U.S. GEOLOGICAL SURVEY
DEPARTMENT OF THE INTERIOR
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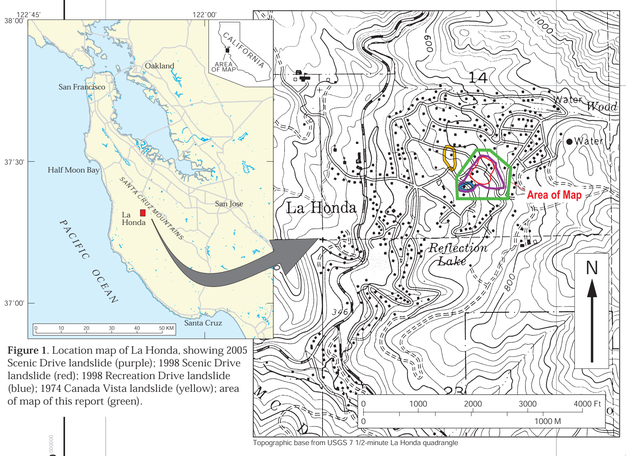

Figure 1. Location map of La Honda, showing 2005 Scenic Drive landslide (purple); 1998 Scenic Drive landslide (red); 1998 Recreation Drive landslide (blue); 1974 Canada Vista landslide (yellow); area of map of this report (green).

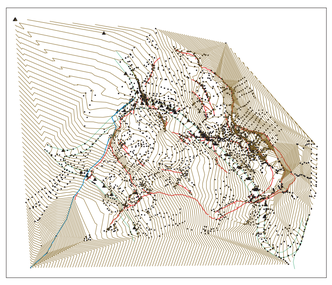

Figure 2. Location of our survey points; 2005 landslide outlined in red. Dots are locations of differential GPS survey points; includes compass and tape measurements in stream. Triangles are differential GPS locations of survey monuments (nails).

UTM10 NAD83 projection
Two-foot contour interval
and road location
generated from differential
GPS locations

APPROXIMATE MEAN DECLINATION, 2005 (TRUE SECTION, APPROX. 1/4° EAST OF GRID NORTH)

SCALE 1:400
0 500 FEET
0 200 METERS

Geology and topography mapped by Ray Wells, Michael Rymer, and Carol Prentice, March 31-May 7, 2005; GIS by Karen Wheeler, Carol Prentice

Contour interval 2 feet (0.6069 meters)
Base contour = 360 feet (109.7280 meters) nominal elevation

INTRODUCTION

This map documents movement of the Scenic Drive landslide in La Honda, California during the early part of 2005 (Figure 1). Land sliding in the Scenic Drive area previously occurred during the El Nino year of 1998 (Jayko and others, 1998). In late February and early March of 2005, cracks developed in Scenic Drive at the location of the 1998 landslide head scarp and the road was subsequently offset. In late March, the landslide enlarged substantially to the south and west. This map provides a snapshot of the landslide features in mid-April, 2005 and its displacement from March 31 through May 7, 2005.

GEOLOGY OF THE LANDSLIDE AREA

The area of activity in 1998 and 2005 occurs within an area mapped as a probable ancient landslide by Brabb and Pampeyan (1972). The landslide area is underlain by late Miocene and Pliocene Tehana Member of the Purisima Formation, a shallow marine sequence of intebedded fine sandstone and mudstone that dips gently to the southwest in the direction of the regional slope (Brabb and others, 1998). The Purisima Formation is glauconitic at its base, where it unconformably overlies more steeply dipping Oligocene and Miocene submarine pillow breccia of the Mindego Basalt (Brabb and others, 1998). These field relations are exposed just east of the La Honda fire station in a road cut on Highway 84.

The head scarp of the 2005 landslide exposes a 1 m thick, nearly black organic soil horizon overlying 3-5 m of an orange-brown diamict consisting of weathered vesicular basalt clasts in a muddy matrix. Locally exposed beneath the diamict in the head scarp are outcrops of vesicular, weathered pillow basalt and pillow breccia of the Mindego Basalt. A 2 meter-high exposure of fine sandstone of the Purisima Formation crops out in a small stream about 70 m southwest of Recreation Drive. A waterfall over Mindego Basalt occurs about 200 m to the south off Recreation Drive, where it crosses a small stream.

