PACIFIC COAST LAND CONSULTING

Engineering Geologic Services

Engineering Geologic Investigation
Bowman Road Proposed Photo Voltaic Electric Field

February 19, 2013

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Dr. Arlen Barksdale
Via Internet

February 19, 2013
F.N. 0072-13.1

Subject: Engineering Geologic Investigation
Bowman Road Proposed Photo Voltaic Electric field

Dear Dr. Barksdale,

At your request, the following report has been prepared to describe the results of the investigation into the engineering geologic characteristics of the Bowman Photo Voltaic field. In general the site encounter no adverse geological conditions. A thin layer of soil that covers granitic rocks underlies the site. The granitic rock is fairly easy to drill to depths of more that 15' except when within about 60 feet of the rock outcrop. The site will be subject to severe ground shaking should an earthquake occur on any of the near by faults. The recent Landers earthquake produced a seismic event of about 7.2 with a few miles of the site.

Thank you for the opportunity to be of service. If you have any questions, please do not hesitate to contact me.
Best regards,

Ralph K. Jeffery
President/Principal Engineering Geologist
Pacific Coast Land Consulting

1.0 INTRODUCTION

1.1 Purpose

Pursuant to your request, an engineering geologic investigation for the proposed solar field has been conducted. The purpose of the investigation is to provide foundation recommendations and engineering geologic parameters that would affect he development of the field. The location of the project is shown on figure 1.

