CALIFORNIA COASTAL COMMISSION

CENTRAL COAST DISTRICT OFFICE
725 FRONT STREET, SUITE 300
SANTA CRUZ, CA 95060
(831) 427-4863
HEARING IMPAIRED: (415) 904-5200

APPEAL FROM COASTAL PERMIT DECISION OF LOCAL GOVERNMENT

Please review attached appeal information sheet prior to completing this form.

SECTION I. Appellant(s):

Name, mailing address and telephone number of appellant(s):

Commissioner Sara Wan	Commissioner Mike Reilly
45 Fremont Street, Suite 2000	45 Fremont Street, Suite 2000
San Francisco, CA 94105	San Francisco, CA 94105
(415) 904-5200	(415) 904-5200

SECTION II. Decision Being Appealed

1. Name of local/port government:
Santa Cruz County

2. Brief description of development being appealed:
Redevelopment of East Cliff Drive between 32nd and 41st Avenues, including park, trail and related public recreational improvements.

3. Development's location (street address, assessor's parcel number, cross street, etc.:
East Cliff Drive between 32nd and 41st Avenues in the Pleasure Point portion of the unincorporated Live Oak beach area of Santa Cruz County.

4. Description of decision being appealed:

a. Approval; no special conditions: ______
b. Approval with special conditions: X
c. Denial: ______

Note: For jurisdictions with a total LCP, denial decisions by a local government cannot be appealed unless the development is a major energy or public works project. Denial decisions by port governments are not appealable.

TO BE COMPLETED BY COMMISSION:

APPEAL NO: A-3-SCO-07-015
DATE FILED: 4-9-2007
DISTRICT: Central Coast

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CENTRAL COAST AREA

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(page 1 of 11 pages)

APPEAL FROM COASTAL PERMIT DECISION OF LOCAL GOVERNMENT (PAGE 2)

5. Decision being appealed was made by (check one):

a. ___ Planning Director/Zoning Administrator

b. X City Council/Board of Supervisors

c. ___ Planning Commission

d. ___ Other: ___

6. Date of local government's decision: March 20, 2007

7. Local government's file number: 00-0797

SECTION III Identification of Other Interested Persons

Give the names and addresses of the following parties: (Use additional paper as necessary.)

a. Name and mailing address of permit applicant:
Santa Cruz County Redevelopment Agency & Public Works Department
701 Ocean Street
Santa Cruz, CA 95060

b. Names and mailing addresses as available of those who testified (either verbally or in writing) at the city/county/port hearings (s). Include other parties which you know to be interested and should receive notice of this appeal.

(1) Coastal Property Owners Association of Santa Cruz County
500 41st Avenue
Santa Cruz, CA 95062

(2) Sierra Club
P.O. Box 604
Santa Cruz, CA 95061

(3) Surfer's Environmental Alliance
1940 Merrill Street
Santa Cruz, CA 95062

(4) Surfrider Foundation
P.O. Box 3968
Santa Cruz, CA 95063

SECTION IV. Reasons Supporting This Appeal

Note: Appeals of local government coastal permit decisions are limited by a variety of factors and requirements of the Coastal Act. Please review the appeal information sheet for assistance in completing this section which continues on the next page.

State briefly your reasons for this appeal. Include a summary description of Local Coastal Program, Land Use Plan, or Port Master Plan policies and requirements in which you believe the project is inconsistent and the reasons the decision warrants a new hearing. (Use additional paper as necessary.)

See Attached.

Note: The above description need not be a complete or exhaustive statement of your reasons of appeal; however, there must be sufficient discussion for staff to determine that the appeal is allowed by law. The appellant, subsequent to filing the appeal, may submit additional information to the staff and/or Commission to support the appeal request.

SECTION V. Certification

The information and facts stated above are correct to the best of my/our knowledge.

Signed: Lara J Wan
Appellant or Agent

Date: April 9, 2007

Agent Authorization: I designate the above identified person(s) to act as my agent in all matters pertaining to this appeal.

Signed: ______________________

Date: ______________________

(Document2)

State briefly your reasons for this appeal. Include a summary description of Local Coastal Program, Land Use Plan, or Port Master Plan policies and requirements in which you believe the project is inconsistent and the reasons the decision warrants a new hearing. (Use additional paper as necessary.)

See Attached.

Note: The above description need not be a complete or exhaustive statement of your reasons of appeal; however, there must be sufficient discussion for staff to determine that the appeal is allowed by law. The appellant, subsequent to filing the appeal, may submit additional information to the staff and/or Commission to support the appeal request.

SECTION V. Certification

The information and facts stated above are correct to the best of my/our knowledge.

Signed: Mike Reilly
Appellant or Agent

Date: April 9, 2007

Agent Authorization: I designate the above identified person(s) to act as my agent in all matters pertaining to this appeal.

Signed: ______________________

Date: ______________________

(Document2)

APPEAL FROM COASTAL PERMIT DECISION OF LOCAL GOVERNMENT (PAGE 3)

State briefly your reasons for this appeal. Include a summary description of Local Coastal Program, Land Use Plan, or Port Master Plan policies and requirements in which you believe the project is inconsistent and the reasons the decision warrants a new hearing. (Use additional paper as necessary.)

See Attachment: Reasons For This Appeal

Note: The above description need not be a complete or exhaustive statement of your reasons of appeal; however, there must be sufficient discussion for staff to determine that the appeal is allowed by law. The appellant, subsequent to filing the appeal, may submit additional information to the staff and/or Commission to support the appeal request.

SECTION V. Certification

The information and facts stated above are correct to the best of my/our knowledge.

See Signed Certification Attached
Signature of Appellant(s) or Authorized Agent

Date ______________________

NOTE: If signed by agent, appellant(s) must also sign below.

SECTION VI. Agent Authorization

I/We hereby authorize ______________________ to act as my/our representative and to bind me/us in all matters concerning this appeal.

____
Signature of Appellant(s)

Date ______________________

CCC Exhibit D
(page 5 of 11 pages)

Attachment: Reasons For This Appeal

Santa Cruz County approved a coastal development permit (CDP) for redevelopment of East Cliff Drive between 32nd and 41st Avenues in the Pleasure Point area of unincorporated Live Oak. The redevelopment project would include significant recreational trail enhancements, and a series of public infrastructure upgrades in the subject roadway prism, including a revised drainage control system ("County CDP project"). The County's approval also recognizes three upper bluff seawalls previously constructed under an emergency County CDP in 2004, and more broadly the County's action also approved seawalls between 32nd and 36th Avenues, and at the intersection of East Cliff Drive and 41st Avenue. However, the County's approval of the seawalls and all components pertaining thereto are not part of the County's CDP action and not subject to the Commission's appeal process.[1] The County's approval may be inconsistent with the Santa Cruz County Local Coastal Program (LCP) and the Coastal Act's access and recreation policies for the following reasons:

1. Hazards. The LCP requires that development be sited and designed to ensure long-term stability, including by requiring a minimum 25-foot setback from coastal bluff edges as adjusted inland as necessary to achieve at least 100 years of development stability (including LUP Chapter 6 and Zoning Code Chapter 16.10). Per the LCP, new development must also avoid the need for shoreline armoring with its attendant impacts. The County CDP project would result in development located with a zero setback from the bluff edge, and in some cases less than a zero setback,[2] and would result in development that is acknowledged by the County to require a seawall to maintain its stability. As such, the County CDP project appears to be inconsistent with the LCP's stability and hazard avoidance provisions.

2. Public Access and Recreation. The LCP and the Coastal Act require that public access and recreation opportunities be maximized, and that shoreline land appropriate for coastal access and recreation uses and facilities be protected for that purpose (including LUP Chapters 3 and 7, Zoning Code Chapter 13.20, and Coastal Act Sections 30210-30223). The County CDP project is clearly a blufftop public access and recreational enhancement. However, the project does not make full use of the public right-of-way for public improvements, and as a result there are areas of public right-of-way that would allow private uses to remain, and that would not be made available for needed public recreational access improvements (e.g., additional public parking, increased trail width, related public amenities, etc.). In addition, the County's approval appears to include unspecified restrictions on parking that may diminish public access and recreation opportunities. As such, the County CDP project appears to be inconsistent with the LCP and the Coastal Act provisions that require public access and recreation opportunities to be protected and maximized.

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[1] The proposed seawalls are located within the Coastal Commission's retained CDP jurisdiction, and the County does not have the authority to approve a CDP for these seawall components of the project. The County's approval of the seawalls and all components pertaining thereto can only be understood as the required local discretionary (but non-CDP) approval for purposes of future application to the Coastal Commission. As a result, and notwithstanding any parts of the County's action to the contrary, the seawalls cannot be and are not a part of the County's CDP project and are not considered here in terms of potential appeal issues. With respect to the required follow-up CDP for the emergency seawalls specifically, the project that would account for these seawalls is the larger seawall of which they would become a part (and not the emergency seawalls themselves), and thus this component as well would be subject to future Coastal Commission review and action.

[2] The less than zero foot setback areas refer to those areas where the County CDP project would use fill supported by the aforementioned seawalls to extend the bluff seaward.

3. Scenic Resources and Community Character. The LCP is highly protective of coastal zone visual resources and community character, and particularly protective when development is proposed along LCP-designated scenic roads such as East Cliff Drive at this location (including LUP Objectives and Policies 5.10 et seq, and Zoning Code Chapter 13.20). Because a component of recreational access includes visual access, the aforementioned Coastal Act sections provide similar protection. The County CDP project would significantly alter the East Cliff Drive corridor in one of its most critical public viewshed locations. Certain aspects of the project would clearly be viewshed enhancements, but it is not clear that the project as a whole has adequately protected public views and the established Pleasure Point community character, among other reasons because it allows private development in the public right-of-way that blocks public views, and includes elements that may not effectively protect public views and the unique character of the Pleasure Point neighborhood (e.g., landscape design, including non-native landscaping; path and roadway configuration and materials; sign locations and numbers; rail design; etc.). As such, the County CDP project appears to be inconsistent with the LCP and the Coastal Act viewshed and character provisions.

4. Water Quality. The LCP requires that water quality be protected, enhanced, and improved (including LUP Objectives and Policies 5.4 et seq and 5.7 et seq, and LUP Chapter 7). The project includes some consolidation of drainage collection apparatus and some additional engineered treatment devices, but it is not clear that these measures will be sufficient to meet the LCP's water quality tests.[3] Given the receiving water bodies offshore, and their high biological and recreational value, it is likely that additional filtration and treatment beyond that that is part of the proposed project will be required. As such, the County CDP project appears to be inconsistent with the LCP's water quality provisions.

In sum, the County's CDP approval raises substantial issues with respect to the approved County CDP project's conformance with LCP and Coastal Act provisions, including those related to long-term stability, access, recreation, public views, community character, and water quality. These issues are also inextricably linked to similar and other coastal resource issues associated with the seawall component of the overall project that is located in the Commission's retained CDP jurisdiction; their resolution will effect the Coastal Commission's review of the seawall application;[4] and they are better evaluated in conjunction with the Commission's review of the CDP application for the seawall. These issues warrant a further analysis and review by the Coastal Commission of the County's CDP approval.

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[3] The drainage is also directed to the Monterey Bay National Marine Sanctuary in the Commission's retained CDP jurisdiction, and the degree to which such discharge meets Coastal Act water quality requirements is also an issue with respect to related future project applications to the Commission.

[4] Including the degree to which the County's approved CDP for East Cliff Drive and related development could prejudice the Commission's review of the proposed seawalls. In other words, to the degree it is conclusively shown that there are existing structures in danger from erosion, one of the fundamental questions when the seawalls are ultimately before the Commission will be understanding the range of potential alternatives to address such an erosion problem. Many of these alternatives include different visions for East Cliff Drive than that approved by the County's CDP (including abandonment, relocation of threatened elements inland, aggressive landscaping and drainage controls, etc.). A CDP for East Cliff Drive as approved by the County would represent a development entitlement to a certain project that could skew the Commission's review of the seawall, and could preclude certain alternatives from consideration.

CALIFORNIA COASTAL COMMISSION
CENTRAL COAST DISTRICT OFFICE
725 FRONT STREET, SUITE 300
SANTA CRUZ, CA 95060-4508
VOICE (831) 427-4863 FAX (831) 427-4877

APPEAL FROM COASTAL PERMIT DECISION OF LOCAL GOVERNMENT

Please Review Attached Appeal Information Sheet Prior To Completing This Form.

SECTION I. Appellant(s)

Name: Charles Paulden

Mailing Address: 415 palisades

City: Santa Cruz Zip Code: california Phone: 831-462-3423

SECTION II. Decision Being Appealed

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CALIFORNIA
COASTAL COMMISSION
CENTRAL COAST AREA

1. Name of local/port government:

Santa Cruz County

2. Brief description of development being appealed:

East Cliff Parkway Project

3. Development's location (street address, assessor's parcel no., cross street, etc.):

East Cliff between 33rd and 41st Ave in Pleasure Point

4. Description of decision being appealed (check one.):

☐ Approval; no special conditions

☒ Approval with special conditions:

☐ Denial

Note: For jurisdictions with a total LCP, denial decisions by a local government cannot be appealed unless the development is a major energy or public works project. Denial decisions by port governments are not appealable.

TO BE COMPLETED BY COMMISSION:

APPEAL NO: A-3-SCO-07-015
4-9-2007
Central Coast

APPEAL FROM COASTAL PERMIT DECISION OF LOCAL GOVERNMENT (Page 2)

5. Decision being appealed was made by (check one):

- ☐ Planning Director/Zoning Administrator
- ☒ City Council/Board of Supervisors
- ☐ Planning Commission
- ☐ Other

6. Date of local government's decision: March 20,2007

7. Local government's file number (if any): 00-0797

SECTION III. Identification of Other Interested Persons

Give the names and addresses of the following parties. (Use additional paper as necessary.)

a. Name and mailing address of permit applicant:

Santa Cruz County
701 Ocean St
Santa Cruz, Ca

b. Names and mailing addresses as available of those who testified (either verbally or in writing) at the city/county/port hearing(s). Include other parties which you know to be interested and should receive notice of this appeal.

(1)

(2)

(3)

(4)

SECTION IV. Reasons Supporting This Appeal

PLEASE NOTE:

- Appeals of local government coastal permit decisions are limited by a variety of factors and requirements of the Coastal Act. Please review the appeal information sheet for assistance in completing this section.
- State briefly **your reasons for this appeal.** Include a summary description of Local Coastal Program, Land Use Plan, or Port Master Plan policies and requirements in which you believe the project is inconsistent and the reasons the decision warrants a new hearing. (Use additional paper as necessary.)
- This need not be a complete or exhaustive statement of your reasons of appeal; however, there must be sufficient discussion for staff to determine that the appeal is allowed by law. The appellant, subsequent to filing the appeal, may submit additional information to the staff and/or Commission to support the appeal request.

Maximize public of right of way
Save scenic views
Protect from urban runoff
Some say that "Without the seawall in the near future the sewer line that runs under East Cliff Dr. will be exposed to the ocean and once again will have raw sewerage in the surf like the old days!"
I do not believe that the Clean Water Act will allow the County to let sewage run into the sanctuary.
They do run untreated urban runoff into the surf. The project deals with silt and grease, yet this is not what hurts the sea life and recreational users. How many got sick this year?
I wish that any permitted seawalls would require an elevated walkway with access to the surf. That way we will have access along the ocean from Natural Bridges to New Brighton as the coast is armored.
The plan calls for the removal of the platform above the stairs by 36th.We will lose a viewing area. They are taking the rocks out at the bottom of the stairs, so the cove where we come in will be lost. Leave in place and cover as the other areas will be.
The removal of the rip-rap will eliminate access to the goat trails. The parking along the ocean side of E-Cliff will block the scenic view and cause conflict with pedestrians and bikes. Put the parking in front of the houses, inland.
Buy the Roadhouse at 2-3905 East Cliff. Use the back for parking and use the front to serve visitors to the coastal trail. A natural history museum and history museum with information of interest to all who live and visit here.
Do we want more parking at Night Fighter Park? Make the road go the other way and expand the park. Use porous material from 33rd to connect to the pedestrian path, or stabilized earth as along Lake Ave at the Harbor
If they are going to put in the seawall, and we don't care if it drowns the surf, go out further and make the road go two ways again. Get the traffic out of the neighborhoods. Put elevated crosswalks at the side streets to work like speed bumps and slow traffic while returning E-Cliff to us.
Use indigenous plants and not replicate Southern California. Make it more natural and less tended.
Replace the street lights with those found along the bridge in Capitola. Underground the wires that are nowconnected to the street lights.

APPEAL FROM COASTAL PERMIT DECISION OF LOCAL GOVERNMENT (Page 4)

SECTION V. Certification

The information and facts stated above are correct to the best of my/our knowledge.

Signature of Appellant(s) or Authorized Agent

Date: April 9, 2007

Note: If signed by agent, appellant(s) must also sign below.

Section VI. Agent Authorization

I/We hereby authorize ______________________________
to act as my/our representative and to bind me/us in all matters concerning this appeal.

Charles Paulden

Signature of Appellant(s)

Date: April. 9. 2007

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CHAPTER 2
PROPOSED PROJECT AND ALTERNATIVES

This chapter is a description of the development of alternatives and the proposed action, which is to protect 1,400 feet (427 meters) of East Cliff Drive from erosion and to implement parkway improvements along the bluff top. The chapter begins with an overview of the project and project alternatives. The No Action Alternative is then described, followed by a description of the alternatives considered and eliminated. The preferred alternative and the three considered alternatives are then described in detail. At the end of this chapter is a summary of potential agency permit and approval requirements.

2.1 PROPOSED PROJECT OVERVIEW

The project area is on East Cliff Drive between 33rd and 41st avenues. A 33-foot (10-meter) coastal bluff borders East Cliff Drive on the southeast for the length of the project area. The bluff consists of a lower layer of nearly vertical stone, known as the Purisima Formation, approximately 11.5 feet (3.5 meters) high, and an upper layer of terrace deposits extending to the top of the bluff at a 45- to 60-degree slope (SAGE [Sanders and Associates] 2005). The base of the Purisima Formation is undercut in some places up to 18 feet (6 meters) horizontally into the bluff (SAGE 2005), and the terrace deposits above are significantly more subject to erosion than the Purisima.

East Cliff Drive was a two-way road until 1995, when it was restricted to one-way traffic due to bluff erosion. Three soil nail walls were constructed as part of emergency repairs of three failing cribwalls in 2004. (A soil nail wall is a type of retaining wall.) These soil nail walls cover approximately 290 feet (88 meters) of the terrace deposits. The County of Santa Cruz has proposed a bluff protection project along 1,100 feet (334 meters) of East Cliff Drive to prevent further erosion (project 1). Because 290 feet (88 meters) of the terrace deposits were already protected in the County's 2004 emergency repairs, project 1 would involve protecting 1,100 feet (334 meters) of Purisima and 810 feet (247 meters) of terrace deposits. In addition, the County has proposed project 2, in which it would improve the road and adjacent pedestrian and bicycle lanes above the bluff, from Pleasure Point Park to 41st Avenue. Project 3 would involve a 300-foot (91-meter) bluff protection project at The Hook. Project 1 would be completed first, and project 2, which focuses on parkway improvements, would be constructed once project 1 is

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completed. Project 3 would be completed before the parkway improvements at The Hook are completed. The three projects are detailed below.

Project 1 (Main Bluff Protection Structure)

- Construct a bluff protection structure from 33rd Avenue to 36th Avenue; and
- Construct both new and replacement beach access stairways (one at Pleasure Point Park and one at 36th Avenue), demolish an abandoned restroom, and remove concrete rubble and rock riprap. A small portion of riprap may be used at the east end of the project as a transition to adjacent private parcels. (Riprap is a protective layer of rock placed to prevent erosion of a bluff.)

Project 2 (Parkway)

- Construct a new curb and drainages along the southern edge of the one-way travel lane, make pedestrian and multiuse path improvements from 32nd Avenue to Larch Lane, make landscape improvements, and install railings;
- Construct a retaining wall near 38th Avenue;
- Construct a new restroom and develop a park (referred to as Pleasure Point Park throughout this document), which will include landscaping, picnic tables, drainage improvements, and an interpretive area for the Monterey Bay National Marine Sanctuary; and
- Reconfigure parking spaces.

Project 3 (The Hook Bluff Protection Structure)

- Construct a second engineered bluff protection structure on a County-owned parcel, near the end of 41st Avenue at The Hook;
- Remove, repair, and replace the wooden stairway near 41st Avenue; and
- Make road and path improvements similar to those in project 2.

2.2 OVERVIEW OF ALTERNATIVES

The alternatives described below for the bluff and parkway project were developed by Santa Cruz County. The alternatives' respective environmental impacts are evaluated in this EIS/EIR.

2.2.1 Alternative 1: Full Bluff Armoring (Preferred Alternative)

Alternative 1 would consist of a bluff protection structure extending vertically from the bedrock on the beach to the top of the bluff, for approximately 1,100 linear feet (335 meters) from 33rd to 36th Avenue and then for 300 feet (91 meters) at The Hook. The bluff protection structure near Pleasure Point Park and associated stairways would be constructed first, followed by road and path improvements during project 2, and then the work at The Hook (project 3). The bluff protection structure would be a soil nail shotcrete concrete structure attached directly to the bluff face, and would be sculpted and painted to resemble the natural untouched surface.

