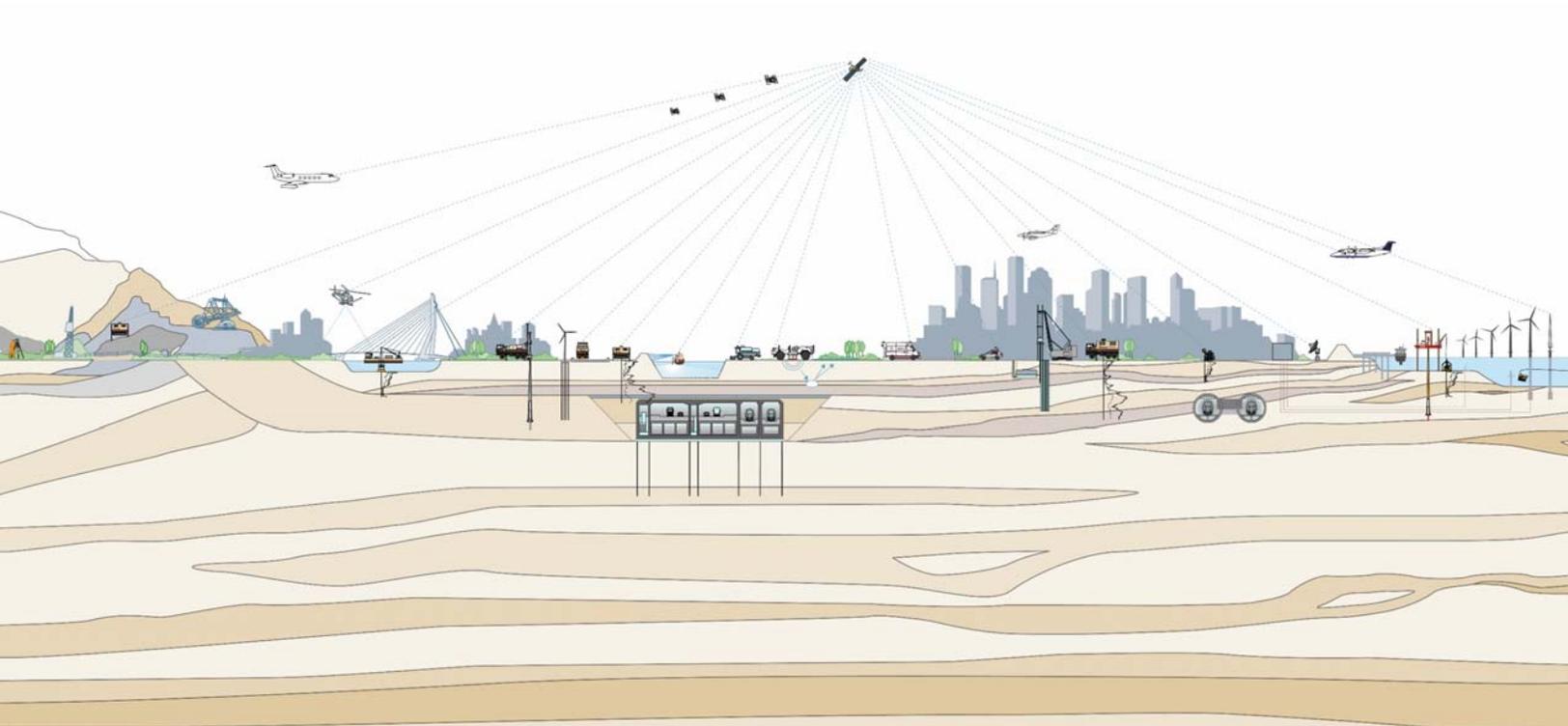


**ANNUAL REPORT  
JULY 2015 THROUGH JUNE 2016  
MALIBU ROAD LANDSLIDE ASSESSMENT DISTRICT  
MALIBU, CALIFORNIA**

Prepared for:  
CITY OF MALIBU

November 2016  
Fugro Project No. 04.62160604





## FUGRO CONSULTANTS, INC.

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November 4, 2016  
Project No. 04.62160604

City of Malibu  
23825 Stuart Ranch Road  
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Attention: Mr. Rob DuBoux, Esq., P.E.

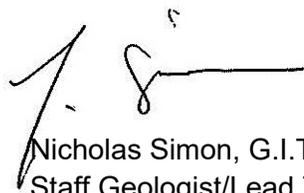
Subject: Annual Report, July 2015 through June 2016, Malibu Road Landslide Assessment District

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 2015 through June 2016.

Fugro appreciates the opportunity to be of service to the City of Malibu and the District homeowners. Please contact Loree Berry at (805) 289-3830, if you have any questions regarding this report.

Sincerely,  
FUGRO CONSULTANTS, INC.



Nicholas Simon, G.I.T.  
Staff Geologist/Lead Technician



Loree A. Berry, P.E.  
Senior Engineer/Project Manager



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



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## 1.0 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 2016-2017 Maintenance Cost Estimate" presented in the Annual Assessment Report (Taussig, 2016).

### 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, 2015 and June 30, 2016 (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 9 standpipes;
- Periodic groundwater measurements from 9 pneumatic piezometers;
- Monthly dewatering production readings from 10 dewatering wells owned by the Assessment District and 3 wells owned by a private homeowner on Bayshore Drive;
- Monthly dewatering production readings from 23 horizontal drains (hydraugers);
- Quarterly ground deformation measurements from 5 slope inclinometers; and
- Periodic maintenance of dewatering and monitoring facilities.

The operating condition of the instrumentation and dewatering facilities was checked during each field monitoring/observation visit and by evaluating preliminary data in the office as they were 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, 2015 to June 30, 2016 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>.

## 2.0 MONITORING

### 2.1 RAINFALL DATA

A graph of historical monthly rainfall and average annual rainfall from October 1968 through September 30, 2016, 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 9.4 inches of precipitation fell during the monitoring period from July 1, 2015, through June 30, 2016. The average annual rainfall from 1968 to 2016 in the "Malibu Area" for the monitoring period is approximately 15.0 inches.

Rainfall data are usually analyzed in terms of the annual "rain season" that covers the time period from October 1 through September 30. Rainfall for October 1, 2015, through September 30, 2016, was approximately 7.4 inches. This is approximately 48 percent of the average annual rainfall of 15.4 inches for the "rain seasons" between 1968 and 2016.

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 (gallons per day, gpd). The data illustrate that the average annual dewatering output has been decreasing with continued below 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 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 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, 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.

In consideration of the generally declining groundwater levels, low rainfall, and close proximity of standpipe piezometers to pneumatic piezometers, the pneumatic water levels were monitored only intermittently (March and June 2016) during the 2015-2016 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. In general, groundwater levels declined slightly during the 2015-16 monitoring period. The calculated area average water level declined by 0.1 feet when compared to the area average for the 2014-15 monitoring period and is 2.4 feet below the mean area average for this area for the period of record. Water levels in individual standpipes declined slightly or remained approximately static over the monitoring year with temporary increases in response to rainfall events in January and March. 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 were measured in March and June 2016, and all showed increased pore pressure readings subsequent to the rain events of early 2016. Pneumatic piezometers in inclinometers SI-1 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 2015-16 monitoring period. The calculated area average water-level declined by 1.4 feet when compared to the area average for the 2014-15 monitoring year and is 6.7 feet below the mean area average for this area for the period of record (1991-2016). Water levels in standpipe SI-5 declined steadily during the 2015-16 monitoring year and reached an all-time low for the period of record in May and June 2016. Water levels in standpipe SI-6 remained approximately static over the course of the monitoring year, with fluctuations of less than 0.4 feet. 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, but also show a declining trend in water elevation consistent with the standpipe readings. Pneumatic water levels at SI-5 increased after the rainfall events of January and March 2016.

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 decreased by 0.1 feet since the prior monitoring year whereas the peak groundwater elevation remained unchanged. 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. 2015-2016	Change from Prior Year Average	Peak Groundwater El. 2015-2016	Change from Prior Year Peak
Malibu Road	5.8	-0.1	6.8	0.0
Bay Shore Drive	19.7	-1.4	20.5	-1.2

**Note:** 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 the following:

- The average total dewatering rate during the monitoring period was approximately 726 gpd. This represents a 49 percent increase in the average rate relative to the 486 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 the following:

- The average total dewatering well production rate for this monitoring period was approximately 528 gallons per day (gpd). That represents an increase of about 80 percent from the previous monitoring period production rate of 292 gpd.
- The increase in dewatering well production is due to repairs (pump replacement) at dewatering well W-5 and an increase in production at dewatering well W-3, which had variable production during the second half of the 2014-2015 period.

### **2.3.3 Hydrauger Production**

Graphs of individual production rates for individual hydraugers are included in Appendix B. Data for the hydraugers indicate the following:

- The average production rate for all hydraugers over the monitoring period is approximately 198 gpd. This represents an increase of approximately 2 percent from the average production rate of 194 gpd for the previous monitoring period.

## **2.4 SLOPE INCLINOMETER MEASUREMENTS**

Fugro monitored 5 slope inclinometers on a quarterly 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.



Interpretation of inclinometer data along Malibu Road shows no clearly defined interpreted movement in any of the inclinometers surveyed during the 2015-2016 monitoring year.

Inclinometers SI-5 and SI-6 are located on Bayshore Drive, upslope and outside the defined limit of the most recent 1998 movement. No detectable movement was observed during this monitoring year in SI-5 or SI-6. Profile changes to the top portion of inclinometer SI-6 are the result of ongoing damage to the casing from construction traffic currently working on Bayshore Drive. The vault and top of the casing have been crushed by heavy equipment.

### **3.0 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 consisted of brush clearance around facilities and 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
7/14/15	Hydrauger HD-16, 13, 11	Modify hydrauvers by installing flow collection ports
	Hydrauger HD-21	Repair damage from vehicle hit
	Hydrauger conveyance line between HD-15 and HD-16	Repair leak/broken conveyance pipe and re-align
7/15/2015	NHD-C and NHD-B	Modify hydrauger by installing flow collection ports
	Hydrauger conveyance line between HD-20 and HD-21	Repair 2 leaking/broken locations
	Hydrauvers HD-22, 22, 23	Clean mineralization from leaking collection port threads and replace with new caps
7/16/15	Hydrauvers HD-9 and HD-6	Install flow collection ports at HD-9 and HD-6
	Hydrauger NHD-A	Repair broke/leaking T-connection to conveyance line
7/25/15	Conveyance line	Use metal hooks to stabilize above ground conveyance line along base of slope, apply reflective tape to vulnerable hydrauvers
	Conveyance line at HD-8	Repair leak to conveyance line
2/4/16	NHD-A and HD-11	Excavate buried conveyance line segments and repair 2 leaks
2/15/16	Dewatering Well W-5	Remove and replace pump/motor assembly, control box and 84 feet of galvanized steel drop pipe
2/16/16	Conveyance line at hydrauvers HD-18, 19, 10	Excavate and replace 30-foot segment of clogged conveyance line from HD-10 to culvert MTD-10
5/25/16	Dewatering Well W-10	Remove and replace pump/motor assembly, control box and pump saver.

### 3.2 CAPITAL IMPROVEMENT PROJECTS

No capital improvements were performed during the current monitoring period.

### 4.0 SUMMARY AND CONCLUSIONS

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

- Measured rainfall during the 2015 - 2016 monitoring year (July 1 through June 30) was 9.4 inches of precipitation. Rainfall during that monitoring period was below the “Malibu Area” historical average of 15.0 inches per monitoring year measured from 1968 through 2016.
- Groundwater levels on Bayshore Drive and along Malibu Road generally declined slightly or remained approximately static over the 2015-2016 monitoring period. Water levels in individual wells generally declined with some variability during the year reflecting responses to significant rainfall events in January and March 2016.

- Average daily dewatering production increased 49 percent from the previous monitoring year with dewatering well production increasing by 80 percent and hydrauger production increasing just 2 percent. This is primarily a reflection of well W-5 returning to service after pump replacement combined with an increased production from dewatering well W-3.
- Readings for the five slope inclinometers show no clearly defined significant movement during the 2015 - 2016 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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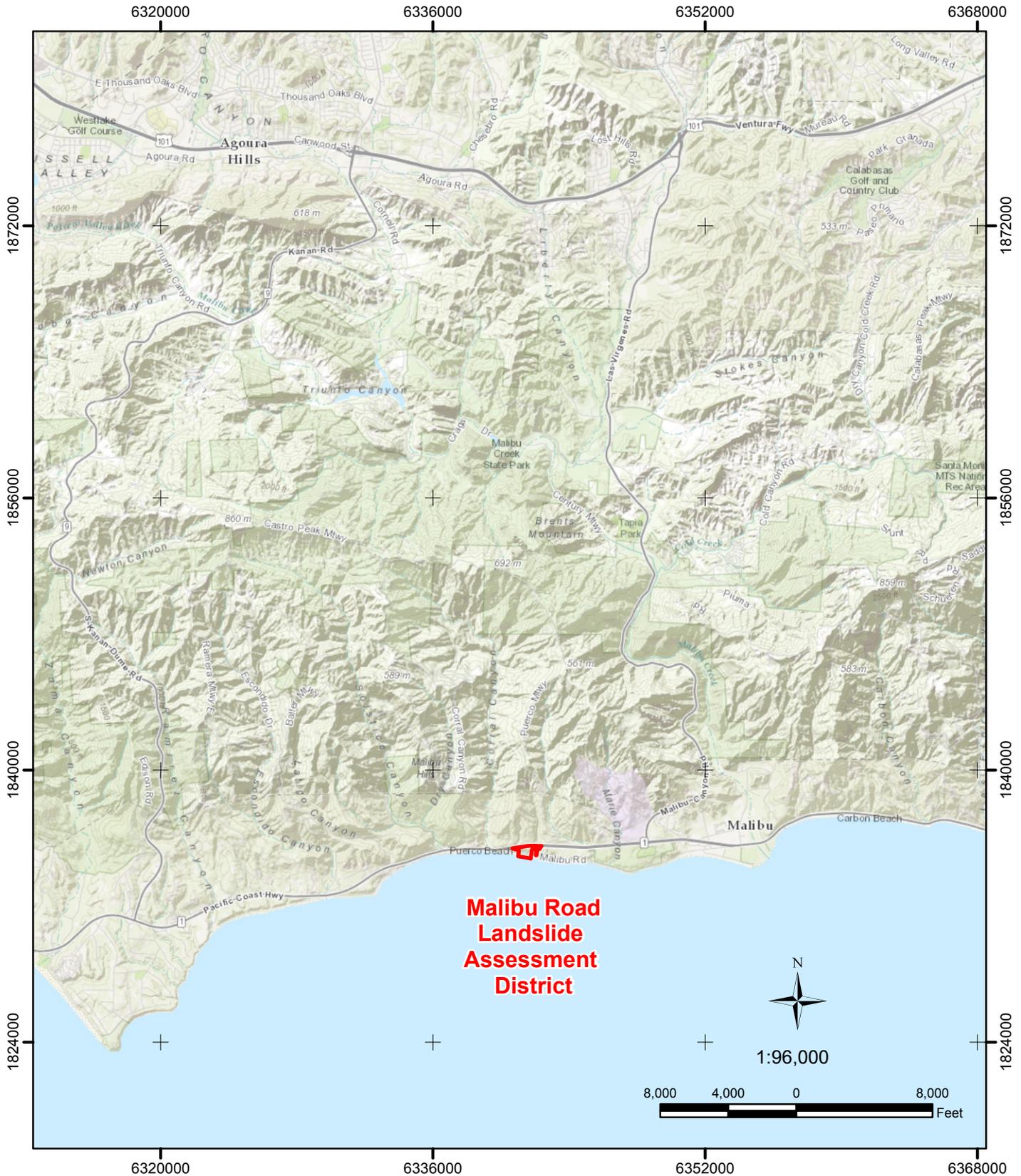
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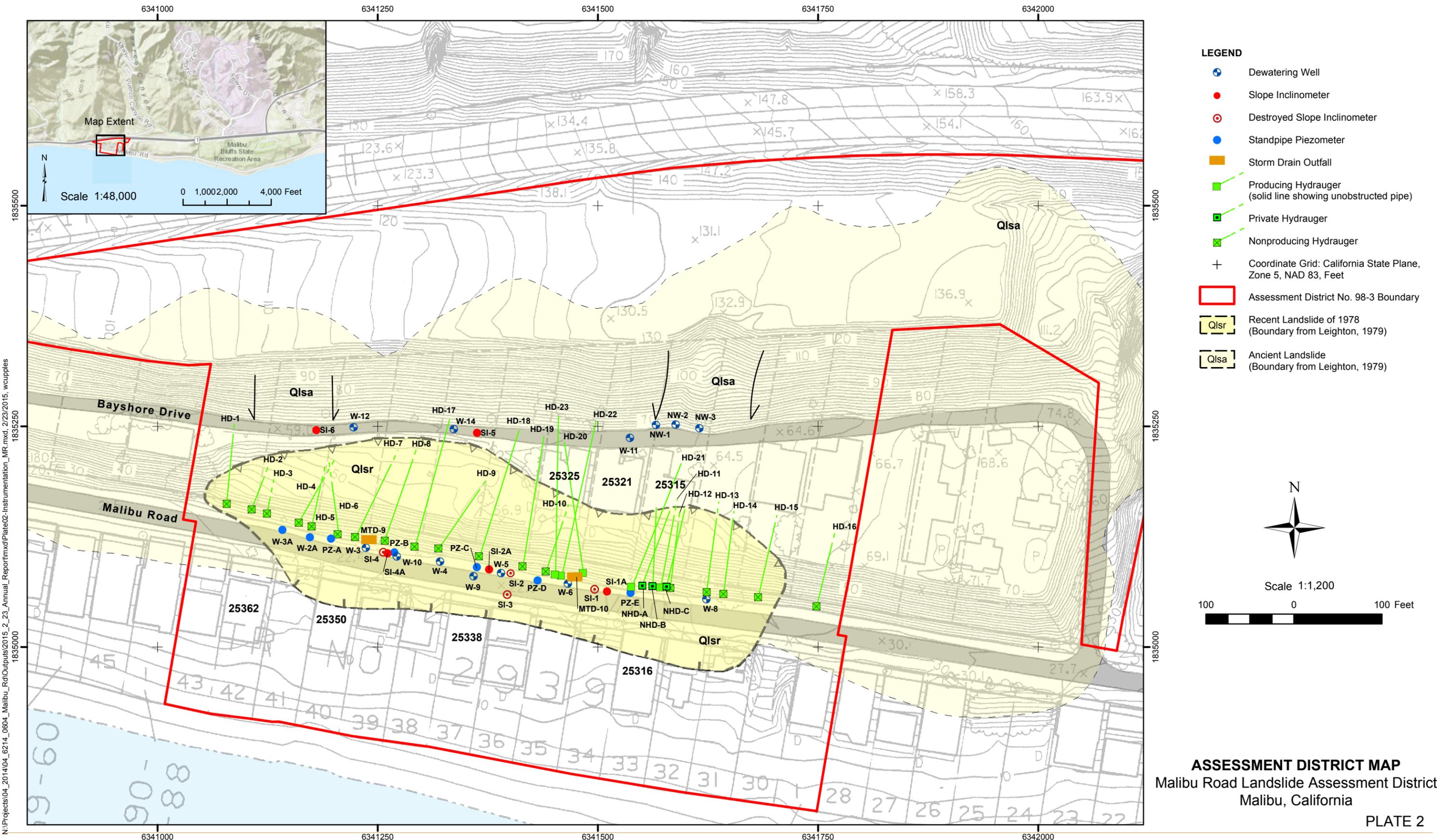
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## PLATES

