13 October 2022 Proposal No. PR 22-168

Envision I, LLC
Attention: Sibley Simon
189 Walnut Ave
Santa Cruz, 95060
Sibley@envisionhousing.us
831-419-4091

Subject: Geological hazards and risks related to infiltration in karst
Proposed apartment housing
900 High Street
Santa Cruz, CA 95060
County of Santa Cruz APN 001-022-40

Dear Sibley,

This letter presents a summary of our geological findings as they pertain to storm water infiltration for the proposed development on the subject property. We are partially relying upon the body of work completed by the author (Erik Zinn) under the auspices of Zinn Geology. That work culminated in a geology report titled "PHASE I KARST AND SLOPE STABILITY HAZARDS INVESTIGATION" dated 2 July 2018 by Zinn Geology (Job #2018011-G-SC).

OVERVIEW

It is our understanding that Project Civil Engineer of Record, C2G, is in the process of coordinating the storm water mitigation approach with the manager of the City of Santa Cruz Stormwater Management Plan, Suzanne Healy. It is also our understanding that the current design scheme is trying to meet Tier 3 requirements from the City of Santa Cruz Mandatory Low Impact Development Requirements. Within the section that describes the steps for designing for Tier 3 (Chapter 4, section 4.3), there is an optional step described as "Step 3" that covers situations arising from infeasible runoff retention. One of the listed conditions for infeasibility is "Geotechnical Hazards", which in our opinion, applies to this project. The end paragraph for Step 3 is as follows:

> *Technical infeasibility must be clearly documented with supporting evidence such as geotechnical reports, hydrological analysis, documentation of pollutant concerns on the property, etc. Technical infeasibility determination will only be granted after demonstration that site layout has been optimized and all storm water retention options have been considered.*

Evidence of karst geology underlying the property and the proposed development area was encountered by Zinn Geology during their prior investigation in 2018 (Zinn Geology, 2018). Zinn Geology presented substantive evidence and findings in their

2018 report describing the hazards and risks related to the underlying karst geology at the site and issued recommendations that flowed from those findings.

The widely spaced gridded boring program pursued in 2018 by the Project Geotechnical Engineer of Record, Becky Dees of Dees and Associates, encountered marble bedrock at depth below the site, mantled by an inconsistent blanket of marble rubble, some soft soil and marine terrace deposits (see attached plates excerpted from the Zinn Geology 2018 report). This is consistent with the University of California at Santa Cruz (UCSC) campus geology that abuts the property to north, the exposure of marble in an old quarry to the east and the marble bedrock that is documented to underlie the City of Santa Cruz Bay Street Reservoir site.

The gently sloping portion of the marble surface that underlies the subject property appears to have been formed and sculpted as part of the creation of the ~213ka second emergent marine terrace. At least one infilled doline cuts the beveled marble surface, based on the morphology of the marble surface and distribution of marble rubble encountered by Zinn Geology (see Plates 1 and 2). It is likely far more complex than that and is probably one of a complex of dolines on the property. In the author's experience of having worked on karst projects on the UCSC campus for over 30 years, dolines and sinkholes typically develop along structural geological features overprinted onto the marble bedrock in the form of ancient fault and fracture zones. The marble bedrock is crushed in those zones and falls prey to the dissolution process that creates caves, voids, dolines and sinkholes within marble bedrock over geologic time.

The following recommendations regarding the handling of stormwater and landscape watering were issued in the 2018 Zinn Geology report:

3. We recommend that all of the storm water generated for this project be disposed in the City of Santa Cruz storm drains. Attenuating the storm flows by detaining the water in impervious structures is geologically acceptable, as long as the water is NOT allowed to infiltrate the soil.

4. Landscape watering for the project should NOT saturate the subgrade in an unnatural fashion. The natural distribution and application rate of rainfall should be emulated for landscaping irrigation, in order to avoid saturating the subgrade and triggering a doline collapse.