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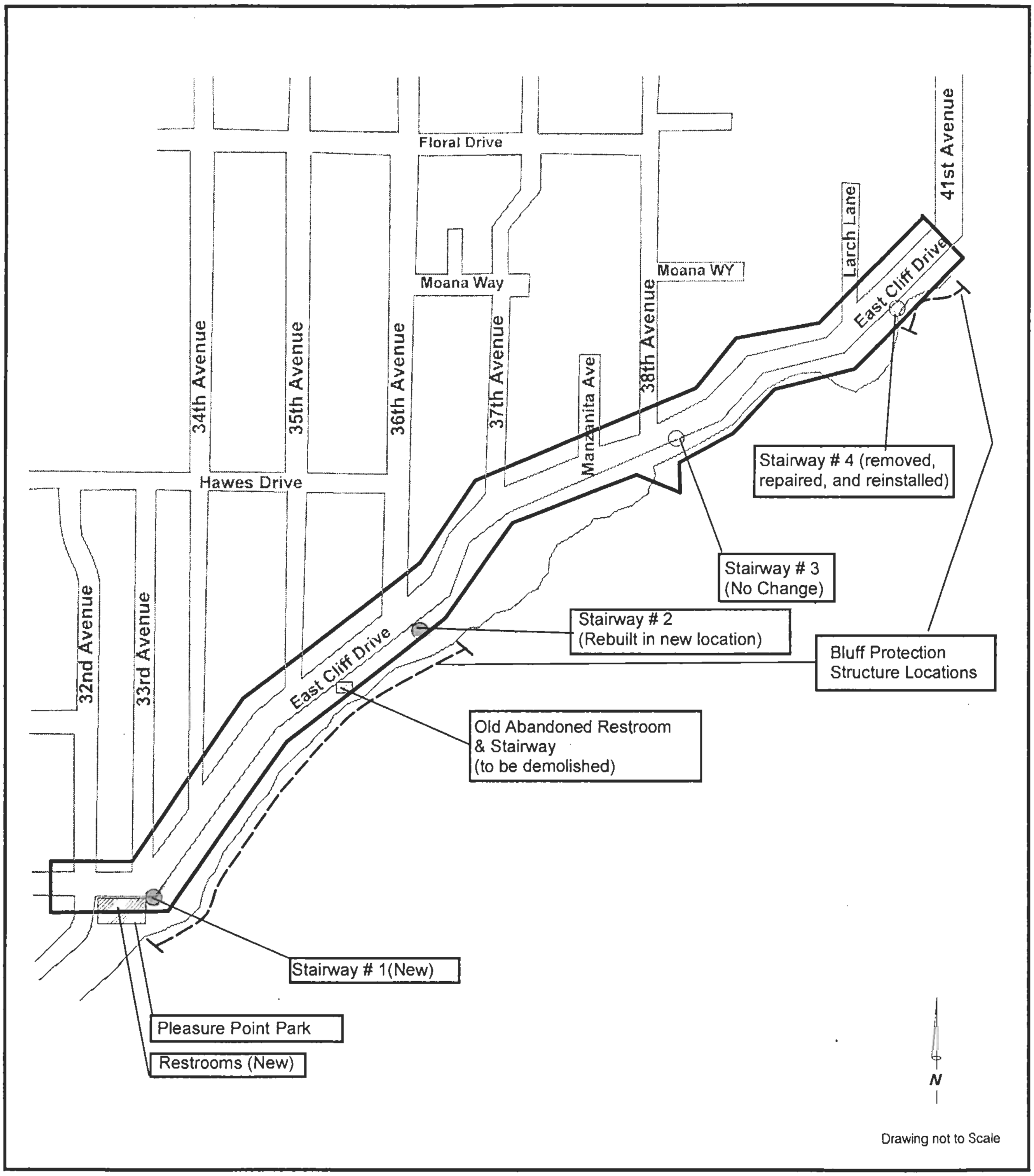

This figure shows changes to stairways, restrooms, and development of Pleasure Point Park that would be conducted under the proposed project.

Legend
- Bluff Protection Structures
- Project Area
- Coastline

Project Overview

Santa Cruz, California

Tetra Tech, Inc.

Figure 2-1a

2.2.2 Alternative 2: Partial Bluff Armoring with Full Parkway

With this alternative, the bluffs would be partially protected from erosion. The Purisima Formation would be completely protected, but only areas of the terrace deposits where there are washouts would be covered by the bluff protection structure. Retaining walls would be constructed and existing retaining walls would be repaired as needed. All other features of the project, such as parkway development and road improvements, are the same as those under Alternative 1.

2.2.3 Alternative 3: Partial Bluff Armoring with Limited Parkway Improvements

This alternative is similar to Alternative 2, except that no new retaining walls would be constructed to retain terrace deposits and no new armoring would be installed at the top of the bluffs. As a result, only limited parkway improvements would be possible, and only one multiuse path for both pedestrian and bicycle use would be constructed.

2.2.4 Alternative 4: Groins and Notch Infilling

This alternative would use means other than armoring to protect the bluffs, such as constructing groins on the beach to protect the bluff from waves and filling in the wave-cut notches at the base of the bluffs with concrete. As a result, only one multiuse path, with a minimum width of eight feet (2 meters), would be constructed. General parkway improvements under this alternative are similar to those under Alternative 3.

2.3 No Action Alternative

The other alternatives are compared against the No Action Alternative. Under this alternative, the project would not be built. Theoretically, this means that the current erosion and damage to the road section would continue, causing road closure and utility damage over time (Corps 2003). Historical rates of bluff erosion at the project site have been calculated up to eight to 12 inches (30 centimeters) per year. However, the bluff does not erode at a regular rate and can involve the loss of as much as six to nine feet (two to three meters) at one time. In order to identify the risk of this kind of episodic failure, the County commissioned SAGE to prepare a threat assessment report in 2005. SAGE evaluated the stability of the bluff at East Cliff Drive and found that roughly 65 percent of the roadway between 33rd and 36th avenues is failing or may be unsafe to use within the next few years (SAGE 2005a).

A recent episodic failure extended about six to nine feet (two to three meters) back into the face of the bluff. This bluff failure overlaps the motor vehicle lane on East Cliff Drive. Based on this pattern of failure, as described in the SAGE report, it is clear that under the No Action Alternative significant portions of the roadway could be lost within the next two or three storm cycles. Loss of as little as ten feet (three meters) of the bluff face could substantially disrupt motorized and pedestrian use of East Cliff Drive, even if the roadway were somehow to remain open. Additionally, utilities underneath East Cliff Drive could be affected soon by bluff collapse, particularly the waterline which is within three feet (one meter) of the bluff face between 35th and 36th avenues.

Emergency Repairs. The No Action Alternative would not necessarily lead to the immediate collapse of East Cliff Drive, unless the County is prevented from conducting repairs. Under this alternative, the County would continue to make emergency repairs, where feasible, in response to

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future bluff failures and to assure public safety. However the County's efforts are unlikely to prevent the erosion of the bluff, particularly where large volumes of the bluff face collapse unpredictably as a result of storms or seismic shaking. This would be particularly true if the emergency walls did not protect the Purisima layers from erosion; thus, the Purisima would still be subject to catastrophic collapses, which in turn could damage the upper sections of the bluff. Because emergency repairs would be conducted only where the bluff face had actually collapsed, or where there was an immediate threat to public safety, other portions of the bluff would continue to erode. Additionally, end effects would likely develop, which occur when the bluff erodes next to and behind the face of a wall or other bluff protection structure.

A series of emergency repairs would be less efficient and more disruptive to the community than a planned and scheduled project. While repairs would significantly slow erosion loss and risk to the roadway and utilities, they would not prevent bluff erosion entirely. Below is an overview of the physical influences to which the bluff is subject, the effects uncontrolled bluff erosion would have on the project area, and the need for emergency and long-term repairs. In order to describe to the public the forces at work on the bluff, much of the following discussion presumes a scenario where the County would not conduct emergency repairs. In reality, the County would likely repair the bluff in increments as the erosion continues, but not to the extent described in any of the four project alternatives. Additionally, the No Action Alternative includes no parkway improvements, because public investment in these improvements would require some assurance of their longer-term benefit.

Short-Term Bluff Erosion Projections. In its evaluation study, SAGE identified the causes of coastal bluff erosion as being wave induced or caused by strong ground shaking during large magnitude earthquakes. Short-term erosion is described by SAGE as occurring episodically as individual events rather than steadily over time.

SAGE suggested that the risk of bluff failure could be best estimated by evaluating the largest potential episodic bluff failure, the likelihood of such an event, and the proximity of improvements to areas likely to experience such an event. As previously noted, episodic bluff failures have occurred at the site or in the immediate vicinity and have extended from 6.5 to 10 feet (2 to 3 meters) inland into the face of the bluff. However, tree cover at the site concealed the bluff in the reviewed aerial photographs, so it was not clear from the aerial photographs if these failures represent the largest potential episodic bluff events.

Based on the information presented, SAGE evaluated the degree of threat to East Cliff Drive between 33rd and 36th avenues, and at 41st Avenue, and assigned specific sections to one of the three threat zones, as shown on Sheets 2 through 6 in the SAGE Report (Appendix G). The zones are as follows:

- *Zone 1. Active impact on improvements.* This includes sections of East Cliff Drive where the shoulder has been lost to erosion and where continued erosion will result in the further loss of road and other improvements. Between Pleasure Point and 36th avenues, Zone 1 covers 133 feet (40 meters), or 13 percent. None of the Hook is in Zone 1.

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- *Zone 2. In Danger.* This pertains to existing structures may be unsafe to use within the next two or three storm season cycles (generally the next few years) if nothing is done. Between Pleasure Point and 36th avenues, Zone 2 covers 518 feet (158 meters), or 52 percent. Approximately 47 linear feet (14 linear meters), or 15 percent, of the Hook is in Zone 2.
- *Zone 3. Potentially In Danger.* This includes sections of East Cliff Drive not likely to be rendered unsafe within two to three storm season cycles but still subject to erosion. Between Pleasure Point and 36th avenues, Zone 3 covers 350 feet (106 meters), or 35 percent. The Hook has 253 linear feet (77 linear meters) or 85 percent of the bluff, in Zone 3.

The sections of East Cliff Drive assigned to Zone 1 generally correspond to where the road shoulder has been lost to erosion. Zone 1 also includes a ten-foot-long (three-meter-long) section of East Cliff Drive near one of the emergency repair structures (Wall 3), where a one-inch-wide (two-centimeter-wide) tension crack was observed in the asphalt shoulder (Sheet 4). An active landslide on the bluff appears to be undermining the road at this location, which has been fenced off for public safety.

Zone 2 generally includes sections of East Cliff Drive that are within ten feet (three meters) of the present bluff top and therefore within the assumed limits of potential episodic bluff failure. SAGE locally adjusted the limits of Zone 2 to reflect bluff configuration, retaining walls, undercuts, and landsliding. For example, the top of the bluff is within three feet (one meter) of East Cliff Drive at Wall 2, and there is evidence of sizable undercuts within the Purisima Formation. However, the terrace deposits are protected by a new soil nail wall, and the undercuts are generally concealed by riprap. Therefore, SAGE assigned this section of East Cliff Drive to Zone 3.

The remaining sections of East Cliff Drive are considered to be potentially in danger but at risk beyond the next two to three storm season cycles. These sections have been designated as Zone 3. Although the existing improvements in Zone 3 are greater than ten feet (three meters) from the present top of the bluff in these areas, SAGE believes there are several possible scenarios that could affect these areas, as detailed below.

Strong Ground Shaking. Santa Cruz is an area of historically high seismicity, characterized by strong ground shaking. As suggested by the slope stability analyses performed by HKA, the size of the potential bluff failure under seismic loading conditions may exceed ten feet (three meters), so larger areas of the site may be classified as being in danger than those currently shown using the ten-foot (three-meter) offset. Based on the SAGE stability analysis, the risk for a bluff failure during a seismic event on a nearby fault is relatively high. SAGE noted that steep slopes standing at angles of 30 degrees to near vertical are subject to topographic amplification of seismic waves and that the seismic-induced failure of these slopes tends to be brittle (Ashford and Sitar 2002, *in* SAGE 2005b). Recent research by the US Geological Survey (USGS) suggests the overall probability of a magnitude 6.7 or greater earthquake occurring in the San Francisco Bay Area between 2002 and 2031 is 62 percent (WGCEP 2003). Although the 1989 Loma Prieta Earthquake did not result in any failures of the bluff, this would not preclude the potential for future failures. In fact, SAGE estimates that the reason no failures were reported at the bluff in

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1989 was probably due to the short duration of the earthquake (15 seconds), the earthquake's frequency of vibration, and a possible high soil strength (SAGE 2005b).

Undercuts in Purisima Formation. As noted previously, the Purisima Formation is locally undercut up to 18 feet (5.5 meters) horizontally from the face of the Purisima Formation bench. Although the Purisima Formation is relatively strong, field observations indicate that the bench will eventually collapse onto the beach after the underlying support has been removed. Where the Purisima Formation fails, the overlying terrace deposits could also be subject to substantial vertical movement.

As previously stated, based on SAGE's analysis, 651 feet (198 meters), or 65 percent, of the total shoreline between 33rd and 36th avenues, and 34 feet (10 meters), or 15 percent of the Hook area, will be affected in one of two ways. The shoreline will be *actively affected* where the road shoulder has already been lost to erosion or where it will continue to erode, resulting in further loss of the road and other improvements. Alternately, the shoreline will be *in danger* and existing structures may be unsafe to use within the next two or three storm season cycles if nothing is done. Of the remaining 350 feet (106 meters) in Zone 3 *(potentially in danger)*, 290 feet (88 meters), or 83 percent, consists of three new sections of bluff stabilization.

Long-Term Bluff Erosion. An important element in calculating the impact of the No Action Alternative is that coastal bluff or cliff erosion is both *episodic* and *site-specific*. This complicates the County's ability to calculate the precise result of the No Action Alternative over the long term, although the short-term projections are discussed above.

The rate at which any particular coastal bluff retreats depends on the interaction or combined effects of the properties of the cliff-forming materials, such as rock strength and its variation both alongshore and from beach level to the top of the bluff, on structural weaknesses, such as joints, fractures, and faults, and on the presence of groundwater, for example. The rate of bluff retreat also depends on the physical forces acting on the cliff or bluff and the magnitude, frequency, and timing of these processes. Of these processes, wave impact, tidal variations, sea level rise rate, rainfall and runoff, seismic shaking, and loading are the most important.

One element complicating the calculation of long-term bluff erosion rates is the difficulty in measuring bluff erosion. While aerial photography is frequently used, it is limited by problems of scale and clarity and of delineating the bluff top, by photographic distortion, and by the experience of the photographer and the analyst.

Another major complicating element is the variation over time in the processes that contribute to bluff erosion. It is now well known that the coast of California experiences different climatic conditions over cycles of 20 or 30 years (now known as the Pacific Decadal Oscillation) (Storlazzi and Griggs 2000; Storlazzi and Griggs 1998). The accuracy of any coastal bluff retreat rate is affected by the period investigated and the range of photograph dates used. Measurements made on aerial photographs taken primarily from a calmer or La Niña-dominated period (1945 to 1978, for example), would tend to underestimate a retreat rate and therefore the risk posed to oceanfront construction. Using only measurements from an El Niño-dominated period (1980 to

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2000, for example) would tend to overestimate the long-term erosion rates. The shorter the period of record used, the more unreliable the extrapolated long-term rates will be (Lester 2005).

A third complicating factor in calculating bluff erosion rates is the unpredictability of some of these processes. For instance, much of the coastal erosion and storm damage along the California coast during the severe 1982-1983 winter was due to the simultaneous occurrence of very high tides with the arrival of the largest storm waves (Griggs, Patsch and Savoy 2005). This took place during seven different storms in the first three months of 1983. While the actual wave heights in 1997-1998 were greater, they did not coincide with the highest tides and therefore produced less storm damage and erosion. However, these conditions are impossible to predict in advance. Seismic shaking, for instance, which can produce significant coastal cliff failures (Griggs and Scholar 1997) cannot be predicted with any reliability.

A significant additional factor affecting future projections of bluff erosion is the future sea level rise rate. Sea level rise has been the primary factor driving shoreline retreat for the past 18,000 years. Sea level has constantly changed throughout the approximately four billion years of the ocean's history, in response to the cycles of global warming and cooling. While the global rate of sea level rise is now generally agreed to be a little less than a tenth of an inch (1.8 millimeters) per year, there is uncertainty in how continued burning of fossil fuels, tropical rain forest destruction, and the addition of other greenhouse gases will affect future climate and therefore the rate of sea level rise. While there is no agreed on projection, there is widespread scientific agreement that sea level rise will continue for at least the next 100 years, and at a rate at least as high as at present and probably higher.

The closest long-term tide gage records for Pleasure Point come from Monterey (1973 to present), where the gage has recorded an average sea level rise rate of 0.61 foot per century (1.86 millimeter per year). San Francisco from 1906 to the present has had a slightly higher rate of 0.7 foot per century (2.13 millimeters per year) (NOAA 2005). Assuming that the relative sea level rise rate along the coastline of northern Monterey Bay is similar to that of Monterey and San Francisco, this suggests that, based on available data, Pleasure Point is probably experiencing an overall sea level rise rate not too different from that of Earth as a whole. There is definitely some uplift going on, as witnessed by the elevated marine terraces that form the coast of the Pleasure Point area. This indicates that the relative sea level rise rate is somewhat lower here than the global average.

Rates of Long-Term Bluff Erosion. Based on the SAGE analysis, previously measured long-term bluff erosion rates in the immediate vicinity of the site average between 4 inches (9 centimeters) per year and 5.5 inches (14 centimeters) per year (Haro, Kasunich and Associates 1998, *in* SAGE 2006; Griggs 2005). Moore (1998), Moore, Benumof and Griggs (1999), and Moore and Griggs (2002) generated average long-term bluff erosion rates at the site using stereo aerial photographs from 1953 and 1994, softcopy photogrammetry, and a geographical information system (GIS). This period includes both a La Niña- and an El Niño-dominated periods, so it should be representative of longer-term conditions. Recent advances in shoreline mapping techniques described in Moore et al. (1999), Moore (2000), and Moore and Griggs (2002) allow for nearly complete removal of displacement and distortion errors common to

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traditional techniques using uncorrected aerial photographs. Bluff positions identified at a 16-foot (five-meter) spacing interval along the bluff using these new techniques indicate that average erosion rates along the bluff are generally less than 8 inches (0.2 meter) per year. In its report, SAGE describes discrepancies between new and previous rates as either a result of displacement or distortion errors or slower erosion rates due to placement of riprap along the base of the bluff. However, the report notes that long-term erosion rates are generally not well suited to estimate erosion over the short term due to the episodic nature of bluff erosion.

In addition to plotting average bluff retreat rates alongshore, as part of a Federal Emergency Management Agency- (FEMA)-funded study, Moore (1998) projected the 40-year erosion rates 60 years into the future along East Cliff Drive (Figure 1-2). This was to determine where the bluff edge would be in 2054 if the average erosion rate continues and no erosion control measures are constructed. While this projection is limited by all of the temporal variations in physical processes described above, it provides the most reasonable estimate of what might be expected over the next 60 years along the East Cliff Drive project area, assuming that the average annual erosion rate remains the same and that no armor or protection is added. It is clear that the bluff edge would extend well into the East Cliff Drive right-of-way and would render even the one-way street and the bicycle and pedestrian pathway impassable.

A FEMA map of the projected bluff edge between 33rd and 36th avenues (Figure 1-2) shows that about 625 feet (191 meters) of coastline would erode at least to the middle of East Cliff Drive by 2054. An approximately 75-foot (23-meter) portion of East Cliff Drive between 33rd and 34th avenues would be completely removed. Another section, about 475 feet (145 meters) long and extending from about midway between 34th and 35th avenues downcoast to 36th Avenue, would erode such that at least half of East Cliff Drive would be removed. At three locations, all of the roadway would be gone. We are already 11 years into that 60-year projection. It simply is not practical or economically feasible to completely relocate the roadway and utilities a few feet inland because this would not guarantee any substantial additional lifetime; a single large episodic event could remove the added buffer (see Section 2.4.1 for more detailed economic analysis).

There are slight variations over the longer term in the bluff erosion rates and projected shoreline. However, the shoreline will retreat in a more or less uniform manner alongshore over the longer term because of the relative uniformity of the bluff-forming materials, the physical processes that drive bluff retreat along this stretch of coastline, and the essentially linear trend of the coastline.

Infrastructure Loss. At some locations within the project area, the retreating bluff top has already caused segments of the road to fail, requiring road or lane closures and emergency repairs. The roadway has already been reconfigured from two lanes to one lane because of past bluff failures. As described above, the SAGE analysis indicates that over half of East Cliff Drive, between 33rd and 36th avenues, is subject to failure within the immediate future. The loss of East Cliff Drive would severely restrict access to the bluffs, thereby greatly reducing recreational access in the area. Such a loss would also disrupt major utilities and other public infrastructure in the area and would lead to the loss of the public right-of-way. The County's emergency repairs would protect these utilities as much as possible but could not prevent loss of the bluff altogether and, inevitably, damage to the utilities.