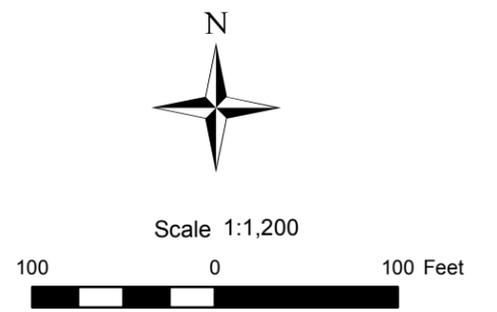


**SITE LOCATION MAP**  
Malibu Road Landslide Assessment District  
Malibu, California

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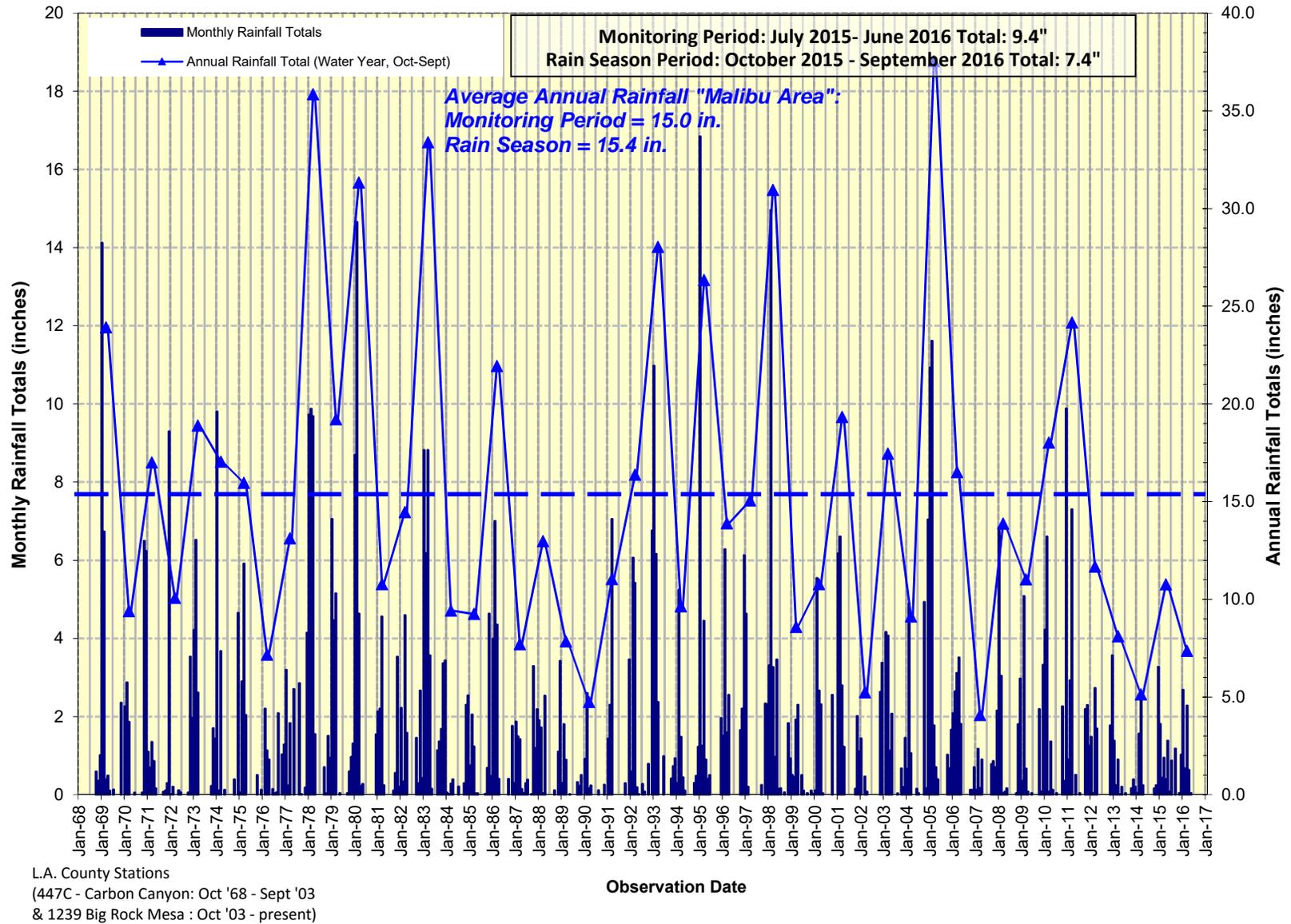


- LEGEND**
- Dewatering Well
  - Slope Inclinometer
  - Destroyed Slope Inclinometer
  - Standpipe Piezometer
  - Storm Drain Outfall
  - Producing Hydrauger (solid line showing unobstructed pipe)
  - Private Hydrauger
  - Nonproducing Hydrauger
  - +
 Coordinate Grid: California State Plane, Zone 5,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

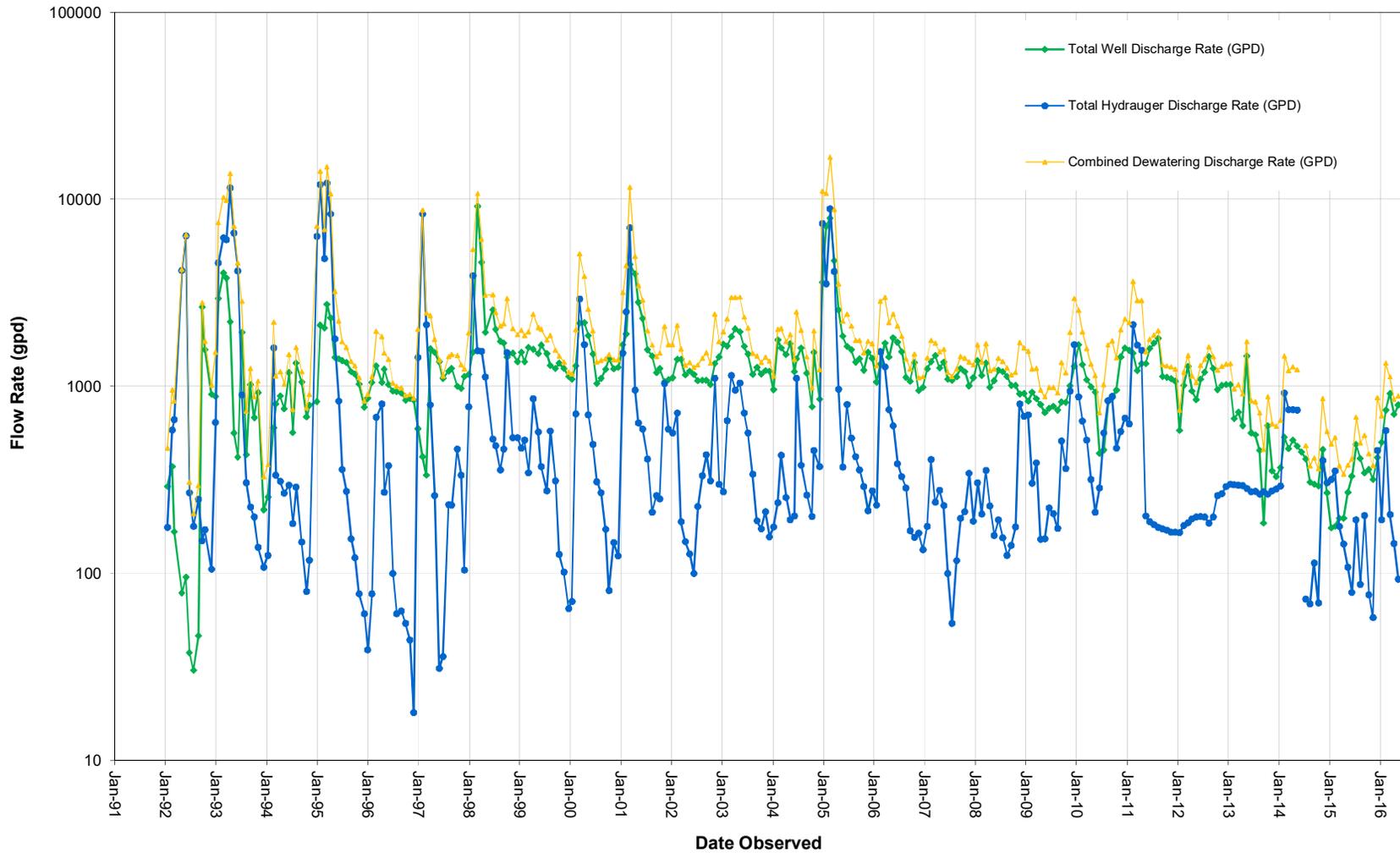


**ASSESSMENT DISTRICT MAP**  
 Malibu Road Landslide Assessment District  
 Malibu, California

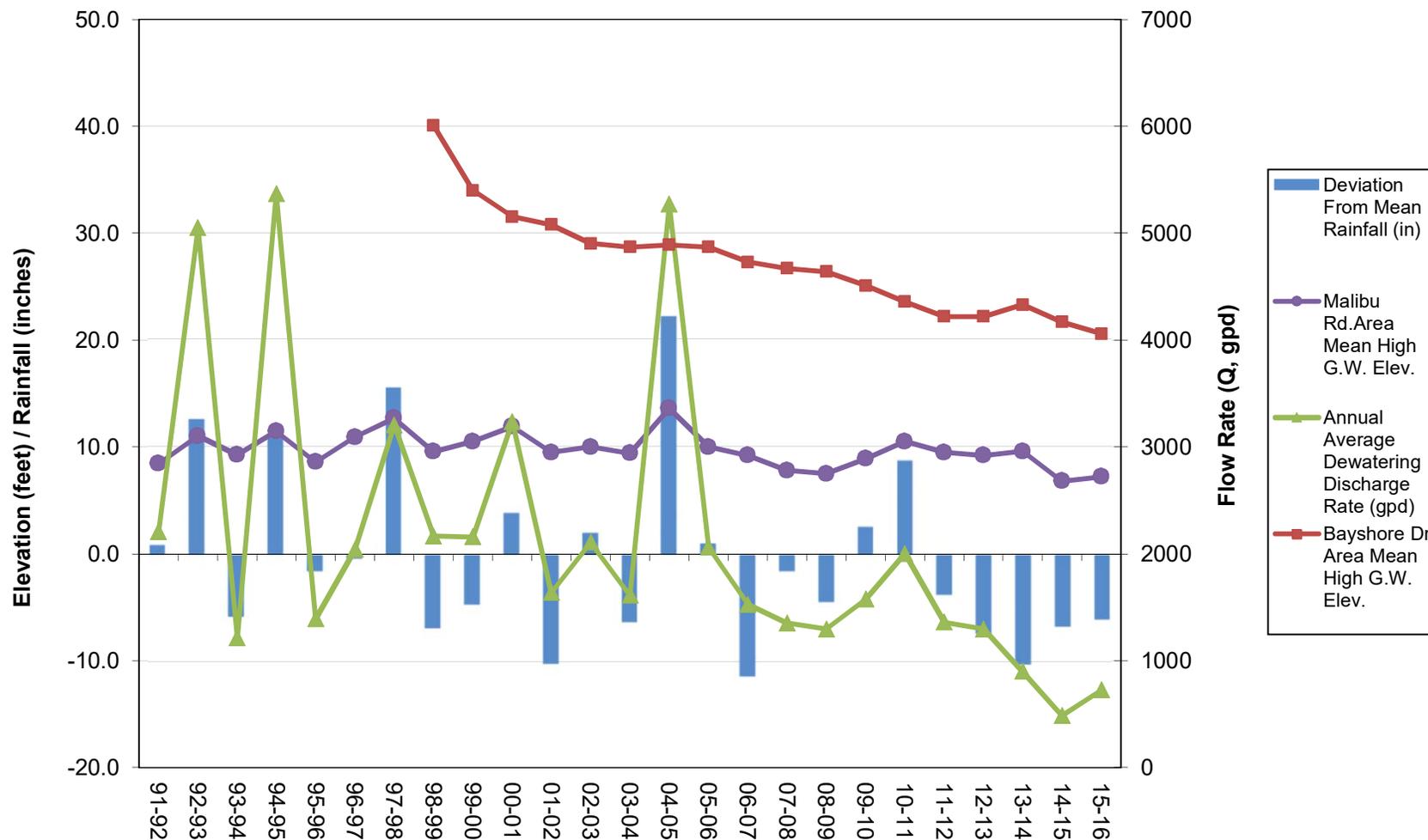
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**RAINFALL GRAPH**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**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>						
<b>Standpipe ID</b>	<b>Previous Reference Elevation (8/91)</b>	<b>Updated Reference Elevation (4/00)</b>	<b>Casing Depth (ft)</b>	<b>Perforation Interval</b>	<b>Installed By</b>	<b>Notes</b>
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	vault damage

Note: + Formerly designated as MR-5

++ Formerly designated as MR-6

<b>MALIBU ROAD LAD - Pneumatic Piezometer Information</b>						
<b>Well Identification</b>	<b>Previous Reference Elevation (8/91)</b>	<b>Updated Reference Elevation (4/00)</b>	<b>Tip Depth (ft.)</b>	<b>Tip El. (ft)</b>	<b>Installed By</b>	<b>Notes</b>
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

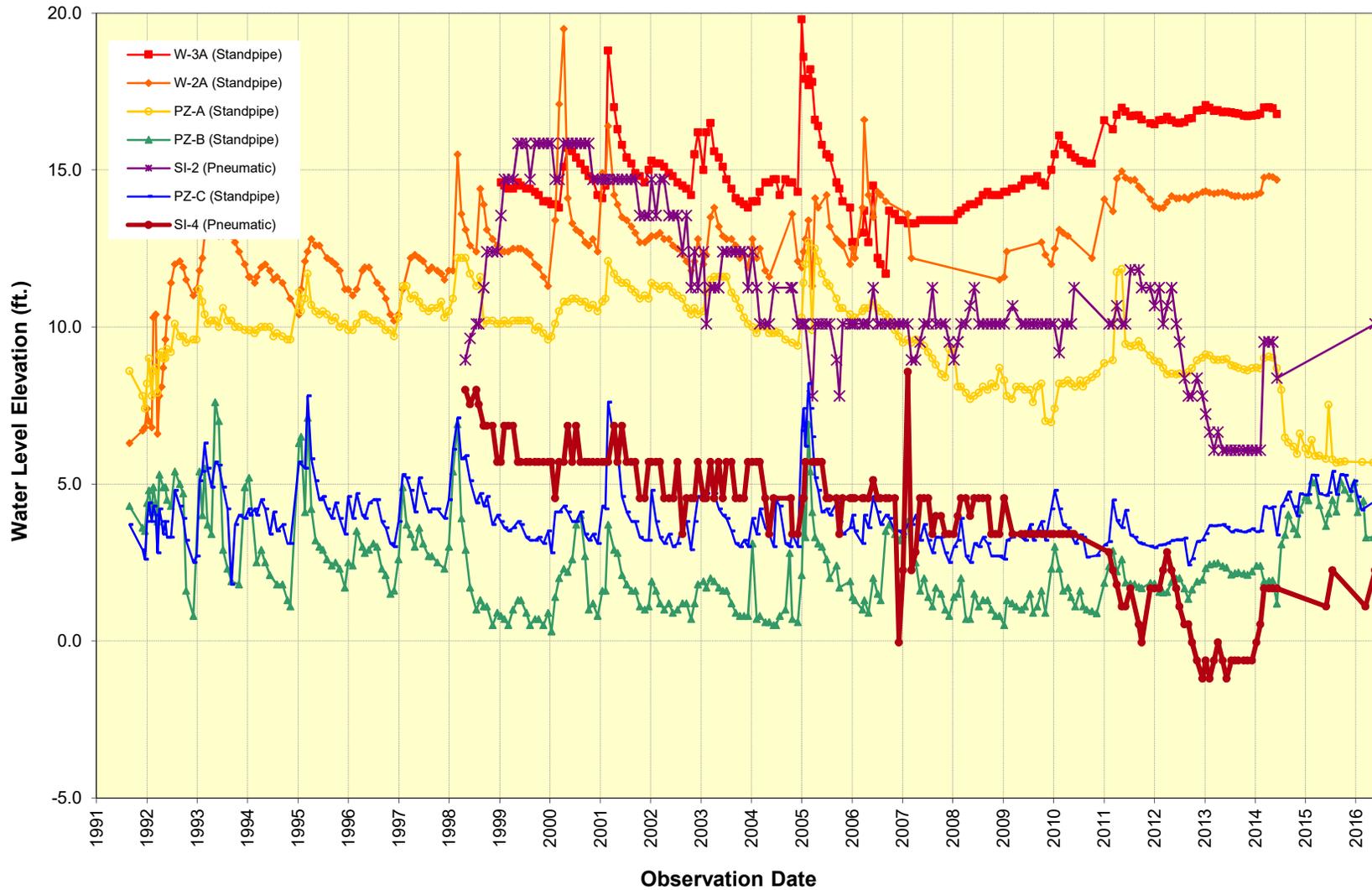
SI-5 and SI-6 were previously designated MR-5 and MR-6

