GEOLOGIC BLUFF STUDY AND GEOTECHNICAL FEASIBILITY EVALUATION MORRO BAY – CAYUCOS CONNECTOR TRAIL/BIKE PATH HIGHWAY 1 SAN LUIS OBISPO COUNTY, CALIFORNIA

February 15, 2008

Prepared for

County of San Luis Obispo

Prepared by

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February 15, 2008

FILE NO.: SL-15272-GA

Ms. Jan Dileo
County of San Luis Obispo
Department of General Services – Parks Administration
1087 Santa Rosa Street
San Luis Obispo, CA 93408

PROJECT: MORRO BAY – CAYUCOS CONNECTOR TRAIL/BIKE PATH
HIGHWAY 1
MORRO BAY, CALIFORNIA

SUBJECT: Geologic Bluff Study and Geotechnical Feasibility Evaluation

REF.: Proposal to Provide a Geologic Bluff Study and Geotechnical Feasibility Evaluation, Morro Bay – Cayucos Connector Trail/Bike Path, Morro Bay, California, by Earth Systems Pacific, Doc. No. 0703-037.PRP, dated March 2, 2007

Dear Ms. Dileo:

In accordance with your authorization of the referenced proposal, this study has been prepared to determine the effect of the local geologic conditions as related to bluff retreat, erosion and stability for the preferred alignment of the Connector Trail/Bike Path on the west side of Highway One. As part of the study, a long-term bluff retreat rate was also estimated.

A geotechnical feasibility evaluation of the abutment areas on both the east and west sides of the existing Highway One bridge at Toro Creek bridge was also conducted by a Registered Geotechnical Engineer. The purpose of this evaluation was to provide general information regarding site conditions, including identification of any geotechnical characteristics that could constitute a constraint to construction of the proposed abutments. The evaluation was limited to visual observations of the site conditions; no subsurface investigation or laboratory testing was requested or performed. Anticipated foundation requirements and recommendations for a design-level soils engineering report are provided. Four copies of this report are provided for your use.

We appreciate the opportunity to have provided geologic services for this project. If there are any questions concerning this study, please feel free to contact the undersigned at your convenience.

Sincerely,

Earth Systems Pacific

Richard T. Gorman, C.E.G.

Date Signed: 2-15-08

Fred J. Potthast, G.E.

Date Signed: 2/15/08

Doc. No.: 0802-084.RPT/tl

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APPENDIX

1.0 INTRODUCTION

Planned Development

The project will consist of a Connector Trail/Bike Path (herein referred to as the "Bike Path") extending from the north end of Morro Bay to the south end of Cayucos, California. The preferred alignment of the Bike Path is along the west side of Highway 1; if this alignment does not receive California Coastal Commission approval, the alignment will follow the east side of the highway. This report only addresses the geologic conditions of the preferred alignment on the west side of Highway 1; geotechnical feasibility of the abutment areas on both east and west sides of the existing Highway 1 bridge over Toro Creek was evaluated.

The section of the Bike Path addressed for the geologic bluff study extends along the edge of the ocean bluff from the north end of Toro Lane in Morro Bay to the south end of Studio Drive in Cayucos, (see the Path Alignment Plans in the Appendix). With the exception of a bridge crossing at Toro Creek and where it will cross an existing rock rip-rap protection structure, the Bike Path will be surfaced with asphalt concrete. Wood planking will most likely be used for the bridge deck and to span the rip-rap. New abutments will be necessary to support the bridge over Toro Creek; it is unlikely that the existing Highway 1 bridge will be augmented or enlarged to support the Bike Path.

For our study, we were provided with the appended as Path Alignment Plans prepared by Boyle Engineers Group.

Purpose and Scope of Work

Geologic Bluff Study

The purpose of the bluff study was to evaluate the on-site geologic structure, stratigraphy, and geomorphology that would influence bluff retreat and stability. This study encompassed the following work:

1. Review of geologic maps, topographic maps and reports pertinent to the area.

2. Field mapping of geologic features observable at the ground surface along the proposed Bike Path and on the bluff face.