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Improvements and Access. Under the No Action Alternative, Pleasure Point Park would remain in its current condition, with any improvements subject to funding. Parkway development, including landscaping and bicycle and pedestrian paths, would not be constructed. There would be no roadway improvements and the existing 27 parking spaces would remain, subject to continued bluff stability. Normal evaluation and maintenance or replacement of the existing drainage system would be conducted by Santa Cruz County Department of Public Works. The abandoned restrooms and access stairs near 35th Avenue would remain, protected as much as possible by the County's ongoing emergency repairs. However, the County's inability to prevent all bluff loss would result in long-term damage to the improvements in the project area. Portions of the bluff top pedestrian path would continue to deteriorate and would drop rubble and debris onto the beach below. Closing the stairways because of deteriorating conditions would limit access to the beach for surfers and other recreationists. Eventually loss of the roadway as the bluff erodes would lead to traffic issues and emergency response time delays for the surrounding neighborhood.

Conclusion. In conclusion, the long-term history of East Cliff Drive and recent studies all indicate that a significant portion of the roadway between 33rd and 36th avenues and at the Hook and its associated infrastructure are in imminent danger of collapse. While the County is committed to repairing any bluff failures so long as it is feasible to do so, such emergency repairs cannot prevent all erosion of the bluff, including catastrophic failures that could result in irreparable damage to the roadway and utilities. Therefore, the No Action Alternative in this particular situation would have serious consequences in terms of impacts on public infrastructure and public access to this stretch of the coastline. While the No Action Alternative in some CEQA situations may have the least environmental effect, that is not the case for this particular proposal.

2.4 ALTERNATIVES AND ALTERNATIVE COMPONENTS CONSIDERED BUT ELIMINATED

A variety of alternatives to control erosion of the bluff have been considered but deemed unsuitable. Nonstructural solutions, such as rerouting traffic and relocating utilities, maintain infrastructure over both the short term and long term but fail to preserve the public right-of-way from erosion. They would also disrupt the general traffic pattern in the area and would result in high projected costs with limited benefits. Planned retreat was found to be less effective than a structural solution because of anticipated long-term environmental impacts and project costs, resulting from the requirement to reroute traffic, relocate utilities, and purchase 12 to 14 private residences along East Cliff Drive to implement such a program. A rock revetment option (riprap) was considered but eliminated because of its high cost and large footprint, which would result in unacceptable environmental impacts. The following alternatives and alternative components were eliminated from further consideration because they failed to meet any or all of the following project objectives in a cost-effective way:

- Protect the coastal bluffs from erosion;
- Avoid loss of the public right-of-way; and
- Improve and enhance public access to the coast.

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2.4.1 Bluff Protection Measures

Soft Solutions/Drainage Improvements

Alternative soft solutions, such as implementing erosion control measures and capturing additional surface drainage, have been suggested as methods to delay the time when coastal bluff protection measures would be needed. This includes new landscaping along the top of the bluff to capture more surface water runoff from the road and installing curbs along the top of the bluff to redirect water to a pipe or storm drain so that the water would not concentrate in one place and run down over the bluff face, contributing to erosion. While these options might be suitable for areas where the road structure is not currently threatened, the threat analysis by SAGE (discussed above under the No Action Alternative) demonstrates that there are five locations where the edge of the road has already been lost to erosion. There are 22 locations where the road is in danger of collapse within the next two or three storm cycles. In total, these areas constitute 651 feet (198 meters), or 65 percent, of the distance between 33rd and 36th avenues. Bluff collapse and loss of the road in even one of these areas would reduce public access and could require the road to be closed. Erosion control measures at the top of the bluff would not protect the Purisima from the effects of wave action and would not prevent larger bluff failures caused by storms, seismic events, or collapse of the Purisima. Nor would they prevent water from seeping through the face of the terrace deposits and causing erosion. Only an overall structural approach would protect the entire area. Landscaping and soft solutions are prevention measures that would not repair the damage that has already been done, nor would they effectively stop the ongoing erosion but would merely slow it to a minor degree. They slow down erosion in areas where there is space between the bluffs and the road, but soft techniques simply cannot withstand the erosive forces that occur during storms at high tide. The practical result of soft solutions would be very similar to that of the No Action Alternative: the County would continue to perform emergency repairs as necessary. The requirements of having to obtain emergency permits and mobilize construction crews to make repeated repairs make this approach difficult, costly, and ineffective.

Bluff Vegetation

Planting vegetation along the face and tops of the bluffs would increase visual quality of the area and could also provide limited protection to the bluff during minor storms. Because large storms are common in the area and the present level of erosion is so severe, plants alone would not provide adequate protection during major storms. Vegetation planted along the bluff would take a long time to become established—possibly a number of years—and thus would not serve the immediate need to protect the bluff face. Moreover, as previously noted, soft techniques like planting vegetation cannot withstand the erosive forces of wave run-up during storms at high tide. The Purisima Formation, underlying the terrace deposits, is subject to less frequent failures but larger and more catastrophic collapses. Even so, vegetation would not protect the Purisima from direct wave action in any measurable way, nor would it be possible to plant vegetation, given the nature of the Purisima.

Including planting pockets in the wall design to reduce visual impacts was considered and rejected because it would be very difficult for the County to access and maintain the vegetation. Small pockets would essentially function like containerized planters and, without regular care, would likely flood during the winter and dry out during the summer. Very few plants would be

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able to survive these conditions. In addition, the natural saline environment would limit plant selection. The few native plants that might be able to survive would probably not achieve the goal of softening the appearance of the wall. As stated above, regarding enhanced drainage solutions, the practical effect of this alternative would be continued erosion of the bluff face and the need for continued emergency repairs by the County. For these reasons, this alternative was eliminated from further consideration.

Move the Road and Utilities Inland ("Buying Time")

Another suggested option is to move the road and utilities to the existing inland right-of-way boundary between 33rd and 41st avenues. This would delay loss of the road to erosion and prolong public access along this stretch of East Cliff Drive, essentially "buying time" before bluff armoring is necessary. An analysis by Santa Cruz County Department of Public Works engineering staff indicates that there is sufficient area in some locations, primarily between 36th and 38th avenues, where public improvements could be moved inland as much as eight to ten feet (two to three meters). For East Cliff Drive, between 33rd and 36th avenues, where the ocean side of the road edge is threatened, there is only about five feet (a meter and a half) of inland shoulder available. Therefore, these locations constrain how far inland the road and utilities can be moved within the existing right-of-way.

Moving the road inland five feet (a meter and a half) between 33rd and 36th avenues alone would provide limited benefit while costing perhaps up to $500,000. Considering the average bluff erosion rate of 8 to 12 inches (20 to 30 centimeters) per year, this would preserve the road for perhaps five to ten years. However, it would likely take several years to obtain the required permits and approvals and to relocate the road. Thus, the amount of time that would actually be gained would be only five or six years, at best. In the meantime, pedestrian and bicycle access along the bluff top would continue to diminish as erosion proceeds. In a relatively short time, erosion would again threaten the road, necessitating bluff armoring in order to protect East Cliff Drive and the public's investment in the new roadway improvements. Under this scenario, road access would be maintained for several years but public access for pedestrians and bicycles along this stretch of the coastline would be lost.

With respect to utilities, the County Sanitation District evaluated the feasibility of moving the two sewer lines beneath East Cliff Drive. These lines could be replaced by a new sewer main one block north beneath Hawes Drive, but all of the lateral sewer service connections and lines beneath 34th, 35th, and 36th avenues would also have to be replaced to flow in a northerly direction to connect to this new main. While this is possible from an engineering standpoint, it would cost up to 1.7 million dollars (Bolich 2004). It is unlikely that this much funding would be available if public access were lost along the road. Additional costs would be associated with moving other utilities, but no estimates have been developed for rerouting the water mains, gas line, and other utilities. Responsibility for these would fall under the jurisdiction of the various utility companies. As with moving the road inland, rerouting utilities would not stop bluff erosion and the eventual loss of public access to this stretch of coastline. Consequently, aside from the limited benefits this approach would realize for considerable public expense, it would not achieve one of the main project objectives, which is maintenance and enhancement of public access.

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Beach Nourishment

Beach nourishment would consist of a formal program of replacing sand that is lost by the force of the waves along the bluff face. Under normal conditions, beaches in the project area are very narrow and sometimes nonexistent. Waves reach near the base of the cliff at virtually every high tide and the cliffs are either actively eroding or armored. Beach nourishment would be an attempt to establish a larger beach profile that would serve to force the shoreline seaward, thus reducing impacts on the base of the bluffs. The reach of the coastline in the project area faces east or southeast, in contrast to the beach areas farther west, which all face southwest. As a result, due to the predominant angle of wave approach from the northwest and wave refraction patterns, littoral (shore) transport is at a maximum along this stretch of coastline, and little sand accumulates.

There are natural variations in beach width along the shoreline from year to year as a function of sediment discharge from source rivers, wave energy and direction of approach, storm severity and frequency. However, in the absence of human activity, beaches tend to vary in width. The Main Beach in Santa Cruz (farther west), while fluctuating in width from winter to summer, returns to about the same width each summer, as do the other beaches in the area. Even after the severe beach erosion of El Niño winter of 1998-1999, all of the beaches monitored between Scott Creek and Capitola had essentially returned to their pre-El Niño width by the next fall (Brown 1998).

In an area with a high littoral drift rate (the Santa Cruz County coast, for example, where the annual average rate is about 300,000 cubic yards [229,000 cubic meters]), nourishing or adding sand to a beach, in and of itself, will not widen the beach if there is no natural beach there to begin with. This is due to the shoreline orientation and lack of a littoral drift barrier or obstruction. Regardless of where the sand comes from, a sand nourishment program is not going to significantly change the condition of the shoreline and create a beach for any significant period where one did not exist naturally.

The construction of the west jetty of the Santa Cruz Small Craft Harbor in 1963 did lead to the trapping of a large volume of littoral sand in the first 15 years or so following construction, significantly widening Seabright Beach. Downcoast beaches narrowed immediately following construction, and the beach at Capitola disappeared altogether a few years later (Griggs and Johnson 1976). However, dredging began in the harbor entrance in 1965 and has continued annually ever since. Sand dredged from the harbor entrance in the winter and spring is discharged onto Twin Lakes Beach and continues on downcoast. By the early 1980s Seabright Beach was essentially fully charged, such that all of the littoral drift now is either transported by waves across the entrance channel or is trapped in the channel, where it is dredged out and pumped onto Twin Lakes Beach. There is no evidence in the bathymetry that any significant volume of sand is diverted offshore so that downcoast beaches now receive the sand that they did prior to harbor construction.

Annual harbor dredging rates vary somewhat based on varying winter wave conditions and, therefore, littoral drift rates, but these rates average about 200,000 cubic yards (153,000 cubic meters). This sand volume is put back into the littoral system after having been moved around the harbor entrance and continues alongshore. It is carried along the Pleasure Point shoreline and

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eventually moves into the head of Monterey Submarine Canyon at Moss Landing. Thus the system today has essentially been in equilibrium for about 25 years. Modifications to the jetties, as suggested by some, would have no permanent impact on the shoreline in the Pleasure Point area as the amount of littoral sand moving along the shoreline annually (about 300,000 cubic yards [229,000 cubic meters]) is the same as it was prior to harbor construction. This would not change. There is no permanent beach at Pleasure Point shown in the aerial photos taken prior to jetty construction (1928, 1943, 1956, or 1963, for example), except in the area immediately upcoast of the O'Neill house, where a short natural rock groin exists and impounds a narrow beach at the bottom of the stairway across from 36th Avenue. Thus, there is no reason for a beach to accumulate now.

Nourishing beaches with imported sand is a process that to date has been little used in California. Most of California's beach nourishment is a by-product of harbor dredging and, therefore, just moves sand from one side of a harbor to the other (the Santa Cruz, Santa Barbara, Ventura, and Channel Islands harbors, for example). A number of southern California beaches, particularly in the Santa Monica cell, were artificially nourished for years with sand derived from several very large coastal construction or dredging projects, but this activity ceased some years ago.

The only significant nourishment project carried out with imported sand for the sole purpose of widening beaches was completed by San Diego Association of Governments in 2002. In this project 2,000,000 cubic yards (1,529,000 cubic meters) of sand was dredged from six offshore sites and placed on 12 northern San Diego County beaches at a cost of $17.5 million ($8.75 per cubic yard [cubic meter]). However, as there were no sand retention devices, and this is an area of high littoral drift rates (about the same as Santa Cruz, approximately 300,000 yards [229,000 cubic meters] per year), most of this sand was carried alongshore or offshore by winter waves and little remained on the beaches within a year. Because of the orientation of the shoreline at Pleasure Point and the lack of any barriers to trap littoral sand, adding sand to this beach or to upcoast beaches would not provide permanent or significant additional protection from wave erosion of the bluffs.

Close East Cliff Drive to Through Traffic

One option considered early in the planning process was to close East Cliff Drive entirely to vehicular traffic, while retaining some pedestrian and bicycle access to East Cliff Drive and thereby the bluff. Through traffic would likely be redirected north to Portola Drive, with traffic-control devices, such as bollards, placed at the intersection with 32nd Avenue. However, this option was not pursued for a number of reasons. It would not prevent the imminent collapse of significant portions of the bluff face, as described in the SAGE report, as the rate of erosion and stability of the bluff face appears unrelated to the load on the roadway. If implemented as the sole County response to the erosion of the bluff, closing East Cliff Drive would not result in any protection of the bluff face from erosion, and would lead inevitably to the results discussed under the No Action Alternative above. The failure of substantial sections of the bluff face in the near future would likely interrupt pedestrians' and cyclists' use of East Cliff Drive. Closing East Cliff Drive to through traffic would not satisfy the project purpose and need, which includes maintaining public access to the shoreline for motorists, cyclists, and pedestrians, increasing the longevity of the public right-of-way, and protecting the right-of-way, including utilities, from bluff face erosion.

Additionally, implementing this proposed alternative would force traffic into adjacent neighborhoods, likely creating traffic congestion problems. Individuals seeking to access the coastline between 32nd and 41st avenues would be forced to the north and onto the primarily residential streets. These streets are relatively narrow (approximately 15 to 20 feet wide) and are not designed as major thoroughfares. Off-street parking is limited. Blocks in neighborhoods closest to the bluff would functionally be turned into dead-ends, further complicating the local traffic pattern. Detouring traffic would restrict public access to the coast and would have negative effects on the businesses along 41st Avenue, south of Portola Drive. It would also increase emergency response times to residences along East Cliff Drive between 32nd and 41st avenues. Closing East Cliff Drive to vehicular traffic would eventually lead to the need to relocate utilities and for private property owners to install bluff protection. Such bluff protection efforts would be privately funded and would first have to be approved by regulatory agencies. Only limited benefit would be realized from implementing this proposal, and bluff erosion would not be reduced in any fashion. For these reasons, this alternative component was eliminated from further consideration.

Acquisition of Private Property (Planned or Managed Retreat)

Planned retreat, sometimes referred to as managed retreat, is an approach to dealing with coastal beach and bluff erosion, whereby the natural erosional processes are allowed to occur, and structures and other improvements are moved, torn down, or otherwise modified as they become threatened. Sometimes this approach uses soft interventions, such as drainage improvements, revegetation, and beach sand nourishment programs to slow the impacts of natural processes. In this context, planned retreat would eventually involve the purchase of private parcels and moving East Cliff Drive inland to allow for continued public access between 32nd and 41st avenues.

To undertake such an alternative requires a comprehensive approach tailored to the context of the local community and environment for which it is proposed. Local geology and shoreline dynamics determine the rates and impacts of erosion. Economics and legal and property rights issues determine what is feasible and what may meet the needs of the community. Public policy and social issues also determine how such a concept would be implemented. Additionally, there is a significant difference between using planned retreat in undeveloped or rural areas and using it in developed or urban settings.

Based on the SAGE threat analysis, with continued erosion, the existing pedestrian, bicycle, and vehicle facilities along East Cliff Drive will soon be lost, and eventually the homes that line the roadway will be threatened. However, implementing planned retreat in the Pleasure Point area raises a number of issues and questions regarding private property rights, loss of development potential, project goals and objectives, cost effectiveness, and the sustainability of such a program. Historically, planned retreat has been most successful as a planning tool in rural or undeveloped areas, where it takes less money for public agencies to purchase and relocate buildings and public infrastructure; East Cliff Drive's very importance to the community as a thoroughfare in a residential neighborhood and means of access to the coastline works against the feasibility of planned retreat as a viable option.

Property Rights. Implementing planned retreat assumes that private property would be acquired through voluntary sale to the County or through the process of eminent domain. In this scenario, if most property owners resist selling their property, the Board of Supervisors would have to use eminent domain to implement this alternative. Historically in Santa Cruz County, eminent domain has not been used to take private residences. It has been used when there are no other viable options available to obtain additional rights-of-way for public improvement roads, side walks, etc. Where programs of planned retreat have been established, for example, along the southeast coast of the United States for preserving dune beaches with very different geologic conditions than found here, the programs have been voluntary and have not had much success. The City of Solana Beach, California, examined the possibility of planned retreat in its master EIR in 2003 and concluded that fully implementing such a program might require a change in state law. When the County of Santa Cruz uses eminent domain, the Board of Supervisors must make a finding of the greatest public benefit for the least private impact. In this case there are other options and the board may not be able to make the findings to meet this test. As the City of Solana Beach found, language within the Coastal Act requires the California Coastal Commission to continue to approve shoreline and coastal bluff protection structures under certain circumstances. Thus, even if a planned retreat policy were adopted, the Coastal Commission's current mandate would conflict with such an approach by allowing the continued approval of seawalls and other coastal armoring in order to protect bluff top structures on private properties. Furthermore, even if state law were changed so that planned retreat could be implemented, the County and Coastal Commission would likely face privately initiated litigation from bluff top property owners alleging the taking of their private property without just compensation (AMEC Earth & Environmental, Inc. 2003).

Project Goals and Objectives. The goals set forth in the initial formulation of the project alternatives for East Cliff Drive included increasing the longevity of the public right-of-way, reducing bluff erosion, and improving and enhancing public access to the area. Planned retreat would fail to meet these goals because the bluffs would continue to erode, requiring road and public pathway improvements to continue to be moved and reconstructed over time. Depending on how planned retreat would be implemented, loss of the public right-of-way along the bluff could reduce public access to the coast and continued erosion could damage other amenities in the area, such as Pleasure Point Park. Therefore, in order to select planned retreat as a viable alternative, the project goals and objectives would need to be modified or abandoned.

Cost Effectiveness. It is not financially feasible to purchase private property, relocate underground utilities, rebuild pedestrian, bicycle, and vehicle access farther back from the bluff top, obtain permits, and prepare additional design plans and environmental documentation.

A rough estimate of the current costs for a planned retreat alternative is as follows, according to County estimates:

- Purchase and demolish 12 to 14 residences along East Cliff Drive at an estimated cost of $2 million to $3 million each; total: $24 to $42 million;
- Relocate utilities. Sanitary sewers lines: $1.7 million (Santa Cruz County Sanitation District 2004), water mains and connections: $250,000; gas lines: $100,000; total: $2,050,000;
- Rebuild pedestrian, bicycle, and vehicle facilities: $2 million; and

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- Design plans and produce environmental documentation: $750,000.

The estimated first time total cost for planned retreat is $28 to $46 million.

Because erosion is expected to continue and to threaten improvements and private property, the costs outlined above are considered first time costs only. It is likely that in about 75 years erosion would advance to a point where relocating facilities and purchasing additional private property would be necessary, at a cost of an additional $20 million. This would result in a total estimated cost of $58 to $66 million for the first 100 years of planned retreat.

Sustainability. For all of these reasons, planned retreat is not practical in an urban developed area. Implementing planned retreat would create a continuing burden on the County and would likely lose community support due to its financial and social costs.

Conclusions. Planned retreat was considered during the early planning process but was removed from further consideration. While planned retreat might have few short-term environmental effects, it would have significant adverse environmental effects related to relocating utilities and providing emergency services, traffic circulation, and public access to coastal resources. Additionally, as discussed above, planned retreat would not be cost effective.

Finally, a planned retreat alternative could not reasonably be devised for the project area alone but would need to be pursued at a policy level and on a regional basis, in concert with other land management agencies. While the County of Santa Cruz does not have a planned retreat policy per se, it requires all new development to be set back at least 25 feet from the top edge of a bluff, and a setback of more than 25 feet may be required based on site-specific conditions (Policy 6.2.12). County Ordinance 16.10.070(h)3 further regulates construction of new coastal structures. Because a planned retreat program would require an extensive public review and political process, the near-term result would be the same as the No Action Alternative, that is, deteriorating conditions and loss of public access.

Riprap (Revetment)

Riprap consists of a layer of large angular stone designed to protect and stabilize areas subject to erosion, such as the East Cliff Drive bluff area. Riprap has been used for many residential protection projects along the Santa Cruz coast and was considered for the proposed project area. In order for riprap to be effective against further bluff erosion in the project area, it would require a base wide enough to support the height needed to protect the Purisima. To achieve this, large amounts of riprap would be placed on the beach, consuming much of the beach area at the project site and eliminating public access. Riprap would be an impediment to surfers exiting the surf. Additionally, as noted in Coastal Protection Structures and Their Effectiveness (Fulton-Bennett and Griggs 1986), "the success rate of riprap walls is marred by relatively high repair and maintenance requirements, and by the fact that significant property damage often occurs when these walls suffer even partial failure." These structures often fail due to loss of material under the foundations or in front of them. Riprap placed on sand would significantly modify the visual character of a beach. The large rocks, crevasses, and gaps between the rocks change the sand habitat to a new rocky habitat, which often supports rats, squirrels, and other burrowing rodents

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that would not normally find habitat on a sandy beach (California Coastal Commission 1999). For these reasons, this alternative was eliminated from further consideration.

