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April 12, 2024

Mr. Don Daniels
22985 El Camino Real
Santa Margarita, CA 93453
c/o Thomas Bond & Associates

SUBJECT: Wave Uprush Analysis for Proposed New Single Family Residence at 495 Sea Court, Shelter Cove California.

Dear Don Daniels:

In accordance with your request and authorization, we are pleased to submit this report regarding wave runup and bluff/shoreline erosion for the proposed residential development at 495 Sea Court on Shelter Cove, California. The purpose of this report is to provide a response to the County of Humboldt February 2, 2024 letter requesting a wave runup analysis as part of a site specific coastal hazard analysis in consideration of Sea-Level Rise (SLR) and the proposed development. It also provides an analysis of the potential bluff erosion over the life of the development. The California Coastal Commission SLR Policy Guidance(CCCSLRG) document was adopted updated in November 2018 and requires the use of the best available SLR science, which at this time is the NOAA (2022), NASA (2023), and the Ocean Protection Council 2024 Draft SLR document. There are two different potential oceanographic hazards identified at this site for the residential project; shoreline erosion and wave runup. The coastal hazard of flooding from the ocean is not considered due to the elevation of the proposed improvements (above +40 feet NAVD88). For ease of review, each of these hazards will be analyzed and discussed separately, followed by a summary of the analysis including conclusions and recommendations.

EXISTING SITE & PROJECT

The existing site is an undeveloped rectangular shaped lot that extends from Sea Court, at elevation ±43 feet NAVD88, down to a utility easement on the bluff face below elevation ±20 feet NAVD88. The project includes a new single family residence, associate flatwork and landscaping. The geology of the site has been provided by the project geotechnical consultant (SHN, 2022a & 2022b)), and consists of a relatively thin layer of paralic deposits over a very erosion resistant bedrock (Point Delgado Formation). Typically residential development has a design life of 75 year. For discussion and analysis herein, the design life of the proposed development will be to about the year 2100. Figure 1 is a recent Google Earth aerial of the site downloaded from the internet. Figure 2 is the FEMA FIRM for the site and shows that the development site is in the FEMA D Zone (undetermined flood risk). Seaward of the development is the FEMA VE Zone with a Base Flood Elevation of +37 feet NAVD88.

Figure 1. Recent Google Earth aerial showing the project site and footprint of the proposed residence in relation to the adjacent properties and the erosion resistant bedrock shoreline.

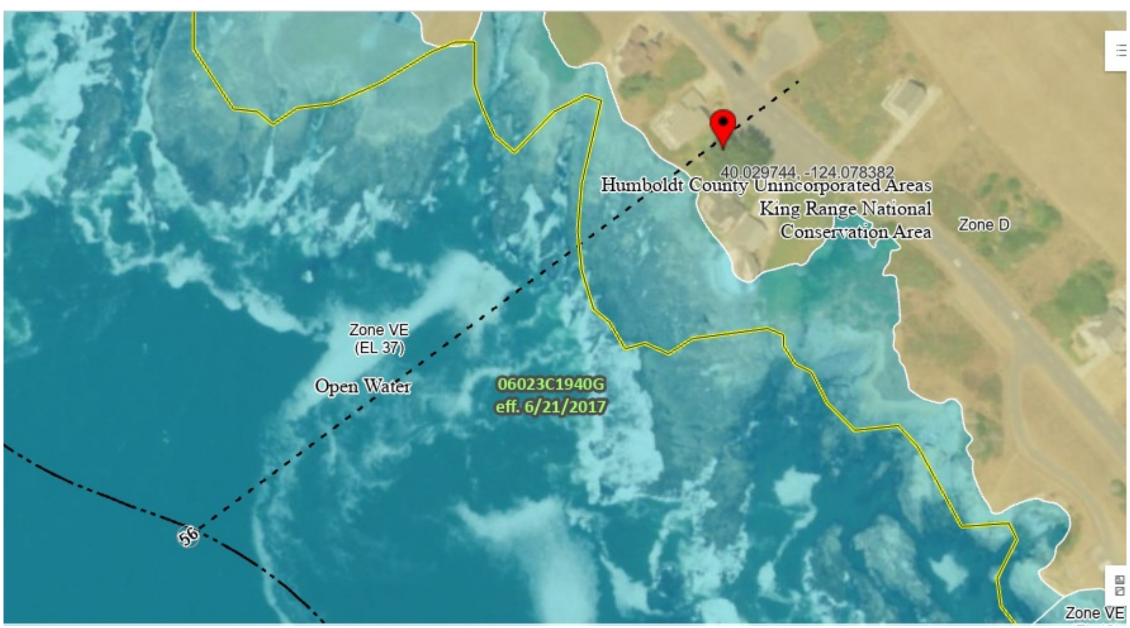

Figure 2. Current FEMA map showing the residence location is in the FEMA D, and the FEMA VE Zone is seaward of the building location.