We have learned valuable lessons at the adjacent UCSC campus in the past with the reactivation of sinkholes in the vicinity of existing storm water treatment systems and bio swales/infiltration areas on campus (see Figure 1 below). Storm water infrastructure sited on karst and over dolines can create an elevated risk of triggering the reactivation of a doline because of the increase in the infiltration rate and volume of storm water. The resulting sinkholes that form can threaten important and expensive facilities. The subsequent repairs and rerouting of the storm water infrastructure also can cost significantly more than the original design and construction costs for the storm water system.

Figure 1 - 2015 photo of sinkhole developed within a reactivated doline under a stormwater treatment system on the UCSC campus

FINDINGS

The subject property is underlain by marble bedrock, marble rubble, doline fill and marine terrace deposits. At least one large, infilled doline cuts the marble surface under the proposed development area footprint and there are likely more infilled dolines on the property based on the experience with karst investigations adjacent to the property.

The potential hazard of doline reactivation and the development of a sinkhole at the surface in the proposed development area and on the property is already high and will be greatly increased if water is infiltrated at the site. Development of a sinkhole may undermine the existing and proposed structures, as well as existing and proposed utilities and infrastructure. Subsequently, if stormwater is infiltrated on the site, the risk to the existing and proposed structures and infrastructure is “greater than ordinary” as defined in Appendix A of this letter.

RECOMMENDATIONS

Based upon the findings listed above, we reiterate the stormwater and landscape watering recommendations from the 2018 Zinn Geology report as follows:

1. We recommend that the storm water generated for this project be disposed in the City of Santa Cruz storm drains. Attenuating the storm flows by detaining the water in impervious structures is geologically acceptable, as long as the water is NOT allowed to infiltrate the soil.

2. Landscape watering for the project should NOT saturate the subgrade in an unnatural fashion. The natural distribution and application rate of rainfall should be emulated for landscaping irrigation, to avoid saturating the subgrade and triggering a doline collapse and the formation of sinkhole.

This concludes our letter. Please do not hesitate to contact us if you have any questions or concerns about this letter.

Sincerely,

PACIFIC CREST ENGINEERING INC.

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PROFESSIONAL GEOLOGIST
ERIK N. ZINN
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Erik N. Zinn
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Attachments: References
Appendix A – Scale of acceptable risks from geologic hazards
Plates 1 and 2 excerpted from 2018 Zinn Geology report (back of letter)

REFERENCES

City of Santa Cruz, 2014, DEVELOPMENT AND REMODELING PROJECTS, Storm Water Best Management Practices For Private and Public Development Projects
Chapter 6B of the Best Management Practices Manual for the City's Storm Water Management Program, publically available at https://www.cityofsantacruz.com/home/showpublisheddocument/36560/635418232770030000

Zinn Geology, 2018, PHASE I KARST AND SLOPE STABILITY HAZARDS INVESTIGATION - Peace United Church - Envision Housing, Proposed Housing Development, 900 High Street Santa Cruz, California, Job #2018011-G-SC, unpublished consultant report.

APPENDIX A

SCALE OF ACCEPTABLE RISKS FROM GEOLOGIC HAZARDS

SCALE OF ACCEPTABLE RISKS FROM SEISMIC GEOLOGIC HAZARDS

Risk Level	Structure Types	Extra Project Cost Probably Required to Reduce Risk to an Acceptable Level
Extremely low[1]	Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power intake systems, plants manufacturing or storing explosives or toxic materials.	No set percentage (whatever is required for maximum attainable safety).
Slightly higher than under "Extremely low" level.[1]	Structures whose use is critically needed after a disaster: important utility centers; hospitals; fire, police and emergency communication facilities; fire station; and critical transportation elements such as bridges and overpasses; also dams.	5 to 25 percent of project cost.[2]
Lowest possible risk to occupants of the structure.[3]	Structures of high occupancy, or whose use after a disaster would be particularly convenient: schools, churches, theaters, large hotels, and other high rise buildings housing large numbers of people, other places normally attracting large concentrations of people, civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads, alternative or non-critical bridges and overpasses.	5 to 15 percent of project cost.[4]
An "ordinary" level of risk to occupants of the structure.[3,5]	The vast majority of structures: most commercial and industrial buildings, small hotels and apartment buildings, and single family residences.	1 to 2 percent of project cost, in most cases (2 to 10 percent of project cost in a minority of cases).[4]

