

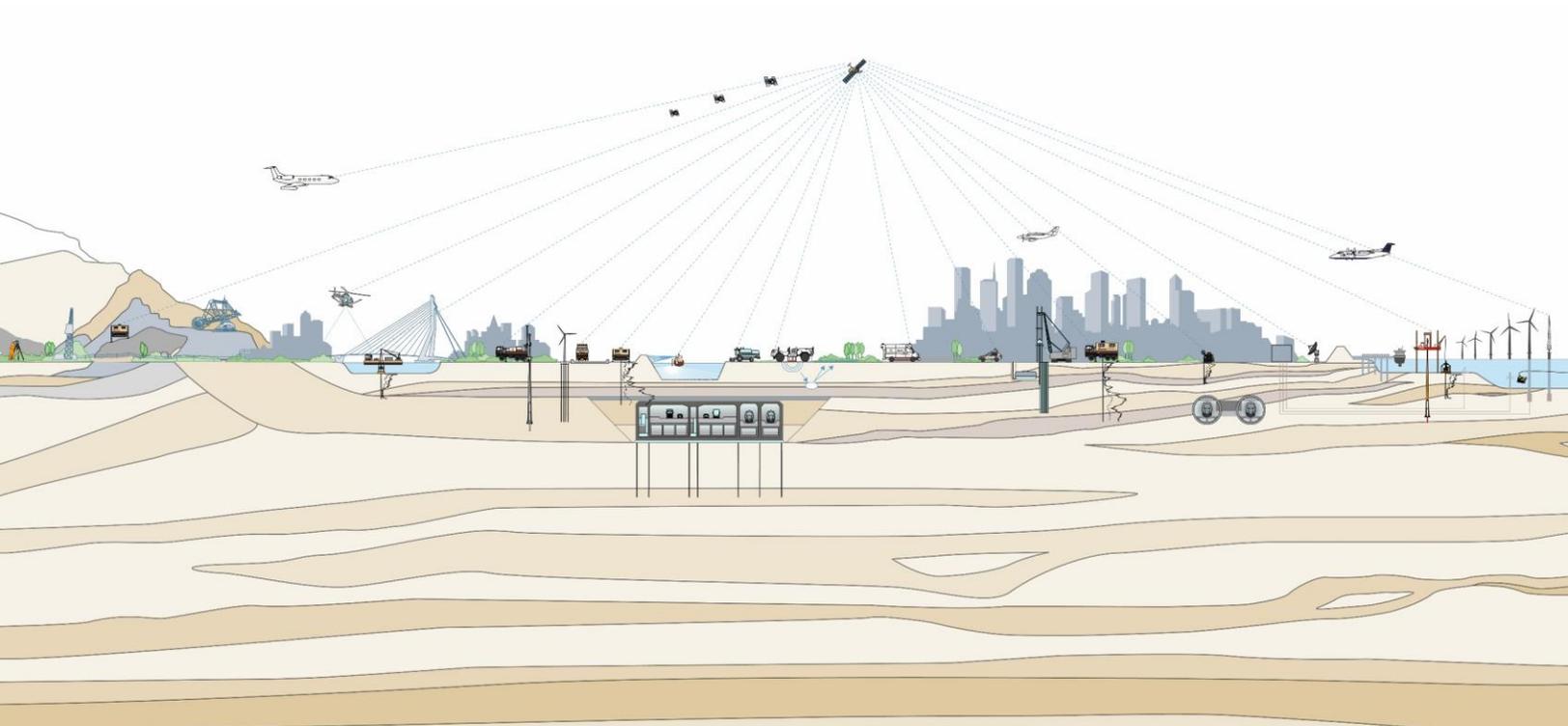
## FUGRO

### Annual Report July 2017 Through June 2018 Malibu Road Landslide Assessment District Malibu, California

March 2019  
Fugro Project No. 04.62160604  
Document No. 04.62160604-PR-002(Rev.00)

City of Malibu

Final





## FUGRO

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Prepared for: City of Malibu  
23825 Stuart Ranch Road  
Malibu, California 90265

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Document No. 04.62160604-PR-002(Rev.00)  
March 8, 2019

City of Malibu  
23825 Stuart Ranch Road  
Malibu, California 90265

**Attention: Mr. Rob DuBoux**

### **Annual Report, July 2017 Through June 2018, Malibu Road Landslide Assessment District, Malibu, California**

Dear Mr. Duboux,

Fugro is pleased to present this annual report for the Malibu Road Landslide Assessment District. This report summarizes the monitoring and maintenance activities completed during the period of July 2017 through June 2018.

Fugro appreciates the opportunity to be of service to the City of Malibu and the District homeowners. Please contact David Thornhill or Matt Pollard at (805) 650-7000 if you have any questions regarding this report.

Sincerely,  
**Fugro USA Land, Inc.**

  
**David Thornhill, PE**  
Project Engineer/Lead Technician



  
**Matthew Q. Pollard, PE**  
Associate Engineer/Project Manager



Distribution: (1) Addressee and PDF  
(1) City of Malibu - Geotechnical Staff and PDF



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## 1. INTRODUCTION

### 1.1 Authorization

Fugro performed the work summarized in this report in accordance with our contract with the City of Malibu (City) and consistent with the cost estimate document "Exhibit A - FY 2017-2018 Maintenance Cost Estimate" presented in the Annual Assessment Report (Taussig, 2017).

### 1.2 Background

The Malibu Road Landslide Assessment District (Assessment District) was established in 1981 by the County of Los Angeles (County) following the activation of a landslide on the west end of Malibu Road in 1978 (Plates 1 and 2). The assessment district provides permanent funding to maintain and monitor dewatering facilities with the purpose of stabilizing the landslide to the extent feasible using dewatering methods only. The County administered the assessment district until 1991 when the City incorporated. The Assessment District was reauthorized in May 1998 under Resolution No. 98-036. The City has administered the assessment district, utilizing consultants to maintain and monitor the district facilities.

### 1.3 Scope of Work

This annual report summarizes the monitoring and maintenance of the geotechnical instrumentation and dewatering facilities within the Malibu Road Assessment District for the period between July 1, 2017, and June 30, 2018 (hereafter, the "monitoring period").

Routine monitoring data collected during the current monitoring period included the following:

- Review of annual rainfall data from a local rain gauge operated by the County of Los Angeles, Department of Public Works - Water Resources Division;
- Monthly groundwater level measurements from eight standpipes;
- Periodic groundwater measurements from nine pneumatic piezometers;
- Monthly dewatering production readings from ten dewatering wells owned by the Assessment District and three wells owned by a private homeowner on Bayshore Drive;
- Monthly to Bi-Monthly dewatering production readings from 23 horizontal drains (hydraugers);
- Monthly, quarterly, and semi-annual ground deformation measurements from 5 slope inclinometers; and
- Periodic maintenance of dewatering and monitoring facilities.

Fugro staff checked the operating condition of the instrumentation and dewatering facilities at each field monitoring/observation location by visual observation and by evaluating preliminary data in the office as information was received. Maintenance was performed as-needed based upon the field observations and preliminary data evaluation, and correspondence from concerned homeowners and tenants.

The scope of services includes monitoring and maintenance of the assessment district facilities. The services provided on an annual basis for the assessment district do not include an engineering evaluation of the stability of the landslide.



#### **1.4 Report Organization**

This report summarizes the monitoring data collected during the July 1, 2017 to June 30, 2018 monitoring period and presents conclusions regarding the annual monitoring results. The location of the assessment district is illustrated on Plate 1 - Site Location Map. Locations of the geotechnical instrumentation are shown on Plate 2 - Assessment District Map. Tabulated and graphic summaries of monitoring data are presented in Appendix A through Appendix C, as indicated in the Table of Contents.

#### **1.5 Report Availability**

The annual Assessment District reports are available for review at Malibu City Hall. Reports may also be viewed on the City's website at <http://www.malibucity.org>.



## 2. MONITORING

### 2.1 Rainfall Data

A graph of historical monthly rainfall and average annual rainfall from October 1968 through June 30, 2018 is shown on Plate 3 - Rainfall Graph. Monthly rainfall totals from 1968 through 2004 were obtained from County of Los Angeles Department of Public Works (LADPW) Carbon Canyon Rain Station 447C and monthly rainfall totals from 2004 to the present were obtained from LADPW Big Rock Mesa Rain Gauge 1239.

Rainfall data indicate that approximately 7.51 inches of precipitation fell during the monitoring period from July 1, 2017, through June 30, 2018. The average annual rainfall from 1968 to 2018 in the "Malibu Area" for the same months is approximately 15.4 inches.

However, rainfall data is usually analyzed in terms of the annual "rain season" that covers the time period between October 1 through September 30. Rainfall for October 1, 2017, through September 30, 2018, was approximately 7.36 inches. That is approximately 47 percent of the average annual rainfall of approximately 15.7 inches for the "rain seasons" between 1968 and 2018.

Plate 5 – Groundwater Levels, Dewatering, and Rainfall shows the yearly magnitude of deviation of each years' rainfall relative to the mean annual rainfall. The graphic also shows the average annual dewatering output in gallons per day (gpd). The data illustrates that the average annual dewatering output is generally consistent with average rainfall.

### 2.2 Groundwater Monitoring

The groundwater level data collected during the current monitoring period are summarized in Appendix A and a summary graph of annual mean high groundwater elevation for the Assessment District is included as part of Plate 5. Groundwater levels fluctuate throughout the year and from year to year in response to natural and man-made influences. The primary natural influence is varying precipitation. Man-made influences include:

- Infiltration from septic systems;
- Infiltration from irrigation;
- Alterations to surface drainage by, for example, grading, landscaping, storm drains, and rain gutters;
- Accidental water discharges from leaking utilities such as water, irrigation, sewer, and storm drain lines as well as swimming pools; and
- Dewatering activities including pumping dewatering wells and hydraugers.

Typically, groundwater levels rise relatively quickly following significant rainfall events and gradually lower after the wet season ends. Groundwater levels at Malibu Road typically peak around late-March to mid-April and gradually decline through late September to November.

### 2.2.1 Standpipe Piezometers

Eight standpipe piezometers (W-2A, PZ-A, PZ-B, PZ-C, PZ-D, PZ-E, SI-5, and SI-6) were measured regularly over the monitoring period. Standpipe W-3A cannot be located and is presumed to be buried under soil creeping down the slope on the northern side of Malibu Road. Slope inclinometers/piezometers SI-5 and SI-6 were installed in 1998 along Bayshore Drive. Los Angeles County installed the other piezometers at earlier dates. The locations of the standpipe piezometers are depicted on Plate 2 - Assessment District Map, and groundwater elevation data are presented in Appendix A.

### 2.2.2 Pneumatic Piezometers

Inclinometer casings installed within the Assessment District after 1998 were typically outfitted with one or two pneumatic piezometer sensors, also referred to as 'Tips', nested at varying depths along the length of the inclinometer casing. Each sensor records saturated soil pore water pressure by measuring differential air pressure between the instrument sensor and groundwater surface across a flexible bladder. Differential pressure is converted into water head, which is translated to a relative groundwater elevation. Measuring pore pressures at specific elevations along a vertical profile can be used to measure flow gradients for groundwater migrating through the formation above and within the water table and to infer the presence of perched or confined groundwater zones. Pneumatic water levels were monitored intermittently during the 2017-2018 monitoring year. The locations of the piezometers are depicted on Plate 2, and groundwater elevation data are presented in Appendix A.

### 2.2.3 Groundwater Level Discussion

**General.** The groundwater data were reviewed by evaluating changes that occurred during the current monitoring period as well as changes in groundwater levels over extended periods. To analyze trends in seasonal groundwater fluctuations, the average (mean) annual and highest annual recorded groundwater elevation for each standpipe piezometer were calculated and compared with those of previous years (Appendix A, Plate A-2).

**Malibu Road.** Groundwater elevation data for the area along Malibu Road are presented on Plates A-3 and A-4. Groundwater levels for that area are monitored using standpipes PZ-A, -B, -C, -D, -E, W-2A, and W-3A along with pneumatic piezometers installed in inclinometers SI-1, -1A, -2, -3, and -4. Groundwater levels increased slightly during the 2017-18 monitoring period. The calculated area average water level increased by 0.1 feet when compared to the area average for the 2016-17 monitoring period and is 1.9 feet below the mean area average for this area for the period of record. Except for PZ-A, water levels in individual standpipes declined slightly or remained approximately static over the monitoring year.

Groundwater levels measured in PZ-A between 2015 and 2017 were low compared to historical water levels. Average groundwater elevation measured in PZ-A for the 2017-2018 monitoring period, while increasing by 2.5 feet from the 2016-2017 monitoring period, are consistent with elevations observed before 2014.

No new data are presented for standpipes W-2A or W-3A because W-2A has been dry since July 2014 and W-3A is buried beneath soil creep from the bluff face.



Pneumatic piezometers in inclinometers SI-1A, SI-2, and SI-4 all showed increased pore pressure readings. Pneumatic piezometers in inclinometers SI-1 (replaced by SI-1A) and SI-3 are no longer functioning and no new data are presented.

**Bayshore Drive.** Groundwater elevation data for the area along Bayshore Drive are presented on Plate A-5. Groundwater levels for that area are monitored using standpipes SI-5 and SI-6 along with the two pneumatic piezometers installed with each standpipe. In general, groundwater levels declined during the 2017-18 monitoring period. The calculated area average water-level declined by 0.7 feet when compared to the area average for the 2016-17 monitoring year and is 7.6 feet below the mean area average for this area for the period of record (1991-2018). Water levels in standpipe SI-5 declined steadily during the 2017-18 monitoring year and reached an all-time low for the period of record in June 2018. Water levels in standpipe SI-6 remained approximately static over the course of the monitoring year, with fluctuations of less than 1 foot. Readings from both the shallow and deep pneumatic piezometers in standpipes SI-5 and SI-6 continue to record water elevation above the standpipe water levels and showed more of a response to the rainfall events of January and March 2018 than was seen in the standpipes.

The average and highest annual groundwater levels are provided on Plate A-2 and are summarized in Table 1, below. The Malibu Road area average increased by 0.1 feet since the prior monitoring year and the peak groundwater elevation decreased by 1.3 feet. The Bayshore Drive average and peak groundwater elevations have decreased since the prior year.

**Table 1. Summary of Average Groundwater Elevations by Area**

Location	Average Groundwater El. 2017-2018	Change from Prior Year Average	Peak Groundwater El. 2017-2018	Change from Prior Year Peak
Malibu Road	6.2	+0.1	6.9	-1.3
Bay Shore Drive	18.0	-0.7	18.2	-1.0
<b>Note:</b> All units are in feet				

**2.3 Dewatering Production**

**2.3.1 Total Dewatering Production**

A combined graph of the total dewatering rate for the monitored dewatering wells and hydraugers is presented on Plate 4. Total dewatering production data for the measured hydraugers and wells indicates that the average total dewatering rate during the monitoring period was approximately 1871 gpd. This represents a 22 percent increase in the average rate relative to the 1533 gpd average recorded during the previous monitoring period.

**2.3.2 Dewatering Well Production**

Graphs showing production rates of individual wells are provided in Appendix B. Production data for the dewatering wells indicate that the average total dewatering well production rate for this monitoring period



was approximately 1225 gallons per day (gpd). That represents an increase of about 10 percent from the previous monitoring period production rate of 1118 gpd.

### **2.3.3 Hydrauger Production**

Graphs of individual production rates for individual hydraugers are included in Appendix B. Data for the hydraugers indicate that the average production rate for all hydraugers over the monitoring period is approximately 646 gpd. This represents an increase of approximately 83 percent from the average production rate of 353 gpd for the previous monitoring period.

The increase in hydrauger production can be attributed to hydrauger HD-8, which experienced greater than normal output between July 2017 and March 2018. The reason for the observed increase in production in HD-8 is not known. Readings taken after March 2018 indicate that dewatering production from HD-8 has returned to normal levels.

### **2.4 Slope Inclinator Measurements**

Fugro monitored five slope inclinometers on a quarterly to semi-annual basis to evaluate subsurface ground deformation. Plots of slope inclinometer measurements (four plots for each monitored slope inclinometer) are presented in Appendix C. The first plot shows the cumulative deflection and incremental deflection for the A-direction and the second plot shows the cumulative deflection and incremental deflection for the B-direction. Those two plots show approximately one measurement per year from about 2006 through the current monitoring year. The third and fourth plots show displacement versus time for the same period for all recorded measurements during that period.

The original 6 inclinometers SI-1 through SI-6 were installed in 1998. SI-1A was installed in August 2006 to replace SI-1 and has a baseline reading from September 2006. SI-2A was installed in September of the 2010-2011 monitoring year as a replacement for SI-2 with a baseline reading in November 2010. SI-4A was installed in August 2012 as a replacement for SI-4 and has a baseline reading from September 2012.

Inclinometer SI-3 was installed in April 1998 and is no longer being monitored due to being sheared off in January 2005.

No significant detectable movement was observed during this monitoring year in any inclinometers within the Malibu Road Assessment District.



**3. DEWATERING FACILITY MAINTENANCE**

**3.1 Facility Maintenance**

The operating status of each dewatering well and hydrauger was checked monthly. When necessary, repair work was scheduled and undertaken as expeditiously as possible, typically within a matter of a few hours or days. Generally, repairs and maintenance performed during the current monitoring period consisted of fixing broken hydraugers and conveyance lines. Table 2. Summary of Facility Maintenance provides a description of significant maintenance activities that were completed during the current monitoring period.

**Table 2. Summary of Facility Maintenance**

Repair Date	Facility	Description
9/22/2017	Hydrauger conveyance line between HD-12 and HD-13	Replaced cracked and clogged PVC line
10/10/2017	Hydrauger conveyance line at HD-11	Repaired conveyance line.
12/20/2017	SI-6	Repaired/replaced well box that was damaged from contractor activity.
1/16/2018	HD-6	Repaired/replaced drain pipe
2/06/2018	W-10	Replaced meter

**3.2 Capital Improvement Projects**

No capital improvements were performed during the current monitoring period.



#### 4. SUMMARY AND CONCLUSIONS

The status of the Malibu Road Landslide Assessment District can be summarized as follows:

- Measured rainfall during the 2017 - 2018 monitoring year (July 1 through June 30) was 7.51 inches of precipitation. Rainfall during that monitoring period was below the “Malibu Area” historical average of 15.42 inches per monitoring year measured from 1968 through 2018.
- Groundwater levels on Bayshore Drive on average declined slightly during the 2017-2018 monitoring period. Groundwater levels on Malibu Road on average increased slightly over the 2017-2018 monitoring period.
- Average daily dewatering production increased 22 percent from the previous monitoring year with dewatering well production increasing by 10 percent and hydrauger production increasing 83 percent.
- No detectable movement was recorded in inclinometers during the 2017 – 2018 monitoring year.
- Water conservation is encouraged throughout the Malibu Road area to reduce the infiltration of domestic water and the potential for future groundwater level increases. Control of groundwater levels within the landslide area is critical to maintaining the stability of the landslides.
- Groundwater production from existing dewatering wells and hydraugers should be expected to gradually decline over time as the efficiency of the wells and hydraugers decrease due to mineralization and aging of the facilities. This may contribute to reduced rates of groundwater lowering or localized increases in groundwater levels. Periodic maintenance of the existing facilities and replacement of older, worn-out pumps should improve the efficiency of the dewatering systems throughout the year, especially during and immediately following the rainy months.



