R-19

CITY OF LONG BEACH

OFFICE OF THE CITY MANAGER

333 West Ocean Boulevard • Long Beach, CA 90802 • (562) 570-5729

December 16, 2014

HONORABLE MAYOR AND CITY COUNCIL
City of Long Beach
California

RECOMMENDATION:

Receive report and provide direction to staff on the options addressing biotechnical and various other alternatives for the Ocean Boulevard (Bluff) Erosion and Enhancement Phase 2 Project. (District 3)

DISCUSSION

Background

On April 22, 2014, the City Council asked staff to consider delaying the continued implementation of the Ocean Boulevard (Bluff) Erosion and Enhancement Phase 2 Project (Project). The City Council adopted the Plans and Specifications (No. R-6959) for the Project on July 9, 2013, and awarded a contract to Drill Tech Drilling & Shoring, Inc. for the work, which included the use of stained, sculpted and landscaped shotcrete to provide bluff erosion control and secure the bluff in the event of a major seismic event.

On April 29, 2014, the City Council held a special meeting and took action to delay the Project for 45 days and directed staff to: (1) conduct an engineering analysis (peer review) of the Bluff; (2) consider other alternatives to Bluff stabilization, other than shotcrete; (3) advise the Council on community improvements to the Bluff that do not involve shotcrete; and (4) report the results of staff's analysis and stabilization alternatives to the Council and online to the public. In response to the City Council's direction, City staff provided the attached May 13, 2014 memorandum (Attachment A).

On July 1, 2014, the City Council considered a geotechnical peer review report (Attachment B) and directed the City Manager to: 1) move forward expeditiously with the top park portion of the Bluff (including the new required irrigation system) and with any of the other infrastructure improvements, such as railing and sidewalk work; 2) evaluate biotechnical alternatives for the remaining portions of the slope that have not received the final shotcrete treatment, as discussed in Section 3.0 of the Peer Review Report and report back to the Council; 3) conduct limited additional shotcrete in transitional areas, complete the staining of the completed shotcrete areas; and, 4) meet with the Bluff Park Neighborhood Association and other interested residents to obtain input on the concepts.

On July 28, 2014, the City Manager provided the Mayor and City Council with an update on efforts taken as a result of City Council direction (Attachment C).

Since July, significant work has occurred in the park, resulting in the completion of a majority of the project. The contractor has completed installing a brand new railing that retains its historic look, and a new sidewalk adjacent to the rail at the edge of Bluff Park. The Bluff Park irrigation system, which for years would continuously fail and require constant repairs, has also been fully replaced with a brand new and more water efficient system, which uses recycled water. The landscaping plan for the top, middle and bottom of the bluff slope was enhanced to maximize vegetative coverage of the shotcrete and improve aesthetics. Most of the enhanced landscaping is also completed, except in those areas that were not completed with the shotcrete treatment. The part of the project that remains incomplete are the two sections that received soil nailing for stability purposes, but did not receive the final shotcrete treatment.

As directed by the City Council, staff has completed the review and evaluation of biotechnical alternatives; however, staff's recommendation is to complete the Project in accordance with the original plans and specifications, especially considering that shotcrete and soil nails are fairly common bluff stabilization techniques used throughout urban areas in coastal California. The options to complete the project are outlined below.

Option #1 - Complete Original Project

Staff has worked with the community over the past several months to design a landscaping plan in previous shotcrete areas that will help maximize coverage of the shotcrete at full implementation (see Attachment D for rendering). Previous experience in other areas demonstrate that shotcrete is the most cost-effective method of erosion control and seismic stabilization and, that with a proper landscape plan and sufficient time, the aesthetic appearance of the shotcrete can be mitigated and allow it to blend in with the existing bluff. Of the alternatives outlined below, completing the project as originally planned with shotcrete would be the most cost-effective and expedient option as well as provide the necessary seismic and bluff stability.

Option #2 - Biotechnical Alternatives

Staff has completed the review and evaluation of biotechnical alternatives for surficial erosion protection for the Project's uncompleted areas as discussed in the Geotechnical Peer Review Report. Staff has researched biotechnical bluff stabilization options applied throughout the State of California and also interviewed biotechnical experts and contractors regarding the feasibility of applying biotechnical alternatives in Long Beach. While biotechnical alternatives in areas with steep slopes have been more widely used in inland areas, they are also feasible in coastal areas, but will likely require active adaptive management to ensure the landscaping takes hold as designed. The City's geotechnical engineer has developed feasible site-specific biotechnical concepts that take the following criteria into consideration: 1) durability and seismic stability; 2) erosion control; 3) vegetation/planting quality (including irrigation); 4) construction and maintenance costs; 5) implementation schedule; and, 6) regulatory permitting requirements.

The two uncompleted areas that require surficial erosion protection are Area 1 and a portion of Area 2 (Attachment E). Area 1 is located adjacent to the Long Beach Museum of Art, approximately between 20th Place and Lindero Avenue. Area 2 is approximately located between Temple Avenue and Orizaba Avenue. Because of varying site conditions between Area 1 and the uncompleted portion of Area 2, there are important differences in the biotechnical solutions. Existing site conditions and the two biotechnical options (Biotechnical Option 1 and Biotechnical Option 2) are outlined in greater detail in Attachment F.

Option # 3 - Major Regrading Alternative

Staff was also asked to evaluate the feasibility of re-grading the entire slope of Area 1 and the uncompleted portion of Area 2 to an inclination of 2H:1V. In order to be feasible, this alternative would require encroachment onto the beach by 15 - 20 feet, or consequently, encroachment into the park by the same amount or a combination thereof. Large amounts of additional soil would need to be imported, estimated at 21,500 cubic yards (or equivalent to 2,150 truck trips). This soil would have to be carefully compacted to ensure structural soundness of the slope. If this option encroached into the park, it would result in the loss of up to 16,000 square feet of current park space, and would have to take into account constraints created by the existing soil nails. If this alternative encroached into the beach, it would not impact the bike or pedestrian paths in Areas 1 and 2, but would result in the loss of sandy beach area and potentially encourage climbing of the re-sloped bluff area. It is anticipated that this project would require a new permit from the California Coastal Commission, and potentially an amendment to the City's Local Coastal Program, which may take 8 to 12 months to secure. Area 2 would also require a retaining wall, additional shotcrete or a concrete drainage trench in the transitional zones to keep the regraded area from losing its integrity as it connects with the shotcreted areas. In Area 1, the stairway to the beach would also have to be rebuilt to accommodate the significant change in slope. The initial shotcrete layer in the uncompleted portion of Area 2 would also need to be demolished; however, it would not have to be disposed off-site and could be reused as fill for the regrading. The imported soil would need to be highly compacted.

This option was considered during the Project's early planning phase, but was not recommended as a result of community concerns and expected permitting challenges. If this option were selected, it would require extensive planning, engineering, design, plan check, and permitting work before the project could be bid to a potential contractor. Construction would likely not begin until 2016 or 2017.

Cost Estimates

The estimated costs for each option are identified in the table below. These estimates include the required engineering, construction management and inspections, project management, and a 20% contingency. The completion of the original Project, currently budgeted at $5.8 million, includes the estimated cost to remobilize the contractor's shotcrete equipment and complete the project (including all delay related costs).

Estimated Costs above $5.8 million Budget

Option #	Option	Area 1	Area 2	Total
1	Completion of Original Project	$794,000	$529,000	**$1,323,000**
2	Biotechnical Option 1	$1,650,000	$2,700,000	**$4,350,000**
	Biotechnical Option 2	$3,800,000	$3,950,000	**$7,750,000**
3	Regrading	$3,000,000	$2,450,000	**$5,450,000**

Maintenance costs also differ for the various alternatives, with Biotechnical Option 1 being the most expensive, and the completion of the original Project being the least expensive. On an annual basis, maintenance costs for Option 1 are estimated to be $11,000. Annual maintenance costs for the biotechnical options are estimated to be $26,000 for Biotechnical Option 1, and $19,000 for Biotechnical Option 2. The annual maintenance costs for the major regrading option is also estimated at $19,000.

This matter was reviewed by Deputy City Attorney Linda Vu on December 5, 2014, and by the Director of Financial Management, John Gross on December 8, 2014.

TIMING CONSIDERATIONS

City Council action is requested on December 16, 2014. Continuing to leave the current soil nails and slope surfaces exposed risks undermining the integrity of the soil nails and the surface of the slope. A recent storm has already caused erosion in Area 1, and leaving the area exposed for more than 6 months may create additional complications, especially if there is significant rainfall during the winter and spring. The current contractor has advised that they would be able to finish the current project in 2015. Any option other than completing the current Project as originally designed will have to be bid. Staff estimates that biotechnical alternative construction could begin in Fall 2015. Existing concepts and additional technical specifications would be used to bid the project. For the regrading option, construction would be estimated to begin in 2016 or 2017.

FISCAL IMPACT

There is $5,800,000 budgeted for the Project in the Tidelands Operations Fund (TF 401) in the City Manager Department (CM). That amount has been fully expended or encumbered. The bulk of the budget is for the construction contract with Drill Tech Drilling and Shoring, Inc. The contract is for $4,442,768, plus a 15 percent contingency in the amount of $666,415 for a total not to exceed amount of $5,109,183. Staff has had lengthy discussions with Drill Tech to determine the cost to cancel the remaining shotcrete and landscaping work, and allow another contractor to implement a biotechnical alternative, if selected. Drill Tech has stated they are not interested in partnering to implement a biotechnical or regrading alternative. Therefore, with the biotechnical or regrading option, the project would have to be rebid.

If it is decided to move forward with the Project using the biotechnical or regrading alternative option, it is estimated that the total cost to cancel the contract with Drill Tech could be near the original contract amount. That would include the cost of all previous change orders that provided for the new irrigation system, landscaping improvements, delay-related costs, and other approved modifications to the Project.

Depending on the option selected to complete the Project, additional funding will be necessary. Additional costs are estimated to range between $1.3 million (to complete the original project) and $7.75 million (to use the biotechnical option 2). These additional costs are unbudgeted. Due to the recent decline in oil prices, it appears likely that there will not be sufficient cash from oil revenues to support the FY15 Tidelands Budget and the 5-year Capital Plan. As a result, the City Manager is developing a strategy for the Tidelands Budget and 5-year Capital Plan for City Council consideration. That strategy, expected to be developed by the end of the year, is likely to result in a recommendation to defer or reduce the budgets for some currently funded or planned projects. Until that strategy and associated report is released and reviewed by the City Council, it is suggested that it should be assumed that any additional costs for this project will need to be funded from reductions to the budget of currently funded projects in the Tidelands or from other additional funding sources such as the General Fund. There is approximately $650,000 budgeted for other Bluff Erosion Control projects that could be dedicated to this project.

Before staff can calculate the full fiscal impact of the Project and the recommended changes to the Tidelands CIP program to accommodate the project, further direction is needed on which alternative the City Council would like to pursue to complete the Project. Staff requests that the City Council provide direction on the alternatives listed above. Once an alternative is selected, the fiscal impact of the project will be included in the review of Tidelands projects the City Manager is currently conducting as a result of recent drops in oil prices. Upon receiving direction on the Project, staff will return to the City Council to request an amendment to the contract and/or increase appropriations in the Tidelands Operations Fund (TF) for the Project, and identify projects that would need to be delayed to accommodate the increased costs.

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,

PATRICK H. WEST
CITY MANAGER

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Attachments

City of Long Beach
Working Together to Serve

Memorandum

Attachment A

Date: May 13, 2014

To: Mayor and Members of the City Council

From: Patrick H. West, City Manager

Subject: **Ocean Boulevard (Bluff) Erosion and Enhancement Phase 2 Project**

Overview

On April 29, 2014, the City Council held a Special Meeting to discuss the Ocean Boulevard (Bluff) Erosion and Enhancement Phase 2 Project. This memo provides an update on efforts taken as a result of the City Council's direction, provides the requested information, and details the process for review of the project.

Background

The City of Long Beach approved a Bluff Master Plan in 2000, which identified a need to stabilize the bluff from everyday erosion and collapse in the event of an earthquake. The Bluff Master Plan identified three stabilization options that were further developed after a comprehensive geotechnical analysis was conducted in 2009. The initial options modified the slope of the bluff for stabilization, but were rejected by the community and the City, as they required either filling in beach area or reducing the size and configuration of Bluff Park.

The preferred stabilization option is the method currently being used for this project, which consists of soil nailing and shotcrete treatment to stabilize the bluff, followed by staining and landscape to the shotcrete to provide aesthetic qualities. This treatment is used on 44 percent of the bluff, and only on areas where it was identified in the geotechnical analysis as the best available option. The remaining areas of the bluff will be addressed without the need for this stabilization option. The City completed Phase 1 in December 2011, and began Phase 2 in October 2013.

