

### Geotechnical Exploration, Inc.

SOIL AND FOUNDATION ENGINEERING • GROUNDWATER • ENGINEERING GEOLOGY

06 November 2024

Mr. Richard Lowenthal 1720 Torrey Pines Road La Jolla, CA 92037 Job No. 01-8018

Subject: Response to DSD-Geology Comments

Lowenthal Residential Project 1720 Torrey Pines Road La Jolla, California

Dear Mr. Lowenthal:

At the request of Mr. Connor Patrick of Marengo Morton Architects, Inc. and as required per the City of San Diego DSD Geology reviewer, we are responding to the following issues presented in the Project Issues Report PRJ-1111223 dated September 10, 2024, for the subject project. The issues report is based on our *Update Report of Preliminary Geotechnical Investigation and Coastal Bluff Edge Evaluation*, dated July 3, 2024.

[DSD-Geology Comment 00004| Page| Open]: The architect may need to update the 40-foot and 50-foot bluff setback lines based on the requested update geotechnical report's coastal bluff edge determination.

**9/5/24** This must match the updated bluff edge as requested in this cycle. The bluff edge must match, an interpreted bluff edge from the geotechnical report will not be adequate.

**GEI Response:** The architect will be provided with our updated interpreted bluff edge location as presented in this DSD-Geology Review response report.

[DSD-Geology Comment 00005| Page| Open]: The Architect of work must show the limits of grading on the grading plan. The limits of grading must encompass the limits of recommended remedial grading provided by the project's geotechnical consultant. This must be delineated on the plans with a call out and or symbol.

**GEI Response:** The limits of grading on the grading plan will be provided by the architect following consultation with the project geotechnical engineer.

match the plan orientation; the architect must adjust accordingly. [DSD-Geology Comment 00067| Page| Open]: The north arrow does not appear to

corrected by the project architect. in the geotechnical report. GEI Response: The north arrow orientation is correct on the plan figures provided The north arrow on the architectural plans will be

of environmental review and the following: update letter that specifically addresses the proposed development for the purposes [DSD-Geology Comment 00068| Page| Open]: Submit a geotechnical addendum or

addendum or update letter. GEI Response: This response document will serve as the requested geotechnical

show the limits of grading may impact environmental resources on the site. geologic/geotechnical map. [DSD-Geology Comment 00069| Page| Open]:If remedial grading is recommended, the limits of the Note, the geotechnical consultant should determine if recommended remedial grading 9 an updated

environmental resources. on our review of the current project plans, the limits of grading will not impact made available will also be shown on an updated geologic/geotechnical map. **GEI Response:** The limits of grading to be shown on the architectural plans when Based

base topography to the newest date. on the geotechnical map is the most recent topographic survey, if not update the [DSD-Geology Comment 00070| Page| Open]: Please clarify if the base topography

of current topography to the northeast and east across the coastal canyon centerline property is from the most recent topographic data available, a survey by Precision information added to the northwest, northeast, southwest, and southeast of the most recent topographic survey available, dated December 5, 2023. The topographic canyon bottom. (Refer to **Appendix A**, the 1851-1889 map). California Coast, T Sheets 1851-1889, matches the 1979 mapped topography of the canyon bottom topography from the U.S. Coast Survey Maps of California, South is derived from City of San Diego Orthophotographic Map Sheets (La Coordinates 246-1683, 246-1689, 250-1683, and 250-1689) dated 1979. Survey and Mapping dated August 1999. The most recent information for extension GEI Response: The base topography within the project property lines is from the Sheets (Lambert



updated geotechnical map with the additional topographic data. topography 50 feet outside of the property line to the northeast. Please provide an [DSD-Geology Comment 00071| Page| Open]: The geotechnical map must show

topography on the subject project as well as across the canyon. outside the property line on the updated plot plan included in this response document. as well as the 1851-1889 maps to add topography for an additional 50 feet or more Survey maps (Lambert Coordinates 246-1683, 246-1689, 250-1683, and 250-1689) utilized topographic information provided on the 1979 City of San Diego Topographic property line, and did not clearly show the canyon bottom topography. We therefore the northwest-draining canyon bottom but did not extend 50 feet beyond the The above-referenced maps were utilized to show pre-grading and post-development GEI Response: The first two topographic sources (referenced above) did include

of safety on an updated geotechnical map. [DSD-Geology Comment 00072| Page| Open]: Show areas with less than a 1.5 factor

safety below 1.5 following project completion. Refer to Appendix H for the slope steepest rear yard slope perpendicular to the topographic contours, there are no new H-H' cross section (see Appendix G of this response), which extends down the stability analysis performed along the H-H' cross section. locations within the proposed project construction area that will possess a factor of report dated July 3, 2024, and additional slope stability analysis prepared along our **GEI Response:** Utilizing the slope stability analysis presented in Appendix F of our

"in our professional opinion, no active or potentially active faults or landslides underlie the site in the proposed construction areas." Please clarify if potentially active faults evaluation, they should be plotted on an updated geotechnical map. required. If potentially active faults were observed in the coastal bluffs or subsurface [DSD-Geology Comment 00073| Page| Open]: The geotechnical consultant indicated part of the parcel, indicate if they are hazardous and if

and Geotechnical Map (Appendix C). As shown on Appendices B and C, the mapped the mapped Zone 12 fault and zone locations on Figure No. II, the updated Geologic crosses the northern rear yard portion of the subject property. We herein provide northwesterly draining canyon centerline. The south-southwest Zone 12 boundary bluff face fault exposure is located approximately 100 feet to the northeast of the mapped section of a Zone 12 fault coming onshore on the northeast side of the Diego Geologic Hazards and Fault Map (attached as Appendix B) shows a short, GEI Response: On Figure No. VI from our July 3, 2024, report, the City of San



face exposure and is not overlain by old enough geologic units to allow comment on southwest zone boundary does not extend to the footprint of the proposed home. boundary of the fault zone is approximately 10+ feet north of the home. proposed home and on the northeast side of the coastal canyon. classification as potentially active. The fault is mapped as concealed to the southeast beyond the actual Point Loma bluff The southwest

feet, the outcrops are fully exposed for geologic evaluation. We provide herein as the northeast and southwest. Due to their heights above beach level, i.e., 20 to 50 surface at low tide across the entire width of the property and extending beyond to bedding is exposed in the lower portion of the bluff as well as the off-shore planated on the property beginning in 2002, southwesterly dipping Point Loma formation property. As observed from the beach and offshore at low tide during our prior work home reveal that no active or potentially active faults cross any portion of the subject photos were originally taken in 1999. Appendix D, Photo Nos. 1 and 3 of Appendix E from our July 3, 2024, report. The More importantly, Point Loma Formation geologic outcrops in the bluff face below the

our conclusion and professional opinion that no active or potentially active faults cross clear and conclusive information is available from fault investigations. It is therefore active or potentially active faulting crosses the property. It is very seldom that such mapped on the southwest across the front of the subject property, indicates that no on the northeast side of the canyon and no faulting or fault-related shearing was the subject property. The fact that faulted Point Loma Formation was mapped only in the bluff exposure

[DSD-Geology Comment 00074] Page Open: Cross section B and Cross section F, the bluff edge will need to be determined using the "simple bluff – multiple step 25 & 40 foot setbacks as necessary. method from Coastal Bluffs and Beach Guidelines. Please adjust the bluff edge and

than the bluff inclination criteria presented in the Coastal Bluffs and Beach Guidelines. warranted. The slope inclinations on cross sections B-B' and F-F' are much shallower definition of a Coastal Bluff as presented in the Coastal Bluffs and Beach Guidelines. and bluff edge topographic break on cross sections B-B' and F-F' does not meet the F-F' to show the average slope and step face inclinations, neither of which meet the We have used larger scale excerpts from the northern ends of cross sections B-B' and Therefore, use of the "Simple Bluff – Multiple Step" method of evaluation is not **GEI Response:** The existing slope face rising from the more well-defined bluff face



Coastal Bluffs and Beach Guidelines definition as a coastal bluff (refer to cross sections  $B_b$ - $B_b$ ' and  $F_f$ - $F_f$ ' in **Appendices E and F**). Furthermore, we have prepared an additional cross section, H-H' (**Appendix G**), oriented perpendicular to the topographic contours and directly downslope to the northeast and provide slope inclination information as on Section  $B_b$ - $B_b$ ' and  $F_f$ - $F_f$ ' (**Appendices E and F**).

We note that upon review of the U.S. Coast Survey Maps of California, South California Coast T-sheets 1851-1889, T-2013 (**Appendix A**) and comparison with existing topography, it becomes clear that significant fill soils have been placed on the northeastern half of the lower elevation yard area. We have added the limits of fill to our updated Geologic and Geotechnical Map (**Appendix C**) and included the fill configuration on our new cross sections  $B_b$ - $B_b$ ' and  $F_f$ - $F_f$ ' (**Appendices E and F**, respectively), H-H' (**Appendix G**), and extended cross section  $E_e$ - $E_e$ ' (**Appendix I**).

On the **Appendix C** map, we indicated the location of fill soil depths ranging up to 10 feet on the northwesterly, northerly, and northeasterly descending slopes. The depths, also shown on **Appendices E, F, G, and I** cross sections, are based on our analysis of overlain pre- and post-development topographic contours as well as data from boring logs and handpit excavations. It is clear from the pre- and post-development topographic contour overlay analysis that the northwesterly, northerly, and northeasterly hillsides descending from the relatively level pad are comprised of fill soils up to 12 feet thick overlying a subaerially eroded coastal canyon side wall surface. Refer to **Appendix J** for a 1972 aerial photo from offshore of the vegetation-covered hillside prior to fill placement that depicts a concave geomorphic configuration.

As presented in the Bluff Recession and Sea Level Rise (SLR) report provided by Dave Skelly dated October 18, 2024 (refer to **Appendix K**), the project bluff would be classified as  $C_c$  (marine erosion is equal to sub aerial erosion) per Figure 1 of "A Primer in Coastal Bluff Erosion" by Mark Johnnson, CCC Staff Geologist. Mr. Skelly assigned this classification under the assumption that the convex topographic surface of the slope that rises from the distinct top of Point Loma Formation bluff face was a natural Marine Terrace (Qbp/Qop6) slope face. Since preparation of Mr. Skelly's report, our extensive analysis of pre-development versus post-development topographic contours on the property revealed that a significant depth of fill soils up to 12 feet in thickness overlies the north, northeastern, and eastern portion of the property depicted in the 1972 photo (**Appendix J**).



classified as  $C_d$  (marine erosion is less than sub aerial erosion). document, the project slopes down to the Point Loma Formation bluff face would be erosional surface underlying the fill soils. Based on Figure 1 of the Mark Johnnson excavations by this firm and others, revealed a distinct convex natural hillside Our cross sections provided in Appendices E, F, G and I, as well as exploratory

eroded side wall of the coastal canyon that drains to La Jolla Cove. The steepest 32and Beaches Guidelines criteria as a coastal bluff, and is indicative of a subaerially slope inclinations on the natural ground surface that underlies the mapped fill soils. intersection with the point of coastal canyon discharge into La Jolla Cove. degree slope occurs at the north end of cross section H-H', which terminates at its 5.2:1.0 to 1.6:1.0 (horizontal to vertical), which does not meet the Coastal Bluffs As shown on the cross sections, slope inclinations range from 10 to 32 degrees, We provide on Appendices E, F, G and I cross sections, a graphical depiction of

