Revised January 20, 2011
November 23, 2010

Ms. Molly Frisbie
San Diego Gas & Electric Company
8315 Century Park Court, CP-21G
San Diego, CA 92123

Subject: Rock Fall Hazard Evaluations
Sunrise Powerlink Project
San Diego and Imperial Counties, California
URS Project No. 27661033.00010

Dear Ms. Frisbie:

URS Corporation Americas (URS) is pleased to present this letter that summarizes the evaluation of rock fall hazards that could impact the proposed Sunrise Powerlink Project. Our work is intended to assist the San Diego Gas & Electric Company (SDG&E) and their consultants with project planning and design, and to address the rock fall portion of Mitigation Measure G-6a. We have revised this letter to address comments from the project design team.

BACKGROUND

Geologic hazards, including rock falls, were discussed in the October 1, 2010 URS report titled "Geotechnical and Geologic Hazards Investigation, Sunrise Powerlink Project, San Diego and Imperial Counties, California". The general discussion presented in that report considered the hazard associated with rock falls generated from adjacent hillsides as low or nonexistent for most of the structures along the proposed transmission line. However, given the locally steep slopes and bold rock outcrops, some potential for rock falls was considered low to moderate at a few locations along the transmission line route. Additional evaluations prior to and during construction were recommended.

The need for additional rock fall evaluations was noted by the California Public Utilities Commission (CPUC) through their consultant, Aspen Environmental (Aspen). On June 28, 2010, Aspen transmitted a letter from Geotechnical Consultants, Inc. dated June 18, 2010 that provided review comments on all geotechnical-related mitigation measures.

SCOPE OF SERVICES AND APPROACH

The transmission line structure sites have been further evaluated for rock fall hazard potential based on additional field review, evaluation of topographic maps and digital imagery, and engineering analyses. Structures located in steep terrain will not have roads or pads built for construction

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access, and foundations will be constructed using micropiles. Since this steeper terrain setting generally coincides with the potential for rock fall hazard, the majority of sites considered for rock fall hazard are also micropile sites. However, conventional foundation tower sites have also been evaluated, and two are specifically discussed in this report. The tower sites not specifically discussed in this report can be considered to have very low to non-existent rock fall potential.

For discussion purposes, rock fall hazards can be divided into three categories: 1) existing rock fall hazards on adjacent hill slopes that could impact the project structures after construction as a result of seismic shaking, 2) existing rock fall hazards in "near-field" work areas, i.e. areas within and immediately surrounding the tower sites, that could impact the project construction activities, and 3) rock fall hazards that could be caused by disturbance or rock removal during construction phase activities. Field and engineering evaluations were performed by URS and Fisher & Strickler Rock Engineering, LLC (FSR). Two reports by F&S are attached to this document as Appendix A. FSR is a subconsultant to the micropile contractor, Crux Subsurface (Crux), and therefore the FSR reports address only micropile foundation sites. The FSR reports also discuss the need for logistical rock removals to facilitate construction (access and setup requirements for foundation areas, etc) that are not related to rock fall hazard. Non-rock fall hazard issues in the FSR reports should not be considered as part of the conclusions of this report.

FIELD REVIEWS

Based on our general site reconnaissance efforts and review of topographic maps and digital imagery, several sites were selected for field evaluation. The criteria for selection are discussed in the Rock Fall Hazard Evaluation section of this letter. The majority of the tower sites requiring further field evaluation are micropile foundation locations, and therefore, field reviews were coordinated with Crux, who planned to visit every micropile site to evaluate both rock fall hazards and the logistical rock removals discussed previously.

For the micropile foundation sites in the Mountain Springs Grade (MSG) area, site reviews were performed by a site visit team consisting of personnel from Crux, SDG&E, URS, Burns & McDonnell (BMcD), Arroyo Engineering and FSR. Based on initial these site visits, five structure locations were identified in the MSG area (EP261A, EP263A-2, EP263B-2, EP266-2 and EP272-3) where adjacent slopes extending out of the right-of-way could potentially generate rock falls. These sites were subsequently revisited, and more detailed field reconnaissance, data collection and engineering analyses were performed for these five structures; this study is described in the report prepared by FSR, dated July 8, 2010 (Appendix A).

Additional field reviews for micropile construction planning were performed in June 2010 and included all proposed micropile foundation sites. The reconnaissance team consisted of SDG&E, BMcD, PAR Electric, Crux, and URS members. As part of those field reviews, several new sites with rock fall hazard potential were identified; additional site visits to perform more detailed evaluations were conducted between August and September 2010. The site visit team consisted of personnel from FSR, URS, BMcD, and Arroyo Engineering. The field visits are summarized in the FSR report dated October 27, 2010 (also presented in Appendix A).

ROCK FALL HAZARD EVALUATION

Initial screening of all tower sites was performed using reconnaissance level evaluations and review of topographic maps and digital imagery, as discussed previously. Tower sites on or adjacent to moderately steep slopes and/or sites with the potential to have unstable boulders were further evaluated as part of this study. All tower locations requiring further evaluation are listed in Table 1.

The first phase of rock fall hazard analyses focused on rock falls from adjacent hillsides impacting five structures within MSG. The results of these initial engineering-based evaluations were presented in the July 8, 2010 report by FSR titled "Sunrise Mountain Springs Grade Rock Fall Hazard Evaluation: Towers, 261A, 263A-2, 263B-2, 266-2, and 272-3" (attached in Appendix A). In this report and appended analyses, FSR outlines a methodology used to evaluate the hazard of rock fall from adjacent hillsides impacting a tower location. A probability of a rock impacting a tower was based on:

1. A design ground motion (0.35g [percentage of gravity] for the MSG area based on a 10% probability of occurrence in 50 years).
2. Identifying the fall-line for possible rock falls.
3. Inventorying the rocks on the adjacent slopes.
4. Identifying the rocks that are free to topple.
5. Performing calculations to establish which blocks could topple.
6. Performing a rock fall simulation using the slope inventory to establish the percentage of toppling rocks that could roll to or past the tower location.

The results of the FSR study suggest a low hazard level for rock falls from adjacent hillsides at the five MSG sites reviewed. The hazard level is expressed as a calculated probability of a rock fall generated upslope of the towers reaching the towers during the life of the structures. Probabilities of impact over the design life of the structures (50 years) were calculated to be less than 0.5 percent and judged to be low.

Subsequently, all micropile structures were evaluated by FSR for rock falls from adjacent hillsides as described above, as well as near-field rock fall hazards and hazards associated construction efforts. The results of these investigations are presented in the FSR report dated October 27, 2010 (Appendix A).

For all towers listed in Table 1, a judgment of rock fall hazard as none or low was assessed based on field conditions or the site was selected for more detailed field evaluation and possible rock fall hazard analysis. The potential for rock fall hazard listed in Table 1 is based on the slope inclination, the character of the rock outcrops including the size, geometry, condition and weathering of the boulders present. Specifically, rock fall hazard analyses were performed by URS for structures CP47A-1, CP49-1, and CP55 in Section 5. These sites were analyzed using a similar methodology to that presented in the July 8, 2010 FSR investigation for MSG sites and summarized above. The URS analysis procedure is also presented in Appendix B.

Table 1 presents the results of the rock fall hazard evaluations for all structures requiring additional evaluation beyond initial screening. The third column provides an assessment of seismically-induced rock fall potential for these locations. The sites that required rock fall hazard analysis to assess are noted with asterisks. The 'Comments' column includes a summary of FSR recommendations for rock fall mitigations for boulders on adjacent slopes or in the near-field area.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the additional field evaluations and the selected rock fall analyses for specific sites by URS and FSR, none of the sites reviewed present a significant risk to the proposed structures from adjacent hillside rock falls, as listed in Table 1. Given the low likelihood for significant damage to a structure as a result of a seismically induced rock fall on adjacent hillsides, no mitigation is recommended for this condition, other than the mitigation recommended by FSR for towers CP47-2, CP47A-1, EP254-2, EP263B-2, and EP265-2.

Rock fall hazards within "near-field" construction areas are present at some micropile foundation structures. These hazards and anticipated mitigations are outlined in the reports prepared by FSR (Appendix A). Mitigation methods include; safely dislodging loose rock to a downslope location, breaking down large rock into smaller fragments that can be safely moved, or stabilizing potentially loose rock in place. Stabilization methods can include rock bolts and wire mesh placement. In addition to the site specific evaluations provided by FSR, an additional, final construction phase evaluation of the rocks in the near-field of the micropile tower sites will be performed to identify rocks to be mitigated and to select methods of final mitigation. Similar near-field evaluations of rock fall hazards during construction for conventional foundations will be completed as part of the geologic observation of the earthwork phase of the project.

The disturbance of boulders at micropile foundation sites during construction phase activities is addressed in the attached FSR reports. Similar impacts to the project in general with respect to the creation of graded access roads and structure pads have been addressed by URS in our report titled "Geotechnical Evaluation, Access Roads, Structure Pads and Temporary Cable Pull Site Pads, Sunrise Powerlink Project, San Diego and Imperial Counties, California," dated October 4, 2010. The construction phase will include geologic oversight to further evaluate the conclusions in these reports and to address changing conditions in the field.

If you have any questions regarding this report, please contact us.

Sincerely,

URS CORPORATION

CERTIFIED ENGINEERING GEOLOGIST
MICHAEL E. HATCH
No. 1925
Exp. 1/31/12
STATE OF CALIFORNIA

Michael E. Hatch, C.E.G 1925
Principal Engineering Geologist

Michael Higgins
Senior Staff Geologist

MEH/MH:mv

Attachments

Cc: Jamey Bertram, Burns & McDonnell

ATTACHMENTS

Table 1
Rock Fall Hazard Assessment
Sunrise Powerlink Project

Section	Tower	Seismic induced-Rock Fall Hazard[1]	Slope[2] (inclination degrees from horizontal)	Comments
5	CP33-2	Low	15 to 27	Break and removal of boulders immediately upslope of Leg C per FSR.
	CP34-2	Low	20 to 26	
	CP35-2	None	18 to 24	
	CP45-1	None	15 to 19	
	CP47-2	Low	15 to 30, locally	Rock bolting during construction to stabilize boulder outcrop 60 feet upslope per FSR.
	CP47A-1	Low**	20 to 27	Rock bolting during construction to stabilize boulder outcrop 60 feet upslope per FSR. Low potential for boulders to impact structure based on rock fall analysis.
	CP48-2	None	10 to15 locally; 30 upslope	
	CP49-1	Low**	15 to 20 locally; 30 upslope	Low potential for boulders to impact structure based on rock fall analysis.
	CP53-1	Low	15 to 27	
	CP54-1	Low	~15, (~30, upslope)	
	CP55	Low**	15 to 30	Low potential for boulders to impact structure based on rock fall analysis.
	CP61-1	None	~30	
	CP79-1	None	25 to 27	
7	CP108	Low	25 to 27 (20 upslope)	
	CP109-1	None	25 to 30	
8a	EP-17	Low	10 to 15	Remove/break large boulder (14 ft high) located between tower legs prior to construction per FSR.
	EP20-2	None	15 to 20 (30, locally)	
	EP28-3	None	20 to 30 (20, upslope)	
	EP41	None	20 to 25	

Table 1
Rock Fall Hazard Assessment
Sunrise Powerlink Project
(Continued)

Section	Tower	Seismic induced-Rock Fall Hazard[1]	Slope[2] (inclination degrees from horizontal)	Comments
8b	EP45-1	Low	25 to 30	
	EP47-2	None	20 to 25 (~27, upslope)	
8c	EP62A-1	None	~10 locally	
8d	EP74-1	None	15 to 25	
	EP75-2	None	10 to 25	
8e	EP116-1	None	10 to 25	
9a	EP120A	Low	25 to 30	Remove potential toppling block adjacent to Leg B per FSR.
	EP134-1	Low	20 to 25	
	EP135	Low	20 to 25	
9b	EP147	Low	20 to 25	
9c	EP225-1	Low	20 to 27 locally (27, upslope)	
	EP254-2	Low	15 to 33 locally (30+, upslope)	Break and remove upslope boulders prior to construction per FSR.
	EP256	Low	15 to 25, 30 distant upslope	Conventional foundation
	EP257	Low	15 to 25, 30 distant upslope	Conventional foundation
	EP259-3	Low	5 to 15	
	EP259B	Low	<10	
	EP261A	Low*	15 locally; 30 upslope	Break and remove boulder adjacent to Leg D per FSR. Low potential for boulders to impact structure based on rock fall analysis.
	EP261-2	Low	<25 locally; 25 upslope	Place Tecco Mesh over nested boulders adjacent to Leg A per FSR.

Table 1
Rock Fall Hazard Assessment
Sunrise Powerlink Project
(Continued)

Section	Tower	Seismic induced-Rock Fall Hazard[1]	Slope[2] (inclination degrees from horizontal)	Comments
9c (Cont'd)	EP262-4	Low	20 to 25	Break boulders adjacent to Legs A and C per FSR.
	EP263A-2	Low*	<20 to >25	Low potential for boulders to impact structure based on rock fall analysis.
	EP263B-2	Low*	25 to 35	Bolt boulders and place Tecco Mesh adjacent to Leg A and break or remove boulders adjacent to Leg D per FSR. Low potential for boulders to impact structure based on rock fall analysis.
	EP264-4	Low	≤20	
	EP265-2	Low	27 to 35	Extensive rock breakage, removal and bolting in and adjacent to tower site per FSR.
	EP266-2	Low*	≤10 increases upslope 100' north of tower	Low potential for boulders to impact structure based on rock fall analysis.
	EP267-2	Low	20 to 40 locally	Break and remove boulders adjacent to Leg D per FSR.
	EP269-1	Low	25 to 35 locally	Verify during construction that upslope rocks are stable following removal of rocks in foundation area for construction per FSR.
10a	EP270-2	Low	25 to 35	Break and remove boulders adjacent to Legs A and D per FSR.
	EP271-2	Low	10 to 25	Break and remove boulders adjacent to Leg C per FSR.
	EP272-3	Low*	15 to 25	Low potential for boulders to impact structure based on rock fall analysis.
	EP273-1	None	<10	
	EP274-1	None	<10	
	EP275-1	Low	5 to 15	
	EP276-1	Low	≤ 5 top of ridgeline	Break and remove large leaning boulder adjacent to Leg B per FSR.
	EP277-1	Low	15 to 25	Break and remove boulder adjacent to Leg D per FSR.

Table 1
Rock Fall Hazard Assessment
Sunrise Powerlink Project
(Continued)

Section	Tower	Seismic induced-Rock Fall Hazard[1]	Slope[2] (inclination degrees from horizontal)	Comments
10a (Cont'd)	EP278-1	Low	25 to 37	Break and remove boulders adjacent to Legs C and D, bolt boulder adjacent to Leg C per FSR.
	EP279-1	Low	15 to 25	Break and remove boulders at all legs per FSR.
	EP280-1	None	< 10	

Notes:

1) Rock fall hazard rating is the potential for rocks / boulders to translate downslope into tower site based on slope inclinations, geometry or structure, boulder size and geometry, and other conditions.

2) Slope range or approximate slope inclinations (max) in the vicinity of tower legs and general area.

* Denotes rock fall analysis performed by others to address potential for boulders to impact structure locations (FSR, Appendix A).

* * Denotes rock fall analysis performed by URS to address potential for boulders to impact structure locations (Appendix B).

Sunrise Mountain Springs Grade Rockfall Hazard Evaluation:

Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Prepared by FSR, dated July 8, 2010

Sunrise Powerlink Project

Rockfall Mitigation and MicroPile Construction Preparation

Prepared by FSR, dated October 27, 2010

FISHER&STRICKLER
ROCK ENGINEERING, LLC

July 8, 2010

Mr. Nick Salisbury; President
Mr. Scott Tunison; Vice President
Crux Subsurface, Inc
16707 E. Euclid Avenue
Spokane Valley, WA 99216

Subject: Sunrise Mountain Springs Grade
Rockfall Hazard Evaluation:
Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Dear Mr. Salisbury and Mr. Tunison:

This letter summarizes a rockfall hazard field investigation and engineering analysis performed at five (5) transmission towers of the Mountain Springs Grade Project. This evaluation was prompted by an earlier site visit attended by members of the project team between April 13 and April 16, 2010. The purpose of the site visit in April was to identify potential rockfall hazards within the right-of-way of the transmission line and to establish the amount of boulder removal required for Crux Subsurface, Inc (Crux) to set up and install micropiles at each of the tower foundation locations. During that visit, we identified the potential for rockfall to be generated outside of the right-of-way (ROW) at Towers 261A, 263A, 263B, 266-2, and 272-3 (see Fisher & Strickler Rock Engineering, LLC report entitled "Sunrise Mountain Grade Site Visit Report for 4/13/10 through 4/16/10 and Recommendations" and dated May 6, 2010). As part of our due diligence obligations, the team returned on June 7 and 8, 2010 to perform more detailed field reconnaissance at those locations.

Summary of Investigation Results

The results of this investigation suggest that the potential for rockfall generated from hillsides adjacent to Towers 261A, 263A, 263B-2, 266-2, and 272-3 is low. Calculated probabilities of rockfall generated upslope of the towers eventually reaching the towers during the life of the structures (50 years) is as follows:

- Tower 261A: Judged low.
- Tower 263A-2: Less than 0.5 percent.
- Tower 263B-2: Less than 0.5 percent.
- Tower 266-2: Less than 0.5 percent.
- Tower 272-3: Less than 0.5 percent.

Half of a percent is judged to be within the limits of error pertaining to the assumptions made and tools used to perform the evaluation and actual probabilities are reported in subsequent sections of this report.

Note that mitigation measures for rocks located directly adjacent to the towers were presented in our report dated May 6, 2010. For example, Tower 263B-2 is located adjacent to a talus slope consisting of boulders that have weathered in place from bedrock. Rock anchors and high tensile strength wire mesh are recommended to help stabilize the toe of the talus pile north of Tower Leg D. At other locations, the Crux Team will break up and remove rocks that impede construction in accordance with their 100% Micropile Foundation Design Package dated December 18, 2009. Sections of the design documents that discuss methodologies for assessing and remediating those hazards during construction are provided in Appendix A.

The information contained in this report should be used by SDG&E to evaluate whether mitigation measures are required at each tower and recommendations regarding how to use this information for that purpose are provided near the conclusion of this report.

Rockfall Hazard Evaluation
The objective of this evaluation was to identify and quantity the rockfall hazard related to impacting a tower location under the following conditions:

1. The design-based earthquake having a 10 percent probability of occurrence over a 50 year period and,
2. A peak ground acceleration of 0.35g.

The methodology used during the investigation and analysis included:

1. Identifying the 'fall-line' for the rocks to establish the most critical path for rockfall from slopes located adjacent to the towers.
2. Inventorying the rocks on adjacent slopes by measuring block height, width, and depth within sampling areas established along the anticipated fall lines. This was accomplished using a 50 ft tape measure placed near the fall line and in general, rocks within a distance of 5 ft from the tape were included in the sample intervals.
3. Identifying the rocks that are 'free' to topple. This was completed in the field by judging whether a block located immediately downhill of an individual block would prevent an individual block from falling over or rolling if it did topple.
4. Performing calculations to establish which blocks will topple during the earthquake using the criteria established by the Crux Team. Details are included in Appendix A.
5. Performing a rockfall simulation using the distribution of the block sizes identified at each of the tower locations to establish the percent of toppling rocks that would roll to or past the tower location.
6. Establishing the overall probability of a rock impacting a tower, based on the variables considered pertinent to this evaluation. This is accomplished by summing the probabilities associated with the design 'checks' above.

The overall probability of a rock impacting a tower during the 50 year design life would be the addition of the:

a. Probability of an earthquake; which is 10 percent.
b. Probability of a rock being free to topple.
c. Probability of a rock free to topple actually toppling in the earthquake.
d. Probability of a rock rolling down the hill to the location of the tower based on the computer simulation.

The equation used to establish the probability of impact is therefore:

$$\begin{aligned} &probability\ of\ impact{:}\, p(impact) \\ &\qquad = p(earthquake) * p(free\ to\ topple) * p(FS < 1) \\ &\qquad * p(rock\ rolling\ into\ structure\ from\ computer\ analysis) \end{aligned}$$

Detailed accounts are provided for each tower below. Appendix B provides a brief description of the rockfall evaluation and computer simulation methodologies. Appendices C through G contain raw field data and computer simulation analysis results for each of the tower locations.

Site Visit

Brendan Fisher of Fisher & Strickler Rock Engineering, LLC (FSR Engineering) and Aaron Hastings of Arroyo Engineering Consultants, Inc. (AEC) accompanied Steve Wilson of Crux during the site visit on June 7 and 8, 2010. Other parties included representatives from Burns and McDonnell, PAR, San Diego Gas and Electric (SDG&E); their biological and archeological sub-consultants and URS who is subcontracted to SDG&E as their Geotechnical Engineer for the project. This group of people will be collectively referred to as the Site Visit Team.

The Site Visit Team met in the mornings between 06:00h and 07:00h at a park-and-ride near the intersection of US80 and SR79 near Decanso, California and caravanned to the project location. The schedule for the day was dictated by the requirements of the rockfall evaluation while SDG&E escorted the Site Visit Team throughout the project site so that we visited the tower locations in an expeditious manner.

Field Preparation Work

Prior to the site visit, Brendan Fisher of FSR Engineering performed a desktop study; reviewing the topography and aerial photographs (provided by Mark Heidecke of Finley Engineering Company, Inc.) of each of the tower locations. Dr. Fisher identified what are judged to be the most critical or steepest rockfall trajectories (or fall lines) at each of the tower locations. The topographic maps were also beneficial for establishing the inclination of the hillsides. Prior work completed by the Crux Team suggests that rocks situated on slopes less steep than about 27 degrees present a low rockfall hazard because the slope is not steep enough for rocks to roll even if they topple over from external loading such as an earthquake (see Appendix A).

Field Data Collection

At each tower location, Brendan Fisher, Aaron Hastings, and Michael Hatch (of URS) made a visual assessment of the rockfall hazards within and outside of the ROW. Dr. Fisher and Mr. Hatch then walked up the hillside and laid out a 50 ft tape near the top of the hillside; working down the hill collecting information pertinent to the individual rock geometries. Photographs of the hillsides are presented in Figures 1 through 4. In general, the sampling locations (traverses) and therefore data collection were coincident with the critical fall lines established during the desktop study.

Site Specific Summaries

Tower 261A - Appendix C

The local topography at Tower 261A is gently-sloping with a steeper slope located southeast of the tower. While in the field, Dr. Fisher and Mr. Hatch judged that the hillside presents a low rockfall hazard to the tower. This conclusion was reached after careful review of the topography and aerial photographs and an assessment of the general rock block geometries on the hillside. Below is a bulleted list of our observations. Figure C-1 is annotated with the items below.

1. The slope can be subdivided into three segments. The first segment is nearest the tower location and not steep enough (less than 2H;1V) to generate rockfall.
2. Between segment 1 and segment 2, there is a natural rockfall barrier consisting of rock blocks that are 5 to 15 feet tall.

