# APPENDIX H-1

***Geotechnical and Environmental Consultation***

# GEOTECHNICAL AND ENVIRONMENTAL CONSULTATION GGBS MANUFACTURING FACILITY Vallejo, California

Ecocem Materials
Dublin, Ireland

20 February 2013
Project 731608801

Treadwell&Rollo
A LANGAN COMPANY

**Treadwell&Rollo**
*A LANGAN COMPANY*

20 February 2013
Project 731608801

Mr. Ken McAvoy
Ecocem Materials
Portview House, 3rd Floor
Thorncastle Street, Ringsend
Dublin, Ireland

Subject: Geotechnical and Environmental Consultation
GGBS Manufacturing Facility
Vallejo, California

Dear Mr. McAvoy:

The accompanying report presents our findings and recommendations concerning the site in Vallejo, California that Ecocem is considering leasing and developing into a GGBS manufacturing facility. This letter presents a summary of our environmental, geotechnical and geologic review; details regarding the reports reviewed and data evaluated are presented in the report.

**ENVIRONMENTAL REVIEW**

Our review of available environmental reports indicates low levels of petroleum hydrocarbons exist in the soil and groundwater at the site. The presence of petroleum hydrocarbons is the primary environmental concern for development of the property under consideration by Ecocem. These compounds pose potential health and safety (H&S) issues to be addressed as part of the site development activities and will require soil and groundwater management plans. The soil and groundwater management objectives for the site should be to minimize exposure to construction workers at the site, nearby residents and/or pedestrians, and future users of the site to constituents in the soil and groundwater.

A soil and groundwater management plan (SGMP) and a health and safety plan (HASP) (prepared by others) should be prepared and should outline specific soil and groundwater handling procedures to be followed during construction and excavation activities at the site. The SGMP should provide recommended measures to mitigate the long-term environmental or health and safety risks caused by the presence of petroleum hydrocarbons in the soil and groundwater. The SGMP should also contain contingency plans to be implemented during excavation activities if unanticipated hazardous materials are encountered. The SGMP should also specify basic health and safety concerns to be addressed by the site contractor or subcontractor responsible for worker health and safety, through the preparation of a detailed HASP by the project contractor.

**GEOTECHICAL REVIEW**

Existing subsurface data indicates bedrock is either exposed or near the existing ground surface over the northeastern portion of the site. Fill and weak marine clay overlie bedrock throughout most of the southwestern portion of the site, extending to the current shoreline. Foundation support for heavily loaded structures should extend to bedrock. Where bedrock is shallow, the proposed structures may be supported on either footings or mats. Where bedrock is too deep to be practically reached by footings or mats, drilled piers or piles can be used. It may be feasible to support lightly loaded structures that are not sensitive to settlement on footings even where the fill and marine clay are relatively thick. However this will require analyses, input from the structural engineer and will depend on performance requirements.

## SEISMICITY AND SEISMIC HAZARDS

The San Francisco Bay Area is a seismically active region. During a major earthquake on one of the several active faults in the area the site is expected to undergo strong to severe shaking. Preliminary analyses of seismic hazards including liquefaction, lateral spreading, seismically induced settlement and fault rupture were evaluated. The potential for these phenomena to occur was determined to be low. Appropriate levels of life safety can be achieved by designing the facility in accordance with the applicable building codes. Recommended minimum seismic design parameters are presented in the report.

## STABILITY OF SLOPES

Preliminary analyses of the slopes along the northeastern portion of the site were evaluated using typical parameters for the bedrock exposed. Our analyses indicate the slopes are statically stable and generally seismically stable as well. However, the steepest slope (see text for location) could experience minor displacements during a strong earthquake. Although global failure is not anticipated, it may be prudent to flatten this portion of the slope to reduce potential movements.

Although the slopes are globally stable, we conclude that there is a rock fall hazard that would not be mitigated by flattening of the slopes. The nature of the exposed bedrock is such that relatively large pieces of rock will be loosened by weathering of the slopes and a significant quantity of rock will roll or fall down the slopes. It is our opinion that a catchment or barrier should be constructed at the toe of the slope to minimize the risk of injury to personnel and damage to nearby structures.

The foregoing is a brief summary of our findings, and preliminary conclusions and recommendations. We refer you to the report and attached figures for more detail. We trust the report meets your present needs for the project, but would be happy to answer questions you may have regarding it.

Sincerely yours,
TREADWELL & ROLLO, A LANGAN COMPANY

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# GEOTECHNICAL AND ENVIRONMENTAL CONSULTATION GGBS MANUFACTURING FACILITY Vallejo, California

**Ecocem Materials**
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**GGBS MANUFACTURING FACILITY**
**Vallejo, California**

## 1.0 INTRODUCTION

This report presents our conclusions regarding existing environmental and geotechnical conditions, seismicity and seismic hazards, and a preliminary slope stability evaluation of a site in Vallejo, California that your firm is considering leasing. The site is at 790 Derr Street as shown on Figure 1. It encompasses approximately the central third of a 45 acre site that was previously used by General Mills (most recent owner) as a grain milling and processing plant. The property is currently occupied by several structures associated with the milling operation that will be demolished and replaced with new manufacturing facilities. The site is relatively flat throughout the southwestern portion; a steep slope that trends northwest to southeast crosses the property along the northeastern side.

The proposed development will be constructed in two phases. Phase 1 will include a grinding mill, a filter building, silos, a workshop, an office building, conveyors and bulk storage stockpiles. Grading will include contouring for the new use and expanding the area for stockpiles laterally into the hillside to the east. In Phase 2, a large clinker storage shed will be added as well as more conveyors to link the facility to a new quay (to be constructed by others) along the shoreline.

## 2.0 SCOPE OF SERVICES

Our scope of services was performed in accordance with our proposal dated 4 January 2013. Specifically our scope included:

- reviewing an environmental report provided by the owner of the property and providing an opinion regarding the adequacy of the report and any environmental liabilities or constraints that would affect development of the property as you plan; providing recommendations for any additional environmental studies if deemed necessary;
- reviewing geotechnical reports provided by the owner, reviewing physical features at the site and providing an opinion regarding the suitability of the site for the proposed development;

- providing an assessment of site seismicity and seismic hazards in accordance with the standard of practice in the San Francisco Bay Area;
- reviewing an existing geotechnical report, performing a geological site reconnaissance, and performing a quantitative slope stability evaluation of the steep rock slope on the property using available soil and rock parameters.

Our findings and conclusions for each of these tasks are presented in this report.

## 3.0 ENVIRONMENTAL REVIEW

From approximately 1869 until 2004, the site was used as a grain mill and processing plant. Site operations included the use and storage of petroleum hydrocarbons that were used for fueling vehicles and for heating facility operations. Petroleum hydrocarbon products were stored in a combination of above ground storage tanks (ASTs) and underground storage tanks (USTs). A total of seven former ASTs and 13 former USTs (T-1 through T-13) were identified as being used during the facility operations. Operations historically conducted on-site included the cleaning, processing, bleaching, and packaging of flour and other General Mills products. The locations of the former ASTs and USTs are shown on Figure 2.

The seven ASTs were removed from operation in the early 1950s to the late 1960s. Eight USTs (T-1 through T-8) were known to be present and were in operation until the mid-1980s to early 1990s. Environmental impacts associated with USTs T-1 through T-7 were investigated from 1994 through 1996 and environmental impacts associated with UST T-8 were investigated in 2003. Solano County Department of Resources Management (SCDRM) with concurrence from the Bay Area Regional Water Quality Control Board (RWQCB) issued case closure letter for USTs T-1 through T-7 on 9 September 1996 and for UST T-8 on 23 August 2004.

In 2005, Clayton Group Services, Inc. (Clayton) completed a Phase I Environmental Site Assessment (ESA) of the site for a potential buyer. Clayton identified eight USTs (T-1 through T-8) that were previously investigated and closed by SCDRM, and five additional USTs (T-9 through T-13). Clayton also identified the seven former ASTs used to store petroleum hydrocarbons, a machine shop/sheet metal working area, use and storage of fumigants, a printing shop area, and fill material on the western portion of the property as potential areas of concern and recommended a soil and groundwater subsurface investigation.

As part of a Phase II ESA, Clayton completed soil and groundwater sampling at various locations across the property. Results of Clayton's Phase II investigation showed elevated concentrations of petroleum hydrocarbons in the groundwater near T-9 through T-13).