Road approximately 500 feet west of the subject property. pedochronological investigation and dating of the soils Furthermore, refer to our response to Comment 00077 wherein we discuss the  $(\mathsf{Qbp}/\mathsf{Qop}_6)$  slope down to the Point Loma Formation bluff edge at 1640 Torrey Pines on the Marine Terrace

eroded coastal canyon side wall overlain by up to 12 feet of fill soils. sections, and as shown on the 1972 aerial photo (Appendix J), consists of subaerial Formation bluff edge topographic break as shown on our expanded and new cross In conclusion, the rising natural ground surface above the more obvious Point Loma H' (as well as on our updated geologic/geotechnical map), are correct as presented. locations, adjusted to the north as presented on cross sections  $B_b$ - $B_b'$ ,  $F_f$ - $F_f'$ , and H-We, therefore, respectfully opine that our bluff edge and 25- and 40-foot setback

refer to the pedochronological report by Glen Borchardt, Appendix L. the age dating of the aerially eroded marine terrace slope faces rising from Point 00077 concerning erosional recession rates. Refer to the discussion of hillside/slope face pedochronological dating under Issue Loma Formation bluff edge along the subject property section of La Jolla coastline, For additional information concerning

north to demonstrate the coastal canyon walls [DSD-Geology Comment 00075| Page| Open]: Please extend cross-section E to the



section, bedding dips are into the southeast wall of the coastal canyon. We are walls and to include the fill soils configuration. We note that as shown on the cross cross section E-E' to the north-northeast to more clearly depict the coastal canyon the updated geotechnical map (Appendix C) provided in this report, we extended providing the extended E<sub>e</sub>-E<sub>e</sub>' cross section as **Appendix I**. GEI Response: Upon update of site topography with extension to the northeast on

southern property line is required. Trending approximately E-W. [DSD-Geology Comment 00076| Page| Open]: An additional cross-section along the

dips are into the southeast canyon wall. as Appendix M. The northeast portion of the cross section includes the coastal canyon walls. map, we are providing cross section I-I', which parallels the southern property line GEI Response: Utilizing the additional topography on the updated geotechnical As stated above and as shown on the new I-I' cross section, bedding

predicted recession rate of 0.17 feet per year, or 12.75 feet in 75 years. erosional rate was determined. [DSD-Geology Comment 00077| Page| Open]: Please clarify how the site-specific Which data was used to determine the conservative

end of the range, 0.17 feet per year or 12.75 feet per 75 years for use on the subject and Measurable Erosion Rates of Sea-Cliff Recession provided in our July 3, year, or 3 to 12.75 feet per 75 years. We elected to assign the conservative high conditions to consider the validity of a recession rate range of 0.04 to 0.17 feet per Kennedy (1973) as well as the 1999 work by Southern California Soil and Testing GEI Response: As described in Section XII, Coastal Bluff Evaluation, Part G, Historic (SCS&T), which included review of several reports by others with similar geologic report, we relied on studies of Cretaceous rock erosion rates by Emery (1941) and

approximately 40 feet in height and descends at vertical to 0.5:1.0 (horizontal to high tide and storm wave impact. vertical) directly down to the beach. property, we performed a coastal bluff edge investigation at 1640 Torrey Pines Road, Approximately 3 years after our original work on the 1720 Torrey Pines approximately 500 feet to the west. The bluff face is fully exposed to northwesterly The bluff face at that location is



showing the septic tank bluff top location and a photograph taken from the beach our work at the toe of the Bay Point slope and top edge of the Point Loma Formation portion failed onto the beach. inset into the cross-section figure showing the septic tank remnant after the outer Refer to Appendix N, the B-B' cross-section from our February 25, 2005, constructed on the bluff edge to discharge sewage directly onto the beach below. located just above the remnants (Kp) bluff face, we recovered a ceramic ant trap patent dated 1926 below hillside descending to the bluff edge. The home at the top of the Bay Point bluff face erosion rate as well as the fact that more gentle sloping marine terrace Our investigation provided physical evidence as to the fully exposed, unprotected  $(\mathsf{Qbp}/\mathsf{Qop}_6)$  marine terrace slope face was built approximately 100 years ago.  $\, \mathsf{During} \,$  $(\mathsf{Qbp}/\mathsf{Qop}_6)$  above the Point Loma Formation  $(\mathsf{Kp})$  bluff edge is a subaerially eroded of a red brick septic tank, which had been

0.04 to 0.17 feet per year range presented in our report and equates to 4.69 feet in in 100 years or approximately 0.0625 feet per year. This is at the lower end of the receded approximately 6.25 feet since tank construction. wall on the northwest side of the remaining bricks indicate that the upper bluff edge recommended retreat. feet in 75 years bluff retreat presented in the Skelly report (Appendix K) as our and 12.75 feet per 75 years recession to be very conservative, we will adopt the 14 75 years. Although we still consider our assigned 0.17 feet per year recession rate As depicted on the cross section, the failed septic tank and a remnant canyon side This equates to 6.25 feet

soils now overlook the Pacific Ocean, they developed within the zone defined by the developed after the down cutting of the adjacent coastal stream. Although these normally would be found on a rapidly eroding coastal bluff. There is no way that the concluded "CONCLUSIONS - The soils examined are magnitudes older than soils that investigation, we retained Mr. Glenn Borchardt to perform a pedochronological 5Crtb2 horizon could have formed without it being the remnant of a former soil that weathered subaerially eroded coastal stream canyon side wall. Mr. Borchardt (Qbp) slope that extends to the bluff edge is not a as **Appendix L**), the soil profiles, profile 1 and profile 2, indicate that the Bay Point bluff edge below the existing home. Based on Mr. Borchardt's evaluation (attached investigation of the marine terrace slope that descends to the Point Loma Formation Hillside/Slope Face Pedochronological Dating: As part of our 1640 Torrey Pines Road Please refer to Mr. Borchardt's full report presented herein as Appendix L. coastal bluff but a deeply



geomorphologically to be due to subaerial erosion and surfaces underlying the fill soils reveals the surfaces are convex in profile and Analysis of our several cross sections defining the configuration of the natural ground soils placed at some time prior to the City of San Diego 1979 orthophoto mapping. marine terrace deposits and Point Loma Formation overlain by up to 12 feet of fill considered to be sloping Bay Point (Qbp/Qop<sub>6</sub>) Marine Terrace materials, are in fact, exposed Point Loma Formation bluff face exposures and have previously been and analysis of historic predevelopment and existing conditions topographic maps Summary Conclusions: revealed that the northerly, northeasterly, and easterly slopes that descend to the In summary, our review of all exploratory excavations data not coastal recession

addition, we provide on the revised map, mapped fill soils that thicken to the north, foot setbacks. We also show a 5-foot setback and 14-foot bluff retreat setback. In building pad. northeast and east from a daylight line crossing the approximate middle of the lower Based on our findings we have updated our Geologic and Geotechnical Map (Appendix C) showing a corrected bluff edge alignment with the 25-, 40- and 50-

the Bluff Edge and Historical Retreat Report by Mr. Dave Skelly, dated October 18, we could have reduced or assigned 12.75 feet of recession over a 75-year period. evaluation and recession evidence for 1640 Torrey Pines Road, 500 feet to the west, 2024. Please refer to the full report provided as **Appendix K**. However, we are accepting the 14 feet per 75-year recession rate as presented in Based on our initial document research on bluff recession, as well as our bluff

# **LIMITATIONS**

generally accepted principles and practice in the field of geotechnical engineering within the City of San Diego. No warranty, either expressed or implied, is made. The findings and opinions presented herein have been made in accordance with



If you have any questions regarding this letter, please contact our office. Reference to our **Job No. 01-8018** will help expedite a response to your inquiry.

Respectfully submitted,

#### GEOTECHNICAL EXPLORATION, INC.

Leslie D. Reed, President

P.G. 3391/C.E.G. 999

Jaime A. Cerros, P.E. R.C.E. 34422/G.E. 2007 Senior Geotechnical Engineer



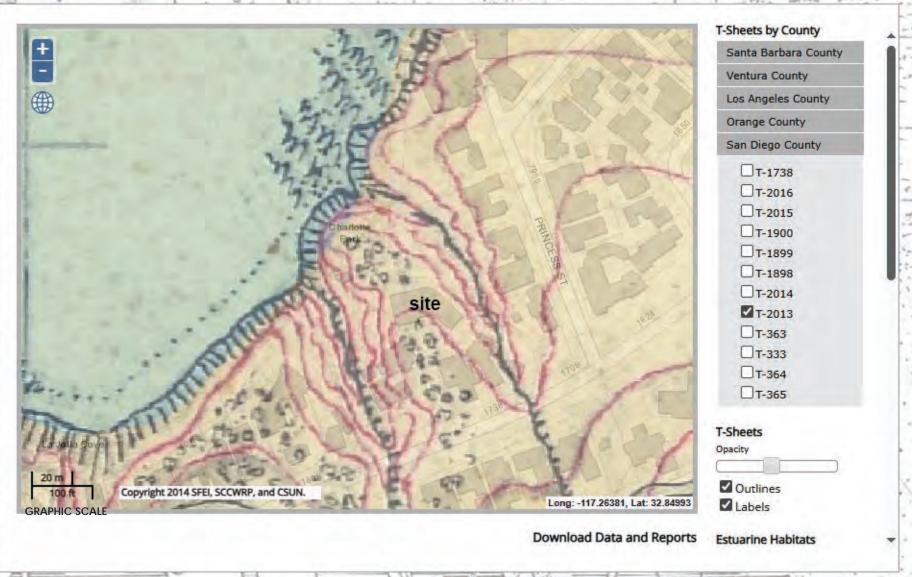


#### **APPENDICES**

- A. U.S. Coast Survey Maps of California, South California Coast T-sheets 1851-1889, T-2013
- B. City of San Diego Geologic Hazards and Fault Map
- C. Updated Geologic and Geotechnical Map
- D. Photos 1 and 3 of Appendix E
- E. Cross Section B<sub>b</sub>-B<sub>b</sub>'
- F. Cross Section F<sub>f</sub>-F<sub>f</sub>'
- G. Cross Section H-H'
- H. Slope Stability Analysis
- I. Cross Section E-E'
- J. 1972 Aerial Photo
- K. Bluff Edge and Historical Retreat Report Review by Mr. Dave Skelly dated October 18, 2024
- L. Report by Mr. Glenn Borchardt
- M. Cross Section I-I'
- N. Cross Section B-B' from our February 25, 2005, report showing the septic tank bluff top location and a photograph taken from the beach