EROSION

Erosion is a form of mass wasting, and is defined as the wearing away of land by natural forces. Erosion on a beach is the carrying away of beach material by wave action, tidal currents, and littoral currents. Erosion in an urban area can be influenced by man's activity (anthropogenic erosion). Anthropogenic erosion is a result of activity such as grading, irrigation, and drainage modification. An example of anthropogenic erosion is the sloughing of the slope due to elevated groundwater levels as a result of over-irrigation or uncontrolled drainage over the bluff. Beach erosion can be impacted by man when the source of sand for the beach, typically erosion of the land, is modified by landscaping and even damming of rivers. Beach erosion and shoreline erosion are often interchanged. Beach sands are a very mobile deposit with sand levels changing rapidly due to large waves (daily), more slowly seasonally due to annual wave climate, and dramatically over the long-term due to natural and anthropogenic causes. Shoreline erosion is typically identified with the longer-term erosion trend of the shoreline, which can be characterized by either beach sand or slope/bedrock material. Erosion of the bedrock bluff below this site will not likely impact the proposed development due to the setback from the shoreline of over 160 feet, and the elevation above the beach.

SHORELINE/BLUFF EROSION

The 495 Sea Court site lies on a rocky headland and is not within an actual littoral cell. A littoral cell is a coastal compartment that contains a complete cycle of littoral sedimentation including sources, transport pathways, and sediment sinks. The Shelter Cove shoreline is characterized by an erosion resistant bedrock below more erosive formations. The United State Geological Survey produced a report in 2007 entitled "National Assessment of Shoreline Change Part 4: Historical Coastal Cliff Retreat along the California Coast." This report looks at survey data as far back as the late 1800's, along with historical aerial photographs to look at shoreline change in California. While data at this site is sparse, the report does not identify any measurable cliff retreat.

Historical aerial photographs of the study area are available on the California Coastal Records Project web site (http://www.californiacoastline.org/), on Google Earth, and at the University of California Santa Barbara historical aerial photograph collection. The purpose of the historical photograph review is to confirm the conclusion of that there is little, if any, bluff or shoreline erosion in the entire site area. Figures 3 and 4 were downloaded, with permission from the Coastal Records website. Figure 3 was taken in 1972 and was part of the California Department of Boating and Waterways inventory of the shoreline conditions at the time the California Coastal Act was being considered. The Coastal Act is the guiding document for the California Coastal Commission. Figure 4 is a photograph that was taken in September 2013 as part of the California Coastal Records Project, a privately funded public service effort. Although the elevation, sun, and angle of the photographs are slightly different, comparison of these photos taken over four decades apart visually verifies that there is little, if any, historical erosion occurring along the shoreline in the site area, even in the open beach areas directly exposed to waves. Many of the surge channels, benches, and notch features are unchanged between figures.

Figure 3. 1972 Coastal Record Project oblique aerial of the site (the site is to the left of the house in the image) for comparison to Figure 4.

Figure 4. 2013 Coastal Record Project oblique aerial of the site (the site is where is boat is in image) for comparison to Figure 3.

For further comparison of the historical bluff, two vertical aerials are used. Figure 5 is the July 1954 UCSB collection photograph (Flight CVL 1954 7N-133) of the site and adjacent bluff. Figure 6 is the July 2023 Google Earth photograph of the same area. Areas and features have been noted on each figure for comparison.