In 2006, Malcolm Pirnie removed T-9 through T-13 and began extensive soil and groundwater subsurface investigations, which included the installation of eight groundwater monitoring wells (MP-1 through MP-8). The monitoring well locations are shown on Figure 2. Results from the soil and groundwater quality investigations confirmed petroleum hydrocarbons to be the chemicals of concern at the site. The impacted areas were determined to be in the vicinity of former USTs T-9, T-10, and T-13. In February 2007, case closure was granted by SCDRM for tanks T-11 and T-12.

Soil remedial activities conducted in 2006 and 2007 included excavation of impacted soils, on-site treatment of excavated soils, and reuse of the treated soil as backfill. On 15 June 2007, Malcolm Pirnie submitted a *Well Installation and Groundwater Monitoring Plan* (GWMP) to the SCDRM. The purpose of the GWMP was to establish the procedures to assess and monitor shallow groundwater quality in the impacted area at the property.

During the remedial activities, four monitoring wells (MP-1, MP-3, MP-6, and MP-7) located within the excavation area or in its immediate vicinity were destroyed. At the request of SCDRM, Malcolm Pirnie installed three additional monitoring wells (MP-9, MP-10 and MP-11) around the eastern extent of the excavation area in December 2006 (Figure 2). Well installation activities were conducted following receipt of SCDRM approval in a letter dated 16 November 2006. In July 2007, Malcolm Pirnie replaced two monitoring wells (MP-1 and MP-6) that were removed during the remedial activities and installed six additional monitoring wells (MP-1R, MP-6R, MP-12, MP-13A, MP-13B, and MP-14) west and north of the former excavation area in July 2007 (Figure 2). Malcolm Pirnie did not replace former monitoring well MP-3, because monitoring well MP-11 was installed approximately 20 feet north of the former monitoring well MP-3 location. Also, Malcolm Pirnie did not replace monitoring well MP-7 because monitoring well pair MP-13A/B was installed approximately 40 feet south of the former monitoring well MP-7 location.

In late 2008, an increase in total petroleum hydrocarbons as diesel fuel (TPHd) concentration was identified in monitoring well MP-6R. In February 2009, a thin layer of free-phase petroleum hydrocarbon was identified in the same well. As a result, Malcolm Pirnie conducted a focused investigation in the vicinity of monitoring well MP-6R to assess the extent of residual petroleum hydrocarbon impacts. Field and laboratory results identified an area approximately 2,800 square feet in size where residual petroleum hydrocarbons remained in the soil and groundwater. According to Malcolm Pirnie, localized pockets of residual product existed behind the northern excavation sidewall and were not exposed during the 2006 soil remediation activities. They concluded that it was possible that disturbance of the soils during the remedial activities resulted in lateral migration of the residual product.

Based on the investigation results, Malcolm Pirnie prepared a *Closure Action Plan* (CAP) dated 7 July 2010, describing the activities to be performed to result in the site be granted regulatory closure. In addition, Malcolm Pirnie prepared the *Closure Action Plan Addendum* (CAP Addendum) dated 9 September 2011, following several discussions with the SCDRM regarding investigation and laboratory analytical procedures. The addendum was approved by SCDRM in a letter dated 12 September 2011.

The CAP summarized the remedial alternatives to remove residual and free-phased petroleum hydrocarbons from beneath the property. Based on the evaluation, Malcolm Pirnie proposed to evaluate the efficacy of remediating the impacted soils and shallow groundwater in the area near monitoring well MP-6R using High-Vacuum Extraction (HiVac). This technology was selected based on a review of potential remedial alternatives, available literature, experience, and site-specific knowledge. The HiVac pilot test was proposed to be conducted in an area north of well MP-6R where residual hydrocarbons were identified in soil samples collected from borings during the 2009 supplemental site investigation.

The CAP and CAP Addendum included installing five pilot test extraction wells, conducting HiVac extraction tests on three of the five wells, and evaluating the data to determine the effectiveness of removing petroleum hydrocarbons from the subsurface using this technology.

Based on the results of the pilot study which was conducted in November 2011, Malcolm Pirnie concluded that HiVac was an effective method for recovering liquids and soil vapor from beneath the Site. However due to the lack of movement of the free phase petroleum hydrocarbons in the area, full scale implementation of a HiVac groundwater remediation program would not be warranted.

Because product had previously been observed in monitoring well MP-6R, in a letter dated 13 April 2012, the SCDRM requested that an additional HiVac test be conducted at MP-6R to verify that product remaining in the vicinity of well MP-6R was not mobile and that residual hydrocarbons in the vicinity of well MP-6R had been remediated to the extent practicable.

Following the second pilot test which was conducted in August 2012, Malcolm Pirnie concluded that the HiVac results were generally consistent with those of the November 2011 pilot test. Therefore, Malcolm Pirnie recommended that following the completion of the two additional SCDRM-mandated monitoring events, all monitoring wells be properly closed and the SCDRM issue a No Further Action (NFA) determination for the site.

As stated in *Third Quarter 2012 Groundwater Monitoring Report* which was the most recent document available for review, Malcolm Pirnie was schedule to conduct an additional groundwater monitoring event in December 2012 at the property. If the December 2012 sampling results were consistent with the historic results, a site closure request would be submitted to the SCDRM for approval.

The results of the environmental investigations indicate low levels of petroleum hydrocarbons exist in the soil and groundwater at the site. The presence of these compounds poses potential health and safety (H&S) issues to be addressed as part of the site development activities and will require soil and groundwater management plans. The soil and groundwater management objectives for the site are to minimize exposure to construction workers at the Site, nearby residents and/or pedestrians, and future users of the Site to constituents in the soil and groundwater.

We recommend that soil and groundwater management plan (SGMP) and a health and safety plan (HASP) (prepared by others) be prepared that outlines specific soil and groundwater handling procedures to be followed during construction and excavation activities at the site. The SGMP should provide recommended measures to mitigate the long-term environmental or health and safety risks caused by the presence of petroleum hydrocarbons in the soil and groundwater. The SGMP should also contain contingency plans to be implemented during excavation activities if unanticipated hazardous materials are encountered. The SGMP should also specify basic health and safety concerns to be addressed by the site contractor or subcontractor responsible for worker health and safety, through the preparation of a detailed HASP by the project contractor.

## 4.0 GEOTECHNICAL REVIEW

As background on the geotechnical conditions at the site the following documents were provided by the property owner and reviewed by us:

- *Preliminary Geotechnical Exploration, Proposed Residential Development, General Mills Property, 790 Derr Street, Vallejo, California,* prepared by Engeo Incorporated and dated 27 June 2008
- *Geotechnical Feasibility Exploration, 790 Derr Street, Vallejo, California,* prepared by Engeo Incorporated and dated 31 August 2006
- *Backfill Report, Large Excavation Site-Leasehold Property, Former General Mills Facility, Vallejo, California,* prepared by Engineering/Remediation Resources Group, Inc. and dated 5 July 2007
- *Final Backfill Report, Large Excavation Site-Leasehold Property, Former General Mills Facility, Vallejo, California,* prepared by Engineering/Remediation Resources Group, Inc. and dated 6 August 2007.

The reports by Engeo included several borings and test pits that were excavated on and around the portion of the property under consideration. They are limited in number and only a few were on the site of interest; these are shown on Figure 3. Additionally, the 2008 Engeo report included a geologic map of the site. The reports by Engineering/Remediation Resources Group (ERRG) relate to removal of contaminated soil and replacement thereof with compacted fill. The remediation does not extend onto the property currently being considered for purchase, and the reports are therefore only of general interest.

### 4.1 Subsurface Conditions

The available data indicates the eastern portion of the site is blanketed by a few feet of soil, which is underlain by Cretaceous Great Valley Sequence bedrock consisting of moderately to well-cemented, strong to friable, thinly-bedded sandstone, with friable, thinly bedded siltstone and claystone interbeds. Cut slopes exposing the bedrock along the northeast and east sides of the site reveal the bedrock exposed in these cuts have a favorable bedding condition, with strikes (bedding orientations) between about N80W to N79E, and dips (downward slopes) 60 to 65 degrees to the north.

The western portion of the site appears to be blanketed by clayey fill. The fill is either underlain by directly by bedrock or soft clay locally referred to as Bay Mud, which overlies bedrock. The contact between bedrock (or shallow bedrock) and fill (deep bedrock) as mapped by Engeo is approximately as shown on Figure 3.