\* Piezometer not functioning

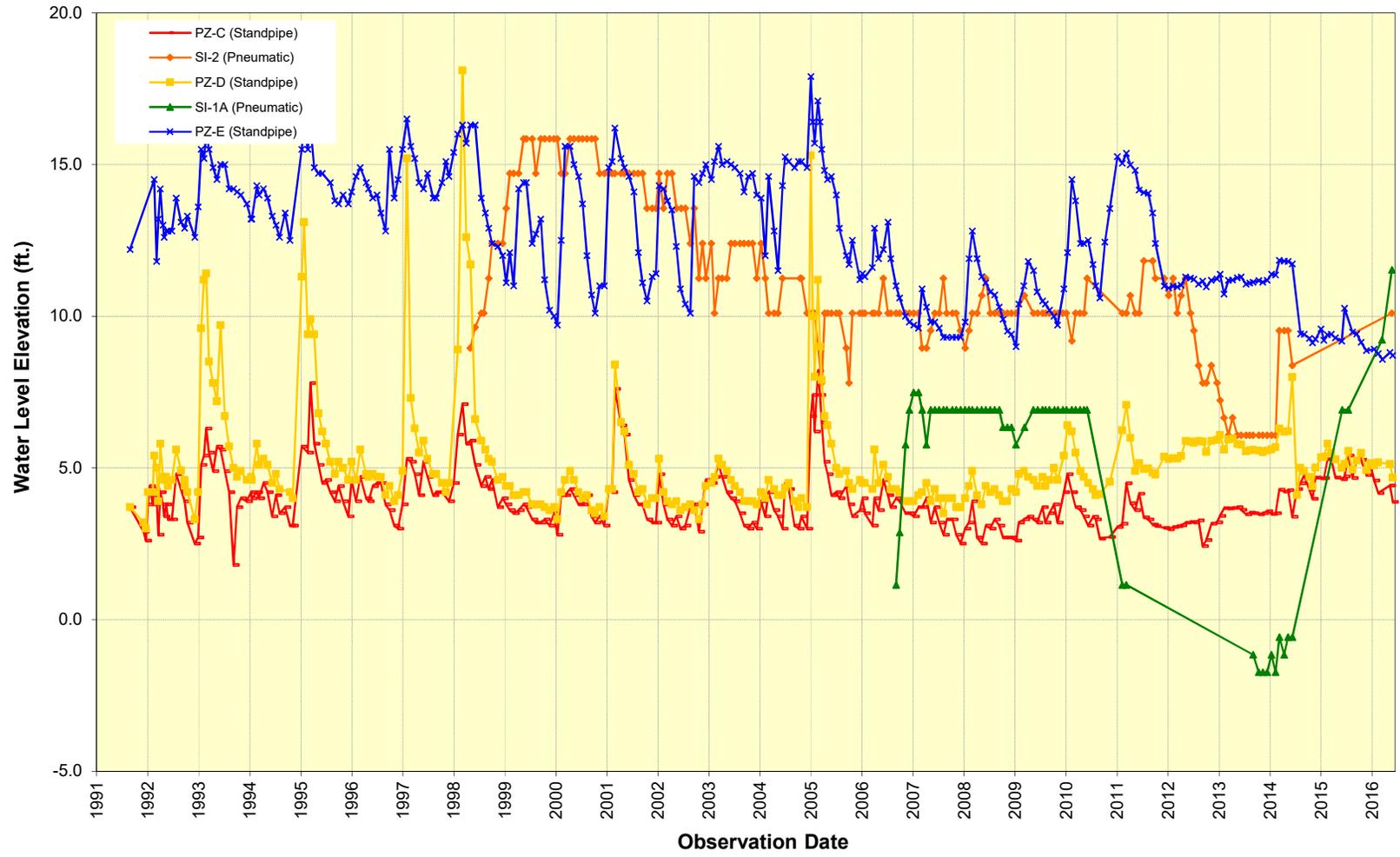


MALIBU ROAD LANDSLIDE ASSESSMENT DISTRICT - SUMMARY OF GROUNDWATER DATA																														
Standpipe / Piezometer I.D.	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	Mean '91-16	Stand Dev.	15-16 vs. 97-98	15-16 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		1.4		
	Highest El.	11.4	13.6	13.1	12.8	12.2	12.3	15.5	14.4	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		1.8		
W-3A	Mean El.							14.5	14.4	15.5	15.0	15.3	14.3	16.4	13.9	13.1	13.6	14.7	15.2	16.1	16.6	16.8	16.8	UTL	UTL		1.2			
	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		1.7			
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	9.6	1.4	-5.1	-3.6
	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	10.5	1.5	-4.7	-3.0
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	2.4	1.7	0.8	1.8
	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	3.8	1.9	-1.8	1.3
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	4.0	0.6	-0.3	0.8
	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	5.1	1.3	-1.7	0.3
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	5.2	1.1	-2.7	-0.1
	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	6.4	7.1	5.9	6.1	8.0	5.8	5.6	7.6	3.8	-12.5	-2.1
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	11.8	9.6	9.1	12.7	1.8	-6.1	-3.6
	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	14.3	2.1	-6.0	-4.0
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	8.2	1.0	-3.3	-2.4
	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	9.7	1.7	-5.9	-2.9
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					
	Highest El.	2.6	-1.8	2.2	-2.9	2.3	1.8	-3.1	0.9	1.4	-2.4	0.5	-0.6	4.1	-3.5	-0.9	-1.4	0.3	1.4	1.7	-1.0	-0.3	0.5	-2.9	0.0					
<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	24.9	6.4			-10.7
	Highest El.							37.8	33.4	31.2	30.4	29.7	29.2	29.0	28.4	28.0	27.5	27.0	24.3	20.5	17.6	17.2	19.4	18.3	15.6	25.8	6.3			-10.2
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	27.8	3.5			-2.7
	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	28.7	4.2			-3.3
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	26.4	4.6			-6.7
	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	27.3	4.9			-6.8
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						
	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						
<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	7.0	1.0	8.6	1.7	
	Highest El.															7.5	6.9	6.9	6.9						11.5	8.0	2.0	11.5	3.6	
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	10.9	2.3	0.8	-0.8	
	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	12.0	2.2	0.5	-1.9	
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	4.1	2.2	-6.1	-2.4	
	Highest El.							8.0	8.0	6.9	6.9	5.7	5.7	5.7	5.1	4.6	4.6	4.6	3.4	2.8	2.8	1.1	1.7	2.3	5.1	2.2	-5.8	-2.9		
<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	29.2	6.5			-8.5	
	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	34.8	32.7	7.4			2.1	
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	31.0	5.5			-6.3	
	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	35.1	8.3			-9.2	
SI-6 Tip 1	Mean El.							42.4													25.7	25.9	23.8	24.6	26.1	28.1	7.1		-2.0	
	Highest El.																				26.8	27.4	24.0	26.3	26.8	29.2	7.4		-2.4	
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	36.5	40.8	3.4			-4.3	
	Highest El.							45.7	48.0	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	43.0	4.3			-6.5	

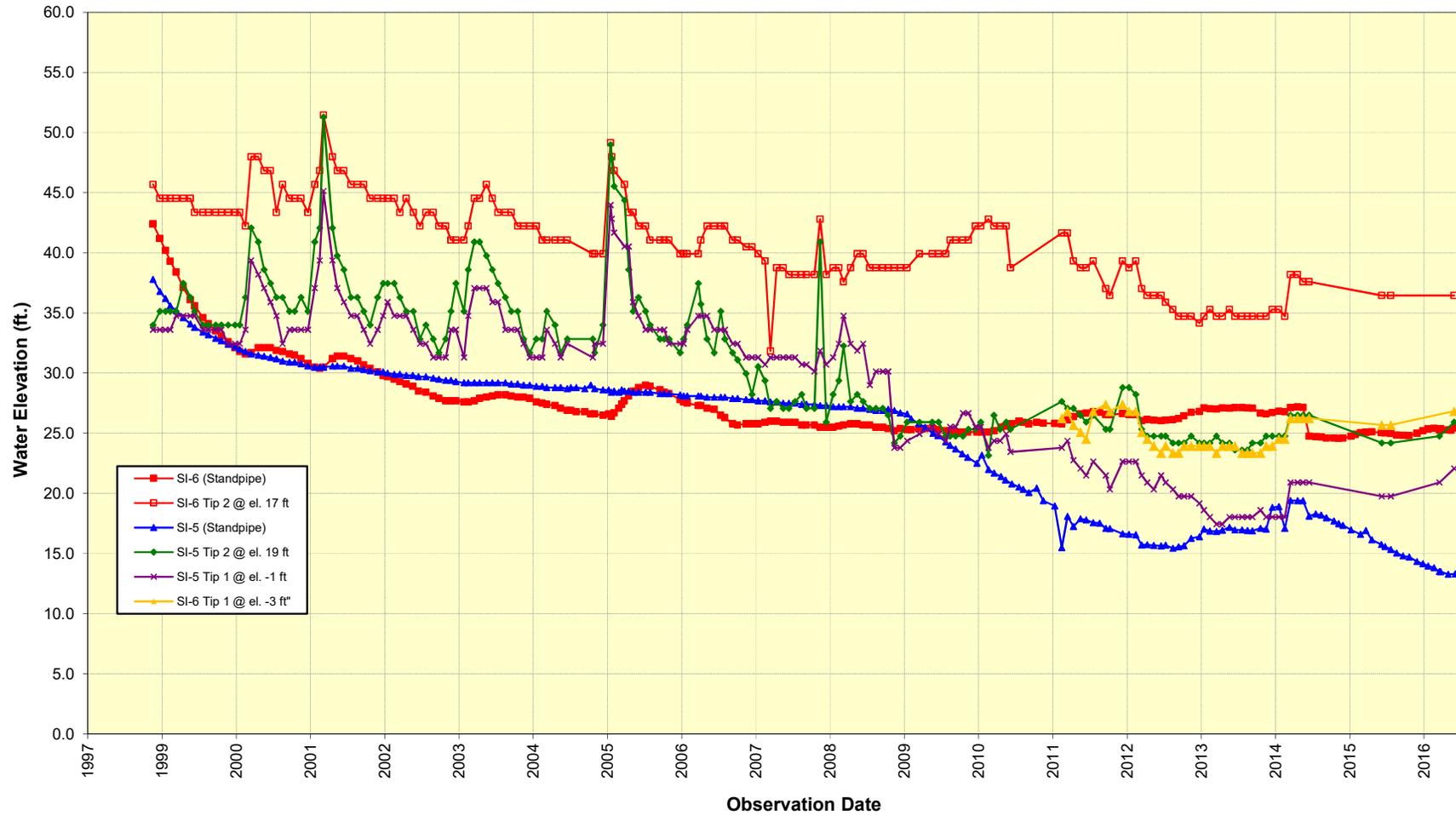
**SUMMARY OF GROUNDWATER DATA**  
 Malibu Road Landslide Assessment District  
 Malibu, California



**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)	2015-2016 Mean Pumping Rate (gpd)	% of Total Well Production	Installed By
W-3	19.5	-4.0	Unknown	1/2	249	47%	LA Co.
W-4	20.0	-9.0	Unknown	1/2	9	2%	LA Co.
W-5	19.0	-9.5	Unknown	1/2	124	24%	LA Co.
W-6	20.0	-4.5	Unknown	1/2	20	4%	LA Co.
W-8	27.5	11.0	Unknown	1/2	3	1%	LA Co.
W-9	20.0	-40.0	-35.0	1/3	14	3%	LA Co.
W-10	19.0	-40.0	-35.0	1/3	5	1%	LA Co.
W-11	61.0	1.0	13.0	1/3	52	10%	BYA
W-12	58.0	-2.0	8.0	1/3	8	1%	BYA
W-14	60.0	-20.0	Unknown	1/3	29	6%	Fugro
NW-1	Unknown	Unknown	Unknown	Unknown	5	1%	Homeowner
NW-2	Unknown	Unknown	Unknown	Unknown	6	1%	Homeowner
NW-3	Unknown	Unknown	Unknown	Unknown	3	1%	Homeowner

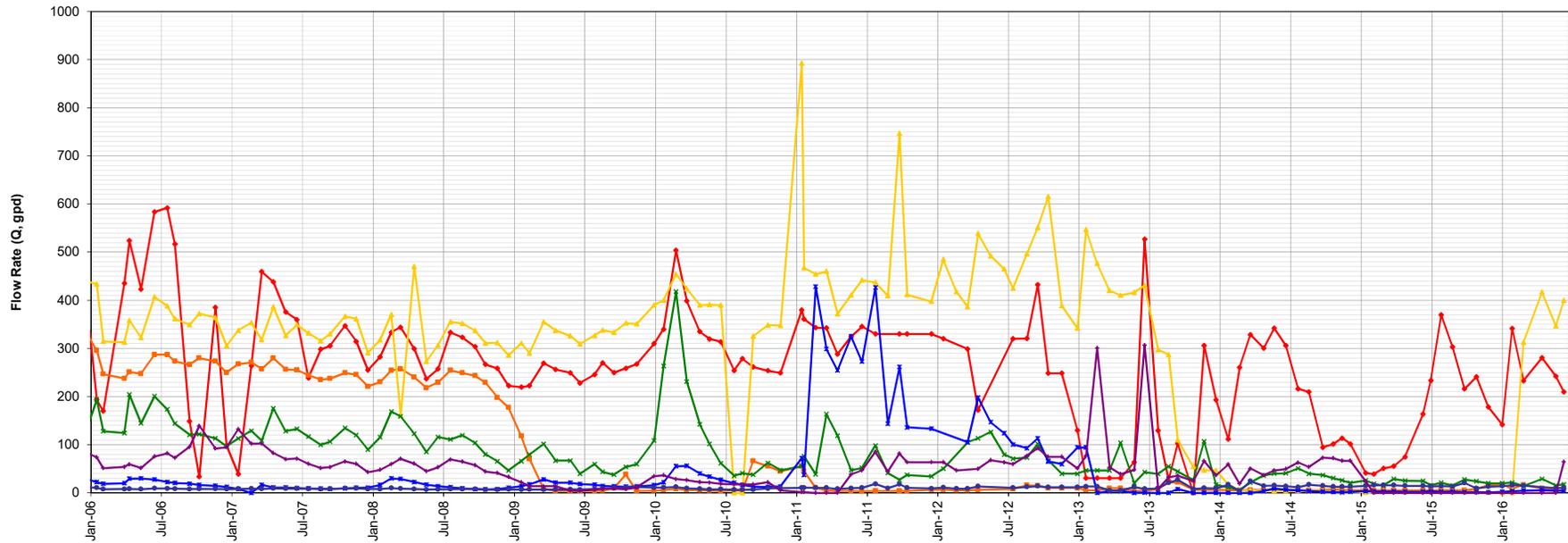
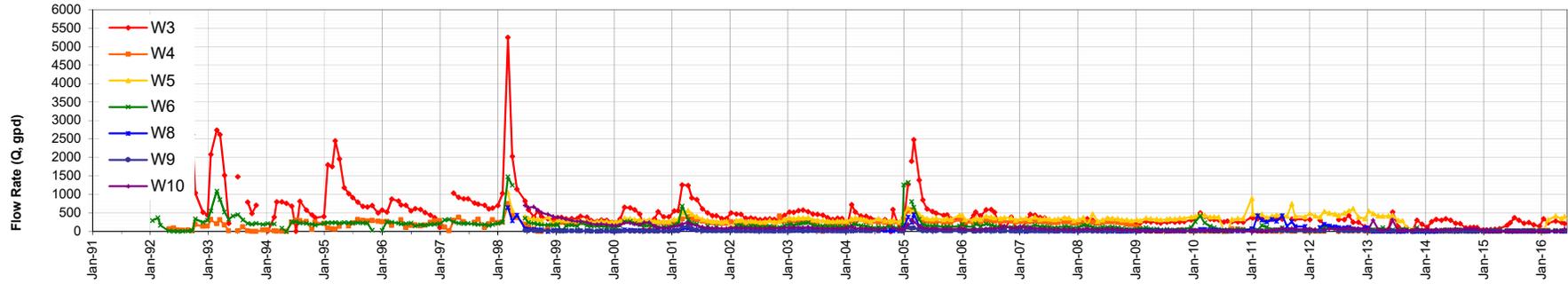
<b>MALIBU ROAD LAD- Hydrauger Information</b>						
Hydrauger ID	Installed Length (ft.)	Bearing	Functional Length* (ft)	2014-2015 Mean Flow Rate (gpd)	% of Total Production	Installed By
HD-1**	Unknown	N05E	74	0	0%	LA County
HD-2**	Unknown	N21E	34	0	0%	LA County
HD-3**	Unknown	N06E	13	0	0%	LA County
HD-4**	Unknown	N29E	53	0	0%	LA County
HD-5	Unknown	N13E	41	0	0%	LA County
HD-6	Unknown	N08W	55	0	0%	LA County
HD-7	Unknown	N26E	87	0	0%	LA County
HD-8	Unknown	N19E	92	7	3%	LA County
HD-9	Unknown	N34E	76	0	0%	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	80	40%	BYA
HD-19	150	N10E	150	42	21%	BYA
HD-20	150	N09W	150	12	6%	BYA
HD-21	150	N22E	150	24	12%	BYA
HD-22	180	N13E	180	24	12%	Fugro West
HD-23	160	N01E	160	14	7%	Fugro West