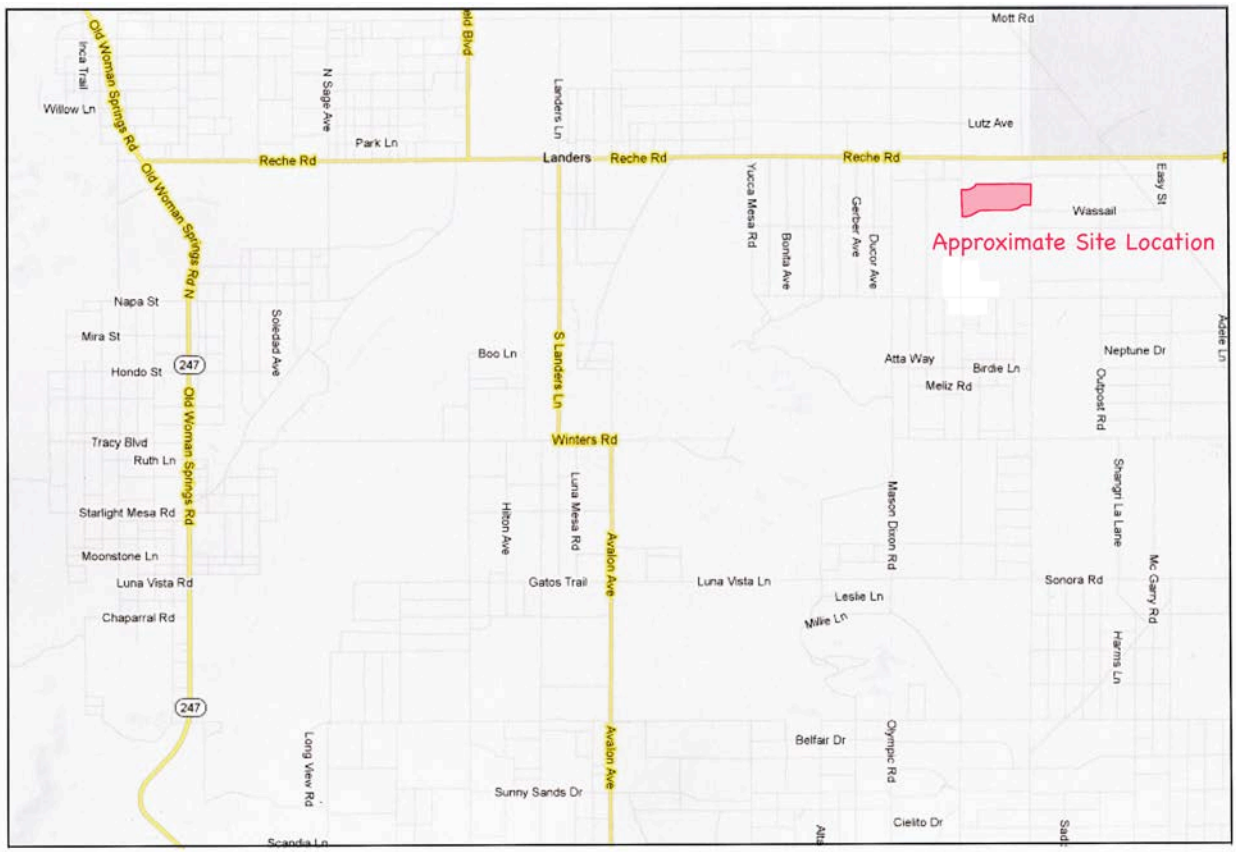


Figure 1 Site Location Map

1.2 Proposed Improvements

The proposed improvements will consist an array of photo voltaic cells design to generate electricity form the sun. These cells will be mounted via bases and actuator arms to track movement of the sun. Associated with the field of photovoltaic cells will be small gravel service roads and out buildings, and a perimeter fences. The expected construction would be very lightweight in nature.

1.3 Scope of Services

The scope of services consists of the following items:

- Review of appropriate regional geologic maps.
- Excavation of 6 borings to 20 feet and numerous shallow trenching test pits determine depth to suitable soils
- Logging and mapping of borings
- Collection of soils for future laboratory testing if needed
- Research into regional geologic conditions
- Concepts for foundations and alternative approaches.
- Recommendations for grading
- Seismic analysis for design parameters.
- Preparation of this report providing findings and recommendations.

2.0 INVESTIGATION

2.1 Site Conditions

The site consists of approximately 50 acres in the area of Landers as shown on figure 1. The site is nearly flat with very minor grades approximately 3% except for a central outcropping of rock. The rock out cropping may have as much as 20 feet of elevation relieve. Currently the grounds are occupied with sparse desert vegetation and weeds. A small drainage ditch is located along the south property line. In the past he site was designated for a residential development as such there are crude dirt roads in the area. Water lines were stubbed out but do not appear active on site.

2.2 Subsurface Investigation

Six borings were excavated using an Ingersol Rand 8300 hollow stem flight auger drill rig. These borings were excavated to depths of 20 feet. The purpose of these boring was to determine the general make up of subsurface materials with respect to the ability to drive steel piles as a support structure for the solar units. The borings were intended to determine if hard rock was encountered or patches of boulders that would preclude the use of such a support system. The attached Simplified Geologic Map Figure 2 shows the general location of the borings. In all borings 4 and 5, which selected close to the rock out crop refusal was encountered at 10 and 11 feet. In boring 6 the hole was easily advanced to 20 feet. All other borings were stopped at 15' in depth.

Numerous small trenches were excavated in random locations around the site with the intention to determine if there were rock layers near the surface that would preclude the use of trenching tools The results indicated although there is substantial amounts of surface rock the trencher was able in most instances to penetrate or dislodge the rock. Representative soil samples from the test pits and borings were collected for testing however testing has not been completed at this time. Boring logs are available in the appendix of the report.

3.0 GEOLOGY

Research was conducted on the site using USGS (United States Geologic Survey) and CGS (California Geologic Survey) resources and resources and the library of Pacific Coast Land Consulting. The site is located in what is termed Mojave Desert Province of California.

3.1 Regional Geologic Setting

The Mojave Desert province of California is characterized by large lat area of desert, which has been intruded by volcanic, and igneous mountain ranges creating enclosed drainage areas and man playas. Two import fault trends, southeast northwest and an east west, control the topography. This particular site is characterized by a broad expanse of desert with an interior are of small intrusive boulders and locally derived limited are of volcanic scree.