1 Failure of a single structure may affect substantial populations.
2 These additional percentages are based on the assumptions that the base cost is the total cost of the building or other facility when ready for occupancy. In addition, it is assumed that the structure would have been designed and built in accordance with current California practice. Moreover, the estimated additional cost presumes that structures in this acceptable risk category are to embody sufficient safety to remain functional following an earthquake.
3 Failure of a single structure would affect primarily only the occupants.
4 These additional percentages are based on the assumption that the base cost is the total cost of the building or facility when ready for occupancy. In addition, it is assumed that the structures would have been designed and built in accordance with current California practice. Moreover the estimated additional cost presumes that structures in this acceptable-risk category are to be sufficiently safe to give reasonable assurance of preventing injury or loss of life during and following an earthquake, but otherwise not necessarily to remain functional.
5 "Ordinary risk": Resist minor earthquakes without damage: resist moderate earthquakes without structural damage, but with some non-structural damage; resist major earthquakes of the intensity or severity of the strongest experienced in California, without collapse, but with some structural damage as well as non-structural damage. In most structures it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. (Structural Engineers Association of California)

Source: *Meeting the Earthquake,* Joint Committee on Seismic Safety of the California Legislature, Jan. 1974, p.9.

SCALE OF ACCEPTABLE RISKS FROM NON-SEISMIC GEOLOGIC HAZARDS[6]		
Risk Level	Structure Type	Risk Characteristics
Extremely low risk	Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power intake systems, plants manufacturing or storing explosives or toxic materials.	1. Failure affects substantial populations, risk nearly equals nearly zero.
Very low risk	Structures whose use is critically needed after a disaster: important utility centers; hospitals; fire, police and emergency communication facilities; fire station; and critical transportation elements such as bridges and overpasses; also dams.	1. Failure affects substantial populations. Risk slightly higher than 1 above.
Low risk	Structures of high occupancy, or whose use after a disaster would be particularly convenient: schools, churches, theaters, large hotels, and other high rise buildings housing large numbers of people, other places normally attracting large concentrations of people, civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads, alternative or non-critical bridges and overpasses.	1. Failure of a single structure would affect primarily only the occupants.
"Ordinary" risk	The vast majority of structures: most commercial and industrial buildings, small hotels and apartment buildings, and single family residences.	1. Failure only affects owners /occupants of a structure rather than a substantial population. 2. No significant potential for loss of life or serious physical injury. 3. Risk level is similar or comparable to other ordinary risks (including seismic risks) to citizens of coastal California. 4. No collapse of structures; structural damage limited to repairable damage in most cases. This degree of damage is unlikely as a result of storms with a repeat time of 50 years or less.
Moderate risk	Fences, driveways, non-habitable structures, detached retaining walls, sanitary landfills, recreation areas and open space.	1. Structure is not occupied or occupied infrequently. 2. Low probability of physical injury. 3. Moderate probability of collapse.

[6] Non-seismic geologic hazards include flooding, landslides, erosion, wave runup and sinkhole collapse