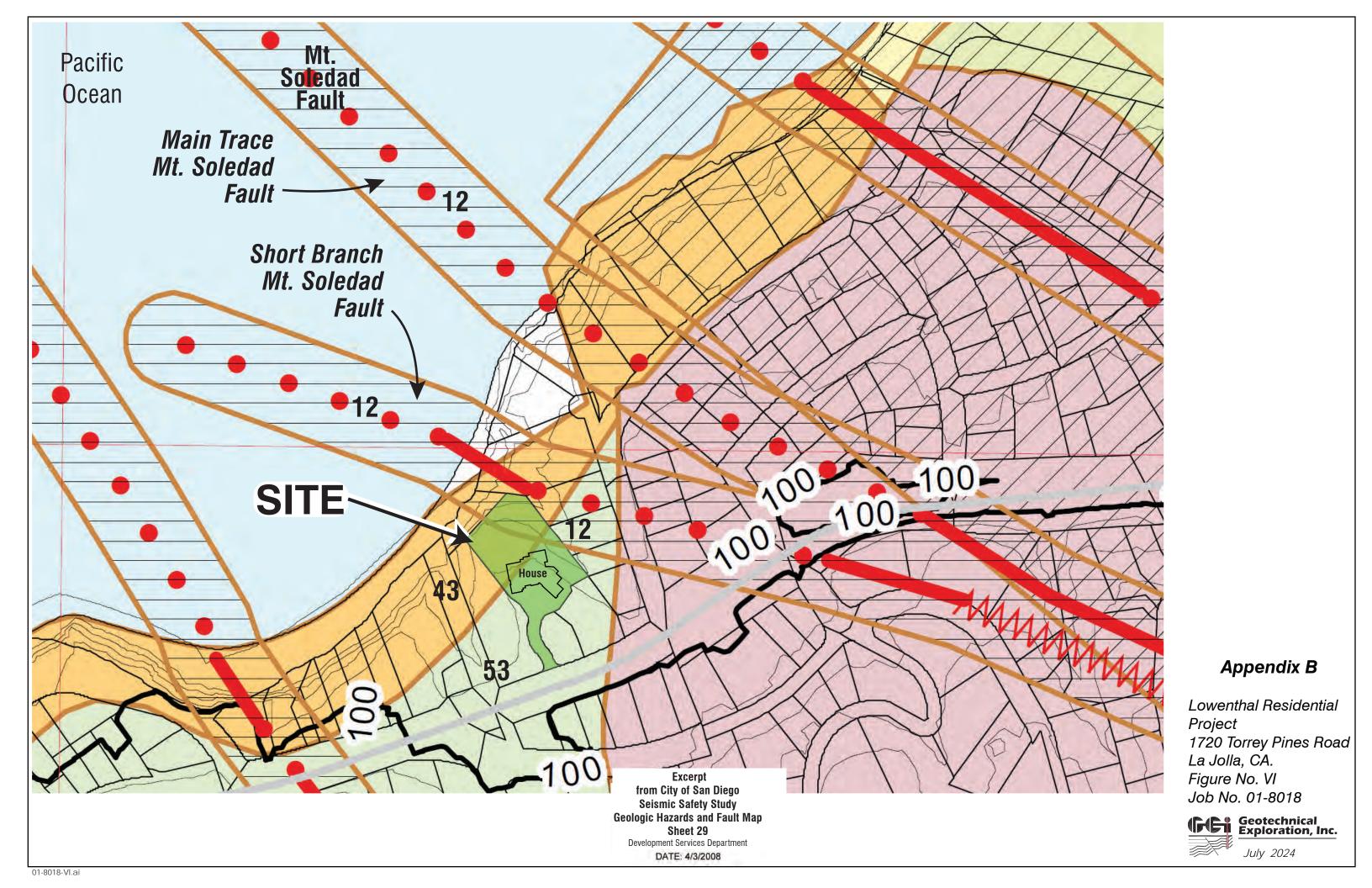


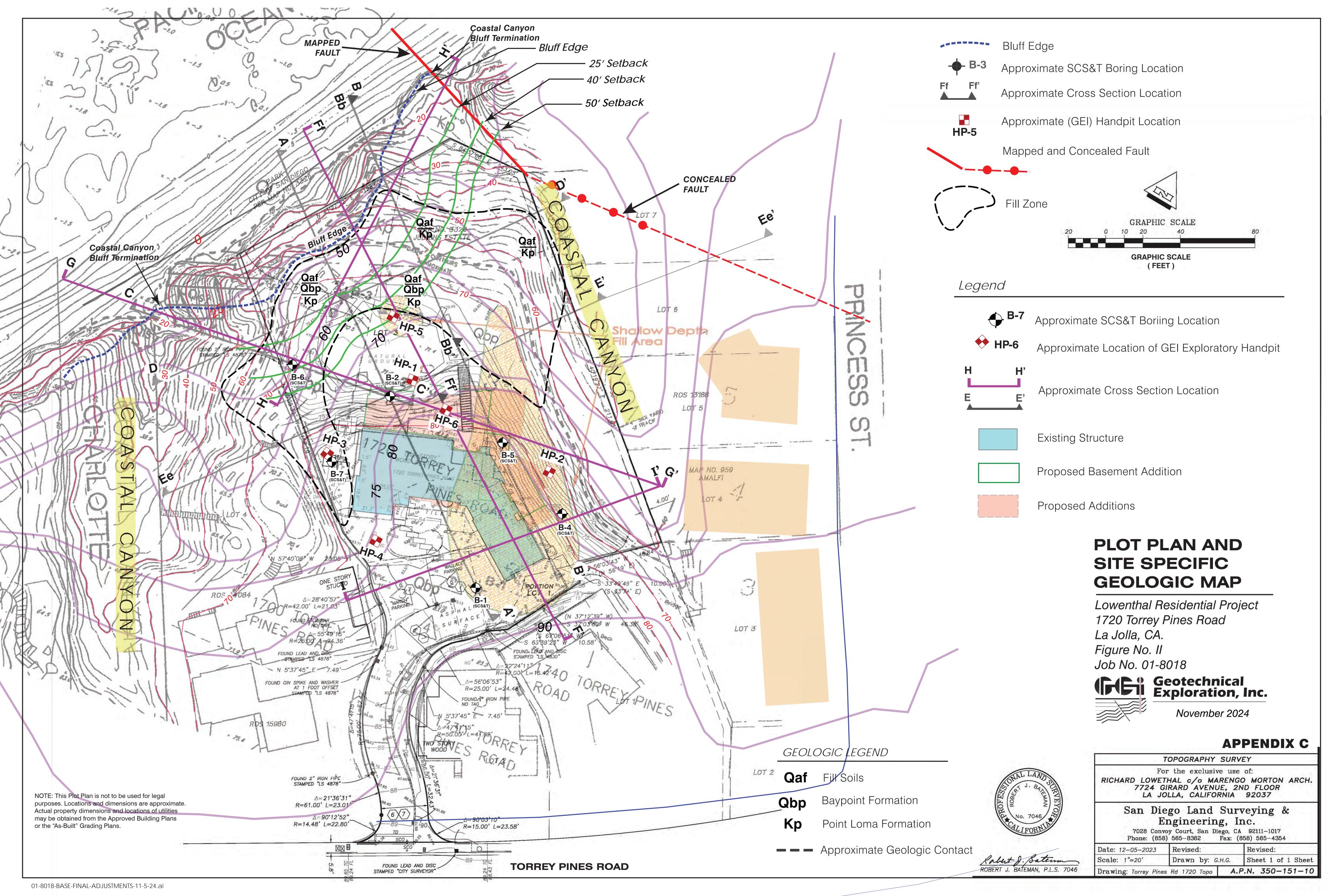
# U.S. COAST SURVEY MAPS OF CALIFORNIA Southern California Coast T-Sheets (1851-1889)



Appendix A Job No. 01-8018





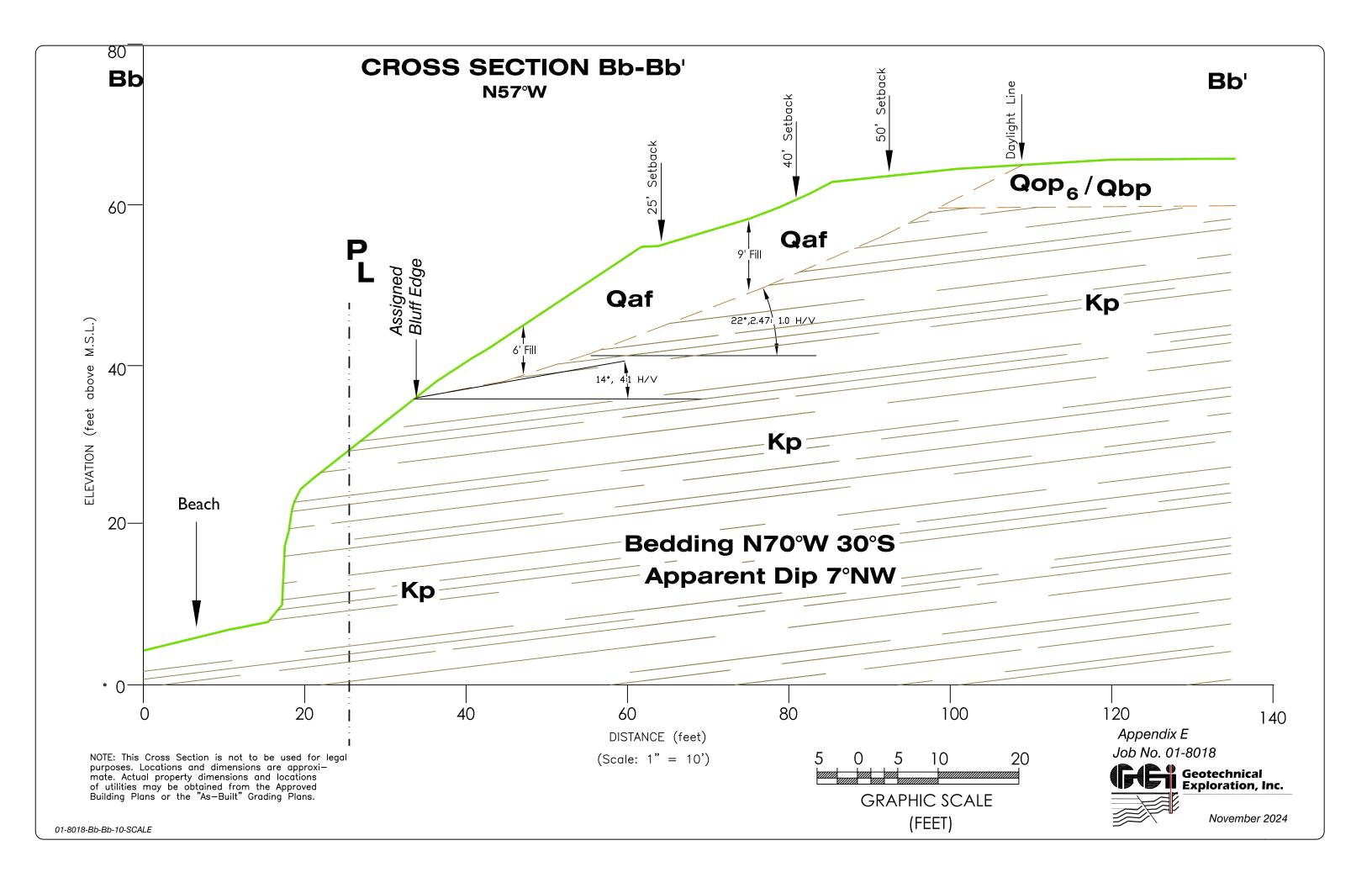


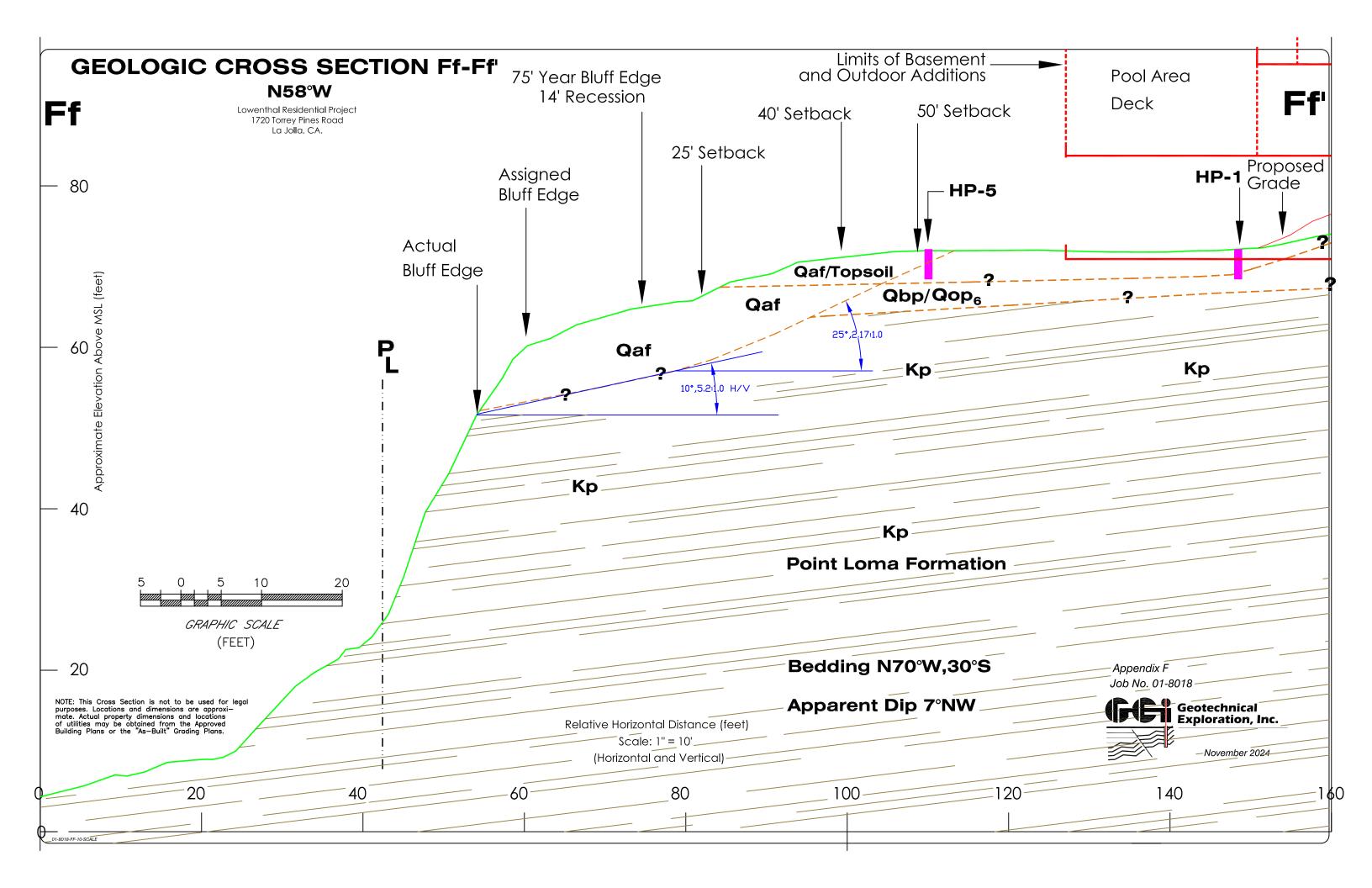


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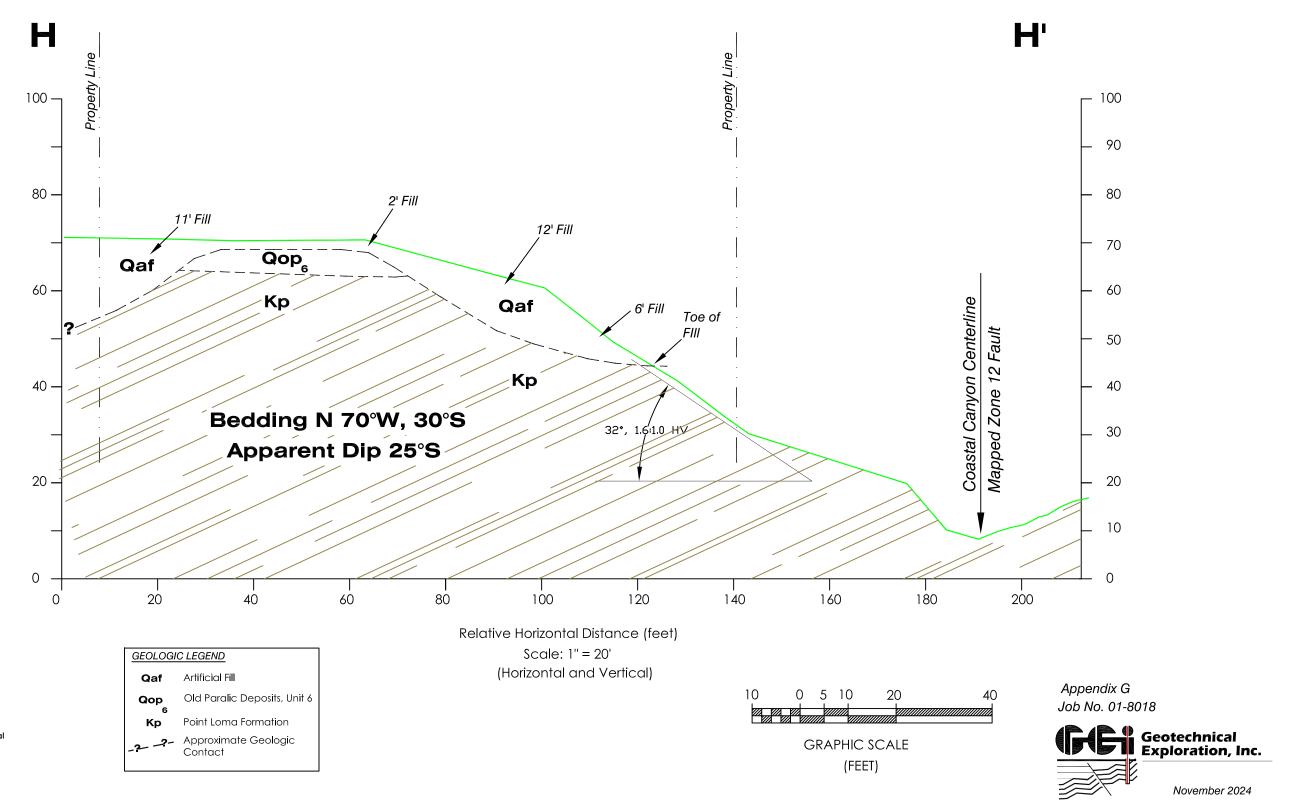
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## GEOLOGIC CROSS SECTION H-H'

Lowenthal Residential Project 1720 Torrey Pines Road La Jolla, CA.