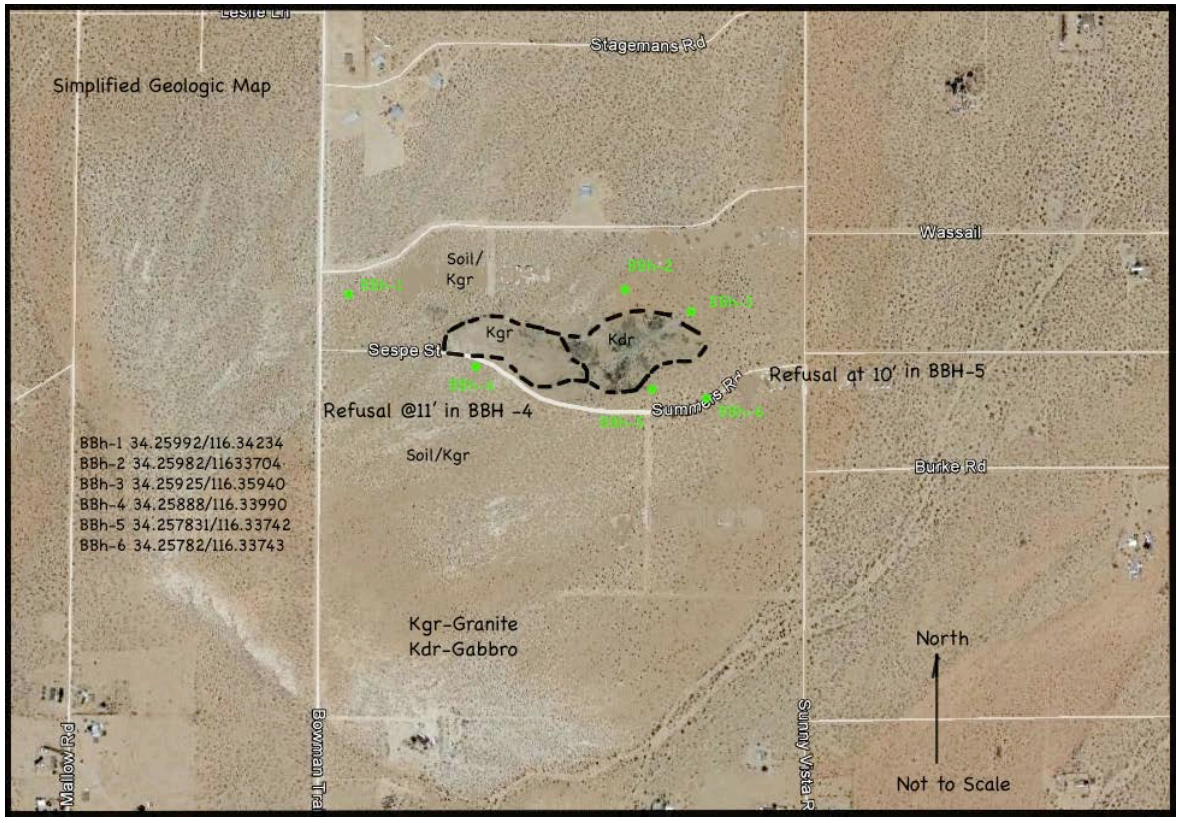


Figure 2 Simplified Geologic Map

3.2 Geologic Units

3.2.1 Topsoil

There is a very sparse layer of topsoil that is badly leached of any organic content that overlies the majority of the site, this material is typically a coarse grained silty sand that may contain small pebbles. The topsoil is a derivative of the underlying granitic rocks.

3.2.2 Granite

Granite is the predominate bedrock on site. This is an intrusive igneous rock that cooled at some depth and slowly allowing the minerals to crystallize into visible size crystals. Mineralogical make-up generally consists of quartz, feldspars, and mica. It is generally weathered and easily penetrated to depth of 15 to 20 feet except when close to the central outcrop of the site. The granite is fairly typical of the area and consists of coarse-grained (phaneric) rock with high contents of quartz and feldspar giving it the light grey appearance. Locally the material outcrops near the center of the site and is direct contact with gabbro.

3.2.3 Gabbro

Gabbro is a dark grey-to-grey black phaneric rock. It is the igneous equivalent of basalt the most common of lava flows. The dark grey color comes from the abundance of pyroxene, plagioclase (feldspar), amphibole, and olivine. It forms a dense rounded outcropping of rocks near the center of the site. Soils derived form this are more reddish brown.

