

# Survey Report

of the

## Portuguese Bend Landslide 2017-2018 Monitoring Surveys

Dated: December 4, 2017, Appended March 23, 2018 and April 23, 2018

for the

### City of Rancho Palos Verdes

prepared by

### McGee Surveying Consulting

*The Portuguese Bend Landslide is monitored on a tri-annual basis beginning with the primary survey of 66 Monitoring Points at the beginning of the rainy season in September-October of each year. The primary survey is addressed in this Report and two subsequent partial monitoring surveys of 30 Points conducted in mid-winter and mid- spring are addressed as Addendums No. 1 and No. 2 to this Report. Consequently, this Report is issued three times with the third being the final Report for the rainy season. The average date of each survey follows.*

**Initial Survey - October 4, 2017 Full Monitoring Survey No. 19 Report**  
**Second Survey - February 12, 2018 Partial Monitoring Survey No. 20 Report**  
**Third Survey - April 16, 2018 Partial Monitoring Survey No. 21**

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# Survey Report

of the

## Portuguese Bend Landslide Monitoring Survey

October 4, 2017 Initial Monitoring No. 19

for the

**City of Rancho Palos Verdes**

Prepared December 4, 2017 Revised March 23, 2018

by

**McGee Surveying Consulting**

### **PROJECT OVERVIEW:**

McGee Surveying Consulting performed a landslide monitoring survey in October 2017 at Portuguese Bend on behalf of the City of Rancho Palos Verdes. This survey established positions on monitoring points to determine overall and periodic movements. The results of the survey are described in this Report and in the attached annual spreadsheet titled "PB MOVEMENT DATA POSTING 2007-2017.10 rev.xlsx". Two partial monitoring surveys follow in the winter and spring and are reported as addendums to this Report.

The field surveys are planned, coordinated and executed by Michael McGee, PLS3945 of McGee Surveying Consulting who is also responsible for the final processing of the observations, network adjustments, analysis and reports. Sixty-six monitoring points covering a 1.5 by 2 mile area were measured to determine the rate and extent of ground movement as reported herein. The City of Rancho Palos Verdes assumed responsibility for monitoring the Portuguese Bend Landslide Complex circa 1994 from the County of Los Angeles. The Global Navigation Satellite System (GNSS) formerly referred to as GPS technology is used to measure positions of points because of its high accuracy and cost efficiency. The horizontal and vertical positions of the monitoring points are based on the North American Datum of 1983 (NAD83) and the North American Vertical Datum of 1988 (NAVD 88). The survey is referenced to physical monuments known as California CGPS (Continuous GPS) Stations in the region which are permanently mounted GPS and GNSS receivers used for monitoring seismic activity. The CGPS in California are comparable to the national CORS (Continuously Operated Reference Stations) network.

Points that move a few inches or less per year are surveyed to meet an accuracy standard of one centimeter (0.033 feet) at the 95% Level of Confidence. In the active slide area where the movements are greater than 0.25 feet per year (PB and UB points), the accuracy standard is two centimeters (0.066 feet) at the 95% Level of Confidence. Field procedures are designed to accomplish this purpose and Quality Control-Quality Assurance (QAQC) processes discussed hereafter are incorporated to verify these accuracies are attained.

Prior to September 2007, successive coordinate differences were used to compute movements; however, arithmetic differences do not provide statistical information about the relative movement accuracies. Beginning with the initial 2007 survey, field and office procedures were designed to assure the accuracy and reliability of measurements and provide for queries between epochs that include statistical information about the relative precisions of the reported movements. Measurements of temporal movements and statistical analysis are based on a rigorous simultaneous least squares adjustment of multiple observations at two different epochs for each monitoring point.

### **HISTORY**

This monitoring survey is a continuation of a program initiated by the County of Los Angeles and taken over by the City of Rancho Palos Verdes circa 1994. McGee Surveying Consulting has conducted the field surveys and reporting since September 2007. The monitoring surveys have occurred annually since 2007, semi-annually since 2012 and three times a year beginning with the September 2014 survey. See the September 2007 Survey

Report for a history of the previous survey process between 1994 and 2007. See the Survey Reports on file with the City commencing in 2007 for details of each monitoring campaign.

**PROJECT DATUMS, REFERENCE SYSTEM**

**Horizontal Datum:** The horizontal datum is the North American Datum of 1983 established by the National Geodetic Survey (NGS) referred to as NAD83 (2007) 2007.00 Epoch. The NAD83 (2007) 2007.00 Epoch adjustment is one of a series of national adjustments of the NAD83 Datum since its adoption in 1986 and is the realization used for these monitoring surveys beginning in 2007. The positions listed below were obtained in September 2007 from the California Spatial Reference Center (CSRC). The CSRC provides California Public Resources Code sanctioned positions for the California CGPS Stations. The current national realization of NAD83 is the 2011 adjustment published by the NGS and referred to as the NAD83 (2011) 2010.00 Epoch Adjustment. The CSRC published an updated adjustment of the CGPS stations in California known as the NAD83(2011) 2017.50 Epoch Adjustment. However, the above referenced NAD83 (2007) 2007.00 Epoch realization is retained by this survey to be consistent with prior reporting and the primary purpose of determining relative movements over time.

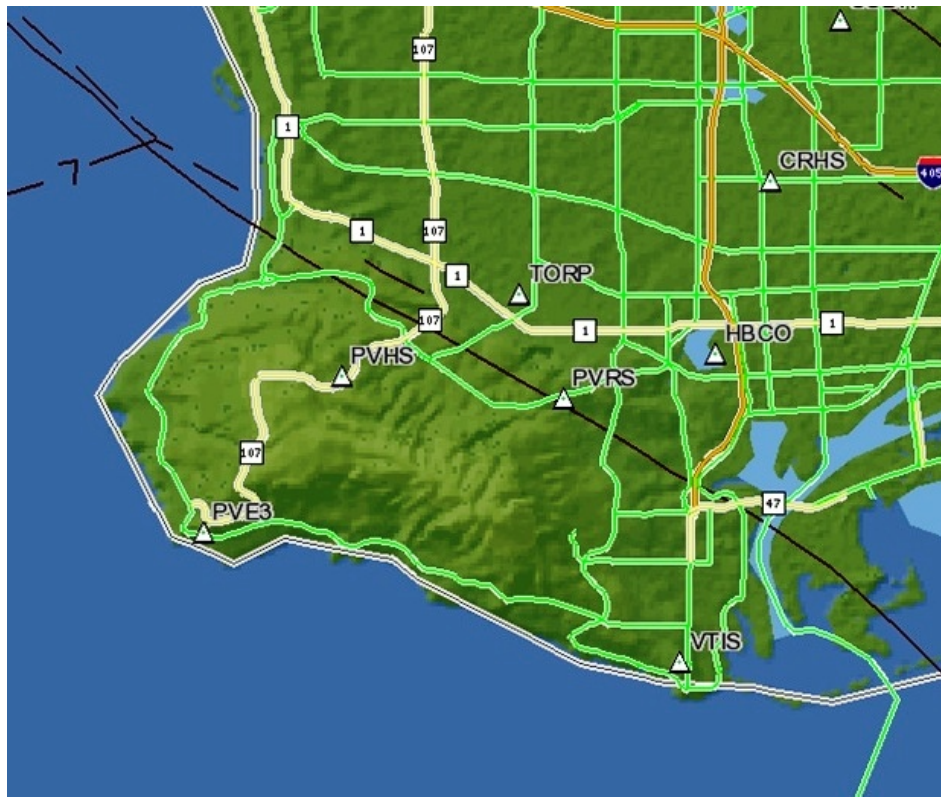
**Reference Network:** The survey is referenced to the CGPS Stations (continuously operating GPS & GNSS receivers). For more information see NGS Data Sheets for the PID's listed below (no data sheet exists for PVE3) and the CSRC website.

**Units:** Feet

NAD83 (2007) 2007.00 Epoch									
CGPS	Latitude (dms)		Longitude (dms)		EH (feet)	NGS PID	NAME		
PVE3	33	44	35.853290	-118	24	15.269036	235.42	none	PALOS VERDES CORS
PVHS	33	46	46.020150	-118	22	19.741258	853.99	AJ1915	PENINSULA HIGH SCH
PVRS**	33	46	25.891904	-118	19	14.067218	198.63	AJ1916	PALOS VERDES RES
VTIS	33	42	45.489584	-118	17	37.712290	197.52	AJ1936	MARINE EXCHANGE

\*\* Falls in the proximity of a Fault Line as shown below but appears unaffected to date

**CGPS Stations (north up)**



**Vertical Datum:** The North American Vertical Datum of 1988 (NAVD88) established by the NGS.

**Reference Network:** CGPS Station VTIS is also a Second Order leveled benchmark and the original basis for the elevations in this survey. See the Record Elevations of CGPS stations following.

<u>CGPS</u>	<u>NAVD88 Ht. (Feet)</u>	
PVE3	none	
PVHS	972.1	Based on a Refined Geoid Model
PVRS	316.37	Based on Second Order Leveling by CSRC
VTIS	315.26	Based on Second Order Leveling by CSRC and basis for this survey

**Geoid Model:** Geoid03 available at the time of the initial 2007 survey. Note the Geoid09 Model became available from the NGS in 2009 and Geoid12B in 2012; however, Geoid03 is retained to be consistent with prior reported heights and the primary purpose of determining relative height changes over time.