Action Taken in Response to City Council Direction

At the April 29, 2014 City Council Special Meeting, the City Council voted to: delay the Bluff Park Stabilization Project for 45 days and directed staff to: (1) conduct an engineering analysis (peer review) of the Bluff; (2) consider other alternatives to Bluff stabilization, other than shotcrete; (3) advise the Council on community improvements to the Bluff that do not involve shotcrete; and (4) report the results of staff's analysis and stabilization alternatives to the City Council and online to the public.

With this direction, on April 30, the City halted work so that no additional soil nailing, concrete or staining would proceed. The City did allow work to continue in the grassy areas of Bluff Park not directly above any seismically vulnerable area that received soil nail treatment. This allowed work to continue on the

Ocean Blvd. front part of Bluff Park, while preserving future options for the areas originally planned for soil nailing treatments. Work in Bluff Park that is continuing (only in areas that are not directly above the seismically vulnerable areas) includes: irrigation improvements in the grass areas and sod installation where feasible; sidewalk construction; and installation of the historic rail.

Additionally, Cherry Park work (between Junipero and Cherry) will continue as we work to grade the bluff, create the walkway, and install landscaping. This area is not seismically vulnerable, and no shotcrete or soil nailing is planned for this area.

Demobilization of Equipment and Cost Estimate

While work ceased immediately on the project, there were ongoing costs related to the contractor's equipment and overhead for the project, totaling approximately $11,000 per day. Given that the City wishes to pause the work for 45 days for further analysis and a review of options, staff requested the contractor demobilize the equipment in order to avoid further charges. By Friday, May 2, the City had directed the contractor to demobilize any equipment related to soil nailing, staining and shotcrete. The demobilization will cost the City $83,000, but has reduced the daily expense incurred from $11,000 to $2,000 during the delay. If the City wishes to proceed with the previously contracted work, the contractor will need to remobilize, at an estimated cost of $104,000 and timing will depend on the availability of the equipment.

Estimates of Work

As part of the direction on April 29, the City Council requested that City staff provide estimates of other work that could continue. The City will move ahead with the work listed above (work in the park not above a seismically-vulnerable area), as it does not impact the bluff project. However, following are items the City Council could consider moving forward with that involve the bluff itself. Keeping in mind that the Council could, at some point, decide that an alternative type of treatment is preferred and direct staff to have the shotcrete removed, City staff will not move forward on these items until further direction is given by the City Council:

1. New landscaping for Phase 1 (above and below the treated area): $60,000

2. Staining the completed portion of Phase 2: $60,000

Information on the Soil Nailing Technique

As part of the City Council Special Meeting, there were questions about where else this treatment has been used in California. Soil-nailing and shotcrete treatment is a fairly common treatment for seismically-vulnerable bluffs. Over the past ten years, projects have been completed in numerous California cities, including Dana Point, San Clemente, Santa Cruz, San Pedro, and Agoura Hills. The specific contractor for the Long Beach project has completed over 106 projects throughout California since 2008. Attached are some photos of completed projects, including projects with mature landscaping.

Contingency

The City Council requested information on the amount of contingency available for this project. The project originally had an approved contingency of $666,000. Of that amount, approximately $450,000 was originally identified for the new irrigation system at Bluff Park and potential additional planting of Phase 1 landscaping. Another $100,000 was originally intended for the additional rail and sidewalk work from Redondo to 36th Place. Approximately $116,000 of the contingency is unallocated, and currently being used to fund the demobilization and other expenses as a result of the April 29, 2014 action.

Peer Review

The direction from the City Council on April 29, 2014 was to examine the available options to determine if the selected method was the preferred method. To accomplish this, the City has engaged in a peer review of the City's 2009 Geotechnical study. Three independent geotechnical firms have been selected to review the City's 2009 study and provide a report back to the City Council. City staff sought input on the selected firms from the community group who raised this issue to the City Council. The peer review effort is expected to cost approximately $20,000 and staff expects to have the firms begin their work on May 14, 2014. The work is estimated to take two to three weeks, at which point the report will be finalized and brought back to the City Council for review and discussion.

Website

City staff have created a website to provide a central repository for information on this project. The website includes the Bluff Master Plan, the Geotechnical study, and other documents, and will continually be updated with materials. The website can be found at:
www.longbeach.gov/citymanager/tidelands_capital_projects/bluff_erosion_phase_ii.asp

Next Steps

City staff are working quickly to perform the review and return to the City Council with information. Based on the estimates for completing the peer review, it is expected that this item will return to the City Council by June 17, 2014 for review and discussion.

For more information, please contact Eric Lopez, Tidelands CIP Officer, at (562) 570-5690.

cc: Charles Parkin, City Attorney
Suzanne Frick, Assistant City Manager
Reginald Harrison, Deputy City Manager
Tom Modica, Deputy City Manager
Ara Maloyan, Director of Public Works
George Chapjian, Director of Parks, Recreation & Marine
John Gross, Director of Financial Management
Jyl Marden, Assistant to the City Manager
Eric Lopez, Tidelands CIP Officer

Attachment B

PEER REVIEW REPORT
OCEAN BOULEVARD EROSION AND ENHANCEMENT
PHASE 2 PROJECT
CITY OF LONG BEACH, CALIFORNIA

Prepared for:

CITY OF LONG BEACH
Tidelands Capital Improvement Division

June 23, 2014

Prepared by:

Leighton Consulting, Inc.
A LEIGHTON GROUP COMPANY

GROUP DELTA

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Site and Project Background

The Ocean Boulevard Erosion and Enhancement Project, Phase 2 involves improvements to the existing slope south of Bluff Park, from the southerly projection of Loma Avenue to the southerly projection of Lindero Avenue. The slope is approximately 4,300 feet long, with an uneven slope face and inclination varying from 4½:1 (horizontal:vertical) to near vertical due to previous shallow failures, accumulations of slump debris, ongoing erosion, and past grading in localized areas to install beach access and utility improvements. Generally, the lower one third of the bluff face has a gentler gradient than the upper two thirds.

The top of the bluff is essentially flat with elevations ranging from 43 to 49 feet above mean sea level (msl). Concrete sidewalks, approximately 5 to 7 feet wide, some of which have been undermined due to erosion, and a historic handrail extend the entire length of the top of the bluff. A partially buried wall exists at the toe of the slope that extends approximately 1 to 2½ above the beach sand. Elevations at the toe of the slope range from 7 to 10.5 feet msl. Portions of the slope had been improved with gabion walls that were constructed on the slope with heights of approximately 9 to 11 feet. Landscaping on the slope face was relatively sparse except where the gabion walls were present and some form of grading had occurred.

In 2000, the City of Long Beach (City) hired Tetra Tech, with Geotechnical Professionals Inc., as a subconsultant, to prepare a Bluff Master Plan for the purpose of beautifying the slope, slowing down the erosion process, and improving slope stability. Additional studies were later performed by Kleinfelder in 2009 and 2010. The final recommendations included slope planting and irrigation, posts and timbers boards to repair undermined areas, and soil nailing and shotcrete in selected areas where the slope inclination is relatively steep. Construction plans prepared by Kleinfelder and RJM Design Group were prepared in 2012.

We understand that the City began construction of Phase 2 in October 2013 and that the construction has been temporarily halted since April 2014. At the direction of the City Council, the City has formed a peer review committee to assess if the selected slope improvements are the preferred method and evaluate available alternatives.

1.2 Peer Review Committee

This peer review is a collaboration of three independent geotechnical consulting firms. The peer review committee (Committee) consists of the following members:

- Djan Chandra, PE, GE; Leighton Consulting, Inc.
- Dr. Arul K. Arulmoli, PE, GE; DGE, Earth Mechanics, Inc.
- Dr. Daniel Pradel, PE, GE, DGE; Group Delta Consultants, Inc.

1.3 Purpose and Scope of Services

The purpose of the peer review is to evaluate if recommendations in the project geotechnical reports are appropriate and if there are other viable options for the subject slope improvements. The scope of services included the following tasks:

- Review of documents provided by the City listed in Section 1.4;
- Site reconnaissance to observe current site conditions and exposed soils; and
- Preparation of this report presenting our findings, conclusion and recommendations.

The Committee will attend a City Council meeting scheduled for July 1, 2014 to answer questions that the City Council may have on this report.

Independent evaluation of the geotechnical analyses performed by Kleinfelder (including selection of soil properties, slope stability analyses, design ground motion characteristics, and other calculations) was specifically outside the scope of services of the Committee.

1.4 Reviewed Documents

The subject of this review was the reports prepared by Kleinfelder in 2009 and 2010, which included as an appendix a report prepared in 2003 by Geotechnical Professionals Inc. These reports are listed below:

- Geotechnical Professionals Inc. (GPI), 2003, *Preliminary Geotechnical Investigation Proposed Belmont Shore Bluff Restoration, Long Beach, California*, dated September 3, 2003.

- Kleinfelder, 2009, DRAFT, *Possible Slope Improvement Options for Project Cost Estimating Bluff Park, East Ocean Boulevard between Loma Avenue and Lindero Avenue, Long Beach, California*, dated December 28, 2009.

- Kleinfelder, 2010, *Geotechnical Study, Proposed Slope Improvements Bluff Park, East Ocean Avenue between Loma Avenue and Lindero Avenue, Long Beach, California*, dated April 30, 2010.

Following the kickoff meeting, the Committee was provided with a memorandum prepared by the City Manager dated May 13, 2014, a memorandum titled "*Long Beach Bluff Stabilization Alternatives*" prepared by ESA PWA dated May 14, 2014, and the approved Construction Plans prepared by Kleinfelder and RJM Design Group. These documents were also reviewed in conjunction with the reports listed above for preparation of this report.

2.0 REVIEW FINDINGS

2.1 Project Parameters

The project site is located in a coastal environment and constrained by an existing sidewalk and handrail immediately on top of the bluff. City's memorandum and Kleinfelder report (2010) indicated that the mitigation measure involving grading to flatten the slope should not be considered. Such measure would involve filling the beach area or reducing the size and configuration of Bluff Park. The option of constructing a concrete retaining wall at the toe or in the middle of the slope was not acceptable either for cost and aesthetic reasons. Additionally, the selected slope improvement measures should be designed to resist ground shaking due to the design earthquake. A design earthquake is a site-specific ground motion that the improvements are required to safely withstand and, as defined in the Kleinfelder report (2010), has a 10 percent probability of occurrence in 50 years.

The slope improvement measures were understood to be developed within the parameters mentioned above. Accordingly, the peer review was conducted within the same parameters, which are specifically summarized below:

1) Proposed improvements to the slope should not extend into the park (at the top) or the beach (at the bottom);

2) Concrete retaining wall is not an acceptable option; and

3) Slope improvement measures should meet seismic requirements that were available at the time the Kleinfelder reports were prepared.

2.2 Field Exploration

Kleinfelder drilled 11 borings to depths of 16.5 to 51.5 feet below the existing grade. Five borings were located at top of the bluff and six borings were located on the beach by the toe of the bluff. GPI (2003) previously advanced three borings and three Cone Penetration Tests (CPT's) at top of the bluff within the Phase 2 project limits.

The soils on the slope were determined to be Pleistocene Old Paralic Deposits consisting of interbedded layers of silty sand and silty clay. The soils in the beach were found to consist of import beach fill underlain by recent beach deposits and the Pleistocene Old Paralic Deposits. Surficial and/or erosional failures were mapped but no deep-seated failure was observed along the slope.

Based on the relative consistency of the soils and the extent of the project, the field exploration program is considered adequate.

2.3 Subsurface Soils and Groundwater Modeling

Shear strength parameters used for the slope stability analysis were generally developed based on laboratory test results, published correlations of blow count during sampling and shear strength parameters, and published literature on geotechnical parameters of cemented sand on steep slopes (Kleinfelder, 2010). The parameters are presented in Table 1 below.

Table 1 – Summary of Shear Strength Parameters

Deposit	Material Type	Cohesion (psf)	Friction Angle
Slope Fill	Sand and Silty Sand	50 – 125	29
Beach Fill	Sand/Sand with Silt	0	32
Beach Deposit	Sand/Sand with Silt	0	34
Colluvium	Sand, Silty Sand and Silt	50 - 125	27 – 28
Paralic Deposits	Clay and Silt	200 - 350	25 -27
Paralic Deposits	Sand and Silty Sand	50 - 125	35 – 36
Import Fill	Sand and Silty Sand	0 - 50	32

Groundwater was encountered in the borings at elevations of +3 to +7 msl. These groundwater levels were used in the slope stability analysis.

