

Portuguese Bend Land Movement Monitoring Surveys

Survey Reports for September 17, 2025 to the Current **October 2, 2025** Survey

for the

City of Rancho Palos Verdes

prepared by

McGee Surveying Consulting

Portuguese Bend was monitored for land movement on a tri-annual basis with the initial surveys of 65-70 points at the beginning of the rainy season (October 1) of each year followed by two subsequent partial Winter and partial Spring Monitoring Surveys of 30-40 points. In past years, an annual survey report was published following the spring survey on file with the City. Land movement began to increase about 2019 and substantially accelerated after 2022. Beginning in early 2024 the surveys were conducted every six weeks, then every month, and then weekly. Land Movement has now substantially slowed. Presently a full survey of about 100 points is conducted at the beginning of each month and a partial survey of about 20 points at mid-month. This document addresses metadata relative to the surveys and individual surveys are addressed in more detail as addendums. The movement results for each survey are listed in the attached “PB MOVEMENT DATA POSTING No.2... .xlsx” spreadsheet. The spreadsheet (No. 2) begins with survey M83 in mid- September 2025. The previous spreadsheet reported surveys M01 to M83 from 2007 to September 17, 2025. The movements are reported for the average date of the surveys.

List of Reported Monitoring Surveys

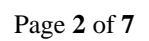
M83 Partial Survey - September 17, 2025 (Page 5)

M84 Full Survey - October 2, 2025

OVERVIEW: McGee Surveying Consulting (MSC) has performed the land movement monitoring surveys at Portuguese Bend since 2007. The planning and coordination of the surveys is overseen by Michael McGee, PLS3945 of MSC who is responsible for the execution of the field surveys, processing observations, network adjustments, analysis, and reports. For a general history, details and procedures utilized in this survey but not re-stated here, see the “Portuguese Bend Land Movement 2020-2021 Monitoring Survey” Report dated October 5, 2021, revised and published May 11, 2022 followed by “Portuguese Bend Land Movement Monitoring Survey Report” dated October 10, 2023 through September 4, 2025. See also prior annual reports dating back to 2007.

About 100 monitoring and five control reference points are presently included in the surveys. PVE3 and other CSRC CGPS (CGNSS) stations, discussed later, are used to reference the survey network, and verify the recovery of the reference frame. Increased velocities of movement were detected about 2019 and substantial accelerations in the Spring of 2023. Up until 2023 about 70 points were monitored. Since then, about 30 additional points have been added to properly assess and distinguish the land movement. The new points and points lost due to the slide or mediation measures are noted in the above referenced reports and the addendums.

M84 October 2025 Monitoring Network



All coordinates and movements of the monitoring surveys are listed in two spreadsheets prepared as a separate Report document but considered an attachment to this narrative Report. The first spreadsheet “PB MOVEMENT DATA POSTING M83 2007 to 09-17-2025.xlsx” includes the results of all surveys from 2007 to September 17, 2025. The second spreadsheet is initiated with this report and covers September 17, 2025 forward titled “PB MOVEMENT DATA POSTING No. 2-M83 09-17-25 to (present).xlsx

PROJECT DATUMS - REFERENCE FRAME

Since 2007, the horizontal positions have been based on the North American Datum of 1983 (NAD83) 2007 Adjustment, Epoch 2007.00 and the vertical positions based on the North American Vertical Datum of 1988 (NAVD 88) referred to as the reference frames or datums. A more current NAD83 adjustment and epoch is available e.g., NAD83 (2011) Epoch 2010.00; however, the 2007 Adjustment at Epoch 2007.00 is retained to maintain consistent relative positions over time since it is the basis for the initial 2007 survey. The NAVD88 elevations (orthometric heights) are based on measured ellipsoid heights combined with the NGS Geoid03 model to convert ellipsoid heights to elevations. The elevations are referenced to National Geodetic Survey (NGS) benchmarks. Although the current geoid model is Geoid18, the Geoid03 model is retained to maintain consistent relative heights over time as explained in the May 2022 Report referred to above. The latitudes and longitudes are determined by Global Satellite Navigation Systems (GNSS) measurement technology, often referred to as GPS, and are converted to grid coordinates by projecting into NAD83 California State Plane Coordinates Zone 5 in US Survey Feet.