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

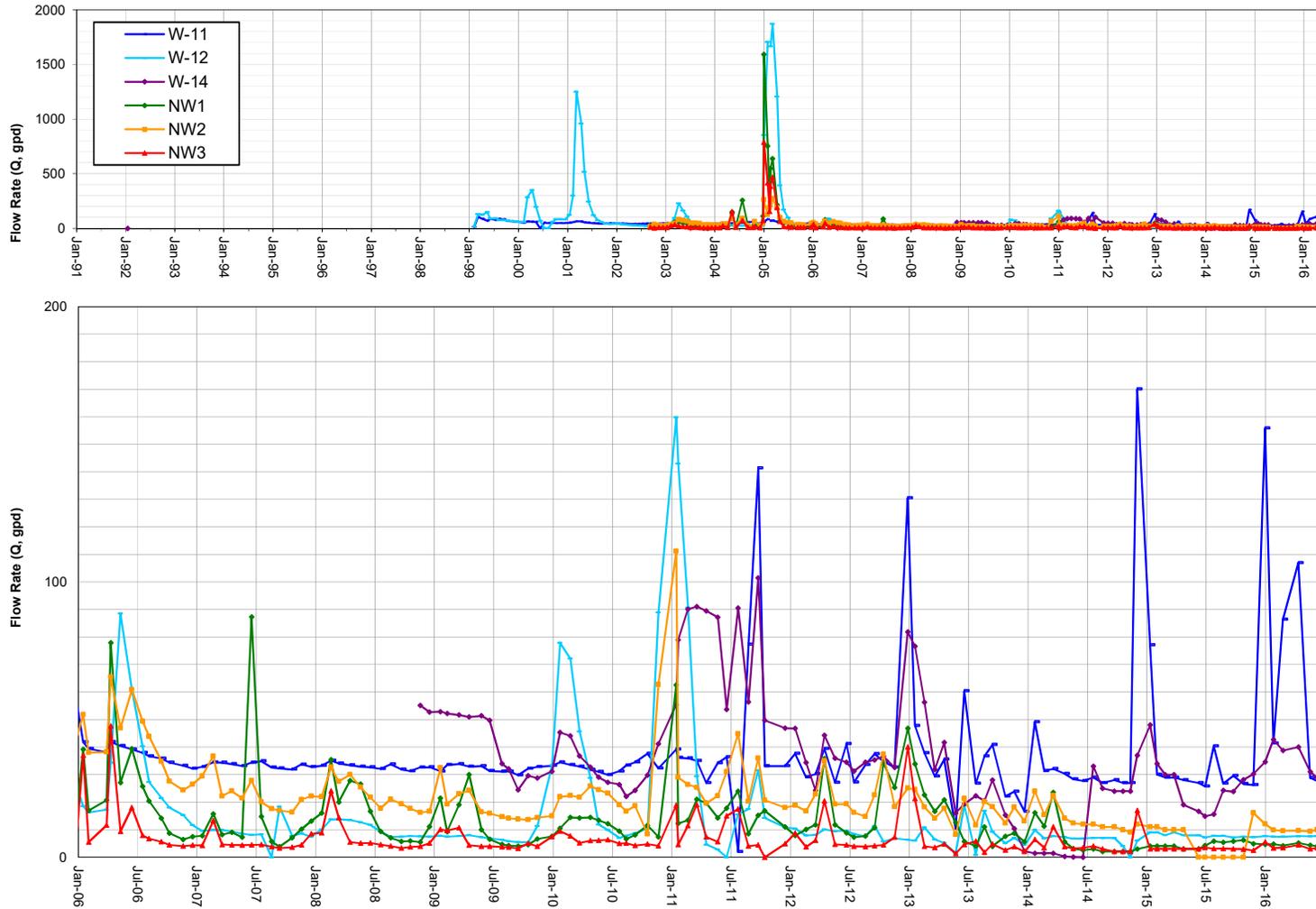
\*\* buried/unable to locate

**DEWATERING WELL / HYDRAUGER INFORMATION**

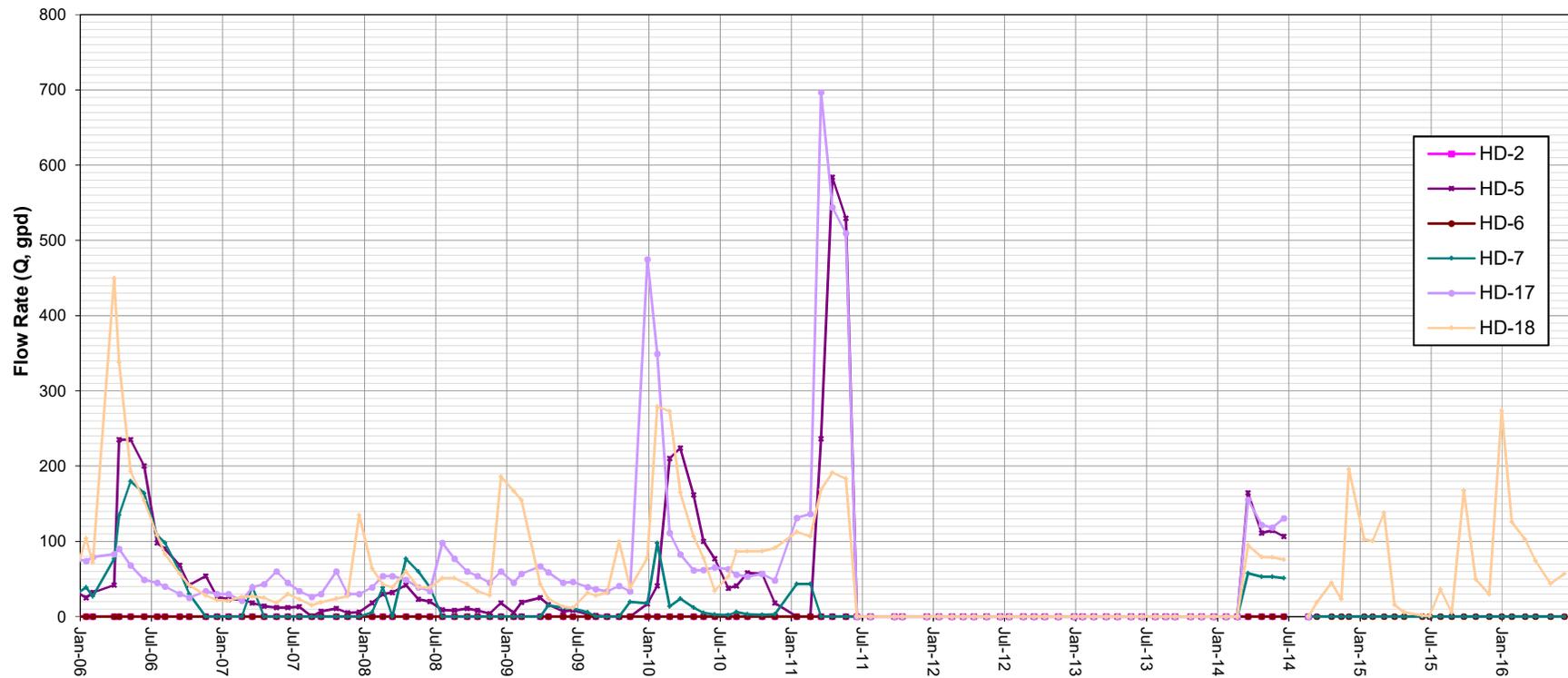
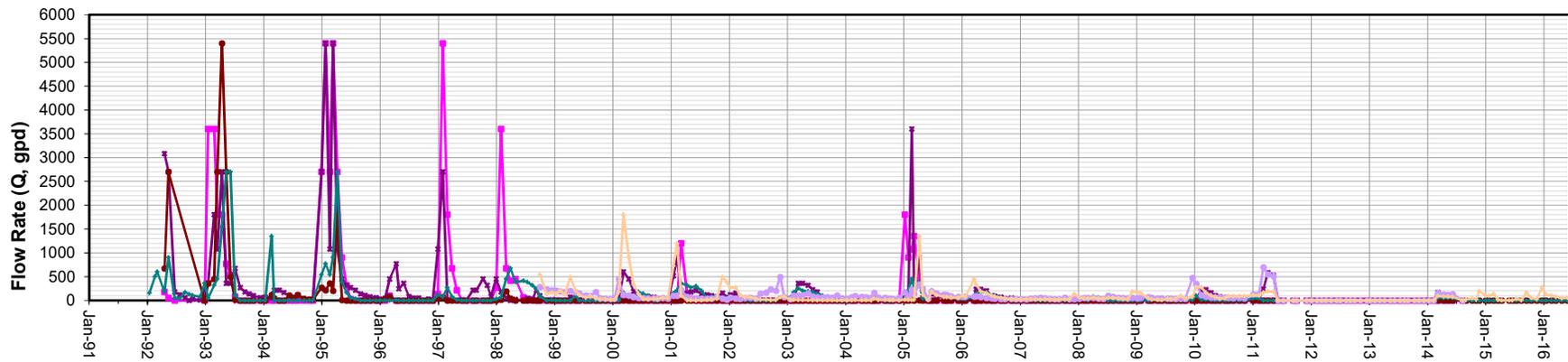
Malibu Road Landslide Assessment District  
 Malibu, California



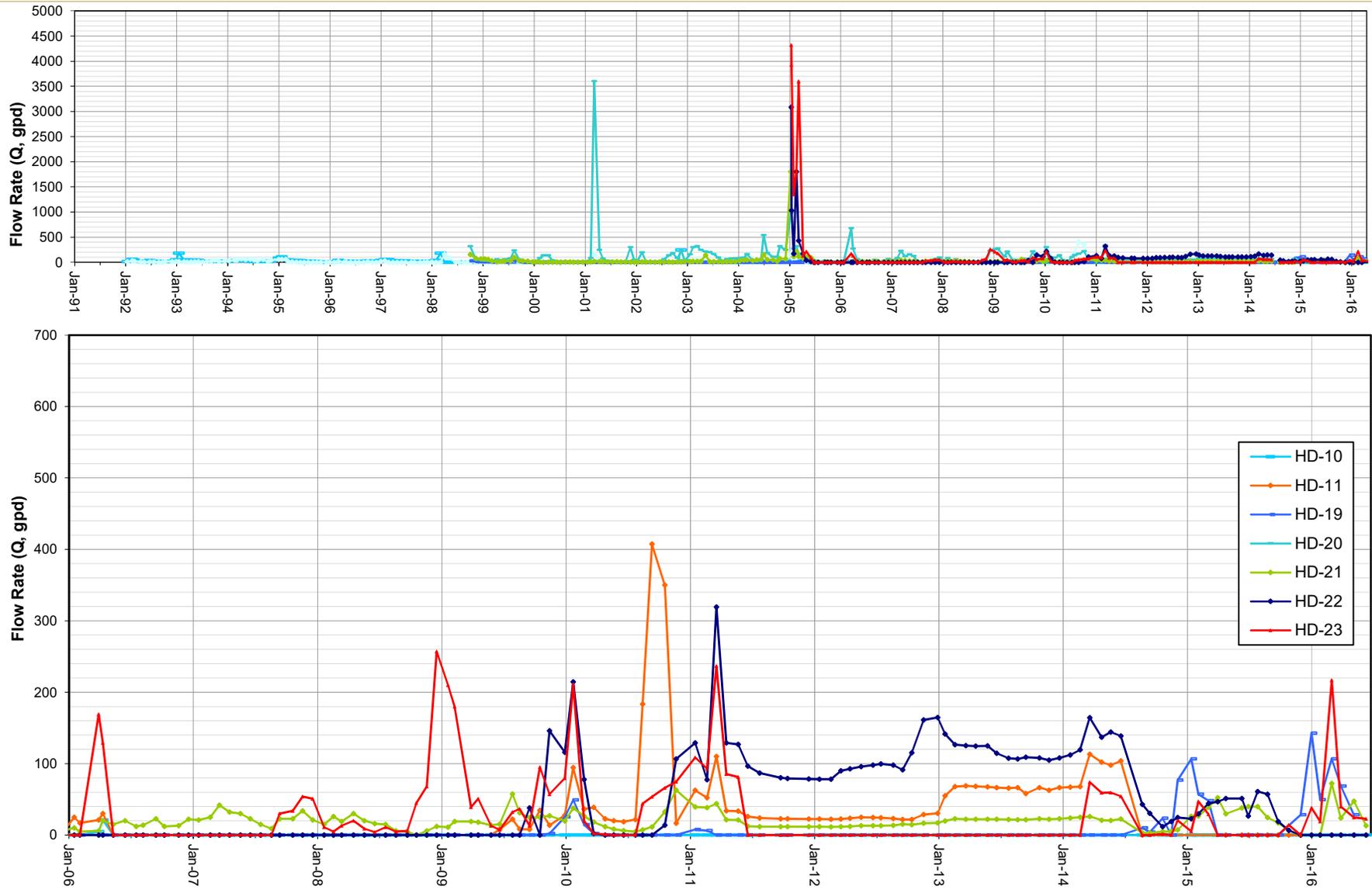
**DEWATERING WELL DISCHARGE RATE GRAPH**  
**Malibu Road**  
Malibu Road Landslide Assessment District  
Malibu, California



**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**



**MALIBU ROAD LAD - Slope Inclinometer Interpretation Summary**

	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	Quarterly	Quarterly
<b>Interpretation Movement (inches)</b>									
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

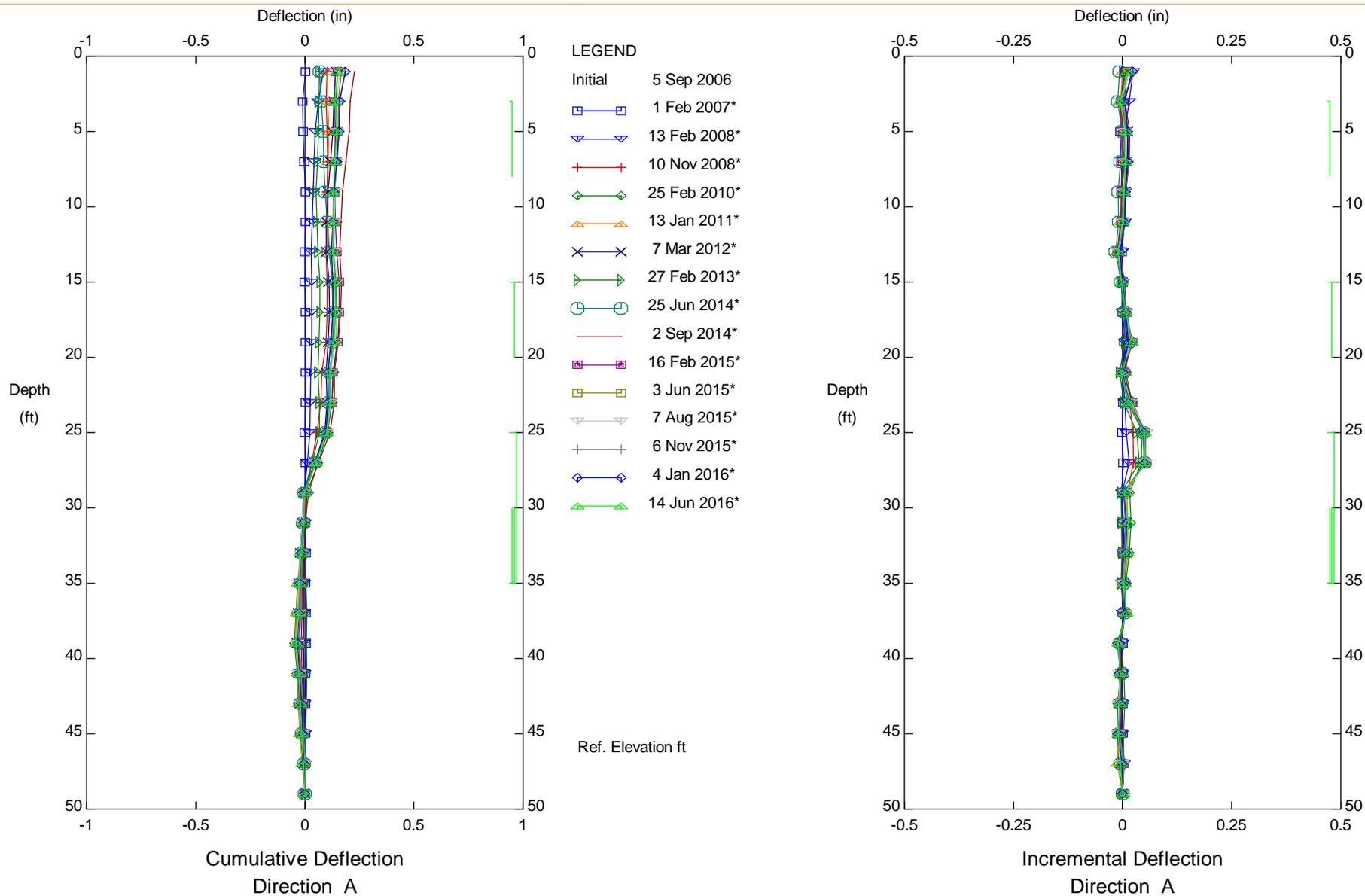
**(3)** Inclinometer sheared off in January, 2005.