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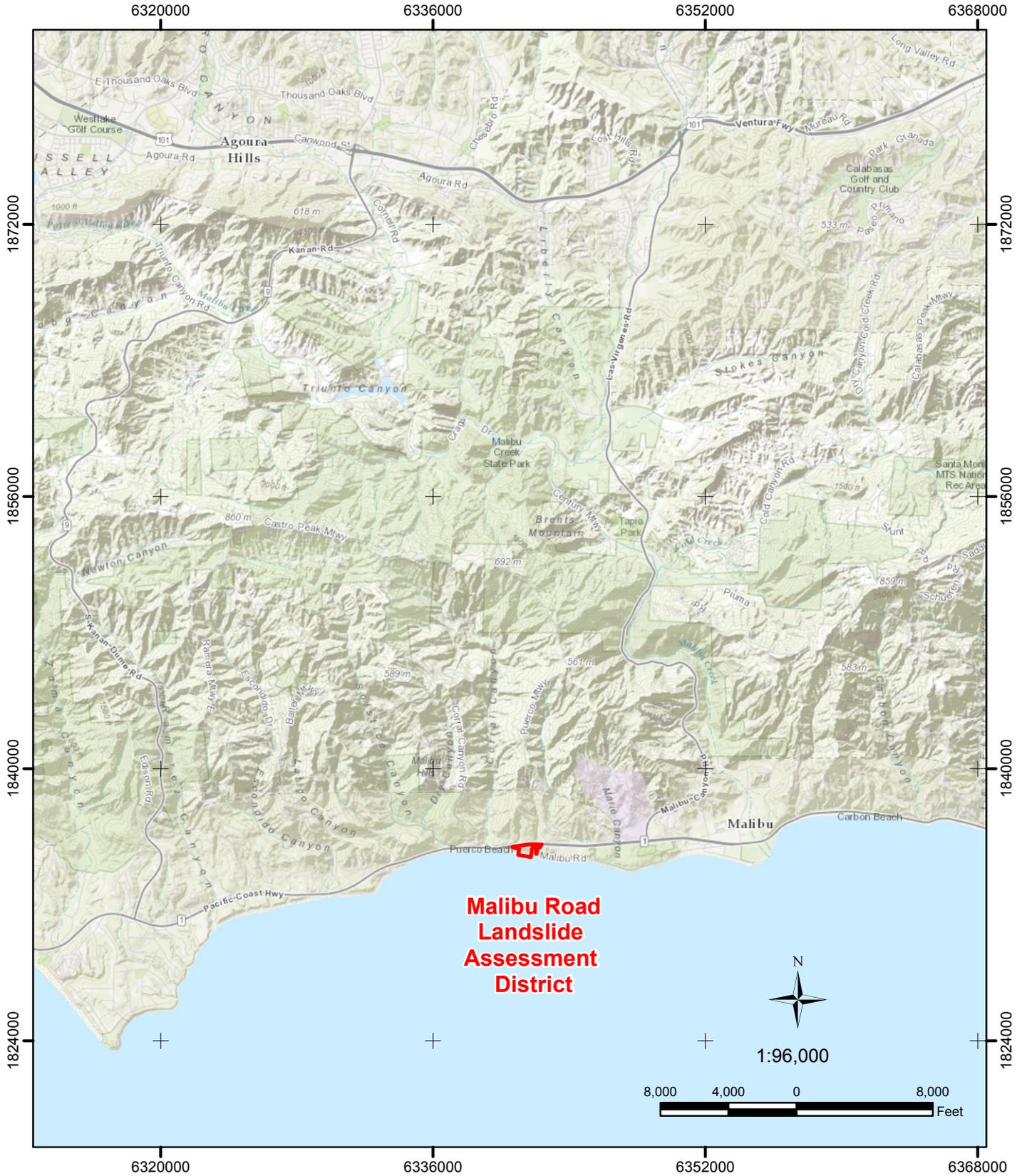
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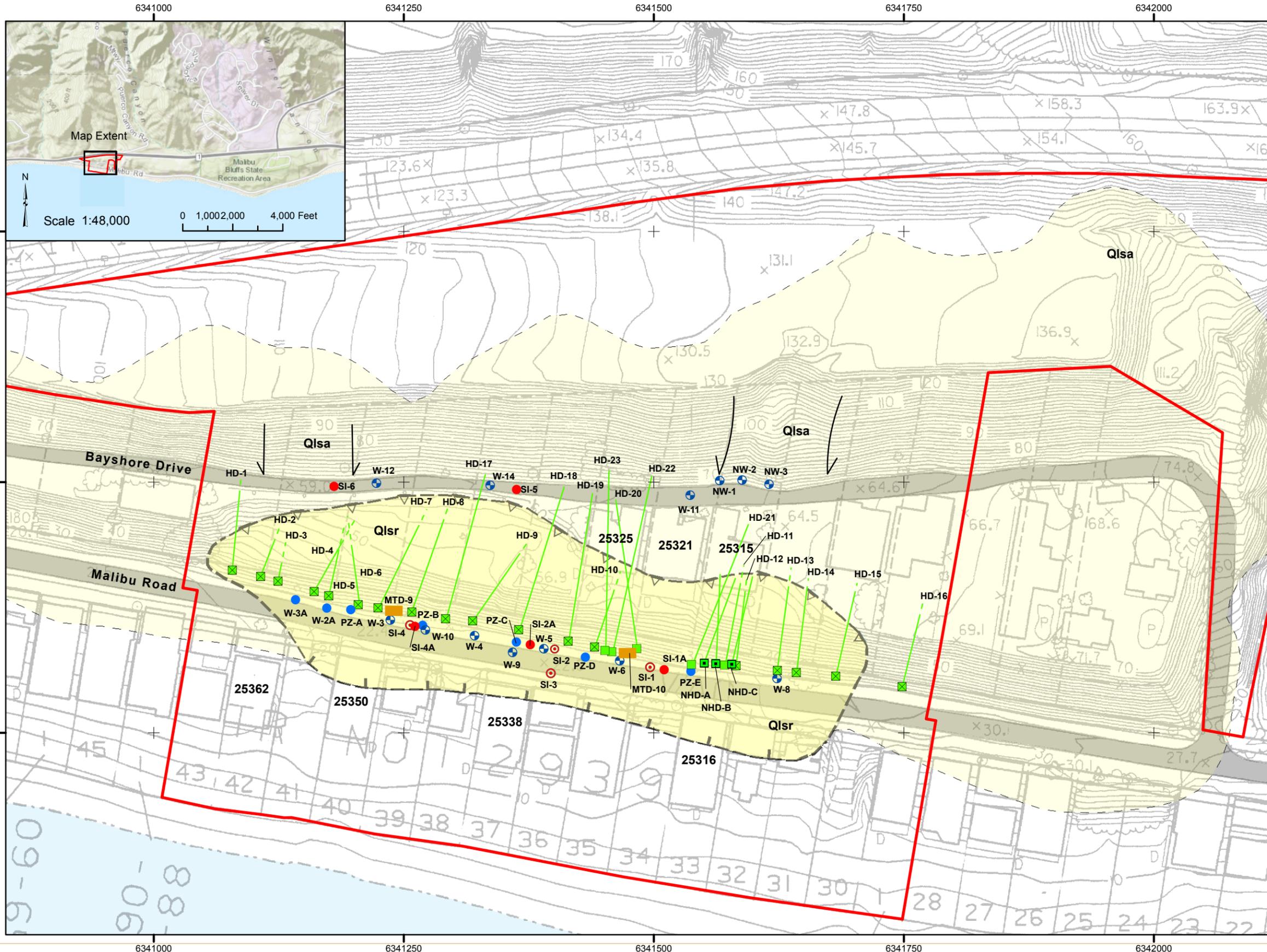
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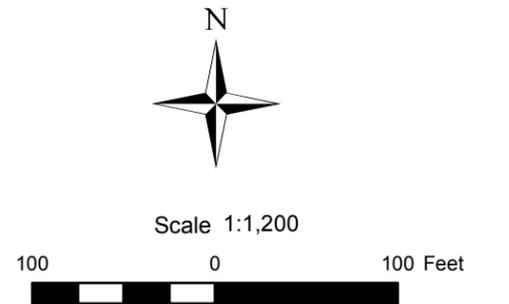
## PLATES



**SITE LOCATION MAP**  
Malibu Road Landslide Assessment District  
Malibu, California

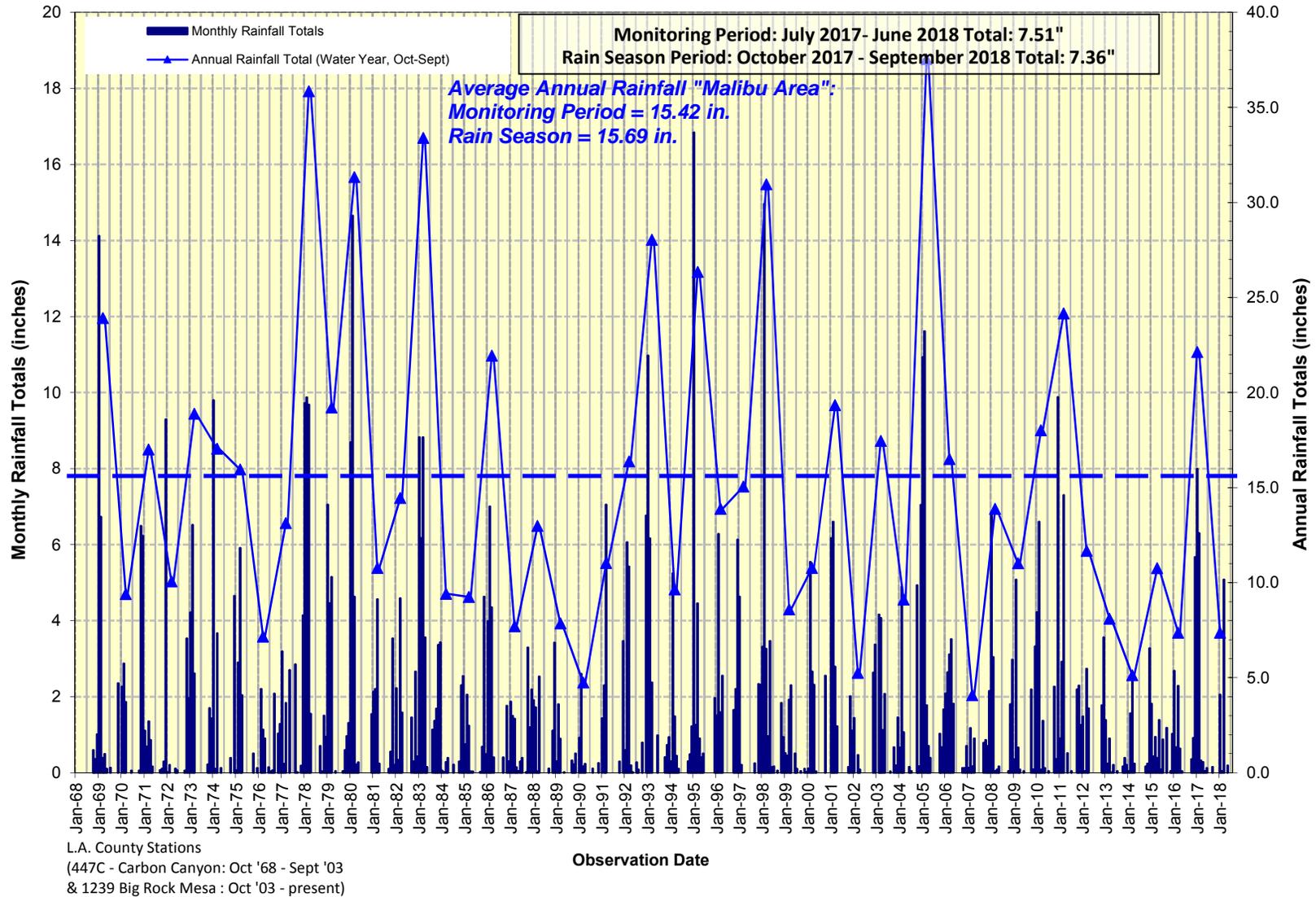


- LEGEND**
- Dewatering Well
  - Slope Inclinometer
  - Destroyed Slope Inclinometer
  - Standpipe Piezometer
  - Storm Drain Outfall
  - Producing Hydrauger (solid line showing unobstructed pipe)
  - Private Hydrauger
  - Nonproducing Hydrauger
  - Coordinate Grid: California State Plane, Zone 5, NAD 83, Feet
  - Assessment District No. 98-3 Boundary
  - Recent Landslide of 1978 (Boundary from Leighton, 1979)
  - Ancient Landslide (Boundary from Leighton, 1979)

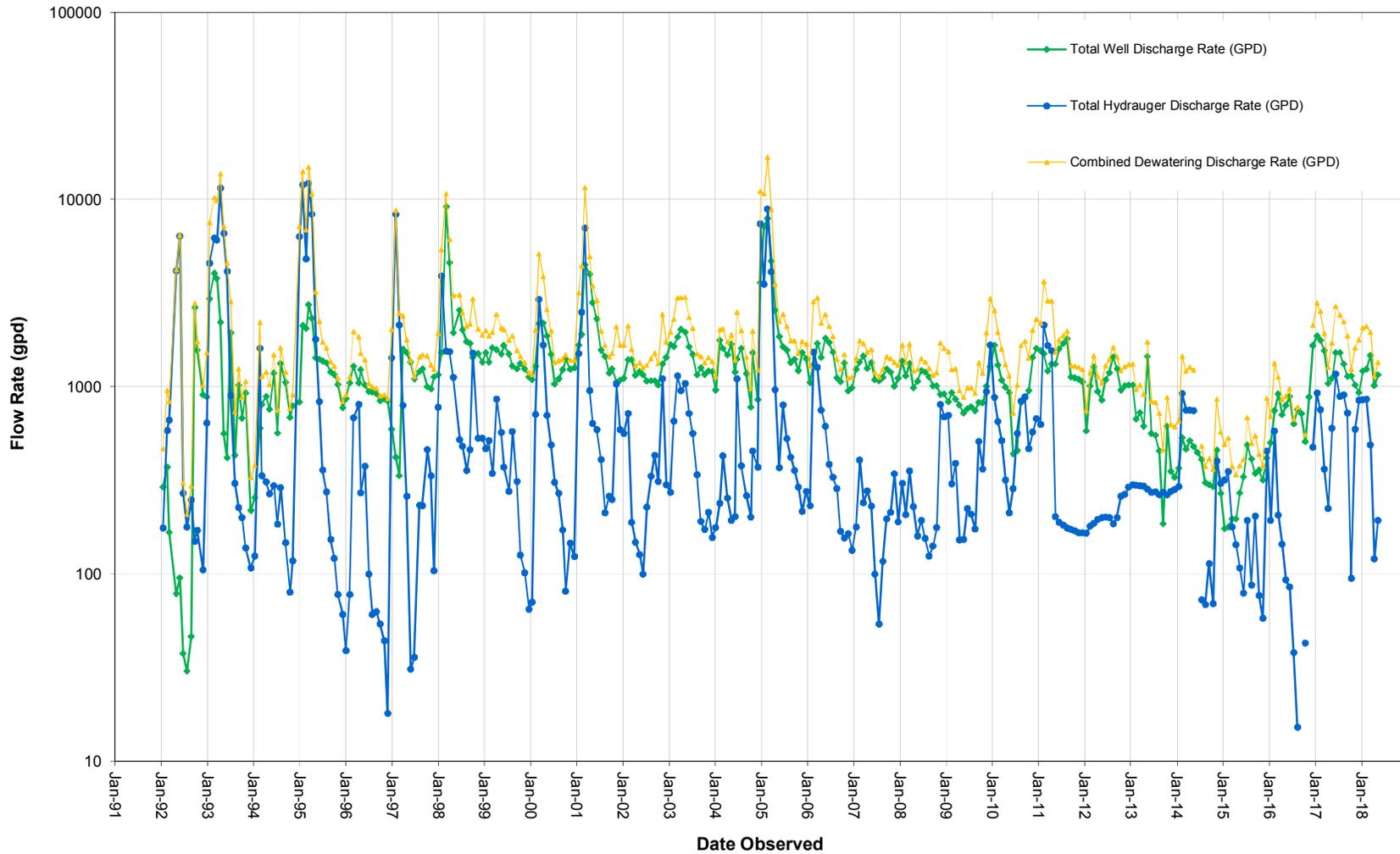


**ASSESSMENT DISTRICT MAP**  
Malibu Road Landslide Assessment District  
Malibu, California

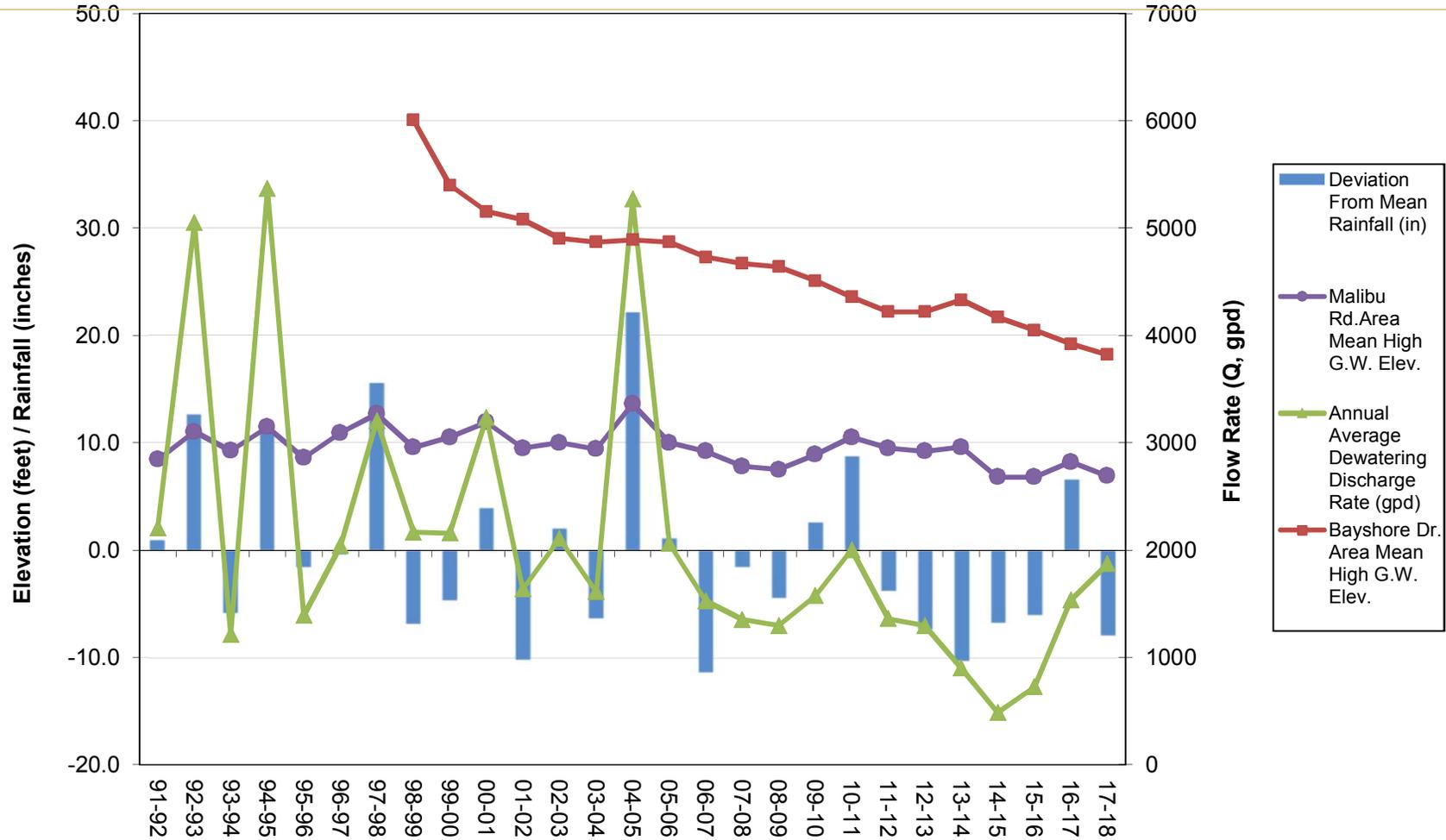
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**RAINFALL GRAPH**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**TOTAL DISCHARGE - WELLS AND HYDRAUGERS**  
Malibu Road Landslide Assessment District  
Malibu, California



\* Graph shows the mean value of the highest groundwater elevations recorded for each standpipe piezometer during the monitoring year.

