LONQUIST

March 14, 2025

From:

Nathaniel Byars, Lonquist & Co. LLC

Sergey Samsonov, PhD, InSAR Corporation

Re: Combined Monthly Surface Deformation Report – February 2025
Sulphur Mines Salt Dome, Louisiana

Please find attached the combined monthly deformation report for the Sulphur Mines dome, which includes results from the precision tiltmeters and GNSS stations for the February monitoring period and the cumulative InSAR results as of the end of the month.

Status of a deformation alert plan. We continue testing a draft deformation alert system that reports daily tiltmeter activity in relation to the full statistical history of the network. Alert thresholds will be set and adjusted to prioritize long-duration signals observed at multiple monitoring sites over anomalous or short-duration tilt signals associated with precipitation, shallow deformation, or mechanical activities near individual sites. We plan to integrate tiltmeter deformation alert levels with real-time monitoring data from Sulphur Mines, which include the Cavern 7 pressure and microseismic monitoring. GNSS and InSAR data will also be used for validation.

Sincerely,

Nathaniel Byars

Nathaniel Byars
Principal Engineer
Lonquist & Co. LLC

Sergey V. Samsonov

Sergey Samsonov, PhD
InSAR Corporation

Attachment List

A. Tiltmeter/GNSS Data Report - February 2025
B. SNT InSAR report - February 19, 2025
C. TSX/PAZ InSAR report - February 25, 2025
D. Vertical & East-West 2D InSAR report - February 25, 2025

ATTACHMENT A

Tiltmeter/GNSS Data Report - February 2025

March 14, 2025

Sergey Samsonov, PhD, InSAR Corporation
Nathaniel Byars, Lonquist & Co. LLC

Re: Tiltmeter/GNSS Data Evaluation – February 2025, Sulphur Mines Salt Dome, Louisiana

The tiltmeter/GNSS network, which includes twenty tiltmeters and five GNSS stations, has been operational since June 1, 2024. It was installed and is currently being operated by Halliburton’s Pinnacle Group. Please refer to Figure 1 for the map of the tiltmeter and GNSS stations. Station coordinates are provided in Appendix 3.

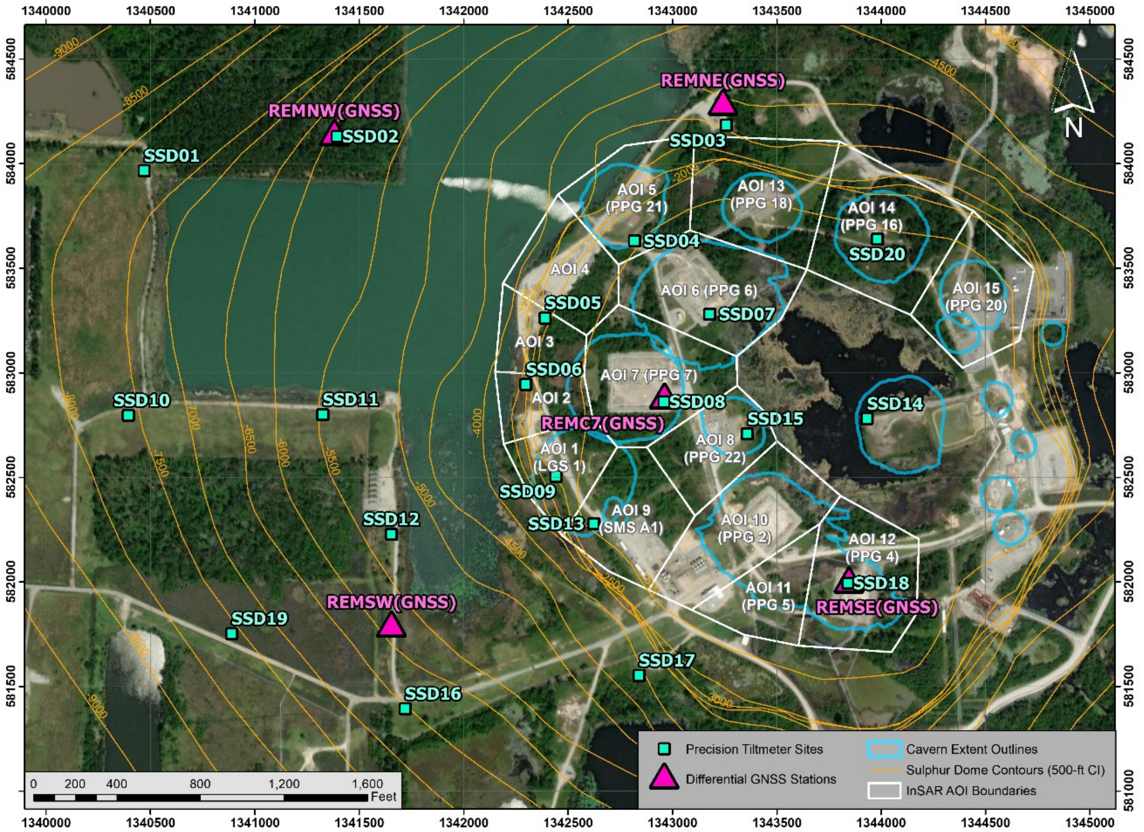


Figure 1. Map of the tiltmeter and GNSS network installed at Sulphur Mines dome. The cyan squares indicate the tiltmeter site locations. The GNSS stations are shown by pink triangles. The InSAR AOI boundaries are shown for reference. The surface projection of the various salt caverns is indicated by blue lines. The salt dome contours are in light orange. The backdrop is an aerial photograph of the Sulphur Mines salt dome.

Introduction

This report describes tiltmeter and GNSS measurements from the Sulphur Mines Salt Dome collected in February 2025.

For each tiltmeter station, the report provides:

- Raw measurements of east and north tilt components with outliers removed by filtering (measured in microradians) at the four-minute temporal resolution and their linear trends.
- Detrended east and north tilt components at four-minute temporal resolution.
- Daily ranges of east and north tilt components.
- Daily precipitation amount (measured in inches).
- Daily tilt direction distribution diagram, along with the direction to Cavern 7 and the direction of the linear trend.

For each GNSS station, the report provides:

- Daily averages of the east, north, and vertical deformation (measured in inches) and their linear trends estimated in the global reference frame.
- Deformation rates (measured in inches per year) estimated in the local reference frame. Deformation rates in a local reference frame are computed by subtracting the tectonic plate deformation rate, common to all sites, from the measurements taken in the global reference frame.

Summary of tiltmeter observations

The tiltmeter network operated without interruption throughout February, and no signals related to anomalous activity in Cavern 7 were detected during this reporting period. Appendix 1 includes plots for each tiltmeter station.

Several precipitation events disrupted the established tilt trends for several days. The effect of these precipitation events is particularly evident in the SSD19 record. We closely monitored tilt directions at all the tiltmeters during the precipitation events to ensure they did also indicate collective behavior directed toward Cavern 7.

Multiple tiltmeters recorded changes in tilt directions at irregular intervals that we cannot explain or attribute solely to the precipitation events. Since these anomalies were only observed at individual stations, they are most likely linked to local, possibly shallow features in the subsurface or mechanical activities near the stations. We suspect the ongoing levee construction has contributed to some unexplained tilt signals.

At SSD18, we previously observed large tilt values from late December to mid- January, as described in the two previous reports. In late January, the tilt rate returned to its long-term value. On February 7, the tiltmeter was replaced with a new one. During February, SSD18 did not record a large tilt; however, it recorded several abrupt tilt signals of about five microradians. It is not clear if these signals are caused by ground deformation or are due to instrument error.

To further investigate the large tilt observed at SSD18 during December and January, a test was conducted to evaluate the theorized relation to pumping activities from Central Lake. The Central Lake pump was operated from 7:40 a.m. CST on February 22 until 4:00 p.m. CST on February 24. We expected this pumping activity to result in an observable abnormal tilt at SSD18, similar to previously recorded. However, no noticeable abnormal tilt was detected during this test.

A large tilt, however, was observed at SSD14 (see Figure 2) during the last week of February. SSD14 is situated at Central Lake, less than 1,000 feet north of SSD18. Beginning on February 23, SSD14 started to detect an increasing tilt rate, which reached approximately 25 microradians by the end of February in the daily range of the northern component. While the exact cause of this tilt remains unclear, we suspect that the pumping activity may have contributed to it. We continue investigating this signal and will provide an update in the next report.

The tilt data is manually reviewed daily using a 7-day rolling window. This process helps identify any changes in trends that are consistently observed at multiple tiltmeter sites over at least a few days. During the reported period, the tiltmeter data did not show any consistent ground movement patterns that would indicate deep-sourced deformation or any immediate concerns regarding Cavern 7.

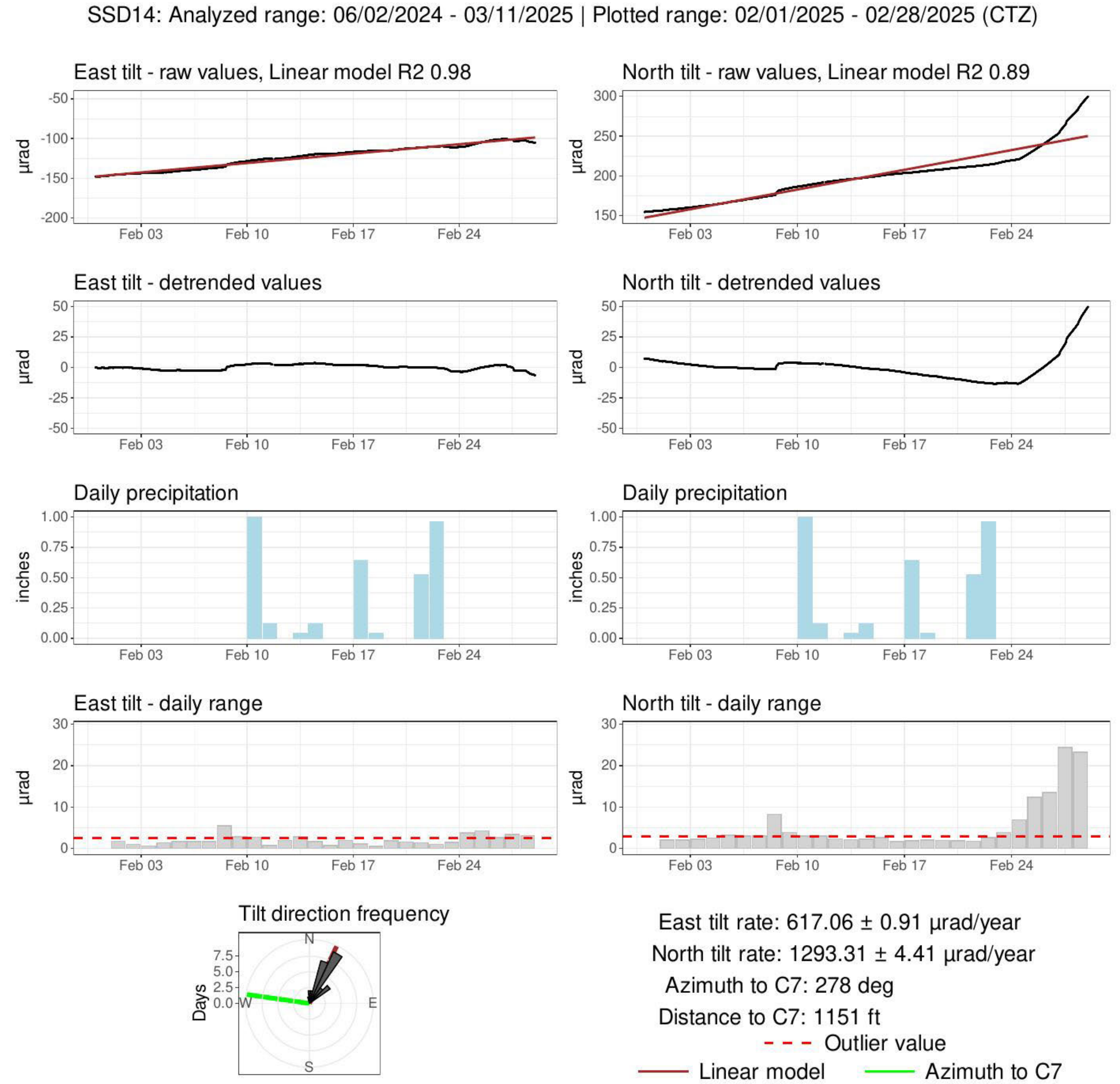


Figure 2. An example of a tilt signal observed by the SSD14 tiltmeter. Note large tilt daily ranges observed during the last week of February.

Summary of GNSS observations

The GNSS network operated without interruption throughout February. After replacing the receiver at the base station in late January, we estimated the offsets caused by this replacement and adjusted the time series accordingly.

Appendix 2 includes plots for each GNSS station. We calculated the annualized three-dimensional (east, north, and vertical) deformation rates at each site within a local reference frame by subtracting a constant tectonic rate that is common to all sites. The daily measurements taken in February supported an observed deformation trend, which was primarily characterized by horizontal motion directed toward Central Lake and accompanied by subsidence. This subsidence rate increased with proximity to Central Lake.

Analysis Maps

Three maps have been created to visually summarize the results of the current analysis. These maps are displayed below and are also included in Appendix 3.

- Figure 3 is a vector map illustrating the direction and magnitude of the tilt and deformation rates identified at each tiltmeter (during the current reporting period) and GNSS station (from July 22, 2024 to the end of the current reporting period).
- Figure 4 presents rose diagrams showing the daily tilt direction frequency for each tiltmeter, covering the entire data history from June 2024 to the present.
- Figure 5 details the daily tilt direction frequency for the current monthly reporting period.

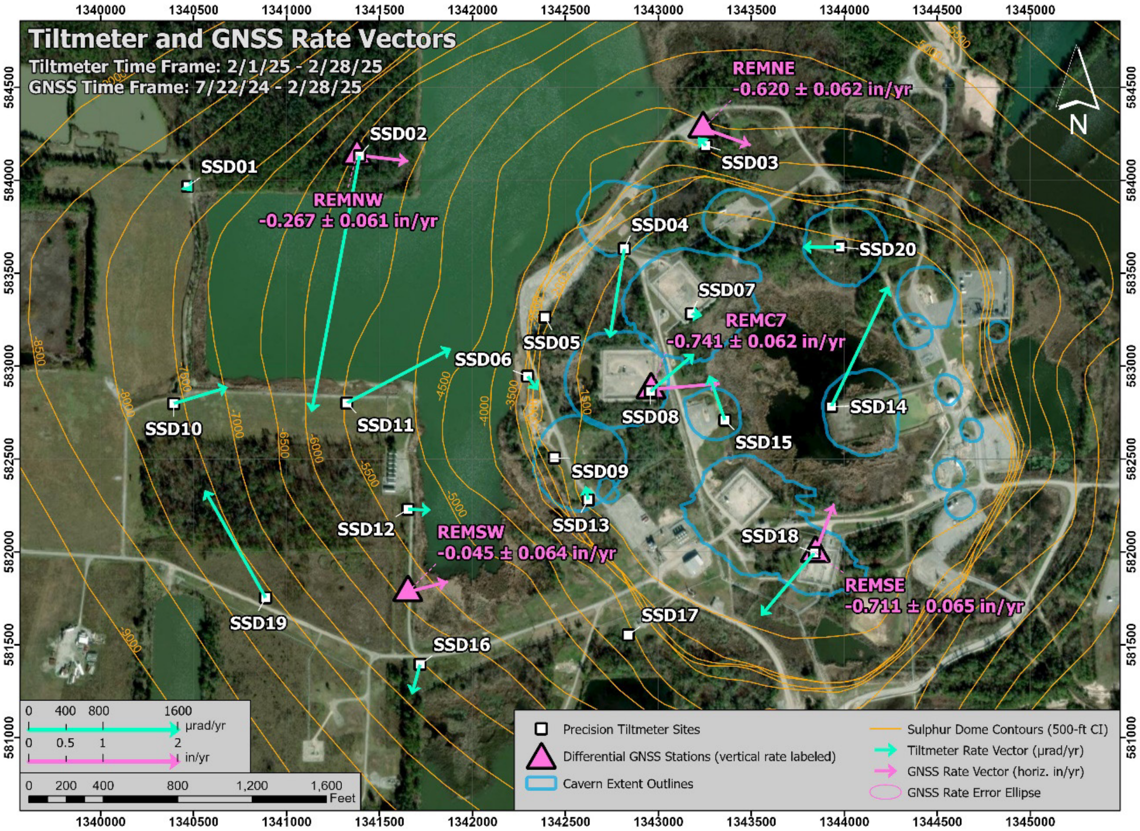


Figure 3. Map of deformation rate vectors for the tiltmeters and GNSS stations over their respective evaluated time frames. The tiltmeter vectors are shown in cyan and scaled by their respective values in units of microradians per year. The GNSS vectors and their corresponding error ellipses (derived from east and north rate errors) are shown in pink representing inches of horizontal movement per year. The GNSS stations are additionally labeled with the vertical motion rate and corresponding error value.

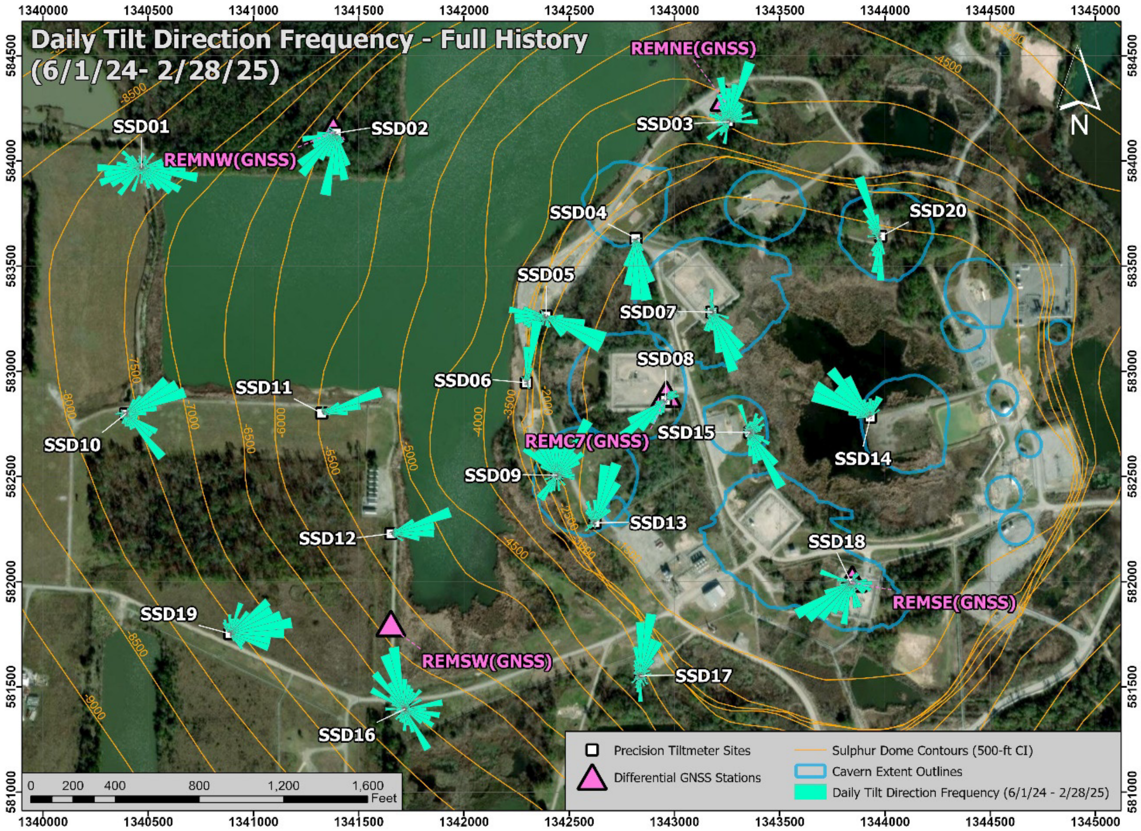


Figure 4. Map of daily tilt direction distribution for each tiltmeter for the full data history beginning in June 2024. Rose diagrams indicate the number of days that tilt was oriented along specific azimuths (bin size is 10°).

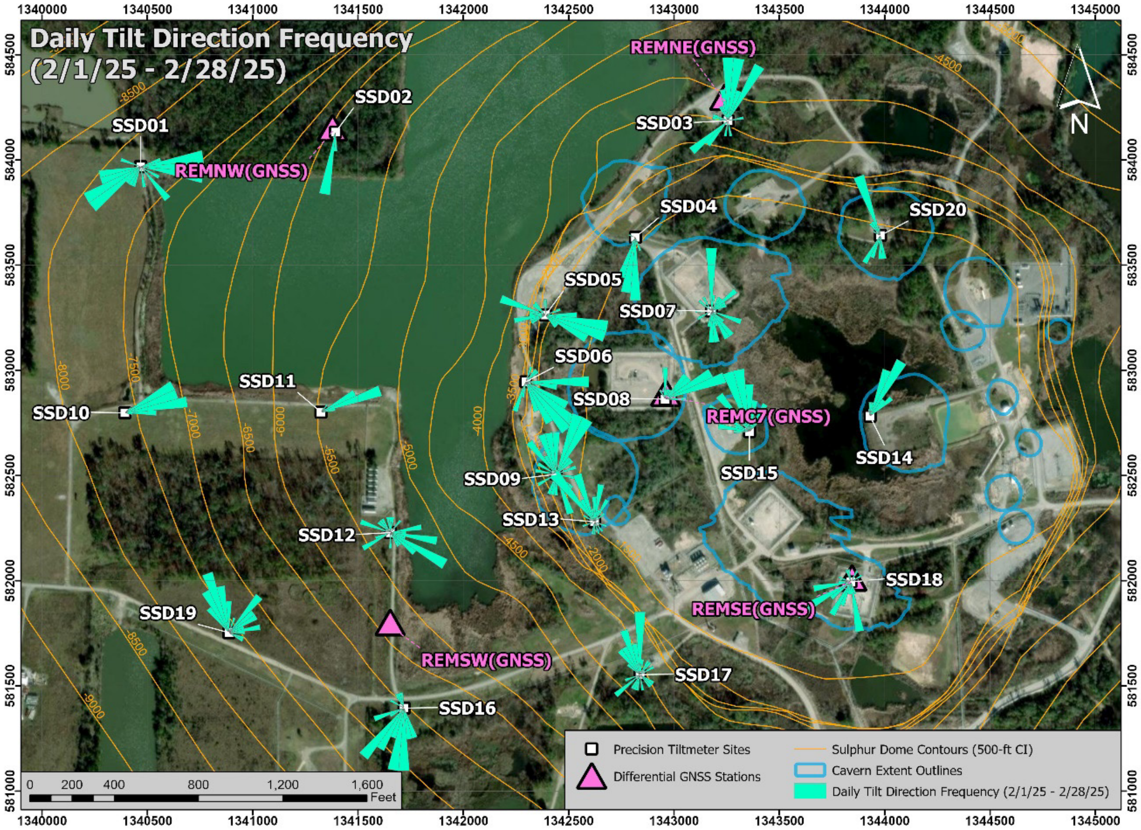


Figure 5. Map of daily tilt direction distribution for each tiltmeter for the current monthly reporting period. Rose diagrams indicate the number of days that tilt was oriented along specific azimuths (bin size is 10°).

Deformation Alert System Update

We continue testing a draft deformation alert system that incorporates the magnitude of daily tiltmeter readings using non-Gaussian statistics across the full tiltmeter network. This allows for the appropriate interpretation of long-duration tilt observations and helps bypass the effects of short-duration anomalous tilt signals associated with precipitation and mechanical activities near the monitoring sites. We plan to evaluate the tilt alert system until we are confident it will give reliable results. In addition, we will use this ongoing analysis to set and adjust the alert triggering thresholds and refine the appropriate response actions due to a change in the alert status.

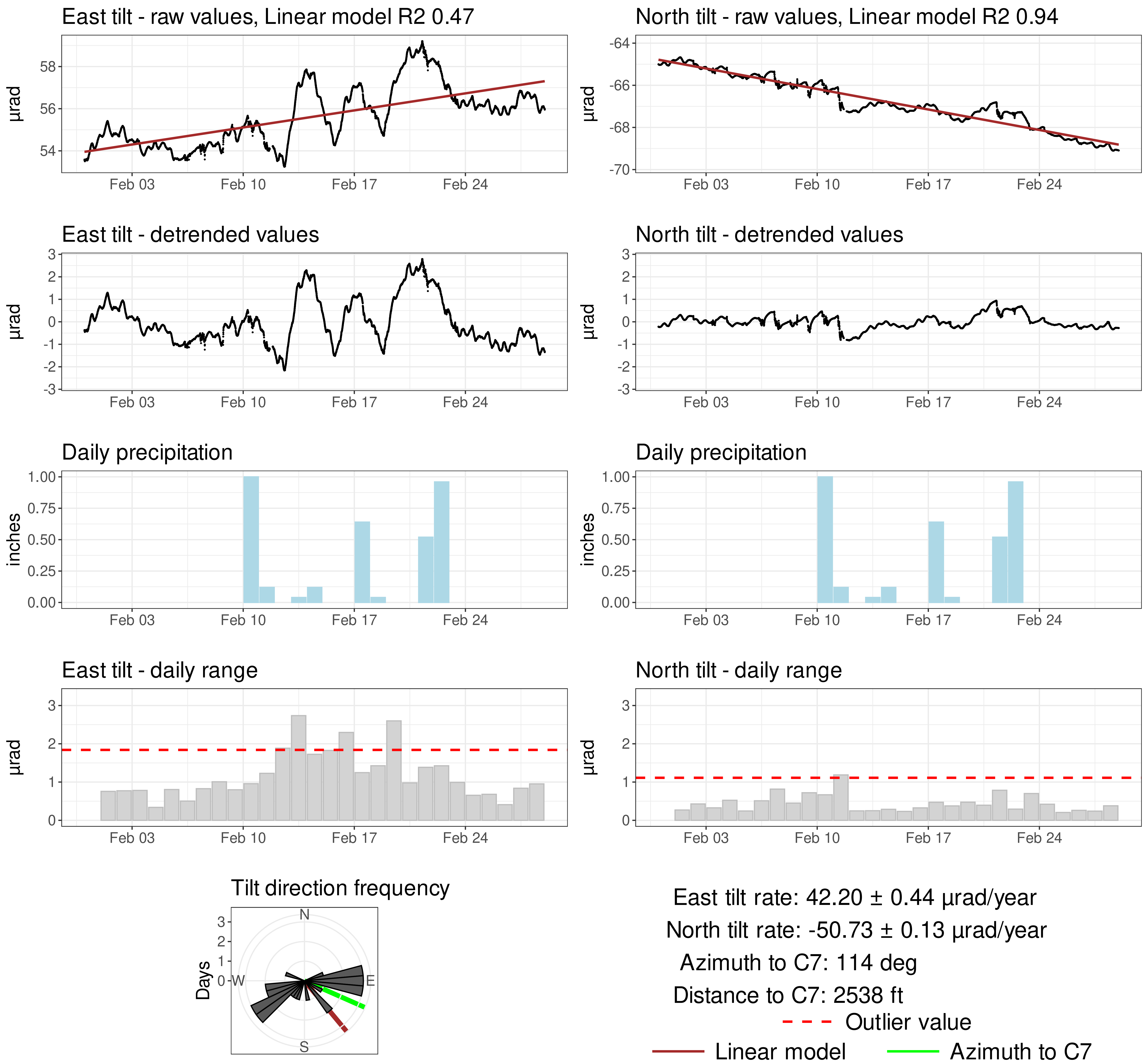
Our theoretical deformation (Mogi) modelling (discussed in the deformation monitoring plan dated December 22, 2023) indicates that deep deformation associated with potential changes in volume at Cavern 7 (located at a depth of approximately 2,500 to 3,160 feet) is expected to impact the entire tiltmeter array. If the deformation moves upward from Cavern 7, we anticipate that the corresponding tiltmeter response will be concentrated at the stations nearest the cavern, and the tilt magnitude will increase. In contrast, local, shallow deformation, such as movement in the caprock, is likely to affect only the nearby tiltmeters.

We anticipate that short-term deformation alert levels will be evaluated with the other real-time monitoring observations currently active at Sulphur Mines, which include the Cavern 7 pressure and microseismic monitoring. Additionally, long-term trends from GNSS and InSAR, which typically become available with some delay, will also be necessary for ongoing alert assessments.

APPENDIX 1

Tiltmeter Data Plots

SSD01: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



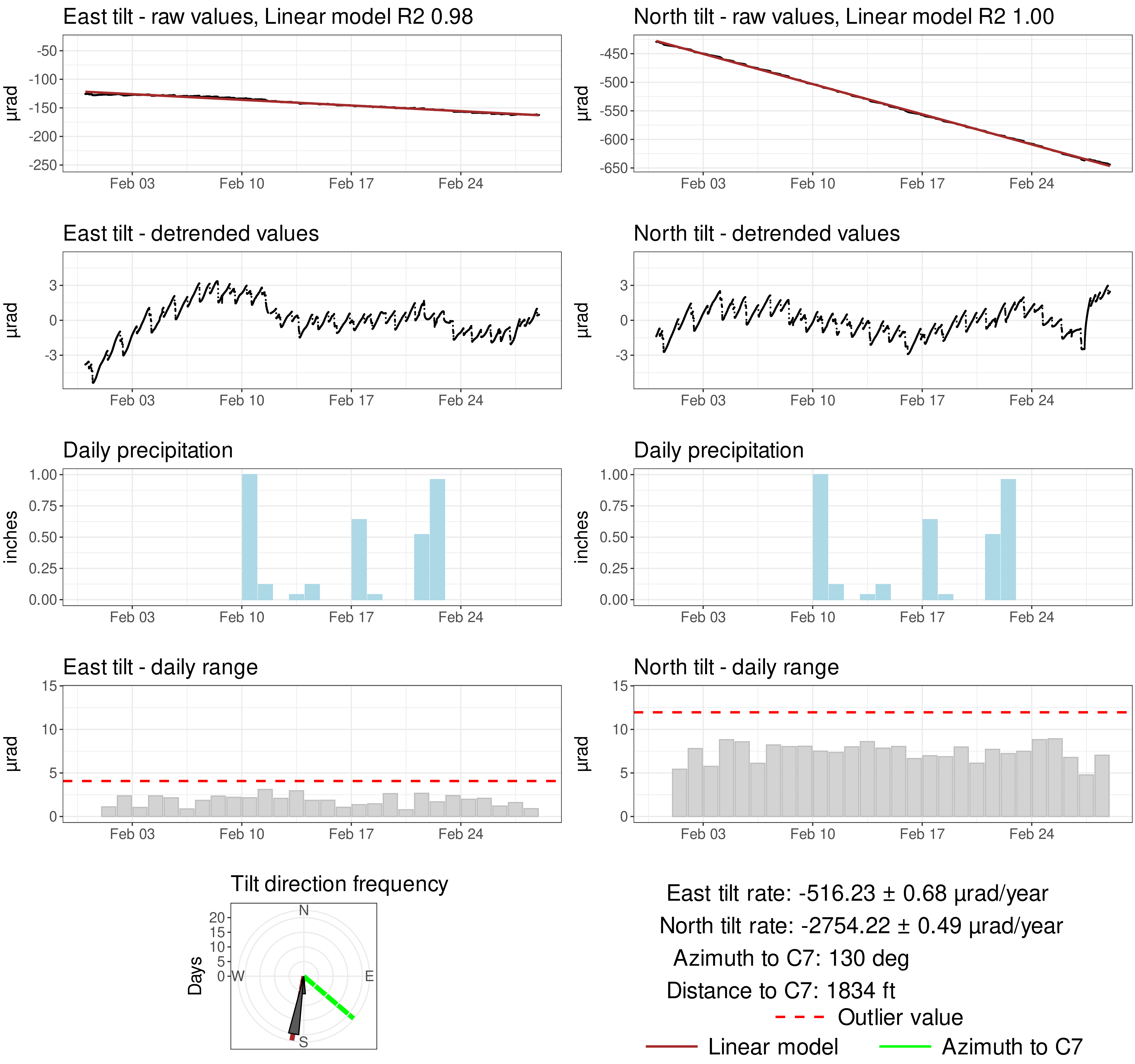
East tilt rate: 42.20 ± 0.44 µrad/year

North tilt rate: -50.73 ± 0.13 µrad/year

Azimuth to C7: 114 deg

Distance to C7: 2538 ft

SSD02: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



East tilt - raw values, Linear model R2 0.98

North tilt - raw values, Linear model R2 1.00

East tilt - detrended values

North tilt - detrended values

Daily precipitation

Daily precipitation

East tilt - daily range

North tilt - daily range

Tilt direction frequency

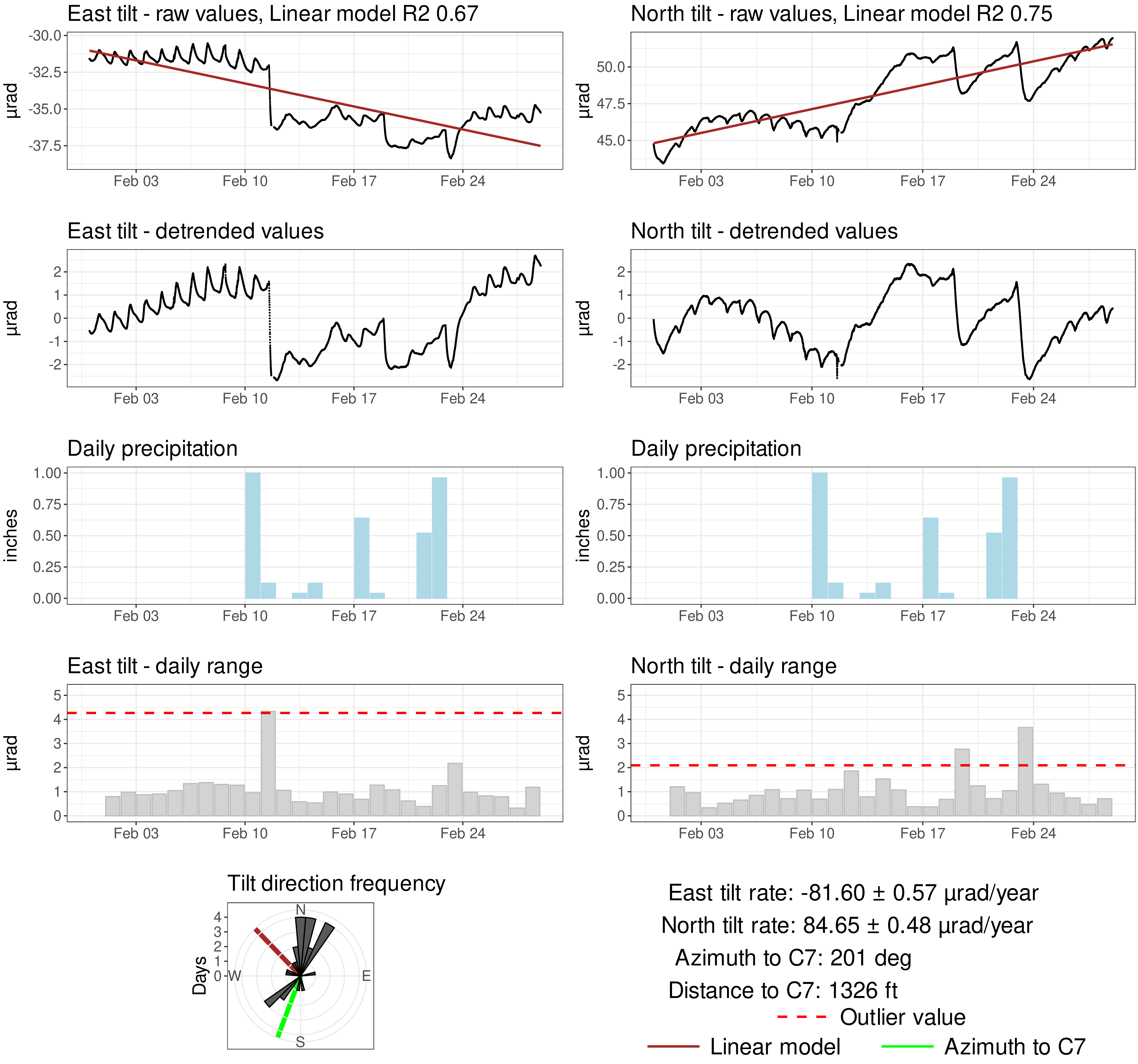
East tilt rate: -516.23 ± 0.68 µrad/year

North tilt rate: -2754.22 ± 0.49 µrad/year

Azimuth to C7: 130 deg

Distance to C7: 1834 ft

SSD03: Analyzed range: 06/09/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



