Pogo Mine
Dry Stack Tailings Facility
Expansion Preliminary Study

Report Prepared for

Sumitomo Metal Mining Pogo LLC

Report Prepared by

srk consulting

SRK Consulting (Canada) Inc.
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Pogo Mine

Dry Stack Tailings Facility Expansion Preliminary Study

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1 Introduction and Scope of Report

In January 2011, SRK Consulting Inc. (SRK) was retained by Sumitomo Metal Mining Pogo LLC (hereafter SMMP) to complete preliminary study of proposed expansion of Pogo Mine's Dry Stack Tailings facility (DSTF) to a total capacity of approximately 20 M tons. The primary objectives of the study were to:

- Develop configurations to expand the capacity of the existing DSTF; and
- Analyse the stability of the expanded facility.

This report was prepared to support internal decision making associated with the proposed DSTF expansion and facilitate conversations with the appropriate regulatory agencies in advance of SMMP's submittal of a request to the regulators to permit expansion of the current DSTF. SRK's scope included the following:

- Updating the existing mass balance for the DSTF with information from the September 2010 topographic survey and preparing annual section and plan views for placement of waste rock and tailings materials in the DSTF through the end of 2017;
- Preparing plan and section views for expansion of the DSTF up to a storage volume of 20 M tons of combined waste rock and tailings. Drawings include recommended alignment for new diversion ditches and extension of the existing finger drains;
- Completing stability analysis for the 20 M ton configuration of the DSTF. This analysis accounted for original design criteria, field and laboratory test data obtained during 2009 and 2010 for tailings material placed within the General Placement Area (GPA) of the DSTF, and assessed potential impacts on stability resulting from possible variability in tailings friction angle and phreatic surface within the facility; and
- Providing recommendations for work to be completed both in support of the detailed engineering design of the expanded DSTF and to maintain best operating and management practice in the DSTF.

Key documents reviewed to complete this work included the following:

- Mass balance for tailings and waste rock production through 2017 prepared by SMMP;
- Original design report for the DSTF that was prepared by AMEC in 2004 (AMEC 2004a); and
- Discussion about seismic design criteria for site infrastructure included in the Pogo Project Feasibility Study (Teck-Pogo 2004).

The results of the work completed as part of this study are summarized and presented in this report. Furthermore it should be noted that final year-round construction recommendations for the expanded DSTF will be provided in two separate technical memos that will be prepared after completion of each phase of a field verification program that was developed to provide recommendations for construction procedures to be included in a revised Construction and Maintenance Manual for the DSTF. The first phase of the field and laboratory test program was completed in March 2011 to verify material properties (including friction angle from Direct Shear testing), and to measure the degree of compaction achieved for filtered tailings material placed during the winter period. The second phase of the program will be completed during summer 2011 to complement the winter program. The results of both programs will form a basis for recommending any modifications to current construction methods used for year round placement of materials in the DSTF.

2 DSTF Material Balance Update

The updated material balance accounts for the Life-of-Mine (LOM) plan developed by SMMP in January 2010 which provides estimated quantities of filtered tailings and waste rock (Potentially Acid Generating (PAG)/Red Rock and Not Potentially Acid Generating (NPAG)/Green Rock) to be produced at the mine through 2017. The updated material balance assumes that the mine life extends to at least 2017 and will have a milling rate of 920,000 tons per year (tpy). All waste rock, in addition to 60% of the filtered tailings, will be placed in the DSTF. The current LOM plan also anticipates use of a reduced quantity of filtered tailings to construct the facility's shell based on the projected availability of Green Rock. As a result, the construction of Shell 1 is entirely from green rock, as is the outer surface of Shell 2 and Shell 3. As will be described in Section 4 of this report, use of rock in shell construction has enhanced and increased stability of the DSTF over the original design configurations analyzed by AMEC in which the shell of the DSTF was entirely comprised of compacted tailings (AMEC 2004a).

2.1 Procedure

The total volume of material stored in the DSTF through September 2010 was estimated using the as-built survey from September 2009 and September 2010 provided by SMMP. By comparing the as-built survey from 2009 and 2010, the incremental volume of material placed in the DSTF was calculated and entered into the Excel-based material balance. A print out of the updated mass balance is presented in Appendix A of this report.

Consistent with current construction design and operational experience gained since 2008 the material balance assumes that there is a 2:1 split between green rock and red rock placed in the DSTF and an almost 5:1 split between filtered tailings placed in the GPA and filtered tailings used to construct the composite shells (Shell 2, and Shell 3). The average difference between total DSTF volumes calculated using survey data and total volume estimates calculated using truck count data is 3 percent. This suggests that truck count data using the indicated material densities provides a reasonable volumetric estimate of material placed in the DSTF. Furthermore, good reconciliation between the two total volume estimates between 2006 and 2009 suggests that assumed densities of filtered tailings and waste rock are reasonable for purposes of volume determination.

Using the surveyed crest elevation for Shell 1 and the as-built survey of the GPA surface through September 2010, SRK used AutoCAD Civil 3D® to estimate additional volumes of material placed in both Shell 1 and the GPA since September 2009. Using estimated quantities of filtered tailings and waste rock to be placed in the DSTF provided by SMMP, annual material deposition plans (presented on Drawings 1 through 8) were developed using the material densities assumed in the material balance.

2.1.1 Key Assumptions

The annual plans were developed assuming the following:

- Shell 1 would continue to be constructed from compacted green rock and have a width of 100 feet;

- A combination of red rock, filtered tailings and green rock would continue to be placed in the GPA. All red rock placed in the GPA would be encapsulated by filtered tailings, and green rock would be used to create a buffer zone between the original valley walls and materials placed within the GPA;
- Volumes of filtered tailings not used for paste production or placement in the GPA would be equally divided and used during construction of Shell 2 and Shell 3;
- Shell 2 would be 180 feet wide and consist of a 20 foot wide layer of green rock placed adjacent to the downstream slope of a 160 foot wide layer of compacted filtered tailings;
- Shell 3 would be 150 feet wide and consist of a 20 foot wide layer of green rock placed adjacent to the downstream slope of a 130 foot wide layer of compacted filtered tailings;
- The surface of the GPA, and of all Shells would have a slope of 2% to mitigate ponding on surfaces of the DSTF;
- A 3H: 1V slope will be used for all DSTF shells, consistent with original design criteria;
- Existing flow through drains would be extended beneath the expanded DSTF footprint; and
- The north and south diversion ditch would be relocated to maintain freshwater diversion around the raised DSTF.

2.2 Results

Graphic presentations of the storage elevation curves and estimated rate of rise for the DSTF through 2017 are presented in Figures 1 and 2 respectively.

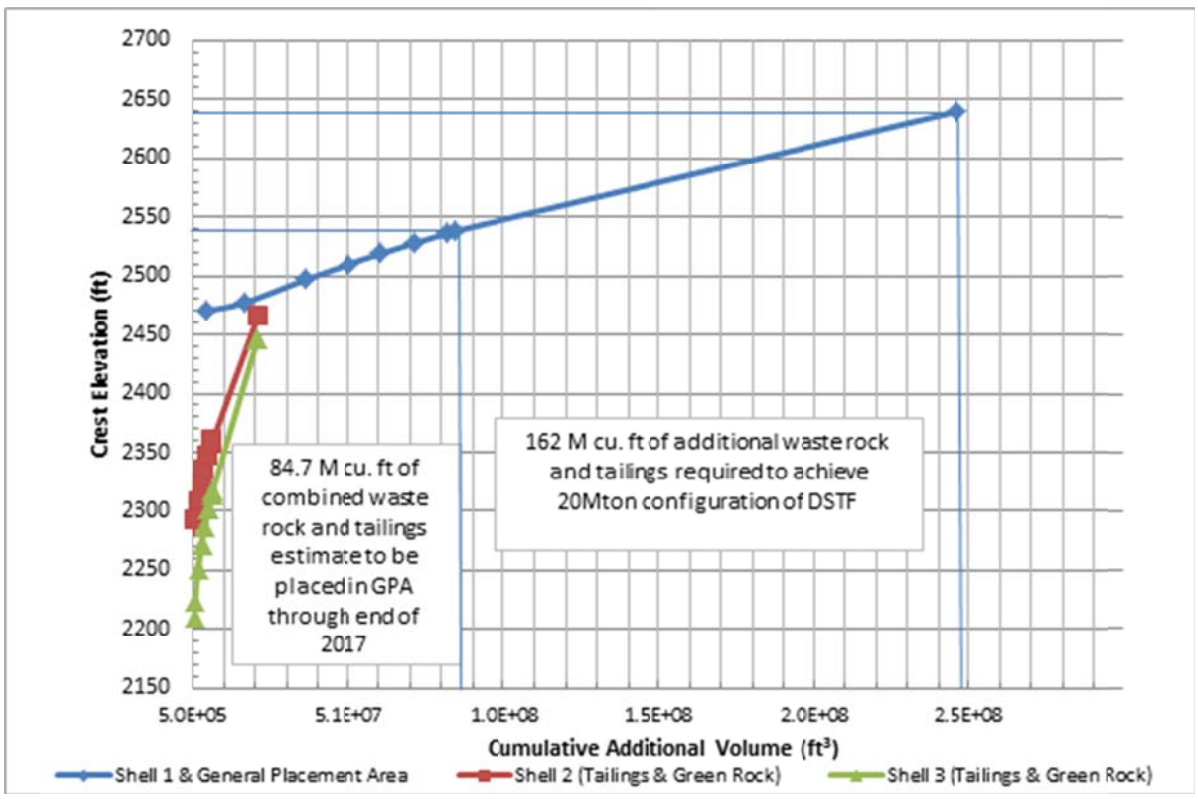

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Figure 1: Storage Elevation Curve for DSTF

Figure 1 indicates approximately 85 M cubic feet of combined waste rock and tailings will be placed and compacted in the GPA through the end of 2017 resulting in a 68 foot rise of the crest of the DSTF over its elevation at the end of 2010. The 2010 Life-of-Mine plan anticipates that a total of approximately 9.8 M tons of combined waste rock and filtered tailings will be stored in the DSTF by the end of 2017. Both Figure 1 and Drawing 8 indicate that as the DSTF is expanded beyond its current capacity the crest elevations of Shell 2 and Shell 3 will generally be approximately 200 feet below the crest of Shell 1 and the GPA surface if the proposed raise configurations are implemented.

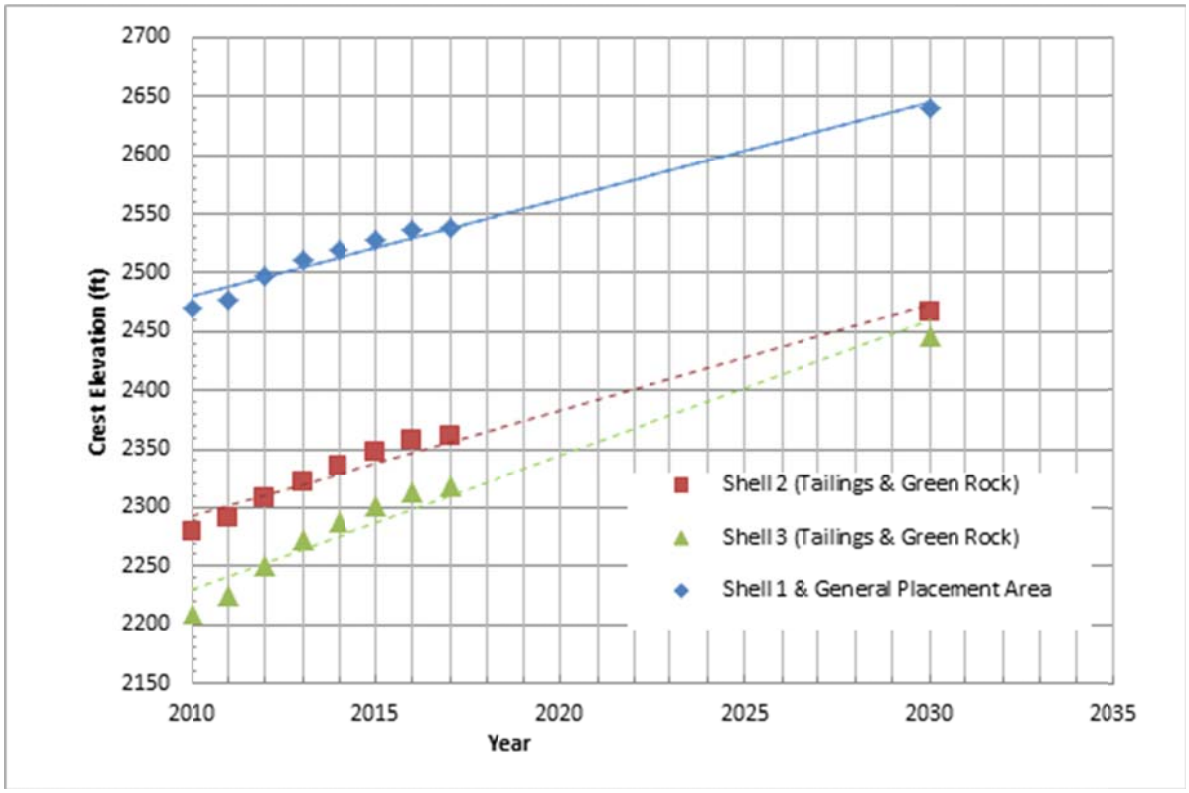

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Figure 2: Estimated Rate of Rise of the DSTF

Assuming that material production and distribution are consistent with those presented in the updated material balance, and that the compacted density of placed material is consistent with values assumed in the mass balance, it is anticipated that the crest of Shell 1 and the GPA will rise at a rate of approximately 10 feet per year while the rate of rise of the crests of Shell 2 and Shell 3 are estimated as 12 feet/year and 15 feet/year respectively. Figure 2 provides a graphic representation of the anticipated rate of rise for the various components of the DSTF.

2.3 Key Findings

During the course of preparing the annual material placement plans for the 2010 LOM plan, SRK noted the following:

- The surface elevation of the GPA surpassed the elevation of the existing south diversion ditch at the end of 2013. The north diversion ditch would be similarly surpassed by the end of 2014.

- Placement of waste materials in the DSTF through 2017 requires construction of new north and south diversion ditches no later than the end of 2013.
- Construction timelines suggest that detailed design of the raised DSTF would need to be completed well in advance of 2012 to provide adequate time for regulatory review and for SMMP to receive the necessary regulatory approvals prior to commencing construction of the new diversion ditches.

Diversion ditch details will be discussed in Section 3 of this report as its location coincides with considerations associated with possible expansion of the DSTF to a storage capacity of 20 M tons.

3 Preliminary Assessment of Expanded DSTF

To develop plan and section views for the DSTF with a 20 M ton capacity, SRK assumed that annual production beyond 2017 would proceed at average production rates achieved between 2012 and 2016. Production rates from this time period were selected as representative of operating conditions beyond 2017 due to the general consistency of estimated material quantities for each year during this period. The material balance was then extended until the total volume of material stored in the DSTF was close to the desired expanded total volume of 20 M tons. A table summarizing the material quantities used to develop expanded configurations of the DSTF is presented in Appendix A.

Assumptions used to develop expanded DSTF configurations were consistent with those used to develop annual material placement plans for 2011 through 2017 as described earlier in this report. Figure 1 indicates where the 20 M ton configuration would plot on the storage-elevation curve while Figure 2 indicates the trend lines of the anticipated rates of rise for the various components of the DSTF raised to a 20 M ton configuration. Drawing 9.1 shows the configuration of the DSTF at a 20 M ton storage capacity.

Drawing 9.2 shows the preliminary alignments of the new north and south diversion ditches that SRK proposes for both the current LOM plan and the proposed 20 M ton DSTF footprint. The new diversion ditches will accommodate storage of a DSTF with a GPA crest elevation up to 2640 feet. The north diversion ditch has been designed to allow segments of the ditch to be utilized for vehicular site access in the future. Where possible, the new diversion ditches would tie in to the remaining segments of the existing diversion ditches that will not be surpassed during construction of the DSTF. Segments of the existing diversion ditches that will be buried during construction of the DSTF will be thoroughly decommissioned to avoid creation of seepage conveyance pathways within the GPA. Preliminary details for the proposed diversion ditches are shown on Drawing 9.3.

4 Structural Stability of Expanded DSTF

4.1 Introduction

SRK considered stability of an expanded DSTF with total storage capacity of 20 M tons in this preliminary study. SRK reviewed the original DSTF and RTP Dam design reports prepared by AMEC in March 2004 in addition to sections of the Pogo Project Feasibility Study (Teck-Pogo 2004) related to seismic design criteria for site structures.

The existing DSTF was designed to provide storage for an estimated minimum 4.4 M tons of combined mineralized waste rock and filtered tailings produced during the mine life which, in March 2004 was anticipated to be 10 years (AMEC 2004a). The facility was also "designed to be readily expanded" and stability analyses were completed to demonstrate the ability to readily increase storage capacity of the DSTF to 20 M tons using specified design criteria (AMEC 2004a). A schematic of the 20 M ton section analyzed in this preliminary study is shown on Drawing 10.

4.1.1 Design Criteria

Design criteria for stability analysis used for the preliminary study were consistent with those specified in the original design report and presented in Table 4-1 (AMEC 2004a). In the 2004 DSTF design, AMEC 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. While the DSTF is not a dam embankment, SRK considers the design criteria set forth in the 2004 DSTF design report for static and pseudo-static to be appropriate for this study.

Table 4.1: Design Criteria for Stability Analyses

Project Phase	Static Loading Factor of Safety
Operations	1.5
Closure	1.5

4.2 Approach

The objective of the stability analysis completed during the preliminary expansion study was to consider the DSTF with a total storage volume of 20 M tons that accounted for the following known as-built conditions:

- Use of non-acid generating (NAG) waste rock (aka green rock) to construct the outer shell adjacent to the General Placement Area (GPA) known as Shell 1. The original design considered placement of GPA materials upstream of the starter dam centerline, with use of compacted tailings downstream of centerline to create a shell; and
- The composite nature of two lower shells (Shell 2 and Shell 3) constructed of an outer layer of NAG waste rock adjacent to compacted filtered tailings. As indicated in the previous point, the original DSTF design anticipated that only compacted tailings would be used to construct the shell. The new configuration results in reducing the quantity of tailings required to construct Shell 1 by approximately 47 percent as tailings material is replaced by green rock which increases resistance against the potential for rotational failure through the GPA.

Stability analysis completed for this preliminary study also differed from stability analysis completed in the original design report by assigning strength characteristics to materials placed in the GPA. In the original design report it was acknowledged that assuming zero strength for the GPA was "highly conservative" but was used to demonstrate that structural stability of the DSTF did not require placement of quality fill in the GPA or use of "special placement or compaction procedures" for

materials placed in the GPA during the winter period (AMEC 2004a). However, the adopted convention for initial design of the DSTF suggests that stability of the DSTF relies solely on construction of the facility's shell. SRK believes that the original design convention is overly conservative and does not account for the fact that materials placed in the GPA are compacted during year round placement, and have frictional strength. In other words, SRK believes that the stability of the DSTF is contributed to by the presence of compacted materials in both the shell and GPA.

In the absence of an as-built report for the DSTF to confirm that the starter and toe berms were constructed from waste rock, SRK used conservative shear strengths that assumed that the starter berm and toe berm were constructed from colluvium with some level of compaction. SRK also evaluated the effect of several phreatic surfaces (the level of water within the facility below which all materials are assumed to be saturated) on the structural stability of the DSTF.

To evaluate some of the potential effects an elevated phreatic surface within the DSTF sensitivity analyses were completed assessing possible impacts of having a phreatic surface above the existing foundation drain.

4.3 Material Strength Parameters

For the 2011 preliminary study strength characterization information for various material types contained in the DSTF was either consistent with original values used by AMEC considered to be conservative or based on SRK's engineering experience with similar materials.

Table 4-2 compares material parameters used in the current analysis against those used in the original DSTF design report (AMEC 2004a). Key differences between material properties used are as follows:

- Where appropriate, material properties were updated to reflect data from recent laboratory and field testing on actual Pogo tailings materials and use of NAG waste rock to construct the shell adjacent to the GPA. While results of triaxial testing completed on one sample of filtered tailings collected by SMMP in 2009 indicated a friction angle of 34 degrees, SRK opted to use a friction angle of 32 degrees for filtered tailings and 34 degrees for co-disposed waste rock and tailings material located in the GPA based on engineering judgement and previous experience with similar filtered tailings and waste rock. The friction angles used are believed to provide a conservative lower bound representation of frictional strength of the Pogo filtered tailings and filtered tailings combinations with waste rock based on particle size distribution and engineering judgement. SRK did not use the tailings friction angle developed in 2009 for two reasons. First, the friction angle was developed from a triaxial test of a single sample of filtered tailings. SRK did not consider that a single test result should be used to characterize all tailings material in the DSTF. Second, SRK does not concur that a reasonable friction angle for actual DSTF materials can be determined by reducing the friction angle obtained from a triaxial test on remolded tailings especially when the design intent is for dry stack materials to remain in an unsaturated condition. However, to assess the potential impact on stability of tailings material with a lower friction angle, SRK completed stability analyses in which the initial SRK-recommended friction angles for filtered tailings and co-disposed GPA materials were further reduced by 20%. These reduced values are considered by SRK to represent lower bound frictional strength characterizations for these materials as they exist in the DSTF based on observed material particle size distribution and field observations of the placed material. The reduction used by SRK was selected to be consistent with the reduction used by AMEC in the original design in

which the friction angle for tailings was taken to be 80% of the friction angle obtained from a triaxial test of pilot test plant tailings. This exercise was completed to assess the sensitivity of DSTF stability to changes in the frictional strength of tailings materials contained in the DSTF;

- Since actual construction materials for the starter berm and toe berm were not confirmed in an as-built report, SRK assigned lower frictional strength to these components as part of the analysis;
- The frictional strength of overburden soils in the foundation of the DSTF was also reduced to assess the potential impact of having increased amounts of fines in the foundation; and
- The bedrock layer was included in the analysis for completeness of the analysed section.

Table 4.2: Material Parameters Used for Stability Analysis of Expanded DSTF

Material type	Source	Bulk Unit Weight kg/m^3	Friction Angle degrees	Cohesion KPa	Basis for Assumptions
Compacted Tailings	AMEC	1810 (Operations) 1714 (Closure)	32	0	**Bulk Unit weight:** Based on compaction testing of gravity flotation tails prepared to simulate tailings from the Pogo ore milling process. Variance based on assumption of 15% MC during operations and 15% MC at closure. **Friction angle:** 80% of the tri-axial compression strength obtained from isotropically consolidated undrained (CIU) tri-axial tests performed on sample flotation tailings prepared to simulate tailings from the Pogo ore milling process. Strength reduction based on anticipated critical failure mode for tailings shell (assumed to be a wedge type failure resulting from passage of direct shear path through tailings shell).
	SRK	1700	32	0	**Bulk Unit weight**: Average bulk unit weight obtained from compaction tests performed on actual tailings samples between May and September 2010. **Friction angle**: AMEC value deemed suitable where tailings are used for shell construction based on engineering judgment.
Co-Disposed General Placement Area (Tailings and Mineralized Waste Rock)	AMEC	1890 (Operations) 1778 (Closure)	None	0	**Bulk Unit weight**: Estimated unit weight of co-disposed materials using lab flotation tails sample and engineering judgment of bulk unit weight of waste rock. Variance based on assumption of 15% MC during operations and 15% MC at closure. **Friction angle:** Frictional strength was not assigned for conservatism.
	SRK	1850	34	0	**Bulk Unit Weight**: Engineering judgment used to estimate unit weight of co-disposed compacted tailings and waste rock **Friction angle**: 2009 tri-axial test data on sample of filtered tailings placed in DSTF.
Rock Shell (NAG waste rock)	AMEC	N/A	40	0	AMEC specified compacted tailings for shell construction.
	SRK	2300	38	0	Reflects actual DSTF construction. Engineering judgment used to assign material properties. Slight reduction in rock friction angle for conservatism to allow for variability in rock quality.
Starter berm & Toe Berm (AMEC design - rockfill SRK assumed use of colluvium for construction since shown on design drawings)	AMEC	2002	40	0	Bulk Unit weight: Engineering judgment using reduction of value presented in Cooke (1993). No geotechnical lab testing completed on Pogo development rock. Friction Angle: Based on Leps (1970) for "average rockfill."
	SRK	2000	32	0	AMEC assumed that this structure was constructed from NAG development rock. However, in the absence of an as-built report, SRK assumed these structures were constructed from colluvium as indicated on the design drawings, and used engineering judgment to assign strength parameters.
Overburden Soils	AMEC	2002	36	0	Engineering judgment based on SPT test hole data collected prior to design of the DSTF.
	SRK	2000	32	0	Engineering judgment accounting for potential for increased fines in overburden materials.
Bedrock	AMEC	N/A	N/A	0	Bedrock considered much stronger than overburden materials and was therefore not considered in the analyses.
	SRK	2500	40	0	Engineering judgment. Layer used to complete analyzed design section.

4.3.1 Phreatic Surface

In the 2004 DSTF geotechnical design report for the DSTSF stability analyses were completed assuming that the phreatic surface would remain within overburden soil foundation materials at a depth of 10 feet below the original ground surface (AMEC 2004a). However, to assess potential effects of an elevated phreatic surface within the DSTF, SRK performed sensitivity analyses varying the height of the phreatic surface as follows:

- At the same level used in the 2004 AMEC DSTF design report (10 feet below the original ground surface);
- At the surface of original ground (~10 feet higher than the phreatic surface used in the 2004 AMEC DSTF design report); and
- Well in excess of the crest elevation of the existing central foundation drain and finger drains (at a maximum height of 50 feet about the original ground surface and within the limits of the GPA).

The three phreatic surfaces analyzed are presented in Drawing 10.

4.3.2 Pseudo-static Evaluation

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. The pseudo-static condition occurs when a dynamic load is applied but structural deformation is not considered and only intact soil parameters are used (instead of using mobilized soil parameters).

As described in the Pogo Feasibility Study, the near surface M7.9 seismic event that occurred on 3 November 2002 within 75 miles of Fairbanks was selected as the operating basis earthquake for the Pogo project. Seismic hazard mapping completed by the USGS after the 2002 event indicated that a peak ground acceleration (PGA) of 0.1g would have a return period of 475 years (10% of occurrence in 50 years) at the Pogo mine site. For the site, a PGA of 0.2g would have a return period of approximately 2,475 years (5% of occurrence in 50 years). Furthermore, deterministic ground motions for the site were found to be "significantly smaller than the probabilistic ground motions" indicated (AMEC 2004a).

SRK completed the pseudo-static analysis using the same reduced peak ground accelerations (at 50% and 25% of the maximum design basis earthquake) that were used in the original design report (AMEC 2004).

4.4 Stability Analysis

Stability analyses were completed using the limit equilibrium program SLOPE/W developed by Geo-Slope (version 2007). Analyses were completed using the Morgenstern-Price method of slices and all materials were assumed to be Mohr-Coulomb frictional materials. Drawing 10 presents the configuration of the proposed expanded 20 M ton DSTF that was analyzed and includes the failure surfaces and phreatic surfaces assessed. As mentioned earlier in this report Table 4-2 presents the material properties that were assigned to the various material types during stability analysis.

4.4.1 Results

Seismic design criteria used by AMEC during the original design are considered reasonable by SRK and accepted for use in the current study. SRK developed plots to show how the factor of safety varied with peak ground acceleration up to the maximum design earthquake (0.2g) specified for "critical structures" at the Pogo mine site (Teck-Pogo 2004).