**(4)** Inclinometer sheared off winter of 2009.

**NR** No reading

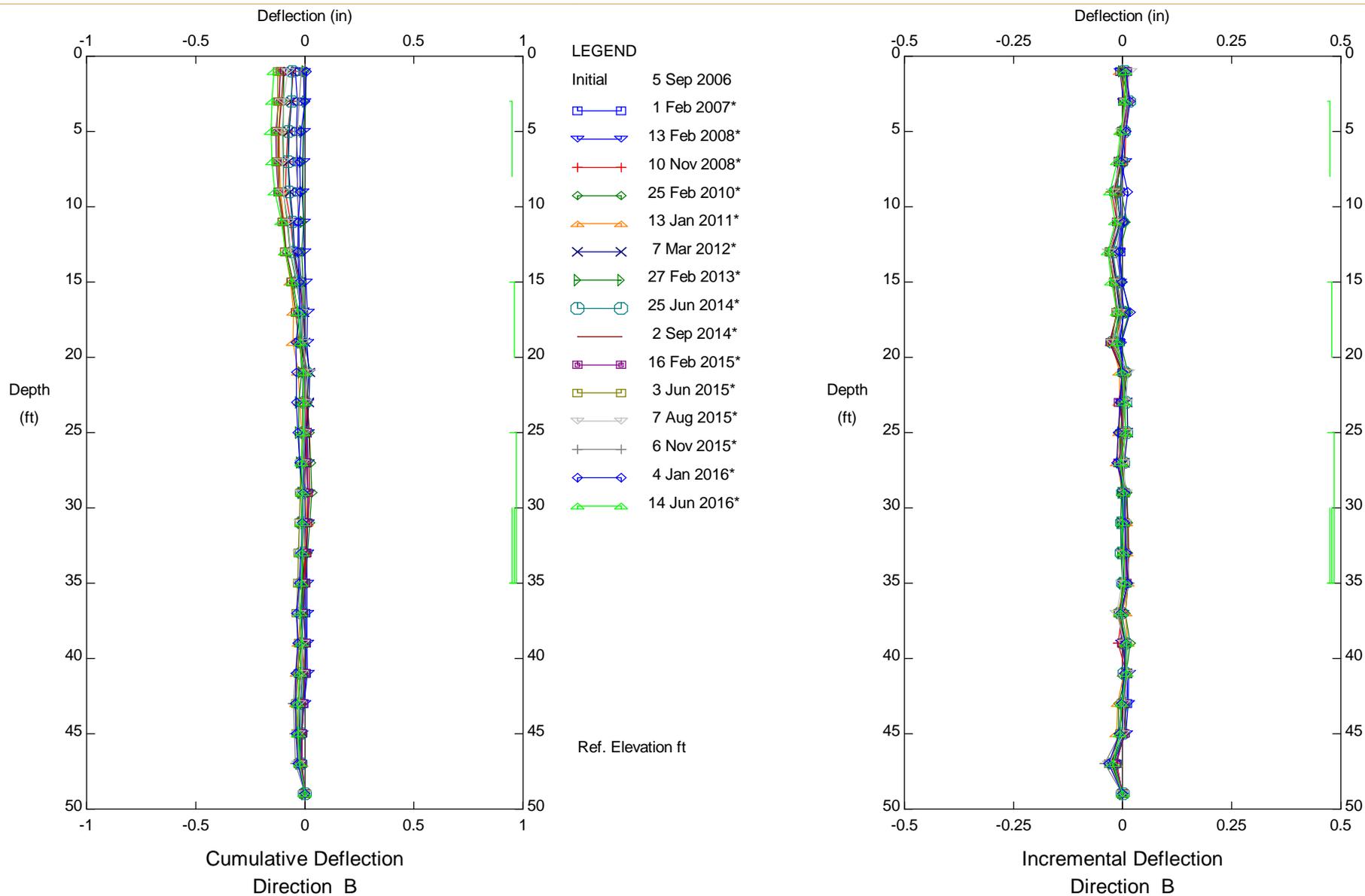
-- No clearly defined interpreted movement.

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



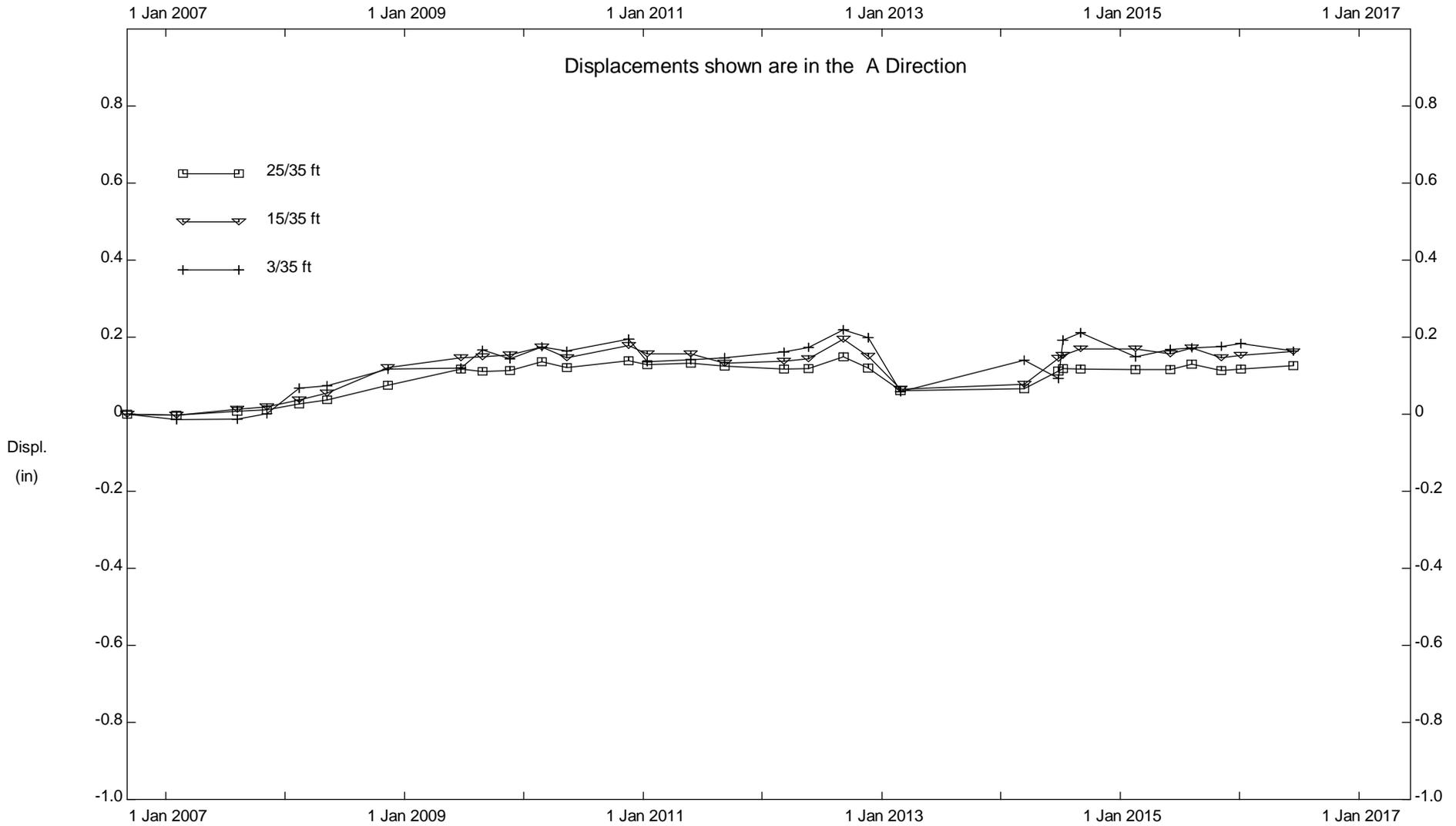
Assessment District 98-3, Inclinometer SI-1A  
City of Malibu

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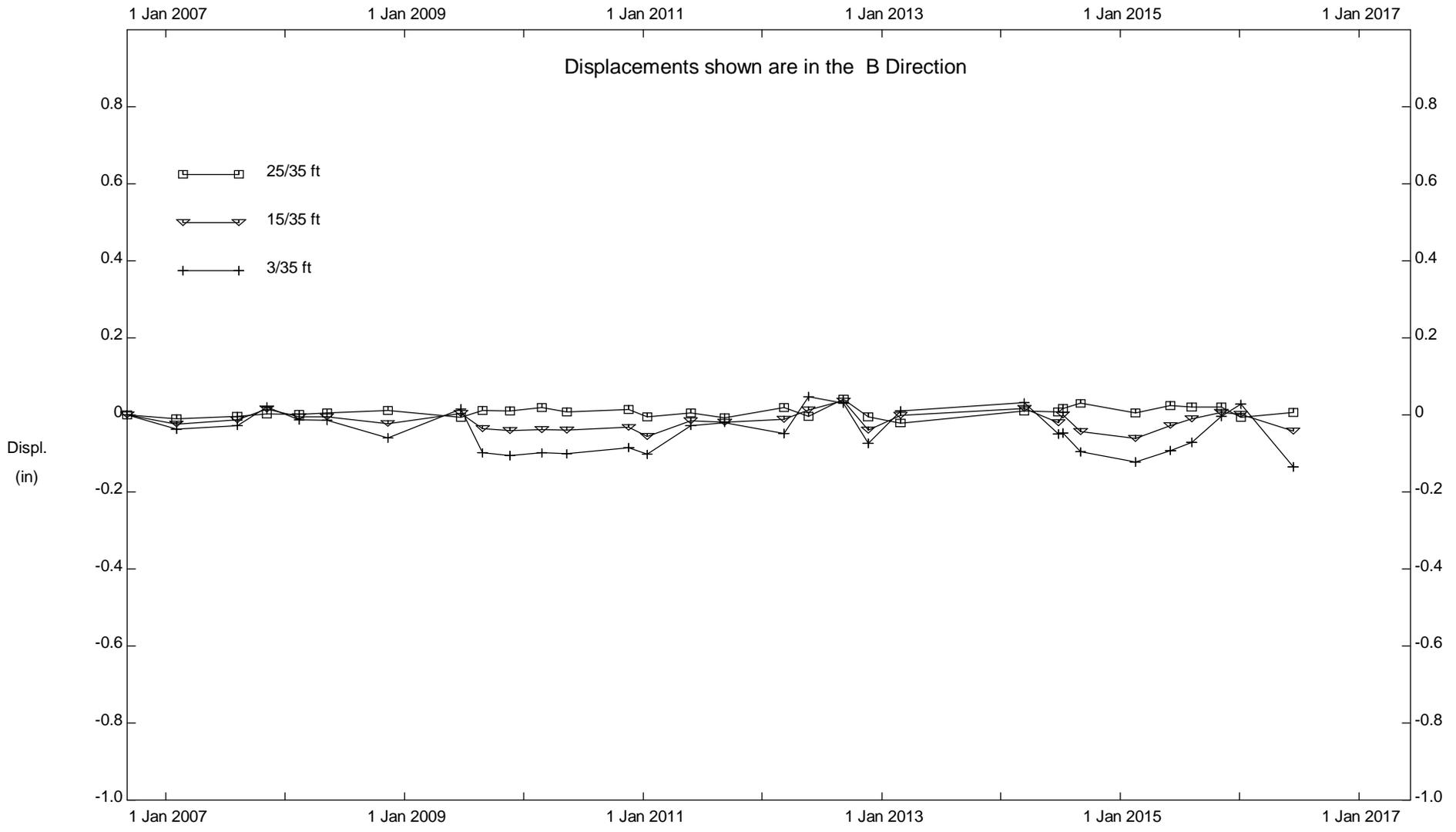
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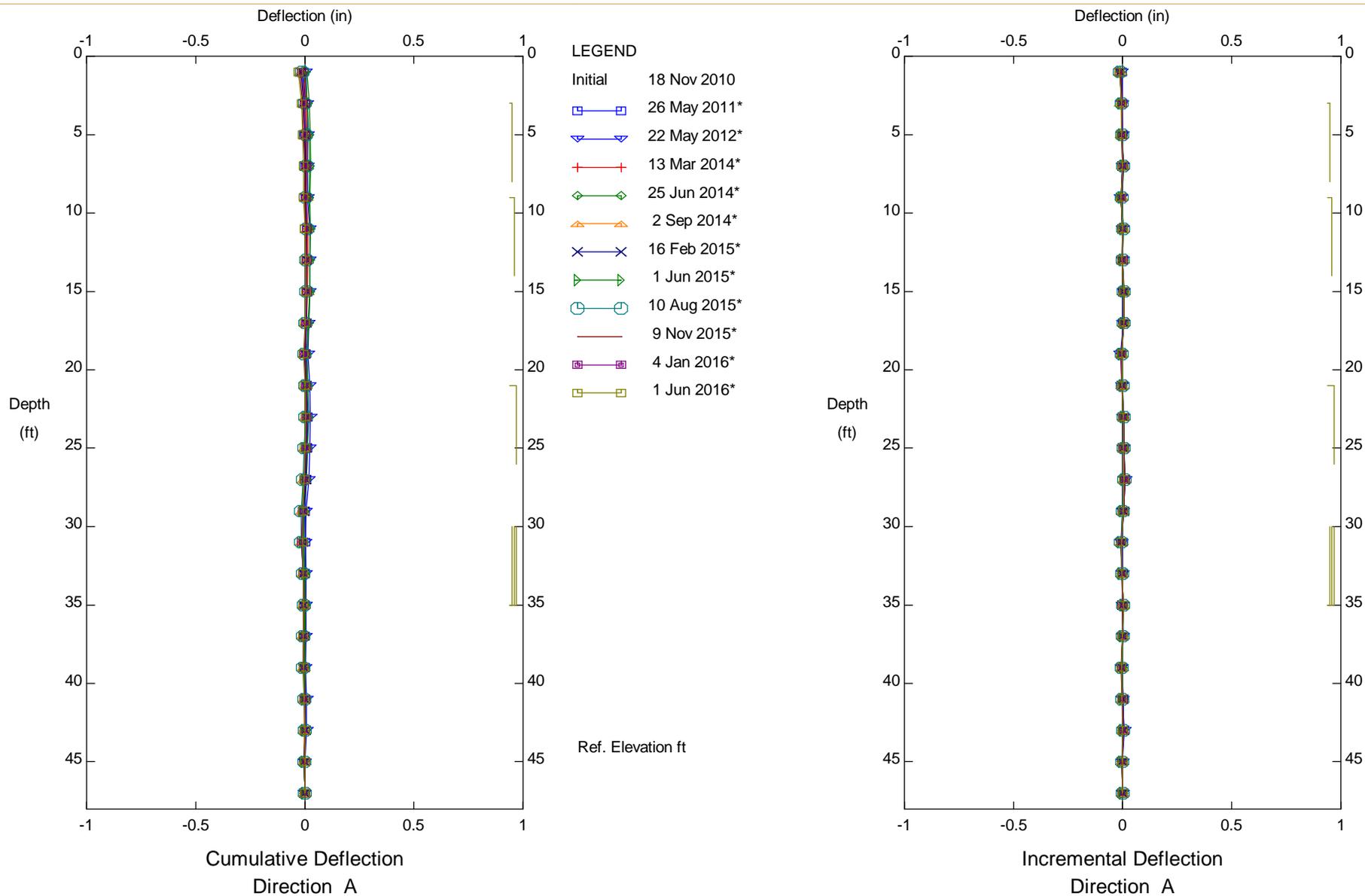
Assessment District 98-3, Inclinometer SI-1A