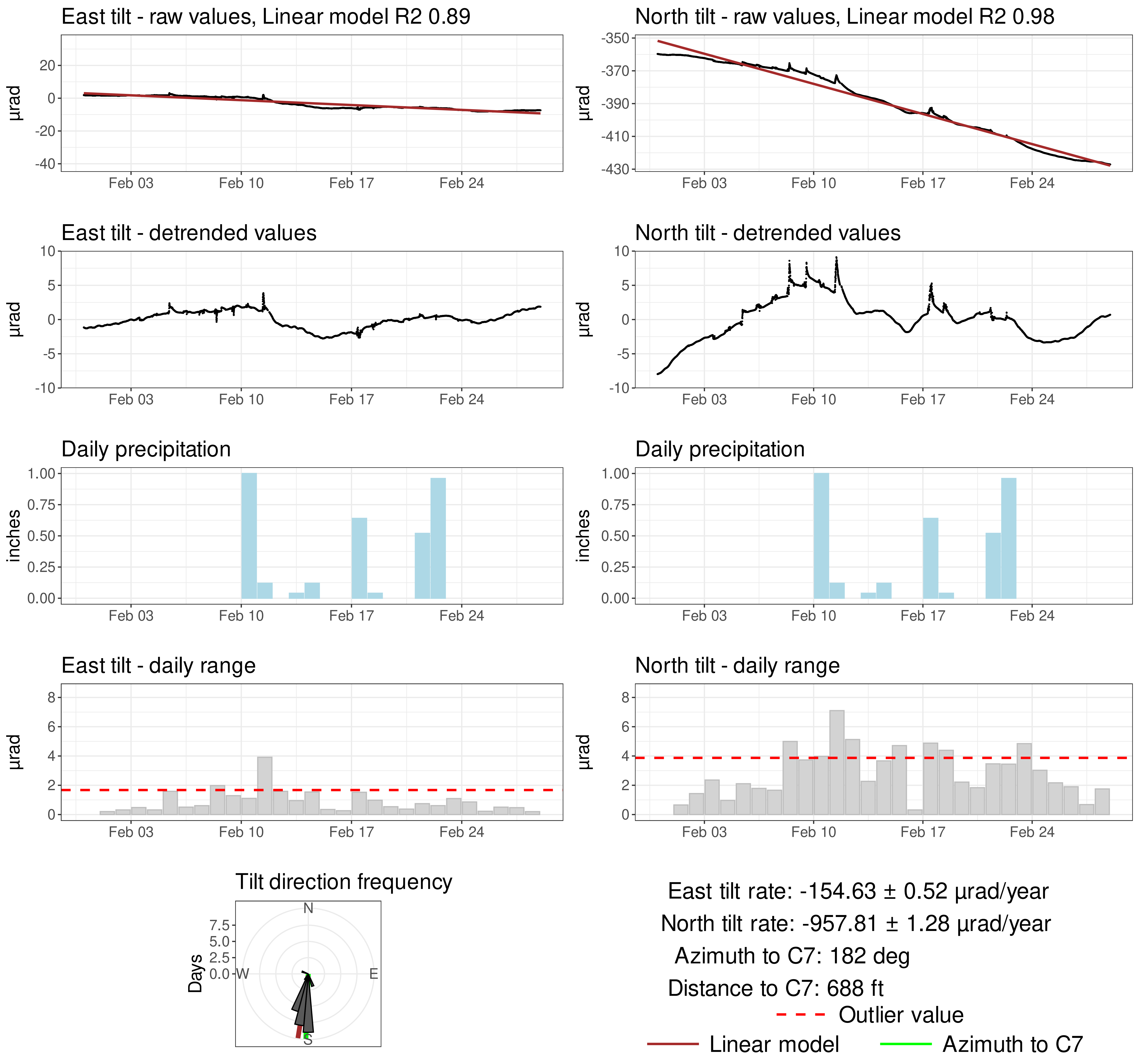
East tilt rate: -81.60 ± 0.57 µrad/year

North tilt rate: 84.65 ± 0.48 µrad/year

Azimuth to C7: 201 deg

Distance to C7: 1326 ft

SSD04: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



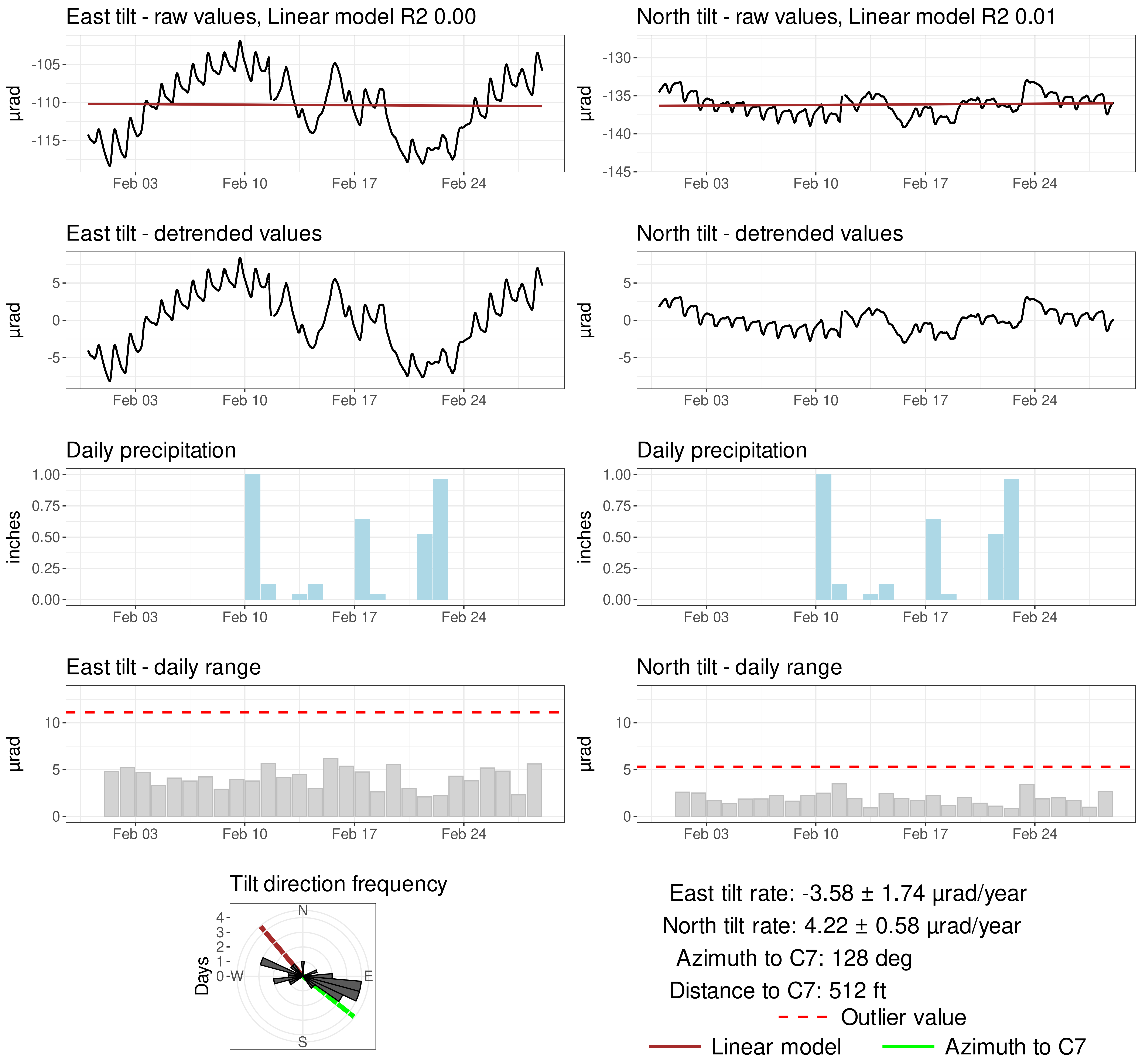
East tilt rate: -154.63 ± 0.52 µrad/year

North tilt rate: -957.81 ± 1.28 µrad/year

Azimuth to C7: 182 deg

Distance to C7: 688 ft

SSD05: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



East tilt - raw values, Linear model R2 0.00

North tilt - raw values, Linear model R2 0.01

East tilt - detrended values

North tilt - detrended values

Daily precipitation

Daily precipitation

East tilt - daily range

North tilt - daily range

Tilt direction frequency

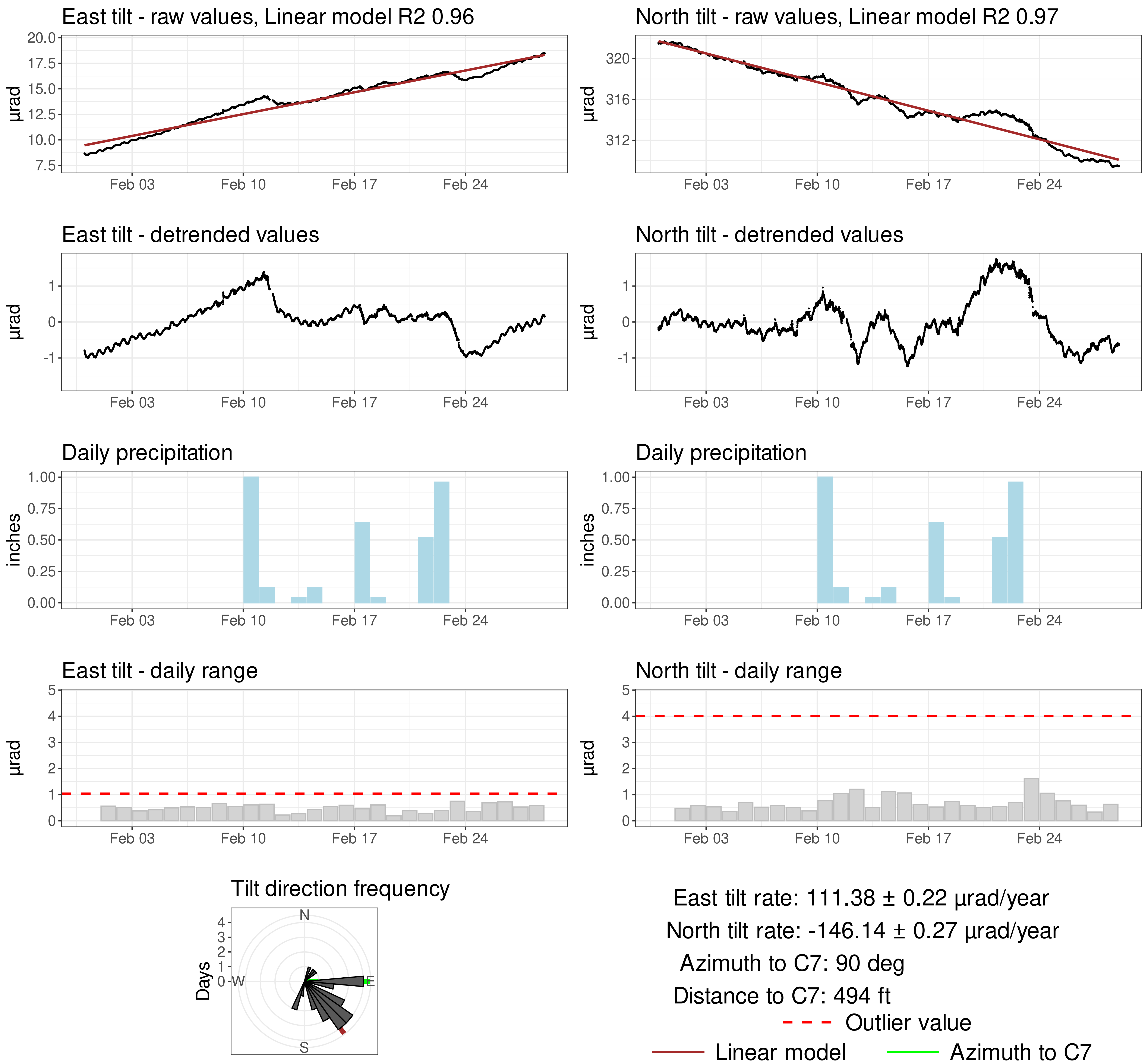
East tilt rate: -3.58 ± 1.74 µrad/year

North tilt rate: 4.22 ± 0.58 µrad/year

Azimuth to C7: 128 deg

Distance to C7: 512 ft

SSD06: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



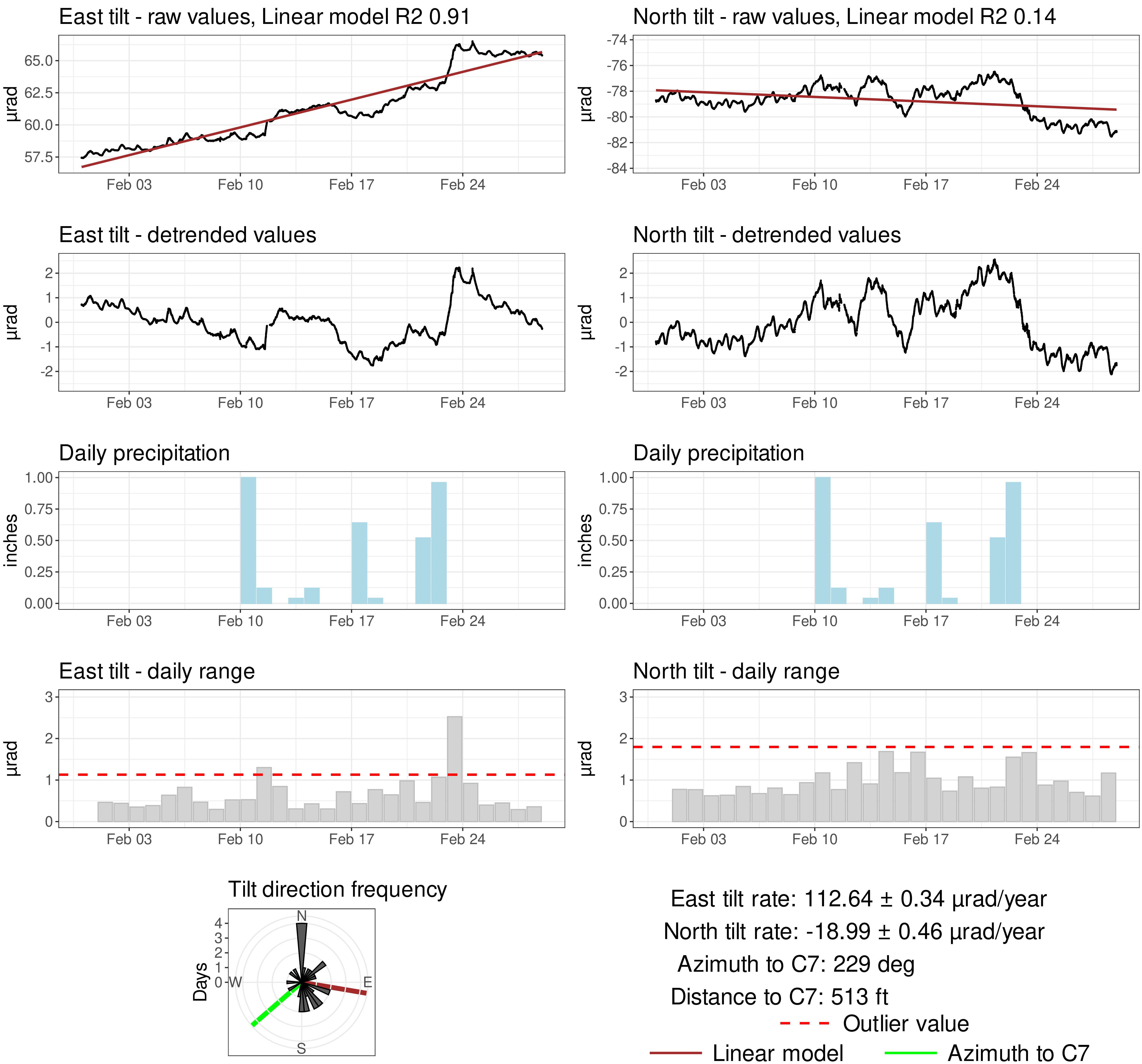
East tilt rate: 111.38 ± 0.22 µrad/year

North tilt rate: -146.14 ± 0.27 µrad/year

Azimuth to C7: 90 deg

Distance to C7: 494 ft

SSD07: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



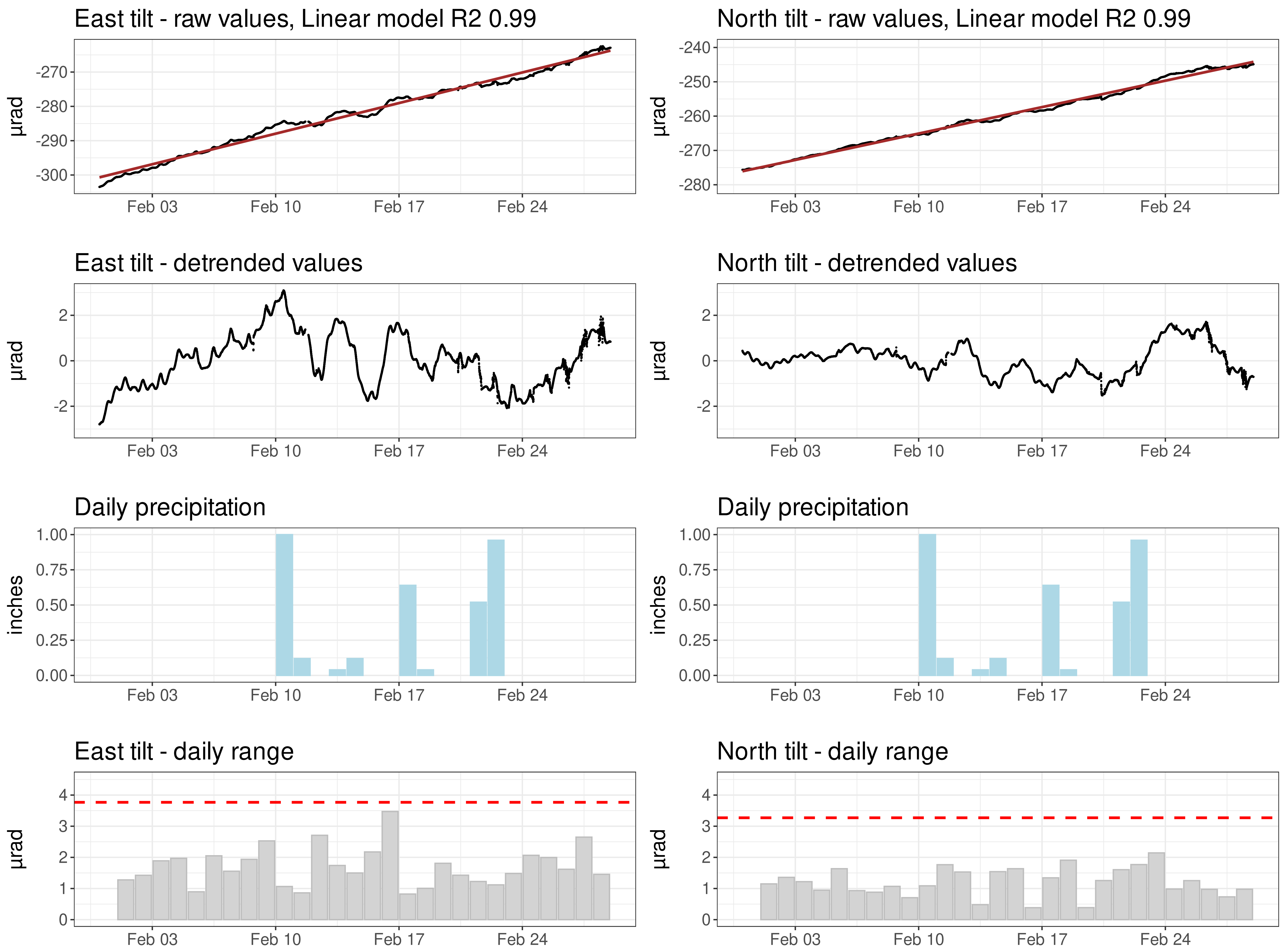
East tilt rate: 112.64 ± 0.34 µrad/year

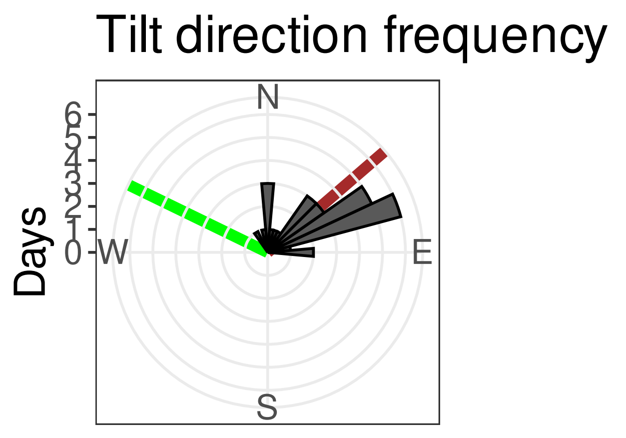
North tilt rate: -18.99 ± 0.46 µrad/year

Azimuth to C7: 229 deg

Distance to C7: 513 ft

SSD08: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)





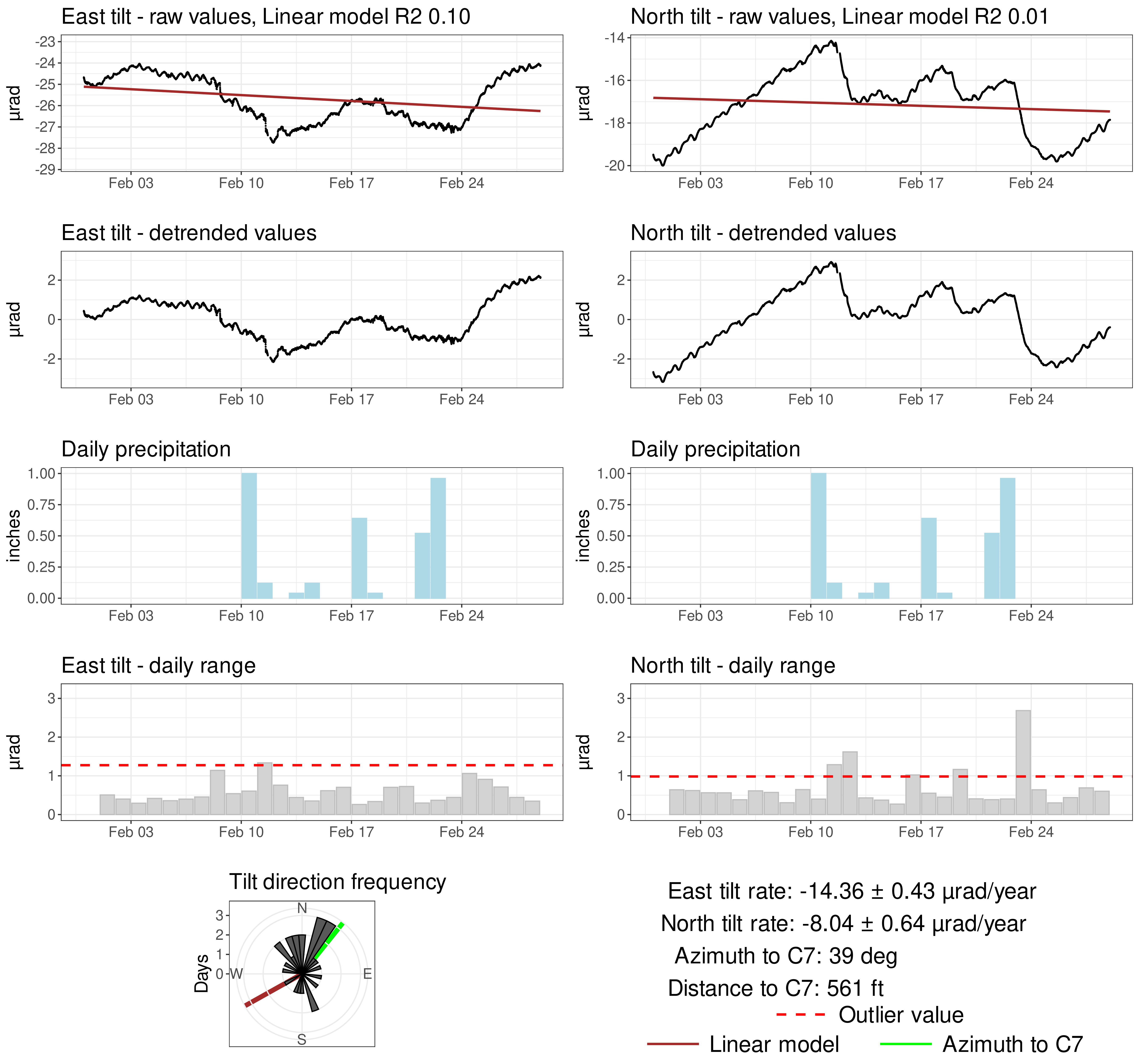
East tilt rate: 464.88 ± 0.50 µrad/year

North tilt rate: 401.39 ± 0.29 µrad/year

Azimuth to C7: 296 deg

Distance to C7: 186 ft

SSD09: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



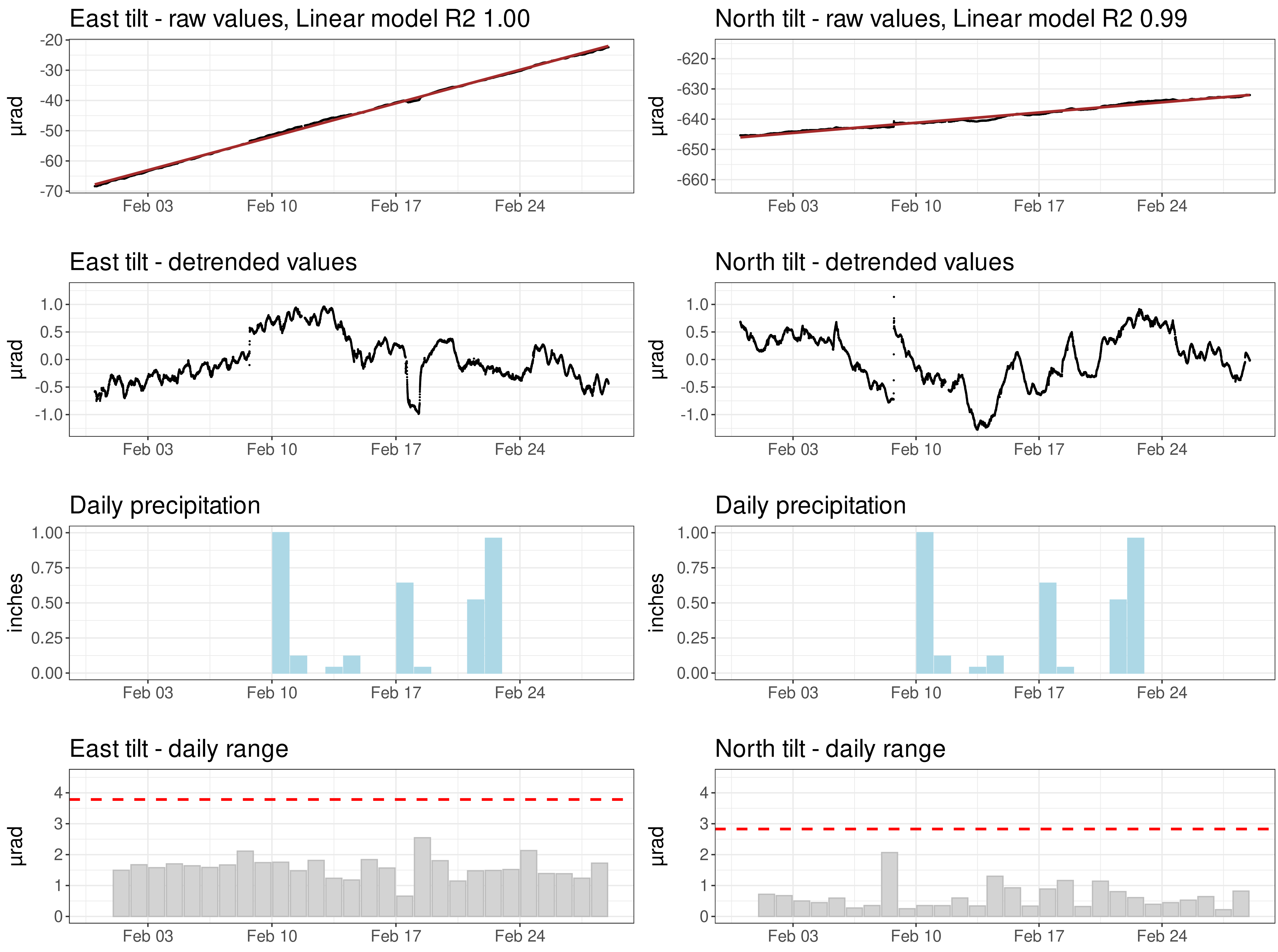
East tilt rate: -14.36 ± 0.43 µrad/year

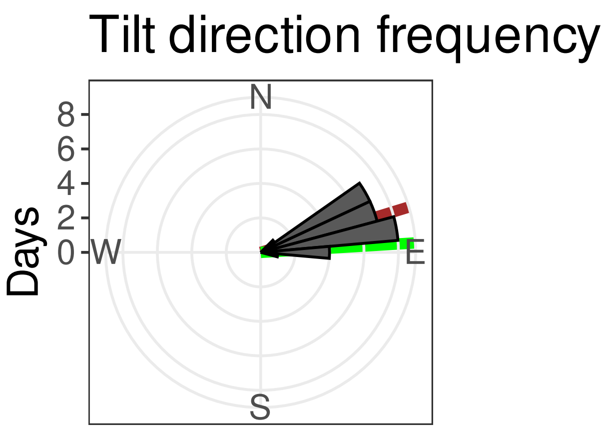
North tilt rate: -8.04 ± 0.64 µrad/year

Azimuth to C7: 39 deg

Distance to C7: 561 ft

SSD10: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)





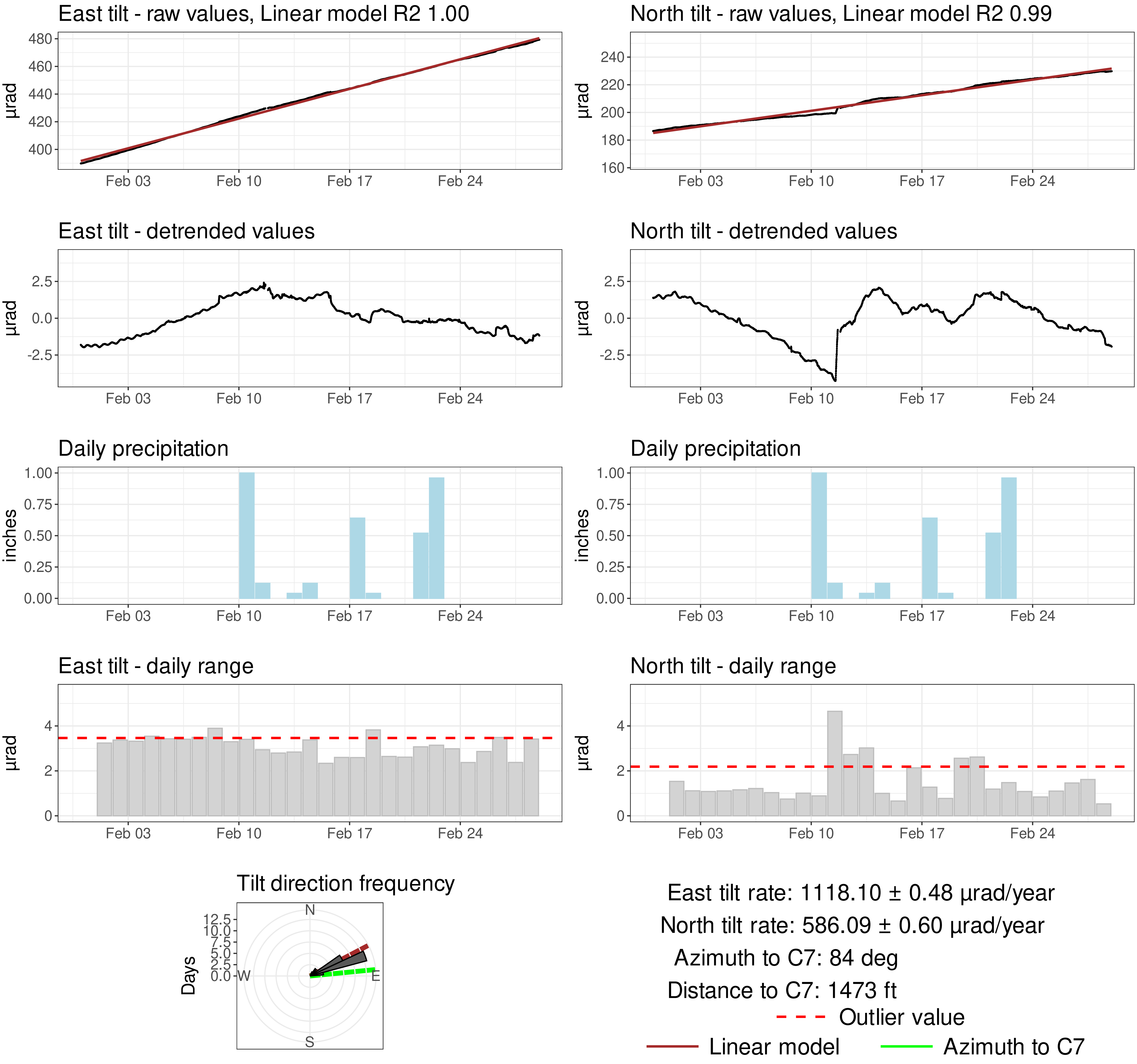
East tilt rate: 576.58 ± 0.18 µrad/year

North tilt rate: 176.31 ± 0.20 µrad/year

Azimuth to C7: 87 deg

Distance to C7: 2402 ft

SSD11: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



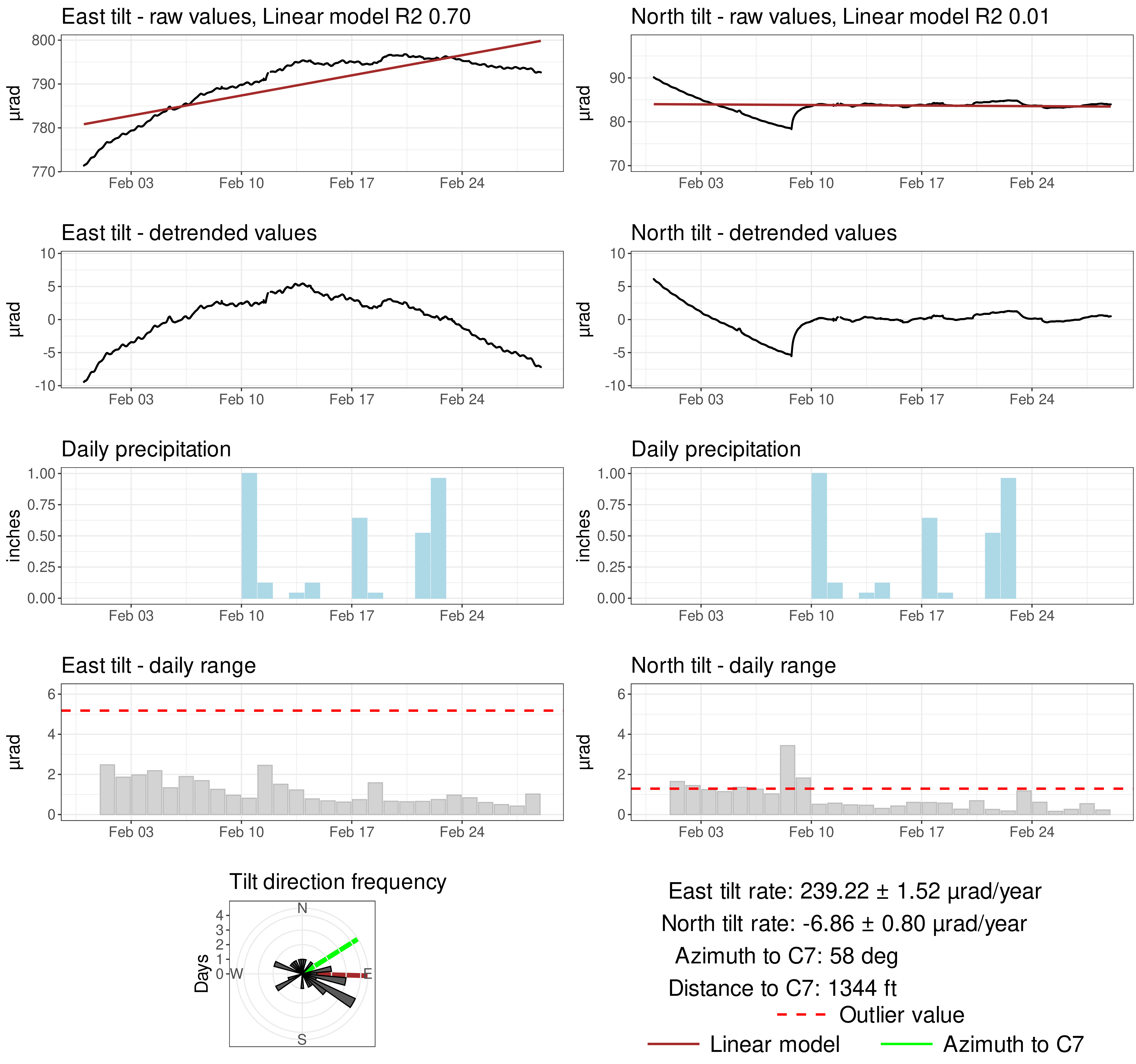
East tilt rate: 1118.10 ± 0.48 µrad/year