**Projection:** Plane coordinates are NAD83 California State Plane Coordinates Zone 5 in US Feet. The State Plane Coordinate Parameters follow: The average Scale Factor is 1.00007543, the Height Reduction Factor based on the average ellipsoid heights is 0.99999092, and the average Combined Grid Factor is 1.00006635. Distances in this survey are grid. To obtain ground distances divide grid distances by the Combined Grid Factor. Grid bearings resulting from this survey must be rotated by a Convergence Angle to obtain geodetic (true) bearings. The average convergence angle is -0-12-30± (rotate left 0-12-30).

**Datum Stability:** Rancho Palos Verdes sits on the Pacific Plate which is moving west-northwesterly relative to the North American Plate about 4 centimeters (0.14 feet) per year. The area southwesterly of the Fault Line shown on the above map includes the City and is moving at a constant rate as exhibited by the International Terrestrial Reference Frame (ITRF) north, east and up velocities of the CGPS Stations obtained from SOPAC and listed below.

SITE	ANNUAL VELOCITIES (mtrs)			ANALYSIS PERIOD	
	N	E	Up	START_DATE	END_DATE
PVE3	0.019	-0.040	-0.000	2000.731	2017.828
PVHS	0.019	-0.040	0.001	1999.511	2017.828
PVRS	0.019	-0.039	0.000	1999.095	2017.828
VTIS	0.019	-0.039	-0.001	1998.938	2017.828

These CGPS Stations surround the Portuguese Bend Landslide providing a rigid reference frame from which to validate the stability of the network during each monitoring campaign. See the September 2007 Monitoring Survey Report by McGee Surveying Consulting and the Adjustment results below for validation of network stability.

## **FIELD SURVEYS, DATA COLLECTION, EQUIPMENT & PROCESSING**

Two Leica geodetic GNSS receivers/antennas listed below were mounted on two-meter fixed height poles to collect satellite signal data. The GS15 receivers tracked Navstar GPS, GLONASS, Galileo and BeiDou satellites. A calibration of the poles is conducted to verify their heights and plumb. The poles were found to be plumb within 0.003 feet consistent with prior years. There were no equipment failures.

Sixty-six monitoring points were occupied and reported in this survey. Site photographs and recovery sheets detailing the location, character of the monuments and obstructions were updated. See the Appendix for "Monitoring Point Status". AB61, established in September 2007 on Portuguese Point, is used as the primary base station in each survey because it sits above a stable basalt formation.

The field survey commenced each day by setting a Leica GS15 GNSS receiver on a fixed height pole at AB61 while a second GS15 GNSS receiver roamed freely collecting observations on a fixed height pole at the remaining 65 points. Points with annual movements less than 0.2' were measured with two or more independent occupations resulting in a minimum of two vectors to each point from AB61. An independent occupation means

the points were occupied under a different constellation of satellites usually on a different day. If the two measurements are within 0.03 feet (1 cm) horizontally, they are accepted, otherwise a third measurement is required. Experience has shown the two measurements are generally less than 0.015 feet. AB61 and the CGPS stations were connected with 4-10 hour observations averaging 8 hours collected over six days. Points in the active areas with annual movements greater than 0.2' were single occupied. AB12 was single occupied due to restricted access. A comparison with the linear movements from prior years is made to verify their accuracy.

Trees and foliage that over-shadowed points interfere with signals received from satellites and affect the quality of measurements. To obtain the best possible accuracies, the satellite constellation is compared with obstruction diagrams to estimate the best time for observing un-obstructed satellites. To improve the accuracy of the measurements, satellites that are obstructed by trees and foliage are either turned off during the observation or noted for removal in post-processing. Generally, if six or more un-obstructed satellites with a GDOP of less than four (measure of the geometry or strength of figure of the constellation) are available, then the measurement commences for a minimum of 15 minutes of data collection. If the geometry and number of satellites are insufficient then the receiver is moved to another point and returned later when satellite availability improves.

**Date of Survey:** 10/01/17 to 10/07/17 (mean date 10/04/2017) between 0600-1800 PDST (+7 hrs for UTC).

**GNSS Survey Parameters:**

**Constellation:** 31 US NAVSTAR GPS satellites, 24 Russian GLONASS, 14 Galileo and 18 Beidou Satellites.

**Observables:** L1 & L2 Carrier Waves on GPS, GLONASS and Beidou, and four Carrier Waves on Galileo Satellites

**Epoch Rate - Occupation Times:** 15 second epoch rate for 15-minute occupations at monitoring points and six 4-10 hour occupations at the base station AB61.

**Satellites:** 17-21; GDOP  $\leq$  2; Elevation Mask for Data Collection at 15° and Processing at 15°

**Ephemeris:** Precise for Static Post-Processing of CGPS connections and Broadcast for onsite.

**Weather:** Mostly clear skies, temperature 60°-90° F, no significant weather.

**Space Weather:** Boulder K Index was 0-3 averaging 1-2 (gauges ionospheric activity on a scale of 0-9; less than 6 preferred)

**Equipment:**

GNSS Base Receiver Unit No.: M8, Operator: M. McGee, PLS; Station Occupied: AB61 (Base1)

Make & Model: Leica GS15; Antenna Leica GS15; Mount: Fixed Height Pole #1; Antenna Height: 1.803m

GNSS Rover Receiver Unit No.: M9, Operator: M. McGee, PLS;

Make & Model: Leica GS15; Antenna Leica GS15; Mount: Fixed Height Pole #3; Antenna Height: 1.800m

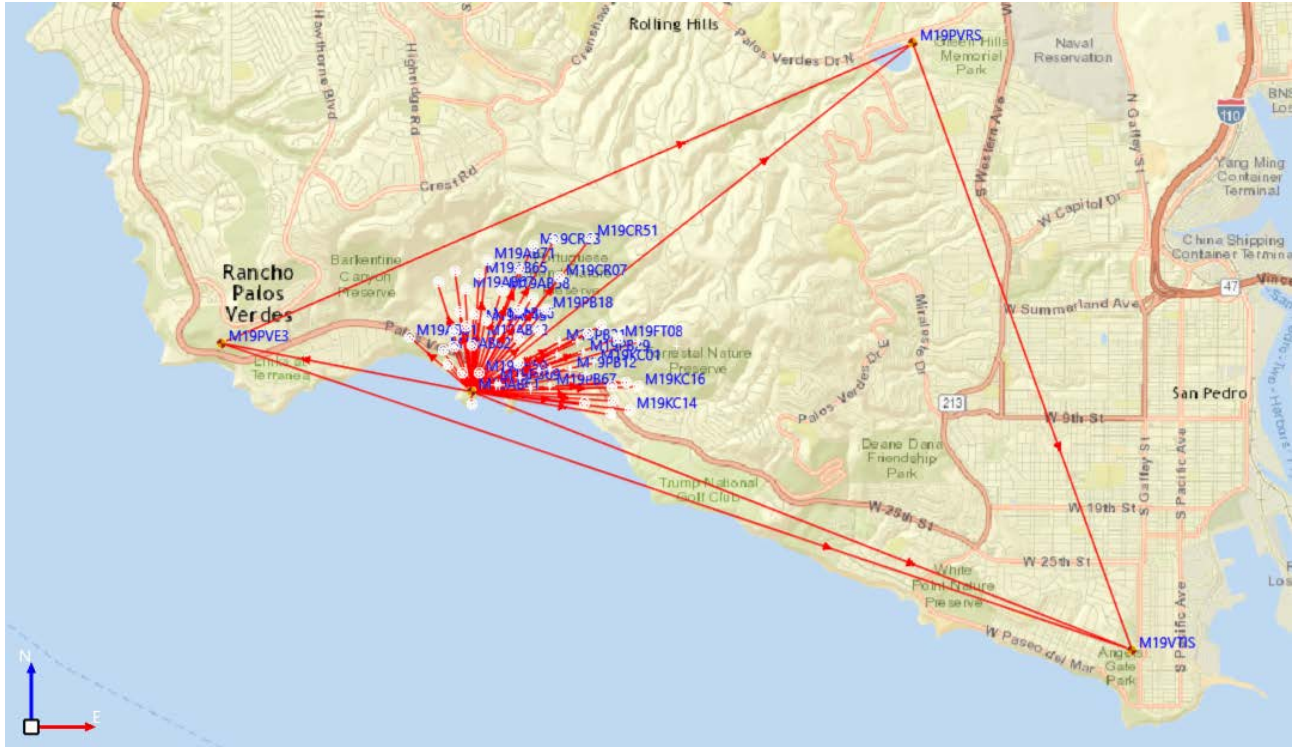
Rinex files (satellite observations) for the CGPS Stations were downloaded from the SOPAC website. Vectors were processed using Leica Infinity v2.4 post processing software with Absolute Antenna Models obtained from the NGS website. Network adjustments and analysis were performed with "Starnet-PRO" version 9.0 software.