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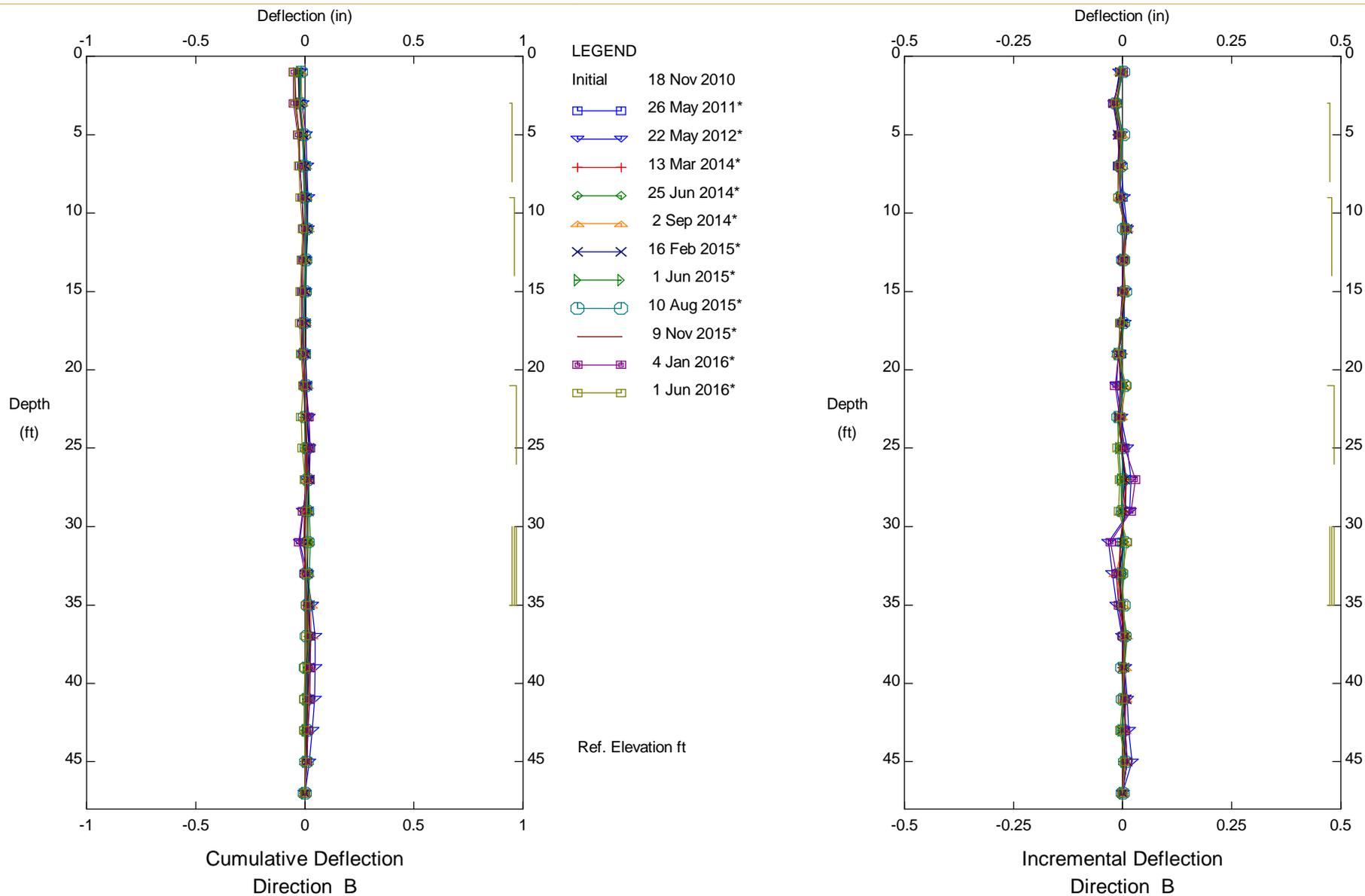
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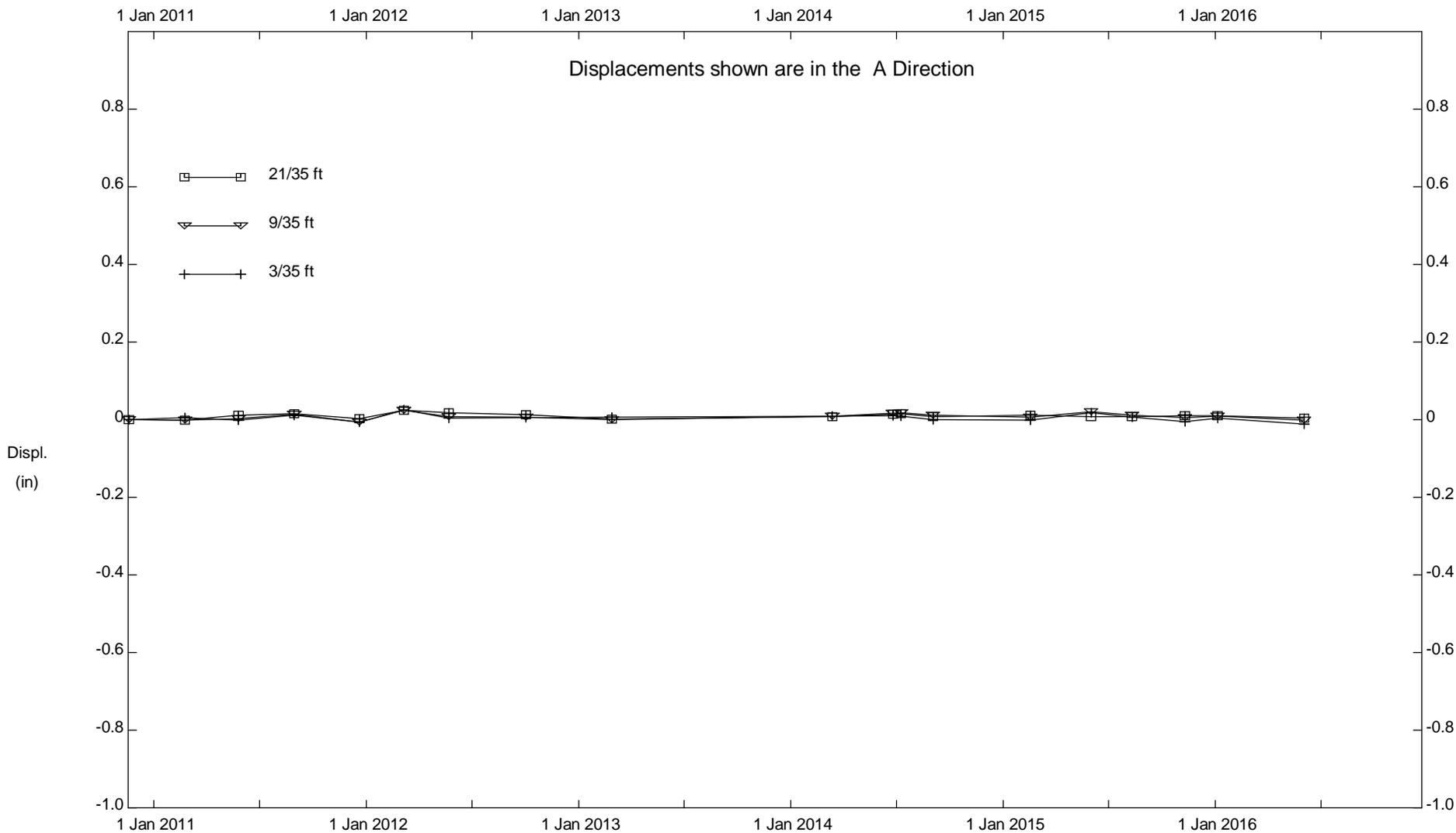
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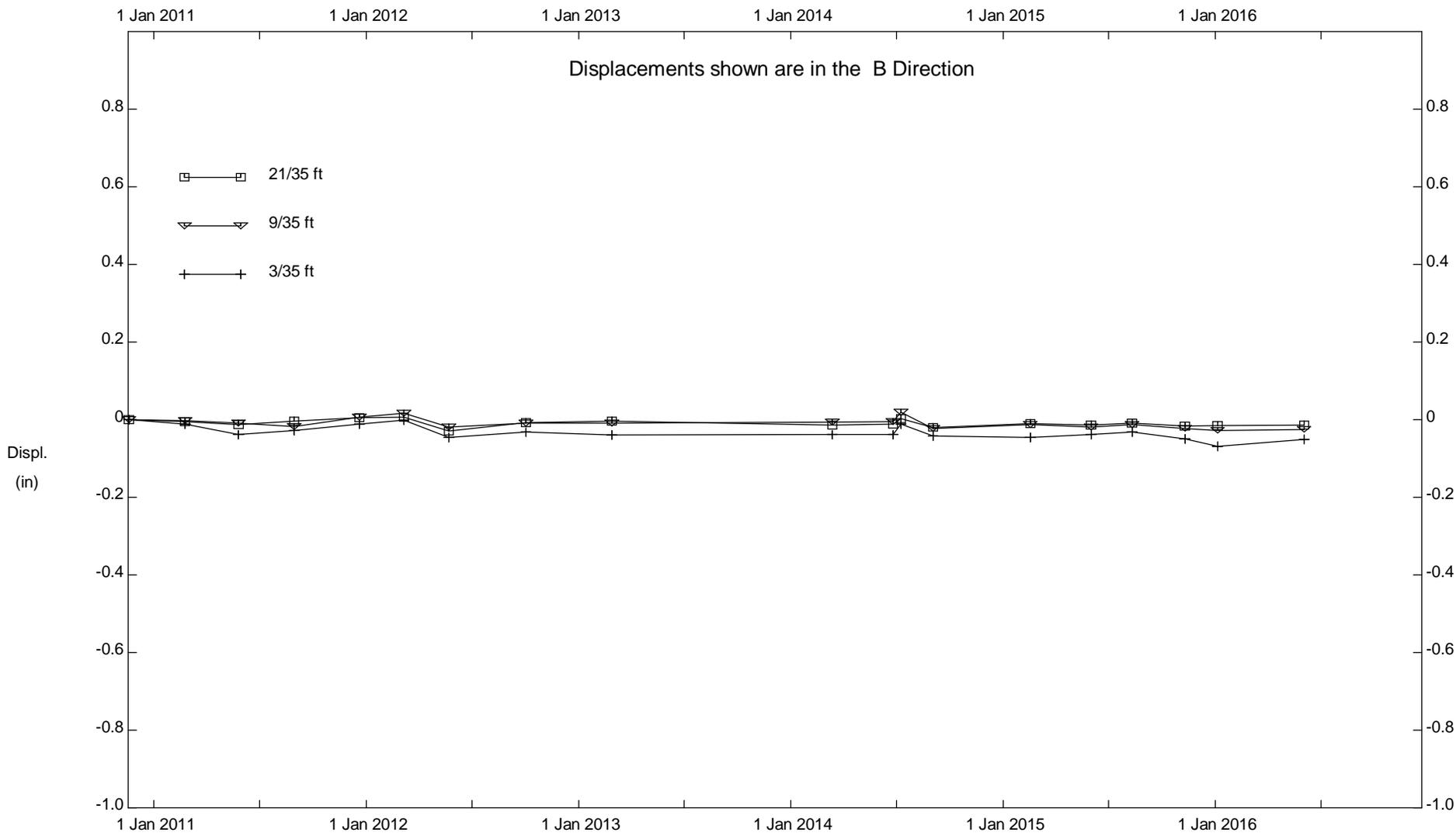
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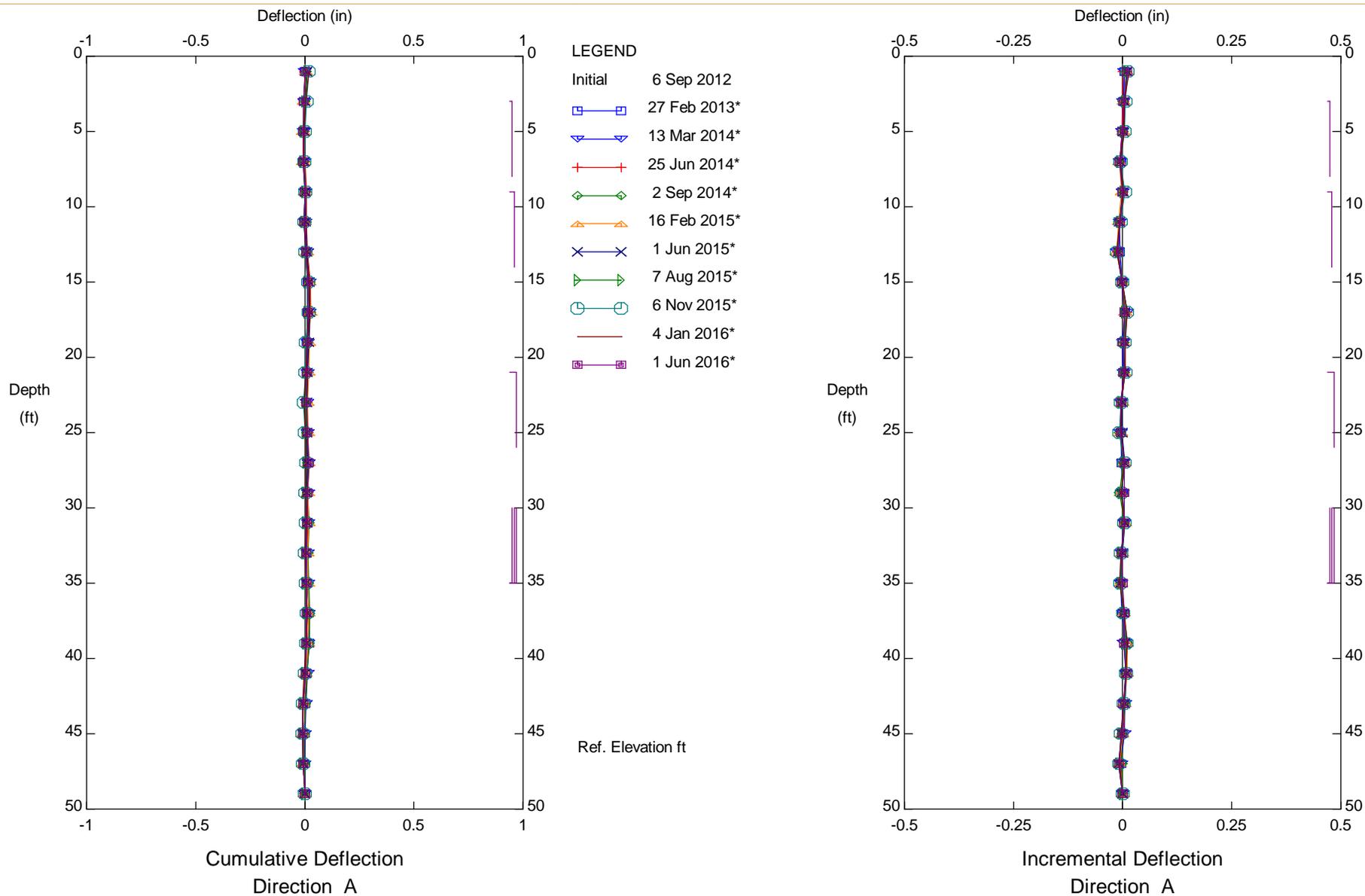
Assessment District 98-3, Inclinometer SI-2A

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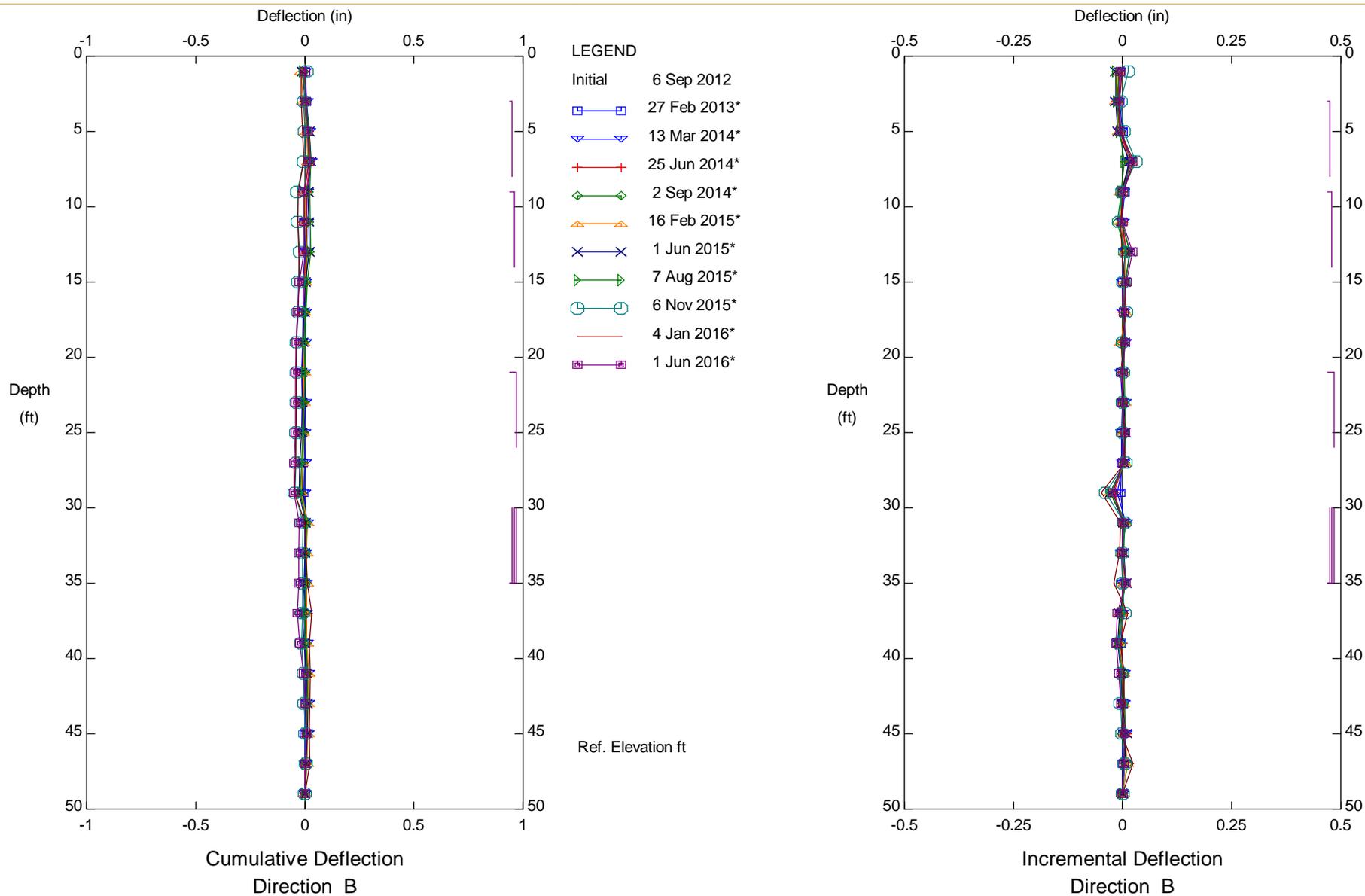
Assessment District 98-3, Inclinometer SI-2A

