Cave Landing Road - Emergency Access
County of San Luis Obispo, California

Alternative Overview

Based on Fugro's October 17, 2007 Preliminary Geotechnical Report five structures types were considered, evaluated and rated. The structures are a bridge-viaduct, soldier pile wall, retaining wall, mass grading, and a land bridge. The factors considered were, estimated cost, environmental impact, maintenance, and performance. The two key factors being estimated cost and environmental impact. Each factor was given a rating from 1 to 10,
10 being the best. The ratings were then totaled and each structure given an average rating.

The results are as follows:

	Estimated Cost*	Environmental Impact	Maintenance	Performance	Average Rating
Bridge-Viaduct	4	9	9	9	7.75
Solider Pile Wall	5	7	7	8	6.75
Retaining Wall	6	5	8	6	6.25
Mass Grading	6	2	8	8	6.00
Land Bridge	9	7	6	5	6.75

*preliminary estimates attached, based on County and Cal-Trans contract cost data

The Bridge-Viaduct's estimated 2007 cost is the most at $19,022,000.00; its site disturbance is the least due the relatively small amount of peers needed to support the structure. It is virtually maintenance free, and will perform for 80 years.

The Solider Pile Wall 2007 cost is estimated at $17,707,000.00; its site disturbance is moderate, the asphalt roadway and timer lagging will require maintenance, and will perform well.

The retaining walls 2007 cost is estimated at $14,419,000.00; its site disturbance is more than the soldier pile wall, the asphalt roadway will require maintenance and the wall may creep lowering its performance.

The Mass Grading 2007 cost is estimated at $14,960,000; its site disturbance would be very large in comparison to the other alternatives, the asphalt roadway will require maintenance and the re-compacted fill may have settlement problem lowering its performance.

The Land Bridge 2007 cost is the is estimated at $4,134,000.00; its site disturbance is moderate, the asphalt roadway will require maintenance, and the performance is very low due the possibility of total soil failure.

In conclusion, based on environmental impact, performance, and maintenance the Bridge-Viaduct is recommended.

Dan Erdman P.E.
Department of Public Works

Bridge Viaduct
Preliminary Cost Estimate

Item Description	Approximate Quantity	Unit of Measure	Unit Price	Total Amount
Bridge	46800	S.F.	$300.00	$14,040,000.00
Design	Lump Sum	L.S.	$500,000.00	$500,000.00
Inspection	Lump Sum	L.S.	$500,000.00	$500,000.00
Environmental	Lump Sum	L.S.	$1,500,000.00	$1,500,000.00
Administration	Lump Sum	L.S.	$200,000.00	$200,000.00
Sub Total				$16,540,019.00
Contingency 15%				$2,481,002.85
Total in 2007				**$19,021,021.85**
* **Total in 2012**				**$22,050,577.50**
* **Total in 2017**				**$25,562,662.82**

* 3% inflation per year

Soldier Pile Wall
Preliminary Cost Estimate

	Item Description	Approximate Quantity	Unit of Measure	Unit Price	Total Amount
	Wall	72000	S.F.	$170.00	$12,240,000.00
	Guardrail	1800	L.F.	$35.00	$63,000.00
	Dike	3600	L.F.	$3.50	$12,600.00
	Drainage	Lump Sum	L.S.	$250,000.00	$250,000.00
	Asphalt Concrete	915	Ton	$90.00	$82,350.00
	Aggregate Base	1250	C.Y.	$40.00	$50,000.00
	Design	Lump Sum	L.S.	$500,000.00	$500,000.00
	Inspection	Lump Sum	L.S.	$500,000.00	$500,000.00
	Environmental	Lump Sum	L.S.	$1,500,000.00	$1,500,000.00
	Administration	Lump Sum	L.S.	$200,000.00	$200,000.00
	Sub Total				$15,397,950.00
	Contingency 15%				$2,309,692.50
	Total in 2007				**$17,707,642.50**
*	**Total in 2012**				**$20,528,010.87**
*	**Total in 2017**				**$23,797,590.80**

* 3% inflation per year

Retaining Wall
Preliminary Cost Estimate

Item Description	Approximate Quantity	Unit of Measure	Unit Price	Total Amount
Concrete	7000	C.Y.	$500.00	$3,500,000.00
Guardrail	1800	L.F.	$35.00	$63,000.00
Excavation	84000	C.Y.	$70.00	$5,880,000.00
Dike	3600	L.F.	$3.50	$12,600.00
Drainage	Lump Sum	L.S.	$250,000.00	$250,000.00
Asphalt Concrete	915	Ton	$90.00	$82,350.00
Aggregate Base	1250	C.Y.	$40.00	$50,000.00
Design	Lump Sum	L.S.	$500,000.00	$500,000.00
Inspection	Lump Sum	L.S.	$500,000.00	$500,000.00
Environmental	Lump Sum	L.S.	$1,500,000.00	$1,500,000.00
Administration	Lump Sum	L.S.	$200,000.00	$200,000.00
Sub Total				$12,537,950.00
Contingency 15%				$1,880,692.50
Total in 2007				**$14,418,642.50**
* **Total in 2012**				**$16,715,158.44**
* **Total in 2017**				**$19,377,449.82**

* 3% inflation per year

Mass Grading
Preliminary Cost Estimate

Item Description	Approximate Quantity	Unit of Measure	Unit Price	Total Amount
Excavation	500000	C.Y.	$20.00	$10,000,000.00
Guardrail	1800	L.F.	$35.00	$63,000.00
Dike	3600	L.F.	$3.50	$12,600.00
Drainage	Lump Sum	L.S.	$250,000.00	$250,000.00
Asphalt Concrete	915	Ton	$90.00	$82,350.00
Aggregate Base	1250	C.Y.	$40.00	$50,000.00
Design	Lump Sum	L.S.	$350,000.00	$350,000.00
Inspection	Lump Sum	L.S.	$500,000.00	$500,000.00
Environmental	Lump Sum	L.S.	$1,500,000.00	$1,500,000.00
Administration	Lump Sum	L.S.	$200,000.00	$200,000.00
Sub Total				$13,007,950.00
Contingency 15%				$1,951,192.50
Total in 2007				**$14,959,142.50**
* **Total in 2012**				**$17,341,746.07**
* **Total in 2017**				**$20,103,836.63**

* 3% inflation per year

Land Bridge
Preliminary Cost Estimate

	Item Description	Approximate Quantity	Unit of Measure	Unit Price	Total Amount
	Pile	3,600	L.F.	$200.00	$720,000.00
	Excavation	20,000	C.Y.	$20.00	$400,000.00
	Guardrail	1,800	L.F.	$35.00	$63,000.00
	Drive Pile	72	E.A.	$1,000.00	$72,000.00
	Drainage	Lump Sum	L.S.	$250,000.00	$250,000.00
	Concrete	1,730	C.Y.	$185.00	$320,050.00
	Steel	234,000	L.B.	$1.15	$269,100.00
	Design	Lump Sum	L.S.	$200,000.00	$200,000.00
	Inspection	Lump Sum	L.S.	$500,000.00	$500,000.00
	Environmental	Lump Sum	L.S.	$1,000,000.00	$1,000,000.00
	Administration	Lump Sum	L.S.	$200,000.00	$200,000.00
	Sub Total				$3,594,150.00
	Contingency 15%				$539,122.50
	Total in 2007				**$4,133,272.50**
*	**Total in 2012**				**$4,791,595.65**
*	**Total in 2017**				**$5,554,772.61**