North tilt rate: 586.09 ± 0.60 µrad/year

Azimuth to C7: 84 deg

Distance to C7: 1473 ft

SSD12: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



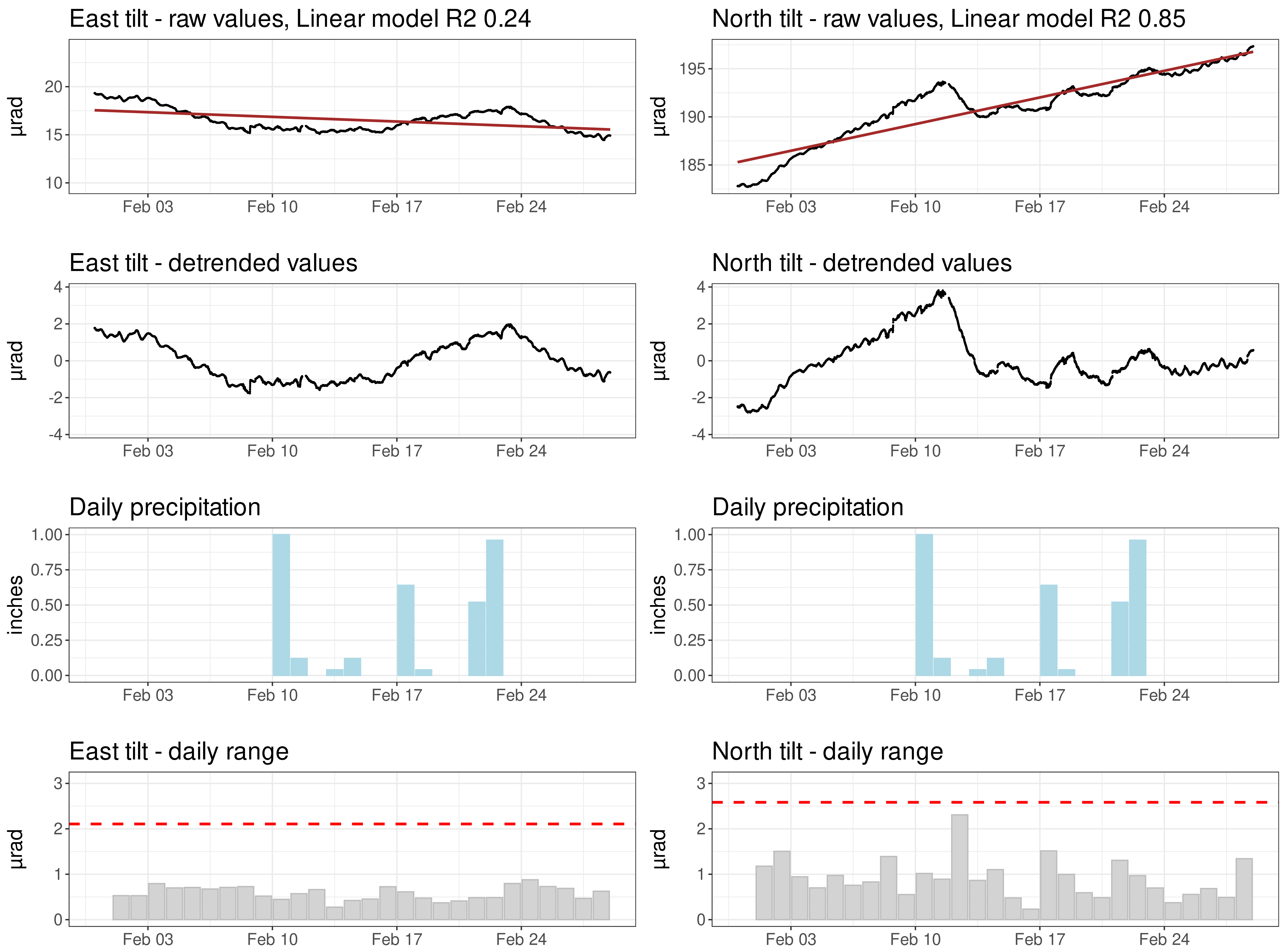
East tilt rate: 239.22 ± 1.52 µrad/year

North tilt rate: -6.86 ± 0.80 µrad/year

Azimuth to C7: 58 deg

Distance to C7: 1344 ft

SSD13: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



East tilt - raw values, Linear model R2 0.24

North tilt - raw values, Linear model R2 0.85

East tilt - detrended values

North tilt - detrended values

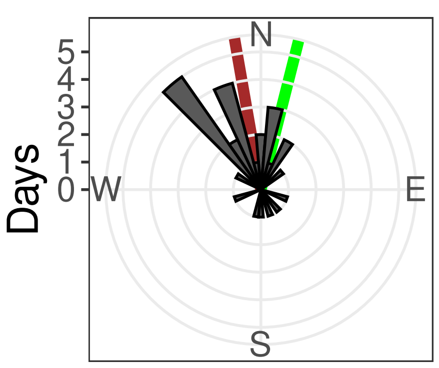
Daily precipitation

Daily precipitation

East tilt - daily range

North tilt - daily range

Tilt direction frequency



East tilt rate: -25.22 ± 0.45 µrad/year

North tilt rate: 144.45 ± 0.59 µrad/year

Azimuth to C7: 14 deg

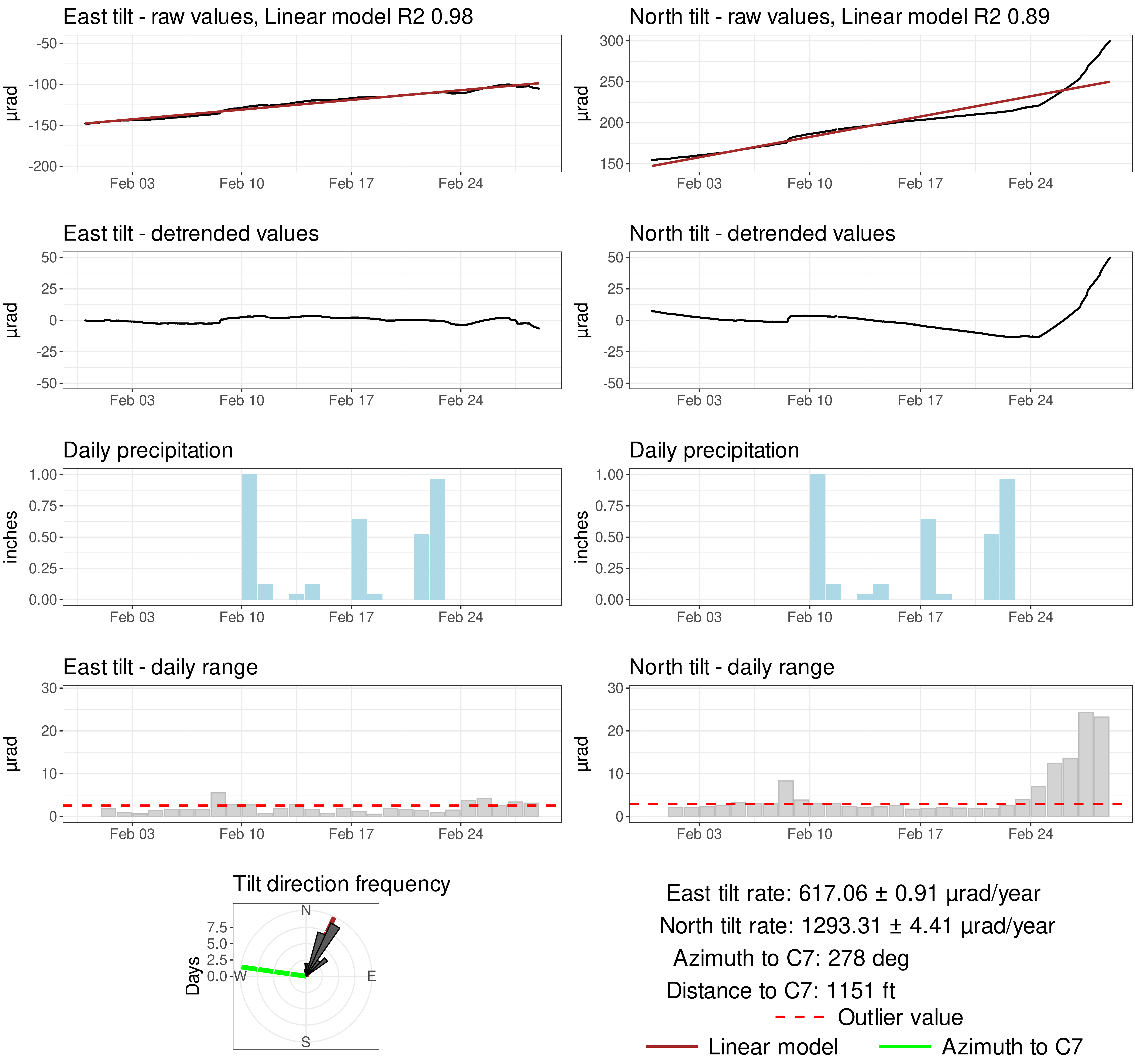
Distance to C7: 686 ft

Outlier value

Linear model

Azimuth to C7

SSD14: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



East tilt rate: 617.06 ± 0.91 µrad/year

North tilt rate: 1293.31 ± 4.41 µrad/year

Azimuth to C7: 278 deg

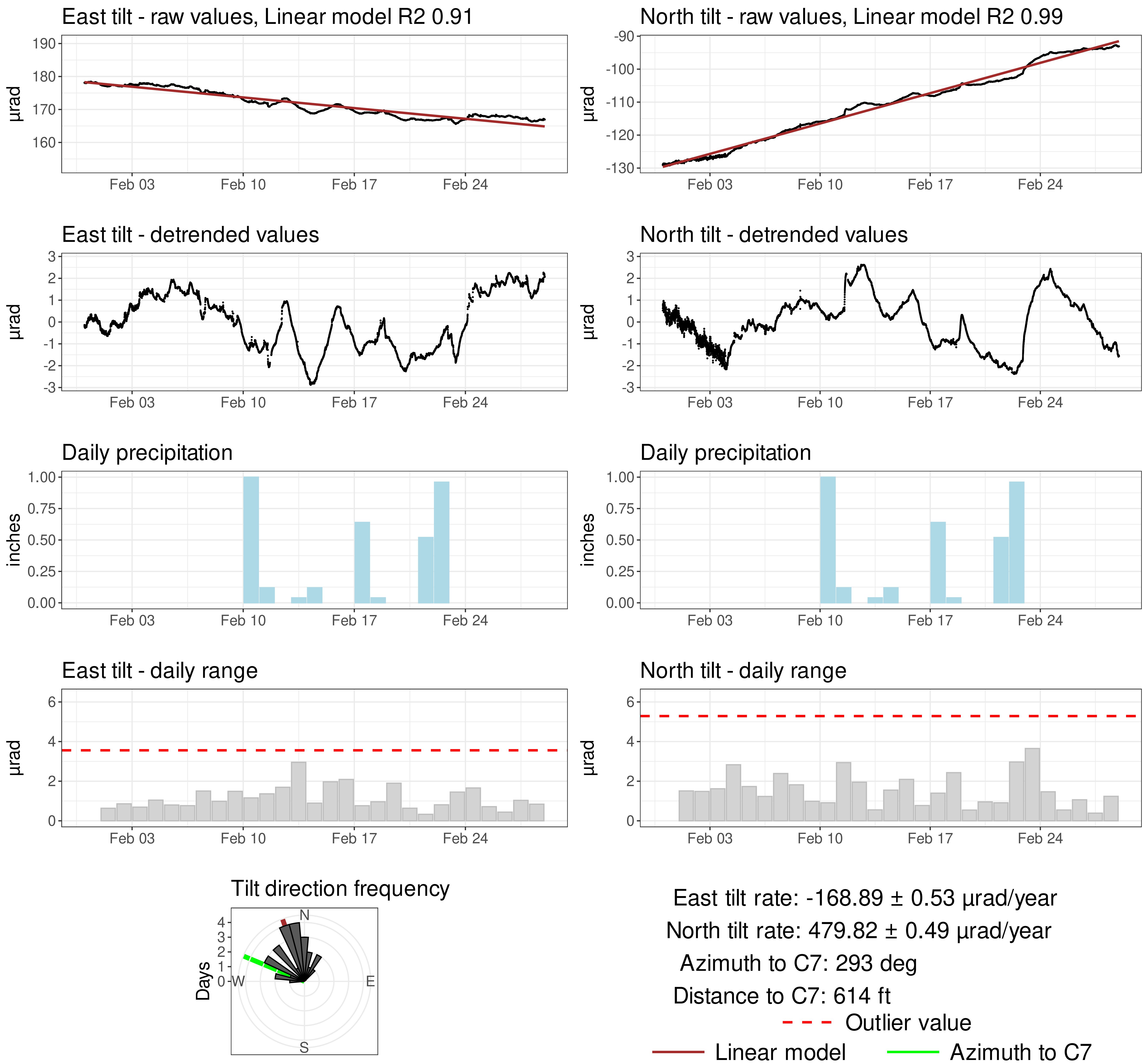
Distance to C7: 1151 ft

Outlier value

Linear model

Azimuth to C7

SSD15: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



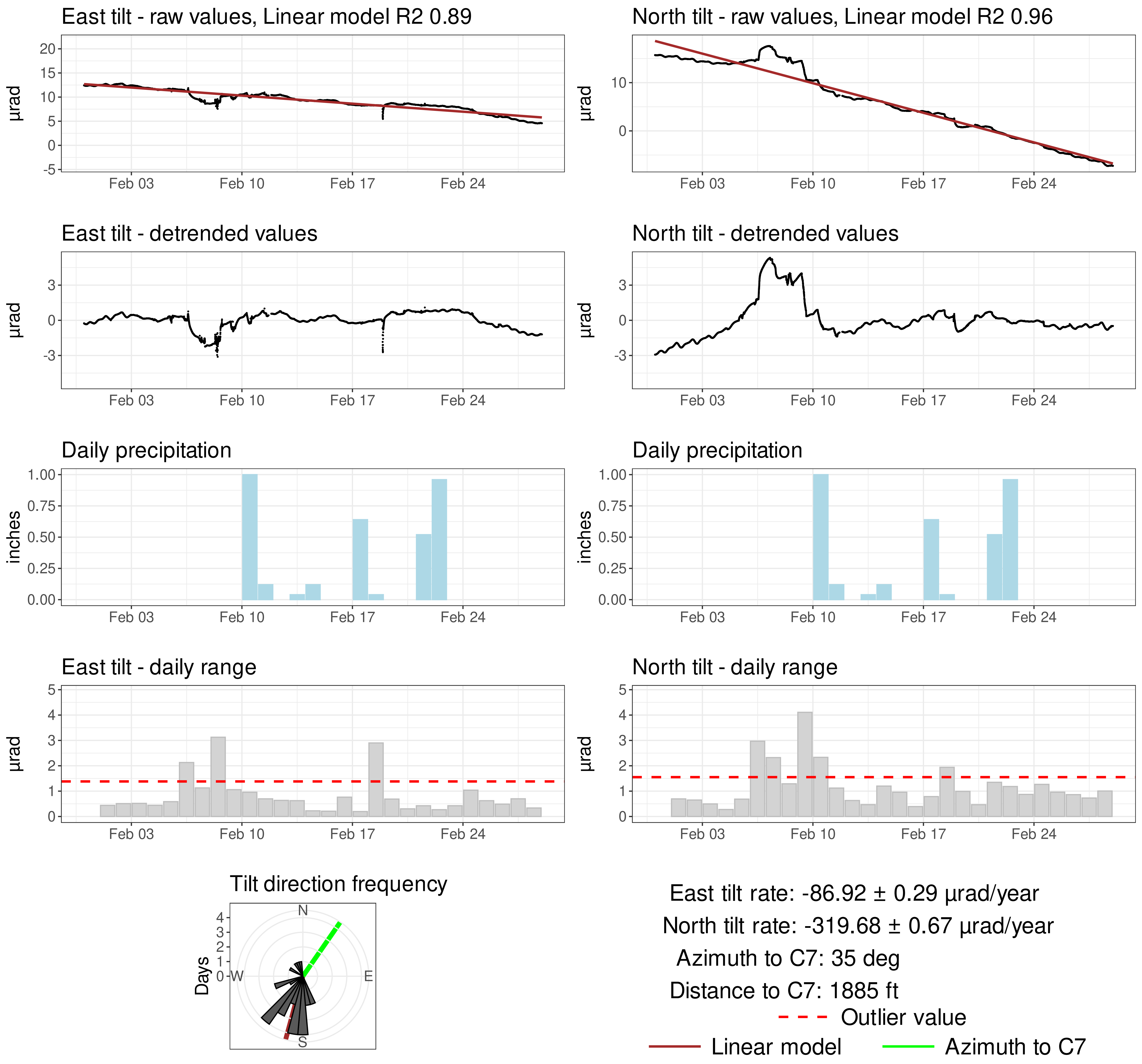
East tilt rate: -168.89 ± 0.53 µrad/year

North tilt rate: 479.82 ± 0.49 µrad/year

Azimuth to C7: 293 deg

Distance to C7: 614 ft

SSD16: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



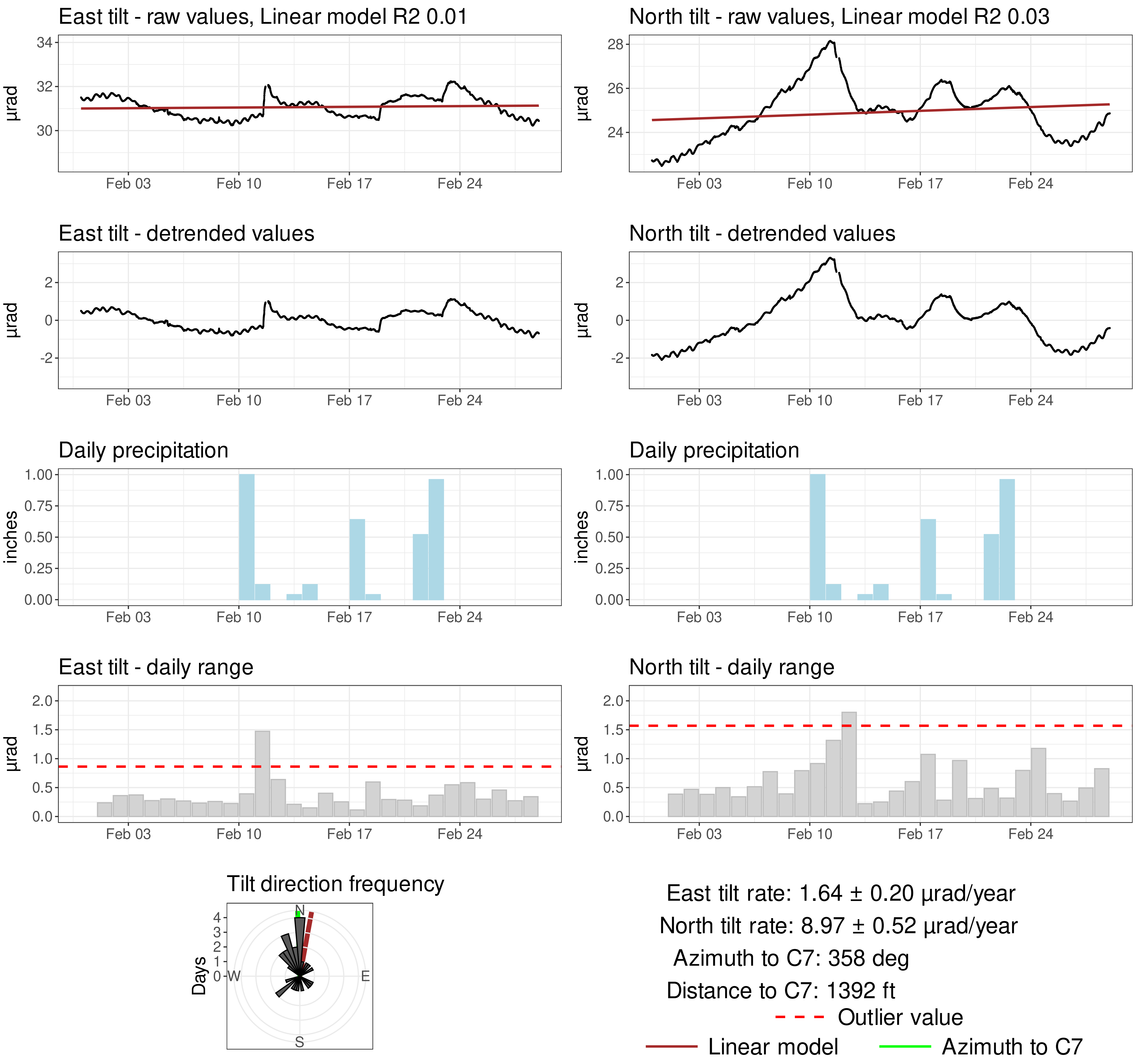
East tilt rate: -86.92 ± 0.29 µrad/year

North tilt rate: -319.68 ± 0.67 µrad/year

Azimuth to C7: 35 deg

Distance to C7: 1885 ft

SSD17: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



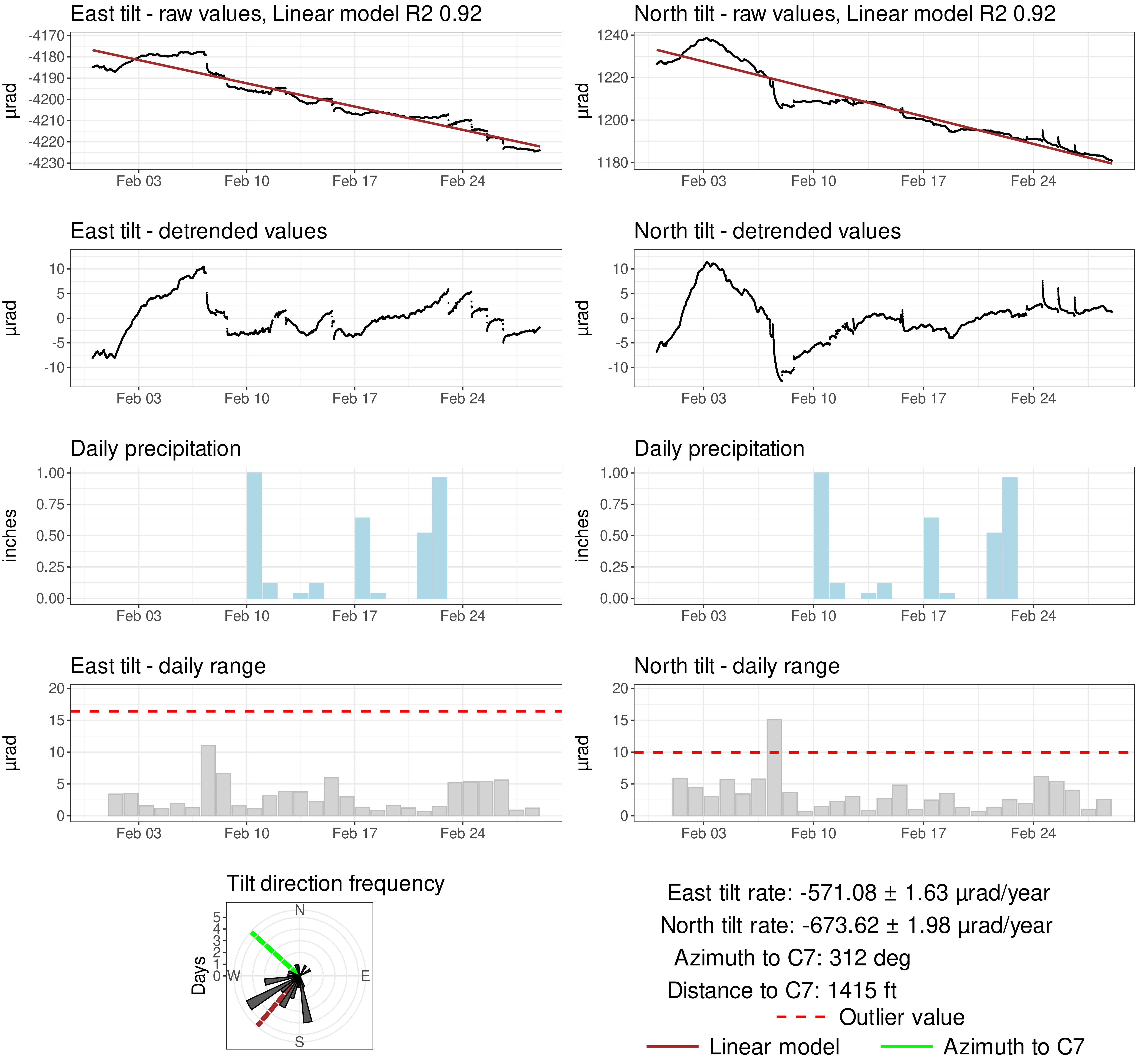
East tilt rate: 1.64 ± 0.20 µrad/year

North tilt rate: 8.97 ± 0.52 µrad/year

Azimuth to C7: 358 deg

Distance to C7: 1392 ft

SSD18: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



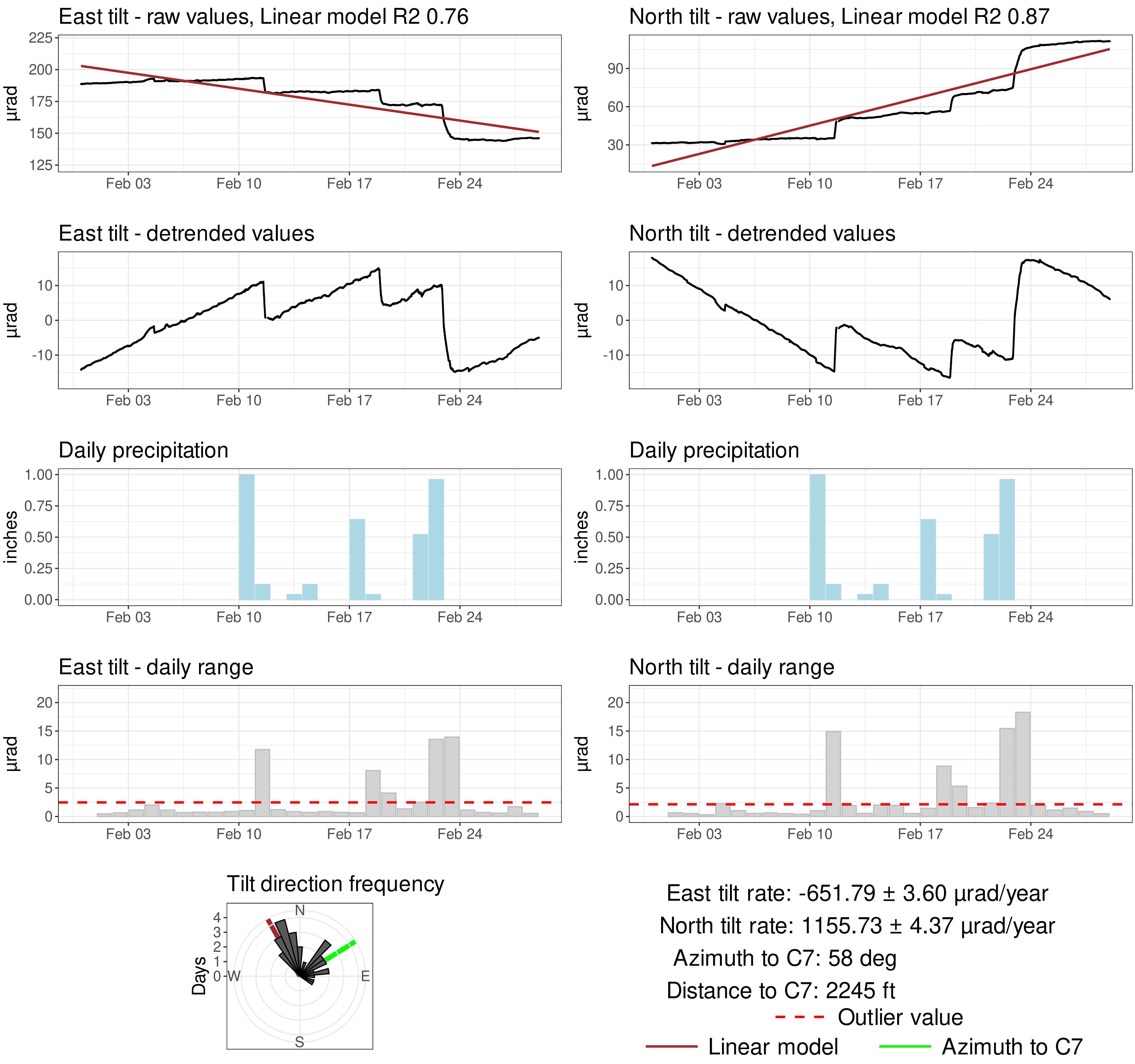
East tilt rate: -571.08 ± 1.63 µrad/year

North tilt rate: -673.62 ± 1.98 µrad/year

Azimuth to C7: 312 deg

Distance to C7: 1415 ft

SSD19: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



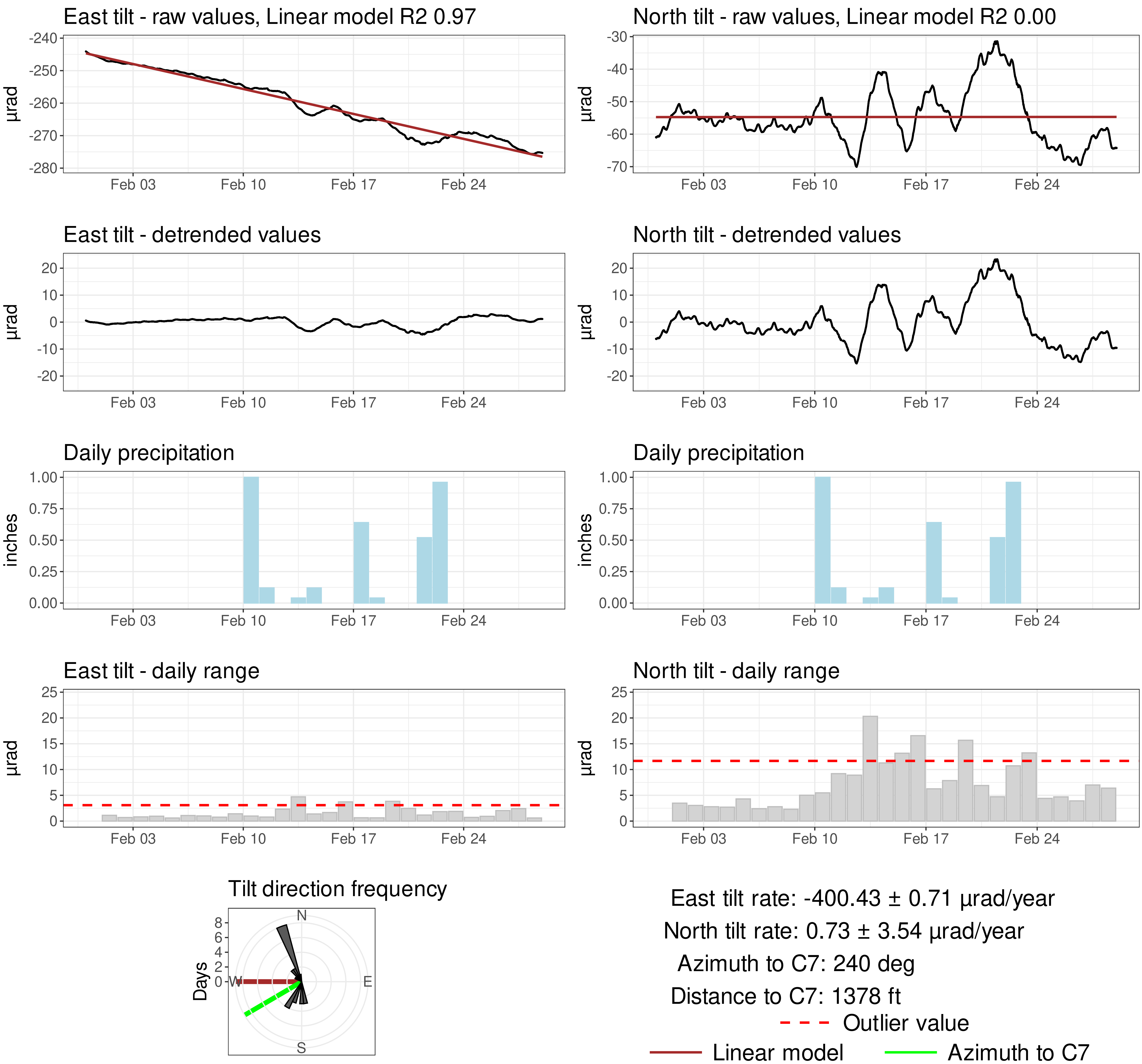
East tilt rate: -651.79 ± 3.60 µrad/year

North tilt rate: 1155.73 ± 4.37 µrad/year

Azimuth to C7: 58 deg

Distance to C7: 2245 ft

SSD20: Analyzed range: 06/02/2024 - 03/11/2025 | Plotted range: 02/01/2025 - 02/28/2025 (CTZ)



East tilt rate: -400.43 ± 0.71 µrad/year

North tilt rate: 0.73 ± 3.54 µrad/year

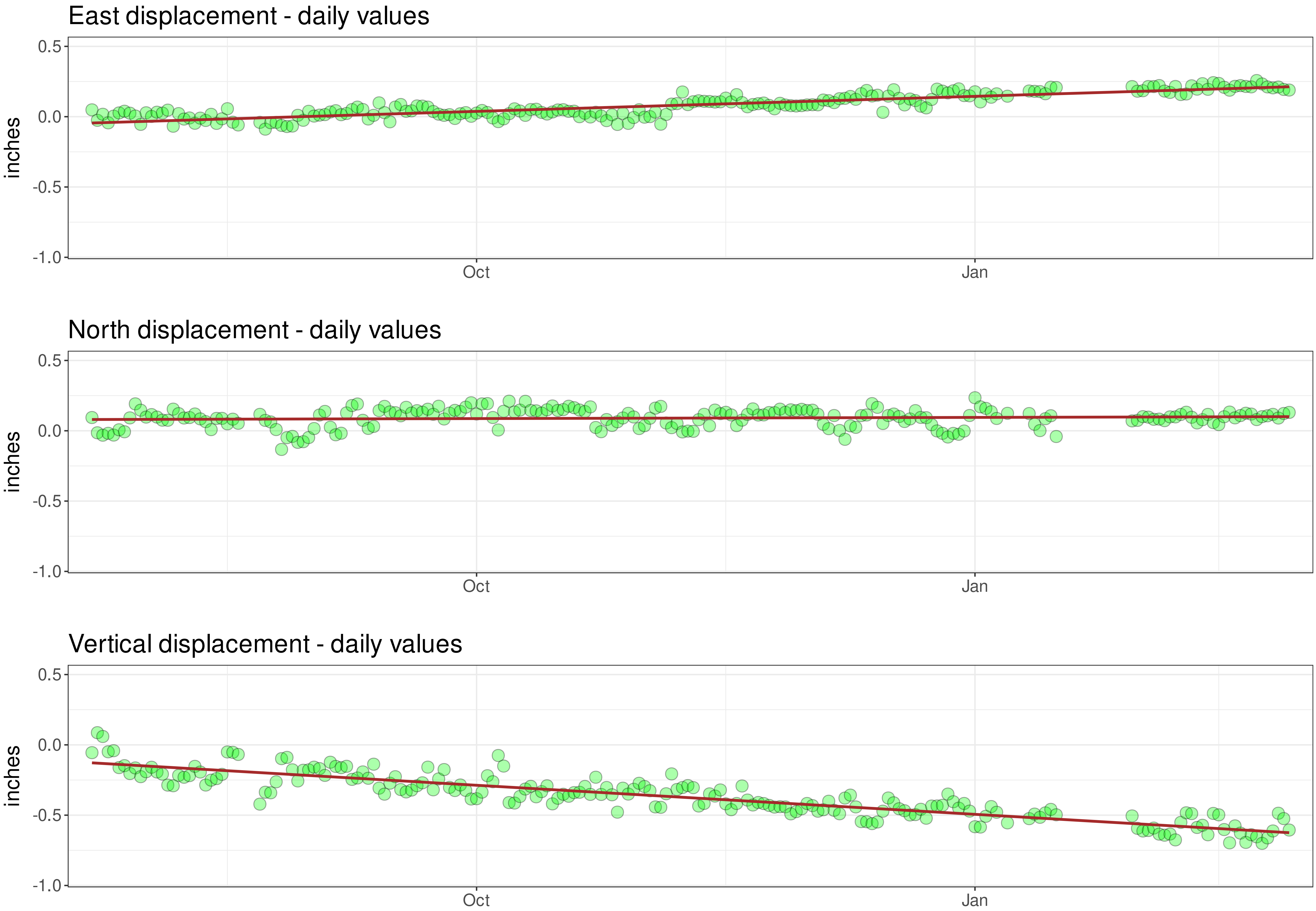
Azimuth to C7: 240 deg

Distance to C7: 1378 ft

APPENDIX 2

GNSS Data Plots

REMC7: Plotted range: 07/22/2024 - 02/28/2025 (CTZ)


East displacement - daily values

North displacement - daily values

Vertical displacement - daily values

Local east rate: 0.909 ± 0.025 inches/year, R2: 0.76

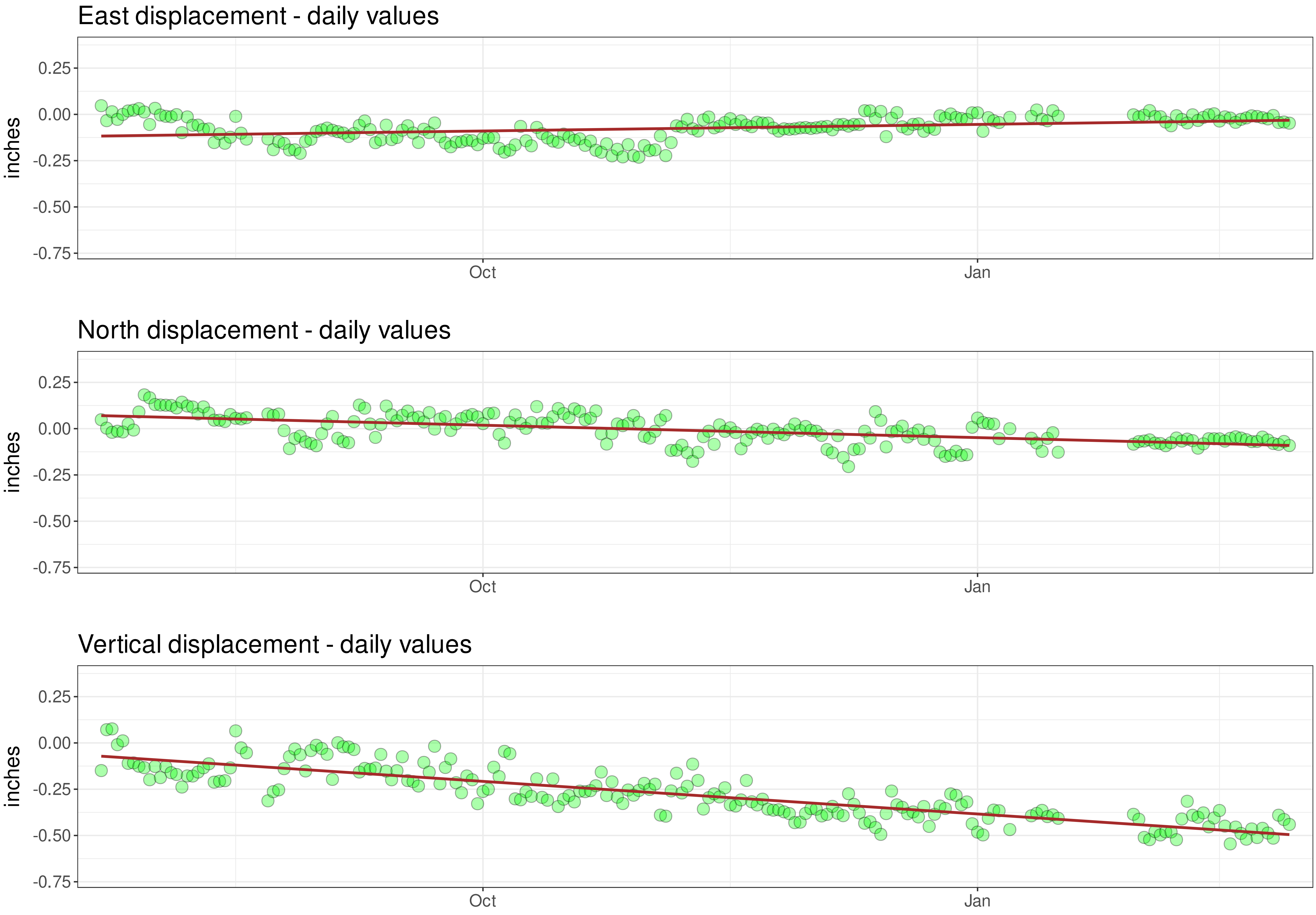
Local north rate: 0.075 ± 0.032 inches/year, R2: 0.01

Local vertical rate: -0.742 ± 0.063 inches/year, R2: 0.80

Linear model

Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMNE: Plotted range: 07/22/2024 - 02/28/2025 (CTZ)



Local east rate: 0.623 ± 0.031 inches/year, R2: 0.14

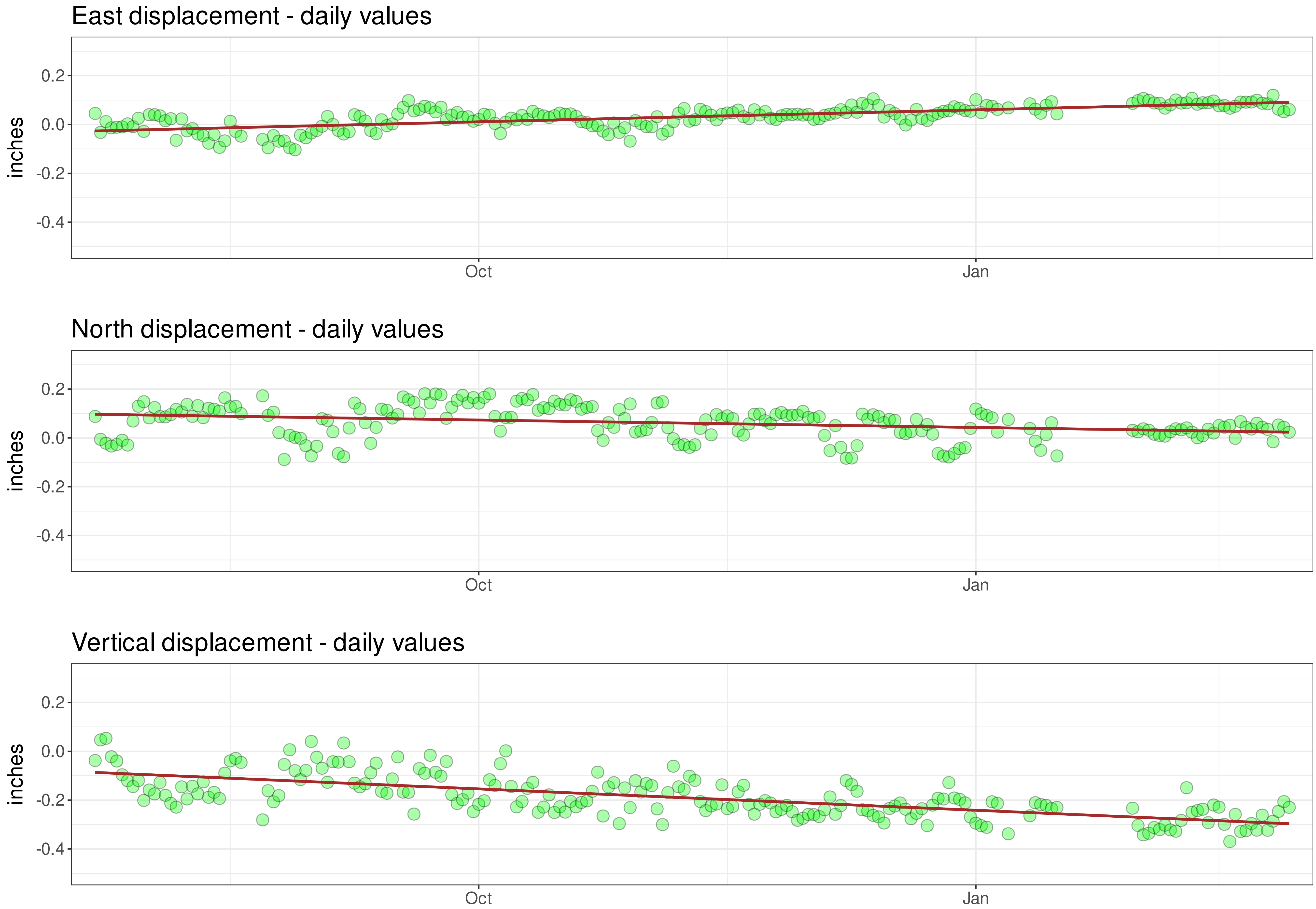
Local north rate: -0.224 ± 0.030 inches/year, R2: 0.37