The shear strength parameters appear to be reasonable for the onsite soils.

2.4 Seismic Design

The project requires that the proposed mitigations be designed to be stable during the design earthquake. For seismic slope deformation evaluations, Kleinfelder (2010) used an allowable slope deformation of approximately 6 inches. Their seismic slope stability evaluations were performed in accordance with "*Special Publication 117A, Guidelines for Evaluating and Mitigating Seismic Hazards in California*" (California Geological Survey, 2008) and "*Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Landside Hazards in California*" (Southern California Earthquake Center, 2002). This approach is considered reasonable and is also consistent with the current practice by the County of Los Angeles.

Kleinfelder (2010) recommended a peak horizontal ground acceleration of 0.39g and a corresponding earthquake magnitude of 7.1 in their slope deformation evaluations, which is reasonable in our opinion. The site has experienced the 1933 Long Beach Earthquake without any reported major damage or collapse of the bluff. The magnitude of the 1933 earthquake was reported as 6.4 and a peak horizontal ground acceleration of 0.29g was measured approximately 2 miles away in downtown Long Beach. The apparent successful performance of the bluff during the 1933 earthquake should not be considered as an indication that it will perform adequately during the design earthquake. Although the shaking was significant, it was smaller than what would be expected from the current design earthquake magnitude of 7.1, which has an anticipated energy release about 11 times larger than the energy released from the 1933 earthquake.

Based on the design considerations presented in section 2.1 above, Kleinfelder concluded that portions of the existing slopes did not meet the seismic requirements without improvements. We agree with this conclusion.

2.5 Slope Stability Analyses

Slope stability analysis was performed using commercially available computer programs PCStabl 5, GStabl 7, SNAIL and Slide 5.0. The limit equilibrium methods employed for the analysis included the Janbu corrected method, simplified Bishop method, and Spencer method. The approach to the slope stability analysis appears to be reasonable.

The slope stability analyses indicated factors of safety less than the code requirements for portions of the slope under static conditions and during the seismic design event. For the portions of the slope that are deficient, Kleinfelder used soil nails and shotcrete to improve them. It is our judgment that static and seismic improvement of the slope will have to utilize either soil nails, tie-backs or other forms of deep anchoring into the slope. Therefore, the soil nail system used on the project is an appropriate solution. Shotcrete is a common method to mitigate surficial slope instability in conjunction with soil nails; however, other options, as discussed later in this report, are also available.

2.6 Recommended Slope Improvements

2.6.1 Erosion Control

To reduce surface erosion, Kleinfelder recommended slope planting with deep-rooted, drought-resistant vegetation and permanent erosion fabrics. The slope planting was recommended to consist of shrubs for portions of the slope no steeper than 1½:1 and ground cover (light-weight vegetation) for steeper portions of the slope. Permanent erosion fabrics, anchored at the top of the slope and stapled to the slope face, were recommended for portions of the slope at 2:1 or steeper. Such measures for erosion control appear to be reasonable.

2.6.2 Soil Nailing

Locally where slope inclinations are steep, the repair method proposed by Kleinfelder involves:

- Soil nails that enhance the deep-seated stability of the bluff under static and dynamic conditions (Figure 1) and locally support portions of the sidewalk; and

- A shotcrete facing (Figure 1) that protects the slope surface from weathering and erosion caused by surface water, and enhances the surficial stability.

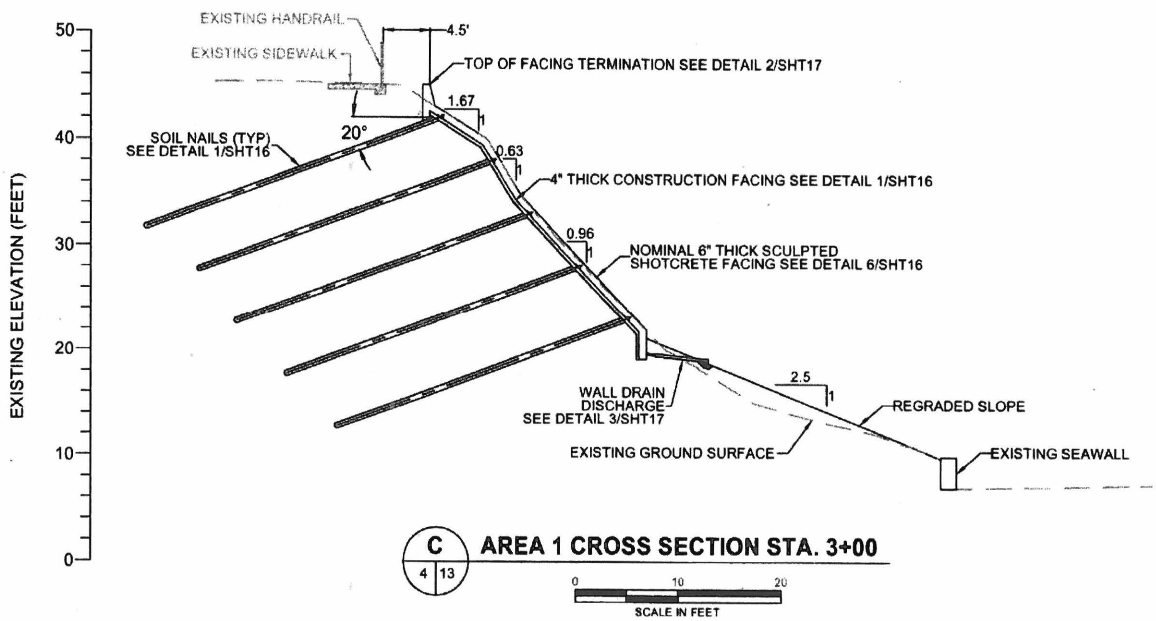
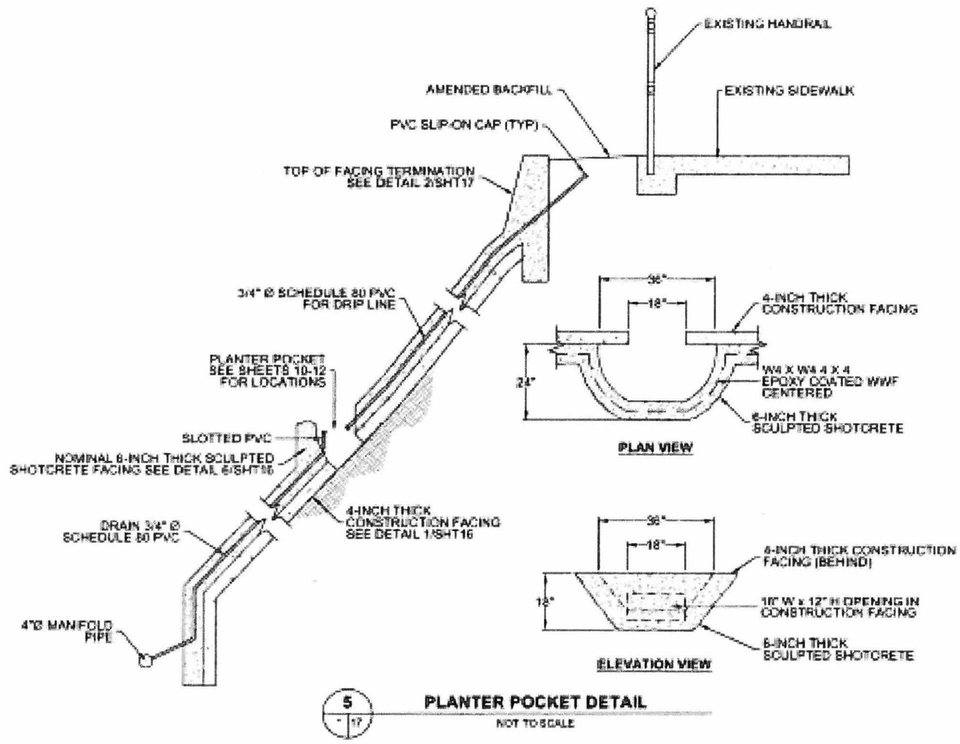


Figure 1 - Design Cross-Section of Soil Nailing

The shotcrete facing will be sculpted to blend in with the surrounding landscape. At specific locations, the shotcrete facing has planter pockets that allow vegetation to grow on the slope and with time will partially cover the shotcrete surface, as exemplified in Figure 2. The design contemplates having open-bottom planters that allow infiltration into the slope. Failure of sprinklers and/or the irrigation pipes may result in a concentrated influx of water directly into the slope which is undesirable. The design includes irrigation PVC pipes embedded into the shotcrete to drain excess irrigation water.

Soil nailing with shotcrete facing is commonly used in southern California for bluff stabilization. Examples of successful bluff stabilization projects include the Del Mar Bluffs Stabilization and Pacific Coast Highway Bluff Stabilization in Dana Point and San Clemente.

It is the Committee's opinion that the recommendations on using soil nailing with shotcrete facing is reasonable considering the project parameters discussed in Section 2.1. An available alternative to shotcrete for slope face protection is using biotechnical techniques as discussed later in Section 3.0.



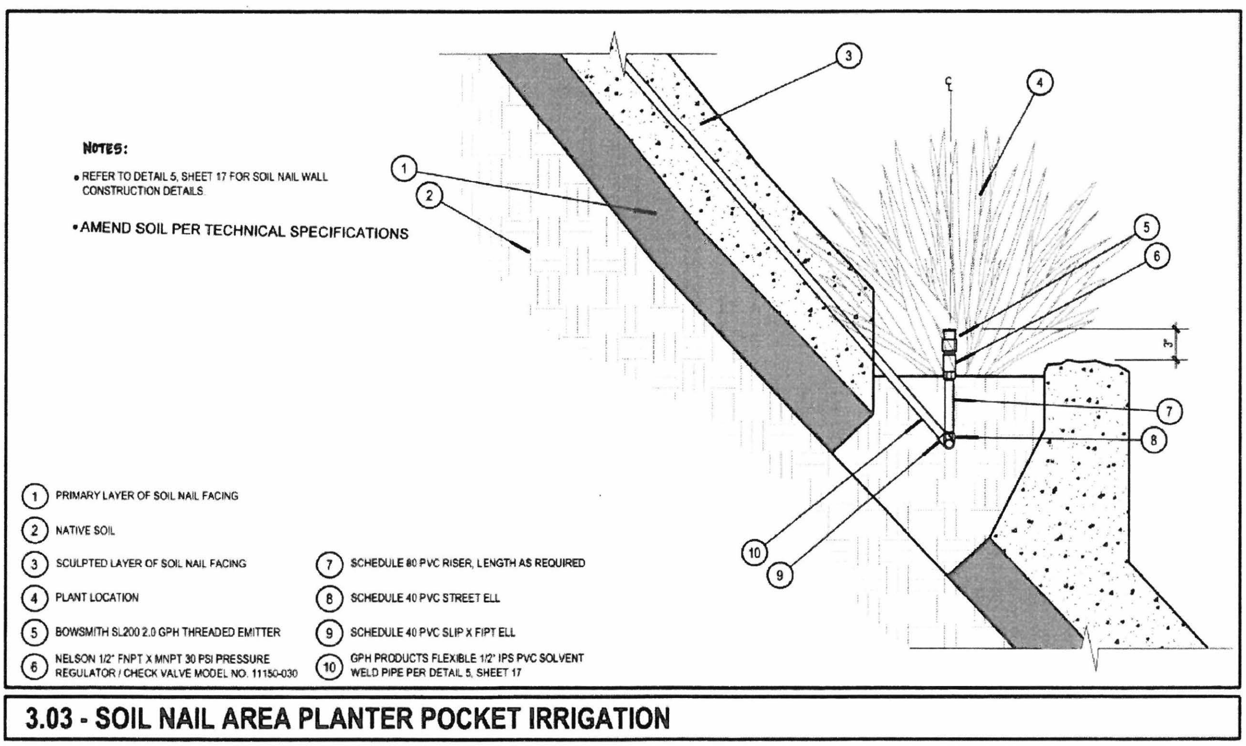


Figure 2 - Planter Details

2.7 ESA PWA Memorandum

The memorandum titled "*Long Beach Bluff Stabilization Alternatives*" dated May 14, 2014, prepared by ESA PWA included nine options for slope stabilization treatment that ranged from vegetation to grading, retaining wall, and soil nailing. The options of vegetation and erosion control fabric are feasible for flatter slopes and were already recommended by Kleinfelder as discussed in Section 2.6.1. The options of grading the slope and construction of retaining walls are not acceptable due to the project constraints discussed in Section 2.1.