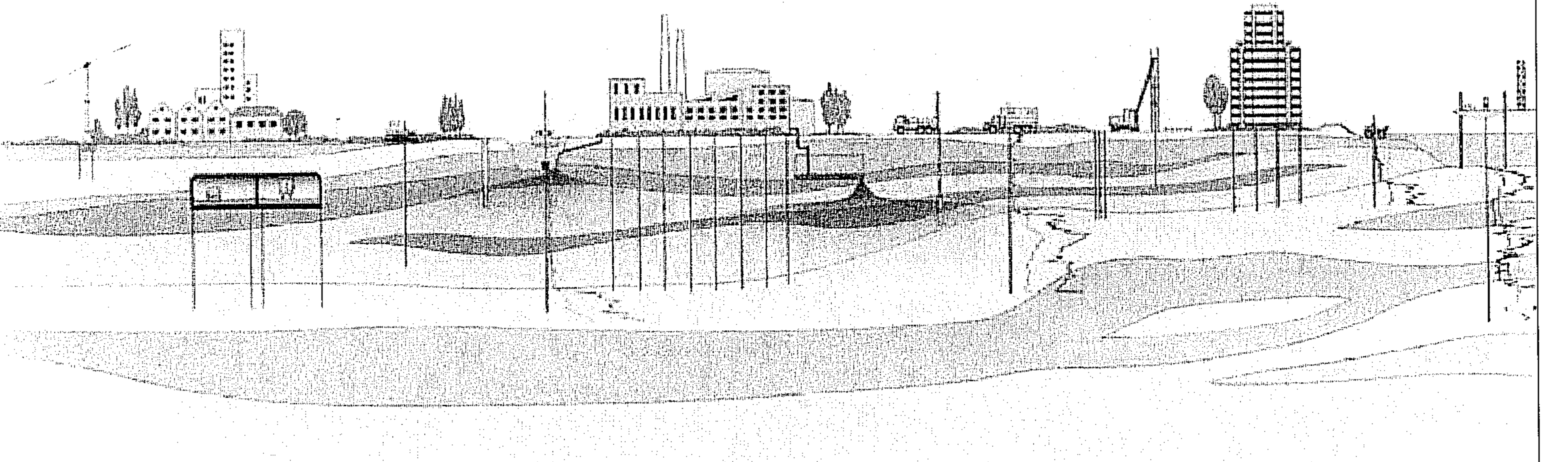
* 3% inflation per year

FUGRO WEST, INC.

PRELIMINARY GEOTECHNICAL REPORT
CAVE LANDING ROAD-BLUFF DRIVE
EMERGENCY ACCESS
SAN LUIS OBISPO COUNTY, CALIFORNIA

Prepared for:
County of San Luis Obispo
Department of Public Works

October 17, 2007



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October 17, 2007
Project No. 3014.028

County of San Luis Obispo
County Government Center, Room 207
San Luis Obispo, California 93408

Attention: Mr. Dan Erdman

Subject: Preliminary Foundation Report, Cave Landing-Bluff Drive Emergency Access, Avila Beach, San Luis Obispo County, California

Dear Mr. Erdman:

Fugro is pleased to submit this Preliminary Geotechnical Report for the emergency access road improvements at Cave Landing. This report was prepared as authorized by the County Blanket Purchase Order No. 25003625 dated June 26, 2007. The purpose of this report is to provide geotechnical input for the initial planning and structure type selection process to create an emergency access route to connect Cave Landing Road to Bluff Drive in Pismo Beach. This report provides a summary of geotechnical considerations that could impact the project (mainly landsliding), and discusses geotechnical alternatives that could be used to help create the emergency access route based on review of existing data. The active landsliding along the alignment is likely to impact the design of the access route, and result in a relatively complex and expensive design. On the basis of our data and site visit, we have provided a summary of the site geology, subsurface conditions, seismicity, and preliminary foundation considerations.

Please contact the undersigned if you have questions or we can be of additional service.

Sincerely,

FUGRO WEST, INC.

Jonathan D. Blanchard, GE 2312
Principal Geotechnical Engineer

Copies: 4-addressee (1 CD ROM)

CONTENTS

LIST OF PLATES

1. PROJECT UNDERSTANDING

The project generally consists of constructing an emergency access route between the existing termini of Cave Landing Road in Avila Beach and Bluff Drive in Pismo Beach. The road will be developed along a coastal route within existing County right-of-way. The location of the site is shown on Plate 1, Vicinity Map.

Cave Landing Road previously extended along the proposed alignment to Bluff Drive. The County has closed the roadway in response to landsliding that impacted the existing route and extended across the right-of-way. The closed portion of the route is approximately 1,600 feet long. This project would reestablish the route to provide emergency access, and would be funded by PG&E for Diablo Canyon. We understand from the County that the route could also be used as a recreational trail for pedestrian and bicycle traffic. The access will be paved and be at least 24 feet wide.

The surrounding terrain generally consists of a marine terrace located along the base of a south-facing hillside and the Pacific Ocean. The route extends along the marine terrace above steep slopes and bluffs that overlook the beach at Pirates Cove. The existing sit grades range from approximately elevation (el.) 166 feet at the parking lot on Cave Landing Road, to approximately el. 194 feet at the high point of the alignment, to el. 125 feet at the cul-de-sac on Bluff Drive. The bluff along the subject route is relatively unstable as a result of active coastal landsliding and erosion. We understand that the County anticipates that structural improvements such as a retaining structure, bridge, or viaduct will be needed to traverse the unstable areas and to mitigate landslide hazards.

2. WORK PERFORMED

2.1 PURPOSE AND SCOPE

The purpose of this report is to provide preliminary geotechnical considerations for the design of an emergency access route that will connect Cave Landing Road to Bluff Drive. As a basis for providing the preliminary geotechnical recommendations presented in this report, we have performed the following scope of work:

1. Visiting the site on August 1, 2007 with Mr. Dan Erdman of the County to observe the alignment and review geologic conditions at the site;
2. Reviewing selected geotechnical information from our in-house files that we previously compiled for the County Planning and Parks Departments regarding the proposed land development and bike trail in this area;
3. Preparing this letter report to provide a summary of the geotechnical conditions at the site, the characteristics of landsliding at the site and how it could impact the project, coastal erosion and estimated retreat, geotechnical alternatives to create the emergency access, and geotechnical considerations for the design of the project. The main alternatives that we evaluated are:

a. Do nothing;

b. Use of retaining structures (such as, gravity, soldier pile, sheet piles, tiebacks, MSE walls, geosynthetics) to retain the slope and provide stability for the roadway;

c. Graded slopes with conventional cut and fill to support the roadway;

d. Slope stabilization with surface and subsurface drains;

e. Provide a bridge or structurally supported roadway across the main landslide areas; or

f. A combination or modification of the above

2.2 PREVIOUS STUDIES

We have reviewed and bee a part of various previous geotechnical studies performed in the project area. The key studies that we reviewed for the project are work by Cotton, Shires & Associates (CSA 2004a, 2004b, 2003). Fugro reviewed the slope stability analyses performed by CSA for the County Planning Department. Fugro (2004, 2005) also provided geotechnical services for the County Parks and Recreation Department to evaluate alternatives for creating a bike and pedestrian trail through the site. CSA performed geologic mapping and slope stability analysis for a residential land development project that was proposed at the Pirates Cove site, and to replace a more limited study performed by GeoSolutions (2003). The GeoSolutions study provides various background geologic maps prepared by England & Associates, the Morro Group, and Cleath & Associates. These studies provide varying interpretations regarding the site geology, faulting, bluff retreat and geotechnical considerations that impact the site.

2.3 GENERAL CONDITIONS

This report is preliminary and is not intended to be used for final design or construction. Fugro prepared the conclusions, recommendations, and professional opinions of this report in accordance with the generally accepted geotechnical principles and practices at this time and location. This warranty is in lieu of all other warranties, either expressed or implied. This report was prepared for the exclusive use of the County of San Luis Obispo and their authorized agents only. It is not intended to address issues or conditions pertinent to other parties or for other uses.

Our characterization of the subsurface and surface conditions is based on observations and explorations performed at specific locations, and the interpolation and extrapolation of data between points of exploration and testing. The boundaries and extent of the subsurface conditions described will vary between points of exploration, and transitions can be gradual. The subsurface soil and groundwater conditions will vary between points of exploration and observation, may change with time, and should be reviewed based on the conditions revealed during design and construction.

3. GEOTECHNICAL CONSIDERATIONS

The following is a summary of the main geotechnical considerations that are likely to impact the design, construction and operation of the emergency access route. The characterization of these considerations is based on review of limited existing information, and will need to be updated for design.

1. The existing County right-of-way along the proposed access road is located on a marine terrace, approximately 120 to 200 feet above the beach at Pirates Cove (see Plate 2). The geologic conditions along the alignment generally consist of surficial soil units of colluvium (Qcol) and terrace deposits (Qt) that overly bedrock units of Obispo Tuff (Tmo, Tmor) and Monterey Formation (Tmm). The marine terrace has been displaced by active landslide deposits (Qls) that extend onto or below the beach at Pirates Cove. The bedrock units exposed along the south-facing hillside upslope of the alignment have been displaced by older landslides (Qoa) and/or faulting. Resistant units of the Obispo Formation (Tmor) crop out south of the access road, and form a prominent point and seacliff (Mallagh Landing) that shelter Pirates Cove from the predominating northwest winter swells.

