RECOMMENDATIONS AND ANALYSIS FOR DRAINAGE IMPROVEMENTS

Abalone Cove Landslide Area
Seaward from Palos Verdes Drive
City of Rancho Palos Verdes,
California

Job No.: 2037-10

Log No.: 6808

October 7, 1983

PREPARED FOR:

City of Rancho Palos Verdes
30940 Hawthorne Blvd.,
Rancho Palos Verdes, CA 90274

Attention: Mr. Carl Abel

Robert Stone & Associates

Robert Stone & Associates, Inc.

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Gentlemen:

In accordance with your request, this report presents plans for improving the surface drainage of the Abalone Cove landslide within the area extending seaward from Palos Verdes Drive South. Specifically, the program includes: (1) minor repairs needed to prevent runoff water from entering fissures and depressions or flowing into the beach property adjacent to Palos Verdes Drive South near Wayfarer's Chapel and direct it eastward for about 400 feet to the 12" diameter culvert which was recently installed beneath Palos Verdes Drive South; (2) installation of storm drains across the Los Angeles County Beach property to transport runoff from the 12" diameter culvert beneath Palos Verdes Drive South to the ocean and provide two inlets for drainage within the beach property, and (3) surficial regrading within the Los Angeles County Beach property in the area west of Altamira Canyon in order to improve surface runoff and prevent water from draining into fissures or ponding in closed depressions.

The above program should be completed prior to the beginning of the main rainy season. It is urgently needed to reduce the amount of runoff water which infiltrates into this portion of the Abalone Cove landslide. Infiltration of runoff during the 1982-83 rainy season caused a resurgence of slow movement within this portion of the landslide. At present, the rate of movement is gradually decreasing. Upon completion of this program and the continuation of ongoing abatement measures within other portions of the landslide, we expect landslide movement to stop within the near future.

The two maps accompanying this report utilize a topographic base prepared by Horizon Surveys for the City of Rancho Palos Verdes. The topography is based on aerial photographs taken on 6/24/83 and uses Los Angeles County survey monuments for control points. Based on measurements with a hand level, we have made minor addendums to the topographic map in order to show small closed depressions which influence surface drainage. The addendums are shown by dashed lines whereas contour lines by Horizon Surveys are continuous. See Geologic Map, Plate 1 and Drainage Improvement Plan, Plate 2.

We regard part of the proposed drainage improvements as temporary measures to abate landslide movement. Once movement has ceased and there are reasonable expectations that movement will not resume, we understand that the City intends to reinstate previously canceled plans to renovate Palos Verdes Drive South within the landslide area. The renovation would reconstruct drainage along Palos Verdes Drive South such that it would flow into the new 120 inch culvert beneath the roadway at Altamira Canyon. This would eliminate the need for the proposed culvert extending from Palos Verdes Drive South onto the Los Angeles County Beach property. A culvert or other form of drain would continue to be needed within the beach property.

BACKGROUND

Prior to 1978, drainage along Palos Verdes Drive South flowed eastward from the vicinity of Wayfarer's Chapel to the culvert at Altamira Canyon, a distance of 1500 feet. During the period from 1978 to 1981, movement of the Abalone Cove landslide caused as much as 16 feet of horizontal displacement and 5 feet of vertical subsidence along this segment of the roadway. An uneven distribution of the subsidence disrupted the normal flow of drainage. Most runoff either entered fissures or ponded in depressions along the north side of the roadway or flowed southward from the roadway onto the Los Angeles County Beach property. The subject portion of the beach property drained to the ocean prior to 1978 but subsequent landslide movement disrupted drainage causing runoff to flow into landslide fissures or pond in closed depressions where it percolated underground.

The removal of ground water by a system of dewatering wells began in March, 1980. This caused an immediate slowing of landslide movement as shown by our monitoring data and Los Angeles County surveying data presented in Table 1. Movement had nearly ceased by the end of 1981; however, there was a renewal of slow movement as a result of the exceptionally high rainfall during 1982-83. It should be noted that at Palos Verdes Fire Station, (Los Angeles County Flood Control Station No. 1011B), 1.7 miles northeast of Abalone Cove, the 1982-83 annual rainfall totaled 29.49 inches compared to 23.85 inches in 1979-80 and 31.10 inches in 1977-78. In Los Angeles, the 1982-83 annual rainfall was 5th highest since measurements began 106 years ago. We believe the renewed movement was the direct result of runoff infiltrating into the landslide and that future episodes of renewed movement can be prevented by careful management of runoff.

