9 June 2023 Project No. 2381

City of Capitola, Public Works
Attention: Jessica Kahn, Public Works Director
420 Capitola Ave
Capitola, California 95010
Phone: (831) 475-7300
jkahn@ci.capitola.ca.us

Re: Limited geological investigation of coastal bluff failure
Grand Avenue footpath near intersection with Oakland Avenue and Saxon Avenue
Capitola, California 95010

Dear Jessica:

This letter presents the results of our limited geological investigation of the bluff failure that has undermined portions of the footpath along Grand Avenue between its intersection with Oakland Avenue and Saxon Avenue (see Plate 1).

Over the long term, the bluff below the footpath has been episodically retreating as the soil and bedrock exposed on the bluff face erodes and fails in the form of shallow landslides, debris flows and rock falls, mostly in response to intense storms, wave erosion and earthquakes. The most recent shallow landslides that have caused the top of the bluff to retreat and undermine the footpath this winter appear to have been driven by saturation of the marine terrace deposits soil that caps the underlying Purisima Formation bedrock, as well as toppling failures of slabs of the bedrock from top to bottom (see Plate 2).

The overall failure process for the coastal bluff at this location is a two-part process. The Purisima Formation bedrock exposed in the lower bluff is eroded and notched by waves until the notch intersects a nearly vertical bluff-parallel joint set, at which point a slab of bedrock topples, typically from top to bottom for the exposed slab. The bedrock topple process also takes the overlying marine terrace deposits along with it leaving a very steeply dipping to nearly vertical scar in the bluff face that freshly exposes both the bedrock and marine terrace deposits. At that point, the wave scour process begins anew at the base of the bluff, eventually carving another notch into the bedrock. The marine terrace deposits concurrently begin to erode and slide in a piecemeal fashion as they seek the angle of repose of about 38 degrees for the sand and gravels that compose that formation. This process continues unabated until the bedrock topples again in the future, resetting the entire retreat process geometry and clock.

We mapped the position of the bluff and the exposed formations using the base map by Bowman and Williams provided to us by the City of Capitola. We relocated the top of the bluff on that map as well as the fence line because the bluff has apparently receded since

the last time that portion of the map was modified and the fence at the top of the bluff has been relocated in locations in response to the bluff failures.

The bluff is in various states of failure between Saxon and Oakland Avenues. Portions of the bluff failed from top to bottom in response to intense storms of this past winter. In some locations, the bedrock exposed in the bluff is dilated and appears to be primed for toppling. Deep notches within the bedrock at the base of the bluff and sea caves were observed during our field reconnaissance on 14 May 2023. Extensional fractures (marked by red hachured lines on Plate 1) were observed on the ground surface in several locations, which indicates that the Marine Terrace Deposits in the bluff face are continuing to fail in reaction to this past winter's landslide.

The base of the bluff where it intersects with the modern day wave cut platform (called the "shoreline angle") was covered by sand, landslide deposits and rubble during our 14 May 2023 reconnaissance. It is likely that the wave carved notches into the bedrock at the base of the bluff are even deeper than observed.

We also reviewed a geological report for the Depot Hill Geological Hazard Abatement District, prepared on 12 April 2000 by Rogers Johnson and Associates. The report documents a past calculated long term bluff retreat rate of about 1.0 feet per year at that time which seems reasonable based upon our experience with past geological investigations in this area. The authors also cautioned the reader that the bluff had been severely undercut at that point, implying that a large failure of the bluff was imminent. This process described by them isn't a one time event – as noted above this is an ongoing cyclical process that is constantly driving the face of the bluff landward.

As noted at the beginning of this letter, the fate of the bluff and the retreat is always tied to what is happening at the base of the bluff with respect to notching and formation of sea caves. We noted two distinct conditions with respect to that observation for the area studied:

1. Various portions of the bluff between Saxon and Oakland Avenues that occurred this winter appear to have been triggered by toppling of undercut bedrock (see Plate 2). Although we could not observe the absolute bottom of the base of the bluff in this area, since it is still obscured by sand and landslide debris, the volume of large sandstone blocks in the debris indicates that bedrock portion of the bluff failed, perhaps more than five feet of the undercut bluff face.

2. Some of landslides that occurred this winter between Saxon and Hollistr Avenues , appear to have been within the marine terrace deposits only (see Plate 2). The bedrock bluff face in some of those areas appears to be undercut by at least five feet and is primed to topple.