Groundwater was encountered at depths of 4 to 9 feet in the low lying western portion of the site. Groundwater was not encountered in the test pits excavated on the slopes in the eastern portion; however, water is likely present in seams and fractures in the bedrock, especially when it rains.

### 4.2 Preliminary Conclusions Regarding Foundations

Based on our discussions with you, we understand that the heaviest foundation will be under the grinding mill. The silos will also have significant foundation loads, but the structural loads of the other facilities will be moderate to light.

We anticipate structures on the eastern portion of the site (where bedrock is exposed or shallow) can be supported on footing or mat foundations that bear on bedrock. Typically it is feasible to use footings where bedrock is no deeper than 5 feet below grade. Where footings are less than 5 feet in thickness, the over-excavation can be backfilled with lean concrete. Depending on the type and competency of the bedrock, we anticipate allowable bearing pressures of from 6,000 to 10,000 pounds per square foot can be expected.

Where bedrock is too deep to be reached by footings, either drilled piers or auger-cast piles should be considered. Capacities of piers or piles would depend on diameter and embedment in the bedrock; however, capacities on the order of 300 to 400 kips are feasible.

The available data suggests that at the mill location bedrock could be 10 to 15 feet below the existing ground surface. We understand the mill will require a massive concrete foundation to dampen vibrations. Although some over-excavation may be required, our preliminary conclusion is that it is feasible to extend the mill foundation to bedrock. If space permits, the excavations may be sloped; alternatively, it may be necessary to shore excavations deeper than 5 feet.

## 5.0 SEISMICITY AND SEISMIC HAZARDS

### 5.1 Regional Seismicity

The major active faults in the area are Hayward, Calaveras, San Andreas, and San Gregorio faults. These and other faults of the region are shown on Figure 3. For each of the active faults within 50 kilometers (km) of the site, the distance from the site and estimated Mean Characteristic Moment Magnitude[1] [2007 Working Group on California Earthquake Probabilities (WGCEP) (2008) and Cao et al. (2003)] are summarized in Table 1.

**TABLE 1**
**Regional Faults and Seismicity**

| Fault Segment | Approximate Distance from Site (km) | Direction from Site | Mean Characteristic Moment Magnitude |
|---|---|---|---|
| West Napa | 9 | North | 6.70 |
| Green Valley Connected | 13 | East | 6.80 |
| Total Hayward | 13 | West | 7.00 |
| Total Hayward-Rodgers Creek | 13 | West | 7.33 |
| Rodgers Creek | 17 | West | 7.07 |
| Mount Diablo Thrust | 29 | Southeast | 6.70 |
| Great Valley 5, Pittsburg Kirby Hills | 30 | East | 6.70 |
| Great Valley 4b, Gordon Valley | 35 | Northeast | 6.80 |
| Total Calaveras | 36 | Southeast | 7.03 |
| Hunting Creek-Berryessa | 42 | North | 7.10 |
| N. San Andreas - North Coast | 42 | West | 7.51 |
| N. San Andreas (1906 event) | 42 | West | 8.05 |
| Greenville Connected | 42 | East | 7.00 |
| N. San Andreas – Peninsula | 44 | Southwest | 7.23 |
| San Gregorio Connected | 48 | Southwest | 7.50 |

[1] Moment magnitude is an energy-based scale and provides a physically meaningful measure of the size of a faulting event. Moment magnitude is directly related to average slip and fault rupture area.

Figure 3 also shows the earthquake epicenters for events with magnitude greater than 5.0 from January 1800 through December 2000. Since 1800, four major earthquakes have been recorded on the San Andreas Fault. In 1836 an earthquake with an estimated maximum intensity of VII on the Modified Mercalli (MM) scale (Figure 4) occurred east of Monterey Bay on the San Andreas Fault (Toppozada and Borchardt 1998). The estimated Moment magnitude, $M_{w,}$ for this earthquake is about 6.25. In 1838, an earthquake occurred with an estimated intensity of about VIII-IX (MM), corresponding to a $M_w$ of about 7.5. The San Francisco Earthquake of 1906 caused the most significant damage in the history of the Bay Area in terms of loss of lives and property damage. This earthquake created a surface rupture along the San Andreas Fault from Shelter Cove to San Juan Bautista approximately 470 kilometers in length. It had a maximum intensity of XI (MM), a $M_w$ of about 7.9, and was felt 560 kilometers away in Oregon, Nevada, and Los Angeles. The most recent earthquake to affect the Bay Area was the Loma Prieta Earthquake of 17 October 1989, in the Santa Cruz Mountains with a $M_w$ of 6.9, approximately 120 km from the site.

In 1868 an earthquake with an estimated maximum intensity of X on the MM scale occurred on the southern segment (between San Leandro and Fremont) of the Hayward Fault. The estimated $M_w$ for the earthquake is 7.0. In 1861, an earthquake of unknown magnitude (probably a $M_w$ of about 6.5) was reported on the Calaveras Fault. The most recent significant earthquake on this fault was the 1984 Morgan Hill earthquake ($M_w$ = 6.2).

The 2007 WGCEP at the U.S. Geologic Survey (USGS) predicted a 63 percent chance of a magnitude 6.7 or greater earthquake occurring in the San Francisco Bay Area in 30 years. More specific estimates of the probabilities for different faults in the Bay Area are presented in Table 2.

**TABLE 2**
**WGCEP (2007) Estimates of 30-Year Probability of a Magnitude 6.7 or Greater Earthquake**

| Fault | Probability (percent) |
|---|---|
| Hayward-Rodgers Creek | 31 |
| N. San Andreas | 21 |
| Calaveras | 7 |
| San Gregorio | 6 |

## 5.2 Seismic Hazards

During a major earthquake, strong to violent ground shaking is expected to occur at the project site. Strong ground shaking during an earthquake can result in ground failure such as that associated with soil liquefaction,[2] lateral spreading[3] and cyclic densification[4]. Each of these conditions has been preliminarily evaluated based on our literature review and are discussed in this section.

### 5.2.1 Liquefaction

The western portion of the site is mapped (USGS Open-File Reports 00-444 and 2006-1037) as having a very high potential for liquefaction. These maps are based on widespread geological data regarding soil types and groundwater level. Our review of the boring and test pit logs indicates the soil layers are cohesive and therefore we preliminarily conclude the potential for liquefaction is low.

### 5.2.2 Lateral Spreading

The proposed development is along the Mare Island Strait and the ground slopes down towards the center of the channel. However, because there does not appear to be a continuous layer of potentially liquefiable soil, we preliminarily conclude that the potential for lateral spreading is low.

### 5.2.3 Cyclic Densification

Seismically-induced compaction or cyclic densification of non-saturated sand (i.e., sand above the groundwater table) due to earthquake vibrations may cause differential settlement. We used the procedure recommended by Tokimatsu and Seed (1984) to evaluate cyclic densification. The soil above the water table contains some fines and is medium dense to dense; therefore, we judge the potential for cyclic densification to occur is low.

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2 Liquefaction is a transformation of soil from a solid to a liquefied state during which saturated soil temporarily loses strength resulting from the buildup of excess pore water pressure, especially during earthquake-induced cyclic loading. Soil susceptible to liquefaction includes loose to medium dense sand and gravel, low-plasticity silt, and some low-plasticity clay deposits.

3 Lateral spreading is a phenomenon in which surficial soil displaces along a shear zone that has formed within an underlying liquefied layer. Upon reaching mobilization, the surficial blocks are transported downslope or in the direction of a free face by earthquake and gravitational forces.

4 Cyclic densification is a phenomenon in which non-saturated, cohesionless soil is densified by earthquake vibrations, causing ground-surface settlement.

### 5.2.4 Fault Rupture

Historically, ground surface displacements closely follow the trace of geologically young faults. The site is not within an Earthquake Fault Zone, as defined by the Alquist-Priolo Earthquake Fault Zoning Act. Therefore, we conclude the potential of surface rupture at the site is low.

## 5.3 Seismic Design

On the basis of our review of the previous studies, we conclude the project site is underlain by soft rock at shallow depths; therefore, we conclude a Site Class C is appropriate for design. For seismic design in accordance with ASCE 7-10/2012 IBC we recommend the following:

- Maximum Considered Earthquake (MCE) $S_s$ and $S_1$ of 1.50 g and 0.60 g, respectively.
- Site Class C
- Site Coefficients $F_A$ and $F_V$ of 1.0 and 1.3
- Risk-targeted Maximum Considered Earthquake ($MCE_R$) spectral response acceleration parameters at short periods, $S_{MS}$, and at one-second period, $S_{M1}$, of 1.50 g and 0.78g, respectively.
- Design Earthquake (DE) spectral response acceleration parameters at short period, $S_{DS}$, and at one-second period, $S_{D1}$, of 1.00 g and 0.52 g, respectively.