Four typical failure modes (different failure surfaces that could likely occur) were analyzed using three loading conditions.

The three loading conditions analyzed were:

- Operations conditions under static loading;
- Operations conditions under pseudo-static loading conditions (0.05g applied); and
- Closure conditions under pseudo-static loading conditions (0.1g applied).

The four failure modes assessed were:

- Shallow shell failure, typically a planar failure near the surface of the shell and parallel to the slope angle of the shell material;
- Deep failure through the GPA, typically a deep rotational failure deep into the GPA;
- Failure of all Shells, typically a shallow rotational failure through all the composite and rock shells; and
- Deep failure of the DSTF, typically a complete failure through the GPA and all the shells.

Indicated failures modes for the three loading conditions described were computed using the material properties shown in Table 4-2. To assess the impact of reduced frictional strength of the filtered tailings material, the stability analysis was also completed using 80 percent of the initial friction angle used for filtered tailings and 80 percent of the friction angle used for GPA materials since filtered tailings are co-disposed in that area of the DSTF. Friction angles for filtered tailings used in the completed analyses are shown on Table 4-3 while results for the completed analyses are summarized in Table 4-4, Table 4-5, and Table 4-6.

For each case analyzed the effect of the elevation of the phreatic surface on the calculated FoS was also assessed. As seen on Table 4-4, Table 4-5, and Table 4-6 the calculated minimum FoS for the cases analysed exceeded the minimum FoS specified in the design criteria for static and pseudo static loading.

Table 4.3: Frictional Strength of Filtered Tailings Used for Stability Analysis

Engineering Parameter	SRK Assumed Values (Degrees)		Reduced Compacted Tailings and Co-Disposed GPA Values by 20% (Degrees)	
	Compacted Tailings	GPA	Compacted Tailings	GPA
Friction Angle	32	34	25.6	27.2

Table 4.4: Factor of Safety with Water Table 10 feet Below Ground

Failure Mode	SRK Calculated Minimum FoS			Calculated Minimum FoS (Friction Angle of compacted tailings reduced by 20%)			Calculated Minimum FoS (Friction Angle of compacted tailings and co-disposed GPA reduced by 20%)		
	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)
Shallow Shell Failure	1.9	1.7	1.4	1.5	1.3	1.1	1.5	1.3	1.1
Failure of all Shells	2.6	2.1	1.8	2.3	1.9	1.6	2.3	1.9	1.6
Deep Failure Through GPA	3.4	2.7	2.2	3.3	2.6	2.2	2.8	2.2	1.8
Deep Failure of DSTF	5.0	3.6	2.8	5.0	3.6	2.8	3.8	2.8	2.2

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Table 4.5: Factor of Safety with Water Table at Original Ground

Failure Mode	SRK Calculated Minimum FoS			Calculated Minimum FoS (Friction Angle of compacted tailings reduced by 20%)			Calculated Minimum FoS (Friction Angle of compacted tailings and co-disposed GPA reduced by 20%)		
	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)
Shallow Shell Failure	1.9	1.6	1.4	1.5	1.3	1.1	1.5	1.3	1.1
Failure of all Shells	2.6	2.1	1.8	2.3	1. 9	1.6	2.3	1. 9	1.6
Deep Failure Through GPA	3.4	2.7	2.2	3.3	2.6	2.2	2. 8	2.2	1.8
Deep Failure of DSTF	4.7	3.4	2. 7	4.7	3.4	2.7	3.8	2.8	2.2

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Table 4.6: Factor of Safety with Elevated Water Table

Failure Mode	SRK Calculated Minimum FoS (initial friction angles used)			Calculated Minimum FoS (Friction Angle of compacted tailings reduced by 20%)			Calculated Minimum FoS (Friction Angle of compacted tailings and co-disposed GPA reduced by 20%)		
	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)	Static	Pseudo-static (k=0.05)	Pseudo-static (k=0.10)
Shallow Shell Failure	1.9	1.6	1.4	1.5	1.3	1.1	1.5	1.3	1.1
Failure of all Shells	2.6	2.1	1.8	2.3	1.9	1.6	2.3	1. 9	1.6
Deep Failure Through GPA	3.2	2.5	2.1	3.1	2.5	2.0	2.6	2.1	1.7
Deep Failure of DSTF	4.0	2.9	2.3	3.9	2.9	2.2	3.3	2.4	1.9

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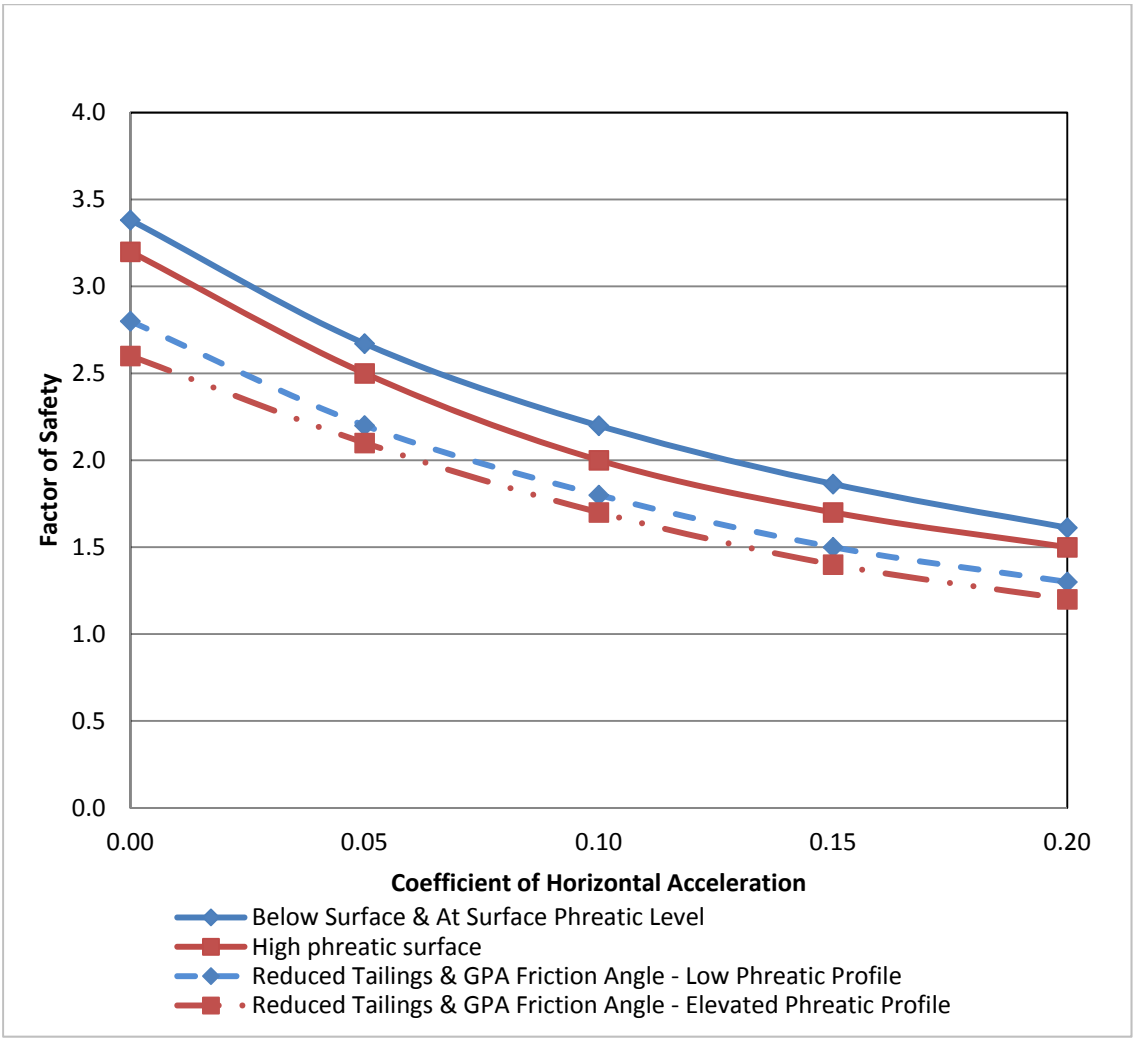
Figure 3 shows how the minimum factor of safety obtained for a deep rotational failure through the DSTF (most critical failure mode) analyzed using the initial strength values provided in Table 4-2, varies as the peak ground acceleration increases up to 0.2 g for both low and elevated phreatic surfaces within the DSTF. The results show the FoS for a phreatic surface at and below original ground is identical whereas the FoS is slightly reduced for the high phreatic surface analyzed.



Van-svr0\projects\01_SITES\Pogo\1CS021.000_Dry Stack TF Expansion\Task 005_Reporting\Report\Figures\ Figure 3_Variance of FOS with k.xlsx

Figure 3: Variation of Factor of Safety with Peak Ground Acceleration for Deep Rotational Failure through the GPA

The results may be summarized as follows:

- For all cases analyzed the calculated FoS for possible modes of failure exceeds the minimum specified FoS;
- For all cases analyzed the minimum calculated FoS was 1.4 which was associated with a shallow shell failure of Shell 3 under pseudo-static loading conditions with a horizontal acceleration of 0.1g at closure;
- Under static and pseudo-static loading conditions the shallow modes of failure provide the lowest factors of safety. This represents a shallow ravelling failure, which in SRK's opinion does not pose a significant risk. However, as seen from the shallow failure surfaces shown in Appendix B, shallow planar failure in the outer shell does not compromise stability of material stored in the GPA (i.e. the failure plane does not cut into the GPA);
- The analysis also indicates that if the phreatic surface does not develop an elevated profile consistent with the one indicated in Drawing 10 the factor of safety associated with failure of GPA materials remains around 2.7 under operational pseudo-static conditions (k = 0.05g).

- The presence of an elevated phreatic surface within the DSTF reduces the FoS associated with a deep failure through the GPA under a pseudo-static load of 0.1g to 2.1 which is well above the design criteria of 1.1.
- The static and pseudo-static design criteria are met using a 20% reduction of the initially SRK assumed friction angle of filtered tailings and co-disposed filtered tailings and waste rock.

Complete results obtained from the stability analyses are presented in Appendix B.

4.5 Conclusions

Stability analysis performed by SRK for the expanded DSTF configuration (raised to elevation 2640 ft. with material properties indicated) suggests that the factors of safety for the overall structure exceed the minimum FoS values specified by the design criteria, even with an elevated phreatic surface and for a range of failure modes.

Results from the analysis also demonstrate that the GPA provides frictional resistance within the DSTF and as such stability of the overall structure is not entirely reliant on the strength and stability of the outer shells. Construction of composite shells (Shell 2 and Shell 3) is still in its early stages. SRK recommends that performance of the outer shells be verified through both observation, field density testing, and laboratory testing as discussed in the following section.

5 Recommendations for Future Work

5.1 Recommendations for Detailed Engineering Design

SRK recommends completion of the tasks indicated in Table 5-1. Key considerations for advancing design and construction of the expanded DSTF are as follows:

- SRK considers establishing a means of monitoring the phreatic level within the DSTF to be important. While SRK modelled an elevated phreatic surface, SRK recommends that the phreatic level be monitored for the proposed expanded DSTF. SRK recognizes that a variety of methods may be used to assess the phreatic profile within the DSTF and recommends development of a detailed plan for installation of instruments suitable to specific site considerations including operations and equipment limitations. Figure 4 provides preliminary locations for recommended piezometer installations. Piezometers could be nested within each hole to provide an indication of the phreatic profile within the DSTF Installation of vibrating wire piezometers would also allow temperature profiles for the DSTF to be monitored. Installation of vibrating wire and standard standpipe piezometers typically requires drilling a 3-inch diameter hole to the target depth. The hole would remain open to allow piezometer installation. Installation holes could be drilled with an air-track drill (of the kind used at Pogo for underground mining) if the material is competent and the hole does not collapse. However if the hole does not remain open long enough to install the piezometers to the desired depth, use of casing may be required following air-rotary drilling. After the piezometers are in place, the holes are typically bentonite sealed above and below the instruments and backfilled with drill cuttings or filled with sand. Where vibrating wires are installed shallow trenches will be dug in the as-built GPA surface to bury the cable leads that will be routed to outside the limits of the GPA to a designated location on the valley wall where readouts can be obtained. Filtered tailings can be used to provide bedding material for the cables in the trenches. Where vibrating wire piezometers are installed there will be no protrusions or equipment extensions above the

working surface of the GPA thereby avoiding obstructions for equipment working on the surface of the DSTF.

- A geotechnical evaluation of the valley slope along the proposed alignment of the new diversion would be prudent if areas are accessible to identify potential problematic foundation conditions.
- The existing closure plan for the DSTF should be reviewed and compared to the actual construction of the DSTF to date. This review should include a desktop review of the geochemical assessment for the DSTF to ensure all closure criteria can be satisfied.

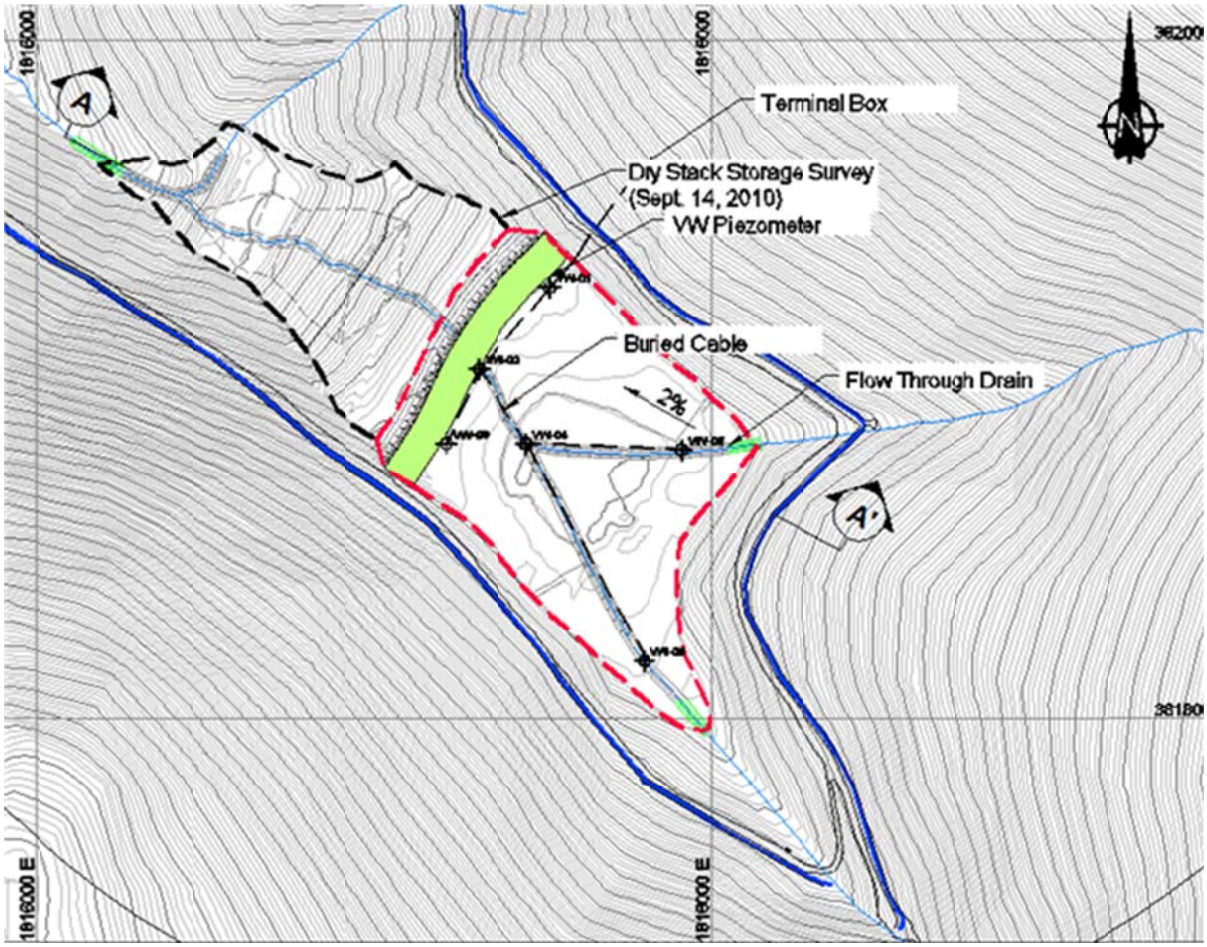


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Figure 4: Preliminary Piezometer Locations

5.2 Recommendations for Best Practices

The following recommended tasks will improve best management practices for the DSTF during operations and closure:

- Review and compile existing water and load balance for the DSTF to evaluate the chemical loading from the DSTF. Based on review of available water quality data, SRK would assess the potential impact of runoff from the DSTF on Liese Creek at closure. SRK would also provide recommendations to mitigate potential impacts.
- The potential for erosion of the outer rock face of the DSTF shells should be verified. The erosion of rock included in the shells has implications for maintenance requirements during the closure period. Tests such as slate durability, soundness using sodium sulphate, and freeze thaw

durability could be completed to provide data on long-term rock durability. Furthermore, Proctor and direct shear tests for large diameter specimens could be completed to provide additional engineering parameters such as density and friction angle for further evaluation on the impact of material density on projected DSTF elevations throughout facility expansion.

- Using the hydrological data from the existing diversion ditches and from Liese Creek, better water balance control could be established to provide better input to a revised water quality model for the DSTF and for the site.

Table 5.1: Recommended Work to Support Detailed Design of DSTF

	Task ID	Task	Purpose	Method & Use
Recommendations for Engineering Design	1.1	Determine piezometric level in DSTF	Provide means of verifying phreatic surface within the DSTF and to gauge any seasonal variability	- Install at least two VW piezometers in the existing DSTF - Data will be used to update stability analyses
	1.2	Complete Geotechnical SI of valley wall along proposed alignment of new diversion ditches	Complete detail design of new diversion ditches, including accounting for potential use of segment of north diversion ditch for vehicle access	- Complete test hole program to characterize properties of materials in which diversion ditch will be constructed - Complete detail design of new diversion ditches including tie ins to select segments of existing diversion ditches
	1.4	Review existing closure recommendation for DSTF	To confirm that specified closure criteria account for as-built conditions and achieve desired closure objectives	- Review closure criteria included in the original design report and determine suitability of recommended methods based on the as-built DSTF - Recommend closure prescriptions for the DSTF
Recommendations for Best Practices	2.1	Complete integrated water and load balance for DSTF	Account for potential chemical loading from the DSTF	- Use available climatic and hydrology data (preliminary estimate initially) and review existing data. Integrated balance should be updated once additional flow data obtained from new
	2.2	Analyze quality of runoff from DSTF	Provide means of assessing potential impact of water in near and longer term of runoff from the DSTF into the RTP and ultimately into Liese Creek at closure	- analyze the collected water sample data
	2.3	Complete geochemical review/assessment of DSTF during operations and closure	Inform considerations recommended for closure of the DSTF	- Review previous geochemical assessments and identify gaps - Review current water quality monitoring plan - Have additional geochemical characterization completed as required - Develop recommendations for closure of the DSTF
	2.4	Characterize foundation of DSTF	Allows for better characterization in stability analysis and considerations about potential seepage paths	- Have specialty contractor complete geophysics characterization of Liese Creek valley for the entire area upstream and downstream of the proposed footprint limits of the expanded DSTF - Results will be used to update design section analyzed
	2.5	Establish hydrologic control for the diversion system and DSTF	More accurate accounting for DSTF and diversion system into the site-wide water balance	- Estimate flow in diversion ditches - Data will be incorporated in the load balance for the DSTF
	2.6	Complete geotechnical characterization of waste rock and literature review for development of frictional strength characterization for co-disposed materials	Provide additional laboratory basis for strength parameters used in stability analysis for green rock and for materials placed in the GPA Provide means of assessing the impact of density on estimated DSTF elevations corresponding to placed volumes of waste rock and tailings.	- Obtain green rock samples and submit to lab for geotechnical characterization - Review select core logs to obtain RMR for green rock - Update stability analysis - Analyses sensitivity of estimated DSTF expansion elevation to changes in material density

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6 Closure

This report, "Dry Stack Tailings Facility Expansion Preliminary Study – Pogo Mine", has been prepared by SRK Consulting (Canada) Inc. All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

Prepared by

Lois Boxill, P.E.

Senior Geotechnical Engineer

Reviewed by

Internal Review completed.
E-Signature will appear on report hardcopy

Terry Mandziak, P.E.

Senior Civil Engineer

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

7 References

AMEC Earth and Environmental. *2004a. Pogo Gold Project Dry Stack Tailings Facility Geotechnical Design Report.* March.

AMEC Earth and Environmental. *2004b. RTP Dam Design Report*. March.

Teck-Pogo. *2004. Pogo Project Feasibility Study*.

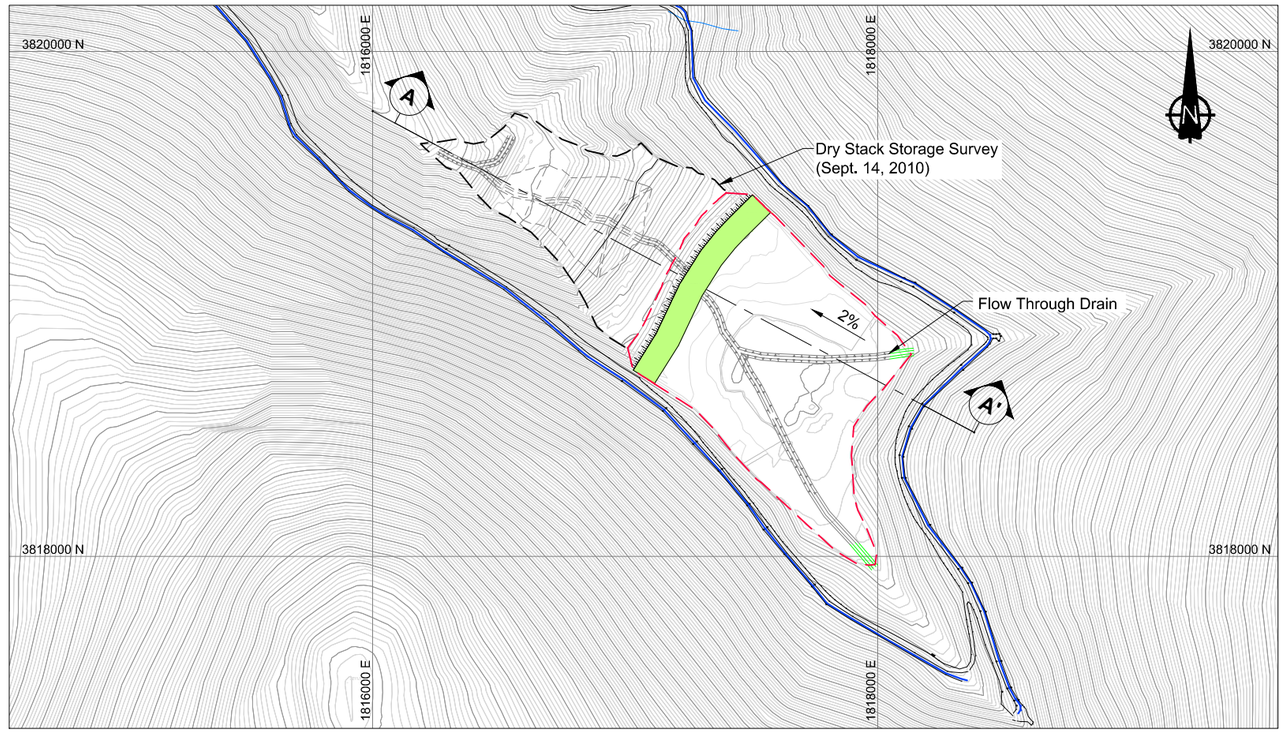
Drawings

LEGEND

- Diversion Ditch
- Extent of Year 2010 Material Placement
- Rock Drain Extension Required for Year 2010
- Green Rock Outer Shell
- GPA Materials
- Tailings

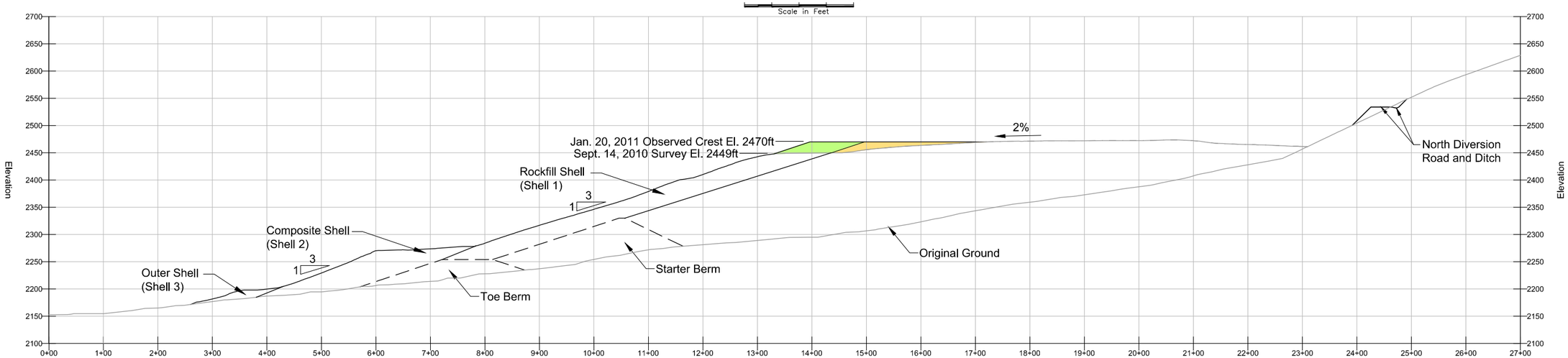
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

srk consulting	Pogo Mine	Dry Stack Tailings Facility Expansion Preliminary Study
SRK JOB NO.: 1CS021.000		Dry Stack Storage Facility Plan and Section End of 2010
FILE NAME: 1CS021-000_2010-2017 R1.dwg	POGO MINE	DATE: Feb. 11 · APPROVED: LB · FIGURE: 1