Options 8 and 9 suggested in the ESA PWA memorandum are two possible ways to improve the slope stability and meet the City's design requirements and project constraints. Option 8 is soil nail walls with geogrid material to assist vegetation growth, which is one of the biotechnical techniques feasible for the site as mentioned later in Section 3.0. This option, however, is only feasible in slope areas where shotcrete has not been constructed. In areas where shotcrete has been installed, this option will require removal of the existing shotcrete which could be potentially detrimental to the soil nails and/or slope face that are already in place and slope face. The challenges of removing existing shotcrete are described in Section 3.0. Option 9 includes soil nail walls fitted with planter pockets which are already implemented for this project (see Section 2.6.2).

3.0 ALTERNATIVES FOR SLOPE FACING

Shotcrete was selected to improve surficial stability of the slope where soil nailing was recommended. Shotcrete acts as a barrier against weathering of the slope face from direct sunshine and saturation during rainstorms; hence reduces the likelihood of shallow slope failures. In recent years, biotechnical techniques have been used to improve slope faces instead of using shotcrete. The main appeal of biotechnical techniques is that they can be more aesthetically pleasing than walls or shotcrete.

Biotechnical techniques typically involve anchoring the near-surface soils using plant roots, often in combination with structural elements. There is a wide variety of available biotechnical techniques, some of which that may be applicable for the site include:

- Deep rooted vegetation as depicted in Figure 3;
- Deep rooted vegetation in combination with geogrid or timber grid used to hold topsoil and slope plantings as shown in Figure 4; and
- Live slope grating where a lattice-like array of vertical and horizontal timbers are fastened or anchored to a steep slope and the openings in the structure are filled with suitable backfill material and layers of live branch cuttings (see Figure 5).

These biotechnical techniques could be considered for the subject slope instead of shotcrete, especially for slope inclinations of 1:1 or flatter. Although biotechnical techniques generally provide excellent erosion protection, the resulting vegetation requires significant maintenance. Biotechnical techniques only improve the stability of the near-surface soils and provide a very limited benefit for deep-seated instabilities; thus, they are not a substitute to soil nails as their depth of influence is limited.

These techniques can be used in the western portion of the project, designated as Area 1 and the western portion of Area 2 on the Construction Plans, where the slope has been stabilized with soil nails but shotcrete has not been installed. Area 1 has slope inclinations varying from 0.63:1 to 1.63:1 (horizontal:vertical) from top to bottom of the slope, which would make the installation of a geogrid or steel mesh facing easier to implement than timber grid or timber grating. Deep-rooted vegetation may be used for the flatter inclination, perhaps in combination with shotcrete or geogrid/steel mesh for the steeper slopes. The western portion of Area 2 has a fairly uniform inclination of 0.85:1 to 1:1 (horizontal:vertical) that can facilitate the biotechnical options mentioned above. Minor grading may be required to create a bench to support the timber grids or grating. Due to steepness and variety of inclinations of the slope, biotechnical techniques must be evaluated and designed by an experienced engineer and landscape architect.

The biotechnical techniques are not recommended on portions of the slope where soil nails and shotcrete have been installed because they require removal of the shotcrete. Since the shotcrete is reinforced with rebar and integrated with the soil nails, removal of the shotcrete may impact the integrity of the soil nails. The removal will require extreme care and is expected to be a labor intensive effort. Additionally, the shotcrete was placed directly on the slope face; removal of the shotcrete will inevitably remove some of the soils on the slope face that adhere to the shotcrete, which will reduce stability of the slope.

An inquiry was brought up in one of the City Council meetings about adding soil nails to the existing design in lieu of shotcrete. More soil nails will certainly improve the stability of the slope but will not eliminate the need for protection of the slope face.

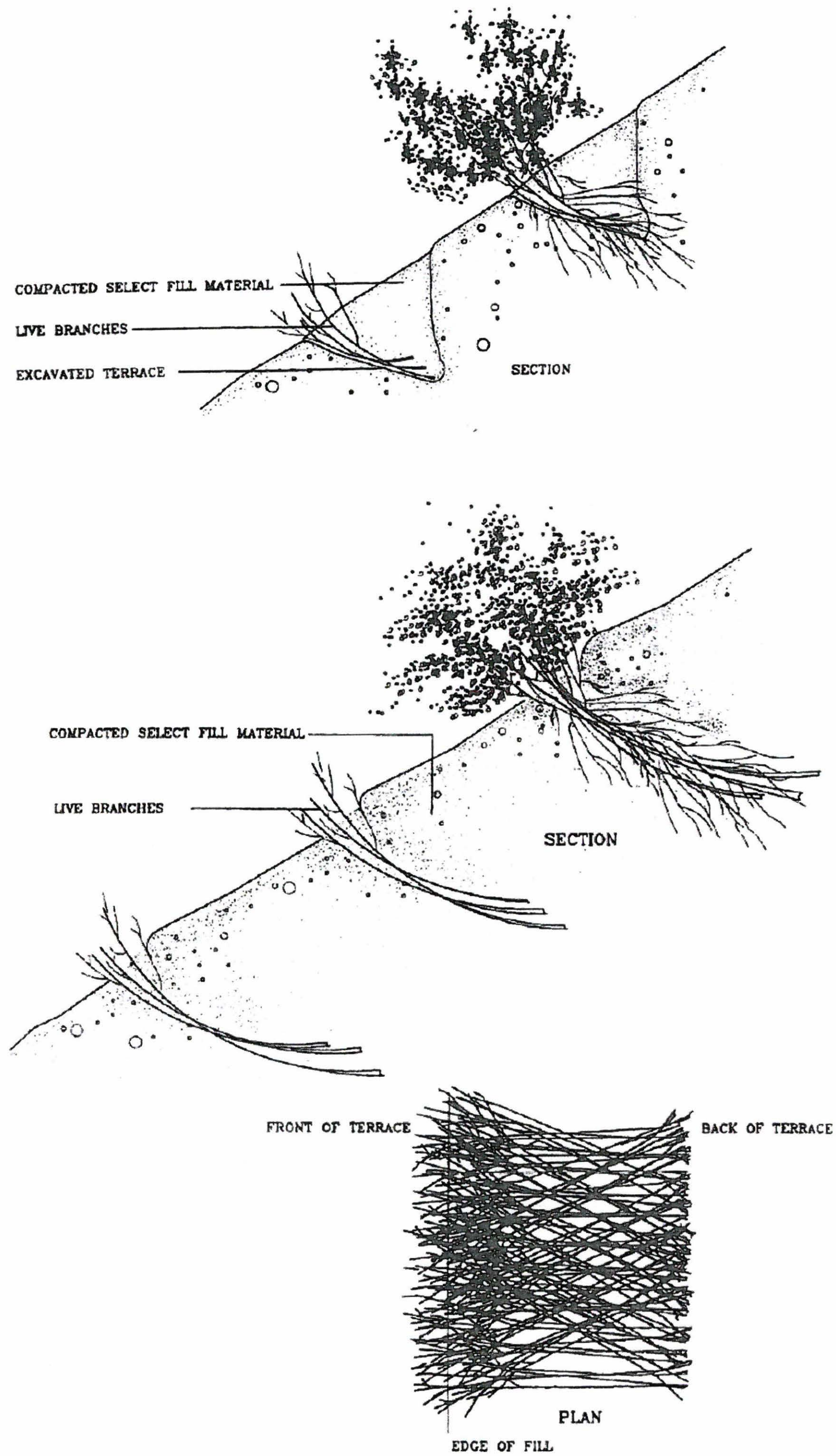


Figure 7-21. Schematic diagram of an established growing *fill slope* brushlayer installation showing alternating layers of live cut brush inserted between lifts of soil.

Figure 3 – Example of Deep-Rooted Vegetation

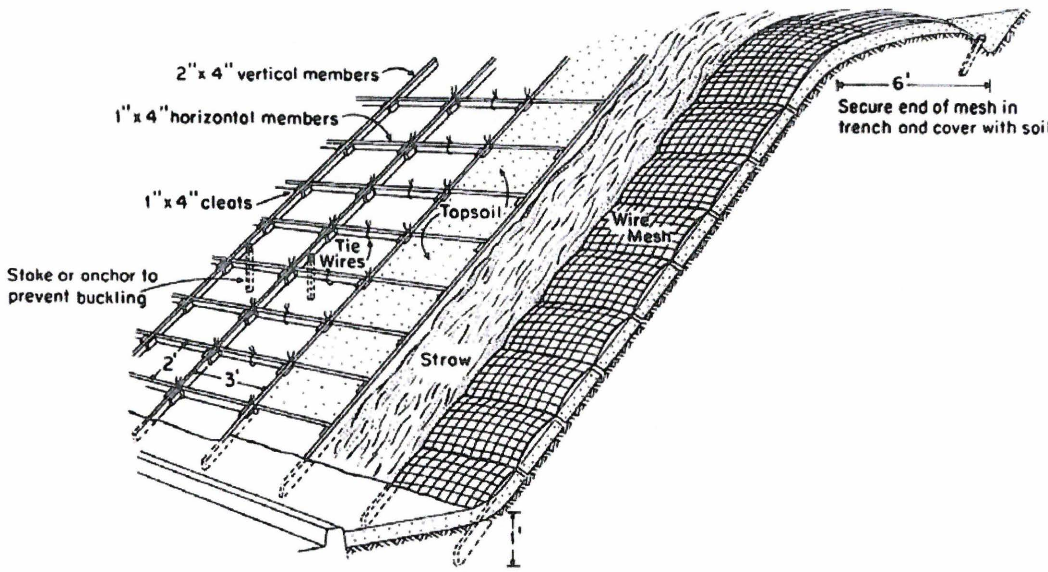


Figure 8-18. Anchored timber grid used to hold topsoil and slope plantings.

Figure 4 – Example of Deep-Rooted Vegetation with Timber Grid

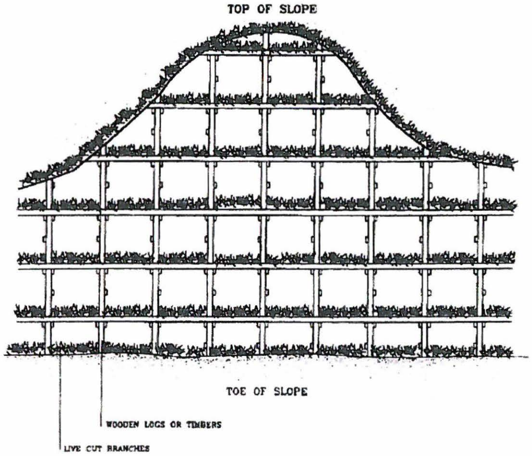


Figure 7-36. Schematic illustration, frontal view, of live slope grating consisting of lattice-like array or grid of horizontal and vertical timbers that are anchored to a steep slope.

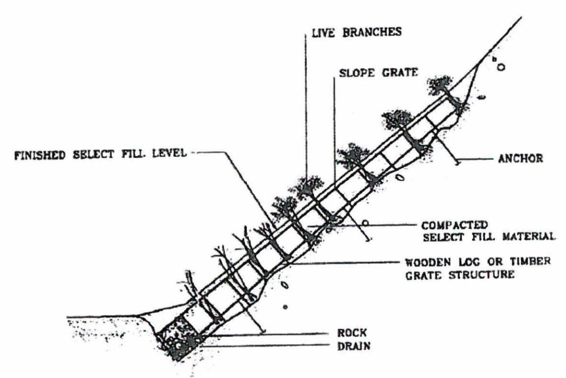


Figure 7-37. Profile view of an established growth slope grating system showing placement of live cuttings or branches in box-like compartments in the grating.

Figure 5 – Example of Live Slope Grating

4.0 CONCLUSIONS AND RECOMMENDATIONS

As documented in the reviewed reports listed in Section 1.4, the original unimproved slope has experienced numerous shallow failures in recent times and is highly vulnerable to surficial instabilities due to their steepness. The calculated factors of safety for portions of the slope were below the code requirements under both static and seismic conditions. It is our opinion that the recommended soil nail system and the surface treatment for portions of the slope with relatively steep inclination is an appropriate solution to improve static and seismic stability of the slope and preserve the existing terrains.

The Committee concluded that the soil nail system and shotcrete are an appropriate solution for the project; however, there are feasible biotechnical alternatives for the soil nailed areas that have not received shotcrete. If biotechnical techniques are considered for those areas where there is no shotcrete, they should be further evaluated and designed by an experienced engineer and landscape architect. The Committee does not recommend the removal of shotcrete to implement these biotechnical alternatives. Removing shotcrete would require extreme care and be a labor intensive activity. The installed shotcrete is reinforced with rebar and integrated with the soil nail system, so its removal may impact the integrity of the installed soil nails.