3.3 Mineralogy

The minerals on site are of the most common on earth. There were no indications that any of the bedrock has any significant economically important or valuable deposits of minerals precious or otherwise.

3.4 Groundwater

Groundwater was not encountered during drilling operation on site to the depths explored. Groundwater (based upon personal communication with the Joshua Tree National Park Science officer is anticipated to be on the order of 300 feet in depth and is not a factor in the proposed project.

3.5 Site Stability

There are no issues with slope stability on site**.** No instances of expansive soils were encountered. There is not an abundance of loose surficial soils on site.

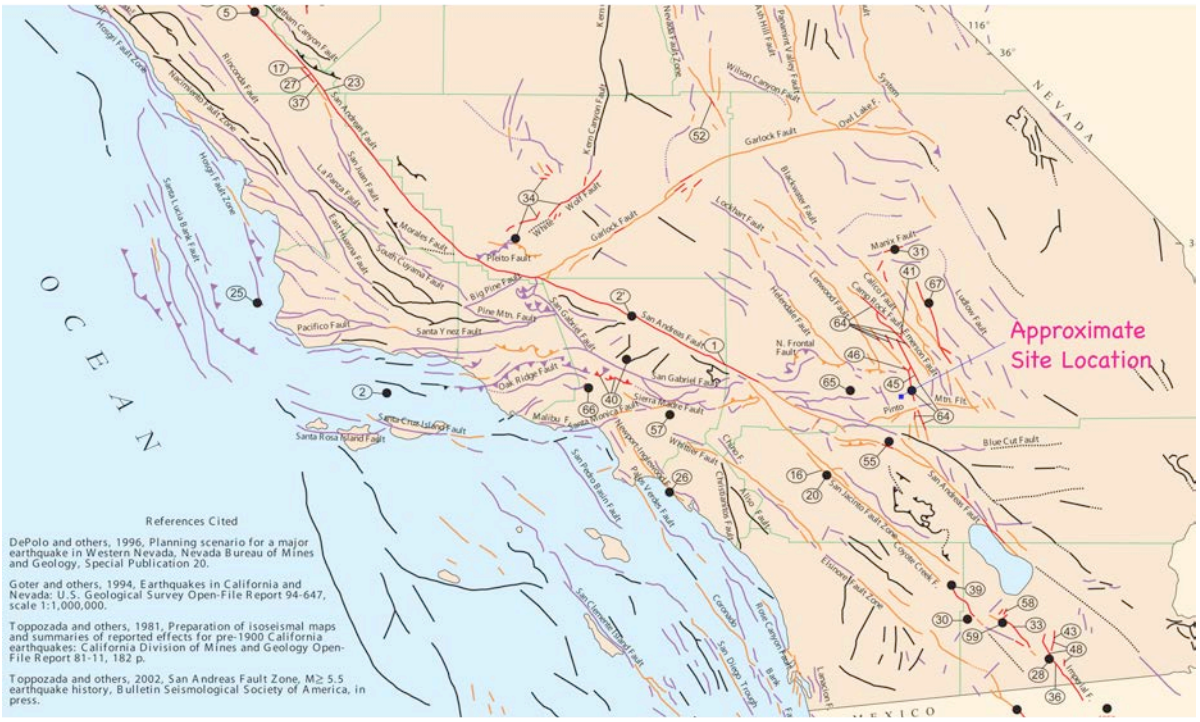
3.6 Seismicity

3.6.1 Fault Locations

There are several major active faults with relatively close proximity of the site.
The site is in close proximity to the San Andreas Fault zone. As such the sit will experience major ground shaking during the life of the structures. This kind of ground shaking can affect significant deposits of loose surficial soils or fine grained ands and silts with high ground water. The terms that describe this are dynamic settling and liquefaction. This site is not subject to either phenomenon.