ZINN GEOLOGY
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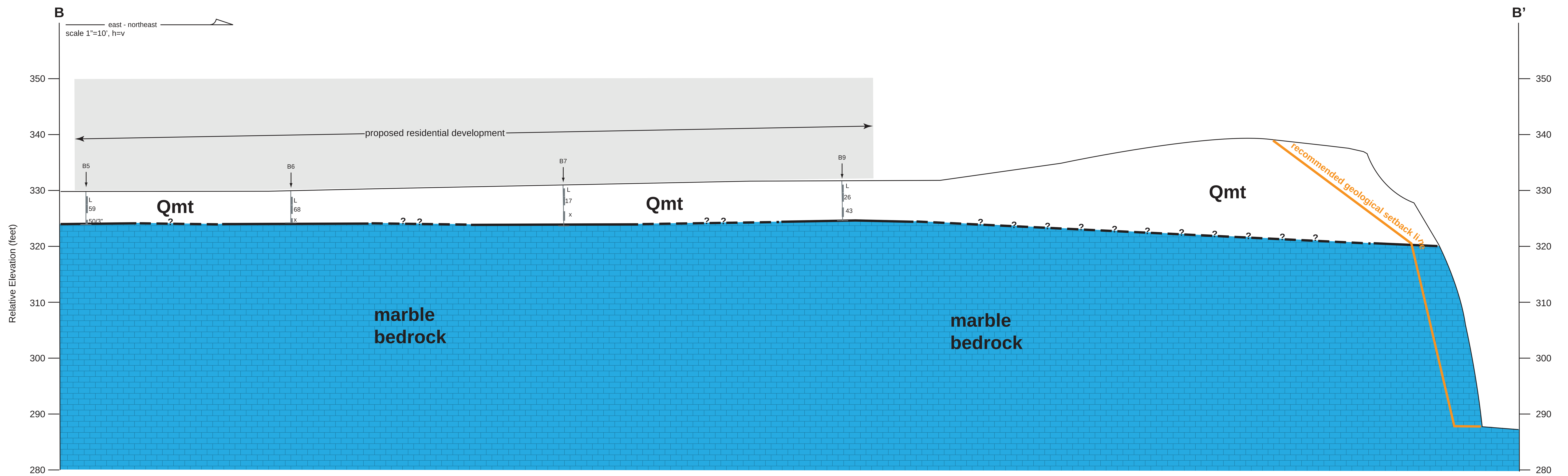
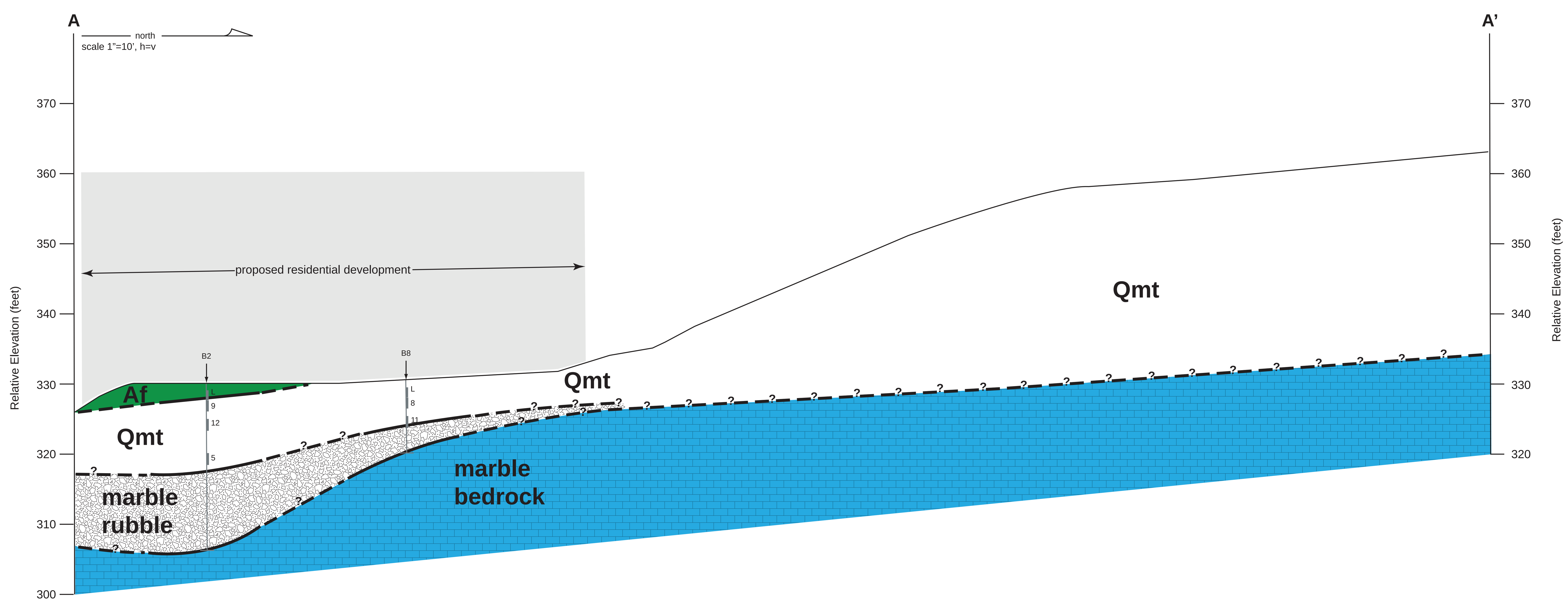
GEOLOGIC SITE MAP
Peace United Church - Envison Housing
900 High Street
Santa Cruz, California
Date: 2 July 2018
Revised:
Job #2018011-G-SC
Scale: 1"=10'
Drawn by: ENZ/enz
Plate 1
CERTIFIED ENGINEERING GEOLOGIST ERIK N. ZINN No. 2139 STATE OF CALIFORNIA
PROFESSIONAL GEOLOGIST ERIK N. ZINN No. 6854 STATE OF CALIFORNIA
284' - 11"
A'
Qmt/mar
UPPER MEADOW
40' - 0"
70' - 0"
Qmt/mar
recommended geologic setback from top of steep slope/steep quarry wall
top of steep quarry wall/top of steep slope
B'
QUAR
SLOPE SETBACK
10' - 0"
B9
332
7'
325
B1
332
10'
322
B7
332
7'
325
B8
331
10.5'
320.5
B10
330
12
318
Qmt/mar
B6
332
6'
326
B5
332
6'
326
B
LOWER LOT
B2
329
24'
305'
QUARRY SETBACK
60' - 0"
B3
329
9'
320
B4
329
9'
320
A
72' - 0"
Qmt/mar
15' - 6"
TYP
170' - 6"
325
320
315
310
EXPLANATION
B10
330
12
318
Small-diameter borings advanced for this project; the elevation of the boring, the depth below the ground surface at which intact marble bedrock was encountered and the elevation at which intact marble bedrock was encountered is beside the boring symbol.
670
Intact marble bedrock surface elevation contours; five-foot contour interval; hachures point downslope within closed depressions in bedrock.
Dolines containing relatively soft soil that pose a risk to the proposed development due to settlement or collapse
B B'
Line of geologic cross section; see Plate 2 for cross sections
Qmt/mar
Marine terrace deposits underlain by marble bedrock
N
W
E
S
0 5 10 20
Feet
BASE MAP: Excerpted from a digital copy of A00 titled "Envision Housing - Peace United Church-Site Plan" , by David Baker Architects, dated 12 April 2018, intended publication scale: 1"=100'.





