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MEMORANDUM

To:	Robert Stevens, CSW | ST2
From:	Mads Jorgensen, P.E., Dilip Trivedi, Dr.Eng, P.E.
Date:	February 2, 2021
Subject:	Beach Sand Replenishment Volume
Project:	Mirada Road Bridge and Bluff Stabilization
M&N Job No.:	10405

1 Introduction

This memorandum provides an assessment of beach sand replenishment volumes for the proposed Mirada Road Bridge and Bluff Stabilization project (Project). At the onset of this project, a substantial quantity of rock slope protection had been emergency placed along the bluff as temporary protection. The basis of the present design assumes that this rock is removed and replaced with a significantly smaller quantity of rock slope protection at the toe of the proposed reinforced shotcrete wall (Figure 3-1). When the beach is at its summer profile, the rock slope protection will generally be buried beneath the sand. The proposed bluff stabilization design therefore significantly reduces the footprint of the structure compared to the rock placed for temporary protection.

Estimation of the beach replenishment volumes follows the Beach Sand Replenishment In-lieu Fee Worksheet and guidelines issued by the California Coastal Commission (CCC).

1.1 Site Description

Figure 1-1 shows a vicinity map of the project location (red star). The bridge is located along the coastal road between Half Moon Bay and Pacifica, approximately 1 mile south of El Granada and Pillar Point Harbor. Half Moon Bay is a crescent-shaped bay formed between Pillar Point and the bluffs downcoast from Miramar. The shoreline is exposed to waves from southwesterly and westerly directions but is somewhat sheltered from northwesterly waves in the lee of Pillar Point.

Figure 1-2 provides a location map for the project site and aerial view of the bridge.

Figure 1-3 provides an excerpt from the project drawings, MN (2020), showing the proposed bluff stabilization. The extent of the bluff stabilization along the beach fronting the bridge abutment includes a portion along the North Wall and along the South Wall. The interior portion of the bluff stabilization is intended for protection along the streambank and is not part of the sand replenishment volume assessment. The North Wall extent (W) along the beach is 123 feet and the South Wall extent is 36 feet.

Figure 1-1: Vicinity map.

Figure 1-2: Location map.