## **NETWORK**

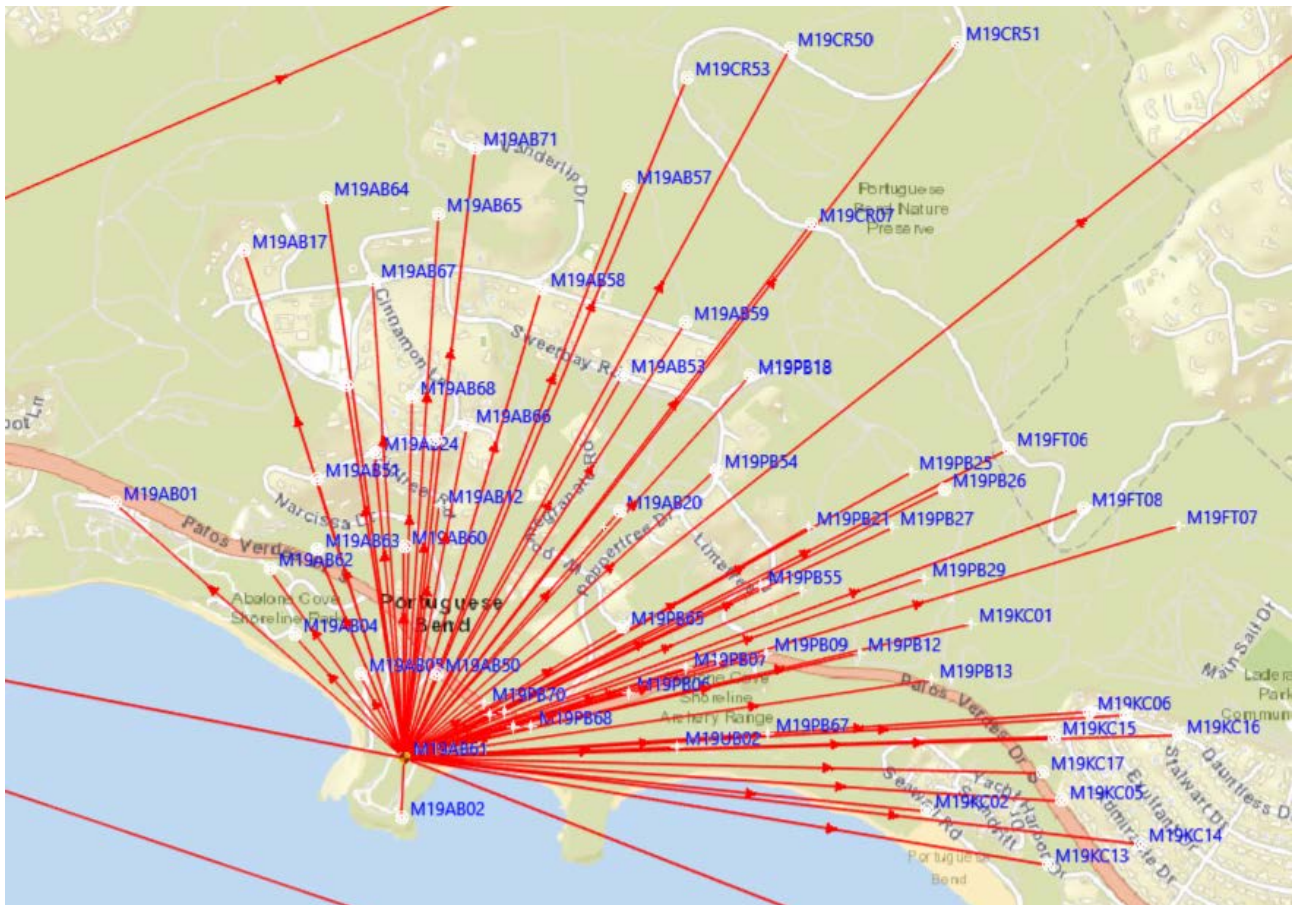
The primary Base Station AB61 is situated on Portuguese Point and is the focal point of the static network connecting the monitoring points and CGPS Stations. Sixty-six points and three CGPS Stations were connected with 130 vectors. See the following Network Maps and the Aerial View in the Appendix.

The monitoring plan utilizes the CGPS Stations to verify the stability of the reference frame. PVE3 is the primary CGPS Station used to control this survey located just south of City Hall and 1.8 miles west-northwest of Base Station AB61. CGPS Stations PVE3, PVRS and VTIS were used to validate the stability of the network.

**Monitoring Network and CGPS Stations (north up)**



**Monitoring Network (north up)**



## **MONITORING POINT HISTORY and STATUS**

This is the 19<sup>th</sup> Monitoring Survey. For data management purposes during the field survey and data processing, the point names are prefixed with a sequential number to distinguish between monitoring surveys. For example, on the 16<sup>th</sup> monitoring survey AB61 was named M16AB61 where M16 indicates the sequence number since the initial September 2007 Monitoring Survey. The prefix is stripped in the “COORDINATES LIST” and “PB MOVEMENT DATA POSTING” documents.

Between 1994 and 2006, 149 monitoring points were established to monitor the Portuguese Bend Landslides, many of which were lost or destroyed. Sixty of the original points were recovered in 2007. Eight of the 60 points were deleted because they were near other points better suited for GNSS satellite measurements leaving 52 original points monitored and reported between September 2006 and September 2007. Three of the 52 points (AB09, KC11 & PB51) were monitored in September 2007 for the last time and replaced by new points, set nearby and better suited for satellite observations.

2007: Eighteen new points were set in 2007 and had their movements reported for the first time in the following December 2008 survey. In September, it was noted that KC01 was previously reported by others on 9/14/2006 to have moved N 29°E 1.24' from its 12/09/2005 position. In September 2008, this survey found a buried partially illegible brass cap in concrete stamped "COUNTY ENGINEER RE8869 1956 STA ??IELDS" S31°W 1.48 feet from the 1" IP used by the previous survey and this survey in the initial September 2007 and subsequent surveys. The original 1994 position of KC01 (brass cap) was re-referenced to the 1" IP, resulting in a correct overall movement as reported by this survey.

2008: In December 2008, 49 original and 18 new points were surveyed for a total of 67 monitoring points. In December, it was noted that AB05 had been disturbed by a mowing machine. AB05 was found chipped and leaning to southerly about 0.4'. The movement reporting resumed in 2009. Analysis of the movement and historic data made it possible to estimate the disturbance to within 0.05'. The original 1995 position of AB05 was re-referenced S14°E 0.29' to be consistent with the disturbed position, resulting in correct overall reported movements.

2009: PB64 was set east of the Archery Range to replace PB63 (set 2007) which had become unsafe to access and was lost in 2010. PB64 was reported for the first time in October 2010.

2010: Points AB03 and BB25 were discontinued. AB03 is on the edge of a cliff 192 feet west-southwest of AB61 making it redundant, and BB25 is on a freestanding rock susceptible to disturbance by wave action. In the summer of 2010, PB62 was destroyed by road construction and in October 2010, PB65 was set 24' south-southwest of PB62's location and reported for the first time in October 2011. The following points may have been disturbed prior to the October 2010 survey: AB05 appears to have been disturbed by mower machinery, AB15 (½" GIP in a meter box) is driven over by vehicles occasionally accessing an adjacent field, and KC02 (½" GIP in a meter box) is occasionally parked on by vehicles accessing the beach.

2011: In October, new points AB62 and AB63 (initially referred to as AB62R and AB63R) were set to replace AB06 and AB07 which were hazardous to occupy due to their location near the traveled way of Palos Verde Drive South.

2012: In September, prior to initiating the survey, eight new monuments AB64, AB65, AB66, AB67, AB68, CR53, KC17 and PB66 were constructed to replace AB54, AB18, AB52, AB55, AB15, CR52, KC04 and PB53 respectively. The monuments were replaced because of poor sky visibility except for KC04 which was difficult to access and AB55 which was destroyed by trenching in the past year. Monuments were set with the following design. Monuments set in soil are 1" x 5' GIP driven flush and encase in a 6" PVC pipe sitting on a concrete collar down about 18". Monuments set in asphalt are 1/2" x 2' rebar driven below the surface inside a free floating 2" plastic collar encased in concrete.

2013: Points AB15, AB18, AB52, AB54, CR52, KC04 and PB53 were surveyed for the last time in 2012 and discontinued. BB52 is on a freestanding rock susceptible to disturbance by wave action and was monitored for the last time in October and discontinued.

2014: In April PB64 was monitored for the last time due to unsafe access conditions and PB67 (a 5' t-bar steel post driven 3' into the ground) was set north-northwesterly about 250' as a replacement and reported for the first time in September 2014 after 4.5 months whereas all other points in the “PB MOVEMENT DATA POSTING”

are reported for 11.5 months since October 2013. In September, AB69 located about 260' NE of AB12 and AB70 located about 140' SE of AB12 were set as potential replacements; however, AB69 was destroyed by lot improvements and AB70 proved to be too obstructed for accurate results.

2015: In April, new points PB68, PB69 and PB70 were set to monitor movements of "Palos Verdes Drive South" and reported in October. In October, Monitoring Point AB56 was found disturbed by construction and AB71 (magnetic nail in AC) was set as a temporary replacement. In October, the steel post for PB67 was not found. An inconspicuous 1/2" x 4' rebar was set flush in its place. Because of the large movement in this area a more permanent monument is not necessary.