3. Segment 2 is a generally flat area that should provide adequate rollout for rocks in the unlikely scenario that rockfall is generated from Segment 3.
4. The inclination of Segment 3 is about 25 degrees which is less than that required for rocks to roll down the hill after toppling.
5. The rocks located on Segment 3 range in diameter from about 2 to 12 feet and appear to have height to depth ratios not conducive to toppling on a 25 degree slope.

Tower 263A-2 - Appendix D
The local topography at Tower 261A is gently-sloping with a steeper slope (about 35 degrees) located southeast of the tower. The geology of the slope consists of granitic outcrops and boulders with shallow soil cover. Figure 2 shows a picture of the slope while Appendix D contains the slope topography and profile, sampling locations, and the results of the computer simulated rockfall evaluation.

The northwest facing slope adjacent the tower is steep near the top with near vertical outcrops and ledges; moderate in the middle, and gentle within about 100 feet (ft) of the tower. This 100 foot wide area at the base of the slope provides a rollout area for rockfall. Rock blocks measured on the slope are tabular and range in largest dimension from about one to 17ft; averaging about 2.5 ft.

Of the 160 rocks measured along the sampling intervals, about 50 percent were judged free to topple while about 30 percent of those blocks have geometries conducive to toppling during the design based earthquake. The rockfall computer simulation suggests that less than 2 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

$$p(impact) \sim 0.1\ x\ 0.5\ x\ 0.3\ x\ 0.02 \sim 3.0x10^{-4}$$

Overall, the rockfall hazard at this location is judged low with a probability of impact over the design life of the structure of less than 0.5 percent.

Tower 263B-2 - Appendix E
The local topography at Tower 261A is steep (about 30 degrees) with a slope located adjacent and north of the tower. The geology of the slope consists of granitic outcrops and boulders with sparse soil cover. Figure 3 shows the topography of the slope located above Tower Leg D and Appendix E contains a slope profile, sampling locations, results of the computer simulated rockfall evaluation and stability analysis.

Within about 150 ft of the tower, the slope is about 30 degrees. Above this the slope flattens out to about 15 to 20 degrees and therefore, rockfall is a concern from the lower slope only. Rock blocks measured on the slope are tabular and range in largest dimension from about one to 10ft; averaging about 2.5 ft.

Of the 90 rocks measured along the sampling intervals, about 53 percent were judged free to topple while about 2 percent of those blocks had geometries conducive to toppling during the design based earthquake. The rockfall computer simulation suggests that less than 2 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

$$p(impact) \sim 0.1\ x\ 0.53\ x\ 0.02\ x\ 0.02 \sim 2.1x10^{-5}$$

Overall, the rockfall hazard at this location is judged low with a probability of impact over the design life of the structure of less than 0.5 percent.

Tower 266-2 - Appendix F

The local topography at Tower 266-2 is gently-sloping at about 15 degrees with a slope of about 35 degrees located north-northwest of the tower. The geology of the slope consists of granitic outcrops and boulders with shallow soil cover. Figure 4 shows a picture of the slope while Appendix F contains a slope profile, sampling locations, and the results of the computer simulated rockfall evaluation.

Rock measured on the south-facing slope adjacent the tower are tabular and range in largest dimension from about one to 5ft; averaging about 1.25 ft. We observed a few rocks outside of the sampling areas that appeared to be up to 8 ft in diameter.

Of the 140 rocks measured along the sampling intervals, about 70 percent were judged free to topple while about 5 percent of those blocks have geometries conducive to toppling during the design based earthquake. The rockfall computer simulation suggests that less than 2 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

$$p(impact) \sim 0.1\ x\ 0.7\ x\ 0.05\ x\ 0.02 \sim 1.0x10^{-4}$$

Overall, the rockfall hazard at this location is judged low with a probability of impact over the design life of the structure of less than 0.5 percent.

Tower 272-3 - Appendix G

The local topography at Tower 272-3 is gently-sloping with a steeper slope (about 35 degrees) located west of the tower. The geology of the hillside consists of granitic outcrops and boulders with shallow soil cover. Figure 5 shows a picture of the hillside while Appendix G contains a slope profile, sampling locations, and the results of the computer simulated rockfall evaluation.

The east facing slope adjacent the tower is steep near the top with outcrops and near vertical ledges while the gentle slope at the base of the hillside provides an area for rockfall catchment. Rock blocks measured on the hillside are tabular and range in largest dimension from about one to 9 ft; averaging about 1.75 ft.

Of the 135 rocks measured along the sampling intervals, about 70 percent were judged free to topple while less than 2 percent of those blocks have geometries conducive to toppling during the design based earthquake. The rockfall computer simulation suggests that less than 2 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

$$p(impact) \sim 0.1\ x\ 0.7\ x\ 0.02\ x\ 0.02 \sim 2.8x10^{-5}$$

Overall, the rockfall hazard at this location is judged low with a probability of impact over the design life of the structure of less than 0.5 percent.

Recommendations

The results of this rockfall hazard field investigation and analysis suggest a low probability of rockfall generated upslope of the towers to impact the towers. One rational of establishing the requirement for rockfall mitigation based on this information would be to weigh the cost of constructing a barrier between a tower and an adjacent slope against the additional benefit gained. For example, assume that the cost of rockfall impacting a tower is judged to be $1mil. This may be the cost associated with repairing a tower leg. If the probability of impact is 0.5% then the amount of justifiable up-front capital available to provide additional rockfall mitigation might be $1mil x 0.5% or $5,000.

We estimate that in all cases, a 4 ft high; 8 ft wide berm constructed out of boulders available on site and placed between the hillsides and the towers would effectively deter rockfall from impacting the towers.

Closure

We appreciate the opportunity to be involved in this project. Should you have any questions, please contact Brendan Fisher at bfisher@fsrengineering.com or (425) 283-9203.

Sincerely,

FISHER & STRICKLER ROCK ENGINEERING, LLC

Brendan R. Fisher, PhD, PE, PG
Geological Engineer

Attachments:

Figures 1 through 4
Appendices A through G

FIGURES

Note: Flag shows one of the tower leg locations. Up slope of the tower is a natural rockfall barrier consisting of large boulders.

Figure 1

Hillside located southeast of Tower 261A

Project No. 134AZ Date: July, 2010

FISHER&STRICKLER ROCK ENGINEERING, LLC

Crux Subsurface
Mountain Springs Grade – Rockfall Assessment for Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Figure 2

Hillside located southeast of Tower 263A-2

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Figure 3

Slope profile of steep slope located north of Tower 263B-2

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Figure 4

Hillside located north of Tower 266-2

Figure 5

Hillside located west of Tower 272-3

Project No. 134AZ Date: July, 2010

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Crux Subsurface
Mountain Springs Grade – Rockfall Assessment for Towers
261A, 263A-2, 263B-2, 266-2, and 272-3

APPENDIX A

ROCKFALL ANALYSIS AND MITIGATION

FROM CRUX 100% MICROPILE DESIGN DOCUMENT

DECEMBER 16, 2009

Design Methodology

100% Design Package, Document 2 of 7

Standard 10-97) and the "Manual of Steel Construction Allowable Stress Design" by the American Institute of Steel Construction (AISC).

The stub modifications use a column bearing plate concept in lieu of the shear clip concept contained in the ASCE 10-97 standard. The modified stub will employ a bearing plate at the top surface of the cap for transfer of downward loads into the cap while a bearing plate near the bottom of the cap will transfer uplift loads into the cap. The plates are either welded to the original stub, which is cut off to fit in theses shallower caps, or bolted to the stub with a series of plates that sandwich the stub and are welded to the bearing plates at the top and bottom of the cap. The design loads used for the stub modifications are based on the loads indicated in Table 1.2 except that a factor of safety of 1.5 was used rather than 2.0.

4 Rock Fall Considerations

4.1 Precariously-Balanced Rockfall Hazard Evaluation

Many of the proposed transmission tower locations at Mountain Springs Grade are occupied by granitic and metamorphic rocks and boulders. In many cases, these blocks are "precariously-balanced rocks" or PBR's and appear to be a potential rockfall hazard. During foundation installation, the Crux team will identify blocks that have potential to impact the transmission towers. The Crux team will break these blocks into smaller, less hazardous blocks thereby reducing rockfall hazard.

4.2 Failure Mechanisms

The failure mechanism anticipated for random blocks sitting on bedrock is either toppling or sliding. A toppling failure occurs when the weight vector of the block falls in front of the toe of the block, caused most commonly by erosion or the addition of an external force such as water pressure or seismic activity. While differential erosion and/or increases in groundwater pressure is common in rock slopes, the most likely external force for a single rock perched on bedrock (such as those at Mountain Springs Grade) is seismic loading.

A second likely failure mechanism is a planar-type failure. A planar-type failure is one where the coefficient of friction between the PBR and the surface below it is exceeded; the result of an external or inertial force such as gravity, water pressure, or seismic acceleration. The most likely triggering mechanism is seismic acceleration at Mountain Springs Grade.

4.3 Rockfall Trigger

According to the Draft Geological Hazards report (URS, May, 2009), the peak ground acceleration expected at Mountain Springs Grade generated by the design-base earthquake ranges from 0.25g to 0.30g. This is for an earthquake that has a 10 percent chance of occurrence over the next 50 years (i.e. a return period of 475 years). During this earthquake, precariously-balanced rock blocks that are marginally stable may topple (or slide) and then potentially roll (or slide) downhill. If there is a transmission tower in the path of the rock, the rock may impact the tower.

4.4 Evaluation Method For Toppling

A toppling evaluation resolves the moments about the toe of a rock block. If the sum of the overturning moments ($\sum M_T$) is greater than the sum of the resisting moments ($\sum M_R$), the block is unstable. An earthquake generates a seismic acceleration that is imparted into the rock block. It is not clear how much of the seismic acceleration is felt by the block, although this acceleration is likely less than the peak ground acceleration, even though the block is sitting on bedrock. This is because there is typically a discontinuity between the bedrock and the block that will attenuate the seismic energy. Because it is not known how much acceleration is felt by the block, it is assumed in the evaluation below, that the block feels 100 percent of the peak bedrock ground acceleration. Figure 4.1 shows a precariously-balanced rock.

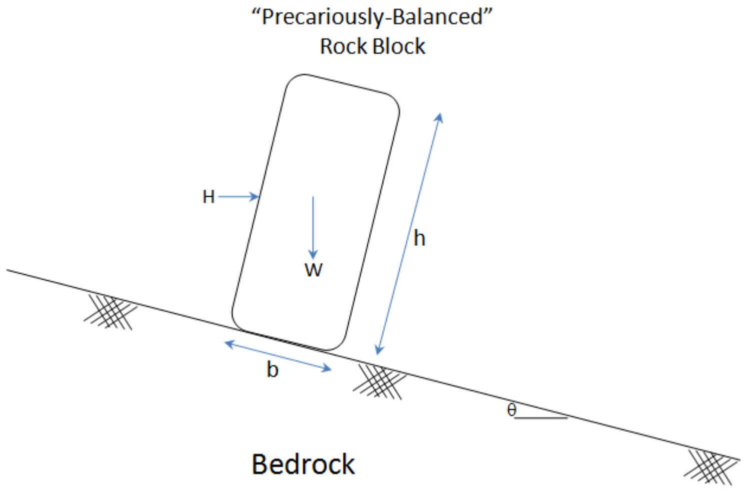

Figure 4.1: Geometry of a Precariously Balanced Rock Block

The evaluation is carried out by summing the moments about the toe of the block. Following are the simple equations used to perform the evaluation:

$$W = b\ x\ h\ x\ \gamma_R \qquad \text{(Equation 1)}$$

$$H = k_h\ x\ W \qquad \text{(Equation 2)}$$

$$\sum M_T = \frac{h}{2}(W sin\theta + H cos\theta) \qquad \text{(Equation 3)}$$

$$\sum M_R = \frac{h}{2}(W cos\theta - H sin\theta) \qquad \text{(Equation 4)}$$

$$Factor\ of\ Safety = \frac{\sum M_R}{\sum M_T} \qquad \text{(Equation 5)}$$

h: Height of rock block.

b: Base width of rock block.

W: Weight of rock block.

γ_R : Unit weight of rock block.

H: Pseudo-static horizontal seismic load.

k_h: Horizontal Seismic Coefficient.

M_T: Overturning Moments

M_R: Resisting Moments

An example calculation assuming that a block is resting on a 2H:1V slope suggests that during an earthquake that generates a peak ground acceleration of 0.3g, blocks with b/h ratios less than about 1.0 would be expected to topple because the overturning moments would be greater than the resisting moments (i.e. safety factor of 1.0 or less).

Toppling is related to the width to height ratio (b/h) of the block. This ratio is dimensionless and does not pertain to one particular block or range of block sizes. The higher the b/h ratio the more stable the block is.

These equations are valid where earthquake frequencies are low enough that the horizontal acceleration is sustained long enough for the rock's center of gravity to be rotated beyond the toe of the block and allow for toppling (Haneberg, 2009). Seismic shaking typically occurs at frequencies of less than 5 Hz which is within the range that toppling may be expected (Haneberg, 2009). Therefore, the equations above are appropriate, although somewhat conservative.

4.5 Evaluation Method for Sliding

Figure 4.2 shows a block that may be susceptible to translational sliding during an earthquake.

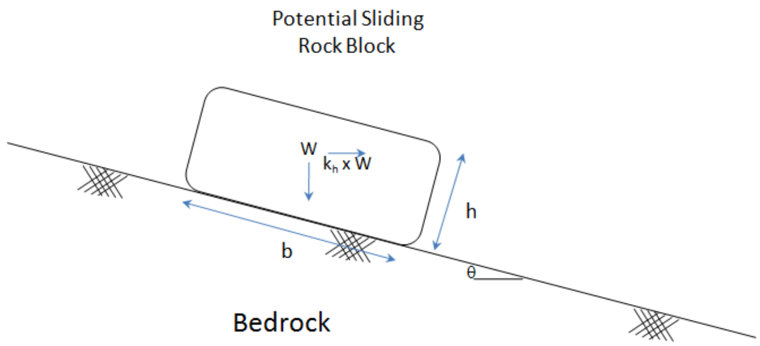

Figure 4.2: Potential sliding block

h: Height of rock block.

b: Base width of rock block.

W: Weight of rock block.

k_h: Pseudo-static coefficient.

θ: Outcrop inclination in relation to the tower foundation.

A sliding evaluation compares the forces resisting translational sliding to those that are driving translational sliding. In the case of a block resting on an inclined bedrock slope, if the angle of repose (or friction angle) at the interface between the block and the bedrock is greater than the inclination of the slope, then the block will remain 'stable' until an external force causes the block to become 'unstable'. This holds true where the interface between the block and the outcrop has a 'friction-only' strength and does not contain any rock bridges that would increase the tensile strength of the interface. According to Newmark (1965), the safety factor against downhill sliding of a block under seismic loading is as follows:

$$Factor\ of\ Safety = \frac{[\cos\theta - k_h \sin\theta]\tan\varphi}{\sin\theta + k_h \cos\theta} \qquad \text{(Equation 6)}$$

Φ': Friction angle at the block/outcrop interface.

Assume that an earthquake generates a 0.3g peak ground acceleration and that the acceleration is not attenuated so that the potential sliding block feels the 0.3g. If the interface friction angle between the rock block and outcrop is 35 degrees, then the maximum slope angle that the rock would remain stable on is about 18 degrees. These calculations do not take into consideration the block size or geometry.

4.6 Safety Factors

The above example calculations are meant to establish the point at which the blocks are at a limiting equilibrium (i.e. safety factor of 1.0) using the peak ground acceleration. This is the suggestion of Haneberg (2009) and Anooshehpoor, et al. (2004) who studied rock toppling because of seismic activity. This criterion is more conservative than existing guidelines for evaluating seismic slope stability in Southern California.

Guidelines for performing pseudo-static slope stability calculations completed in Southern California (SECE, 2002) suggest using a pseudo-static coefficient (k) of 0.15 with coupled with a required safety factor of 1.10 to 1.15. The criterion of k of 0.15 and a safety factor of 1.15 is calibrated so that the deformation of a slope would not exceed one meter during a magnitude 8.25 earthquake. The criterion of k of 0.15 with the safety factor of 1.10 is based on the experiences of Los Angeles County and required by that authority.

Comparison of the results of toppling analyses utilizing the three criteria above suggest that there is little practical implications found between choosing one criterion over the other. For instance, the range of b/h ratio expected to topple on a 27 degree (2H:1V) ranges from about 0.85 to 1.0. The 1.0 b/h ratio is the result of assuming that the toppling block is subjected to 100 percent of the peak ground acceleration (conservative).

The sliding evaluation below is based on a Newmark displacement analysis which implicitly assumes limiting equilibrium when the block slides.

4.7 Probability of Failure

The design earthquake has a return period of 475 years and therefore the probability of failure is 1/475 or 0.20 percent or greater per year for blocks that have b/h ratios that suggest toppling would occur during the design earthquake or are situated on slopes that are greater than about 18 degrees with respect to sliding.

4.8 Toppling and Sliding Limit Equilibrium Analyses

Figure 4.3 graphically shows the results of the sliding and toppling analysis for Sunrise Mountain Springs Grade. This will be used as a screening tool while the Crux team evaluates and mitigates potential rock fall hazards prior to foundation installation.

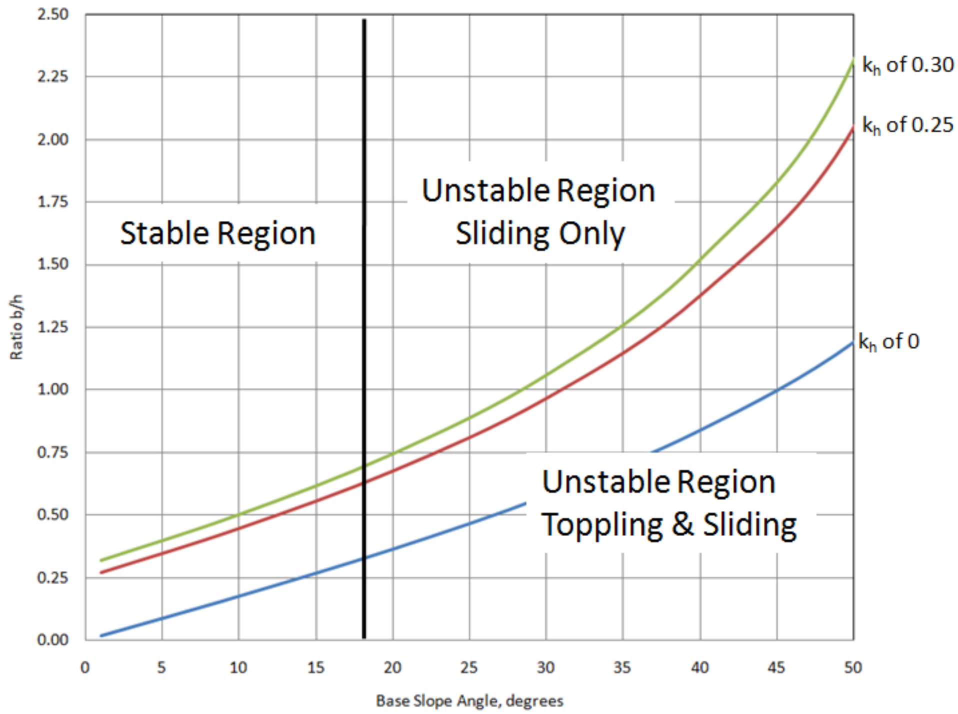

Figure 4.3: Results of the Toppling and Sliding Evaluation

4.9 Rockfall Evaluation

Toppling

The toppling evaluation (Equations 1 thru 5) provides a means to establish whether a particular rock will topple during the design earthquake. The next step is to evaluate whether the rock will continue to roll once it topples and then if it will impact a transmission tower. Parametric rockfall evaluations suggest that on slopes as shallow as 2H:1V (27 degrees) rocks will readily roll after toppling if unobstructed. Minimal rockfall is generated on slopes less than 2H:1V.

Translational Sliding

Equation 6 provides a means to establish whether or not translational sliding would be expected. A sliding rock block may transition into a rockfall if it obtains a rotational velocity by rotating over its toe, similar to a toppling failure. However, in most cases the b/h ratio of most sliding blocks is too large to allow rotation of the block without changes in slope condition (e.g. vertical edge). Sliding failures will only translate for a finite distance. Where sliding is initiated by an earthquake, the distance of translation can be determined by performing a "Newmark" analysis. This is where yield acceleration is compared to the earthquake time history. Hynes-Griffin and Franklin (1984) performed Newmark analyses using 348 time histories and 6 synthetic accelerograms. Figure 4.4 shows the results of their evaluation. This figure relates the ratio of yield acceleration (N) to anticipated acceleration (A) versus the total anticipated displacement or translation.

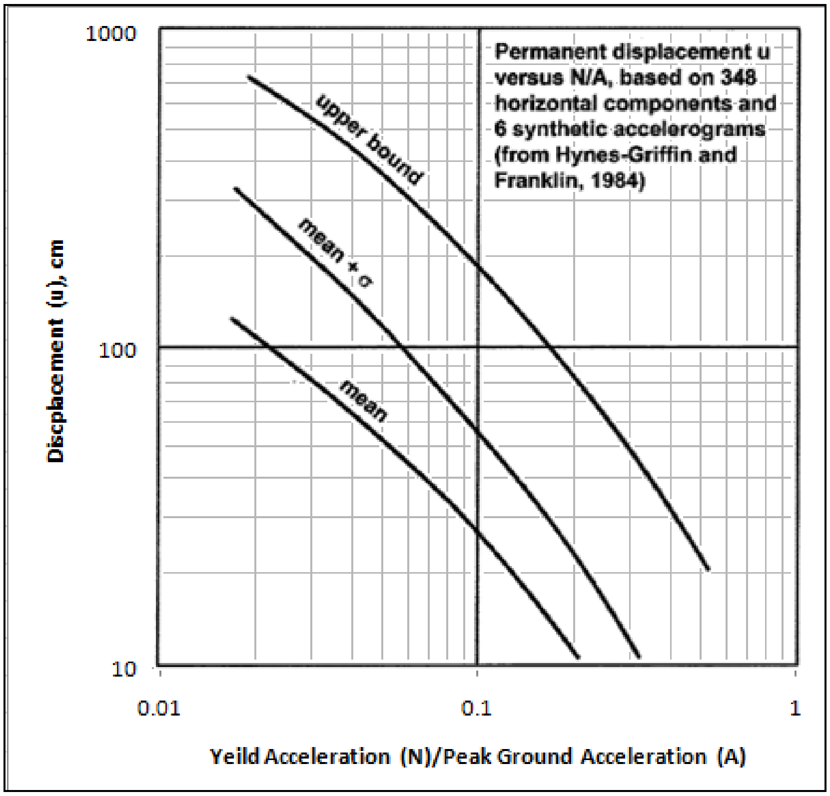

Figure 4.4: Permanent displacement of sliding rock blocks during an earthquake

The yield acceleration/anticipated acceleration (N/A) ratios for blocks at Sunrise Mountain Springs Grade are presented in Table 4.1. It is assumed that the friction angle at the interface between the blocks and the bedrock ranges from 35 to 40 degrees and that the peak ground acceleration is 0.3g.