A valid recovery of the survey reference frame is essential to accurately measure and assess actual movements of individual points relative to the greater peninsula outside the slides influence. The method for recovering the monitoring survey reference frame was modified as reported in 2019 to improve the efficiency of the processing and analysis of the surveys. Since 2007, GNSS Station PVE3 a California Spatial Reference Center (CSRC) Continuously Operated GPS Station (CGPS) at City Hall along with other CGPS Stations on the peninsula have been the anchor for referencing the monitoring surveys and assuring the integrity of the reported movements. In 2014, a “PK” nail (PVE3RP) was set as a reference point in the concrete base of Station PVE3 to allow access and indirect measurements of PVE3. The position listed here is based on five years of observations relative to PVE3.

Pt#	Latitude	Longitude	NAVD88 Ht
PVE3RP	33-44-35.74239	118-24-15.27451	346.88 ft

The procedure for the surveys is to include the reference point PVE3RP (thereby including PVE3) and reference points RP01, RP02, RP03 and RP05 all located outside of the slide zones to recover and verify the stability of the reference frame for each survey. Comparing the positions of the reference points with PVE3RP and PVE3 at City Hall and other CSRC CGPS Stations provides a redundant verification that the reference frame is stable and successfully recovered.

As stated, the rate of movement (velocities) of the land masses have increased over the past seven years compared to the 2007-2018 average but substantially slowed in the last year. For more information see “Assessment of Movements & Accelerations” on Page 11 of the October 2023 Report referred to above.

NETWORK - BASE STATIONS – POINT NAMES

AB61, AB20 and AB73 have previously served as suitable Base Stations for the GNSS instrument (receiver) for referencing measured positions of the monitoring points. AB61 was suspended several years ago due to its environmental sensitivity and lack of security. AB20 and AB73 were abandoned due to the continuously increasing velocities of land movements. Reference Points outside the present active slide zones serve as base stations since January 2024 for referencing GNSS measurements. The Reference Points are RP02, RP03 and RP05 located in the near vicinity of each other about 1400 feet northerly of the entrance to Abalone Cove Park and about ¼ mile westerly of the slide boundary and,

Monitoring point name conventions were established in the early 1990 surveys by others. The points are named for the slides they fall within. The slide acronyms are AB, PB, KC, CR and FT. The point numbers are

incremented as new points are established to replace abandoned or destroyed points or expand the network. Many of the original points are lost or no longer monitored. For data management purposes during each survey the point names are prefixed with a sequential monitoring number to distinguish successive surveys. For example, the occupation of AB01 on the 80th monitoring survey is point M80AB01 where M80 indicates the sequence number since the first M01 Monitoring Survey by MSC in September 2007. The prefix is stripped in the spreadsheet reports.

GNSS General Survey Parameters, Metadata & Equipment

Date of Initial Survey Report: M83 – September 17, 2025 between 0800-1700 PDST reported as an Addendum here

Constellations & Satellites: GPS (31), Russian GLONASS (23), Galileo (24) and Beidou (40+)

Observables (Carrier Waves): GPS (L1, L2, L5), GLONASS (L1, L2), Beidou (L1, L2); & Galileo (4 Carrier Waves)

Data Epoch Rate - 0.2 seconds (5 Hz) at the Roving Receiver; 1 second at the Base Receiver

Satellites: 20-40; **GDOP:** < 2; **Elevation Mask:** 10° at the Base Station; 10° at the Rover

Ephemeris: Broadcast for real time positioning (RTK).