2016: In October, the temporary point for AB71 was destroyed by road work prior to this survey. AB71 was reset 12' easterly with a 2" screw and brass washer drilled into a granite curb on Vanderlip Road. No movement information will be available until the fall 2017. KC16 was raised about 0.29' to the surface of the road by others between the two October 2016 occupations.

2017: Movement of AB71 (replacement for AB56) reported for the first time in October.

### ADJUSTMENTS & ANALYSIS

**Adjustment 1:** An adjustment to develop NAD83 (2007) 2007.00 Epoch Latitude, Longitude, Ellipsoid Heights and State Plane Coordinates. CGPS Station PVE3 was fixed at its published NAD83 (2007) 2007.00 Epoch position listed previously in a Minimally Constrained Adjustment to determine positions of points in this survey and verify its stability relative to other CGPS stations. PVE3 is located 1.8 miles westerly of and outside the influence of the slide area and has been fixed in all adjustments since 2007. The SOPAC published Time Series indicates the horizontal and vertical position of PVE3 is stable. The primary base station AB61 and other operating CGPS Stations were measured relative to PVE3 and used to assess stability of the survey reference frame. The positions are based on six 4-10 hour occupations (observations). The results are listed in the Coordinate List in the Appendix. Differences between surveys for key points are listed in the table below in feet.

09/2014 Positions to 10/2015					9/2007 Positions to 10/2015			
ID	dN	dE	dZ		ID	dN	dE	dZ
PVE3	-0.000	-0.000	-0.000	< Fixed >	PVE3	-0.000	-0.000	-0.000
PVRS	0.001	0.007	0.016		PVRS	-0.004	0.016	0.000
VTIS	0.003	0.005	0.049		VTIS	-0.000	0.017	-0.007
AB17	0.015	-0.017	0.042		AB17	-0.004	-0.022	-0.020
AB61	-0.007	0.003	-0.001	<Base Station>	AB61	-0.005	0.007	-0.055
CR51	0.011	0.005	0.017		CR51	-0.028	0.014	-0.112
KC16	0.014	0.008	0.010		KC16	0.013	-0.005	-0.048

10/2015 Positions to 10/2016					9/2007 Positions to 10/2016			
ID	dN	dE	dZ		ID	dN	dE	dZ
PVE3	-0.000	-0.000	-0.000	< Fixed >	PVE3	-0.000	-0.000	-0.000
PVHS	-0.007	0.000	0.024	<10/2013	PVHS	-0.006	0.011	0.042
PVRS	0.000	0.003	0.019		PVRS	-0.003	0.019	0.019
VTIS	-0.001	-0.010	0.009		VTIS	-0.002	0.006	0.002
AB17	-0.019	-0.010	0.051		AB17	-0.023	-0.032	0.031
AB61	0.000	-0.002	0.016		AB61	-0.004	0.005	-0.038
CR51	-0.014	-0.011	0.012		CR51	-0.042	0.002	-0.099
KC16	-0.022	0.001	-----		KC16	-0.009	-0.003	-----

10/2016 Positions to 10/2017					9/2007 Positions to 10/2017			
ID	dN	dE	dZ		ID	dN	dE	dZ
PVE3	-0.000	-0.000	-0.000	< Fixed >	PVE3	-0.000	-0.000	-0.000
PVRS	-0.004	-0.001	-0.007		PVRS	-0.008	0.018	0.012
VTIS	0.002	0.003	-0.001		VTIS	0.000	0.009	0.000
AB17	-0.001	0.018	-0.001	<Base Station>	AB17	-0.025	-0.013	0.029
AB61	-0.004	0.000	0.112		AB61	-0.008	0.006	0.074
CR51	0.004	0.004	0.013		CR51	-0.037	0.007	-0.087
KC16	-0.004	-0.003	0.059		KC16	-0.014	-0.006	0.381



Comments: The Base Station AB61 has no significant differences since October 2016 and 2007 as referenced to PVE3. Given that PVE3 and AB61 agree, the survey reference frame is deemed stable and successfully recovered. An adjustment constrained to the other CGPS Stations is not necessary because the purpose here is to track their movements over time to test the stability of the reference frame and validate the measured movements. See the “COORDINATE LIST” in the Appendix for a list of coordinates resulting from this adjustment. See prior Survey Reports for coordinates resulting from earlier surveys.

**Adjustment 2:** An adjustment to develop NAVD88 Orthometric Heights (Elevations). The CGPS Station PVE3 was fixed horizontally at its NAD83 position and vertically at its NAVD88 height determined in the September 2007 survey. The 2007 height was based on the published 2<sup>nd</sup> Order NAVD88 Height of CGPS Station VTIS. This Adjustment combines the measured ellipsoid height differences with the NGS Geoid03 Model (models the separation between the ellipsoid and geoid surfaces) to determine the NAVD88 orthometric heights of the CGPS Stations and monitoring points. The results are listed in the Coordinate List in the Appendix.

**ACCURACY**

This survey conforms to the intent of the California Spatial Reference Center & California Lands Surveyors Association’s “GNSS Surveying Standards and Specifications, 1.1” (2014) and the Federal Geodetic Control Subcommittee (FGCS) “Specifications for GPS Relative Positioning” (1988).

**Vector Residuals:** The vector lengths, two dimensional residuals and the absolute value of the vertical residuals are listed below in feet. Analysis of residuals resulting from minimally constrained Adjustment #1 led to the rejection of 4 out of 21 vectors connecting the CGPS Stations to the Base Station AB61 with 4-10 hour observations and 0 out of 108 vectors connecting AB61 to monitoring points with 15 minute observations. Vectors to single occupied points are excluded to avoid optimistically skewing the results; however, the statistics given below are applicable to all measurements.

Network	Vector Lengths		Two Dimensional Residuals			Vertical Residuals (absolute)		
	Vary	Average	Average	Std.Dev.	Maximum	Average	Std.Dev.	Range
Mon. Pts	479-7182	3849	0.007	0.004	0.017	0.009	0.008	-0.038 to +0.033
CGPS	9397-35383	19436	0.007	0.005	0.016	0.007	0.005	-0.017 to +0.016

**Local Accuracy:** The relative accuracy of points resulting from the minimally constrained Adjustment #1 is estimated at the 95% Level of Confidence in feet.

Average	Monitoring Points		CGPS Stations	
	2D	Vertical	2D	Vertical
	0.013	0.029	0.006	0.007

**Movement Accuracy:** The relative movements reported between October 5, 2016 and October 4, 2017 (12.0 months) statistically attained an average accuracy of 0.016 feet at the 95% Level of Confidence and range 0.006 to 0.024 feet. The actual accuracy of measurements held to the “one-centimeter standard” are estimated to approach 0.01 feet as demonstrated by the vector residuals, repeatability of measurements at points considered stable, and deflection analysis. Refer to the sections titled ACCURACY and QAQC ANALYSIS in this Report for more information.

Statistically, the probability at the 95% level of confidence is that movement (signal) has occurred at a point when the horizontal distance between two epochs is greater than the 95% Error (noise). No movement is considered detected unless the movement exceeds the 95% Error for individual points. Applying this criterion, 5 points have not moved. See the attached “PB MOVEMENT DATA POSTING 2007-2017.10.xlsx” for the relative movements and the estimated error at the 95% Level of Confidence for individual points.

**NAVD88 Heights:** The North American Vertical Datum of 1988 orthometric heights resulting from Adjustment #2 are derived from the difference in ellipsoid heights combined with the Geoid03 Model and constrained to the NAVD88 height of PVE3 determined in 2007 based on the second order orthometric height of VTIS. The relative accuracy of the heights is expected to be 0.03 feet or better, but can be greater at obstructed sites. The absolute accuracy of the heights relative to the datum is dependent on the published orthometric height on the CGPS Station VTIS. Up until October 2011 there were no specific requirements for vertical accuracies. In October 2011, a 0.03-foot relative vertical accuracy preference was introduced for points AB17, AB57, CR07, CR50 and CR51. In the September 2012 and subsequent surveys the preference was extended to all points.

## **QUALITY CONTROL - QUALITY ASSURANCE (QAQC) ANALYSIS**

To ensure the accuracy and validity of the measurement systems used in these GNSS monitoring surveys, an independent test was conducted in 2007 using conventional terrestrial based instruments as reported in the "QAQC ANALYSIS" section of the September 2007 Monitoring Survey Report. Comparing the results of the GNSS systems with conventional instrumentation found horizontal measurements agreed 0.01 feet on average. In November 2011, the GNSS instruments and fixed height poles used in this survey were calibrated on the National Geodetic Survey's Santa Maria Baseline and found to agree with published distances 0.003 to 0.006 feet. In February 2018, the GNSS instruments and fixed height poles were calibrated on the NGS Camarillo Baseline and found to agree with published distances 0.003 feet.