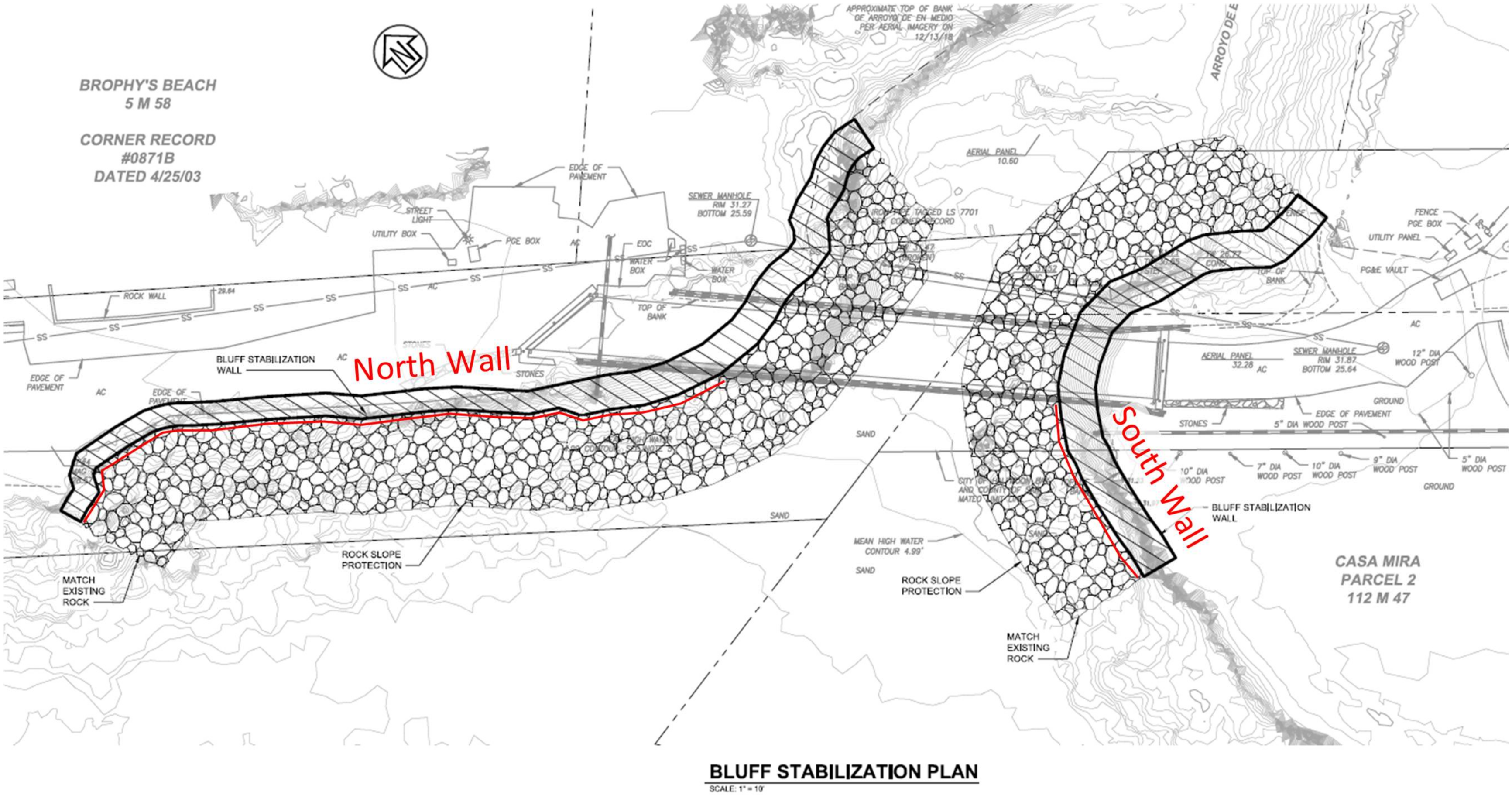


Figure 1-3: Bluff stabilization plan, MN (2020).

2 Beach Sand Replenishment Volume

An assessment of the beach sand replenishment volume is provided in Table 2-1 following the CCC Beach Sand Replenishment In-lieu Fee Worksheet, CCC (2020).

Table 2-1 summarizes the beach replenishment volumes estimated for the North Wall and the South Wall, respectively. The parameters indicated in the table follow the notation from CCC (2020). In the first section of the table, the volume of sand (V_e) to rebuild the area of beach lost due to encroachment by the seawall is estimated. In the next section, the volume of sand (V_w) to rebuild the area of beach lost due to long-term erosion is estimated, followed by the amount of beach material (V_b) that would have been supplied to the beach if natural erosion continued. The respective volumes are then carried to the bottom of the table and added up to a total volume (V_t).

Table 2-1: Sand replenishment volumes.

Parameter	North Wall	South Wall
V_e (cy)	1,230	360
A_e (sf)	1,230	360
W (ft)	123	36
E (ft)	10.0	10.0
v (cy/sf)	1.0	1.0
V_w (cy)	3,444	1,008
A_w (sf)	3,444	1,008
R (ft/yr)	0.7	0.7
L (yr)	40	40
V_b (cy)	1,262	369
S (%)	43%	43%
h_s (ft)	23.0	23.0
h_u (ft)	0.0	0.0
R_{cu} (ft/yr)	0.7	0.7
R_{cs} (ft/yr)	0.0	0.0
V_e (cy)	1,230	360
V_w (cy)	3,444	1,008
V_b (cy)	1,262	369
V_t (cy)	5,936	1,737

The calculation indicates that 5,936 cubic yard of material would be needed to replenish the beach along the North Wall, and 1,737 cubic yards along the South Wall. The total volume is 7,673 cubic yards.

The cost of the sand replenishment will depend on the material unit cost and delivery fee, which will vary depending on sourcing and contractor retained for delivery and placement of the material.

The following unit cost rates were estimated:

- Material cost for sand: $44 per cubic yard ($30 per ton).
- Cost including truck delivery to the site and end-dumping to the beach: $63 per cubic yard.

Based on this unit rate the sand replenishment cost could be on the order of $480k.

The above estimates are based on Angel Island Coarse Sand from Hanson, which is similar to the bluff material in composition. Refer to Appendix A for the gradation curve, which is included as the dark yellow line in Figure 3-7.

Values for dimensional parameters indicated in Table 2-1 were obtained from the project drawings, MN (2020). These parameters include: W, E, h_s, and h_u.

A commentary regarding the coastal engineering parameters indicated in Table 2-1 is provided in the following. The remainder of the parameters in the table were calculated based on the equations provided in CCC (2020).

3 Commentary

The following sections provide a commentary and discussion of coastal engineering parameters adopted for the beach sand replenishment volume calculation.

3.1 Project Design Life

The project design life (L) is 40 years.