   The site geology presents a relatively complex geotechnical environment that should be considered in selecting an appropriate design for the access route. The geology, landslide conditions, and bluff retreat are a dynamic coastal environment that will change and will likely need to be continually evaluated relative to slope stability, bluff retreat and coast erosion, earthquakes, and particularly following periods of prolonged or intense rainfall, heavy surf, major storm events, or a combination of these factors.

2. Active landsliding has impacted existing right-of-way along the westerly approximately 600 feet of the alignment. Approximately 20- to 30-foot high, near vertical to steeply sloping scarps associated with the active Pirates Cove Landslide Complex border or encroach into the downslope side of the alignment. The landslide deposits and/or relatively weak bedrock units appear to extend approximately 40 feet or more below the existing ground surface along the right of way. The landslides in this area are active, are likely to continue to migrate upslope, and will likely experience relatively large displacements (10 feet or more) periodically if not mitigated. Tension cracks and smaller scarps are also present upslope of the alignment as shown on Plate 2.

   The design will need to consider mitigation to stabilize or repair the active landsliding to provide the access that can be maintained. The depth and extent of the landslides will likely require a relatively rigorous and costly mitigation to provide reliable access through this portion of the site.

3. East of the active landsliding, the middle third (approximately 600 feet) of the alignment is located at the high point of the site and along the abandoned alignment of Cave Landing Road. The upslope side of the alignment is bordered by older landslides and colluvium deposits. While landsliding in this vicinity does not appear

to be active, grading or excavation that would cut into or undermine the support for the older landslide and colluvium could result in additional slope instability that could impact the access road and slopes upslope of the alignment. Active landsliding (discussed above) and ongoing coastal erosion is encroaching upon the western end of the older landslide deposits, and could eventually remove support from the toe of the older landslides and cause them to reactivate.

Structural or graded slope improvements (if proposed in this area) will need to consider the stability of the hillside in the area of the older landslides and may need to consider mitigation to stabilize the landslides depending on the potential impact that instability of the landslides could have on the proposed access road.

4. The project site is within a dynamic coastal environment. Landslide movements and coastal erosion tend to be episodic events and are likely to occur in response to periods of prolonged or intense rainfall, heavy surf, major storm events, or a combination of these factors. We understand that the project is only considering that the access road would be constructed along the existing County right of way, and therefore moving the access road further away from the coastline to provide a greater setback from the bluff is not an option. The impacts of coastal erosion over the life of the project (next 20 years or more) are likely to be secondary impacts resulting from landsliding as discussed previously in this report.

   Mitigation of coastal erosion and coastal landsliding would be improved by controlling surface drainage; however, aggressive mitigation such as placing rock revetment along the base of the bluff would impact beach access and would likely involve difficult or unfeasible coastal permitting. Beach nourishment, or more passive approaches to mitigating coastal erosion that do not impact beach access, are likely easier to permit; however, the active landsliding that is already occurring above the beach is likely to remain unstable and continue to impact the access road alignment. The concepts presented in this report have therefore focused on improvements that would be performed mainly along the existing right-of-way and away from the beach.

5. Surface drainage is a key element that impacts slope instability and should be considered in the design of the project. The existing surface drainage along the alignment is poorly controlled. There are 3 predominant drainages along the route that discharge into landslide and/or unstable bluff areas: a culvert that discharges into the landslide complex near the gate at the Cave Landing Road parking lot, a culvert that discharges beneath the abandoned Cave Landing Road alignment and into the active landslide mass about midway along the alignment, and a spillway type structure that discharges onto the bluff face near the existing terminus of Bluff Drive. Control of surface drainage is recommended for all of the concepts discussed in this report to direct surface water away from landslide areas and slopes.

6. The groundwater conditions at the site appear complex and are likely influenced by the existing poor surface drainage conditions, faulting within the underlying bedrock, and landsliding. Rising groundwater conditions adversely impact slope stability. Groundwater was reported by CSA (2003) as zones of seepage along joints and shear planes, contacts between geologic units, and along the base of the colluvium

or marine terrace deposits. Groundwater was typically encountered at a depth of approximately 40 feet below the existing ground surface. Springs daylight at various locations along the buff. Groundwater conditions will vary seasonally due to changes in runoff, storm conditions, rainfall, and other factors. The various concepts include provisions for subsurface drainage behind retaining structures or from subhorizontal drains.

7. The site is within a seismically active area, has been impacted by strong ground motion from historical earthquakes, and could be again in the future. Based on review of the Caltrans Seismic Hazard Map (Mualchin 1996) the peak bedrock acceleration for the site is about 0.5g. Mualchin shows several faults near the site that are capable of generating a M6.0 to 7.5 earthquake (such as the Hosgri, Oceano, Santa Maria River-Wilmar Avenue, Los Osos faults). The design of structures should consider the affects of strong ground motion in accordance with applicable design guidelines.

4. PRELMINARY ALTERNATIVES

The following provides a description of the alternatives that were considered to create an emergency access to reconnect the southern terminus of Cave Landing Road in Avila to the northern terminus of Bluff Drive in Shell Beach. These concepts are not intended to be inclusive of all possible alternatives. The most suitable mitigation may be selected for reasons of cost, practical and physical site constraints, aesthetic, simplicity of design or other factors. Various concepts may be better suited for portions of the alignment. The three main segments that should be evaluated are:

1. The western third of the alignment where approximately 600 feet of the alignment is being undermined or impacted by active landslides;
2. The middle third of the alignment where approximately 600 feet of the upslope area is underlain by older landslide and colluvium that are marginally stable and could reactivate if not properly supported by the design and during construction;
3. The eastern third where approximately 600 feet of the existing alignment descends along a relatively constant grade, and active landsliding is occurring downslope of the alignment.

These concepts are provided as a basis for subsequent discussions, and evaluation of structure types or concepts for design. This letter and the attached drawings provide concept-level information and should not be used for final design or construction.

4.1 DO NOTHING

The existing site conditions are summarized on Plate 3. The alignment is potentially unstable as a result of the existing landslide conditions. Active landsliding has impacted the existing alignment, and older landslide deposits are mapped in some areas upslope of the existing alignment. Coastal erosion and poor surface drainage likely contribute to the instability of the site. The existing alignment was closed by the County in response to past landslide movements. Since the route was closed, no site improvements have been performed to mitigate the landslide, surface drainage, or coastal erosion conditions at the site. Instability of the Pirates Cove Landslide Complex has been most common during periods of severe weather (relatively heavy rainfall and high surf). Instability of the landslide tends to be episodic where: portions of the landslide fail to a more stable condition; the debris from the landslide temporarily buttresses that portion of the slope; and other portions of the slope become unstable.

The main factors that appear to impact the stability of the slope are: coastal erosion along the Pirates Cove Beach that removes material from the toe of the landslide; poor surface drainage and the resistant tuff (that outcrops along the westerly flank of the main landslide) that promote perched groundwater conditions within the landslide complex. The landslide movement and bluff erosion have resulted in the alignment being bordered by relatively steep to near vertical slopes that show evidence of creep that is impacting the existing alignment, and are potentially unstable.

4.2 RETAINING STRUCTURES

4.2.1 Conventional Retaining Wall or Reinforced Earth

This concept would generally consist of constructing the new access road on a retaining wall that is embedded below the existing roadway and landslide deposits. The type of wall could likely vary and consist of either a concrete cantilever retaining wall, a variety of reinforced earth/mechanically stabilized embankment (MSE) systems, or a geogrid reinforced embankment (GRE). The key elements of this system would be to support the retaining wall on stable ground below the depth of the existing landslide deposits, and to retain the head scarp and areas upslope of the existing landslide with the new earth retention system. A concept for supporting the access road using an MSE wall system is presented on Plate 4.

The retaining wall would be relatively high, and would likely need to be embedded about 40 to 50 feet below the existing roadway to provide suitable foundation support for the new retaining wall and extend below the Pirates Cove Landslide Complex. The wall would be designed to support the backslope, upslope of the existing landslide complex. Depending on the stability of the older landslides, this concept may not be feasible where older landslide deposits are mapped upslope of the existing alignment (see Plate 2). Alternative retaining wall types (tieback walls) may need to be used in areas where the existing landslides are mapped upslope of the roadway. The retaining wall would be combined with improved surface and subsurface drainage (similar to the graded slope concept).

The existing active landslide deposits downslope of the retaining wall would not be mitigated, and would need to be reviewed periodically to evaluate whether or not continued landslide movements are undermining the support for the wall. This concept would also need to consider whether or not the temporary back cut could be safely excavated to allow for construction of the wall, or would need to be shored to resist additional landslide movements. If the back cut is potentially unstable, relatively elaborate shoring systems (likely tiebacks) would be needed to support the back cut, provide a safe working area for the excavation, and reduce the potential for further or reactivation of landslides upslope of the alignment; particularly if there is a potential for groundwater to be present at the time of construction.