5.0 LIMITATIONS

This peer review was performed using the degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical consultants practicing in this or similar localities. We reviewed the approach, methology, and results presented in the geotechnical reports to verify that they meet the standard of care; however, independent evaluation of the geotechnical analyses performed by Kleinfelder (including selection of soil properties, slope stability analyses, design ground motion characteristics, and other calculations) was specifically outside the scope of services of the Committee. The findings, conclusion, and recommendations included in this report are considered preliminary and are subject to verification. We do not make any warranty, either expressed or implied.

City of Long Beach
Working Together to Serve

Memorandum

Attachment C

Date: July 28, 2014

To: Mayor and Members of the City Council

From: Patrick H. West, City Manager

Subject: **Ocean Boulevard (Bluff) Erosion and Enhancement Phase 2 Project**

On July 1, 2014, the City Council directed staff to proceed with the Ocean Blvd. (Bluff) Erosion and Enhancement Project, and to further develop design concepts for biotechnical alternatives in lieu of the sculpted and landscaped shotcrete. Staff will complete conceptual designs for the biotechnical alternatives in 2-3 months, and will also evaluate the rough order of magnitude costs for construction and ongoing maintenance requirements. The results of the evaluation and cost estimates will be presented to the City Council when complete.

In the meantime, the contractor is proceeding with work at the top of Bluff Park, with the exception of the area under evaluation for biotechnical alternatives. The sidewalk work will be fully completed within the next week, and handrail installation will begin today. The plan is to begin installing the handrail at the Redondo Ave./Ocean Blvd. section of Bluff Park, and work westward towards the Museum of Art. The handrail installation is expected to be completed by August 30th. The contractor has submitted a plan and cost estimate to replace the existing irrigation system at Bluff Park, which has failed regularly and required constant repair. The irrigation installation work at Bluff Park is expected to take between 25-30 days and will begin as soon as the final cost is negotiated.

The landscaping improvements at the top, middle and bottom of the bluff are estimated to begin in 3-4 weeks. The final soil nails in Area 1 were completed today. No additional shotcrete will be used on areas (Area 1 and half of Area 2) with exposed soil nails; however, Area 2 may require minimal shotcrete (approximately 300 square feet) in order to adequately transition from an area with final shotcrete to an area with exposed soil nails and the engineers are currently developing this transition detail. The contractor is proceeding with the staining of Area 2 and 3 and should be completed in the next couple of weeks. The landscaping of the planter pockets on the bluff will begin after the staining is fully complete and the irrigation system has been fully installed. Final grading at the bottom of the bluff is expected to begin two weeks after the staining is complete.

Next steps include completing all improvements at Bluff Park (with the exception of the biotechnical evaluation area mentioned above) as soon as possible, including the handrail, sidewalk and irrigation system, and to develop the biotechnical alternative concepts for those areas with exposed soil nails. The final cost of the unbudgeted expenses such as demobilization, remobilization, peer review, cost of additional landscaping, irrigation improvement, and estimates of the biotechnical solution is also being finalized, and will be reported to the City Council as soon as possible.

For more information, please contact Eric Lopez, Tidelands CIP Officer, at (562) 570-5690.

cc: Suzanne Frick, Assistant City Manager
Reginald Harrison, Deputy City Manager
Tom Modica, Deputy City Manager
Ara Maloyan, Director of Public Works
John Gross, Director of Financial Management
Jyl Marden, Assistant to the City Manager
Eric Lopez, Tidelands CIP Officer

Attachment D

Attachment E

Attachment F

Attachment F

Biotechnical Alternatives

A technical memorandum has been prepared by Kleinfelder, the engineering firm of record for the Ocean Blvd. (Bluff) Erosion and Enhancement Phase 2 Project, which outlines the feasible alternatives for surficial bluff stabilization (Exhibit 1). The biotechnical options for Area 1 and a portion of Area 2 are outlined in further detail below.

Biotechnical Solutions for Area 1

The existing bluff in Area 1 is up to approximately 37 feet high with an inclination varied from approximately 0.6H (Horizontal): 1.0V (Vertical) in the upper portion to approximately 2.5H: 1.0V at the toe of the slope, below the soil nailed area (Exhibit 2). The bluff contains fully exposed soil nails that are up to 30 feet long and are designed to improve global stability of the bluff slope and reduce potential for future deep-seated sliding, particularly during or following a strong seismic event. However, there is currently no surficial erosion protection in Area 1, which resulted in noticeable erosion during the last rainstorm. A new Coastal Development Permit would not be necessary for either of the biotechnical options; however, a minor modification and time extension to the existing permit would be required.

- **Option 1 (Area 1):** Biotechnical Option 1 would entail the installation of a high-tensile steel wire mesh that can be planted with a native hydroseed mix and include some shrub/vine cutouts. The steel mesh would overlay the face of the bluff and tie into the existing soil nails, and provide about an inch of high quality top soil. It could be rapidly installed, but would provide limited protection from surface erosion until the grasses and plants are well established. Mesh is used throughout California as an erosion control method on steep slopes; however, the steeper the slopes are the more difficult it is to successfully establish plants and maintain them. Intensive ongoing monitoring would be required, especially during plant establishment in the initial two years of the Project, to ensure that the landscaping is successful and the system works as designed. Hydroseeding is expected to be required on an annual basis in order to maintain adequate plan coverage. Monitoring should also be conducted after every significant rain event to repair any damage that is observed. While this option would be less expensive to implement, it does carry a significantly higher rate of failure than Option 2. A conceptual rendering for this option has been prepared (Exhibit 3).

- **Option 2 (Area 1):** Option 2 would involve some regrading to create less steep slopes. A steel mesh would also be used as in Option 1, but a cellular confinement system (honeycomb-like vegetative cells composed of synthetic or biodegradable material) would be pinned to the mesh. These cells would be filled with 4 - 8 inches of high quality top soil, which would allow a greater diversity of plants to establish. This option would be more aesthetically pleasing and would provide greater erosion control than the first option, but would also be significantly more expensive than Option 1. The less steep slope would also require less maintenance and is expected to have lower failure rates. A conceptual rendering for this option has been prepared (Exhibit 4).

Biotechnical Options for Area 2

The existing bluff in Area 2 is up to approximately 35 feet high with an inclination varied from 0.67H : 1.0V in the upper portion to 2.5H : 1.0V at the toe of the slope, below the soil nailed area (Exhibit 5). In this area, the bluff contains partially exposed soil nails that are up to 30 feet long and are designed to improve global stability of the bluff slope and reduce potential for future deep-seated sliding, particularly during or following a strong seismic event. The soil nails are only partially exposed because the uncompleted portion has received a base layer of approximately four inches of shotcrete. While this initial layer of shotcrete is serving to protect it from surficial erosion, it does complicate the implementation of biotechnical alternatives.

The two biotechnical options available for Area 1 would only be viable in the uncompleted portion of Area 2 if the initial layer of shotcrete is removed. While not recommended, the City's geotechnical engineer has determined that it is feasible to do so if completing the project per original plans and specifications is not viable and some consistency with the Area 1 biotechnical alternative is desired. It is important to note that a retaining wall, additional shotcrete or a concrete drainage trench may be required between the fully completed shotcrete section of Area 2 and the section that would be receiving the biotechnical alternative.

- Option 1 (Area 2): This option would be similar to Option 1 identified above for Area 1, and would entail the installation of a high-tensile steel wire mesh that can be planted with a native hydroseed mix and include some shrub/vine cutouts.

- Option 2 (Area 2): This option would be similar to Option 2 identified above for Area 1, and would include a cellular confinement system (honeycomb-like vegetative cells composed of synthetic or biodegradable material) that would be pinned to the mesh.

While the removal of shotcrete is not recommended overall, its removal from the uncompleted portion of Area 2 could be done with limited impacts to existing soil nails. While some soil nails would likely be damaged during the process, they could be repaired or new ones installed. The fact that the initial layer of shotcrete in Area 2 is only approximately four inches, compared to 10 inches in the fully shotcreted areas, makes a major difference. Following removal of shotcrete and repair or replacement of some soil nails, the biotechnical alternatives listed above could then be implemented.

KLEINFELDER
Bright People. Right Solutions.

November 18, 2014
Revised December 1, 2014
Revision 2 December 5, 2014
Project No: 00124406.001A

Mr. Eric Lopez
Tidelands CIP Officer
The City of Long Beach
333 W. Ocean Boulevard, 9th Floor
Long Beach, California 90802

Subject: **Technical Memorandum (Revised)**
Conceptual Alternatives for Biotechnical Bluff Stabilization
Ocean Boulevard Erosion and Enhancement Project, Phase 2
Long Beach, California

Agreement No. 32123.1
Blanket Agreement No. BPPW11000039
Purchase Order No. DPPW12001022, Project No. PW8260-13

Dear Mr. Lopez:

This technical memorandum summarizes conceptual and feasible alternatives for surficial bluff stabilization utilizing biotechnical slope protection measures for the bluffs adjacent to Ocean Boulevard in Long Beach as alternatives to the previously designed soil nail wall with sculpted concrete face. The alternatives discussed were developed by our design team consisting of Kleinfelder, RJM Design Group, and Tidal Influence, as well as by interactions with City of Long Beach project representatives. In general, biotechnical measures combine structural (reinforcement) elements along with biological components (plants and shrubs) to effect a strengthening of the surficial soils and improve vegetative cover to resist surface erosion. It should be pointed out that although the biotechnical alternatives are considered feasible, they come with increased risk of surficial erosion, diminished life expectancy, and increased maintenance costs as compared with the originally designed approach of a sculpted face soil nail wall. The following sections describe briefly the existing site conditions, surficial stability, and our findings and conclusions related to potential implementation of biotechnical measures for the subject project.

BLUFF - AREA 1 (STATION 0+50 TO 5.00)

The existing bluff in Area 1 is up to approximately 37 feet high with an inclination varied from approximately 0.6H: 1.0V (horizontal to vertical) in the upper portion to approximately 2.5H: 1.0V at the toe of the slope. A system of soil nails, up to 30 feet long, was recently installed in a grid, approximately 6 feet by 6 feet, to improve global stability of the bluff slope and reduce potential for future deep-seated sliding, particularly during or following a strong seismic event. The existing present conditions are shown in Figure 1.

Figure 1 – Existing Slope Condition in Area 1

BLUFF - AREA 2 (STATION 15+75 TO 19+25)

The existing bluff in Area 2 is up to approximately 35 feet high with an inclination varied from approximately 0.67H:1.0V in the upper portion to approximately 2.5H:1.0V at the toe of the slope. The western portion of the previously designed shotcrete stabilized bluff in Area 2, approximately between stations 14+25 and 15+75, has been already

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completely constructed by installing soil nails with a layer of sculpted shotcrete (total shotcrete thickness of about 10 inches) and planter pockets. The central and eastern portion of the bluff between stations 15+75 and 19+25 has been partially constructed by installation of soil nails with an initial layer of shotcrete, approximately 4 to 5 inches thick. Pictures showing the existing conditions are shown in Figures 2 and 3.

Figure 2 – Initial Layer of Shotcrete in Central/Eastern Portion of Area 2

Figure 3 – Transition Zone - Full and Initial Layer of Shotcrete in Area 2

SURFICIAL STABILITY – AREA 1

We have evaluated surficial slope stability for the existing conditions in Area 1 where the exposed soil on the slope is subject to rain and erosion. The cohesion of fine-grained soils (clays and silts) and some cementation of coarse-grained soils (sands) have allowed the formation of relatively steep slope segments comprising the original bluff. Erosive forces such as wind, rain, and surficial runoff have caused loss of ground at the bluff face. If left unprotected, water from rain, irrigation from Bluff Park or other sources will continue the process of dissolving the cementation and will contribute to erosion. With the present steep slope faces there is a high potential for surficial instability including slumps and downslope movements. Therefore, surficial slope protection is recommended.

CONCEPTUAL ALTERNATIVES FOR BIOTECHNICAL SLOPE PROTECTION

General

The selection of appropriate and feasible biotechnical slope protection system depends on slope configuration (geometry), strength of on-site soils, and availability of plant species. Based on the existing site conditions, review of several published case studies, discussion with construction firms specializing in implementation of biotechnical soil stabilization measures, and with feedback from our landscape architect subconsultants including RJM Design Group and Tidal Influence, conceptual alternative measures to improve stability of the bluff and reduce a potential for future erosion have been identified and are discussed in the following sections. Please note that any biotechnical measure will require much higher maintenance and higher risk due to climatic and man-induced impacts to vegetation, as compared to a structural improvement (sculpted face shotcrete with planter pockets). Further, vegetation will need an establishment period during which an even greater risk of erosion will exist. A sufficient irrigation system will need be constructed on all slopes where biotechnical measures are considered. Greening of the bluff with any biotechnical stabilization system should be done by an experienced landscape contractor who is aware of the local circumstances including but not limited to climate, natural plant population, and subsurface soils.