Table 4.1: N/A ratios for potential sliding blocks at Sunrise Mountain Springs Grade

Θ (deg)	N	φ'	FS	N/A	u inches (mean)	u inches (mean + σ)	u inches (upper bound)
20	0.27	35	1	0.9	---	---	---
30	0.09	35	1	0.3	---	4	20
34	0.02	35	1	0.07	16	32	107
30	0.18	40	1	0.6	---	---	7
39	0.02	40	1	0.07	16	32	107

Comparison of the N/A ratios of Table 4.1 and Figure 4.4 suggests that during the design-based earthquake, translational sliding of blocks could approach 107 inches (9 feet) where slope angles approach 35 or 40 degrees. Translational sliding of rock blocks at a radius of more than 9 feet from the tower legs are not considered a risk to the tower.

4.10 Field Engineering/Decision Making/Rockfall Mitigation

To establish the potential for "Toppling" rockfall to impact the planned transmission structures, the Crux team will:

1. Establish whether there is a slope with a grade of 2H:1V or steeper located above the transmission tower where if rockfall is generated, it can roll towards the tower.
2. Measure the height and width of rock blocks on the slope above the planned tower and compare the measured b/h ratios to Figure 4.3.
3. Where blocks have a b/h ratio less than 1.0, use expandable grout, explosives, hydroblasting or other approved methods to break rocks so that the resulting fragments have acceptable b/h ratios or (if possible) tip the rocks over so that the b/h ratio is increased.

To establish the potential for "sliding" rockfall to impact the planned transmission structures, the Crux team will:

1. Establish whether there is a slope as steep as about 2H:1V or steeper located above the transmission tower where rock may slide towards the tower foundations. On slopes shallower than 2H:1V, translational sliding will be minimal.
2. Where rock slopes are greater than 2H:1V, rocks within a uphill radius of 9 feet will be moved from an uphill position (this may require breaking the blocks) so that they do not impact a transmission tower during the design-based earthquake.

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APPENDIX B

ROCKFALL HAZARD &

COMPUTER ROCKFALL ANALYSES

Rockfall Hazard and Computer Simulation Evaluation

The objective of the rockfall hazard evaluation was to identify quantity the hazard of rockfall impacting a tower location during the design-based earthquake having a 10 percent probability of occurrence over a 50 year period and a peak ground acceleration of 0.35g.

The methodology used during the investigation and analysis included:

1. Identifying the 'fall-line' for the rocks to establish the most critical path for rockfall from slopes located adjacent to the towers.

This was completed prior to the site visit by tracing the rockfall path working backwards from the tower to the top of an adjacent steep slope.

2. Inventorying the rocks on adjacent slopes by measuring block height, width, and depth within sampling areas established along the anticipated fall lines. This was accomplished using a 50 ft tape measure placed near the fall line and in general, rocks within a distance of 5 ft from the tape were included in the sample intervals.

Each Appendix contains the raw data showing the height, width, depth, and angle of each block recorded.

3. Identifying the rocks that are 'free' to topple. This was completed in the field by judging whether a block located immediately downhill of an individual block would prevent an individual block from falling over or rolling if it did fall.

4. Performing calculations to establish which blocks will topple during the earthquake using the criteria established by the Crux Team. Details are included in Appendix A.

The results of these calculations are shown for each of the blocks that are considered free to topple in the design-based earthquake event within Appendix C through G.

5. Perform a rockfall simulation using the distribution of the block sizes identified at each of the tower locations to establish the percent of toppling rocks that would roll to or past the tower location.

The computer simulation program chosen for this evaluation was RocSciences' program RocFall Version 4.0 which is a statistical analysis program designed for this purpose. The input required includes:

a. The slope cross-section - provided by Mark Heidecke of Finley Engineering Company, Inc.,
b. Rock block mass - estimated using the field measurements,
c. Friction angle of the contact between the rocks and the ground surface - estimated at 30 degrees.
d. Coefficient of normal restitution (RN) - established based on published references,
e. Coefficient of tangential restitution (RT) - established based on published references,
f. Slope roughness - assumed zero degrees and accounted for in the RN and RT coefficients.

For each of the slope evaluated the computer 'threw' 2,500 rocks down the slope at various locations along the slope profile. The initial velocity of the rocks as calculated based on the peak ground acceleration of 0.35g as follows for time equal to one second:

$$velocity\ (V) = acceleration(a)x\ time(t)$$

$$v = 0.35 * \frac{32.2ft}{sec^2} * 1\,\mathrm{sec} = 11.3ft/sec$$

6. Establish the overall probability of a rock impacting a tower, based on the variables considered pertinent to this evaluation. This is accomplished by summing the probabilities associated with the design 'checks' above.

The overall probability of a rock impacting a tower during the 50 year design life would be:

a. Probability of an earthquake which is 10 percent.
b. Probability of a rock being free to topple.
c. Probability of a rock free to topple actually toppling in the earthquake.
d. Probability of a rock rolling down the hill to the location of the tower based on the computer simulation.

The equation used to establish the probability of impact is therefore:

$$\begin{aligned} probability\ of\ impact\colon p(impact) \\ &= p(earthquake) * p(free\ to\ topple) * p(FS < 1) \\ &* p(rock\ rolling\ into\ structure\ from\ computer\ analysis) \end{aligned}$$

Table B-1. RN and RT values used for the rockfall computer simulations.

	RN (Normal)			RT (Tangential)			
Reference	Min.	Max.	**Ave.**	Min.	Max.	**Ave.**	Notes
Pheiffer and Brown, 1989	0.330	0.370	**0.350**	0.830	0.870	**0.850**	Bedrock or boulders with little soil or vegetation.
Chau et al., 1996	0.487	0.487	**0.487**	0.910	0.910	**0.910**	Rock slope.
Giani, 1992	0.350	0.350	**0.350**	0.850	0.850	**0.850**	Bedrock covered with large blocks.
Giana, 1992	0.500	0.500	**0.500**	0.950	0.950	**0.950**	Bedrock.
Hoek	0.350	0.350	**0.350**	0.850	0.850	**0.850**	Bedrock outcrop with hard surface, large boulders.
Hoek	0.530	0.530	**0.530**	0.990	0.990	**0.990**	Clean, hard bedrock.
Pfeiffer and Higgins, 1990	0.330	0.370	**0.350**	0.850	0.850	**0.850**	Most bedrock and boulder fields.
Pfeiffer and Higgins, 1990	0.370	0.420	**0.395**	0.870	0.920	**0.895**	Smooth bedrock surfaces.
Values Used	**0.350**	**0.530**	**0.42**	**0.85**	**0.99**	**0.90**	**Mixture of bedrock and bedrock with boulders.**

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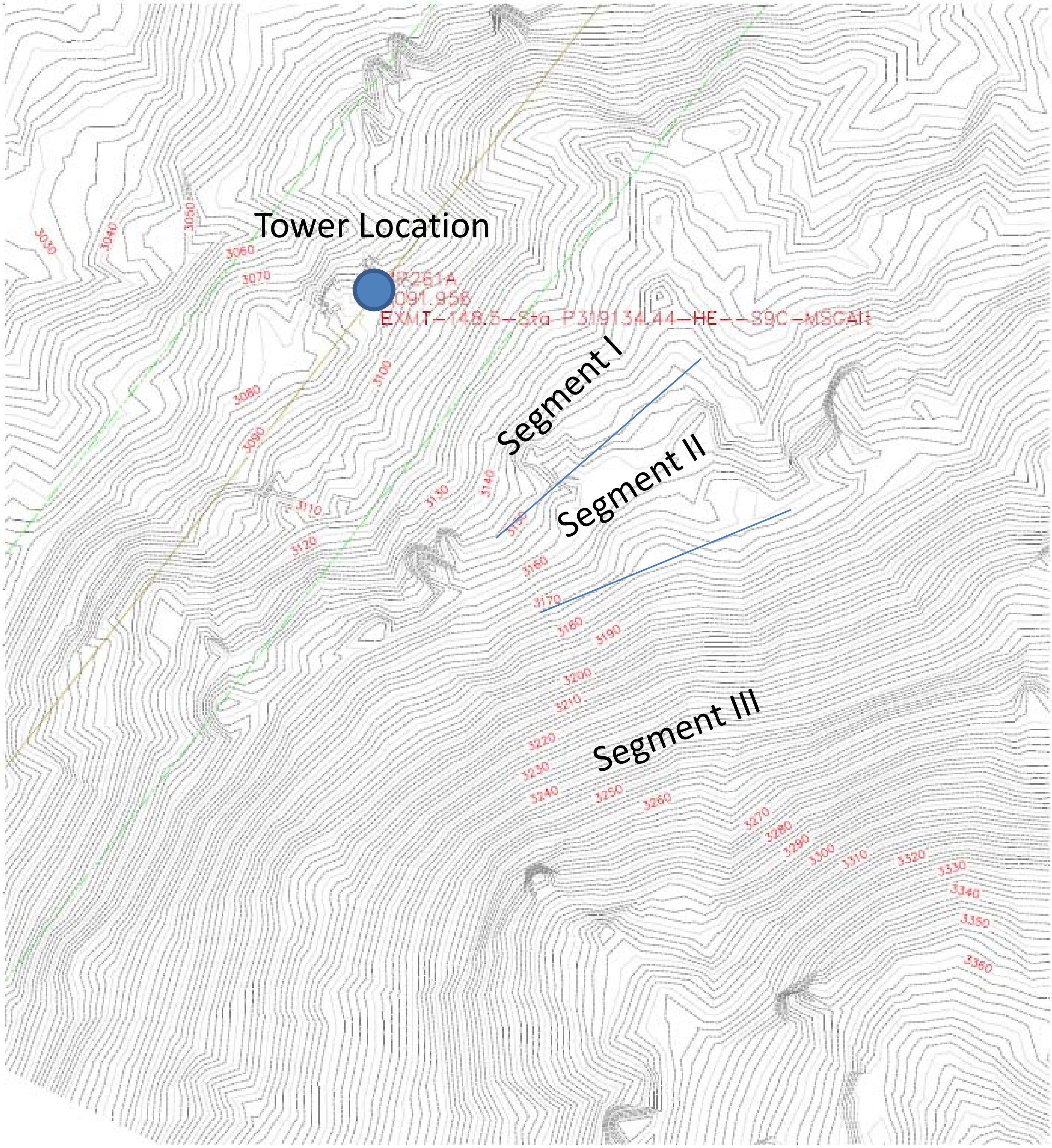
APPENDIX C

RAW DATA AND ROCKFALL HAZARD ANALYSIS

TOWER 261A



Note: Green ROW lines are located 100' from transmission line.

Figure C-1

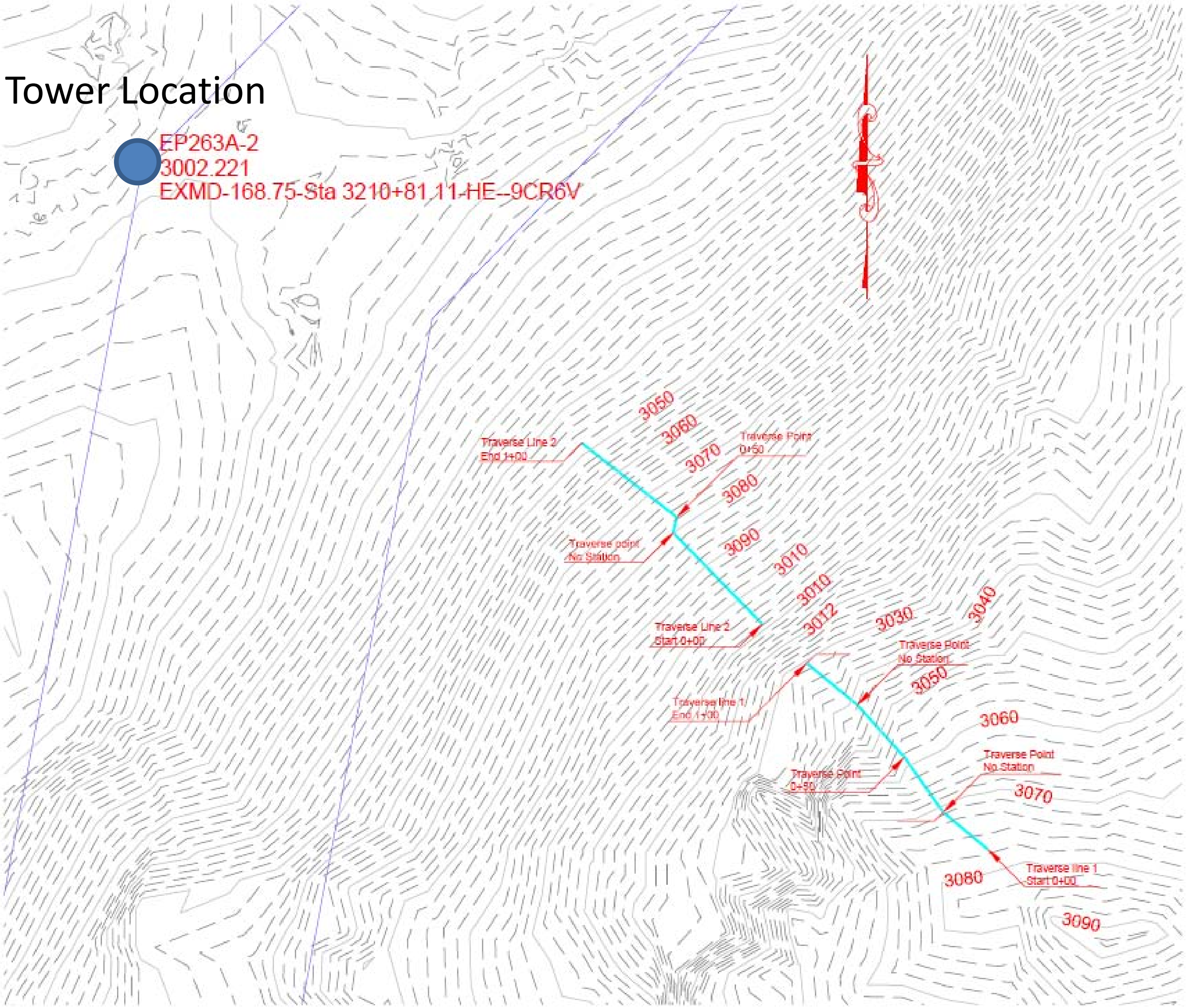
Topographic map of Tower 261A location

Project No. 134AZ Date: July, 2010

APPENDIX D

RAW DATA AND ROCKFALL HAZARD ANALYSIS

TOWER 263A-2



Project No. 134AZ

Date: July, 2010

Figure D-1

Sampling traverse intervals for Tower 263A-2

Note: Blue ROW line is located 100' from transmission line.

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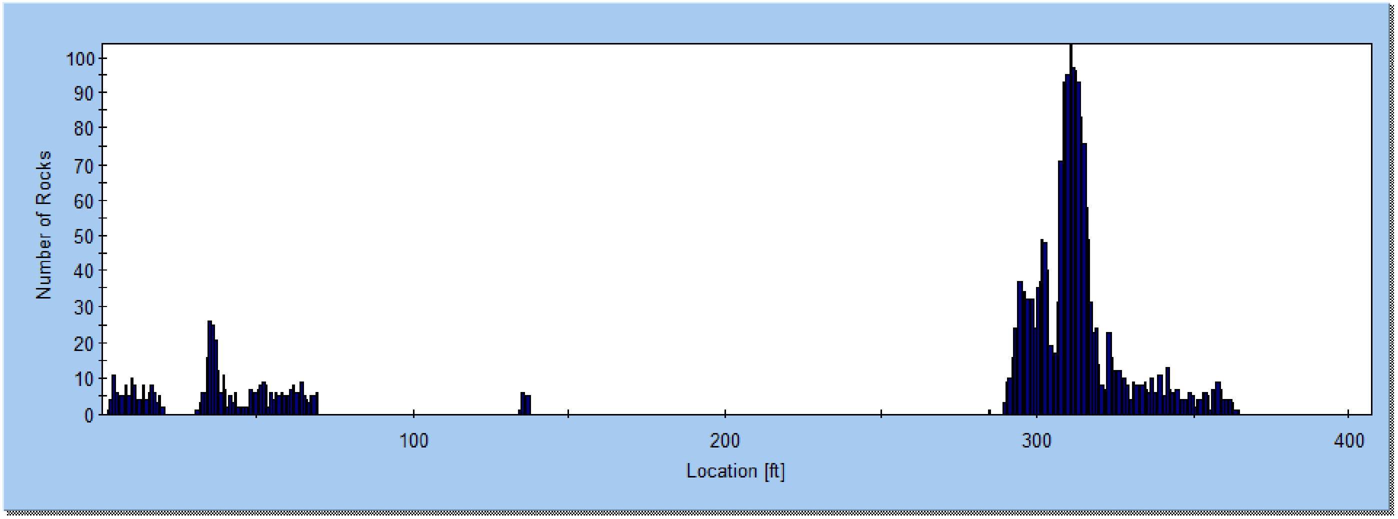
Mountain Springs Grade – Rockfall Assessment for Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Tower 263A - Horizontal Location of Rock End-points



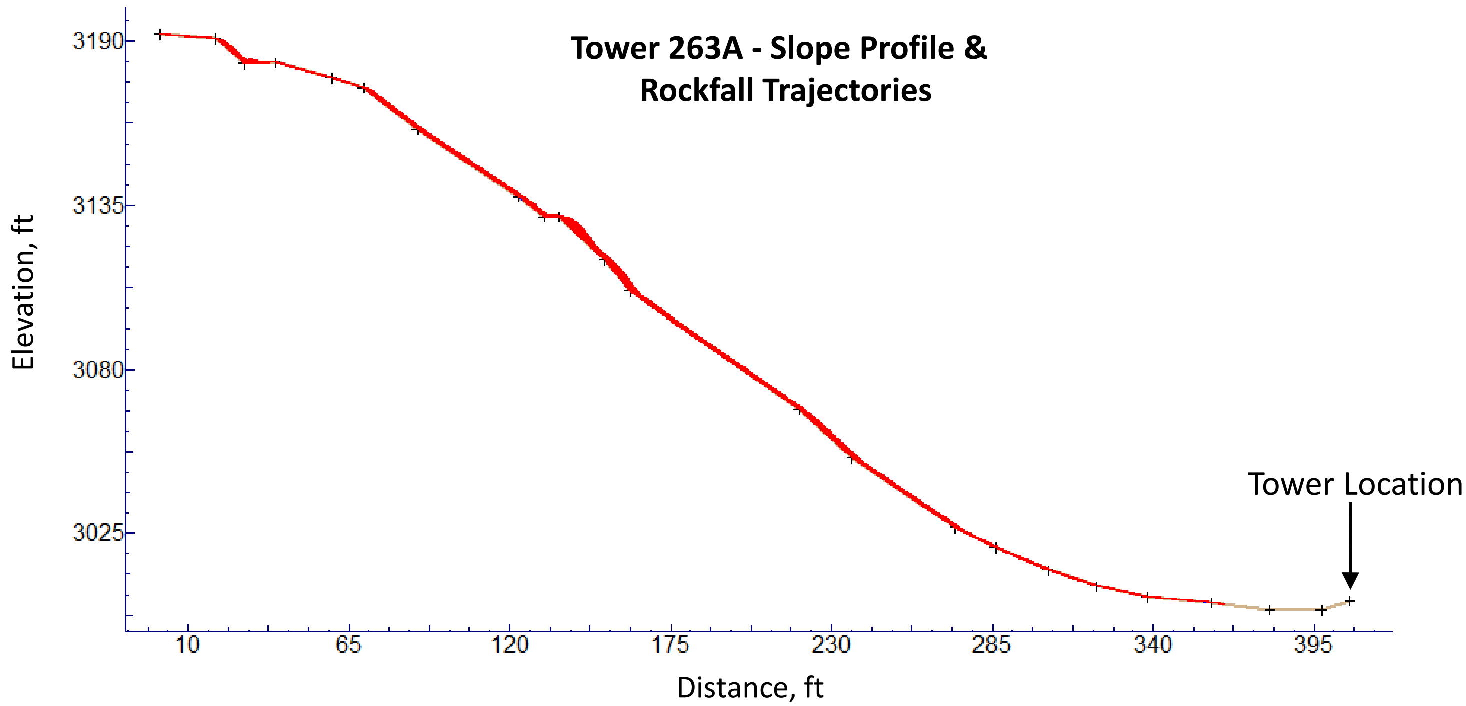


Figure D-2

Rockfall Simulation Results for Tower 263A-2

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Crux Subsurface
Mountain Springs Grade – Rockfall Assessment for Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Tower 263A-2 Field Data

	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
Traverse I	1.0	y	4.50	5.50	0.75	15
	1.0	y	1.50	3.00	0.75	15
	1.0	n	2.00	2.25	0.50	15
	1.0	n	2.25	1.75	0.75	15
	1.0	y	4.00	3.00	7.00	15
	4.0	y	4.50	3.75	4.00	15
	2.0	y	8.50	7.00	5.00	15
	4.0	y	2.50	2.00	1.50	15
	5.0	n	2.75	3.25	3.00	15
	6.0	n	1.50	0.75	0.75	15
	9.0	n	2.25	2.00	2.00	15
	9.0	y	2.50	3.50	0.75	25
	9.0	n	0.50	1.25	1.25	28
	17.0	y	1.75	1.25	0.50	28
	17.0	y	2.00	3.00	2.00	28
	18.0	n	2.00	1.75	0.75	28
	22.0	n	2.25	2.50	3.50	-10
	24.0	n	5.00	5.50	6.00	0
	25.0	n	0.75	0.50	1.00	28
	25.0	y	0.75	1.00	0.75	28
	25.0	n	0.50	0.25	0.25	28
	25.0	n	0.75	0.75	1.50	28
	25.0	y	1.00	2.00	1.25	28
	25.0	y	1.25	2.00	1.50	28
	26.0	y	0.50	1.25	1.25	28
	29.5	n	4.50	3.00	3.75	28
	30.0	n	2.25	2.00	2.25	28
	32.0	n	1.00	2.25	2.00	28
	35.0	n	3.50	2.00	4.00	28
	36.0	n	3.00	0.75	3.00	28
	39.0	n	5.00	5.00	6.50	28
	41.0	y	3.50	4.00	5.50	28
	42.5	n	1.75	1.75	2.00	28
	42.5	n	2.75	2.00	1.75	28
	42.5	n	1.00	1.00	1.25	28
	42.5	y	0.75	1.00	0.75	28
	42.5	y	0.50	0.50	0.75	28
	43.0	y	1.00	1.00	1.00	28
	43.0	n	1.75	2.00	2.00	28
	44.0	n	2.00	3.25	2.00	-10
	46.0	n	2.50	2.25	1.75	28
	46.0	y	1.25	0.75	1.00	28
	47.0	y	0.75	0.75	0.75	28
	47.0	y	2.00	1.00	1.25	28