SYMBOLS

Interpreted contact between earth material units; queried where uncertain

B-10
49

Exploratory boring advanced by Dees & Associates; Small filled rectangles indicate where samples were taken; integers next to rectangles are blow counts for that sample, normalized to a Terzaghi sampler.

EARTH MATERIALS

Af	Artificial fill
Qmt	Marine terrace deposits
Marble rubble	Marble rubble - angular gravel to boulder sized fragments of marble that have collapsed into doline
Marble	Intact marble bedrock

NOTES

1. Marble rubble are shown only on cross section.

2. The configuration of the marble surface portrayed on our geologic profile does not exactly match the marble surface portrayed on Geologic Site Map (Plate 1). The marble surface contour map was used as a general guideline for the profile constructions. The karst geometry is conservatively interpreted on the profile; hence, the marble surface shown on the profile varies slightly from the configuration portrayed on Plate 1.

3. Final location and foundation depth of proposed buildings has not been decided upon as of the publication of this report. Buildings shown on this cross are schematic and are intended only to aid the reader in understanding where the building might approximately lie upon the existing ground surface with respect to the underlying geologic structure.

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GEOLOGIC CROSS SECTIONS

Peace United Church - Envison Housing

900 High Street

Santa Cruz, California

Date: 2 July 2018	Revised:
Job #2018011-G-SC	
Scale: 1"=10’, h=v	**Plate 1**
Drawn by: ENZ/enz	