3.2 Encroachment by Seawall

Figure 3-1 shows a representative section of the planned bluff protection from the project drawings, MN (2020). In the typical usage condition, the beach elevation is at around El. +11 feet NAVD88, based on USACE NCMP 2014 LiDAR from NOAA (2021a) as shown in Figure 3-2. In this condition, the rock slope protection fronting the reinforced shotcrete wall is buried beneath the sand. To err on the side of caution, the encroachment of the bluff protection was based on a beach face 3 feet lower at around El. +8 feet NAVD88 to account for years where the beach face doesn’t build up to the full height. The estimated encroachment width is estimated to E = 10 feet, which includes the extent of exposed rock slope protection and the depth of the reinforced shotcrete wall.

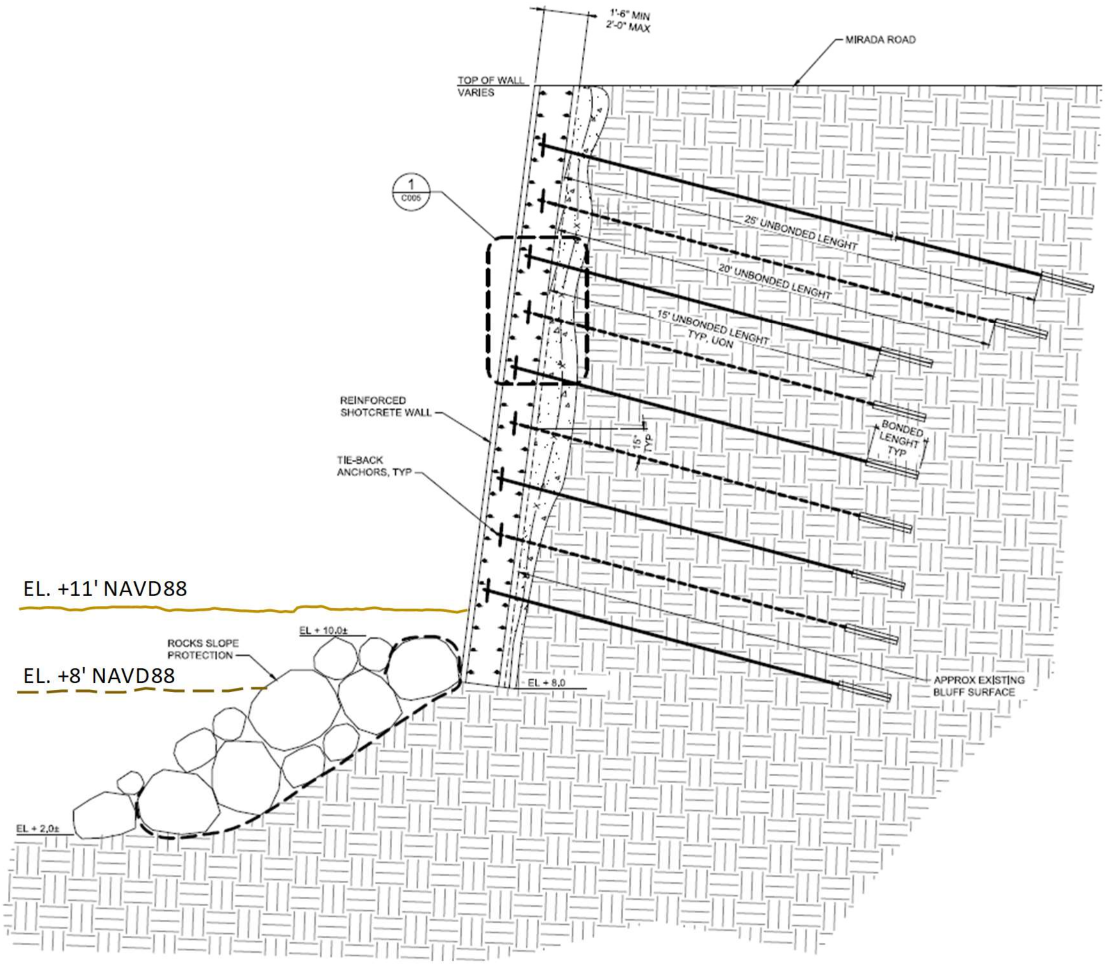


Figure 3-1: Bluff protection section, MN (2020).