4.2.2 Sheetpile

Driving sheet piling for a tieback retaining wall is likely not practical due to the relatively hard driving conditions that would be encountered within the underlying bedrock. The sheet piles would need to be driven approximately 40 to 50 feet below the existing roadway to penetrate below the active landslide deposits. Relatively hard driving conditions would likely limit the depth that sheet piles could be driven below the landslide deposits.

4.2.3 Tieback and/or Soldier Pile Retaining Wall

This concept is similar to the retaining wall concept discussed in the previous section of this report, except that the retaining wall system would include tiebacks and/or deep foundation support to provide additional lateral support for backslope areas that may be prone to landsliding. A soldier pile and tieback type retaining wall could be used to help limit the need for shoring to support the temporary back cut (by using a retaining wall type that can be constructed from the top down and would avoid the need for temporary shoring). This type of wall system may be suitable for portions of the alignment that are likely to be impacted by landsliding because the solider piles and tiebacks can provide greater lateral support than can typically be achieved using a conventional retaining wall or grading. A concept for supporting the access road using a soldier pile and tieback retaining wall is shown on Plate 5.

The base of the lagging should be embedded below the existing landslide deposits to reduce the potential for the lagging to be undermined by erosion and landslide movement downslope of the retaining wall. Excavation downslope of the wall would also be needed to allow for installation of the tiebacks (ground anchors drilled slightly downward into the hillside, and grouted in place).

Typically, timber lagging will provide a relatively free-draining face for the wall. However, additional subsurface drainage may be needed to help relieve hydrostatic pressures within the landslide and potentially unstable slope areas upslope of the retaining wall. Horizontal drains (a gravity well drilled slightly upward into the hillside) can be relatively easily installed along the base of the wall. Horizontal drains are typically drilled and installed using the same equipment that is used to install tiebacks.

4.3 GRADED CUT AND FILL

Conventional grading to mitigate landslides and slope instability typically consists of flattening the slope, buttressing the slope with a shear key, or removal of the landslide. To improve the stability of the access road alignment, grading would be needed to excavate the existing landslide deposits, install subsurface drains, and provide a suitable buttress fill to support the new roadway. A concept for grading the landslide is shown on Plate 6.

Grading could be used to improve the stability of the alignment, and to remove a portion of the landslide downslope of the roadway. Grading would include benching the fill into the underlying stable bedrock to provide an earthen buttress/shear key that would resist landslide movement and support the new roadway. The grading would be combined with improved surface and subsurface drainage. The existing landslide deposits downslope of the new embankment would be left in place. Similar to the MSE wall concept, the existing active landslide deposits downslope of the retaining wall would not be mitigated, and would need to be reviewed periodically to evaluate whether or not continued landslide movements are undermining the support for the fill.

We understand that grading downslope of the alignment (within the Pirates Cove Landslide Complex) can likely not be performed because of the presence of archeological resources. The grading for this concept could be relatively massive compared with other alternatives: 40 to 50 feet deep and extending 100 feet or more across the alignment. The actual size of the excavation would be estimated for design based on slope stability analyses. The concept would also need to consider whether or not the temporary back cut could be safely excavated to allow for construction of the wall, or would need to be shored to resist additional landslide movements. If the back cut is potentially unstable, relatively elaborate shoring systems (likely tiebacks) would be needed to support the back cut, provide a safe working area for the excavation, and reduce the potential for further or reactivation of landslides upslope of the alignment; particularly if there is a potential for groundwater to be present at the time of construction.

4.4 DRAINAGE

The stability of the existing landslide and coastal erosion is likely influenced by the poor surface drainage and local groundwater conditions at the site. Because the existing landslides and areas of the slopes adjacent to the route are potentially unstable already, solely improving the site drainage would likely not be sufficient to protect the new access road from being impacted by slope instability. However, drainage improvements should be provided to better control surface and subsurface water as part of the overall project.

4.4.1 Surface Drainage

Surface drainage improvements should be provided to intercept surface water that is currently flowing into the existing Pirates Cove Landslide Complex or being discharged into unstable bluff areas. Boyle Engineering Corporation (2006) and CSA (2003) have evaluated the existing surface drainage conditions for a bike trail project being evaluated for the San Luis Obispo County Parks and Recreation Department, and for a proposed residential development. During our study with Boyle, it was identified that the outlet points for the surface drainage are of particular interest of the Coast Commission (telephone conference 2007).

The control of surface water is an important factor related to instability of the existing sea cliff and landslides. There are 3 predominant drainages along the route that discharge into landslide and/or unstable bluff areas: a culvert that discharges into the landslide complex near the gate at the Cave Landing Road parking lot, a culvert that discharges beneath the abandoned Cave Landing Road alignment and into the active landslide mass about midway along the alignment, and a spillway type structure that discharges onto the bluff face near the existing terminus of Bluff Drive. The outlets of all of these drainages are in areas of the most recent landslide activity and movement.

1. Water should not be permitted to run uncontrolled into unstable bluff or landslide areas.
2. Where drainage must run over the seacliff, the drainage should be either carried to the base of the cliff in a solid pipe or lined swale or be directed to more stable areas of the bluff that are underlain by resistant bedrock materials that are less prone to slope instability and erosion.
3. Some surface water could potentially be directed to existing or improved roadway drainage systems along Cave Landing Road.
4. The existing drainage along the abandoned Cave Landing Road is relatively poor, and should be reviewed and improved as needed. The main goal would be to collect and properly control surface water along the route that may be impacting the stability of the seacliff or landslides.
5. If possible, the drainage from the existing spillway type structure on Bluff Drive should be collected and directed to the base of the sea cliff via a solid pipe. Recent erosion and ground cracks are present in this general area.

4.4.2 Subsurface Drainage

Subsurface drainage would be a component of various alternatives discussed in this report. The main purpose of providing subsurface drainage would be to reduce the potential for hydrostatic (water) pressure to build up behind retaining wall structure or buttress fill, and to help lower groundwater levels in landslide or potentially unstable areas. Subsurface drainage improvements are likely to consist of providing subsurface drains in association with the placement of retaining wall backfill or compacted fill, and by horizontal drains bored into the hillside for selected alternatives.

4.5 STRUCTURALLY SUPPORTED ROADWAY

4.5.1 Land Bridge

This concept would generally consist of constructing a pile-supported roadway along the proposed alignment. The roadway would generally consist of a slab-type structure supported on deep foundations. The deep foundations would likely consist of cast-in-drilled hole (CIDH) pile foundations embedded in the underlying bedrock and below any landslide deposits. The CIDH piles would be designed to resist lateral loads associated with earth pressures and potential slope instability, and to support the structural loads from the bridge. The piles would essentially be designed to help retain the soils and rock upslope of the access road, and to support the access road should landslide movement and coastal erosion encroach upon the new access road. Using a relatively large number of closely spaced piles could allow the piles to act as shear pins and help limit upslope migration of landslides. The concept may need to include tiebacks to help resist landslide movements. The design of a pile supported roadway should consider the potential for the CIDH piles to be exposed in the future, and whether or not the design may require maintenance or evaluation of the structure would be needed.

4.5.2 Viaduct

This concept would be a similar to the concept of the Land Bridge, except that the viaduct would be supported by a single or series of widely spaced foundations. The viaduct would not be designed to retain soil and rock along the alignment (like the land bridge) but rather would be designed to consider that landslides within the soil and rock could either remove or add lateral pressure to the piles. The piles would likely need to be relatively large (perhaps 8 to 12 feet in diameter) to support the viaduct and resist landslide movements. The resulting viaduct would be a relatively large fly-over type structure, constructed above the unstable ground. The concept may need to include tiebacks to help resist landslide movements. A challenge for the design of this foundation system would be that it is relatively difficult to predict future loading associated with landslide movements. Blocks of rock that may be associated with the landsliding (moving with or floating within the landslide), can apply greater pressures than can be predicted using conventional earth pressure theory.

5. ADDITIONAL SERVICES

The conclusions and recommendations of this report are preliminary and are subject to revision during the subsequent phases of the project. Embankment and cut slope inclinations as well as design foundation recommendations and seismic design considerations will be provided based on the results of the design level field exploration, laboratory testing, and additional geotechnical evaluation.