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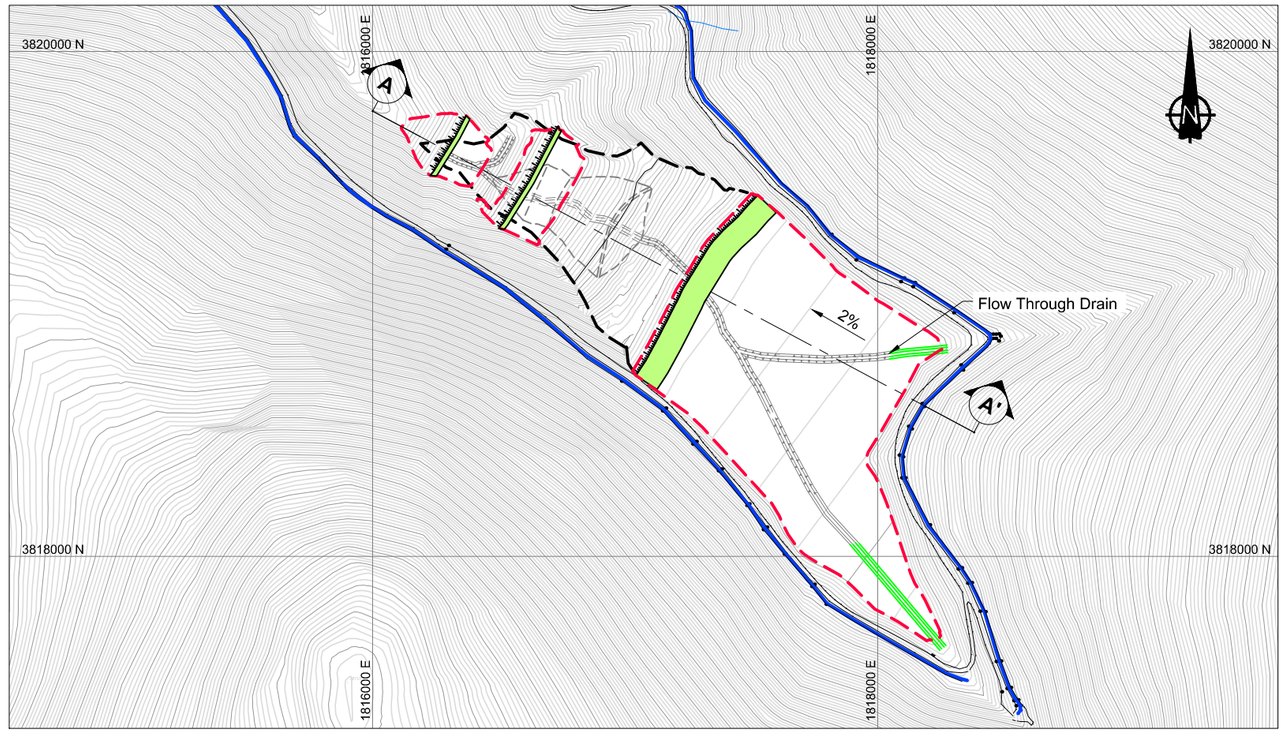
LEGEND

- Diversion Ditch
- Extent of Year 2011 Material Placement
- Rock Drain Extension Required for Year 2011
- Green Rock Outer Shell
- GPA Materials
- Tailings

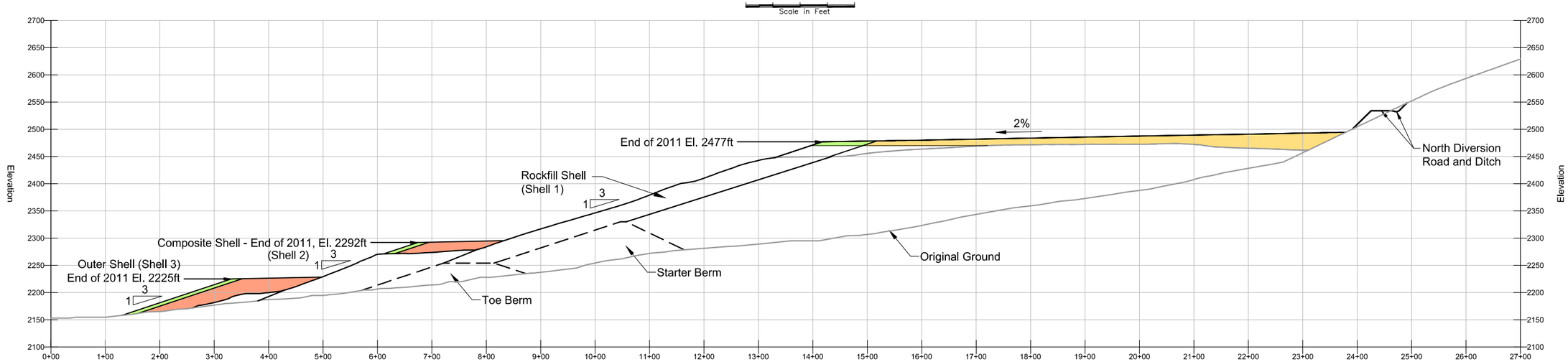
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

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FILE NAME: 1CS021-000_2010-2017 R1.dwg	POGO MINE	DATE: Feb. 11 / APPROVED: LB / FIGURE: 2

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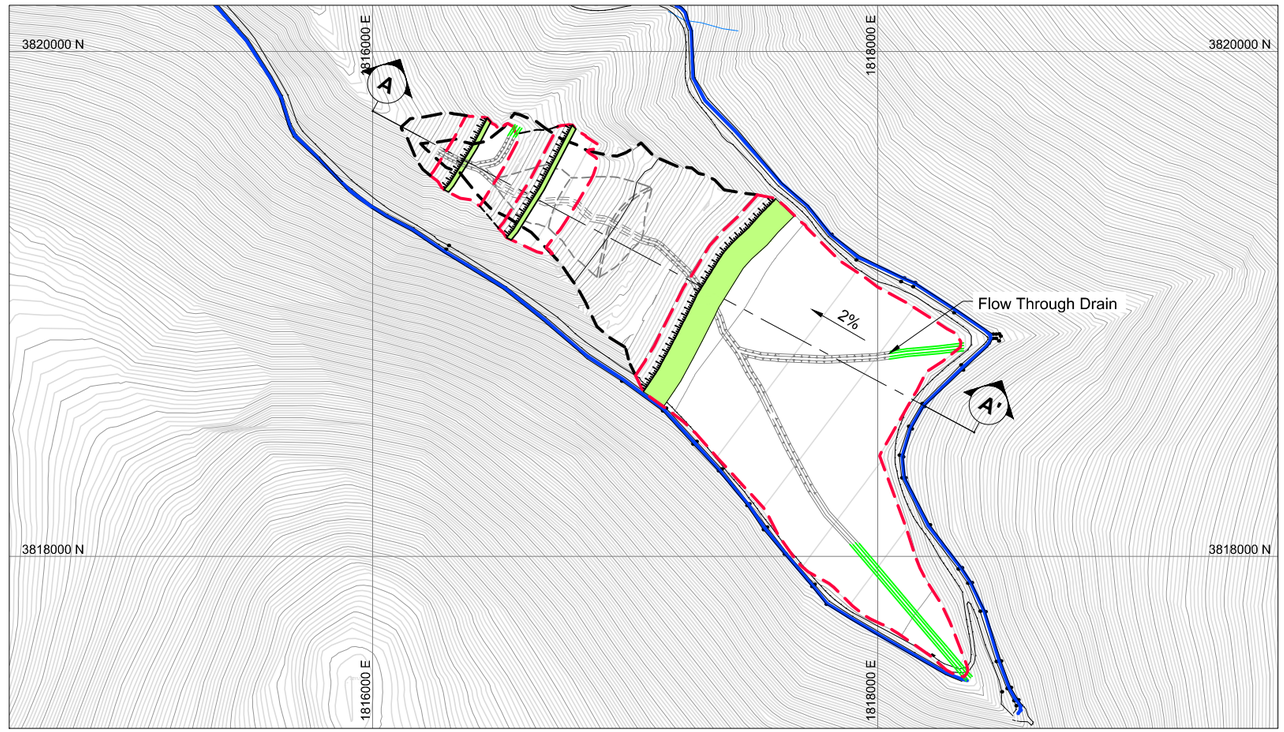
LEGEND

- Diversion Ditch
- Extent of Year 2012 Material Placement
- Rock Drain Extension Required for Year 2012
- Green Rock Outer Shell
- GPA Materials
- Tailings

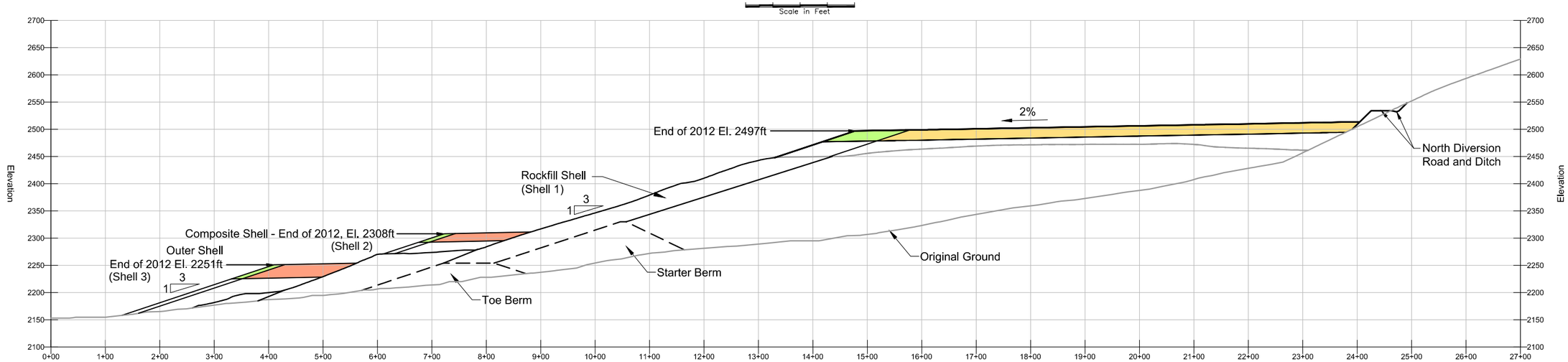
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

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FILE NAME: 1CS021-000_2010-2017 R1.dwg		DATE: Feb. 11 / APPROVED: LB / FIGURE: 3

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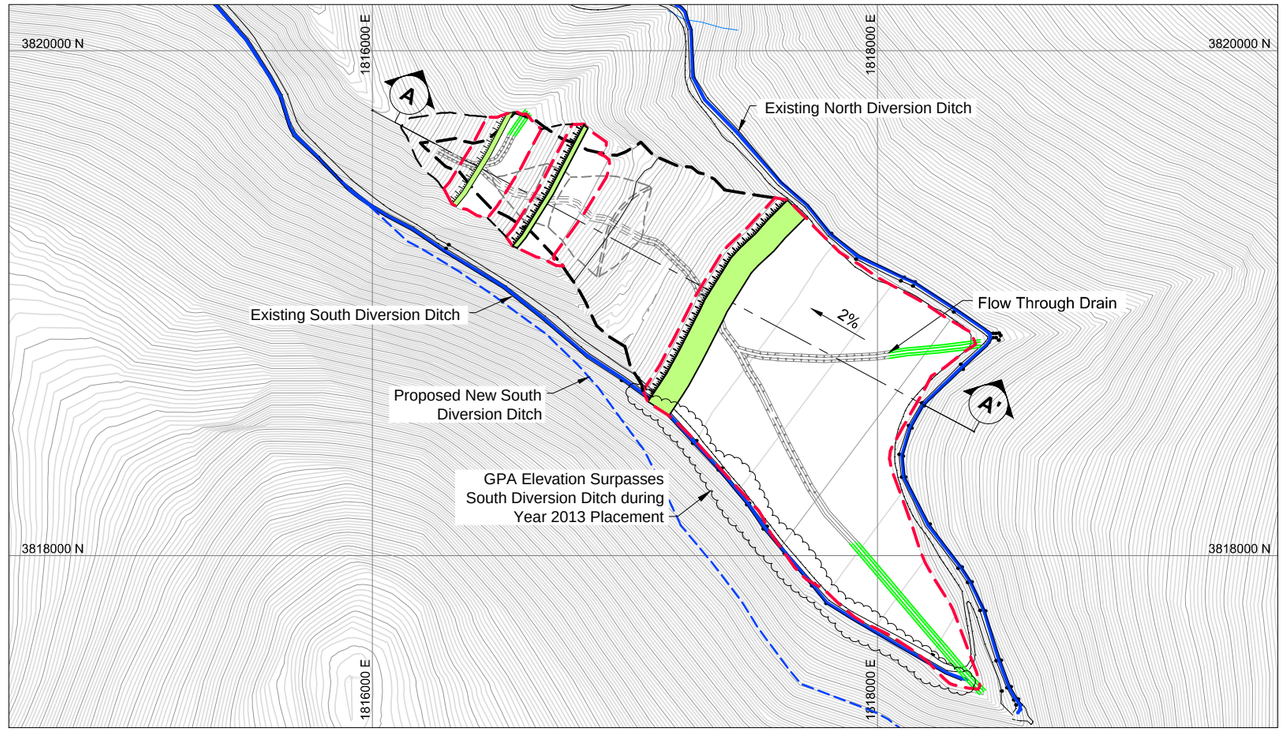
LEGEND

- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2013 Material Placement
- Rock Drain Extension Required for Year 2013
- Green Rock Outer Shell
- GPA Materials
- Tailings

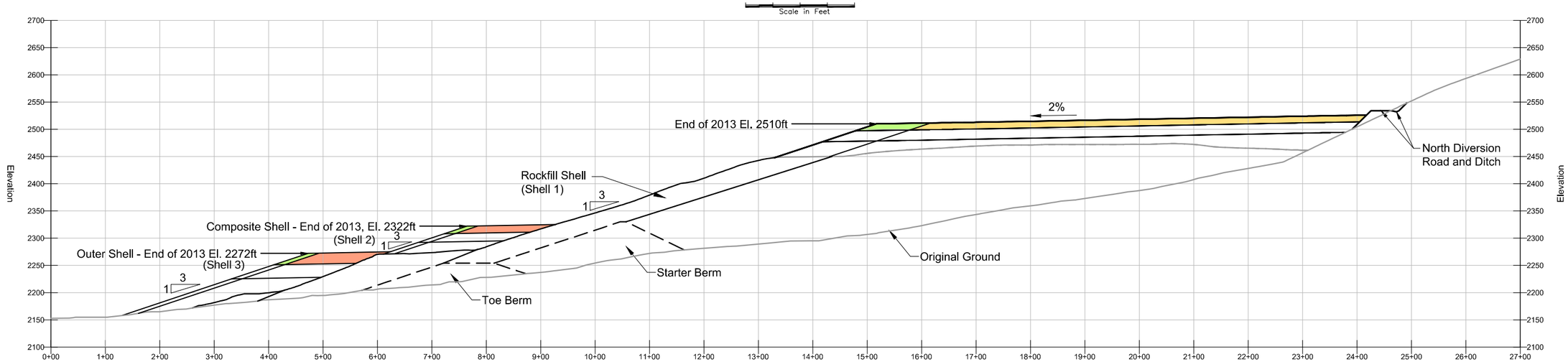
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

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SRK JOB NO.: 1CS021.000
FILE NAME: 1CS021-000_2010-2017 R1.dwg

Pogo Mine

POGO MINE

Dry Stack Tailings Facility
Expansion Preliminary Study

Dry Stack Storage Facility
Plan and Section End of 2013

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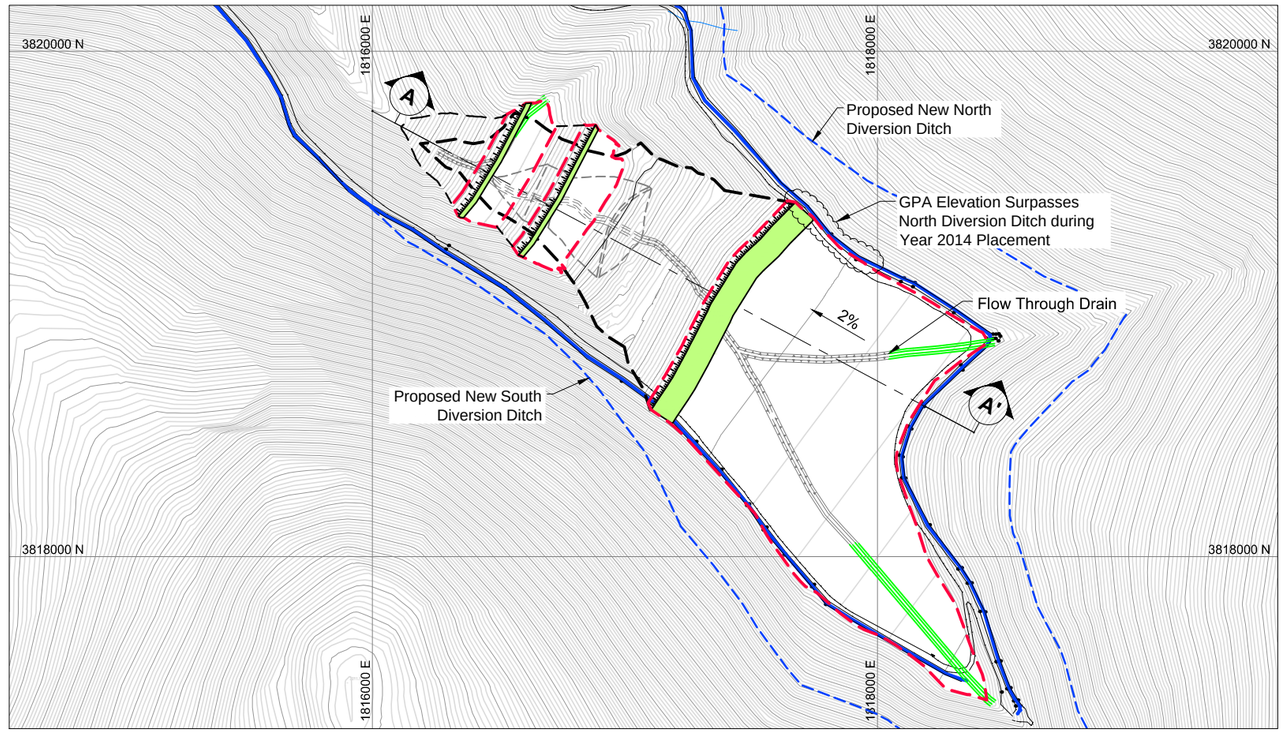
LEGEND

- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2014 Material Placement
- Rock Drain Extension Required for Year 2014
- Green Rock Outer Shell
- GPA Materials
- Tailings

NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

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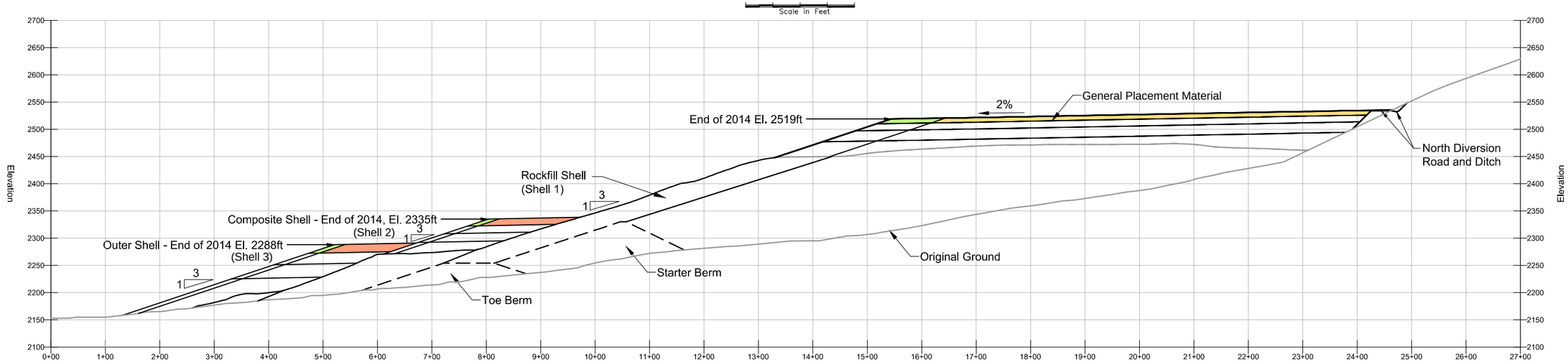
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

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FILE NAME: 1CS021-000_2010-2017 R1.dwg

Pogo Mine

POGO MINE

Dry Stack Tailings Facility
Expansion Preliminary Study

Dry Stack Storage Facility
Plan and Section End of 2014

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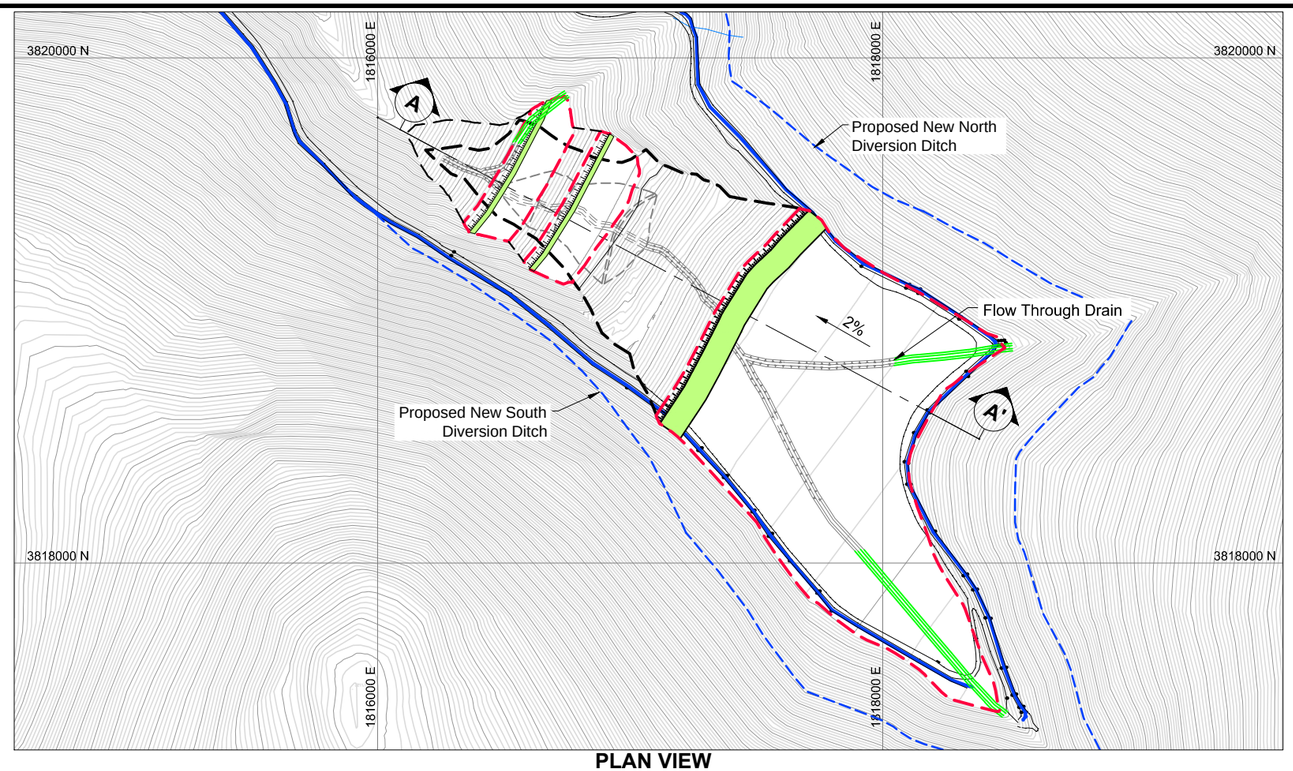
LEGEND

- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2015 Material Placement
- Rock Drain Extension Required for Year 2015
- Green Rock Outer Shell
- GPA Materials
- Tailings

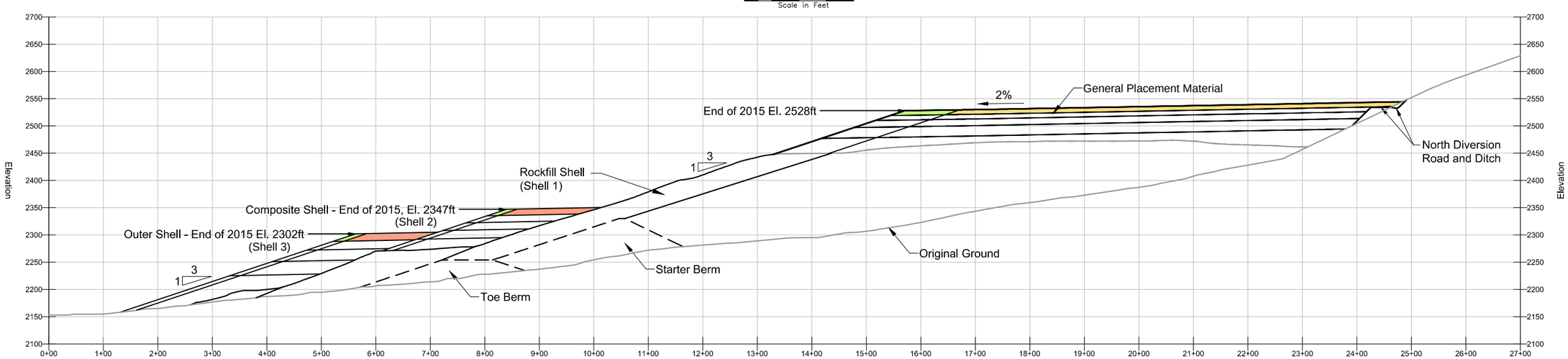
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

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Pogo Mine

POGO MINE

Dry Stack Tailings Facility
Expansion Preliminary Study

Dry Stack Storage Facility
Plan and Section End of 2015

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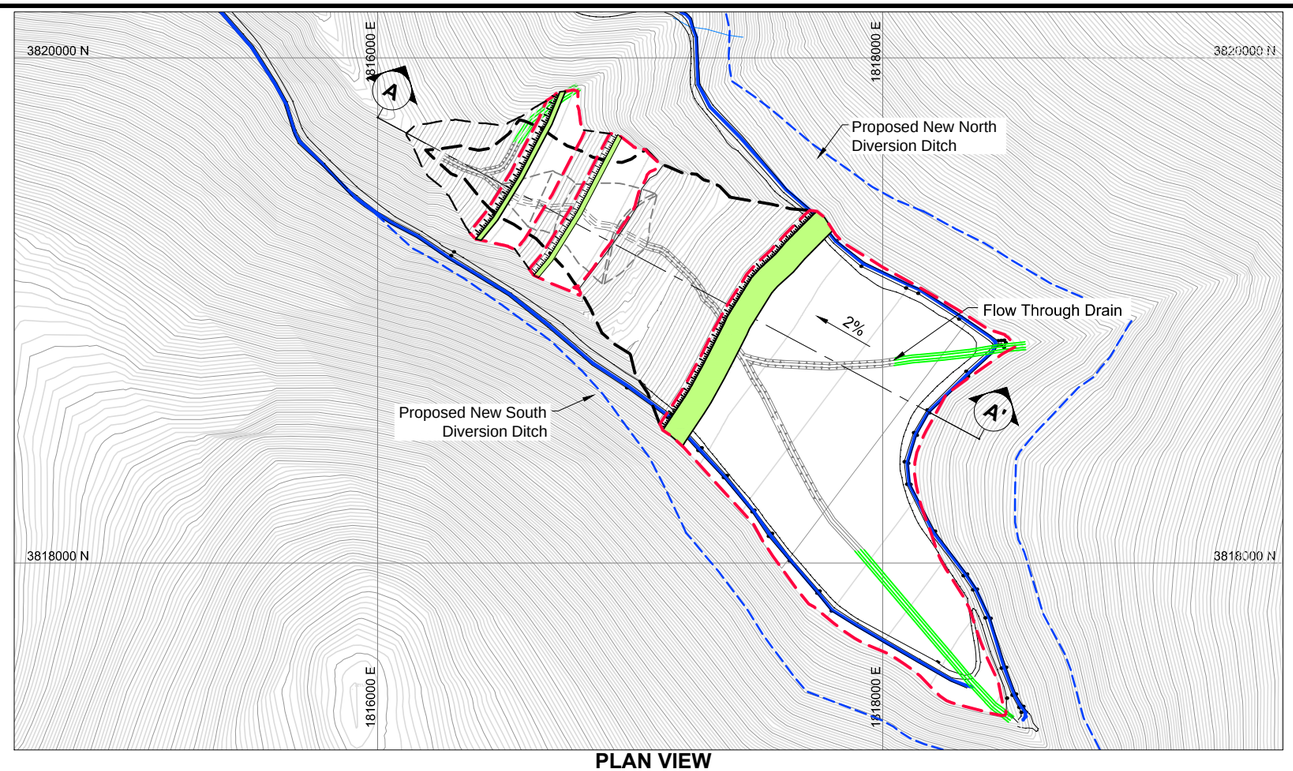
LEGEND

- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2016 Material Placement
- Rock Drain Extension Required for Year 2016
- Green Rock Outer Shell
- GPA Materials
- Tailings

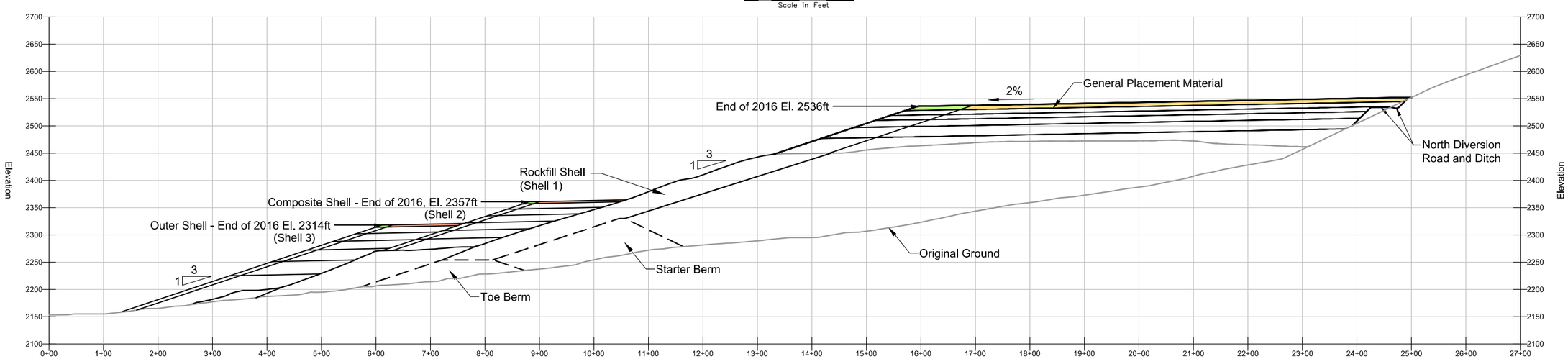
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

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FILE NAME: 1CS021-000_2010-2017 R1.dwg

Pogo Mine

POGO MINE

Dry Stack Tailings Facility
Expansion Preliminary Study

Dry Stack Storage Facility
Plan and Section End of 2016

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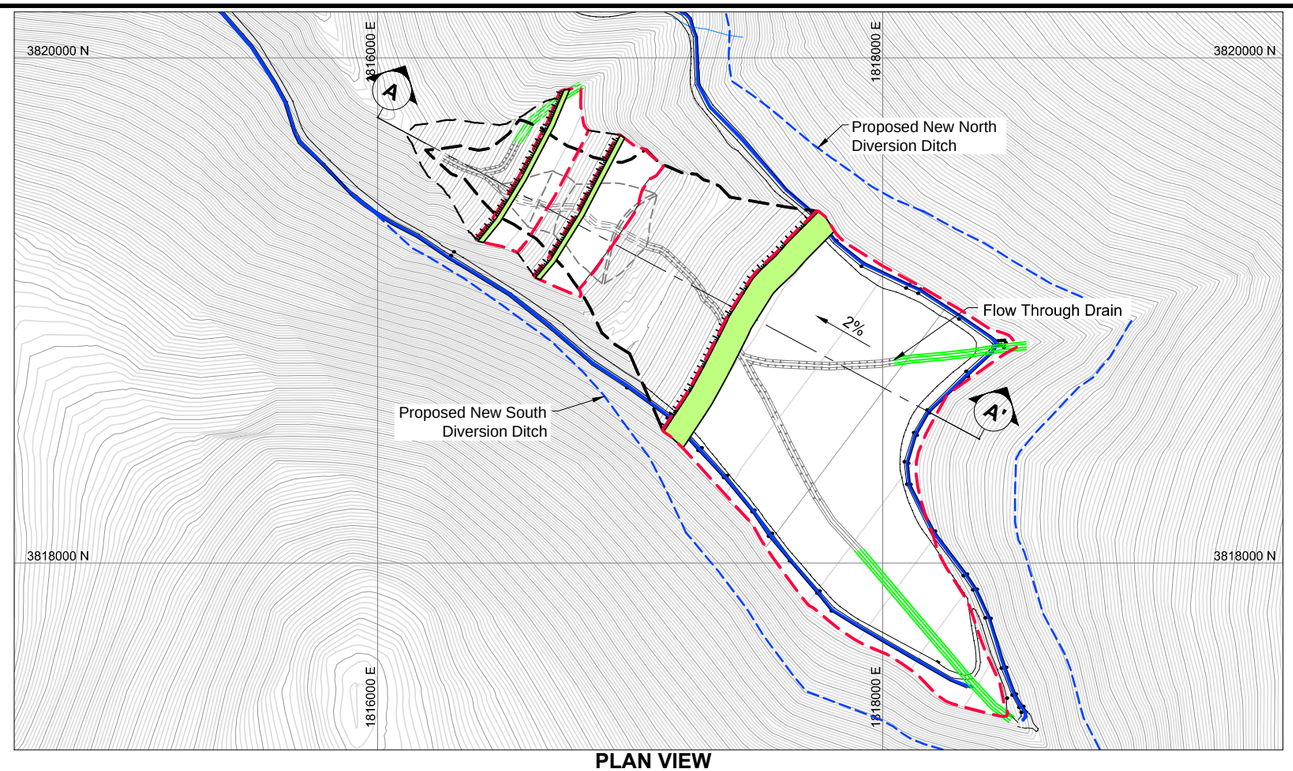
LEGEND

- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2017 Material Placement
- Rock Drain Extension Required for Year 2017
- Green Rock Outer Shell
- GPA Materials
- Tailings

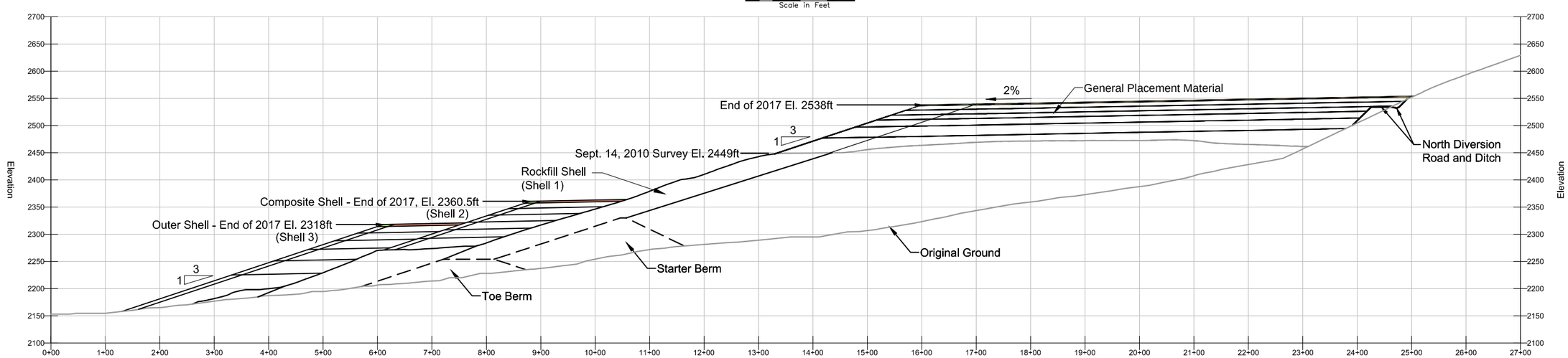
NOTES

1. Contour interval is 5ft.
2. Base contour data received from POGO mine site dated May 20, 2010.



PLAN VIEW
DRY STACK STORAGE AREA

0 150' 300' 450' 600'
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

srk consulting	Pogo Mine	Dry Stack Tailings Facility Expansion Preliminary Study
SRK JOB NO.: 1CS021.000		Dry Stack Storage Facility Plan and Section End of 2017
FILE NAME: 1CS021-000_2010-2017 R1.dwg	POGO MINE	DATE: Feb. 11 / APPROVED: LB / FIGURE: 8

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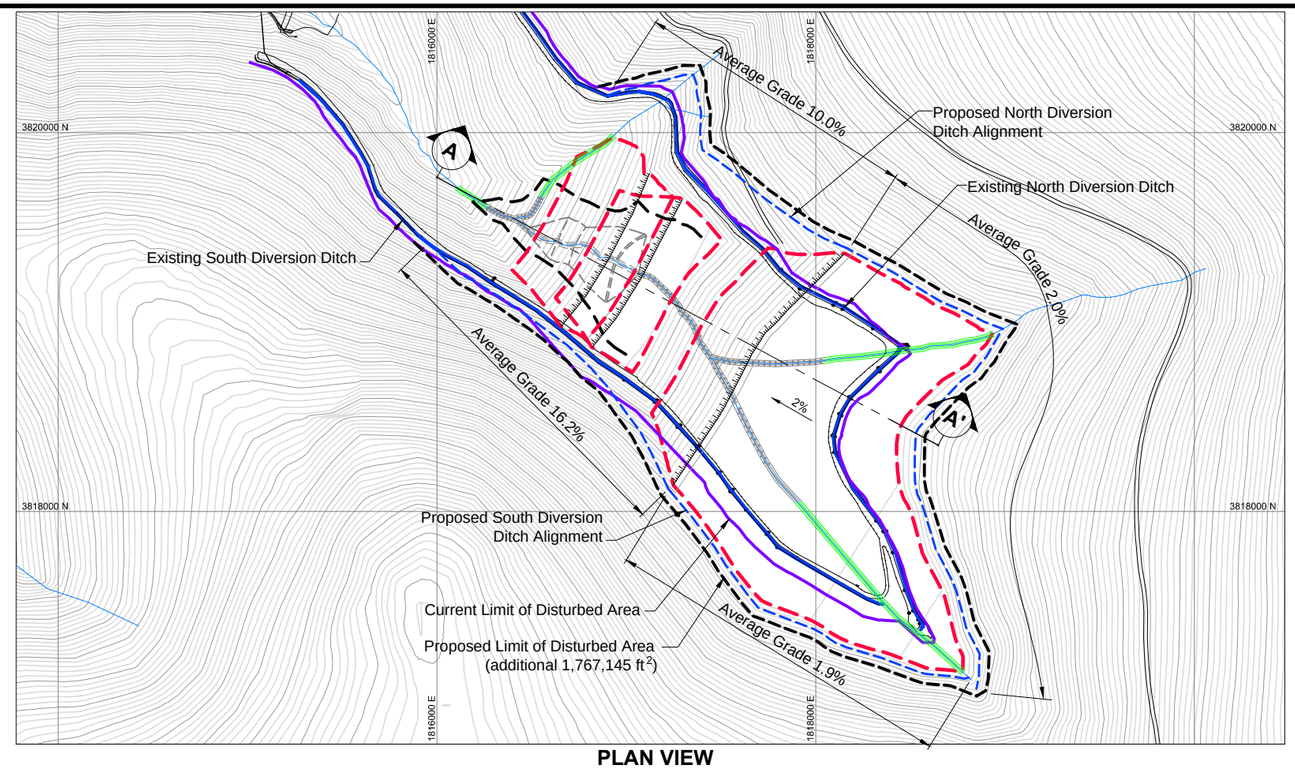
LEGEND

- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2030 Material Placement
- Rock Drain Extension Required for Year 2030
- Green Rock Outer Shell
- GPA Materials
- Tailings

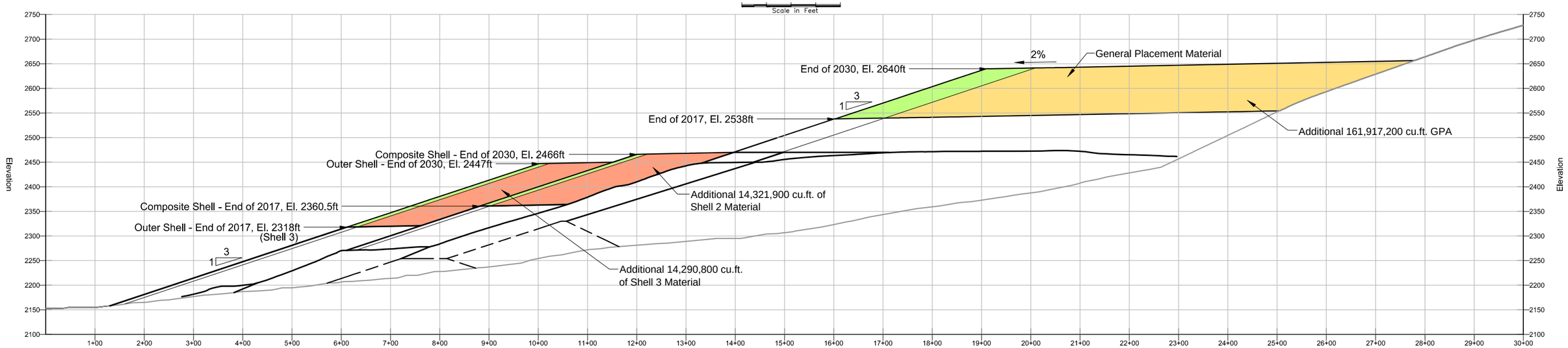
NOTES

1. Contour interval is 10ft.
2. Base contour data received from POGO mine site dated May 20, 2010.
3. 20 M ton configuration developed for assessment of proposed ultimate configuration.



PLAN VIEW
DRY STACK STORAGE AREA

0 200' 400' 600' 800'
Scale in Feet



A **CROSS SECTION A - A'**

0 50' 100' 150' 200'
Scale in Feet

srk consulting	Pogo Mine	Dry Stack Tailings Facility Expansion Preliminary Study
SRK JOB NO.: 1CS021.000	POGO MINE	Dry Stack Storage Facility Plan and Section End of 2030 (20 million Tons)
FILE NAME: 1CS021–000_Ultimate Storage Scenarios.dwg		DATE: Feb. 11 / APPROVED: LB / FIGURE: 9.1

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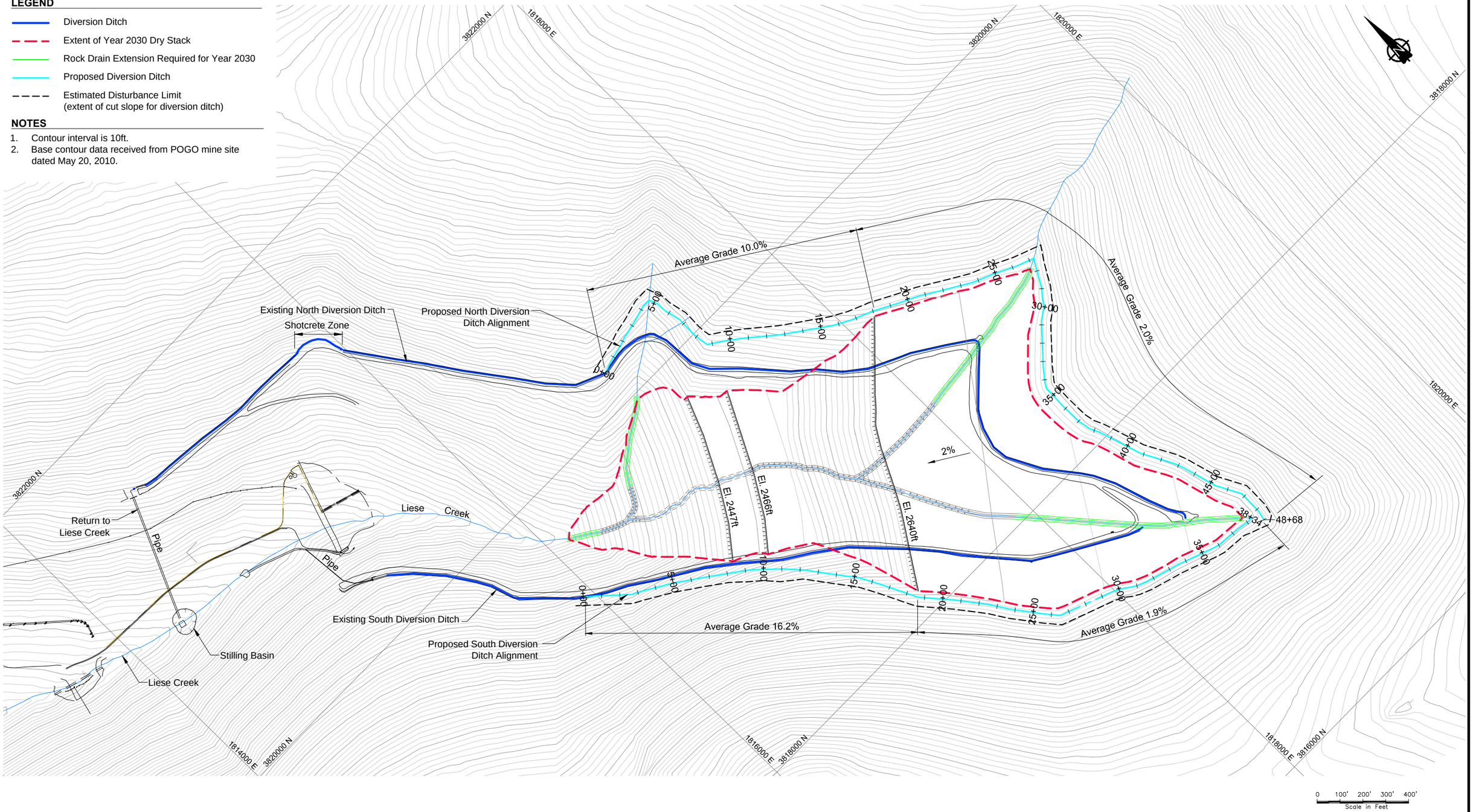
LEGEND

- Diversion Ditch
- Extent of Year 2030 Dry Stack
- Rock Drain Extension Required for Year 2030
- Proposed Diversion Ditch
- Estimated Disturbance Limit (extent of cut slope for diversion ditch)

NOTES

1. Contour interval is 10ft.
2. Base contour data received from POGO mine site dated May 20, 2010.

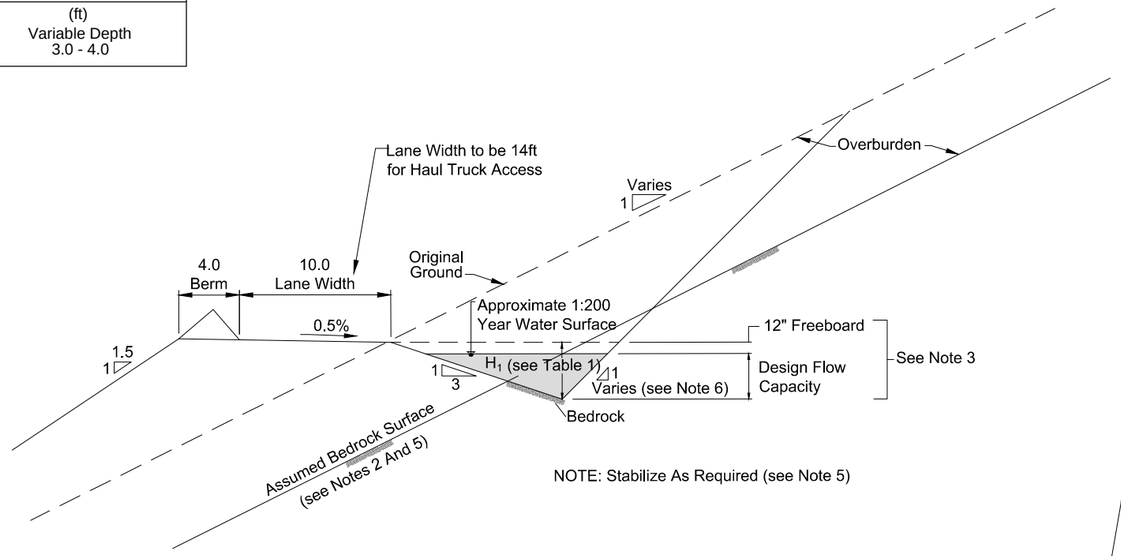


srk consulting	Pogo Mine	Dry Stack Tailings Facility Expansion Preliminary Study
SRK JOB NO.: 1CS021.000	POGO MINE	Plan View of Proposed Diversion Ditch for 20 M ton DSTF Configuration
FILE NAME: 1CS021-000_20MT Diversion Ditch.dwg		DATE: Feb. 11 / APPROVED: LB / FIGURE: 9.2

J:\01_SITES\Pogo\1CS021.000_Dry Stack TF Expansion\040_AutoCAD\1CS021-000_20MT Diversion Ditch.dwg

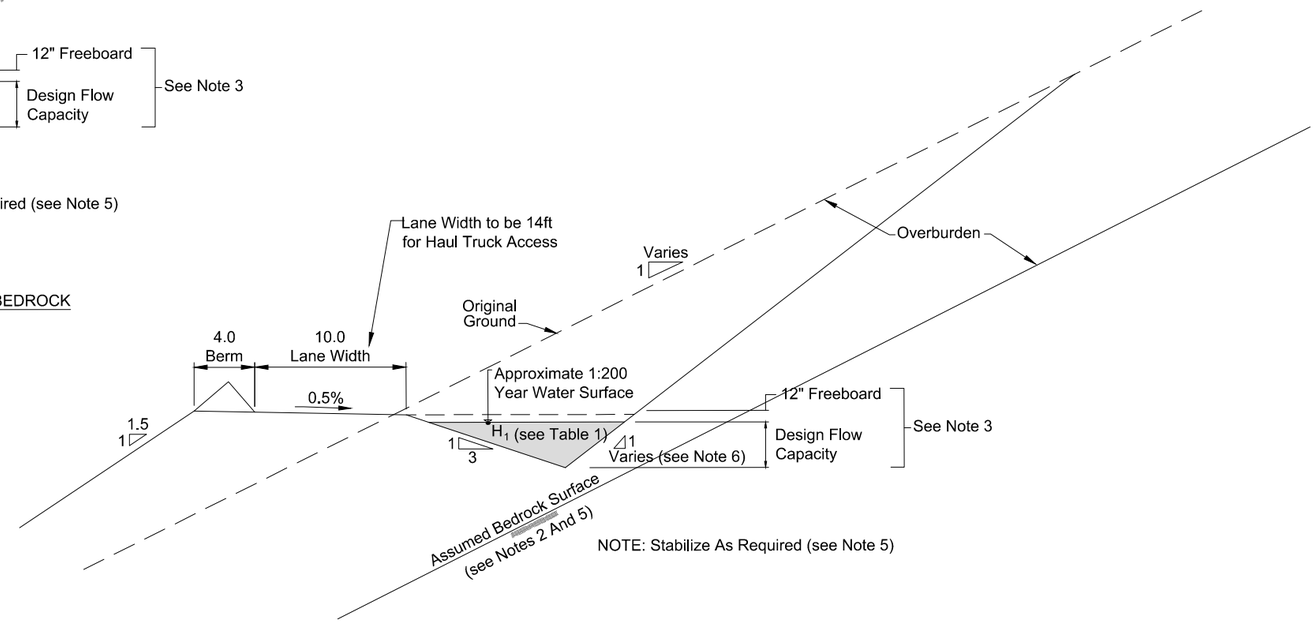
TABLE 1

STATIONING	TOTAL DEPTH (H_1)
South Ditch 0+00 to 38+34 (End)	(ft) 2.5
North Ditch 0+00 to 48+68	(ft) Variable Depth 3.0 - 4.0



TYPICAL DIVERSION DITCH SECTION WHEN PRIMARILY IN BEDROCK

0 2.5' 5' 7.5' 10'
Scale in Feet



TYPICAL DIVERSION DITCH WHEN PRIMARILY IN OVERBURDEN

0 2.5' 5' 7.5' 10'
Scale in Feet

NOTES

1. Detail design of ditch configurations will be completed during design engineering phase. Current configurations are based on configurations of existing diversion ditches.
2. Bedrock surface may not be reached in all areas particularly along south-facing slopes. Bedrock will likely not be intersected in drainage draws.
3. Section depths indicative of typical conditions. Maintenance control of ice/aufeis anticipated in stewardship of diversion ditch.
4. Slope excavation support, e.g. Mesh and anchors, only placed as required in field.
5. Where bedrock not intersected, base of ditch may require geofabric, imported material, soil treament, shotcrete, or other appropriate method
6. Side slope varies: as an appropriate guide to field fit under the direction of the field engineer - in bedrock use 0.5H:1V; in ripable bedrock use 1H:1V; and in unsupported overburden use 1.5H:1V. Where mesh and soil anchors are used, overburden slopes can be 1H:1V or greater as directed by the engineer.
7. Existing slopes of valley in vicinity of proposed diversion ditches varies between 2.5H:1V and 3H:1V.

srk consulting	Pogo Mine	Dry Stack Tailings Facility Expansion Preliminary Study
SRK JOB NO.: 1CS021.000	POGO MINE	Typical Diversion Ditch Sections
FILE NAME: 1CS021-000_20MT Diversion Ditch.dwg		DATE: Feb. 11 / APPROVED: LB / FIGURE: 9.3

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LEGEND

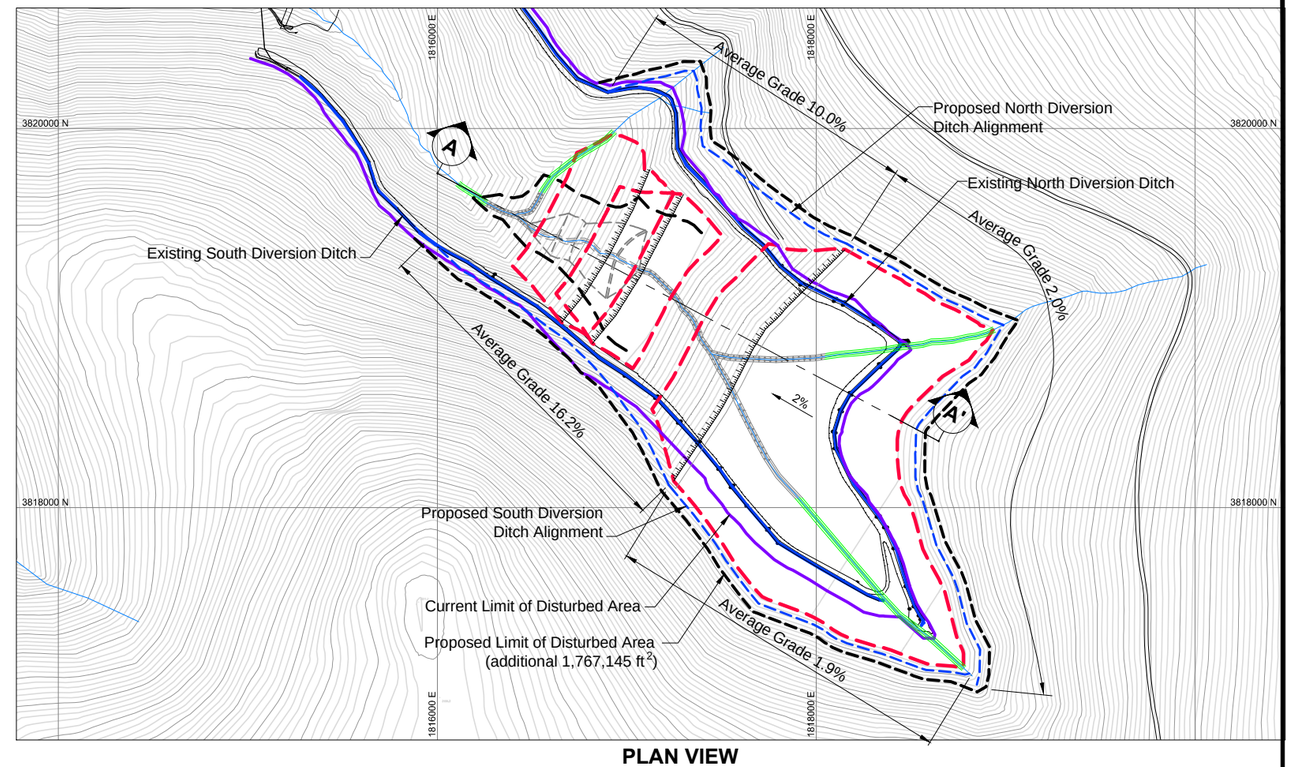
- Existing Diversion Ditch
- Proposed Diversion Ditch
- Extent of Year 2030 Material Placement
- Rock Drain Extension Required for Year 2030
- Green Rock Outer Shell
- GPA Materials
- Tailings

NOTES

1. Contour interval is 10ft.
2. Base contour data received from POGO mine site dated May 20, 2010.
3. 20 M ton configuration developed for assessment of proposed ultimate configuration.