# 6.0 STABILITY OF SLOPES

We were provided with a slope stability analysis prepared by Mr. P.E. Durnal, dated 8 February 2013. The analysis included preparation of five slope profiles (designated A-A' through E-E'), and a quantitative slope stability analysis of one of the sections (B-B'). The analysis of B-B' indicated that this slope should remain stable during static and seismic loading conditions. The slope profiles appear to be based on a topographic map with 10-foot contour intervals of unknown origin. There is no reference for the soil and rock properties and strength values used in the analysis.

We used the computer program Slope/W (version 6.22) by Geo-Slope International, Ltd. (2004) in our analyses. Factors of safety[5] were computed using various two-dimensional limit equilibrium methods, including Modified Bishop, Janbu, and Spencer's Methods. Given various parameters, the program internally searched for the most critical failure surface, i.e. lowest factor of safety. Typically a slope with a static factor of safety of at least 1.5, and a pseudo static factor of safety of 1.15 with a horizontally seismic coefficient of 0.10 to 0.15 times gravity (g) is generally considered stable (Seed 1979); however, slope movements may occur even if the slope is globally stable.

## 6.1 Slope Stability Model

We performed engineering analyses to evaluate the stability of the descending slopes on the northeast and east sides of the site, along the alignments of profiles A-A' and B-B' as shown on Figure 3. These profiles were generated based on subsurface and topographic information provided in the Engeo report dated 27 June 2008. They were selected to represent the most critical slopes from a topographic standpoint that may impact the site. We concluded that the critical slope condition appears to be in the southeast corner of the site, near Mr. Durnal's profile D-D'. We performed an analysis on a profile of the slope at this critical location (our A-A'), and a second analysis on a profile just southwest of Mr. Durnal's B-B' profile (our B-B').

The engineering properties of the fill, colluvium, and bedrock materials were developed based on the results of the prior Engeo investigation (borings and test pits), and published values for the geologic units from the California Geologic Survey (CGS) Seismic Hazard Zone Report for the Oakland West 7 ½-Minute Quadrangle (CGS 2003). A summary of engineering properties for the different material types used in our slope stability analysis is presented in Table 3.

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5 The factor of safety is the ratio of the available resistance to sliding divided by the driving force; the higher the factor of safety, the more stable the slope.

**TABLE 3**
**Engineering Properties used in Slope Stability Analyses**

| Material Description | Total Unit Weight (pcf) | Effective Strength Parameters | |
|---|---|---|---|
| | | Effective Cohesion, C′ (psf) | Effective Internal Friction, $\phi'$ (degrees) |
| Fill | 120 | 315 | 28 |
| Colluvium | 125 | 315 | 28 |
| Great Valley Sequence Siltstone, Claystone, and fine-grained Sandstone | 133 | 450 | 33 |

On the basis of our observations of no apparent seeps or springs on the site slopes during our site visit, and our understanding that no groundwater was encountered in any of Engeo's test pits excavated in this portion of the site, we did not include the effects of groundwater in the analysis.

### 6.2 Slope Stability Results

Results of our analyses indicate the static factors of safety for the existing slopes vary from about 1.2 to 2.1. The location of the critical slope failure surfaces for each of the profiles evaluated are provided in Figures 6 and 7.

We used a pseudo-static approach to evaluate the seismic slope stability of the two profiles. In this method of analysis, an earthquake is represented by an equivalent horizontal static force. This seismic force is modeled by applying a horizontal ground acceleration (a horizontal seismic coefficient) multiplied by the mass of the potential slide material. The magnitude of this equivalent horizontal seismic coefficient is typically taken as 2/3 of the anticipate peak ground acceleration for a given seismic event. We used a design peak ground acceleration (PGA) of 0.4g as the design maximum horizontal ground acceleration, based on the 2010 California Building Code Design Earthquake (DE) spectral response. For our analyses, the PGA correlates to an equivalent horizontal seismic coefficient equal to 0.267g (2/3 x 0.4g).

The pseudo-static analysis for profile A-A′ resulted in a factor of safety of less than 1.0. Figure 8 presents the critical failure plane for section A-A′. By modifying the horizontal seismic coefficient within each stability run (using the SLOPE/W program) we obtained the magnitude of the horizontal seismic coefficient that corresponds to a seismic factor of safety equal to 1.0 for this profile; the results of the yield analysis for section A-A′ are presented on Figure 9. The corresponding horizontal seismic coefficient is referred to as the yield acceleration for that profile.

To evaluate the magnitude of the anticipated slope movement along profile A-A′ during a design level earthquake, the Makdisi and Seed (1978) method was used. The input parameters used in this analysis are the expected design level maximum horizontal acceleration and the yield acceleration of the slope being analyzed, along with the anticipated earthquake magnitude (M=7-1/4), and thickness of each pseudo-static failure along those specific sections.

The results of our analyses indicate the steep west facing slope (profile A-A′) may exhibit permanent slope displacements of about 4 to 5 inches during a peak seismic event. The less-steep, southwest facing slope (profile B-B′) uphill of the site should be stable during a peak seismic event. The results of our pseudo static analysis for section B-B′ are presented on Figure 10. The results of our slope stability analyses and seismic slope displacements are summarized in Table 4. We understand the property owner has indicated the slope presented in profile A-A′ can be flattened to 2:1. Flattening the slopes would help reduce the predicted seismic displacements.

**TABLE 4**
**Slope Stability and Seismic Slope Displacements**

| Profile | Static Factor of Safety | Pseudo-Static Factor of Safety | Yield Acceleration (g) | Seismic Slope Displacement during Design Earthquake |
|---|---|---|---|---|
| A-A′ | 1.194 | 0.813 | 0.118 | About 4 to 5 inches |
| B-B′ | 2.055 | 1.227 | ---- | Negligible |

### 6.3 Rockfall Hazards

To provide a quantitative analysis of rockfall hazards associated with the steep rock slope (profile A-A′), we used the Colorado Rockfall Simulation Program (CRSP), version 4.0 (Jones et al., 2000). The CRSP program simulates rockfall events from site data describing slope profile, slope irregularities, slope materials, and rock size. Output from CRSP includes a prediction of probable rockfall velocity and bounce height.

Slope geometry parameters that influence the behavior of rockfall include slope angle, slope length, surface roughness, and lateral variability of the slope surface. Slope angle is critical because it partly defines zones of acceleration and deceleration during the rockfall event. Slope length determines the distance over which the rock accelerates or decelerates. Slope angles and lengths are entered into CRSP by dividing the slope into multiple straight-line segments denoting areas of constant slope gradient, and entering the beginning and ending coordinates of each segment.

Surface roughness affects the interaction between the rock and surface irregularities on the slope. Two material properties, a normal coefficient and a tangential coefficient, of each segment of the slope were also entered into CRSP. The normal coefficient is a measure of the slope material's elasticity during a rock collision normal (into) to the slope. The tangential coefficient is a measure of the frictional resistance to movement parallel to the slope.

The program also accounts for different rock diameters and four different rock shapes: spherical, cylindrical, angular, and disk shaped. After observing the rocks present on the hillslope, we concluded that they are mostly shaped as angular blocks, and were modeled as 1-foot cubes.

The results of rockfall analysis of one cubic foot rocks indicate that, if not mitigated, a high percentage of these size rocks will likely roll all the way down the slope and be launched a sufficient distance from the base of the slope onto the pad. The CRSP allows the user to view probable rockfall trajectories on a topographic profile of the slope. The slope consists of distinct segments, varying in slope gradient and vegetation coverage. All of the rockfalls simulated begin by rocks falling in a topple mechanism or by breaking off of the slope and tumbling downhill. Many of the rocks become airborne after hitting various outcrops along the way, flying through the air until touching down on the next downhill slope segment or on the pad at the base of the slope. Approximately 94 percent of the rocks resume rolling downhill beyond the base of the cutslope.