6. REFERENCES

Boyle Engineering Corporation (2006), *Preliminary Design Report for Cave Landing Bike Path,* unpublished consultant report prepared for San Luis Obispo County Parks, draft dated October.

Cotton, Shires & Associates (2004a), *Supplemental Geotechnical Services – Slope Stability Analysis, Pirates Cove Development – Building Site No. 2, San Luis Obispo County, California,* unpublished consultant report prepared for Howard & Howard, Inc., File No. G0133D, dated September 15.

Cotton, Shires & Associates (2004b), *Response to County (Fugro) Review Comments, Pirates Cove Development, San Luis Obispo County, California,* unpublished consultant report prepared for Howard & Howard, Inc., File No. G0133C, dated September 15

Cotton, Shires & Associates (2003), *Slope Stability Investigation, Pirates Cove Development, Proposed 4-lot Residential Subdivision, San Luis Obispo County, California,* unpublished consultant report prepared for Howard & Howard, Inc., File No. G0133B, dated November 26.

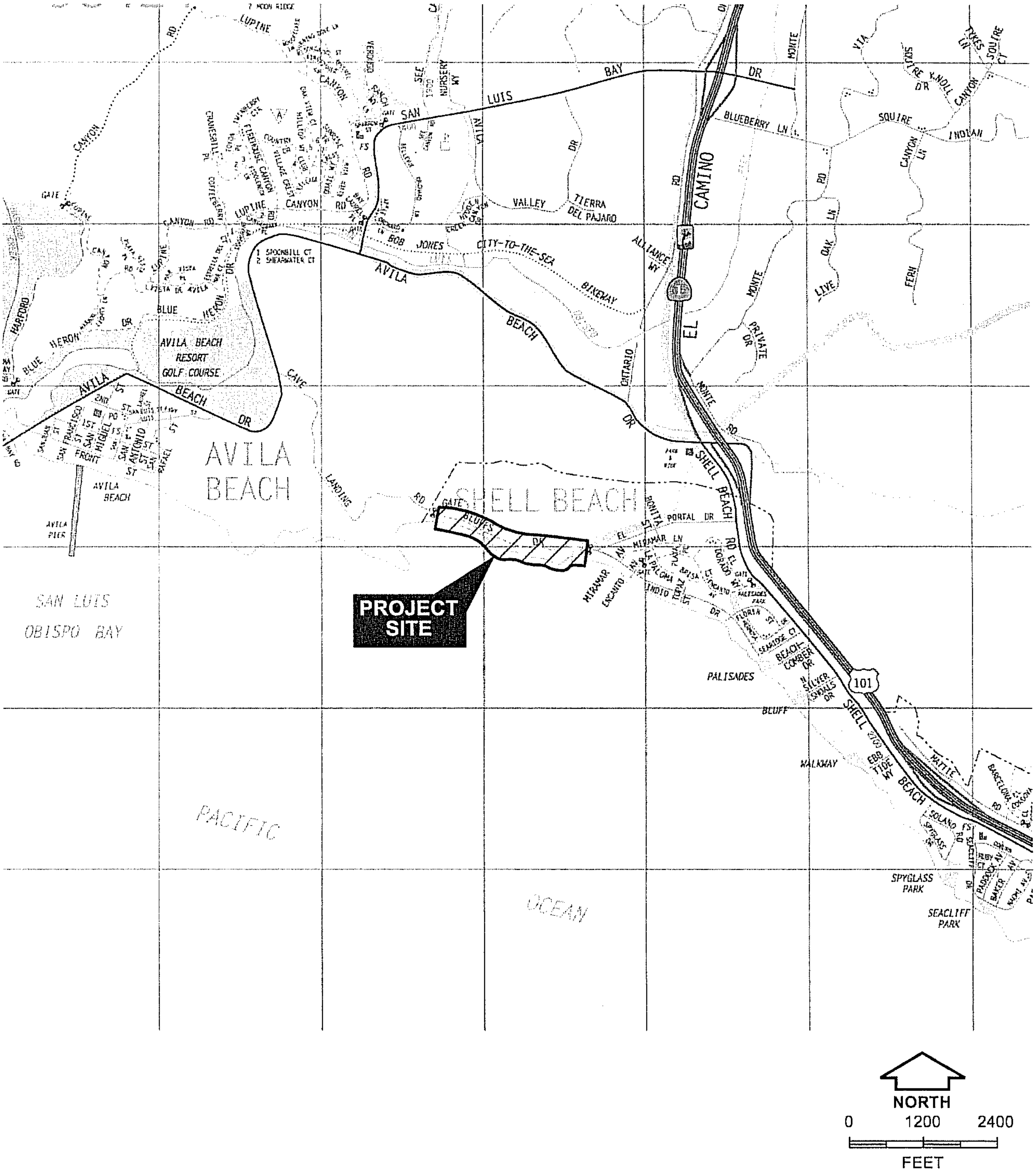
Fugro West, Inc. (2005), *Project Memorandum, Cave Landing Bike Trail,* unpublished consultant report prepared for County of San Luis Obispo, Parks, File No. 3014.016, dated April 21.

Fugro West, Inc. (2004), *Summary Geologic Evaluation of Feasible Route for the Cave Landing Pathway between Avila Beach and Shell beach, San Luis Obispo County, California,* unpublished consultant report prepared for County of San Luis Obispo, Parks, File No. 3014.011, dated April 21.

GeoSolutions, Inc. (2003), *Response to Peer Review Comments, parcels 1-5, COAL 96-036, Cave Landing Road, Avila Beach Area, San Luis Obispo County, California,* unpublished consultant report prepared for Mr. Robert Howard, File No. SLO803-5, dated April 14.

Mualchin, L. (1996), "California Seismic Hazard Map and A Technical Report to Accompany the Caltrans California Seismic Hazard Map 1996 (Based on Maximum Credible Earthquakes), California Department of Transportation Engineering Service Center, Office of Earthquake Engineering, Sacramento, California, June.

FUGRO



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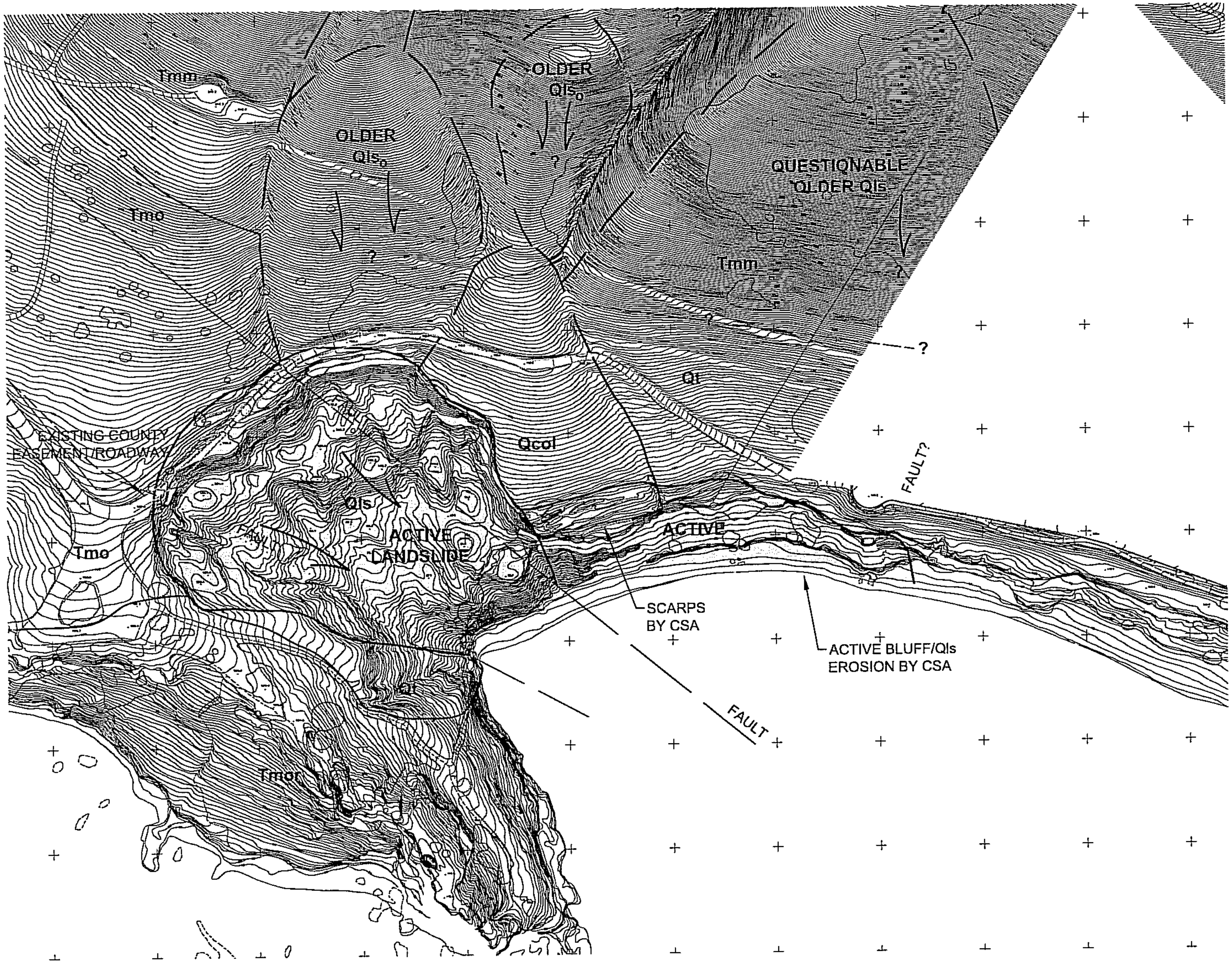
VICINITY MAP
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California