Local vertical rate: -0.621 ± 0.063 inches/year, R2: 0.73

— Linear model

Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMNW: Plotted range: 07/22/2024 - 02/28/2025 (CTZ)



Local east rate: 0.677 ± 0.023 inches/year, R2: 0.51

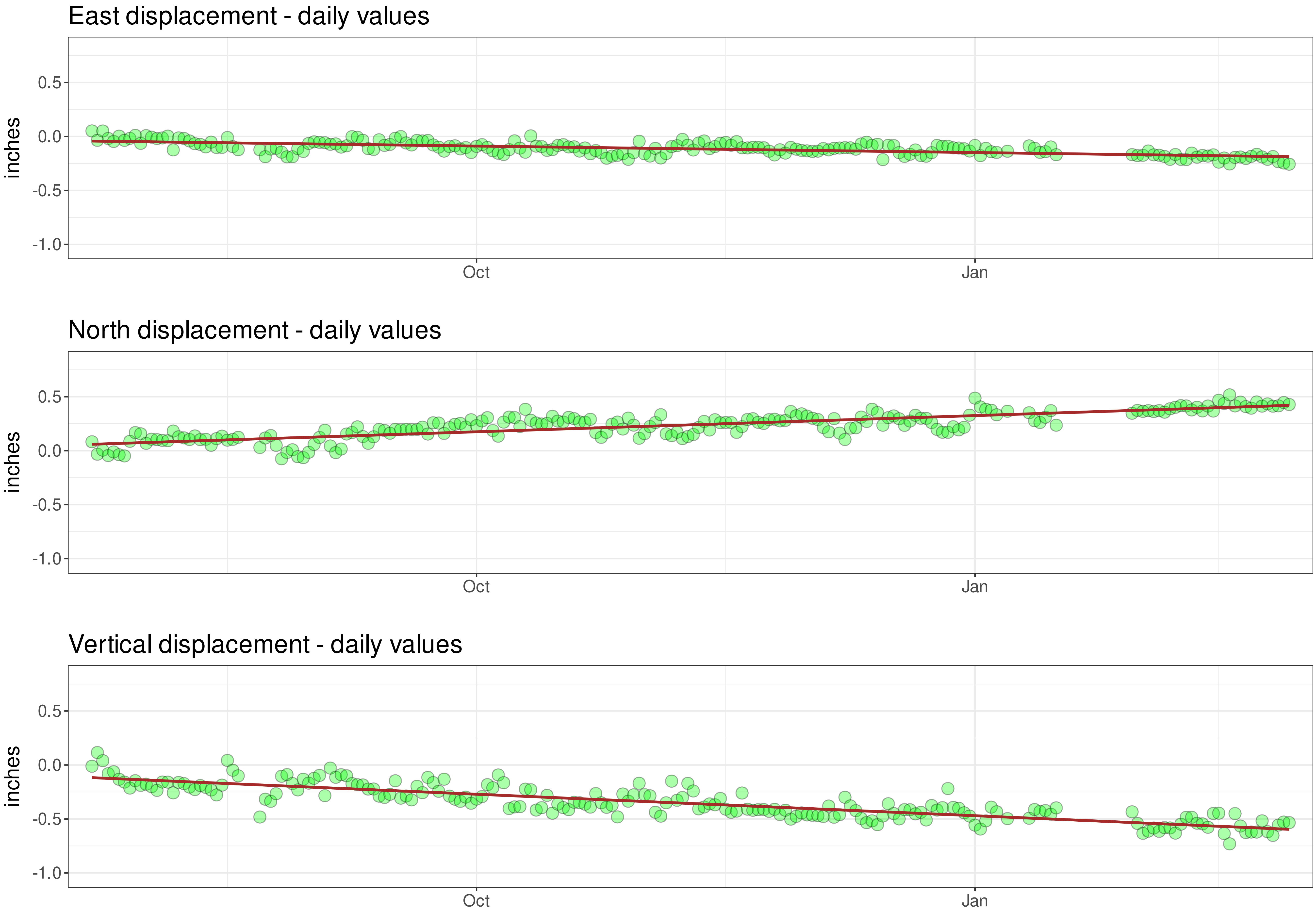
Local north rate: -0.079 ± 0.031 inches/year, R2: 0.10

Local vertical rate: -0.268 ± 0.061 inches/year, R2: 0.47

— Linear model

Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMSE: Plotted range: 07/22/2024 - 02/28/2025 (CTZ)



Local east rate: 0.244 ± 0.026 inches/year, R2: 0.46

Local north rate: 0.638 ± 0.034 inches/year, R2: 0.68

Local vertical rate: -0.712 ± 0.065 inches/year, R2: 0.73

— Linear model

Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

REMSW: Plotted range: 07/22/2024 - 02/28/2025 (CTZ)

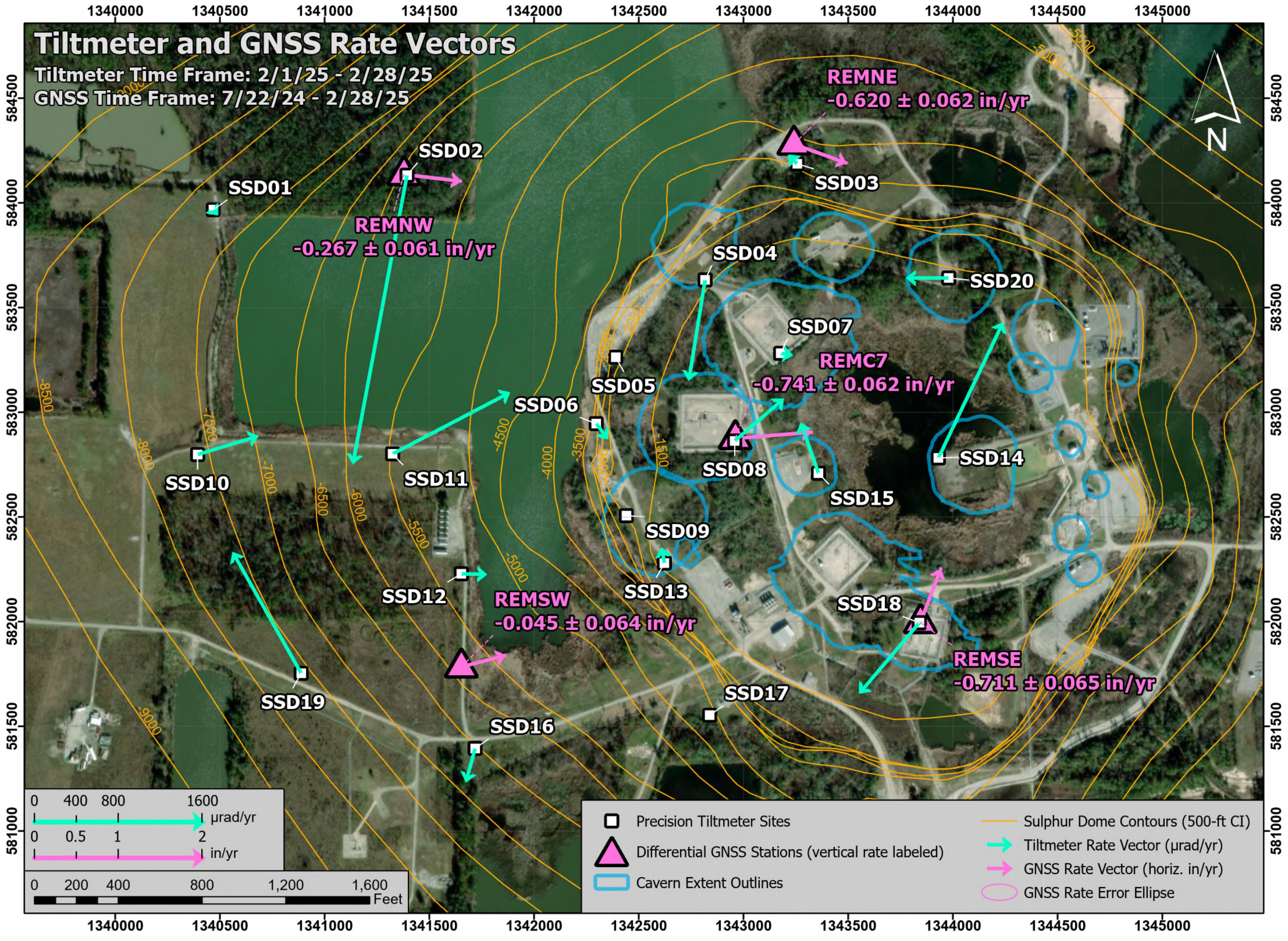
Local east rate:	0.524 ± 0.023 inches/year,	R2: 0.04
Local north rate:	0.136 ± 0.031 inches/year,	R2: 0.06
Local vertical rate:	-0.046 ± 0.064 inches/year,	R2: 0.07

— Linear model

Local rate values have been calculated by removing the regional tectonic plate rates from the raw data displayed in the charts.

APPENDIX 3

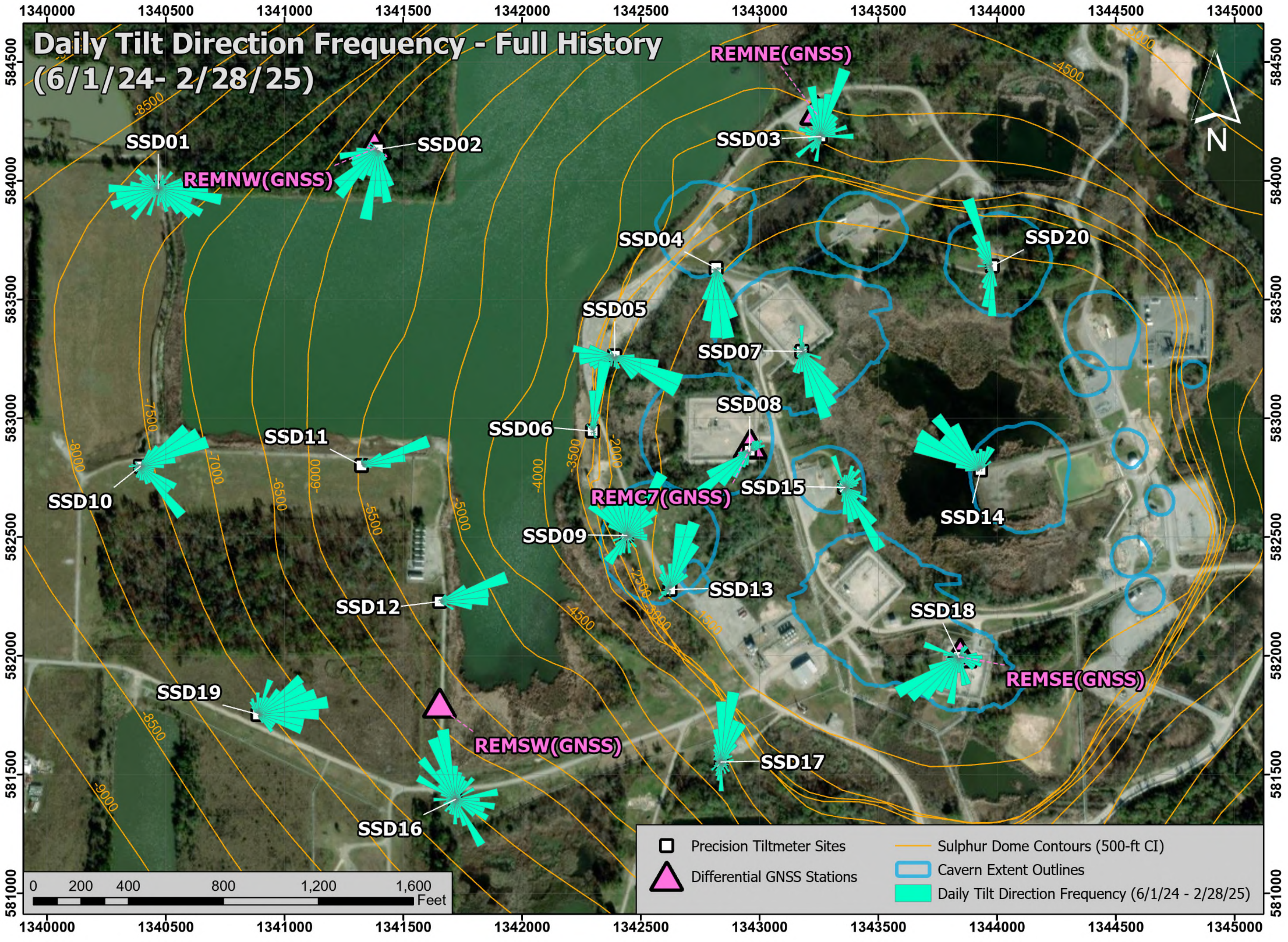
Analysis Maps

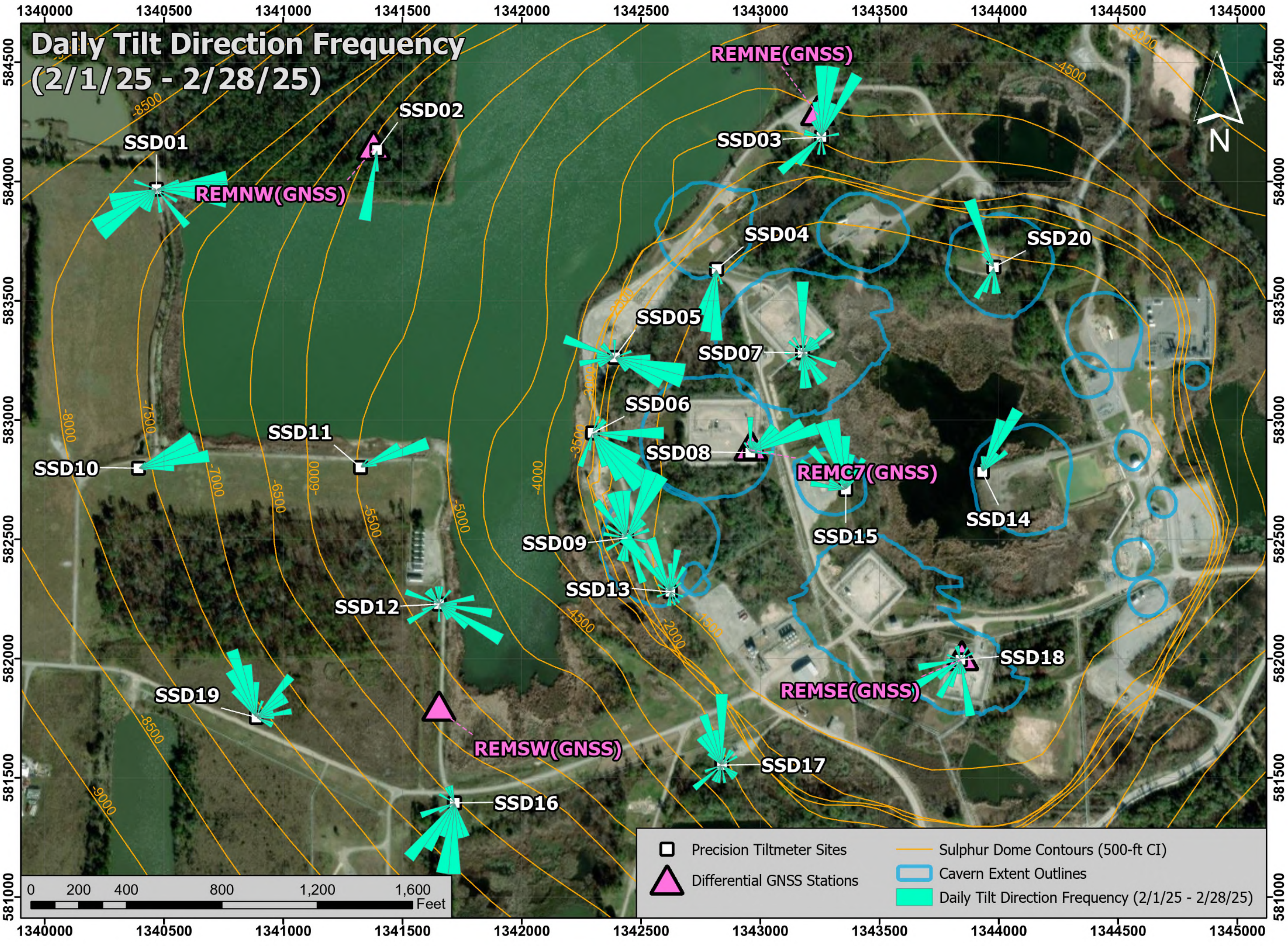


Tiltmeter and GNSS Rate Vectors

Tiltmeter Time Frame: 2/1/25 - 2/28/25

GNSS Time Frame: 7/22/24 - 2/28/25


Daily Tilt Direction Frequency - Full History
(6/1/24- 2/28/25)
REMNE(GNSS)
SSD01
SSD02
REMNW(GNSS)
SSD03
SSD04
SSD20
SSD05
SSD07
SSD08
SSD06
SSD11
SSD10
REMC7(GNSS)
SSD15
SSD14
SSD09
SSD13
SSD12
SSD18
REMSE(GNSS)
SSD19
REMSW(GNSS)
SSD17
SSD16
N
-8500
-8000
-7500
-7000
-6500
-6000
-5500
-5000
-4500
-4000
-3500
-3000
-2500
-2000
-1500
-9000
0
200
400
800
1,200
1,600
Feet
1340000
1340500
1341000
1341500
1342000
1342500
1343000
1343500
1344000
1344500
1345000
584500
584000
583500
583000
582500
582000
581500
581000
□ Precision Tiltmeter Sites
▲ Differential GNSS Stations
Sulphur Dome Contours (500-ft CI)
Cavern Extent Outlines
🟩 Daily Tilt Direction Frequency (6/1/24 - 2/28/25)


Daily Tilt Direction Frequency
(2/1/25 - 2/28/25)
N
REMNE(GNSS)
SSD01
SSD02
SSD03
REMNW(GNSS)
SSD04
SSD20
SSD05
SSD07
SSD06
SSD08
SSD11
SSD10
REMC7(GNSS)
SSD14
SSD15
SSD09
SSD13
SSD12
SSD18
REMSE(GNSS)
SSD19
REMSW(GNSS)
SSD17
SSD16
-8500
-8000
-7500
-7000
-6500
-6000
-5500
-5000
-4500
-4000
-3500
-3000
-2500
-2000
-1500
-9000
1340000
1340500
1341000
1341500
1342000
1342500
1343000
1343500
1344000
1344500
1345000
584500
584000
583500
583000
582500
582000
581500
581000
0
200
400
800
1,200
1,600
Feet
Precision Tiltmeter Sites
Differential GNSS Stations
Sulphur Dome Contours (500-ft CI)
Cavern Extent Outlines
Daily Tilt Direction Frequency (2/1/25 - 2/28/25)

Location of GNSS and Tiltmeter Stations

Sulphur Mines Salt Dome

(Coordinate Datum: WGS 84)

Differential GNSS Stations		
Name	**Latitude**	**Longitude**
REMC7	30.253327	-93.414588
REMNE	30.257206	-93.413782
REMNW	30.256713	-93.419670
REMSE	30.250953	-93.411739
REMSW	30.250263	-93.418668
Off-dome Reference Station	30.257750	-93.426649

Precision Tiltmeter Sites		
Name	**Latitude**	**Longitude**
SSD01	30.256207	-93.422543
SSD02	30.256705	-93.419624
SSD03	30.256947	-93.413727
SSD04	30.255402	-93.415087
SSD05	30.254365	-93.416418
SSD06	30.253489	-93.416695
SSD07	30.254456	-93.413924
SSD08	30.253295	-93.414595
SSD09	30.252288	-93.416215
SSD10	30.252987	-93.422714
SSD11	30.253043	-93.419765
SSD12	30.251485	-93.418691
SSD13	30.251674	-93.415624
SSD14	30.253120	-93.411511
SSD15	30.252891	-93.413320
SSD16	30.249195	-93.418437
SSD17	30.249687	-93.414899
SSD18	30.250951	-93.411754
SSD19	30.250140	-93.421087
SSD20	30.255485	-93.411405

ATTACHMENT B

SNT InSAR report - February 19, 2025

SNT Satellite Update

Continuous InSAR Monitoring of Ground Displacement At Westlake Caverns and Western Dome Flank

Sulphur Mines Salt Dome

Prepared for:
Westlake Chemical

Prepared by:
Lonquist Field Service, LLC
8591 United Plaza Blvd., Suite 280
Baton Rouge, LA 70809

Dataset
Satellite Source
Sentinel-1 (SNT)
Most Recent Image Date
Wednesday, February 19, 2025

Analysis Report Date:

February 27, 2025

Summary and Observations

Dataset Information

Satellite Source	Sentinel-1 (SNT)
Revisit Frequency	12 days
Most Recent Image Date	Wednesday, February 19, 2025
Dataset Image Count	220
Dataset Time Range	October 4, 2016 - February 19, 2025
Dataset Length	8.38 Years
Satellite Line-of-Sight (LOS)	43° West of Vertical (Viewing site from the West)

Analysis Methodology

Time Series Charts

Trend lines were calculated for the averaged displacement values within each AOI. Quadratic regression was used to determine Velocity and Acceleration of LOS displacement. Trends calculated for the AOI point groups are depicted for each AOI in the Time Series section of this report.

Contour Maps

A quadratic trend was also calculated for each individual measurement point across the analysis region. Trend values for each point were used to generate Velocity and Acceleration contour maps to depict the spatial distribution of the movement trends. Negative velocity values indicate subsidence or eastward movement. Negative acceleration values indicate increasing rates of subsidence, increasing eastward movement, or slowing westward movement and positive acceleration values indicate slowing rates of subsidence, slowing eastward movement, or increasing westward movement. Maps depicting the individual data points colored by these trend values are also included in the last section of the report.

Recent vs. Historical Data

The multi-year SNT dataset timeframe allows for Recent data to be evaluated separately from Historical data and for trends from the two timeframes to be compared. The change in the velocities and accelerations from the two timeframes are provided in the Time Series and Contour Map sections. Velocity values are calculated for the final date in either the Recent or Historical datasets.

Observations

To-date there have been <u>no acute deviations</u> from established subsidence trends in the areas investigated.

The comparison of Recent to Historical trends in the SNT data does not show any material increases (≥ -0.10) in the negative velocity and/or negative acceleration of LOS displacement in any of the 15 AOI point groups. This suggests that subsidence rates have not increased over the past two years relative to the historical data that has been collected since October 2016.

The mapped contours of the change in recent vs. historical subsidence velocity and acceleration mostly display minor fluctuations around 0, intermittently distributed within the AOIs. This suggests that statistically relevant areas of change are not currently evident within the rate change maps.

NATHANIEL L. BYARS
License No. 40697

Nathaniel Byars

Date Signed: February 27, 2025
Austin, Texas

Nathaniel L. Byars, P.E.
Principal Engineer
Louisiana License No. 40697

InSAR Data Sources

InSAR Data

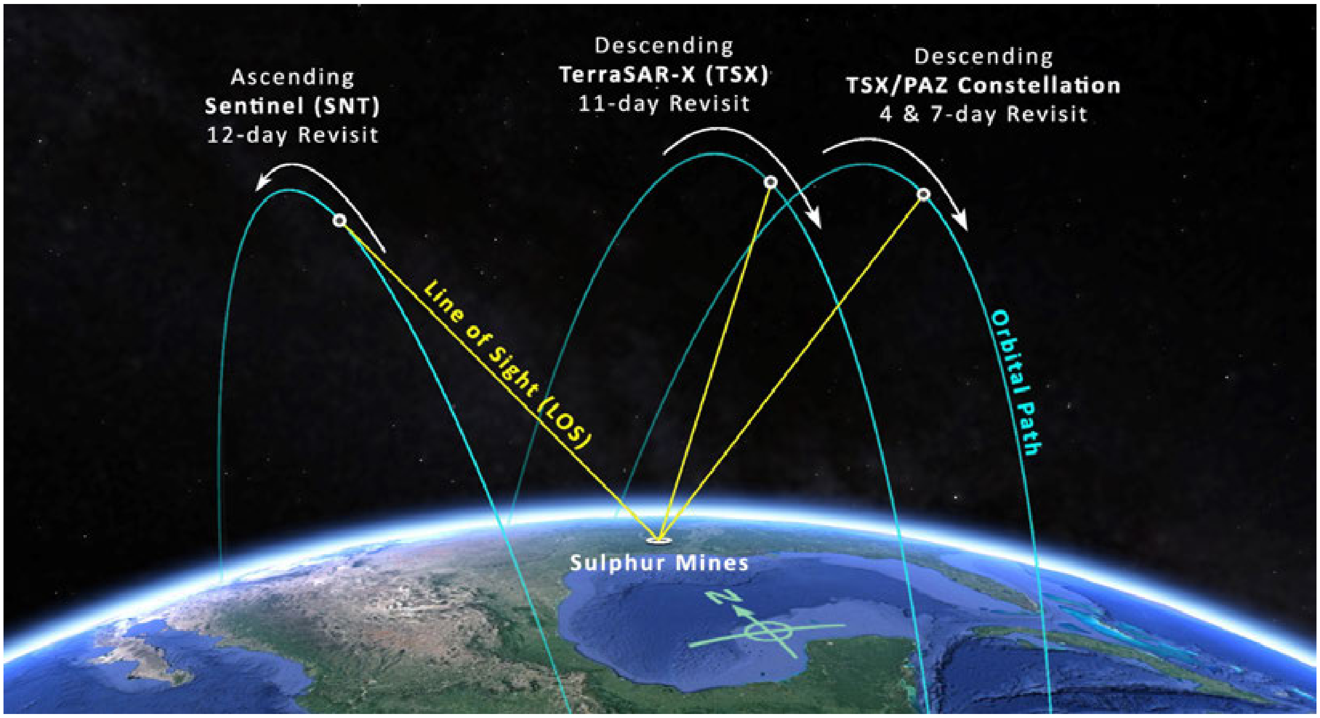
Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the ground. Objects or ground features providing a stable reflection of radar energy such as buildings, roads, and infrastructure produce the highest quality measurement points. InSAR analysis identifies the change in distance between the satellite and each measurement point over time relative to a stable reference point within the imaged area.

Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacment measurements from both ascending and descending orbits. An ascending orbit denotes the satellite's longitudinal course from south to north as it passes over the site, while a desceding orbit denotes the satellite is moving from north to south.

The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These are a TSX satellite and the PAZ satellite (TSX/PAZ constellation), both with an 11-day revisit frequency. Their orbits are offset with the PAZ satellite passing over the site 4 days after the TSX satellite. Prior to May 2023, data was captured from a different high-resolution TerraSAR-X (TSX) satellite on a descending orbit that captured data from the east of the site on an 11-day frequency. The transition was made for the increased data frequency that resulted from a 4 and 7-day revisit period. The image below depicts the orbital paths of the satellites in relation to the Sulphur Mines Salt Dome.

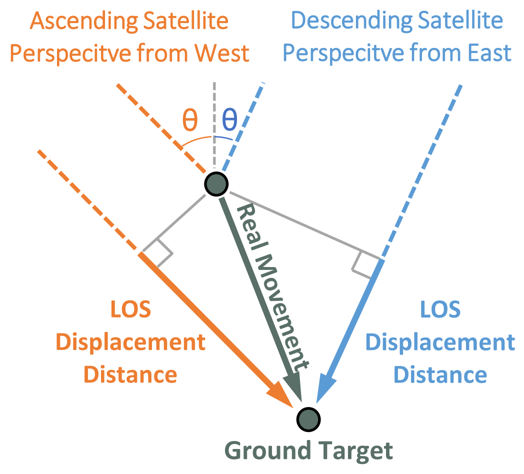
Satellite Orbital Diagram



InSAR Line-of-Site (LOS) Data

LOS displacement measurements refer to a change in distance between the satellite sensor and the ground target. Measurement positions on the west side of the Sulphur Dome are are known to be experiencing some eastward movement toward the dome center due to the geometry of the subsidence basin. The InSAR satellites view the site from eastward and westward positions so LOS measurements are understood to convey a movement distance that is not purely vertical. The diagram to the right illustrates the geometric relationship between the theoretical Real movement of a ground target and LOS displacement measurements from two different satellite viewing directions.

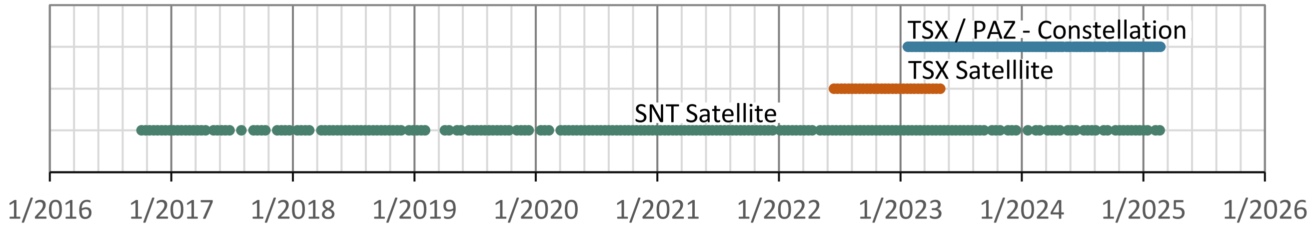
<-- West **Side View** East-->



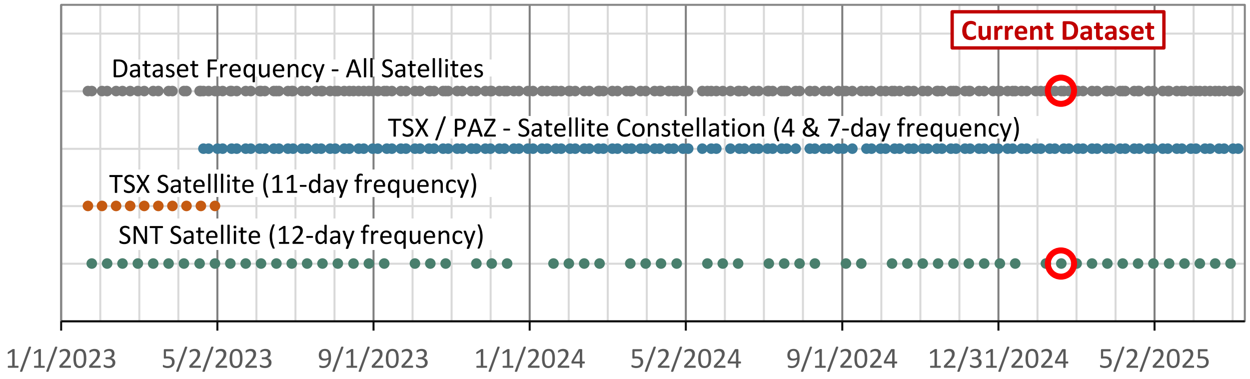
Satellite Properties & Image Frequency

Satellite and Data Properties	SNT	TSX	TSX/PAZ Constellation
Band (Wavelength)	C-band (2.20 in)	X-band (1.22 in)	X-band (1.22 in)
Track	T136	T29	T67 & T120
Pixel resolution	65 x 16 ft	3 x 3 ft	3 x 3 ft
Revisit frequency	12 days	11 days	4 & 7 days
Orbit (LOS Angle, θ)	Ascending (43^o)	Descending (17^o)	Descending (37^o)
Data Start Date	10/4/2016	6/16/2022	1/24/2023
Measurement error range	± 0.20 in	± 0.03 in	± 0.03 in

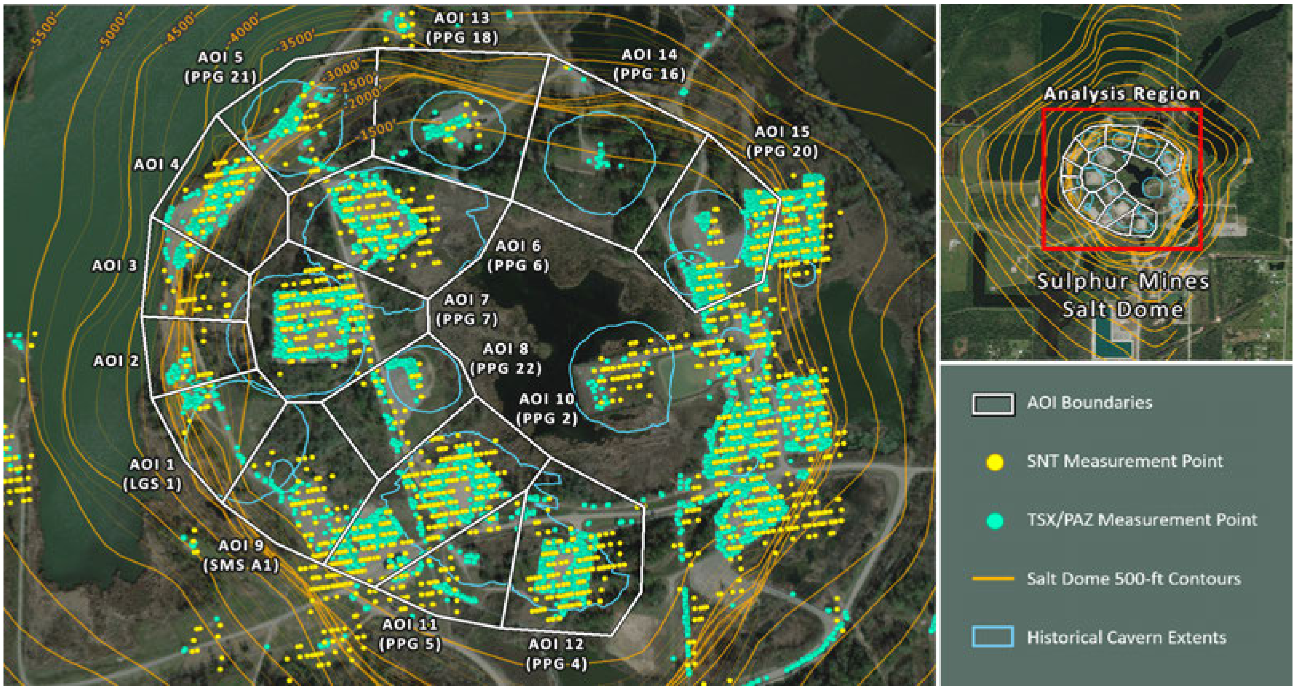
Dataset Measurement History



Dataset Update Frequency



AOI Boundaries & InSAR Measurement Points

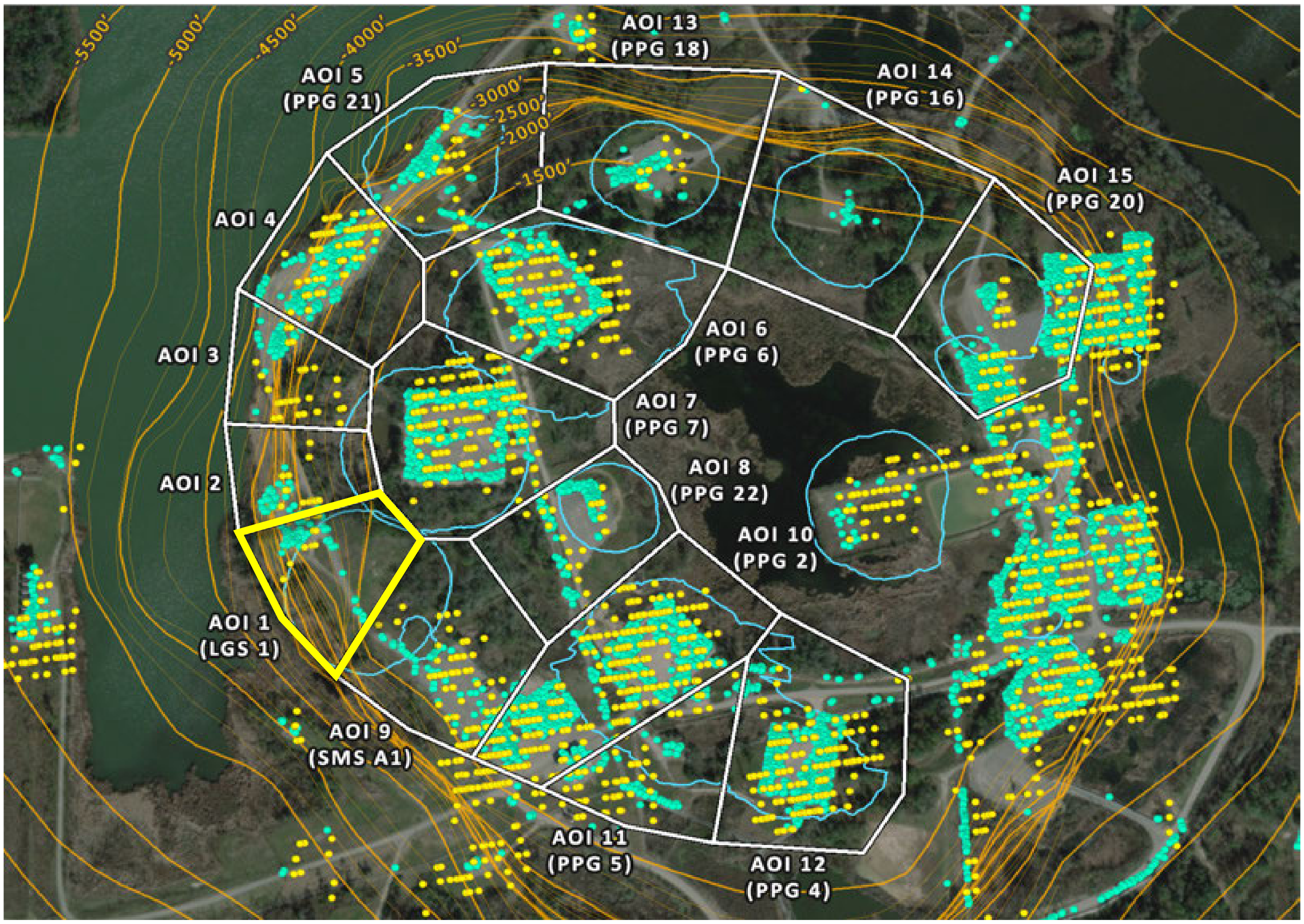


Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the trend values calculated in each AOI for the dataset evaluated in this report.