**GROUNDWATER LEVELS, DEWATERING, AND RAINFALL**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**APPENDIX A  
GROUNDWATER DATA**



<b>MALIBU ROAD LAD - Standpipe Piezometer Information</b>						
Standpipe ID	Previous Reference Elevation (8/91)	Updated Reference Elevation (4/00)	Casing Depth (ft)	Perforation Interval	Installed By	Notes
W-2A	22.6	20.6	9.0	Unknown	LA COUNTY	Dry
W-3A	22.0	20.5	32.5	Unknown	LA COUNTY	Buried
PZ-A	20.0	19.8	17.2	Unknown	LA COUNTY	
PZ-B	20.0	19.1	27.9	Unknown	LA COUNTY	
PZ-C	20.0	19.4	29.7	Unknown	LA COUNTY	
PZ-D	20.0	19.2	24.7	Unknown	LA COUNTY	
PZ-E	20.0	21.4	15.8	Unknown	LA COUNTY	
SI-5 <sup>+</sup>	59.0	59.3	78.0	-19.0 to -14.0	BYA	
SI-6 <sup>++</sup>	57.0	58.0	78.0	-21.0 to -16.0	BYA	

Note: + Formerly designated as MR-5

++ Formerly designated as MR-6

<b>MALIBU ROAD LAD - Pneumatic Piezometer Information</b>						
Well Identification	Previous Reference Elevation (8/91)	Updated Reference Elevation (4/00)	Tip Depth (ft.)	Tip El. (ft)	Installed By	Notes
SI-1*	20.0	20.1	34.6	-14.6	BYA	leaking
SI-2	20.0	19.7	65.1	-45.1	BYA	
SI-3*	20.0	20.3	49.8	-29.8	BYA	clogged
SI-4	22.0	18.9	43.9	-21.9	BYA	
SI-5 Tip 1	59.0	59.3	60	-1	BYA	
SI-5 Tip 2**	59.0	59.3	40	19	BYA	
SI-6 Tip 1	57.0	58.0	60	-3	BYA	
SI-6 Tip 2**	57.0	58.0	40	17	BYA	
SI-1A	20.0	20.0	50	-30	FUGRO	

Note: SI-1 thru SI-4 were previously designated MR98-1 thru MR98-4

SI-5 and SI-6 were previously designated MR-5 and MR-6

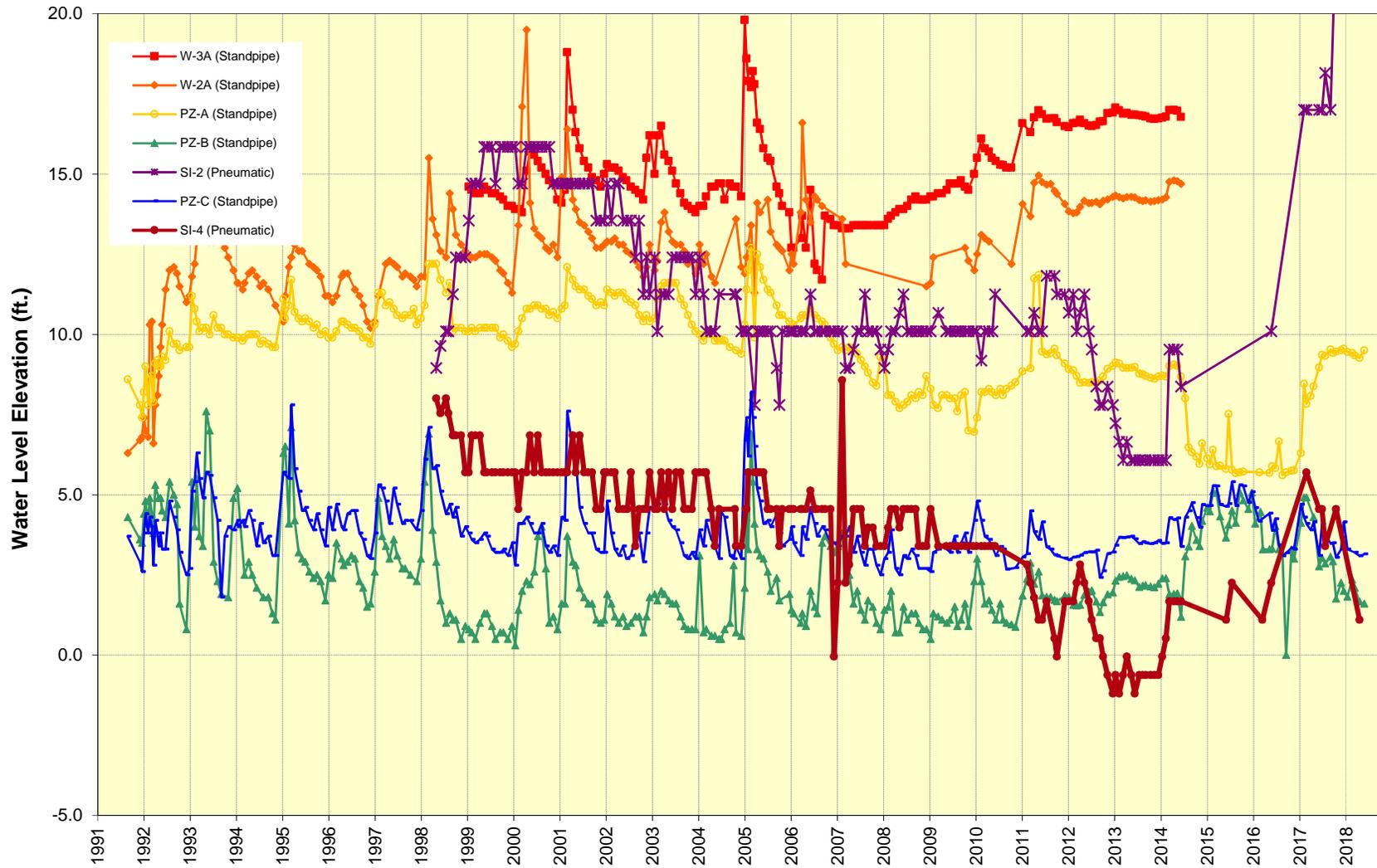
\* Piezometer not functioning



**CITY OF MALIBU  
ANNUAL REPORT, JULY 2017 THROUGH JUNE 2018  
MALIBU, CALIFORNIA**

Standpipe / Piezometer I.D.		91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	Mean '91-'18	Stand Dev.	17-18 vs. 97-98	17-18 vs. mean		
<b>MALIBU ROAD - Standpipe Piezometers</b>																																		
W-2A	Mean El.	8.3	12.3	12.1	11.8	11.7	11.2	12.4	12.8	13.5	13.7	12.9	12.6	12.3	12.8	13.4	13.7	--	--	--	14.1	14.2	14.2	14.4	DRY	DRY	DRY	DRY						
	Highest El.	11.4	13.6	13.1	12.8	12.2	12.3	15.5	14.4	19.5	16.4	13.4	13.8	12.8	14.1	16.6	14.3	--	--	--	15.0	14.7	14.3	14.8	DRY	DRY	DRY	DRY						
W-3A	Mean El.								14.5	14.4	15.5	15.0	15.3	14.3	16.4	13.9	13.1	13.6	14.3	15.2	16.1	16.6	16.8	16.8	UTL	UTL	UTL	UTL						
	Highest El.								14.6	15.7	18.8	15.4	16.5	14.7	19.8	15.5	13.7	13.9	14.7	16.1	17.0	16.7	17.1	17.0	UTL	UTL	UTL	UTL						
PZ-A	Mean El.	8.6	10.1	10.0	10.4	10.2	10.5	11.1	10.4	10.2	11.1	11.2	11.0	10.3	10.8	10.7	9.9	8.5	8.1	7.9	9.2	9.0	8.9	8.8	6.3	6.0	6.9	9.4	9.5	1.5	-1.7	0.0		
	Highest El.	9.3	11.2	10.6	11.7	10.5	11.3	12.2	11.6	10.9	12.1	11.4	11.6	11.6	12.7	11.4	10.6	9.3	8.7	8.3	11.9	9.6	9.1	9.1	8.0	7.5	9.0	9.6	10.4	1.4	-2.7	-0.8		
PZ-B	Mean El.	4.4	4.5	2.9	3.7	2.6	2.9	3.4	1.0	1.3	2.3	1.3	1.5	1.0	2.8	1.7	2.7	1.3	1.0	1.6	1.8	1.7	2.1	2.1	4.1	4.2	3.8	2.3	2.4	1.1	-1.1	-0.2		
	Highest El.	5.3	7.6	5.2	7.1	3.5	4.9	6.9	1.3	2.6	4.0	1.9	2.0	3.1	6.9	2.6	3.8	2.0	1.3	3.0	2.9	2.0	2.5	2.4	5.1	5.1	4.9	3.1	3.8	1.9	-3.8	-0.7		
PZ-C	Mean El.	3.6	4.6	3.9	4.7	4.2	4.2	5.1	4.0	3.6	4.5	3.6	4.1	3.4	5.2	3.9	3.7	3.0	3.0	3.7	3.4	3.1	3.3	3.7	4.6	4.8	3.7	3.5	3.9	0.6	-1.6	-0.5		
	Highest El.	4.4	6.3	4.9	7.8	4.7	5.3	7.1	4.7	4.3	7.6	4.8	5.1	4.2	8.2	4.6	4.1	3.9	3.4	4.8	4.5	3.4	3.7	4.3	5.3	5.4	4.7	4.2	5.0	1.3	-3.0	-0.9		
PZ-D	Mean El.	4.4	6.9	5.1	7.6	5.0	5.9	7.8	4.7	4.0	4.8	4.2	4.3	4.1	7.0	4.7	4.2	4.0	4.4	5.1	5.2	5.3	5.8	5.9	5.0	5.1	4.8	4.5	5.2	1.1	-3.4	-0.7		
	Highest El.	5.8	11.4	6.7	13.1	5.8	15.2	18.1	5.9	4.9	8.4	5.3	5.3	4.6	15.3	5.6	4.7	4.9	4.9	8.4	7.1	5.9	6.1	8.0	5.8	5.6	6.1	5.1	7.5	3.7	-3.0	-2.4		
PZ-E	Mean El.	13.0	14.3	13.9	14.5	14.2	14.6	15.2	12.8	12.7	13.3	12.5	14.1	13.8	15.6	12.1	10.5	10.4	10.4	11.6	13.5	11.9	11.2	11.4	9.3	9.1	11.4	11.4	12.5	1.8	-3.9	-1.2		
	Highest El.	14.5	16.0	15.0	16.3	14.9	16.5	16.3	14.4	15.6	16.2	14.3	15.6	14.9	17.9	14.0	13.1	12.8	11.8	14.5	15.4	14.1	11.4	11.8	9.6	10.3	16.1	12.7	14.3	2.0	-3.6	-1.6		
Area Average	Mean El.	7.0	8.8	8.0	8.8	8.0	8.2	9.2	8.6	8.5	9.3	8.7	9.0	8.5	10.1	8.6	8.2	6.8	6.9	7.5	9.0	8.8	8.9	9.0	5.9	5.8	6.1	6.2	8.1	1.2	-3.0	-1.9		
	Highest El.	8.5	11.0	9.3	11.5	8.6	10.9	12.7	9.6	10.5	11.9	9.5	10.0	9.4	13.6	10.0	9.2	7.8	7.5	8.9	10.5	9.5	9.2	9.6	6.8	6.8	8.2	6.9	9.5	1.7	-5.8	-2.6		
Change vs. Prior	Mean El.		1.7	-0.8	0.8	-0.8	0.3	0.9	-0.6	-0.1	0.8	-0.6	0.3	-0.5	1.6	-1.5	-0.4	-1.4	0.1	0.6	1.5	-0.2	0.1	0.1	-3.1	-0.1	0.3	0.1						
	Highest El.		2.6	-1.8	2.2	-2.9	2.3	1.8	-3.1	0.9	1.4	-2.4	0.5																					
<b>Bayshore Drive - Standpipe Piezometers</b>																																		
SI-5	Mean El.								35.5	32.2	30.7	30.1	29.3	29.0	28.6	28.2	27.8	27.3	26.3	22.6	18.8	16.5	16.4	18.0	17.4	14.3	12.2	11.2	23.6	7.3		-12.4		
	Highest El.								37.8	33.4	31.2	30.4	29.7	29.2	28.0	28.4	28.0	27.5	27.0	24.3	20.5	17.6	17.2	19.4	18.3	15.6	12.9	11.5	24.4	7.3		-12.9		
SI-6	Mean El.								38.8	32.6	31.2	29.9	27.9	27.7	27.2	27.9	26.0	25.7	25.4	25.3	26.1	26.4	26.7	26.8	24.8	25.1	25.2	24.8	27.6	3.4		-2.8		
	Highest El.								42.4	34.6	31.9	31.2	28.4	28.2	28.8	29.0	26.5	25.9	25.7	25.8	26.7	26.8	27.1	27.2	25.1	25.4	25.5	25.0	28.4	4.2		-3.4		
Area Average	Mean El.								37.2	32.4	31.0	30.0	28.6	28.3	27.9	28.0	26.9	26.5	25.8	23.9	22.4	21.5	21.6	22.4	21.1	19.7	18.7	18.0	25.6	5.0		-7.6		
	Highest El.								40.1	34.0	31.5	30.8	29.1	28.7	28.9	28.7	27.3	26.7	26.4	25.1	23.6	22.2	22.2	23.3	21.7	20.5	19.2	18.2	26.4	5.4		-8.2		
Change vs. Prior	Mean El.								-4.7	-1.5	-1.0	-1.3	-0.3	-0.4	0.2	-1.2	-0.4	-0.6	-1.9	-1.5	-0.9	0.1	0.8	-1.3	-1.4	-1.0	-0.7							
	Highest El.								-6.1	-2.5	-0.7	-1.8	-0.4	0.2	-0.2	-1.5	-0.6	-0.3	-1.3	-1.5	-1.4	0.0	1.1	-1.6	-1.2	-1.3	-1.0							
<b>MALIBU ROAD - Pneumatic Piezometers</b>																																		
SI-1	Mean El.																																	
	Highest El.																																	
SI-1A	Mean El.																5.8	6.9	6.5	6.9						8.6	13.8	15.7	9.2	3.9	15.7	6.5		
	Highest El.																7.5	6.9	6.9	6.9						11.5	13.8	18.4	10.3	4.5	18.4	8.2		
SI-2	Mean El.							9.3	13.2	15.6	15.1	14.1	11.9	11.5	10.1	9.9	9.9	10.1	10.2	10.1	10.2	11.0	7.4	7.1		10.1	17.0	19.5	11.7	3.2	10.2	7.9		
	Highest El.							9.6	15.9	15.9	15.9	14.7	13.6	12.4	11.3	11.3	10.1	11.3	10.7	11.3	10.7	11.8	9.5	9.5		10.1	17.0	22.8	12.8	3.4	13.1	10.0		
SI-3	Mean El.																																	
	Highest El.																																	
SI-4	Mean El.							7.8	6.6	5.7	6.0	5.2	4.8	5.0	4.9	4.5	4.0	4.0	3.9	3.4	1.8	1.6	-0.3	0.3		1.7	5.1	3.4	4.0	2.1	-4.4	-0.6		
	Highest El.							8.0	8.0	6.9	6.9	5.7	5.7	5.7	5.7	5.1	8.6	4.6	4.6	3.4	2.8	2.8	1.1	1.7		2.3	5.7	4.6	5.0	2.1	-3.5	-0.4		
<b>Bayshore Drive - Pneumatic Piezometers</b>																																		
SI-5 Tip 1	Mean El.								34.2	34.7	36.3	34.2	33.9	32.7	37.6	33.6	31.8	31.7	26.9	25.1	22.9	21.7	18.9	19.0		20.6	27.6	26.7	29.0	6.1		-2.3		
	Highest El.								34.8	39.4	45.1	35.9	37.1	35.9	44.0	34.8	33.6	34.8	30.1	26.7	24.4	22.6	20.9	20.9		22.1	29.0	26.7	31.5	7.5		-4.8		
SI-5 Tip 2	Mean El.								35.4	36.1	39.1	35.8	36.5	34.0	39.5	33.7	29.8	29.2	26.0	25.2	26.8	26.3	24.3	25.1		24.8	30.5	29.8	30.9	5.1		-1.1		
	Highest El.								37.5	42.1	51.3	37.5	40.9	37.5	49.0	37.5	35.1	40.9	27.1	26.5	27.7	28.8	24.8	26.5		25.9	30.5	30.5	34.6	7.9		-4.1		
SI-6 Tip 1	Mean El.								42.4												25.7	25.9	23.8	24.6		27.1	34.8	35.6	30.0	6.7		5.6		
	Highest El.								44.1												26.8	27.4	24.0	26.3		30.3	36.1	38.4	31.7	7.1		6.7		
SI-6 Tip 2	Mean El.								44.5	44.6	46.0	44.4	43.0	42.0	43.8	41.0	39.5	39.0	39.0	41.4	40.0	37.7	34.9	35.9		34.5	52.2	42.5	41.4	4.3		1.1		
	Highest El.								45.7	49.0	51.5	45.7	45.7	43.4	49.1	42.2	42.2	42.8	39.9	42.8	41.6	39.3	35.9	38.2		36.5	56.1	44.5	43.7	5.1		0.8		

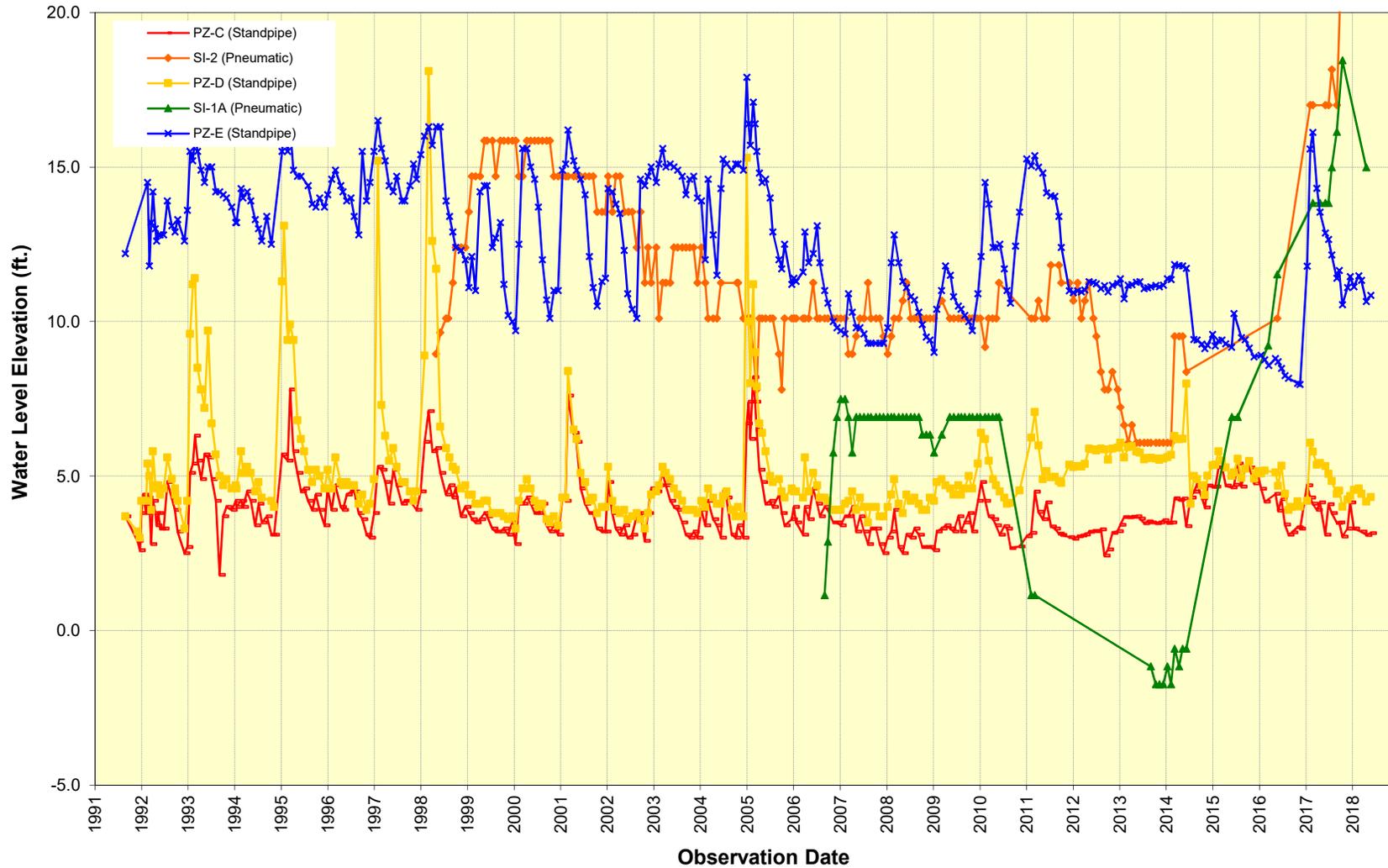
**SUMMARY OF GROUNDWATER DATA**  
Malibu Road Landslide Assessment District  
Malibu, California