To validate the radial survey method used in these surveys to position points from base stations AB61, independent GNSS intra-net cross connections were measured and compared with the stand alone computed inverse distances in the 2007, 2008 and 2009 surveys. The results found the two-dimensional accuracy to agree 0.01 feet on average, indicating the radial method of measurements is reliable and the additional labor cost of measuring cross connection between points is not warranted. See the "QAQC ANALYSIS" section of the September 2007 and the December 2008 Monitoring Survey Reports for detailed analysis.

Deflection Analysis is a method established by this surveyor to assess the consistency of the direction of movements reported from period to period. Assuming that movements are generally linear for points moving less than a foot, the separation or the deflection between the direction of the previous and present periods taken over the moved distance implies the accuracy obtained with the equipment, methods and procedures. Analysis of individual deflections found the separations and implied accuracy varied 0.01 to 0.02 feet.

## **SUMMARY**

Point movement ranges by slide zones are listed below in feet:

(AB##) 0.00 to 0.29  
(CR##) 0.00 to 0.13  
(FT##) 0.04 to 0.29  
(KC##) 0.00 to 0.25  
(PB##) 0.19 to 2.43 and 12.44 at PB67  
(UB02) 2.78

See the Appendix for a graphic of the horizontal movements depicted by 1" and 1' contours.

See the attached " PB MOVEMENT DATA POSTING 2007-2017.10.xlsx " spreadsheet for overall and periodic movements of each point. The movements are given in north, east and up or down as well as a vector of distance and direction relative to north. The direction is given as an azimuth in degrees where 0° is north and increases clockwise (90° East, 180° South, 270° West). The overall movements listed in the spreadsheet are from the date when a point was first set to the present survey.

The present status of monitored points is provided in the Appendix under "Monitoring Point Status". The historical status of all monitoring points is provided in the September 2007 Survey Report. The historical 1994-2006 positions of all points are listed in the Charles Abbott Associates Inc. file "ALL POINTS MOST RECENT OBSERVED POSITION AS OF SEPTEMBER 15, 2006.xls". This file was attached as an electronic file to the 2007 Survey Report.

### RECOMMENDATION

An ongoing re-location program for monuments has long term benefits resulting in better accuracy and lower cost surveys due to improved sky visibility for tracking satellites. No monuments were re-located during this survey. Points AB16, AB17, AB24 and AB58 have limited sky visibility and are candidates for re-location or deletion. AB12 is in a horse corral and is difficult to access; however, there are no nearby alternatives.

Two points could be substantially improved by tree trimming along public roads where there are no adjacent residences by trimming the Pepper Trees northeast and southwest of AB17 on Fruit Tree Road and northeast of AB58 on Narcissa Drive.

**Attachments:** The following document is attached to this Report.  
"PB MOVEMENT DATA POSTING 2007-2017.10.xlsx" listing the coordinates of the initial positions, the overall and periodic movements of monitoring points since 2007.

### SURVEYOR'S STATEMENT

This is a Report on the procedures, criteria and results of the City of Rancho Palos Verdes Portuguese Bend Landslide Monitoring Surveys. This Report includes the Initial Survey conducted in the fall, the Second Survey Addendum No.1 added in the winter and the Third Survey Addendum No.2 added in the spring. This survey was conducted and the report prepared by me at the request of Ron Dragoo, Principal Engineer of the City of Rancho Palos Verdes.

#### Initial Survey - Full Monitoring Signature

 12/5/17  
Michael R. McGee P.L.S. 3945 Date

#### Second Survey - Partial Monitoring Signature

 3/23/18  
Michael R. McGee P.L.S. 3945 Date

#### Third Survey - Partial Monitoring Signature

 4/23/18  
Michael R. McGee P.L.S. 3945 Date



### APPENDIX

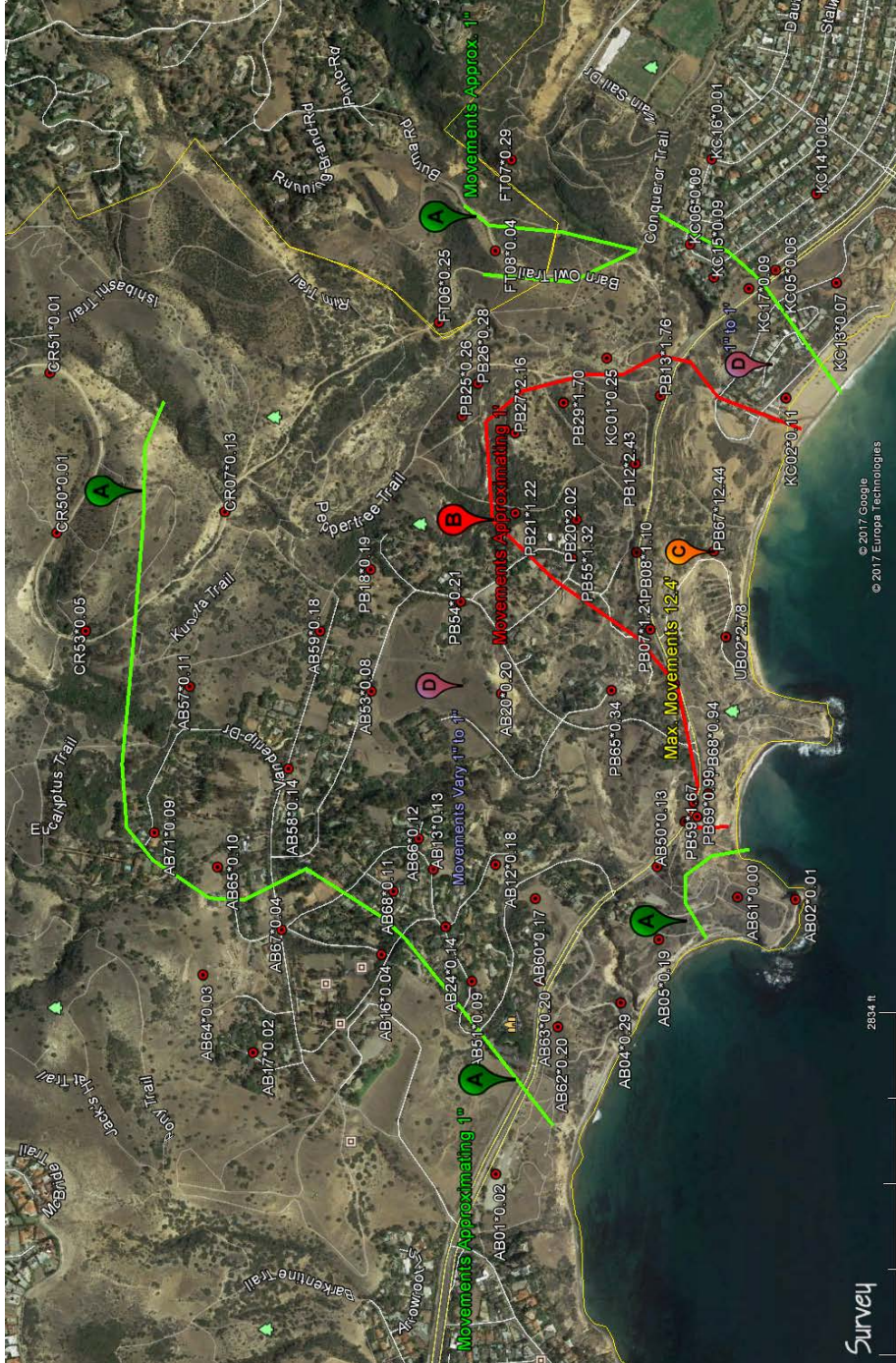
- 12- Aerial Photo of Monitoring Points with Movements and Contours
- 13- Table of Horizontal and Vertical Movements
- 14- Monitoring Point Status
- 15- Coordinate List for the Oct. 4, 2017 Survey: NAD83 (2007) 2007.00 Epoch Geodetic, Grid, NAVD88
- 16- ADDENDUM No. 1: Second Survey – February 12, 2018 Partial Monitoring Survey No. 20
- 17- ADDENDUM No. 2: Third Survey – April 16, 2018 Partial Monitoring Survey No. 21
- 18- ADDENDUM No. 1 & 2: Table of Partial Monitoring Survey Horizontal and Vertical Movements

## Aerial Photo of Monitoring Points with Movements and Contours (north is left)

**General Depiction of Horizontal Movements - October 5, 2016 to Oct. 4, 2017**  
(Generalized depiction of movements and not to be used for planning or development purposes)

- A = Approximate 1 inch Contour Line**
- B = Approximate 12 inch or 1 foot Contour Line**
- C = Maximum Measured Movement of 12.4 feet**
- D = Movements Vary 1 inch to 1 foot between Lines A & B**

AB24\*0.14 = Typical Point ID with Movement in Feet



**Table of Movements at Monitoring Points**  
**Portuguese Bend Landslide Monitoring**  
**Horizontal and Vertical Movements in Feet**  
**October 5, 2016 to October 4, 2017 - 12.0 Months**

Listed below are the horizontal movements and vertical (elevation) changes in the last annual period. See the attached spreadsheet titled "PB MOVEMENT DATA POSTING 2007-2017.10.xlsx" for more details and a history of movements. Note: The measurement confidence is 0.02' (1/4"); therefore, movements greater than 0.02' are deemed to have actually moved.