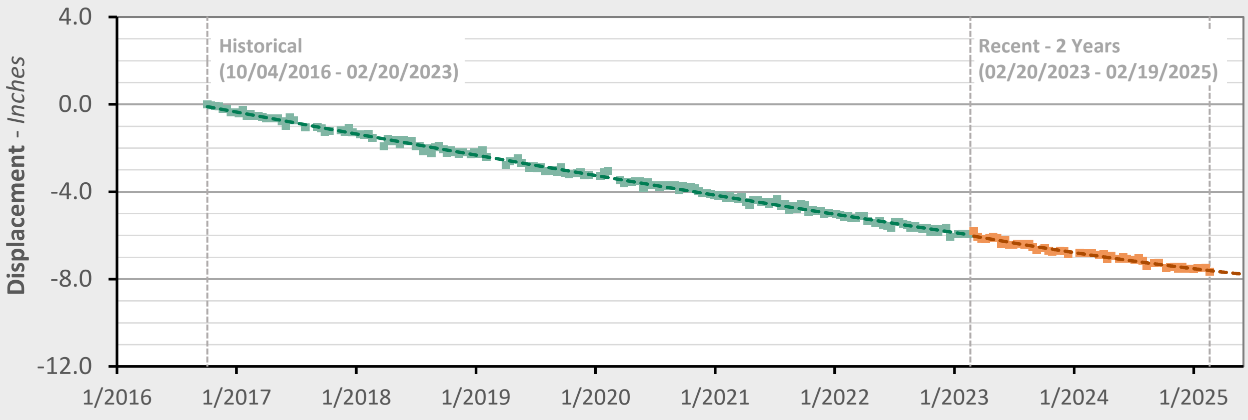
AOI Name	**SNT (2/19/2025)**	**LOS Velocity** *(in/yr)*			**LOS Acceleration** *(in/yr^{2})*		
	Point Count	**Historical**	**Recent**	**Change**	**Historical**	**Recent**	**Change**
AOI 1 *(LGS 1)*	14	-0.82	-0.68	+0.14	+0.03	+0.11	+0.08
AOI 2	15	-0.77	-0.50	+0.27	+0.05	+0.33	+0.28
AOI 3	29	-0.64	-0.60	+0.04	+0.03	+0.06	+0.03
AOI 4	62	-0.78	-0.72	+0.05	+0.00	+0.04	+0.03
AOI 5 *(PPG 21)*	25	-0.66	-0.54	+0.12	+0.02	+0.06	+0.05
AOI 6 *(PPG 6)*	134	-0.86	-0.84	+0.02	+0.05	+0.03	-0.02
AOI 7 *(PPG 7)*	139	-0.98	-0.96	+0.02	+0.06	+0.11	+0.05
AOI 8 *(PPG 22)*	20	-1.05	-1.12	-0.06	+0.09	+0.12	+0.03
AOI 9 *(SMS A1)*	58	-0.84	-0.77	+0.07	+0.07	+0.07	+0.01
AOI 10 *(PPG 2)*	233	-0.89	-0.98	-0.09	+0.08	+0.03	-0.05
AOI 11 *(PPG 5)*	51	-0.85	-0.86	-0.01	+0.06	+0.03	-0.03
AOI 12 *(PPG 4)*	120	-0.75	-0.64	+0.10	+0.04	+0.01	-0.03
AOI 13 *(PPG 18)*	12	-0.56	-0.65	-0.09	+0.05	-0.04	-0.09
AOI 14 *(PPG 16)*	1	-0.15	+0.36	+0.51	+0.07	+0.62	+0.55
AOI 15 *(PPG 20)*	69	-0.30	-0.37	-0.07	+0.04	-0.03	-0.07

AOI 1 *(LGS 1)* - Location Map



AOI 1 *(LGS 1)* - Displacement Time Series

SNT (2/19/2025) Point Count: **14**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.82 in/yr	-0.68 in/yr	+0.14 in/yr
Acceleration:	+0.03 in/yr^2	+0.11 in/yr^2	+0.08 in/yr^2

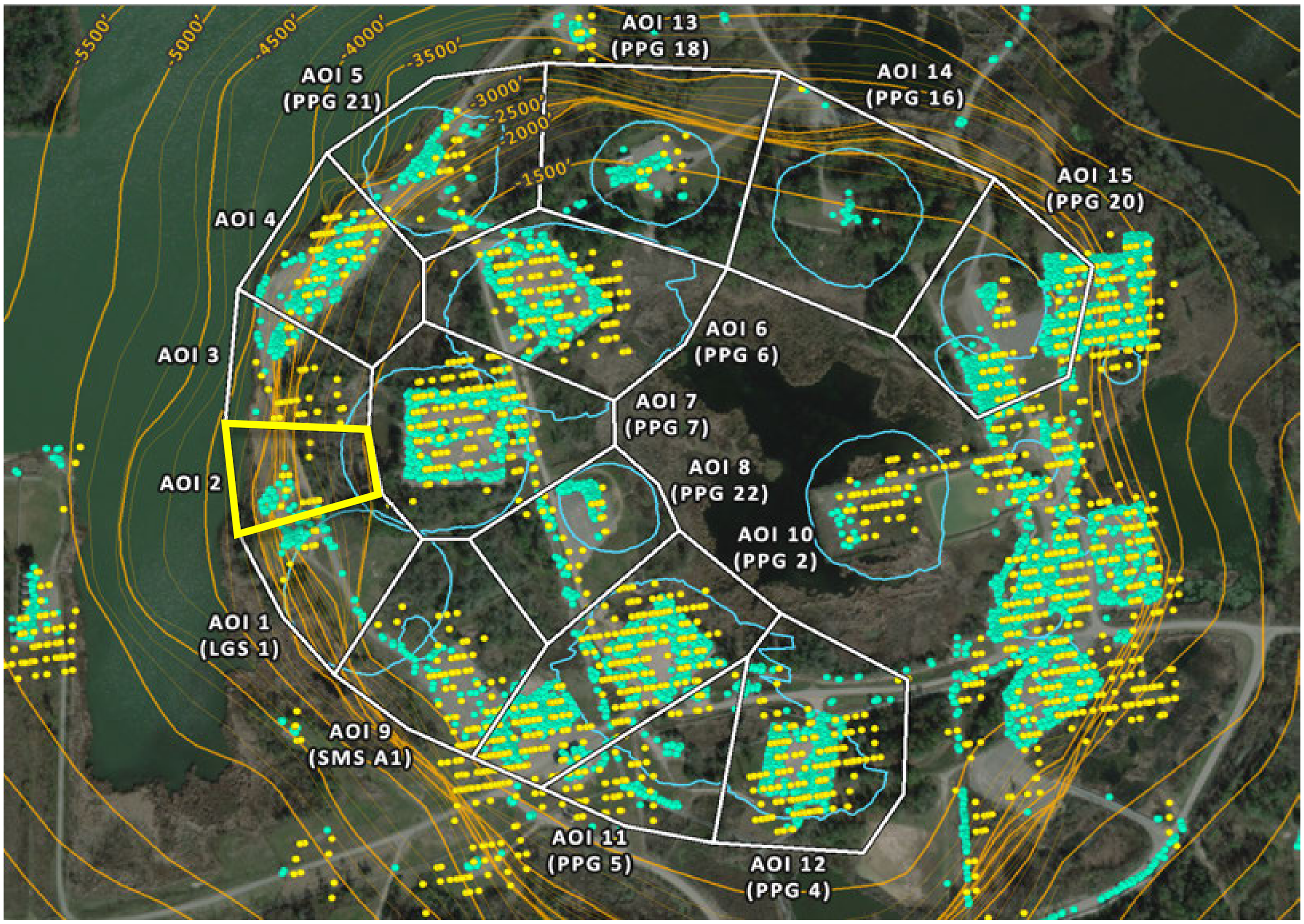
■ Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

■ Recent LOS Displacement Measurement

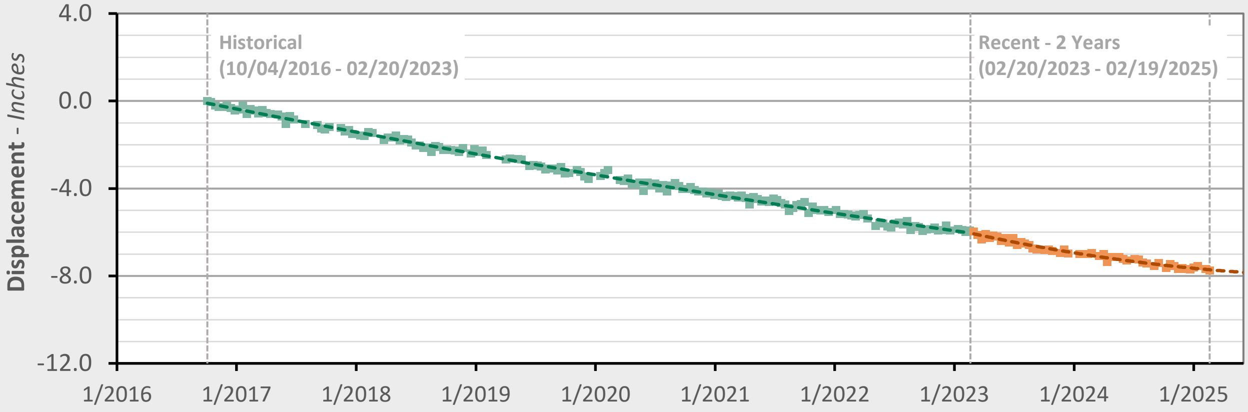
---- Historical Trend Line (Quadratic Regression)

AOI 2 - Location Map



AOI 2 - Displacement Time Series

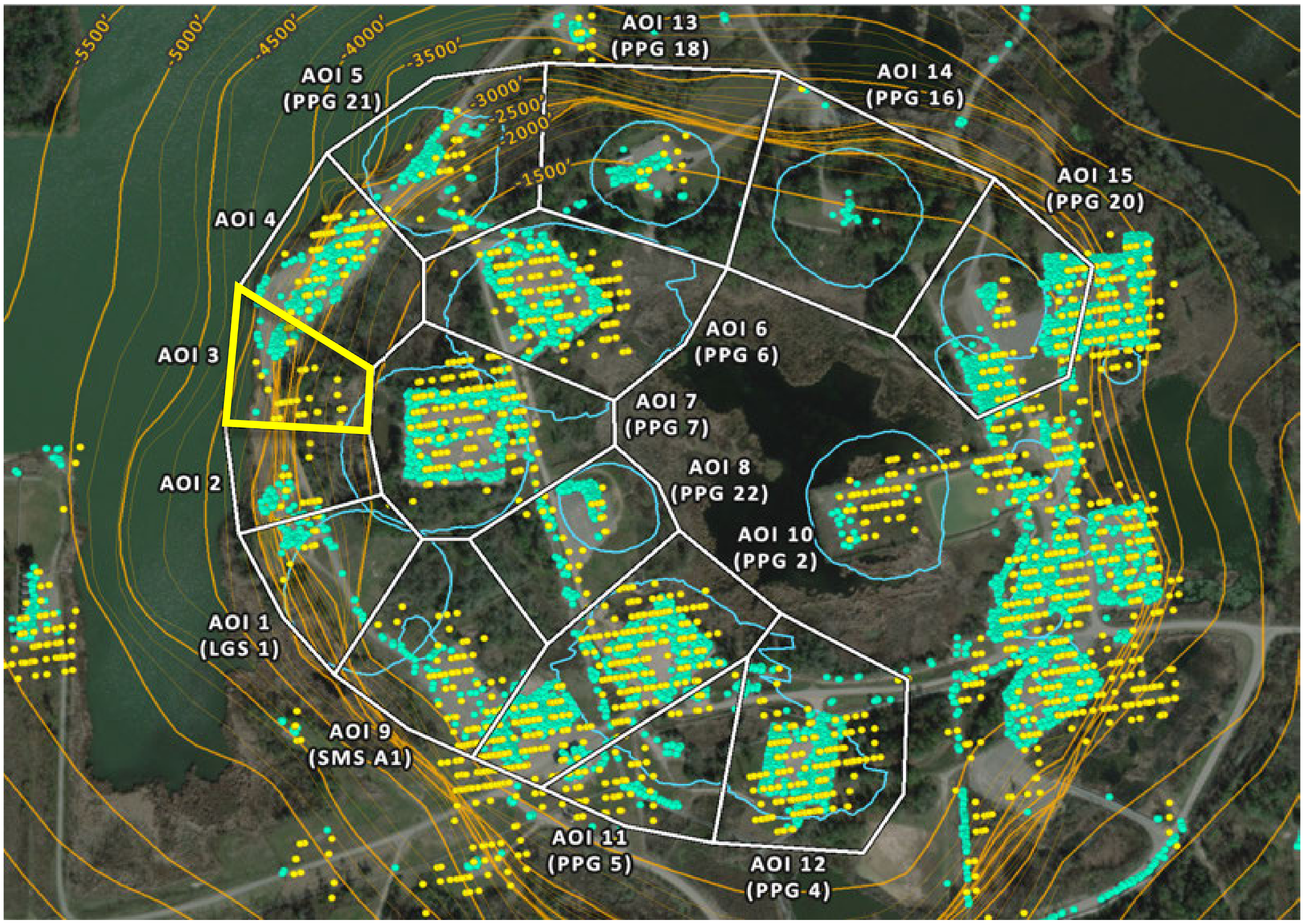
SNT (2/19/2025) Point Count: 15



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.77 in/yr	-0.50 in/yr	+0.27 in/yr
Acceleration:	+0.05 in/yr^2	+0.33 in/yr^2	+0.28 in/yr^2

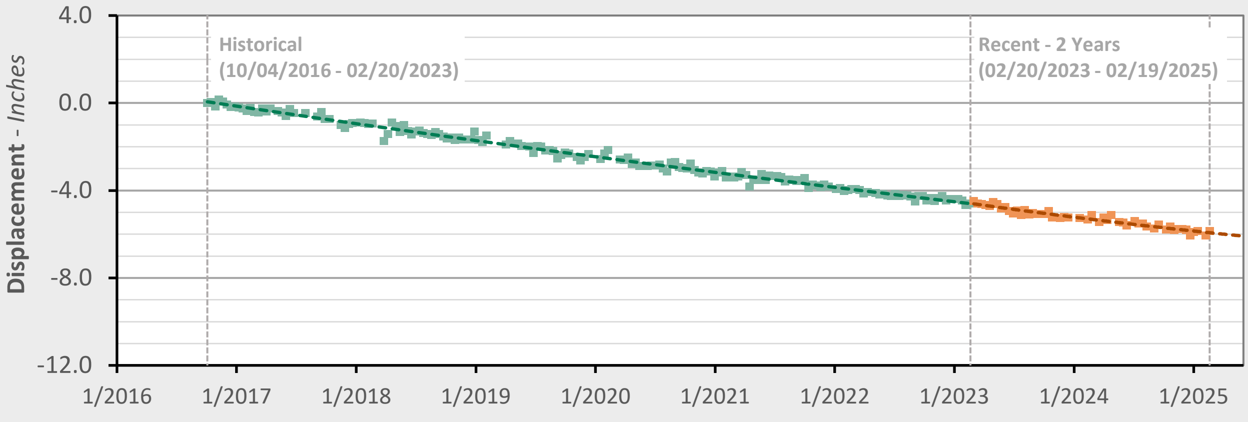
■ Historical LOS Displacement Measurement
---- Historical Trend Line (Quadratic Regression)
■ Recent LOS Displacement Measurement
---- Historical Trend Line (Quadratic Regression)

AOI 3 - Location Map



AOI 3 - Displacement Time Series

SNT (2/19/2025) Point Count: **29**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.64 in/yr	-0.60 in/yr	+0.04 in/yr
Acceleration:	+0.03 in/yr^2	+0.06 in/yr^2	+0.03 in/yr^2

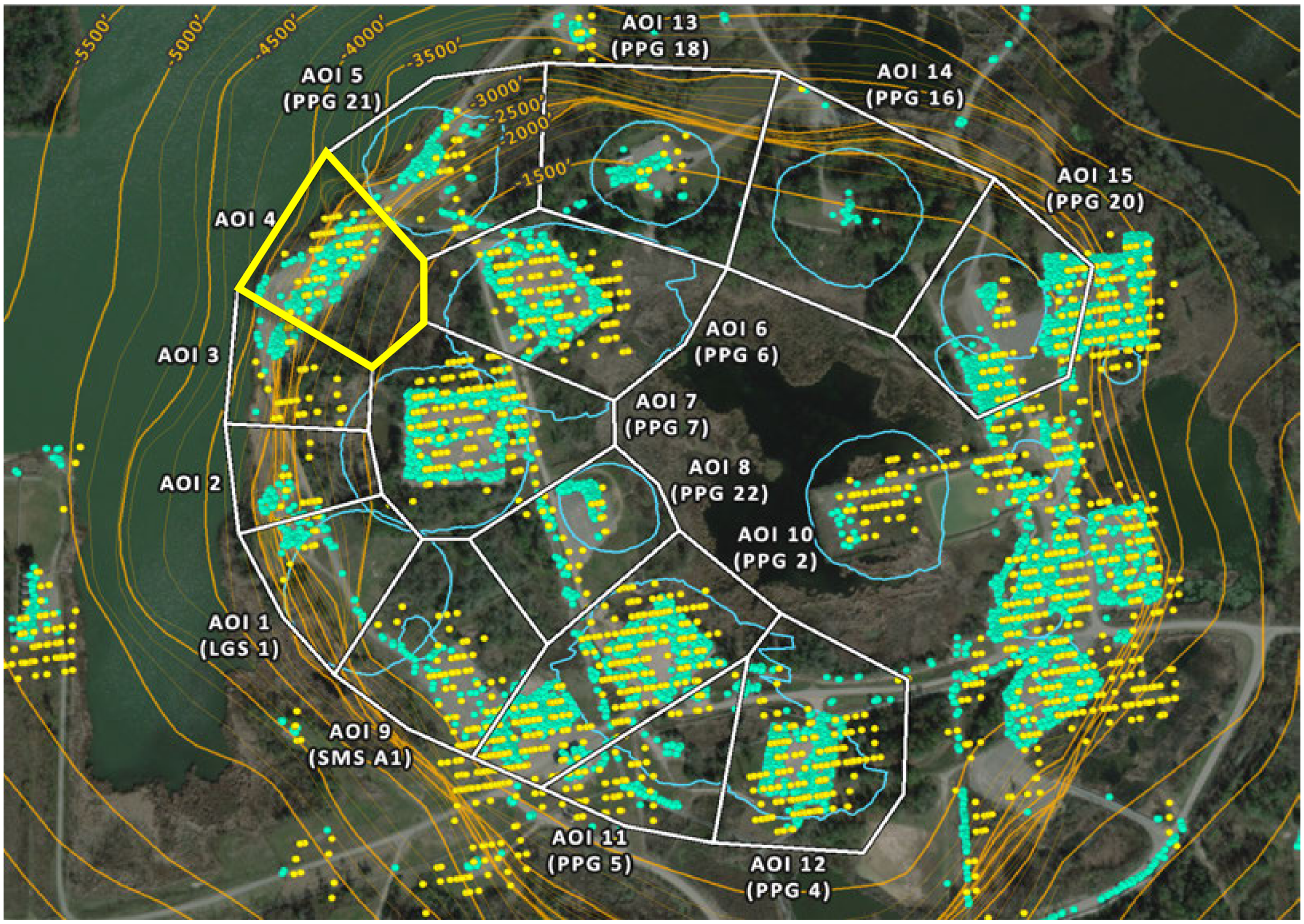
■ Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

■ Recent LOS Displacement Measurement

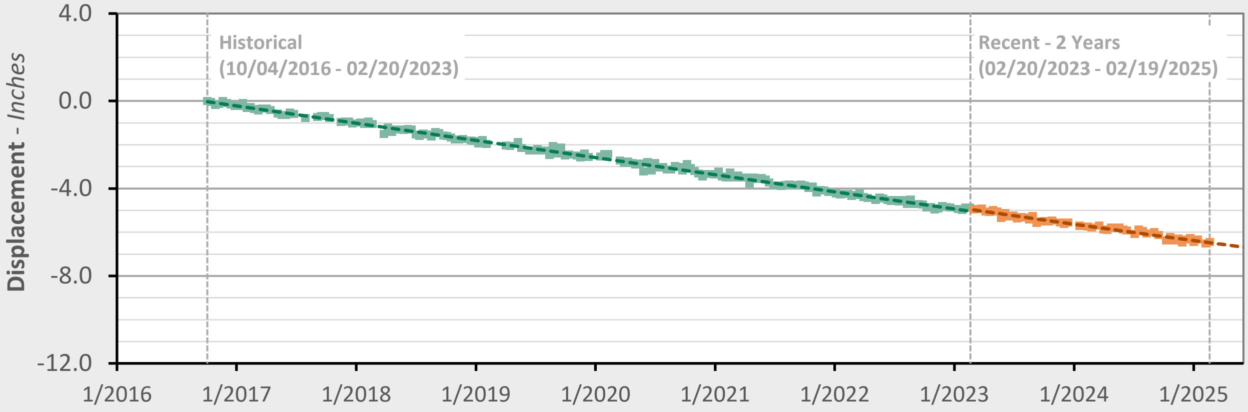
---- Historical Trend Line (Quadratic Regression)

AOI 4 - Location Map



AOI 4 - Displacement Time Series

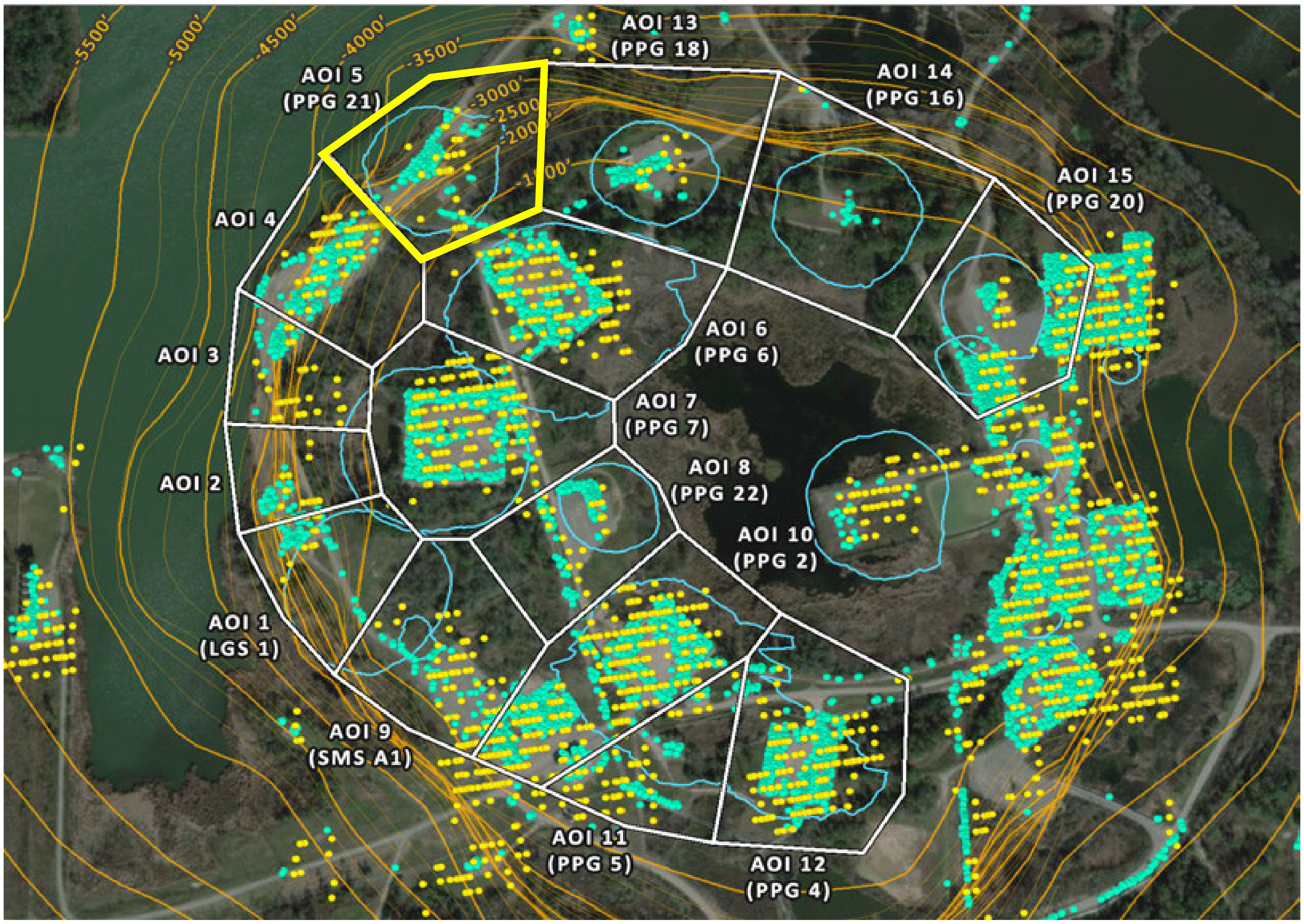
SNT (2/19/2025) Point Count: **62**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.78 in/yr	-0.72 in/yr	+0.05 in/yr
Acceleration:	+0.00 in/yr^2	+0.04 in/yr^2	+0.03 in/yr^2

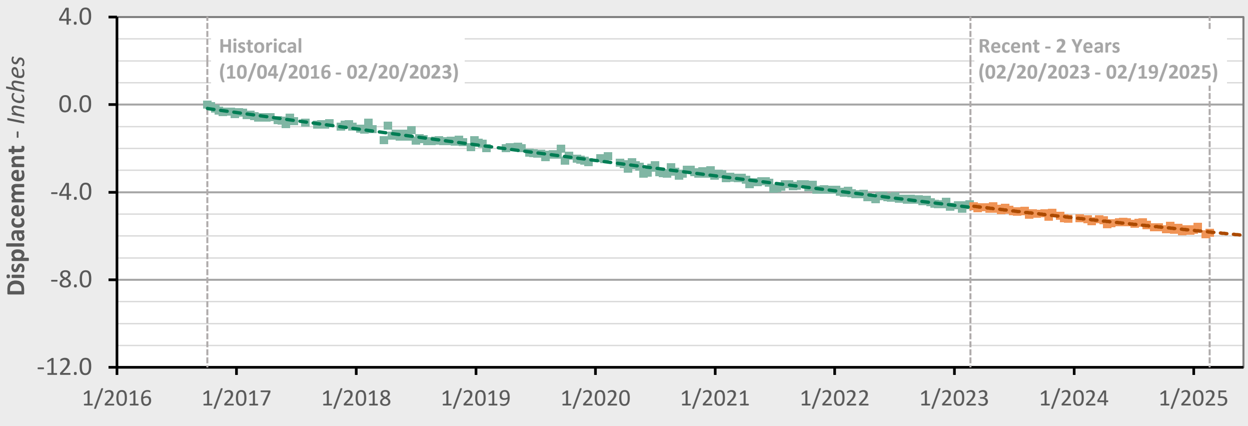
🟩 Historical LOS Displacement Measurement
---- Historical Trend Line (Quadratic Regression)
🟧 Recent LOS Displacement Measurement
---- Historical Trend Line (Quadratic Regression)

AOI 5 *(PPG 21)* - Location Map



AOI 5 *(PPG 21)* - Displacement Time Series

SNT (2/19/2025) Point Count: **25**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.66 in/yr	-0.54 in/yr	+0.12 in/yr
Acceleration:	+0.02 in/yr^2	+0.06 in/yr^2	+0.05 in/yr^2

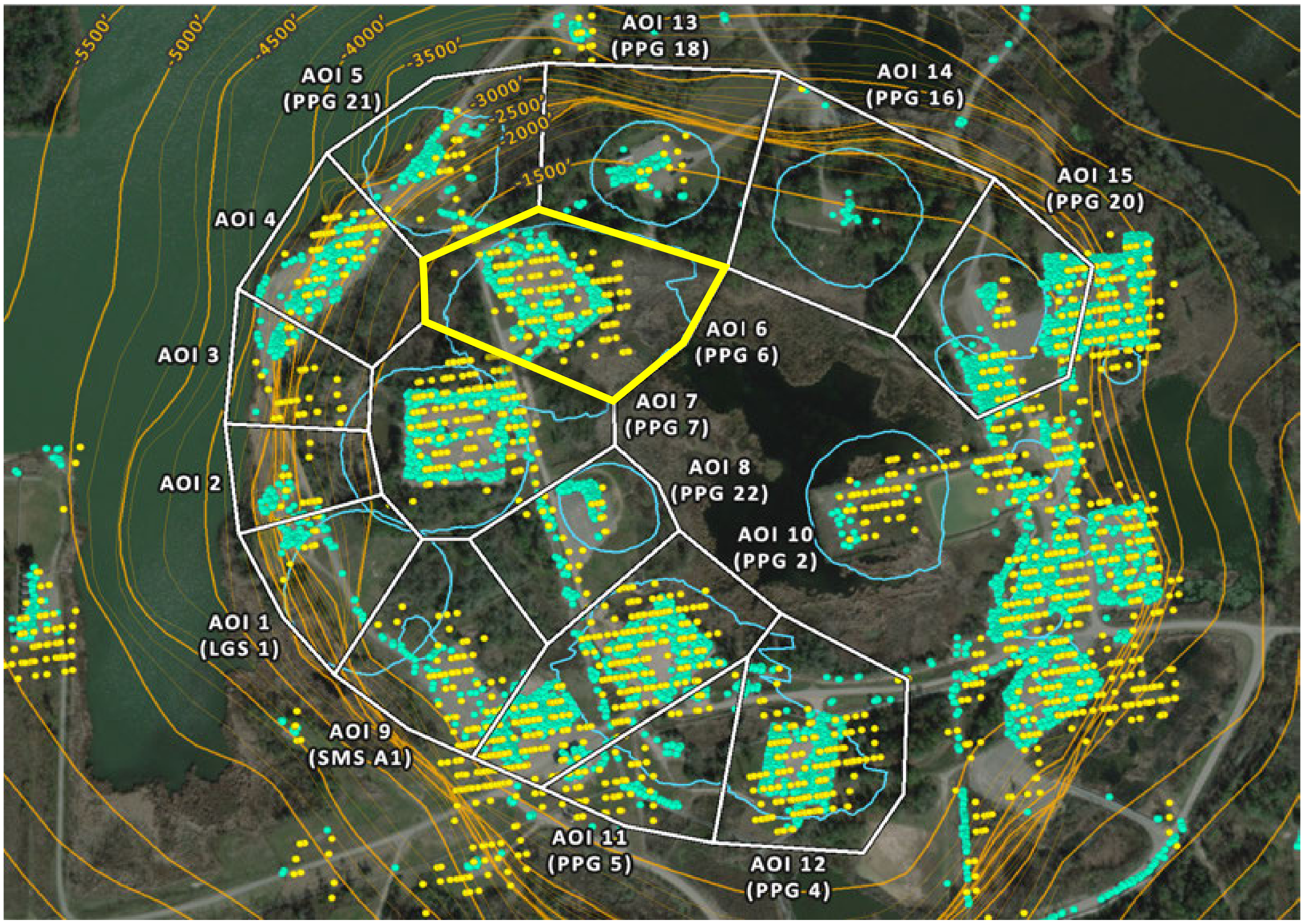
🟩 Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

🟧 Recent LOS Displacement Measurement

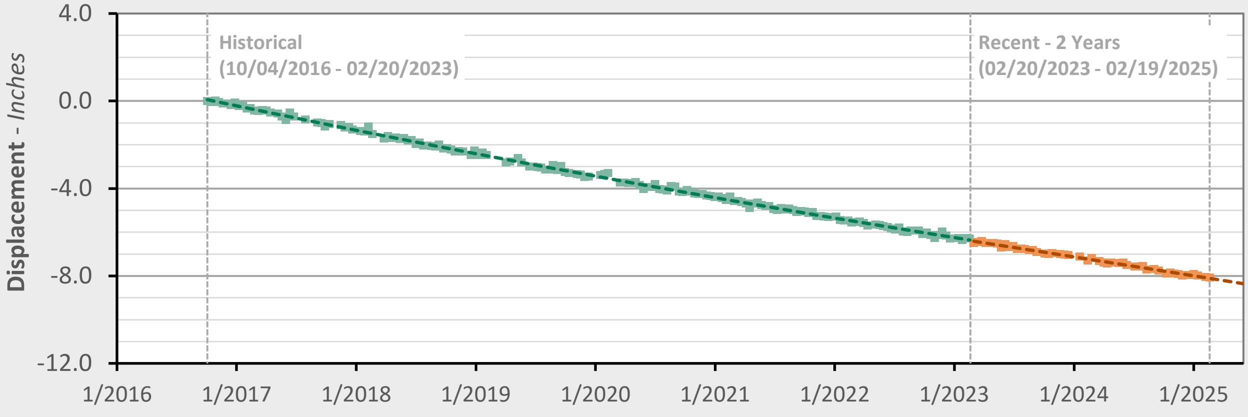
---- Historical Trend Line (Quadratic Regression)

AOI 6 *(PPG 6)* - Location Map



AOI 6 *(PPG 6)* - Displacement Time Series

SNT (2/19/2025) Point Count: **134**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.86 in/yr	-0.84 in/yr	+0.02 in/yr
Acceleration:	+0.05 in/yr^2	+0.03 in/yr^2	-0.02 in/yr^2

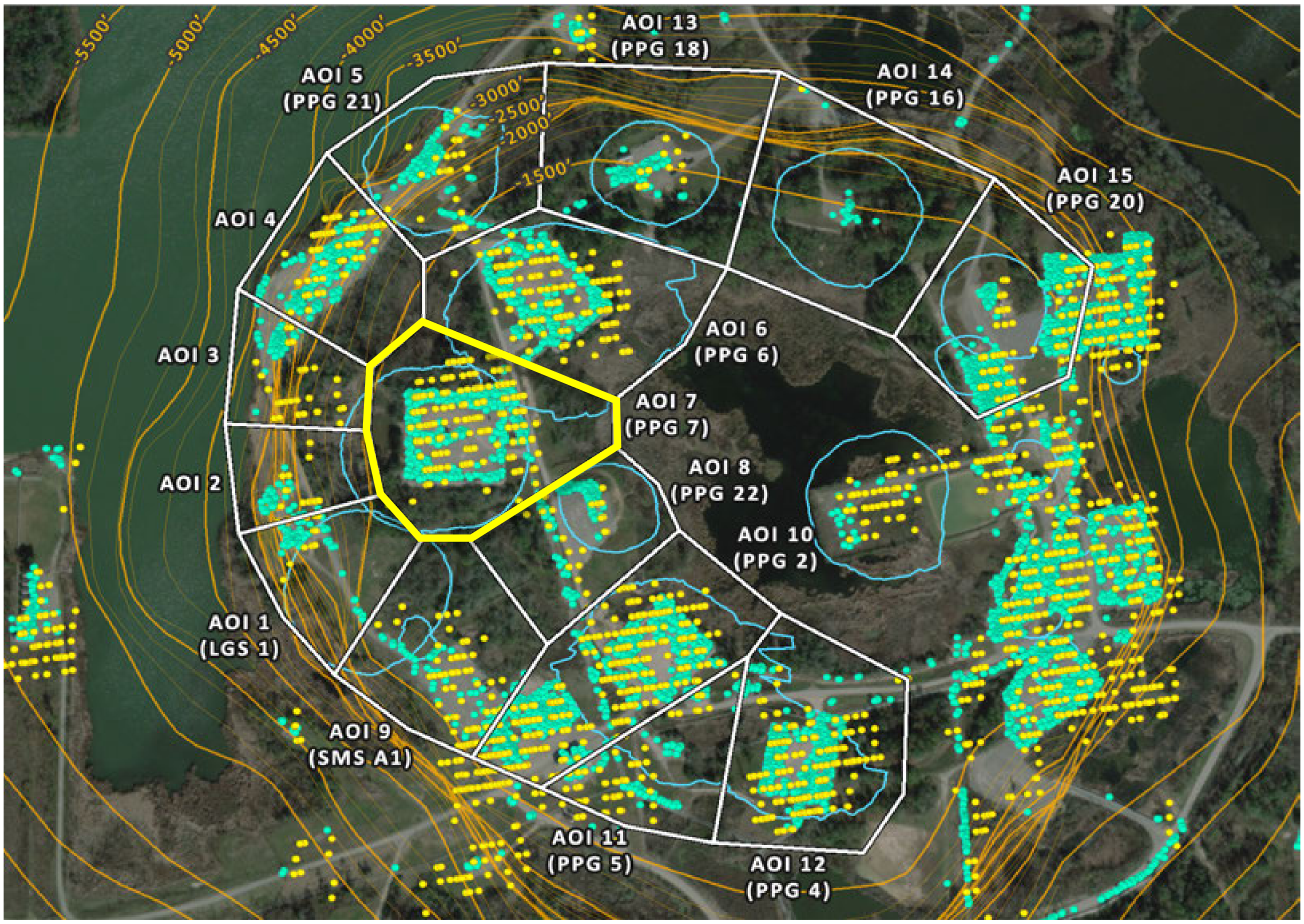
🟩 Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

🟧 Recent LOS Displacement Measurement

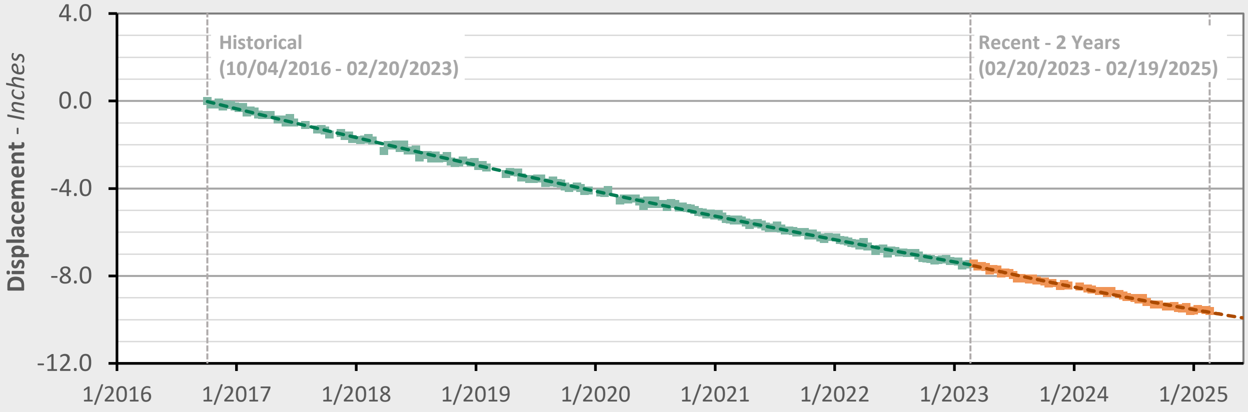
---- Historical Trend Line (Quadratic Regression)

AOI 7 *(PPG 7)* - Location Map



AOI 7 *(PPG 7)* - Displacement Time Series

SNT (2/19/2025) Point Count: **139**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.98 in/yr	-0.96 in/yr	+0.02 in/yr
Acceleration:	+0.06 in/yr^2	+0.11 in/yr^2	+0.05 in/yr^2

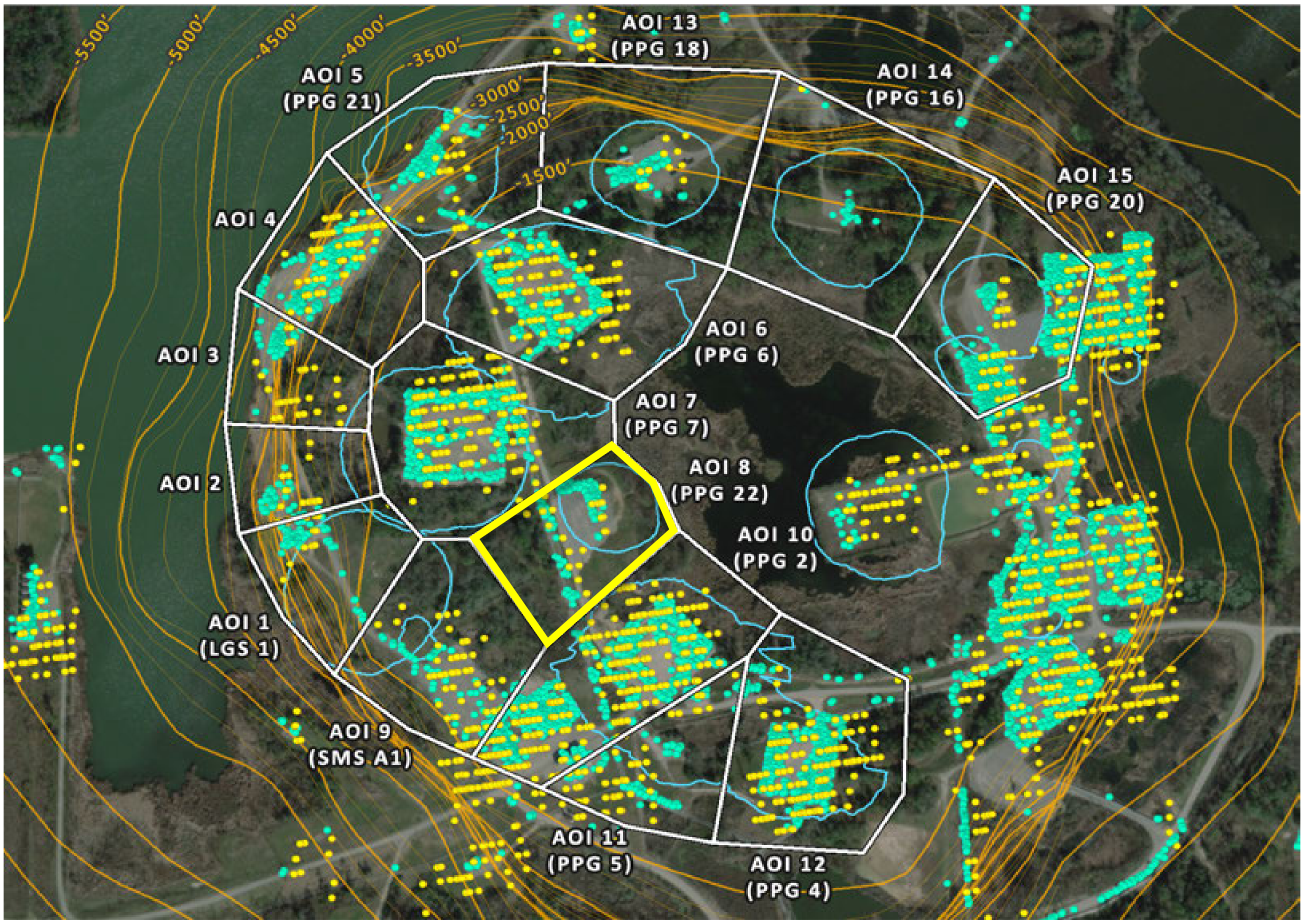
■ Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