The channel along Altamira Canyon is one of the main sources of infiltration of runoff water. During the past summer a 120 inch diameter culvert was installed along the 600 foot segment of Altamira Canyon from Palos Verdes Drive South northeastward to Narcissa Drive. We have recommended that the culvert or other form of impervious channel be extended a distance of 800 feet from the terminus of the newly installed culvert to the head of the Abalone Cove landslide. We regard this as less urgent than the recently installed culvert because dewatering wells are able to remove much of the water which infiltrates along the northern segment of the channel. Although the project will be expensive, we expect it to be undertaken by the Abalone Cove Landslide Abatement District within the next few years notwithstanding the expense. Once the project is completed, only the segment of Altamira Canyon located seaward of Palos Verdes Drive South will remain unimproved within the landslide area. The seaward segment of the channel should be improved so as to render it impervious but we assign this project a low priority because this segment of the channel is less permeable than the upslope segments. Also, water infiltrating along this segment of the channel has a shorter distance to migrate to springs along the toe of the slide and therefore affects the slide for a shorter period of time than water infiltrating along upslope segments.

The most urgently needed drainage improvements are those recommended in this report, particularly the culvert designed to transport runoff from Palos Verdes Drive South to the ocean. The segment of roadway draining to the culvert is about 1100 feet long and 80 feet wide, including level dirt areas bordering the roadway (this does not include slopes draining toward the roadway). Assuming that (1) rainfall along this segement of the road was 70% of the 1982-83 annual rainfall of 29.49 inches, and (2) 90% of the rainfall ran off (with the remaining 10% lost by evaporation and percolation into the road bed), the runoff along the subject segment of Palos Verdes Drive South should have been slightly over 1 million gallons during 1982-83. None of this water left the landslide via surface drainage. All water which drained into the Los Angeles County Beach property percolated underground without leaving ponds. Much of it flowed into a fissure where drainage from Palos Verdes Drive South flows onto the dirt apron near the curve in the road leading to the beach (Fig.1.). We believe infiltration of runoff from Palos Verdes Drive South was a major causitive factor in renewing slide movement during the past year. The renewed movement is concentrated within the area under discussion, in the south-western part of the landslide. Our monitoring data show that accelerated movement occurred immediately after major storms. Since the area lacks dewatering wells and is not suited for them, drainage improvements offer the only economically feasible method of stabilizing this portion of the landslide.

DESCRIPTION AND PROPOSED DESIGN OF DRAINAGE IMPROVEMENTS

Drainage Repairs Along Palos Verdes Drive South

The problem of ponding along Palos Verdes Drive South has been solved by installation of a 12 inch diameter culvert beneath the roadway and by local deepening of the drainage swale leading to the culvert. A significant drainage problem still remains along the north side of the road at the western edge of the landslide. During the August rains, runoff along the north side of Palos Verdes Drive South flowed into fissures in the dirt apron at the western edge of the slide. Some runoff also flowed into an adjacent depression which is covered by a dense growth of ice plant. The depression (graben) has formed by downdropping toward the rear of the seaward portion of the slide which moved more rapidly than the landward portion. This graben is an area where runoff could rapidly percolate to the slip surface at the base of the slide; consequently it is important to keep water from entering the depression. This can be done by constructing a drainage swale and berm for a distance of about 250 feet along the northern edge of the roadway as indicated on Plate 2. The drainage swale should be paved with asphalt for a distance of at least 10 feet on each side of the slide margin to reduce the likelihood of fissures opening within the swale. We would prefer to have the entire length of the swale and berm coated with asphalt. Because of its minor nature, it is most practical to construct the swale in the field without a detailed plan.