PLATE 1

San Luis Obispo County
Project No. 3014.028



BASE MAP SOURCE: Golden State Aerial Surveys, Inc. (photography dated: 5-14-02).

LEGEND

[box]	Active landslide/slope instability
— — —	Geologic contact, dashed where approximate
— —	Scarps by CSA
═══	Existing County easement/roadway
Qcol	Colluvium
Qt	Terrace deposits
Qls_a	Landslide deposits (active)
Qls_o	Landslide deposits (older)
Tmm	Monterey formation -shale
Tmo	Obispo Formation - tuffaceous shale, mudstone, claystone and siltstone
Tmor	Obispo Formation - resistant volcanic tuff

Geology modified from CSA(2003), Fugro(2004)

NORTH

0 150 200 400
FEET

SITE PLAN
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California

PLATE 2

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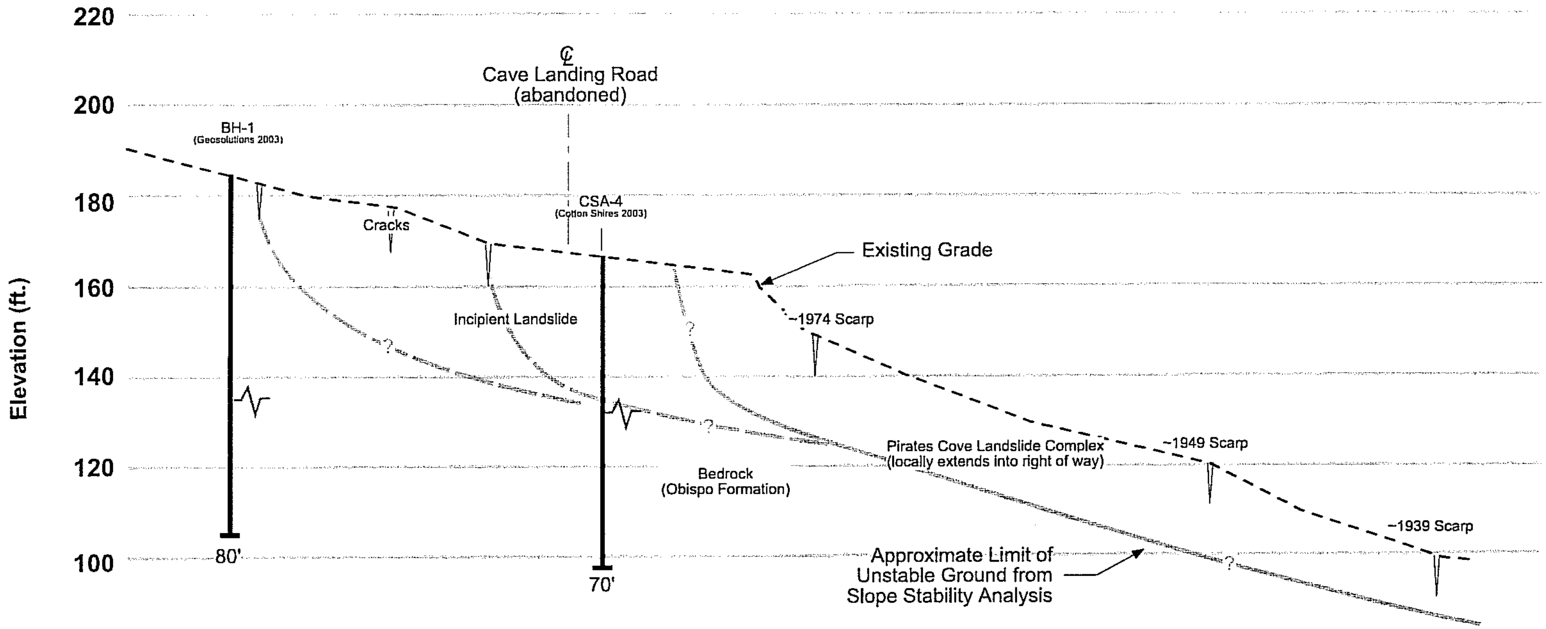
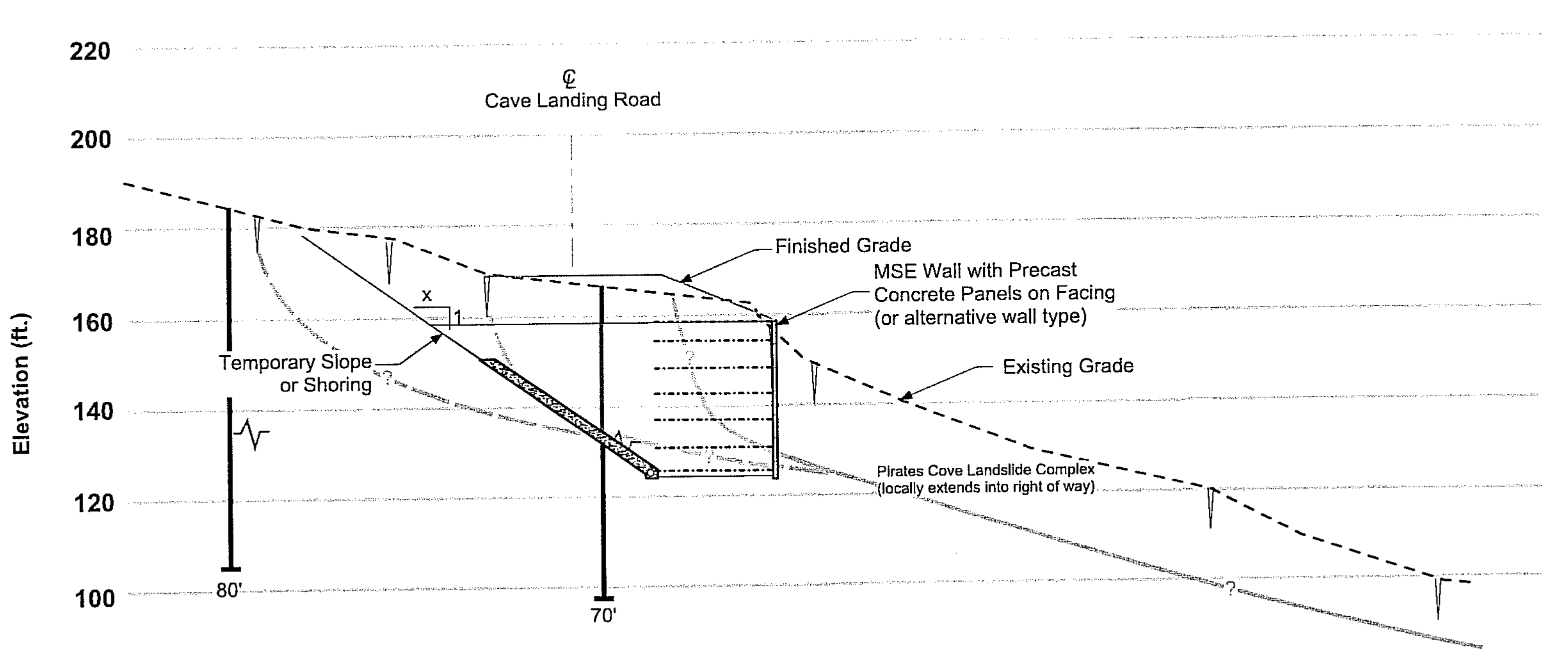


Notes:

1. Section based on geologic conditions as reported by Cotton Shires (2003), Fugro (2004).
2. Upslope migration of landslide is characterized by Cotton Shires (2003).
3. Existing surface drainage and culverts discharge directly into landslide area.
4. There is no deep boring information within existing landslide from previous geotechnical studies.