Rockfall bounce heights varied over different portions of the slope. As rocks encountered various outcrops, bounce heights increased to as much as 8.5 feet in the air at lower areas of the slope. Approximate maximum kinetic energy estimated for angular 1-foot cubic rocks where impacting a possible catchment fence or debris wall at the toe of the slope, was about 4,950 foot-pounds.

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# FIGURES


0 1,000 2,000 Feet

Approximate scale

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|---|---|---|
| SITE LOCATION MAP | | |
| Date 01/16/13 | Project No. 731608801 | Figure 1 |

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**EXPLANATION**

| | |
|---|---|
| T-6 ☐ | Approximate location of former underground storage tank (UST) |
| AST-3 ◓ | Approximate location of former above ground storage tank (AST) |
| MP-2 ⌖ | Approximate location of monitoring well by Malcolm Pirnie, July 2007 |
| EW-1 ⌖ | Approximate location of extraction well by Malcolm Pirnie, October 2011 |
| MP-7 ⊗ | Approximate location of monitoring well by Malcolm Pirnie, January and February 2006 |
| — · — | Approximate location of Grain Mill boundary |
| —— | Approximate Site boundary |

Aerial basemap is provided through Langan's Esri ArcGIS software licensing and ArcGIS online.

0 150
Approximate scale

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**SITE PLAN SHOWING ENVIRONMENTAL INFORMATION**

Date 02/15/13 | Project No. 731608801 | Figure 2

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**EXPLANATION**

- Approximate location of Grain Mill boundary
- Approximate Site boundary
- Approximate demarcation between shallow and deep bedrock
- A A' Idealized subsurface profile location
- B-3 Approximate location of boring by Engeo, April 2006
- TP-2 Approximate location of test pit by Engeo, April 2008

0 200 Feet
Approximate scale

Aerial basemap is provided through Langan's Esri ArcGIS software licensing and ArcGIS online.

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**SITE PLAN SHOWING GEOTECHNICAL INFORMATION**

| Date 02/15/13 | Project No. 731608801 | Figure 3 |
|---|---|---|

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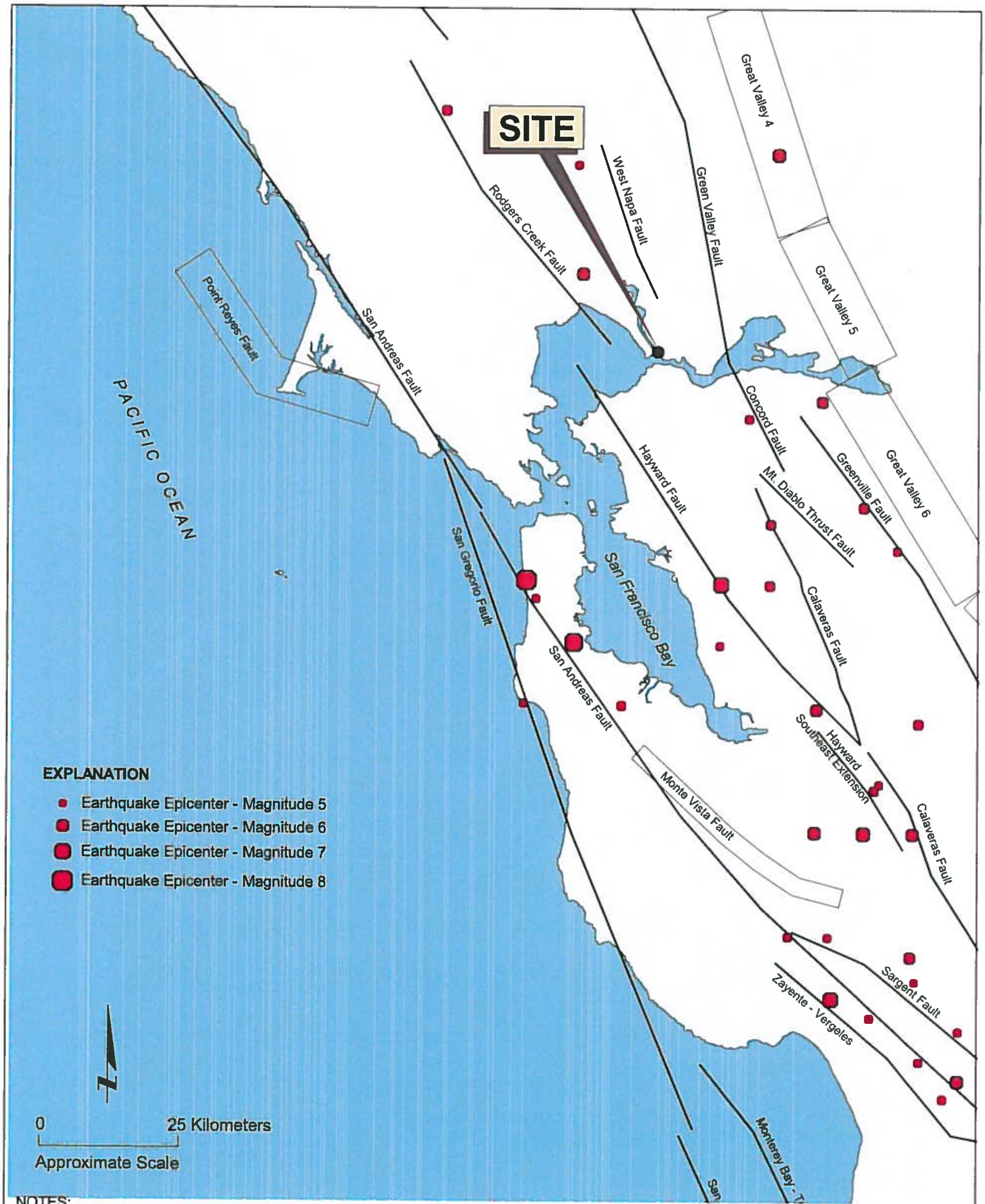
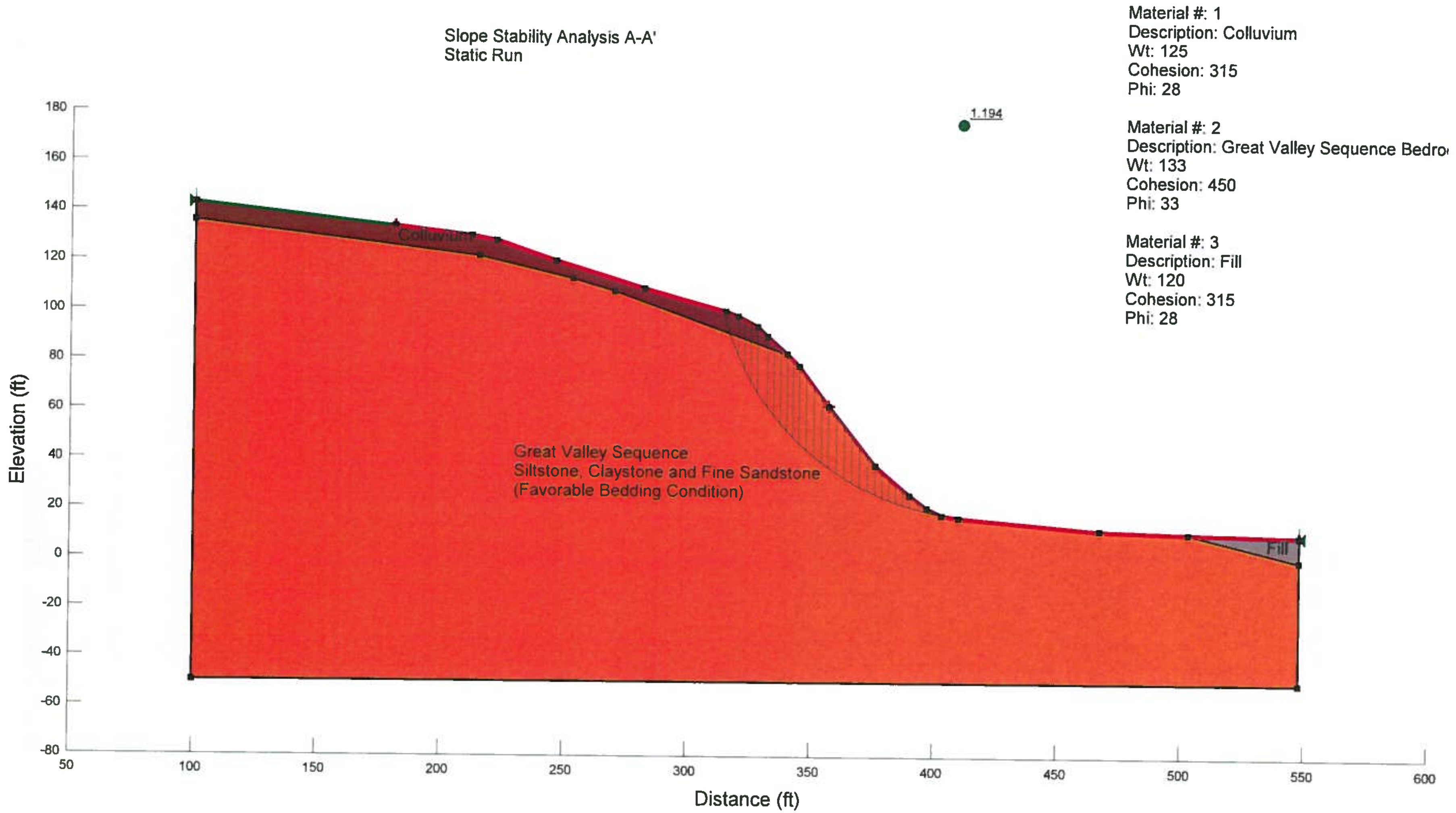