Weather: See Addendums

Space Weather: See Addendums (Boulder K-Index gauges ionospheric activity on a scale of 0-9; <6 preferred)

Equipment: GNSS Base Receiver Operator: S. Wolters, PLS/CA5; Occupied Base Station

Receiver Make & Model: Trimble R10 with integrated Antenna; Mount: Tripod & Tribrach

GNSS Rover Receiver Operator: S. Wolters, PLS/CA5

Receiver Make & Model: Trimble R12i with integrated Antenna; Mount: Fixed Height Pole

Adjustments: "Starnet-PRO"

Prior to 2019, geodetic grade GNSS receivers collected static satellite signal data for post processing. The instrumentation was upgraded to an RTK System operating in real-time with an FM radio system in 2019 utilizing the latest technology to deliver increased productivity and precision of point positions. These receivers incorporate an Inertial Measurement Unit (corrects pole tilt) and track all satellites in all four GNSS constellations (GPS, GLONASS, Galileo and Beidou). The differences in two independent positions resulting from two measured vectors are acceptable if on average they fall within 0.03 feet (1 cm) horizontally.

NETWORK ADJUSTMENT & ANALYSIS

Network Adjustment: Minimally constrained adjustments are utilized to develop NAD83 (2007) 2007.00 Epoch, Zone 5 State Plane Coordinates and NAVD88 elevations of the monitoring points. The NAVD88 elevations are determined by combining the measured ellipsoid heights with the Geoid 03 Model. The reference point occupied by the base station receiver is fixed and the stability verified relative to PVE3 by occupations (measurements) to other reference points referred to above and PVE3RP all outside the influence of land movement. See the attached file "PB MOVEMENT DATA POSTING No. 2.... .xlsx" for movements and coordinates. The adjustment results are listed as differences in the following format example in the Addendums.

ID	Differences in Feet			
	dN	dE	dZ	
RP05	0.00	0.00	0.00	Fixed
PVE3RP	-0.01	-0.02	-0.05	Check
RP02	-0.03	0.00	0.03	Check

Comments: Fixing the base station, the computed differences at the other Reference Points between the measured and known positions are expected to be insignificant (measurement noise) and therefore confirm the survey reference frame is stable and successfully recovered from which local land movements are accurately determined.

ACCURACY STATEMENT

Vector Residuals: The vector residuals are based on a network adjustment of independent observations and are listed in the Addendums. The horizontal two-dimensional vector residuals and the vertical residuals resulting from multiple observations on a point are a good indicator of the accuracy of the survey. The horizontal are expected on average to be less than 0.03 feet and the vertical less than 0.10 feet.

Movement Accuracy: A point is deemed to have moved if, at the 95% level of confidence the horizontal movement (signal) of a point between two epochs (surveys) is greater than the 95% Error (noise). The accuracy or uncertainty of the horizontal (2D) movements between two monitoring surveys is estimated to be 0.04 feet at

the 95% Level of Confidence. The estimated vertical uncertainty is about 0.06 to 0.10 feet. Accuracy is dependent on environmental conditions and obstructions to satellite signals. If a computed movement is less than the Confidence Level then the movement is statistically indeterminate and has not moved.

MONITORING POINT MONUMENT NOTES & STATUS

See previous Survey Reports and the October 2023–September 2025 Report + Addendums for Point Descriptions.

Addendum No. 01

M83 Partial Monitoring Survey

Survey Report on the Portuguese Bend Land Movement Monitoring

Date: Sept. 17, 2025; 13 days after the previous Monitoring Survey.

Survey Type: Partial Mid-Month Monitoring Survey Addendum Report.

Performed By: Shane Wolters, PLS of CA5 under the direction of Michael McGee, PLS of MSC.

Points: 20 Monitoring Points and 5 Reference Control Points.

Instruments: GNSS Receivers - Trimble R12i Rover & R10 Base Receiver with FM Transmitter

Base Station: RP05 (Reference Control Point)

Weather:

Space Weather: Boulder K-Index was 1-4 (Gauges ionospheric activity on a scale of 0-9; less than 6 preferred)

Movements are listed in the attached spreadsheet “PB MOVEMENT DATA POSTING... .xlsx”.