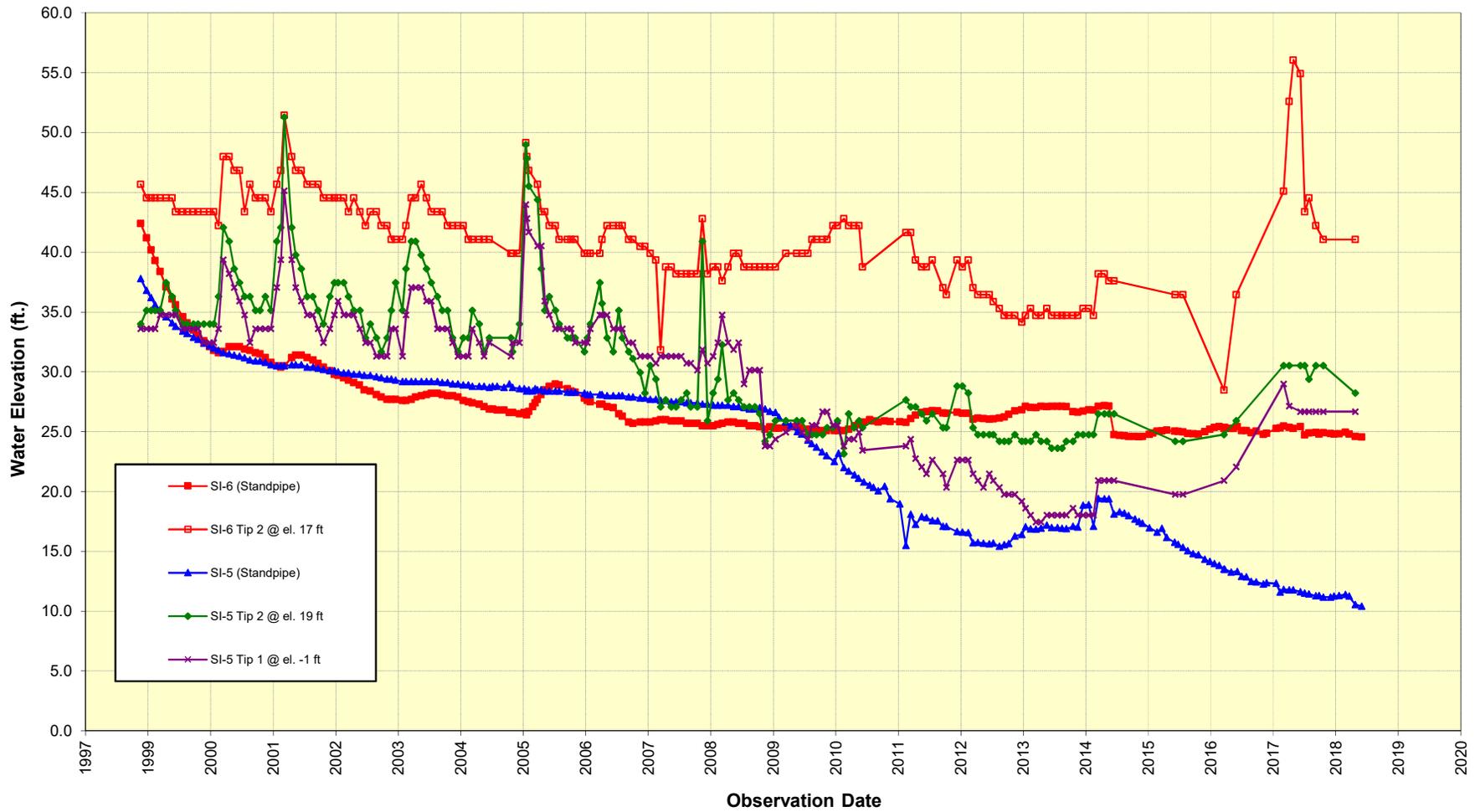
\*Note: W-3A uncovered in Jan. '99 and covered in 2014, presumably due to soil creep  
 W-2A has been dry since July 2014

Observation Date

**GROUNDWATER HYDROGRAPH**  
 Malibu Road (West End)  
 Malibu Road Landslide Assessment District  
 Malibu, California



**GROUNDWATER HYDROGRAPH**  
**Malibu Road (East End)**  
Malibu Road Landslide Assessment District  
Malibu, California



**GROUNDWATER HYDROGRAPH**  
**Bayshore Drive**  
Malibu Road Landslide Assessment District  
Malibu, California



**APPENDIX B  
DEWATERING DATA**



<b>MALIBU ROAD LAD - Dewatering Well Information</b>							
Well ID	Vault Elevation (ft.)	Bottom Elevation (ft.)	Pump Elevation (ft.)	Pump Size (hp)	2016-2017 Mean Pumping Rate (gpd)	% of Total Well Production	Installed By
W-3	19.5	-4.0	Unknown	1/2	169	15%	LA Co.
W-4	20.0	-9.0	Unknown	1/2	15	1%	LA Co.
W-5	19.0	-9.5	Unknown	1/2	480	42%	LA Co.
W-6	20.0	-4.5	Unknown	1/2	25	2%	LA Co.
W-8	27.5	11.0	Unknown	1/2	6	1%	LA Co.
W-9	20.0	-40.0	-35.0	1/3	11	1%	LA Co.
W-10	19.0	-40.0	-35.0	1/3	73	6%	LA Co.
W-11	61.0	1.0	13.0	1/3	128	11%	BYA
W-12	58.0	-2.0	8.0	1/3	81	7%	BYA
W-14	60.0	-20.0	Unknown	1/3	106	9%	Fugro
NW-1	Unknown	Unknown	Unknown	Unknown	24	2%	Homeowner
NW-2	Unknown	Unknown	Unknown	Unknown	15	1%	Homeowner
NW-3	Unknown	Unknown	Unknown	Unknown	9	1%	Homeowner

<b>MALIBU ROAD LAD- Hydrauger Information</b>						
Hydrauger ID	Installed Length (ft.)	Bearing	Functional Length* (ft)	2016-2017 Mean Flow Rate (gpd)	% of Total Production	Installed By
HD-1**	Unknown	N05E	74	0	0%	LA County
HD-2**	Unknown	N21E	34	0	0%	LA County
HD-3**	Unknown	N06E	13	0	0%	LA County
HD-4	Unknown	N29E	53	0	0%	LA County
HD-5	Unknown	N13E	41	0	0%	LA County
HD-6	Unknown	N08W	55	34	11%	LA County
HD-7	Unknown	N26E	87	0	0%	LA County
HD-8	Unknown	N19E	92	1	0%	LA County
HD-9	Unknown	N34E	76	26	9%	LA County
HD-10	Unknown	N19E	55	0	0%	LA County
HD-11	Unknown	N11E	78	0	0%	LA County
HD-12	Unknown	N08E	70	0	0%	LA County
HD-13	Unknown	N09E	79	0	0%	LA County
HD-14	Unknown	N08E	80	0	0%	LA County
HD-15	Unknown	N14E	82	0	0%	LA County
HD-16	Unknown	N15E	69	0	0%	LA County
HD-17**	150	N15E	150	0	0%	BYA
HD-18	150	N18E	150	47	16%	BYA
HD-19	150	N10E	150	1	0%	BYA
HD-20	150	N09W	150	114	38%	BYA
HD-21	150	N22E	150	30	10%	BYA
HD-22	180	N13E	180	0	0%	Fugro West
HD-23	160	N01E	160	49	16%	Fugro West

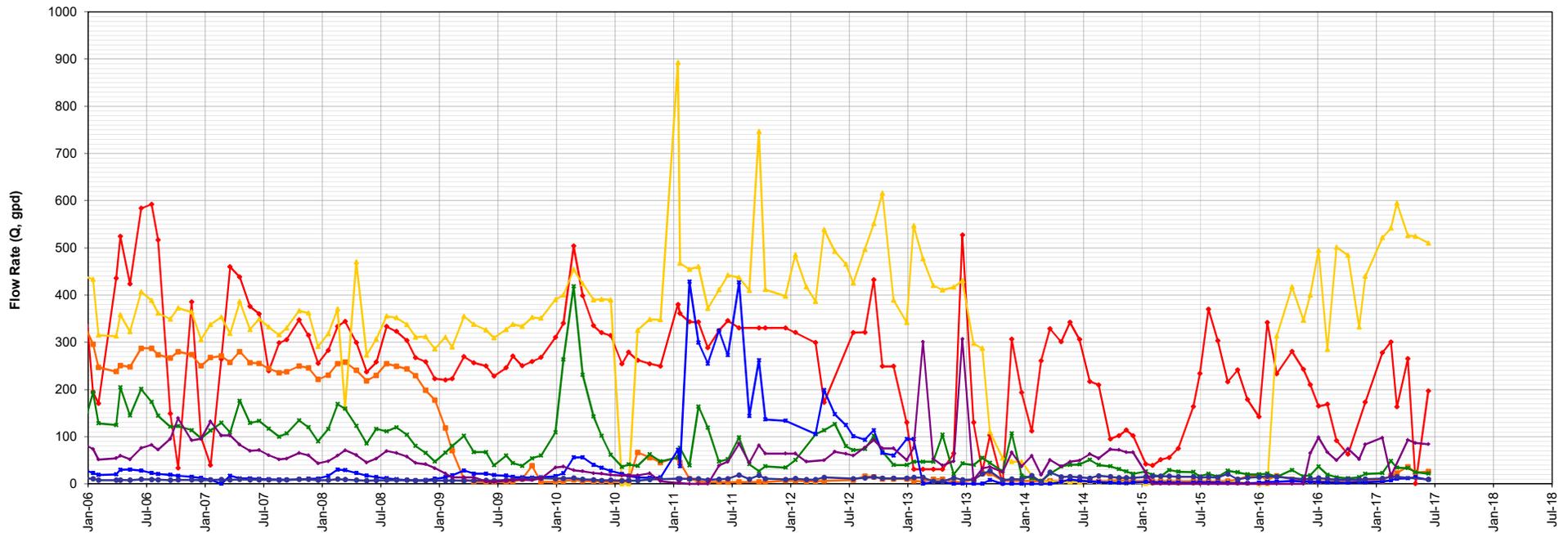
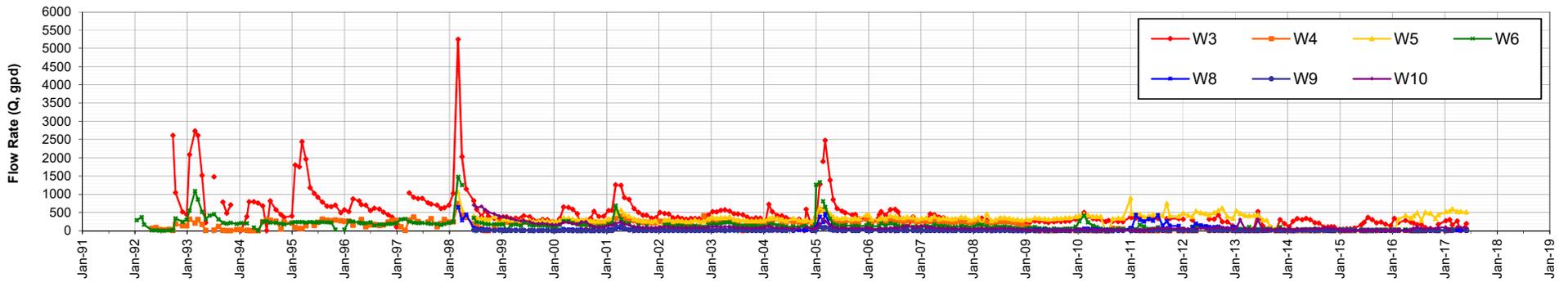
Note: \* Measured on 4/1/98 (except HD-22 and HD-23 installed 1/22/05)

\*\* buried/unable to locate

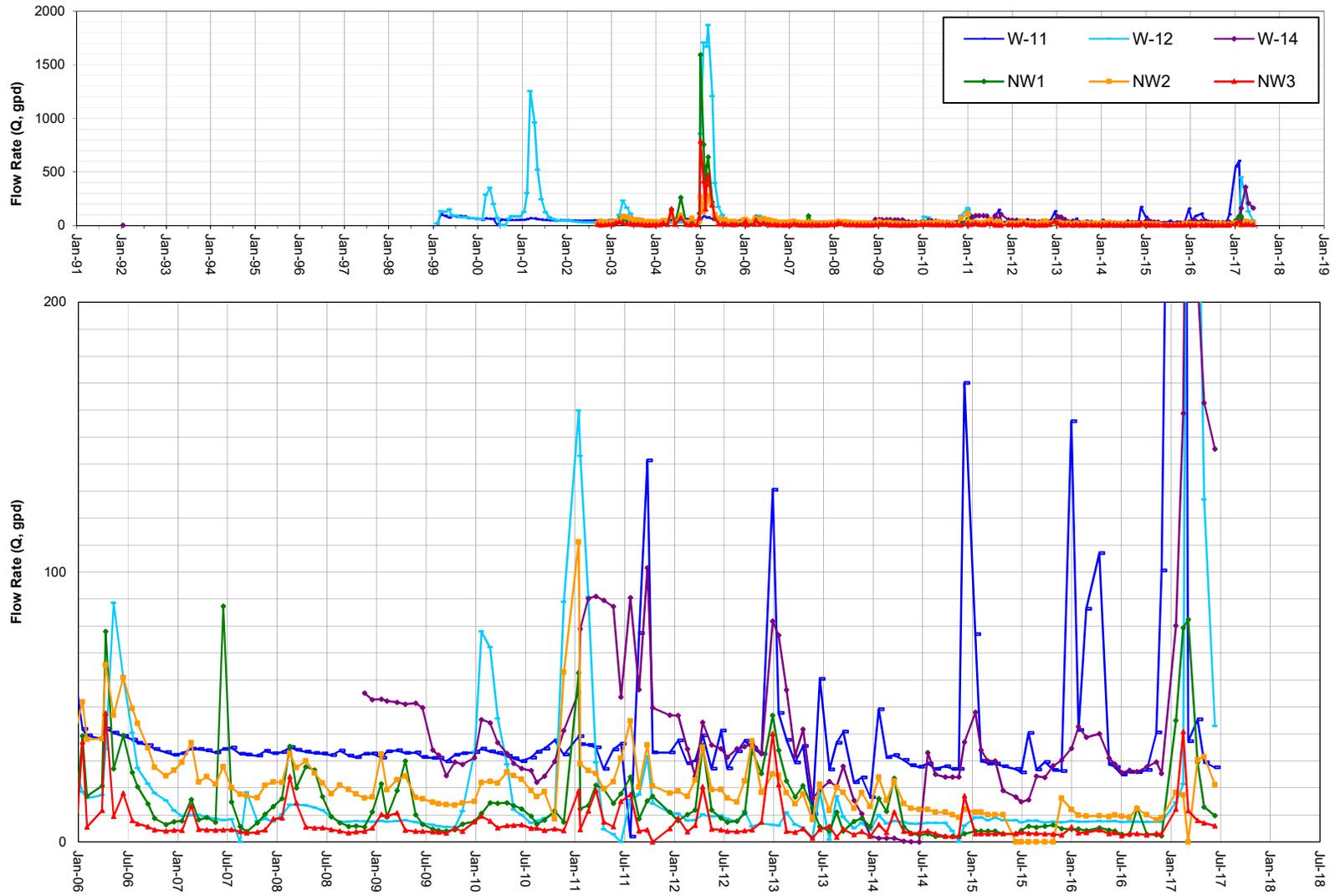
**DEWATERING WELL / HYDRAUGER INFORMATION**

Malibu Road Landslide Assessment District

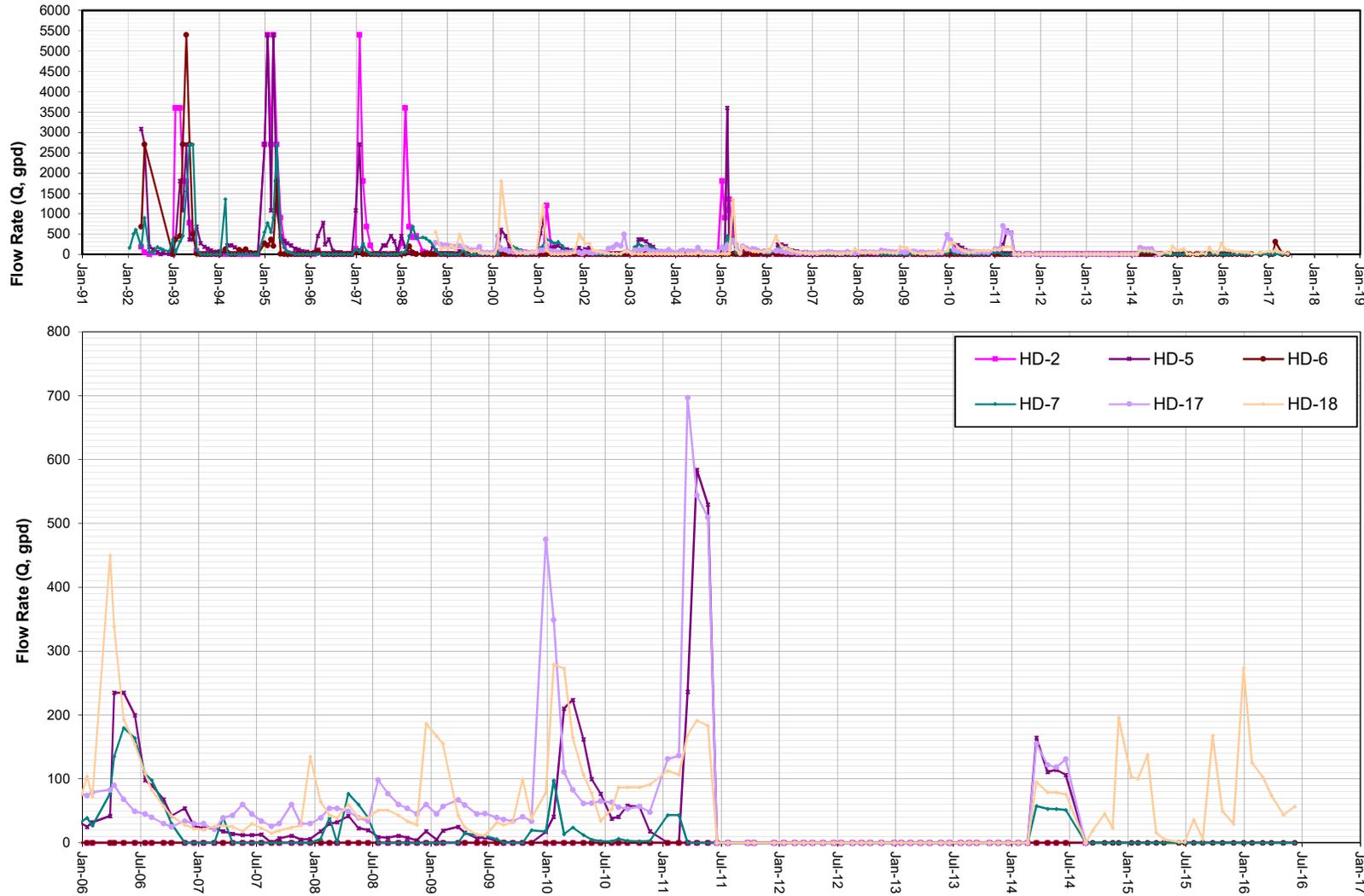
Malibu, California



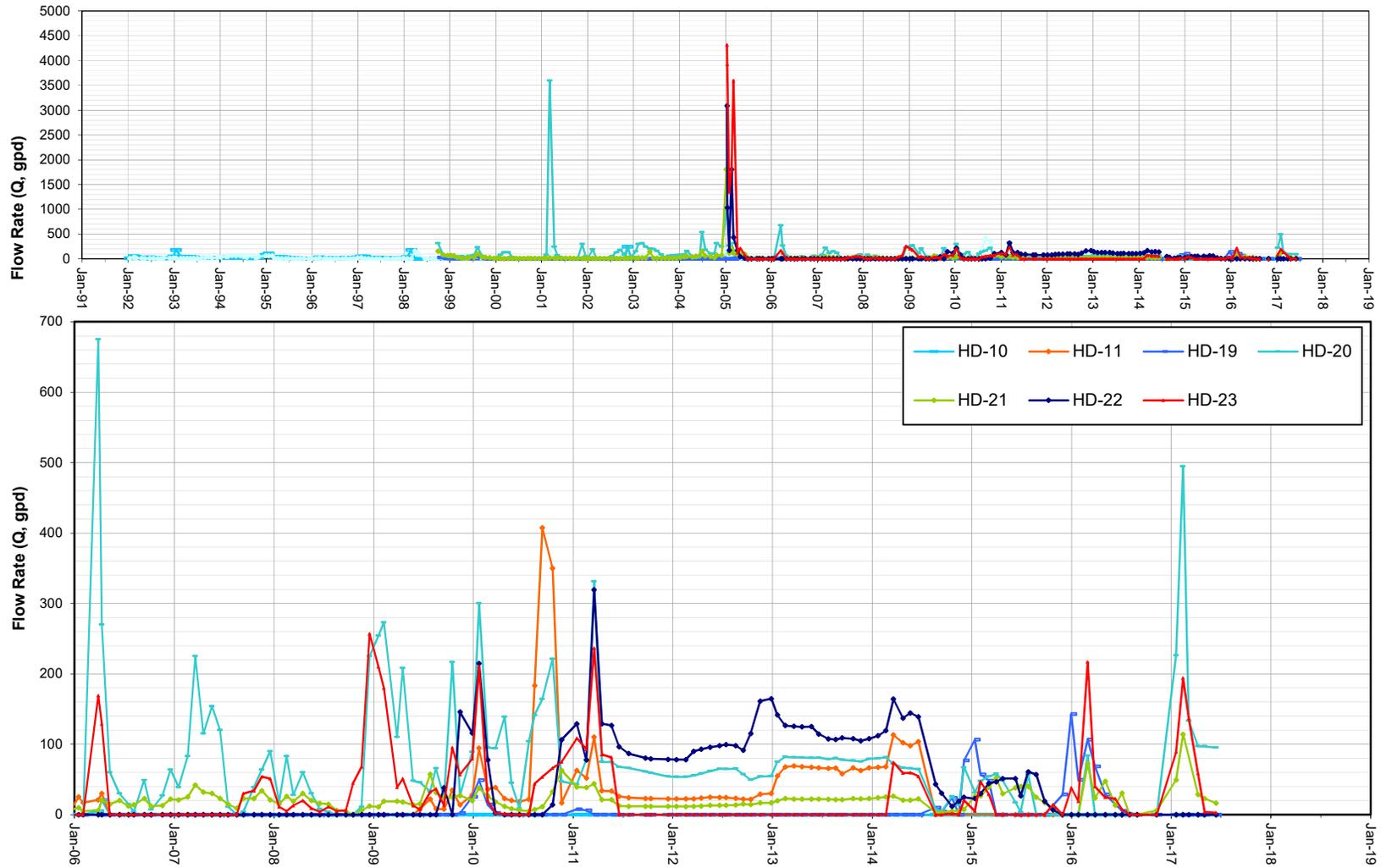
**DEWATERING WELL DISCHARGE RATE GRAPH  
Malibu Road  
Malibu Road Landslide Assessment District  
Malibu, California**