A drainage problem also exists along the south side of Palos Verdes Drive South where runoff water flows into the Los Angeles County Beach property at several locations along the roadway. A berm and drainage swale should be constructed along the south side of the roadway to direct the water from the western edge of the slide to the point where the recently installed 12" drain passes beneath the south edge of the roadway. An inlet structure should be constructed to the drain at this point. The inlet structure can be designed similar to the inlet structure shown in Detail "E" with the exception that the inlet and outlet pipes may be reduced to 12 inches in diameter. It has been assumed that all drainage to this point can be handled by the 12 inch downdrain. Water also flows onto the beach property south of survey station P-2A and at the entrance to the beach road (see Plate 1 for locations). This problem is most easily handled by improving drainage within the beach property as discussed later.

During the rainy season the subject segment of Palos Verdes Drive South should be closely monitored to determine if drainage is flowing properly and to correct deficiencies as they arise. The south side of the roadway should be observed to make sure runoff does not flow onto the beach property in an uncontrolled manner.

STORM DRAIN INSTALLATION ACROSS COUNTY BEACH PROPERTY

A 12 inch diameter c.m.p. drain will be added at station 0+00 to pick up drainage from the existing 12 inch c.m.p. pipe recently installed beneath Palos Verdes Drive South as well as drainage from the proposed inlet structure to be constructed at the south edge of the street. This surface pipe will trend down the erosion gully previously formed at this location to station 1+00 (approximate elevation 110) at which point the pipe will go beneath the existing ground surface to an invert elevation of 108. From elevation 108 at station 1+00 the pipe will extend 125' southwest beneath the surface at an approximate 6% gradient to an inlet structure (Detail B) located at Station 2+25.

A surface inlet structure (Detail A) will also be installed as shown on Plate 2 to pick up runoff from the Beach Access Road at the curve and direct this runoff a distance of about 50 feet beneath the road to the inlet structure at Station 2+25.

Water collected at Station 2+25 will outlet beneath the surface (approx. elevation 100.0) in a southerly direction to Station 2+60 at which location we have shown two drainage alternatives. The eastern alternative, which we prefer because of its flexibility, consists of a transition to 30 inch corrugated metal pipe half round as shown on Detail C. This alternative has advantages of being able to pick up surface drainage locally and of being able to accommodate slide movement by adjustment at junctures between pipe lengths without rupture. The curvature of this route will also accommodate slide movement. Stationing along this route has been designated 3+00hr, 4+00hr etc. where hr designates half round pipe.

A second alternative has been shown in which an 18" c.m.p. full round pipe is used along the surface of the ground from Station 2+60 to Station 6+00 at which location the pipe will go underground. A thrust block will need to be installed at Station 5+45 to resist lateral forces of drainage at the bend in the pipe at this Station. See Detail "D" for Thrust Block construction.

At Station 6+45 (6+70hr) another inlet structure will be needed to pick up surface drainage previously accumulating in a depression at this location. This structure will be designed according to Detail "E" and will accept surface water as well as water from an 18 inch pipe. The detail for transitioning from 30 inch half round back to 18 inch full round is also shown as part of Detail "E". Water exiting from Station 6+45 will be conducted a distance of about 150 feet via 24 inch corrugated metal pipe beneath the surface to outlet near the top of the beach cliff at approximate elevation 22 feet above sea level. Detail "F" provides a dissipater structure intended to minimize erosion of the cliff by spreading the water flow over a wider area.

SURFICIAL REGRADING WITHIN COUNTY BEACH PROPERTY

Grading necessary to implement the storm drain installation above Station 4+50 (or 5+50 hr) will consist of minor surface compaction, fissure filling and berm and trench diversion to inlet structures. This grading will have no impact on slide stability related to redistribution of mass but will improve stability by improving drainage. Important in this regard is smoothing and compacting the surface along the north and south sides of the Beach Access Road between the entrance and the inlet structure at Detail "A".