<b>Point ID</b>	<b>Horizontal Movements</b>	<b>Vertical Changes</b>	<b>Point ID</b>	<b>Horizontal Movements</b>	<b>Vertical Changes</b>
AB01	0.02	0.09	KC01	0.25	0.03
AB02	0.01	0.08	KC02	0.11	0.11
AB04	0.29	0.07	KC05	0.06	0.08
AB05	0.19	0.11	KC06	0.09	0.02
AB12	0.18	0.09	KC07	0.01	0.06
AB13	0.13	0.08	KC13	0.07	0.11
AB16	0.04	0.11	KC14	0.02	0.05
AB17	0.02	0.00	KC15	0.09	0.04
AB20	0.20	0.06	KC16	0.01	0.06
AB24	0.14	0.05	KC17	0.09	0.10
AB50	0.13	0.10	PB04	1.12	-0.26
AB51	0.09	0.08	PB06	1.00	-0.06
AB53	0.18	0.05	PB07	1.21	-0.05
AB57	0.11	0.00	PB08	1.10	0.11
AB58	0.14	0.08	PB09	1.32	-0.11
AB59	0.18	0.04	PB12	2.43	-0.38
AB60	0.17	0.12	PB13	1.76	-0.01
AB61	0.00	0.11	PB18	0.19	0.09
AB62	0.20	0.07	PB20	2.02	-0.34
AB63	0.20	0.06	PB21	1.22	0.00
AB64	0.03	0.08	PB25	0.26	0.01
AB65	0.10	0.14	PB26	0.28	0.05
AB66	0.12	0.03	PB27	2.16	-0.30
AB67	0.04	0.03	PB29	1.70	-0.31
AB68	0.11	0.05	PB54	0.21	0.07
AB71	0.09	-0.01	PB55	1.31	-0.13
CR07	0.13	-0.04	PB59	1.67	-0.60
CR50	0.01	0.02	PB65	0.34	0.06
CR51	0.01	0.01	PB67	12.44	-1.97
CR53	0.05	0.04	PB68	0.94	-0.21
FT06	0.25	-0.05	PB69	0.99	-0.27
FT07	0.29	0.02	PB70	0.82	-0.91
FT08	0.04	0.05	UB02	2.78	0.10

MCGEE SURVEYING CONSULTING							
RANCHO PALOS VERDES - PORTUGUESE LAND SLIDE MONITORING POINT STATUS Prepared 12/04/2017							
Notes:	180+/- Monitoring Points established since 1994 through 2016						
09/01/07	71 Points Surveyed 60 old points found with 52 monitored plus 19 new points						
12/01/08	67 Points Surveyed AB09, KC11, PB51 discontinued; BB53 destroyed; AB05 disturbed						
11/01/09	68 Points Surveyed Set PB64 to replace PB63 destroyed subsequently						
10/01/10	65 Points Surveyed Discontinued AB03, BB25; set PB65 to replace PB62 destroyed by paving						
10/03/11	69 Points Surveyed; Set AB62 & AB63 to replace AB06 & AB07						
09/14/12	72 Points Surveyed; Discontinued AB06, AB07; AB55 destroyed by trenching; Added 8 new points						
10/06/13	65 Points Surveyed; Discontinued AB15, AB18, AB52, AB54, CR52, KC04, PB53						
09/19/14	64 Points Surveyed; Discontinued BB52, PB67 set in April 2014; Added PVE3RP (reference to PVE3 antenna)						
10/08/15	66 Points Surveyed; AB56 Destroyed & Replaced by AB71A; PB68, PB69, & PB70 Set in April 2015						
10/05/16	66 Points Surveyed; AB71A Destroyed & Replaced by AB71;						
10/04/17	66 Points Surveyed; 30 Points to Survey in Feb 2018 and April 2018						
Pt ID	Last Obs'd	Comments	GNSS	Pt ID	Last Obs'd	Comments	GNSS
AB01	10/04/2017	Base Station 1994-2006	G	KC01	10/04/2017	NE'ly/2 monuments 1.5' apart	G
AB02	"		G	KC02	"		G
AB04	"		G	KC05	"		G
AB05	"		G	KC06	"		G
AB12	"		G	KC07	"		G
AB13	"		F	KC13	"		G
AB16	"		P	KC14	"		G
AB17	"		F	KC15	"		F
AB20	"	NE'ly/ 2 monuments	G	KC16	"	Raised 0.29' by others 10/2016	G
AB24	"		F	KC17	"	Replaced KC04	G
AB50	"		G	PB04	"		G
AB51	"		G	PB06	"		G
AB53	"		F	PB07	"		G
AB57	"		G	PB08	"		G
AB58	"		P	PB09	"		G
AB59	"		G	PB12	"		G
AB60	"		G	PB13	"		G
AB61	"	Base Sta.. 2007-Present	G	PB18	"		G
AB62	"		G	PB20	"	S'ly/ 2 monuments 5.3' apart	G
AB63	"		G	PB21	"		F
AB64	"		G	PB25	"		G
AB65	"		G	PB26	"		F
AB66	"		G	PB27	"		G
AB67	"		G	PB29	"		G
AB68	"		G	PB54	"		F
AB71	"	Replaced AB56 10/2016	F	PB55	"		F
CR07	"		G	PB59	"		G
CR50	"		F	PB65	"		G
CR51	"		G	PB67	"		G
CR53	"		G	PB68	"		G
FT06	"		F	PB69	"		G
FT07	"		G	PB70	"		G
FT08	10/04/2017		G	UB02	10/04/2017		G
GNSS column indicates site is Good, Fair or Poor for Satellite Visibility Conditions							

10/04/17 COORDINATE LIST

Portuguese Bend Landslide 10/04/2017 Monitoring Survey No. 19  
Prepared by McGee Surveying Consulting: Document Date 12/04/2017 Rev. 03/23/18

Datum: Horizontal & EH are NAD83 (2007) 2007.00 Epoch; California State Plane Zone 5; Vertical: NAVD88  
Note, Fixed CGPS Station PVE3 at Record 3D Position & NAVD88 Height per September 2007 Survey;  
See 2007 and subsequent Survey Reports