3. Although no landsliding occurred this past winter in some locations between Saxon and Oakland Avenues (see heavily vegetated areas on bluff face on Plate 2), the bedrock is primed to topple at this location due to being notched at the base.

Most of the marine terrace deposits in this area are over steepened and will likely lay back to an average angle of about 38 degrees. This may come about in one to three rainy seasons. Since this region is subject to wet and dry cycles that can last for years, we need to assign a range of years to the concept of one to three rainy seasons. The conservative analysis would assume that we will have back-to-back wet seasons for the next several years, which may lay back the marine terrace deposits to the angle of repose. A more liberal analysis would assume that we will enter a drought period of three to five years, followed by wet year. Using those ranges implies that the top of the bluff within Blocks A and C may retreat significantly within one to six years.

A review of the most recent El Nino status by NOAA (which can be accessed here: https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/enso_evolution-status-fcsts-web.pdf) indicates that “A transition from ENSO-neutral to El Niño is favored during May-July 2023, with chances of El Niño increasing to greater than 90% into the winter 2023-24.” Although El Nino climatic conditions do not always result in greater than average precipitation and large storm waves, the condition itself raises the probability of those types of events impacting central California. If we have a repeat of this past storm season next year, the top of the bluff may retreat significantly by the end of next winter in the study area.

We have projected where the top of the bluff will retreat if the marine terrace deposits lay back to the angle of repose of about 38 degrees on two cross sections and the site map (see Plate 1). Using just this analysis pushes the top of the bluff back between 11 to 19 feet from the current position. This line represents the retreat that could happen in one to six years.

We have not factored in the collapse of the undercut portion of the bluff bedrock or the landsliding and subsequent retreat that would occur in the event of a large magnitude earthquake. If either of those processes are factored in and occur within that time period of one to six years, the amount of bluff retreat may be even greater.

On a final note, we understand that if the footpath is to be reopened, it will need to be repositioned further landward from its current position. Any work toward that end should be completed in a manner that will not exacerbate the tenuous stability of the marine terrace deposits exposed in the bluff face.

BLUFF TOP BETWEEN OAKLAND AND HOLLISTER AVENUES

We also mapped the current position of the top of the bluff between Oakland and Hollister Avenues. Portions of the bluff have continued to retreat since the author of this letter last looked at it in 2017 (Zinn Geology, 2017). The portion of the bluff nearest to the residence on the northeastern side of Oakland Avenue (402 Oakland Avenue) appears to have retreated the most in the last five years since we looked at this area, with very little of the original 2017 footpath remaining.

FINDINGS

Turning to Plate 1, the reader may note that our projected one to six year bluff retreat line impinges upon the seaward end of the residential properties. This implies that even if the footpath is pushed landward and snugged up against those properties, it may be undermined and threatened in less than a decade.

The marine terrace deposits exposed in the upper bluff are in a very fragile state with respect to landsliding. The usage of heavy equipment within 15 feet of the top of the bluff, particularly if the soils are wet, may trigger further landsliding of the marine terrace deposits.

RECOMMENDATIONS

1. The City should consider the effective life of the footpath when contemplating short term and long term expenditures for keeping the footpath open. In the long term, the City will need to protect the entire bluff from further erosion and landsliding with very expensive top-to-bottom armoring methods if they want to keep the existing alignment of the footpath open.

2. Any work performed on the footpath between Oakland Avenue and Saxon Avenue should be done by hand within 15 feet of the top of the bluff. The use of heavy vibratory equipment should be avoided if possible, to lessen the possibility of triggering further landsliding of the bluff. If heavy equipment is used, the work should only be performed when the marine terrace deposits are dry, typically late spring (May) through fall (October).

This concludes our geological letter regarding the impacts of landslide and bluff top retreat for the Grand Avenue footpath between its intersection between Saxon Avenue and Oakland Avenue. Please do not hesitate to contact us if you have any questions about this letter or our work or need further assistance.

Sincerely,

PACIFIC CREST ENGINEERING INC.

Erik N. Zinn
Principal Geologist
P.G. #6854, C.E.G. #2139

Attachments: Plate 1 – Site Map & Geologic Cross Sections
Plate 2 – Annotated April 2023 Snapshot Of Coastal Bluff

Pacific Crest
ENGINEERING INC

SITE MAP & GEOLOGIC CROSS SECTIONS

City of Capitola
Grand Avenue Footpath
Between Saxon Ave. and Oakland Ave.