**DEWATERING WELL DISCHARGE RATE GRAPH**  
**Bayshore Drive**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**HYDRAUGER DISCHARGE RATE GRAPH**  
**Malibu Road (West End)**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**HYDRAUGER DISCHARGE RATE GRAPH**  
**Malibu Road (East End)**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**APPENDIX C**  
**SLOPE INCLINOMETER DATA**



<b>MALIBU ROAD LAD - Slope Incliner Interpretation Summary</b>									
	SI-1 (MR98-1)	SI-1A	SI-2 (MR98-2)	SI-2A	SI-3 (MR98-3)	SI-4 (MR98-4)	SI-4A	SI-5	SI-6
<b>Installation Details</b>									
Previous Ref.Elev.(8/91)	20.0	20.0	20.0	20.0	20.0	22.0	N/A	59.0	57.0
Updated Ref.Elev.(4/00)	20.1	20.0	19.7	19.7	20.3	18.9	18.9	59.3	58.0
Depth (ft.)	34	50	64	64	49	43	50	78	78
Install Date	Apr-98	Aug-06	Apr-98	Sep-10	Apr-98	Apr-98	Aug-12	Apr-98	Apr-98
A+ Axis orientation (deg)	184	197	201	200	190	204	204	176	186
Casing	RST	SI	RST	RST	RST	RST	SI	SI	SI
Installer	BYA	Fugro	BYA	Fugro	BYA	BYA	Fugro	BYA	BYA
Interpreted Rupture Depth (ft)	30-32	23-30	28-32	28-32	35-38	32-34	32-34	unknown	unknown
Status	D	F	D	F	D	D	F	F	F
Reading Interval	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Semi	Semi
<b>Interpretation Movement (inches)</b>									
2017-2018	NR	--	NR	--	NR	NR	--	--	--
2016-2017	NR	0.1	NR	0.15	NR	NR	0.15	--	--
2015-2016	NR	--	NR	--	NR	NR	--	--	--
2014-2015	NR	<0.1	NR	--	NR	NR	--	--	--
2013-2014	NR	0.1	NR	--	NR	NR	--	--	--
2012-2013	NR	<0.1	NR	<0.1	NR	NR	--	0.1	0.1
2011-2012	NR	<0.1	NR	--	NR	--	NR	--	<0.1
2010-2011	NR	<0.1	NR	--	NR	0.6	NR	--	<0.1
2009-2010	NR	<0.1	NR	--	NR	--	NR	--	<0.1
2008-2009	NR	<0.1	<0.1 (4)	NR	NR	--	NR	--	<0.1
2007-2008	NR	<0.1	--	NR	NR	--	NR	--	<0.1
2006-2007	NR	NR	--	NR	NR	--	NR	--	0.1
2004-2005	0.5 (3)	NR	0.4	NR	>1(3)	0.4 to 0.5	NR	~ 0.2 *	--
2003-2004 (1)	--	NR	--	NR	--	--	NR	--	--
2002-2003	~ 0.2 *	NR	~ 0.1 *	NR	--	--	NR	--	--
2001-2002	--	NR	--	NR	--	--	NR	--	--
2000-2001	0.5	NR	0.4	NR	0.3	0.6	NR	--	--
1999-2000	--	NR	--	NR	--	--	NR	--	--
1998-1999	3.1	NR	1.5	NR	4.1	1.3 (2)	NR	--	--

**NOTES:**

D Destroyed

F Functioning

NI No information

(1) Readings only through March 2004

(2) Readings are through 2000, although majority of movement occurred in 1998

(3) Inclinerometer sheared off in January, 2005.

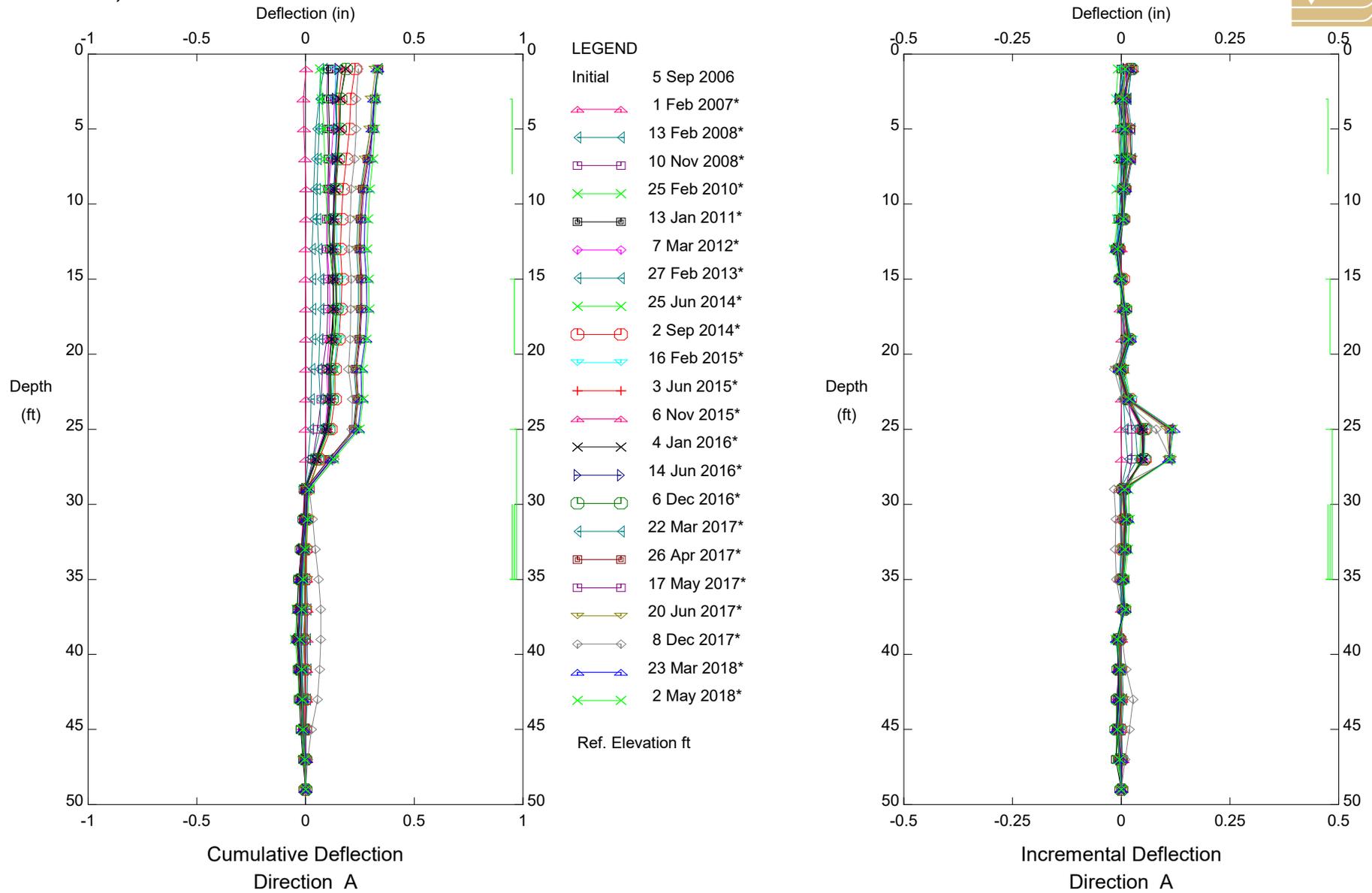
(4) Inclinerometer sheared off winter of 2009.

NR No reading

-- No clearly defined interpreted movement.

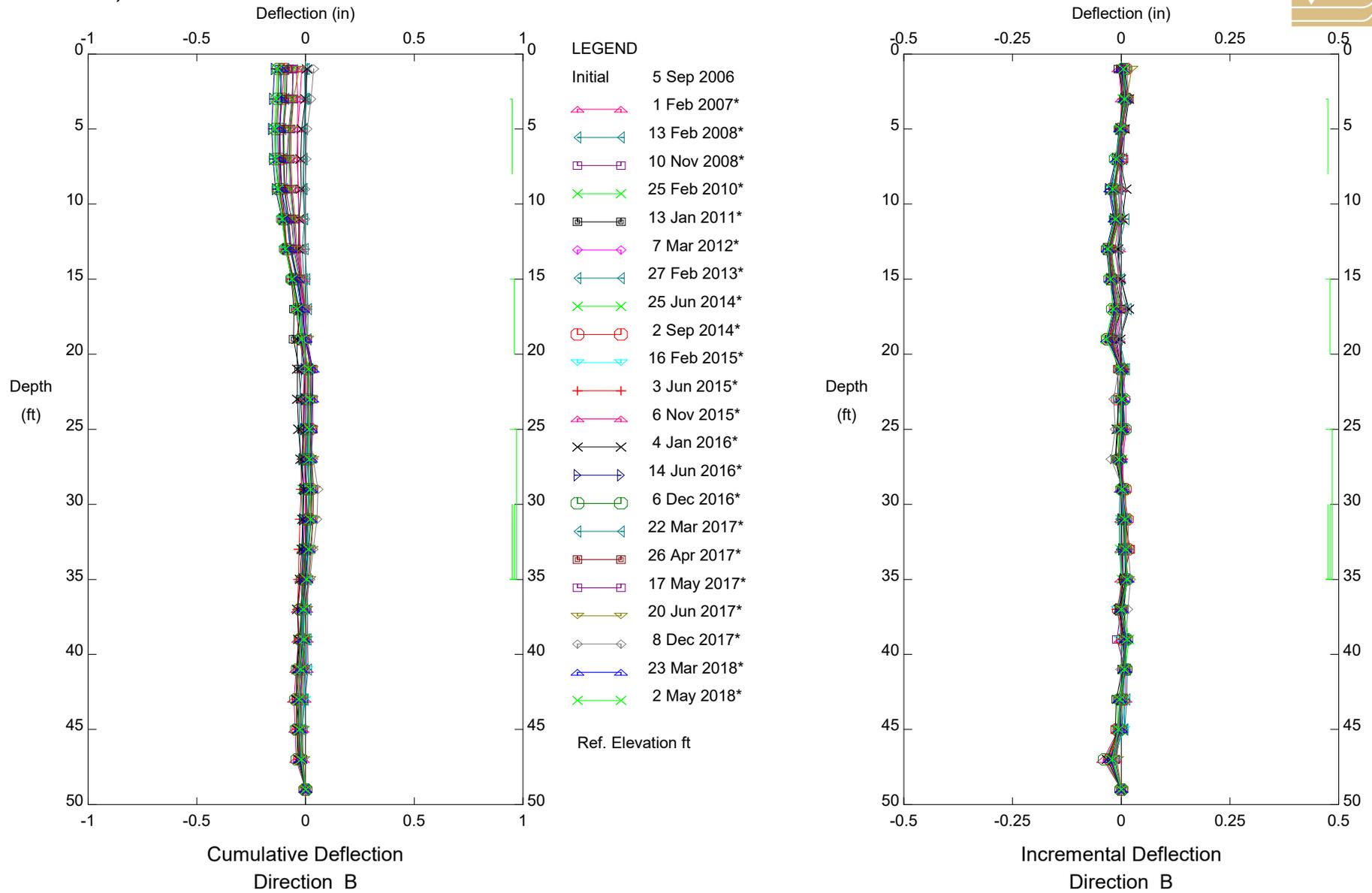
~ 0.1 \* Indicated displacement is less than reliable instrument accuracy. Interpreted movement is theoretical.

**SUMMARY OF SLOPE INCLINOMETERS**  
Malibu Road Landslide Assessment District  
Malibu, California



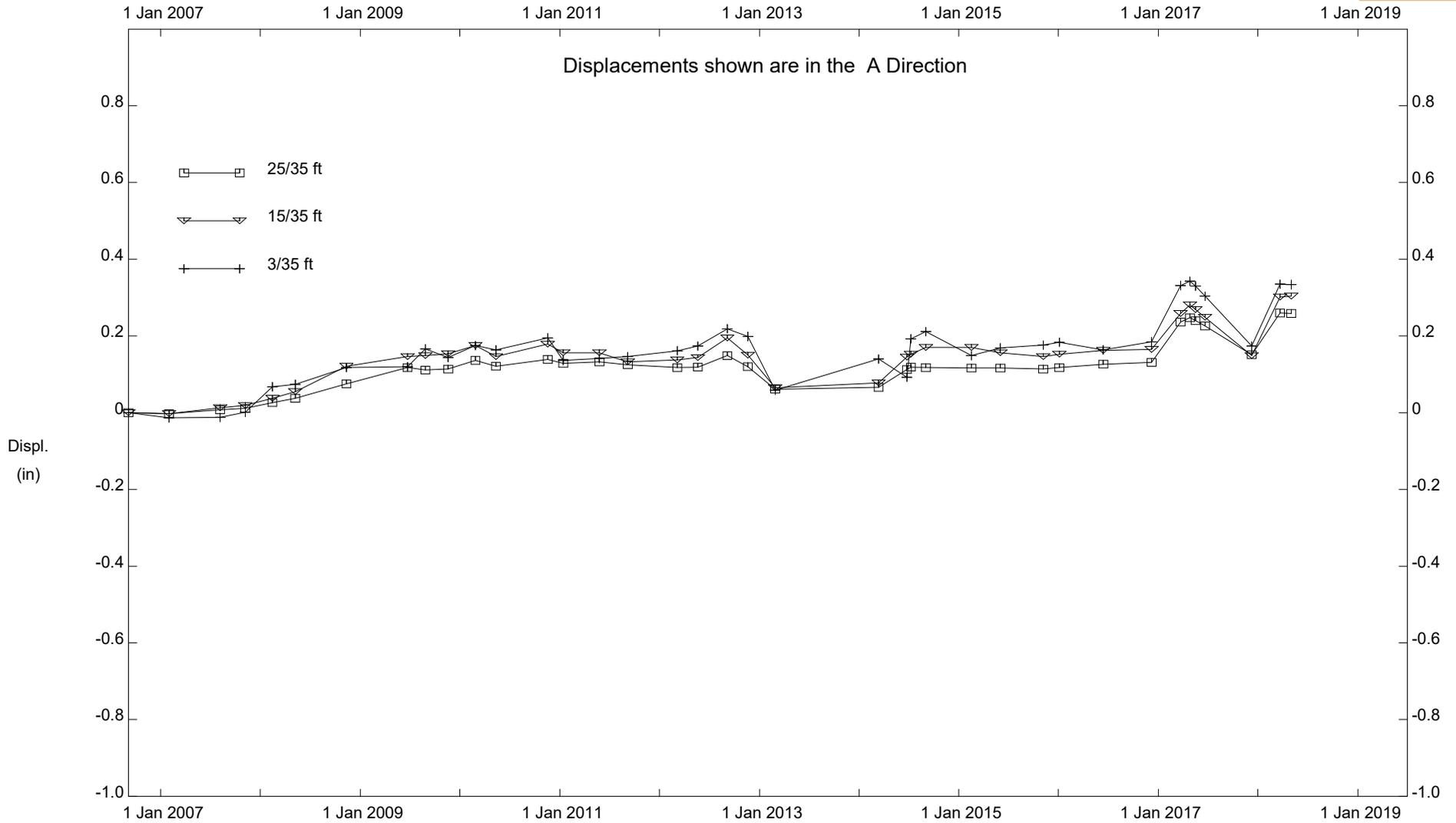
Assessment District 98-3, Inclinometer SI-1A  
 City of Malibu

Sets marked \* include zero shift and/or rotation corrections.