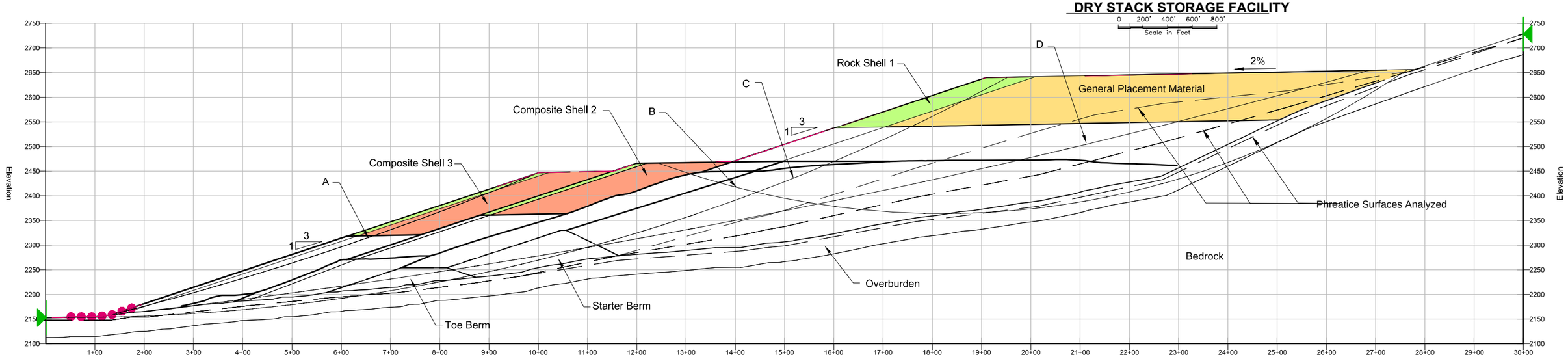
EXPANSION SLIP SURFACES (20 MT)

A - SHALLOW SHELL FAILURE
B - DEEP FAILURE THROUGH GPA
C - FAILURE OF ALL SHELLS
D - DEEP FAILURE OF DSTF



PLAN VIEW
DRY STACK STORAGE FACILITY

0 200' 400' 600' 800'
Scale in Feet



A CROSS SECTION A - A'

0 50' 100' 150' 200'
Scale in Feet

srk consulting

SRK JOB NO.: 1CS021.000
FILE NAME: 1CS021-000_Ultimate Storage Scenarios.dwg

POGO MINE

Dry Stack Tailings Facility
Expansion Preliminary Study

Failure Surface Analyzed
For Expanded DSTF

DATE:	APPROVED:	FIGURE:
Feb. 11	LB	10

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Appendices

Appendix A:
Updated DSTF Material Balance

Pogo Dry Stack Tailings Facility (DSTF) Mass Balance (Expanded Storage)
(Shell Construction During Summer Only)

Design Criteria				
			pcf	
Dry density tails=	19.2	ft3/ton	104.0	In-situ dry density measured by Troxler was 102 - 104 pcf
Dry density waste rock=	16.0	ft3/ton	125.0	
Tails in pastefill=	32.5	ft3/ton	61.525	Solid 64%, Cement 6.5%, Paste S.G. 107pcf

Dates of survey	DSTF volume calculated from survey data (ft3) (A)	Load of tails to DSTF (dry tons)	volume of tails placed into DSTF (ft3) at assumed density	Load of waste rock placed into DSTF from site records (dry tons)	volume of waste rock placed into DSTF (ft3) at assumed density	Total volume of materials placed into DSTF (ft3) at assumed density (B)	DSTF volume reconciliation (%) (B-A)/A
2006 (start to 7/06)	6,297,708	184,039	3,539,212	180,909	2,894,551	6,433,763	2%
2007 (8/06 to 6/07)	15,255,904	385,722	7,417,731	503,813	8,061,002	15,478,732	1%
2008 (7/07 to 8/08)	19,311,535	686,111	13,194,442	421,911	6,750,581	19,945,024	3%
2009 (8/08 to 9/09)	16,849,122	662,425	12,738,942	285,469	4,567,500	17,306,442	3%
2010 (10/09 - 9/10)	18,278,100	760,019	14,615,745	324,219	5,187,500	19,803,245	8%
Cumulative start to 6/07	21,553,612	569,761	10,956,942	684,722	10,955,553	21,912,495	2%
Cumulative start to 8/08	40,865,147	1,255,872	24,151,385	1,106,633	17,706,134	41,857,519	2%
Cumulative start to 9/09	57,714,269	1,918,297	36,890,327	1,392,102	22,273,634	59,163,961	3%
Cumulative start to 9/10	75,992,369	2,678,316	51,506,072	1,716,321	27,461,134	78,967,206	4%

year	As of Sep 2010	Oct-Dec 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Ore milled (tons)		233,928	944,174	920,100	920,440	920,136	920,161	920,266	143,456	920,221	920,221	920,221	920,221	920,221	920,221	920,221	920,221	920,221	920,221	920,222	920,223	920,224
Paste fill volume (ft3)		3,041,299	11,554,440	11,858,427	11,831,107	11,833,088	11,850,791	11,817,668	1,939,267	11,838,216	11,838,216	11,838,216	11,838,216	11,838,216	11,838,216	11,838,216	11,838,216	11,838,216	11,838,216	11,838,217	11,838,218	11,838,219
Tailings to pastefill (tons)		93,558	355,443	364,795	363,954	364,015	364,560	363,541	59,657	364,173	364,173	364,173	364,173	364,173	364,173	364,173	364,173	364,173	364,173	364,173	364,173	364,173
Tailings to DSTF (tons)		140,370	588,731	555,305	556,486	556,121	555,601	556,725	83,799	556,048	556,048	556,048	556,048	556,048	556,048	556,048	556,048	556,048	556,048	556,049	556,050	556,051
Tailings to DSTF (ft^3)		2,699,424	11,321,741	10,678,945	10,701,646	10,694,628	10,684,635	10,706,250	1,611,525	10,693,228	10,693,228	10,693,228	10,693,228	10,693,228	10,693,228	10,693,228	10,693,228	10,693,228	10,693,228	10,693,247	10,693,266	10,693,284
Waste Rock (ton)		111,085	464,481	459,445	264,240	188,224	147,631	155,120	34,272	242,932	242,932	242,932	242,932	242,932	242,932	242,932	242,932	242,932	242,932	242,933	242,934	242,935
Red Rock (ton)	34%	37,769	157,924	156,211	89,842	63,996	50,195	52,741	11,652	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,598	82,598
Green Rock (ton)	66%	73,316	306,557	303,234	174,398	124,228	97,436	102,379	22,620	160,335	160,335	160,335	160,335	160,335	160,335	160,335	160,335	160,335	160,335	160,336	160,336	160,337
General Placement Area:																						
Tailings (ft^3) --> Summer 60%, Winter 100%	83%	2,699,424	9,434,784	8,899,121	8,918,038	8,912,190	8,903,863	8,921,875	1,342,937	8,911,024	8,911,024	8,911,024	8,911,024	8,911,024	8,911,024	8,911,024	8,911,024	8,911,024	8,911,024	8,911,039	8,911,055	8,911,070
Red Rock into GPA (100% of Red Rock) (tons)		37,769	157,924	156,211	89,842	63,996	50,195	52,741	11,652	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,597	82,598	82,598
Green Rock into GPA (100% of Green Rock) (tons)		73,316	281,557	278,234	149,398	99,228	72,436	77,379	(2,380)	135,335	135,335	135,335	135,335	135,335	135,335	135,335	135,335	135,335	135,335	135,335	135,334	135,334
Total Waste Rock into GPA (100% of Red Rock) (tons)		111,085	439,481	434,445	239,240	163,224	122,631	130,120	9,272	217,932	217,932	217,932	217,932	217,932	217,932	217,932	217,932	217,932	217,932	217,932	217,932	217,932
Mine Rock into GPA (ft^3)		1,777,356	7,031,696	6,951,120	3,827,840	2,611,584	1,962,096	2,081,920	148,352	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912	3,486,912
Total Materials in General Placement Area (ft^3)		**4,476,780**	**16,466,480**	**15,850,241**	**12,745,878**	**11,523,774**	**10,865,959**	**11,003,795**	**1,491,289**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,936**	**12,397,951**	**12,397,967**	**12,397,982**
Cumulative (ft^3)	**59,185,351**	**63,662,131**	**80,128,611**	**95,978,852**	**108,724,730**	**120,248,504**	**131,114,462**	**142,118,257**	**143,609,547**	**156,007,482**	**168,405,418**	**180,803,354**	**193,201,290**	**205,599,225**	**217,997,161**	**230,395,097**	**242,793,032**	**255,190,968**	**267,588,904**	**279,986,855**	**292,384,822**	**304,782,804**
Crest Level (ft E.L.)	**2,449**	**2,470**																				
Shell Area:																						
Tailings to Shell (Summer 40%) (ft3)	17%	0	1,886,957	1,779,824	1,783,608	1,782,438	1,780,773	1,784,375	268,587	1,782,205	1,782,205	1,782,205	1,782,205	1,782,205	1,782,205	1,782,205	1,782,205	1,782,205	1,782,205	1,782,208	1,782,211	1,782,214
Green Rock to Shell (ton)		0	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,001	25,002	25,003
Green Rock to Shell (ft3)		0	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,016	400,032	400,048
Total Materials Placed to Shell (ft3)		**-**	**2,286,957**	**2,179,824**	**2,183,608**	**2,182,438**	**2,180,773**	**2,184,375**	**668,587**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,205**	**2,182,224**	**2,182,243**	**2,182,262**

Material Tonnage into DSTF

year	As of Sep 2010	Oct-Dec 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
General Placement Area		251,455	930,090	897,199	702,978	626,658	585,632	594,057	79,105	681,305	681,305	681,305	681,305	681,305	681,305	681,305	681,305	681,305	681,305	681,306	681,307	681,308
Shell		-	123,122	117,551	117,748	117,687	117,600	117,787	38,967	117,675	117,675	117,675	117,675	117,675	117,675	117,675	117,675	117,675	117,675	117,676	117,677	117,678
Total		251,455	1,053,212	1,014,750	820,726	744,345	703,232	711,845	118,071	798,980	798,980	798,980	798,980	798,980	798,980	798,980	798,980	798,980	798,980	798,982	798,984	798,986
Total-Cumulative (dry tons)	4,394,637	4,646,091	5,699,303	6,714,053	7,534,779	8,279,123	8,982,355	9,694,200	9,812,272	10,611,252	11,410,231	12,209,211	13,008,191	13,807,171	14,606,151	15,405,131	16,204,111	17,003,091	17,802,070	18,601,052	19,400,036	**20,199,022**

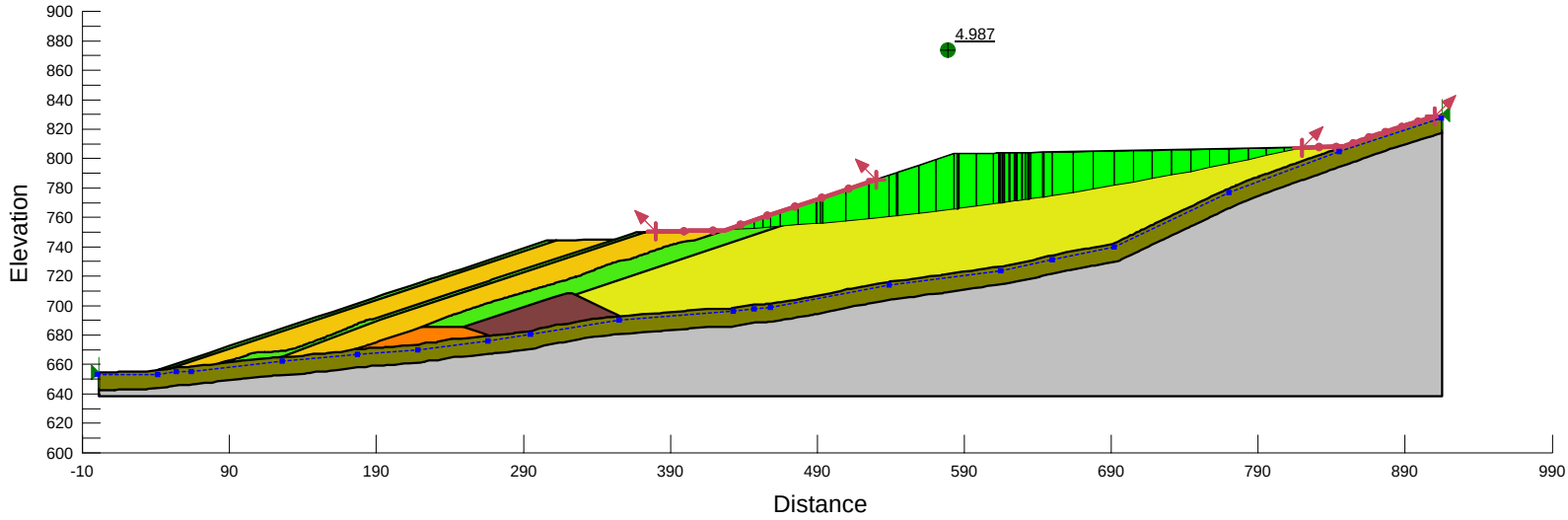
Notes:
- It is assumed that all of waste rock are placed into DSTF, though, some of green rock may be used for other construction (worst case).
- It is assumed that dry stack can be stacked at shell for 5 month in a year. During summer, 40% of dry stack is placed at shell, and the remaining is placed at general placement area.
- Total volume of DSTF as of September 2010 was calculated by SRK using Civil 3D by AutoDesk.
- In-situ dry density of dry stack at DSTF was assumed based on the results of Troxler measurements.
- Waste development plan beyond 2017 assumes that average production rates will be consistent with those used between 2012 and 2017.

Appendix B:
Stability Analysis Results

Appendix B_Table 1: Stability Analysis Results

ID	Scenario	Condition Analyzed			Calculated Minimum FoS (with recommended SRK friction angles for Tailings & GPA)	Calculated Minimum FoS (with 0.8* Friction Angle of Tailings and GPA)	Failure Mode /Comments
		Static	Operations Pseudo-static (k=0.05)	Closure Pseudo-static (k=0.10)			
1	Water table 10 feet below surface_01	X			1.9	1.5	shallow - shell failure
2	Water table 10 feet below surface_02	X			2.6	2.3	deep_seated failure
3	Water table 10 feet below surface_03	X			3.4	2.8	deep_seated failure, DSTF
4	Water table 10 feet below surface_04	X			5.0	3.8	deep_seated - GPA failure
5	Low phreatic surface_01	X			1.9	1.5	shallow - shell failure
6	Low phreatic surface_02	X			2.6	2.3	deep_seated failure
7	Low phreatic surface_03	X			3.4	2.8	deep_seated failure, DSTF
8	Low phreatic surface_04	X			4.7	3.8	deep_seated GPA failure
9	High phreatic surface_01	X			1.9	1.5	shallow - shell failure
10	High phreatic surface_02	X			2.6	2.3	deep_seated failure
11	High phreatic surface_03	X			3.2	2.6	deep_seated failure, DSTF
12	High phreatic surface_04	X			3.9	3.2	deep_seated GPA failure
13	Water table 10 feet below surface_01a		X		1.7	1.3	shallow - shell failure
14	Water table 10 feet below surface_02a		X		2.1	1.9	deep_seated failure
15	Water table 10 feet below surface_03a		X		2.7	2.2	deep_seated failure, DSTF
16	Water table 10 feet below surface_04a		X		3.6	2.8	shallow - GPA failure
17	Low phreatic surface_01a		X		1.6	1.3	shallow - shell failure
18	Low phreatic surface_02a		X		2.1	1.9	deep_seated failure
19	Low phreatic surface_03a		X		2.7	2.2	deep_seated failure, DSTF
20	Low phreatic surface_04a		X		3.4	2.8	deep_seated GPA failure
21	High phreatic surface_01a		X		1.6	1.3	shallow - shell failure
22	High phreatic surface_02a		X		2.1	1.9	deep_seated failure
23	High phreatic surface_03a		X		2.5	2.1	deep_seated failure, DSTF
24	High phreatic surface_04a		X		2.9	2.4	deep_seated failure
25	Water table 10 feet below surface_01b			X	1.4	1.1	shallow - shell failure
26	Water table 10 feet below surface_02b			X	1.8	1.6	deep_seated failure
27	Water table 10 feet below surface_03b			X	2.2	1.8	deep_seated failure, DSTF
28	Water table 10 feet below surface_04b			X	2.8	2.2	shallow - GPA failure
29	Low phreatic surface_01b			X	1.4	1.1	shallow - shell failure
30	Low phreatic surface_02b			X	1.8	1.6	deep_seated failure
31	Low phreatic surface_03b			X	2.2	1.8	deep_seated failure, DSTF
32	Low phreatic surface_04b			X	2.7	2.2	deep_seated GPA failure
33	High phreatic surface_01b			X	1.4	1.1	shallow - shell failure
34	High phreatic surface_02b			X	1.8	1.6	deep_seated failure
35	High phreatic surface_03b			X	2.0	1.7	deep_seated failure, DSTF
36	High phreatic surface_04b			X	2.2	1.8	deep_seated failure

Operations Static Loading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Elevation
900
880
860
840
820
800
780
760
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660
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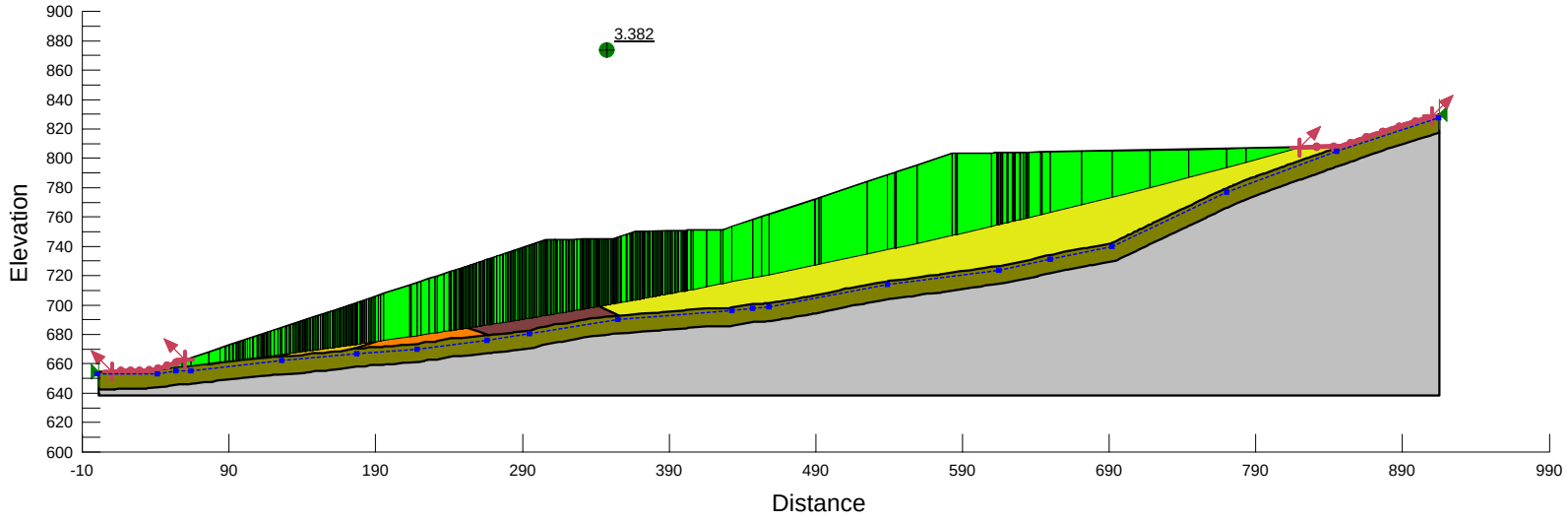
890
990
Distance


3.382
Elevation
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840
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800
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760
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290
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490
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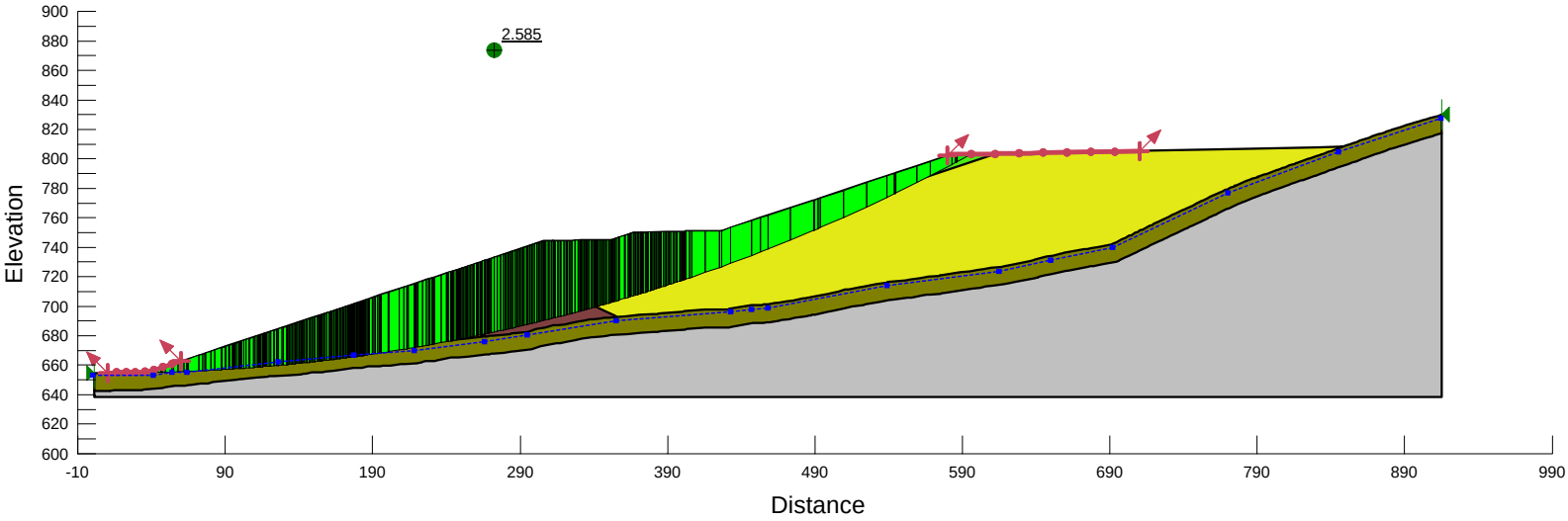
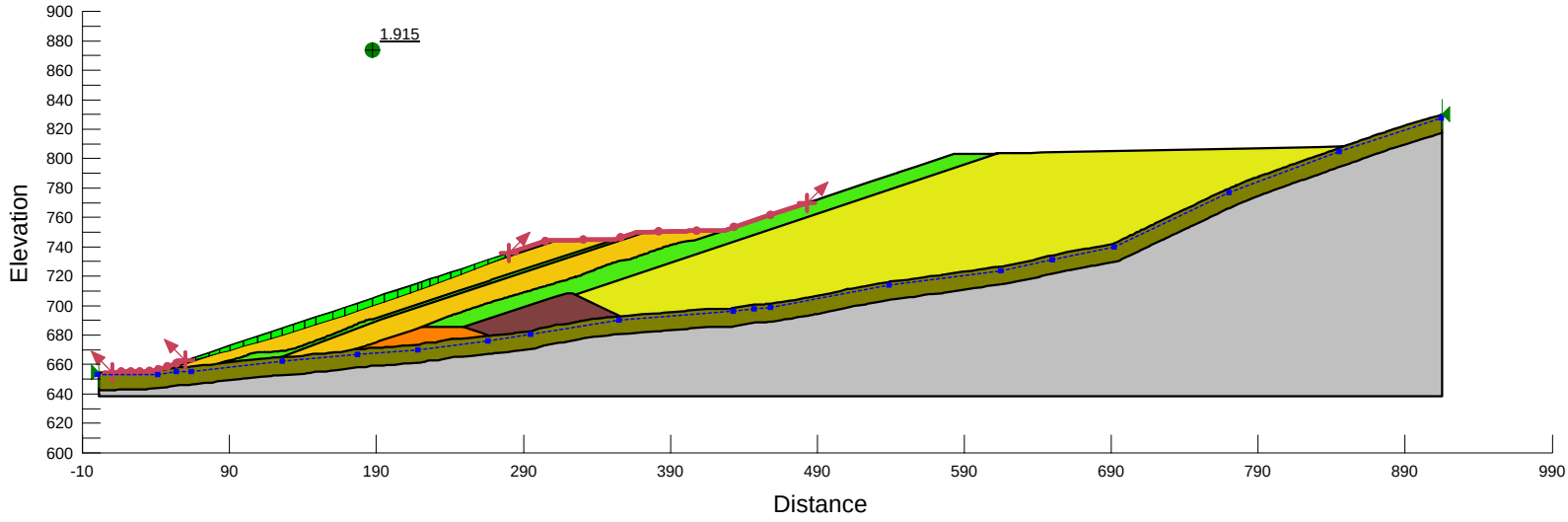
890
990
Distance