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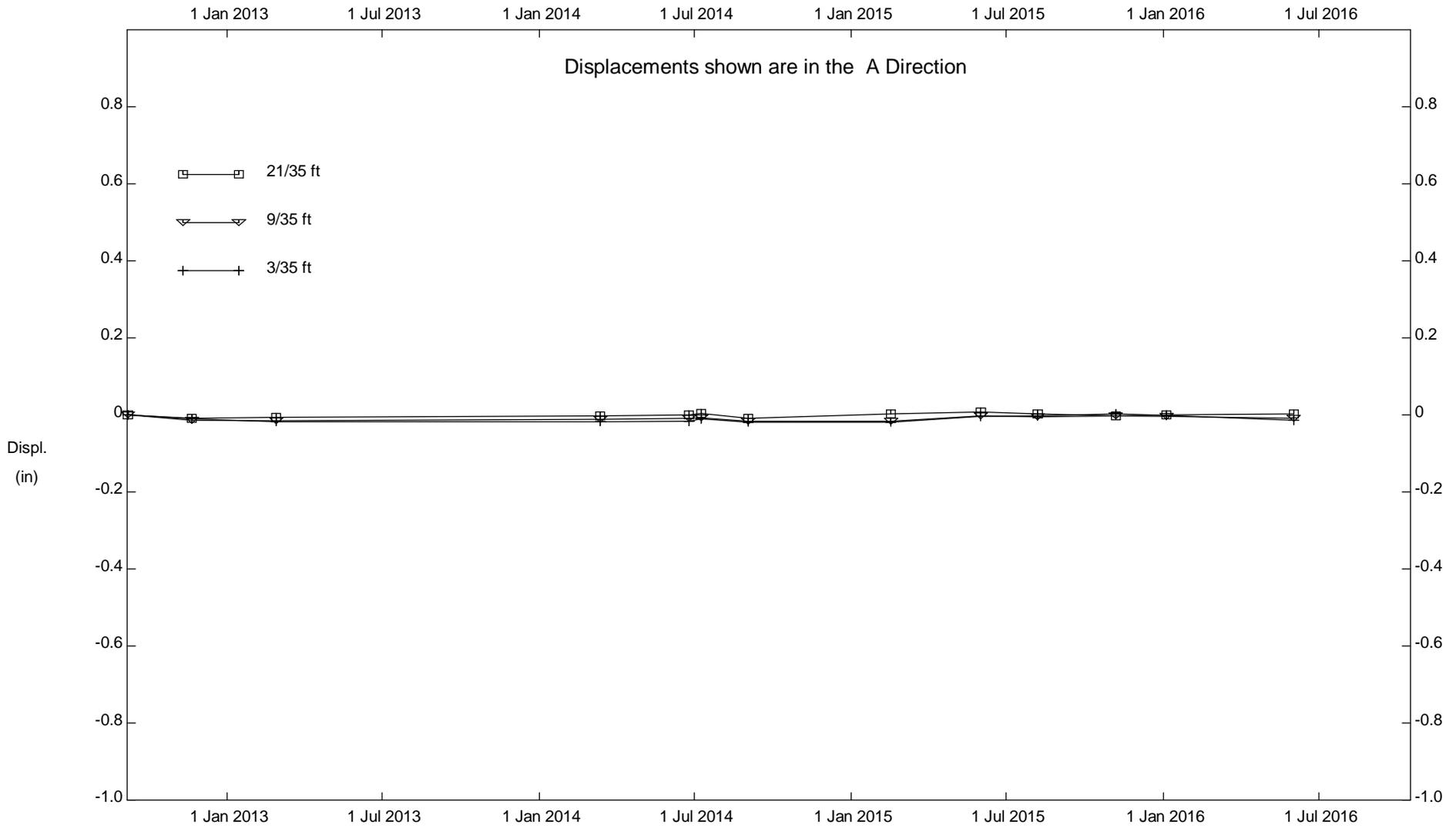
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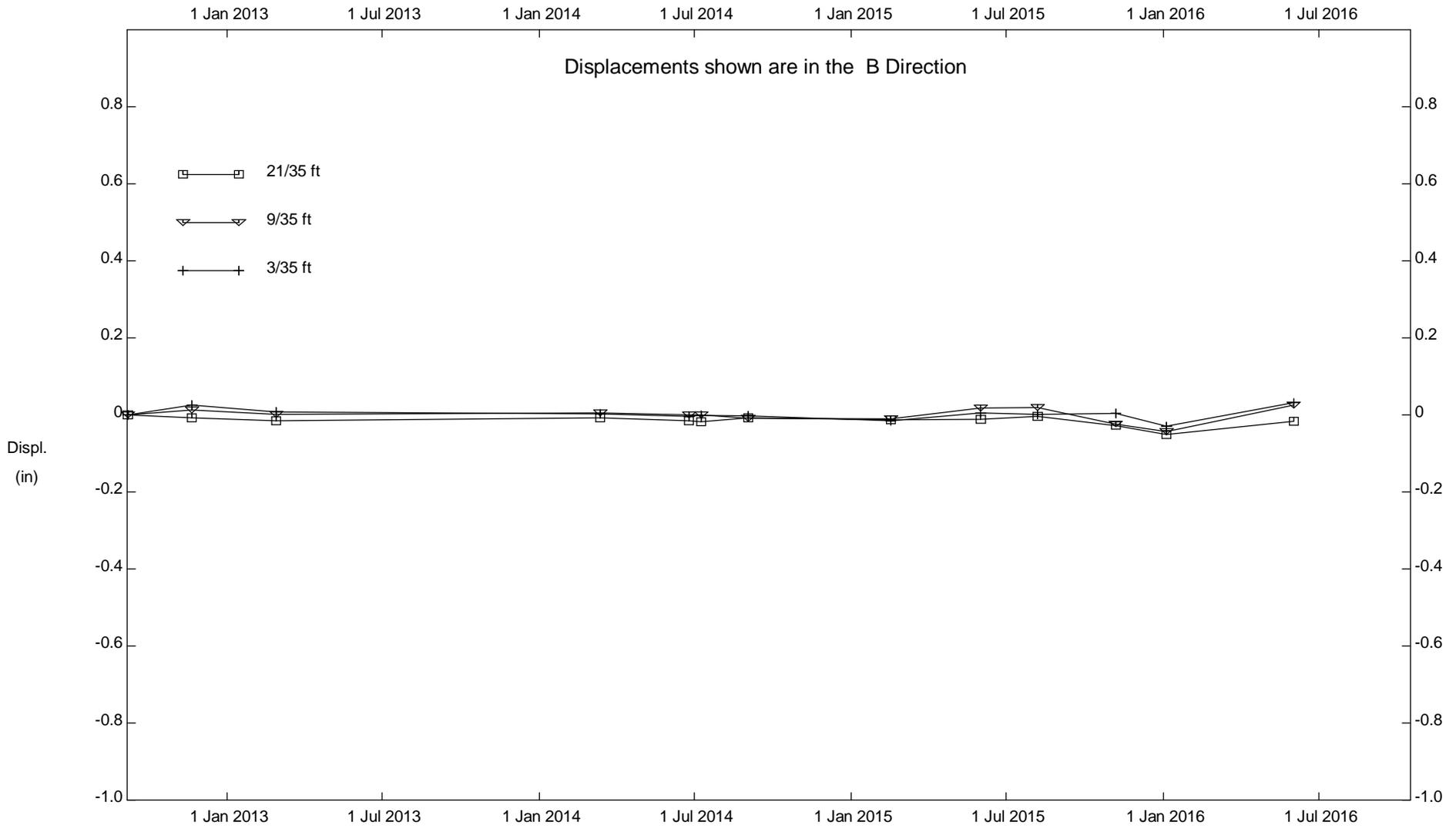
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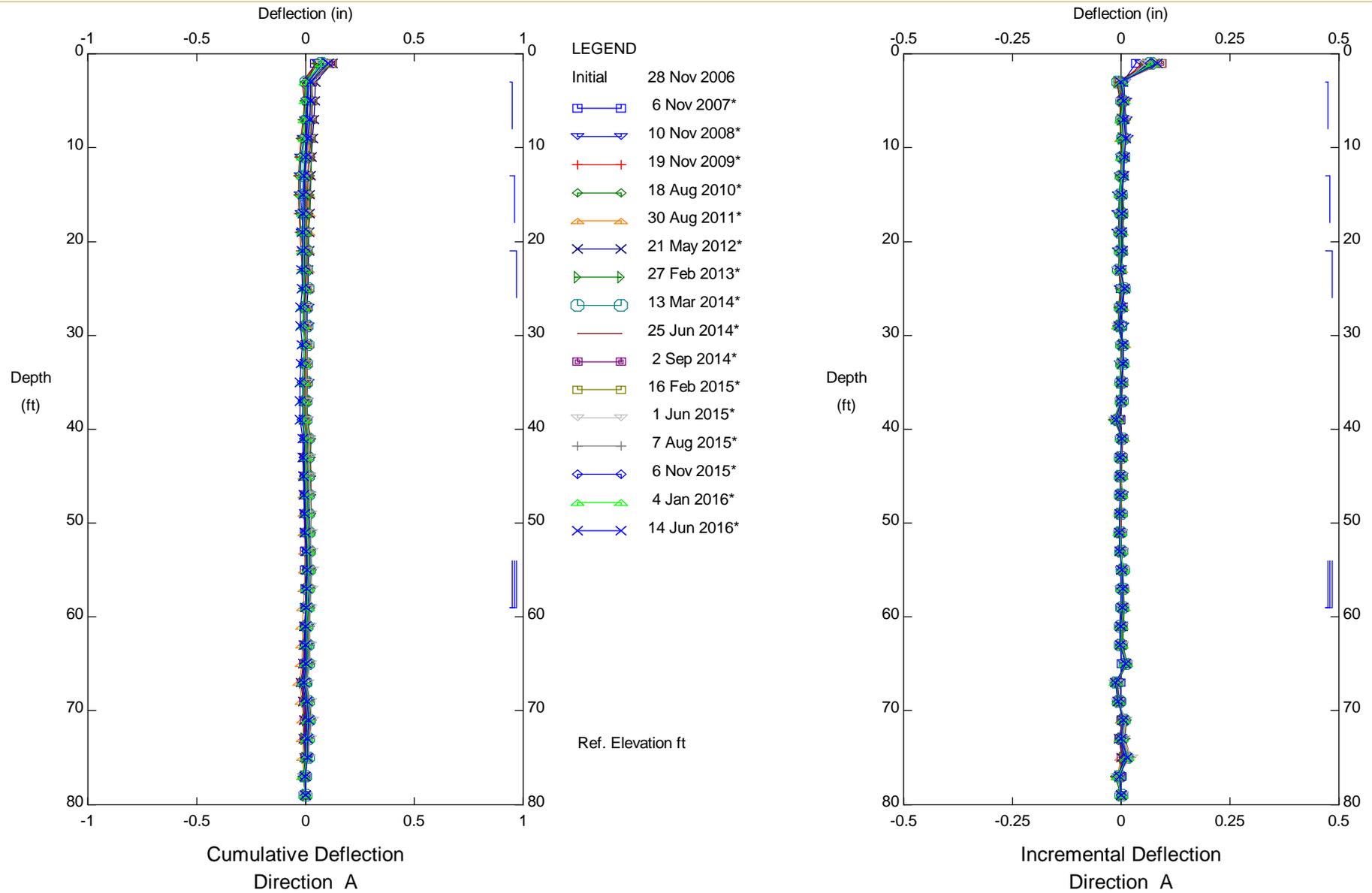
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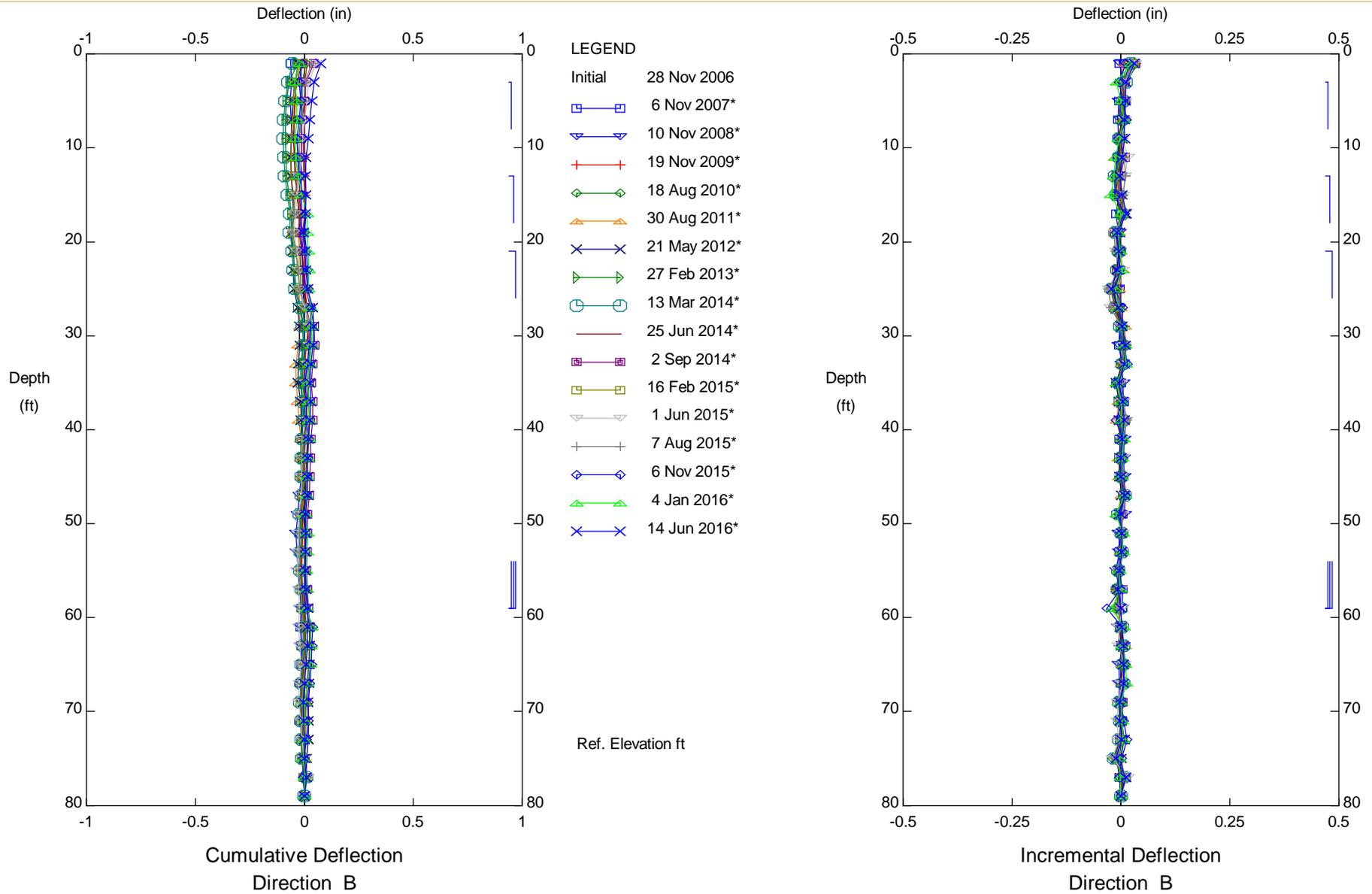
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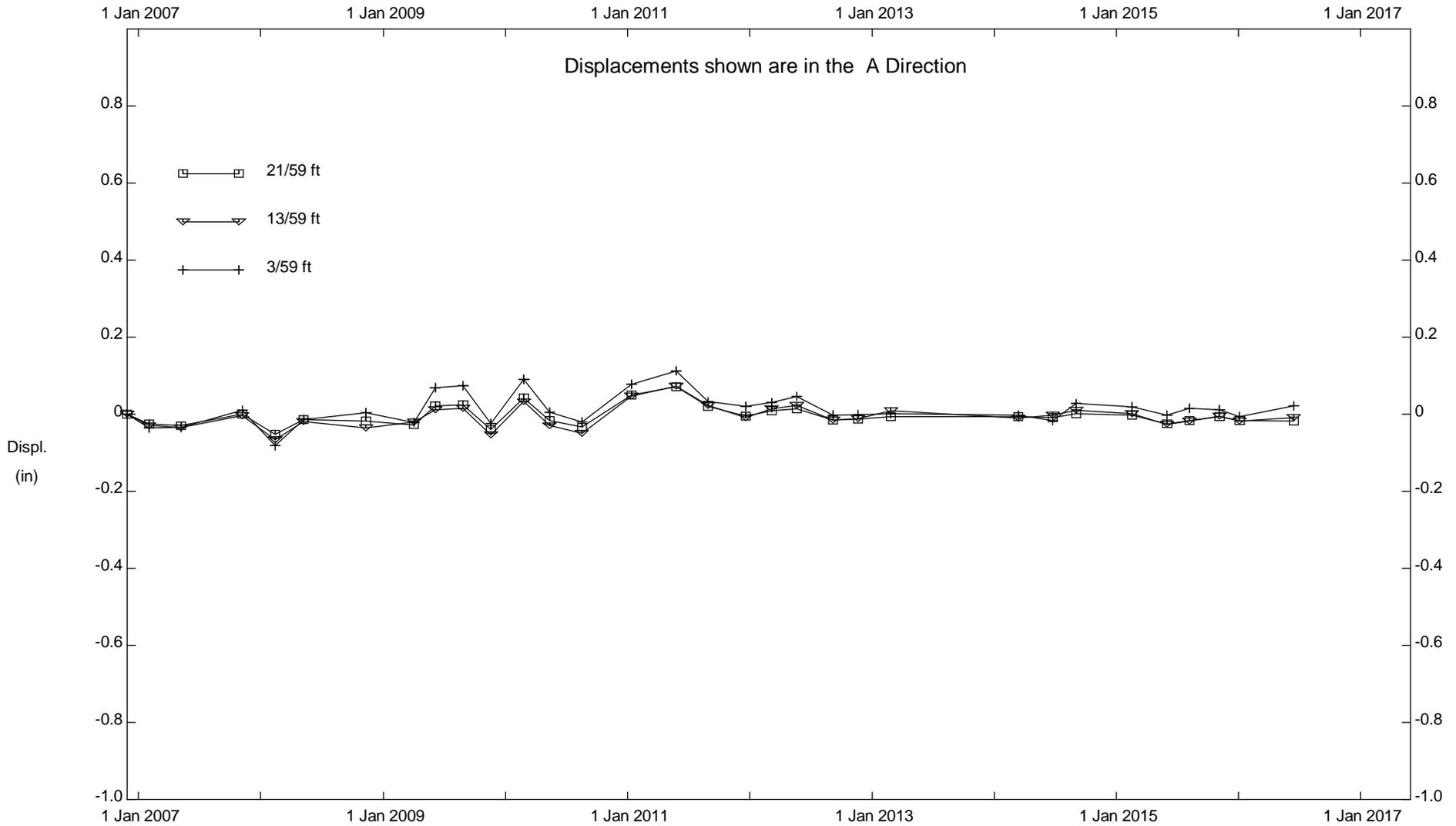
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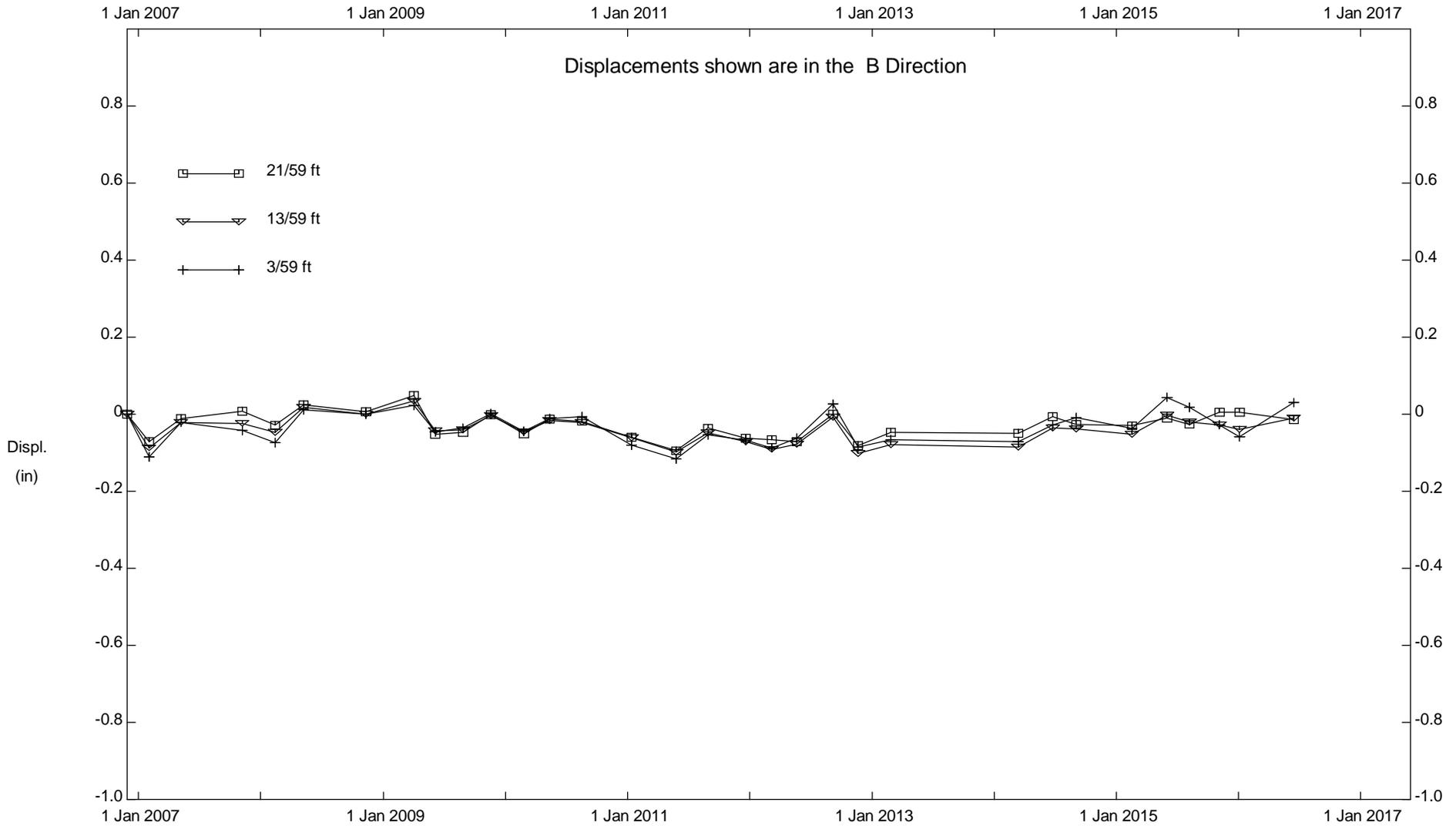
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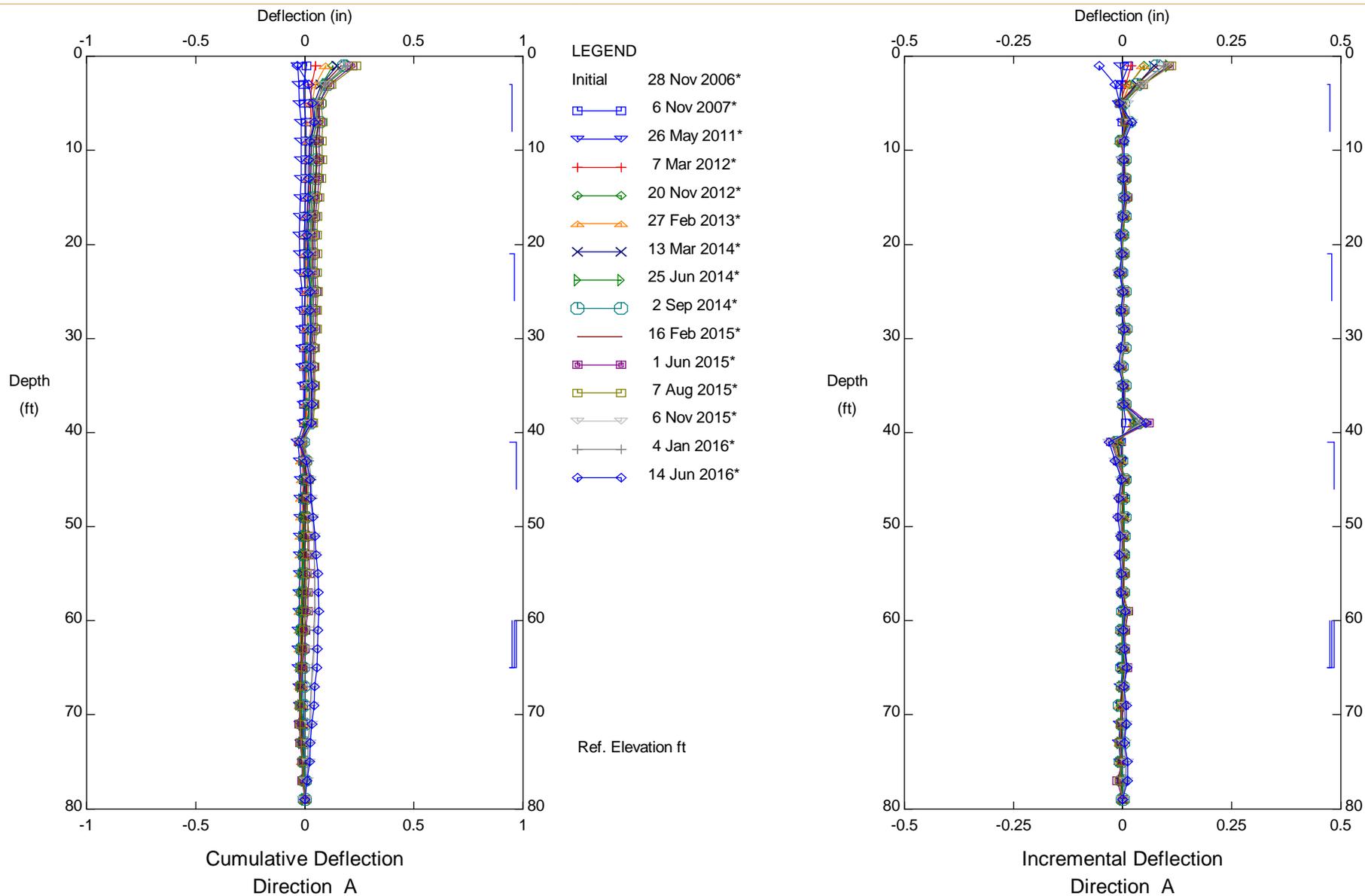
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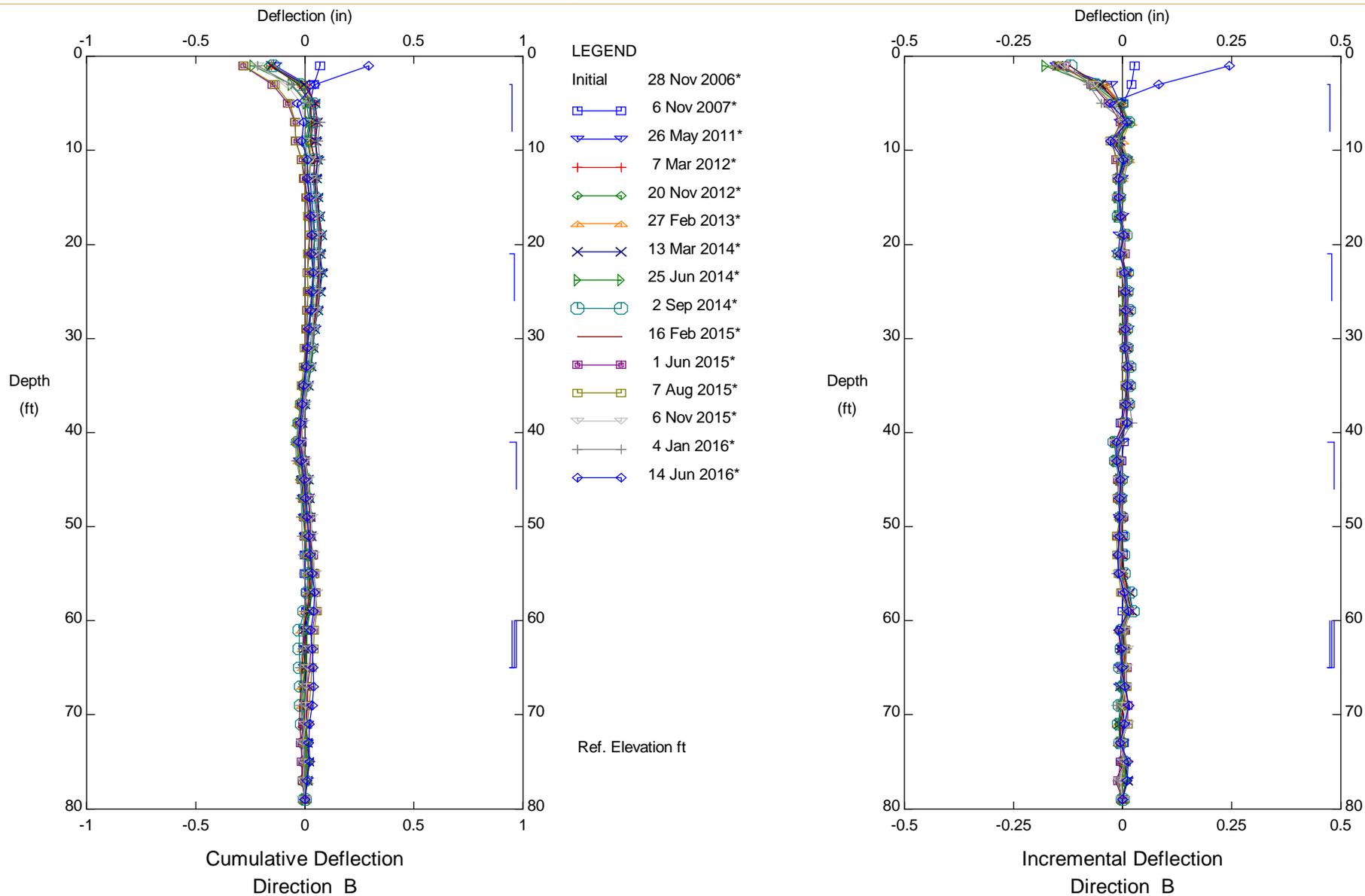
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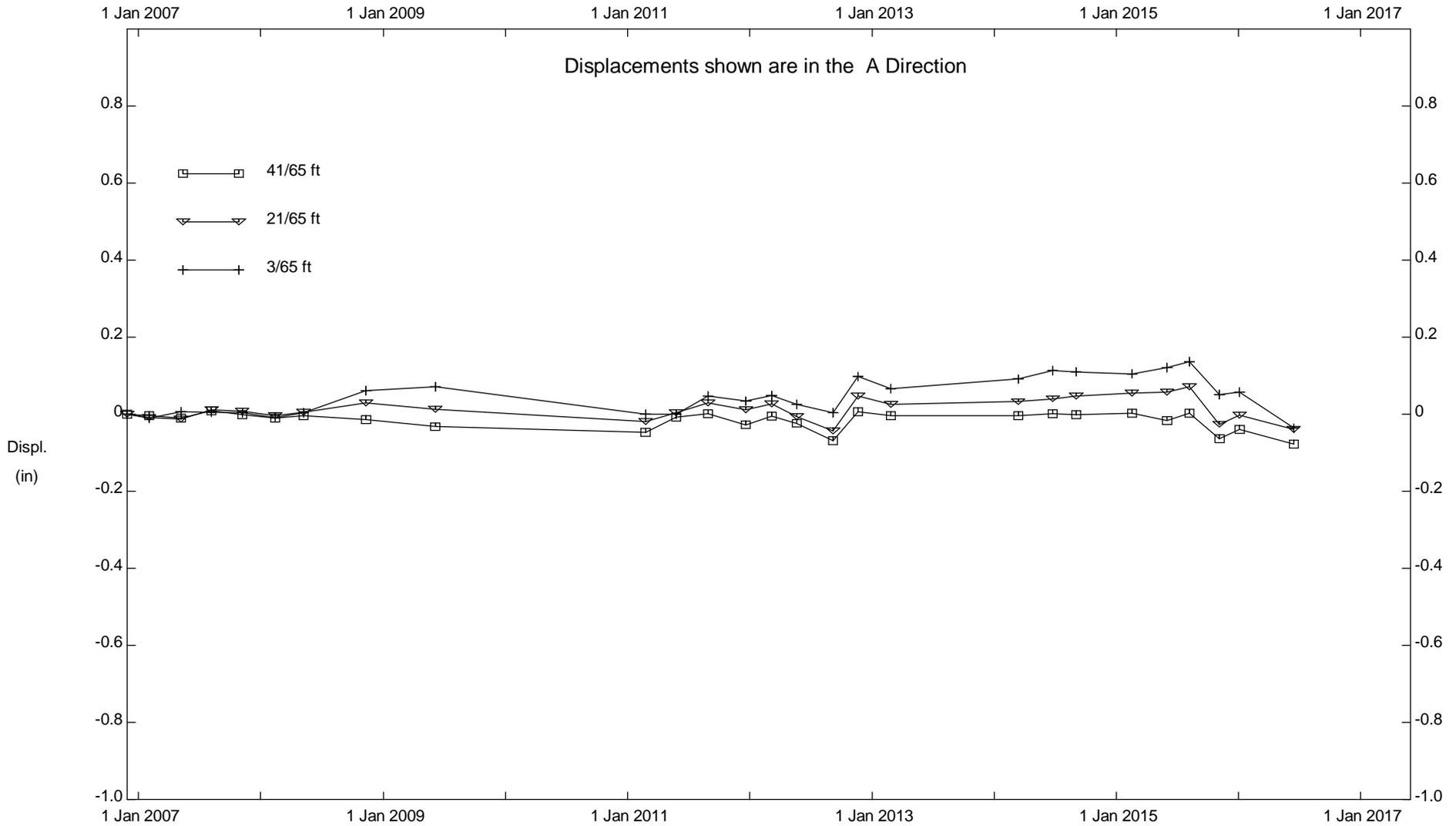
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City of Malibu

