties of tailings material placed during the test program. The results show the specific gravity and Standard Proctor values are very consistent and indicative of a well-controlled process in which the filtered tailings are produced. Moisture content results near the surface of dumped tailings steadily decreased with increased exposure time.

Table 12, Field Density Measurements, summarizes field density testing results from the nuclear densometer. It indicates a general trend of increasing in situ density as the number of compaction passes increased. Nuclear densometer results also show that compacted density achieved tended to decrease with increasing exposure time. Table 11 shows that the heaps exposed three days or less meet 90% Standard Proctor with a minimum four compaction passes, and one day and two days duration heaps meet 95% Standard Proctor with a minimum six compaction passes.

Table 11: Laboratory Tests Results – Material Properties

Trial	Moisture Content			Specific Gravity	Standard Proctor	
	Surface	6" below surface	3' below surface		Maximum Dry Density (pcf)	Optimum Moisture Content (%)
1 Day	17.9	n/a	17.9	2.56	109.3	15.0
2 Days	20.2	n/a	17.7	2.56	109.3	15.3
3 Days	13.9	16.5	17.2	2.54	109.3	15.7
7 Days	10.5	19.7	16.8	2.55	107.9	16.3

Table 12: Field Density Measurements

Duration of Pile Exposure	Compaction Effort Trial	Nuclear Densometer		% to Maximum Dry Density
		Density (pcf)	Moisture (%)	
1 Day	4 Passes	102.0	16.2	93.3
	6 Passes	105.4	15.4	96.4
	8 Passes	105.1	16.7	96.2
2 Days	4 Passes	102.3	16.8	93.6
	6 Passes	103.7	16.1	94.9
	8 Passes	106.4	16.7	97.3
3 Days	4 Passes	98.4	16.8	90.0
	6 Passes	100.6	16.9	92.0
	8 Passes	102.7	17.1	94.0
7 Days	4 Passes	90.0	15.5	83.4
	6 Passes	87.8	15.3	81.4
	8 Passes	86.4	15.6	80.1

Shear Strength

Table 13, Summary of Direct Shear Results, shows the results of direct shear tests. The tests were completed on remoulded samples compacted to 90, 95, and 100% Standard Proctor compaction effort. The laboratory results showed a general increase in material friction angle along with compaction effort, and adequate shear strength can be developed in the dewatered flotation tailings at 90% Standard Proctor compaction in comparison with the design criteria of 32 degree in friction angle of dewatered flotation tailings.

Table 13: Summary of Direct Shear Results

Sample Compaction Effort	Average Dry Density of Specimen (pcf)	Average Cohesion (psf)	Average Friction Angle (degree)
90%	99.0	140	37
95%	105.1	90	39
100%	109.9	60	41

Major Findings from Compaction Test in March 2011

This section summarizes the major findings obtained from the compaction test conducted in March 2011.

- Dewatered flotation tailings can be placed in the DSTF within the limits of both GPA and Shell during winter conditions once the appropriate construction procedures are consistently followed.
- Adequate shear strength which exceeds the design criteria can be developed in the dewatered flotation tailings at 90% Standard Proctor compaction.
- To achieve 90% Standard Proctor compaction effort during winter/freezing conditions, dewatered flotation tailings should be spread within three days of placement and compacted with a minimum of four passes using a 12-ton compactor.

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ASTM D6938 In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Project: 2018 Pogo Drystack
Pogo Mine, AK
Client: Sumitomo Metal Mining Pogo LLC

Project #: 2018-058
Date: June 25, 2018
Area Tested: Drystack Pads

Material / Source:
Dry stack / pogo 109.3

Gauge: Instrotek 3500 **Ser: #** 18243
Operator: Axel Knight

Test #	Soil Type	Test Depth(in)	Lift Elev	Location	Wet Density	% Moist.	Dry Density	Proctor Value	Percent Density	Required Density
1	CF	12"		Drystack pads	118.9	21.3	98.0	109.3	89.7%	None Specified
2	CF	12"		Drystack pads	114.8	19.8	95.8	109.3	87.7%	None Specified
3	CF	12"		Drystack pads	113.8	19.3	95.4	109.3	87.3%	None Specified
4	CF	12"		Drystack pads	128.9	18.6	108.7	109.3	99.4%	None Specified

Approved By: *Stefan Mack* Stefan Mack PE, Lab Manager

Figure 7: 2018 Drystack Density Test Locations