NOTE: This Cross Section is not to be used for legal purposes. Locations and dimensions are approximate. Actual property dimensions and locations of utilities may be obtained from the Approved Building Plans or the "As—Built" Grading Plans.

01-8018-HH.dwg

#### APPENDIX H

#### SLOPE STABILITY CALCULATIONS WITH SLIDE 6 COMPUTER PROGRAM

Lowenthal Residence
Job No. 01-8018

We performed gross slope stability calculations using the *SLIDE 6* program by Roc Science. The program is a limit equilibrium method, slope stability program that allows the use of several slope stability methods to calculate the factors of safety against shear failure. On this project, the Bishop Simplified method was used as the basis for calculations when using circular surfaces for the analyzed site geologic cross section.

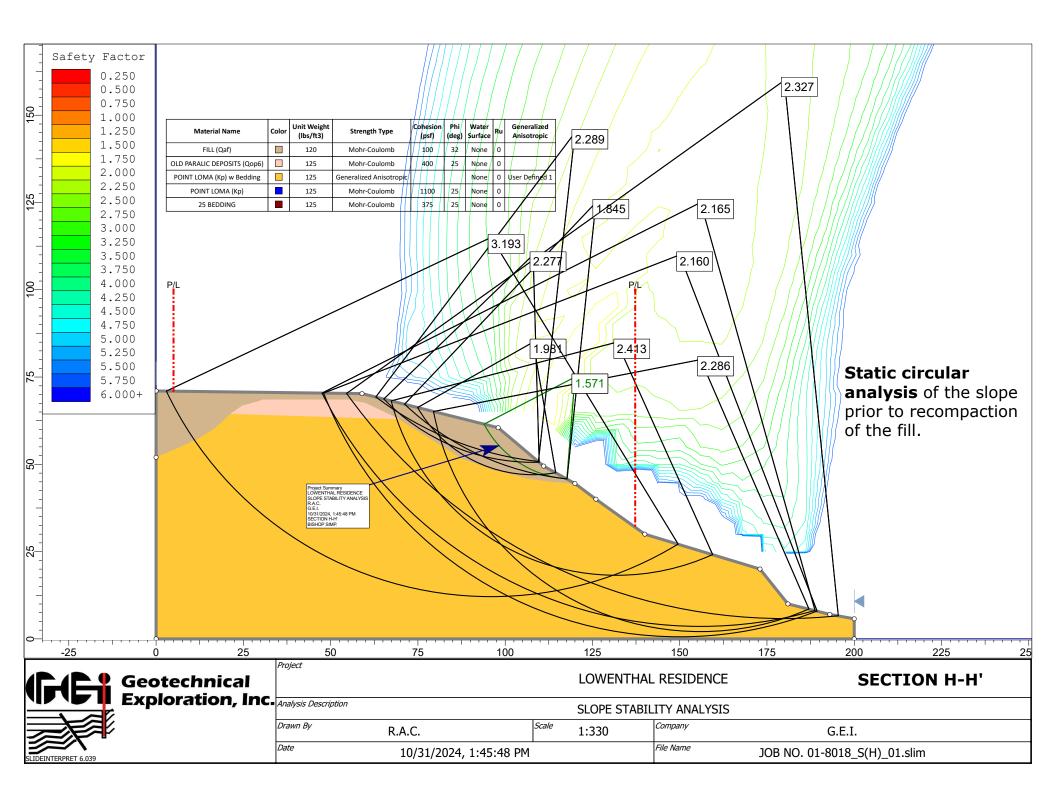
The program calculates the factor of safety against shear failure for potential slide surfaces over a selected range. We chose the range of slide surfaces where failures are most likely to occur. When analyzing the circular surfaces, the printout shows a block with contours of different colors and shades that correspond to the different factors of safety calculated that can be obtained for the analyzed range of slide surfaces for Section H-H', which include the most unfavorable slope conditions at the site (see attached printouts). The green circular surface displayed in the printout is the lowest/ minimum possible factor of safety value located within the specified search range of the cross-section analysis. Soil strength values, geometry, and water conditions (seepage was not encountered) used in the program were based on geological information from the site, also used in our previous report. Direct shear strength values were conservatively adjusted.

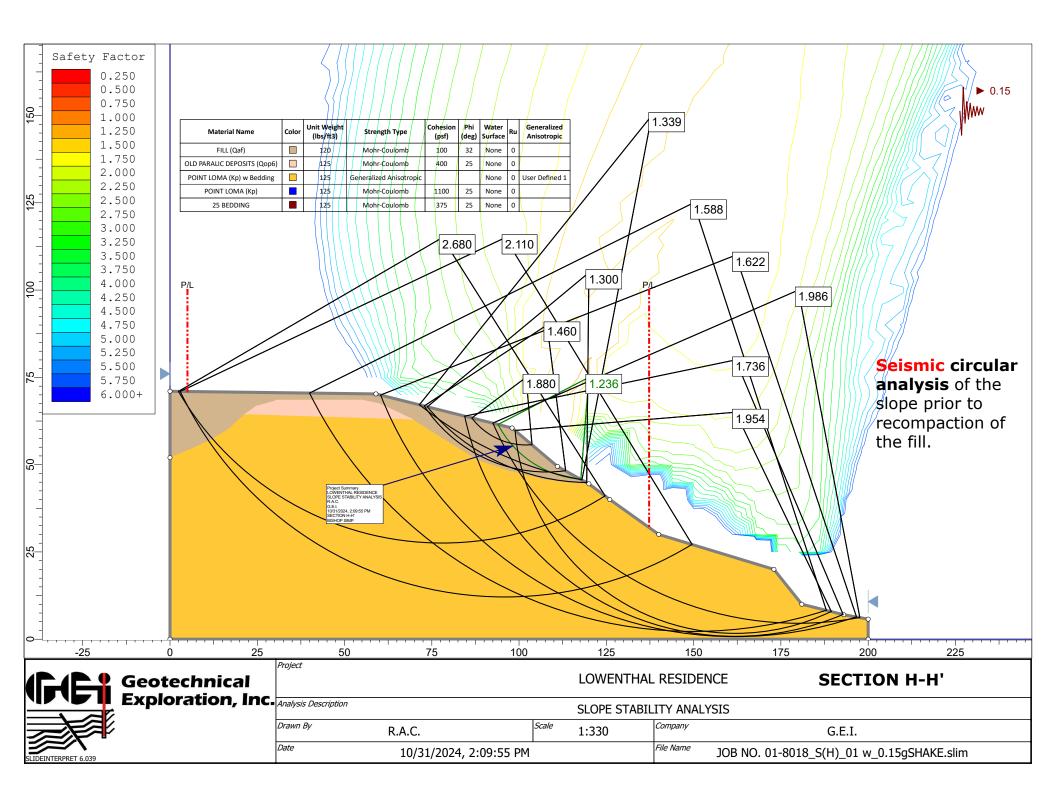
The static circular global stability factors of safety were calculated and yielded a factor of safety value greater than the acceptable value of 1.5.

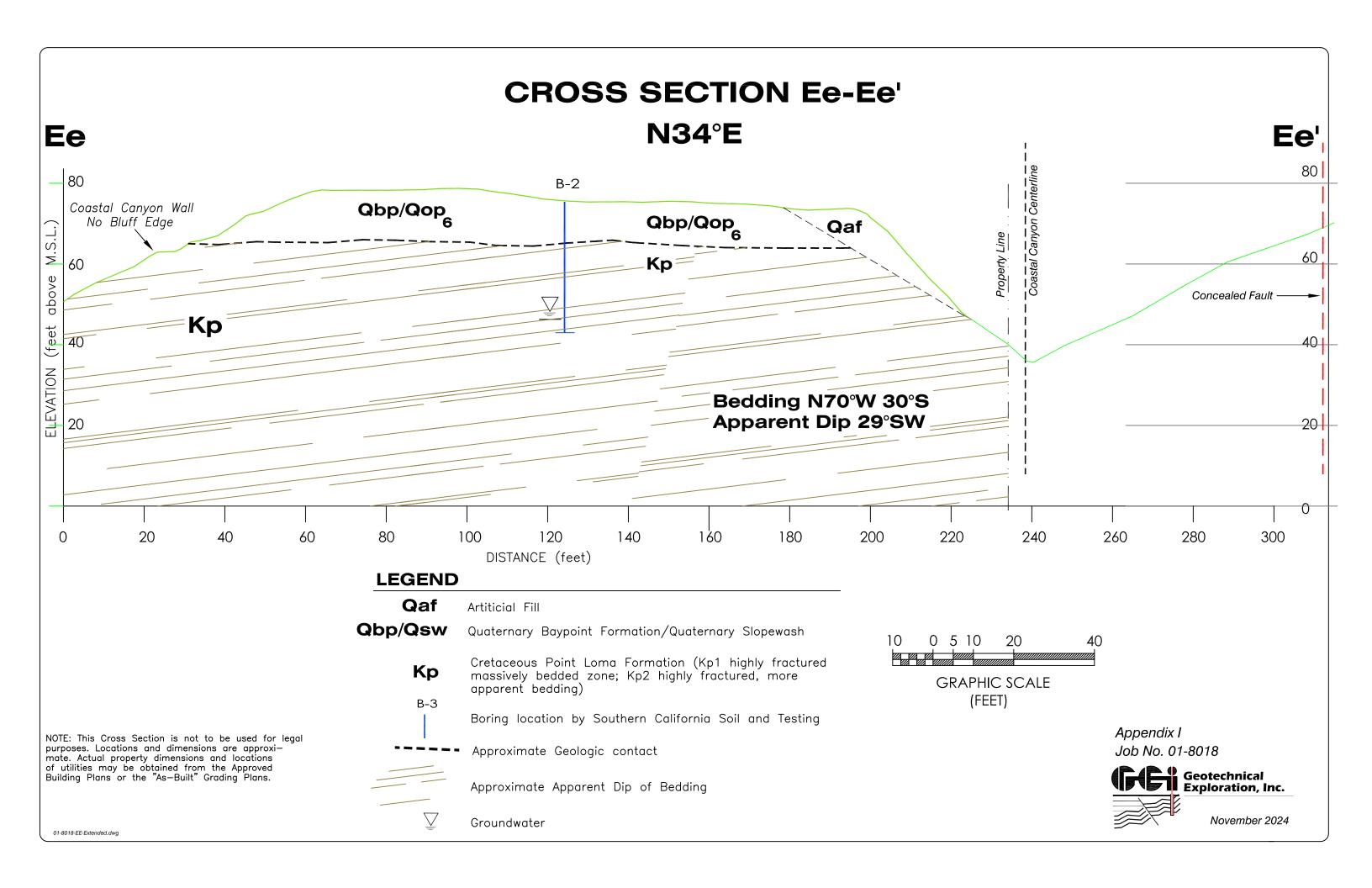
Once the static gross stability was determined, a seismic analysis was performed for the same analyzed sections. The seismic analysis yielded a factor of safety value above the acceptable value of 1.15 as required by the City of San Diego and the State of California.

It is our professional opinion that the construction will not destabilize the slope, adjacent structures, or city right of way following our geotechnical report recommendations.











Appendix J Job No. 01-8018



# APPENDIX K

Bluff Edge and Historical Retreat Report Review by Mr. Dave Skelly dated October 18, 2024



#### **Skelly Engineering**

#### 1771 Tattenham Road, Encinitas, CA 92024

619-995-8378

#### MEMORANDUM

**DATE:** October 18, 2024

TO: Les Reed

Geotechnical Exploration Inc.

7420 Trade Street San Diego, CA 92121

**FROM:** David W. Skelly, PE, Coastal Engineer

**SUBJECT:** Bluff Edge and Historical Retreat Report Review, and Future Bluff Retreat

Analysis in Consideration of Sea Level Rise, 1720 Torrey Pines Road, La

Jolla, CA 92024.