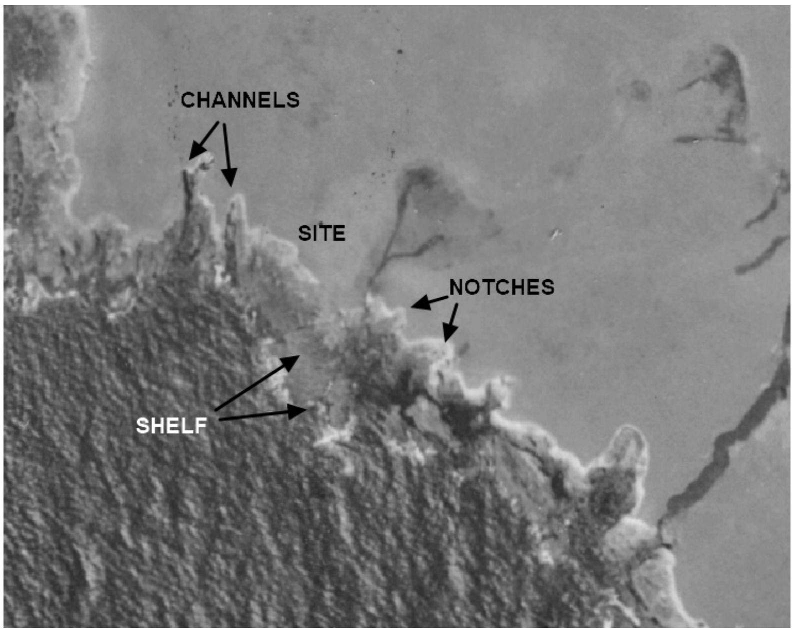

Figure 5. UCSB 1947 vertical aerial photo of the site for comparison to Figure 6.

Figure 6. Google Earth 2023 photograph of the site area from comparison to Figure 5.

The time period from 1957 to 2022 shows no overall shoreline or bluff top erosion. It also shows a very erosion resistant bedrock and intertidal platform in front of the site. This feature is a very effective wave energy dissipater and provides protection of the site from wave runup. This is further evidenced by the slope of the cliff at the site compared to the steeper cliffs to either side of the site. Based on our review of the referenced report, site observations, and review of aerial photographs, there has been no observable bluff top erosion at the site and little to no erosion of the actual bluff.

SEA LEVEL RISE

The CCCSLRG requires the use of the "best available SLR science" to determine the project SLR. The CCCSLRG is based upon the California Ocean Protection Council (OPC) update to the State's Sea-Level Rise Guidance in March 2018. These OPC estimates are based upon a 2014 report entitled "Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites" by Kopp, et al., 2014. The Kopp et al. paper used 2009 to 2012 SLR modeling by climate scientists for the probability analysis, which means the "best available science" used by the CCC is about 10 years old. The SLR models used as the basis for the OPC and CCCSLRG have been in place for over a decade. The accuracy of any model can be determined by comparing the measured SLR (real time data) to the model predicted SLR (model prediction). If the model does not predict, with any accuracy, what has happened in the past, it is very unlikely that the model will increase in accuracy when predicting SLR over the next 100 years.

The National Oceanic and Atmospheric Administration (NOAA) has been measuring SLR globally, and specifically in North Spit, which is the closest NOAA SLR monitoring station to Shelter Cove. The NOAA Shelter Cove SLR rate is ~5 mm/yr as shown in Figure 7. If we assume that the North Spit rates do not change significantly in the next 76 years (which is likely) the amount of North Spit SLR by the year 2100 will be about 1.3 feet.

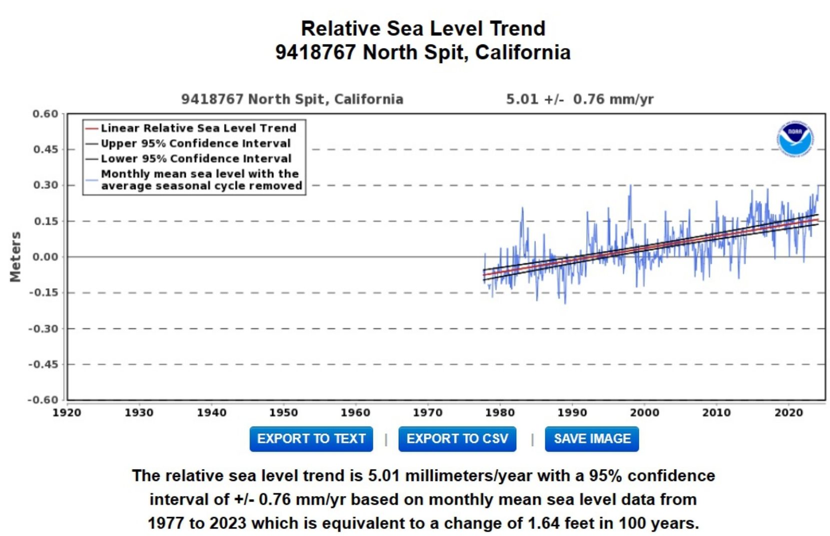

Figure 7. Historical measured SLR at North Spit from NOAA.