Table 1 Distance to Major Faults

San Andreas ……9 mi
San Jacinto……..41 mi
Elsinore……...57 mi



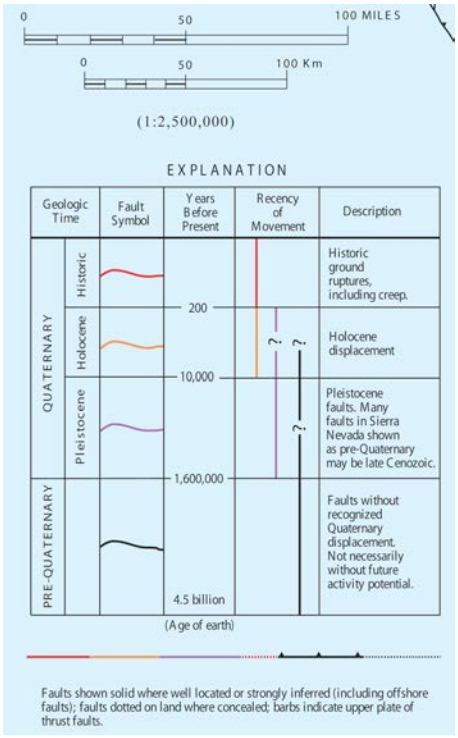


Figure 3 Fault Map of Southern California

Table 2: Probabilistic Seismic Hazards Mapping Ground Motion

User Selected Site

Longitude	-116.3427
Latitude	34.2652

Ground Motions for User Selected Site

Ground motions (10% probability of being exceeded in 50 years) are expressed as a fraction of the acceleration due to gravity (g). Three values of ground motion are shown, peak ground acceleration (Pga), spectral acceleration(Sa) at short (0.2 second) and moderately long (1.0 second) periods. Ground motion values are also modified by the local site soil conditions. Each ground motion value is shown for 3 different site conditions: firm rock (conditions on the boundary between site categories B and C as defined by the building code), soft rock (site category C) and alluvium (site category D).

Ground Motion	Firm Rock	Soft Rock	Alluvium
Pga	0.383	0.387	0.425
Sa 0.2 sec	0.91	0.932	1.021
Sa 1.0 sec	0.336	0.417	0.506

4.0 FINDINGS

- ***The site is underlain by granitic rock***
- ***The rock may be excavated with conventional equipment***
- ***Drill depths of 20 feet can be easily reached in most areas***
- ***No groundwater was present in any borings***
- ***There are no indications of active faulting on site***
- ***There are no indications of valuable mineral resources on site***
- ***The site will experience sever ground shaking***
- ***Conditions are not suitable for the site to experience dynamic settling or liquefaction***
- ***The soils types should not present issue of corrosion, pending results of laboratory testing***

4.0 CONCLUSIONS

The site is suitable for the proposed improvements. It is understood that the preferred method for supporting the solar cells is via pile driving. In some instance there may be a requirement to rock bolt or pre-dill holes for concrete piles. The following conclusions are presented:

- **Soil types encountered consisted of naturally occurring, loose silty sands overlying granitic rocks, which are locally dry to damp and slightly porous in the upper 2 feet.**
- **Non-expansive soils were present on the site.**
- **Minor grading may be anticipated to be required as a part of the preparation of this site.**
- **No critical structures are currently anticipated therefore simple adherence to grade is acceptable.**
- **The site should be easily excavated with conventional equipment**
- **The contractor should verify ability to drive piles.**
- **There were no signs of gross instability on the site and it is considered extremely unlikely that any will develop.**
- **The site design should take into account the seismic activity in the region.**
- **The structural engineer in accordance with the parameters presented herein should design all foundation systems and / or retaining walls systems.**
- **All foundations shall bear in similar materials I.E fill or firm natural ground as determined by the engineering geologist.**
- **Any predrilled piles should be tested for pullout resistance.**
- **The structural engineer should design all support foundations whether driven, predrilled or rock bolted to withstand the wind and seismic forces as shown in the California Building Code 2007 edition chapter 6 section 1609.**

5.0 RECOMMENDATIONS

The following recommendations have been prepared to assist the builder, other professionals, and the contractor in the completion of their duties. Conditions have been anticipated that will likely be encountered during the project have been addressed. If certain conditions are encountered which are not provided for herein then this office should be immediately contacted for further assessment.