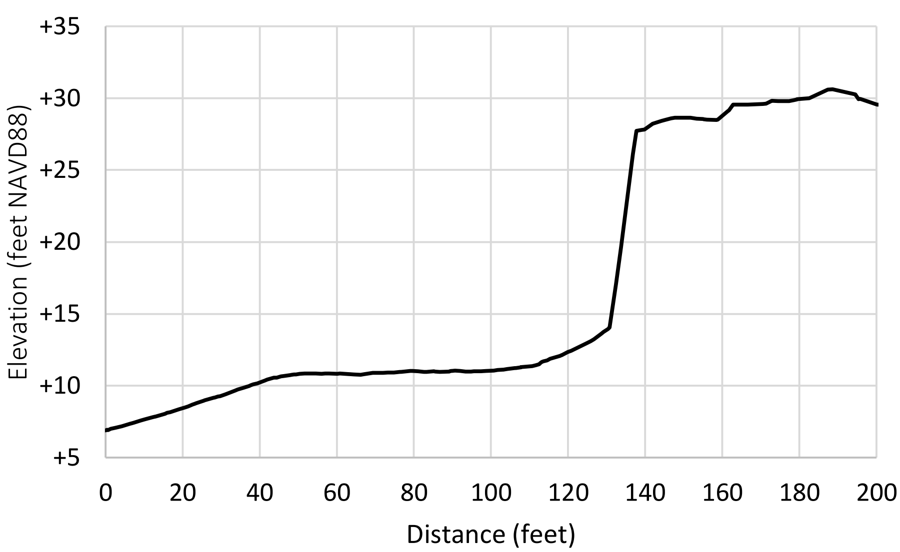


Figure 3-2: Beach and bluff profile from USACE-NCMP LiDAR, NOAA (2021a).

3.3 Closure Depth

Figure 3-3 provides an excerpt of the nautical chart for Half Moon Bay, NOAA (2021b). The project site is located at Arroyo de en Medio near Miramar.

The depth where the seabed contours start to flatten out indicates the approximate closure depth, which is estimated to 16 feet MLLW in the area of Arroyo de en Medio and Miramar per the figure. The active portion of the beach profile extends from the depth of closure up to the elevation of the beach face.

Figure 3-4 summarizes geodetic datums and tidal datums in Half Moon Bay, from NOAA (2021c). Per the figure, NAVD88 is located at nearly the same level as MLLW. The closure depth for the active portion of the beach profile is therefore estimated as: 16+11 = 27 feet. The Volume of material (v) required to replace or reestablish one foot of beach seaward of the bluff protection is therefore: v = 27’×1’×1’ = 27 cubic feet per square foot = 1 cy/sf.