2.585
Elevation
900
880
860
840
820
800
780
760
740
720
700
680
660
640
620
600
-10
90
190
290
390
490
590
690
790
890
990
Distance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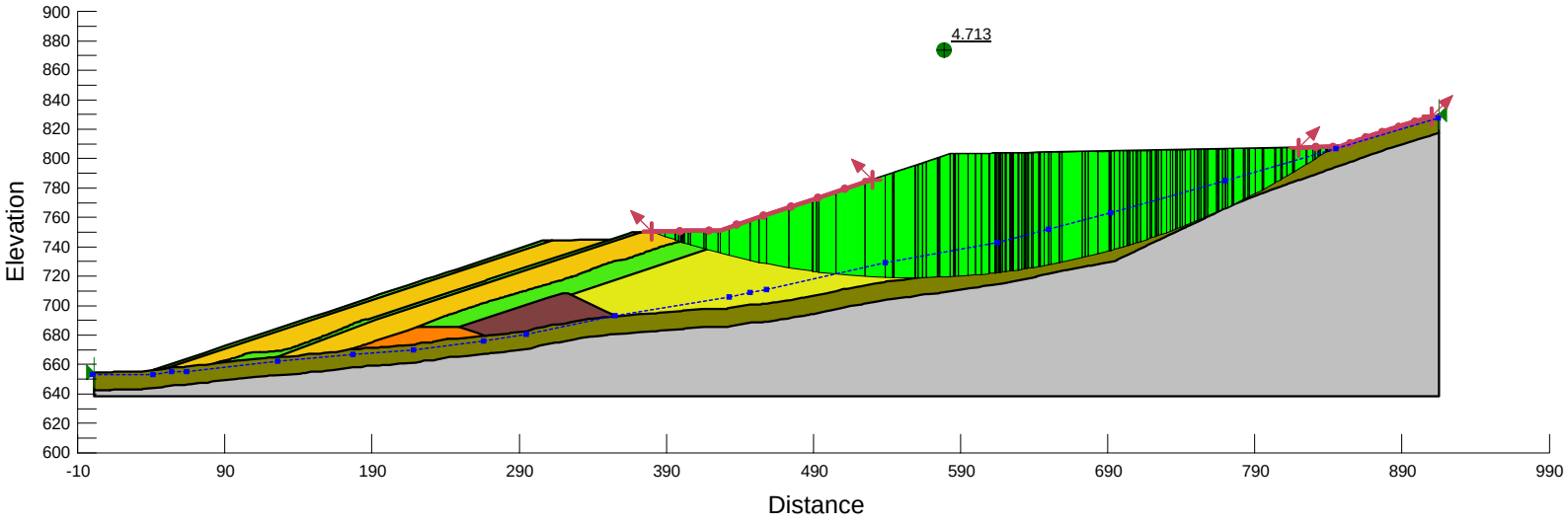
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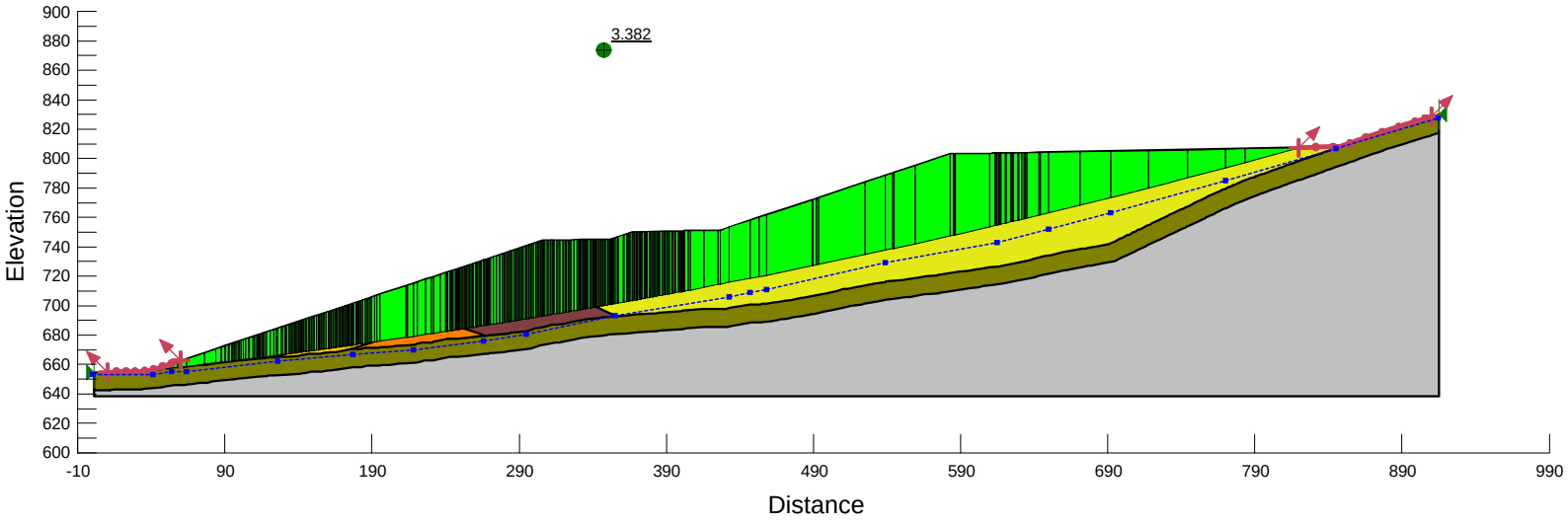
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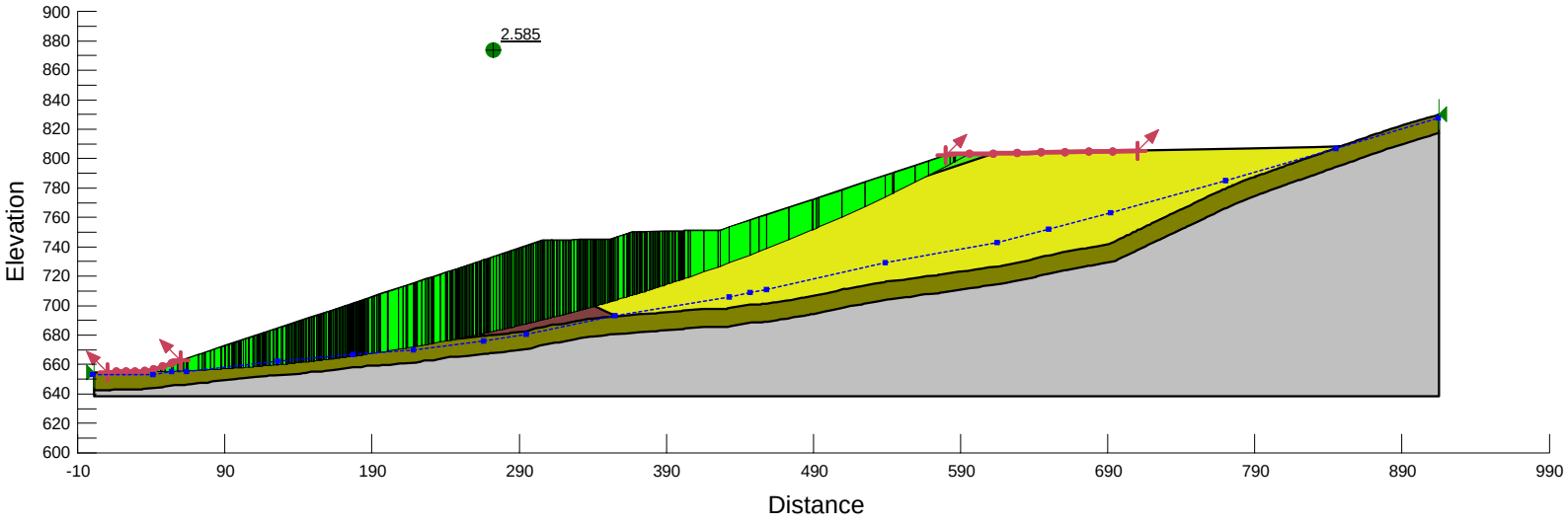
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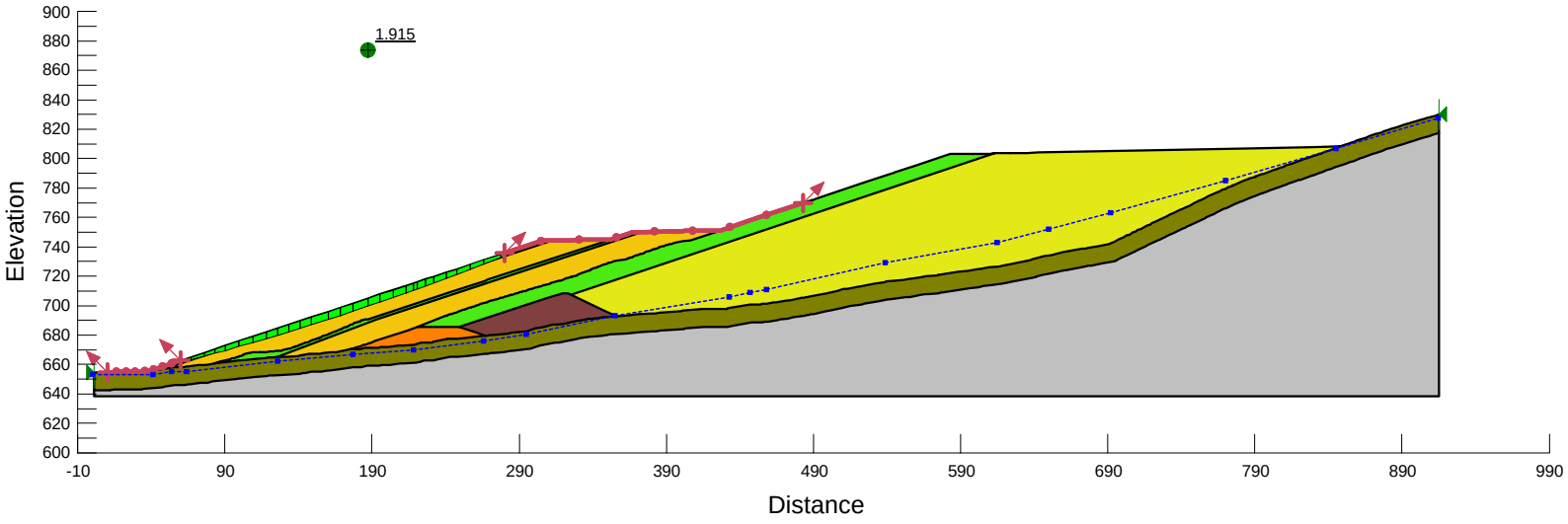
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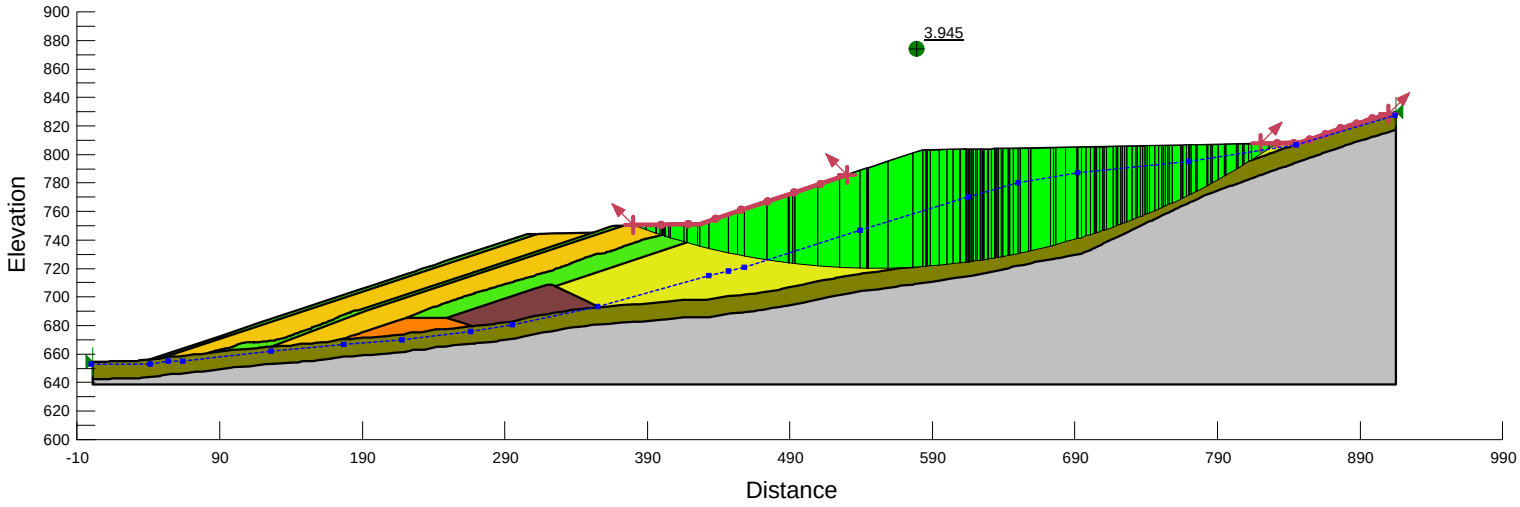
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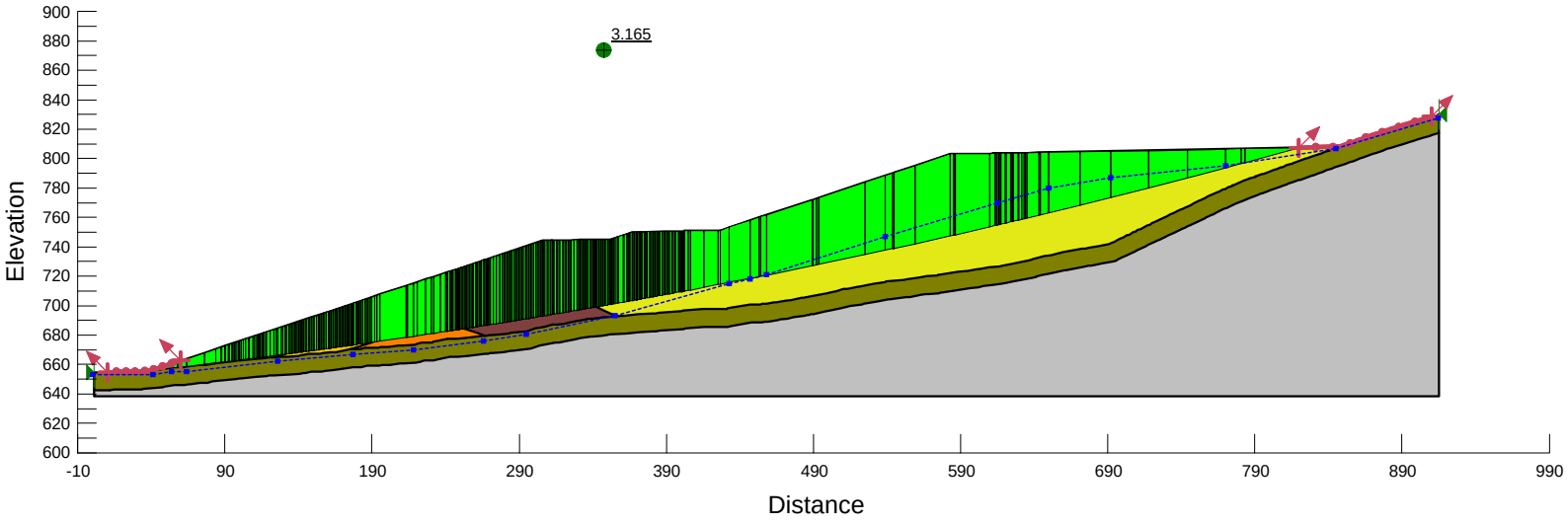
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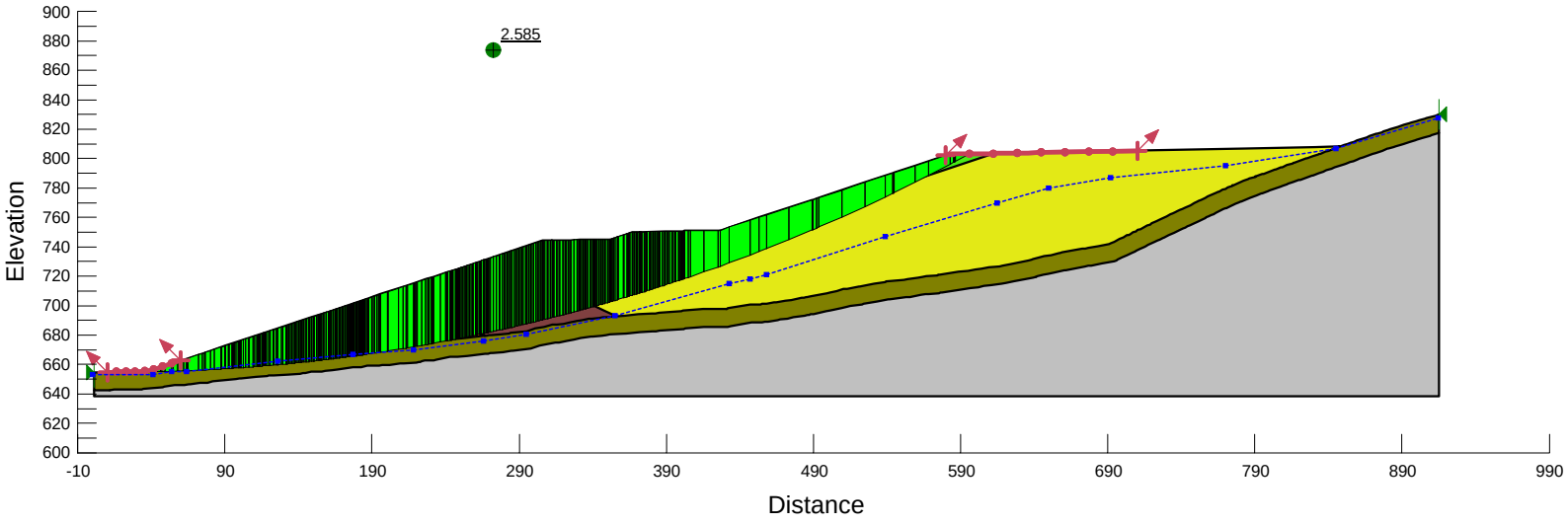
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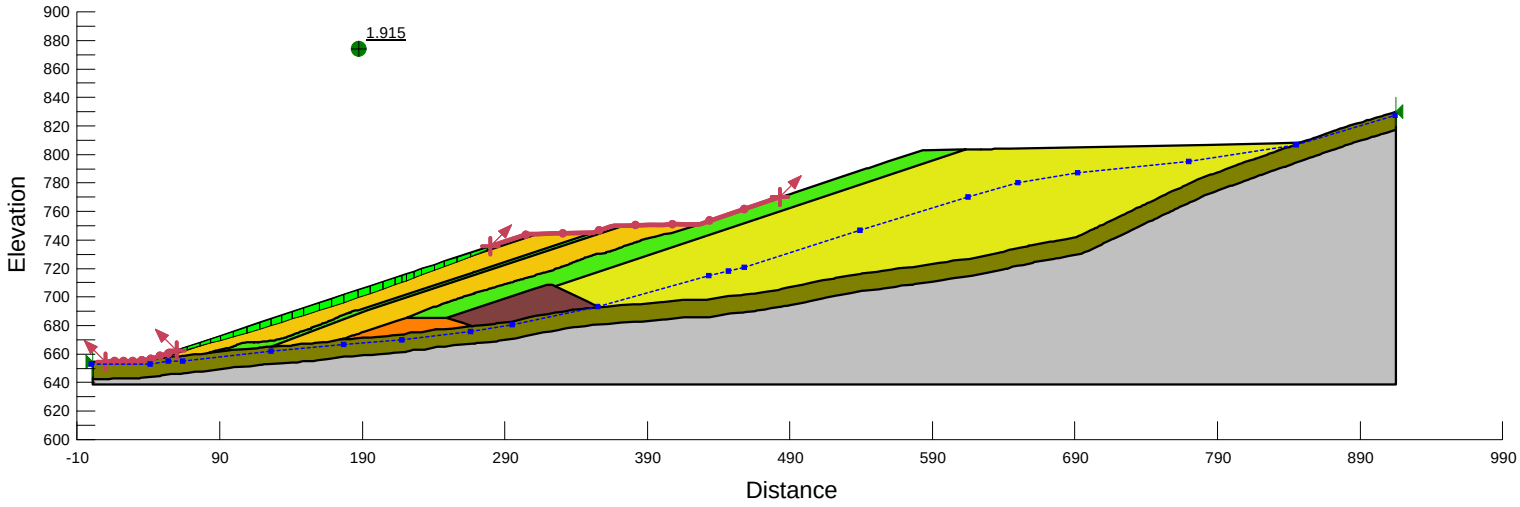
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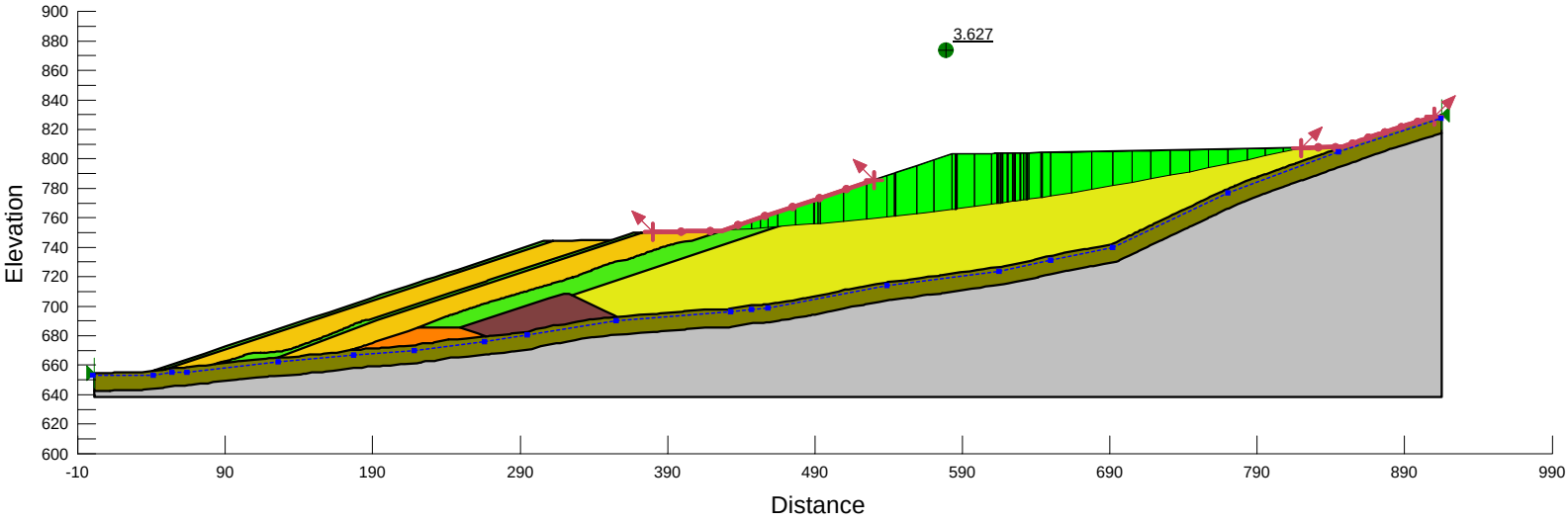
Operations Pseudo-Static Loading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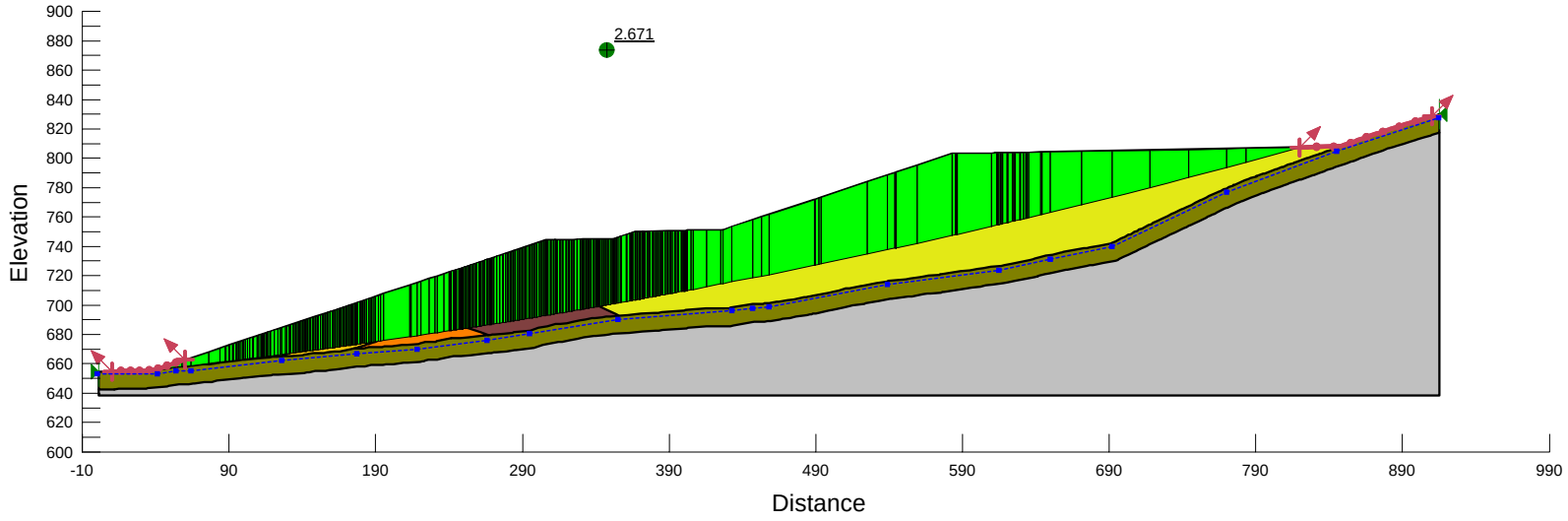