NOTES:
Digitized data for fault coordinates and earthquake catalog was developed by the California Department of Conservation Division of Mines and Geology. The historic earthquake catalog includes events from January 1800 to December 2000.

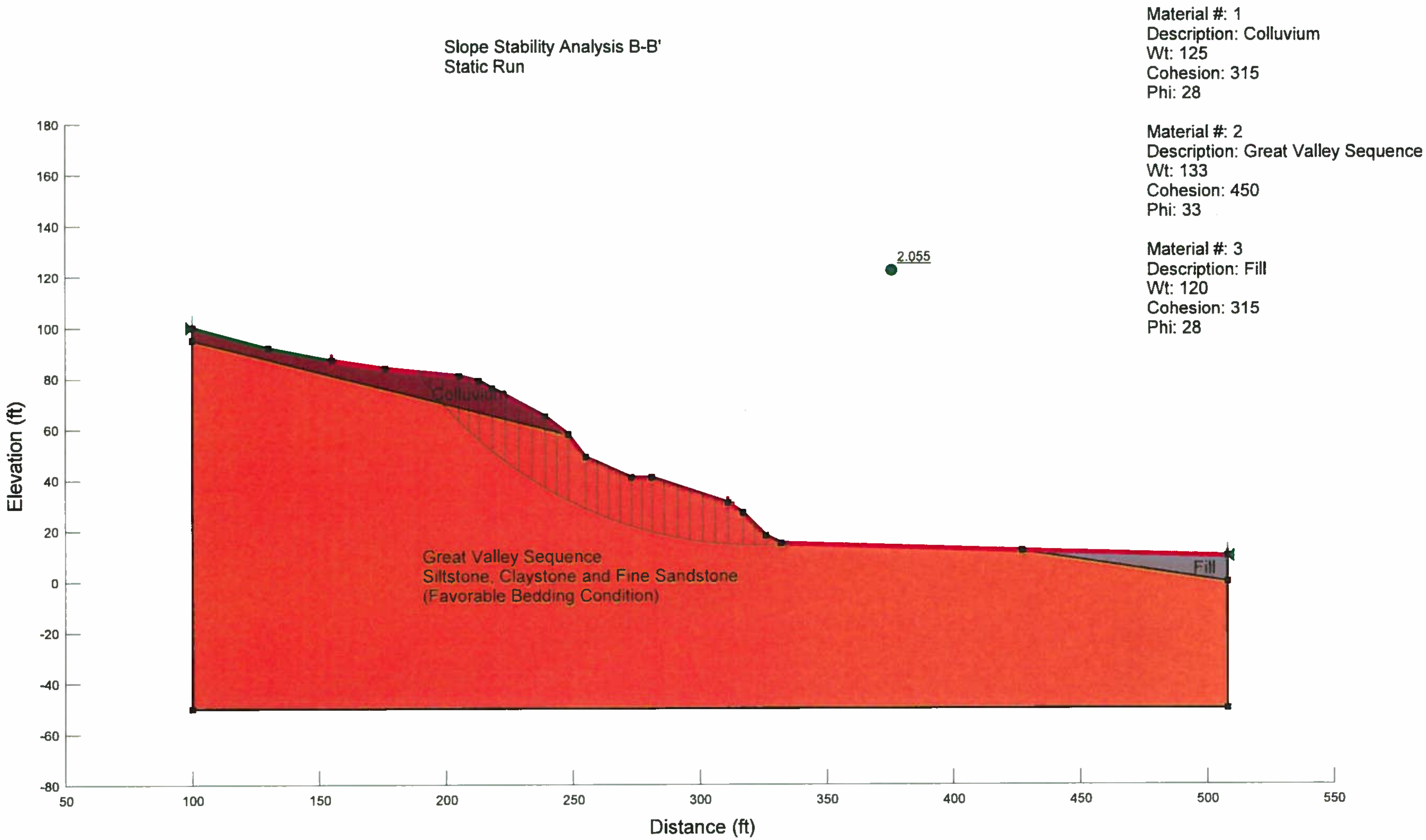
| | |
|---|---|
| **GGBS MANUFACTURING FACILITY**<br>Vallejo, California | **MAP OF MAJOR FAULTS AND EARTHQUAKE EPICENTERS IN THE SAN FRANCISCO BAY AREA** |
| Treadwell&Rollo<br>A LANGAN COMPANY | Date 02/15/13 \| Project No. 731608801 \| Figure 4 |