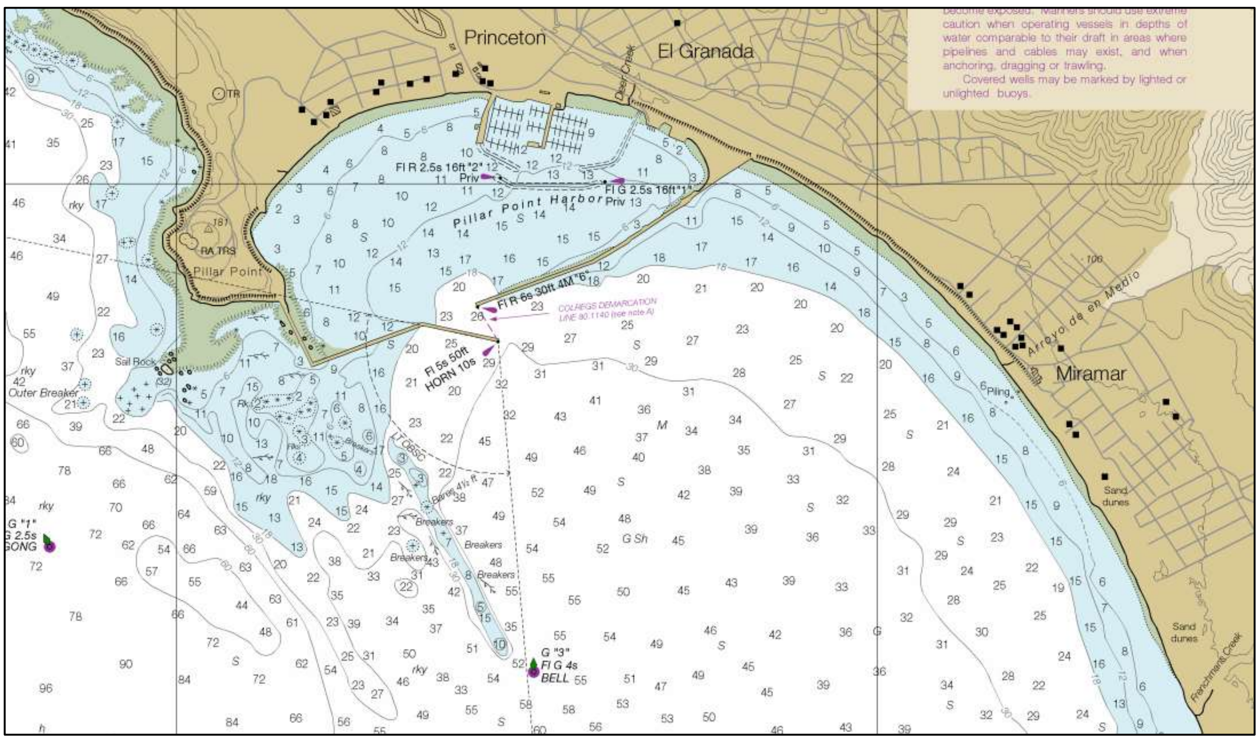


Figure 3-3: Excerpt from Navigation Chart 18682, NOAA (2021b).

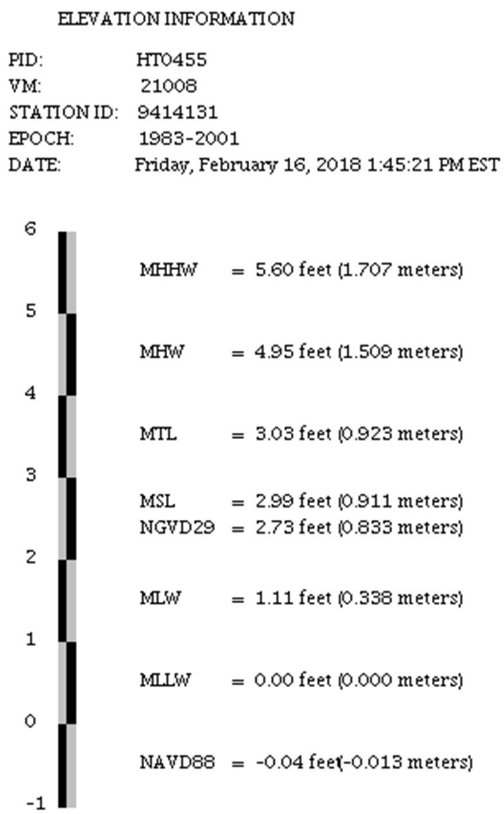


Figure 3-4: Datum information, Half Moon Bay.

3.4 Rate of Bluff Recession

Figure 3-5 shows transects (yellow bands) developed by USGS for assessment of long-term rates of shoreline recession, USGS (2021). The data shown in the figure is a digital product developed based on the work for the National Assessment of Shoreline Change, USGS (2007), to assess rates of shoreline and coastal cliff retreat along the California Coast.

The long-term rate of recession about 1,500 feet north (and further north) of Arroyo de en Medio where the shoreline is unarmored is R = 0.2 m/yr = 0.7 feet per year.