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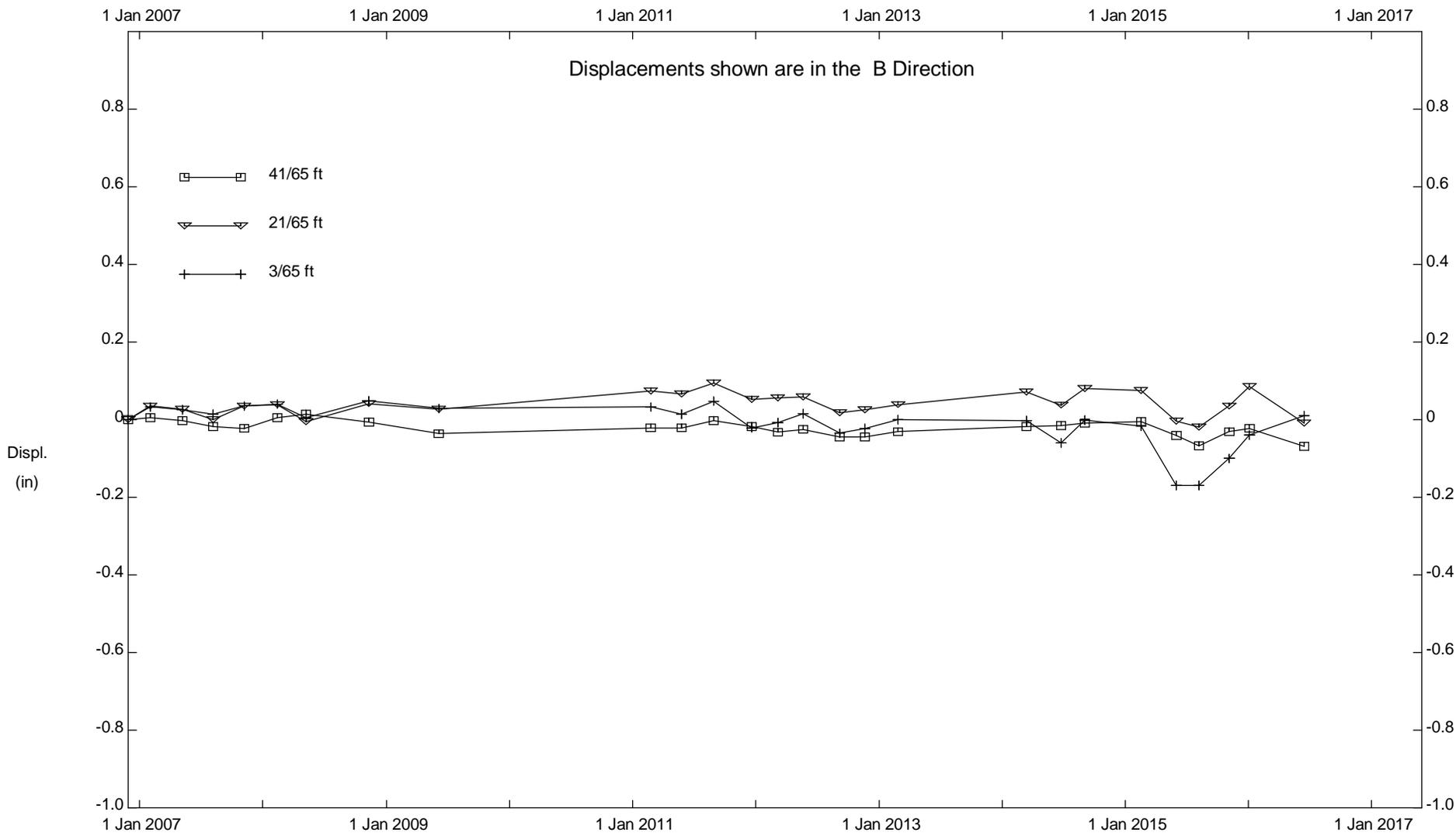
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City of Malibu

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Assessment District 98-3, Inclinator SI-6

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