3. Analysis of the accumulated data.

4. Bluff retreat analysis.

5. Preparation of this report with associated graphics.

This report is intended to be in accordance with the requirements of the San Luis Obispo County Coastal Zone Land Use Ordinance, and common engineering geologic practices in this area under similar conditions at this time.

Geotechnical Feasibility Evaluation

The purpose of the geotechnical feasibility evaluation was to provide general information regarding site conditions, including identification of any geotechnical characteristics that could constitute a constraint to construction of bridge abutments. The evaluation encompassed limited visual observations of the site conditions only; no subsurface investigation or laboratory testing was requested or performed. Anticipated foundation requirements and recommendations for a design-level soils engineering report are provided. The evaluation was conducted in accordance with common geotechnical engineering practices in this area under similar conditions at this time.

Site Setting

The Bike Path is planned to extend from the north end of Morro Bay to the south end of Cayucos, a distance of approximately 1 mile. The alignment is bounded to the west by an ocean bluff and the Pacific Ocean, and to the east by Highway 1. The route is essentially flat, with one crossing over Toro Creek. The ocean bluff varies in height from about 6 feet at the northern end to about 25 feet at the southern end.

2.0 GEOLOGIC BLUFF CONDITIONS

The bluff generally consists of a gently westerly sloping wave cut terrace that is capped predominantly by marine terrace deposits. Parts of the bluff face and bluff top are covered by sand dune deposits. In some areas along the bluff the wind blown dune sand accumulates on the bluff top and bluff face extending these areas towards the ocean causing an accretion effect of the bluff. Descriptions of geologic features in the bluff are addressed in the following text. The geologic features are identified on the Bluff Photographs in the Appendix.

Feature 1

Sandstone bedrock is exposed in the lower half of the bluff face. The bedrock is approximately 5 feet high and overlain by 5 feet of marine terrace deposits. The top of bluff is covered with a thick growth of ice plant. The bluff face is cut by an erosional gully created by drainage from a culvert below Highway 1.

Feature 2

A small pocket beach is present in this area. The sandstone bedrock exposed in the bluff face is less than 3 feet high, and is overlain by 4 to 5 feet of marine terrace deposits.

Feature 3

Sandstone bedrock is approximately 5 to 7 feet high, and is overlain by 2 to 4 feet of terrace deposits. The bedrock forms a small point at this location.

Feature 4

This bluff area consists of two small pocket beaches that were formed by surface water erosion of the bluff top, and sea wave attack at the bottom. The bluff face in this area exposes about 5 to 6 feet of terrace deposits.

Feature 5

In this location there is an isolated block of sandstone exposed in the bluff face that is bounded both upcoast and downcoast by terrace deposits. Dune sand/beach deposits cover the lower part

of the bluff. Down coast of Feature 5, the sandstone bedrock appears to have been eroded and/or covered with dune sand, it is not exposed in the bluff face.

Feature 6

In this area the ocean bluff consists of a small exposure of terrace deposits that are capped by dune sand deposits. The dune sand is covered with a thick growth of ice plant.

Features 7a & 7b

This stretch of ocean bluff consists of occasional isolated blocks of metavolcanic/serpentinite rock that are approximately 3 to 6 feet high, capped by 4 to 5 feet of terrace deposits and dune sand. The bedrock appears to be generally buried in this area, as only terrace deposits and dune sand are exposed in the bluff face.

Feature 8

Toro Creek has eroded a corridor through the bluff at this location. The bluff up coast of the creek consists of a thick deposit of dune sand that has buried the bedrock and terrace deposits. Alluvium capped by dune sand was observed downcoast of the creek.

Feature 9

A wooden post and plank structure is present along the bluff and it appears to be in good condition. This structure was the landfall of a pier used for off-loading of tanker ships for storage at the facility on the east side of Highway 1. The pier was never rebuilt after its destruction during winter storms in the early 1980s.