The CCCSLRG states that it is an advisory and not a regulatory document or a legal standard for review for the actions that the Commission or local governments may take under the Coastal Act. The CCCSLRG emphasizes that Coastal Commission and local government action on a CDP is subject to requirements of the Coastal Act, certified Local Coastal Program "and other applicable laws and regulations as applied in the context of the evidence in the record for that action." The CCCSLRG sets forth certain guiding principles that broadly lay out common ideas and a framework by which SLR planning and permitting actions can be assessed. In this context, the Guidance states, "CDPs should analyze the medium-high and/or extreme risk aversion projections (from the 2018 [Ocean Protection Council ("OPC") Sea Level Rise Guidance ("OPC Guidance")] of sea level rise, as appropriate, in order to understand the implications of a worst case scenario."

Again, the OPC projections are computer models based upon a 2014 report entitled "Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites" by Kopp, et al. The Kopp et al. paper used SLR data generated between 2009 to 2012 and modeled 6 risk scenarios associated with different probabilities that the projected SLR will be met or exceeded as follows:

(i) Very Low Risk (99.5% probability of being met or exceeded)
(ii) Likely Risk (66% probability of being met or exceeded)
(iii) Median Risk (50% probability of being met or exceeded)
(iv) Low High-Risk Aversion (17% probability of being met or exceeded)
(v) Intermediate High Risk (5% probability of being met or exceeded)
(vi) Medium High Aversion Risk (0.5% probability of being met or exceeded)

In addition to these scenarios, the OPC Guidance provides an Extreme Risk Aversion scenario (also known as H++) based on Sweet et al. 2017, which has less than a 0.01% probability of being met or exceeded. The Guidance suggests that a city use the Medium High Risk Aversion scenario - a model with a 99.5% probability that the projected SLR will not occur - and/or an Extreme Risk Aversion scenario – a model with over a 99.9% probability that the projected SLR will not occur.

Figure 8, from the OPC Guidance, shows the projected SLR at the North Spit gauge above a 2000 baseline year. It shows that sea level is projected to rise 6.3 feet to 7.6 feet by 2100 using the Medium High Risk Aversion scenario, with a 99.5% probability that those SLR levels will not occur. The very recent OPC 2024 Draft SLR Update predicts statewide SLR of 1.8 feet to 5.5 feet by the year 2100. Figure 9 is the COPC 2024 Draft SLR table for North Spit. The message herein is that the measured SLR has been less than the models the CCC suggested to be used predicted. Simply put the CCCSLRG models are incorrect. For the purpose of this analysis a very conservative SLR of 5.5 feet for the design life of the development is used.

NORTH SPIT CALIFORNIA NOAA

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.6	0.5 -	0.7	0.8	1	1.2
	2040	0.9	0.7 -	1.1	1.2	1.6	2.0
	2050	1.2	0.9 -	1.5	1.7	2.3	3.1
Low emissions	2060	1.3	1.0 -	1.7	2	2.8	
High emissions	2060	1.5	1.2 -	1.9	2.2	3.1	4.3
Low emissions	2070	1.6	1.2 -	2	2.4	3.5	
High emissions	2070	1.9	1.4 -	2.4	2.9	4	5.6
Low emissions	2080	1.8	1.4 -	2.4	2.9	4.4	
High emissions	2080	2.3	1.7 -	2.9	3.5	5.1	7.2
Low emissions	2090	2.1	1.5 -	2.7	3.4	5.3	
High emissions	2090	2.7	2.0 -	3.5	4.3	6.2	8.9
Low emissions	2100	2.3	1.7 -	3.1	3.9	6.3	
High emissions	2100	3.1	2.3 -	4.1	5.1	7.6	10.9
Low emissions	2110*	2.5	1.9 -	3.3	4.2	7.1	
High emissions	2110*	3.3	2.6 -	4.3	5.2	8	12.7

Figure 8. 2018 OPC projections for North Spit.

Table 2. Sea Level Scenarios for N. Spit, Humboldt Bay.

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.

Year	Low	Int-Low	Intermediate	Int-High	High
2020	0.3	0.4	0.4	0.4	0.4
2030	0.5	0.6	0.6	0.6	0.7
2040	0.7	0.8	0.9	1	1.1
2050	0.9	1	1.2	1.4	1.6
2060	1.1	1.3	1.5	2	2.4
2070	1.3	1.5	1.9	2.7	3.5
2080	1.4	1.8	2.5	3.6	4.7
2090	1.6	2.1	3.1	4.5	6
2100	1.8	2.4	3.9	5.5	7.3
2110	1.9	2.7	4.6	6.5	8.7

Figure 9. Draft 2024 OPC SLR estimates for North Spit NOAA tide station.