REFERENCE: "Update Report of Preliminary Geotechnical Investigation and Coastal Bluff Edge

Evaluation, Lowenthal Residential Project, 1720 Torrey Pines Road, La Jolla, California,"

by Geotechnical Exploration Inc., dated July 3, 2024.

#### **COASTAL SETTING**

The subject site is in a unique coastal setting where the shoreline actually turns about 90 degrees nearby, and there is a submarine canyon just offshore of the site. The offshore canyon refracts wave energy away from the site. Incoming wave energy is directed to Point La Jolla and La Jolla Shores. This canyon allows year around novice kayakers to use the ocean in front of the site. The bluff fronting the site up to about elevation +70 feet MSL. It is composed of an erosion resistant bedrock called Point Loma Formation to about elevation +60 feet overlain by terrace deposits. In addition, fronting the bluff at the site is a very broad erosion resistant low tide terrace and bedrock shore platform. This low tide terrace and shore platform are composed of the same erosion resistant bedrock as the bluff. The platform and terrace act like a natural submerged breakwater to any wave energy that leaks into the area. Both of these features, the canyon and broad shore platform, significantly reduce the wave energy reaching the site, and the potential for marine erosion at the site. Given this unique setting and resilient shoreline earth materials, marine erosion rates of the shoreline and bluff proper are expected to be very small.

The above referenced report by Geotechnical Exploration Inc. (GEI) provides a comprehensive analysis of the historical bluff retreat at the site/area using reviewed



scientific papers, State of California Geological Survey data, reports by other consultants on nearby properties, site specific geology reports by other consultants, and a site specific aerial photograph analysis. The GEI report determined a range of erosion rates from 0.02 feet/year to 0.17 feet/yr. We have reviewed the GEI report and are in agreement with the historic bluff top retreat analysis methodology and the range in retreat rate reported. We are also in agreement with the GEI delineation of the top of the coastal bluff in accordance with the City of San Diego Municipal Code definitions.

#### QUALITATIVE FUTURE BLUFF TOP RETREAT DISCUSSION

The future bluff retreat rate in consideration of sea level; rise (SLR) is important in determining the bluff top setback. The purpose of the project bluff top setback is to insure the proposed development is safe over it's design life. The setback is measured from the top of the bluff and includes consideration of the site specific geology, and potential erosion (movement) of the top of the bluff over the design life. The following discussion concerns the potential for movement of the top of the bluff over the design life of the project. It should be noted that based upon the analysis by the project geotechnical consultant, GEI, there has been very little movement of the bluff top over the last several decades.

The importance of marine erosion and subaerial erosion of the site bluff can be determined based upon our review of A Primer in Coastal Bluff Erosion, by Mark Johnnson CCC Staff Geologist. The bluff needs to erode due to marine forces to move the bluff top. The bluff at the subject site is a composite bluff with a very erosion resistant material (Point Loma Formation) up to about elevation +60 feet. Above the erosion resistant bedrock is terrace deposit and fill. Figure 1 below is taken from the CCC primer and is based upon a paper by K.O. Emery and G. G. Kuhn entitled "Sea cliffs: Their processes, profiles, and classification." When Figure 1 is compared to Figure 2 below, the site specific bluff profile and geology from GEI, the site bluff can be classified as **Cc** (Marine Erosion = Subaerial Erosion). Marine erosion and subaerial erosion have been very small over the last century.

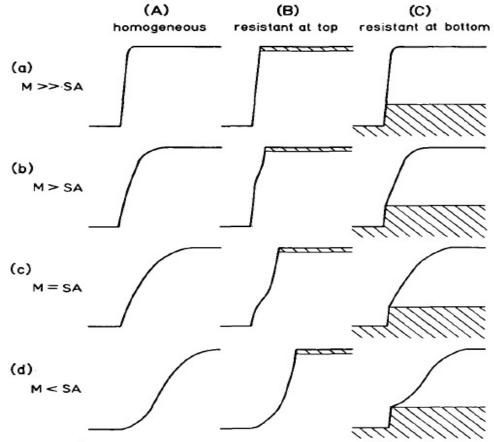


Figure 1. Matrix of active sea-cliff profiles to be expected from bedrock of three different limiting degrees of homogeneity with respect to relative erodibility at bottom and top, and of four different major degrees of relative effectiveness of marine (M) versus subaerial (SA) erosion. It assumes that sea cliffs are cut into plateaus and are near steady state equilibrium. Diagonal lines denote resistant beds.

Figure 1. Matrix of sea-cliff profiles based upon marine erosion versus subaerial erosion.

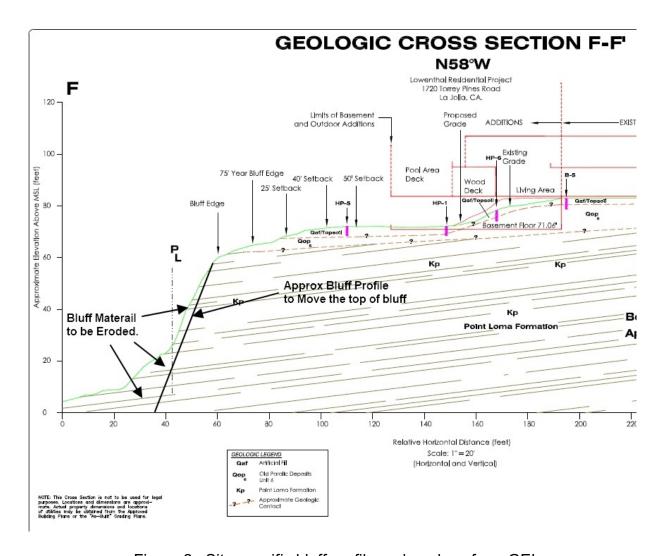


Figure 2. Site specific bluff profile and geology from GEI.

For the actual bluff top to move, the bedrock at the base of the bluff needs to erode back to the point where the bluff profile is steep enough for marine erosion to move the bluff top. The rate of marine erosion will need to increase in the future for this to happen. Based upon the GEI section, about 35 feet of the bedrock at the base of the bluff would need to erode over the next 75 years to move the top of the bluff (see Figure 2). Based upon the strength of the bedrock this very high erosion rate is not possible.

The idea that "sea level rise is likely to cause an acceleration of bluff retreat," to our knowledge, is not supported by any scientific analysis. There are site specific reasons that are contrary to the opinion that SLR will cause acceleration of bluff retreat at this site.

Reason 1. The equilibrium beach profile principal of coastal engineering, illustrated below in Figure 4, shows that the beach material (large cobbles) will move up in response to SLR.

Essentially, creating the same buffer of littoral material at the base of the bluff that exists today, but at a higher elevation. The idea that the beach will stay at the current elevation and the water will "drown the beach" is not supported by science.

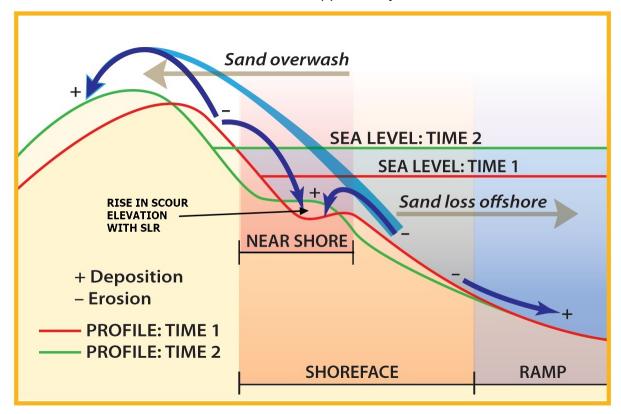


Figure 4. Graphic of equilibrium beach principal.

Reason 2. The bluffs below the site are already subject to small waves at high tides. With SLR, the small waves will act higher on the bluff to a height about equal to the amount of SLR. However, the wave runup will encounter the same strength material as it has in the past. If the wave runup were to encounter softer material with SLR, then the rate of erosion of that material would likely accelerate. That is not the case at this site.

#### **QUANTITATIVE BLUFF TOP RETREAT ANALYSIS**

The California Coastal Commission (CCC) observes the simplified numerical models (Young, et al., 2014) as tools for assessing the long-term retreat of coastal bluffs relative to current SLR projections. These simplified models build upon and generally follow the core principles of the Soft Cliff and Platform Erosion (SCAPE). The simplified model produces a dynamic equilibrium profile of an eroded shoreline, similar to the SCAPE model, whereby the erosion rate is a function of the velocity of cliff retreat. More specifically, the model initially shows a direct relationship between erosion and SLR, but for higher rates of SLR, the erosion rates begin to diminish as the equilibrium erosion profile steepens.

The simplified numerical model ("SCAPE") equation is defined as:

 $R_2 = R_1 (S_2/S_1)^m$ 

Where:  $R_2$  = Future retreat rate

 $R_1$  = Historical retreat rate

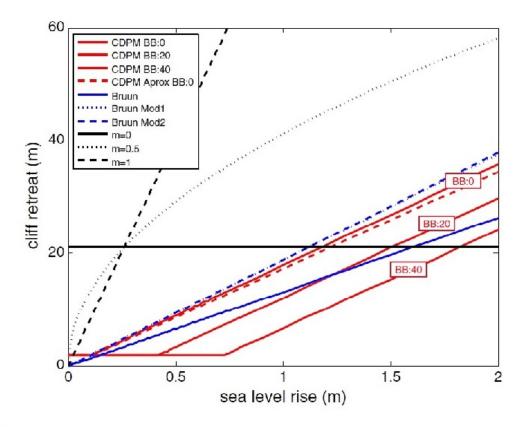
S<sub>1</sub> = Historical rate of sea level rise
 S<sub>2</sub> = Future rate of sea level rise
 m = Site-specific response parameter

The parameter "m" is dependent on the feedbacks between the shore profile geometry and erosion. An instant or linear feedback (m=1) represents an eroding shoreline where the erosion rate and SLR rate increase linearly. Potential examples of eroding shorelines exhibiting an instant response are dominated by sediment flux gradients and include coasts with bluffs and cliffs with high sediment yields. A negative feedback or nonlinear system (0<m<1) include eroding shorelines with negative feedbacks, such as high earth material strengths or a protective beach that reduce erosion. Potential examples of negative feedback systems are shorelines dominated by wave-driven erosion, such as rocky shore platforms and coastal bluffs adjacent to low volume beaches. A no feedback system (m=0) include eroding shorelines where the magnitude of erosion is independent of SLR. Potential examples of no feedback systems include shorelines comprised of hard rock without shore platforms, shorelines dominated by bioerosion, or shorelines subjected to low wave energy.

#### Presence of a Protective Beach and Shore Platform

The shoreline along the toe of the coastal bluff, fronting the site, is generally composed of Point Loma Formation with sporadic cobbles and failed, boulder-sized fragments of Point Loma Formation. These shoreline deposits are more concentrated seaward of the bluff toe, forming a shingle rampart. This quasi-revetment helps dissipate the already reduced wave energy before it can impact the coastal bluff, and will equilibrate in step with SLR over the 75-year design life of the proposed residential structure. The broad shore platform attenuates in-coming wave energy prior to impacting the coastal bluff, also limiting runup.

Most of the time, the shoreline is wider than 50 feet, similar to a conditionally decoupled profile model (CDPM) curve BB:0 (see Figure 5, which is Figure 12 of Young, et al., 2014). Curve BB:0, which is below the m=0.5 (or  $\frac{1}{2}$ ) curve of the simplified numerical equation, and closer to m=0, near the 2 meter SLR endpoint (when the design 6.7 feet of SLR will have occurred). Given the proximity to the BB:0 (m=0) line and the aforementioned geologic and bathymetric factors that limit marine-induced bluff erosion, we judge that m=0.1 (or 1/10) appears appropriate for the coastal bluff adjacent to the site.



**Fig. 12.** Comparison of the conditionally decoupled profile model (CDPM) with 0, 20, and 40 m beach buffers (BB) and original Bruun, modified Bruun (Bruun Mod1 and Mod2), no feedback (m=0), approximate SCAPE (m=0.5), and linear extrapolation (m=1). Exponent m models are based on historical cliff and MSLR, while others are sediment balance based.

Figure 5 - Sea Level Rise (meters) and Cliff Retreat (meters)

#### **FUTURE BLUFF RETREAT SUMMARY**

#### Sea Level Rise

In July 2024, the CCC provided a Draft Sea Level Rise (SLR) Policy update (State of California, 2024a) and has recommended it be considered in the analysis. The newer CCC estimate range from 0.9 feet to 4.8 feet (excluding the very uncertain "HIGH" scenario). Figure 6 provides the latest CCC table for the La Jolla NOAA station.

Table F-13. Sea Level Scenarios for La Jolla

Projected SLR Amounts (in feet)					
	Low	Intermediate- Low	Intermediate	Intermediate- High	High
2030	0.3	0.4	0.4	0.4	0.5
2040	0.4	0.5	0.6	0.7	0.8
2050	0.5	0.7	0.8	1.0	1.3
2060	0.6	0.8	1.1	1.6	2.0
2070	0.7	1.0	1.4	2.3	3.0
2080	0.8	1.2	1.8	3.1	4.1
2090	0.9	1.4	2.4	3.9	5.3
2100	0.9	1.6	3.1	4.8	6.6
2110	1.0	1.8	3.8	5.7	7.9
2120	1.1	2.0	4.4	6.4	9.0
2130	1.2	2.2	4.9	7.1	9.9
2140	1.2	2.4	5.5	7.6	10.9
2150	1.3	2.6	6.0	8.2	11.8

Median values of Sea Level Scenarios, in feet, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion. The red box highlights the three scenarios that the *State Sea Level Rise Guidance* (OPC 2024) and this guidance recommend for use in various planning and project contexts.