Network Adjustment & Analysis: The vector observations (measurements) were processed in a minimally constrained network adjustment in US Survey Feet. Checks were made to other reference points listed below. The adjustment basis and results follow.

Horizontal Positions: Based on NAD83 (2007) Epoch 2007.00 Reference Frame (Datum)

Elevations: NAVD88 Datum

Coordinates: CA State Plane Coordinates in Zone 5 in US Survey Feet

Constraints: RP05 (Reference Control Point)

The differences from the measured and known positions of the Reference Points are listed below.

ID	Differences in Feet			
	dN	dE	dZ	
PVE3RP	-0.01	-0.02	0.11	Reference at City Hall (Primary Control)
RP01	-0.04	-0.01	0.09	Check Point
RP02	-0.01	-0.01	0.04	Check Point
RP03	0.02	-0.02	0.03	Check Point
RP05	0.00	0.00	0.00	Fixed Base Station

Note, the recovery and confirmation of a stable reference frame is essential for assessing the actual movement of the monitoring points. These differences are within the expected measurement uncertainty, are insignificant, and confirm the successful recovery of a stable reference frame (coordinate system) to assess movements.

2D Horizontal & Vertical Movements: In the attached “PB MOVEMENT DATA POSTING...” spreadsheet, the measured land movements are listed for overall and the referenced period. The movements are shown as azimuths (directions clockwise from north) in degrees, the two-dimensional horizontal movements, and vertical (elevation) changes for the period in US Survey Feet. The rates of movement for the period are normalized to an average month of 30.42 days for comparison with previous periods.

Number of Points: 20 Points

Period: M82 to M83 (13 days)

Movements greater than the confidence level: 16

Movement: Average 0.6 feet/month; Maximum of 0.8 feet

Change in Rate of Land Movement (velocity): -34% to +9%; Average -15%.

Note, the values are derived by normalizing the semi-monthly movements to an average month which is less accurate due to the signal to noise ratio and propagation of the uncertainty compared with observations for a monthly period.

Accuracy Statement: Vector Residuals based on an analysis of multiple occupations are an indication of the precision of the survey. Residuals are estimated as follows:

Horizontal (2D): 0.02 feet; Standard Deviation 0.01 feet; Range 0.01 to 0.06 feet.

Vertical Residuals: Absolute Value 0.02 feet; Standard Deviation 0.02 feet; Range -0.05 to +0.07 feet.

The accuracy or uncertainty of the horizontal (2D) movements between two monitoring surveys is estimated to be 0.04 feet at the 95% Level of Confidence. The estimated vertical uncertainty is about 0.05 to 0.10 feet.

Accuracy is dependent on environmental conditions and obstructions to satellite signals. If a computed movement is less than the Confidence Level then movement is statistically indeterminate. The confidence level for a semi-monthly measurement when normalized to a monthly is greater.

Monitoring Point Notes & Descriptions

For Point Descriptions, see previous Reports. New Points are listed here. For California State Plane Coordinates Zone 5 in the NAD83 (2007) Epoch 2007.00 and elevations in the NAVD88 Datum. See the attached spreadsheet file "PB MOVEMENT DATA POSTING No. 2.... .xlsx"

Notes: None

New Points: None

Addendum No. 02

M84 Full Monitoring Survey

Survey Report on the Portuguese Bend Land Movement Monitoring

Date: Oct. 2, 2025; 29 days after the prior Full Monitoring Survey.

Survey Type: Full Monthly Monitoring Survey Addendum Report.

Performed By: Shane Wolters, PLS of CA5 under the direction of Michael McGee, PLS of MSC.

Points: 102 Monitoring Points and 5 Reference Control Points.

Instruments: GNSS Receivers - Trimble R12i Rover & R10 Base Receiver with FM Transmitter

Base Station: RP05 (Reference Control Point)

Weather: Generally calm clear skies, temperature 65-75° F, no significant weather.