WAVE RUNUP ANALYSIS

As waves approach the shoreline and the site, they break and water rushes up the bedrock shelf, and to and bluff. Wave runup is defined as the vertical height above the still water level to which a wave will rise on a structure (the bluff) of infinite height. Wave runup at the site is calculated using the USACOE Automated Coastal Engineering System (ACES). The methods to calculate runup implemented within this ACES application are discussed in greater detail in the Coastal Engineering Manual (2004). Figure 10 from the ACES manual shows some of the variables involved in the runup and overtopping analysis.

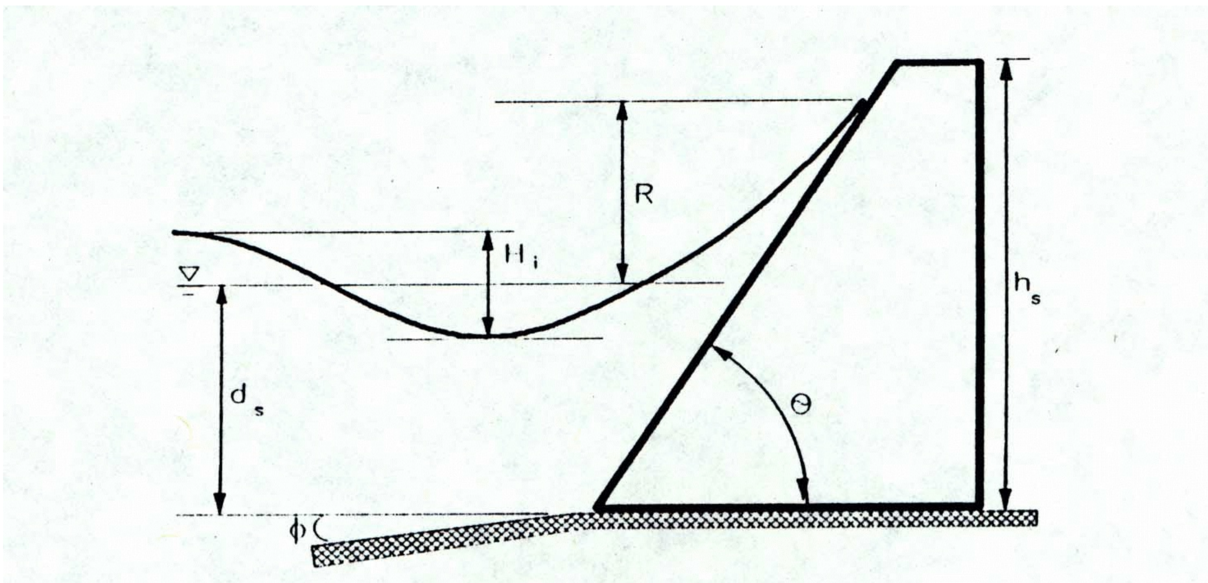

Figure 10. Wave runup terms from ACES analysis.

During storm conditions, the sea surface rises along the shoreline (super-elevation) and allows waves to break closer to the shoreline and runup on the beach. Super-elevation of the sea surface can be accounted for by: wave set-up, wind set-up and inverse barometer, wave group effects, and El Niño sea level effects. The design water elevation for this analysis is the highest observed water elevation of about +9 feet NAVD88.

There are several factors that are important to the analysis of the vulnerability of a site along the shoreline. Some of the factors are based upon the existing topography, bathymetry, roughness of the bluff, and elevation of the improvements/structures at the site. The offshore slope is relatively steep at 1/50 (V/H) (from Google Earth). The slope of the bedrock bluff is about 1/4. The design water elevation will be +14.5 feet NAVD88 (+9 feet NAVD88+ 5.5 feet of SLR).

Determination of the maximum scour depth at the toe of the site enables the engineer to determine the actual water depth at the toe of the bluff and wave break point under the design water level conditions. The design scour elevation is estimated based upon the erodability of the materials at the site. Based upon the elevation of the bedrock bench at the toe of the site bluff, a conservative estimate of the scour elevation at the toe of the site in 75 years is about +3 feet NAVD88. This is reasonable based upon the presence of bedrock at the shoreline. Using the maximum still water elevation and the maximum scour yields a total water depth of 11.5 feet at the site toe for the 5.5 feet SLR case. This value represents the extreme possible wave runup conditions at the site over the next 75 years and will be used in the design analysis.