Figure 6. 2024 Draft CCC SLR estimates for the La Jolla NOAA Station.

Based on the discussion above (the current best available science), the SLR range for the project is about 0.9 feet (likely) to 4.8 feet (unlikely). The rate of SLR for the Intermediate-High SLR would be (4.8 - 0.2)/75 = 0.0613 ft/yr

The calculated long-term rate of future bluff retreat using the simplified numerical model equation is presented below, based on the aforementioned three curvilinear sections and:

- 1. Maximum Historical rate based on the GEI is  $0.17 \text{ ft/yr} = R_1$ .
- 2. Avg SLR rate over 90 years (1932 to 2023), based on NOAA (Gloss Station Handbook Scripps Pier, La Jolla) is 2.15 mm/yr = 0.00705 ft/yr = S1
- 3. Future SLR rate =  $4.6 \text{ ft/}75 \text{ yrs} = 0.0613 \text{ ft/yr=}S_2$
- 4. m=1/10

Solving the equation yields  $R_2$  = 0.21 ft/yr in the year 2100. While the increase in retreat rate will occur exponentially like SLR in the later years of the development, one can conservatively say the retreat rate is the average of the historic retreat rate and the future retreat rate at the end of the life of the development. The average retreat rate is 0.19 ft/y, which over the life of the development would account for about than 14 feet of bluff retreat.

#### CONCLUSIONS

The use of 0.17 ft/yr as the future bluff retreat rate in consideration of SLR by GEI is reasonable and justified. The unique coastal setting for this site and coastal bluff top location may reasonably not be impacted by SLR. A conservative and cautious future retreat at the site over the next 75 years as a result of SLR is 14 feet.

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#### APPENDIX L

Report by Mr. Glenn Borchardt



## PEDOCHRONOLOGICAL REPORT FOR 1640 TORREY PINES ROAD, LA JOLLA, CALIFORNIA

August 29, 2004

Geotechnical Exploration Inc. Job. No. 04-8600

Soil Tectonics P.O. Box 5335 Berkeley, CA 94705

Glenn Borchardt

Principal Soil Scientist

Certified Professional Soil Scientist No. 24836

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#### PEDOCHRONOLOGICAL REPORT FOR 1640 TORREY PINES ROAD, LA JOLLA, CALIFORNIA

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#### INTRODUCTION

An assessment of seismic risk due to fault rupture can be aided greatly by the techniques of pedochronology (Borchardt, 1992, 1998), soil dating. This is because the youngest geological unit overlying fault traces is generally a soil horizon. The age and relative activity of faulting often can be estimated by evaluating the age and relative tectonic disturbance of overlying soil units.

Soil horizons exhibit a wide range of physical, chemical, and mineralogical properties that evolve at varying rates. Soil scientists use various terms to describe these properties. A black, highly organic "A" horizon, for example, may form within a few centuries, while a dark brown, clayey "Bt" horizon may take as much as 40,000 years to form. Certain soil properties are invariably absent in young soils. For instance, soils developed in granitic alluvium of the San Joaquin Valley do not have Munsell hues redder than 10YR until they are at least 100,000 years old (Birkeland, 1999; Harden, 1982). Still other properties, such as the movement and deposition of clay-size particles and the precipitation of calcium carbonate at extraordinary depths, indicate soil formation during a climate much wetter than at present. In the absence of a radiometric age date for the material from which a particular soil formed, an estimate of its age must take into account all the known properties of the soil and the landscape and climate in which it evolved.

#### **METHOD**

The first step in studying a soil is the compilation of the data necessary for describing it (Birkeland, 1999; Borchardt, 2004). At minimum, this requires a Munsell color chart, hand lens, acid bottle, meter for 1:1 soil:water pH and conductivity measurements. The second step may involve the collection of samples of each horizon for laboratory analysis of particle size. This is done to check the textural classifications made in the field and to evaluate the genetic relationships between horizons and between different soils in the landscape. When warranted,

the clay mineralogy and chemistry of the soil is also analyzed in order to provide additional information on the changes undergone by the initial material from which the soil weathered. The last step is the comparison of this accumulated soil data with that for soils having developed under similar conditions. Such information is scattered in soil survey reports (e.g., Welch and others, 1966), soil science journals, and consulting reports. In a particular locality, there is seldom enough comparative data available for this purpose. That is why, at the very least, the study of one soil profile always makes the evaluation of the next that much easier.

### RESULTS OF THIS EVALUATION

Two soil profiles were measured, sampled, and described in detail in the back yard of this residence overlooking the Pacific Ocean (Table 1). Soil Profile No. 1 was at the 80' elevation, while Soil Profile No. 2 was at the 70' elevation. The object of the investigation was to determine if the residence was built upon a coastal bluff or upon a coastal stream bank. Buildings on the coastal bluff at La Jolla are founded on the 120,000-yr old soils of the Bay Point Formation, an uplifted marine terrace near the 100' elevation. The ocean side of these properties generally has 120,000-yr old soils up to the edge of the bluff, where the slopes give way to soils developed on historic colluvium. On the other hand, buildings overlooking coastal streams may have ocean side property that contains sloping soils that formed on the banks of the coastal stream.

### Soil Profile No. 1

This soil has a 25-cm thick dark brown sandy loam Ap horizon (disturbed by people) overlying a 16-cm thick cobbly sandy clay loam BtA horizon that shows signs of having incorporated significant amounts of the A horizon (Table 1). The underlying Bt and 2Bt horizons comprise a 105-cm thick section having medium moderate subangular blocky structure. The Bt has many medium thick clay films on pores and sand grains and common thin patchy clay films on rounded and angular clasts to 8 cm. The angular clasts here are "angular orphans," that is, "Angular fragments separated from weathered, well-rounded cobbles in colluvium derived from conglomerate" (Borchardt and others, 1980). The terrace gravels of the Bay Point Formation, from which these probably were derived, are well-rounded. The angular fragments here prove that the soil has developed on colluvium rather than on the Bay Point Formation itself. The clay films and other soil development characteristics (e.g., 7.5YR hues) attest to the considerable time since the colluvium was deposited.

Age: During the last ice age, sea level was about 120 m lower than at present (Shackleton and Opdyke, 1973; Clark and Lee, 1992). Streams along this continually uplifting coast would have had steep gradients toward the coastline, which would have been far to the north of its present location. When sea level began to rise again at 22 ka, erosion produced by these coastal streams diminished. This soil has colors approaching the 7.5YR hues seen in Pleistocene soils. The soil structure and the depth of the Bt horizon is consistent with a 22 ka-age.

### Soil Profile No. 2

This soil has artificial fill to the 45-cm depth (Table 1). The Bt horizon was about half as thick as it was in Soil Profile No. 1 and the clay films are thin instead of medium thick. None of the hues are redder than 10YR. A paleosol (fossil soil) with a solum of similar thickness (58-cm) underlies the 2Bt horizon. The 3Btb1 horizon has a few thin patchy clay films on sand grains and

rounded clasts. A few angular orphans in this horizon lack clay films, denoting that the material is a mixture derived from various horizon in the Bay Point Formation. Many of the clay films on the rounded clasts may be inherited from the soil formed on that terrace.

Of particular note is the 5Crtb2 horizon at the base of this profile (Fig. 1). This is the upper portion of the Point Loma Formation, a Cretaceous mudstone that underlies the Bay Point terrace gravels. Normally, the surface of this mudstone forms the unweathered, planated surface of the wave-cut platform upon which the marine sands and gravels of the Bay Point Formation were deposited. The terrace gravels are so thick, that there would not have been an opportunity for dark brown clay films to penetrate the joints and coat the clasts as we see here (Table 1). The only possibility of this happening would be along coastal streams that happen to cut through the Bay Point and the top of the wave-cut platform, deposit colluvium, and form soils old enough to allow the translocation of clay from A horizons to the 5Crtb2, which now appears as a remnant of a second paleosol that once was the active soil within this coastal stream channel.

Age: This soil profile consists of three soils. The upper two soils are derived from colluvial debris from the Bay Point Formation and the 5Crtb2 at its base is a remnant of the first soil that formed after the coastal stream cut through the wave-cut platform.

### **CONCLUSIONS**

The soils examined are magnitudes older than soils that normally would be found on a rapidly eroding coastal bluff. There is no way that the 5Crtb2 horizon could have formed without it being the remnant of a former soil that developed after the down cutting of the adjacent coastal stream. Although these soils now overlook the Pacific Ocean, they developed within the zone defined by the stream.

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1640

Table 1. Description of profiles representative of soil development north of the house at 1740 Torrey Pines Road, La Jolla, California. Abbreviations are given in USDA-Natural Resources Conservation Service publications (Soil Survey Staff, 1993, 1999; 2003).

Described by Glenn Borchardt on August 27, 2004 in the south wall of hand pits at 32° 50.912' latitude and 117° 15.883' longitude. Parent material is colluvium derived primarily from the Bay Point Formation and mudstone of the Cretaceous Point Loma Formation. Aspect north and about 100% slope. Mediterranean climate. Vegetation is Torrey pine and Canary Island date palms and ornamentals. Excellent drainage. Soils range from medium acid to neutral.

Horizon Depth, cm Description

## Soil Profile No. 1, HP-5, 80.2' Elevation

Ap 0-25 Dark brown (10YR4/3m, 5/2d) sandy loam; medium strong granular, angular, and subangular blocky structure; slightly sticky and slightly plastic when wet, very friable when moist, and very hard when dry; many fine to coarse roots; many fine continuous random tubular pores; fragment of broken glass; clear smooth boundary; pH 5.9; conductivity >1990 uS (Sample No. 04B461).

BtA 25-41 Dark brown (7.5YR4/2m, 5/2d) cobbly sandy clay loam with few very fine prominent white mottles due to calcite to 1 mm and many medium faint dark brown (10YR4/3m) peds from a previous A horizon; medium strong angular and subangular blocky structure; sticky and plastic when wet, firm when moist, and very hard when dry; many fine to coarse roots; many fine continuous random tubular pores; many medium thick clay films on pores and sand grains, common thin patchy clay films on rounded clasts to 4 cm; vermiculite grains to 2 mm; clear smooth boundary; pH 6.8; conductivity >1990 uS (Sample No. 04B462).

Bt 41-86 Dark brown (7.5YR4/2m, 6/2d) cobbly sandy clay loam with very few very fine prominent white mottles due to silica to 1 mm and few fine to medium distinct yellowish red (5YR5/6md) mottles due to iron oxides; medium moderate subangular blocky structure; sticky and plastic when wet, firm when moist, and very hard when dry; many fine to coarse roots; many fine continuous random tubular pores; many medium thick clay films on pores and sand grains; common thin patchy clay films on rounded clasts and angular orphans to 8 cm; vermiculite grains to 2 mm; clear smooth boundary; pH 6.7; conductivity >1990 uS (Sample No. 04B463).

2Bt 86-146 Dark brown (10YR3/3m, 6/3d) sandy clay loam with very few very fine prominent white mottles due to silica to 1 mm and few fine to medium distinct yellowish red (5YR5/6md) mottles due to iron oxides; medium moderate subangular blocky structure; sticky and plastic when wet, firm when moist, and very hard when dry; few fine to medium roots; common fine discontinuous random tubular pores; few thin clay films in interstitial pores and on sand grains; common thin patchy clay films on angular orphans;

vermiculite grains to 2 mm; Poway granitic clasts with yellowish red (5YR4/3m, 5/6d) interiors; pH 6.8; conductivity >1990 uS (Sample No. 04B464).

\*ESTIMATED AGE:  $t_o = 22 \text{ ka}$   $t_b = 0 \text{ ka}$  $t_d = 22 \text{ ky}$ 

# Soil Profile No. 2, HP-3, 70.2' Elevation

Ap 0-48 Artificial fill, abrupt smooth boundary; pH 6.9; conductivity 1090 uS (Sample No. 04B481).

BAt 48-62 Dark grayish brown (10YR4/2m, 6/3d) gravelly sandy clay loam with very few very fine distinct yellowish red (5YR5/6md) mottles due to iron oxides; medium strong subangular blocky structure; slightly sticky and slightly plastic when wet, very friable when moist, and very hard when dry; many fine to medium roots; many fine continuous random tubular pores; many thin clay films on pores with many thin patchy clay films on angular orphans (angular clasts; see glossary) to 4 cm; clear smooth boundary; pH 7.2; conductivity 1450 uS (Sample No. 04B482).

2Bt 62-90 Very dark grayish brown (10YR3/2m, 6/3d) sandy clay loam; medium strong subangular blocky structure; slightly sticky and slightly plastic when wet, firm when moist, and very hard when dry; common fine to medium roots; few fine continuous random tubular pores and many fine interstitial pores; few thin clay films on pores and interstices with many thin to thick patchy clay films on angular orphans to 4 cm; clear smooth boundary; pH 6.8; conductivity >1990 uS (Sample No. 04B483).