Below Station 4+50 (or 5+50 hr) minor cutting and filling to obtain soil material and fill depressions is proposed as shown on Plate 2. This grading entails removal of about 80 cubic yards. of porous beach sand from the area along the east end of the tennis courts to an off site area along the beach west of the slide and filling closed depressions near the northwest corner, northeast corner and east end of the tennis courts in order to establish improved drainage to the inlet in the east end of the southerlymost depression with a low elevation of about 30 feet. Yardage to fill the depressions will be obtained from the adjacent knoll between the tennis courts and the Beach Access Road as shown on Plate 2.

Section A-A' shown on Plate 3 depicts balance of masses resulting from the proposed shallow grading. Our calculations also shown on Plate 3 indicate this redistribution of mass will have no discernable affect on the Factor of Safety of the landslide. Of course, the improvement in drainage will be beneficial to slide stability and should contribute greatly to eventual arresting of slide movement.

Although this work will not provide a final solution to the sliding problems in the beach area, improvements (such as recommended in this report) must be undertaken. Lacking such improvements, sliding will surely continue in this area, particularly during rainy periods. Confirmation of this is shown by County Survey Data (Tables 1 and 2) and our own monitoring data. County Survey Data shows a pronounced increase in the average daily rate of displacement in the most recent survey period. Our own monitoring of a station located at Narcissa Drive upslope from Wayfarer's Chapel shows acceleration occurred in direct association with heavy rainfall.

Very truly yours,
ROBERT STONE AND ASSOCIATES, INC.

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Enclosures:

Distribution: (5) City of Rancho Palos Verdes

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Since 1956

HYDROLOGY CALCULATIONS
Rancho Palos Verdes

Calculations by:

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A. DESIGN CRITERIA

1. L.A.C.F.C.D. Hydrology Manual
2. Hydrologic Map: C-1.3
3. Soil Classification Area: 004
4. Debris Potential Area: DPA-6
5. Rainfall Zone: 'K'
6. Storm Frequency: 10 yr.
7. Time of Concentration (Tc): Gregory-Arnold

Tc Calculations:

R_1 for zone 'K', Q_{10}=1.02"/HR.

$$c=\frac{(1.02-0.57)(0.25)+(0.55)(0.9)(1.02)}{1.02} = 0.61$$

C A R_1

Drainage Area (A) = 3.2 ACS. $CAR_1=0.61(3.2)1.02=1.99$
Drainage Area (B) = 5.2 ACS. $CAR_1=0.61(5.2)1.02=3.24$

Tc For Drainage Area (A): Use F=4.6

Elevation @ Most Distant Point: 152
Elevation @ Point of Concentration: 102
Elevation Difference: 50 ft.
Length of Travel: 580 ft.
$S=50/580=86.2/1000:L/W=580^2/43,560(3.2)=2.41$
$P=0.45:P/L=0.45/580=0.0007759$ $\sqrt{P/L} = 0.028$
Tc=1.8 min ∴ use 10 min.

Tc For Drainage Area (B): Use F=4.6

Elevation @ Most Distant Point: 160
Elevation @ Point of Concentration: 31
Elevation Difference: 129 ft.
Length of Travel: 610 ft.
$S=129/610=211.5/1000:L/W=610^2/43,560(5.2)=1.71$
$P=0.45:P/L=0.45/610=0.007377$ $\sqrt{P/L}=0.086$
Tc=<1min.∴ use 10 min.

HYDROLOGY CALCULATIONS
Rancho Palos Verdes

B. RUNOFF CALCULATIONS

Q=ACI: I for Q_{10} Zone 'K', 10 min. Dur. = 2.55"/HR.

$$C=\frac{(2.55-0.81)(0.25)+(0.55)(0.9)(2.55)}{2.55}=0.67$$

Drainage Area A Q=3.2(0.67)2.55=5.5 CFS
Drainage Area B Q=5.2(0.67)2.55=8.9 CFS

HYDRAULIC CALCULATIONS

A. Catch Basin Size

Q_{10}=5.5 c.f.s. QB=5.5(1.61)=8.9 C.F.S. A
Q_{10}=8.9 c.f.s. QB=8.9(1.61)=14.3 C.F.S. B

Existing 12-inch Pipe

S=0.04 $S^{1/2}$=0.2 d=1 ft. n=0.021

$$d=\left(\frac{2.159(Q)n}{S^{1/2}}\right)^{3/8} \qquad 1=\left(\frac{2.159(Q)\ 0.021}{0.2}\right)^{3/8}$$

∴ Q=4.4 C.F.S.