Corps of Engineer Wall Plans

When the East Cliff Drive Bluff Protection Project was originally proposed as a County/Corps project, the Corps identified several possible wall plans, as described below.

Shotcrete/Cribwall Plan

This option would use a combination of a "shotcrete" base and a cribwall extension to protect the bluff. Shotcrete is the process of forcing concrete through a hose onto a surface at a high velocity using compressed air. A two-foot-thick (.6-meter-) shotcrete (gunnite) wall would be constructed from the toe to 16 feet (5 meters) National Geodetic Vertical Datum (NGVD) to provide necessary protection from incident waves. The formed concrete toe would consist of a three-foot-deep (one-meter-deep) footing into the Purisima sandstone and a four-foot-wide (1.5-meter-wide) toe apron. Typically, erosion directly in front of seawalls is exacerbated due to the increased turbulence caused by the wall. Sandstone still would erode in front of the apron but at a rate more typical of the beach slope erosion.

From 16 feet NGVD to the top of the bluff, a cribwall would be constructed to protect the bluffs above the shotcrete wall from wave run-up and spray. The cribwall (built to California Department of Transportation [Caltrans] specifications) would be closed faced from 16 feet NGVD to 24 feet (7 meters) NGVD to protect against the heaviest portion of the run-up. From 24 feet NGVD to the top of the bluff, the crib wall would be open faced with stone fill to protect against the remaining run-up (Corps 2003).

To secure the wall to the bluff face, tiebacks would be used. One row of tiebacks would be required with horizontal spacing of eight feet (2.4 meters). The tiebacks would be installed 18 feet (5.5 meters) into the Purisima to provide the necessary horizontal support for the shotcrete wall.

The soil behind the wall would be drained by installing a porous plastic mat and a PVC pipe network between the shotcrete and Purisima. Without proper drainage a potentially damaging hydrostatic head could build up behind the wall. Drainage of the soil behind the cribwall is not an issue since the cribwall would not block the bluff.

This plan met erosion prevention objectives but was not found to be economically justified based on the Corps' benefit-to-cost analysis model. It would also result in greater construction impacts and would have poor visual aesthetics. For these reasons, it was not recommended for implementation.

Concrete/Shotcrete Plan

Under this option, the same wall as in the Shotcrete Plan would be installed, but the shotcrete base wall portion would be replaced by a two-foot (four-meter) thick, formed concrete wall covered with six inches (15 centimeters) of shotcrete, resulting in a final wall thickness of two and one-half feet (.8 meter). The soil behind the concrete portion of the wall would be drained by using stone fill between the wall and the Purisima and PVC pipes through the concrete wall.

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Above the concrete/shotcrete base wall, the same cribwall described under the shotcrete plan would be constructed (Corps 2003).

This plan met erosion prevention objectives but was also found to be uneconomical based on the Corps' model. Similar to the shotcrete/cribwall plan, it would also result in greater construction impacts and would have poor visual aesthetics. For these reasons, this plan was not recommended for implementation.

Gravity Wall Plan

This option is similar to the Shotcrete and the Concrete/Shotcrete Plans but would use a gravity based, formed concrete seawall. The wall would have had a base thickness of five and one-half feet (1.7 meters) and then would taper to a minimum thickness of two and one-half feet (.8 meter) at the top. The toe would be built to accommodate these dimensions. The wall would not need to be tied back into the bluff face due to the shear weight of the wall. The soil behind the concrete portion of the wall would be drained by using stone fill between the wall and the Purisima and PVC pipes through the concrete wall (Corps 2003).

This plan met the erosion prevention objectives of the project and provided benefits of the project (such as protecting infrastructure, roadway, and utilities). However, it was not recommended for implementation because the Shotcrete Wall Plan included in Alternative 1, Full Bluff Armoring, provided similar benefits and was strongly preferred by the community and the County of Santa Cruz over the Gravity Wall Plan, based on aesthetic appearance and constructability.

2.4.2 Road and Parkway Improvements

The options below for road and parkway improvements were considered and eliminated from further consideration.

Two-Level Pedestrian/Multiuse Path

It has been suggested that a grade separation between pedestrian and vehicles or bicycles would benefit the quality of experience for visitors to the area. This approach might be successful if more space were available between the bluff top and the road.

Installing a two-level pedestrian and bicycle path would create severe complications along the path. A two-level design would require extensive ramps and walls to comply with the Americans with Disabilities Act. In most locations, secondary railings would also be needed, adding to visual clutter with limited benefits. This alternative component was eliminated from further consideration for these reasons, as well as drainage complications associated with two levels.

One-Way Traffic on East Cliff Drive

In response to the failure of the cliff and road in the vicinity of Larch Lane during heavy storms in January 1994, East Cliff Drive was converted to one-way operation in the westbound direction between 38th and 41st avenues. The purpose of the one-way conversion was to respond to the narrowed road width in that area following cliff repairs, and to reduce future vehicular loading on the cliff edge. As a result of the westbound one-way conversion, East Cliff Drive saw a reduction of approximately 2,000 to 3,000 vehicles per day, while 38th Avenue experienced a traffic increase

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of approximately 1,000 vehicles per day from rerouted eastbound traffic (Santa Cruz County 1996).

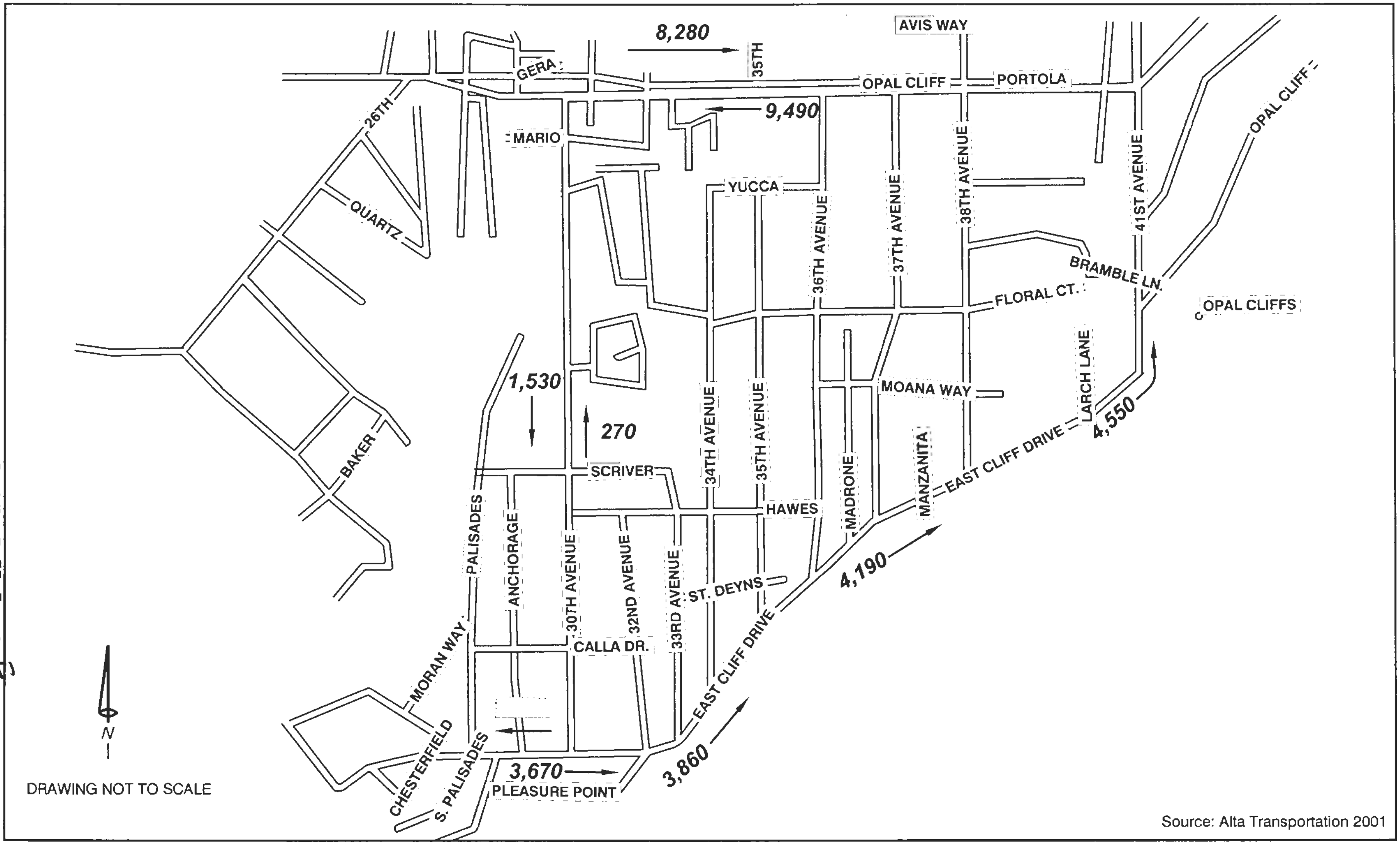
The County of Santa Cruz conducted a community meeting in February 1994 to gather public comments on the westbound one-way conversion. According to a County memorandum, there was strong community consensus at the meeting that the one-way westbound traffic pattern should be reversed to reduce the traffic volume on 38th Avenue. Following the meeting, on the recommendation of the County Planning and Public Works Departments, traffic flow between 38th and 41st avenues was reversed to an eastbound one-way direction. Subsequently, East Cliff Drive between 32nd and 38th avenues was converted to an eastbound one-way direction to reduce vehicular loading along the entire road. As a result of these decisions, by early 1995 East Cliff Drive was an eastbound one-way road for the entire segment between 32nd and 41st avenues.

Following the conversions, the County Public Works Department extensively studied the effects of eastbound one-way traffic on neighborhood traffic volumes. Traffic counts, conducted in the summer to obtain a worst-case scenario, showed that traffic decreased for most roads in the study area with the exceptions of 30th Avenue and Hawes Drive. Following conversion, 30th Avenue carried approximately 500 to 800 more vehicles per day and Hawes Drive carried approximately 400 more vehicles per day.

A community meeting was conducted in October 1995 to gather public comments on the eastbound one-way conversion. According to a County memorandum dated October 26, 1995, the community strongly supported maintaining the eastbound one-way conversion of East Cliff Drive between 32nd and 41st avenues. However, residents of 30th Avenue were concerned about increased traffic volumes. To respond to these concerns, the County installed road bumps on 30th Avenue to reduce traffic and speeding.

Still, some community members have suggested that the segment of East Cliff Drive between 32nd and 41st avenues be reversed to the westbound one-way direction as part of the proposed parkway improvements, a primary reason for which being safer viewing of the ocean for motorists. While such a reversal would allow easier ocean viewing, it would also alter traffic patterns within the area. Using turning movement counts conducted in July 2001 at the intersections of 32nd Avenue/East Cliff Drive and 41st Avenue/East Cliff Drive and average daily traffic volume counts conducted in 1995 by the County Public Works Department (increased by a factor of 13 percent to correlate to the July 2001 counts), the circulation effects of reversing the one-way direction on East Cliff Drive were evaluated as part of this EIS/EIR. The July 2001 traffic counts and the January 1996 East Cliff Drive Traffic Study (which contains the 1995 Public Works counts) are both included in Appendix D.

Currently, there is an overall west-to-east movement of vehicles along the Santa Cruz coastline, and within the traffic corridor that includes the arterial roads of Portola Drive and East Cliff Drive (approximately 12,500 vehicles per day move in the eastbound direction, and 9,500 vehicles per day move in the westbound direction; see Figure 2-2). The reasons for this east-west traffic imbalance may vary, but they likely include a pattern of motorists traveling progressively



Within the traffic corridor that includes the arterial roadways of Portola Drive and East Cliff Drive, approximately 12,500 vehicles per day move in the eastbound direction and 9,500 vehicles per day move in the westbound direction.

Existing Traffic Volumes in Vicinity of East Cliff Drive

Santa Cruz, California

Tetra Tech, Inc.

Figure 2-2

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east from Santa Cruz for coastal viewing or surfing, then looping back to Santa Cruz via 41st Avenue and Highway 1. For this traffic analysis, it was assumed that this overall regional circulation pattern would not be affected by a localized reversal of traffic on East Cliff Drive.

The preparers of this analysis also assumed that existing overall traffic volumes along the study segment of East Cliff Drive would not be affected by a reversal in the one-way direction. Thus, a one-way reversal would not make it more or less attractive for motorists to drive on the study segment of East Cliff Drive but would simply alter the way in which they accessed the road. However, note that the one-way reversal would be expected to decrease traffic along the segments of East Cliff Drive west of 30th Avenue, as motorists traveling to the study area would use the more direct Portola Drive from points west.

Reverse Traffic Circulation

Under the reverse (westbound) one-way scenario, eastbound motorists on East Cliff Drive would be required to detour to Portola Drive via 30th Avenue. Those motorists wanting to view the coastline, but still wishing to continue eastbound to 41st Avenue or other areas of Capitola, would be required to drive a loop: north on 30th Avenue, east on Portola Drive, south on 36th, 37th, 38th, or 41st Avenue, and west on East Cliff Drive back to 30th Avenue, thus increasing overall vehicle miles traveled in the area (Figure 2-3).

On 30th Avenue, an increase of up to 1,500 additional vehicles per day would be expected, consisting of eastbound traffic detouring up 30th Avenue to Portola Drive and looping traffic turning right from the westbound one-way portion of East Cliff Drive.

On Portola Drive, overall traffic volumes would increase slightly, and a wider imbalance between eastbound and westbound traffic would occur. Specifically, the number of westbound motorists would decrease by approximately 3,700 vehicles per day as these motorists use westbound East Cliff Drive, and the number of eastbound motorists would increase by approximately 4,000 vehicles per day. The eastbound increase would include motorists detouring up 30th Avenue from East Cliff Drive and motorists traveling to the study area on Portola Drive.

As noted above, traffic on the residential avenues providing direct access between Portola Drive and East Cliff Drive would also increase as motorists drive in the looping pattern. Most of the traffic increase would occur on 36th, 37th, and 38th avenues, which would provide the earliest opportunities to directly cut between Portola Drive and East Cliff Drive. Traffic on these three roads would increase by up to 1,000 vehicles per day. Compared with existing volumes, traffic on 41st Avenue would decrease from approximately 4,500 vehicles per day to approximately 3,800 vehicles per day.

On Hawes Drive, traffic levels would decrease as there would be fewer motorists cutting through to East Cliff from 30th Avenue via 32nd, 33rd, 34th, and 35th avenues. Under the reverse one-way scenario, this pattern would be less prevalent because most westbound motorists on East Cliff would continue on to 30th Avenue, where there is a direct connection to Portola Drive. Along with Hawes Drive, traffic on the avenues that do not provide direct connections between East Cliff Drive and Portola Drive would decrease. Table 2-1 summarizes both the existing traffic flow and the projected traffic flow for the reversed one-way option.

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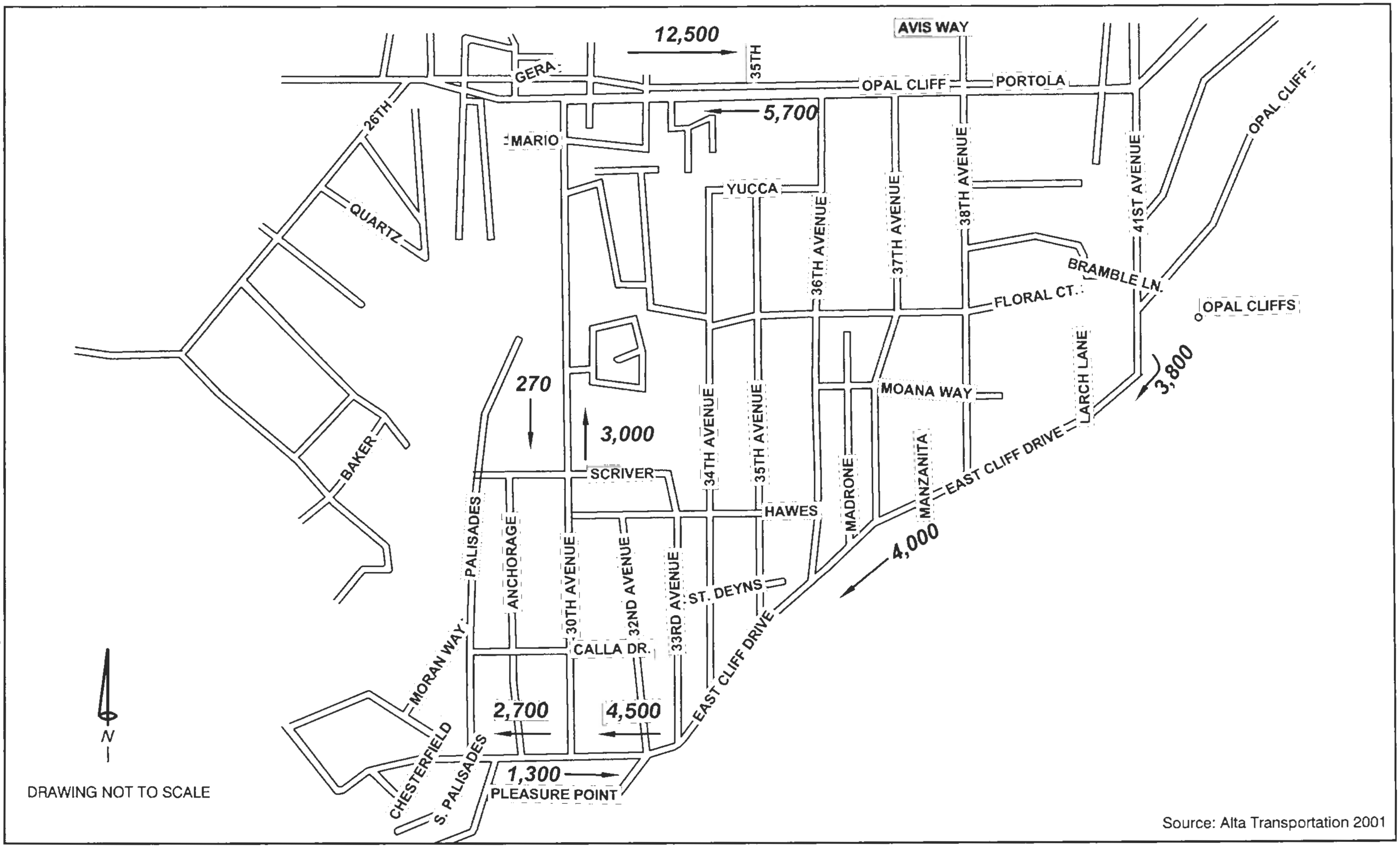

A reversal of the one-way traffic direction on East Cliff Drive from eastbound to westbound would be counter to the prevailing east-to-west traffic pattern in the area, would result in a "looping" driving pattern in the study area causing an increase in vehicle miles traveled (VMT), and would increase neighborhood intrusion and "cut-through" by motorists.

Expected Traffic Volumes Following Reversal of One-Way Traffic

Santa Cruz, California

Tetra Tech, Inc.

Figure 2-3

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Table 2-1
Projected Increases in Residential Traffic
Under One-Way Reversal

Road Segment	Existing ADTs[1,2]	Reverse Flow ADTs[3]	Percent Change
30th Avenue (near Scriver Street)	3,790	5,290	+40%
36th Avenue (near East Cliff Drive)	580	920	+60%
38th Avenue (near Floral Drive)	1,450	1,800	+24%
41st Avenue (near East Cliff Drive)	4,530	3,800	-16%
Hawes Drive (near 32nd Avenue)	960	470	-50%

Source: Alta Transportation 2001

Notes:

1. ADT (Average Daily Traffic) =. Historic traffic volumes adjusted to July 2001 levels. Actual July 2001 counts and historic traffic counts are contained in Appendix D.
2. Adjusted or actual traffic volumes with current East Cliff Drive configuration.
3. Adjusted traffic volumes with projected changes from reverse in East Cliff Drive one-way flow.

In summary, a reversal of the one-way traffic direction on East Cliff Drive from eastbound to westbound would be counter to the prevailing west-to-east traffic pattern in the area, would result in a looping driving pattern in the study area, causing an increase in vehicle miles traveled, and would increase neighborhood intrusion and "cut through" by motorists. Most motorists would continue to travel through the area from west to east and would be required to use Portola Drive as a detour then loop around through the residential neighborhood to East Cliff Drive. Traffic levels would increase on 30th Avenue as motorists detoured to Portola Avenue, and would increase on 36th, 37th, and 38th avenues as motorists cut through to access East Cliff Drive. Traffic levels would decrease on 41st Avenue, on Hawes Drive, and on the adjacent avenues that do not provide a direct connection to Portola Drive.

The neighborhood traffic effects of reversing the one-way flow on East Cliff Drive are not desirable for three reasons:

- It would be counter to the overall eastbound traffic pattern within the study area;
- Previous neighborhood concerns with high traffic volumes on 30th, 37th, and 38th avenues; and
- Overall community support of the eastbound one-way traffic during the 1995 studies.

The expected traffic volumes on 38th Avenue following the one-way reversal would be approximately 1,800 vehicles per day, which is normally considered the maximum desirable traffic volume for a residential street. Expected traffic volumes on 30th Avenue would be approximately 3,000 vehicles per day. Therefore, this alternative component was considered unreasonable and was eliminated from further consideration.