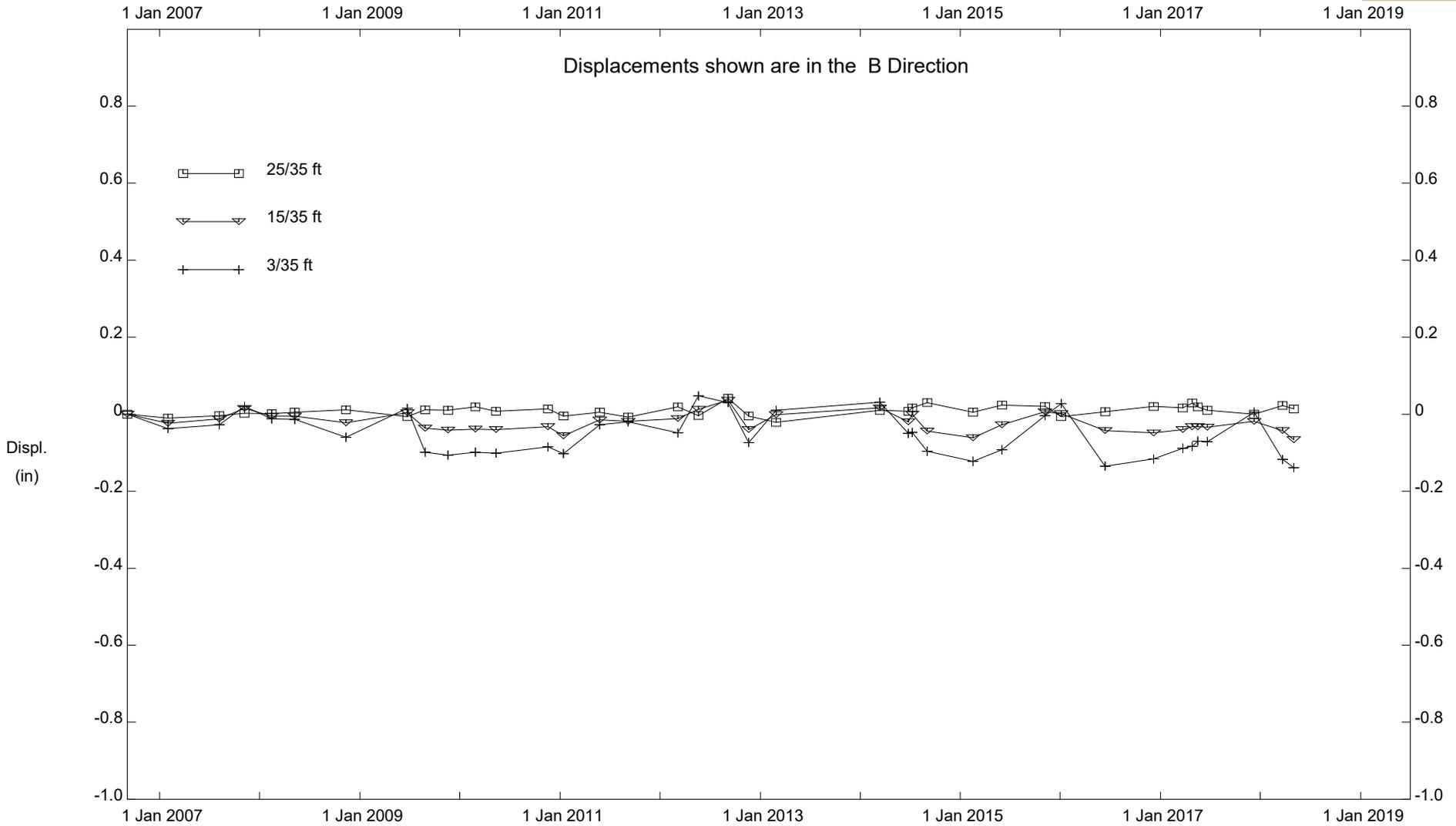


Assessment District 98-3, Inclinometer SI-1A  
City of Malibu

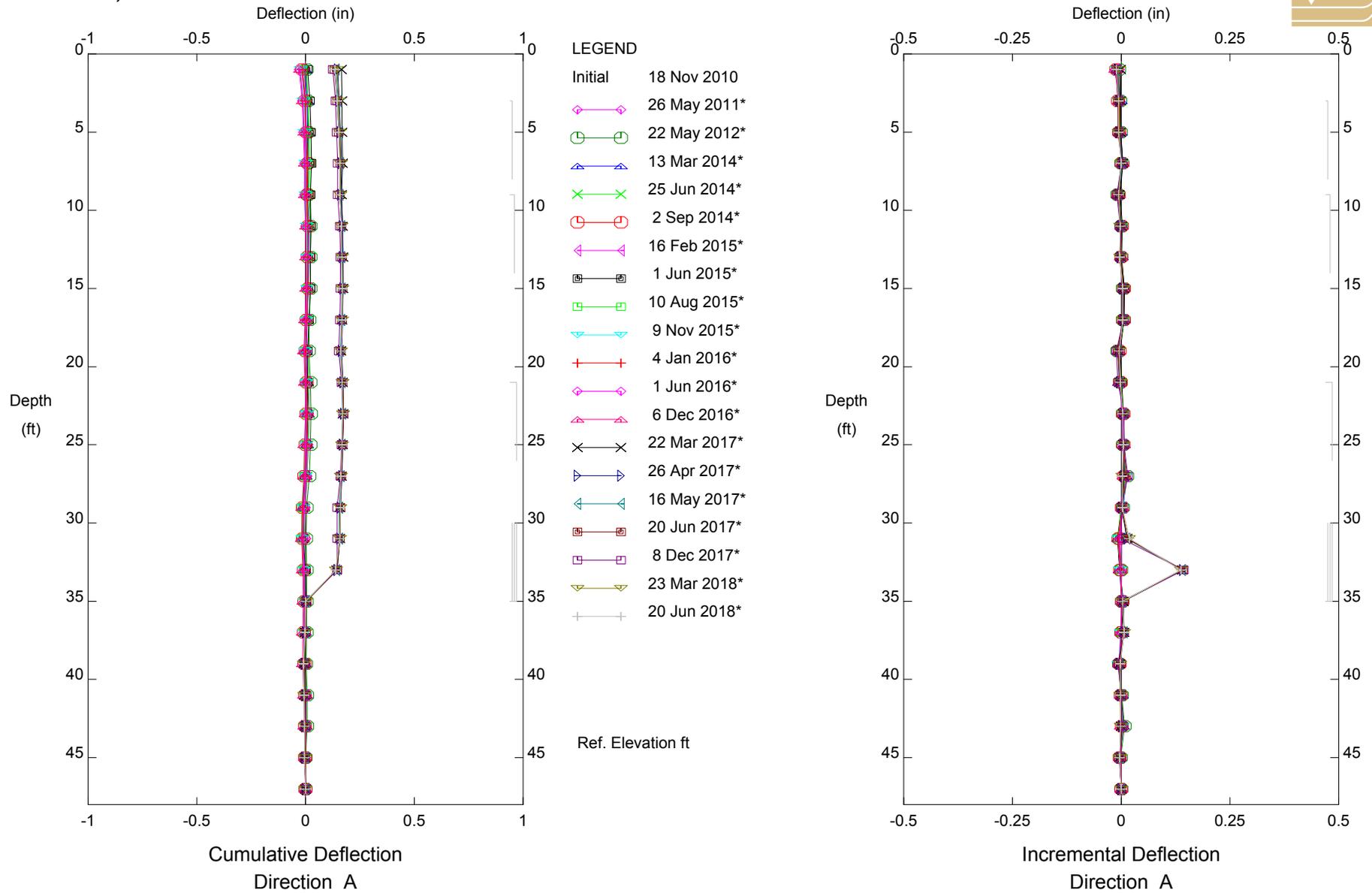
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Assessment District 98-3, Inclinator SI-1A



Assessment District 98-3, Inclinometer SI-1A

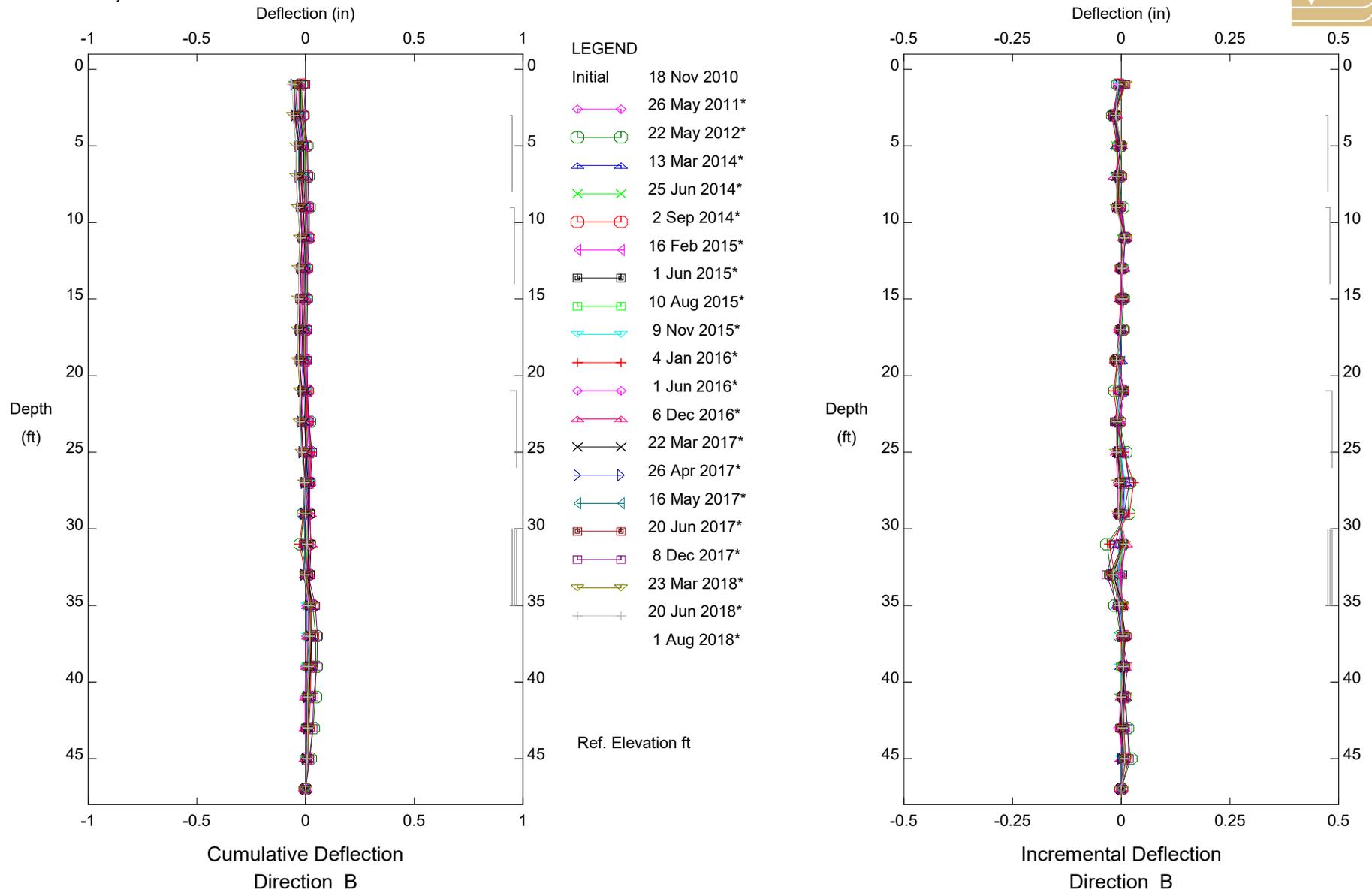


Assessment District 98-3, Inclinerometer SI-2A

City of Malibu

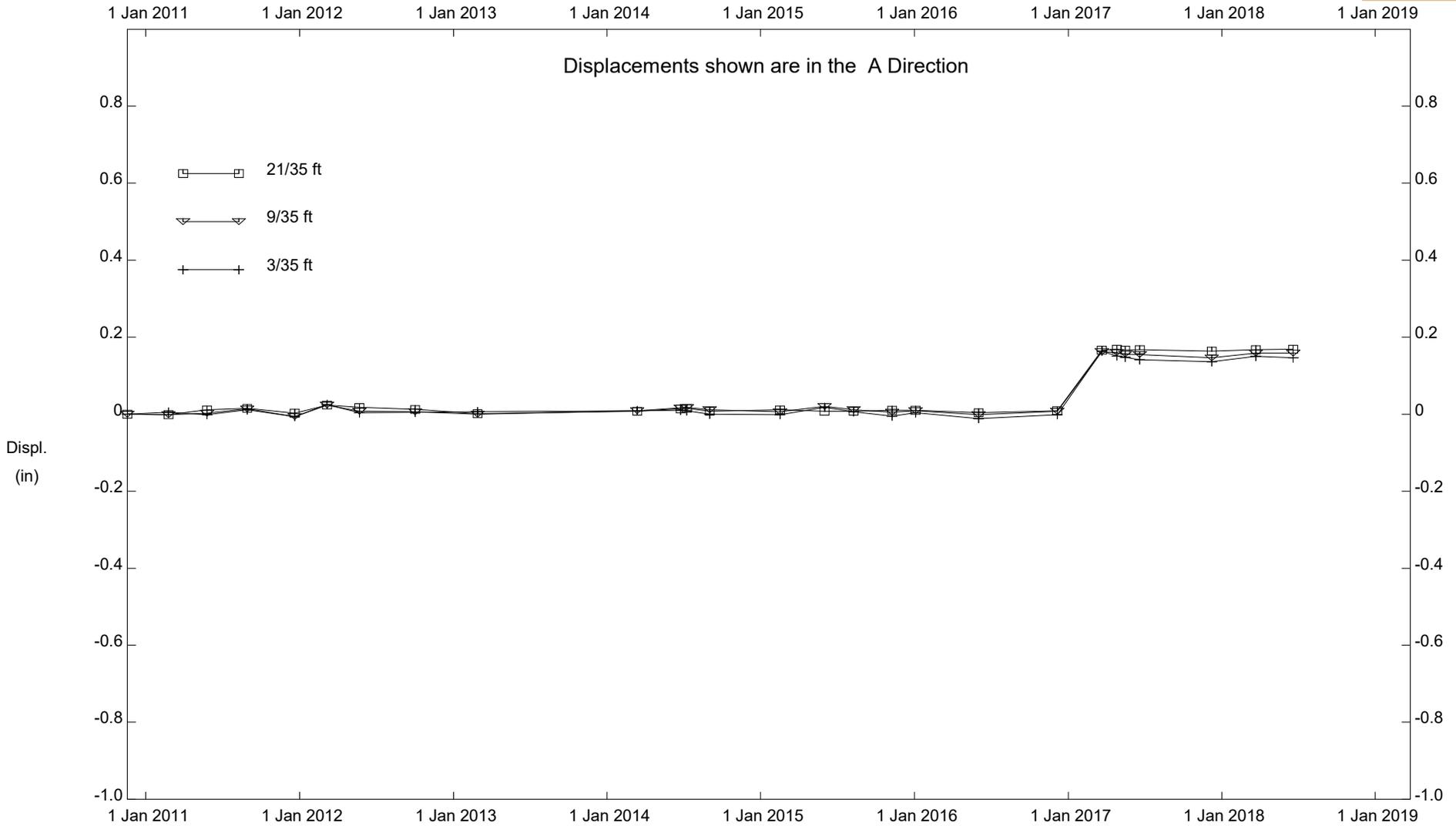
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PLATE C-3a

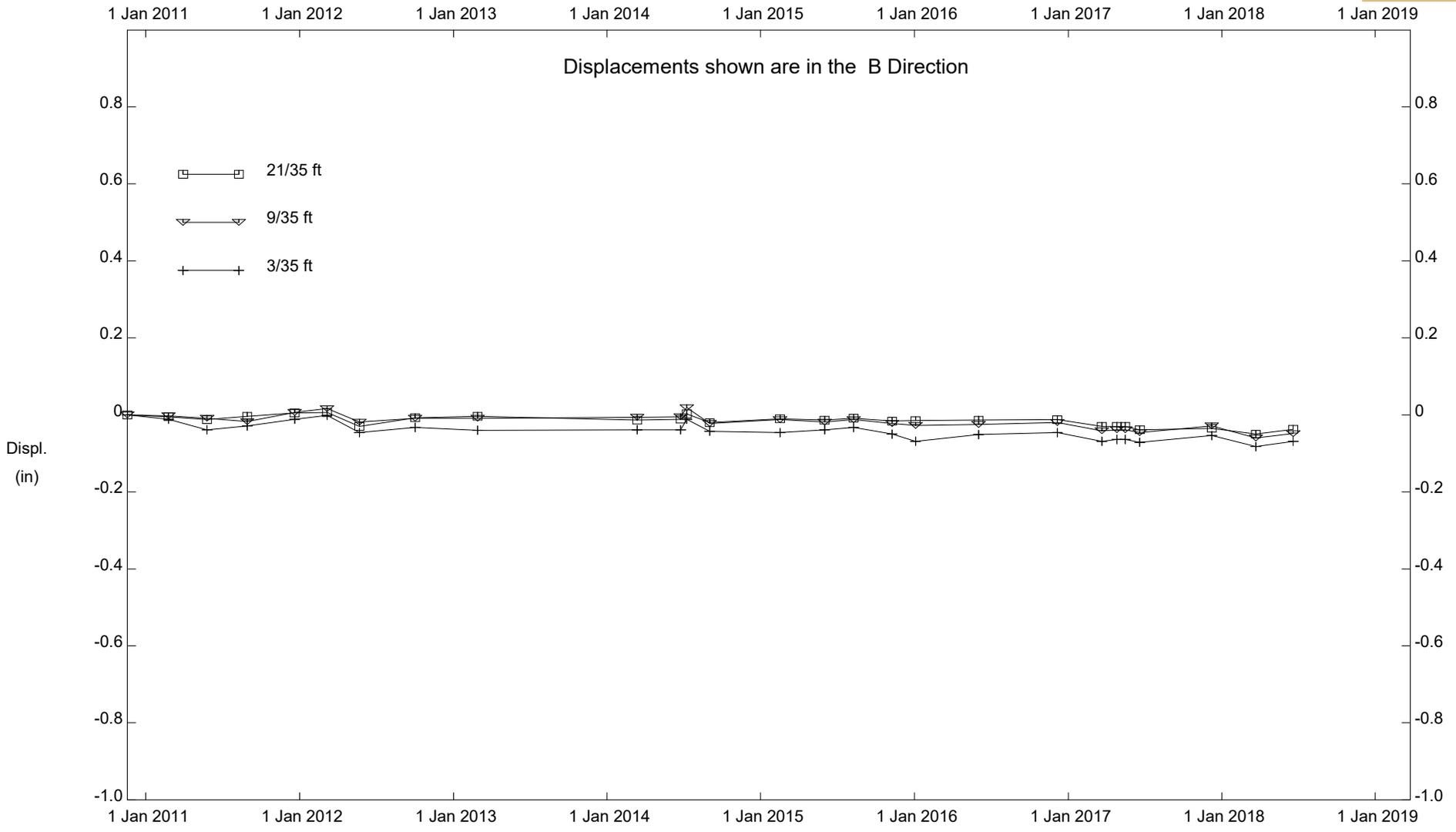


Assessment District 98-3, Inclinometer SI-2A  
City of Malibu

Sets marked \* include zero shift and/or rotation corrections.