Feature 10

Adjacent to the post and plank structure, dune sand has buried a rip-rap bluff protection structure. The rip-rap structure is exposed approximately 200 feet downcoast and extends to a broad, rocky sandstone point. A small cluster of rip-rap is exposed adjacent to a drainage culvert downcoast of the post and plank structure.

Feature 11

A rip-rap structure lies along the ocean side shoulder of Highway 1. It is approximately 6 feet high and about 300 feet long. Although some boulders have fallen off the structure face and onto the beach, the structure appears to be in good condition.

Feature 12

A broad, sandstone rock point lies at the southern end of the proposed Bike Path. Sandstone is exposed in the bluff face, which various from 15 to 25 feet high.

3.0 BLUFF RETREAT

Methodology

To estimate the bluff retreat rate at the site, a historical aerial photograph analysis was conducted. For this analysis, primary data consisted of vertical stereographic aerial photographs proximal to and covering the site acquired in November, 1963 and May, 2005. These photographs were interpreted in combination with USGS topographic maps, oblique pictorial aerial photography and *in situ* ground level imagery.

The aerial photographs and site-specific ancillary data were processed and compiled in a digital database at a common format and scale. Stereographic interpretation of the aerial photography was first performed to determine the bluff conditions in 1963. These conditions were then combined with data derived by similar interpretation of the 2005 photography. Bluff edge locations for the two dates were co-registered and measurements were made using standard manual photogrammetric procedures and digital image processing and geographic information system techniques. Areas of maximum erosion and accretion were identified and measured. Annual maximum bluff loss and accretion rates were calculated for the 42 year period between November, 1963 and May, 2005. These results were then used to project maximum bluff loss and accretion for a 100 year period, as indicated on the Bluff Retreat Analysis Mosaic in the Appendix.

This analysis indicates that during the period between November, 1963 and May, 2005:

1. The maximum bluff retreat on the site was measured at 62 feet.
2. The maximum bluff accretion on the site was measured at 58 feet.
3. The maximum bluff retreat rate was calculated as 17.7 inches/yr.
4. The maximum bluff accretion rate was calculated as 16.8 inches/yr.
5. The maximum projected 100 year bluff retreat was calculated as 147.5 ft.

4.0 GEOTECHNICAL EVALUATION OF BRIDGE ABUTMENTS

On September 4, 2007, a Registered Geotechnical Engineer of this firm conducted a site reconnaissance of the east and west sides of the Highway 1 bridges over Toro Creek where a bridge structure is anticipated for the Bike Path. As the project is in the planning stages, the location of the proposed bridge (i.e. the east or west side of Highway 1) has not been identified. We have assumed that, regardless of its location, the Bike Path bridge will likely be placed immediately adjacent, but not structurally connected to, the highway bridges.

We understand that the bridge is envisioned to be a prefabricated clear span structure, supported only at the abutment ends. The bridge is anticipated to be designed for pedestrian and bicycle use only, and will not carry vehicle loads. Depending on the exact locations of the abutments, the span width may be in the range of 110 to 130 feet.

It appears that the existing Highway 1 bridges are supported by three rows of columns each, probably bearing on driven or drilled piles well below the bottom of the creek, with abutments at each end. Support for the existing abutments at the ends (either piles or conventional foundations) could not be determined during the field reconnaissance. The north and south banks of the creek on the west side of the bridges, as well as the areas beneath both bridges, are armored with rip-rap. Rip-rap and possible remnants of another bridge foundation are also present on the south creek bank, on the east side of the bridges. Significant vegetation precluded

a thorough examination of the north side of the creek bank on the east side of the bridges, however it appears that there may be little if any rip-rap armoring of the creek bank in this area. It also appears that some of the rip-rap below the bridges has sloughed into the creek, at least to the first line of columns on both sides of the creek.