Counterflow Bike Lane

A Class II counterflow bike lane, adjacent to the car lane, would address the needs of high-speed cyclists wishing to travel westbound on East Cliff Drive. However, due to safety concerns at the numerous avenue intersections and residential driveways with East Cliff Drive, the existing back

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out and diagonal parking along the road and the overall lack of space for such a lane, a counterflow Class II bike lane is not recommended. The number of conflicts the additional space would require make this alternative difficult to implement. Also, immediately to the north, the Portola Drive arterial provides a functional bike lane for bicyclists wishing to pass through the area in the westbound direction. For these reasons, this alternative component was eliminated from further consideration.

Note that slow counterflow traffic would be permitted on the proposed curb-separated bicycle path on the ocean side of the road. High-speed westbound cyclists would use Portola Drive or other two-way neighborhood streets as a detour to East Cliff Drive.

2.5 ALTERNATIVES DEVELOPMENT

Various construction methods and designs were considered for the different alternatives selected to be evaluated in this EIS/EIR. The following criteria were used in determining the most appropriate design for the project area:

- The design has to be able to protect the bluff from toe scour (where the base or foundation is undermined);
- The design needs to be tied into the existing protective structures installed as emergency repairs in 2004 and at both ends of the project site;
- The design has to be compatible with recreational uses of the area so as to preserve as much of the beach as possible; and
- The design has to ensure adequate protection against most wave effects.

The County determined that the soil nail type of construction (see Figure 2-4) would be the most effective in protecting the bluffs in the project area and meeting the requirements of a scenic area. The following criteria were used to determine the most appropriate construction method:

- The bluff protection has to be technically feasible;
- The protection has to minimize construction-related impacts on the natural environment; and
- The finished construction has to look natural.

Soil nail construction, along with the natural looking concrete face (colored, stained, and sculpted to match the natural cliff face), were determined by the County to be the best technical and visual solutions to the problem of ongoing coastal bluff erosion in the project area. The proposed structures would offer coastal bluff protection while maintaining sensitivity to the valuable scenic coastal resources and the recreational uses of the area (including use of the surf and access for motorists, bicycles, and pedestrians).

Below is a brief description of each of the construction methods that make up the different alternatives. To recapture recently lost bluff top areas, mechanically stabilized earth (MSE) construction would be used only in a few select locations where small build outs are planned.

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ADDITIONAL BACKGROUND FOR EAST CLIFF DRIVE PROJECT

Recreational Surfing and Wave Conditions Change Over Time

The attached copy of text material entitled "Potential Impacts on Surfing" was used to prepare the Project EIR (Section 6.2.1 – pp 6-31 to 6-34). In that discussion the factors which determine wave formation and the quality of the surf in the area of Pleasure Point are explained.

The following table (Figure 1) shows the number of factors involved in surf/wave formation. In order to model or predict wave formation – location of breaks, water depth, and thus the quality of the surf for recreational use, values must be established for all of the variables. The majority of these may be interrelated but are independent of whether there is a natural bluff configuration or whether the bluff has been hardened

Variables Required to Model Potential Recreational Surf & Determine Where Waves Will Break	Variables **independent** of wall/ armoring	Variable **depends** on wall/ armoring
1. Wave height and period		
Depends on wind speed, direction, duration across the entire Pacific	●	
Distribution of atmospheric pressure variations and storm systems	●	
2. Water depth		
Tidal variations (low to high tide) - 3.5 ft. average; max. 8.5ft	●	
Long term sea level rise - estimated at 1-2mm/yr.	●	
Geologic uplift - reduces water depth approx. 0.5mmper year	●	
Fixing back beach – depth increase per sea level rise		❍
3. Bathymetry		
Offshore bedrock reefs that change over time	●	
Transitory sand bars and deposits	●	
4. Wave direction		
NW & W – predominant fall, winter, spring swells	●	
SW & S - more common in summer season	●	
5. Coastal orientation.		
SW/ NE orientation – waves refract at local geologic formations.	●	

Figure 1

The dominant control for wave breaking is the ratio of wave height to water depth. Therefore larger waves break further offshore and smaller waves break closer to shore. The main breaks in the area are a result of the offshore geology, in that the waves shoal, refract and break over bathymetric highs (shallow water that are formed by the uplift of the more resistant sandstone layers) of the Purisima Formation that comprise the seafloor in this area. Currently, the only waves that actually interact with the bluffs in the area are either: reformed shore break waves within the surf zone, extremely small waves at high tide, and storm waves associated with wind and wave induced setup. None of these conditions result in good surfing waves.

Fixing the back beach location, potentially increasing water depth immediately in front of the hardened bluff under certain conditions, is the only project dependent factor. While water depth in front of the wall would potentially increase over the long term (50 or 100 years), the conclusion is that it cannot be correlated directly as a factor which would result in degradation of recreational surfing. Near shore bathymetric variability, tidal variation and wave height and approach direction are much more significant factors governing local wave formation than water depth inshore of the zone of wave breaking. It is theoretically possible to say that small waves breaking in the vicinity of the wall may change, given long term sea level rise. Calculating that specific change over time would require an assigned value and assumptions for each of the other many variables and it is not possible to predict how these will change and interact - daily, seasonally and long-term.

It was also pointed out that many of the best known surf breaks in the project area are adjacent to where coastal armoring already exists (Figure 2). While some of this armoring has been in place for more than 25 years, there is no indication that wave formation and surfing activities have changed as a result of these or other fixed bluff positions. This observation leads to the conclusion that, at least, in this project area, the theory of fixing the back beach may not be directly linked to degradation of coastal recreational surfing resources.

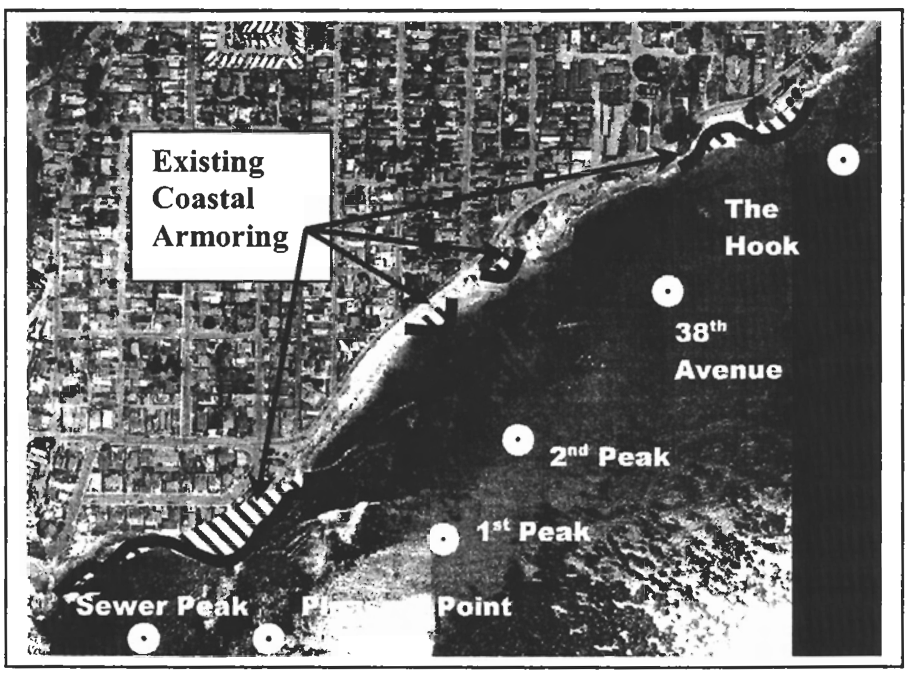

Figure 2 - Armoring & Main Surf Breaks

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POTENTIAL IMPACTS ON SURFING (BLUFFTOP VERSUS BEACH/SURFING TRADE-OFF)

The Pleasure Point area is a well-known surfing spot that has been enjoyed by surfers for over 50 years. A recent issue of *Surfer's Journal* has an article about well known big wave rider Fred Van Dyke who lived and taught high school in the San Lorenzo Valley in the late 1940's and describes surfing Pleasure Point in the summer of 1950. There are several distinct breaks that extend from directly offshore of Pleasure Point itself to The Hook at 41st Avenue. On crowded days, there may be well over a hundred surfers spread out over this area.

Several factors are key to producing good surfing waves. Of primary importance are the characteristics of the waves themselves, their direction of approach, their period and their height. The dominant waves that reach the Pleasure Point area and those that provide for the best surfing conditions arrive from the northwest from storms generated in the North Pacific. Equally important to the waves themselves are the geological conditions in any particular coastal or shoreline area. These include the orientation of the coastline relative to the approaching waves, the bottom topography or bathymetry, location of "reefs" or rock outcrops and sand bars, and also the tidal conditions or tidal range.

At Pleasure Point, the waves arriving from the northwest refract or bend around Pleasure Point and change direction almost 180 degrees (Figure 1). Waves approaching any coastline begin to refract or bend when the water depth is equal to one-half their wavelength, so water depth is an important factor in how and where waves break. The relationship between wave height and water depth will determine when a wave will break. A general rule of thumb is that a wave will break when the relationship between wave height and water depth is ~ 3:4, or a wave 3 feet in height will break in 4 feet of water, a 6 foot wave will break in 8 feet of water, etc (Figure 2).

Over the past 50 years, with the coastline in the Pleasure Point area eroding at about 4 to 6 inches/year, the cliffs have retreated about 15–25 feet, although the riprap and rubble on the beach and the concrete crib walls have no doubt reduced the original natural rate somewhat. Rising sea level (~4 inches in 50 years) and large storm waves at times of high tides, as well as rainfall and slope failure, have all contributed to this retreat.

About 270 feet of the 960 feet of project coastline has now been stabilized and the proposed project would stabilize the remaining 690 feet of cliffs. If successful, this will halt the retreat of the coastal bluff for the near-term future. A logical question to ask prior to stabilizing the cliff is whether or how will this affect the waves that break at Pleasure Point. If there is a significant effect? If so, can this be mitigated?

It is important to realize that no area of coastline remains the same for very long, either over the short or the long-term. The coastline is one of the most dynamic physical environments on Earth and undergoes constant change. Wind, waves, tidal variations, sea level change, El Niño events, as well as the erosion of seafloor and transport of sand in the nearshore zone provide for an extremely active geologic environment. Each of these factors has an effect either on the waves that approach the shoreline at Pleasure Point or how those waves will break and, therefore, on surfing conditions.

TIDAL ELEVATIONS. One of these variables is fairly predictable, that of the tidal conditions or tidal height to expect at any particular time in the future. This component of sea level is based primarily on the gravitational attraction and therefore the positions of the moon and sun relative to the earth. We know with considerable precision what tidal heights we should expect, hours, days, years and decades into the future. In the Monterey Bay area, we experience a mixed semi-diurnal tide with two high and two low tides each 24 hours and 50 minutes that are unequal in magnitude or height. Extreme high and low tides range between about 6.9 feet and –1.6 feet, respectively, or a maximum range of about 8.5 feet, with an average range between high and low tide of about 3.5 feet. Because of the astronomical motions involved, tidal oscillations occur twice daily, twice monthly, twice yearly, and every 4.4 years, with a smaller 18.6 year cycle as well.

However, during major El Niño events, the sea surface elevation may increase as much as 1.5 or 2 feet above the predicted tidal level due to a combination of atmospheric pressure differences, thermal expansion of seawater, wave setup and wind direction. These events and their future impacts on sea level are completely uncertain and cannot be predicted in advance.

Because the water depth is a primary factor influencing how waves of a particular length and height will break, the condition of the tide is important in determining surfing conditions. There are some surfing areas that break better at high tides and others at low tides. Tidal elevation is therefore a major, but mostly predictable variable in surfing conditions. For perspective however, the 8.5 feet of water surface elevation difference between extreme high and low tides in this area that can occur during a single 24-hour period, is equivalent to 2590 mm or 1295 years of 2mm/year of sea level rise [(8.5 ft X 12 in/ft X 25.4 mm/in) ÷ 2 mm/yr].

SEA LEVEL INCREASE. A lengthy discussion of changing sea level was included earlier under the discussion of the NO PROJECT ALTERNATIVE. Sea level rise has been the primary factor driving shoreline retreat for the past 18,000 years. Sea level has constantly changed throughout the approximately 4 billion years of the ocean's history in response to the cycles of global warming and cooling. Oscillations in sea level of up to about 400 feet have occurred regularly in cycles that extend for tens of thousands of years. While the global or "eustatic" rate of sea level rise is now generally agreed to be about 1.8 to 2.0 mm/year, or a little less than a tenth of an inch, the uncertainty is in how continued burning of fossil fuels, tropical rain forest destruction and the addition of other greenhouse gases (methane, for example) will affect future climate and the therefore, the rate of sea level rise. There are many scientists working on this question but still significant variations in what might occur over the next century. Globally sea level rose about 8 or 9 inches over the past century and there are a variety of models for future sea level rise which project anywhere from a foot to about 3 feet by 2100. There is no agreed upon projection but there is widespread scientific agreement that the sea level rise will

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continue for at least the next 100 years, and at a rate at least as high as at present and probably higher.

Tide gage records are the best source of information for local relative sea level rise rates (http://140.90.121.76/sltrends/sltrends.shtml). The closest long-term tide gage records to Pleasure Point come from Monterey (which extend from 1973 to present) where the gage has recorded an average sea level rise rate of 1.86 mm/yr (0.61 ft/century), and also at San Francisco (1906 to the present) with a slightly higher rate of 2.13 mm/century or 0.7 ft/100 years Assuming that the relative sea level rise rate along the coastline of northern Monterey Bay is similar to that of Monterey and San Francisco would suggest that based on available data, Pleasure Point is probably experiencing an overall sea level rise rate not too different than that of the Earth as a whole, about 2 mm/yr. There is definitely some uplift taking place as witnessed by the elevated marine terraces that form the coast of the Pleasure Point area, however. This would indicate that the relative sea level rise rate is somewhat lower here than the global average. This is again, however, an area of some uncertainty in terms of exact uplift rate and therefore, precise sea level rise rate, and subsequently, effects of sea level rise on the shoreline.

It is important to place this sea level rise in context with the daily or monthly changes in sea level at Pleasure Point due to tidal fluctuations. At 2 mm/yr, it would take 1295 years of sea level rise to raise sea level as much as the present difference between low and high tide levels. If the future sea level rise rate doubled to 4 mm/yr, it would take 648 years. An extreme El Niño elevated sea level condition of 2 feet, such as that experienced at the San Francisco tide gage in 1983, is equivalent to 305 years of sea level rise at 2mm/yr.

Waves break today in the Pleasure Point area at both high and at low tides, although they provide different surfing conditions. Looking 100 years ahead, which seems to be a reasonable time consideration for the consideration of many natural phenomena (100 year flood, 100 year storm, for example) or structures or projects being constructed today, sea level would most likely rise between 1 and 3 feet above today's sea level.

What does this mean for waves breaking and for surfing conditions at Pleasure Point? At the present time waves break at a number of different locations depending upon the specific wave heights and tidal conditions. The offshore water depths and bottom topography, which affect how and where the waves will break, will be the same whether or not the bluff is allowed to retreat. At low tide or high tide, water depths will most likely be somewhere between 1 and 3 feet deeper than at present by 2100. Everything else being equal, these waves will break closer to the shoreline. However, the bottom conditions (the presence of rock outcrops or "reefs" and the location of sand bars or sand deposits) that produce the wave breaks are variable across the nearshore zone and will change gradually with a rising sea level. Whether or not there is a beach along the shoreline or how wide that beach is, or whether it is covered with rocks or sand, will not affect the waves breaking several hundreds of feet offshore. The presence or absence of a beach doesn't affect the wave break now and it won't affect it in the next 100 years. The tidal conditions and waves themselves are the critical factors.

BATHYMETRY OR SEAFLOOR TOPOGRAPHY. Pleasure Point is a popular surfing spot primarily because of the refraction of waves around Pleasure Point and the bottom topography. The distribution of rock outcrops and sand bars or areas of sand on the seafloor affect where waves will break. However, the location of sand bars changes weekly and seasonally and from year to year, and the rock outcrops are gradually worn down or eroded slowly over time due to a combination of wave impact, sand abrasion and also bio-erosion. This is why we have a relatively flat, rocky intertidal zone just offshore and a continental shelf instead of a steep drop-off into deep water. These bottom conditions change over time in unpredictable ways and while waves will always break along this coast (and all exposed coasts for that matter) there is no way to determine how the bottom conditions and, therefore, the surfing conditions, will change in the future. What is certain, however, is that they will change.

While access to the shoreline is a consideration in getting into the water to surf, the presence or absence of a beach in many of Santa Cruz's surfing spots is not a consideration. Virtually all of the surfing locations between Steamer Lane and Natural Bridges are at locations where there are no or very narrow beaches onshore. The waves break due to the bottom rock conditions. At Steamer Lane, there is no beach but rather a 30-foot high vertical cliff, armored in part with riprap that surfers navigate in order to get into and out of the water. Surfers take off heading right for the cliff at times. At Cowell's Beach, a classic surfing spot due to wave refraction around Pt. Santa Cruz, the lack of a beach and ongoing cliff erosion led to the emplacement of riprap in the early 1960's and the waves continue to form an ideal and gentle break and hundreds of surfers of all ages continue to surf and enjoy the waves here. The Steamer Lane and Cowell's Beach area is similar in many ways to the Pleasure Point area. They both have rocky outer points with larger waves (The Lane and outer Pleasure Point, the former a vertical cliff with riprap, and the latter a point that has been armored with gunnite, concrete seawalls and riprap for nearly 50 years), and then somewhat lower wave heights further to the northeast (Cowells and then the area fronting East Cliff Drive east of Pleasure Point). Both areas, as discussed earlier, are oriented NE-SW, and have no significant beach which led to constant wave attack and active cliff erosion. Cowell's was armored but it hasn't affected the refracted breaking waves offshore, which are dependent upon the sandy bottom conditions offshore, not the riprap along West Cliff Drive.

WAVE CLIMATE. The waves breaking along any particular area of shoreline are constantly changing in unpredictable ways. Day to day, week to week, one winter to the next, the waves approaching the Pleasure Point area will change because the forces that create the waves are constantly changing. We now understand that the storm and wave climate (driven by geographic differences in wind direction and velocity resulting from atmospheric pressure differences), as well as water surface temperature and elevation, change over decadal cycles (now know as the Pacific Decadal Oscillation or PDO) and produce periods dominated alternately by El Niño conditions and then La Niña conditions. For example, the period from the late 1920's to about 1945 was one of more frequent El Niño events which translates to heavier rainfall, more frequent and severe coastal storms, generally coming from the west or southwest, elevated sea levels, larger waves, and more coastal erosion and storm damage (Griggs and Brown, 1998; Griggs and others, 1998; Storlazzi and Griggs, 1998, 2000). From 1945 to 1978, the central coast experienced milder or more benign conditions overall. Conditions changed again in 1978 as we again entered an El Niño dominated period, which produced widespread coastal storm damage, beach and bluff erosion (Figure 3).

However, there is no way to predict when the climate cycle will shift, and when associated wave conditions will change. Komar and Shih (200) have also determined that there has been an overall wave climate change along the northern California and Oregon coast. Flick (2005) has determined a change in the wave climate of the northern San Diego County area, which has produced a shift in littoral drift direction. Wingfield and Storlazzi (In Press) have analyzed ~20 years of wave data from 8 NOAA buoys along the central California coast which suggest increasing wave heights and wave periods between 1980 and 2002. All this is to say that the Pleasure Point shoreline, like all other surfing locations along the coastline of California experiences a changing wave climate that varies on hourly to decadal scales, and that there is no way to predict what may come beyond a few days or weeks in advance. Wave conditions are not the same from year to year and there is no reason to believe that they will stay the same over the years and decades ahead.

SUMMARY

There are a set of conditions that exist at any particular day at Pleasure Point but it is the overall wave climate along the central coast, the orientation of the coastline, and the offshore bottom conditions or bathymetry that produce the excellent surfing conditions in this area. Sea level, tidal height, wave conditions, and the distribution of sand and rocky bottom are all changing, some more rapidly than others, but they are all changing. While stabilizing the position of the cliff for perhaps the next 50 years will fix the position of the shoreline, and with a gradually rising sea level this will very progressively over more of the rubble covered beach at high tide conditions, for the next 100 years it is the wave climate and offshore bottom conditions that will exert the dominant conditions on the surfing conditions. The conditions that create ideal surfing waves at Pleasure Point will gradually change over time and will not be significantly affected in this time period by a small change in water level at the shoreline. As is evidenced in the Steamer Lane, Cowell's Beach and West Cliff Drive area, many of Santa Cruz' prime surfing areas are not dependent on sandy beaches at the coastline.

science for a changing world

High-Resolution Topographic, Bathymetric, and Oceanographic Data for the Pleasure Point Area, Santa Cruz County, California: 2005-2007

By Curt D. Storlazzi, Patrick L. Barnard, Brian D. Collins, David P. Finlayson, Nadine E. Golden, Gerry A. Hatcher, Robert E. Kayen, and Peter Ruggiero.