ESTIMATED AGE:  $t_o = 6 \text{ ka}$   $t_b = 0 \text{ ka}$   $t_d = 6 \text{ ky}$ 

3Ab1 90-114 Grayish brown (10YR5/2m, 6/3d) gravelly sandy clay loam; medium strong subangular and angular blocky structure; slightly sticky and plastic when wet, very friable when moist, and very hard when dry; common fine to medium roots; few fine discontinuous random tubular pores; common thin patchy clay films on rounded clasts and angular orphans to 3 cm; clear smooth boundary; pH 6.4; conductivity 1310 uS (Sample No. 04B484).

3Btb1 114-148 Dark brown (10YR3/3m, 6/3d) gravelly sandy clay loam with few very fine distinct yellowish red (5R5/8md) mottles due to iron oxide coatings in fine pores; medium strong subangular and angular blocky structure; sticky and plastic when wet, very friable when moist, and very hard when dry; few fine to medium roots; few fine continuous random tubular and many fine interstitial pores; few thin patchy clay films on sand grains and rounded clasts to 3.5 cm; few angular orphans to 5 cm lack clay films; clear smooth boundary; pH 6.4; conductivity 950 uS (Sample No. 04B485).

4CBb1 148-181 Dark brown (10YR4/3m, 5/3d) sand with many medium faint mottles due to iron and manganese oxide coatings; massive structure; nonsticky and nonplastic when wet, loose when moist, and slightly hard when dry; very few medium roots; few fine continuous random tubular and many fine interstitial pores; few fine thin mangans; abrupt smooth boundary; pH 6.7; conductivity 230 uS (Sample No. 04B486).

ESTIMATED AGE:  $t_o = 12 \text{ ka}$   $t_b = 6 \text{ ka}$   $t_d = 6 \text{ ky}$ 

5Crtb2 148-181 Olive gray (5Y5/2m, 6/3d) fractured Cretaceous mudstone of the Point Loma Formation with many coarse prominent dark brown (10YR3/3m, 6/3d) mottles due many medium thick clay films in joints and on angular clasts; massive structure; very few medium roots; pH 6.2; conductivity 280 uS (Sample No. 04B487).

ESTIMATED AGE:  $t_o = 22 \text{ ka}$ (of pedogenesis)  $t_b = 12 \text{ ka}$  $t_d = 10 \text{ ky}$ 

t<sub>o</sub> = date when soil formation or aggradation began, ka

t<sub>b</sub> = date when soil or strata was buried, ka

t<sub>d</sub> = duration of soil development or aggradation, ky



<sup>\*</sup>Pedochronological estimates based on available information. All ages should be considered subject to ±50% variation unless otherwise indicated (Borchardt, 1992).



Fig. 1. 5Crtb2 horizon showing medium thick dark brown (10YR3/3m) clay films in joints and on clasts of fractured mudstone of the Point Loma Formation north of 1640 Torrey Pine Road, La Jolla, California. At this elevation, these features only could have formed after stream erosion cut through contact between the marine terrace deposits of the Bay Point Formation and the underlying Cretaceous Point Loma Formation.

### **GLOSSARY**

AGE. Elapsed time in calendar years. Because the cosmic production of C-14 has varied during the Quaternary, radiocarbon years (expressed as ky B.P.) must be corrected by using tree-ring and other data. Abbreviations used for corrected ages are: ka (kilo anno or years in thousands) or Ma (millions of years). Abbreviations used for intervals are: yr (years), ky (thousands of years). radiocarbon ages = yr B.P. Calibrated ages are calculated from process assumptions, relative ages fit in a sequence, and correlated ages refer to matching units. (See also yr B.P., HOLOCENE, PLEISTOCENE, QUATERNARY, PEDOCHRONOLOGY).

AGGRADATION. A modification of the earth's surface in the direction of uniformity of grade by deposition.

ALKALI (SODIC) SOIL. A soil having so high a degree of alkalinity (pH 8.5 or higher), or so high a percentage of exchangeable sodium (15 % or more of the total exchangeable bases), or both, that plant growth is restricted.

ALKALINE SOIL. Any soil that has a pH greater than 7.3. (See Reaction, Soil.)

ANGULAR ORPHANS. Angular fragments separated from weathered, well-rounded cobbles in colluvium derived from conglomerate.

ARGILLAN. (See Clay Film.)

ARGILLIC HORIZON. A horizon containing clay either translocated from above or formed in place through pedogenesis.

ALLUVIATION. The process of building up of sediments by a stream at places where stream velocity is decreased. The coarsest particles settle first and the finest particles settle last.

ANOXIC. (See also GLEYED SOIL). A soil having a low redox potential.

AQUICLUDE. A saturated body of sediment or rock that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.

AQUITARD. A body of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. It does not readily yield water to wells or springs but may serve as a storage unit for groundwater.

ATTERBERG LIMITS. The moisture content at which a soil passes from a semi-solid to a plastic state (plastic limit, PL) and from a plastic to a liquid state (liquid limit, LL). The plasticity index (PI) is the numerical difference between the LL and the PL.

BEDROCK. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

BISEQUUM. Two soils in vertical sequence, each soil containing an eluvial horizon and its underlying B horizon.

BOUDIN, BOUDINAGE. From a French word for sausage, describes the way that layers of rock break up under extension. Imagine the hand, fingers together, flat on the table, encased in soft clay and being squeezed from above, as being like a layer of rock. As the spreading clay moves the fingers (sausages) apart, the most mobile rock fractions are drawn or squeezed into the developing gaps.

BURIED SOIL. A developed soil that was once exposed but is now overlain by a more recently formed soil.

CALCAREOUS SOIL. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

CATENA. A sequence of soils of about the same age, derived from similar parent material and occurring under similar climatic conditions, but having different characteristics due to variation in relief and drainage. (See also Toposequence.)

CEC. Cation exchange capacity. The amount of negative charge balanced by positively charged ions (cations) that are exchangeable by other cations in solution (meq/100 g soil = cmol(+)/kg soil).

CLAY. As a soil separate, the mineral soil particles are less than 0.002 mm in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

CLAY FILM. A coating of oriented clay on the surface of a sand grain, pebble, soil aggregate, or ped. Clay films also line pores or root channels and bridge sand grains. Frequency classification is based on the percent of the ped faces and/or pores that contain films: very few--<5%; few--5-25%; common--25-50%; many--50-90%; and continuous--90-100%. Thickness classification is based on visibility of sand grains: thin--very fine sand grains standout; moderately thick--very fine sand grains impart microrelief to film; thick--fine sand grains enveloped by clay and films visible without magnification. Synonyms: clay skin, clay coat, argillan, illuviation cutan.

COBBLE. Rounded or partially rounded fragments of rock ranging from 7.5 to 25 cm in diameter.

COLLUVIUM. Any loose mass of soil or rock fragments that moves downslope largely by the force of gravity. Usually it is thicker at the base of the slope.

COLLUVIUM-FILLED SWALE. The prefailure topography of the source area of a debris flow.

COMPARATIVE PEDOLOGY. The comparison of soils, particularly through examination of features known to evolve through time.

CONCRETIONS. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

CONDUCTIVITY. The ability of a soil solution to conduct electricity, generally expressed as the reciprocal of the electrical resistivity. Electrical conductance is the reciprocal of the resistance (1/R = 1/ohm = ohm<sup>-1</sup> = mho [reverse of ohm] = siemens = S), while electrical conductivity is the reciprocal of the electrical resistivity (EC = 1/r = 1/ohm-cm = mho/cm = S/cm or mmho/cm = dS/m). EC, expressed as uS/cm, is equivalent to the ppm of salt in solution when multiplied by 0.640. Pure rain water has an EC of 0, standard 0.01 N KCl is 1411.8 uS at 25C, and the growth of salt-sensitive crops is restricted in soils having saturation extracts with an EC greater than 2,000 uS/cm. Measurements in soils are usually performed on 1:1 suspensions containing one part by weight of soil and one part by weight of distilled water.

CONSISTENCE, SOIL. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are --

Loose.--Noncoherent when dry or moist; does not hold together in a mass.

Friable.--When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.--When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.--When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.--When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.--When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.--When dry, breaks into powder or individual grains under very slight pressure.

Cemented.--Hard and brittle; little affected by moistening.

CTPOT. Easily remembered acronym for climate, topography, parent material, organisms, and time; the five factors of soil formation.

CUMULIC. A soil horizon that has undergone aggradation coincident with its active development.

CUTAN. (See Clay Film.)

DEBRIS FLOW. Incoherent or broken masses of rock, soil, and other debris that move downslope in a manner similar to a viscous fluid.

DEBRIS SLOPE. A constant slope with debris on it from the free face above.

DEGRADATION. A modification of the earth's surface by erosion.

DURIPAN. A subsurface soil horizon that is cemented by illuvial silica, generally deposited as opal or microcrystalline silica, to the degree that less than 50 percent of the volume of air-dry fragments will slake in water or HCl.

ELUVIATION. The removal of soluble material and solid particles, mostly clay and humus, from a soil horizon by percolating water.

EOLIAN. Deposits laid down by the wind, landforms eroded by the wind, or structures such as ripple marks made by the wind.

FAULT-LINE SCARP. A scarp that has been produced by differential erosion along an old fault line.

FIRST-ORDER DRAINAGE. The most upstream, field-discernible concavity that conducts water and sediments to lower parts of a watershed.

FLOOD PLAIN. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

FOSSIL FISSURE. A buried rectilinear chamber associated with extension due to ground movement. The chamber must be oriented along the strike of the shear and must have vertical and horizontal dimensions greater than its width. It must show no evidence of faunal activity and its walls may have silt or clay coatings indicative of frequent temporary saturation with ground water. May be mistaken for an animal burrow. Also known as a paleofissure.

FRIABILITY. Term for the ease with which soil crumbles. A friable soil is one that crumbles easily.

GENESIS, SOIL. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum (A and B horizons) from the unconsolidated parent material.

GEOMORPHIC. Pertaining to the form of the surface features of the earth. Specifically, geomorphology is the analysis of landforms and their mode of origin.

GLEYED SOIL. A soil having one or more neutral gray horizons as a result of water logging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent water logging.

GRAVEL. Rounded or angular fragments of rock 2 to 75 mm in diameter. Soil textures with >15% gravel have the prefix "gravelly" and those with >90% gravel have the suffix "gravel."

HIGHSTAND. The highest elevation reached by the ocean during an interglacial period.

HOLOCENE. The most recent epoch of geologic time, extending from 10 ka to the present.

HORIZON, SOIL. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

- O horizon.--The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.
- A horizon.--The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).
- E horizon -- This eluvial horizon is light in color, lying beneath the A horizon and above the B horizon. It is made up mostly of sand and silt, having lost most of its clay and iron oxides through reduction, chelation, and translocation.
- B horizon.--The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these.
- C horizon.--The relatively unweathered material immediately beneath the solum.

  Included are sediment, saprolite, organic matter, and bedrock excavatable with a spade. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a number precedes the letter C.
- R layer.--Consolidated rock not excavatable with a spade. It may contain a few cracks filled with roots or clay or oxides. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

These lower-case letters may be appended:

-a Mostly decomposed organic matter; rubbed fiber content is than 17%.

- -b Buried soil horizon. If more than one buried soil exists, this letter is followed by an Arabic number indicating the sequence.
- -c Concretions or nodules cemented by iron, aluminum, manganese, or titanium.
- -d Dense horizon physically restricting root penetration.
- -e Intermediately decomposed organic matter; rubbed fiber content is between 17 and 40%.
- -f Frozen horizon cemented by permanent ice.
- -g Gleyed horizon in which iron has been removed during soil formation or saturation with stagnant water has preserved a reduced state. Strong gleying is indicated by chromas of one or less, and hues bluer than 10Y. Bg is used for a horizon with pedogenic features in addition to gleying, while Cg is not.
- -h Humus. Illuvial accumulation of amorphous organic matter-sesquioxide complexes that either coat grains, form pellets, or form sufficient coatings and pore fillings to cement the horizon.
- -i Least decomposed organic matter; rubbed fiber content is greater than 40%.
- -j Used in combination with another horizon designation (e.g., Btj, Ej) to denote incipient development of that feature.
- -k Carbonates. Illuvial accumulation of alkaline earth carbonates, mainly calcium carbonate; the properties do not meet those for the K horizon.
- -l Unused as of 1992.
- -m Cemented. Horizon that is more than 90% cemented. Denote cementing material (zm, soluble salts; ym, gypsum; km, carbonate; sm, iron; kqm, carbonate and silica)
- -n Sodium. Accumulation of exchangeable sodium.
- -o Oxides. Residual accumulation of sesquioxides.
- -p Plowed or otherwise disturbed by *Homo sapiens* or domesticated animals.
- -q Silica (secondary) accumulation.
- -r Rock weathered in place. Saprolite.
- -s Sesquioxides. Illuvial accumulation of sesquioxides with color value and chroma greater than three.
- -ss Slickensides
- -t Accumulation of silicate clay that has either formed in place or has been translocated from above. Only used with B horizons.
- -u Unweathered.
- -v Plinthite. Iron-rich, reddish material that hardens irreversibly when dried.
- -w Development of color (redder hue or higher chroma relative to C) or structure with little or no apparent illuvial accumulation of material.
- -x Fragipan. Subsurface horizon characterized by a bulk density greater than that of the overlying soil, hard to very hard consistence, brittleness, and seemingly cemented when dry.
- -y Gypsum. Accumulation of gypsum.
- -z Salts. Accumulation of salts more soluble than gypsum.