Lithologies within the landslide were observed during the installation of three 40-foot-deep dewatering wells on April 26 and 27th. Additional subsurface information is available for the area in Upp (1998). The 2005 wells encountered landslide debris derived from both the Purisima Formation and the Mindego Basalt. On Scenic Drive the wells were drilled through wet, mottled, brown to greenish gray, broken and disturbed fine sandstone and mudstone of the Purisima Formation containing clay seams and lenses of cobbles and boulders of basalt. Basaltic debris was more common in the southern Scenic Drive well. Drilling of the well near Recreation Drive exposed wet, disturbed, broken, and mottled fine brown and gray sandstone diamict with horizons containing basalt cobbles to a depth of about 16.5 feet (R. Wells, field notes). Below that depth, the hole encountered largely dry, cross-laminated and burrowed, fine-grained, greenish-gray, stiff sandstone of the Purisima Formation. A trickle of water was noted at 20 feet. The bottom of the hole at 37 feet (J. DeMouthe, written communication) is in zeolitized basalt pillow breccia, probably the Mindego Basalt. Subsequent to drilling, the well bore was sheared off by landslide movement at a depth of 19 feet from the top of the pipe (about 3 feet above ground surface, B Molver, written communication).

METHODS

We mapped the Scenic Drive landslide using a Leica differential GPS system with a local base station set up outside of the moving landslide. Most of the landslide was surveyed at an average spacing of about 3 m on April 9-10, 2005 and again on April 16-17, 2005 (Figure 2). The landslide perimeter and the evolving head scarp region in the SE corner of the landslide were surveyed April 21. Observations with horizontal and vertical accuracy of 5 cm or less were typical of open ground. Beneath the tree canopy and in steep, high relief areas, a few survey points were accepted with uncertainties ranging from 0.1 to 0.9 m.

We installed an array of 30 nails along Scenic Drive, Recreation Drive, and Canada Vista Drive and measured their displacement with differential GPS on April 9, 10, 16, 17, 20, 21, 24, and on May 1 and 7. We acquired repeat measurements of the azimuth, inclination, and amount of slip on the head scarp, major internal scarps, lateral scarps, and in the toe region with compass and tape on February 27, March 3, 4 10, 31, April 2, 4, 6, 9, 10, 16, 17, 21, 24, 30, and May 7.

We compiled the data in ArcGIS and deleted two obvious survey errors whose elevations were more than 2 m above the surrounding surface. We created a triangular network (TIN) representation of the surface from the data and generated contours with a contour interval of 0.6096 m (2 feet). We have multiple topographic coverages of the landslide but used only the April 16-21 data in areas of rapid landslide motion to create the contour map. Some areas beneath trees in the toe area and along parts of the head scarp have no GPS coverage, and in these areas, the contours do not reflect the complexity of the ground surface and its deformation (Figure 2).

OBSERVATIONS

The Scenic drive landslide is roughly triangular in shape and about 200 m on a side. It has most of the characteristics of a deep-seated landslide (Figure 3). Its eastern, upslope edge is the head scarp--the steep, exposed part of the surface along which the landslide mass moved downhill. The head scarp is slickensided and grooved and is more than 7 meters high (21+ feet) at its southern end. Displacements along the head scarp diminish to near zero at its northern end. Internally, the landslide is locally folded and cut by numerous extensional cracks and normal-displacement scarps up to 2 m high.

The western lobe of the landslide is the toe area, a zone of compressional deformation defined by transverse ridges and closely spaced thrust faults. The 1998 toe, a prominent ridge just upslope from Recreation Drive, has deformed substantially in 2005. Significant motion has extended down slope from this toe, as evidenced by the offset in Recreation Drive. By April 2nd, thrusting was affecting Recreation Drive. Subsequently, the rising toe area of the 1998 landslide began to collapse with closely spaced, down-to-the-southwest normal faults.