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
47.0	n	2.50	1.75	1.25	28
48.0	n	2.00	3.25	2.50	28
49.0	y	3.00	6.50	3.50	28
50.0	n	2.50	3.50	1.25	28
50.0	y	1.75	1.00	1.25	28
50.0	y	1.25	1.50	1.25	28
51.0	y	1.50	1.50	1.50	35
51.0	y	0.75	0.75	0.75	35
53.5	y	2.50	3.00	8.00	35
53.5	n	4.50	3.00	9.50	35
54.0	n	3.75	3.00	8.50	35
55.0	y	8.00	10.00	3.00	35
65.0	n	4.50	2.00	4.50	35
65.0	y	3.50	3.00	4.00	35
65.0	y	3.00	2.50	4.00	35
65.0	n	1.00	2.50	1.00	35
66.0	y	3.25	2.25	2.00	35
72.0	n	12.00	6.50	10.50	-10
69.0	y	1.25	2.00	2.25	35
69.0	n	0.50	2.00	2.00	35
70.0	y	1.25	1.25	1.50	35
74.0	n	2.75	4.00	6.00	0
73.0	n	7.00	5.00	13.00	-10
73.0	y	2.00	2.50	1.50	-5
73.0	y	3.00	2.00	2.50	35
73.0	y	4.50	4.00	4.50	-15
74.0	y	3.00	2.25	1.50	35
75.0	y	4.25	1.00	3.00	35
77.0	y	2.00	1.25	2.00	35
78.0	y	2.50	2.00	2.00	35
78.0	y	3.00	2.25	3.25	35
78.0	y	0.75	0.75	1.25	35
78.0	y	1.00	0.75	1.50	35
78.0	y	2.50	2.00	2.50	35
79.0	y	1.50	0.75	2.00	35
80.0	y	0.50	1.50	1.50	35
80.0	y	2.50	2.00	2.50	15
81.0	n	3.00	3.00	5.00	15
83.0	y	1.00	1.50	1.25	15
83.0	y	2.00	1.00	1.50	15
84.0	y	1.00	1.00	1.00	15
85.0	y	1.25	0.75	0.75	15
86.0	y	2.50	3.00	2.00	15
86.0	y	2.00	2.50	1.25	15
86.0	y	2.00	2.50	1.50	15
87.0	y	0.75	1.25	0.75	15

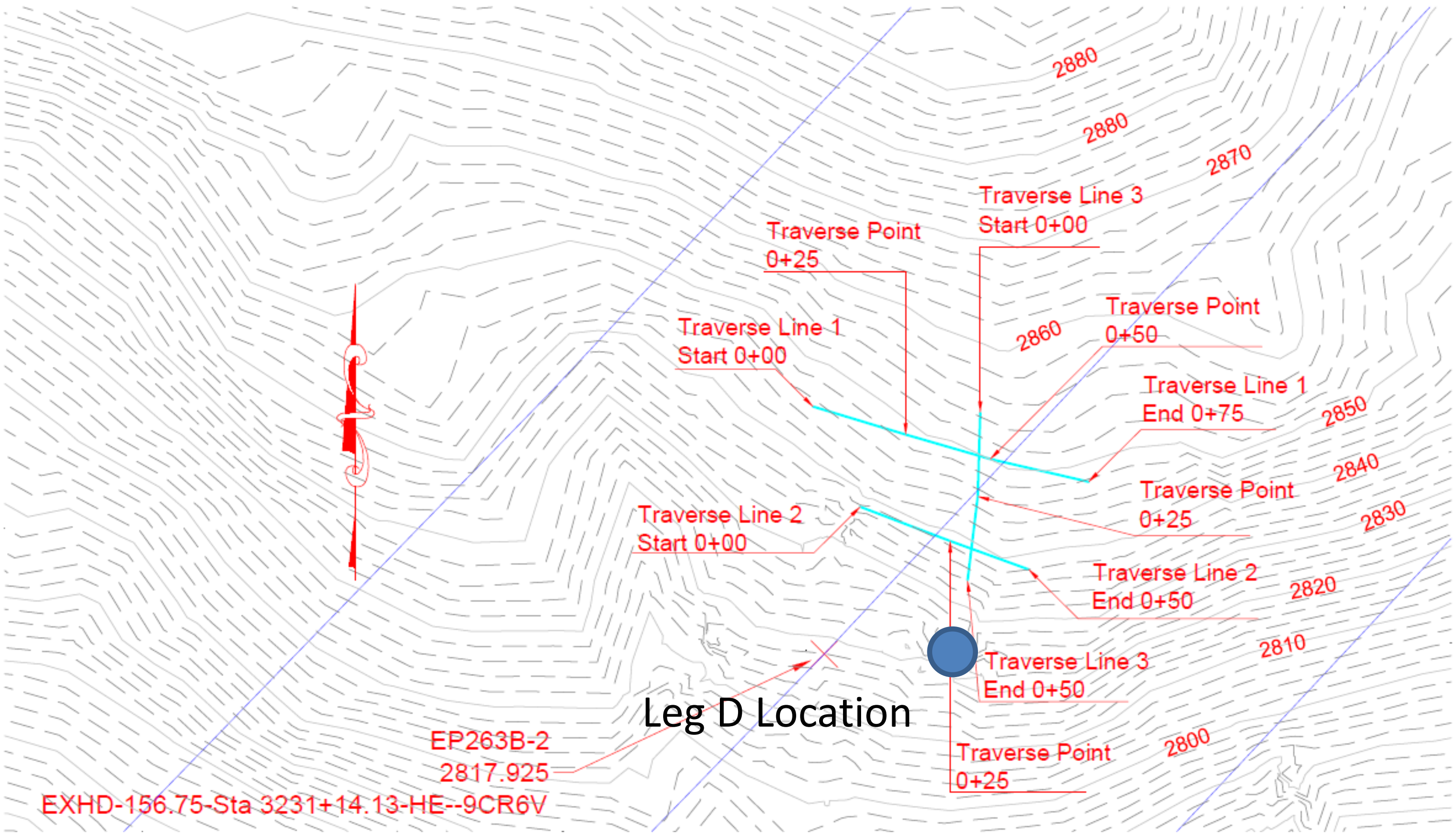
	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
	87.0	n	2.00	4.50	3.50	10
	87.0	n	10.00	7.00	5.50	20
	88.0	y	3.00	2.00	2.00	15
	88.0	y	1.50	1.25	1.50	15
	89.0	y	5.00	2.50	3.50	15
	90.0	n	3.00	2.50	3.50	25
	92.0	n	4.50	1.50	3.00	25
	92.0	y	1.25	1.50	1.75	185
	92.0	y	1.50	1.25	1.75	15
	94.0	y	4.00	9.50	5.50	15
	95.0	y	4.00	6.00	5.00	15
Traverse II	1.0	y	1.50	2.00	2.25	15
	1.0	y	2.00	2.50	1.75	20
	3.0	y	1.50	2.00	1.75	20
	4.0	n	4.25	8.00	6.75	15
	5.0	n	3.75	4.50	4.50	10
	6.0	n	1.50	3.50	2.00	15
	7.0	n	2.50	2.75	1.50	15
	7.0	n	4.00	6.50	4.00	-15
	10.0	n	3.50	2.50	1.75	-15
	10.0	n	2.00	3.75	3.00	10
	12.0	n	1.75	2.50	2.50	10
	17.0	y	2.50	2.75	2.00	33
	19.0	y	3.00	3.50	2.25	33
	19.0	n	0.75	1.50	2.50	33
	20.0	n	1.00	4.50	2.50	0
	22.0	n	2.25	2.50	2.25	33
	24.0	n	0.75	2.00	1.00	33
	30.0	n	5.00	17.00	9.00	15
	34.0	n	1.50	4.00	3.00	10
	35.0	y	1.00	1.25	0.75	33
	40.0	n	1.50	1.50	0.75	15
	41.5	n	1.50	0.75	1.50	10
	43.0	n	1.25	0.75	1.00	10
	43.0	n	2.00	1.75	2.50	15
	44.0	n	2.25	2.50	3.50	15
	45.0	y	3.00	1.50	2.50	-10
	46.0	y	5.00	5.50	4.50	10
	47.0	n	4.25	4.50	3.50	0
	48.0	n	1.50	1.25	0.75	0
	49.0	y	1.50	1.50	2.00	0
	50.0	y	3.00	5.00	4.00	-10
	53.0	n	2.00	1.50	4.50	10
	57.0	y	1.50	2.50	3.00	10
	59.0	n	1.75	3.50	3.50	10
	63.0	y	1.50	1.00	1.00	-10

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
63.0	n	2.00	2.00	2.50	10
65.0	n	0.75	1.50	1.25	10
64.0	n	4.50	3.00	3.00	30
6.0	n	6.50	4.00	4.00	15
71.0	n	2.75	1.75	3.00	20
71.0	n	1.75	1.50	1.50	20
72.0	y	1.50	1.75	0.50	10
74.0	n	2.50	1.50	4.50	25
76.0	n	2.50	3.75	4.50	25
77.0	y	2.00	1.25	1.50	20
79.0	y	1.75	1.50	1.25	20
82.0	y	2.00	2.00	2.75	20
84.0	n	1.00	1.50	2.50	10
86.0	n	1.00	2.00	2.00	10
86.0	y	1.25	0.75	1.50	10
87.0	y	2.00	1.00	0.75	10
88.0	n	2.00	2.00	2.00	30
89.0	n	0.50	2.00	1.75	30
90.0	n	2.00	1.00	1.00	30
92.0	y	0.50	1.00	0.75	20
95.0	n	1.00	1.00	0.75	-10
96.0	n	0.50	0.75	1.00	-10
97.0	n	0.75	1.25	2.00	10
97.0	n	4.50	2.50	2.25	20
100.0	n	1.50	1.00	1.00	15

APPENDIX E

RAW DATA AND ROCKFALL HAZARD ANALYSIS

TOWER 263B-2



Project No. 134AZ Date: July, 2010

Note: Blue ROW lines are located 100' from transmission line.

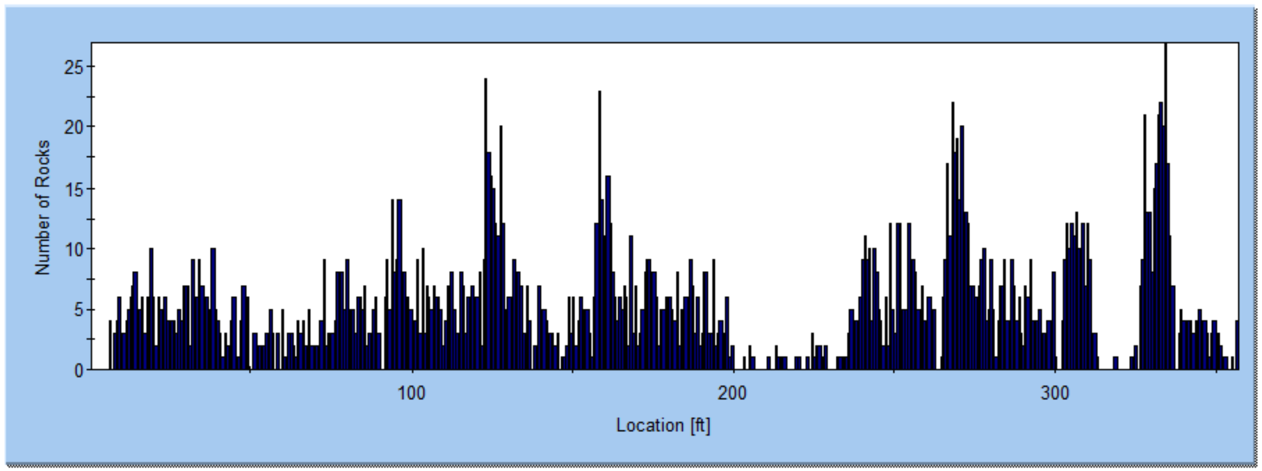
Figure E-1

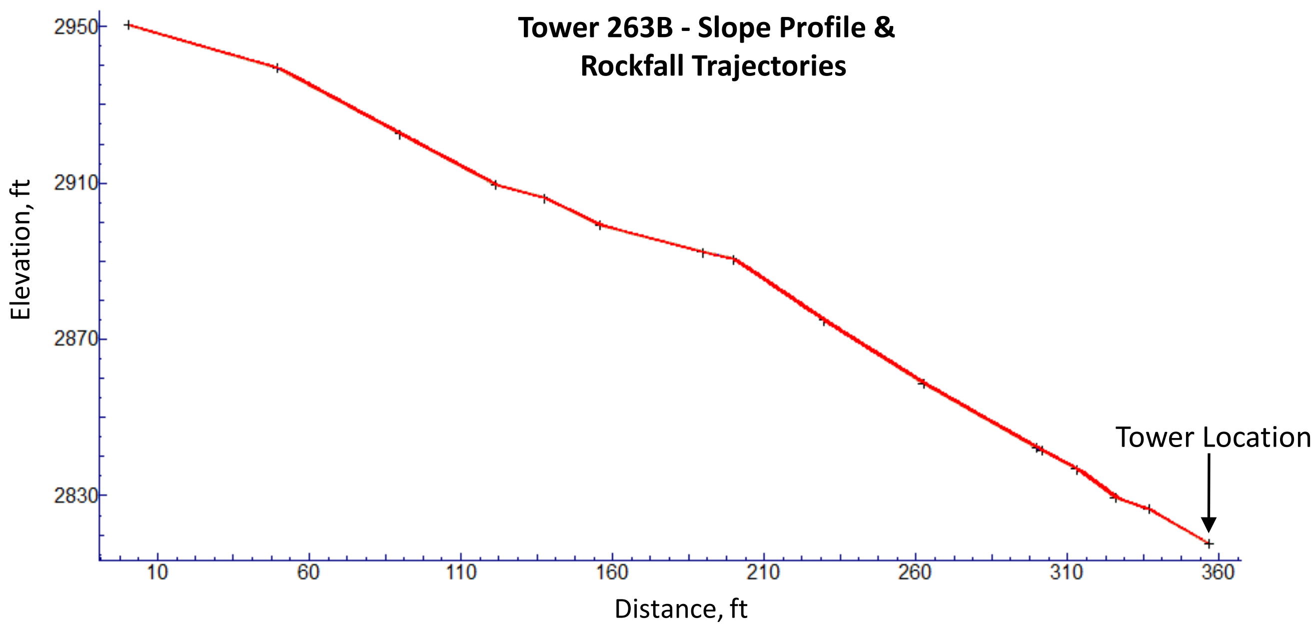
Sampling traverse intervals for Tower 263B-2

FISHER&STRICKLER ROCK ENGINEERING, LLC

Crux Subsurface
Mountain Springs Grade – Rockfall Assessment for Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Tower 263B - Horizontal Location of Rock End-points





Project No. 134AZ Date: July, 2010

Figure E-2

Rockfall Simulation Results for Tower 263B

Tower 263B-2 Field Data

	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
Traverse I			0' to 15' Bedrock			
	15.0	y	1.00	1.00	1.00	10
	16.0	y	1.50	1.50	1.00	10
	17.0	n	1.50	1.50	2.25	10
			17' to 21' Bedrock			
	23.0	n	2.25	2.75	4.00	10
	24.5	n	1.00	0.50	3.00	10
	28.5	n	1.00	1.00	2.00	10
	30.0	y	1.50	1.25	2.00	10
	3.4	n	3.00	2.75	4.00	10
	38.5	n	1.75	3.00	3.00	10
			39' to 47' Bedrock			
	48.0	n	0.75	1.25	1.75	15
	50.0	n	1.00	1.50	1.50	15
			50' to 60' Soil Cover			
			60' to 63' Bedrock			
	65.0	y	4.00	2.00	8.00	20
	68.0	y	4.00	2.50	5.00	20
	75.0	n	2.00	2.00	2.25	20
			0' to 3' Bedrock			
	3.0	y	1.00	1.00	1.00	20
			4' to 5' Bedrock			
Traverse II	5.0	n	0.75	0.50	1.00	15
	6.0	y	1.25	1.25	1.50	20
	7.0	n	2.00	1.50	1.00	20
	7.0	n	3.50	2.00	4.50	-5
			10' to 10.5' Bedrock			
	12.0	y	1.75	1.00	1.00	10
	13.0	y	2.00	1.00	3.00	15
			14' to 21' Bedrock			
	21.0	n	2.25	0.75	2.25	15
	22.0	n	2.25	2.00	2.25	15
	22.5	y	2.00	1.50	2.75	15
	24.0	y	1.00	0.25	1.75	15
	24.5	y	2.00	1.25	2.50	15
	27.5	y	1.75	0.75	1.75	15
	28.0	y	2.50	0.50	2.00	15
			28' to 29.5' Bedrock			
	29.5	y	2.25	1.50	3.00	15
	30.0	y	1.25	1.00	1.50	15
	31.0	y	1.50	1.25	3.00	15
	32.0	n	5.25	4.00	7.25	15
	36.0	y	2.00	1.50	3.50	15
	37.0	y	6.00	5.00	5.50	15

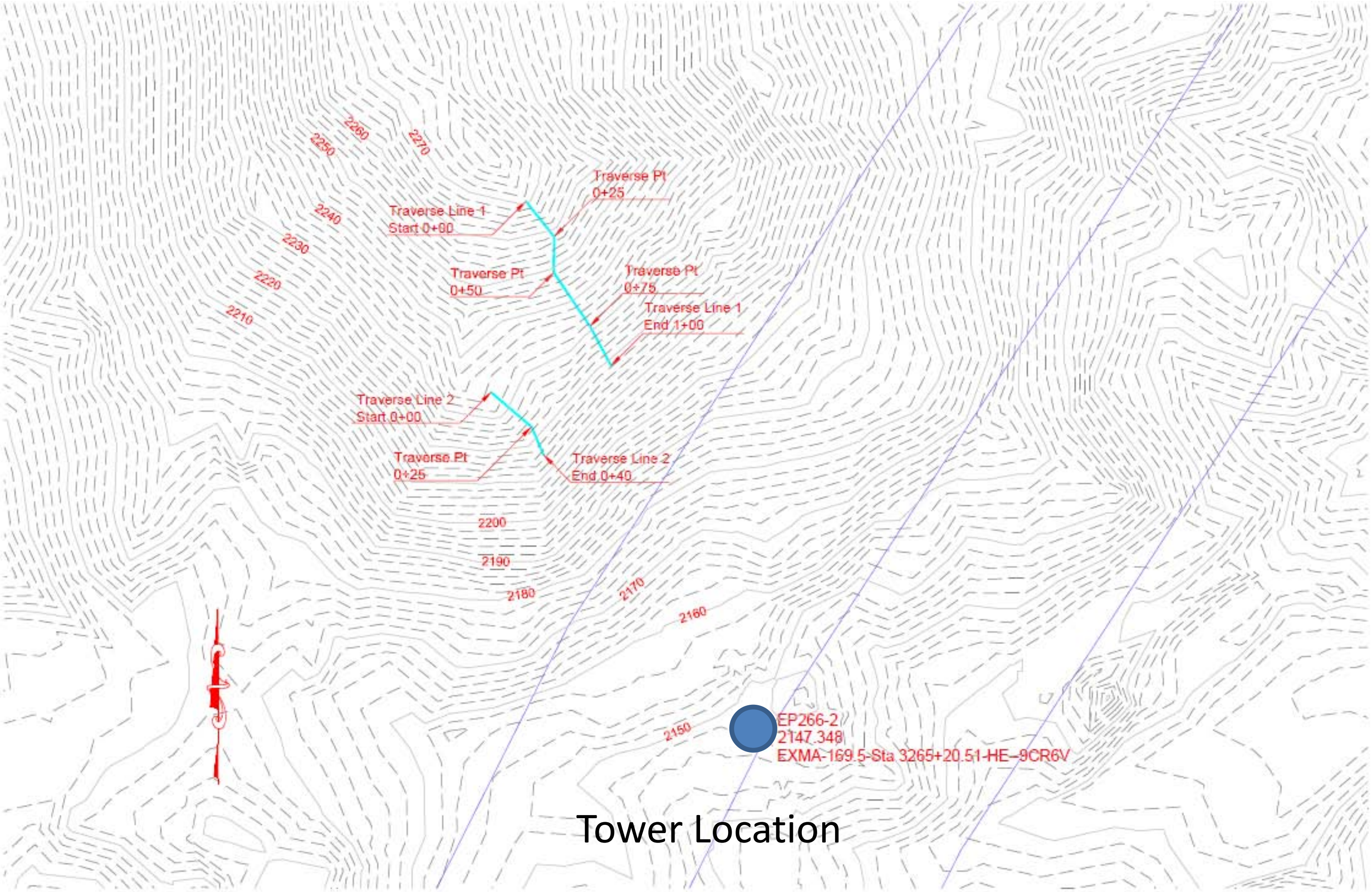
	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
	44.0	n	6.00	7.00	8.00	-5
	47.0	n	3.00	2.00	3.00	-10
	49.0	y	1.50	2.00	2.00	25
	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
	0.0	y	1.50	1.00	1.75	20
	1.0	n	4.00	3.00	4.50	20
+/- 5 ft of the tape	4.0	n	1.75	3.00	1.00	-10
Traverse I	5.0	y	1.50	2.00	0.75	15
	6.0	y	1.50	2.00	1.00	20
	7.0	n	3.00	1.00	3.50	-20
	8.0	y	2.50	0.50	1.50	-20
	10.0	n	8.00	4.00	10.00	15
	14.0	n	3.00	3.00	2.50	15
	17.0	n	1.50	5.00	3.50	-20
	18.0	n	2.50	1.75	3.50	15
	19.0	n	1.50	1.00	2.00	15
	20.0	n	1.00	0.75	1.50	-5
	20.0	n	1.00	0.75	3.00	10
	21.0	n	1.25	2.50	2.50	10
	21.0	y	1.25	1.25	1.50	10
	21.5	n	2.00	2.50	1.00	-15
	21.0	y	0.75	1.00	0.75	-10
	21.0	n	0.75	1.00	1.50	10
	21.0	n	1.50	1.00	1.25	10
	24.0	n	2.50	0.75	1.75	15
	25.0	n	1.50	4.00	3.00	20
	25.0	n	1.25	3.50	3.75	20
	24.0	n	2.50	4.50	6.00	25
	24.0	n	1.00	1.00	1.25	20
	25.0	y	2.00	2.00	2.50	20
	27.0	y	2.50	1.50	3.00	20
	28.0	n	2.50	0.75	2.25	15
	29.0	n	2.75	1.75	3.00	20
	30.0	n	5.00	2.00	5.00	25
	29.0	n	4.00	4.00	4.50	20
	28.0	y	3.50	3.50	3.50	15
	29.0	y	6.00	4.50	3.50	10
	30.0	y	1.25	0.75	1.50	15
	32.0	y	1.25	1.50	2.75	10
	34.0	y	2.50	1.75	2.25	10
	37.0	y	4.00	5.00	3.00	30
	38.0	n	2.00	3.00	2.50	-10
	39.0	n	2.25	2.50	2.75	15
	39.0	y	6.50	5.00	5.50	25
	40.0	n	5.00	3.50	7.00	15
	40.0	y	1.25	1.50	3.75	5

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
41.0	y	1.50	1.75	2.50	-5
41.0	y	0.75	1.00	1.50	5
41.5	y	1.75	1.50	3.50	15
42.0	y	1.50	2.25	1.75	5
45.0	y	1.75	1.00	2.00	5
48.0	n	3.00	1.25	3.50	15
49.0	n	1.75	0.75	1.00	10
50.0	n	3.00	2.25	2.50	15

APPENDIX F

RAW DATA AND ROCKFALL HAZARD ANALYSIS

TOWER 266-2



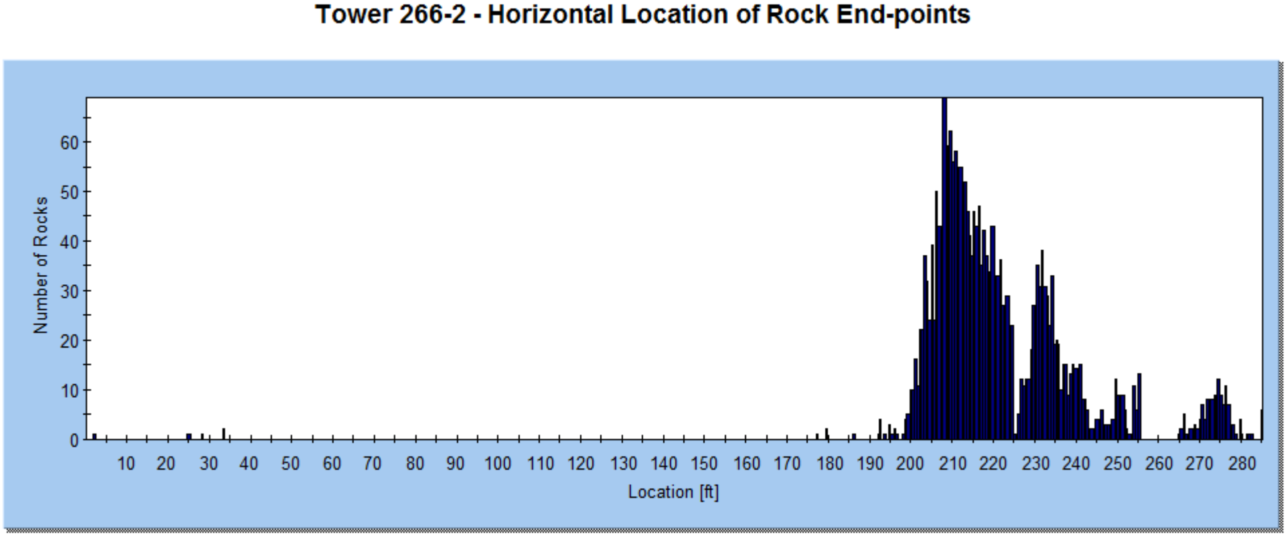
Date: July, 2010

Project No. 134AZ

Figure F-1

Sampling traverse intervals for Tower 266-2

Note: Blue ROW lines are located 100’ from transmission line.