Distance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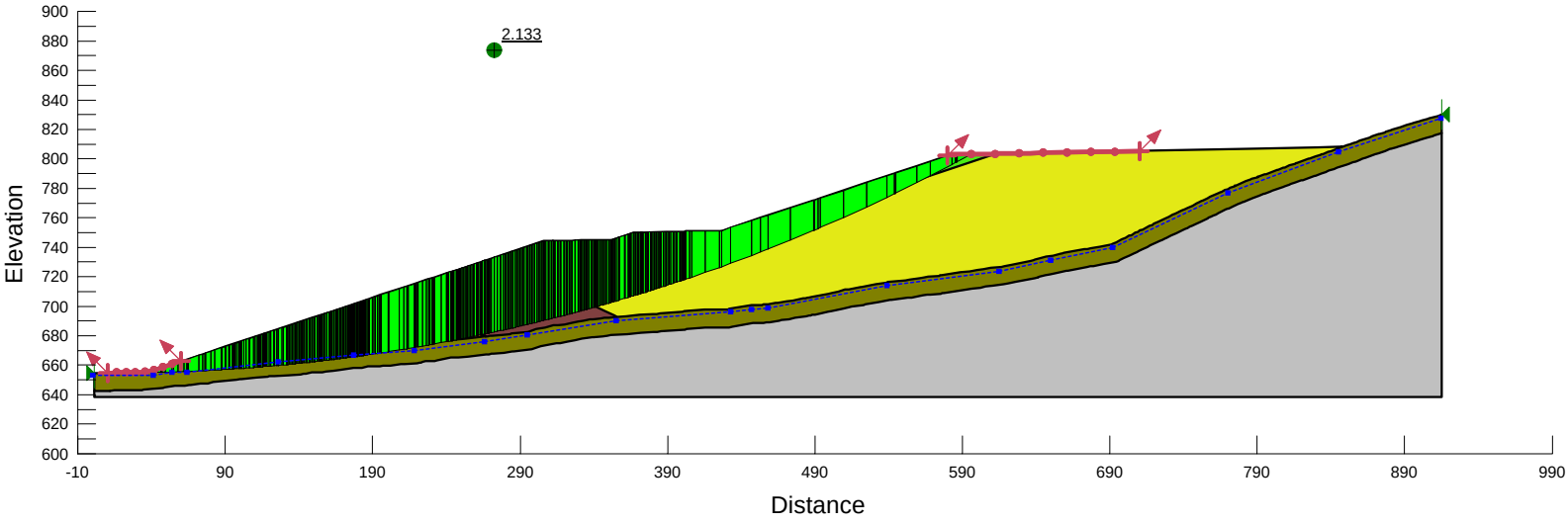
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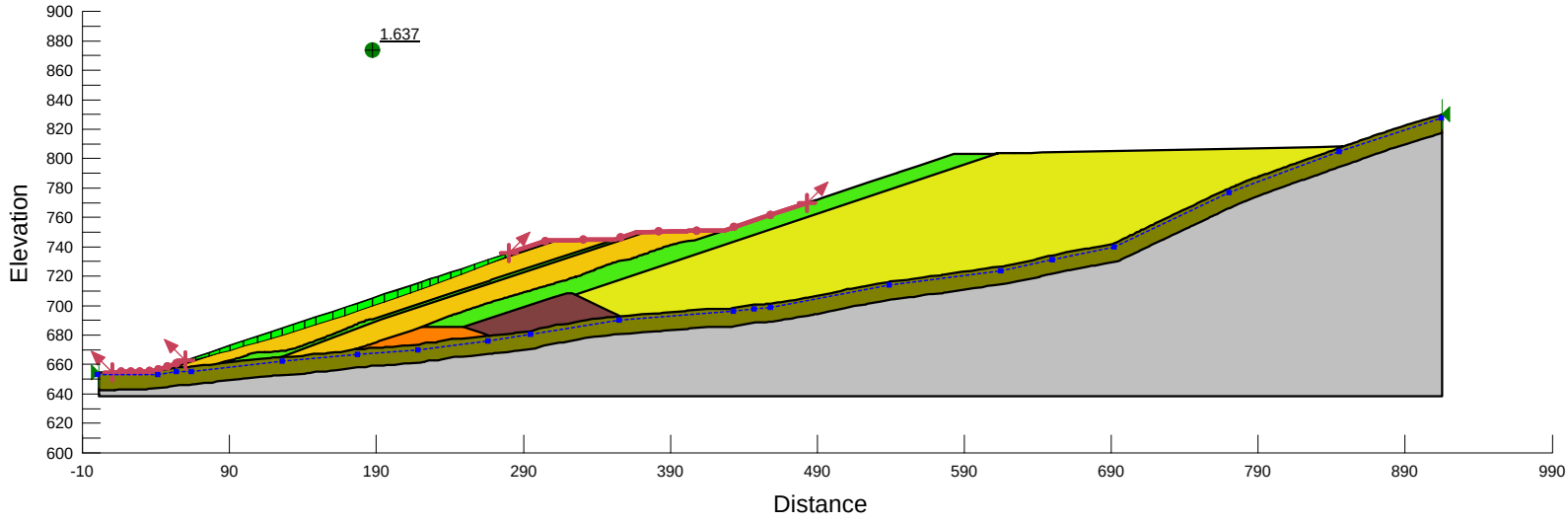
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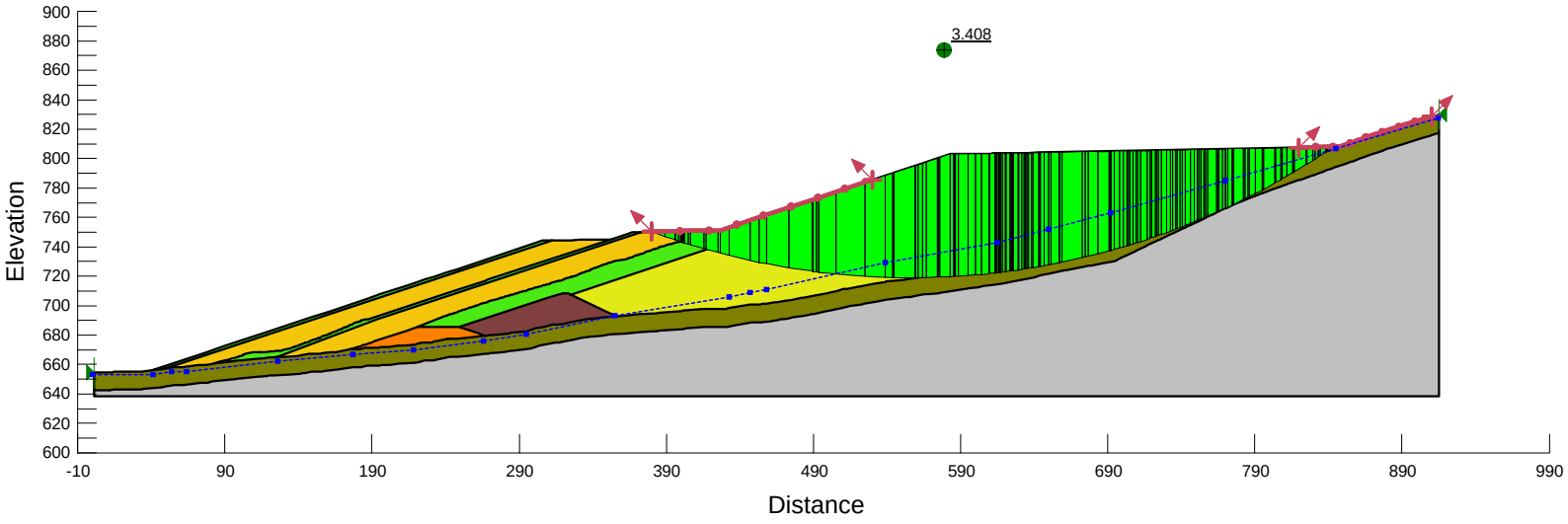
Distance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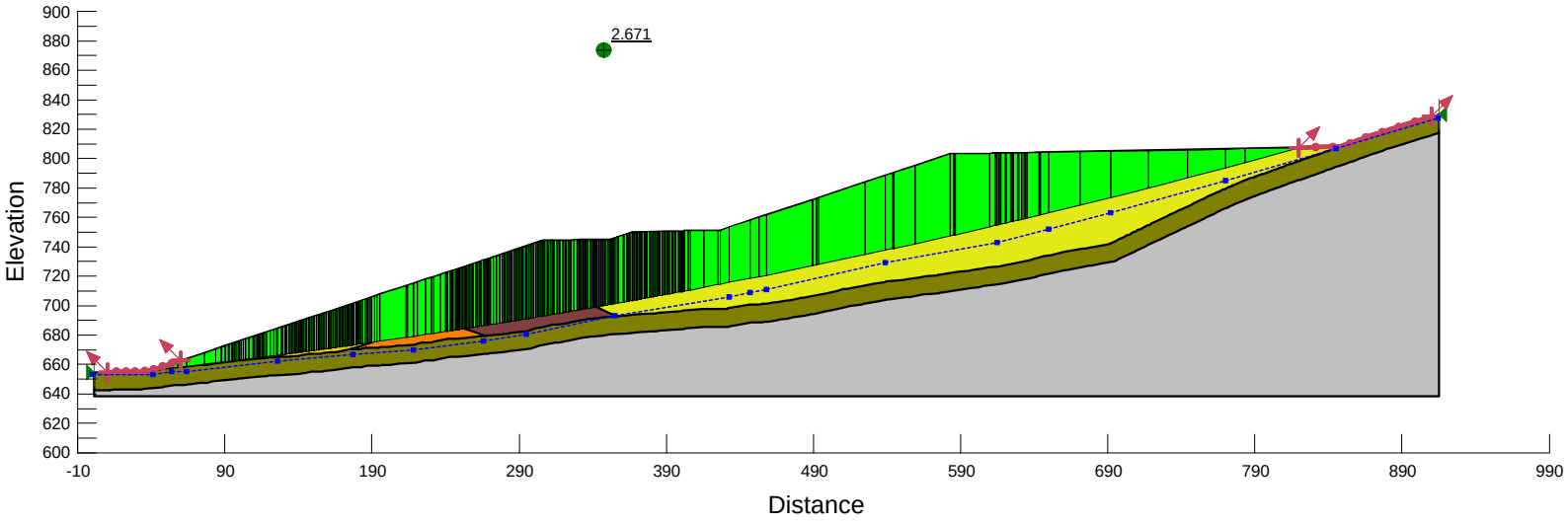
Distance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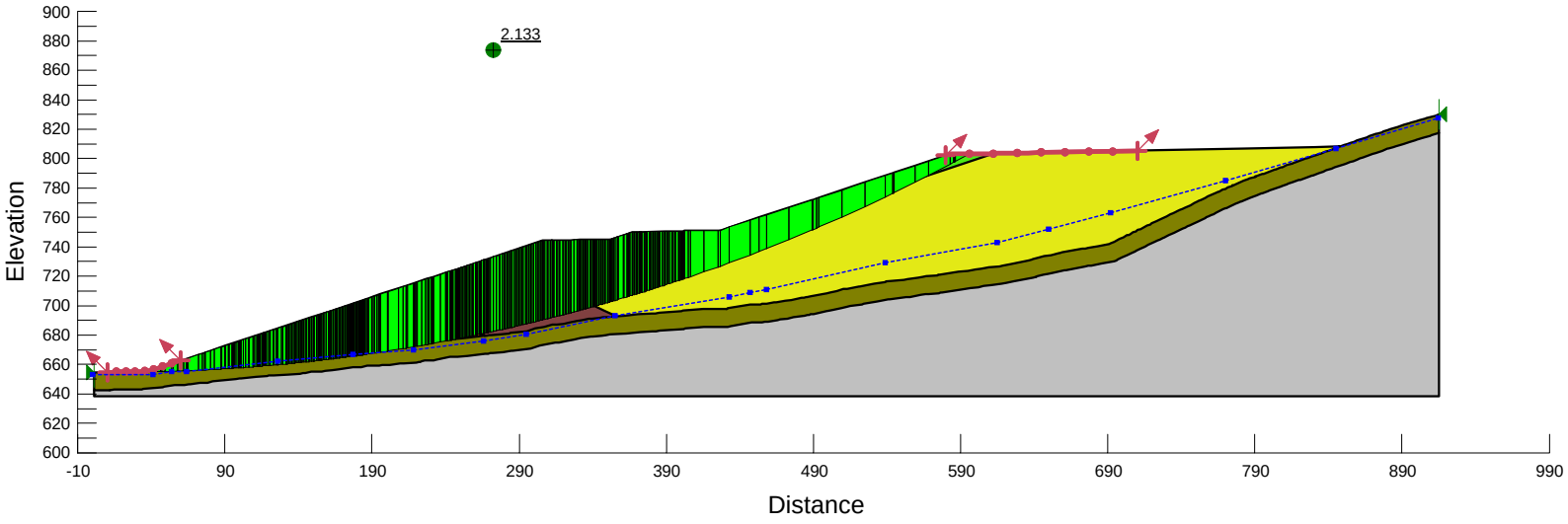
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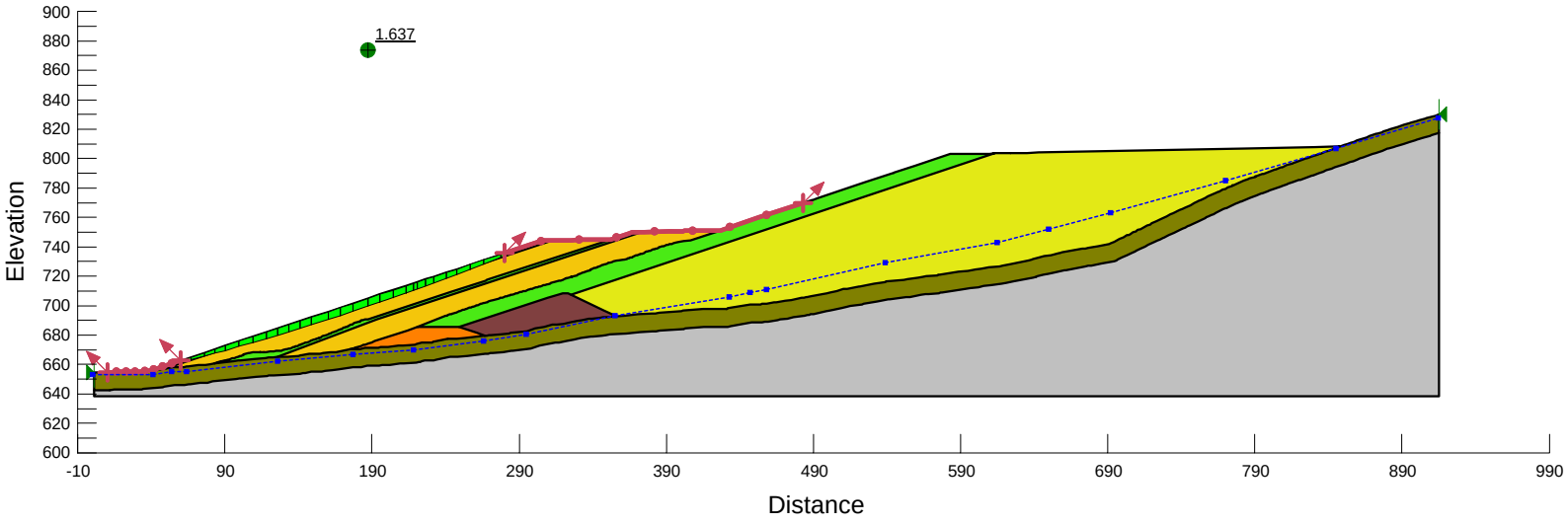
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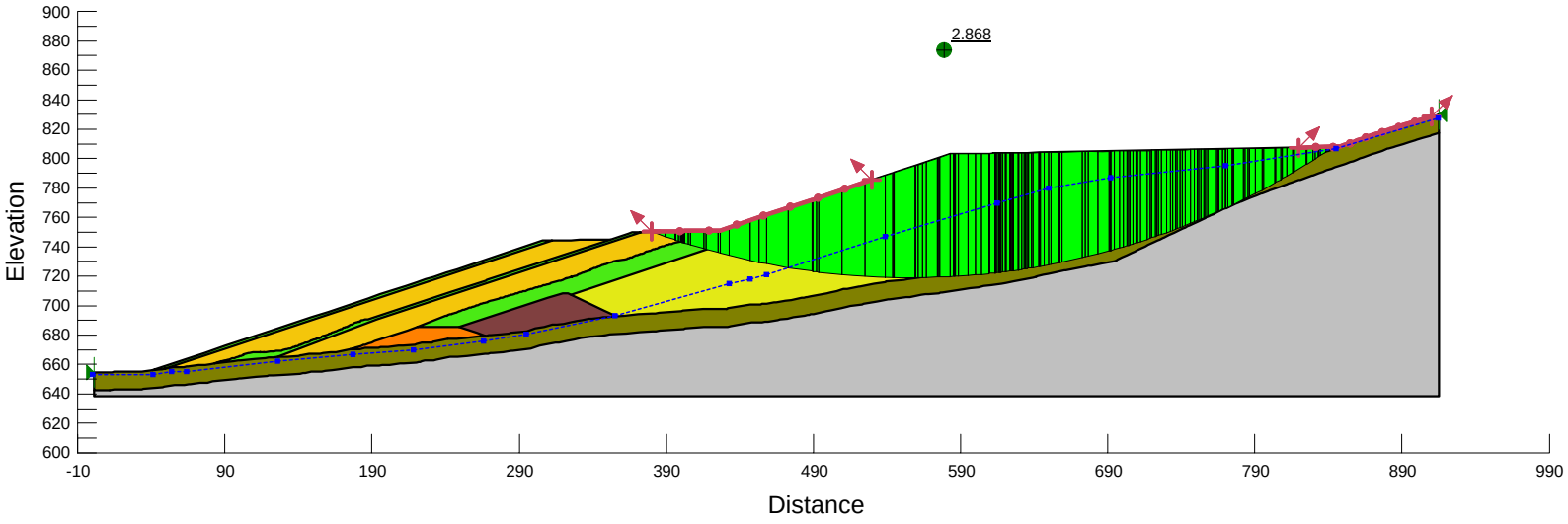
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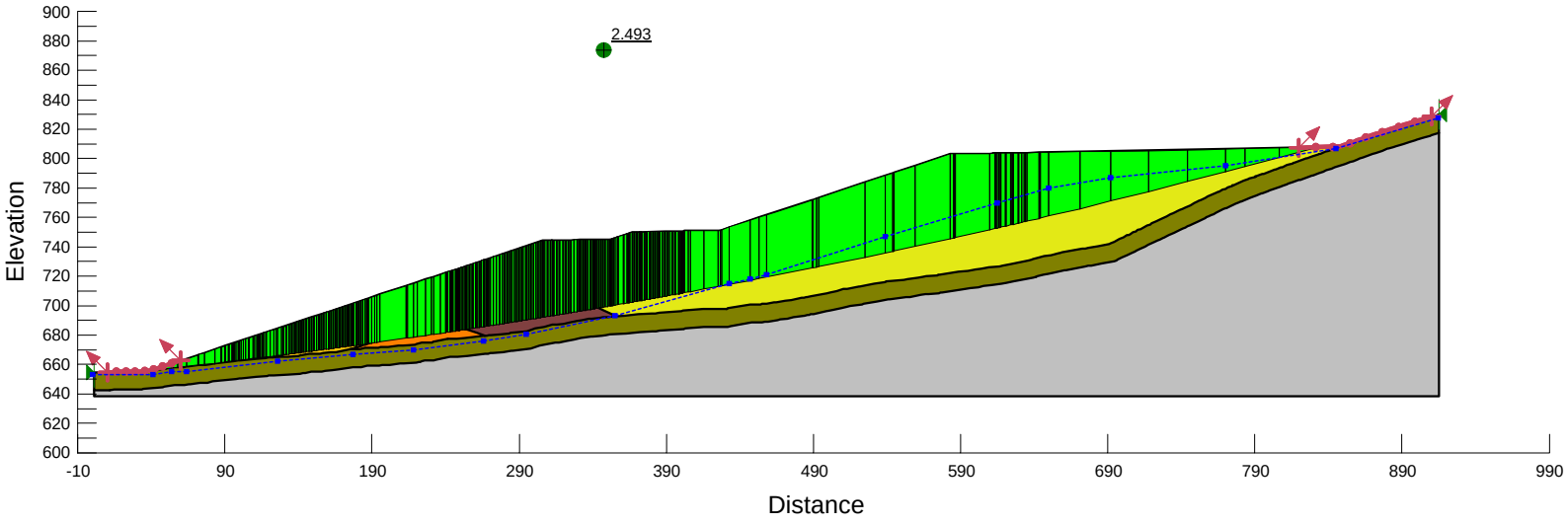
Distance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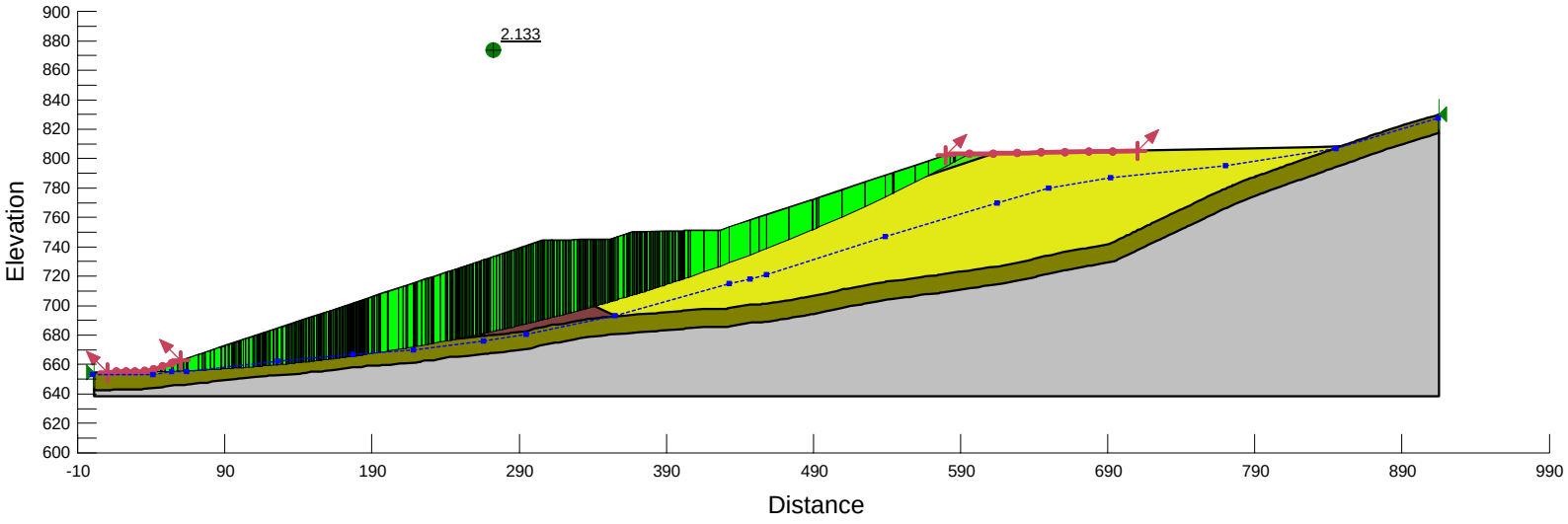
Distance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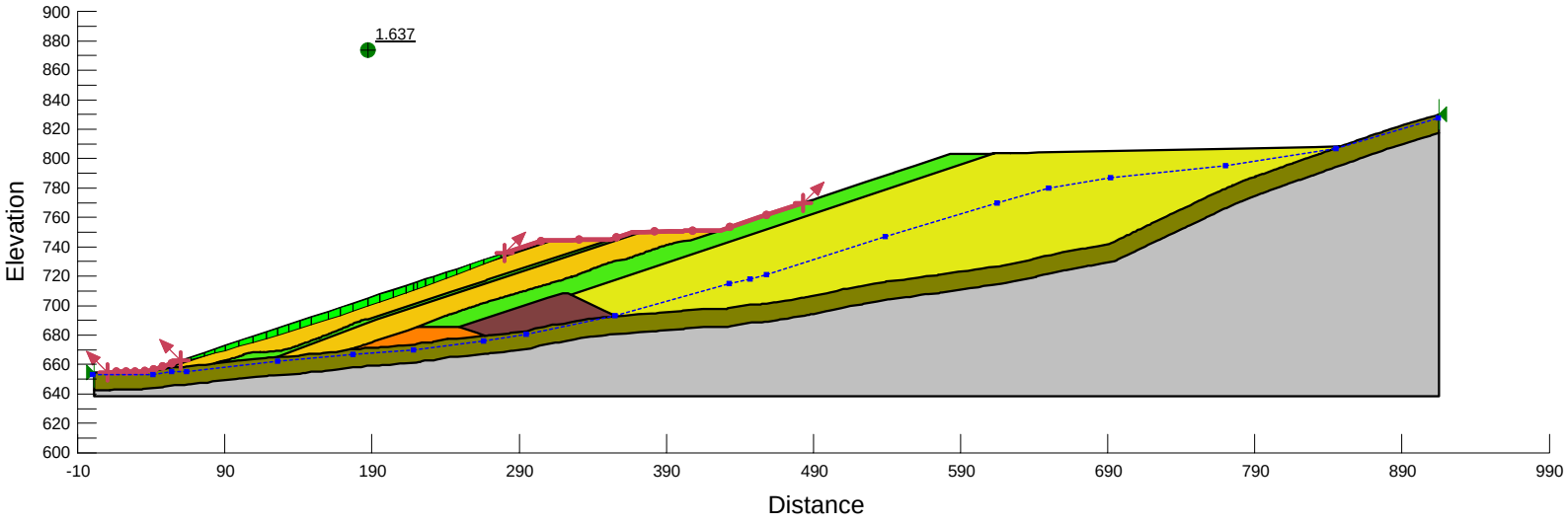
Distance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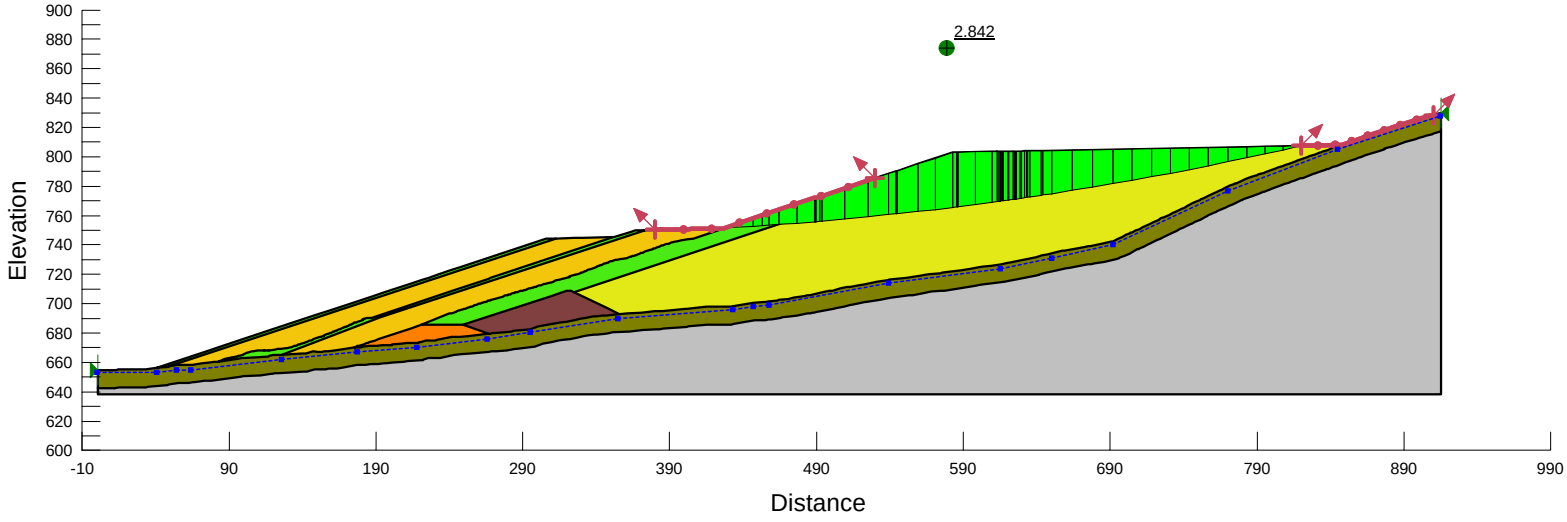
Distance