Area 1 (Station 0+50 to 5.00)

OPTION 1 – TECCO® Mesh with Hydroseed Mix and Shrub/Vine Cut Outs

TECCO® Mesh is a high-grade slope protection and stabilization system which consists of high-tensile steel wire and associated spike plates and nails. An example of TECCO mesh is shown in Figure 4.

Figure 4 – TECCO Mesh

It is feasible to use TECCO Mesh on the existing slope in Area 1 where mesh can be installed on the slope and fasten to the already installed soil nails in a square pattern of approximately 6 x 6 feet. The slope must be suitably prepared before the TECCO® system is put in place. It should include clearing and cleaning of the slope as well as some localized leveling and removal of loose materials. A cross section prepared by RJM Design Group showing implementation of this alternative is included in Appendix A. Details about vegetation establishment were prepared by Tidal Influence and are discussed in Appendix B.

OPTION 2 – Cellular Confinement with Hydroseed and Shrubs

This option includes import of top soil and re-grading of the existing slope in Area 1 at a uniform inclination of approximately 1.4H: 1V. A layer of high strength steel reinforcement mesh (TECCO® mesh or similar) is attached to the already installed soil nails and torque tensioned onto the slope. A cellular confinement system composed of synthetic material such as GEOWEB® system that forms cells is placed on the reinforcement mesh and is fastened to the slope with anchor pins. These cells are backfilled with compacted topsoil, "overfilled" at least 1-inch above cells, and are vegetated. Since these cells are typically 4 – 8-inches deep, a greater volume of soil is provided compared to traditional hydroseeding. An example of cellular confinement system (synthetic) is shown in Figure 5.

Figure 5 – Cellular Confinement System - GEOWEB®

As an alternative option to synthetic confinement system is to use organic, biodegradable enhancements such as CellScape™ which are attached to the high strength steel wire mesh and filled with a custom blend of soil and mulch prior to hydroseeding and planting. An example of cellular confinement system (biodegradable) is shown in Figure 6. A conceptual cross section is shown in Appendix A. The feasibility of vegetation establishment is discussed in Appendix B.

Figure 6 – Cellular Confinement System - **CellScape™**

Alternative Option – Slope Re-grading

The option of slope re-grading could be implemented by either creating a flattened fill slope that extends some distance onto the beach or by cutting from the existing toe of slope into the park above. In the case of fill onto the beach, an incursion onto the existing sand of about 20 feet would be required at the toe of the new slope unless a new retaining structure is placed at the current toe of slope location. We estimate that a wall at the toe of a 2H:1V fill slope would likely be about 13 feet in height above the existing beach grade and would require driven pile support to mitigate the potential for excessive seismic settlement. An alternative to a structural wall could be a rock fill (similar to a jetty) backed by an engineered graded filter (progressively finer rock layers) to retain soil behind the open rock lattice.

In the case of excavation of the presently existing slope from its current toe location, back at a stable 2H:1V configuration, approximately 20 feet of parkland incursion between Ocean Drive and the current bluff would be required. Existing soil nails could be either removed or cut off during excavation of this slope.

Similar to Option 2, these options would require import of top soil. The new constructed slope with a uniform inclination of 2H:1V will not require any structural improvements (such as TECCO® mesh or cellular confinement systems) as discussed above. Please see a conceptual cross section of the fill slope alternative shown in Appendix A. With this option, the encroachment on the beach, south of the existing sea wall at the toe of slope will be generally about 20 feet. The existing sea wall will need be demolished and relocated south on the beach, or buried with new fill and reconstructed to the south. With the construction of a new slope, the existing stairway, immediately west of Area 1 most likely will require relocation and/or reconstruction. A biodegradable mesh (such as jute netting) should be installed on the surface of slope to control superficial erosion until vegetation is established. The feasibility of vegetation establishment is discussed in Appendix B. Please note that steeper slopes such as 1.75H to 1V or 1.5H to 1V can be considered as alternatives to the slope with an inclination 2H to 1V. However, to maintain a surficial stability of the slope, any steeper slopes will require additional structural components such as a cellular confinement system and/or TECCO® mesh as discussed for Option 2 above.

Area 2 (Station 15+75 TO 19+25)

The TECCO mesh and/or cellular containment biotechnical options are not feasible in Area 2 unless the initial layer of shotcrete, approximately 4- 5- inches thick will be removed. Please note that future plants will require root zone for vegetation. Without removal of shotcrete, a very limited thickness of soil layer (on the order of 6 inches or less) will not be sufficient for future plant establishment. In addition, from the engineering standpoint, any infill soils should be properly placed and compacted. Without a proper compaction a loose infill soil will be subject to wash out, settlement, and disappearance. Therefore, due to the existing steep grades and presence of initial layer of shotcrete, compaction and overfilling to match the existing slope configuration without shotcrete removal is not feasible and not recommended. After shotcrete removal, either Option 1 or Option 2 can be implemented as discussed previously for Area 1.

In the case of not removing the shotcrete, the 4 to 5 inch layer may be broken into pieces of maximum 8 inches width and left in place and may be covered with new soil fill (re-grading option). It appears that placement of fill above the thinner shotcrete with

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maximum 2H: 1V transition slopes from the existing adjacent fully completed shotcrete could be accomplished. This would result in thicker soil in which to root plants nearer the base of the steep portion of the current partially constructed slope. With this option, the encroachment on the beach, south of the existing sea wall at the toe of slope will be generally about 20 feet.

A transition to the new soil slope from the existing full thickness shotcrete wall section would be required. To maintain stability within this transition zone, we recommend that maximum transition slopes be maintained at no steeper than 2H: 1V. At the join line of the transition zone and existing 10 inch thick shotcrete, we recommend excavation of at least a 2-foot wide by 12-inch deep (relative to the top of existing shotcrete) trench and placement of clean angular 2-inch drain rock. This will provide a drainage path for moisture at the join and will reduce erosion at the toe of the new fill. The drain trench will need to be constructed for the full height of the slope.

CONCLUSIONS

Biotechnical alternatives exist for partially constructed Bluff stabilization areas. To work, shotcrete would have to be removed and anchors not disturbed in so doing. Slope re-grading would have more development permit requirements and more impact on the beach and area below the bluff than the biotechnical options. Slope grading would reduce the appearance of the bluff to simply that of a graded slope. Slope grading will also modify the useable width of property at the beach or park (toe or the top of the slope).

All biotechnical stabilization alternatives will require significantly more maintenance than the previously designed and partially constructed shotcrete with planter pocket approach due to the intensity and function of the vegetation. Without successful vegetation on the slope, erosion and surficial instability will continue, hence biotechnical options hold greater risk for future instability than does the designed shotcrete slope. The life expectancy of the structural components of the soil nail wall or graded slope exceed that of the other biotechnical options.

LIMITATIONS

Our services were performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided.

This report contains general information regarding conceptual and feasible measures for implementation of biotechnical slope stabilization at the subject project. This report is not intended as a specification document and does not contain sufficient information for this use.

CLOSING

We appreciate the opportunity to be of service on this project. Please contact the undersigned if you have any questions, comments or require additional information.

Respectfully submitted,

KLEINFELDER, INC.

Mariusz P. Sieradzki, PhD, PE, GE
Senior Project Manager

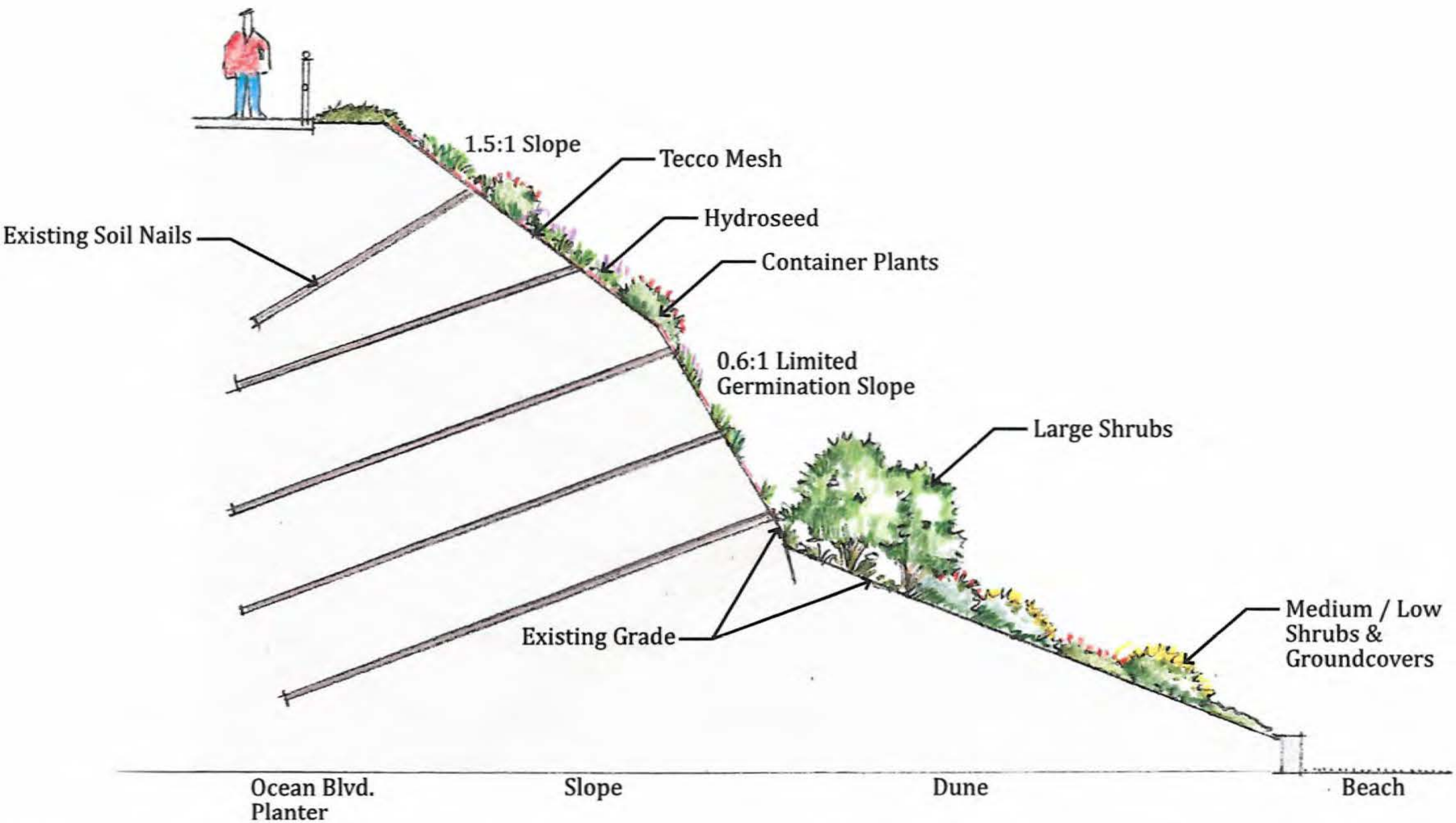
Lawrence N. Perko, PE, GE
Senior Principal Geotechnical Engineer

Attachments:

Appendix A - Conceptual Cross Section (RJM Design Group)
Appendix B - Vegetation Establishment Feasibility (Tidal Influence)

APPENDIX A

CONCEPTUAL CROSS SECTIONS
(RJM DESIGN GROUP)