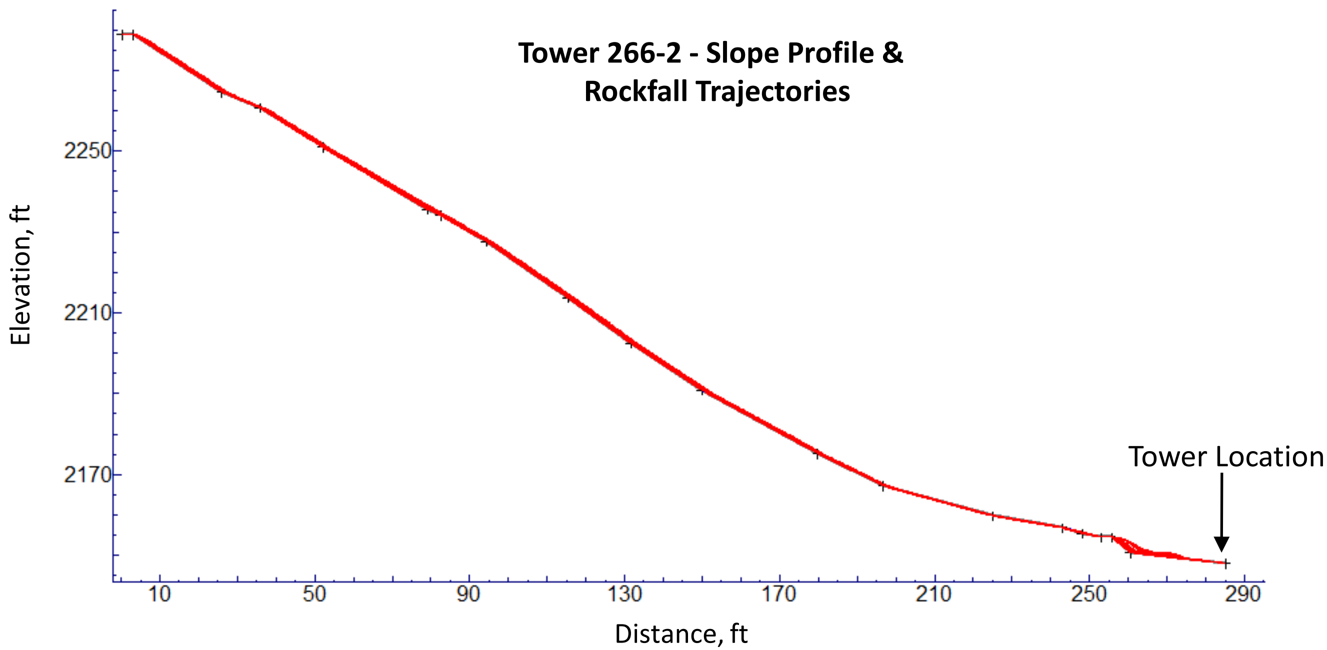


Figure F-2

Rockfall Simulation Results for Tower 266-2

Project No. 134AZ

Date: July, 2010

FISHER&STRICKLER ROCK ENGINEERING, LLC

Crux Subsurface
Mountain Springs Grade – Rockfall Assessment for Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Tower 266-2 Field Data

	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
Traverse I	5.0	n	0.75	2.00	1.25	10
	5.0	n	0.50	1.50	1.00	15
	5.0	n	3.00	4.00	3.00	5
	7.0	n	1.00	2.75	2.75	5
	15.0	n	1.75	0.75	1.50	-10
	16.0	n	0.50	1.25	0.75	10
	16.0	n	0.50	1.00	0.75	10
	17.0	n	0.50	0.75	0.75	10
	18.0	n	0.50	1.00	0.75	-5
	19.0	n	0.25	1.75	1.00	5
	20.0	n	0.75	1.25	1.00	10
	20.0	n	0.75	0.75	1.25	15
	18.0	n	1.00	0.75	1.00	10
	18.0	n	0.75	0.75	1.00	10
	19.0	n	1.25	1.25	1.50	10
	19.0	n	1.00	1.25	0.75	10
	19.0	n	0.25	1.00	0.75	10
	20.0	n	0.50	1.00	1.25	10
	22.0	y	0.50	0.75	1.00	10
	23.0	n	1.50	0.50	1.25	-10
	24.0	n	0.75	0.25	0.75	-10
	34.0	n	0.75	0.75	0.50	0
	35.0	n	1.25	1.50	1.50	20
	35.0	n	0.50	1.00	1.00	10
	36.0	n	1.00	1.25	1.00	10
	37.0	n	0.50	0.75	1.00	15
	37.0	n	0.50	1.25	1.50	15
	37.0	n	1.50	1.00	0.75	-10
	37.0	n	0.75	1.25	1.25	10
	37.0	n	1.00	2.00	0.75	10
	37.0	n	1.50	2.25	1.50	10
	40.0	n	0.75	1.00	0.50	25
	41.0	n	0.50	0.75	1.00	25
	41.0	n	0.75	1.25	1.50	25
	43.0	n	1.00	1.25	0.50	25
	44.0	n	0.75	1.25	0.75	15
	45.0	n	0.75	1.00	0.75	15
	45.0	n	0.75	1.00	1.25	25
	45.0	n	0.73	1.25	1.25	25
	45.0	n	0.75	0.75	1.25	25
	45.0	n	0.50	1.00	1.25	25
	46.0	n	1.50	1.50	1.25	25
	47.0	n	0.75	0.75	1.00	25
	48.0	n	0.75	0.75	0.75	20

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
49.0	n	0.50	0.75	1.00	25
50.0	n	0.50	0.75	0.75	25
49.0	n	0.75	1.00	0.50	25
53.0	n	1.00	1.00	1.25	-10
54.0	n	0.75	1.00	1.25	10
55.0	n	0.75	1.25	1.00	15
56.0	n	0.75	2.00	0.75	20
57.0	n	0.75	1.00	1.00	20
58.0	y	0.50	1.00	0.50	15
59.0	n	0.75	0.75	1.25	20
62.0	n	0.75	1.00	0.75	10
62.0	n	0.25	1.00	0.75	15
65.0	n	0.75	1.00	0.75	15
65.0	n	0.50	0.75	0.75	15
65.0	y	0.50	0.75	0.50	10
68.0	n	0.75	0.50	1.00	10
68.0	n	1.25	1.25	2.00	-10
69.0	n	1.00	2.25	1.00	10
70.0	n	0.50	2.00	1.00	10
70.0	n	1.00	1.25	1.25	-5
71.0	n	0.75	1.00	1.25	25
72.0	n	0.75	0.75	1.00	15
72.0	n	0.75	0.75	1.25	10
73.0	n	0.50	1.00	2.25	-15
73.0	n	1.50	0.75	0.75	-10
74.0	n	0.50	0.75	1.50	0
75.0	n	0.75	0.50	0.75	10
76.0	n	0.50	1.25	0.75	-5
77.0	n	0.50	0.75	0.75	0
78.0	n	0.50	0.50	0.75	0
79.0	n	0.50	0.50	1.50	25
80.0	n	1.00	1.00	0.75	25
81.0	n	0.75	1.00	0.75	25
82.0	n	1.75	1.00	2.00	-10
83.0	n	0.75	0.75	1.00	25
84.0	n	0.75	0.75	1.00	20
85.0	n	0.50	0.50	0.50	10
86.0	n	0.50	0.75	0.50	10
87.0	n	0.50	1.50	1.25	20
88.0	n	0.50	0.50	0.50	10
89.0	n	0.75	0.75	0.75	10
90.0	n	0.50	0.75	0.75	10
91.0	n	0.50	0.75	0.50	10
92.0	n	0.75	0.75	0.75	10
93.0	n	1.00	0.75	1.25	10
94.0	n	1.25	1.75	1.50	-5

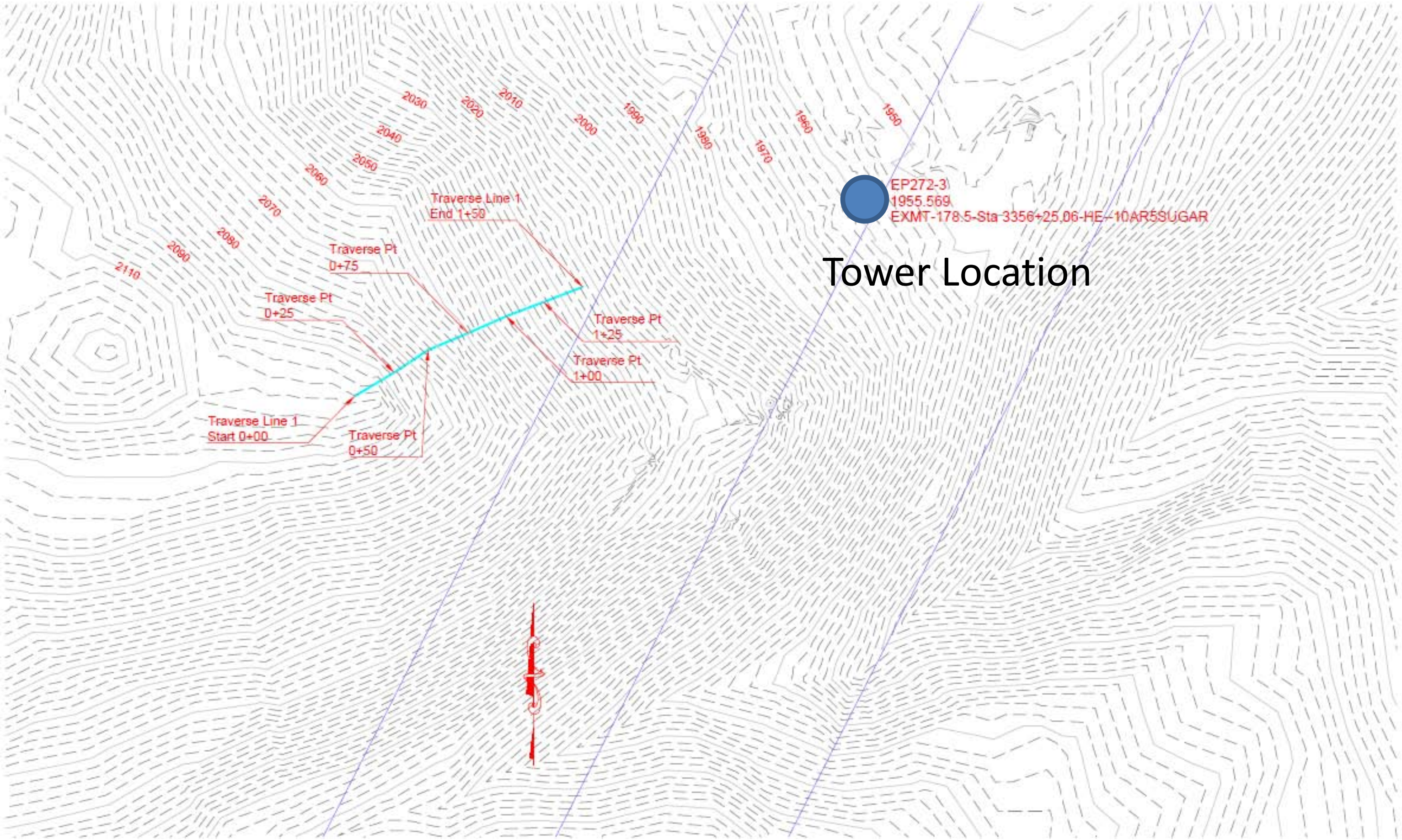
	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
	95.0	n	1.00	1.00	1.50	10
Traverse II	0.0	y	2.00	1.50	1.00	0
	1.0	y	1.50	1.00	1.00	0
	1.0	y	0.50	0.75	0.75	0
	2.0	y	0.25	0.75	0.75	-10
	2.0	y	2.00	1.50	1.75	-10
	8.0	n	2.00	3.50	2.00	-10
	8.0	y	1.25	1.75	1.00	-10
	8.0	y	1.00	1.00	0.75	-10
	8.0	y	1.75	1.25	2.00	-10
	8.0	n	1.00	0.50	0.75	0
	9.0	y	1.25	2.50	1.50	-10
	10.0	y	0.75	1.25	1.00	10
	10.0	y	0.75	1.50	1.00	0
	11.0	y	1.50	1.75	1.50	-10
	11.0	y	1.50	0.75	1.00	-10
	11.0	y	1.50	0.75	1.50	-10
	12.0	y	3.50	2.75	2.50	-10
	13.0	y	1.50	1.50	1.50	-10
	13.0	n	1.75	1.75	2.25	0
	14.0	n	3.25	1.00	1.50	-10
	14.0	y	3.00	1.50	2.25	-10
	14.0	y	1.50	3.00	1.00	-10
	14.0	y	1.50	2.00	1.50	-10
	15.0	n	3.00	2.50	3.25	-10
	15.0	y	1.50	1.25	1.25	0
	16.0	y	1.00	0.75	1.00	-10
	17.0	y	1.75	1.50	3.00	5
	17.0	n	2.00	2.75	1.50	-10
	18.0	n	2.00	4.00	3.00	10
	19.0	y	2.25	2.50	4.50	15
	22.0	y	0.75	1.00	1.75	20
	25.0	y	2.00	3.50	2.00	-10
	26.0	y	2.50	1.75	1.00	5
	27.0	y	3.50	2.00	1.00	5
	27.0	y	2.00	1.75	1.00	5
	28.0	n	0.75	0.75	0.75	5
	28.0	n	0.75	1.25	1.00	5
	29.0	n	1.50	2.50	1.25	10
	29.0	y	1.50	2.00	1.25	10
	30.0	y	2.00	1.75	1.75	0
	32.0	y	1.50	1.50	0.75	0
	30.0	y	1.50	1.50	1.00	-10
	33.0	y	0.50	1.25	0.50	-10
	35.0	y	1.00	1.00	1.00	-10
	36.0	y	0.75	0.75	1.00	-10

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
37.0	y	1.00	1.00	1.50	-10
38.0	y	1.50	1.00	1.00	-10
39.0	y	2.00	3.00	2.50	-10
40.0	y	1.50	1.50	1.25	0
40.0	y	1.75	2.00	2.50	0
41.0	y	1.75	1.75	1.75	0

APPENDIX G

RAW DATA AND ROCKFALL HAZARD ANALYSIS

TOWER 272-3

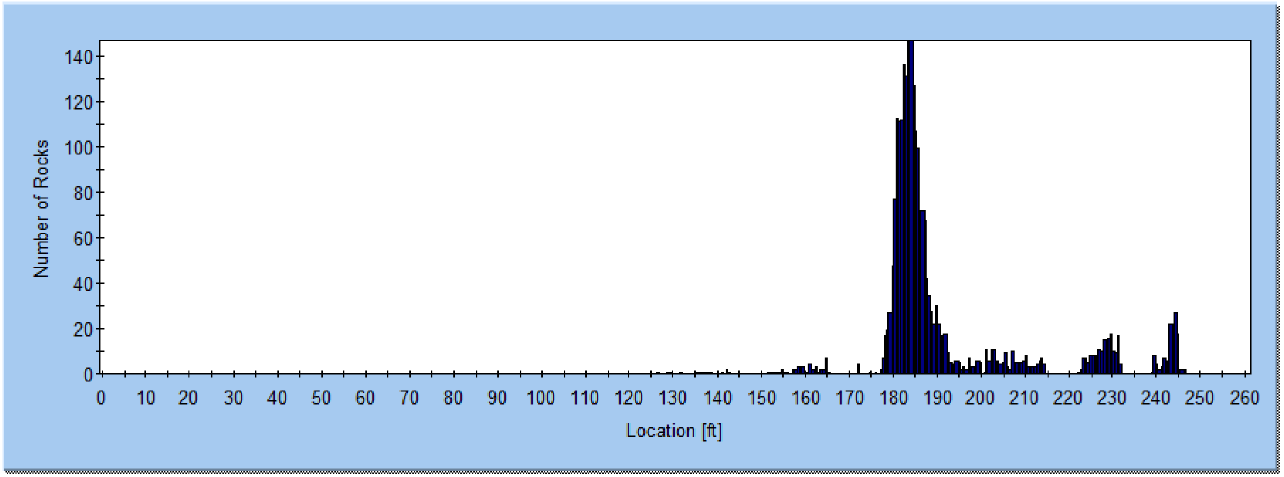


Note: Blue ROW lines are located 100' from transmission line.