The relatively steep offshore area allows for energy from large waves to come relatively close to the shoreline. Once a wave reaches a water depth that is about 1.28 times the wave height, the wave breaks and runs up onto the shore. The design wave height at the toe of the bluff is the maximum unbroken wave at the toe when the bedrock is at the maximum scour condition (the bedrock platform elevation at the toe of the bluff). For the total water depth of 11.5 feet the design wave height is ~9 feet using the FEMA depth limited design wave criteria. The ACES output is provided below in **TABLE I**.

TABLE I

ACES	Mode: Single Case	Functional Area: Wave - Structure Interaction
Application: Wave Runup and Overtopping on Impermeable Structures		

Item		Unit	Value
Incident Wave Height	Hi:	ft	9.000
Wave Period	T:	sec	18.000
COTAN of Nearshore Slope	COT(ø):		50.000
Water Depth at Structure Toe	ds:	ft	11.500
COTAN of Structure Slope	COT(θ):		3.500
Structure Height Above Toe	hs:	ft	36.000
Rough Slope Coefficient	a:		0.956
Rough Slope Coefficient	b:		0.160
Wave Runup	R:	ft	20.594
Deepwater Wave Height	H0:	ft	5.752
Relative Height	ds/H0:		1.999
Wave Steepness	H0/(gT^2):		0.001

Rough Slope Runup

495 Sea Court

Wave Runup

5.5 Feet SLR

The runup analysis shows that with 5.5 feet of SLR in the next 75 years, the maximum wave runup elevation is ~+35 feet NAVD88 (14.5 feet NAVD88 + 20.5 feet of runup in **TABLE I** above). Comparing Figure 4 with the topographic map shows the current maximum wave runup (denoted by the dead vegetation line) is about elevation +31 feet NAVD88. The increase in wave runup elevation on the rough sloping bluff surface due to SLR is a little less than the amount SLR. In other words, 5.5 feet of SLR resulted in about a 4 feet increase in the wave runup elevation over the rough and sloping bedrock. This is typical of rocky sloping shorelines through out California. The existing lowest FF is above +40 feet NAVD88, and should be safe from future wave runup with SLR due to the elevation of the improvements, and setback from the shoreline.

FUTURE EROSION

Provided that the natural and anthropogenic causes of erosion are expected to remain constant over the next 75 years, the future erosion rate will be roughly equal to the historical erosion rate. It is clear that there has been little, if any, erosion of the site area for the past 70+ years. What is clear is that the bedrock bluff at the site is very erosion resistant as seen by comparing Figures 3 through 6. Even when the near shore bedrock is subject to daily wave action, the rate of erosion is very low. As sea level rises, the waves will encounter the same bedrock, albeit at a higher elevation. Based upon the non-erodible nature of the shoreline bedrock and the extension of the bedrock well above the current elevation of the ocean, sea level rise will not substantially increase the rate of bluff erosion at the site.

CONCLUSIONS

The potential coastal hazards associated with the proposed residence at 495 Sea Court, Shelter Cove, include shoreline erosion and wave runup. This report uses the guidelines in the CCCSLRG document for determination and discussion of coastal hazards. As discussed and demonstrated herein, the bedrock shoreline fronting the site is stable over the long term. During the coincidence of high tides, and high waves, the bluff face fronting the site may be subject to wave runup. However, based upon our analysis, and because the proposed development is located well above the wave runup elevation even in consideration of about 6 feet of SLR, the development is safe from coastal hazards. It should also be noted that there is a bedrock shelf in the intertidal surf zone at this site that acts like a breakwater to incoming waves. There are no recommendations necessary to mitigate potential coastal hazards. New shore protection will not be required to protect the proposed development over the next 75 years. The proposed development will neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or adjacent area.

LIMITATIONS

Coastal engineering is characterized by uncertainty. Professional judgements presented herein are based partly on our evaluation of the technical information gathered, partly on our understanding of the proposed construction, and partly on our general experience. Our engineering work and judgements have been prepared in accordance with current accepted standards of engineering practice; we do not guarantee the performance of the project in any respect. This warranty is in lieu of all other warranties express or implied.

The opportunity to be of service is sincerely appreciated. If you should have any questions, please do not hesitate to contact me.

Respectfully submitted,

David W. Skelly MS, PE
RCE#47857

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REFERENCES

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