Point	Latitude	Longitude	EH(ft)	North(ft)	East(ft)	OrthoHt(ft)	Description
AB01	33-44-38.30264	118-22-53.05190	60.200	1729427.563	6445709.554	178.68	Punched 1/2" GIP in meter box
AB02	33-44-13.84885	118-22-26.19248	-1.955	1726946.981	6447968.680	116.54	4" BC "SAN PEDRO 1936" on conc. block
AB04	33-44-28.08825	118-22-36.29052	-51.221	1728389.642	6447121.211	67.24	BC "CO ENG STA Q2.." on 2"GIP in mass of conc.
AB05	33-44-24.98844	118-22-30.09368	-37.911	1728074.322	6447643.392	80.54	BC "CO ENG STA Q3.." on 2"GIP in mass of conc.
AB12	33-44-38.27281	118-22-22.72200	164.904	1729414.936	6448270.954	283.25	BC "CO ENG STA 7A.." in mass of conc.
AB13	33-44-43.34363	118-22-23.16216	246.207	1729927.688	6448235.684	364.53	Punched 1/2" GIP in meter box
AB16	33-44-47.57883	118-22-31.51213	258.174	1730358.454	6447532.126	376.51	Punched 1/2" GIP in meter box
AB17	33-44-58.06058	118-22-41.08420	324.493	1731421.094	6446727.759	442.83	Punched 1/2" GIP in meter box
AB20	33-44-37.77222	118-22-05.96721	278.027	1729359.113	6449685.739	396.30	BC "CO ENG STA W. FIX 1956.." in mass of conc.
AB24	33-44-42.35218	118-22-28.79581	217.438	1729829.231	6447759.547	335.79	Cotton spindle in conc. In road
AB50	33-44-25.11020	118-22-22.94748	63.672	1728084.385	6448246.974	182.09	Nail in conc. collar of well
AB51	33-44-40.22869	118-22-34.15228	186.829	1729616.255	6447306.387	305.21	PK mag nail in plastic plug "LS6957" in 1"GIP
AB53	33-44-48.36573	118-22-05.70081	234.659	1730429.939	6449712.161	352.88	Chiseled + on s edge conc. Vault
AB57	33-45-03.16837	118-22-05.20529	446.587	1731926.199	6449759.488	564.74	6" mag nail & washer in conc. in 2"x 36" GIP
AB58	33-44-55.14231	118-22-13.27651	287.427	1731117.340	6449074.926	405.65	Punched RR spike on s side road
AB59	33-44-52.53793	118-21-59.79463	316.046	1730849.888	6450212.470	434.22	6" mag nail & washer in conc. in 2"x 36" GIP
AB60	33-44-35.03968	118-22-26.06633	61.056	1729089.145	6447987.304	179.43	6" mag nail & washer in conc. in 2"x 28" GIP
AB61	33-44-18.57310	118-22-25.95798	22.073	1727424.487	6447990.262	140.54	6" mag nail & washer in conc. in 2"x 24" GIP
AB62	33-44-33.22832	118-22-38.63305	24.598	1728909.999	6446925.324	143.04	6" mag nail & washer in conc. in 1"x 24" GIP
AB63	33-44-34.71584	118-22-34.12199	62.411	1729058.966	6447306.860	180.82	Punched 1/2 x 48" rebar
AB64	33-45-02.13598	118-22-33.46046	413.997	1731830.665	6447373.095	532.28	2" mag nail on NE side 2' conc. Collar/Well B12
AB65	33-45-00.93070	118-22-22.90337	340.395	1731705.500	6448264.137	458.64	2" mag nail & washer in conc. in 1"x 60" GIP
AB66	33-44-44.53376	118-22-20.15074	255.978	1730047.056	6448490.446	374.28	1/2"x 24" punched rebar 1" below AC conc. collar
AB67	33-44-55.71641	118-22-29.06611	287.060	1731180.319	6447741.758	405.35	1/2"x 24" punched rebar 1" below AC conc. collar
AB68	33-44-46.61108	118-22-25.31252	275.153	1730258.673	6448055.314	393.47	1/2"x 24" punched rebar 1" below AC conc. collar
AB71	33-45-06.07061	118-22-19.51937	453.316	1732224.039	6448551.824	571.52	2"screw&brass washer"PLS3945" on VanderlipDr.
CR07	33-45-00.26727	118-21-48.09417	513.912	1731627.667	6451203.373	632.01	6" mag nail & washer in conc. in old 1" IP
CR50	33-45-13.97074	118-21-50.11955	754.612	1733013.582	6451037.353	872.67	Tack & shiner on lower rock wall
CR51	33-45-14.49681	118-21-34.43627	858.171	1733061.996	6452361.868	976.16	Tack & shiner on conc. pad
CR53	33-45-11.63359	118-21-59.73971	662.646	1732780.269	6450224.148	780.75	2" mag nail & washer in conc. in 1"x 60" GIP
FT06	33-44-42.78226	118-21-29.58686	370.450	1729854.480	6452759.935	488.53	6" mag nail & washer in conc. in 2"x 36" GIP
FT07	33-44-36.86844	118-21-13.66300	470.552	1729251.883	6454102.608	588.60	6" mag nail & washer in conc. in 2"x 36" GIP
FT08	33-44-38.19515	118-21-22.57469	540.411	1729388.659	6453350.472	658.49	6" mag nail & washer in conc. in 2"x 36" GIP
KC01	33-44-29.13081	118-21-33.11047	194.139	1728475.502	6452457.432	312.32	6" mag nail & washer in conc. in old 1" IP
KC02	33-44-14.54623	118-21-37.05778	-104.440	1727002.323	6452118.780	13.83	Punched 1/2" GIP in meter box
KC05	33-44-15.36995	118-21-24.51042	109.343	1727081.814	6453178.806	227.55	Punched 1/2" GIP in meter box
KC06	33-44-22.33164	118-21-21.96741	181.710	1727784.818	6453396.077	299.87	Punched 1/2" GIP in meter box
KC07	33-44-22.09033	118-21-18.55899	195.374	1727759.405	6453683.853	313.52	Punched 1/2" GIP in meter box
KC13	33-44-10.41128	118-21-25.78319	72.951	1726580.919	6453069.529	191.18	Cotton spindle in AC turnout
KC14	33-44-12.03472	118-21-17.07094	141.776	1726742.428	6453805.940	259.96	Punched spike in center road
KC15	33-44-20.39699	118-21-25.21829	168.882	1727590.216	6453120.825	287.06	Cotton spindle in cul-de-sac
KC16	33-44-20.55003	118-21-13.64613	209.157	1727602.232	6454098.227	327.29	Brass pin&washer "LS8773" set above spike in Xn
KC17	33-44-17.54910	118-21-26.32512	97.120	1727302.651	6453026.322	215.32	2" mag nail & washer in conc. in 1"x 50" GIP
PB04	33-44-20.94963	118-22-15.81517	47.338	1727661.559	6448847.783	165.75	Nail & tag "RCE26120" in conc. in 3" pipe
PB06	33-44-23.65349	118-22-05.05375	58.437	1727931.553	6449757.657	176.78	Punched cap on 2" GIP
PB07	33-44-25.63253	118-21-59.69309	78.868	1728129.962	6450211.126	197.18	Brass tag "LA CO DPW" in conc. in 2" GIP
PB08	33-44-26.27748	118-21-56.72479	76.109	1728194.248	6450462.052	194.41	Punched cap on 2" GIP
PB09	33-44-26.73575	118-21-52.15204	69.770	1728239.172	6450848.411	188.04	Punched cap on 2" GIP in cable box
PB12	33-44-26.82104	118-21-43.48444	63.850	1728245.148	6451580.464	182.08	Punched cap on 2" GIP in cable box
PB13	33-44-24.76864	118-21-36.79290	88.034	1728035.639	6452144.855	206.25	Punched cap on 2" GIP in cable box
PB18	33-44-48.40781	118-21-53.76880	244.758	1730430.518	6450719.822	362.93	Punched 1/2" GIP in meter box
PB20	33-44-31.63026	118-21-48.93012	112.213	1728732.977	6451122.309	230.44	Punched cap on 2" GIP in cable box
PB21	33-44-36.61155	118-21-48.27938	153.538	1729236.343	6451179.087	271.74	Punched cap on 2" GIP in cable box
PB25	33-44-40.92754	118-21-38.74199	207.808	1729669.749	6451986.106	325.95	Punched cap on 2" GIP in cable box
PB26	33-44-39.63338	118-21-35.58778	164.825	1729537.966	6452252.014	282.95	Brass tag "LA CO DPW" in conc. in 2" GIP
PB27	33-44-36.60985	118-21-40.42532	151.634	1729233.780	6451842.379	269.80	Punched cap on 2" GIP in cable box
PB29	33-44-32.66740	118-21-37.47488	50.319	1728834.339	6452090.121	168.49	Brass tag "LA CO DPW" in conc. in 2" GIP
PB54	33-44-41.07614	118-21-56.95133	239.500	1729690.329	6450448.364	357.72	PK mag nail in plastic plug "LS6957" in 1"GIP
PB55	33-44-31.97884	118-21-52.73767	120.556	1728769.381	6450800.875	238.80	PK mag nail in plastic plug "LS6957" in 1"GIP
PB59	33-44-21.84289	118-22-18.06036	38.186	1727752.560	6448658.496	156.60	PK mag nail in plastic plug "LS?" in 1" GIP
PB65	33-44-28.81389	118-22-05.66966	169.322	1728453.414	6449707.551	287.64	2" alum. cap "MCGEE SURVEYING" on 5/8"x 24"rebar
PB67	33-44-20.44978	118-21-52.05737	-46.962	1727603.687	6450854.103	71.34	1/2" x 3' rebar
PB68	33-44-20.97613	118-22-14.21541	54.166	1727663.740	6448982.903	172.57	2" Alum Cap "PLS3945" in 1"x 30" GIP
PB69	33-44-22.13163	118-22-16.64715	45.670	1727781.308	6448777.958	164.08	2" Alum Cap "PLS3945" in 1"x 30" GIP
PB70	33-44-22.83979	118-22-18.53308	35.979	1727853.485	6448618.945	154.39	2" Alum Cap "PLS3945" in 1"x 30" GIP
UB02	33-44-19.47128	118-22-00.45904	-55.686	1727507.351	6450144.164	62.66	PK mag nail in plastic plug "?" in 1"GIP
PVE3	33-44-35.85329	118-24-15.26904	235.421	1729207.091	6438765.184	354.36	CGPS Pos. Fixed in 2007 and subsequent surveys
PVHS							CGPS Non-Operational
PVRS	33-46-25.89195	118-19-14.06714	198.609	1740239.294	6464237.895	316.32	CGPS Pos. Determined as by this Survey
VTIS	33-42-45.48966	118-17-37.71221	197.513	1717933.684	6472307.229	315.26	CGPS Pos. Determined as by this Survey

## Addendum No. 1

# Monitoring Survey No. 20 Report Portuguese Bend Landslide Monitoring February 12, 2018 Partial Monitoring Survey for the City of Rancho Palos Verdes by McGee Surveying Consulting

### Overview:

This Addendum No. 1 Report describes the February 12, 2018 (average date) tri-annual Portuguese Bend Monitoring Survey. This partial survey included 30 points which are a sub-set of the full monitoring set reported above. AB13 was substituted for AB12 due to access issues on private land used as a horse corral with guard dogs. Reviewing the movements of AB12 and AB13 over the last 10 years finds the movements are consistent in direction, and the distance at AB12 is generally about equal or up to 1/3 greater than at AB13. It is recommended AB13 be substituted for AB12 and that AB12 be monitored once a year during the primary fall survey.

This survey followed the procedures described in previous surveys. For a detailed history of the program and surveys see “History” above and Monitoring Survey Reports by this surveyor dating back to 2007. The field survey took place February 11-13, 2018. The Field Surveys, Equipment, Data Collection and Network Design were as described in the above Report. Four continuously operating GPS stations (CGPS) were connected to this survey with three 4-8 hour observations.