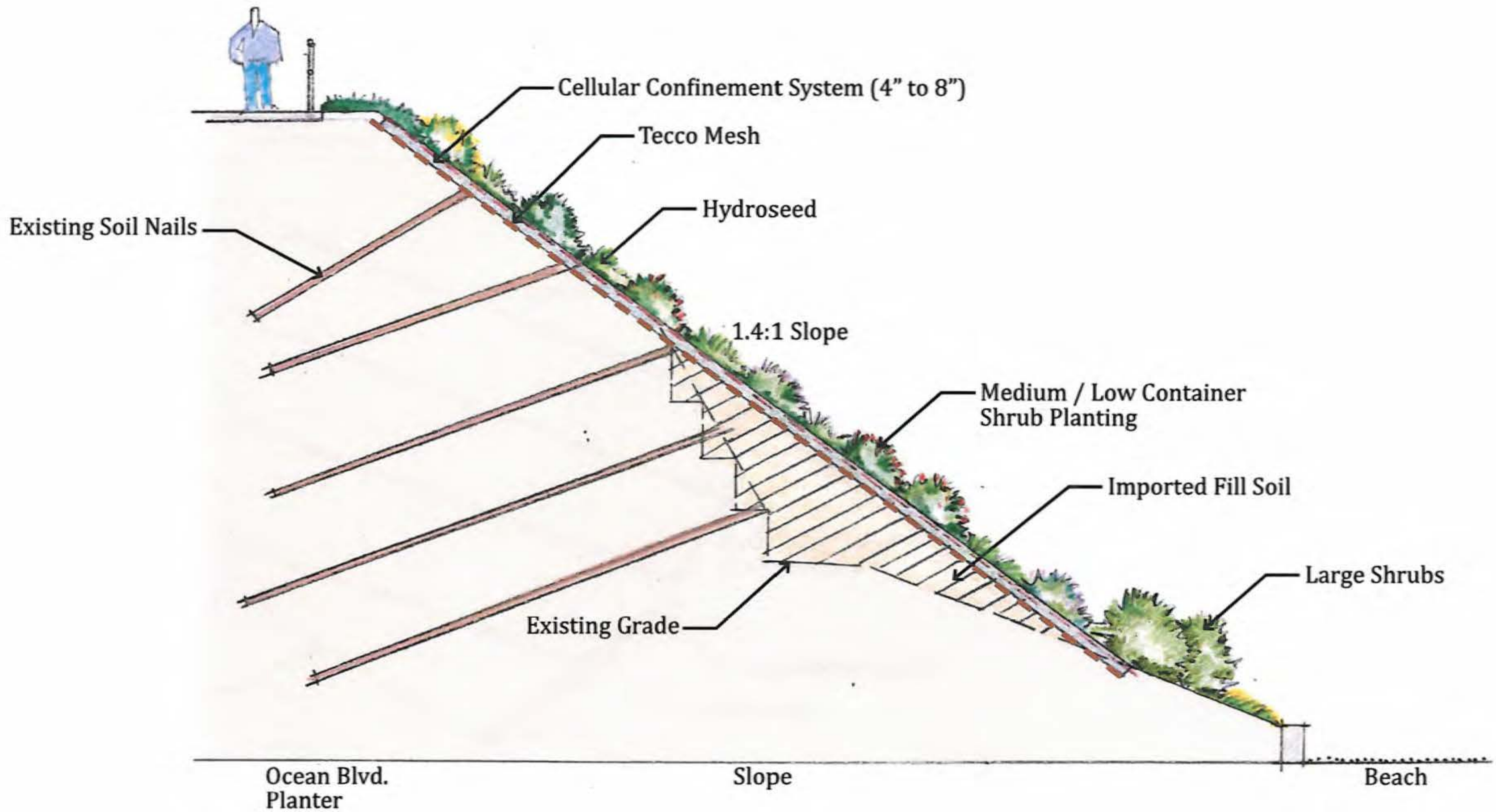


12/3/2014

AREA 1 - OPTION 1 - TECCO MESH/HYDROSEED/SHRUB/VINE CUT OUTS

OCEAN BOULEVARD BLUFFS EROSION AND ENHANCEMENT PROJECT
BIO-TECHNICAL SLOPE STABILIZATION

CITY OF LONG BEACH, CALIFORNIA



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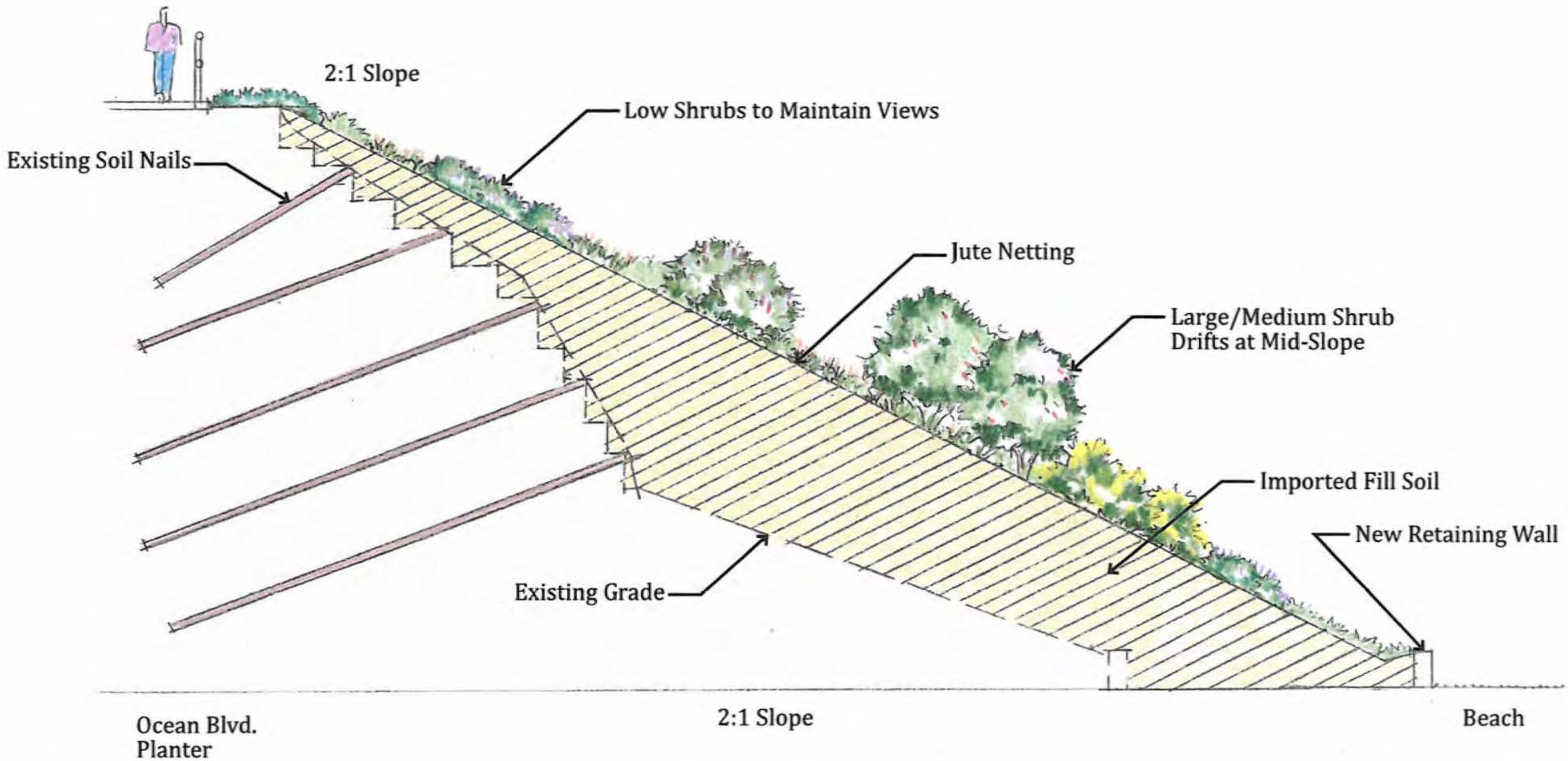
AREA 1 - OPTION 2 - TECCO MESH/CELLULAR CONFINEMENT SYSTEM/HYDROSEED/SHRUB

OCEAN BOULEVARD BLUFFS EROSION AND ENHANCEMENT PROJECT
BIO-TECHNICAL SLOPE STABILIZATION

CITY OF LONG BEACH, CALIFORNIA



12/3/2014

AREA 1 - ALTERNATE OPTION - RE-GRADE TO 2:1 SLOPE

OCEAN BOULEVARD BLUFFS EROSION AND ENHANCEMENT PROJECT
BIO-TECHNICAL SLOPE STABILIZATION

CITY OF LONG BEACH, CALIFORNIA

APPENDIX B

VEGETATION ESTABLISHMENT FEASIBILITY
(TIDAL INFLUENCE)

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Memorandum

To: Mariusz Sieradzki, Kleinfelder

From: Eric Zahn and Taylor Parker, Tidal Influence, LLC

Cc: Eric Lopez, City of Long Beach;
Andrew Quinn, City of Long Beach;
Larry Mouri, RJM

Date: November 18, 2014
Subject: Vegetation Establishment Feasibility for the Phase 2 Ocean Blvd. Erosion/Enhancement Project (Construction Areas 1 and 2) Biotechnical Engineering Solutions

The purpose of this communication is to present an analysis and evaluation of vegetation establishment feasibility utilizing biotechnical engineering solutions in-lieu of Shotcrete on the Ocean Boulevard Erosion and Enhancement Project. After considering a wide range of approaches, the City of Long Beach requested for us to consider the applicability of the TECCO® System and Cellular Confinement for this project in regards to vegetation establishment. These considerations are based on a review of provided biotechnical engineering literature and our analysis of specific constraints related to the project site and local reference sites. Analysis is limited to Construction Area 1 and a portion of Construction Area 2. Furthermore, this analysis is only in regards to the feasibility of vegetation establishment and not seismic stability or other considerations.

Natural Coastal Bluff Systems

It is important to recognize how the Long Beach Bluffs were formed originally. They are composed of sandstone that likely was once a raised sea terrace that became exposed when sea level dropped during the most recent ice age a millions of years ago. These sea terraces remain exposed presently and the sandstone that composes them naturally erodes due to the forces of rain and gravity. This erosion is exacerbated by human disturbance from the construction of recreational/access facilities, climbing, digging, and installation of improper vegetation. These compounding erosion pressures lead to the bluff faces being steep in grade. This steep grade makes it a challenge for vegetation to naturally establish itself. Figure 1 shows photographs of four southern California natural bluff systems and the apparent depravity of vegetation where slopes are steep.

The Long Beach Bluffs are no longer natural and are now heavily constrained. Stabilizing bluffs is a common issue for coastal communities to protect infrastructure and promote human safety along beaches. Finding solutions to stabilize this particular system in an attractive manner is a significant challenge. Vegetation can play a critical role in providing integrity to a bluff face and there are a variety of methods that can be applied depending on the situation. According to Myers (1993) the practicality of utilizing different vegetation establishment techniques depends on the slope angle. They provide 6 alternatives for vegetation establishments (seeding, container or bare root, live staking, contour wattling, brush layering, and avoidance/retreat or biotechnical solutions) and state that slope steeper than 1.5H:1V will not be stabilized just with the installation of vegetation.

Figure 1. Southern California natural coastal bluff systems. A. Huntington Beach; B. Palos Verdes Peninsula (Pointe Vicinte); Del Mar (Torrey Pines State Beach); D. Goleta (UCSB campus)

Current Conditions

The subject bluffs are steeper than a 1.5H:1V slope; therefore, outside of shotcrete, biotechnical engineering solutions must be employed in order to both stabilize the system and allow for vegetation to establish itself. Avoidance/retreat is not an option in order to preserve Bluff Park.

Currently Construction Area 1 has been treated with soil nails and small patches of thin concrete are apparent around some of the soil nails. Otherwise the native bluff soil remains exposed. Meanwhile, the Shotcrete work in Construction Area 2 is about one-third complete, with the remaining portions of the site containing exposed soil nails and up to four inches of superficial concrete. This concrete layer is perforated where the planter pocket locations were specified. Biotechnical engineering solutions for both of these locations are being considered.

<u>Area 1 Opportunities and Constraints to Vegetation Establishment</u>
Opportunities: Soil nails present, Native soil still exposed
Constraints: Steep slope; Fine grained soils; Close proximity to staircase
<u>Area 2 Opportunities and Constraints to Vegetation Establishment</u>
Opportunities: Soil nails present
Constraints: Steep slope; Native soil covered by concrete, Must match slope with already shotcreted portion

Feasibility of Vegetation Establishment

The vegetation establishment effort has three primary objectives: 1) rapid bluff face coverage, 2) aesthetics, and 3) protection against surface soil erosion. In-lieu of Shotcrete, Tidal Influence has been requested to prepare an analysis of vegetation establishment prospects when utilizing the TECCO® system or Cellular Confinement. With soil nails already installed throughout all locations, large-scale sloughing is not a concern and the TECCO® system or Cellular Confinement will help hold the bluff face in place.