■ Recent LOS Displacement Measurement

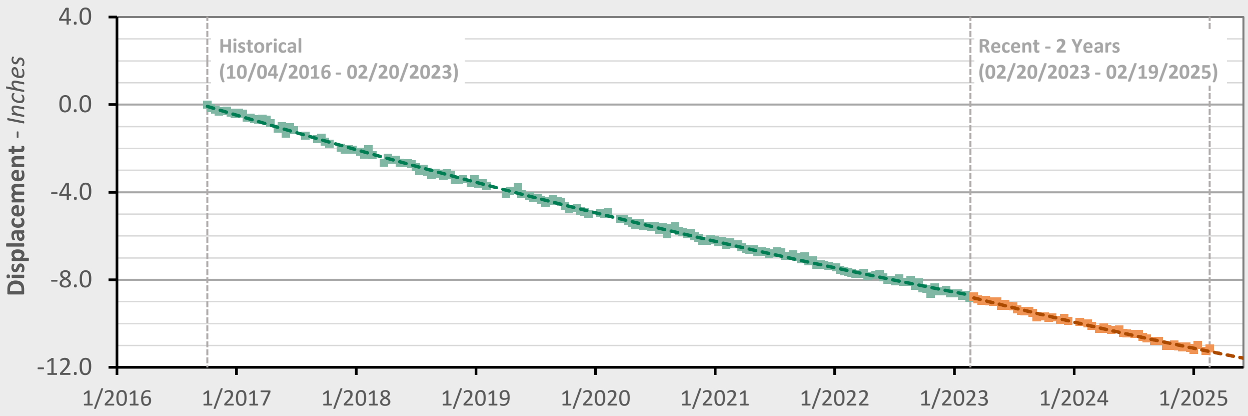
---- Historical Trend Line (Quadratic Regression)

AOI 8 *(PPG 22)* - Location Map



AOI 8 *(PPG 22)* - Displacement Time Series

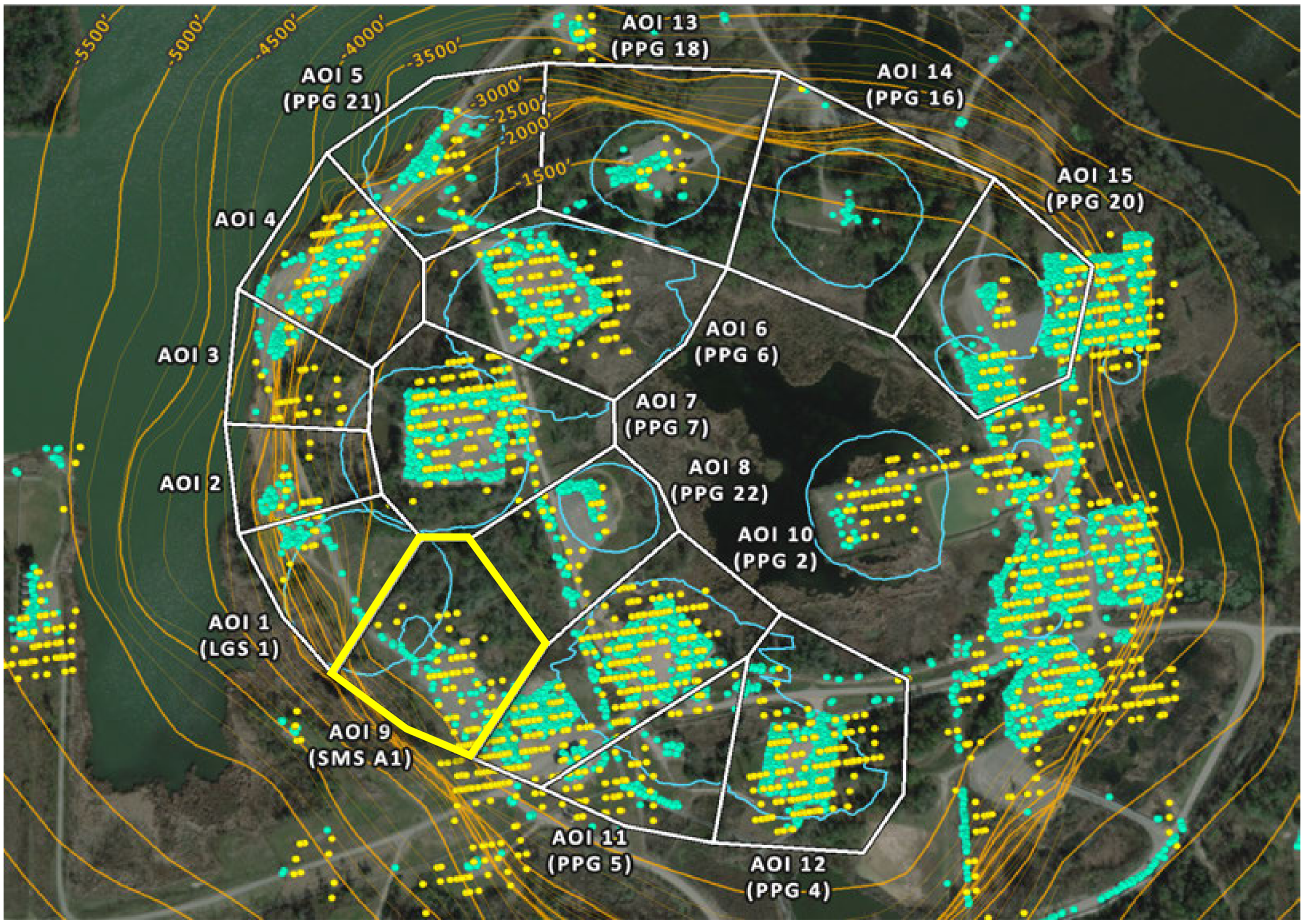
SNT (2/19/2025) Point Count: **20**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-1.05 in/yr	-1.12 in/yr	-0.06 in/yr
Acceleration:	+0.09 in/yr^2	+0.12 in/yr^2	+0.03 in/yr^2

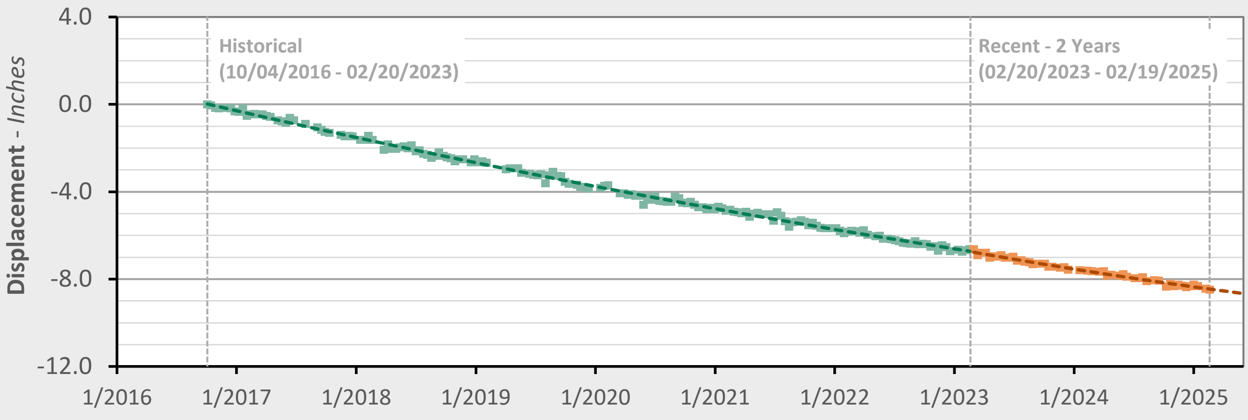
■ Historical LOS Displacement Measurement	---- Historical Trend Line (Quadratic Regression)	■ Recent LOS Displacement Measurement	---- Historical Trend Line (Quadratic Regression)

AOI 9 *(PPG A1)* - Location Map



AOI 9 *(SMS A1)* - Displacement Time Series

SNT (2/19/2025) Point Count: 58



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.84 in/yr	-0.77 in/yr	+0.07 in/yr
Acceleration:	+0.07 in/yr^2	+0.07 in/yr^2	+0.01 in/yr^2

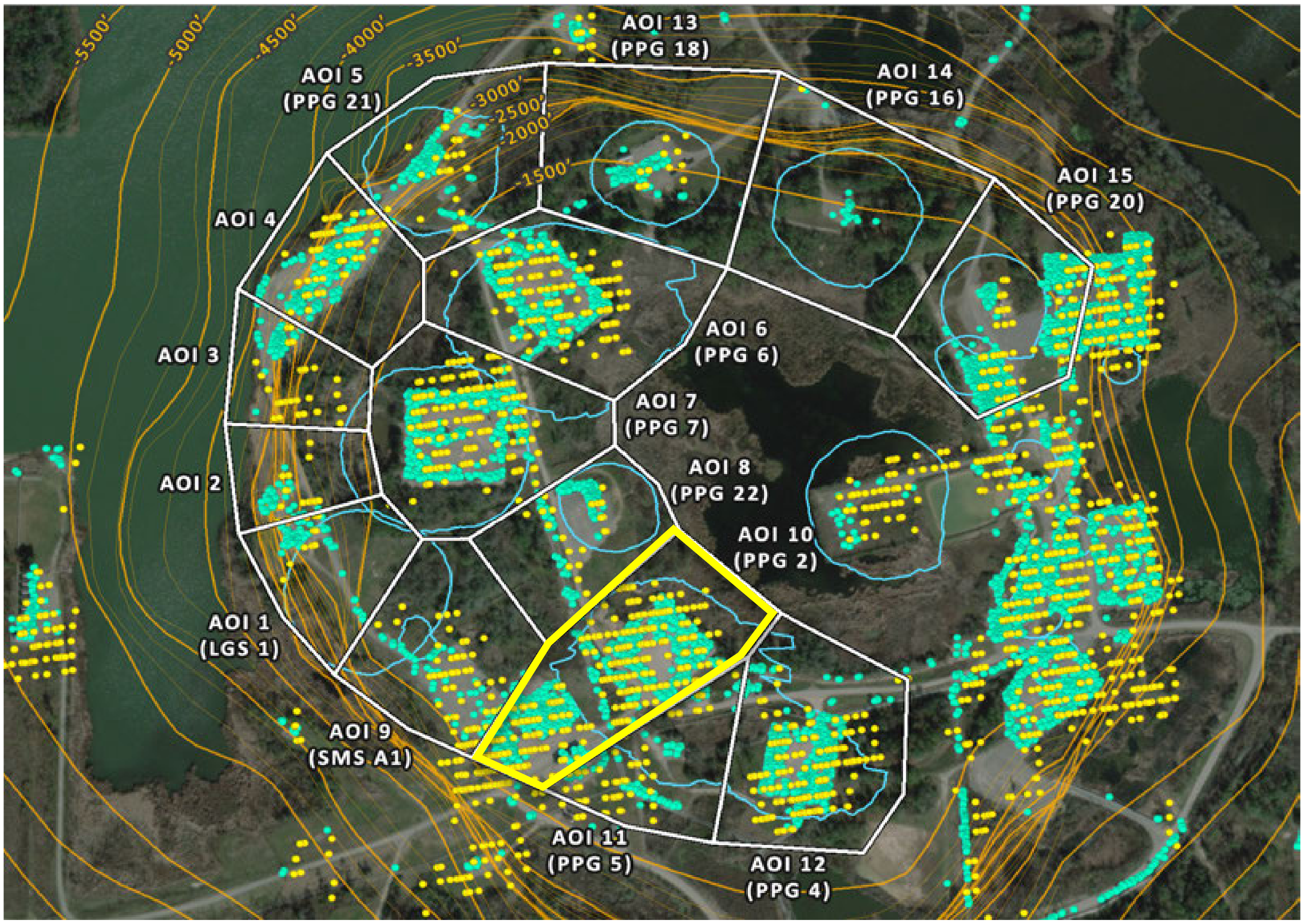
🟩 Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

🟧 Recent LOS Displacement Measurement

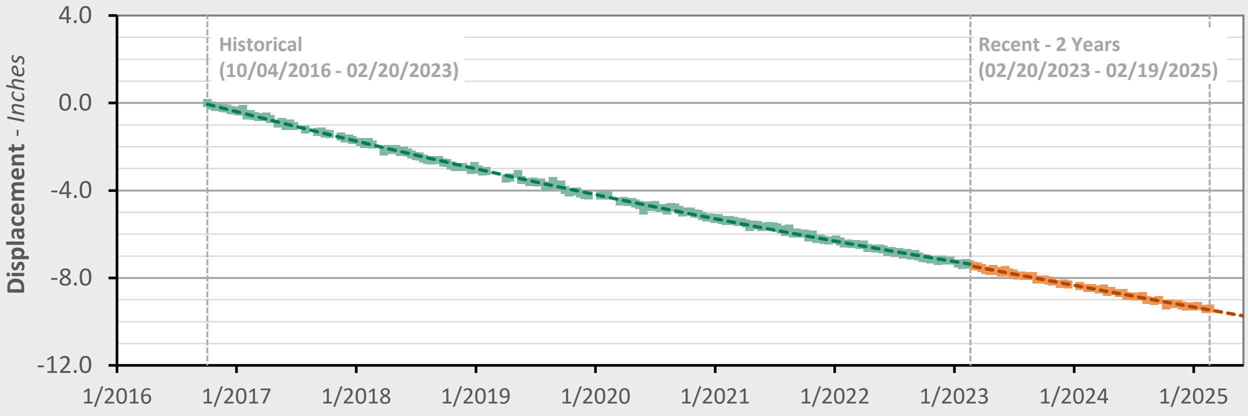
---- Historical Trend Line (Quadratic Regression)

AOI 10 *(PPG 2)* - Location Map



AOI 10 *(PPG 2)* - Displacement Time Series

SNT (2/19/2025) Point Count: **233**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.89 in/yr	-0.98 in/yr	-0.09 in/yr
Acceleration:	+0.08 in/yr^2	+0.03 in/yr^2	-0.05 in/yr^2

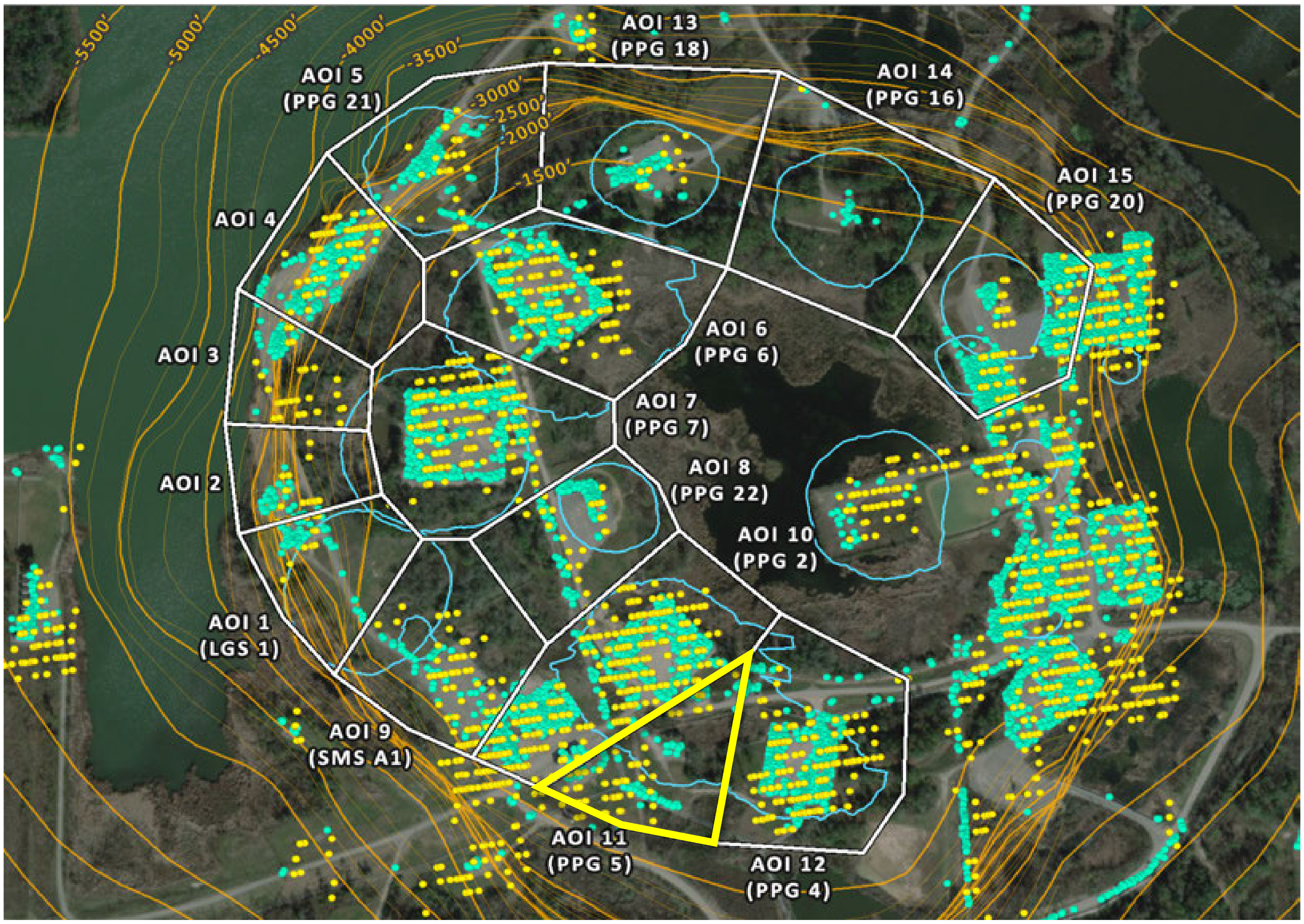
🟩 Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

🟧 Recent LOS Displacement Measurement

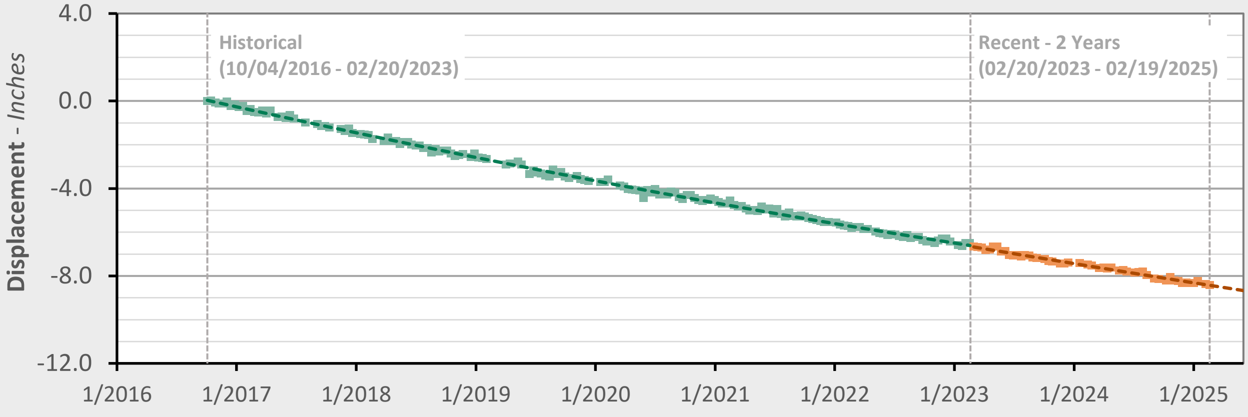
---- Historical Trend Line (Quadratic Regression)

AOI 11 *(PPG 5)* - Location Map



AOI 11 *(PPG 5)* - Displacement Time Series

SNT (2/19/2025) Point Count: **51**



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.85 in/yr	-0.86 in/yr	-0.01 in/yr
Acceleration:	+0.06 in/yr^2	+0.03 in/yr^2	-0.03 in/yr^2

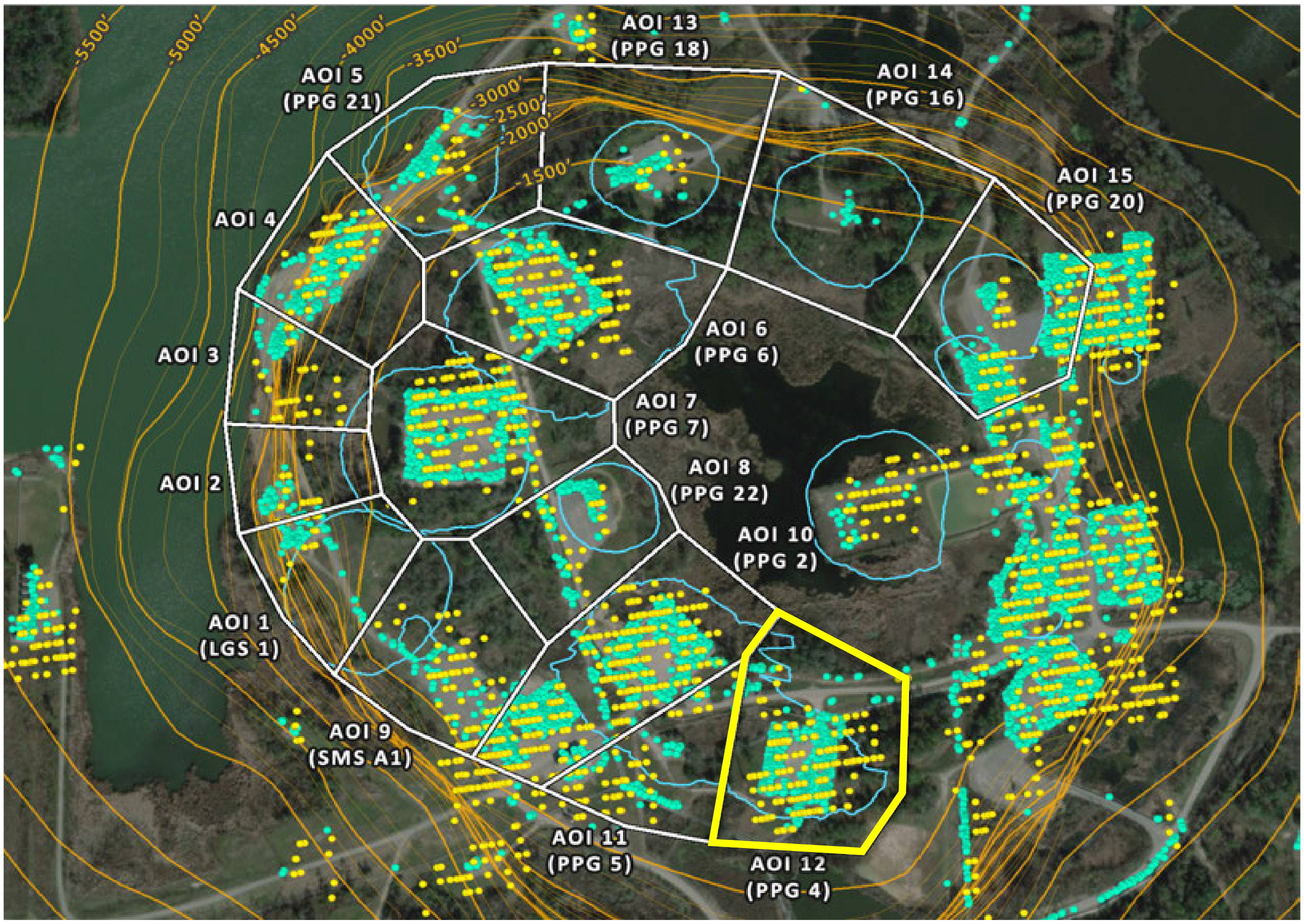
🟩 Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

🟧 Recent LOS Displacement Measurement

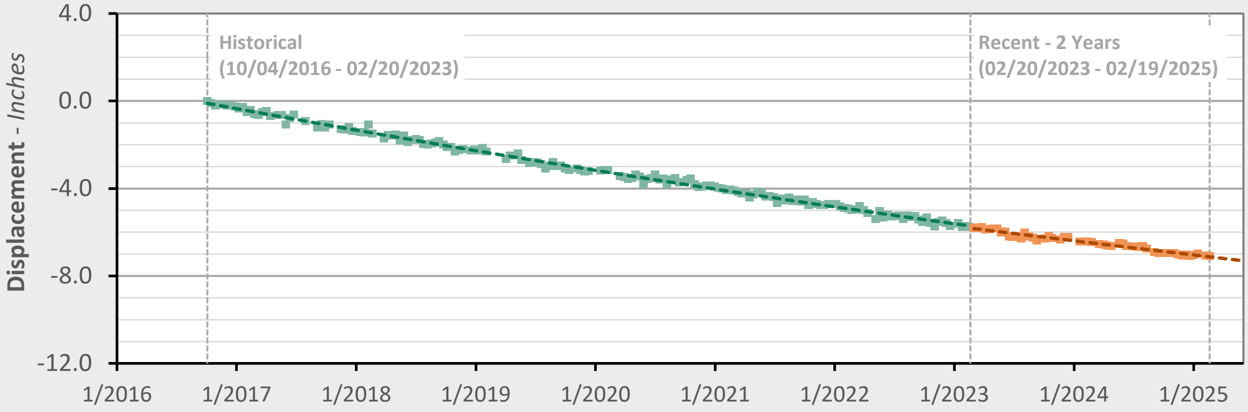
---- Historical Trend Line (Quadratic Regression)

AOI 12 *(PPG 4)* - Location Map



AOI 12 *(PPG 4)* - Displacement Time Series

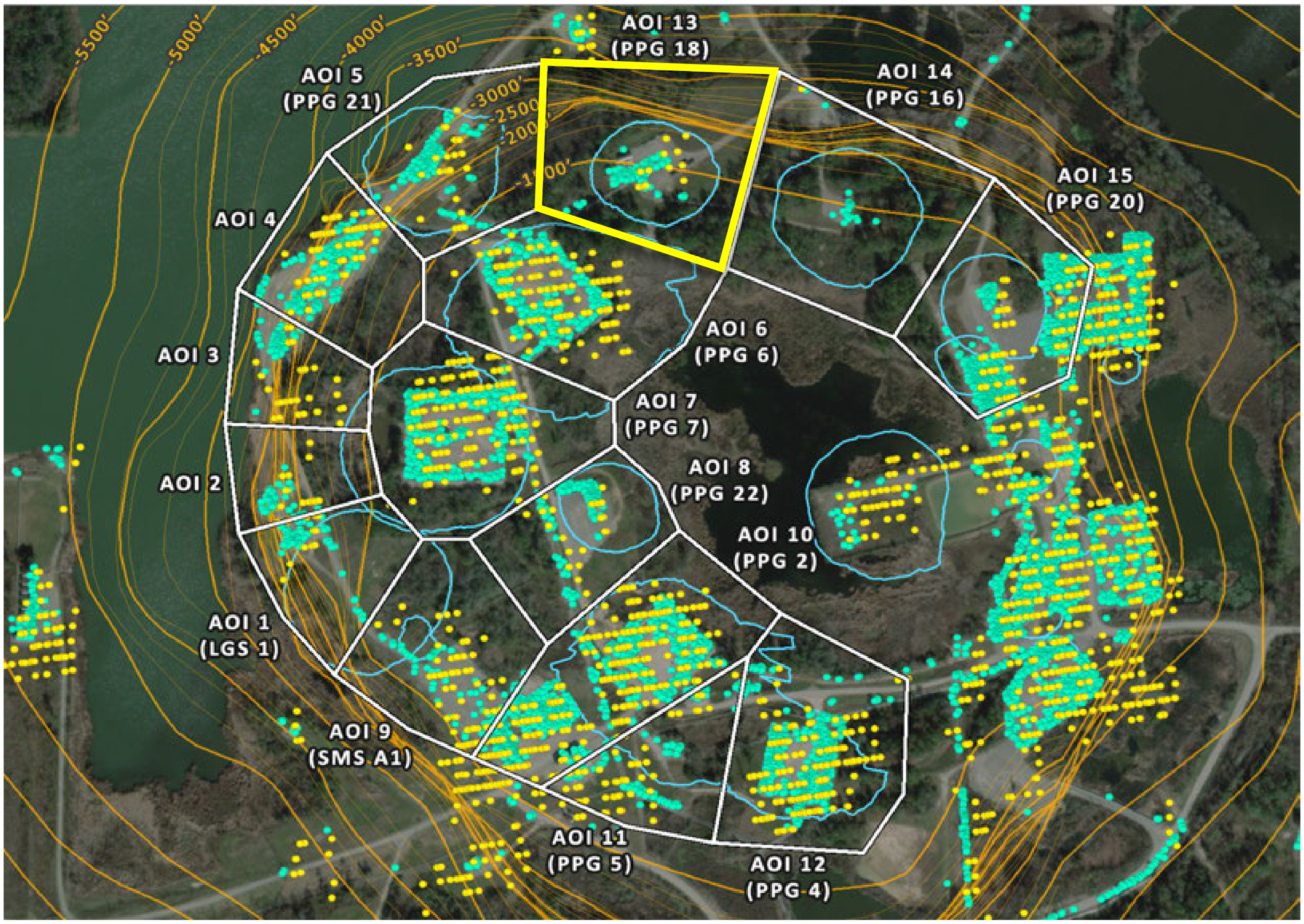
SNT (2/19/2025) Point Count: **120**



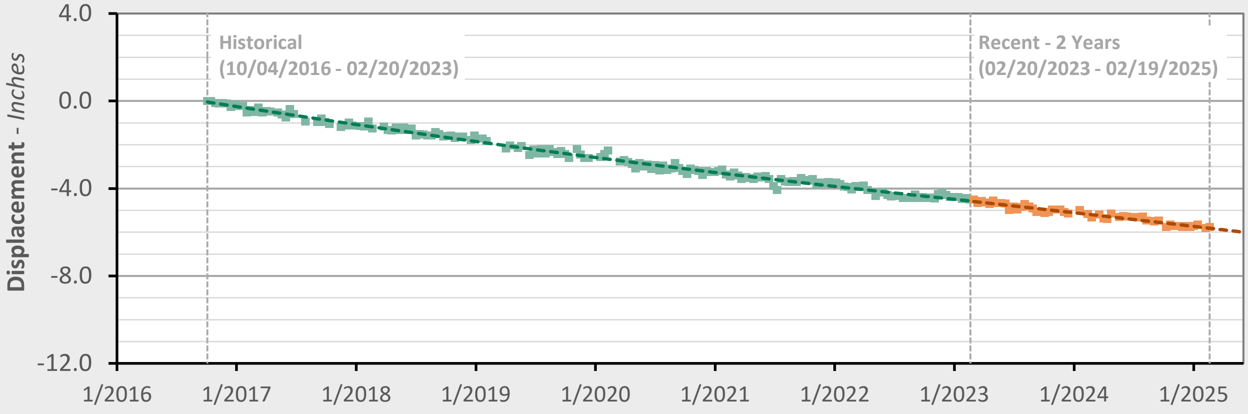
	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.75 in/yr	-0.64 in/yr	+0.10 in/yr
Acceleration:	+0.04 in/yr^2	+0.01 in/yr^2	-0.03 in/yr^2

- 🟩 Historical LOS Displacement Measurement
- ---- Historical Trend Line (Quadratic Regression)
- 🟧 Recent LOS Displacement Measurement
- ---- Historical Trend Line (Quadratic Regression)

AOI 13 *(PPG 18)* - Location Map



AOI 13 *(PPG 18)* - Displacement Time Serie SNT (2/19/2025) Point Count: 12



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.56 in/yr	-0.65 in/yr	-0.09 in/yr
Acceleration:	+0.05 in/yr^2	-0.04 in/yr^2	-0.09 in/yr^2

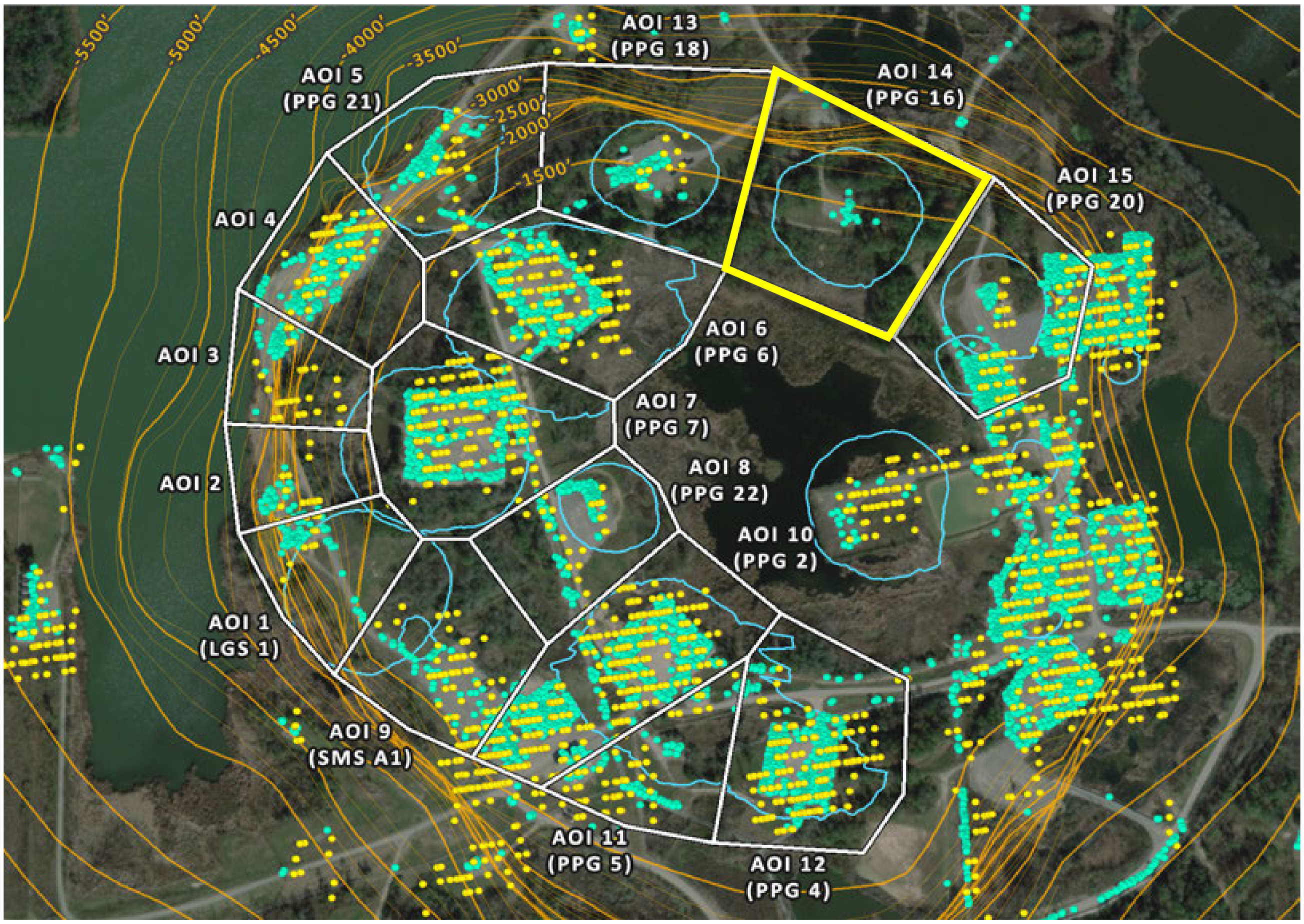
■ Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

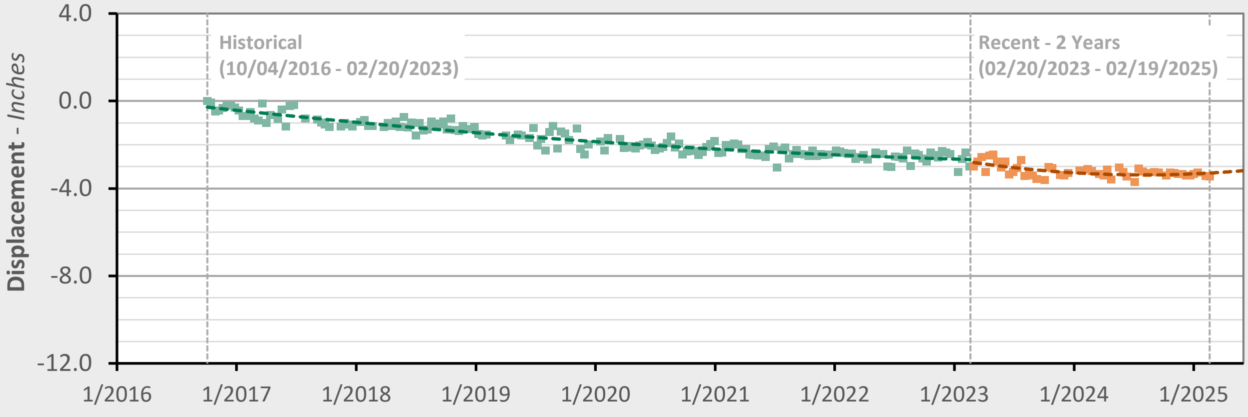
■ Recent LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