West of Recreation drive, the landslide toe is poorly exposed in dense tree cover. It appears to form a series of ridges that step down toward the creek along the landslide's northwest side. The termination of the landslide as shown on the map is based on a few compass-and-tape survey points in the creek and is poorly constrained by data.

The Scenic Drive landslide can be divided into three lobes based on its geometry and kinematics (Figure 4). Major deformation of the north Scenic lobe occurred in late February and the first week of March, offsetting Scenic Drive approximately along the locus of major movement in 1998 (Figure 4). A nail array installed to measure motion recorded 18 cm of displacement between February 27 and March 10 but was paved over in mid-March.

In the last week of March, a new landslide head scarp developed more than 75 m (240 feet) uphill along Scenic Drive. The area between the old and new head scarps (south Scenic lobe) began moving westward in excess of 29 cm per day (Table 1, Figure 4). Cumulative slip in this southern lobe of the landslide exceeds 8 m (25+ feet) through May 7 (Figure 5).

Since mid-April, the southern lobe of the landslide has been moving much faster than the northern lobe (Figure 4; Tables 1 and 2). A major right-lateral boundary between the two landslide segments has developed just south of the southernmost of three dewatering wells in the 1998 landslide mass, between nails 8 and 10. Slip has since slowed to about 12-18 cm per day in the southern lobe (Tables 1 and 2), and motion of the northern lobe has nearly stopped (within the measurement error).

In the western lobe, thrusting along the toe of the 1998 landslide has increased its height up to 2 m (>6 ft) and has offset a fence crossing the toe by about 6 m (>18 ft) near station G24. Closely spaced thrust ridges have developed southwest of the 1998 toe as far as Recreation Drive. A continuous left-lateral boundary has developed between the Scenic Drive landslide toe and the southeast flank of the 1998 Recreation drive landslide. Station 28 in the toe region has been moving 8-10 cm per day through May 7. The lateral boundary fault has offset the wooden barrier around the 1998 head scarp on Recreation Drive about 6.5 m (21 ft), which is similar to the offsets seen on upper Scenic Drive.

LIMITATIONS AND UNCERTAINTIES

This map represents a snapshot of an evolving landslide that is still moving several centimeters a day as of May 7, 2005. Although individual data points are located within a few centimeters at the time of measurement, the uncertainties may exceed several meters, given the continued motion of the landslide, the lack of GPS data beneath trees in critical areas, and artifacts of the contouring method. Property lines and cultural features aside from portions of Scenic Drive have not been determined. Survey elevations are derived directly from the differential GPS. Relative elevations are likely quite precise where data coverage is good, but the relation of the GPS frame of reference to local benchmarks has not been determined.

REFERENCES

Brabb, E.E, and Pampeyan, E.H., 1972, Preliminary map of landslide deposits in San Mateo County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-344, 1 oversize sheet, scale 1: 62,500.

Brabb, E.E., Graymer, R.W., and Jones, D.L., 1998, Geology of the onshore part of San Mateo County, California: A digital database: U.S. Geological Survey Open-File Report 98-137, 2 oversize sheets, scale 1:62,500.

Eckel, E. B., ed., 1958, Landslides and engineering practice: Washington, D.C., Highway Research Board Special Report 29, NAS-NRC A544, 232 pp.

Jayko, Angela S., Rymer, Michael J., Prentice, Carol S., Wilson, Ray C., and Wells, Ray E., 1998, Scenic Drive Landslide of January-March 1998, La Honda, San Mateo County, California, U.S. Geological Survey Open File Report 98-229, 1 sheet.

Upp, R. R., 1998, Geotechnical investigation - Landslide Mitigation, Scenic Drive, San Mateo County, California: Upp Geotechnology Incorporated - a report to San Mateo County Environmental Services Agency

Figure 3. Characteristics and nomenclature of a deep-seated landslide (from Eckel, 1958).