The movements reported between October 4, 2017 and February 12, 2018 (4.3 months) statistically attained an average accuracy of 0.019 feet at the 95% Level of Confidence. The vectors residuals follow: the 2D averaged 0.007’ with a maximum of 0.021’ and the vertical averaged 0.011’ with a maximum of 0.075’.

A Minimally Constrained Adjustment was processed to develop NAD83 (2007) 2007.00 Epoch Geodetic and State Plane Coordinates in feet. CGPS Station PVE3 was fixed and the differences in north, east and up from the 10/04/2017 survey to the 02/12/2018 survey are listed in feet below.

10/04/2017 to 02/12/2018			
Station	dN	dE	dz
AB04	-0.057	-0.044	-0.034
AB13	-0.035	0.004	-0.051
AB16	-0.028	-0.005	-0.037
AB17	-0.008	-0.003	0.012
AB20	-0.044	-0.011	-0.025
AB50	-0.018	-0.023	-0.027
AB59	-0.044	0.008	-0.006
AB60	-0.042	-0.014	-0.026
AB61	-0.009	0.004	-0.016
AB65	-0.006	-0.003	-0.050
CR07	-0.032	0.010	-0.021
CR50	-0.010	-0.006	-0.001
FT06	-0.072	-0.003	-0.038
FT07	-0.019	-0.042	-0.019
KC06	-0.011	-0.009	0.011
KC07	-0.000	0.010	-0.014
KC13	-0.017	0.000	-0.015
KC16	0.005	0.001	-0.006
KC17	-0.014	0.004	-0.031
PB04	-0.158	-0.033	-0.082
PB12	-0.587	-0.177	-0.196



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PB13	-0.380	-0.182	-0.063
PB18	-0.031	-0.001	-0.028
PB26	-0.072	-0.013	0.009
PB55	-0.263	0.022	0.110
PB59	-0.242	-0.039	-0.116
PB67	-1.812	-0.196	-0.300
PB68	-0.134	-0.010	-0.089
PB69	-0.124	-0.055	-0.068
PB70	-0.114	-0.053	-0.156
PVE3	-0.000	-0.000	-0.000
PVRS	-0.016	0.000	-0.025
VTIS	0.001	0.003	-0.026

The differences from the original 2007 positions below

PVRS	-0.024	0.018	-0.013
VTIS	0.002	0.013	-0.026

As a standard procedure the adjustment was constrained to the CGPS station PVE3 and finds no difference, within the accuracy of the measurement system, in the positions of the primary base station AB61 and the positions of the CGPS stations PVRS and VTIS. The CGPS stations and KC16 are known to be stable over time and indicate the survey reference frame was stable and successfully recovered.

The Movement Distances and Elevation Changes are summarized in the “**Periodic Horizontal & Vertical Movement in Feet**” below.

## Addendum No. 2

### **Monitoring Survey No. 21 Report Portuguese Bend Landslide Monitoring April 16, 2018 Partial Monitoring Survey for the City of Rancho Palos Verdes by McGee Surveying Consulting**

#### **Overview:**

This Addendum No. 2 Report describes the April 16, 2018 (average date) tri-annual Portuguese Bend Monitoring Survey. This partial survey included 30 points which are a sub-set of the full monitoring set reported above.

This survey followed the procedures described in previous surveys. For a detailed history of the program and surveys see “History” above and Monitoring Survey Reports by this surveyor dating back to 2007. The field survey took place April 15-17, 2018. The Field Surveys, Equipment, Data Collection and Network Design were as described in the above Report. Four continuously operating GPS stations (CGPS) were connected to this survey with three 5-8 hour observations.

The movements reported between February 12, 2018 and April 16, 2018 (1.6 months) statistically attained an average accuracy of 0.02 feet at the 95% Level of Confidence. The vectors residuals follow: the 2D averaged 0.005’ with a maximum of 0.016’ and the vertical averaged 0.009’ with a maximum of 0.031’.

A Minimally Constrained Adjustment was processed to develop NAD83 (2007) 2007.00 Epoch Geodetic and State Plane Coordinates in feet. CGPS Station PVE3 was fixed and the differences in north, east and up from the 02/12/2018 survey to the 04/16/2018 survey are listed in feet below.

02/12/2018 to 04/16/2018			
Station	dN	dE	dZ
AB04	0.00	-0.01	0.01
AB13	0.00	0.00	-0.01
AB16	0.01	0.00	-0.02
AB17	0.01	0.00	0.01
AB20	-0.01	-0.01	0.03
AB50	0.00	-0.01	0.01
AB59	0.00	0.00	0.02
AB60	0.01	0.00	0.00
AB61	0.01	-0.01	0.01
AB65	0.01	-0.01	0.01
CR07	0.01	0.01	0.01
CR50	0.03	0.00	0.01
FT06	-0.01	0.00	0.02
FT07	-0.01	-0.03	0.05
KC06	0.00	-0.01	-0.01
KC07	0.01	0.00	0.03
KC13	0.00	0.01	0.01
KC16	0.00	0.00	0.01
KC17	0.01	-0.01	0.01
PB04	-0.03	-0.01	-0.01
PB12	-0.22	-0.10	0.01
PB13	-0.16	-0.08	0.02
PB18	-0.01	-0.01	0.03
PB26	0.00	-0.01	-0.02
PB55	-0.05	-0.05	-0.07
PB59	-0.09	-0.02	-0.03

PB67	-0.62	-0.05	-0.10
PB68	-0.04	0.00	0.00
PB69	-0.04	-0.02	0.00
PB70	-0.03	-0.03	-0.06
PVE3	0.00	0.00	0.00
PVRS	0.03	0.01	0.01
VTIS	0.00	0.00	0.03

As a standard procedure the adjustment was constrained to the CGPS station PVE3 and finds no difference, within the accuracy of the measurement system, in the positions of the primary base station AB61 and the positions of the CGPS stations PVRS and VTIS. The CGPS stations and KC16 are known to be stable over time and indicate the survey reference frame was stable and successfully recovered.

The Movement Distances and Elevation Changes are summarized in the “**Periodic Horizontal & Vertical Movement in Feet**” below.

<b>PORTUGUESE BEND LANDSLIDE MONITORING</b>						
<b>Partial Monitoring Horizontal &amp; Vertical Movements in Feet</b>						
	<b>10/04/2017 to</b>		<b>02/12/2018 to</b>		<b>10/04/2017 to</b>	
	<b>02/12/2018 = 4.3 months</b>		<b>04/16/2018 = 1.6 months</b>		<b>04/16/2018 = 5.9 months</b>	
<b>Mon. Pt.</b>	<b>Movement</b>	<b>Elevation</b>	<b>Movement</b>	<b>Elevation</b>	<b>Movement</b>	<b>Elevation</b>
	<b>Distance</b>	<b>Change</b>	<b>Distance</b>	<b>Change</b>	<b>Distance</b>	<b>Change</b>
AB04	0.07	-0.03	0.01	0.01	0.08	-0.02
AB13	0.04	-0.05	0.00	-0.01	0.03	-0.06
AB16	0.03	-0.04	0.01	-0.02	0.02	-0.06
AB17	0.01	0.01	0.01	0.01	0.00	0.02
AB20	0.05	-0.03	0.01	0.03	0.06	0.00
AB50	0.03	-0.03	0.01	0.01	0.04	-0.02
AB59	0.04	-0.01	0.00	0.02	0.05	0.01
AB60	0.04	-0.03	0.01	0.00	0.04	-0.03
AB61	0.01	-0.02	0.01	0.01	0.00	0.00
AB65	0.01	-0.05	0.02	0.01	0.01	-0.04
CR07	0.03	-0.02	0.01	0.01	0.03	-0.01
CR50	0.01	0.00	0.03	0.01	0.02	0.01
FT06	0.07	-0.04	0.01	0.02	0.08	-0.02
FT07	0.05	-0.02	0.03	0.05	0.08	0.03
KC06	0.01	0.01	0.01	-0.01	0.02	0.00
KC07	0.01	-0.01	0.01	0.03	0.02	0.01
KC13	0.02	-0.02	0.01	0.01	0.02	0.00
KC16	0.01	-0.01	0.00	0.01	0.01	0.00
KC17	0.01	-0.03	0.01	0.01	0.01	-0.02
PB04	0.16	-0.08	0.03	-0.01	0.20	-0.10
PB12	0.61	-0.20	0.24	0.01	0.85	-0.19
PB13	0.42	-0.06	0.18	0.02	0.60	-0.05
PB18	0.03	-0.03	0.01	0.03	0.04	0.01
PB26	0.07	0.01	0.01	-0.02	0.07	-0.01
PB55	0.26	0.11	0.07	-0.07	0.31	0.05
PB59	0.25	-0.12	0.09	-0.03	0.34	-0.15
PB67	1.82	-0.30	0.62	-0.10	2.45	-0.41
PB68	0.13	-0.09	0.04	0.00	0.18	-0.09
PB69	0.14	-0.07	0.05	0.00	0.18	-0.07
PB70	0.13	-0.16	0.04	-0.06	0.17	-0.21

Note: The measurement confidence is 0.02' (1/4"); therefore, movements greater than 0.02' are deemed to have actually moved. See "PB MOVEMENT DATA POSTING 2007-(Present).xlsx" for details.