Oblique aerial photograph of the Pleasure Point area

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High-Resolution Topographic, Bathymetric, and Oceanographic Data for the Pleasure Point Area, Santa Cruz County, California: 2005-2007

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ADDITIONAL DIGITAL INFORMATION

For additional information on the instrument deployments, please see:
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http://walrus.wr.usgs.gov/infobank/w/w105mb/html/w-1-05-mb.meta.html
http://walrus.wr.usgs.gov/infobank/p/p105mb/html/p-1-05-mb.meta.html
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http://walrus.wr.usgs.gov/infobank/p/p107mb/html/p-1-07-mb.meta.html

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For more information on the U.S. Geological Survey Western Region's Coastal and Marine Geology Team, please see:
http://walrus.wr.usgs.gov/

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INTRODUCTION

The County of Santa Cruz Department of Public Works and the County of Santa Cruz Redevelopment Agency requested the U.S. Geological Survey (USGS) Western Coastal and Marine Geology Team (WCMG) to provide baseline geologic and oceanographic information on the coast and inner shelf at Pleasure Point, Santa Cruz County, California. The rationale for this proposed work is a need to better understand the environmental consequences of a proposed bluff stabilization project on the beach, the nearshore and the surf at Pleasure Point, Santa Cruz County, California (FIG. 1). To meet these information needs, the USGS-WCMG Team collected baseline scientific information on the morphology and waves at Pleasure Point. This study provided high-resolution topography of the coastal bluffs and bathymetry of the inner shelf off East Cliff Drive between 32nd Avenue and 41st Avenue. The spatial and temporal variation in waves and their breaking patterns at the study site were documented. Although this project did not actively investigate the impacts of the proposed bluff stabilization project, these data provide the baseline information required for future studies directed toward predicting the impacts of stabilization on the sea cliffs, beach and nearshore sediment profiles, natural rock reef structures, and offshore habitats and resources. They also provide a basis for calculating potential changes to wave transformations into the shore at Pleasure Point.

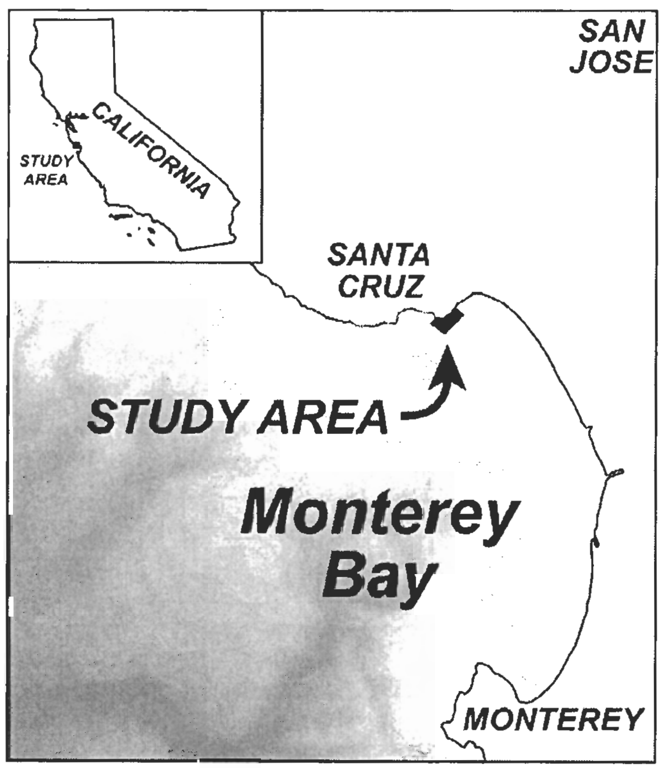

FIGURE 1. Location of the study area.

Background

The Pleasure Point area in northern Monterey Bay is a complex coastal setting of sea cliffs and small pocket beaches that are influenced by a variable wave climate due to its south-facing

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orientation. Large winter swells typically arrive from the northwest and west; however, this area also experiences un-refracted waves out of the southwest during the summer. Spatially and temporally variable wave conditions and the complex, shallow, rocky seafloor at this site have restricted comprehensive field surveys in the past. Recent innovations in field techniques and equipment, as well as remote-sensing techniques, now make it possible to perform a detailed analysis of the morphology and physical processes operating on this type of complex coastline. Understanding the morphology and waves off Pleasure Point is important because it is part of the Monterey Bay National Marine Sanctuary and the seacliffs in this area protect infrastructure (road, water and sewage lines) that is crucial to Santa Cruz County. Continuing erosion has threatened this infrastructure, and thus it has become increasingly important to provide scientific data that will allow the various government agencies involved with the area to make the best informed management decisions.

Project Description and Objectives:
The USGS Pleasure Point Study provided baseline information for future studies of impacts of the proposed East Cliff Drive Stabilization Project. An integrated study to document both the coastal and nearshore morphology and the spatial and temporal variation in waves at the study site was conducted. These data were collected by means of three-dimensional beach and seacliff mapping, nearshore bathymetric surveys, video monitoring and oceanographic instrumentation. All of the data were collected to USGS standards and thus are the foundation for any future surveys conducted to investigate change in morphology or processes at the study site. These surveys, initiated in October, 2005, and extending through May, 2007, were required to determine future long-term impacts by the proposed bluff stabilization project on the study area.

Task 1 – Mapping

High-resolution maps of the Pleasure Point area were compiled for both the terrestrial and subaqeous parts of the study area from a combination of historical and newly collected data. The morphology of the seacliffs was documented using historic airborne lidar (Light Detection and Ranging) data and terrestrial lidar data. The bathymetry of the inner shelf was collected using single-beam fathometers and an interferometric side-scan swath bathymetric sonar. This topographic and bathymetric data will provide the baseline data for any future survey efforts trying to detect change and a valuable resource for management decisions for Pleasure Point. Furthermore, these data will provide the necessary topographic and bathymetric boundary information for any future numerical modeling efforts attempting to predict coastal erosion or changes to wave breaking patterns under different future scenarios (climate change, sea level rise, seawall construction, etc.).

Subtask 1.1 - Historical Data
Historic airborne scanning lidar survey data provided topographical coverage for determining regional shoreline position and seacliff morphology for comparison with the higher-resolution survey work described here.

Subtask 1.2 – Terrestrial Lidar
The terrestrial portion of the study area, from the top of the seacliffs down to the beach and intertidal bedrock reefs were surveyed at very high resolution (typical point to point spacing of several centimeters) using a terrestrial lidar scanner. Because ground-based lidar scanning can be performed with a horizontal look angle, not only is the cliff topography point density much higher that from an airborne platform, but geologic features such as sea caves and wave cut notches can also be captured. The terrestrial lidar collected along the Pleasure Point study area

was used to create a high-resolution digital elevation model of the terrestrial portion of the study area. The fieldwork component of this subtask was conducted from the fall of 2005 through the winter of 2006.

Subtask 1.3 – Shallow Nearshore Bathymetry
To map the bathymetry in very shallow water (depths < 5 m/16 ft) where larger traditional survey vessels cannot operate, the single-beam USGS Coastal Profiling System (CPS) with real-time kinematic differential global positioning system (RTK-DGPS) and echo sounder equipment was employed to collect single beam bathymetry over the shallow nearshore off Pleasure Point. The fieldwork component of this subtask was conducted in the fall of 2005.

Subtask 1.4 – Deeper Nearshore Bathymetry
An interferometric side-scan swath bathymetric sonar survey was run offshore Pleasure Point, the first ever high-resolution swath bathymetric survey in this region, to complement the shallower single-beam CPS survey discussed above. This provided broad spatial coverage from approximately 0.5 km offshore into water depths of 3-4 m; the shallower portion of the swath bathymetry thus overlapped the deeper portion of the CPS survey. The fieldwork component of this subtask was conducted in the fall of 2005.

Task 2 – Wave Characterization
The spatial and temporal variation in the incoming waves and the resulting breaking wave patterns at Pleasure Point area were documented from a combination of *in situ* instrumentation and remote sensing techniques. The information on the incident wave and current field at the study site was collected by way of oceanographic instrumentation deployed just offshore of the coast at a depth of 14 m. Wave breaking patterns were documented using a web-based camera system deployed at a private residence on East Cliff Drive. These data will provide the baseline data for any future survey efforts trying to detect change and be a valuable resource as management decisions for Pleasure Point are being made. Furthermore, these data will provide the necessary incident forcing parameter boundary information for any future numerical modeling efforts attempting to predict coastal erosion or changes to wave breaking patterns under different future scenarios (climate change, sea level rise, seawall construction, etc.).

Subtask 2.1 – Temporal Variation in Currents and the Incident Wave Field
An acoustic Doppler current profiler (ADCP) was deployed for 12 months offshore Pleasure Point to document the range of tide, wave and current conditions observed over a single year. This sensor will make it possible to determine the link between the offshore wave conditions measured by the deep-water NDBC Monterey Bay #46042 (NDBC, 2007) directional wave buoy and the resulting wave breaking patterns at Pleasure Point imaged by the web-based camera system. The fieldwork component of this subtask was initiated in the late spring of 2006 and data were collected through the late spring of 2007.

Subtask 2.2 – Spatial and Temporal Variation in Breaking Wave Patterns
A digital camera system was installed to document the patterns of breaking waves across the study area in real-time. This video monitoring made it possible to track wave breaking patterns, rip-channel development and potentially infer rock reef and/or sand-bar location(s) under a range of wave and tide conditions. These data can then be compared to offshore deep-water offshore wave conditions measured by the deep-water National Data Buoy Center (NDBC) Monterey Bay #46042 (NDBC, 2007) directional wave buoy and the ADCP discussed above. The fieldwork

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component of this subtask was initiated in late spring 2006 and data were collected through the late spring of 2007.

DATA ACQUISITION

Subtask 1.1 - Historical Data

The Airborne Topographic Mapper (ATM) lidar data were collected in partnership with the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, the NASA Wallops Flight Facility, the USGS Center for Coastal and Regional Marine Geology, and the NOAA Aircraft Operations Center. The ATM can survey beach topography along hundreds of kilometers of coast in a single day with data densities that cannot be achieved with traditional survey technologies (FIGURE 2). For each pass along the coast, the ATM lidar scanned a 375-m wide swath along the aircraft flight line. For most of the study area, four overlapping passes were flown yielding a typical surveyed swath approximately 700-m wide with laser spot elevations every 3 m^2. The aircraft pitch, roll, and heading were obtained with an inertial navigation system and the positioning of the aircraft was determined using kinematic Global Positioning System (GPS) techniques. The twin-engine turboprop aircraft, a De Havilland Twin Otter, was provided and operated by NOAA's Aircraft Operations Center, McDill Air Force Base, Tampa, FL. The local topography of the area was derived from ATM data acquired on 04/17/1998 and 04/18/1998 following the intense storms of the 1997-1998 winter; these data were obtained from the Coastal Services Center (2006) website. More than 918,100 data points were acquired during the two days of surveying, extending from the water line up to the top of the seacliffs and some distance landward. See http://coastal.er.usgs.gov/lidar/AGU_fall98/ for more information.

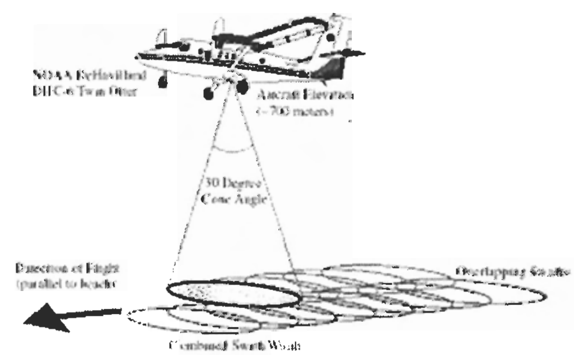


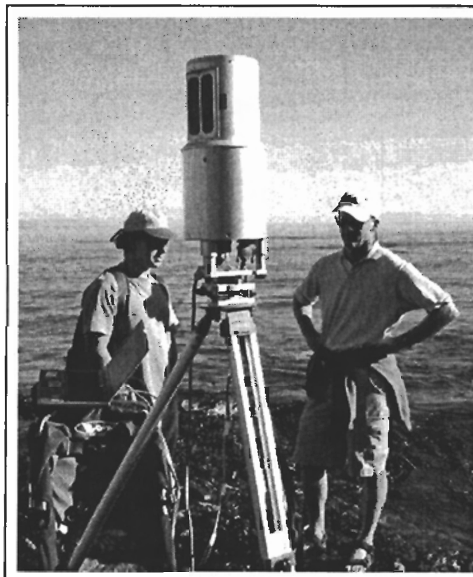
FIGURE 2. Schematic showing the elliptical scan pattern of the ATM. Image from http://coastal.er.usgs.gov/lidar/AGU_fall98/

Subtask 1.2 – Terrestrial Lidar

Terrestrial lidar data were collected of the seacliffs, beaches, and intertidal bedrock reef platform areas. Terrestrial lidar is the newest and most accurate technology being used to map and monitor coastal bluff stability (Collins and Sitar, 2004, 2005). The data collection technique consists of sending and receiving laser pulses to build a point file of three-dimensional coordinates of virtually any reflective surface. The time of travel for a single pulse reflection is measured along a known trajectory such that the distance from the laser and consequently the exact location of a point of interest is computed. The USGS WCMG terrestrial lidar system consists of a Riegl Z210 instrument mounted on a tripod platform (FIGURE 3). The instrument captures data at approximately 8,000 points per second with a typical range of 100's of m and at an accuracy of 25 mm for each point. Additional specifications of the unit are provided in APPENDIX 1.

Data collection consisted of setting up the instrument with the best possible field of view for each location along and above the seacliffs (FIGURE 4). The unit was then moved to the next scan location, which was determined by the required data density and the relative irregularity of the seacliffs (i.e. cliffs with many caves or inlets require more scans to capture all aspects of the features). In October, 2005, data were collected from the seacliff crest during high tide, capturing topographic data of the crest area to some 50 m back from the cliff edge along with some seacliff data captured from key vantage points near the edge. In January, 2006, data were collected from the intertidal bedrock platform during a period of extremely low tides. This field effort collected data of the seacliff, beach, and intertidal reef. In February, 2006, data were collected of a section of cliff immediately adjacent to Pleasure Point (Opal Cliffs area) again, at a low tide from the intertidal bench. Additional data were collected of this area in January, 2007, to improve final data accuracy.

In total, scans from 54 individual locations were performed, collecting a total of 38.1 million points of ground topographic data and an additional 6.6 million points of cultural features such as houses, signs, fences, etc. Several post-processing steps were necessary. The data were filtered to remove non-terrain objects (people, cars, etc.). Adjacent scans were registered to one another through a local fit of overlapping points, and georeferenced to geodetic coordinates through the use of control points visible in the scan data and locatable in the field. Field survey of the control points was performed in June, 2006, and consisted of a post-processed differential



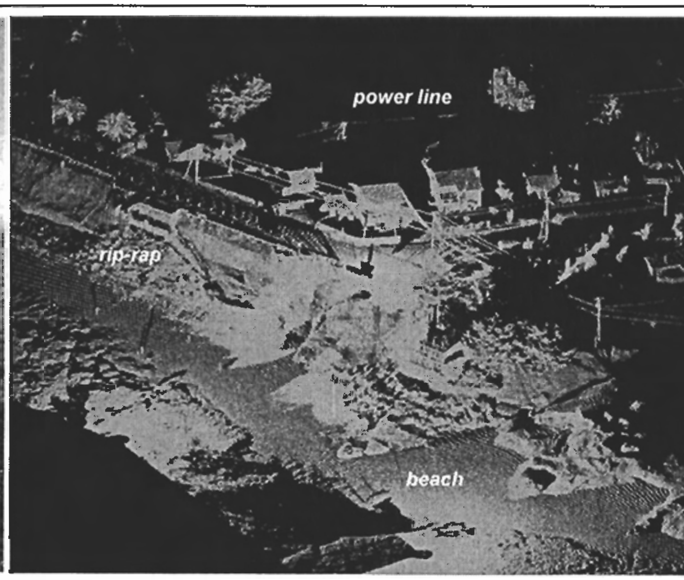


FIGURE 3: Topographic lidar data acquisition and an example scan. LEFT: Photograph of the lidar scanner during data acquisition on the intertidal bedrock reefs at low tide. Laser pulses exit and enter the scanner through the two vertical windows on the panning unit; the data acquisition computer is in the baby jogging stroller. RIGHT: Individual scan taken just east of the stairwell at 36th Avenue. Houses, rip-rap, people and even individual power lines are clearly identifiable in the data.

GPS survey on 30 control points. In some cases, a differential RTK GPS unit was placed directly on the lidar instrument to achieve an increased level of accuracy. The georeferenced points were then filtered to obtain a consistently dense data set for surface modeling. The final digital elevation model (DEM) was created from a point set with a typical point-to-point spacing of 20 cm.

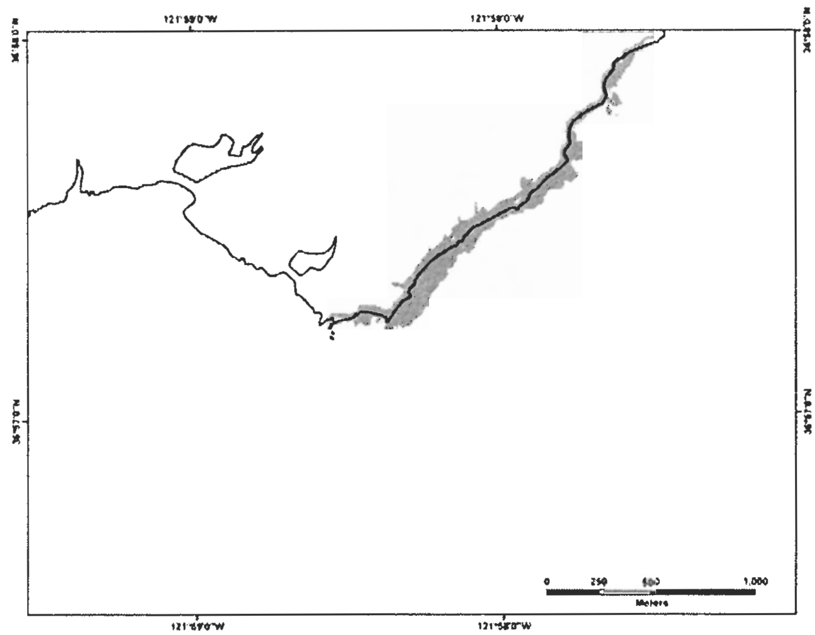


FIGURE 4: Region of topographic lidar data coverage in the study area.

Subtask 1.3 – Shallow Nearshore Bathymetry

The Coastal Profiling System (CPS), a hydrographic surveying system mounted on a Personal Watercraft (PWC), was used to collect shallow-water bathymetric data off Pleasure Point (FIGURE 5). Combining the high accuracy positioning of Differential Global Position System (DGPS), the efficiency of an acoustic echo sounder, and the mobility of a personal watercraft, the CPS provides a fast and accurate method to achieve sub-decimeter accuracy; reasonable variations in water temperature and salinity (not measured), however, can affect depth estimates by as much as 3% of the water depth. The CPS collected data at 5 Hz and, while traveling at 3 m/s, generated a depth sounding every 0.6 m along the sea floor. These data were collected assuming a sound velocity of 1500 m/s. A more complete discussion of the CPS can be found in MacMahan (2001), Ruggiero et al. (2005) and APPENDIX 2.

Twenty-five shore-normal and 23 shore-parallel track lines were collected (FIGURE 6). Due to heavy kelp coverage in some locations and RTK-GPS problems, data coverage was sometimes intermittent. In general, however, data quality was extremely high and more than 90% of the planned study area was covered. Data was collected into water depths less than 1 m and out into depths of more than 12 m.