| | | |
|---|---|---|
| I | **Not felt by people, except under especially favorable circumstances. However, dizziness or nausea may be experienced.** Sometimes birds and animals are uneasy or disturbed. Trees, structures, liquids, bodies of water may sway gently, and doors may swing very slowly. | |
| II | **Felt indoors by a few people, especially on upper floors of multi-story buildings, and by sensitive or nervous persons.** As in Grade I, birds and animals are disturbed, and trees, structures, liquids and bodies of water may sway. Hanging objects swing, especially if they are delicately suspended. | |
| III | **Felt indoors by several people, usually as a rapid vibration that may not be recognized as an earthquake at first. Vibration is similar to that of a light, or lightly loaded trucks, or heavy trucks some distance away. Duration may be estimated in some cases.** Movements may be appreciable on upper levels of tall structures. Standing motor cars may rock slightly. | |
| IV | **Felt indoors by many, outdoors by a few. Awakens a few individuals, particularly light sleepers, but frightens no one except those apprehensive from previous experience. Vibration like that due to passing of heavy, or heavily loaded trucks. Sensation like a heavy body striking building, or the falling of heavy objects inside.** Dishes, windows and doors rattle; glassware and crockery clink and clash. Walls and house frames creak, especially if intensity is in the upper range of this grade. Hanging objects often swing. Liquids in open vessels are disturbed slightly. Stationary automobiles rock noticeably. | |
| V | **Felt indoors by practically everyone, outdoors by most people. Direction can often be estimated by those outdoors. Awakens many, or most sleepers. Frightens a few people, with slight excitement; some persons run outdoors.** Buildings tremble throughout. Dishes and glassware break to some extent. Windows crack in some cases, but not generally. Vases and small or unstable objects overturn in many instances, and a few fall. Hanging objects and doors swing generally or considerably. Pictures knock against walls, or swing out of place. Doors and shutters open or close abruptly. Pendulum clocks stop, or run fast or slow. Small objects move, and furnishings may shift to a slight extent. Small amounts of liquids spill from well-filled open containers. Trees and bushes shake slightly. | |
| VI | **Felt by everyone, indoors and outdoors. Awakens all sleepers. Frightens many people; general excitement, and some persons run outdoors.** Persons move unsteadily. Trees and bushes shake slightly to moderately. Liquids are set in strong motion. Small bells in churches and schools ring. Poorly built buildings may be damaged. Plaster falls in small amounts. Other plaster cracks somewhat. Many dishes and glasses, and a few windows break. Knickknacks, books and pictures fall. Furniture overturns in many instances. Heavy furnishings move. | |
| VII | **Frightens everyone. General alarm, and everyone runs outdoors.** People find it difficult to stand. Persons driving cars notice shaking. Trees and bushes shake moderately to strongly. Waves form on ponds, lakes and streams. Water is muddied. Gravel or sand stream banks cave in. Large church bells ring. Suspended objects quiver. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Plaster and some stucco fall. Many windows and some furniture break. Loosened brickwork and tiles shake down. Weak chimneys break at the roofline. Cornices fall from towers and high buildings. Bricks and stones are dislodged. Heavy furniture overturns. Concrete irrigation ditches are considerably damaged. | |
| VIII | **General fright, and alarm approaches panic.** Persons driving cars are disturbed. Trees shake strongly, and branches and trunks break off (especially palm trees). Sand and mud erupts in small amounts. Flow of springs and wells is temporarily and sometimes permanently changed. Dry wells renew flow. Temperatures of spring and well waters varies. Damage slight in brick structures built especially to withstand earthquakes; considerable in ordinary substantial buildings, with some partial collapse; heavy in some wooden houses, with some tumbling down. Panel walls break away in frame structures. Decayed pilings break off. Walls fall. Solid stone walls crack and break seriously. Wet grounds and steep slopes crack to some extent. Chimneys, columns, monuments and factory stacks and towers twist and fall. Very heavy furniture moves conspicuously or overturns. | |
| IX | **Panic is general.** Ground cracks conspicuously. Damage is considerable in masonry structures built especially to withstand earthquakes; great in other masonry buildings - some collapse in large part. Some wood frame houses built especially to withstand earthquakes are thrown out of plumb, others are shifted wholly off foundations. Reservoirs are seriously damaged and underground pipes sometimes break. | |
| X | **Panic is general.** Ground, especially when loose and wet, cracks up to widths of several inches; fissures up to a yard in width run parallel to canal and stream banks. Landsliding is considerable from river banks and steep coasts. Sand and mud shifts horizontally on beaches and flat land. Water level changes in wells. Water is thrown on banks of canals, lakes, rivers, etc. Dams, dikes, embankments are seriously damaged. Well-built wooden structures and bridges are severely damaged, and some collapse. Dangerous cracks develop in excellent brick walls. Most masonry and frame structures, and their foundations are destroyed. Railroad rails bend slightly. Pipe lines buried in earth tear apart or are crushed endwise. Open cracks and broad wavy folds open in cement pavements and asphalt road surfaces. | |
| XI | **Panic is general.** Disturbances in ground are many and widespread, varying with the ground material. Broad fissures, earth slumps, and land slips develop in soft, wet ground. Water charged with sand and mud is ejected in large amounts. Sea waves of significant magnitude may develop. Damage is severe to wood frame structures, especially near shock centers, great to dams, dikes and embankments, even at long distances. Few if any masonry structures remain standing. Supporting piers or pillars of large, well-built bridges are wrecked. Wooden bridges that "give" are less affected. Railroad rails bend greatly and some thrust endwise. Pipe lines buried in earth are put completely out of service. | |
| XII | **Panic is general.** Damage is total, and practically all works of construction are damaged greatly or destroyed. Disturbances in the ground are great and varied, and numerous shearing cracks develop. Landslides, rock falls, and slumps in river banks are numerous and extensive. Large rock masses are wrenched loose and torn off. Fault slips develop in firm rock, and horizontal and vertical offset displacements are notable. Water channels, both surface and underground, are disturbed and modified greatly. Lakes are dammed, new waterfalls are produced, rivers are deflected, etc. Surface waves are seen on ground surfaces. Lines of sight and level are distorted. Objects are thrown upward into the air. | |

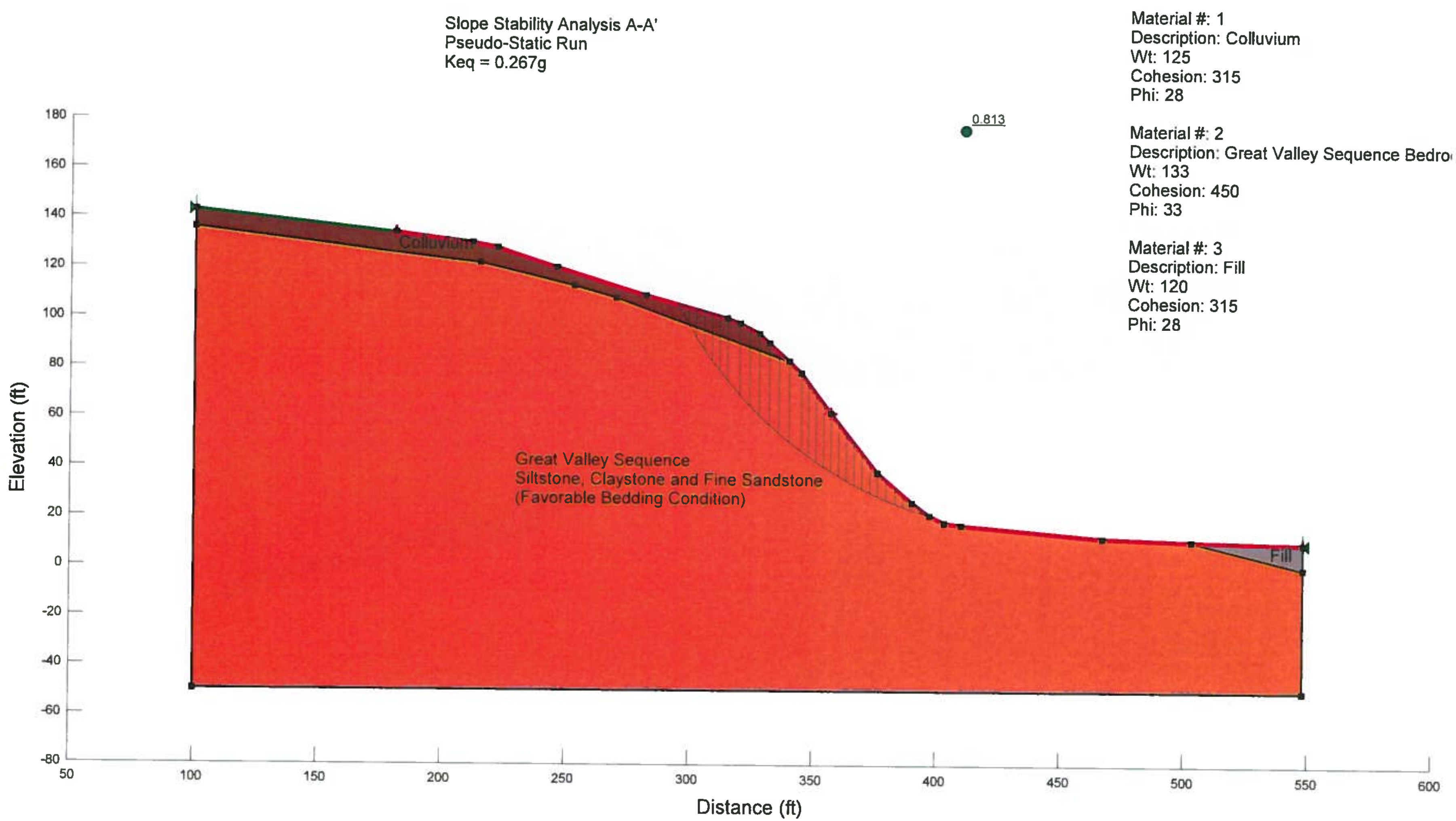
| | | |
|---|---|---|
| **GGBS MANUFACTURING FACILITY**<br>Vallejo, California | **MODIFIED MERCALLI INTENSITY SCALE** | |
| **Treadwell&Rollo**<br>*A LANGAN COMPANY* | Date 02/15/13 | Project No. 731608801 — Figure 5 |