Figure G-1

Sampling traverse intervals for Tower 272-3

Tower 272-3 - Horizontal Location of Rock End-points



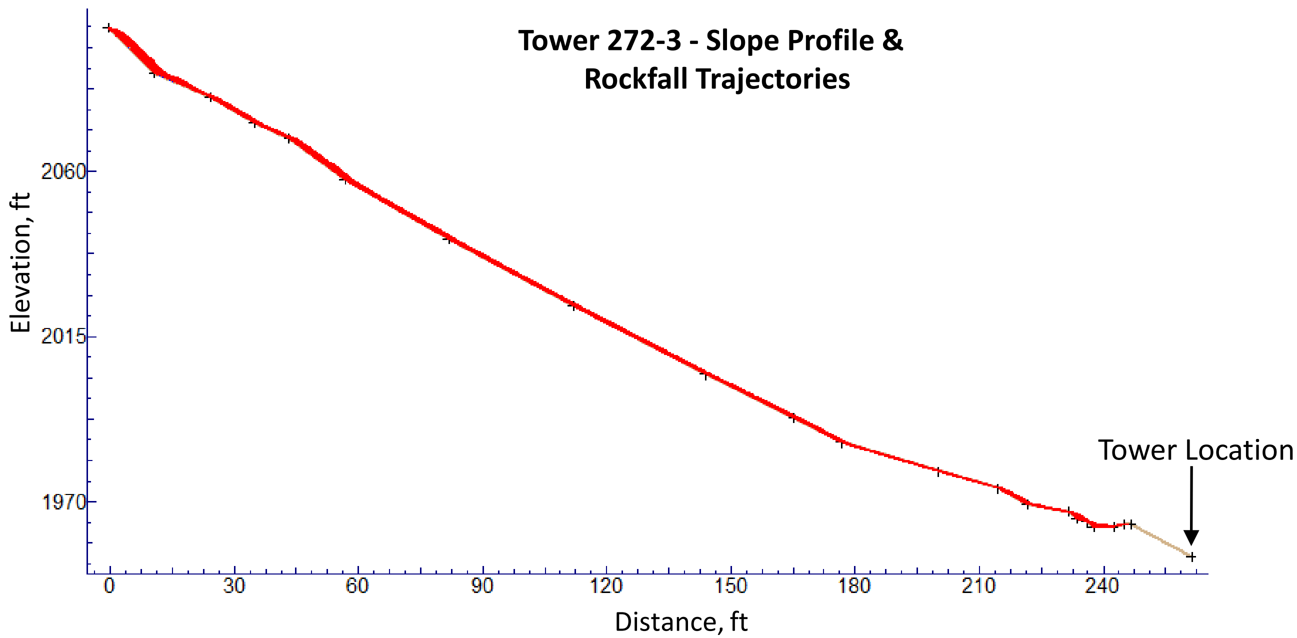


Figure G-2

Rockfall Simulation Results for Tower 272-3

Date: July, 2010

Project No. 134AZ

FISHER&STRICKLER ROCK ENGINEERING, LLC

Crux Subsurface
Mountain Springs Grade – Rockfall Assessment for Towers 261A, 263A-2, 263B-2, 266-2, and 272-3

Tower 272-3 Field Data

	Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
Traverse I	0.00	n	1.50	0.75	1.75	10
	0.0	n	2.50	1.50	4.50	10
	1.0	y	1.50	1.25	1.75	10
	3.0	n	2.00	1.50	2.75	-15
	4.0	n	1.00	2.00	1.50	-15
	5.0	n	1.50	2.50	1.50	-15
	6.0	n	1.00	1.50	1.00	-15
	6.0	n	1.00	1.00	0.75	-15
	6.0	n	1.50	1.75	0.75	-15
	6.0	n	0.50	0.50	0.50	-10
	7.0	n	0.75	0.75	1.00	-10
	7.0	n	0.50	0.75	1.00	-10
	7.0	y	0.50	0.75	0.75	-10
	8.0	n	1.50	1.50	1.50	0
	8.0	y	0.75	1.00	1.00	5
	8.0	y	0.75	0.75	1.00	5
	8.0	y	1.00	0.50	1.00	5
	8.0	y	0.75	1.00	1.50	5
	8.0	y	1.00	1.50	2.50	20
	8.0	y	0.75	1.50	1.25	10
	8.0	y	1.50	1.75	1.25	-10
	8.0	y	1.25	1.00	1.75	10
	8.0	y	2.50	1.00	1.50	-20
			8' to 18' is Bedrock			
	18.0	n	2.50	1.50	3.00	-20
	18.0	n	2.00	1.00	2.00	-20
	18.0	y	2.00	1.50	1.50	10
	18.0	y	1.50	1.50	1.00	10
	18.0	y	1.50	3.00	3.50	15
	19.0	n	3.50	5.50	6.00	0
	20.0	y	1.25	1.50	1.25	10
	21.0	y	1.25	1.75	1.00	5
	22.0	n	1.50	1.25	2.50	10
	23.0	n	1.75	5.25	2.25	-20
	23.0	n	1.25	1.75	1.25	-20
	25.0	n	2.25	1.50	2.25	-20
	28.0	y	1.00	2.00	1.25	-20
	28.0	y	0.75	1.50	1.50	-20
	29.0	n	2.50	2.00	1.00	0
	29.0	y	1.00	1.00	1.50	0
	30.0	y	1.00	1.00	1.50	10
	31.0	n	1.00	1.00	1.25	15
	29.0	n	1.25	1.00	1.25	10
	29.0	y	1.75	1.50	1.50	-20

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
29.0	n	1.00	1.25	2.00	-15
30.0	n	1.50	2.00	1.00	10
31.0	y	1.00	1.00	0.50	10
32.0	y	1.50	2.00	1.25	10
32.0	n	1.25	1.00	1.50	-15
32.0	n	1.50	1.50	1.00	-20
35.0	n	2.00	4.50	3.50	10
35.0	y	0.50	0.75	1.00	10
35.0	n	1.25	1.50	1.00	-10
37.0	n	0.75	0.50	0.75	-20
37.0	n	3.00	2.25	2.50	-20
39.0	n	2.00	2.50	1.75	-10
40.0	n	1.00	1.50	1.50	0
40.0	y	2.00	2.50	1.25	10
45.0	y	1.50	2.50	2.50	10
46.0	y	1.00	1.25	1.25	10
47.0	n	2.00	2.00	1.50	-15
48.0	n	0.50	1.00	1.25	5
48.0	y	1.00	1.00	1.00	10
49.0	n	0.75	1.75	1.00	0
50.0	y	2.50	2.00	2.00	-5
50.0	y	2.00	3.75	1.75	-10
52.0	y	3.00	4.50	2.25	-10
53.0	n	3.50	4.00	2.75	0
56.0	n	2.25	2.50	3.00	-10
56.0	n	1.50	2.00	2.00	-10
57.0	n	4.00	5.50	5.00	-20
61.0	y	1.75	1.75	2.50	-15
62.0	y	1.75	1.50	3.00	10
67.0	y	1.00	2.50	2.75	10
68.0	y	4.50	5.50	4.00	15
70.0	y	1.00	2.00	2.25	0
70.0	y	1.25	2.00	1.50	0
70.0	n	2.00	1.75	3.00	10
73.0	n	1.25	1.75	1.75	0
76.0	n	9.00	7.00	8.00	-20
80.0	n	2.00	2.00	2.00	10
82.0	y	3.50	4.00	3.00	-15
84.0	n	3.50	2.00	1.50	-5
86.0	n	0.75	1.25	1.50	0
88.0	n	1.75	3.50	1.50	-15
89.0	n	1.50	2.00	1.25	-10
90.0	n	2.75	4.00	2.50	0
90.0	n	2.50	2.00	1.50	-10
91.0	n	1.50	1.25	1.25	0
91.0	n	1.25	2.50	2.00	10

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
98.0	n	0.75	0.75	0.75	-15
99.0	n	0.50	1.00	0.75	-15
99.0	n	0.75	1.25	1.00	-15
100.0	n	1.00	1.25	0.75	-15
100.0	n	1.00	1.50	0.75	-15
101.0	n	1.50	3.00	1.50	-10
103.0	n	2.00	2.00	1.50	-20
104.0	n	0.50	2.00	1.50	-10
106.0	n	1.00	1.50	1.00	-10
108.0	n	0.75	0.75	1.00	-15
109.0	n	1.00	1.00	0.75	-15
111.0	n	0.75	1.50	1.50	10
111.0	n	1.50	2.00	3.00	15
112.0	n	1.00	1.25	2.00	10
112.0	n	1.00	1.75	1.50	-15
113.0	y	1.25	2.25	1.25	-15
114.0	n	0.50	0.75	1.00	-10
114.0	n	0.75	1.00	1.50	0
114.0	n	1.50	2.00	1.50	-15
115.0	n	0.50	1.00	1.00	-15
115.0	n	1.50	1.00	2.00	-15
116.0	n	1.50	2.25	1.50	-15
117.0	y	2.00	2.00	1.50	-15
117.0	n	1.50	0.75	2.00	-15
117.0	n	0.75	1.50	1.25	0
118.0	n	3.00	2.00	5.00	0
119.0	n	0.75	2.00	2.50	10
120.0	y	1.50	3.00	2.00	10
122.0	n	1.75	2.00	2.50	15
123.0	n	1.75	2.00	1.50	10
125.0	n	2.25	3.50	1.50	-10
127.0	n	2.00	3.25	3.25	10
127.0	n	0.50	0.75	1.00	10
128.0	n	0.50	0.75	1.00	10
129.0	n	1.50	1.25	2.50	10
130.0	n	1.75	2.25	4.50	10
131.0	n	0.50	0.75	1.25	0
132.0	n	3.00	2.50	3.50	10
135.0	n	1.75	1.50	3.00	10
139.0	n	2.75	4.25	6.00	10
140.0	n	0.75	1.00	1.25	10
141.0	n	1.00	1.25	2.00	10
142.0	n	1.00	1.00	1.50	10
143.0	n	1.00	1.25	1.00	10
145.0	n	0.75	1.00	1.50	10
147.0	n	0.50	1.00	0.75	10

Tape	Locked	Height, ft	Width, ft	Depth, ft	Angle, deg.
150.0	n	0.75	1.25	1.00	10

October 27, 2010

Mr. Nick Salisbury; President
Mr. Scott Tunison; Vice President
Crux Subsurface, Inc
16707 E. Euclid Avenue
Spokane Valley, WA 99216

Subject: Sunrise Powerlink Project
Rockfall Mitigation and Micro Pile Construction Preparation

Dear Mr. Salisbury and Mr. Tunison:

This letter summarizes the site visits made by Fisher & Stickler Rock Engineering (FSR Engineering) and Arroyo Engineering Consultants, Inc. (AEC) to the Sunrise Powerlink Project for the purpose of viewing the rockfall hazards associated with transmission towers and to provide recommendations for site clearing and rockfall mitigation activities required for construction of the micropile foundations.

Rockfall Hazard and Rock Removal Investigation Background

FSR Engineering and AEC completed an assessment of the Mountain Grade Segment during March, 2010 and issued a report outlining our findings and recommendations on May 6, 2010. The report; entitled "Sunrise Mountain Grade Site Visit Report for 4/13/10 through 4/16/10 and Recommendations" provided recommendations regarding rockfall hazard mitigation and rock removal/demolition required for construction of the proposed micropile foundations at Sunrise Mountain Springs Grade. This report also contained recommendations for further evaluation of rockfall hazards outside of the project right-of-way at five tower locations.

With authorization from Crux Subsurface Inc. (Crux), FSR Engineering completed a follow-up visit to investigate rockfall hazard from outside the right-of-way at the Sunrise Mountain Springs Grade during June, 2010. The June visit was followed by a report authored by FSR Engineering dated July 8, 2010 and entitled "Sunrise Mountain Springs Grade Rockfall Hazard Evaluation: Towers 261A, 263A-2, 263B-2, 266-2, and 272-3". The findings outlined in the July 8, 2010 report suggested that the rockfall hazard from outside the right-of-way was judged "low" at Tower 261A and calculated at a less than 0.5 percent probability during a 50-year period at towers 263A-2, 263B-2, 266-2 and 272-3.

During the later part of June, 2010; Crux performed site visits at numerous tower locations along the Sunrise Powerlink Project outside of the Mountain Springs Grade section. The purpose of these tower visits was to assess the rockfall hazard based on a matrix of factors established by FSR Engineering and to infer the depth to bedrock. Based on the findings of Crux's June 2010 site visit, FSR Engineering and AEC were authorized to investigate additional towers where Crux noted the potential for rockfall hazard (based on the matrix established by FSR Engineering) and the requirement for rock removal/demolition for installation of the tower foundations. FSR and AEC visited those sites during the later part of August and early September, 2010.

Report Outline and Limitations

This report summarizes the rockfall hazard mitigation, rock removal/demolition and micropile construction preparation for the Sunrise Powerlink Project and includes recommendations related to the Mountain Springs Grade section of the project. *This report is a standalone document that addresses construction considerations for rockfall hazard mitigation and foundation preparation within the right-of-way for the Sunrise Powerlink Project.* In addition to construction preparation, the report discusses the rockfall potential from outside of the right-of-way at five of the tower locations within the Mountain Springs Grade section of the project. We understand that San Diego Gas and Electric (SDG&E) requested that URS; their geotechnical representative, complete any additional rockfall hazard investigation that may be required outside of the project right-of-way.

Below is a brief summary of the ground, rock mass, and potential rockfall hazard conditions at the towers that were visited. At each location, members of AEC (Aaron Hastings) and Crux (Jesse Salisbury and/or Steve Wilson) generated notes regarding the rocks that need to be removed to provide drilling access for each of the tower legs. Brendan Fisher of FSR Engineering noted the locations where rockfall is a concern in collaboration and agreement with URS Geologists (SDG&E geotechnical representative) while FSR, AEC and CRUX established remediation measures based on the anticipated materials available and the expertise of the Contractor.

A bulleted summary of specific recommendations related to *rockfall hazards only* is included in each of the tower subheadings below. The text is accompanied by figures showing general conditions at the tower locations requiring rockfall mitigation and select individual blocks that require removal, demolition, or reinforcement prior to constructing the tower foundations and legs.

Attached to this report are "Field Notes" which summarizes the rock removal required in preparation for the micropile installation. The matrix includes a summary of the rock block dimensions of the blocks identified for both the rockfall mitigation and also rocks that should be removed in preparation for setting up the drill rigs for the installation of the micropiles. Where actual dimensions were not established in the field, an estimate of the total volume of rock for removal and/or demolition is provided.

Our intent is to transmit a document that may be used by the Contractor for costing purposes. Because this is a preliminary document and the time allotted for our sites visit were not sufficient to perform a detailed reconnaissance of the rockfall hazard conditions, it is our opinion that the estimate generated by the Contractor should reflect the uncertainty associated with the site visit and report. For that reason, *the estimate of the rockfall hazard mitigation should be increased by up to 20 percent* to account for additional hazards and remediation that will be observed and mitigated during construction.

Site Visits

Brendan Fisher of FSR Engineering and Aaron Hastings of AEC accompanied Steve Wilson and/or Jesse Salisbury of Crux during the site visits. Other parties included representatives from Burns and McDonald, PAR, Finley Engineers, SDG&E; SDGE&E's biological and archeological subconsultants, and URS who is subcontracted to SDG&E as their Geotechnical Engineer for the project. This group of people will be collectively referred to as the Site Visit Team.

The Site Visit Team met in the mornings between 06:00h and 7:00h at various locations near the project site. The schedule for the day was dictated by the requirements of the CRUX Team while SDG&E and/or Finely Engineers escorted the Site Visit Team throughout the project site so that we visited the tower locations in an expeditious manner.

Rockfall Conditions and Recommendations at Mountain Springs Grade

Tower 261-A: Figure 1

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The site is locally gently-sloping with a steep slope located southeast of the tower location. This slope has the potential to generate rockfall although the potential is deemed low because there is a drainage swale between the slope and the tower location that should route rolling rocks away from the tower.

At Leg C, the tower foundation is situated on a large block which is about 6 feet tall and shown in Figure 1. This block is bounded at the base by two intersecting joints that form a wedge. Lateral loading at the top of the foundation could cause the block to move away from the foundation.

At leg D, there is a potential toppling block that could impact the structure should the block fall over.

Rockfall Hazard and Construction Recommendations

- The rockfall hazard from outside of the right-of-way was investigated by FSR Engineering during out June 7 and 8, 2010 site visit. Rockfall hazard was judged to be low.
- The block at Leg C should be removed so that the tower leg is situated on intact bedrock. This would require lowering the leg elevation by about 4 to 6 feet.
- The potential toppling block located at Leg D should be broken into smaller pieces and the pieces situated so they are not a hazard to the tower leg.

Tower 261-2: Figure 2

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. Locally, the site is gently-sloping ranging in inclination from about 5 to 10 degrees at tower legs B, C, and D. At leg A, there is a slope located uphill from the leg that is inclined at about 27 degrees (2H:1V) with loose rocks that may be a hazard to that leg. No hazards were noted at Legs B, C, or D.

Rockfall Hazard and Construction Recommendations

- The loose rock at Leg A should be stabilized using an active restraint system such as Tecco® Mesh. Plan on 175 ft^2 of mesh and about 6 rock anchors (5 feet long) to anchor the loose rocks.

Tower 262-4: Figure 3

Geologic Description

At this location, the geology consists of granitic outcrops and shallow soil. The rock mass is pervasively jointed and weathering of the rock mass has resulted in numerous precariously balanced rocks. In general, the rock geometries coupled with the slope inclination of 20 to 25 degrees result in minimal rockfall hazard. We did identify one block above Tower Leg A that is tilted toward the leg and will pose a threat during the design-based earthquake.

Rockfall Hazard and Construction Recommendations

- Breakup and/or remove the block at Leg A.

Tower 263A-2: Figure 4

Geologic Description

At this location, the geology consists of granitic outcrops and shallow soil. There is a slope located to the southeast of the tower location where weathering of the rock mass has resulted in numerous precariously balanced rocks that dictate the rockfall hazard at this tower location. The overall slope angle is about 35 degrees. There is a rock rollout area at the base of the slope and between the slope and the tower of about 100 feet. Ten foot diameter boulders were observed on the slope face with 5 to 6 ft diameter blocks at the base of the slope.

The local slope angle at the tower is about 15 degrees and no immediate rockfall threats were noted at the tower legs.

Rockfall Hazard and Construction Recommendations

- The rockfall hazard from outside of the right-of-way was investigated by FSR Engineering during out June 7 and 8, 2010 site visit. Rockfall hazard was calculated to be less than 0.5 percent probability of rockfall impacting the tower during a 50 year period.

Tower 263B-2: Figure 5

Geologic Description

At this location, the geology consists of granitic outcrops and shallow soil. The tower site is located on a slope that ranges inclination between 20 and 30 degrees. There is a large talus slope situated just behind Leg A. This talus slope poses the most significant threat to the tower.

Rockfall Hazard and Construction Recommendations

- The slope at Leg D is about 30 degrees and loose rock is located up slope of the tower leg. Therefore, loose rock within 15 feet of the leg needs to be removed so that it will not impact the tower (sliding potential) during the design based earthquake.
- The large talus slope located above Leg D should be stabilized during construction with numerous rock anchors (assume 20; 20 foot anchors for estimating purposes) and Tecco® mesh (400ft^2) to bridge the anchors and help to secure the talus to the slope. This will decrease the hazard posed to the workers during construction and also help to mitigate rockfall from impacting the tower after construction.

- The rockfall hazard from outside of the right-of-way was investigated by FSR Engineering during out June 7 and 8, 2010 site visit. Rockfall hazard was calculated to be less than 0.5 percent probability of rockfall impacting the tower during a 50 year period.

Tower 265-2: Figures 6 & 7

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. There is some joint control in the rock with joints that are nearly orthogonal and dip steeply with a shallow joint set that dips out of slope at about 35 degrees (i.e. dip slope). The dip slope has created a ramp so that loose blocks can slide towards Leg A. Figure 7 is a hand sketch of the rock blocks that should be bolted in place or removed from the 35 degree slope. Other blocks were noted at Legs A, B, C, and D that need to be broken and/or removed. Some of these blocks are upwards of 20ft in diameter. The potential hazards at Leg A are sliding so that all blocks located within a distance of 13ft uphill of the tower leg need to be removed. At the other legs, toppling and/or rolling is the primary concern.

Rockfall Hazard and Construction Recommendations

- Remove/break blocks as noted in the rock removal matrix attached. This site will require the most rockfall hazard removal of any of the site visited during this reconnaissance.
- Plan on about 15; 15ft long rock bolts to stabilize the loose rocks on the 35 degree slope above Leg A.

Tower 266-2: Figure 8

Geologic Description
At this location, the geology consists of granitic outcrops with some soil at the surface. The site is relatively flat with local slopes that range from about 5 to 10 degrees. To the north, there is a slope that may generate rockfall although the rockfall hazard is judged to be low. The slope north of the structure location is about 27 degrees (2H:1V) and joint controlled with joints that dip about 15 degrees oblique to the slope (northeast). Blocks on the slope are judged to range in dimensions up to about 8ft by 4ft by 4ft. Blocks are orthogonal because of the persuasive jointing of the rock mass.

Rockfall Hazard and Construction Recommendations

- The rockfall hazard from outside of the right-of-way was investigated by FSR Engineering during our June 7 and 8, 2010 site visit. Rockfall hazard was calculated to be less than 0.5 percent probability of rockfall impacting the tower during a 50 year period.

Tower 267-2: Figure 9

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The rock is joint controlled although precariously balanced rocks were also observed. Where joint controlled, the joints are near vertical with a conjugant set that dips back into the slope at about 10 degrees. At Leg D, there are two blocks resting on a joint that dips towards the tower leg which poses a threat to the leg and should be removed. The threat is increased by removal of the blocks

required to set up the drill rig. Leg B is situated on a rock outcrop with a vertical face located 1ft from the planned micropile location.

Rockfall Hazard and Construction Recommendations

- The potentially hazardous blocks located at leg D should be removed.
- An extension at Leg B may be required because of removal of 5.5 ft diameter block.

Tower 270-2: Figure 10

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The rock is joint controlled with a joint set that strikes parallel to the slope and another set that dips out of slope at 25 to 35 degrees. In addition, precariously balanced rocks were also observed that have the potential to impact the tower legs. There are five boulders at Leg D that should be broken/removed because this leg is on a 30 degree slope.

Rockfall Hazard and Construction Recommendations

- The potentially hazardous blocks located at Leg A should be removed.
- Break/remove five boulders at Leg D.

Tower 271-2 Figure 11

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. Although precariously balanced rocks were noted at this location, the slope of the ground and the geometry of the rocks suggest that there is only minor rockfall hazard at this location. One block at Leg C may pose a hazard once the blocks required to for drill rig access are removed.

Rockfall Hazard and Construction Recommendations

- The potentially hazardous block at Leg C should be removed. Although not a hazard at this point, during construction blocks underneath this will have to be relocated. This relocation will create a hazard.

Tower 272-3: Figure 12

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. There are no immediate rockfall hazards identified at the tower legs although there is a steep slope (25 to 30 degrees) located to the southwest of the tower that poses a low rockfall hazard to the structure. The slope is mostly joint controlled although there are loose rocks on the slope that range from 1 to about 8ft in diameter.

Rockfall Hazard and Construction Recommendations

- The rockfall hazard from outside of the right-of-way was investigated by FSR Engineering during out June 7 and 8, 2010 site visit. Rockfall hazard was calculated to be less than 0.5 percent probability of rockfall impacting the tower during a 50 year period.

Tower 276-1: Figure 13

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The rock is joint controlled with general slope of 10 degrees to the northwest. One hazard was noted at Leg B. This is a potential toppling block that will be 'daylighted' toward the leg after removal of the blocks required to set up the drill rig.

Rockfall Hazard and Construction Recommendations

- Break the potential toppling block at Leg B so that it is less than half its height once broken. This will reduce the toppling hazard and create a geometry where if the block topples, it will not impact the tower leg.

Tower 277-1: Figure 14

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The rock does not appear to be significantly joint controlled although where evident, one joint set dips back into the slope. There is a drainage located near the middle of the structure which does not appear to pose a significant hazard to the tower legs. One block was identified at Leg D that because of rock removal for the drill pad, the remaining block may be a hazard to this leg. Rockfall hazards were not identified at legs A, B, or C.

Rockfall Hazard and Construction Recommendations

- Remove the block identified at Leg D.

Tower 278-1: Figure 15

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The tower is located on a slope with a general inclination of about 25 to 30 degrees. This creates a sliding hazard for rocks located upslope of the tower legs at Leg C. At other leg locations, the local slope is more shallow or jointing in the rock dips back into the slope creating a stable rockfall condition. One very large block was noted that could impact the tower. The block is about 9ft tall; 6ft wide and 14ft laterally dipping down slope at about 40 degrees.

Rockfall Hazard and Construction Recommendations

- At Leg C, rocks within 9 ft of the tower leg will need to be removed. In addition, plan to install 3; 10ft long rock bolts into a block that is acting as a buttress for potentially unstable blocks above the tower leg.
- Break the large block noted in two pieces. There is a joint located at about the mid height of the block that will act to help spilt the block. Place debris in front of the remaining block to help prevent future toppling. The rock breakage volume will be about 6.5 yds^3.

Tower 279-1: Figure 16

Geologic Description
At this location, the geology consists of granitic outcrops and shallow soil. The rock is joint controlled with joints that dip into the slope direction (south) at about 70 degrees. Rockfall hazards were noted at three of the four leg locations. The fourth location (Leg D) will require decreasing the elevation of the tower leg so that it is not setting upon a block with a vertical face. The proposed location of Leg D is shown in Figure 16.

Rockfall Hazard and Construction Recommendations

- At Leg A, plan to remove one rockfall hazard.
- At Leg B, there is a loose rock just above the tower leg that should be removed.
- At Leg C, removal of ½ of a block will be required.
- At Leg D, the elevation of the tower leg should be decreased so that the leg is not setting atop of a rock outcrop with a vertical face. After rock removal, the location should be inspected for additional rockfall hazards. Anticipate that 5 rock bolts; about 15 feet long may be required to secure additional rock.