Space Weather: Boulder K-Index was 2-4 (Gauges ionospheric activity on a scale of 0-9; less than 6 preferred)

Movements are listed in the attached spreadsheet "PB MOVEMENT DATA POSTING No. 2... .xlsx".

Network Adjustment & Analysis: The vector observations (measurements) were processed in a minimally constrained network adjustment in US Survey Feet. Checks were made to other reference points listed below. The adjustment basis and results follow.

Horizontal Positions: Based on NAD83 (2007) Epoch 2007.00 Reference Frame (Datum)

Elevations: NAVD88 Datum

Coordinates: CA State Plane Coordinates in Zone 5 in US Survey Feet

Constraints: RP05 (Reference Control Point)

The differences from the measured and known positions of the Reference Points are listed below.

ID	Differences in Feet			
	dN	dE	dZ	
PVE3RP	-0.01	-0.01	0.06	Reference at City Hall (Primary Control)
RP01	0.01	-0.02	0.10	Check Point
RP02	-0.02	-0.01	0.00	Check Point
RP03	0.01	-0.03	0.00	Check Point
RP05	0.00	0.00	0.00	Fixed Base Station

Note, the recovery and confirmation of a stable reference frame is essential for assessing the actual movement of the monitoring points. These differences are within the expected measurement uncertainty, are insignificant, and confirm the successful recovery of a stable reference frame (coordinate system) to assess movements.

2D Horizontal & Vertical Movements: In the attached “PB MOVEMENT DATA POSTING...” spreadsheet, the measured land movements are listed for overall and the referenced period. The movements are shown as azimuths (directions clockwise from north) in degrees, the two-dimensional horizontal movements, and vertical (elevation) changes for the period in US Survey Feet. The rates of movement for the period are normalized to an average month of 30.42 days for comparison with previous periods.

Number of Points: 102 Points

Period: M82 to M84 (29 days)

Movements greater than the confidence level: 53

Movement: Average 0.5 feet/month; Maximum of 0.8 feet

Change in Rate of Land Movement (velocity): -85% to -17%; Average -43.7%.

Note, the values are derived by normalizing the movements to an average month.

Accuracy Statement: Vector Residuals based on an analysis of multiple occupations are an indication of the precision of the survey. Residuals are estimated as follows:

Horizontal (2D): 0.01 feet; Standard Deviation 0.01 feet; Range 0.00 to 0.3 feet.

Vertical Residuals: Absolute Value 0.02 feet; Standard Deviation 0.01 feet; Range -0.03 to +0.05 feet.

The accuracy or uncertainty of the horizontal (2D) movements between two monitoring surveys is estimated to be 0.04 feet at the 95% Level of Confidence. The estimated vertical uncertainty is about 0.05 to 0.10 feet.

Accuracy is dependent on environmental conditions and obstructions to satellite signals. If a computed movement is less than the Confidence Level then movement is statistically indeterminate.

Monitoring Point Notes & Descriptions

For Point Descriptions, see previous Reports. New Points are listed here. For California State Plane Coordinates Zone 5 in the NAD83 (2007) Epoch 2007.00 and elevations in the NAVD88 Datum. See the attached spreadsheet file “PB MOVEMENT DATA POSTING.... .xlsx”

Notes: Point AB74 will be lost in short time; set new Point AB85 about 15 feet south-southeasterly

New Points: AB85 - 2" mag nail & washer in Narcissa (abandoned asphalt road)

SURVEYOR'S STATEMENT

This Fall October 2025 Survey and subsequent Surveys and Addendum Reports on the procedures, criteria, and results of the City of Rancho Palos Verdes Portuguese Bend Land Movement

Monitoring Surveys was prepared by me or under my direction on **October 10, 2025** with updates as indicated by the Addendums at the request of Ramzi

Awwad, Director of Public Works for the City of Rancho Palos Verdes.


Michael R. McGee, PLS3945