AOI 14 *(PPG 16)* - Location Map



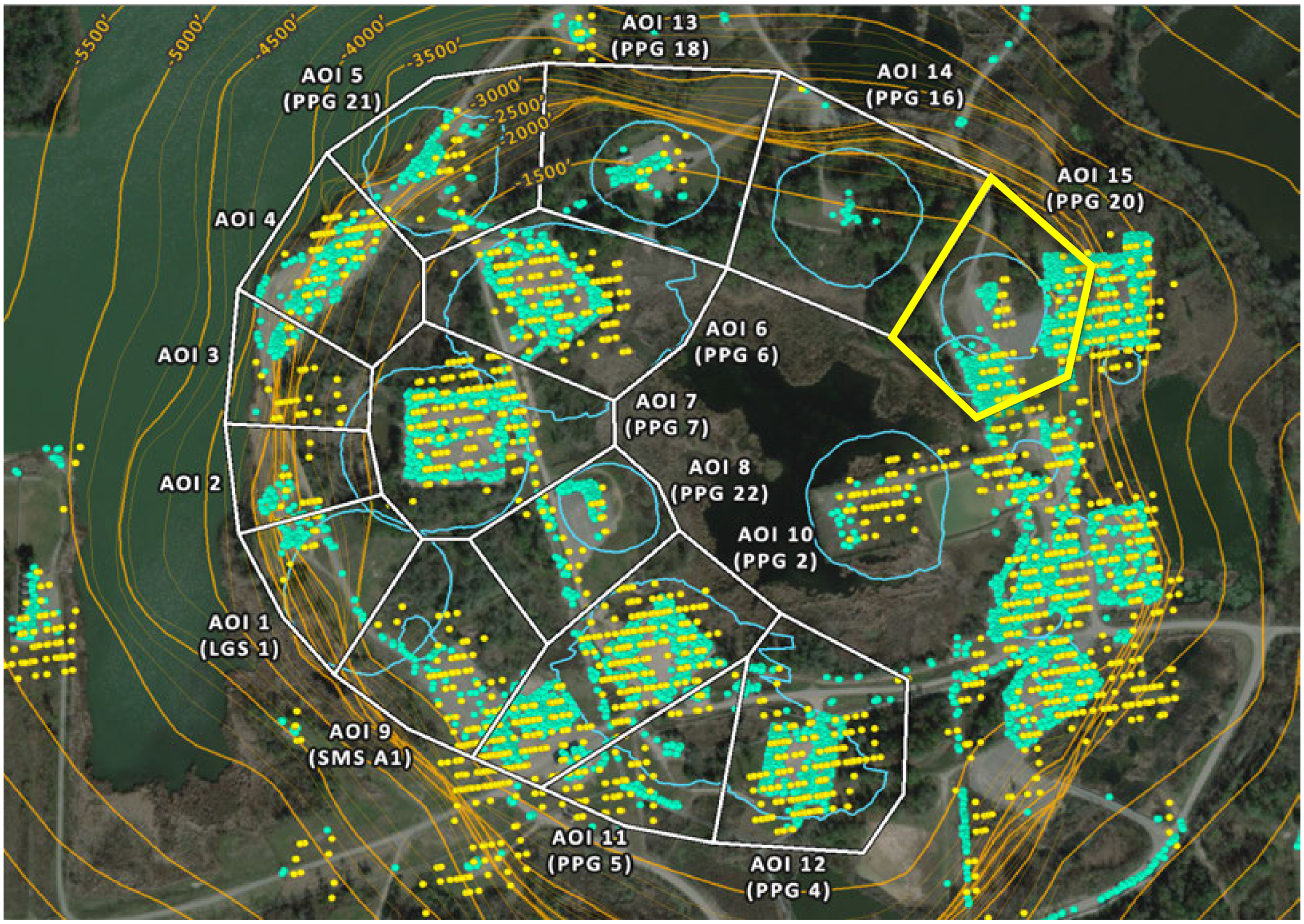
AOI 14 *(PPG 16)* - Displacement Time Serie SNT (2/19/2025) Point Count: 1



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.15 in/yr	+0.36 in/yr	+0.51 in/yr
Acceleration:	+0.07 in/yr^2	+0.62 in/yr^2	+0.55 in/yr^2

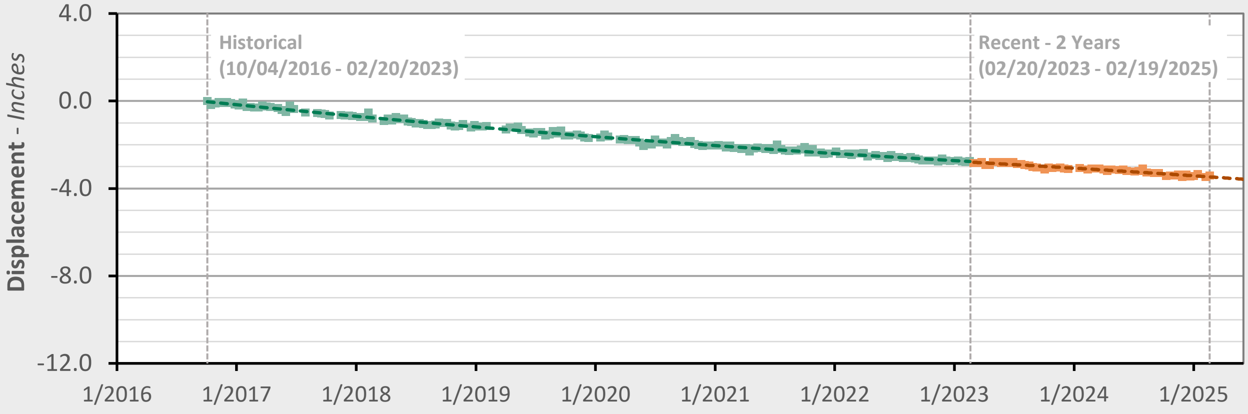
Historical LOS Displacement Measurement	Historical Trend Line (Quadratic Regression)	Recent LOS Displacement Measurement	Historical Trend Line (Quadratic Regression)

AOI 15 *(PPG 20)* - Location Map



AOI 15 *(PPG 20)* - Displacement Time Serie

SNT (2/19/2025) Point Count: 69



	Historical Trend Values	Recent Trend Values	Trend Change
Velocity:	-0.30 in/yr	-0.37 in/yr	-0.07 in/yr
Acceleration:	+0.04 in/yr^2	-0.03 in/yr^2	-0.07 in/yr^2

■ Historical LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

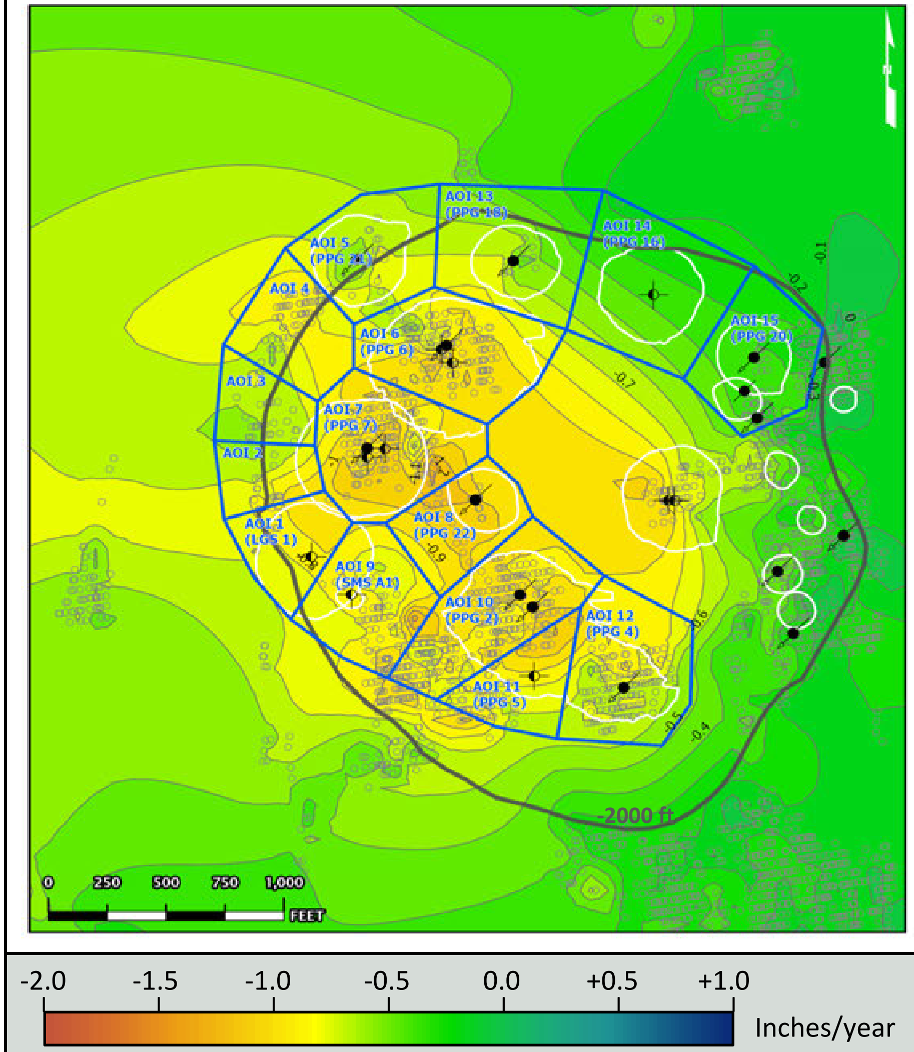
■ Recent LOS Displacement Measurement

---- Historical Trend Line (Quadratic Regression)

Historical SNT Data (10/04/2016 - 02/20/2023)

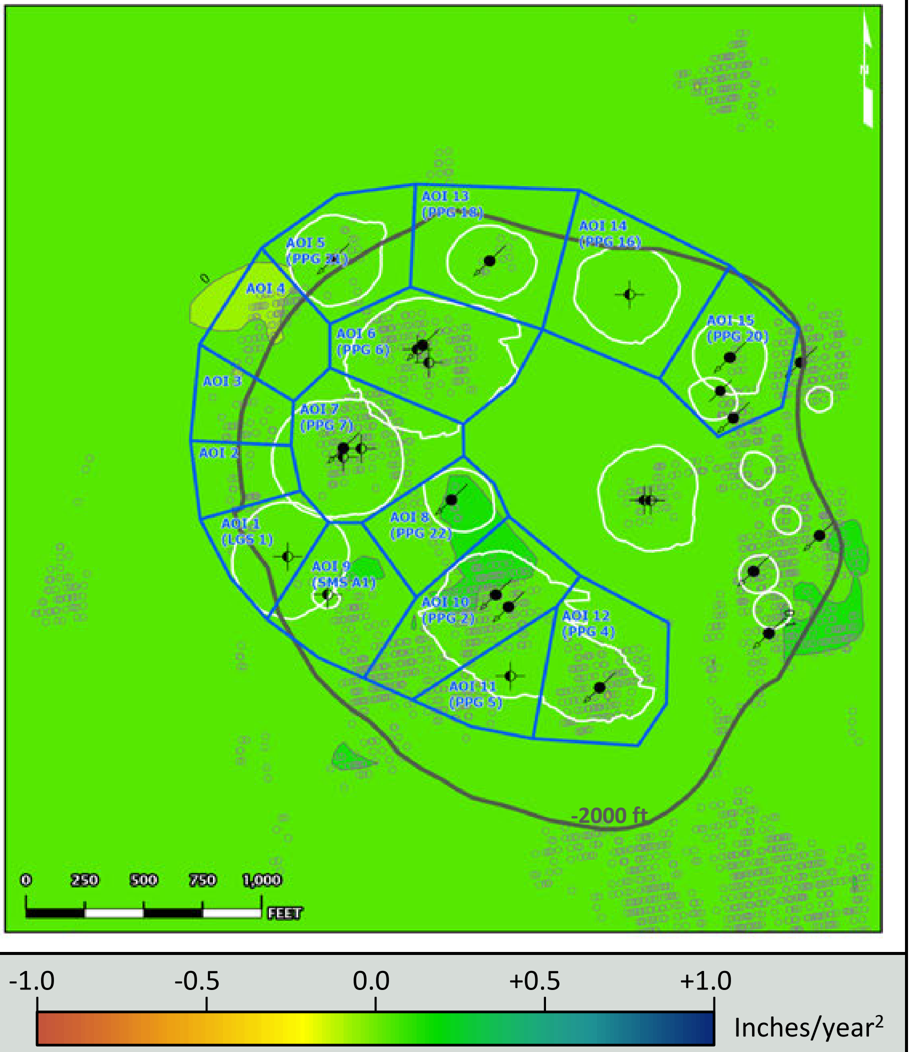
Velocity Contours

As of date: 02/20/2023



Acceleration Contours

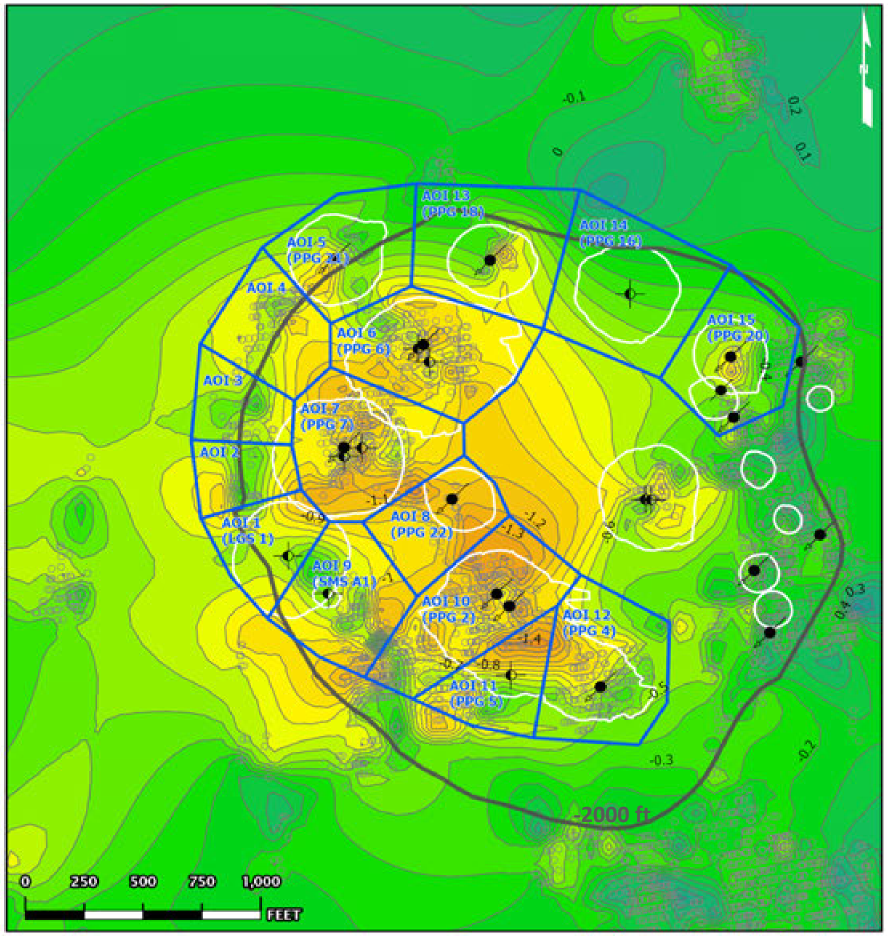
Date range: 10/04/2016 - 02/20/2023

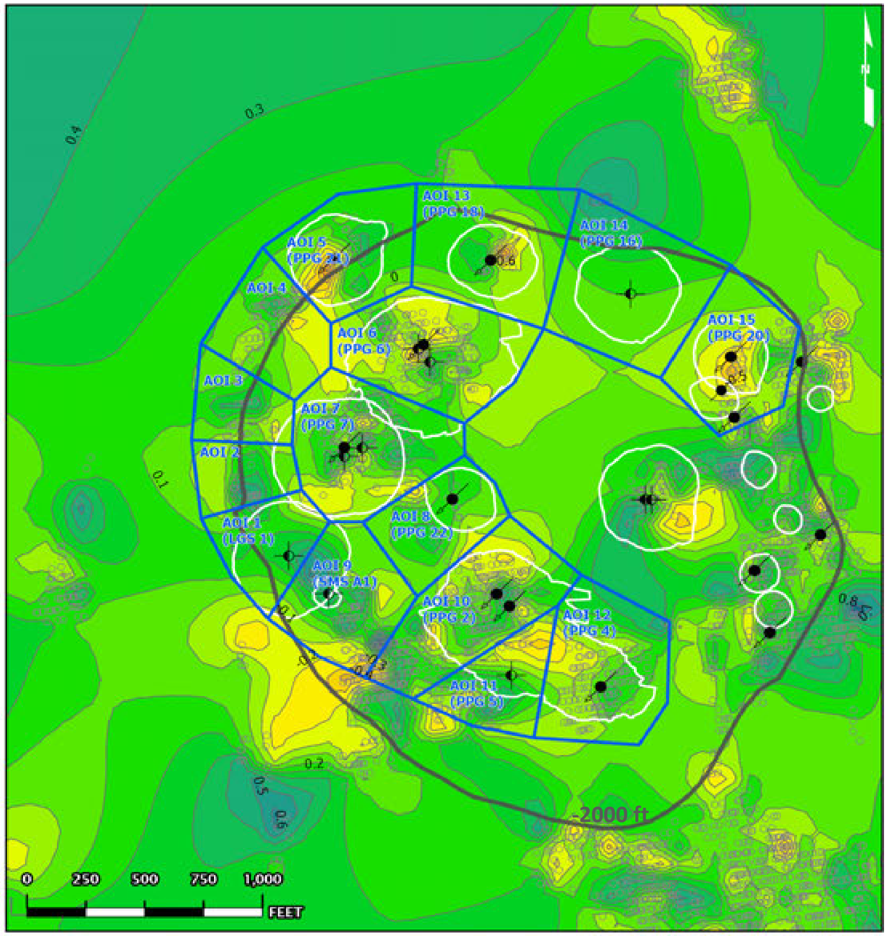


AOI Boundary
○ InSAR LOS Measurement Point
Contour (0.1)
Cavern Well Surface Locations
Historical Cavern Extent
Top of Dome (-2000 ft Contour)
09 - Active - Injection
29 - Dry and Plugged

Recent SNT Data - 2 Years (02/20/2023 - 02/19/2025)

Velocity Contours As of date: 02/19/2025	Acceleration Contours Date range: 02/20/2023 - 02/19/2025





Velocity Contours: -2.0 -1.5 -1.0 -0.5 0.0 +0.5 +1.0 Inches/year

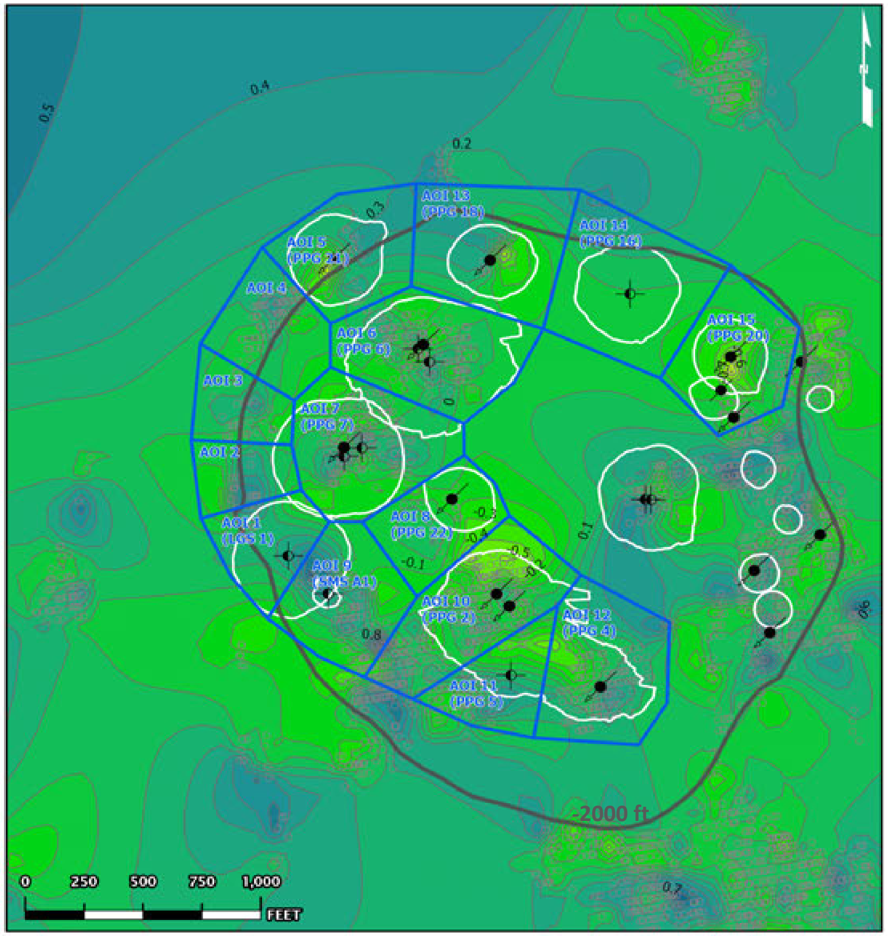
Acceleration Contours: -1.0 -0.5 0.0 +0.5 +1.0 Inches/year^2

▭ AOI Boundary	○ InSAR LOS Measurement Point	— Contour (0.1)	Cavern Well Surface Locations
▭ Historical Cavern Extent	▭ Top of Dome (-2000 ft Contour)	● 09 - Active - Injection	⊕ 29 - Dry and Plugged

Change from Historical to Recent SNT Data

Velocity Contours

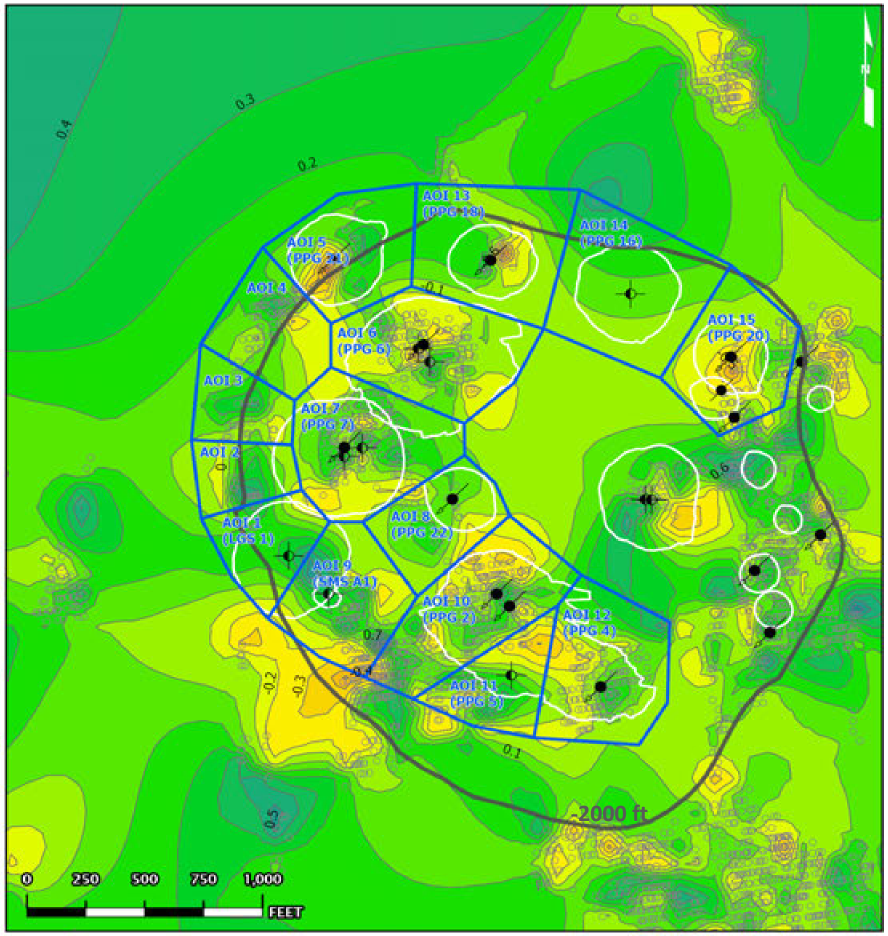
Historical Velocity subtracted from Recent Velocity



-2.0 -1.5 -1.0 -0.5 0.0 +0.5 +1.0 Inches/year

Acceleration Contours

Historical Acceleration subtracted from Recent Acceleration



-1.0 -0.5 0.0 +0.5 +1.0 Inches/year^2

🟦 AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.1)

⬜ Historical Cavern Extent ⬛ Top of Dome (-2000 ft Contour)

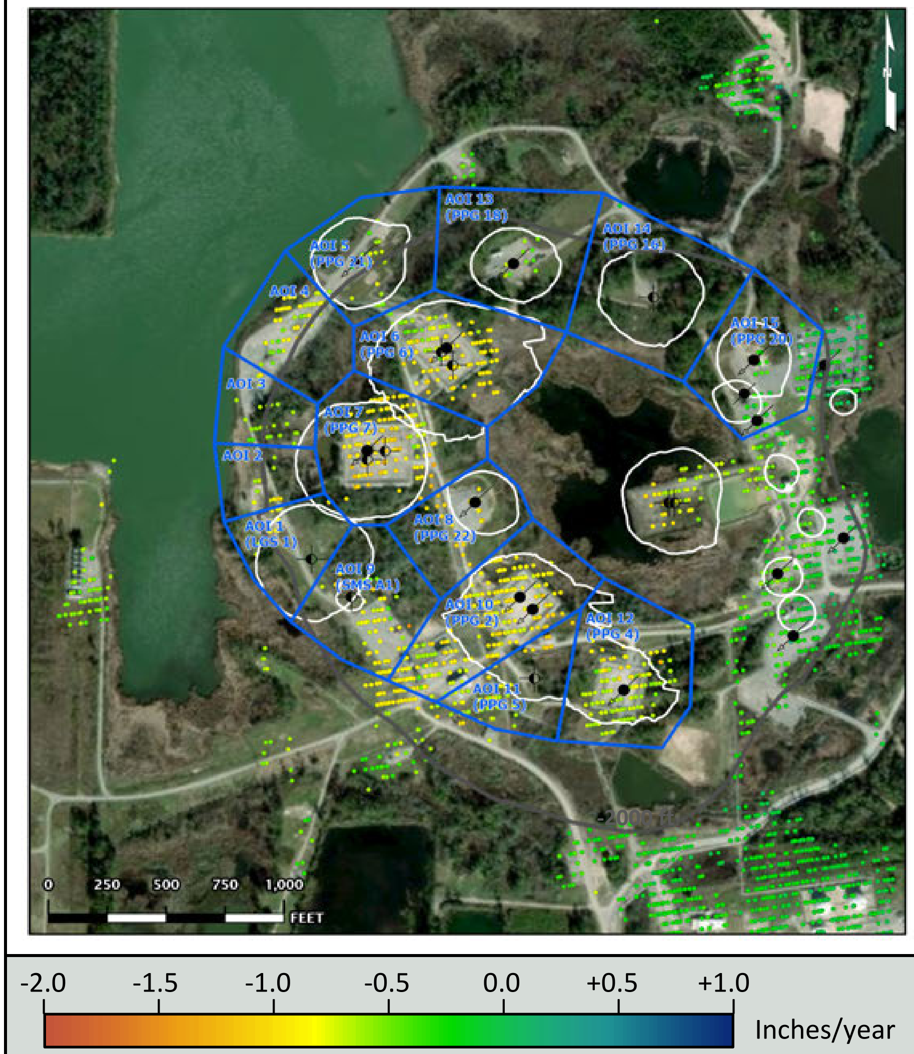
Cavern Well Surface Locations

● 09 - Active - Injection ⊕ 29 - Dry and Plugged

Historical SNT Data (10/04/2016 - 02/20/2023)

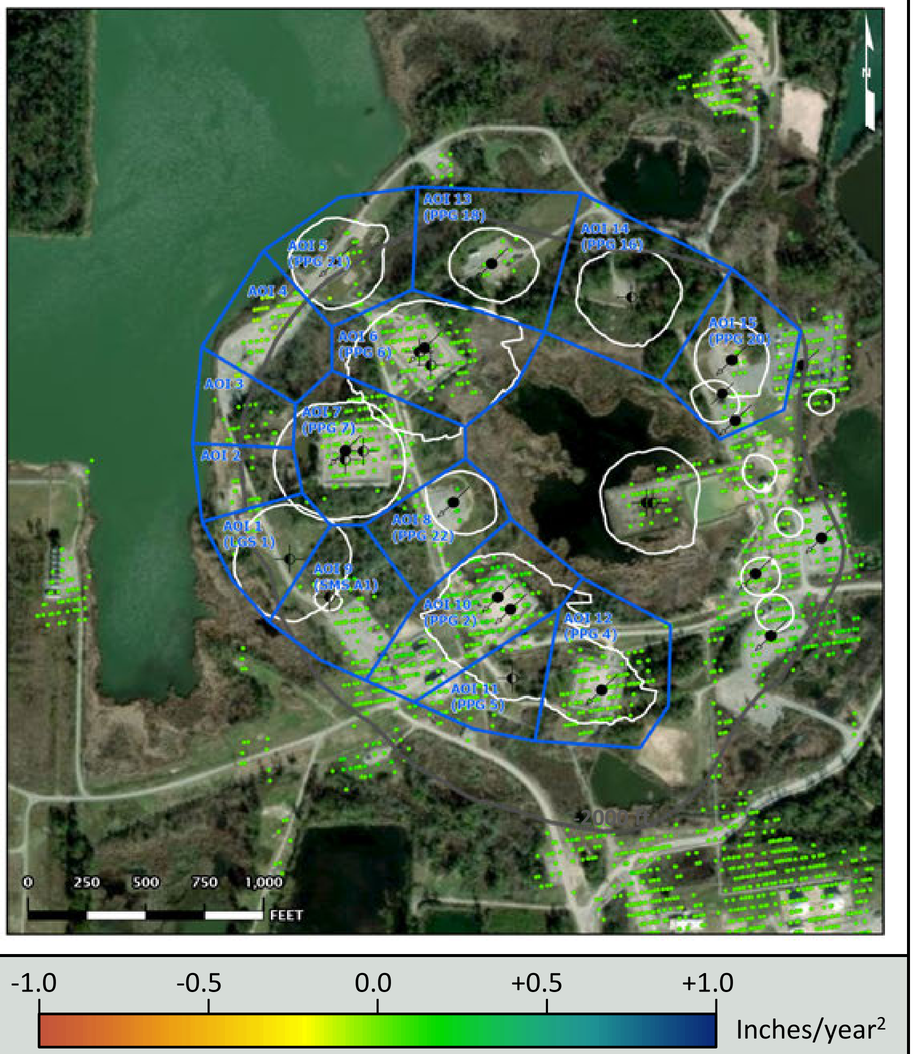
Velocity Data Points

As of date: 02/20/2023



Acceleration Data Points

Date range: 10/04/2016 - 02/20/2023



▭ AOI Boundary
○ InSAR LOS Measurement Point
▭ Historical Cavern Extent
▭ Top of Dome (-2000 ft Contour)

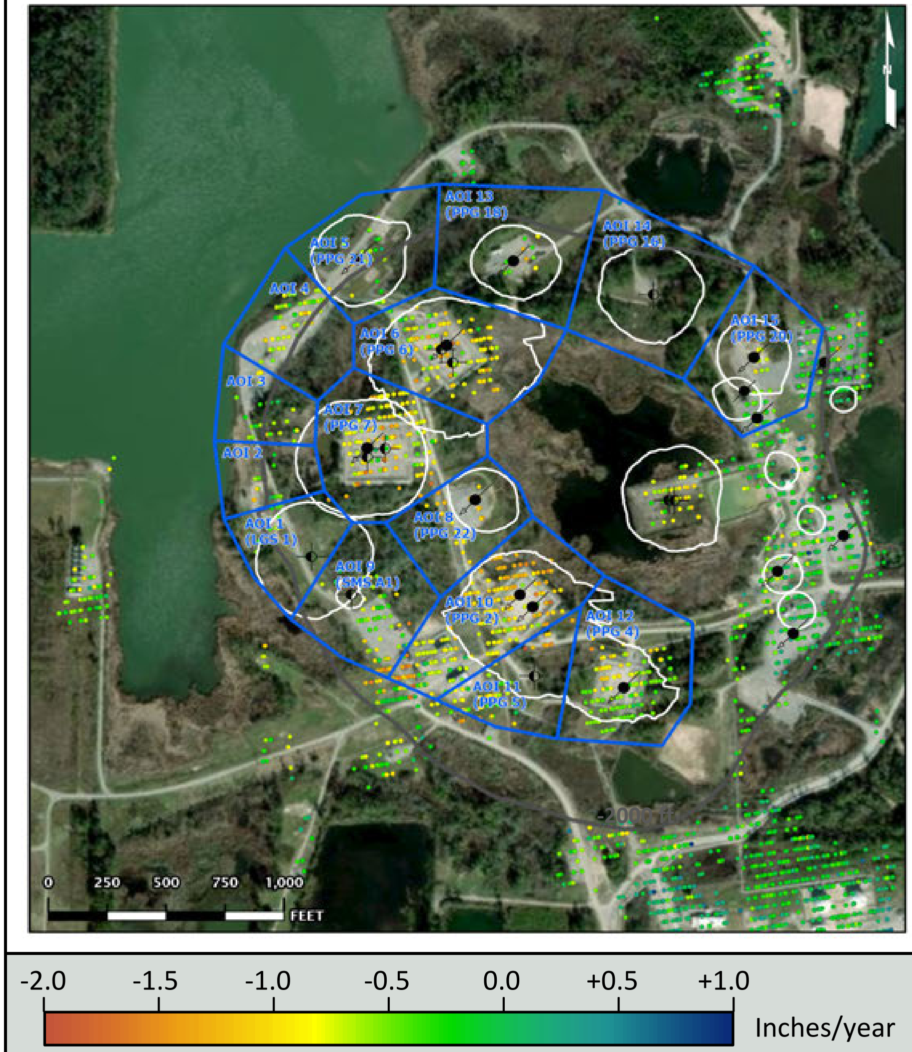
Cavern Well Surface Locations

● 09 - Active - Injection
⊕ 29 - Dry and Plugged

Recent SNT Data - 2 Years (02/20/2023 - 02/19/2025)

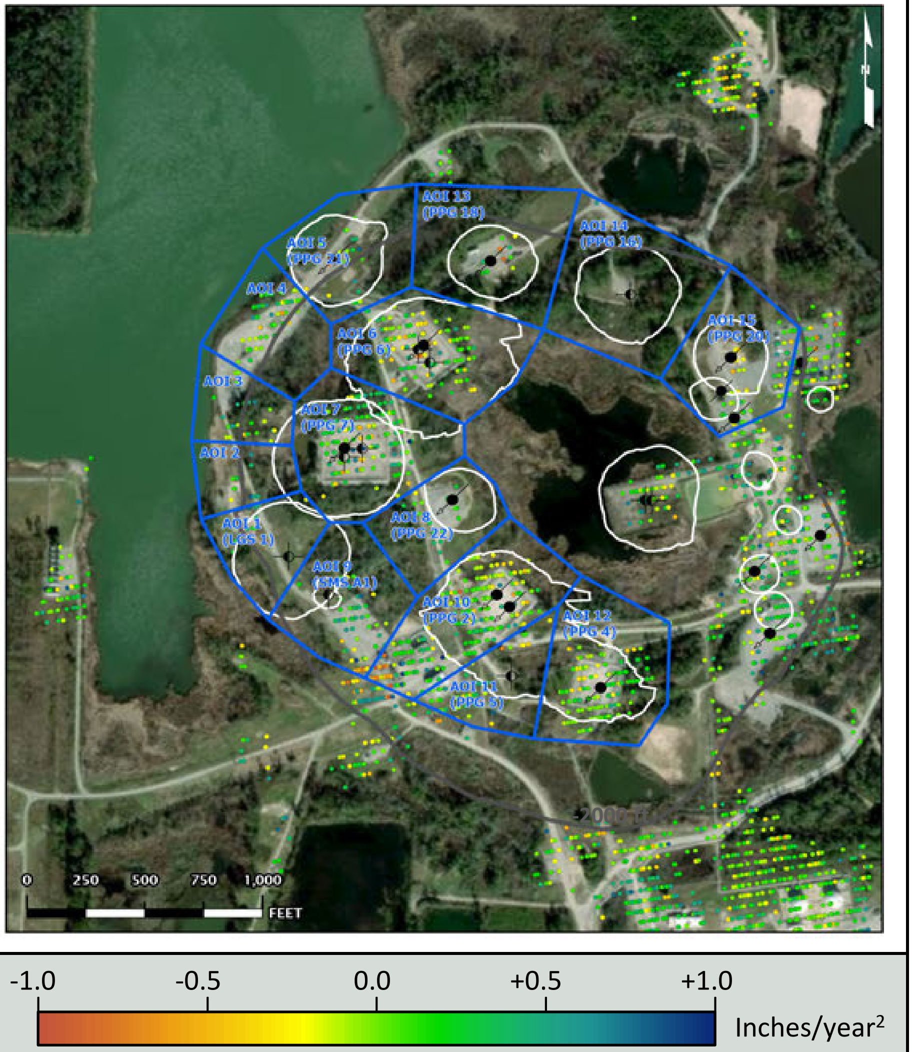
Velocity Data Points

As of date: 02/19/2025



Acceleration Data Points

Date range: 02/20/2023 - 02/19/2025



- ▭ AOI Boundary
- ▭ Historical Cavern Extent
- ○ InSAR LOS Measurement Point
- ▭ Top of Dome (-2000 ft Contour)

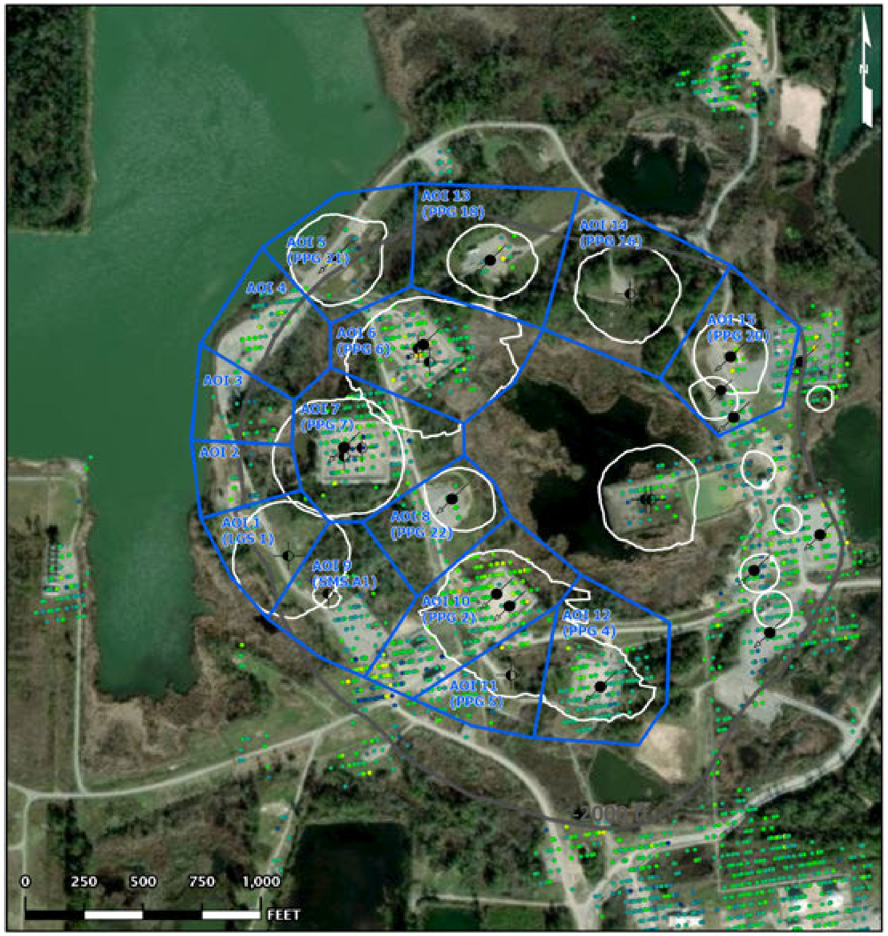
Cavern Well Surface Locations

- ● 09 - Active - Injection
- ⊕ 29 - Dry and Plugged

Change from Historical to Recent SNT Data

Velocity Data Points

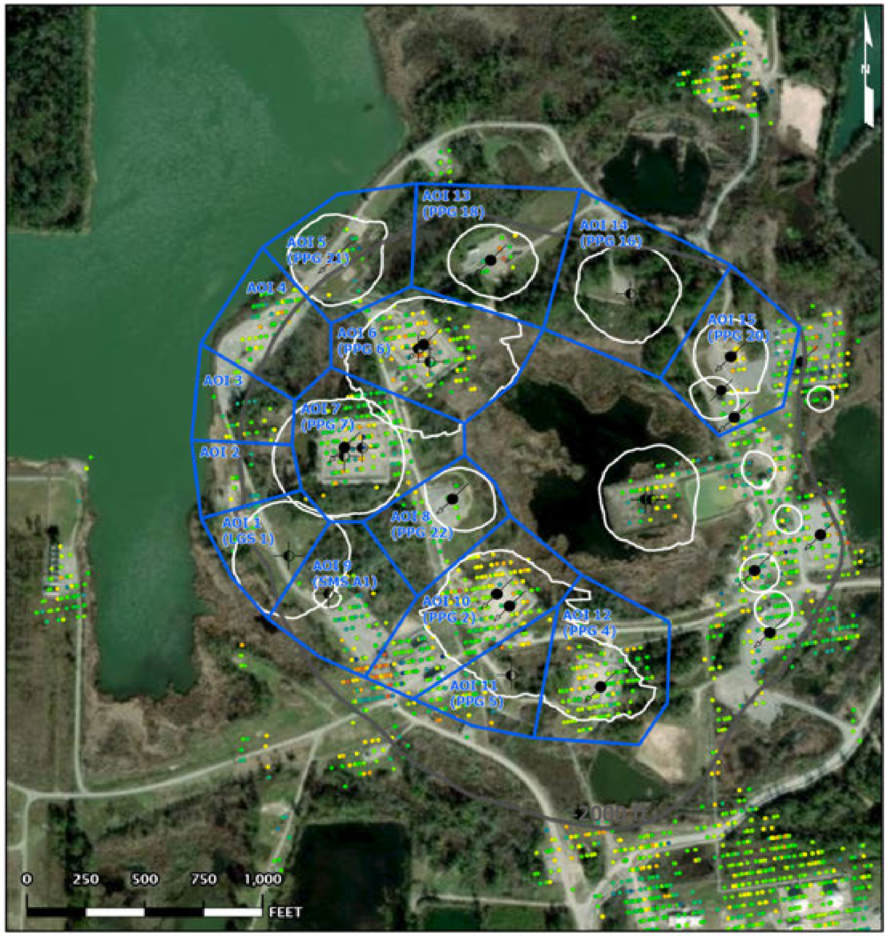
Historical Velocity subtracted from Recent Velocity



-2.0 -1.5 -1.0 -0.5 0.0 +0.5 +1.0 Inches/year

Acceleration Data Points

Historical Acceleration subtracted from Recent Acceleration



-1.0 -0.5 0.0 +0.5 +1.0 Inches/year^2

▭ AOI Boundary
○ InSAR LOS Measurement Point
▭ Historical Cavern Extent
▭ Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations
09 - Active - Injection
29 - Dry and Plugged

ATTACHMENT C

TSX/PAZ InSAR report - February 25, 2025

TSX/PAZ Satellite Update

Continuous InSAR Monitoring of Ground Displacement At Westlake Caverns and Western Dome Flank

Sulphur Mines Salt Dome

Prepared for:
Westlake Chemical

Prepared by:
Lonquist & Co., LLC
8591 United Plaza Blvd.
Suite 280
Baton Rouge, LA 70809

Dataset
Satellite Source
TerraSAR-X - PAZ Constellation
Most Recent Image Date
Tuesday, February 25, 2025

Analysis Report Date:

March 4, 2025

Dataset Information

Satellite Source	TerraSAR-X - PAZ Constellation
Revisit Frequency	4 and 7 days
Most Recent Image Date	Tuesday, February 25, 2025
Dataset Image Count	134
Dataset Time Range	January 24, 2023 - February 25, 2025
Dataset Length	2.09 Years
Satellite Line-of-Sight (LOS)	37° East of Vertical (Viewing site from the East)

Analysis Methodology

Time Series Charts

Trend lines were calculated for the averaged displacement values within each AOI. Both a nonlinear (quadratic) and linear regression were applied to each AOI point group to identify rates of change in LOS displacement. These trends are displayed in the Time Series section of this report.