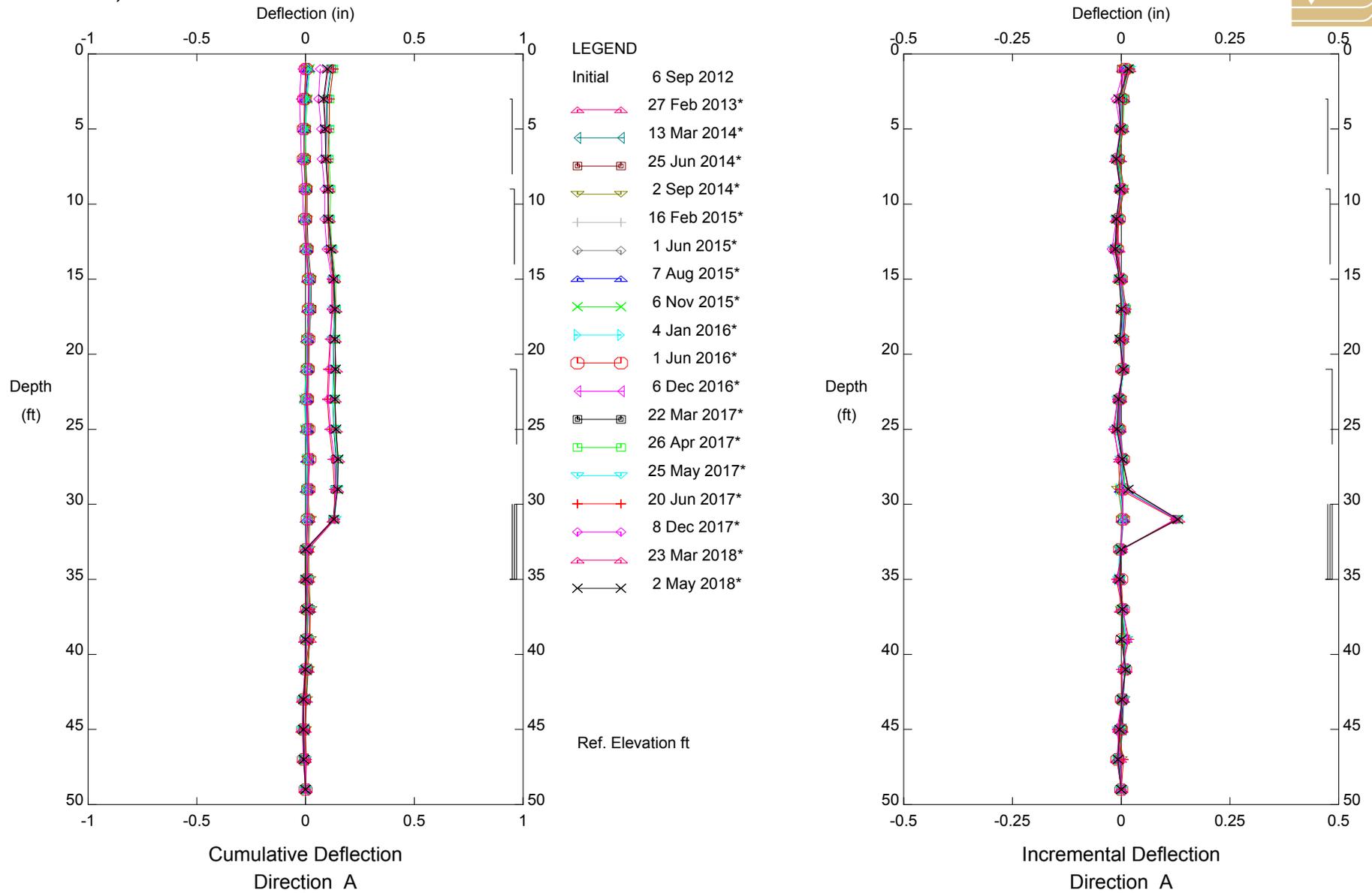


Assessment District 98-3, Inclinometer SI-2A



Assessment District 98-3, Inclinometer SI-2A

City of Malibu

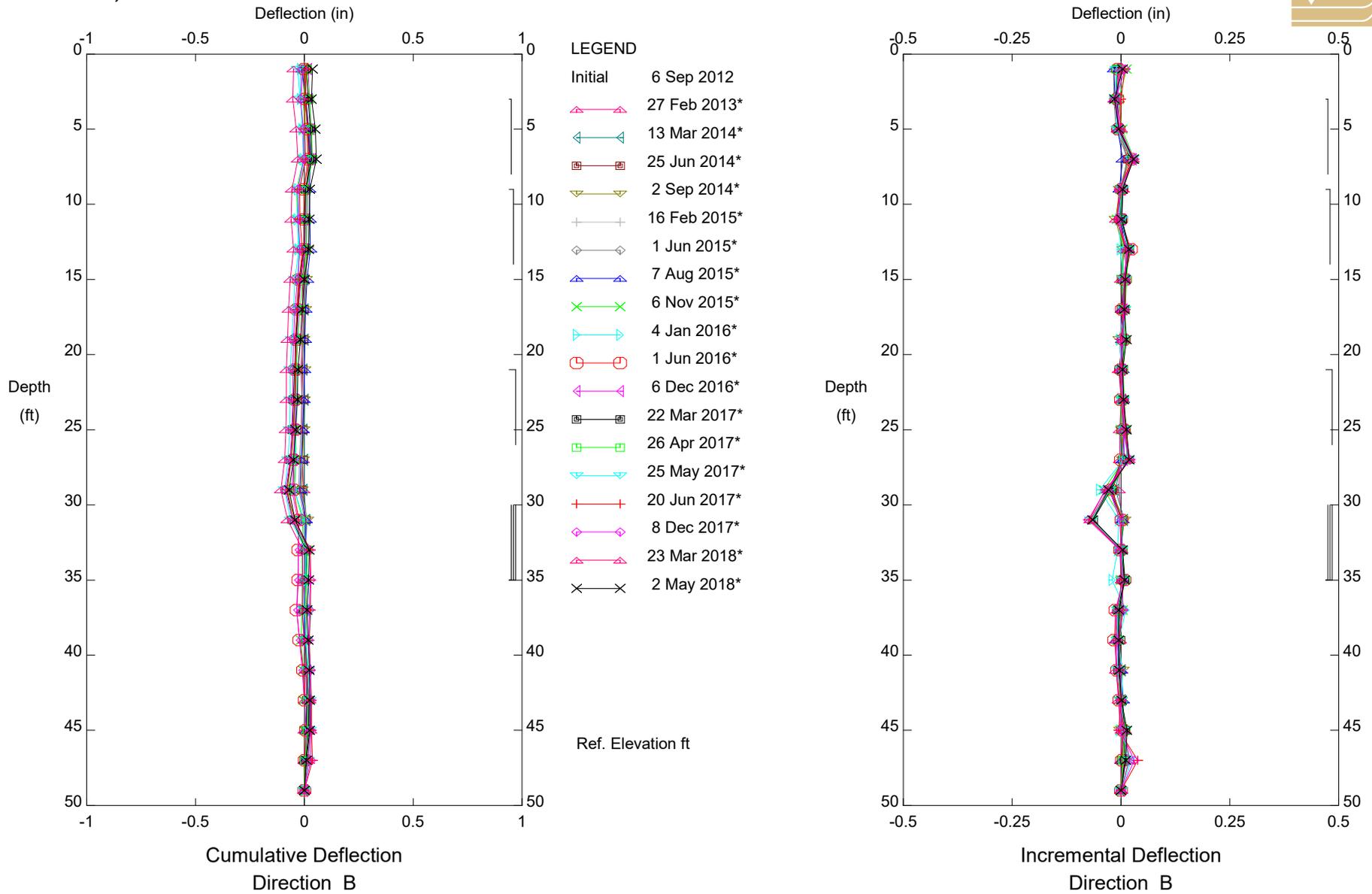


Assessment District 98-3, Inclinometer SI-4A

City of Malibu

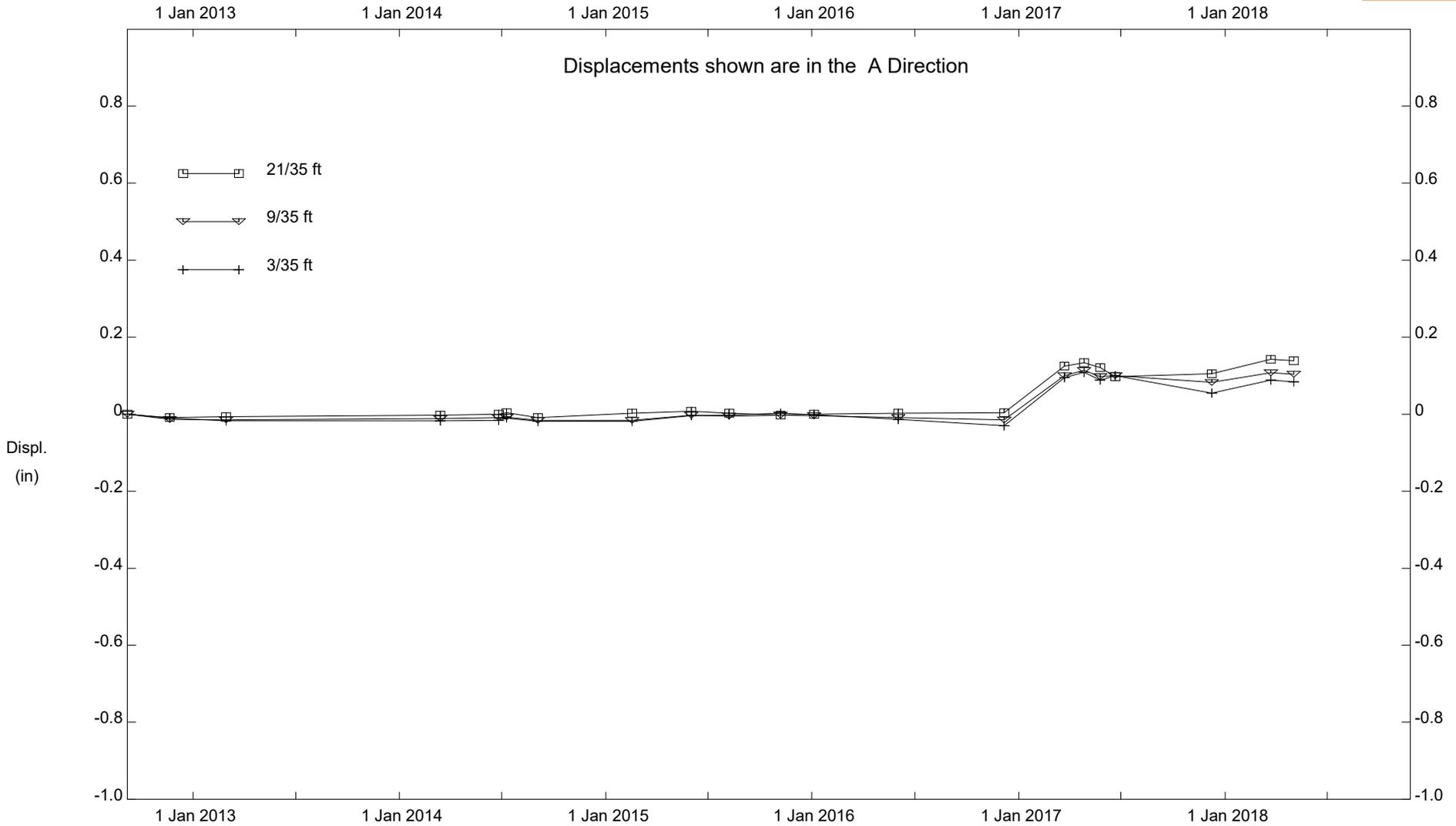
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PLATE C-4a

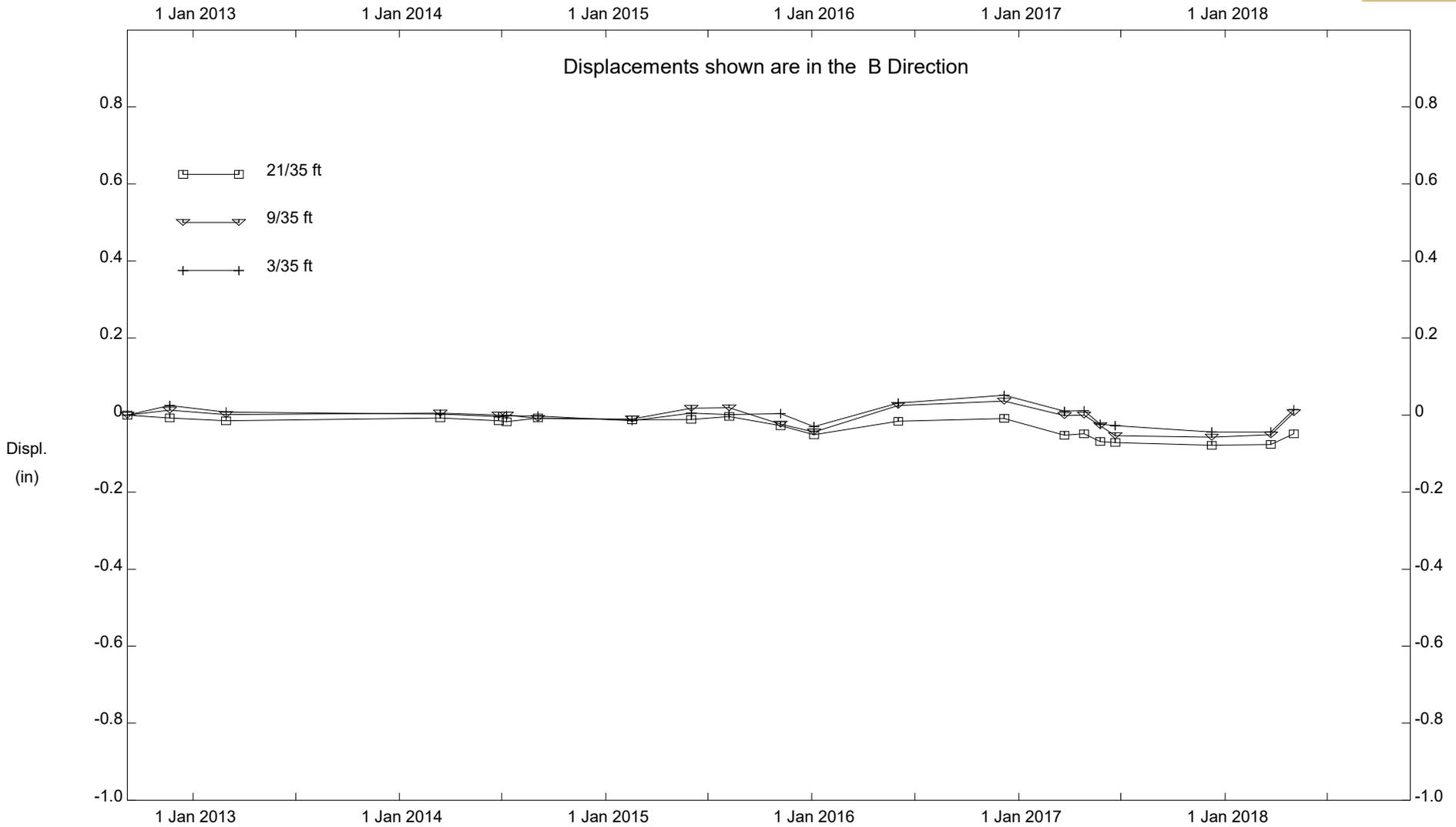


Assessment District 98-3, Inclinometer SI-4A  
City of Malibu

Sets marked \* include zero shift and/or rotation corrections.

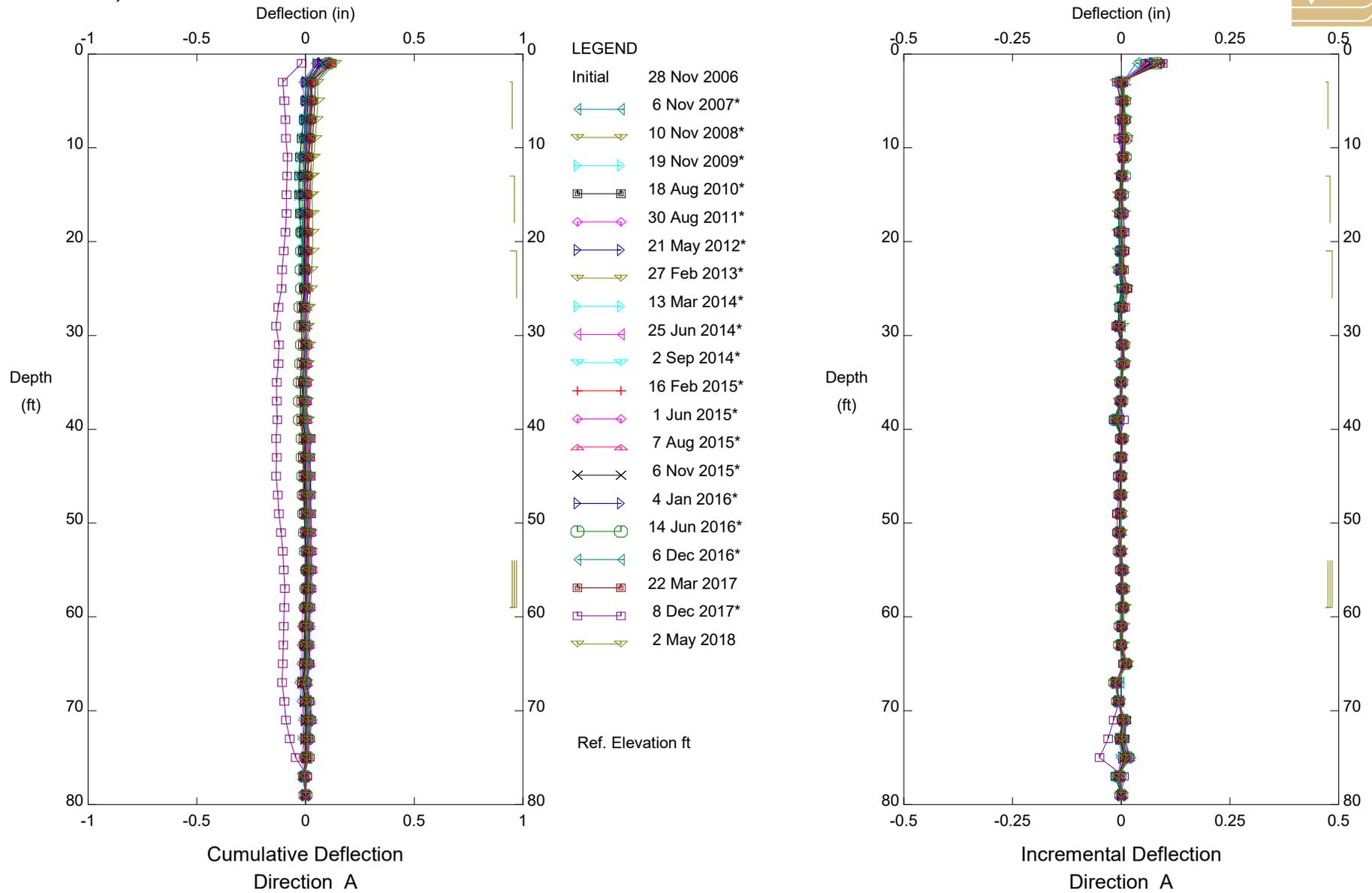


Assessment District 98-3, Inclinator SI-4A



Assessment District 98-3, Inclinometer SI-4A

City of Malibu

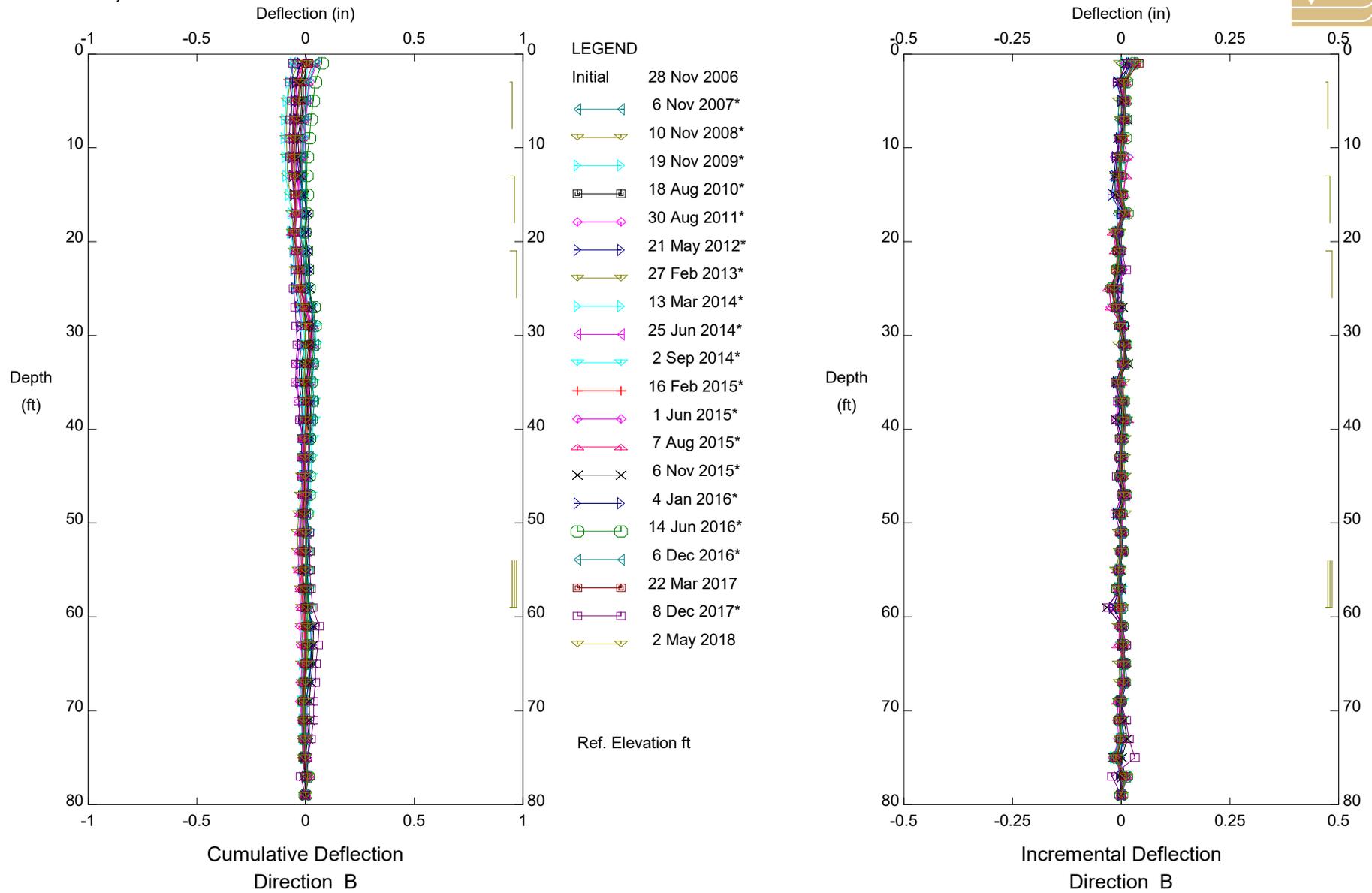


Assessment District 98-3, Inclinometer SI-5

City of Malibu

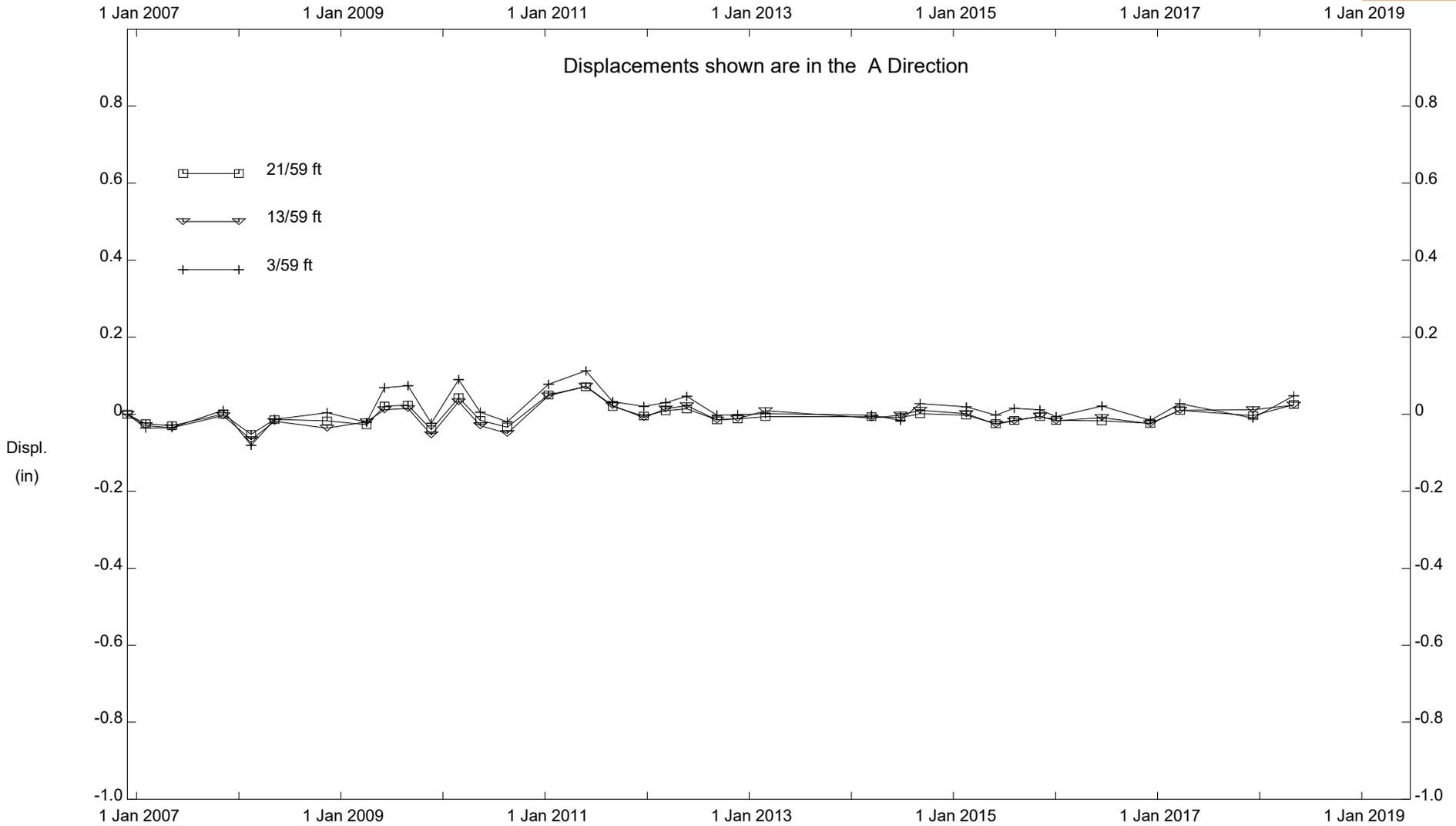
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PLATE C-5a