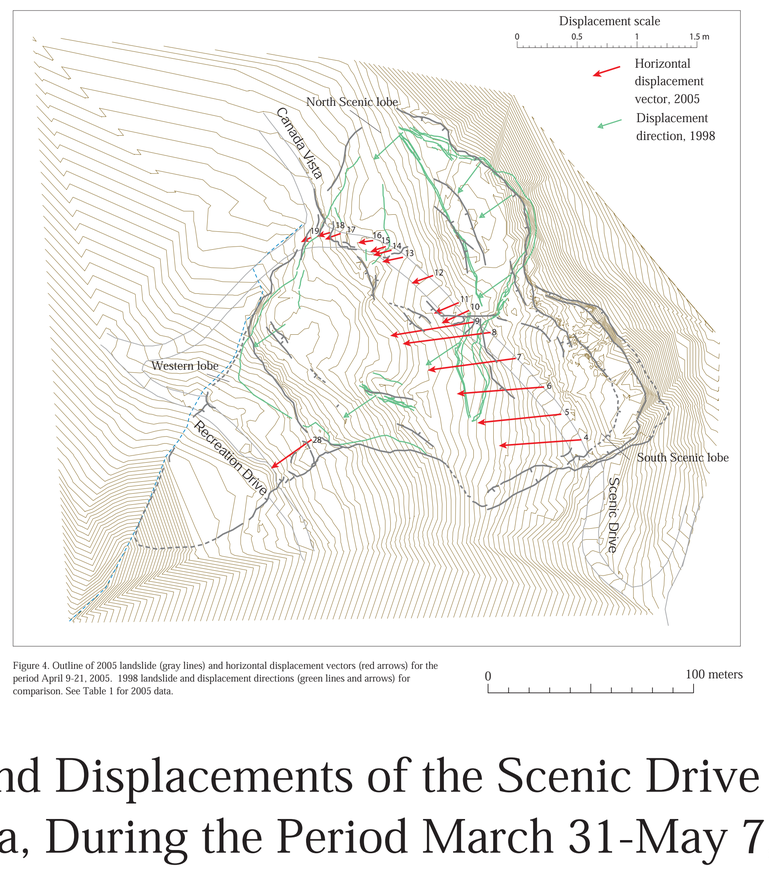

Figure 4. Outline of 2005 landslide (gray lines) and horizontal displacement vectors (red arrows) for the period April 9-21, 2005. 1998 landslide and displacement directions (green lines and arrows) for comparison. See Table 1 for 2005 data.

Table 1. Horizontal component of landslide displacement and average daily rates (in meters) of survey monuments (nails) from repeat differential GPS measurement, April 9 - May 1, 2005.