HUMUS. The well-decomposed, more or less stable part of the organic matter in mineral soils.

ILLUVIATION. The deposition by percolating water of solid particles, mostly clay or humus, within a soil horizon.

INTERFLUVE. The land lying between streams.

ISOCHRONOUS BOUNDARY. A gradational boundary between two sedimentary units indicating that they are approximately the same age. Opposed to a nonisochronous boundary, which by its abruptness indicates that it delineates units having significant age differences.

KROTOVINA. An animal burrow filled with soil.

LEACHING. The removal of soluble material from soil or other material by percolating water.

LOWSTAND. The lowest elevation reached by the ocean during a glacial period.

MANGAN. A thin coating of manganese oxide (cutan) on the surface of a sand grain, pebble, soil aggregate, or ped. Mangans also line pores or root channels and bridge sand grains.

MORPHOLOGY, SOIL. The physical make-up of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

MOTTLING, SOIL. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance--few, common, and many; size--fine, medium, and coarse; and contrast-faint, distinct and prominent. The size measurements are these: fine, less than 5 mm in diameter along the greatest dimension; medium, from 5 to 15 mm, and coarse, more than 15 mm.

MRT (MEAN RESIDENCE TIME.) The average age of the carbon atoms within a soil horizon. Under ideal reducing conditions, the humus in a soil will have a C-14 age that is half the true age of the soil. In oxic soils humus is typically destroyed as fast as it is produced, generally yielding MRT ages no older than 300-1000 years, regardless of the true age of the soil.

MUNSELL COLOR NOTATION. Scientific description of color determined by comparing soil to a Munsell Soil Color Chart (Available from Macbeth Division of Kollmorgen Corp., 2441 N. Calvert St., Baltimore, MD 21218). For example, dark yellowish brown is denoted as 10YR3/4m in which the 10YR refers to the hue or proportions of yellow and red, 3 refers to value or lightness (0 is black and 10 is white), 4 refers to chroma (0 is pure black and white and 20 is the pure color), and m refers to the moist condition rather than the dry (d) condition.

OVERBANK DEPOSIT. Fine-grained alluvial sediments deposited from floodwaters outside of the fluvial channel.

OXIC. A soil having a high redox potential. Such soils typically are well drained, seldom being waterlogged or lacking in oxygen. Rubification in such soils tends to increase with age.

PALEOSEISMOLOGY. The study of prehistoric earthquakes through the examination of soils, sediments, and rocks.

PALEOSOL. A soil that formed on a landscape in the past with distinctive morphological features resulting from a soil-forming environment that no longer exists at the site. The former pedogenic process was either altered because of external environmental change or interrupted by burial.

PALINSPASTIC RECONSTRUCTION. Diagrammatic reconstruction used to obtain a picture of what geologic and/or soil units looked like before their tectonic deformation.

PARENT MATERIAL. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

PED. An individual natural soil aggregate, such as a granule, a prism, or a block.

PEDOCHRONOLOGY. The study of pedogenesis with regard to the determination of when soil formation began, how long it occurred, and when it stopped. Also known as soil dating. Two ages and the calculated duration are important:

t<sub>o</sub> = age when soil formation or aggradation began, ka

 $t_b$  = age when the soil or stratum was buried, ka

t<sub>d</sub> = duration of soil development or aggradation, ky

Pedochronological estimates are based on available information. All ages should be considered subject to ±50% variation unless otherwise indicated.

PEDOCHRONOPALEOSEISMOLOGY. The study of prehistoric earthquakes by using pedochronology.

PEDOLOGY. The study of the process through which rocks, sediments, and their constituent minerals are transformed into soils and their constituent minerals at or near the surface of the earth.

PEDOGENESIS. The process through which rocks, sediments, and their constituent minerals are transformed into soils and their constituent minerals at or near the surface of the earth.

PERCOLATION. The downward movement of water through the soil.

pH VALUE. The negative log of the hydrogen ion concentration. Measurements in soils are usually performed on 1:1 suspensions containing one part by weight of soil and one part by weight of distilled water. A soil with a pH of 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid or "sour" soil is one that gives an acid reaction; an alkaline soil is one that gives an alkaline reaction. In words, the degrees of acidity or alkalinity are expressed as:

Extremely acid------ <4.5 Very strongly acid--- 4.5 to 5.0 Strongly acid---- 5.1 to 5.5 Medium acid----- 5.6 to 6.0 Slightly acid---- 6.1 to 6.5 Neutral---- 6.6 to 7.3 Mildly alkaline--- 7.4 to 7.8 Moderately alkaline-- 7.9 to 8.4 Strongly alkaline--- 8.5 to 9.0 Very strongly alkaline >9.0

Used if significant: Very slightly acid--- 6.6 to 6.9 Very mildly alkaline- 7.1 to 7.3

### PHREATIC SURFACE. (See Water Table.)

PLANATION. The process of erosion whereby a portion of the surface of the Earth is reduced to a fundamentally even, flat, or level surface by a meandering stream, waves, currents, glaciers, or wind.

PLEISTOCENE. An epoch of geologic time extending from 10 ka to 1.8 Ma; it includes the last Ice Age.

PROFILE, SOIL. A vertical section of the soil through all its horizons and extending into the parent material.

QUATERNARY. A period of geologic time that includes the past 1.8 Ma. It consists of two epochs--the Pleistocene and Holocene.

PROGRADATION. The building outward toward the sea of a shoreline or coastline by nearshore deposition.

RELICT SOIL. A surface soil that was partly formed under climatic conditions significantly different from the present.

RUBIFICATION. The reddening of soils through the release and precipitation of iron as an oxide during weathering. Munsell hues and chromas of well-drained soils generally increase with soil age.

SALINE SOIL. A soil that contains soluble salts in amounts that impair the growth of crop plants but that does not contain excess exchangeable sodium.

SAND. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 mm. Most sand grains consist of quartz, but they may be of any mineral composition. The

textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

SECONDARY FAULT. A minor fault that bifurcates from or is associated with a primary fault. Movement on a secondary fault never occurs independently of movement on the primary, seismogenic fault.

SHORELINE ANGLE. The line formed by the intersection of the wave-cut platform and the sea cliff. It approximates the position of sea level at the time the platform was formed.

SILT. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very find sand (0.05 mm.) Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

SLICKENSIDES. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may form along a fault plane; at the bases of slip surfaces on steep slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

SLIP RATE. The rate at which the geologic materials on the two sides of a fault move past each other over geologic time. The slip rate is expressed in mm/yr, and the applicable duration is stated. Faults having slip rates less than 0.01 mm/yr are generally considered inactive, while faults with Holocene slip rates greater than 0.1 mm/yr generally display tectonic geomorphology.

SMECTITE. A fine, platy, aluminosilicate clay mineral that expands and contracts with the absorption and loss of water. It has a high cation-exchange capacity and is plastic and sticky when moist.

SOIL. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

SOIL SEISMOLOGIST. Soil scientist who studies the effects of earthquakes on soils.

SOIL TECTONICS. The study of the interactions between soil formation and tectonism.

SOIL TONGUE. That portion of a soil horizon extending into a lower horizon.

SOLUM. Combined A and B horizons. Also called the true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

STONE LINE. A thin, buried, planar layer of stones, cobbles, or bedrock fragments. Stone lines of geological origin may have been deposited upon a former land surface. The fragments are more often pebbles or cobbles than stones. A stone line generally overlies material that was subject to weathering, soil formation, and erosion before deposition of the overlying material.

Many stone lines seem to be buried erosion pavements, originally formed by running water on the land surface and concurrently covered by surficial sediment

STRATH TERRACE. A gently sloping terrace surface bearing little evidence of aggradation.

STRUCTURE, SOIL. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are--platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

SUBSIDIARY FAULT. A branch fault that extends a substantial distance from the main fault zone.

TECTOTURBATION. Soil disturbance resulting from tectonic movement.

TEXTURE, SOIL. Particle size classification of a soil, generally given in terms of the USDA system which uses the term "loam" for a soil having equal properties of sand, silt, and clay. The basic textural classes, in order of their increasing proportions of fine particles are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sand clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

TOPOSEQUENCE. A sequence of kinds of soil in relation to position on a slope. (See also Catena.)

TRANSLOCATION. The physical movement of soil particles, particularly fine clay, from one soil horizon to another under the influence of gravity.

UNIFIED SOIL CLASSIFICATION SYSTEM. The particle size classification system used by the U.S. Army Corps of Engineers and the Bureau of Reclamation. Like the ASTM and AASHO systems, the sand/silt boundary is at 80 um instead of 50 um used by the USDA and FAA. Unlike all other systems the gravel/sand boundary is at 4 mm instead of 2 mm and the silt/clay boundary is determined by using Atterberg limits.

VERTISOL. A soil with at least 30% clay, usually smectite, that fosters pronounced changes in volume with change in moisture. Cracks greater than 1 cm wide appear at a depth of 50 cm during the dry season each year. One of the ten USDA soil orders.

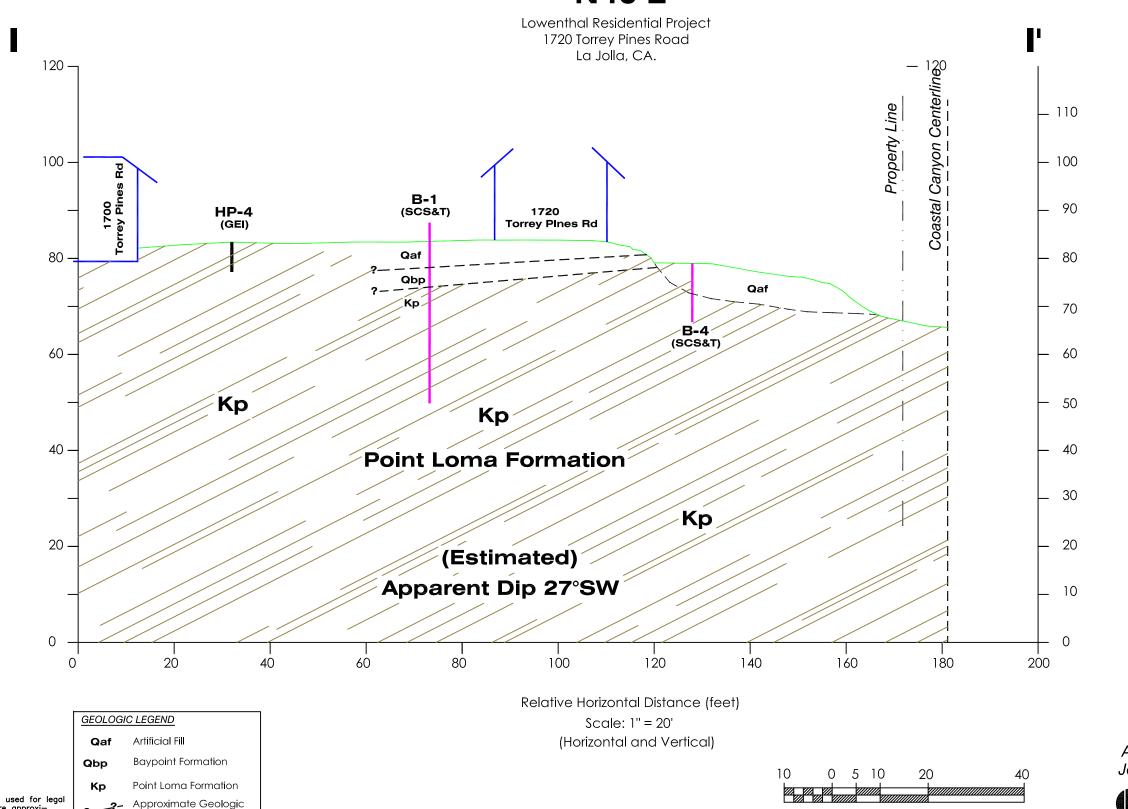
WATER TABLE. The upper limit of the soil or underlying rock material that is wholly saturated with water. Also called the phreatic surface.

WAVE-CUT PLATFORM. The relatively smooth, slightly seaward-dipping surface formed along the coast by the action of waves generally accompanied by abrasive materials.

WEATHERING. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

yr B.P. Uncorrected radiocarbon age expressed in years before present, calculated from 1950. Calendar-corrected ages are expressed in ka, or, if warranted, as A.D. or B.C.

# **GEOLOGIC CROSS SECTION I-I'** N40°E



NOTE: This Cross Section is not to be used for legal purposes. Locations and dimensions are approximate. Actual property dimensions and locations of utilities may be obtained from the Approved Building Plans or the "As—Built" Grading Plans.

Contact

01-8018-SECT-II.dwg

**GRAPHIC SCALE** (FEET)

Appendix M Job No. 01-8018



Geotechnical Exploration, Inc.

November 2024