The creek bank material below the rip-rap is alluvium, with bedrock at depth. The alluvium may be poorly consolidated above the bedrock, and there is a potential that the creek bank areas may be susceptible to liquefaction and lateral spreading in the event of a seismic event. The alluvial soils may also be expansive, which could have a minor effect on the foundation system and any adjacent approach pavement.

Considering the planned clear span distance over Toro Creek, the proposed Bike Path bridge will probably generate moderate foundation loads. Abutments located behind the top of the creek bank supported by conventional foundations may be possible, but the depth required to reach competent material and support the anticipated loads, while mitigating the possible effects of liquefaction and lateral spreading, may be significant. Also, as the exact thickness of the rip-rap armoring on the creek banks is unknown, it may be necessary to remove a considerable amount of the rip-rap in order to establish the foundation area to support the abutments. In our opinion, a more feasible foundation alternative may be the placement of drilled, cast-in-place caissons or driven piles to support the abutments. Drilling for caissons or driving of the piles may only require the removal of rip-rap in a limited area. The caissons/piles could be constructed with their tops closer to the existing grade, thus requiring less excavation for a final grade beam/abutment structure to connect the caissons/piles and support the bridge. A caisson/pile foundation would also provide ample capacity for support, which may allow a slightly longer clear span length for the bridge, thus reducing the potential to impact the creek and its banks during and after construction. Lastly, a properly designed caisson/pile foundation would mitigate the potential for liquefaction, lateral spreading and/or slumping of the creek banks to affect the structure.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Bluff Retreat

Based on the results of the bluff retreat analysis, the maximum bluff retreat was estimated to 17.7 inches per year in the vicinity of Geologic Features 1 through 8. In some areas along this part of the proposed Bike Path dune sand has been deposited on the bluff top and face, causing accretion of the bluff. This dune sand bluff accretion was neglected in the retreat analysis due to its low resistance to sea wave erosion. Using the bluff retreat rate of 17.7 inches per year, the setback distance would be approximately 147 feet, which in most areas would be within the current alignment of Highway 1. In the vicinity of Features 8 through 11, a bluff retreat rate could not be established due to the extensive grading that took place in the late 1950's and early 1960's, and the presence of the rip-rap that was placed in the early 1960's. As the bluff top in this area is less than 15 feet from the west edge of pavement Highway 1, the proposed Bike Path would likely be within the setback zone. North of Toro Creek, the Bike Path will also be within the setback zone. As the Bike Path is considered to be a sacrificial structure, it is our understanding that it cannot be protected from sea wave impact or erosion. If the Bike Path is severely damaged due sea wave impact or erosion, it is recommended that provisions be made to remove any resultant from the public beach area.

Bridge Abutments

All of the impacts discussed in Section 5.0 above are considered significant but mitigable. The final site selected for the structure should be addressed in a soils engineering report conforming to the applicable sections of the California Building Code. A subsurface exploration and analysis should be performed to determine the potential for liquefaction and lateral spreading. Laboratory tests should be performed to determine the strength and expansion characteristics of the bearing materials. The report should present seismic parameters for use in structural design, and should contain recommendations, as applicable, for mitigation of erosion, liquefaction, lateral spreading and surficial slumping along the creek banks. The design and construction of the proposed structure should conform to the recommendations presented in the soils report and the applicable sections of the California Building Code.

6.0 CLOSURE

This report is valid for conditions as they exist at this time for the type of protection structure described herein. Our intent was to perform this study in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in the locality of this project under similar conditions. No representation, warranty, or guarantee, is either expressed or implied.

If changes to the project become necessary, if items not addressed in this report are incorporated into plans, or if any of the assumptions stated in this report are not correct, this firm should be notified to provide modifications as necessary to this report. Any items not specifically addressed in this report are beyond our scope of services.

If future property owners wish to use this report, such use will be allowed to the extent the report is applicable, only if the user agrees to be bound by the same contractual conditions as the original client, or contractual conditions that may be applicable at the time of the report's use.

End of Text.

REFERENCE

California Building Code, 2001 Edition.