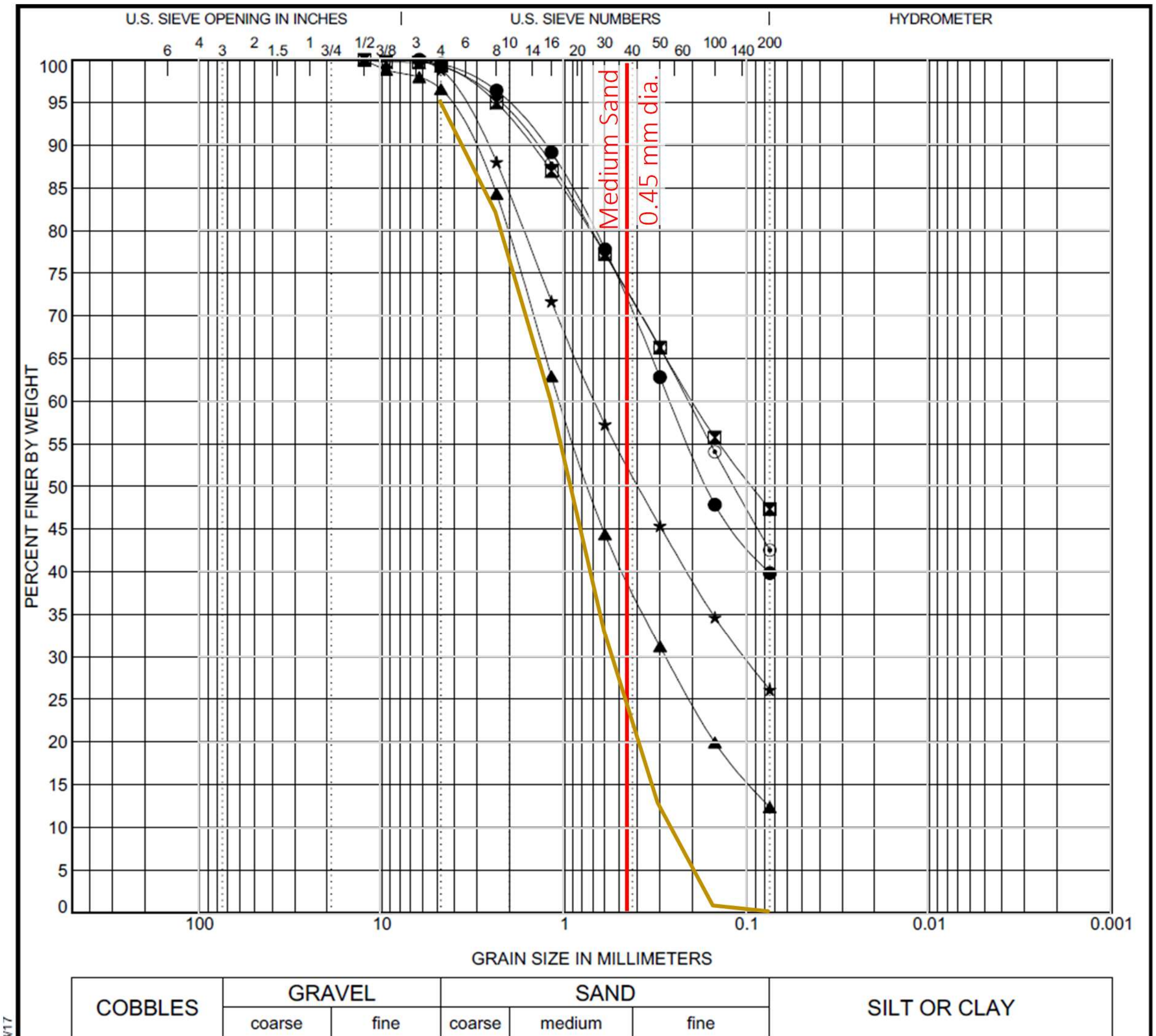
Figure 3-5: Long-term shoreline recession transects, USGS (2021).

3.5 Fraction of Beach Quality Material in Bluff Material

The fraction of beach quality material in the bluff material was estimated based on available project boring logs. Figure 3-6 summarizes boring locations from WRECO (2017). Boring R-17-007B was taken as a representative boring for the project location.

Figure 3-6: Boring locations from WRECO (2017).

The grain size distribution is shown in Figure 3-7. The curves pertaining to Boring R-17-007B over the height of the bluff are indicated by the following symbols and (depths): hourglass (5'), triangle (15'), and star (31.5'). The dark yellow curve is the gradation of Angel Island Coarse Sand (Appendix A).



Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● R-17-006	40.0	CLAYEY SAND (SC)	34	15	19		
⌧ R-17-007B	5.0	CLAYEY SAND (SC)	29	16	13		
▲ R-17-007B	15.0	CLAYEY SAND (SC)	34	23	11	1.21	17.56
★ R-17-007B	31.5	CLAYEY SAND (SC)	32	20	12		
⊙ R-17-008	10.0	CLAYEY SAND (SC)	25	17	8		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● R-17-006	40.0	6.25	0.263			0.5	59.7	39.8	
⌧ R-17-007B	5.0	12.5	0.199			0.7	52.0	47.3	
▲ R-17-007B	15.0	12.5	1.062	0.279		3.4	84.2	12.4	
★ R-17-007B	31.5	6.25	0.682	0.103		1.2	72.7	26.1	
⊙ R-17-008	10.0	6.25	0.21			0.7	56.7	42.5	

WRECO
8331 Sierra College Blvd.
Suite 208
Roseville, CA 95661
(916) 757-6150

GRAIN SIZE DISTRIBUTION

DIST.	COUNTY	ROUTE	POSTMILE	PROJECT NO.
04	San Mateo	Mirada Road		P15102 TO3

PROJECT OR BRIDGE NAME			
Mirada Road Revetment Project			
BRIDGE NUMBER	**PREPARED BY**	**DATE**	**SHEET**
	Jeff Newgard	3-2-17	4 of 6

Figure 3-7: Grain size distribution for Boring R-17-007B, WRECO (2017).

Komar (1998) studied the relationship between beach slope and sediment size retained on beaches. He collected data for beaches in high and low wave energy environments, including Half Moon Bay, which transitions from a low energy exposure to a high energy exposure in proportion to the sheltering effected by Pillar Point. Figure 3-8 shows the relationship between median grain size of beach material relative to the slope of the beach. The slope of the beach at Arroyo de en Medio is approximately 11.8H:1V, refer to Figure 3-2. The size of material retained on the beach is around 0.45 mm as indicated by the red lines in the figure for the respective beach slope where they intersect the curve and data points for Half Moon Bay. The grain size of 0.45 mm corresponds to medium sand.