Rockfall Conditions and Recommendations Outside of Mountain Springs Grade

Tower CP20: Figure 17

Geologic Description
At this location, the geology consists of granitic bedrock with a unknown depth of soil cover at the tower legs. The local slope is about 18 degrees and hummocky. The tower appears to be situated on colluvium with loose cobbles at the surface.

Geologic Hazards Recommendations
Tower CP20 should be evaluated by the owners Geotechnical Engineer regarding the potential for slope instability at the tower location. Crux should plan on evaluating the depth of the colluvium during the foundation installation and modify the foundation design based on the origin and depth of the colluvium.

Tower CP33-2: Figure 18

Geologic Description
At this location, the geology consists of granitic outcrops with minimal soil cover at the tower legs. The overall slope angle is about 28 degrees which indicates that sliding potential of loose blocks should be considered within 15 feet of each leg center location.

Three loose blocks were noted at Leg B. One of the blocks is located adjacent to Leg B and has the potential to topple on the foundation (b/h ratio less than 1.0) if not removed. Two other blocks were noted to the north of the foundation and these are judged to be a hazard to the tower foundation at Leg C. This is because the slope between Leg B and Leg C is greater than 30 degrees with minimal soil cover.

No rockfall hazards were observed upslope of legs A and D.

Rockfall Hazard Recommendations

- Remove or break up the three rock blocks located at Leg B. General dimensions are provided in the attached matrix.

<u>Tower CP47A-1: Figure 19</u>

Geologic Description
At this location, the geology consists of granitic outcrops with shallow soil cover at the tower legs. The tower is situated on a 30 degree slope and there is a granitic outcrop located about 60 feet upslope of the tower.

About 10 individual blocks were identified within the rock outcrop upslope of the tower that should be secured in place using rock anchors.

Rockfall Hazard Recommendations

- Individual blocks were noted that should be anchored in place. Plan on up to ten rock anchors. Each will be up to 15 feet long.

<u>Tower CP53-1: Figure 20</u>

Geologic Description
At this location, the geology consists of granitic outcrops with shallow soil cover at the tower legs. The tower slope faces west and is about 25 to 30 degrees. There are rock outcrops located behind and upslope of the tower. Much of the rock located above the tower is loose and there is a high potential for rockfall to impact the this tower.

A number of individual blocks were identified for removal and the block dimensions are provided in the attached Field Notes section of the report. At Leg C, rocks were identified within 15 feet of the tower legs that may pose a hazard after removal of rock for construction purposes. Additional blocks were identified further up slope. A more detailed evaluation of the actual blocks that should be removed should be completed during the rock removal activities for the drill-rig access prior to constructing the tower leg foundations.

Rockfall Hazard Recommendations

- Individual blocks were noted that should be broken up or removed behind tower Leg C. Additional blocks were identified further up slope. Total volume estimated is about 50 cubic yards of rock removal.

<u>Tower CP55: Figure 21</u>

Geologic Description
At this location, the geology consists of granitic outcrops with two or three feet of soil cover at the tower legs. The overall slope angle (north facing) is about 34 degrees. There are rock outcrops located upslope of the tower and within the right-of-way. The outcrops are structurally controlled with a joint set that dips out of the outcrop towards the tower at about 10 to 15 degrees. Because of the shallow dip of this joint set and the geometry of the rock blocks, rockfall hazard within the ROW is judged to be low.

The slope located to the south of the tower has rock blocks that appear to have the potential to topple and roll toward the tower. During the site visit, Dr. Fisher and Mr. Higgins inventoried the rocks within the projected fall-line to the tower.

Rockfall Hazard Recommendations

- URS is currently completing a rockfall evaluation to establish the potential for rocks from outside of the ROW to impact the tower.

<u>Tower CP108: Figure 22</u>

Geologic Description
At this location, the geology consists of metamorphic rocks with shallow soil cover at the tower legs. The south facing slope behind the tower is about 20 degrees. In front of the tower the slope is about 25 to 30 degrees. There is arcuate-shaped feature located down slope of the tower and Leg A is located within this feature.

Geologic Hazards Recommendations
Leg A is located on what appears to be colluvium. The colluvium is judged to be about four or five feet deep. The tower area should be evaluated by the owners Geotechnical Engineer regarding the potential for slope instability at the tower location. Crux should plan on evaluating the depth of the colluvium during the foundation installation and modify the foundation design based on the origin and depth of the colluvium.

<u>Tower EP17: Figure 23</u>

Geologic Description
At this location, the geology consists of granitic outcrops with shallow soil cover at the tower legs. There is a large block (about 12ft by 8ft by 4ft) that appears unstable located between tower legs A and B.

Construction Recommendations

- The block located between tower legs A and B should be removed prior to constructing the foundations.

<u>Tower EP45-1: Figure 24</u>

Geologic Description
At this location, the geology consists of granitic outcrops with shallow soil cover at the tower legs. The tower slope faces south and is about 30 degrees. There are rock outcrops located behind and upslope of the tower. There is a topographic 'high' 50 to 100 feet behind the tower that would decrease the likelihood of up-slope blocks (outside of the ROW) from impacting the tower. Because of the geologic structure, most of the rocks on the hillside above the tower lean back into the hillside suggesting that toppling of the blocks is not likely.

Rockfall Hazard Recommendations

- A few individual blocks which appeared unstable were identified for removal during the site visit. One is located about 200 feet upslope of the tower and this block is shown in

Figure 24. Two other blocks were identified for removal which are located about 25 feet upslope of the tower.

Tower EP73: Figure 25

Geologic Description
At this location, the geology consists of granitic outcrops. Average slope angle is about 9 degrees. The geometry of the outcrop at EP73 will make the foundation set up difficult and the tower legs are located near vertical edges of the outcrop.

Rockfall Hazard Recommendations

- No rockfall hazards were observed at this location. Tower EP73 is included in the report text because of the volume of rock that needs to be removed to construct the tower. We estimate that about 160 cubic yards of material should be removed and this will require demolition with explosives or expandable grout.

Tower EP75-2: Figure 26

Geologic Description
At this location, the geology consists of granitic outcrops with shallow soil cover at the tower legs. The geologic structure dictates the block stability and there is a dominant joint set that dips back into the slope at about 10 degrees. Rock blocks rest on this joint set and therefore, toppling hazard is low and no rockfall hazards where identified at this tower location.

Geologic Hazards Recommendations
Tower EP75-2 is included in the report text because there is a large block; about 8.5' tall, situated in the center of the tower which may be a construction issue when erecting the tower lattice.

Tower EP120A: Figure 27

Geologic Description
At this location, the geology consists granitic rock with shallow soil cover at the tower legs A, C, and D. At Leg B, the tower is located on a large outcrop with a vertical face on the down slope edge of the outcrop. The tower is situated on a 25 to 30 degree slope and one boulder was identified behind Leg B that may pose a hazard to the tower.

Rockfall Hazard Recommendations

- Remove the potential toppling block behind Leg B. The block is about 6 ft tall, 2.7 ft long, and 5.5 ft wide.

EP254-2: Figure 28

Geologic Description
At this location, the geology consists of volcanic outcrops with shallow soil cover at the tower leg locations. The slope which the tower is located on dips steeply (up to 60 degrees at the rock outcrop) to the south. The outcrop located behind the tower is structurally-controlled with

jointing that is perpendicular to the slope face. Jointing within the outcrop creates tabular blocks with the potential to topple toward the tower legs.

Numerous blocks were identified that are unstable and have toppled in the past. These unstable blocks should be removed prior to construction of the foundation.

Rockfall Hazard Recommendations

- Individual blocks were noted that should be broken up or removed within the outcrop upslope of the tower. Total volume estimated ranges from 90 to 120 cubic yards of rock removal.

Closure

We appreciate the opportunity to be involved in this project. Should you have any questions, please contact Brendan Fisher at bfisher@fsrengineering.com or (425) 283-9203 or Aaron Hastings at aec@aec-nv.com or (702) 241-5339.

Sincerely,

FISHER & STRICKLER ROCK ENGINEERING, LLC

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Project Engineer

ARROYO ENGINEERING CONSULTANTS, INC.

Aaron, C. Hastings, PE
Project Engineer

Attachments:
    Figures 1 through 28
    Field Notes for Mountain Springs Grade
    Field Notes for Sunrise Powerlink

Figure 1

Tower 261-A: Large block situated below planned location for Leg C

Project No. 134AZ Date: October, 2010

Figure 2

Tower 261-2: Location for Tecco® mesh at Leg A

Project No. 134AZ   Date: October, 2010

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Crux Subsurface
Sunrise Powerlink Project – Construction Preparation

Figure 3

Tower 262-4: Precariously balanced rocks to be removed

Project No. 134AZ Date: October, 2010

Figure 4

Tower 263A-2: Slope located to the southeast of tower

Figure 5

Tower 263B-2: Rock talus pile located above Leg D

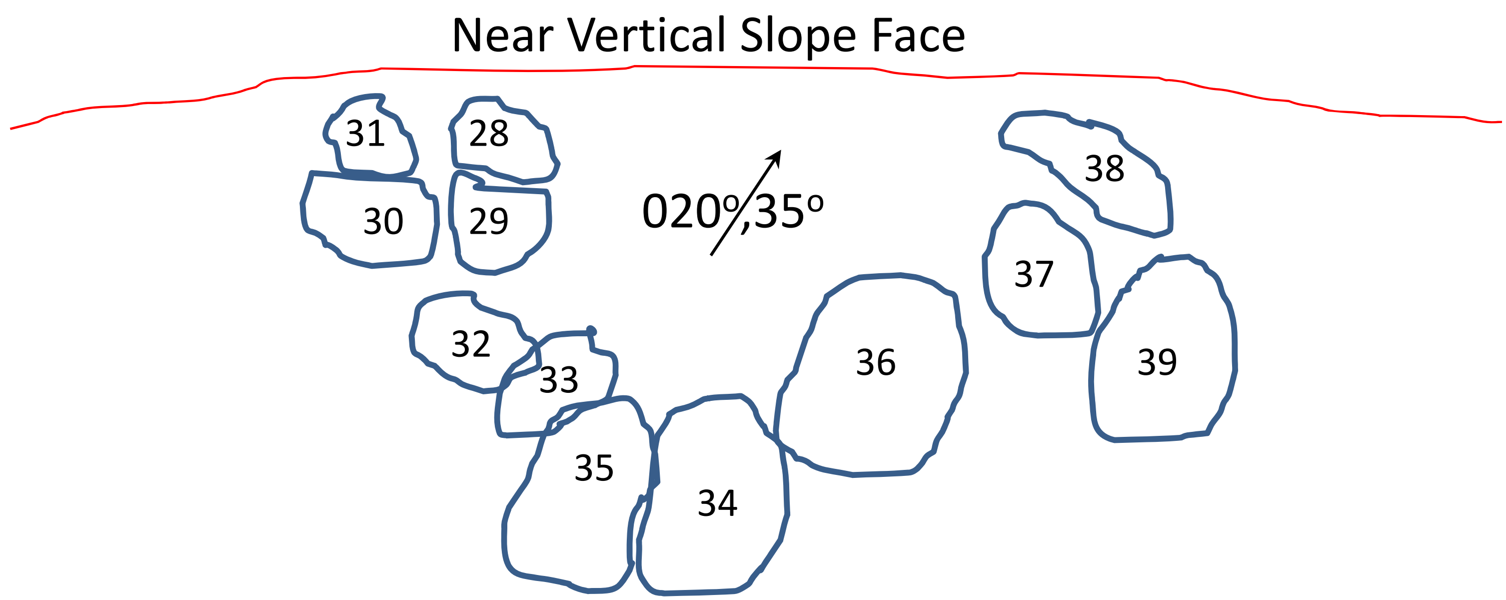
Project No. 134AZ Date: October, 2010

Figure 6

Tower 265-2: Blocks resting on a 35 degree slope above Leg A

Approximate Leg A
Location

Not to Scale



Note: Number in blocks are the 'boulder' numbers recorded by the surveyors.

Figure 7

Tower 265-2: Blocks located on 35 degree dip slope

Figure 8

Tower 266-2: Slope located north of the tower

Figure 9

Tower 267-2: Rock fall hazard at Leg D

Figure 10

Tower 270-2: Unstable blocks at Leg D

Project No. 134AZ Date: October, 2010

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Crux Subsurface
Sunrise Powerlink Project – Construction Preparation

Figure 11

Tower 271-2: PBR that may be a threat after removal of rocks for drill rig

Project No. 134AZ Date: October, 2010

Figure 12

Tower 272-3: Slope located to the southwest of the tower

Project No. 134AZ Date: October, 2010

Figure 13

Tower 276-1: Potential rockfall hazard

Note: Block is not a hazard until other rock blocks are removed for drill rig access.

Figure 14

Tower 277-1: Photograph at Leg D

Figure 15

Tower 278-1: Large block that should be broken to mitigate toppling

Project No. 134AZ Date: October, 2010

Figure 16

Tower 279-1: Leg D will require decreasing the foundation elevation

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Figures

Sunrise Powerlink

(Outside of Mountain Springs Grade)

Figure 17

Tower CP20: Colluvium at tower location

Figure 18

Tower CP 33-2: Three rock blocks that should be removed at leg B

Figure 19

Tower CP 47A-1: outcrop located up slope of tower

Figure 20

Tower CP 53-1: Unstable block located above the tower location

Figure 21

Tower CP55: Structurally-controlled block located above tower location

Figure 22

Tower CP108: Colluvium of unknown thickness at tower Leg A

Figure 23

Tower EP17: Block located between tower legs A and B

Figure 24

Tower EP45-1: Block to remove located upslope of tower

Figure 25

Tower EP73: Large outcrop located at tower location

Project No. 134AZ Date: October, 2010

Figure 26

Tower EP75-2: 8.5’ tall block located near center of tower

Figure 27

Tower EP120A: Boulder located upslope of tower

Figure 28

Tower EP254-2: Outcrop located upslope of tower

Field Notes

Mountain Springs Grade

LEGEND

(1)2/2/3 – Rock number 1; dimensions are 2ft by 2ft by 3ft.

BR – Break or remove the rock.

BLT – Contractors option to bolt in place or remove.

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
261-A	A	Gentle sloping site with surficial boulders	NO		NONE		Geologist to check South East slope for possible rockfall hazards, note that slope is > 100 feet from CL of alignment.
	B		NO		Minor Hand Removals		
	C		YES	This leg has a nearby overhanging boulder, lower tower elevation to avoid this boulder	Break and remove 1 boulder	BR(1) 2/2/2	
	D		YES - Boulder leaning 15 degrees towards tower leg	Break 1 boulder 7.5/8/3	Break and remove 4 boulders up to 48 inches high	BR (1 to 4) 4/2/2	
261-2	A	Gentle sloping site adjacent to slope	YES. Nested boulders on East steep slope, within 10 feet.	Place Tecco Mesh over @ 175 Square feet.	Hand removals for rocks up to 24 inches		Boulder between Legs A and D may need removal for tower placement BR(1)4/12/4 Place 6 anchors at 10' for Tecco Mesh
	B		NO	None	Minor Hand Removals		
	C		NO	None	Partial Breaks of 6 Boulders	Break Boulders to make room, 48/24/24	
	D		NO	None	Break and remove 4 boulders	BR(1) 8/2/2 BR(2) 4/4/10 BR(3)(4) each 20 Inch Diam	
262-4	A	Boulder field on Ridge slope from 20 to 25 degrees	YES - Boulder leaning 15 degrees towards tower leg	Break 1 boulder 2.5/3/3	Break and remove 4 boulders up to 60 inches high	BR (1 to 4) 5/2.5/2	
	B		NO		Minor Hand Removals		
	C		YES -2 Boulders	Break 2 boulders BR (1) 3.5/3/5.5 BR (2) 4/3/5	Break and remove 2 boulders	BR (1 to 2) 2/3/3	
	D		NO		NONE		
263A-2	A	Top of a pass, with high East Slope @ 100	NO		NONE		Geologist to check East slope for possible rockfall hazards, note that slope is > 100 feet from CL of alignment.
	B		NO		NONE		
	C		NO		Minor Hand Removals		
	D		NO		Break and remove 4 boulders	BR (1 to 4) 3/3/2	

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
263B-2	A	West facing steep slope 30 degrees w/ rock talus leg A	YES - Local slope 37 Degrees	Bolt 10 boulders (20 bolts) also, Tecco Mesh 400 sf	Break and remove 3 Boulders	BR (1 to 3) 4/8/4 average	Note: Discussed moving this tower, if tower is moved see notes for new site conditions Estimate 20 foot length on anchors
	B		NO		Break and Remove 5 boulders	BR (1 to 5) 2.5/3/3 Ave	
	C		NO		Hand removals for rocks up to 24 inches		
	D		YES Local slope 30 Degrees	BR or Move @ 10 Boulders within 13 feet of 24 to 36 inch diameter	NONE		
264-4	A	Top of hill with gentle slope of 5 degrees	NO		NONE		
	B		NO		Minor Hand Removals		
	C		NO		Minor Hand Removals		
	D		NO		Break and remove 2 boulders	BR (1 and 2) 2/2/2	

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
265-2	A	Steep North slope with many boulders, note legs A and B ontop of boulders	YES - Break and remove 5	BR(1) 4/3/2.5 BR(2) 12/10/4 BR(3) 10/20/4 BR(4) 5/3/2 BR(5) 9/7/16	NONE		Large Boulder Between Legs B and C to be removed for Tower Erection BR(1) 20/20/20 **Additional Upslope hazards for this tower are documented in the report
	Upslope of A		Yes - Break and remove 8 Reposition 5-10 blocks manually after breaking rock noted above	BR(1) 4/4/2 BR(2) 4/2/3 BR(3) 4/4/2.5 BR(4) 4/3/3 BR(5) 4/3/2.5 BR(6) 4/3.5/2 BR(7) 3.5/5/3 BR(8) 5.5/2.5/4.5		Plan on 15; 15 ft long bolts to stabilize boulders on dip slope	
	Dip Slope		YES - Bolt in place or remove 12	BLT(1) 2/2/2.5 BLT(2) 4.5/3/2.5 BLT(3) 3/3.5/2 BLT(4) 3/2/2 BLT(5) 4/3.5/4 BLT(6) 6/6/5 BLT(7) 9/7/5 BLT(8) 9/7/2.5 BLT(9) 4/4/3 BLT(10 6/3.5/1 BLT(11) 4/3/2.5 BLT(12) 5/4/1			
	B		YES - Break and remove 3 Local Slope 35 Deg	BR(1) 6/6/8 BR(2) 1.5/3/4 BR(3) 2/3/3 **Note leg height needs to ADD 3 feet	NONE		
	C		YES - Break and remove 3 Local Slope 35 Deg	BR(1) 8/5/10 BR(2) 3/5/10 BR(3) 3/3/3	Hand removals for rocks up to 24 inches		
	D		YES Break and Remove 1	BR(1) 5/5/5	Hand removals for rocks up to 24 inches		
266-2	A	Flat valley between ridges with few boulders, average slope 5 degrees	NO		Break and remove 1 boulder	BR(1) 3/9/9	
	B		NO		NONE		
	C		NO		Break and remove 1, Hand Clear small ones	BR(1) 2/2.5/2	
	D		NO		Minor Hand Removals		

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	**LEG**	**TOWER SITE SETTING NOTES**	**HAZARDS**	**REPAIR DETAILS**	**SETUP ROCK REMOVALS**	**DETAILS**	**OTHER NOTES**
267-2	A	Top of ridge, legs over sides at A, B and D	NO		Break and remove outcrop	BR(1) 3/8/3	Leg B may require extension due to removals of 5.5 foot high boulder
	B		NO		Large removals at tower leg up to 5 feet deep	BR(1) 5.5/3/27	
	C		NO		Break and remove outcrop	BR(1) 2/3/30	
	D		YES - Break and remove 2	BR(1) 4/3/6 BR(2) 4/3/1.5	Break and remove 1	BR(1) 2/3/3 and hand removals (Roll) up to 24 inch diameter	
269-1	A	Steep west facing slope, 35 degrees note that Jointing is favorable in this location	NO		Break and remove 1	BR(1) 3/3/3 and hand removes small boulders	Need to verify after removals that uphill rocks are stable
	B		NO		Break and remove 2 boulders	BR(1 to 2) 2/2/5	
	C		NO		Break and remove 2 boulders	BR(1 to 2) 3/2/2 one hand move of 24 inches (roll)	
	D		NO		Break and remove 2 boulders	BR(1) 2/3/3 BR(2) 3.5/2/3	
270-2	A	North East slope with boulders typical 25 to 30 degree	YES - Break and remove 2	BR(1) 4/4/2.5 BR(2) 4/6/8	Break and remove 1 boulder in 1/2	BR(1) 3/3/3	
	B		NO		Break and remove 1 Boulder	BR(1) 2.5/3/2	
	C		NO		Break and remove @ 13 each 2-3 foot diam. Boulders	BR (1 to 13) 2.5/2.5/2.5	
	D		YES - Break and remove 5 boulders slope 30 degrees	BR(1) 3/4/1.5 BR(2) 5/2/4 BR(3) 1.5/2/3.5 BR(4) 2/2/4.5 BR(5) 2/2/3	Break and remove 2 boulders	BR(1 and 2) 5/5/3	

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	**LEG**	**TOWER SITE SETTING NOTES**	**HAZARDS**	**REPAIR DETAILS**	**SETUP ROCK REMOVALS**	**DETAILS**	**OTHER NOTES**
271-2	A	Flat area on a ridge with east slope (Ave 15 Degree slope)	NO		Hand removals for rocks up to 24 inches (10 Each)		
	B		NO		Hand removals for rocks up to 24 inches		
	C		YES - Break and remove 1 boulder	BR(1) 2/4/3	Break and remove boulders (2)	BR(1) 8/5/2 BR (2) 10/3/2 (combined boulder	
	D		NO		Break and remove 6 Boulders	BR(1 to 6) 4/3/3 Hand move 4 boulders	
272-3	A	At base of North East sloping Ridge 15 to 20 Degrees	NO		Hand move several small boulders		
	B		NO		Hand move several small boulders		
	C		NO		NONE		
	D		NO		Break and remove 5 boulders	BR(1 to 5) 3/4/3	
273-1	A	Flat to gently sloping surface with 5 degree slope average	NO		NONE		
	B		NO		NONE		
	C		NO		NONE		
	D		NO		Hand Move small boulders		
274-1	A	Flat to gently sloping surface with 5 degree slope average	NO		Break and remove 2 boulders	BR(1 to 2) 2/2/2	
	B		NO		NONE		
	C		NO		Break and remove 1 boulder	BR(1) 4.5/4/7	
	D		NO		Remove steep outcrop at foundation	BR(1) 3/3.5/9	