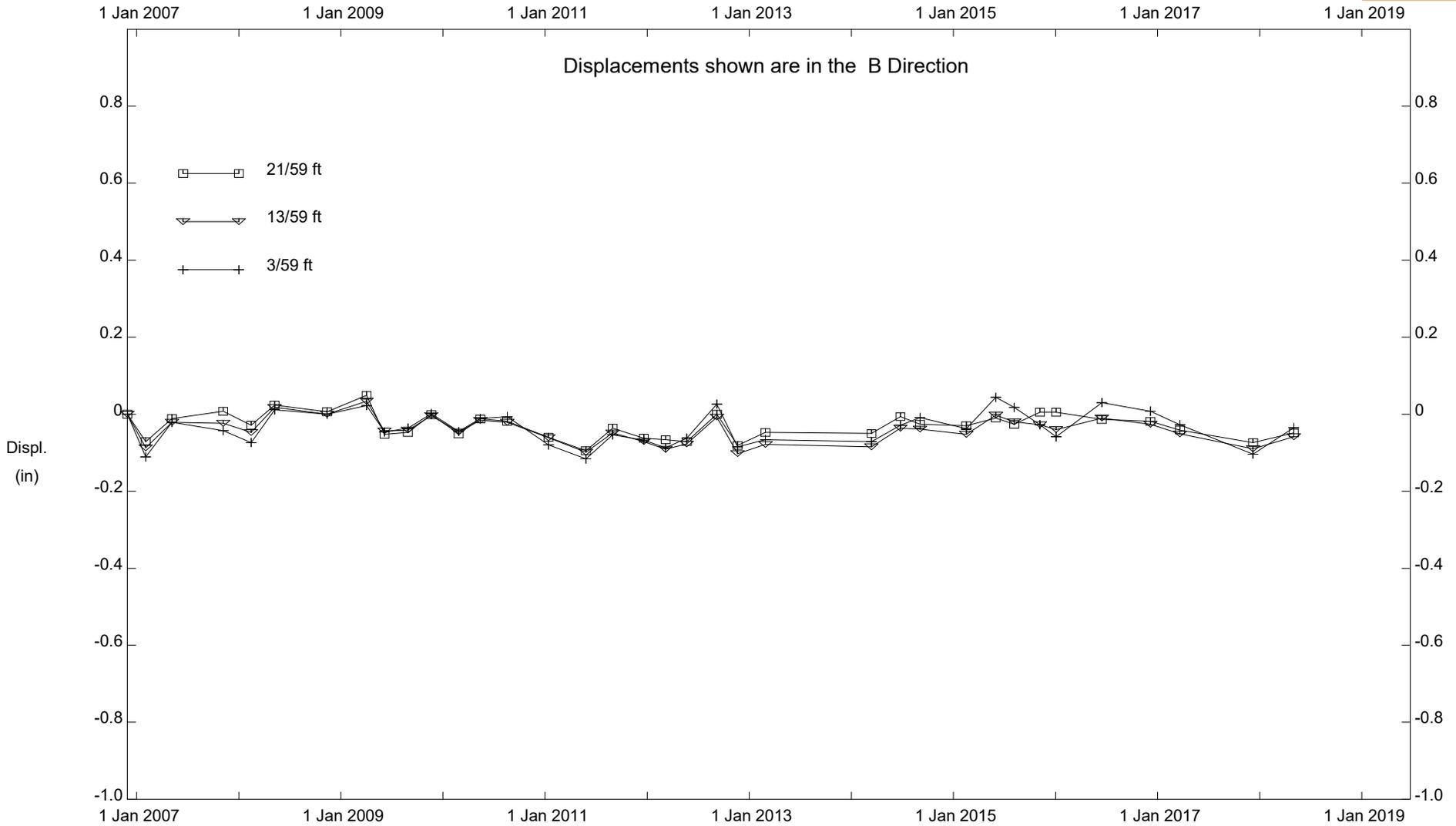
Assessment District 98-3, Inclinator SI-5  
 City of Malibu

Sets marked \* include zero shift and/or rotation corrections.



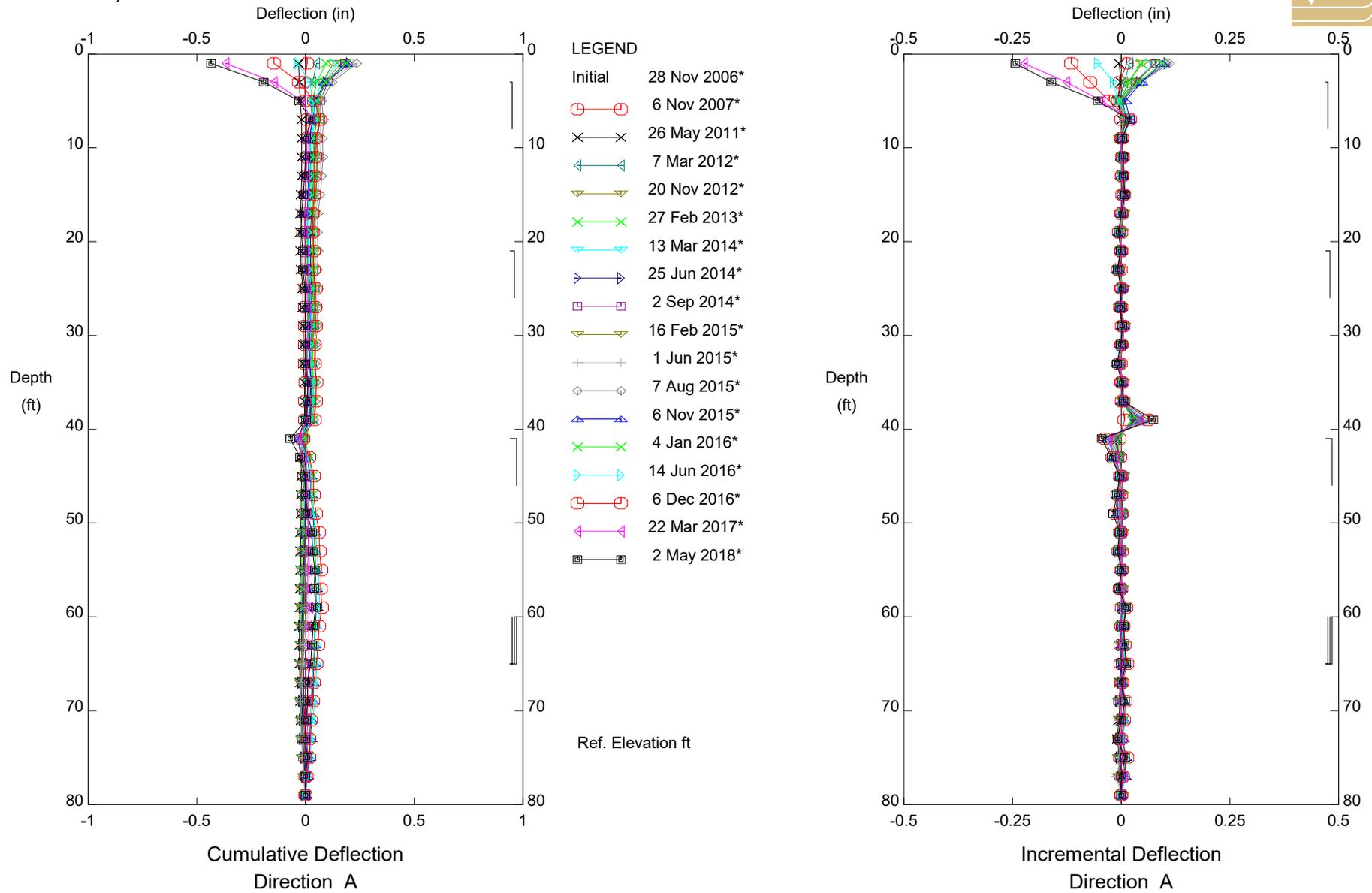
Assessment District 98-3, Inclinator SI-5

City of Malibu



Assessment District 98-3, Inclinator SI-5

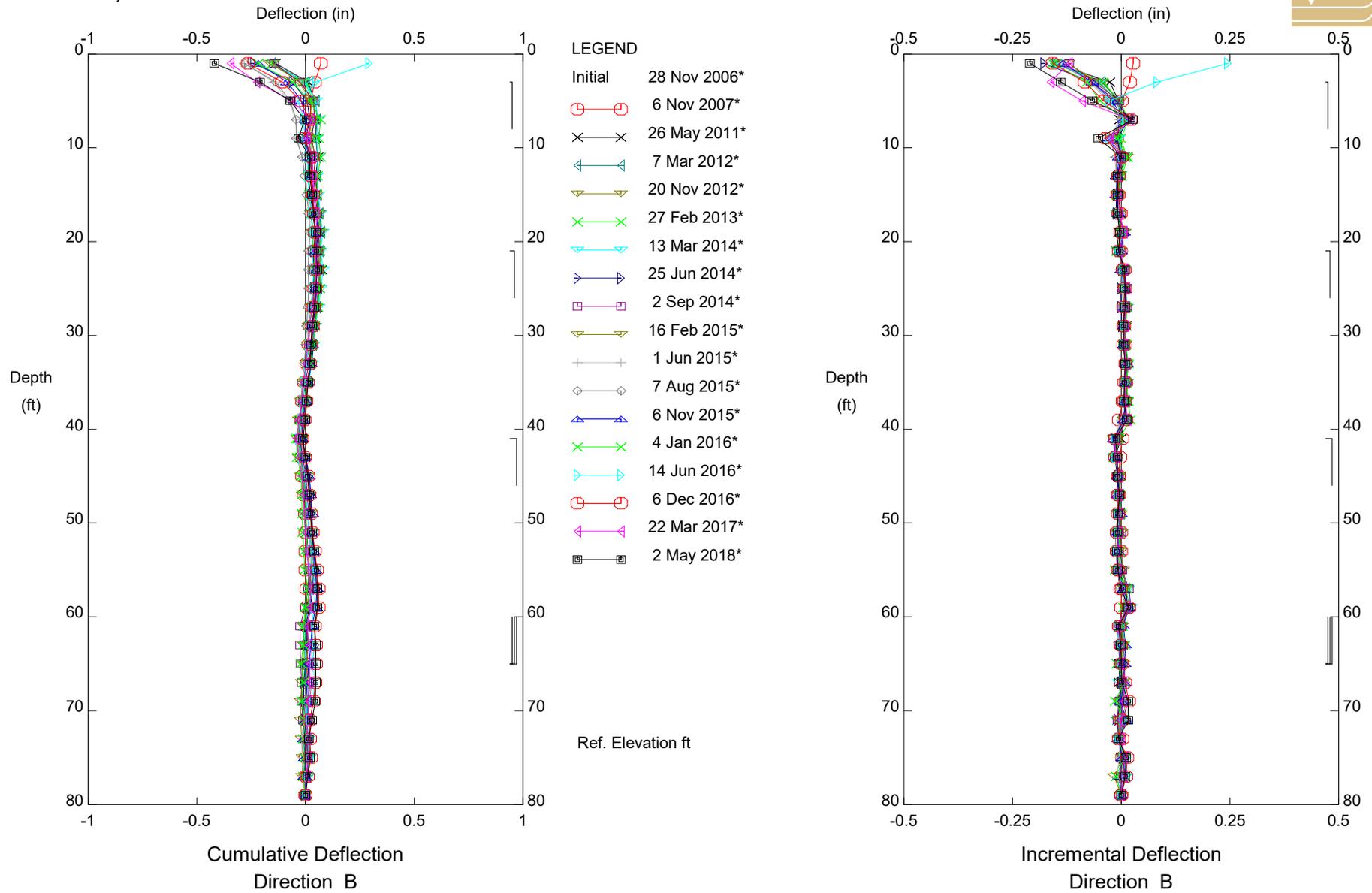
City of Malibu



Assessment District 98-3, Inclinometer SI-6

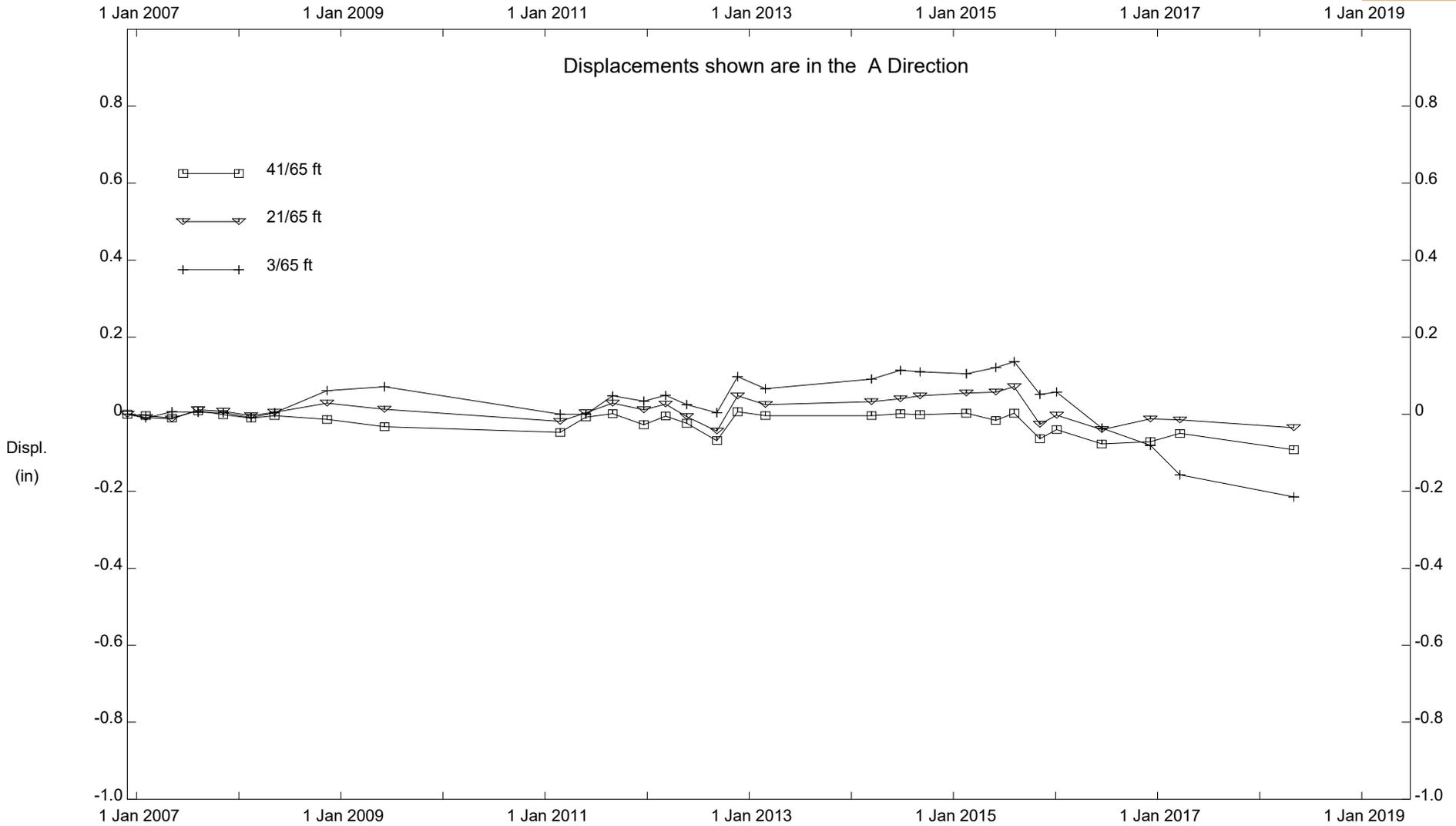
City of Malibu

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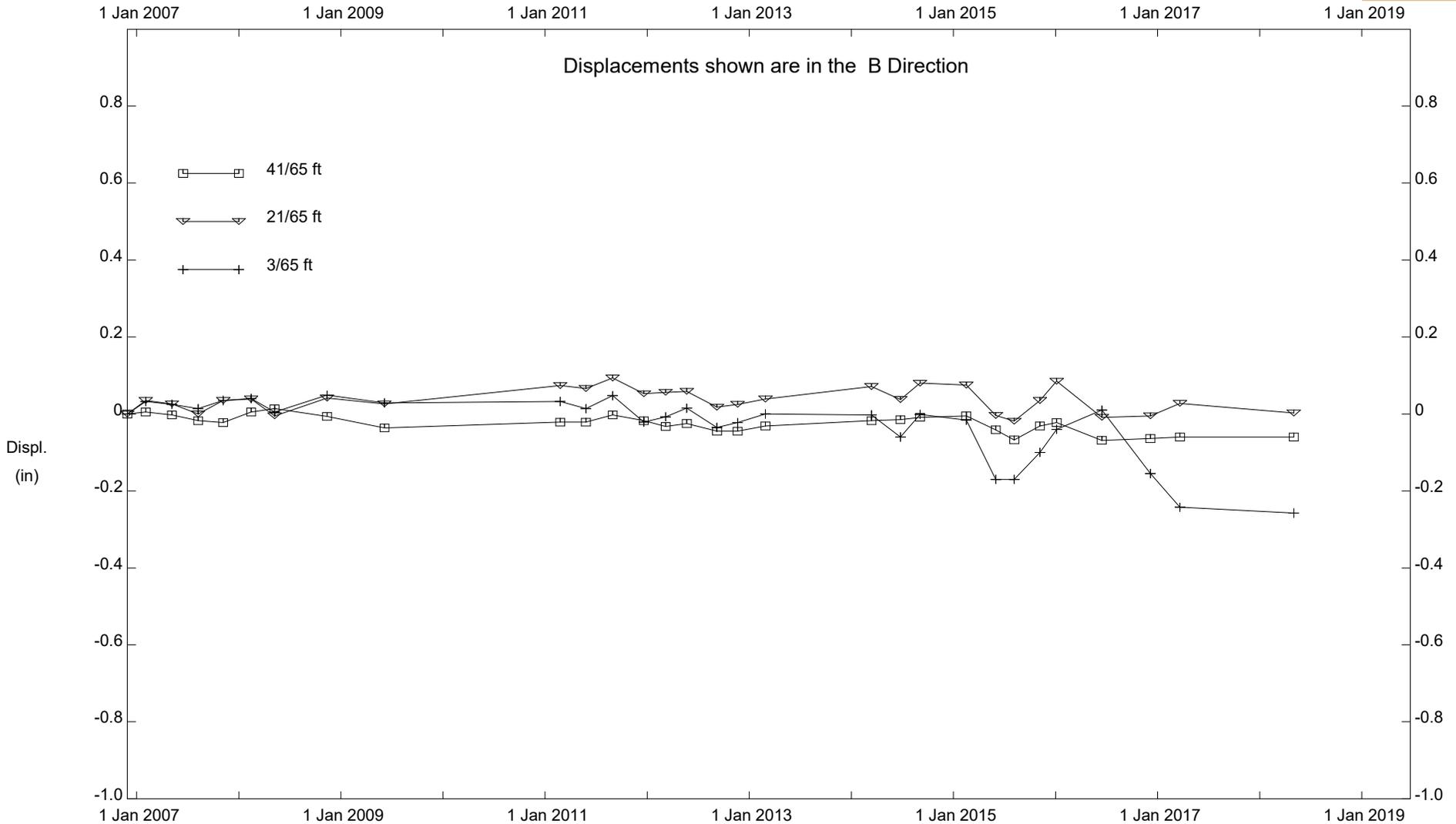
Assessment District 98-3, Inclinometer SI-6  
City of Malibu

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Assessment District 98-3, Inclinator SI-6

City of Malibu



Assessment District 98-3, Inclinator SI-6

City of Malibu