Closure Pseudo-Static Loading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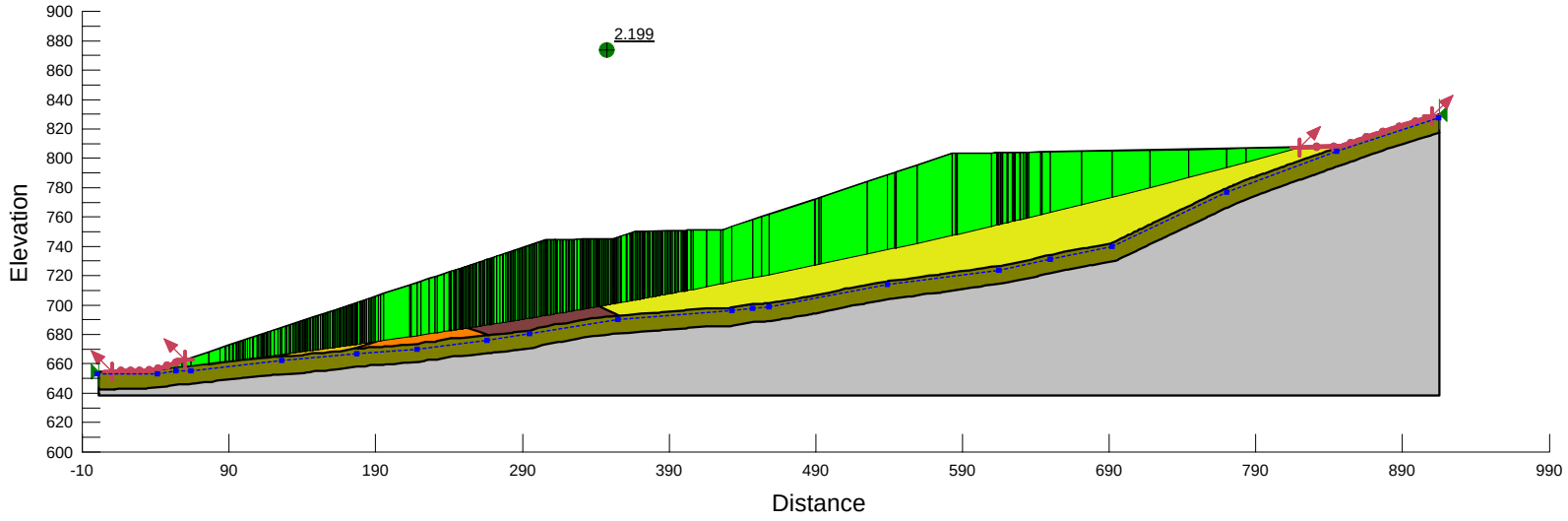
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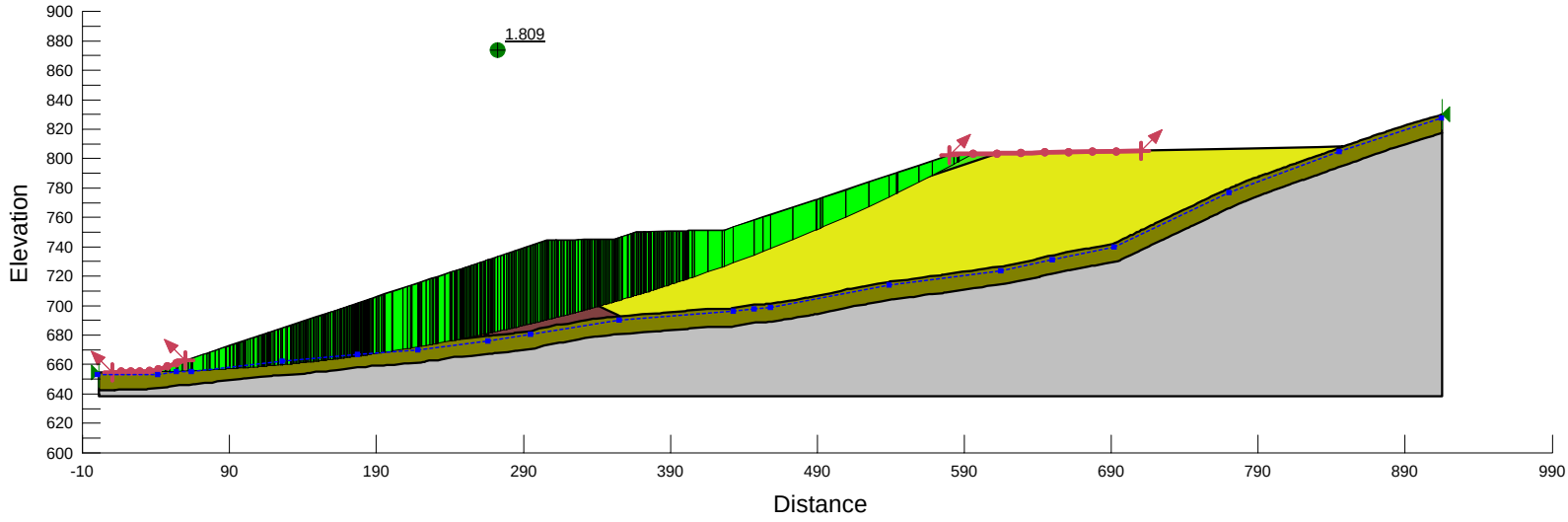
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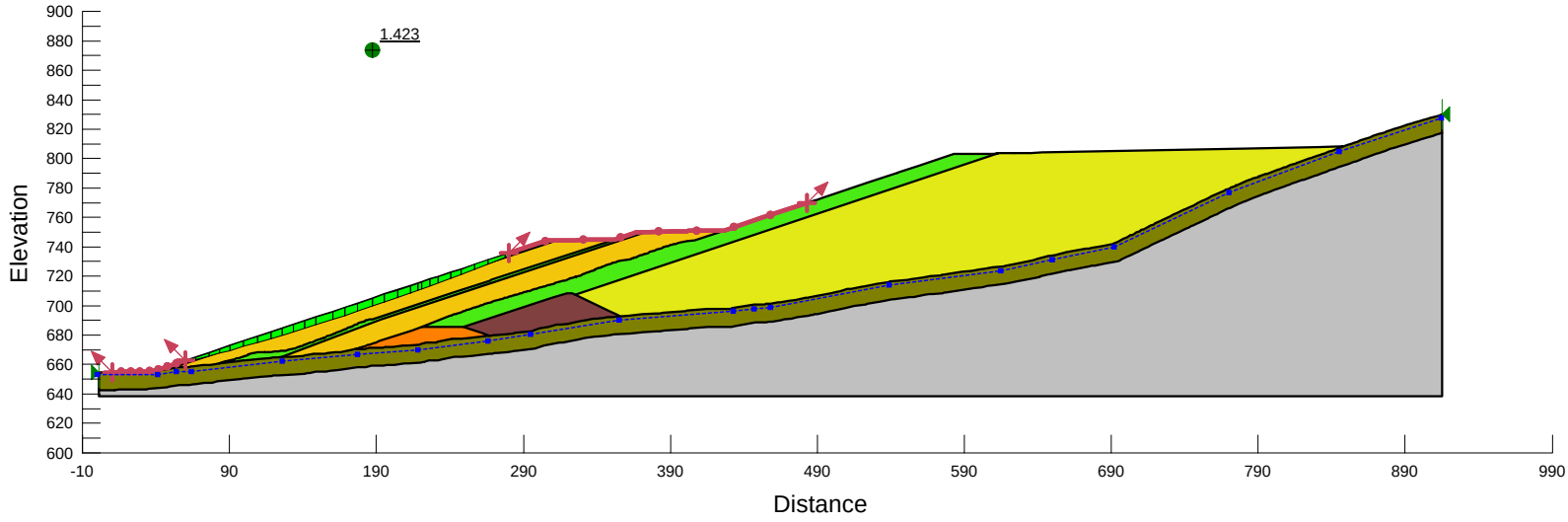
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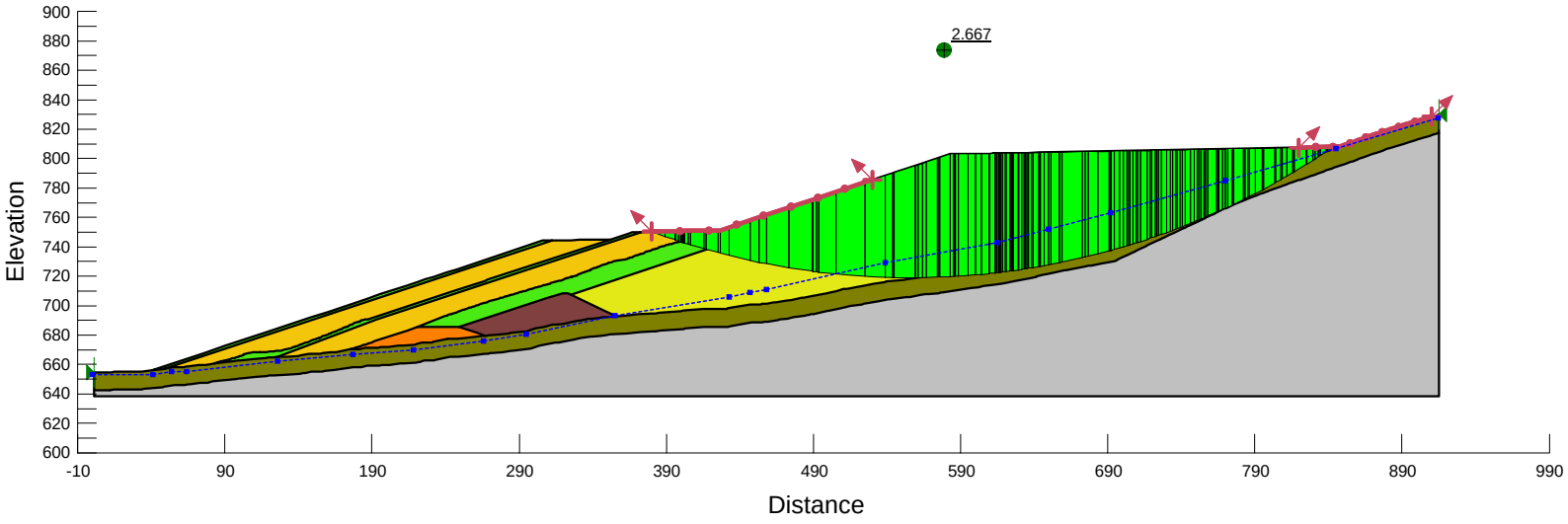
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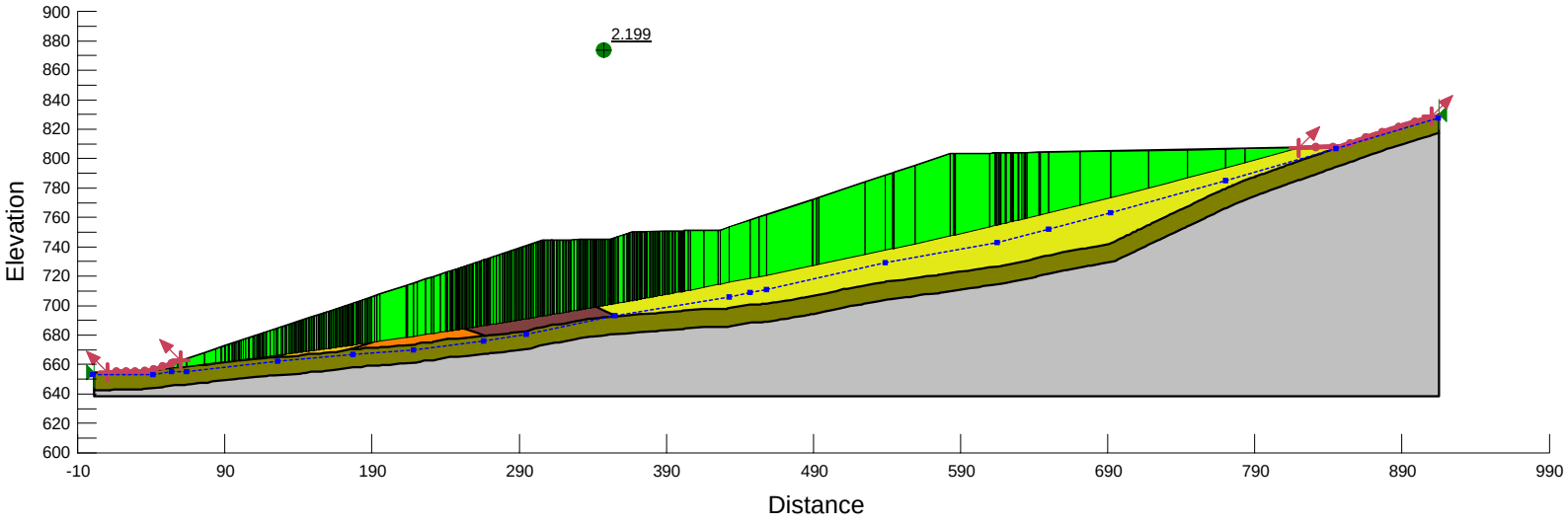
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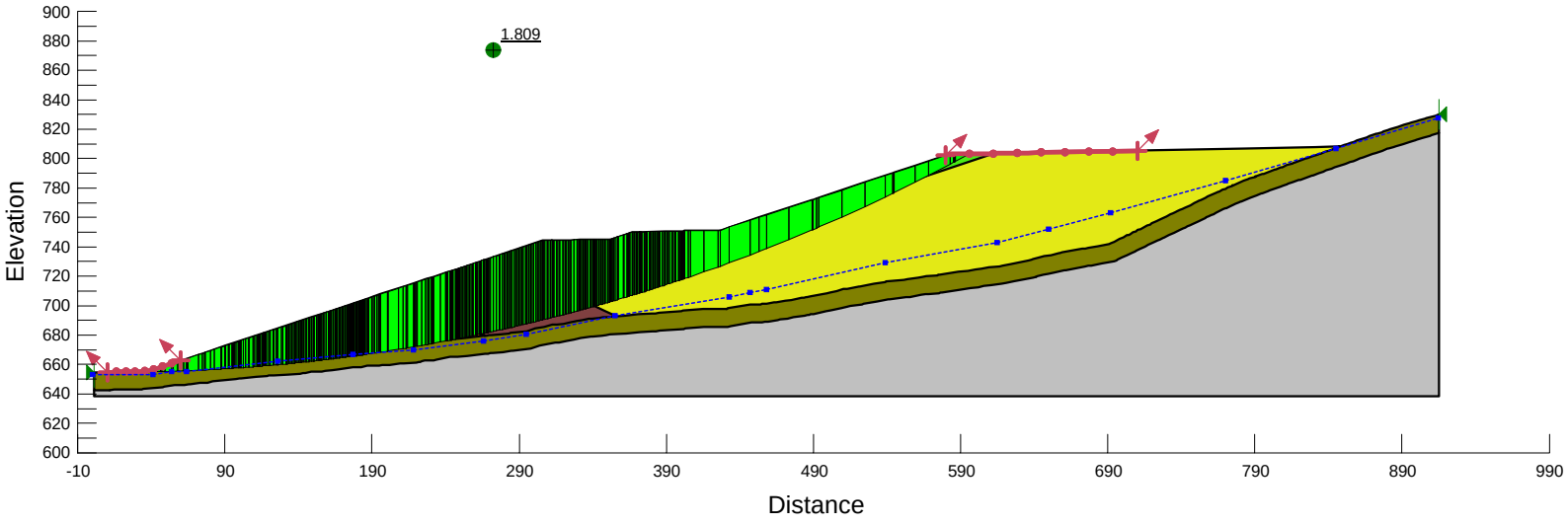
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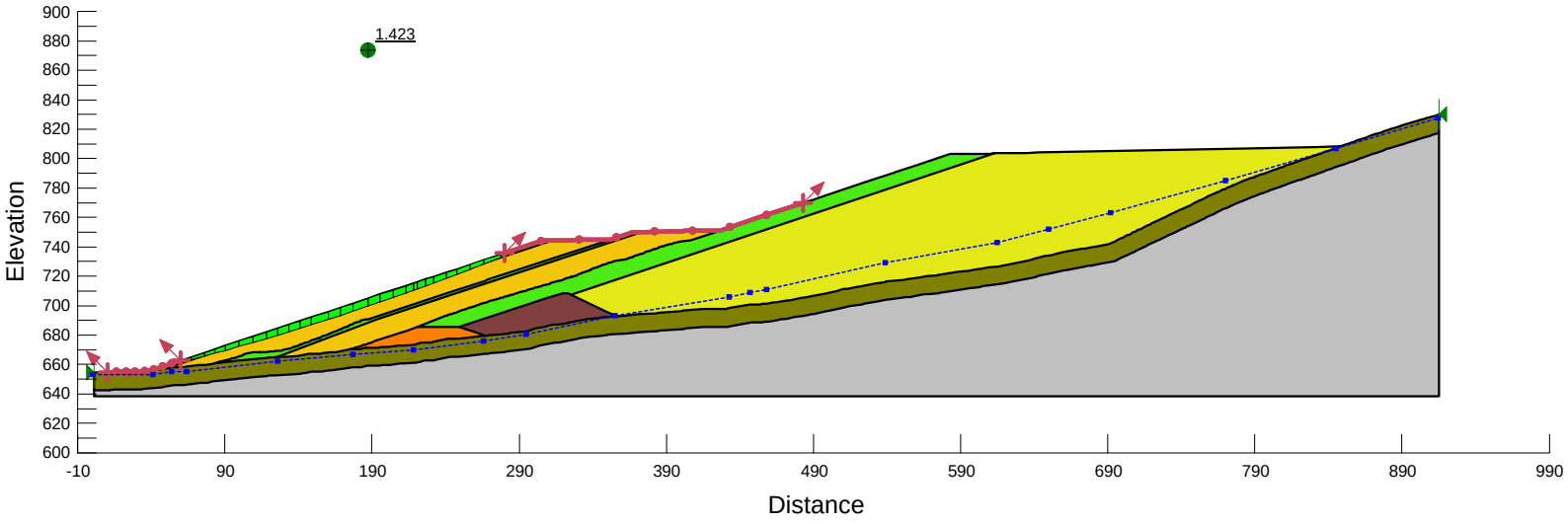
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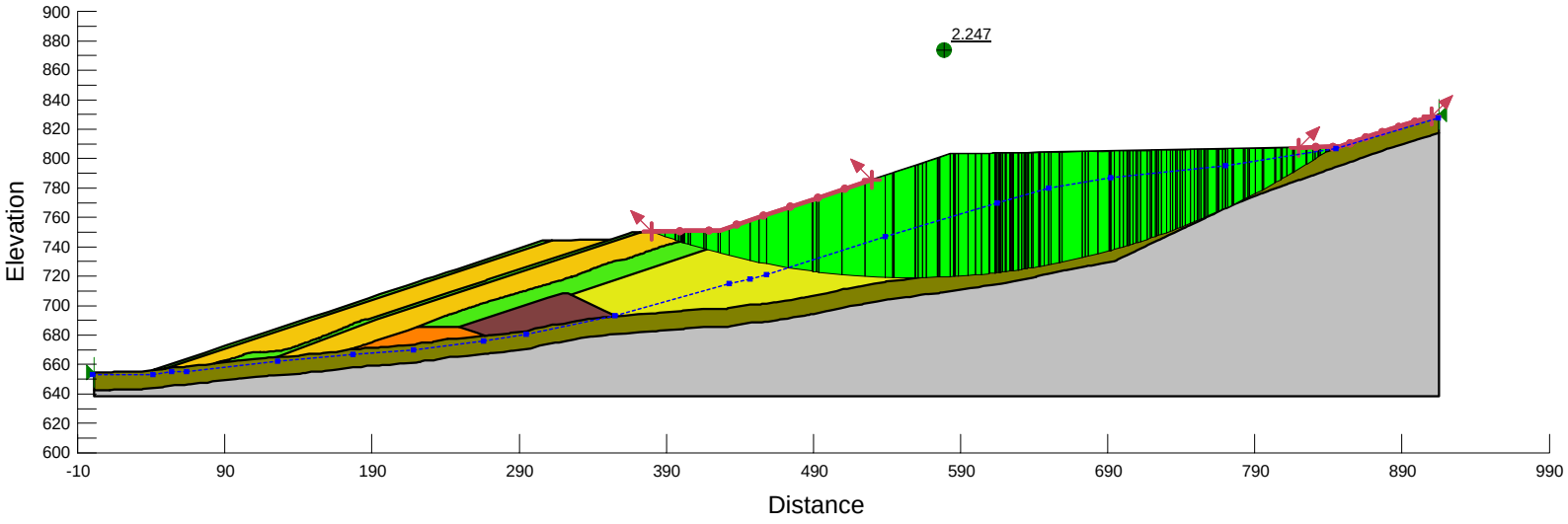
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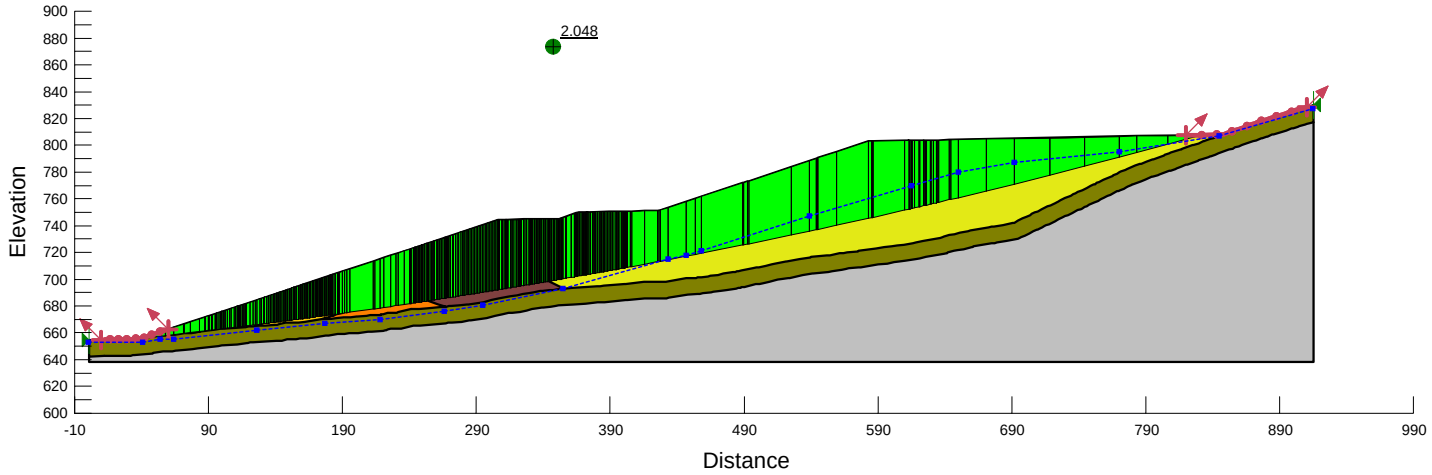
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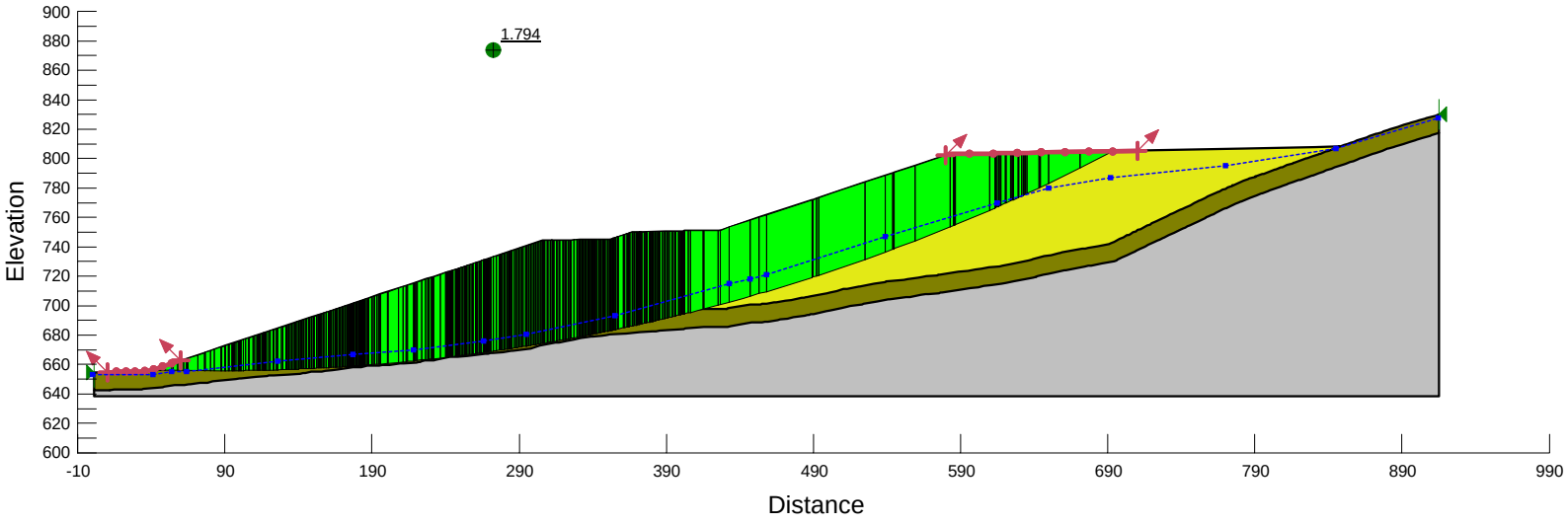
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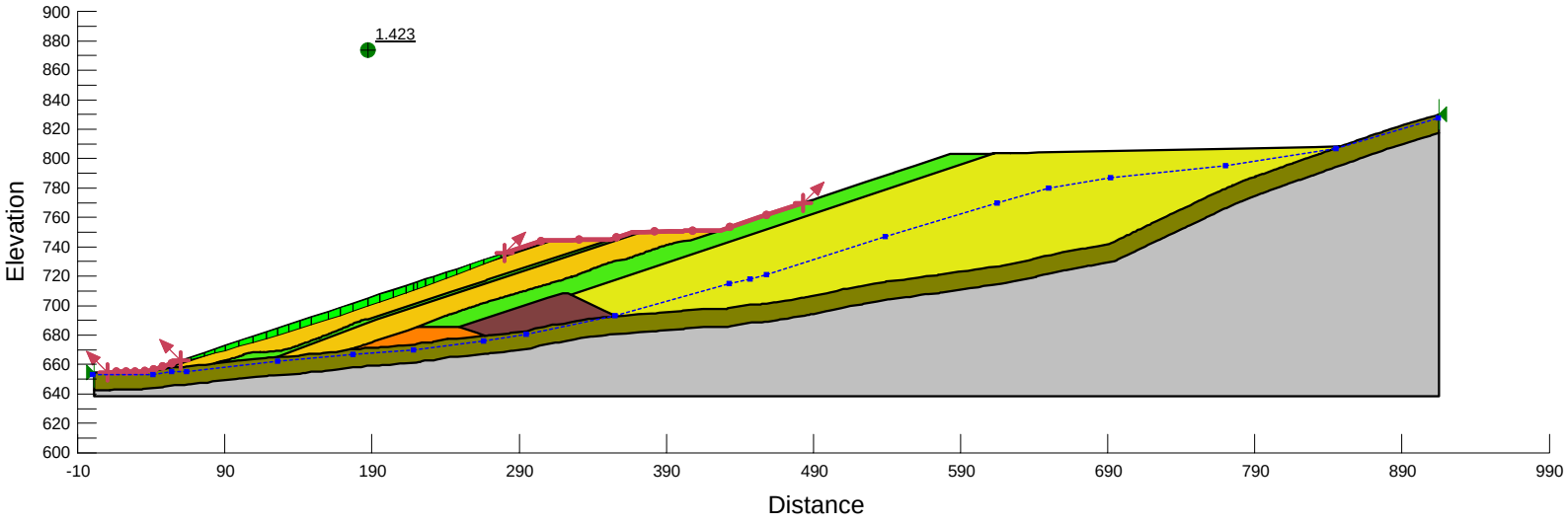
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