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
275-1	A	Boulder field on Ridge slope from 10 to 15 degrees	NO		Break and remove 2 boulders	BR(1) 4/3/3 BR(2) 3/3/3	
	B		NO		Break and remove 1 and hand move 2	BR(1) 2/4/6	
	C		NO		Break and remove 3 Boulders	BR(1) 1/3/4 BR(2) 1.5/2.5/5 BR(3) 2/6/4	
	D		NO		Break and remove 4 boulders - Hand move 1	BR(1) 2/4/4 BR(2) 2/3/3 BR(3) 1/3/3 BR(4) 1/5/4	
276-1	A	Top of Ridge with boulders average slope 5 degrees	NO		Break and remove 2 boulders	BR(1 to 2) 2.5/2.5/3	
	B		YES - Break and remove large leaning boulder	BR(1) 8/3/14	Break and remove 2 boulders	BR(1) 3.5/5/5 BR(2) 3.5/4/3	
	C		NO		Hand Move small boulders		
	D		NO		Break and remove 3 Boulders	BR(1) 2/4/3 BR(2) 3/2/1 BR(3) 3/2/1	
277-1	A	East Facing slope 15 to 25 degrees with boulders and rock at surface	NO		Break and remove 4 Boulders	BR(1) 2/6/2 BR(2-4) 2/2.5/2	
	B		NO		Break and remove 5 boulders	BR(1 to 5) 2.5/2.5/2.5	
	C		NO		Break and remove 3 Boulders	BR(1 to 3) 2/2.5/2	
	D		YES - Break and remove 1 boulder	BR(1) 4/3/2	Break and remove 1 Boulders	BR(1) 4/5/7	
278-1	A	Steeply sloping ridgeline to the North East with average slope of 25-35 degrees	NO		Break and remove 2 Boulders	BR(1) 2/3/5 BR(2) 4/2.5/5	Plan on 3; 10ft long rock bolts at Leg C. In addition to the blocks noted in the matrix, plan on breaking large toppling block. Total volume of breakage (this block alone) is 6.5 cubic yards.
	B		NO		Break and remove 5 boulders	BR(1 to 5) 3/3/3	
	C		YES Bolt one Boulder, Break and remove 3 - Slope 28 Deg	Bolt (1) 3/8/4 BR(1) 1.5/4/5 BR(2) 2/4/3 BR(3) 1/3/2	Move small boulders by hand		
	D		YES Break and remove all - Slope 30-35 Deg	Remove all small boulders by hand due to slope	Remove steep outcrop at foundation	BR(1) 1.5/8/4	

FIELD NOTES

TOWER SETTING			ROCKFALL HAZARDS & MITIGATION		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
279-1	A	Moderate slope with boulders and average slope of 10 to 20 degrees	YES - Break and remove 2 boulders	BR(1) 3,5/6/8 BR(2) 2/4/3	Break and Remove 1 boulder Several hand	BR(1) 0.5/2/5	Leg D has vertical bedrock outcrop 1 foot to the west that requires some removals and some bolts
	B		YES Break and remove 1 boulder	BR(1) 4/4/8	Break and remove 2 boulders	BR(1) 4/4/6 BR(2) 5/5/3	
	C		YES - Break and remove 1 boulder	BR(1) 5/6/5	Break and remove 2 boulders	BR(1) 4/3/2 BR(2) 1/3/3	
	D		YES - Break and remove 2 boulders	BR(1) 5/4/8 BR(2) 6/6/9	Break Vertical face of rock and rock bolt the remaining face	BR(1) 6.5/3/8 Bolt 5 each at 15'	
280-1	A	Gently sloping colluvium slope	NO		NONE		
	B		NO		NONE		
	C		NO		NONE		
	D		NO		NONE		
281-1	A	Gently sloping colluvium slope	NO		NONE		
	B		NO		NONE		
	C		NO		NONE		
	D		NO		NONE		

FISHER&STRICKLER
ROCK ENGINEERING, LLC

Field Notes

Sunrise Powerlink

(Outside of Mountain Springs Grade)

FIELD NOTES

TOWER SETTING			ROCK HAZARDS		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	ROCK HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
CP20	A	Mod. Steep Slope (18 Ave), Cobbles on Surface	NO		Soil at Surface	Soil at Surface	Tower located on colluvium. Need confirmation of origin from owner's Geotech.
	B		NO		Soil at Surface	Soil at Surface	
	C		NO		Soil at Surface	Soil at Surface	
	D		NO		Soil at Surface	Soil at Surface	
CP33-2	A	Steep Slope (28 Ave), Rock Outcrop Within Tower Footprint	NO			BR(1) 2/2/1	Granitic Rock Note that haz. 2 and 3 are uphill hazards to leg C.
	B		YES - Break and remove boulders	BR(1) 7.5/7/4 BR(2) 3.5/2.5/5 BR(3) 2/3.5/3	Hand clear	Small rocks	
	C		See Leg B		NO	Rock at surface	
	D		NO		Hand Clear	Small rocks	
CP34-2	A	Mod. Steep slope (25 ave) with exposed bedrock in footprint	NO		Break and Remove 7 boulders	BR(1) 6/4/3.5 BR(2) 1/1/1 BR(3) 1/1/1 BR(4) 1/1/1 BR(5) 1/1/1 BR(6) 3/2/1 BR(7) 2/2/3	Rock at surface A,B,C
	B		NO		Hand clear	Small rocks	
	C		NO		Break and remove 4 boulders	BR(1) 3/1/3 BR(2) 3/3/2 BR(3) 1/1/1 BR(4) 1/1/1	
	D		NO		NO		
CP35-2	A	Mod. Steep Slope (18 Ave), Cobbles on Surface	NO		NO		
	B		NO		NO		
	C		NO		Break and remove 1 boulder	BR(1) 4/4/3	
	D		NO		NO		
CP45-1	A	Mod. Steep Slope (18 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Rock at Surface Leg B
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP47A-1	A	Steep Slope (28-30 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Rock at Surface all Legs Note that 60 feet upslope are large weathered in place boulders May require bolting, evaluate in field
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP47-2	A	Mod. Steep Slope (12-30 Ave), Rock Outcrop Within Tower Footprint	YES	Plan on up to 10 rock bolts; 15 feet long to stabilize outcrop located 60 feet above tower.	Break and remove 1 boulder	BR(1) 2/2.5/4.5	Leg A on Rock that is near vertical 10' to W.
	B		YES		Large Vert. Joint may Require Rock removal		
	C		YES		NO		
	D		YES		Break and remove 1 boulder	BR(1) 4/4/6	
CP53-1	A	Steep Slope (26 Ave), Rock Outcrop Within Tower Footprint	YES	Volume estimate for rockfall hazard removal is about 50 cubic yards.	NO		Leg C, on rock outcrop, tower GL elevation will drop by @3' after removals
	B		YES		NO		
	C		YES		Break and remove 2 boulders	BR(1) 4/6/4 BR(2) 2/2/4	
	D		YES		NO		
CP55	A	Steep Slope (29 Ave), Rock Outcrop Within Tower Footprint	Not within ROW	Potential for upslope rockfall hazard being evaluated by URS.	Break and remove 1 boulder	BR(1) 2/2/3	Soil at surface, with probe depths less than 30 inches
	B		Not within ROW		NO		
	C		Not within ROW		NO		
	D		Not within ROW		NO		

FIELD NOTES

TOWER SETTING			ROCK HAZARDS		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	LEG	TOWER SITE SETTING NOTES	ROCK HAZARDS	REPAIR DETAILS	SETUP ROCK REMOVALS	DETAILS	OTHER NOTES
CP61-1	A	Steep Slope (31 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Soil at surface, with probe depths less than 30 inches
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP62A-1	A	Gentle slope (12 Ave) soil at surface	NO		NO		On ridge with soil at surface.
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP65-1	A	Gentle slope (8 Ave) soil at surface	NO		NO		Outcrop of rock exposed within tower footprint.
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP66-2	A	Gentle slope (8 Ave) soil and boulders at surface	NO		NO		
	B		NO		Break and remove 1 boulder	BR(1) 2/4/3	
	C		NO		Break and remove 1 boulder	BR(1) 3/2/4	
	D		NO		NO		
CP67-3	A	Mod. Steep Slope (12-30 Ave) on ridge, Rock Outcrop Within Tower Footprint	NO		NO		Legs A and D over ridge
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP-68-1	A	Gentle slope (8 Ave) on Ridge soil and boulders at surface	NO		Rock at surface	Minor clearing	Leg C, Local slope of 20.
	B		NO		NO		
	C		NO		Break and remove 1 boulder	BR(1) 3/3/2	
	D		NO		NO		
CP79-1	A	Steep slope (27 Ave) with Rock outcrope within tower footprint.	NO		Break and remove 1 boulder	BR(1) 2/3/3	Leg A, remove rock outcrop for setup Leg B on outcrop
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
CP108	A	Steep slope (27 Ave) with Rock outcrope within tower footprint.	Colluvium Hazard	Located in Colluvium	Break and remove 1 boulder	BR(1) 2.5/1/3.5	Leg A has local slope of 35, boulder removal Leg D on Outcrop
	B		YES	BR(1) 6/5.5/2.7	NO		
	C		NO		NO		
	D		NO		Break and remove 1 boulder Chipping required at Leg D	BR(1) 2/4/2 Chipping	
CP109-1	A	Steep slope (28-30 Ave) with Rock outcrope within tower footprint.	NO		YES	Remove outcrop upslope for cap	No upslope issues noted
	B		NO		NO		
	C		NO		Hand clear	Small rocks	
	D		NO		NO		

FIELD NOTES

TOWER SETTING			ROCK HAZARDS		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	**LEG**	**TOWER SITE SETTING NOTES**	**ROCK HAZARDS**	**REPAIR DETAILS**	**SETUP ROCK REMOVALS**	**DETAILS**	**OTHER NOTES**
EP17	A	Gentle slope (13 Ave) Exposed Bedrock at surface	NO		NO		Legs A, B, C require some chipping in Bedrock for setup. Between Leg A and D is outcrop tower, 12 H with 4W base
	B		YES	Same boulder as C	NO		
	C		YES	BR(1) 12/8/4	NO		
	D		NO		NO		
EP18	A	Gentle slope (5-10 Ave) Exposed Bedrock within tower footprint	NO		NO		Shallow soil at surface, heavy Brush
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP20-2	A	Mod. Steep Slope (15 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Leg B will require GL change of 2 to 3 feet Leg D, 3' from leg is 6' Vertical drop, remove at least 3' to install piles, tower GL will change by at least 3'
	B		NO		Break and remove 1 boulder	BR(1) 3/6/2	
	C		NO		Break and remove 2 boulers	BR(1) 2.5/5/3 BR(2) 3/3/2	
	D		NO		YES	Bedrock removal see notes	
EP28-3	A	Steep Slope (32 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Probe indicates +/- 1' to rock
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP37-2	A	Gentle slope (5-10 Ave) Exposed Bedrock within tower footprint	NO		NO		Large Boulder between B and C may require removals for tower clearance Leg D, Remove outcrop due to downhill exposure adjust tower GL 2.5 feet
	B		NO		NO		
	C		NO		Break and remove 1 boulder	BR(1) 3/3/6	
	D		NO		Break and remove 1 boulder	BR(1) 2.5/4/6	
EP42	A	Steep Slope (28 Ave), Rock Outcrop Within Tower Footprint	NO		Hand clear	Small rocks	
	B		NO		Break and remove 1 boulder	BR(1) 2/3/2	
	C		NO		Hand clear	Small rocks	
	D		NO		NO		
EP43-1	A	Mod. Steep Sloping Ridge (15 20 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Soil at surface probe to 24 inches
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP45-1	A	Steep Slope (30-34 Ave), Rock Outcrop and Boulders Within Tower Footprint	Break and remove 2 boulders	BR(1) 4/7/8.5 BR(2) 7/2/4.5	NO		
	B		Break and remove 1 boulder	BR(1) 3/3/3 (200' up slope)	NO		
	C		NO		NO		
	D		NO		NO		

FIELD NOTES

TOWER SETTING			ROCK HAZARDS		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	**LEG**	**TOWER SITE SETTING NOTES**	**ROCK HAZARDS**	**REPAIR DETAILS**	**SETUP ROCK REMOVALS**	**DETAILS**	**OTHER NOTES**
EP53-3	A	Gentle slope (12 Ave) Exposed Bedrock within tower footprint	NO		See Notes	Bedrock	Leg A, 4' out the rock drops vertical to3', may require GL modification for exposure on those legs.
	B		NO		NO	Bedrock	
	C		NO		NO	Bedrock	
	D		NO		NO	Bedrock	
EP62A-1	A	Gentle slope (12-15 Ave) Ridgeline, Exposed Bedrock within tower footprint	NO		NO	Soil to +/-24"	Leg C, Steep Rock (45deg) with 7' Vertical between uphill and downhill, may require tower GL adjustment
	B		NO		NO	Bedrock	
	C		NO		See Notes	Bedrock	
	D		NO		NO	Soil to +/-24"	
EP64	A	Gentle slope (7 Ave) Exposed Bedrock within tower footprint	NO		Break and remove 1 boulder	BR(1) 2/3/3	
	B		NO		NO	Bedrock	
	C		NO		NO	Bedrock	
	D		NO		NO	Bedrock	
EP71	A	Gentle slope (9 Ave) Exposed Bedrock within tower footprint	NO		NO		Exposed bedrock all legs
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP-73	A	Gentle slope (9 Ave) with large outcrop in center of tower	NO		Break and remove 1 boulder	BR(1) 10/6/6	Legs A and D on the large outcrop, major removals, outcrop may also conflict with tower setup. Total estimated size of coutcrop is 30/12/12.
	B		NO		NO		
	C		NO		NO		
	D		NO		Break and remove 1 boulder	BR(1) 6/6/12	
EP74-1	A	Gentle slope (5-10 Ave) with large outcrops in tower footprint	NO		NO	Soil	Leg D is on steep outcrop, removals required for cap, and for downslope exposure, tower leg GL may move down by 6'
	B		NO		NO	Soil	
	C		NO		NO	Bedrock	
	D		NO		Break and remove 1 boulder	BR(1) 6/3/3	
EP75-2	A	Mod. Steep Slope (15-20 Ave), Rock Outcrop Within Tower Footprint	NO		NO		Center outcop (8.5' High) may conflict with tower setup.
	B		NO		NO		
	C		NO		Break and remove 1 boulder	BR(1) 1/2/1	
	D		NO		NO		

FIELD NOTES

TOWER SETTING			ROCK HAZARDS		SETUP CONSIDERATIONS		OTHER NOTES
TOWER	**LEG**	**TOWER SITE SETTING NOTES**	**ROCK HAZARDS**	**REPAIR DETAILS**	**SETUP ROCK REMOVALS**	**DETAILS**	**OTHER NOTES**
EP116-1	A	Mod. Steep Slope (22 Ave), Rock Outcrop Within Tower Footprint	NO		NO	Bedrock	Leg B, Check downhill piles for exposure due to 3' vertical drop 3' away from center. May require Tower Leg GL lower to 3'.
	B		NO		See Notes	Bedrock	
	C		NO		NO	Bedrock	
	D		NO		NO	Bedrock	
EP120-4	A	Gentle slope (5-10 Ave) with large outcrops in tower footprint	NO		NO	Soil probe to 36"	Leg C, minor chipping for setup
	B		YES	BR(1) 6/5.5/2.7	NO	Soil	
	C		NO		NO	Rock	
	D		NO		Break and remove 2 boulders	BR(1) 2/2/3 BR(2) 2/2/3	
EP120A	A	Steep Slope (27 Ave), Rock Outcrop and Boulders Within Tower Footprint	NO		NO		Leg B, On outcrop with Vertical drop of 8', minimum remove 5H, 7W,5L and Tower Leg GL adjust -5' or more
	B		NO		See Notes		
	C		NO		NO		
	D		NO		NO		
EP121-3	A	Mod. Steep Slope (20 Ave), Rock Outcrop Within Tower Footprint	NO		NO		All legs on shallow (12") soil over rock
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP121A-1	A	Gentle slope (11 Ave) with soil at surface	NO		NO		
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP138-2	A	Gentle slope (7 Ave) with soil at surface	NO		Hand clear	Small rocks	All site has heavy brush, Rock appears to be metamorphic.
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP232-1	A	Gentle slope (4-6 Ave) Exposed Bedrock and boulders within tower footprint	NO		Break and remove 1 boulder	BR(1) 2/3/1.5	Eall legs on rock, combination of granitic and metamorphic rocks.
	B		NO		Hand clear	Small rocks	
	C		NO		NO	Bedrock	
	D		NO		NO	Bedrock	
EP224-1	A	Mod. Steep Ridge with Slopes (20-25 Ave), Rock Outcrop Within Tower Footprint	NO		Break and remove 1 boulder Chip outcrop for MP installation	BR(1) 4/6/4.5 Chip outcrop	Predominantly granitic rock with some gnesis (metamorphic) in outcrops
	B		NO		NO	Probe to 10"	
	C		NO		Break and remove 3 boulders	BR(1) 2/2/3 BR(2) 2/2/3 BR(3) 2/2/3	
	D		NO		NO	Probe to 12 inches	

FIELD NOTES							
TOWER SETTING			**ROCK HAZARDS**		**SETUP CONSIDERATIONS**		**OTHER NOTES**
TOWER	**LEG**	**TOWER SITE SETTING NOTES**	**ROCK HAZARDS**	**REPAIR DETAILS**	**SETUP ROCK REMOVALS**	**DETAILS**	**OTHER NOTES**
EP225-1	**A**	Steep Slope (25-30 Ave), Rock Outcrop and Boulders Within Tower Footprint	NO		NO	Probe to 12"	
	B		NO		NO	Probe to 12"	
	C		NO		NO		
	D		NO		NO	Rock at surface	
EP246	**A**	Gentle slope (5 Ave) with soil at surface	NO		NO	Soil Probe 12" to refusal	Nearby outcrops noted
	B		NO		NO		
	C		NO		NO		
	D		NO		NO		
EP254-2	**A**	Steep Slope (25-30 Ave), Rock Outcrop and Boulders Within Tower Footprint	Break and remove numerous boulders	Total rockfall hazard removal estimate is 90 to 120 cubic cards.	NO		Leg C, Outcrop with vertical drop, remove as necessary to manimize exposure, Tower Leg GL may change by up to -8' Leg D, Large Reval on down slope legs, may require Tower Leg GL to change -3'
	B				Break and remove 1 boulder	BR(1) 2/2/3	
	C				Break and remove 1 boulder	BR(1) 8/10/6	
	D				See Notes	Large reveal due to down slope drop	

Introduction

The information contained in this appendix describes the additional field reconnaissance and quantitative analysis for rock fall performed for Section 5 towers CP47A-1, CP49-1, and CP55. The methodology used is similar to the methodology used on the Mountain Springs Grade report provided by Fisher and Strickler Rock Engineering (FRS, July, 8, 2010). The design-based earthquake having 10 percent probability of being exceeded in 50 years is estimated to have a peak ground acceleration of 0.25g.

The overall probability of a rock impacting a tower during a 50 year design life would be the addition of:

1. Probability of an earthquake is 10 percent.
2. Probability of a rock being free to topple.
3. Probability of a rock free to topple will topple during the earthquake.
4. Probability of a rock rolling downslope to the location of the tower based on the computer simulation.

The equation used to establish the probability of impact is therefore:

> probability of impact: ***p(impact)***= *p(earthquake)* × *p(free to topple)* × *p(FS<1)* × *p(rock rolling into tower*)*
> (*) from computer simulation analyses

Data was collected along line traverses upslope of the tower in areas where the slope inclinations are 2:1 (horizontal:vertical) or greater in rocky terrain. The computer simulation used is the Colorado Rockfall Simulation Program (CRSP) sponsored by Colorado Department of Transportation. The program simulates rock translating down a slope and predicts the statistical distribution of velocity and bounce height.

The model uses the slope profile, rebound and friction characteristics of the slope and the rotational energy of the rocks. The rock fall parameters for the model includes: 1) slope geometry (i.e., inclination, length, surface roughness, lateral variability); 2) slope material properties or behavior of a rock rebounding from a slope, such as slope coefficients (R_n, normal coefficient of restitution) and rock coefficients (R_t, the tangential coefficient of frictional resistance); 3) rock geometry (i.e. size and shape); and 4) rock material properties such as rock mass and durability.

Specific Structure Area Evaluations

CP47A-1. The tower is located on a fairly steep slope (about 30 degrees or less) with a steeper slope (about 35 degrees) located adjacent upslope northeast of the tower. Upslope about 105 feet from the tower, there is a large grouping of outcrops forming a 5 to 10 foot high ledge traversing the slope. The slope then flattens above the ledge to about 20 to 25 degrees where there is minimal rock fall hazard.

The slope is scattered with granitic boulders, massive outcrops locally with thin colluvium and soil cover. Two line traverses were performed to collect rock data; one traverse is 100 feet long directly upslope of the tower and the second traverse is 75 feet long that is perpendicular and located at the end of traverse one. The boulders measured are subrounded and range in the largest dimension from about one to four feet, averaging two feet.

There were 33 rocks measured along the sampling intervals, about 49 percent were judged free to topple while 9 percent of those boulders were observed to have geometries favorable to toppling during an earthquake. The rock fall computer simulation suggests that less than 1 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

p(impact) ≈ 0.1 x 0.49 x 0.09 x (≤0.1) **≈ 4.4x10^{-4}**

CP49-1. The tower is located on a fairly steep slope inclined at 25 degrees or less with a thin soil cover and embedded boulders. Upslope about 30 to100 feet north of the tower, the slope is a rocky ridge that steepens to about 35 degrees and then flattens to about 20 to 25 degrees.

Upslope of the tower, the ridge has mostly embedded and interlocking granitic boulders overlaying blocky to massive bedrock. A 100 foot long line traverse was performed to collect rock data directly upslope of the tower. The boulders measured are subrounded and range in the largest dimension from about one to six feet, averaging 2.5 feet.

There were 57 rocks measured along the sampling intervals, about 19 percent were judged free to topple while 12 percent of those boulders were observed to have geometries favorable to toppling during an earthquake. The rock fall computer simulation suggests that less than 2 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

p(impact) ≈ 0.1 x 0.19 x 0.12 x (≤0.02) ≈ 4.7x10-5

CP55. The tower is located on a steep slope inclined at about 35 to 30 degrees near the tower. The slope inclination decreases to about 27 to 30 degrees about 200 feet upslope south of the tower.

The slope is scattered with granitic boulders and soil with localized massive bedrock outcrops. A 200 foot line traverse was performed to collect rock data directly upslope of the tower. The boulders measured are tabular and subrounded, and range in the largest dimension from about one to six feet, averaging three feet.

There were 69 rocks measured along the sampling intervals, about 84 percent were judged free to topple while 11 percent of those boulders were observed to have geometries favorable to toppling during an earthquake. The rockfall computer simulation suggests that less than 19 percent of rolling rocks would reach the tower.

The probability of a rock impacting the tower is therefore:

p(impact) ≈ 0.1 x 0.84 x 0.11 x 0.19 ≈ 1.7x10-3

References: Colorado Rockfall Simulation Program (CRSP)
Authors: Cristopher L. Jones, Jerry D. Higgins, and Richard D Andrew
Performing Organizations:
Colorado Dept. of Trans.; Colorado Geol. Survey; and Colorado School of Mines