Indicates zone of seepage or groundwater encountered

EXISTING CONDITION
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California



Imported sand backfill

Drainage material with drain outlet directed to base of slope

Notes:

1. MSE wall can be proprietary system or designed according to Catrans details. Likely to be built as an equivalent proprietary system.

2. Concept would be similar for concrete or alternative gravity retaining wall systems.

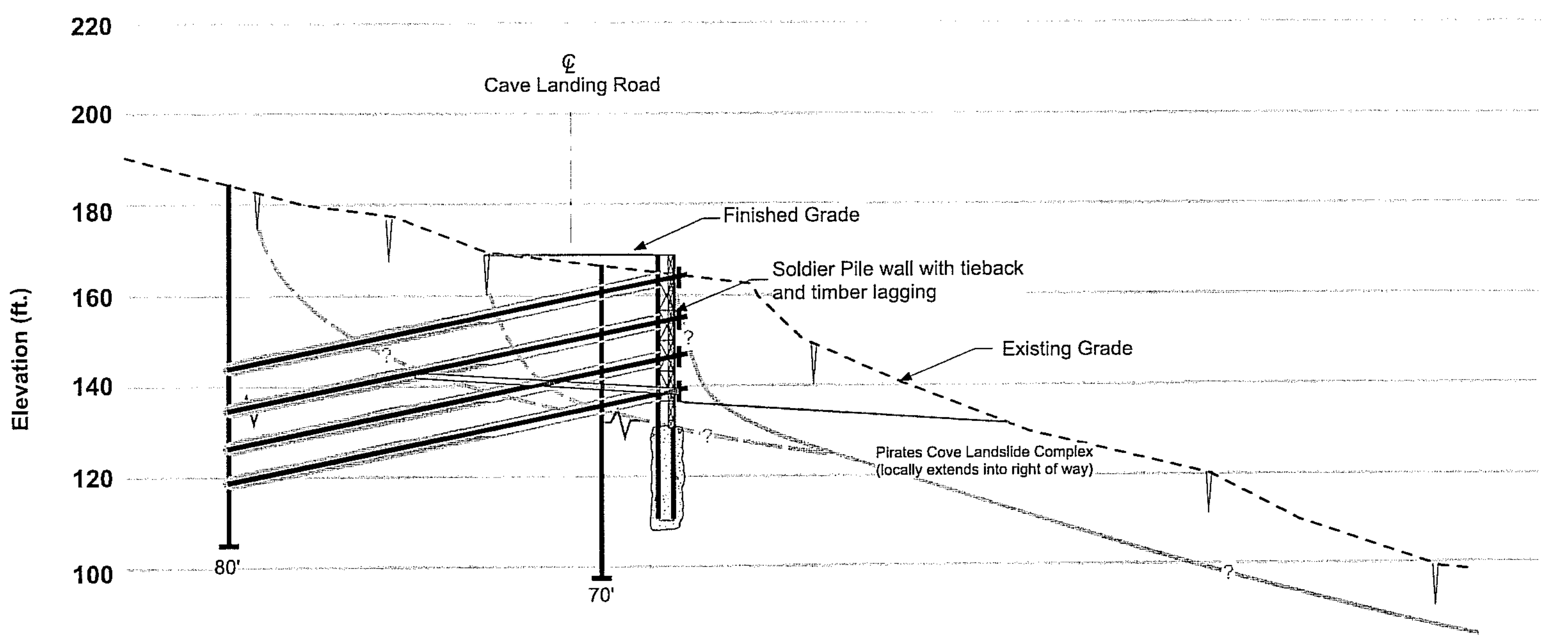
3. Temporary slope is likely to be 1.5:1 or flatter but would need to be estimated from slope stability analysis and/or be supported by shoring.

4. Retaining wall should be supported on firm bedrock materials below the depth of the existing landslide deposits.

5. Other surface drainage, landscape and roadway improvements should also be provided.

Conceptual only. All locations and dimensions are approximate. Not for design, estimates, or construction.

RETAINING WALL CONCEPT
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California



Horizontal drain with drain outlet directed to base of slope

Notes:

1. Retaining wall would consist of drilled shafts spaced 6 to 8 feet oncenter with timber lagging between the piles. Tieback anchors drilled and grouted into the hillside would be installed at the pile locations to provide lateral support. Tiebacks are typically installed about 6 to 12-foot vertical intervals, depending on landslide forces.

2. Once the solider piles are in place, the wall and lagging are constructed from the top down. Temporary slopes and backfill would not be required.

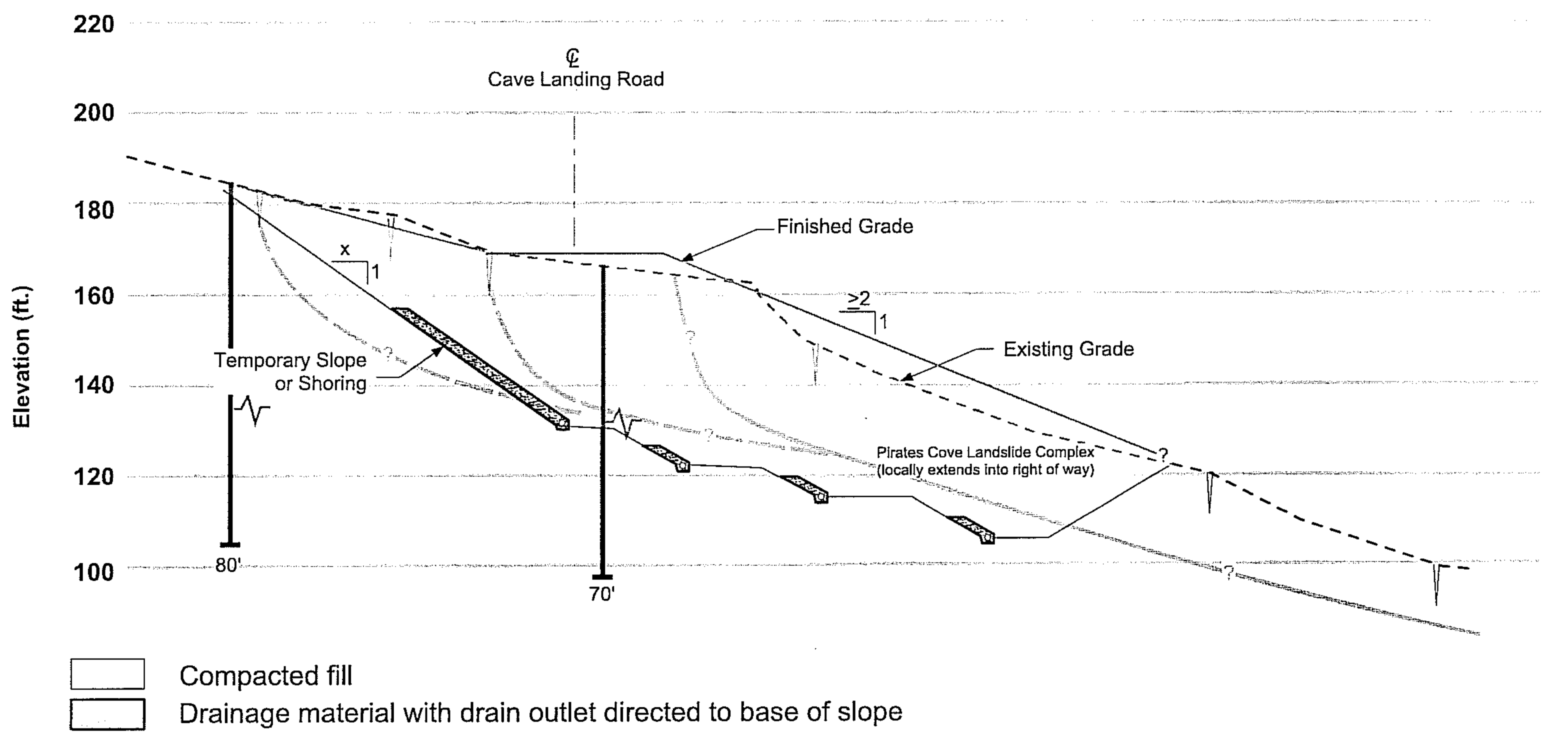
3. The base of the wall and material in front of the wall would need to be removed below the existing landslide deposits to allow for the lagging to be installed.