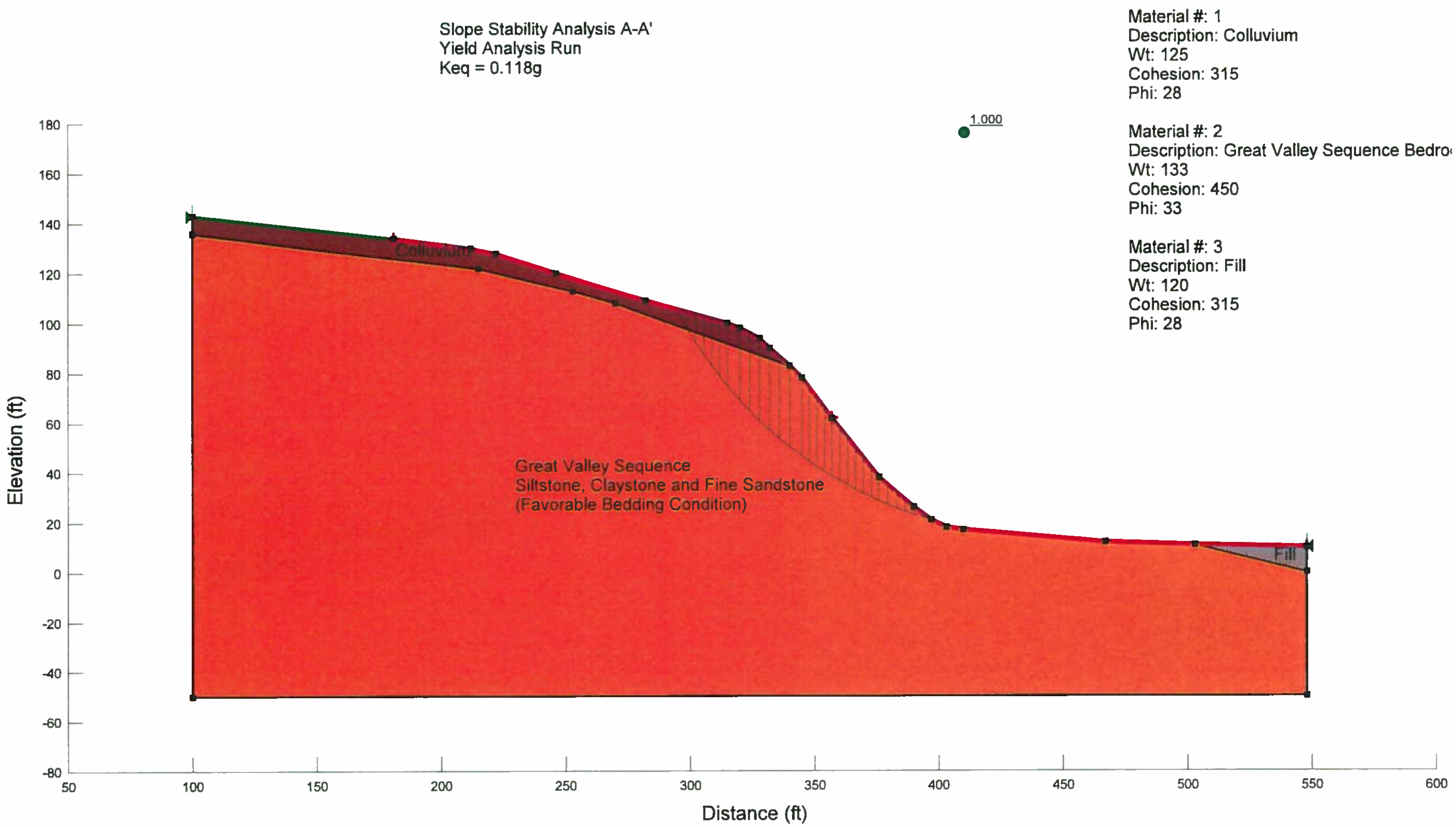

| GGBS MANUFACTURING FACILITY<br>Vallejo, California | A-A' STATIC ANALYSIS | | |
|---|---|---|---|
| Treadwell&Rollo<br>A LANGAN COMPANY | Date 02/14/13 | Project No. 731608801 | Figure 6 |



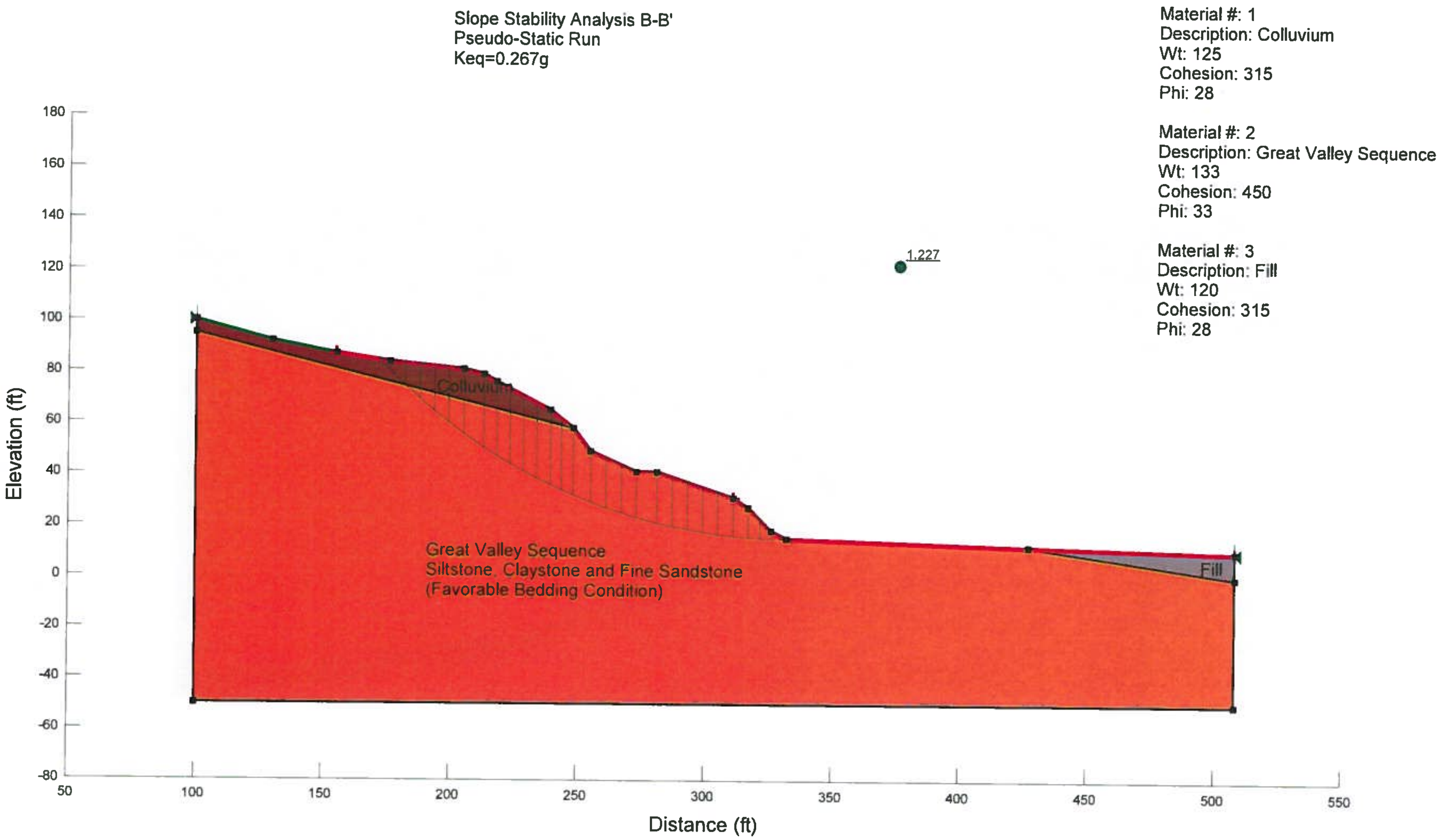

| GGBS MANUFACTURING FACILITY<br>Vallejo, California | B-B' STATIC ANALYSIS | | |
|---|---|---|---|
| Treadwell&Rollo<br>A LANGAN COMPANY | Date 02/14/13 | Project No. 731608801 | Figure 7 |




| GGBS MANUFACTURING FACILITY<br>Vallejo, California | A-A' PSEUDO-STATIC ANALYSIS | | |
|---|---|---|---|
| Treadwell&Rollo<br>A LANGAN COMPANY | Date 02/14/13 | Project No. 731608801 | Figure 8 |




| GGBS MANUFACTURING FACILITY<br>Vallejo, California | A-A' YIELD ANALYSIS | | |
|---|---|---|---|
| Treadwell&Rollo<br>A LANGAN COMPANY | Date 02/14/13 | Project No. 731608801 | Figure 9 |




| GGBS MANUFACTURING FACILITY<br>Vallejo, California | B-B' PSEUDO-STATIC ANALYSIS | | |
|---|---|---|---|
| Treadwell&Rollo<br>A LANGAN COMPANY | Date 02/14/13 | Project No. 731608801 | Figure 10 |