Date: 8 June 2022	Revised:
Job #2381	
Scale: 1"=20'	**Plate 1**
Drawn by: ENZ/enz	

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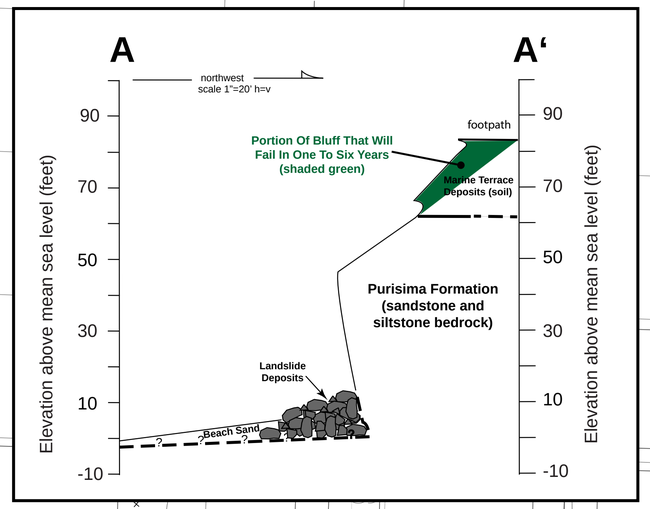

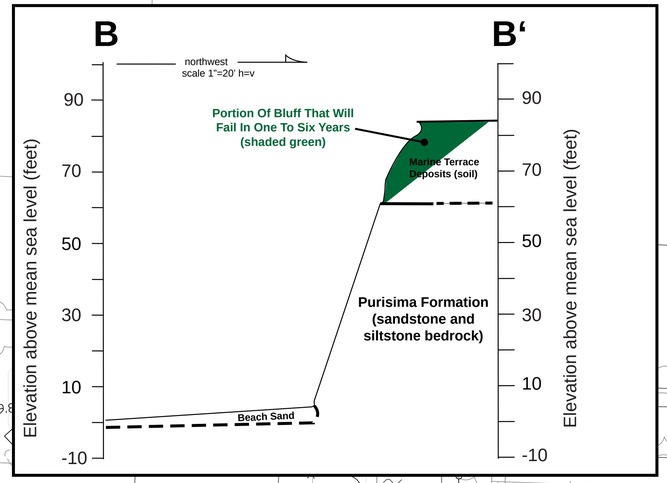

SAXON AVE
OAKLAND AVE
HOLLISTER
DENSE TREES
DENSE BRUSH
#4
#5
#8
#9
#13
#14
CB 83.1
CB 82.3
CB 81.6
CB 88.9
OMH 91.0
MEAN HIGH TIDE 1.63
WATER LINE
PROJECTED TOP OF BLUFF ONE TO SIX YEARS FROM NOW
CURRENT TOP OF BLUFF
bluff concealed by thick brush
extensional cracking (typ.)
undermined
B'
A'
B
A

0 10 20 40
Feet

N
W
E
S

BASE MAP: Digitally excerpted from AutoCAD file of topographic map sheets titled "Topographic Map - Grand Avenue & Viciinty", prepared by Bowman & Williams - Consulting Civil Engineers with an intended publication scale of 1"=20'. The map respresents topography compiled from Aero-Geodetic Corp. Job Number 996942 (dated photgraphy 6 June 1999) and Bowman & Williams surveys (4 June 1999, 8-10 November 1999, 22-24 November 199). Topography along beach and toe of cliff was during low tide -1.3 feet (22-24 November 1999)

E 10800
N 10200

BASE PHOTO: Screen shot taken of “2023 04 04 Capitola Depot Hill and Explanade” by Misa Burich; drone video can be accessed at https://www.youtube.com/watch?v=Lt5N3-Gl5zM&t=1s

Pacific Crest
ENGINEERING INC

ANNOTATED APRIL 2023
SNAPSHOT OF COASTAL BLUFF
City of Capitola
Grand Avenue Footpath
Between Saxon Ave. and Oakland Ave.

Date: 8 June 2022	Revised:
Job #2381	
Scale: n/a	**Plate 2**
Drawn by: ENZ/enz	

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