5.1 Seismic Considerations

Seismic design considerations are presented in accordance with CBC 2007 edition. This site is in an area with a constant spectral response acceleration of 60%. The seismic design considerations are as follows:

Site Class	**A**
Occupancy Category	**I**
S_s from map 1613.5(3)	**1.3**
S_1 from map 1613.5(4)	**.90g**
Value of site coefficient F_a	**0.8**
Value of site coefficient F_v	**0.8**
S_{DS}=2/3 (S_{ms})	**0.76**

5.2 Soil Bearing Parameters

The Chapter , 18 California Building Code provides parameters, which are appropriated for use in design of new foundations. The analysis of the soils encountered during the investigation indicates that these parameters are appropriate for use in the design of the structure as described.

These parameters are summarized in the tables below:

Table 1804a.2

- Allowable Bearing granite rock ..... 12,000 psf
- Coefficient of friction …….0.7
- Lateral bearing psf/f below grade……1200psf

5.3 Concrete Design

The project structural engineer shall design all concrete in accordance with the seismic parameters. The requirements shall in no case be less that the outlined parameters below:

- Minimum Thickness of Slab on Grade..... 4 inches
- Minimum Slab Reinforcement..... #4 rebar at 24" on center each way
- Minimum Footing Reinforcement..... 2 #4 rebar, 1 top and 1 bottom
- Piles (to be designed by the structural engineer)
- Water to Cement ratio……..0.5

Any slabs shall be underlain with 2 inches of sand a plastic vapor retarder and then an additional 6 inches of coarse sand or gravel that shall have no expansive characteristics. The vapor retarder should consist of a minimum of a 10-mil product. In order to prevent punctures to this retarder it may be necessary to place either two layers of 10-mil plastic or to overlay the gravel with a light non-woven filter fabric. The vapor retarder should be properly lapped or otherwise sealed at all splices and properly sealed at all penetrations.

5.4 Concrete and Other Considerations

The slab concrete should have a maximum water/cementatious materials ratio of 0.5. This will help to minimize the potential for shrinkage cracks and moisture vapor migration through the floor slab. It should be understood that by nature concrete cracks and the appearance of a few finer cracks may appear in the slab and that this will not necessarily indicate a problem. Concrete

cracks should be expected. These cracks can vary from sizes that are essentially unnoticed to more than 1/8 inch in width. Most cracks in concrete while unsightly do not significantly impact long-term performance. While it is possible to take measures (proper concrete mix, placement, curing, control joints, etc.) to reduce the extent and size of cracks that occur, some cracking will occur despite the best efforts to minimize it. Concrete undergoes chemical processes that are dependent on a wide range of variables, which are difficult, at best, to control. Concrete while seemingly a stable material also is subject to internal expansion and contraction due to external changes over time

Control joints are more effective the more closely spaced. We would suggest that control joints be placed in two direction spaced the numeric equivalent of two times thickness of the slab in inches changed to feet (e.g. a 4 inch slab would have control joints at 8 feet centers). As a practical matter this is not always possible nor is it a widely applied standard.

5.5 Grading Requirements

Upon completion of a grading plan it should be forwarded to this office for review.

5.6 Standard Grading Recommendations

The contractor shall adhere to the grading guidelines as attached in the appendix of this report. The following steps are a general summation of those guidelines as they affect this proposed work.

1. All unsuitable topsoil and fills are to be removed prior to placing any fill as determined by the engineering geologist.

2. All foundations shall have a minimum embedment depth of 12 inches and be founded in firm natural ground.
3. Areas of cut where a foundation is proposed are do not need to be over-excavated.
4. All soils to be compacted are to be moistened properly to near-optimum moisture content as determined by the maximum dry density.
5. Prior to placement of any fill the exposed keyway bottom or exposed area to receive fill shall be reviewed by an engineering geologist or a geotechnical engineer and approved to receive fill. Prior to placing any fill in the keyway, the bottom shall scarify to a depth of approximately 4 inches.
6. Soils shall be compacted to a minimum of 90% of the maximum dry density at near-optimum moisture content. Soils shall be compacted in thin horizontal lifts, not measuring any thicker than 6 inches in an un-compacted state.
7. As fill elevation rises, the existing fill-suitable natural soils shall be benched into a stair-step manner.
8. The soils shall be tested for compaction as the fill is placed.