To eliminate bed data or data outliers, each individual transect was examined, typically using a Perl script and HYPACK software (the program used to collect the data), to detect and remove any data points collected when the GPS receiver was not initialized in kinematic mode. This

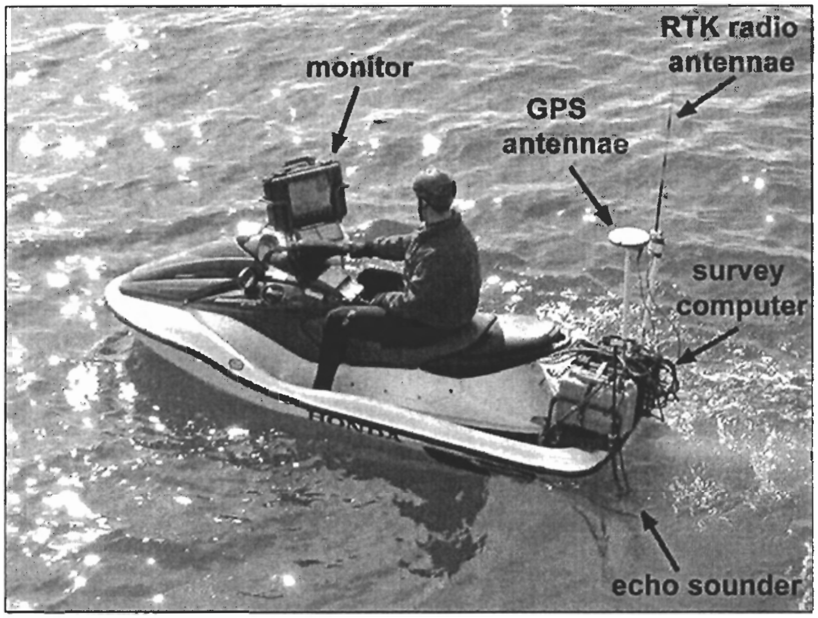


FIGURE 5. A Coastal Profiling System acquiring data. The black waterproof case by the handlebars holds the navigation display and quick keyboard, the white circular GPS antenna and black RTK whip antenna are mounted directly over the fathometer on a pole attached to the stern, and the waterproof cases on the stern hold the batteries and electronics for the computer, GPS and fathometers.

script also eliminated any obvious outliers from the raw files that are either shallower than the echo sounder blanking interval or deeper than a user defined cutoff value. The individual files were then exported in UTM Zone 10 Easting, Northing, Elevation ASCII triplets with one data file per transect. A smoothing operation was then performed using a median filter on the z-

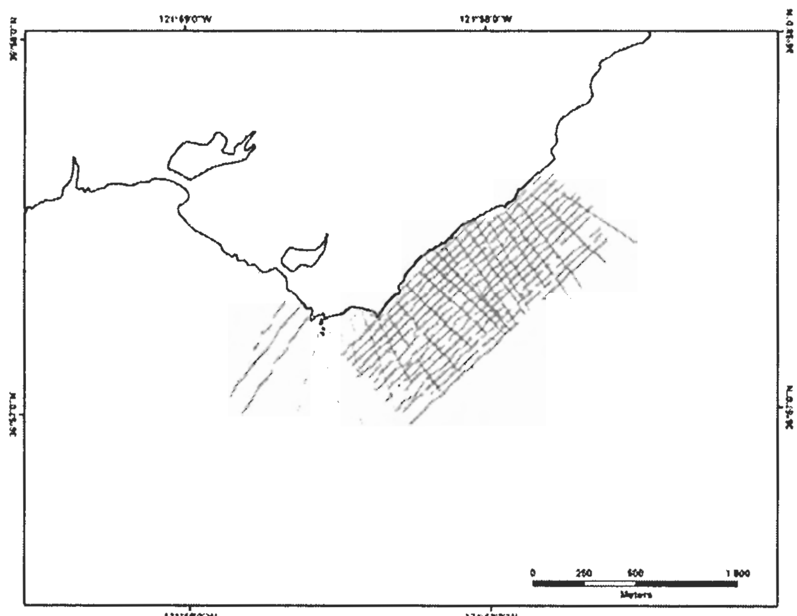


FIGURE 6. Coastal Profiling System survey track lines in the study area.

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coordinate in the alongline direction to reduce high frequency fluctuations. Varying window sizes were used to obtain a smooth profile while maintaining the integrity of the actual data points. In total, more than 103,033 data points were acquired during the one day of surveying, extending from mean sea level down to water depths just less than 12 m.

Subtask 1.4 – Deeper Nearshore Bathymetry

The deeper nearshore bathymetric survey was conducted aboard the *R/V Paragon*, a 10 m (32 ft) Radon-style, twin outboard vessel owned and operated by the University of California, Santa Cruz (FIGURE 7). A temporary data processing shed was placed on the fantail to protect the acquisition computers and operator from the weather, and the SEA SWATHplus interferometric side-scan swath bathymetric sonar was pole-mounted to the starboard gunnel (FIGURE 8). SWATHplus is a 234 kHz side scan system that simultaneously collects bathymetry and backscatter information using amplitude and phase difference information from multiple transducers (APPENDIX 3).

FIGURE 7. Loading the temporary data processing shed onto the fantail of the R/V Paragon.

No direct vertical control was available in the study area during the survey. Instead, vertical control was established using observed water levels from the National Ocean Service (NOS, 2007) Tide Station #9413450 located in Monterey Harbor (36° 36.3' N, 121° 53.3' W). NOAA has established tidal harmonics for Santa Cruz that deviate slightly from the Monterey Bay reference station, however, the maximum deviation between the reference station and Santa Cruz is approximately 10 cm at full tide range. This difference is the same as the theoretical maximum precision of the SWATHplus system (~10 cm) under ideal conditions, so the Monterey Bay observed tides were used without adjustment during post processing.

The time series of observed water levels at Monterey Bay was downloaded from the NOS web site (NOS, 2007) prior to post processing. These data were then entered into the SEA Swath Processor acquisition software to establish Mean Lower Low Water (MLLW) as the vertical datum of the survey. This survey can be converted to other vertical datums (such as NAVD 88) by

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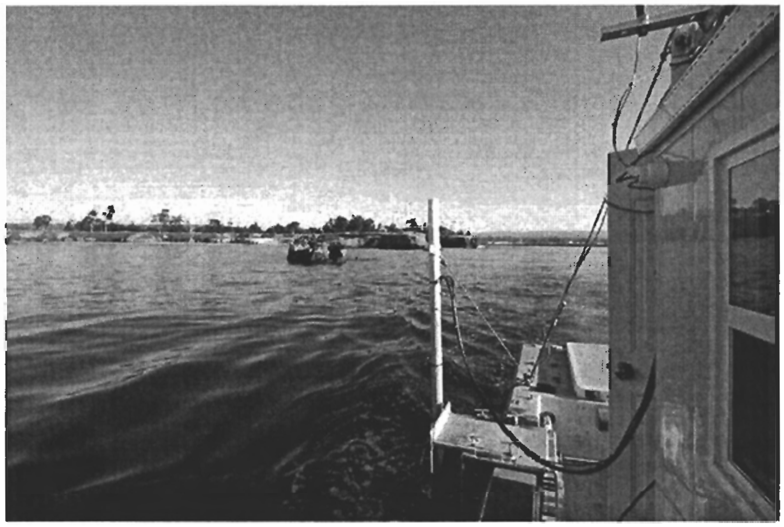

FIGURE 8. Underway view of the starboard gunnel of the R/V Paragon showing the pole mount used to deploy the transducers.

referring to the tidal benchmark sheet for NOS Station 9413450 (Epoch 1983-2001). For reference, NAVD 88 is 0.04 cm below MLLW at the benchmark.

Sound velocity profiles (SVP) for the survey were estimated by manually dropping a sound velocity profiler. SVPs were collected at the beginning of each day and periodically during the day as dictated by the environment. Overall, 11 SVPs were collected over five survey days. In

FIGURE 9: Color-coded swath bathymetry of the study area overlaid on a 2005 black and white digital orthophotograph.

total, more than 3,242,199 soundings were acquired during this survey, extending from water depths just less 2 m to more than 21 m (FIGURE 9).

Subtask 2.1 – Temporal Variation in Currents and the Incident Wave Field

An upward-looking 1-MHz Nortek AWAC ADCP was deployed for 12 months offshore Pleasure Point to document the range of wave energy conditions observed over a year. The AWAC (FIGURE 10, TABLE 1) collected a vertical profile of current velocity and acoustic backscatter (a proxy for suspended sediment) through the water column, along with water depth and temperature data, once a second for 6 min. These 3,600 samples were averaged to produce one sample per parameter every 20 min (APPENDIX 4). Every hour, the AWAC collected current and pressure (water depth) data twice a second for 8.5 min; these data were then used to compute wave height, wave period, wave direction, and directional wave energy spectra once an hour. This sensor will make it possible to determine the link between the offshore wave conditions measured by the deep-water NDBC Monterey Bay (#46042) directional wave buoy and the resulting wave breaking patterns at Pleasure Point imaged by the web-based camera system (see below). These data, in conjunction with the proposed nearshore bathymetry, are crucial if accurate modeling of waves in the study area under a range of scenarios (engineering, climate, etc.) is desired by resource managers in the future. The fieldwork component of this subtask was initiated in the late spring of 2006 and data were collected through the late spring of 2007.

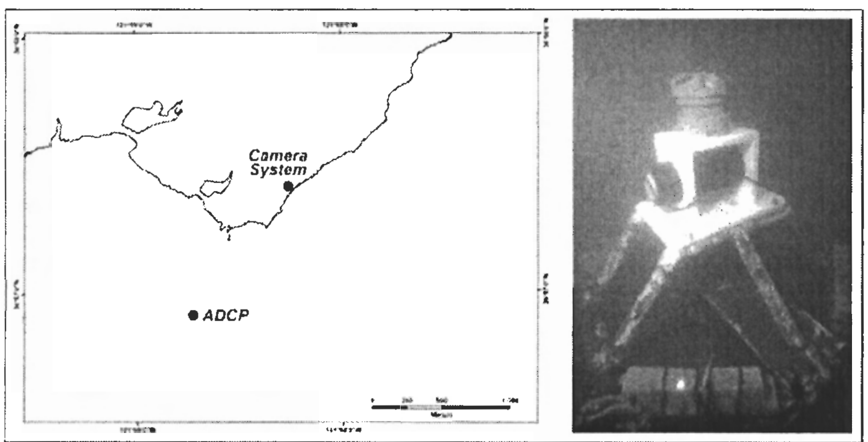

FIGURE 10: Location and image of the AWAC deployed off Pleasure Point from 05/2006-06/2007.
LEFT: Location of the AWAC and the camera system relative to the shoreline.
RIGHT: Underwater photograph of the AWAC deployed at a depth of 13 m.

TABLE 1: AWAC deployment log.

Deployment	Deployment Date [MM/DD/YYYY]	Recovery Date [MM/DD/YYYY]	Current Measurements	Wave Measurements
1	05/19/2006	08/21/2006	6769	2255
2	08/24/2006	11/29/2006	6985	2327
3	12/04/2007	03/12/2007	7059	2352
4	03/14/2007	06/05/2007	5981	1993

Overall, 8,927 wave bursts (>400,000 individual waves) and 26,794 current profiles were collected (FIGURE 11). The minimum, mean ± one standard deviation wave heights during the period were

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0.34 m, 0.92 ± 0.27 m, and 5.10 m, respectively. The minimum, mean ± one standard deviation, and maximum wave periods during the study period were 3.2 s, 12.3 ± 2.1 s, and 23.8 s, respectively; the mean ± one standard deviation wave direction during the study period was 211.3 ± 8.6°, with a range of 182.7° – 240.6°.

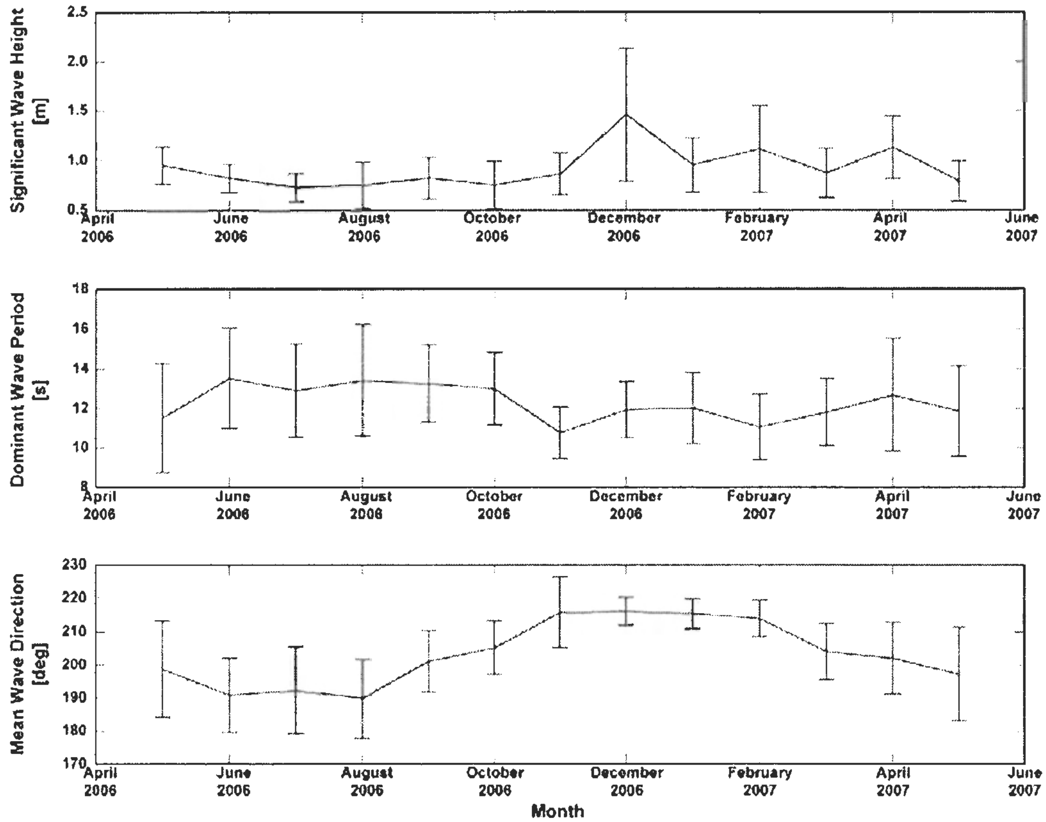

FIGURE 11: Variation in the incident wave field during the periods of data acquisition. TOP: Significant wave height, in meters. MIDDLE: Dominant wave period, in seconds. BOTTOM: mean wave direction, in degrees true. The lines denote the monthly mean values while the error bars denote ± one standard deviation.

Subtask 2.2 – Spatial and Temporal Variation in Breaking Wave Patterns

The web-based camera system was comprised of an analog video camera and a digital still camera, housed in a single pan and tilt unit (FIGURE 12), and linked to a computer and DSL connection such that the camera could be controlled remotely from the USGS office in Santa Cruz (APPENDIX 5). Data from various sections of the study area were therefore collected (TABLE 2). Since these data were posted automatically to the web, the Santa Cruz County Redevelopment Agency, Santa Cruz County Department of Public Works and the California Department of Boating and Waterways and other agencies were able to access the data in real time. The video monitoring makes it possible to track wave breaking patterns (FIGURE 13-15), rip channel development and potentially infer sand-bar location(s) under a range of wave conditions. When considering the cultural usage of the Pleasure Point area, these data could also be used to document number of individuals in the imagery, either for (a) simply documenting the number of people who actually surf, or (b) for determining carrying capacity for any new infrastructure (new bathrooms, stairs, etc). The digital imagery can be compared to offshore deep-water offshore wave conditions measured by the deep-water NDBC Monterey Bay directional wave buoy and

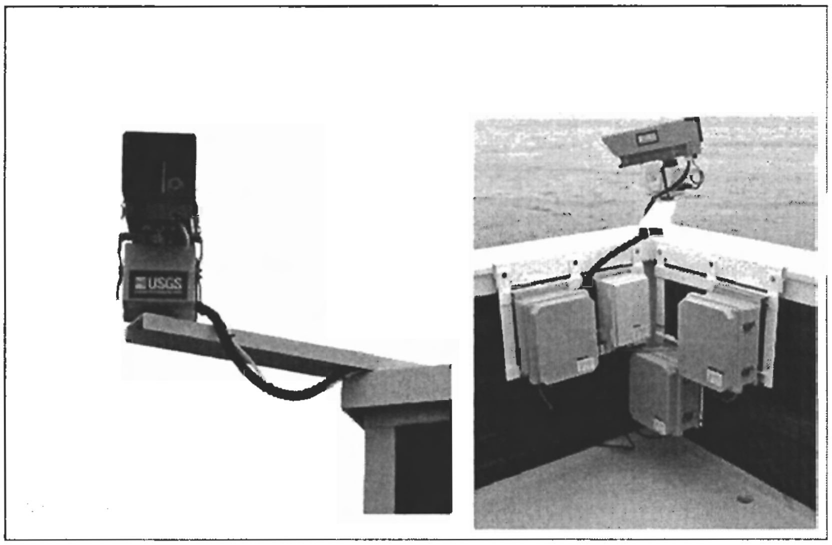

FIGURE 12: Components of the digital imaging system. LEFT: The front of the camera housing, with the Sony Block video camera on the left and the Olympus 8 mega-pixel still camera on the right. RIGHT: Weatherproof enclosures containing the power supply, data acquisition computer, pan/tilt controller, DSL modem and windshield washer tank. See FIGURE 10 for location information.

the USGS ADCP measurements to understand the relationships between the incident wave field and breaking patterns in the field area. The fieldwork component of this subtask was initiated in the late spring of 2006 and data were collected through the late spring of 2007. Overall, 30,317 digital stills and 12,744 digital video time averages were collected (TABLE 2).

TABLE 2: Digital imaging system data acquisition statistics.

Scene	Type	Description	Images
p1	Still	Hook	3,027
p2	Still	38th Avenue	3,027
p3	Still	Jack's	3,027
p4	Still	Pleasure Point 3rd peak	3,027
p5	Still	Pleasure Point 1st peak	3,027
p10	Still	Hook zoom	1,326
p11	Still	38th Avenue zoom	1,355
p20	Still	Pleasure Point 3rd peak zoom	1,355
p21	Still	Pleasure Point 1st peak zoom	1,398
d12	Still	Pleasure Point composite	3,443
d14	Still	Hook-38th Avenue composite	3,427
d38	Still	Study Area panoramic	2,878
s5	Video	Pleasure Point 1st peak	3,257
s18	Video	Pleasure Point 3rd peak	3,173
s23	Video	38th Avenue-Jack's	3,166
s32	Video	Hook-38th Avenue	3,148
Total		Still	30,317
Total		Video	12,744

FIGURE 13. Two merged 8 mega-pixel digital still photographs taken of the Pleasure Point surf breaks.

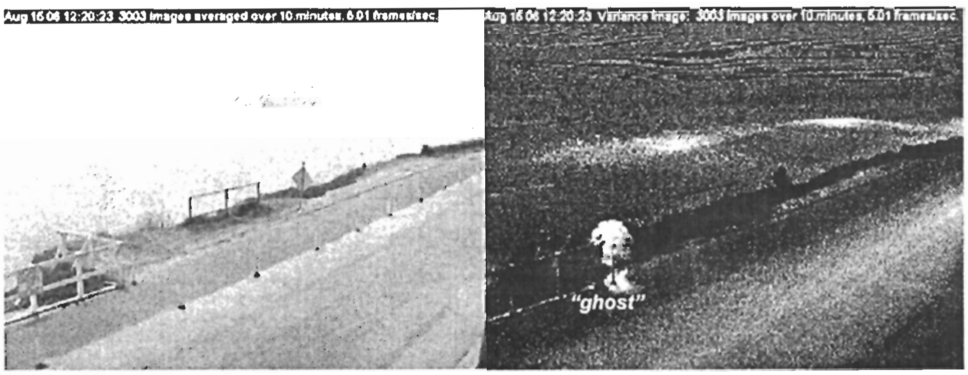

FIGURE 14: Video camera data from a period with small (0.5 m) waves (08/15/2006). LEFT: Average of more than 3,000 images taken at 5 Hz. RIGHT: Variance of more than 3,000 images taken at 5 Hz. Note that, due to the sun angle, it is difficult to delineate the region of wave breaking and whitewater (wave bores); however, these areas are easily identifiable as white regions in the variance data. "Ghosts" in the imagery are where people were in the field of view for a part of the 10 min period of data acquisition.

FIGURE 15: Video camera data from a period with larger (1.5 m) waves (09/20/2006). LEFT: Average of more than 3,000 images taken at 5 Hz. RIGHT: Variance of more than 3,000 images taken at 5 Hz. Note the much larger regions of wave breaking and whitewater (wave bores) as compared to the period of smaller waves shown above in FIGURE 14.

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SUMMARY

The USGS conducted an integrated study to document both the coastal and nearshore morphology and the spatial and temporal variation in waves at Pleasure Point, Santa Cruz County, California. These data were collected by means of three-dimensional beach and seacliff mapping using airborne and terrestrial lidar scanners, nearshore bathymetric surveys using single-beam fathometers and an interferometric side-scan swath bathymetric sonar, video monitoring using a digital still camera and digital video camera and *in situ* oceanographic measurements using a acoustic Doppler current profiler and directional wave gauge. In all, more than 39 million points of ground topographic data, 3.3 million points of seafloor bathymetric data, 40,000 images of wave breaking patterns and 8,900 in situ directional wave spectra measurements were collected. These data provide the baseline information needed for future studies directed toward predicting the impacts of stabilization on the seacliffs, beach and nearshore sediment profiles, natural rock reef structures, and offshore habitats and resources.

ACKNOWLEDGEMENTS

This work was funded by the Santa Cruz County Redevelopment Agency, Santa Cruz County Department of Public Works and the California Department of Boating and Waterways, and the USGS WCMG. The USGS funds were allotted as part of an effort by the Benthic Habitats Project to better understand the affect of geologic and oceanographic processes on nearshore ecosystems. Paul Rodriguez (Santa Cruz County Redevelopment Agency), Ralph Norberg (Santa Cruz County Department of Public Works), and Kim Sterrett (California Department of Boating and Waterways) were the county and state liaisons, and provided support and advice throughout the experiment. We would like to thank residents Liz and Don Darst, who graciously donated their time and effort during our numerous survey operations. Annie, Jim and Joel Marshall overextended themselves by hosting our digital imaging system at their house for 12 months, and for that we owe them great thanks. Brian Foss and the staff at Santa Cruz Small Craft Harbor provided us with launching and loading facilities. We would also like to thank Amy Draut (USGS) and Jon Warrick (USGS), who contributed numerous excellent suggestions and a timely review of our work. Use of trademark names does not imply USGS endorsement of products.

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APPENDIX 1

Terrestrial Lidar System Information

Riegl LMS-Z210 3D Laser Mirror Scanner (S/N: 9992980) Terrestrial Lidar System
(~~http://www.riegl.com/terrestrial_scanners/lms-z210i_/210i_all.htm~~)

Technical Description: Near infrared, Laser Class 1 (eye safe) pulsed laser diode with true color channel operating on time-of-flight measurement principle with panning head and rotating triangular mirror.