The TECCO® slope stabilization system is a mitigation system consisting of a mesh of high-tensile steel wire. It is used in combination with soil and/or rock nails to stabilize steep slopes in unconsolidated material and rock liable to slip and break out. Vegetation would grow through the mesh and establish itself into the bluff face with the potential of additional topsoil being introduced. The mesh size is around 2.5 inches wide, but modifications can be mode for cut-outs to allow for larger plants to be installed.

Cellular Confinement is a treatment composed of a geotextile material that forms cells that can be fastened to the slope with anchor pins. It is most successful for slopes flatter than 1.5H:1V, however, it has been successfully installed on steeper slopes. Once fastened in place, these cells can be backfilled with local topsoil and vegetated. As these cells typically run between 4 to 8 inches deep and wide, this approach provides a greater soil volume for plant root establishment, allowing for a combinations of container plants and hydroseeding to be utilized.

The pros and cons of two vegetation establishment options have been analyzed:
1) TECCO® Mesh System with Hydroseed and shrubs/vines
2) Cellular Confinement with shrubs and hydroseed.

We have also included analysis of an alternative option for consideration that does not utilize the TECCO® system or Cellular Confinement. This alternative presents the option of re-sloping the bluff face so that it is constructed with a more gradual slope similar to the western extent of Bixby Park's bluff face. This slope would likely extend outside of the current project boundary.

Following are brief descriptions of the different vegetation establishment alternatives:

<u>Option #1 - TECCO® System with hydroseed and shrub/vine cut outs</u>: This option would include the application of a hydroseed mix to the bluff surface before the TECCO® metal mesh has been installed. The hydroseed mix will be comprised of plant species that will not have stem widths that may grow larger than the mesh diameters (approx. 2.5 inches wide). A potential hydroseed mix is provided in Table 2. Additionally cut-outs would be created in the mesh to allow for the installation of container shrubs throughout the bluff face. A potential shrub/vine plant palette is provided in Table 3.

<u>Option #2 – Cellular Confinement with hydroseed and shrubs</u>: This option would involve altering the bluff face by import of additional top soil so that it is a smooth 1.4:1 slope instead of the sheer slope that currently exists. After some regrading the TECCO® metal mesh would be applied to hold the new soil in place. Then a Cellular Confinement geotextile material would be installed over this new slope face to provide areas for top soil to be applied and vegetation installed. Any new soil introduced for this alternative should be a clean fine-grained silty sand that is debris free. Container plants would be installed with uniform spacing throughout the cell grid and a hydroseed mix would spread between those container plants.

<u>Alternative Option - Bluff re-sloping</u>: This alternative option would not implement the use of the TECCO® System or Cellular Confinement. Instead it would involve the import of additional soil to the bluff face similar

to Option #2, but would be built at a gentle enough slope (2:1) so that the bluff face would be properly stabilized by vegetation and without any biotechnical engineering. Any new soil introduced for this alternative option should be clean fine-grained silty sand that is debris free. Initially superficial erosion would be controlled by the application of a biodegradable burlap mesh until the vegetation is established. A combination of hydroseeding and container plant installation would be feasible for this alternative. Since the constraints of the TECCO® system mesh size would no longer exist, the hydroseed mix could include thicker stemmed plant species similar to those utilized in the hydroseed mix for the toe slope of construction area 3. No special accommodations for container plants would be required.

Figure 2. Photo of vegetation growing through Tecco mesh. Source: geostablization.com

Figure 3. Photo of vegetation growing in a cellular confinment grid. Source: geosoulutionsinc.com

Alternatives Analysis

Table 1. The pros and cons for the 2 vegetation establishment biotechnical engineering options compared with those of an alternative re-sloping option and the original Shotcrete treatment.

Vegetation Establishment Alternative	Pros	Cons
Option #1 **TECCO® Mesh System with Hydroseed and Shrub cut-outs**	• Use of native bluff soils • Shrubs will help hold fine grained sediment • Shrubs will display vegetative establishment faster than hydroseed alone • Steep slopes deter climbing and vagrancy • Will fit within current project boundaries • No imported soil needed	• Better for controlling erosion of coarse grained soils & rocks • Mesh shrub holes are labor intensive • Steep slopes will limit locations for successful shrub establishment • Intensive maintenance the first 2 years • Irrigation design challenge • Fire concerns (grasses & annuals)
Option #2 **Cellular Confinement with Hydroseed/Shrubs**	• Faster vegetation establishment than steeper options • More topsoil available for shrub establishment • Less chance of soil surface erosion • Irrigation design less complex than steeper options • Will fit within current project boundaries	• Easier to climb • Higher potential for vagrancy • Necessary soil import may be costly • Shrub size limited by cell size • Resloping in Area 2 will not match slope of existing Shotcrete
Alternative Option **Bluff Re-sloping**	• No biotechnical materials or Shotcrete required • Affordable erosion control with biodegradable burlap mesh • Irrigation design simplified • Container plants easier to install • Visible vegetation establishment faster • Broader plant palette options	• Will not fit in current project boundary and will consume a portion of the beach • Permit intensive • Easy to climb • Soil import may be costly • Resloping in Area 2 will not match slope of existing Shotcrete
Shotcrete	• Vegetation plan already designed • No exposed surface soils that may erode • Steep slopes deter climbing • Easier maintenance of bluff face vegetation • Irrigation system already designed	• Limited soil surface for plant establishment on bluff face • Blank space will take more time to cover

References

Myers, Rian D. 1993. Slope Stabilization and Erosion Control Using Vegetation: A Manual of Practice for Coastal Property Owners. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia. Publication 93-30. http://www.ecy.wa.gov/programs/sea/pubs/93-30/index.html.

Potential Plant Palettes

Table 2. Potential hydroseed mix plant species for the four biotechnical alternatives.

Common Name	Scientific Name	Opt #1	Opt #2	Alt Opt
<u>Wildflowers</u>				
Arroyo Lupine	*Lupinus succulentus*	x	x	x
Beach evening primrose	*Camissonia cheiranthifolia*	x	x	x
Blue dicks	*Dichelostemma capitatum*	x	x	x
Blue-eyed grass	*Sisyrinchium bellum*	x	x	x
California Goldfields	*Lasthenia californica*	x	x	x
California Poppy	*Eschscholzia californica maritime*	x	x	x
Pink sand verbena	*Abronia umbellate*	x	x	x
Red sand verbena	*Abronia maritime*	x	x	x
Sea pink	Armeria maritime	x	x	x
Seaside Heliotrope	*Heliotropium curassavicum*	x	x	x
Yarrow	*Achillea milliflorum*	x	x	x
<u>Grasses</u>				
Alkali sacaton	*Sporobolus airoides*	x	x	
California fescue	*Festuca californica*	x	x	
California melic	*Melica imperfect*	x	x	
Deergrass	*Muhlenbergia rigens*	x	x	
Purple needle grass	*Nassella pulchra*	x	x	
Saltgrass	*Distichlis spicata*	x	x	x
Tall flatsedge	*Cyperus eragrostis*	x	x	
Toad rush	*Juncus bufonius*	x	x	
<u>Small Shrubs</u>				
California buckwheat	*Eriogonum fasciculatum*		x	x
California sagebrush	*Artemisia californica*		x	x
California sunflower	*Encelia californica*		x	x
Deerweed	*Acmispon glaber (Lotus scoparius)*		x	x
Sea dahlia	*Coreopsis maritime*		x	x
Sticky monkeyflower	*Mimulus aurantiacus*		x	x
Wishbone bush	*Mirabilis californica*		x	x

Table 3. Potential container plant species (shrubs and vines) for the four biotechnical alternatives.

Common Name	Scientific Name	Opt #1	Opt #2	Alt Opt
Shrub/Vines				
Mock heather	*Ericameria ericoides*	x	x	x
Big pod ceanothus	*Ceanothus macrocarpus*	x	x	x
Bladderpod	*Peritoma arborea*	x	x	x
Bush poppy	*Dendromecon harfordii*	x	x	x
California fuschia	*Epilobium canum*	x	x	x
Catalina island mallow	*Lavatera assurgentifolia*	x	x	x
Cleveland sage	*Salvia clevelandii*	x	x	x
Coastal strawberry	*Frageria chiloensis*	x	x	x
Gumplant	*Grindellia camporum*	x	x	x
Holly-Leaf cherry	*Prunus illicifolia*	x	x	x
Laurel sumac	*Malosma laurina*	x	x	x
Lemonade berry	*Rhus integrifolia*	x	x	x
Morning glory	*Calystegia macrostegia*	x	x	x
Sawtooth goldenbush	*Hazardia squarrosa*	x	x	x
Sea daisy	*Erigeron glaucus*	x	x	x
Showy island snapdragon	*Galvezia speciosa*	x	x	x
St. Catherine's lace	*Eriogonum giganteum*	x	x	x
Toyon	*Heteromeles arbutifolia*	x	x	x

Exhibit 2

Exhibit 3

Exhibit 4

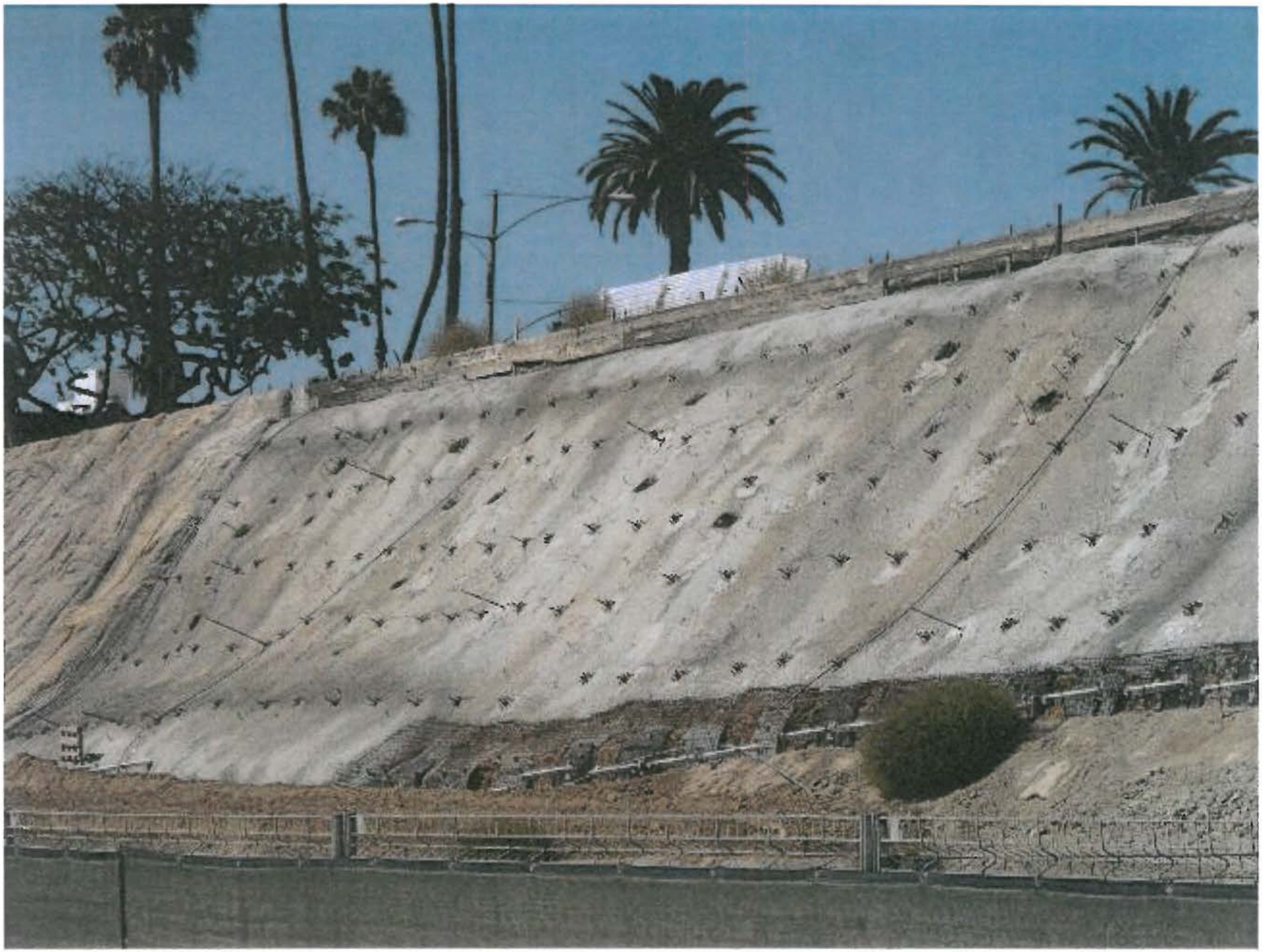

Exhibit 5