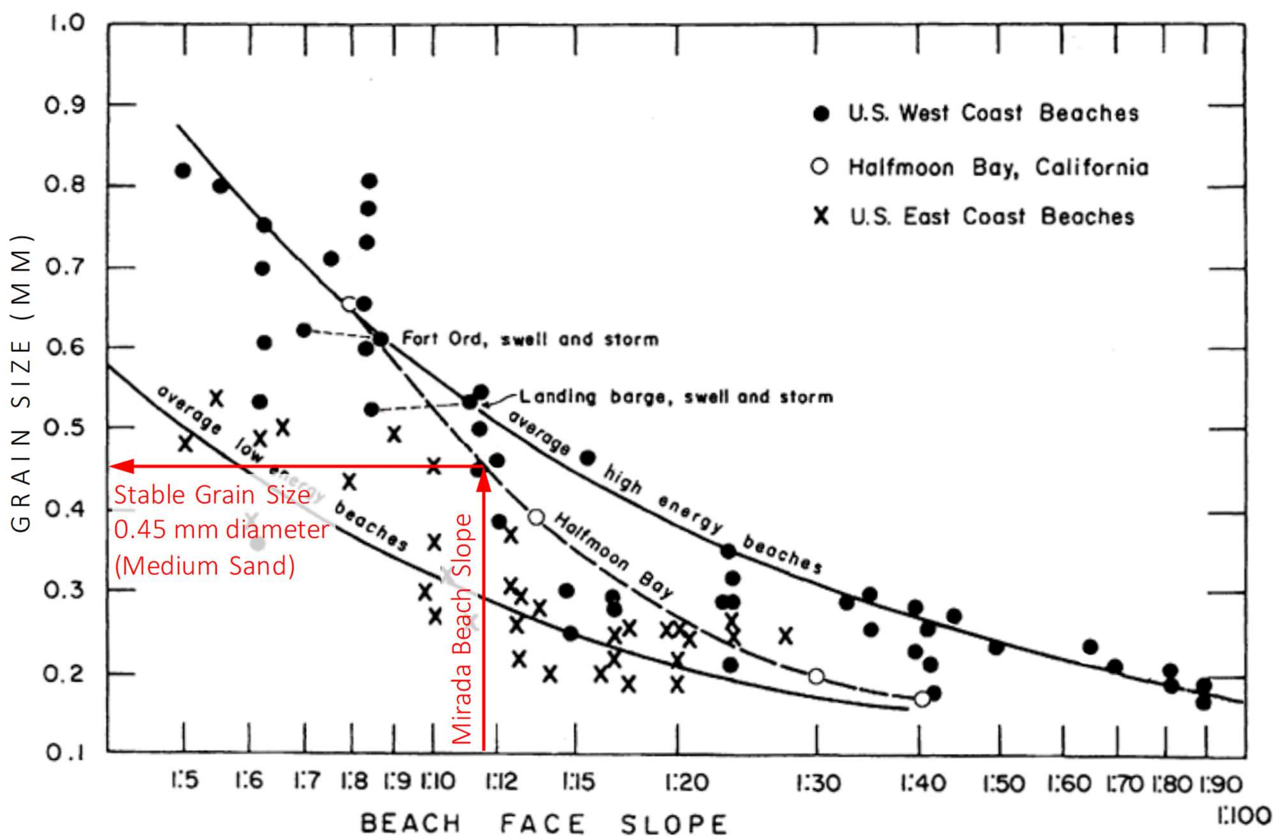


Figure 3-8: Relationship between median grain size and beach slope, Komar (1998).

The fraction of beach quality sand contained in the bluff material is estimated to be 43% based on the boring information shown in Figure 3-7, taken as the percentages by depth of the sand fraction that will remain on the beach. Figure 3-9 shows how this estimate was determined. The colored areas in the figure indicate the fraction of gravel (dark brown), sand (yellow), and silt/clay (blue) as a function of the depth. Zero depth is at the top of the bluff. The vertical dimension of 23 feet indicates the height of the bluff from the base to the top. The percentage of beach quality material was determined as the fraction of medium to coarse sand contained in the bluff material, which is the area enclosed by the dashed black line. Note, per Figure 3-8 only medium to coarse sand and gravel will remain on the beach, while material in the fine sand to silt/clay fraction will be washed out.