B. Pipe Size Drainage Area A

By Formula $d=\left(\frac{2.159\ Qn}{S^{1/2}}\right)^{3/8}$

$$d=\left(\frac{2.159(13.3)0.021}{.41}\right)^{3/8}=1.16'$$ ∴ 15" Pipe OK odd size use 18" pipe
30" ½ Pipe OK

Drainage Area A+B

$$d=\left(\frac{2.159(27.6)0.021}{.20}\right)^{3/8}=1.99'$$ ∴24"Pipe OK

TABLE 1. Average rates of horizontal displacement at Los Angeles County survey stations in inches per day for observation periods since November, 1978. From data provided by Survey Division, County of Los Angeles Department of County Engineer-Facilities. See Geologic Map for station locations.

Time Interval	STATION DESIGNATION P-2	P-2A	P-3	Q-1A	Q-2	Q-3	Q-5	
11/14/78-4/30/79	.19	.21	.15	.04	.32	.20	.06	
4/30/79-10/31/79	.22	.26	.19	.13	.34	*	.05	
10/31/79-12/13/79	.19	.17	.11	.18	.28	.23	.04	
12/13/79-2/20/80	.32	.39	.29	.24	.48	.33	.07	
2/20/80-4/24/80	.44	.52	.37	.30	.76	.50	.12	- Dewatering Started March 2, 1980
4/24/80-5/15/80	.24	.26	.15	.14	.29	.45	.05	
5/15/80-8/12/80	.11	.13	.09	.06	.14	.08	.03	
8/12/80-11/18/80	.07	.07	.05	**	**	**	.03	
11/18/80-2/5/81	.05	.04	.03	.05	.07	.05	.01	
2/5/81-3/24/81	.04	.05	.04	.05	.07	.05	.04	
3/24/81-8/5/81	.03	.03	.02	.02	.04	.03	.02	
8/5/81-4/13/82	.01	.01	.01	.01	.01	.01	.01	
4/13/81-11/19/82	.01	.01	.01	.01	.01	.01	.01	
11/19/82-9/6/83***	.07	.07	.04	.06	.10	.06	.03	

* - No data for 10/31/79

**- No data for 11/18/80

***- Partial results for 9/6/83 survey received by telephone on 10/5/83.

TABLE 2. Total displacement recorded at Los Angeles County survey stations. Data source same as in Table 1.

Survey Station	Horizontal Displacement Time Interval	Distance	Bearing	Vertical Displacement Time Interval	Distance	Plunge
P-2	6/18/57-11/17/82	14.9 feet	S 20.6 W	6/18/57-11/17/82	-3.1 feet	-11.7°
P-2A	2/10/76-11/19/82	17.5 feet	S 27.8 W	11/1/78-11/19/82	-4.3 feet	-15.0°
P-3	6/18/57-11/19/82	12.6 feet	S 29.0 W	11/15/77-11/19/82	-1.3 feet	-6.0°
Q-1A	1/15/76-11/19/82	8.5 feet	S 35.0 W	11/15/77-11/19/82	-1.0 feet	-7.0°
Q-2	1/18/57-11/19/82	30.4 feet	S 39.6 W	11/15/77-11/19/82	-3.1 feet	-7.0°
Q-3	1/18/76-11/19/82	19.3 feet	S 45.1 W	11/15/77-11/19/82	-3.3 feet	-11.5°
Q-5	1/15/76-11/19/82	5.7 feet	N 88.6 W	11/16/77-11/19/82	+0.9 feet	+9.5°

Figure 1. Hole along beach road into which runoff water from Palos Verdes Drive South flowed during rainfall in August, 1983. Hole has formed by collapse of surface soil into a slide fissure. Hardhat used for scale is 12 inches long.

ROBERT STONE & ASSOCIATES ENGINEERING GEOLOGY SOIL MECHANICS FOUNDATION STUDIES		
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