Nail #	April 9-10 displacement	April 10-13 displacement	April 10-13 rate	April 13-17 displacement	April 13-17 rate	April 17-20 displacement	April 17-20 rate	April 9-20 displacement	April 20-21 displacement	April 21-24 displacement	April 21-24 rate	April 24 - May 1 displacement	April 24 - May 1 rate	May 1-7 displacement	May 1-7 rate	April 9-May7 displacement
3	0.35	0.89	0.30	0.75	0.19	0.54	0.18	2.53	0.13	0.48	0.16	0.93	0.13	0.7	0.12	4.77
4	0.34	0.85	0.28	0.81	0.20	0.58	0.19	2.58	0.12	0.53	0.18	0.87	0.12	0.7	0.12	4.79
5	0.36	0.89	0.30	0.79	0.20	0.54	0.18	2.57	0.14	0.5	0.17	0.94	0.13	0.72	0.12	4.86
6	0.36	0.92	0.31	0.84	0.21	0.56	0.19	2.68	0.16	Nail buried	-	-	-	-	-	-
7	0.39	0.92	0.31	0.82	0.21	0.59	0.20	2.71	0.15	0.53	0.18	1.01	0.14	0.8	0.13	5.21
8	0.37	0.92	0.31	0.83	0.21	0.58	0.19	2.69	0.16	0.56	0.18	1.05	0.15	0.83	0.14	5.31
9	0.36	0.88	0.29	0.79	0.20	0.55	0.18	2.57	0.16	0.51	0.17	1.03	0.15	0.8	0.13	5.07
10	0.19	0.36	0.12	0.24	0.06	0.10	0.03	0.89	0.01	0.03	0.01	0.03	0.004	0.04	0.007	0.98
11	0.17	0.34	0.11	0.17	0.04	0.09	0.03	0.77	0.03	0.03	0.01	0.04	0.006	0.02	0.003	0.85
12	n.d.	0.47	0.12	1.13	0.03	0.08	0.03	1.69	0.03	0.05	0.02	0.03	0.004	0.03	0.005	0.72
13	0.16	0.23	0.08	0.13	0.03	0.09	0.03	0.61	0.01	0.03	0.01	0.03	0.004	0.02	0.003	0.67
14	0.11	0.20	0.07	0.15	0.04	0.06	0.02	0.50	0.03	0.02	0.01	0.01	0.001	0.03	0.004	0.59
15	0.10	0.16	0.05	0.13	0.03	0.03	0.01	0.39	0.03	0.04	0.01	0.01	0.001	0.06	0.01	0.47
16	0.10	0.16	0.05	0.10	0.03	0.05	0.02	0.42	0.03	0.04	0.01	0.01	0.001	0.02	0.003	0.47
17	0.10	0.18	0.06	0.13	0.03	0.04	0.01	0.45	0.02	0.07	0.02	0.04	0.006	0.01	0.002	0.47
18	0.05	0.17	0.06	0.08	0.02	0.03	0.01	0.32	0.03	0.13	0.04	0.08	0.01	0.03	0.005	0.56
19	0.05	0.09	0.03	0.07	0.02	0.01	0.00	0.21	0.02	0.07	0.02	0.04	0.006	0.01	0.002	0.33
28	0.19	0.49	0.16	0.45	0.11	0.33	0.11	1.46	0.08	0.31	0.1	0.61	0.09	0.55	0.09	3.00

Table 2. Displacement vectors and average daily displacement rates of landslide from repeat compass and tape measurements (in m)

Station	az	inc	3/31 - 4/2	4/2-4	4/2-6	4/4-6	4/6-9	4/6-10	4/4-16	4/6-16	4/9-17	4/10-17	4/16-24	4/17-21	4/24-30	4/30-5/7
G7	265	10														
G11	238	64			0.08		0.06				0.07					
G12	220	75			0.00		0.00				0.01					
G13	224	68			0.00		0.08				0.01					
G15	268	66			0.10						0.06					
G16	305	49														
G17	244	68	0.50	0.36	0.28		0.24				0.15			0.18		
G18	255	70														
G19	282	40	0.43													
G20 FENCE	270	0				0.33		0.35				0.25		0.18		
G21	265	40														
G24	250	10		0.22					0.19							
G25	249	32								0.11			0.10		0.11	0.12

az, inc indicate azimuth and inclination (plunge) of slip vector, in degrees

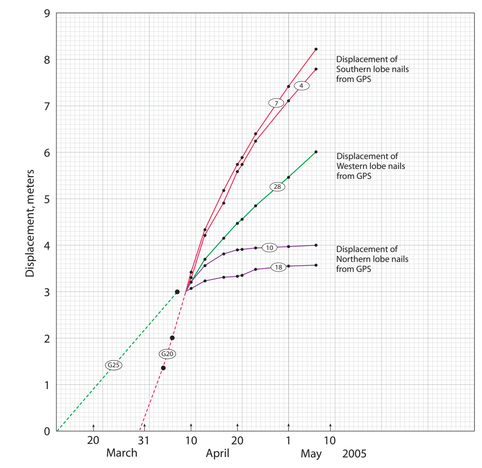

Figure 5. Horizontal displacement, in meters, of survey monuments (nails) from GPS (solid lines). Offset of fences from compass and tape measurements (dotted lines). Start of deformation uncertain for station G 25.

Map showing Features and Displacements of the Scenic Drive Landslide, La Honda, California, During the Period March 31-May 7, 2005

by

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2005