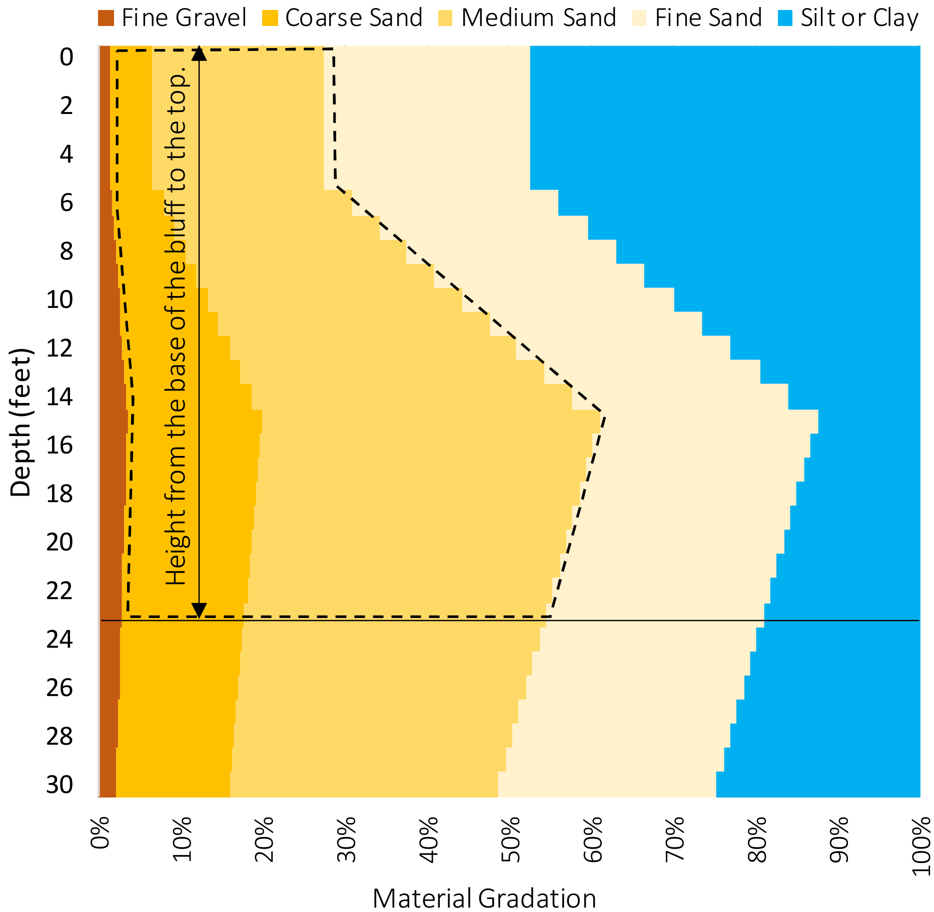


Figure 3-9: Composition of bluff material.

4 References

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USGS (2021). *Coastal Change Hazards Portal.* United States Geological Survey (USGS), Science for a changing world. Version 1.1.72. https://marine.usgs.gov/coastalchangehazardsportal

WRECO (2017). *Geotechnical Engineering Study.* Mirada Road Retaining Wall, County of San Mateo, California. Prepared for: County of San Mateo, California. 555 County Center, Redwood City, California 94063. Prepared by: WRECO, 8331 Sierra College Boulevard, Suite 208. Roseville, California 95661. WRECO Project No. P15102 TO3. May 2017.

Appendix A

Angel Island Coarse Sand Gradation

Hanson
HEIDELBERGCEMENTGroup

Pier 92
480 Amador Street
San Francisco, CA. 94124

12/02/2020

Lehigh Hanson

Attn:

Project Reference: General Information

This sand supplied by Hanson Aggregate is extracted from Point Knox Shoals San Francisco Bay and contains varying amounts of naturally occurring chlorides and sulfates. SMARA #'s: 91-38-0003, 91-38-0002

110133-ANGEL ISLAND CRS SAND

Procedure	Sieve/Test	Average	Unit	Angel Island Crs Sand
	#4 (4.75mm)	95	%	
	#8 (2.36mm)	82	%	
	#16 (1.18mm)	60	%	
	#30 (.6mm)	33	%	
	#50 (.3mm)	13	%	
	#100 (.15mm)	1	%	
	#200 (75µm)	0.3	%	
	FM	3.16		
CTM - 206	Specific gravity, bulk SSD	2.86		
CTM - 206	Absorption	1.0 +/- .3 %		
D-4318	Plasticity Index	Non-Plastic		

Should you have questions regarding this aggregate material, please do not hesitate to call your Sales Representative

Name/Title Antonio Fuentes / QC Manager