Technical Specifications:

Physical Dimensions:	0.5 m in height, 0.2 m in diameter, and 13 kg in mass.
Range Information	Up to 200 m typical, up to 700 m under optimal atmospheric conditions.
Angular extents:	0° to 336° horizontally, 0° to 80° vertically
Measurement Accuracy:	Typically 15 mm to 25 mm
Measurement Resolution:	5 mm
Measurement Rate:	Up to 8000 points/s
Power:	One gel cell 12-volt battery running at 6.5 amps (typ.) and 78 watts (typ.).

Survey Description: The lidar unit is set-up on a 1.5 m adjustable tripod and leveled with a tribrach. Typically, the tripod is located on the beach or intertidal platform and aimed at the seacliffs or located on the seacliff top and aimed over or along the seacliffs. A laptop computer controls the lidar instrument via parallel and serial cables. Each scan typically obtains 1 million data points; collected in approximately 5 min. The equipment is moved along the beach every 50 to 100 m and the survey is repeated.

Survey Schedule: Data were collected from the top of the seacliff on October 5-6, 2006, consisting of 37 scans. Data was collected from the beach and intertidal bedrock reef platform on January 27, 2006, consisting of 17 scans. Due to differing beach conditions between these two efforts, only beach data of the lowest beach geometry (January 27, 2006) was utilized in the processed data set. Of these 54 scans, only 46 were utilized due to existing overlapping data or poor registration fit with some of the scans. Additional data adjacent to the Pleasure Point study area (Opal Cliffs area) was collected on February 9, 2006, and January 31, 2007, consisting of 8 additional scans and were utilized in the final georeferencing of the data set.

Position Information: Data were registered to geodetic coordinates through the collection of 30 local control points visible in the scan data. The local control points were surveyed using a pair of Ashtech Z-Xtreme geodetic quality, dual frequency (L1/L2) GPS receivers. One receiver acted as a base station and the other as a rover located over each control point. The data was post processed differentially using Ashtech's proprietary software in a Stop-and-Go methodology.

Lidar data in January, 2007, were collected using a pair of Topcon Hyper+ RTK, dual frequency GPS/GLONASS receivers using a similar base-rover methodology, but processed in real-time using a Pacific Crest radio link.

Position Accuracy: The GPS equipment used in the survey program provided local control point accuracies on the order of less than 5 cm.

The GPS/GLONASS equipment used for the January, 2007, lidar surveys provided point accuracies on the order of less than 6 mm.

Processing Information: Data processing was performed using I-SiTE Studio 2.4 and 3.0 software, specifically designed for terrestrial Lidar data processing. Scans were filtered, registered, and georeferenced according to standard post-processing

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	techniques. Three-dimensional surfaces and digital elevation models (DEMs) and grids were then extracted from the data. ArcGIS was utilized for final extraction of DEMs using data filtered to a minimum individual point to point separation of 20 cm.
Processing Accuracy:	Individual scans each have an internal accuracy of 2.5 cm. Adjacent scans were registered to one another through local fit of overlapping data typically consisting of several hundred thousand points. Measurements between adjacent scans have an internal accuracy of 5 cm. The internal accuracy of the data for measurements made within the lidar data set is 2.5 + 5 = 7.5 cm or approximately 0.08 m. All scans were georeferenced to NAD83 UTM Zone 10N and NAVD88 coordinates using surveyed control points visible in the scan data. Measurement fit of all data to georeferenced coordinates is 0.5 m.

Internal Horizontal and Vertical Positional Accuracy Assessment: ±0.08 m

Georeferenced Horizontal and Vertical Positional Accuracy Assessment: ±0.50 m

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APPENDIX 2

Coastal Profiling System Information

Vessel Specifics

Description:	2003 Honda AquaTrax F-12 4-stroke PWC
Dimensions:	3.2 m in length, 1.3 m in width, and 1.1 m in height
Survey speed:	3 m/s (6 knots); can operate for ~5 hours on 60-L fuel tank
Instruments:	The instruments are placed on a bracket at the stern of the vessel, and forward upper part of the vessel in front of the handlebars. On the stern bracket are three large watertight cases, which house the GPS, computer, echo sounder electronics and batteries.
Power:	Two gel cell 12-volt marine batteries, configured in parallel and housed in a Pelican box mounted on the PWC's stern.

Position Information: Trimble 4700 GPS receiver, with Pacific Crest GPS radio modem to communicate with the shore base station. The L1/L2 microcentered GPS antenna and the radio antenna were mounted directly above the echo sounder transducer.

Depth Information: ESE-50 single frequency echo sounder with a 200 kHz transducer manufactured by Flash Fire Technology, Inc. The transducer has a 10° conical beam width and generates a pulse at 200 kHz. The CPS collected data at 5 Hz and while traveling at 3 m/s, generated a depth sounding every 0.6 meters along the sea floor.

Navigation: HYPACK hydrographic surveying software was used as the data synchronization software and navigation system. Navigation and surveying are aided by a 12 inch Big Bay Technologies outdoor monitor that is mounted in a watertight case on a bracket forward of the PWC's handlebars. A small 17-button programmable Logic Controls keypad is placed in a waterproof radio bag mounted on the handlebars.

Survey Accuracy: The survey-grade GPS equipment used in the monitoring program have manufacturer reported Root Mean Square (RMS) accuracies of approximately ±3 cm + 2 ppm of baseline length (typically 10 km or less) in the horizontal while operating in Real Time Kinematic surveying mode. The horizontal uncertainty of individual data points is ~0.05 m.

Quantitative Horizontal Positional Accuracy Assessment: ±0.05 m

Quantitative Vertical Positional Accuracy Assessment: ±0.15 m

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APPENDIX 3

Swath Bathymetry System Information

SEA Group Ltd 234 kHz Interferometric Submetix SWATHplus-M Bathymetric Sonar System
(~~http://www.sea.co.uk/swathplus.aspx?nav=products~~)

Dimensions (cm):	16H x 35W x 6D
Maximum Water Depth:	100 m
Maximum Swath Width:	300 m
Maximum Range/Depth Ratio:	15:1
Across-track resolution:	7.5 cm maximum, 1.1° azimuth beamwidth
Accuracy:	0.1 m or 1% accuracy versus water depth
Operating Environment:	Microsoft Windows NT
Data Processors:	SEA Swath Processor, v. 2.05 SEA Grid Processor v. 2.05
Navigation:	CodaOctopus, Model F180, Differential Global Positioning System (DGPS)
Navigation Logging:	Yo-Nav version 1.19
Heading Information:	KVH Industries Inc. azimuth digital gyro compass provided ship headings with 0.5° accuracy
Spatial Resolution:	0.2 m raw, 1.0 m processed
Data Format:	Correct x-position, y-position, depth, and acoustic amplitude data

Data Processing:

Started with SXP files that were the output from A 234 kHz Interferometric Submetix Swath Bathy Sonar System. Imported these SXP files on at a time into a SEA Grid Processor v. 2.05, environment with a bin size of 1 (bin size is in meters). In SEA Grid Processor environment ran the following filter on each bathymetry file: Standard deviations > 0.5. Individually exported each bathymetry file from SEA Grid Processor environment which converts the SXP file to an ASCII grid text file. Imported bathymetry ASCII grid text files into Fledermaus v.6.2.0a, Build 45 Professional, using the Fledermaus Data Magic extension. Exported bathymetry files from Fledermaus Data Magic to ASCII ArcView grid format. In ArcGIS v. 9.1, Toolbox environment, converted ASCII ArcView grid files from ASCII to ArcGIS Raster; defined projection for each raster as NAD_1983_UTM_Zone_10N; and built ArcGIS pyramids for each raster file. In ArcGIS v. 9.1, Toolbox environment, Spatial Analysis Tools-->Math-->Plus tool, added 0.043 to grid depth in order to correct for difference between MLLW and NAVD 88.

Vessel Information:

University of California at Santa Cruz *R/V Paragon*
32' Radon style, twin 250HP diesels, radar, fathometer, autopilot and davit.
SWATHplus-M data acquisition and real-time processing van was installed on the aft deck.
SWATHplus-M transducer was mounted on the starboard side aft quarter.

Sound Velocity Profile (SVP) casts were made using an Applied Microsystems SV-Plus V.2 sound velocity profiler off the port side aft quarter. Navigation was provided using the YoNav software package, which allowed for the creation of sets of parallel survey lines of a given length at a given line spacing. The navigation information, including position, speed, heading and distance along the transect line, were provided to the vessel captain via a LCD display.

Survey Information:

Number of Lines:	97 (89 ~straight, 8 shore-parallel)
Water depths:	1-22 m
Sound Velocity Profiles:	11 sound velocity profiles (minimum = 1/day)
Dates:	
Mobilization:	10/12/2005 YD285
Survey:	10/13/2005 YD286 - 10/14/2005 YD287, 10/17/2005 YD290 - 10/19/005 YD292
Demobilization:	10/20/2005 YD293

Quantitative Horizontal Positional Accuracy Assessment: ±0.2 m

Quantitative Vertical Positional Accuracy Assessment: ±0.3 m

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APPENDIX 4

Acoustic Doppler Current Profiler

Nortek 1 MHz AWAC (S/N: 2074) Acoustic Doppler Current Profiler and Directional Wave Gauge (http://www.nortekusa.com/hardware/AWAC.html)

Transmitting Frequency:	1 MHz
Depth of Transducer:	13 m
Blanking Distance:	0.4 m
Height of First Bin above Bed:	1.0 m
Bin Size:	0.5 m
Number of Bins:	34
Sampling Frequency:	2 Hz surface tracking, 1 Hz currents
Profile Ensemble Interval:	0:20:00.00
Profile Averaging interval:	0:06:00.00
Wave Ensemble Interval:	1:00:00.00
Number of Wave Samples:	1024
Sound Speed Calculation:	Set salinity (35 PSU), updating temperature via sensor
Velocity Precision:	horizontal: 0.5 cm/s, vertical: 1.4 cm/s
Coordinate System:	East-North-Up
Compass Update Rate:	0:20:00.00
Magnetic Compass:	Set to –10° magnetic offset
Location Latitude:	N 36° 56.907'
Longitude:	W 121° 58.722'

Data Processing:

The data were averaged into 1 hour ensembles, all of the spurious data above the water surface were removed and all of the data in bins where the beam correlation dropped below 70% were removed for visualization and analysis.

Position Information: Garmin GPS-76 GPS; s/n: 80207465

APPENDIX 5

Digital Imaging System Information

Erdman Video Systems, Inc. C5050-PT Biscut with Real-Time Video Upgrade
(~~http://www.video-monitoring.com/allinone.htm~~)

Digital Camera:	Olympus SP-350 Ultra Zoom camera
Digital Video:	Sony FCB-EX480A Block camera
Control Interface:	667 megahertz embedded PC with 256 megabytes PC133 memory and 100 gigabyte hard drive
Camera Scene Sampling Frequency:	1 per hour
Number of Camera Scenes:	9
Video Scene Sampling Frequency:	5 frames/s for 10 min
Number of Video Scenes:	4
Location Latitude:	N 36° 57.407'
Longitude:	W 121° 58.254'
Position Information:	Garmin GPS-76 GPS; s/n: 80207465

APPENDIX 6

Experiment Personnel

Person	Affiliation	Responsibilities
Curt Storlazzi	USGS	Chief Scientist
Patrick Barnard	USGS	CPS Survey
Michael Boyle	USGS	Swath Bathymetry Acquisition
Bradley Carkin	USGS	Terrestrial Lidar Survey Assistant
Brian Collins	USGS	Terrestrial Lidar Survey
Jodi Eshleman	USGS	CPS Survey Processing
Jared Figurski	UCSC	Vessel Captain, *R/V Paragon*
David Finlayson	USGS	Geospatial Data Processing
Nadine Golden	USGS	Geospatial Data Processing
Dave Gonzales	USGS	Oceanographic Instrumentation
Jamie Grover	UCSC	Vessel Captain, *R/V Paragon*
Gerry Hatcher	USGS	Swath Bathymetry Acquisition
Robert Kayen	USGS	Terrestrial Lidar Survey
Joshua Logan	USGS	Geospatial Information, diver
Diane Minasian	USGS	Terrestrial Lidar Survey Assistant
Kevin O'Toole	USGS	Mechanical Fabrication/Field Support
Kathy Presto	USGS	Oceanographic Instrumentation
Tom Reiss	USGS	Dive Safety Officer, Geodetic Survey
Peter Ruggiero	OSU	CPS Survey
Randy Russell	USGS	Computer Support
Randolf Skovan	UCSC	Vessel Captain, *R/V Paragon*
Andrew Stevenson	USGS	Geospatial Data Processing

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Additional surf/ wave evaluation:

The data collected by the USGS under contract with the County of Santa Cruz – including the offshore bathymetry, tidal and wave amplitude information provide an up-to-date record of existing conditions. With this information the County has been able to develop a theoretical assessment of incremental change. Based solely on the assumption of changing depth of water a map has been prepared to assist with visualization of existing conditions. The map (Attachment 3) illustrates the concept, showing the range of all possible locations for breaking waves of a fixed size, in this case - one meter in height (approximately three feet). As the mapped area indicates, a one meter wave will break anywhere between 10-15 meters or about 33 feet off shore (at high tide) to upwards of 150 meters or about 500 feet off shore (at periods of low tide). The solid pink zone shows a broad area with all the possible locations for a one meter wave to break during the course of daily tidal variation. For any given water depth between high and low tide a one meter wave would be expected to break somewhere within this zone.

As the informational table (Attachment 2) indicates the current assumed global sea level change estimate (IPCC 2007) is for an increase of approximately 3.8 cm (1.5 inches) per decade. In order to apply this increment in the table it has been assume that all other factors would remain unchanged. This estimate of sea level change would translate into a migration shoreward of 1.9 meters for any given one meter wave over a ten year period.

In order to simplify and illustrate the concept, the solid red line which traverses the pink zone indicates a mean wave break location (half way between high and low tides). In ten years, with an expected sea level rise of approximately 1.5 inches (0.4cm) this wave location migrates shoreward but the distance is nearly indistinguishable on the map (green dashed line); over a one hundred year period (the time frame requested to be evaluated by Coastal staff) the wave would migrate shoreward to the blue dot & dashed line (Attachment 3). It is clear that the overall location of the range of waves would remain within the same one meter wave zone. One hundred years of projected sea level rise willresult in a change in the distance from the mean break location to the shore for any given wave. The essential pattern and incremental change over time would be similar for any other given wave size. While this represents a small incremental horizontal change over a ten year time frame, it also shows that over a theoretical time frame of 100 years, that the surf zone would still remain essentially the same for one meter wave breaks. Note the map indicates a mean break location based for a mapped isobath location so the position for any one meter breaks approximate bathymetric conditions.

It is important to note that a sizeable area to the west of the proposed bluff protection structure contains wave breaks known locally as "sewer peak" and "Pleasure Point" which are already armored and have been for more than twenty years. These breaks do not appear to have been affected by any increase in water depth.

Furthermore, surfers who use the area on a regular basis would confirm that waves breaking at extreme high tides or smaller waves in the range of less than one meter in height in most locations are too close to the existing bluffs (20-30 meters) to provide safe or practical recreational value. The length of the ride is too short or the risk of crashing into the base of the bluff too dangerous. As well, existing wave reflection and interference patterns occur primarily within this near shore area, resulting in mixed surfing conditions. This situation exists irrespective of whether there is a natural cliff face or whether an irregular hardened cliff face is constructed. So, even with an assumption of one hundred years of sea level rise the effect on the location of most of the one meter wave breaks and the recreational surfing affected would be quite minimal. The table (Attachment 2) and the map prepared by County GIS staff provide a simplified graphic representation of the concepts which may be of assistance when explaining this information to the public.

Additional recent information published by USGS regarding wave amplitude measurements along the California coast (USGS Scientific Investigations Report 2005-5985) actually provides a basis for questioning the assumptions of even this simplified wave change evaluation. This recent analysis of offshore wave data has determined that, over the last twenty years, wave amplitude in the Pacific Ocean has increased. From a surfing perspective this indicates a pattern for waves to break further offshore - a counter balancing affect to sea level rise (Attachment 4). This emphasizes even further the difficulty of accurate prediction of future wave patterns and wave break scenarios since this information seems to indicate the offshore migration as a result of bigger waves would progress more rapidly than sea level rise.

Attachment 1

Variables Required to Model Potential Recreational Surf & Determine Where Waves Will Break	Variables **independent** of wall/ armoring	Variable **depends** on wall/ armoring
1. Wave height and period		
Depends on wind speed, direction, duration across the entire Pacific	●	
Distribution of atmospheric pressure variations and storm systems	●	
2. Water depth		
Tidal variations (low to high tide) - 3.5 ft. average; max. 8.5ft	●	
Long term sea level rise - estimated at 1-2mm/yr.	●	
Geologic uplift - reduces water depth approx. 0.5mmper year	●	
Fixing back beach – depth increase per sea level rise		○
3. Bathymetry		
Offshore bedrock reefs that change over time	●	
Transitory sand bars and deposits	●	
4. Wave direction		
NW & W – predominant fall, winter, spring swells	●	
SW & S - more common in summer season	●	
5. Coastal orientation.		
SW/ NE orientation – waves refract at local geologic formations.	●	

ATTACHMENT 2

CCC Exhibit F
(page 39 of 40 pages)

Waves Break When Their Height to Water Depth Exceeds a Certain Ratio (Munk, 1949; Komar and Gaughan, 1972; Komar, 1998)

CHANGE IN LOCATION OF WAVE BREAKING DUE TO TIDES

Nearshore — Mean tidal range = 1.08m

Slope	dxb(m) low tide	dxb(m) high tide	Ddxb(m)
1/100 (0.11)	-54.0	54.0	108.0
2/100 (0.15)	**-29.5**	**29.5**	**59.0**
3/100 (0.19)	-19.5	19.5	39.0

dxb = change in distance offshore to breakpoint due to tidal elevation relative to mean sea level
Ddxb = change in distance offshore to breakpoint due to variation in water level between low tide and high

Nearshore — Max tidal range = 1.63m

Slope	dxb(m) low tide	dxb(m) high tide	Ddxb(m)
1/100 (0.11)	-81.5	81.5	163.0
2/100 (0.15)	**-40.8**	**40.8**	**81.6**
3/100 (0.19)	-26.9	26.9	53.8

CHANGE IN LOCATION OF WAVE BREAKING DUE TO CHANGE IN SEA LEVEL

Nearshore — Hb = 1.0m — hb today = 1.28m

Slope	xb(m) today	Dxb(m) +10yr	xb(m) +10yr	Dxb(m) +100yr	xb(m) +100yr
1/100 (0.11)	128.0	3.8	124.2	38.0	90.0
2/100 (0.15)	**64.0**	**1.9**	**62.1**	**19.0**	**45.0**
3/100 (0.19)	42.0	1.3	40.7	13.0	29.0

Assume: 3.8cm/1.5" per decade sea level rise (IPCC, 2007)
Hb = wave height at breakpoint
hb = water depth at breakpoint
xb = distance offshore to breakpoint
Dxb = change in distance offshore to breakpoint due to change in sea level
Assume: Hb/hb = 0.78 (Munk, 1949; Komar and Gaughan, 1972; Komar, 1998)

Nearshore — Hb = 2.0m — hb today = 2.56m

Slope	xb(m) today	Dxb(m) +10yr	xb(m) +10yr	Dxb(m) +100yr	xb(m) +100yr
1/100 (0.11)	256.0	3.8	252.2	38.0	218.0
2/100 (0.15)	**128.0**	**1.9**	**126.1**	**19.0**	**109.0**
3/100 (0.19)	84.5	1.3	83.2	13.0	71.5

Nearshore — Hb = 3.0m — hb today = 3.84m

Slope	xb(m) today	Dxb(m) +10yr	xb(m) +10yr	Dxb(m) +100yr	xb(m) +100yr
1/100 (0.11)	384.0	3.8	380.2	38.0	346.0
2/100 (0.15)	**192.0**	**1.9**	**190.1**	**19.0**	**173.0**
3/100 (0.19)	126.7	1.3	125.4	13.0	113.7

0.03720339
0.23784314

Compare RED boxes to and DARK GREEN boxes.

The data shown here suggest that on an average tide the breakpoint migrates 59.0m cross-shore, while 10 years of projected sea level rise will move the average wave's breakpoint 1.9m landward (a 3% change compared to total range)

The data shown here suggest that on a spring tide the breakpoint migrates 81.6m cross-shore, while 100 years of projected sea level rise will move the average wave's breakpoint 19.0m landward (a 23% change compared to total range)

NOTE: The nearshore slope at Pleasure Point is roughly 2:100 (0.15) and the mean wave height over the 2006-2007 USGS study was 0.9
NOTE: Wave height distributions within a given set of waves often vary on the order of 10-25%
NOTE: Studies by Allen and Komar (2000), Bromirski et al. (2005), and Storlazzi and Wingfield (2005) show wave heights are increasing in the Northeast Pacific Ocean. If wave height is increasing and the ratio of Hs/h must remain steady, then waves in the future will break in greater water depths that are further offshore to preserve the Hs/h ratio. The increase in wave height offshore central California (Storlazzi and Wingfield, 2005) is 20cm per decade, half an order of magnitude greater than the projected increase in sea level rise due to global cliomate change (IPCC, 2007), suggesting that even with sea level rise, the average breakpoint will likely migrate offshore.

ATTACHMENT 3