4. Tiebacks for this type of landslide repair could potentially be more than 100 feet deep and designed for capacities of 100 tons for more.

5. Other surface drainage, landscape and roadway improvements should also be provided.

Conceptual only. All locations and dimensions are approximate. Not for design, estimates, or construction.

SOLDIER PILE AND TIEBACK WALL CONCEPT
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California



Notes:

1. Existing landslide and unstable slope materials are removed from below the roadway.

2. The fill is keyed and benched into underlying stable bedrock to provide a buttress/shear key to stabilize the slope below the roadway. Limits would be estimated from slope stability analysis.

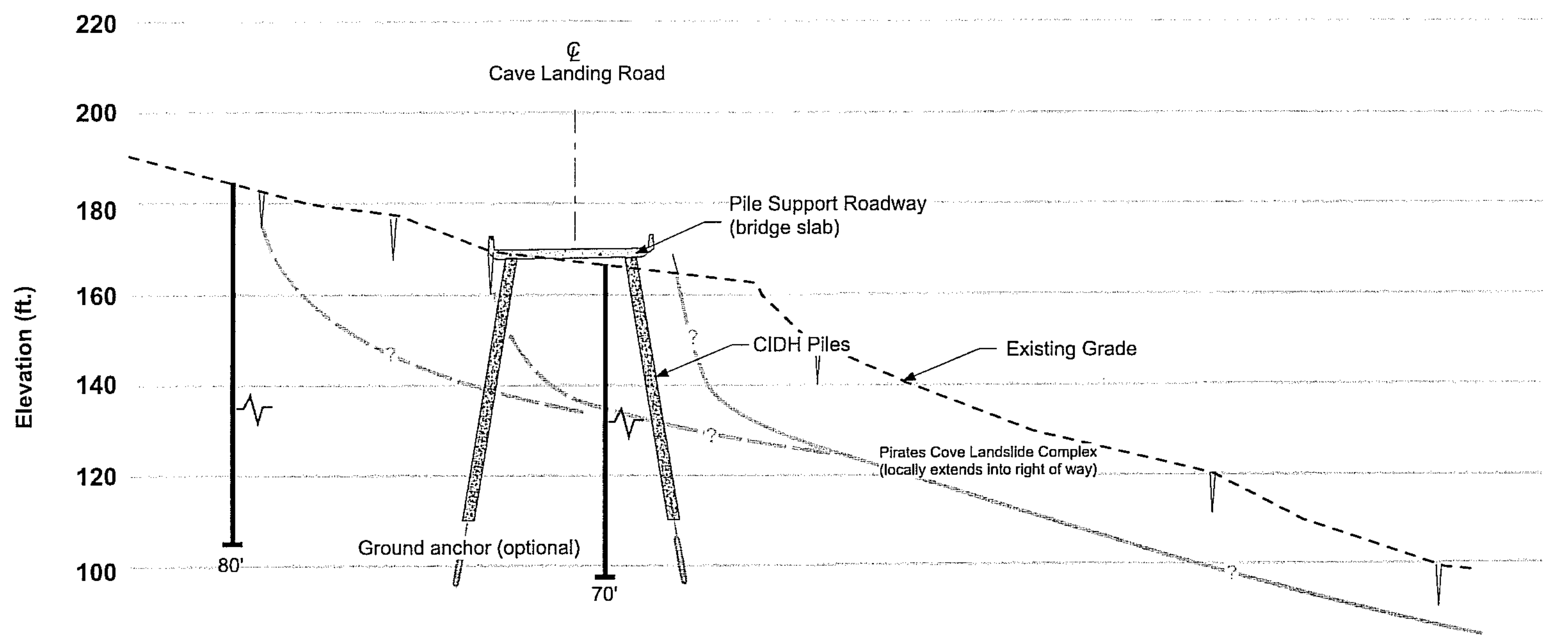
3. Temporary slope is likely to be 1.5:1 or flatter but would need to be estimated from slope stability analysis and/or be supported by shoring.

4. Backslope and bench drains should be provided to control subsurface water.

5. Surface drainage should be controlled to direct water away from slopes.

Conceptual only. All locations and dimensions are approximate. Not for design, estimates, or construction.

GRADED CUT AND FILL CONCEPT
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California

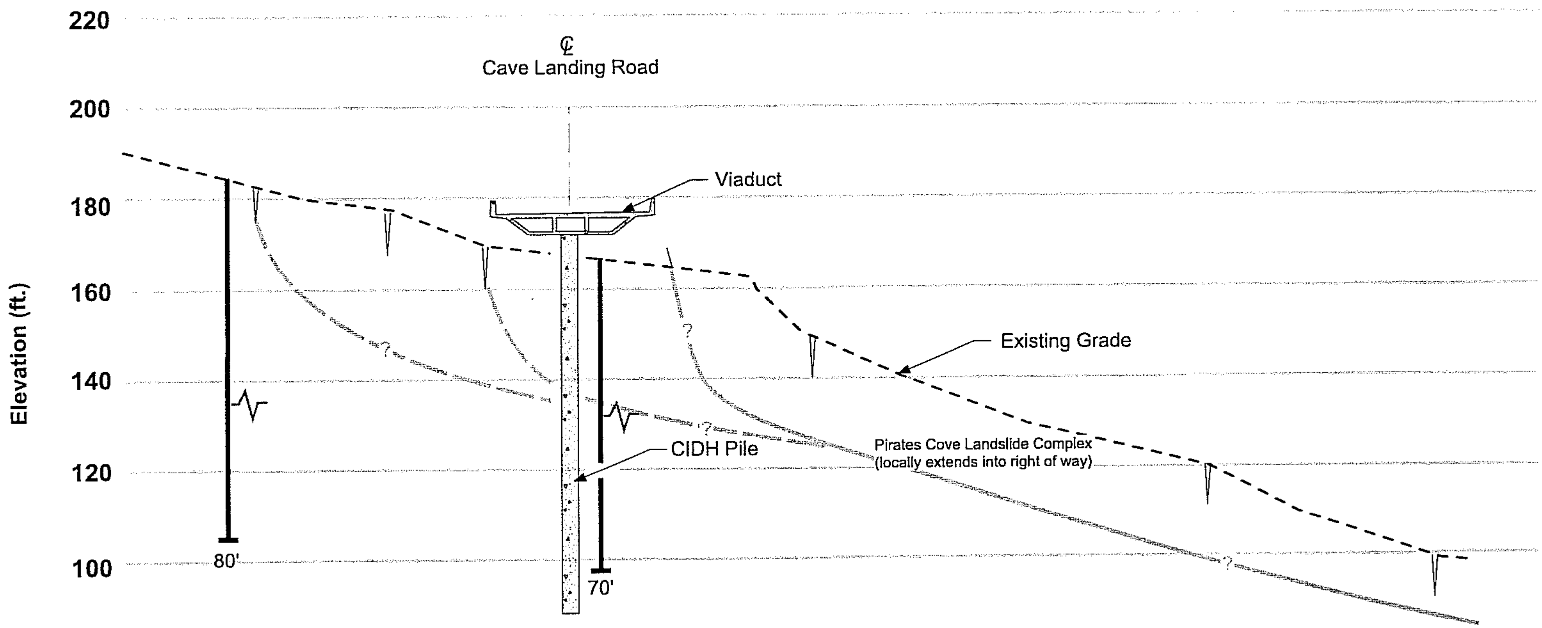


Notes:

1. Structure would consist of a pile supported slab-type roadway.
2. Piles are likely to be drilled shafts/cast-in-drilled hole (CIDH) piles embedded below existing landslide deposits.
3. Piles can be battered and/or provided with ground anchors to help resist lateral forces.
4. Other surface drainage, landscape and roadway improvements should also be provided.

Conceptual only. All locations and dimensions are approximate. Not for design, estimates, or construction.

LAND BRIDGE CONCEPT
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California



Notes:

1. Structure would consist of an elevated structure supported on deep foundations.
2. Piles are likely to be drilled shafts/cast-in-drilled hole (CIDH) piles embedded existing landslide deposits.
3. Piles would need to be designed to resist lateral forces and loss of support in response to landslide movements.
4. Other surface drainage, landscape and roadway improvements should also be provided.

Conceptual only. All locations and dimensions are approximate. Not for design, estimates, or construction.

VIADUCT CONCEPT
Cave Landing Road - Bluff Drive
Emergency Access
San Luis Obispo County, California