5.7 Construction Review

It is required that all footing excavations and grading be reviewed by this office. A review will be performed to determine if the intent of the report has been adequately carried forth.
This office should be notified at least two working days in advance of any reviews of this nature so that staff personnel may be made available.

6.0 DRAINAGE

6.1 Drainage Recommendations

A well thought out and planned drainage system is important because buildup of water can cause many problems including triggering latent or concealed problems. Drainage is only likely to become an issue during rare periods of heavy rainfall. A comprehensive drainage system should be designed and incorporated into the final plans. This system may consist of sheet flow drainage patterns. The site should be well drained.

7.0 GEOTECHNICAL DISCLOSURES

Owners and Buyers should be informed that any proposed buildings, appurtenant structures and improvements may be subject to City or County building permit requirements and could be subject to geotechnical review and possibly special foundation requirements.
Positive drainage should not be blocked by homeowner improvements.
It should be the owner's responsibility to maintain and clean drainage swales and control burrowing animals. In order to be effective, the maintenance should be conducted on a routine schedule, and necessary corrections made prior to each rainy season.

8.0 CLOSURE AND LIMITATIONS

This is a limited investigation for the purpose of providing a report for the new construction. This site was not graded nor constructed by Pacific Coast Land Consulting, Ralph K. Jeffery, and/or any combination of these entities. None of these entities assumes nor accepts any liability whatsoever for work done on this project, not done by these entities.

As a practical matter soils and geologic investigations and studies are considered an inexact science and earth conditions have been known to vary from location to location and with depth. The recommendations contained in this report are considered to be both practical and appropriate for the soils encountered. Typically risk of damage due to soils movement decreases with

increased foundation depths, slab thickness, and steel reinforcement schedules. However cost also goes up dramatically with such increases. It is possible to provide much more rigid recommendations, however the cost could go up dramatically and such recommendations would be beyond the standard of practice in the industry. Other professionals could come to differing recommendations and opinions. No warranty or guarantee is implied nor given as a result of this work.

Appendix

Boring Logs (see figure 2 for Gps and map locations)

BBH-1

0-2' Topsoil: Silty sand light grey dry, coarse grained.
2-15' Granitic rock weather near the surface becomes gradually harder with depth light grey in color

SPT sample at 5'
20 blows -6"
22 blows-6"
32 blows -6"
Hammer weight 140 lbs
TD 15'

BBH-2

0-2' Topsoil: Silty sand light to medium brown gabbro derived dry, medium to coarse grained.
2'-15' Gabbro: Gabbro rock weathered near the surface becomes gradually harder with depth medium grey to brown in color harder at 7 ' light brown to med grey in color
TD 15'

BBH-3

0-1.5' Topsoil: Silty sand light grey to slightly tan dry, coarse grained.
1.5'-15' Granitic rock weather near the surface becomes gradually harder with depth light grey in color @ 10 ' fresher and harder drilling
TD 15'

BBH-4

0-1.0' Topsoil: Silty sand light grey to slightly tan dry, coarse grained.
1.0'-15' Granitic rock weathered near the surface becomes gradually harder with depth light grey in color. Hard zone @4' and @ 10 ' fresher and harder drilling refusal at 11'
TD 11'

BBH-5

0-1.0’ Topsoil: Silty sand light grey to slightly tan dry, coarse grained.

1.0’-15’ Granitic/Gabbro rock weathered near the surface becomes gradually harder with depth light grey in color. Hard zone @7’ and @ 9 ‘ fresher and harder drilling refusal at 10’

TD 10’

BBH-6

0-2.0’ Topsoil: Silty sand light grey dry, coarse grained.

1.0’-20’ Granitic rock weathered near the surface becomes gradually harder with depth light grey in color. Becomes darker grey at 10’- 15’ indicating fresher rock. Hard drilling at 18-20’

TD 20’