Contour Maps

A nonlinear (quadratic) and linear trend was also calculated for each individual measurement point across the analysis region. Nonlinear trend values for each point were used to generate Velocity and Acceleration contour maps to convey the spatial distribution of the calculated movement. The linear trend values for each point (which lack an acceleration component) were used to generate an additional Velocity contour map. Maps depicting the individual data points colored by these trend values are also included in the last section of the report.

Negative velocity values indicate subsidence or westward movement and positive velocity indicates uplift or eastward movement. Negative acceleration values indicate increasing rates of subsidence, increasing westward movement, or slowing eastward movement and positive acceleration values indicate slowing rates of subsidence, slowing westward movement, or increasing eastward movement.

Observations

To-date there have been no acute deviations from established subsidence trends in the areas investigated.

The time series charts show broadly consistent near-linear trends among the analysis AOIs. Acceleration values for the quadratic (non-linear) trend fit are positive in all AOIs (slowing negative displacement) but minor overall. A slight seasonal fluctuation is evident in some of the charts.

The contour maps show the greatest negative displacement centered aroud the eastern central portion of the dome where the combination of subsidence and western horizontal movement (toward the dome center) are expected to produce the greatest rate of movement away from the satellite's line of sight from the east.

NATHANIEL L. BYARS
License No. 40697

Nathaniel Byars

Date Signed: March 4, 2025
Austin, Texas

Nathaniel L. Byars, P.E.
Principal Engineer
Louisiana License No. 40697

InSAR Data Sources

InSAR Data

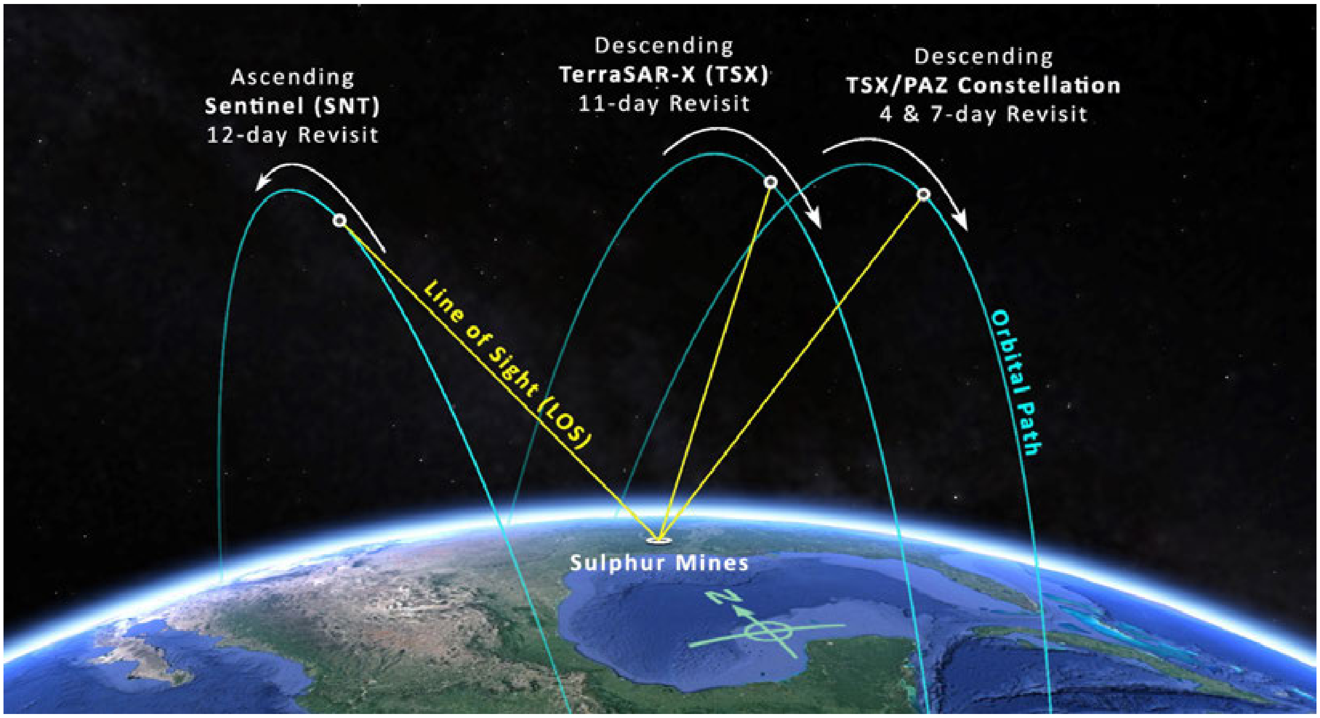
Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the ground. Objects or ground features providing a stable reflection of radar energy such as buildings, roads, and infrastructure produce the highest quality measurement points. InSAR analysis identifies the change in distance between the satellite and each measurement point over time relative to a stable reference point within the imaged area.

Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacment measurements from both ascending and descending orbits. An ascending orbit denotes the satellite's longitudinal course from south to north as it passes over the site, while a desceding orbit denotes the satellite is moving from north to south.

The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These are a TSX satellite and the PAZ satellite (TSX/PAZ constellation), both with an 11-day revisit frequency. Their orbits are offset with the PAZ satellite passing over the site 4 days after the TSX satellite. Prior to May 2023, data was captured from a different high-resolution TerraSAR-X (TSX) satellite on a descending orbit that captured data from the east of the site on an 11-day frequency. The transition was made for the increased data frequency that resulted from a 4 and 7-day revisit period. The image below depicts the orbital paths of the satellites in relation to the Sulphur Mines Salt Dome.

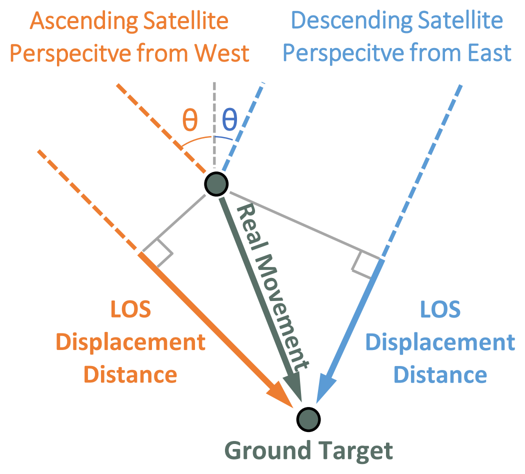
Satellite Orbital Diagram



InSAR Line-of-Site (LOS) Data

LOS displacement measurements refer to a change in distance between the satellite sensor and the ground target. Measurement positions on the west side of the Sulphur Dome are are known to be experiencing some eastward movement toward the dome center due to the geometry of the subsidence basin. The InSAR satellites view the site from eastward and westward positions so LOS measurements are understood to convey a movement distance that is not purely vertical. The diagram to the right illustrates the geometric relationship between the theoretical Real movement of a ground target and LOS displacement measurements from two different satellite viewing directions.

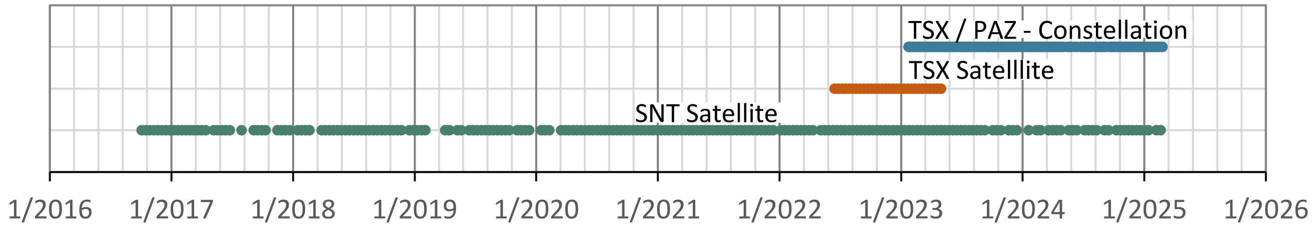
<– West Side View East–>



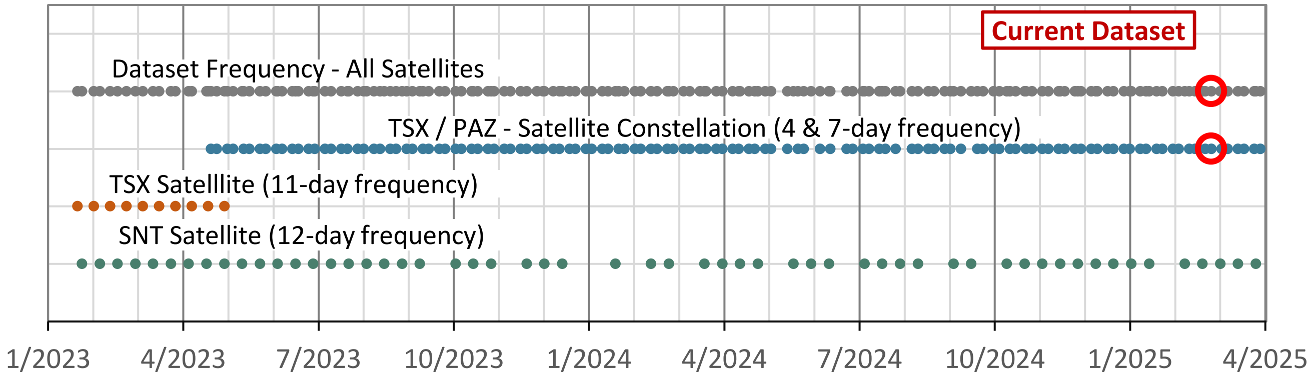
Satellite Properties & Image Frequency

Satellite and Data Properties	SNT	TSX	TSX/PAZ Constellation
Band (Wavelength)	C-band (2.20 in)	X-band (1.22 in)	X-band (1.22 in)
Track	T136	T29	T67 & T120
Pixel resolution	65 x 16 ft	3 x 3 ft	3 x 3 ft
Revisit frequency	12 days	11 days	4 & 7 days
Orbit (LOS Angle, θ)	Ascending (43^o)	Descending (17^o)	Descending (37^o)
Data Start Date	10/4/2016	6/16/2022	1/24/2023
Measurement error range	± 0.20 in	± 0.03 in	± 0.03 in

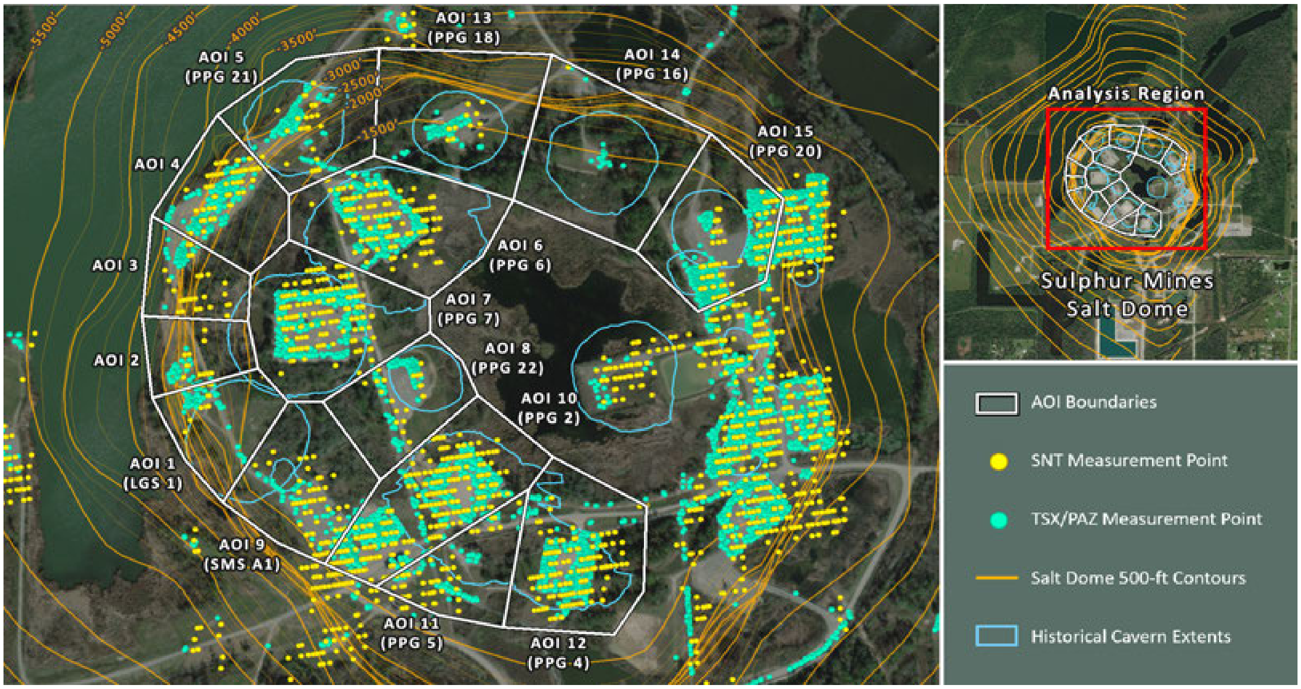
Dataset Measurement History



Dataset Update Frequency



AOI Boundaries & InSAR Measurement Points

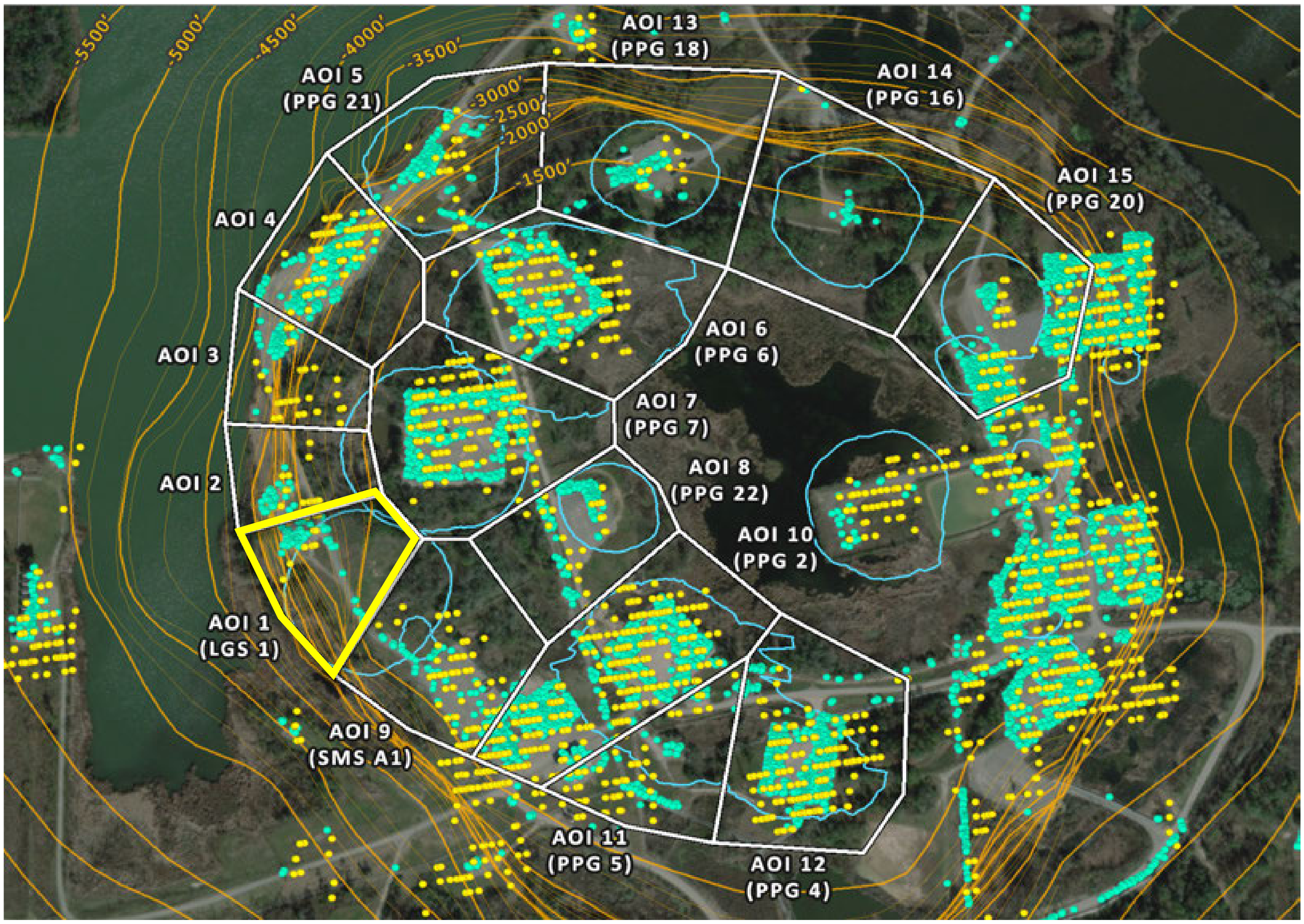


Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the trend values calculated in each AOI for the dataset evaluated in this report.

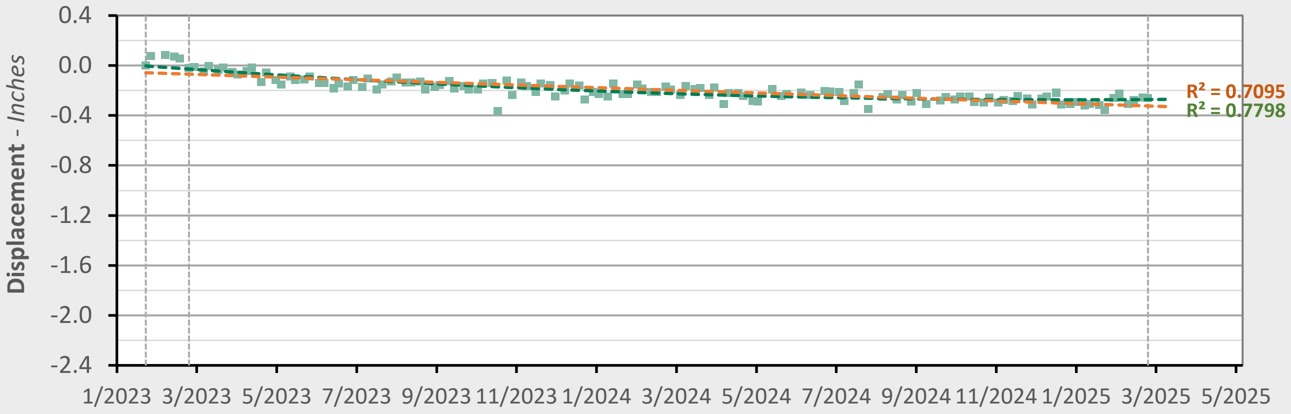
AOI Name	TSX/PAZ (2/25/2025)	LOS Velocity (in/yr)		LOS Acceleration (in/yr^2)	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
AOI 1 *(LGS 1)*	77	+0.03	-0.13	+0.15	0.00
AOI 2	44	-0.03	-0.19	+0.15	0.00
AOI 3	71	-0.22	-0.30	+0.07	0.00
AOI 4	225	-0.05	-0.13	+0.08	0.00
AOI 5 *(PPG 21)*	138	-0.11	-0.20	+0.09	0.00
AOI 6 *(PPG 6)*	355	-0.37	-0.46	+0.09	0.00
AOI 7 *(PPG 7)*	396	-0.28	-0.36	+0.08	0.00
AOI 8 *(PPG 22)*	127	-0.52	-0.67	+0.15	0.00
AOI 9 *(SMS A1)*	68	-0.03	-0.27	+0.23	0.00
AOI 10 *(PPG 2)*	811	-0.47	-0.55	+0.08	0.00
AOI 11 *(PPG 5)*	127	-0.41	-0.53	+0.11	0.00
AOI 12 *(PPG 4)*	552	-0.75	-0.80	+0.05	0.00
AOI 13 *(PPG 18)*	108	-0.24	-0.41	+0.17	0.00
AOI 14 *(PPG 16)*	22	-0.51	-0.82	+0.29	0.00
AOI 15 *(PPG 20)*	742	-0.86	-0.93	+0.06	0.00

AOI 1 *(LGS 1)* - Location Map



AOI 1 *(LGS 1)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **77**



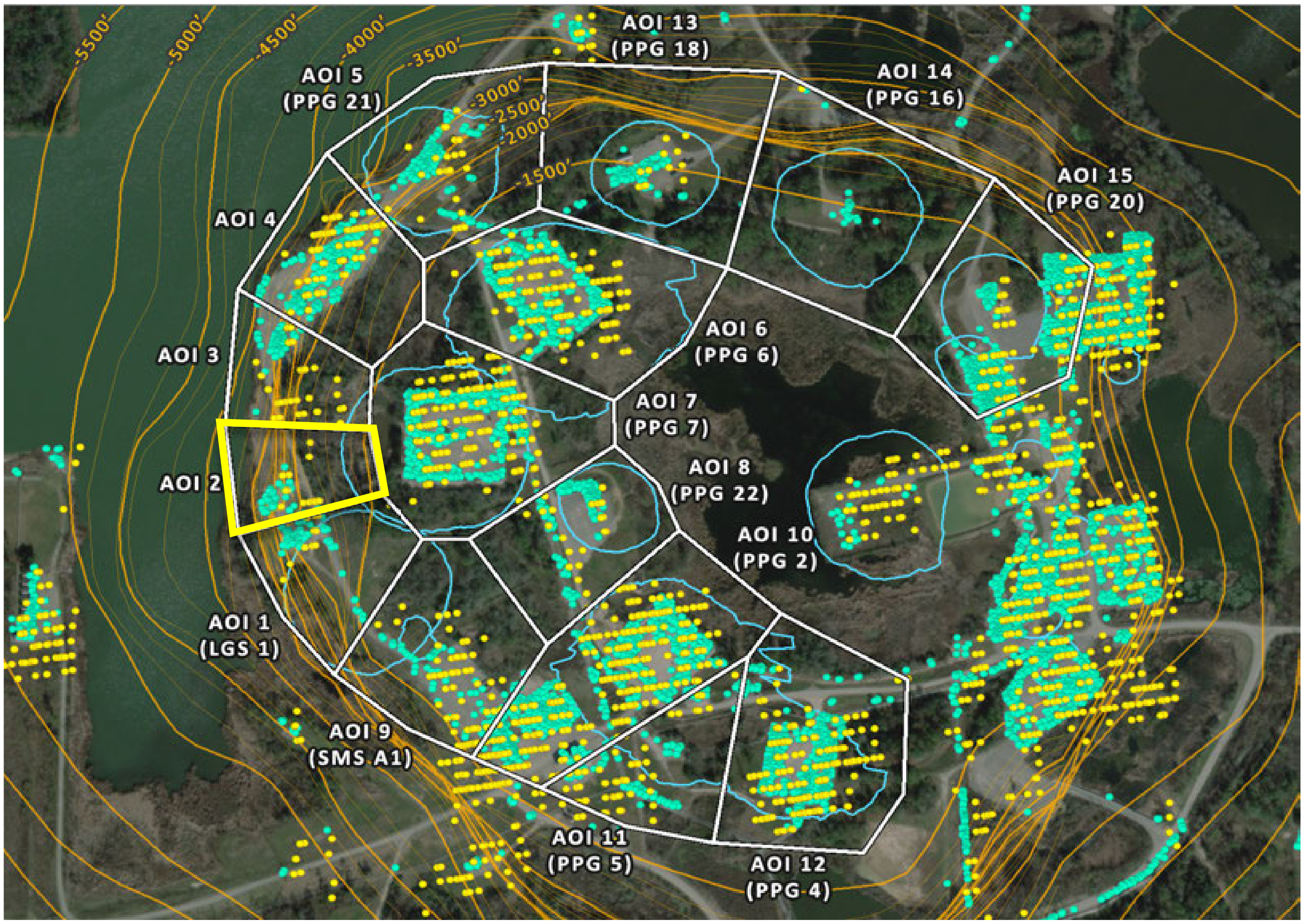
	Nonlinear Trend		Linear Trend	
Velocity:	+0.03	in/yr	-0.13	in/yr
Acceleration:	+0.15	in/yr^2	0.00	in/yr^2

■ LOS Displacement Measurement

- - - - Nonlinear Trend Line (Quadratic Regression)

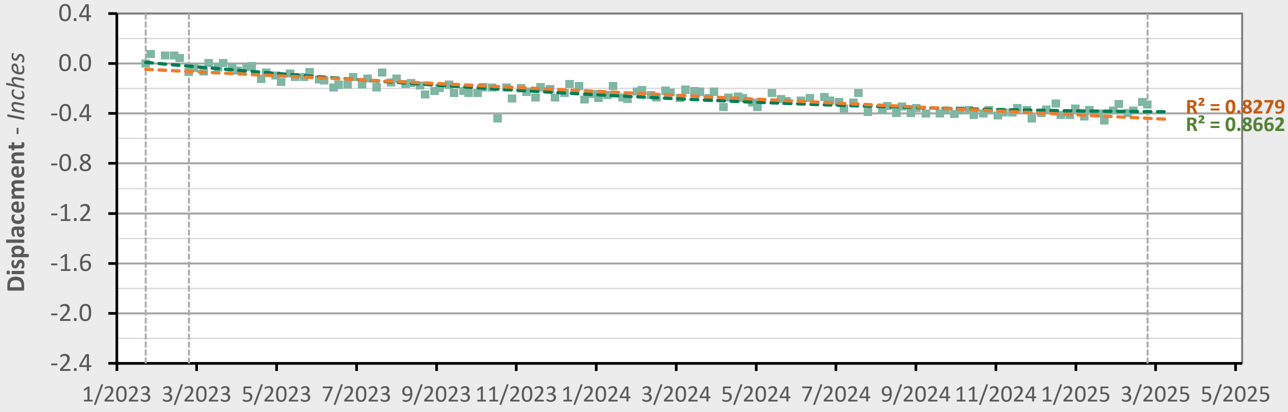
- - - - Linear Trend Line (Linear Regression)

AOI 2 - Location Map



AOI 2 - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **44**



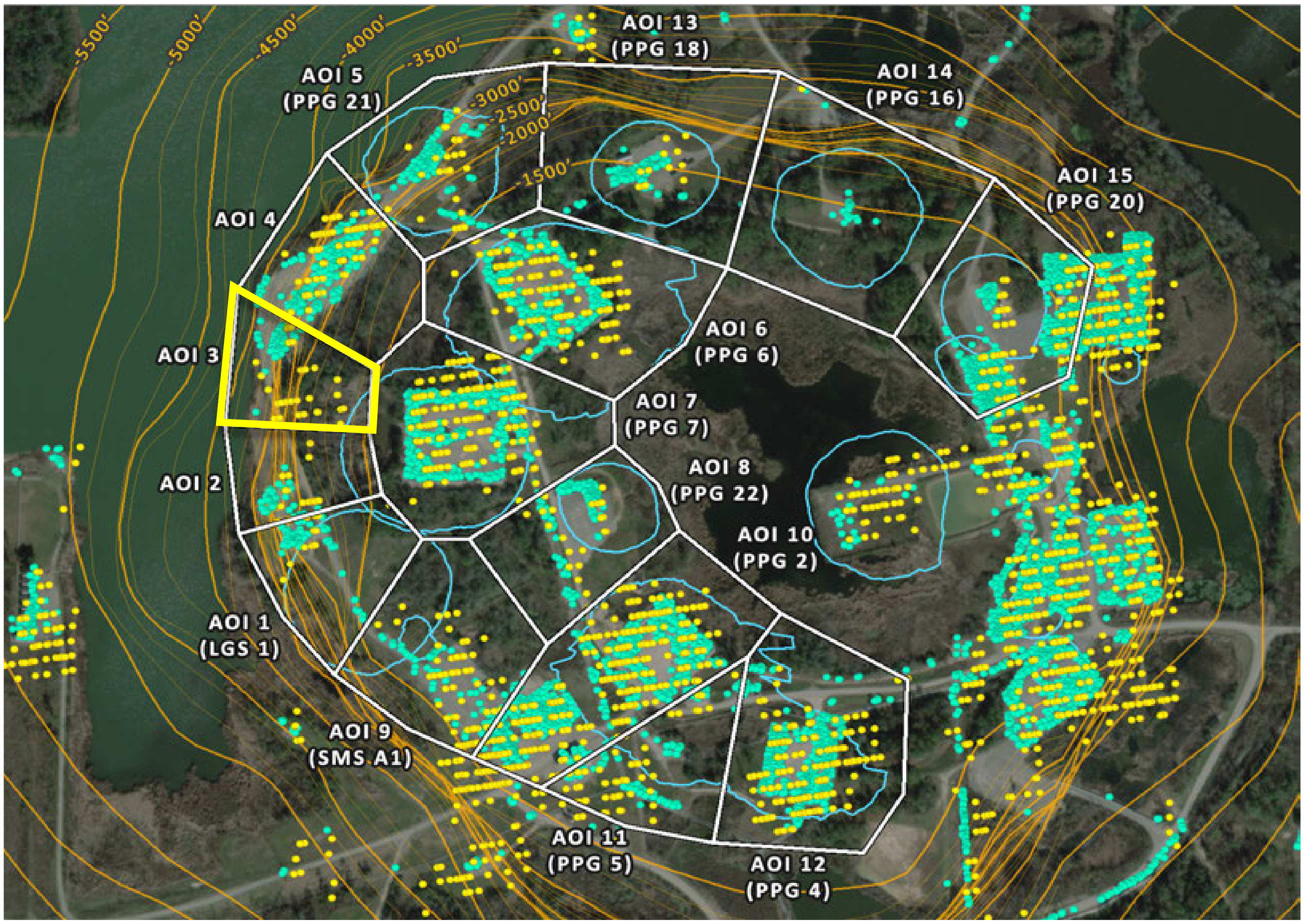
	Nonlinear Trend	Linear Trend
Velocity:	-0.03 in/yr	-0.19 in/yr
Acceleration:	+0.15 in/yr^2	0.00 in/yr^2

■ LOS Displacement Measurement

- - - - Nonlinear Trend Line (Quadratic Regression)

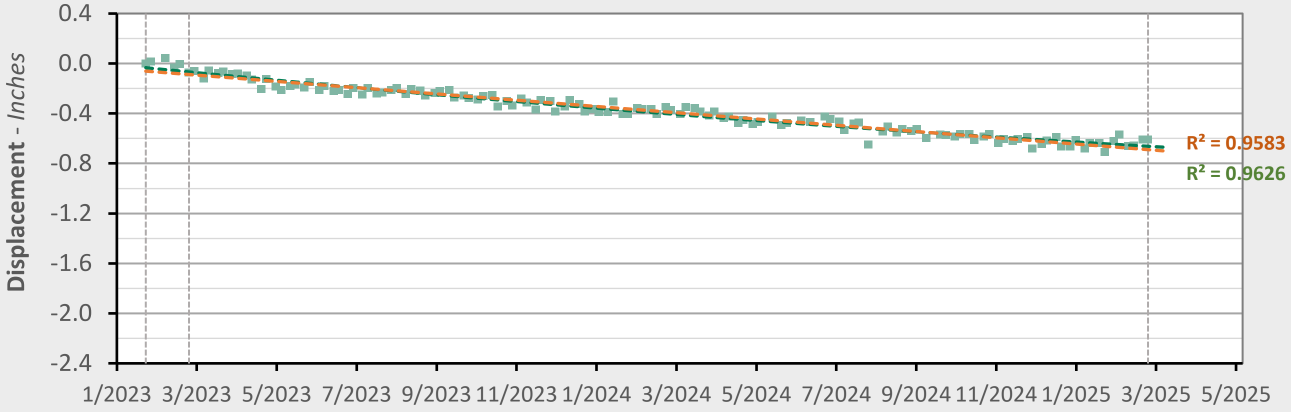
- - - - Linear Trend Line (Linear Regression)

AOI 3 - Location Map



AOI 3 - Displacement Time Series

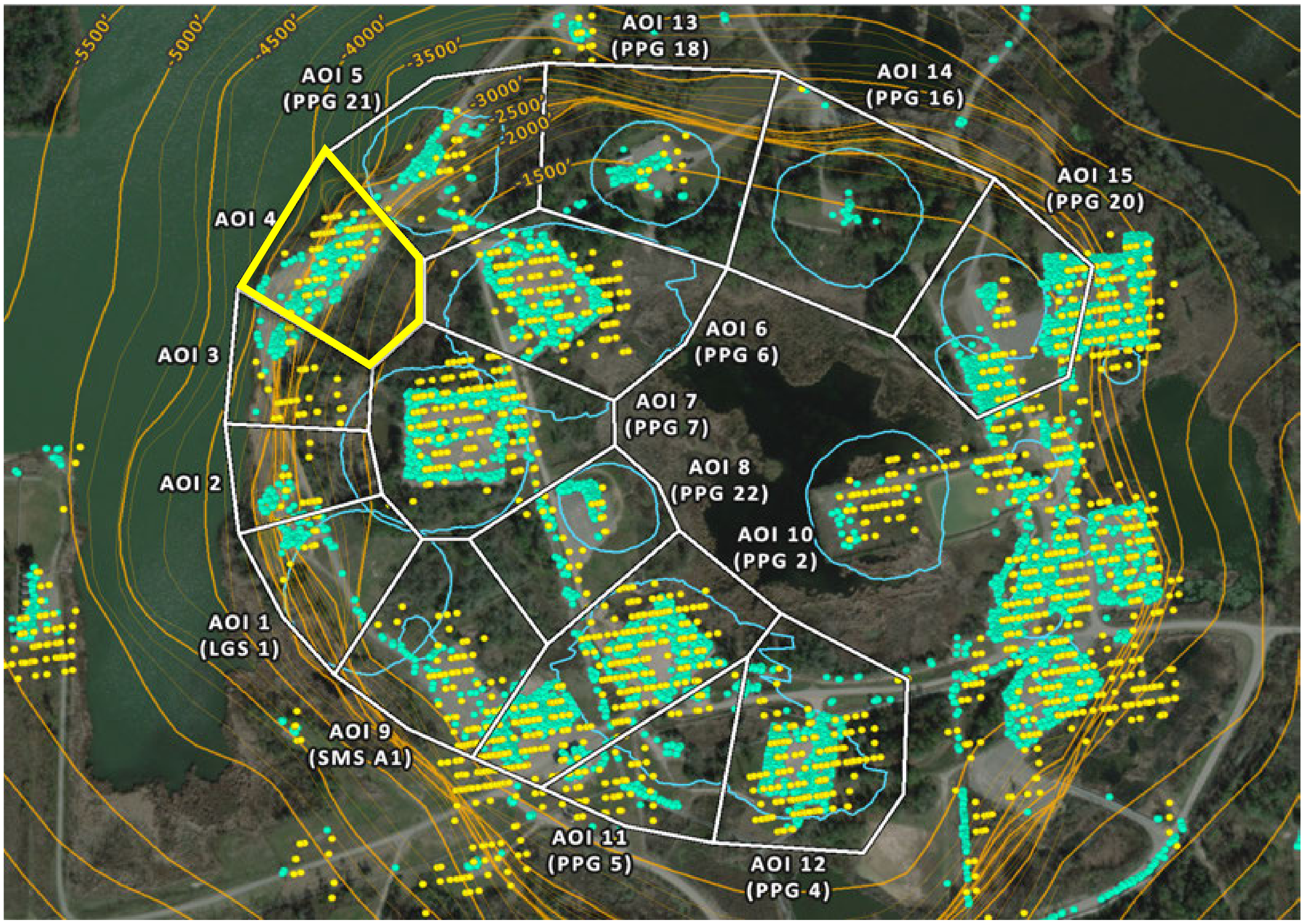
TSX/PAZ (2/25/2025) Point Count: 71



	Nonlinear Trend		Linear Trend	
Velocity:	-0.22	in/yr	-0.30	in/yr
Acceleration:	+0.07	in/yr^2	0.00	in/yr^2

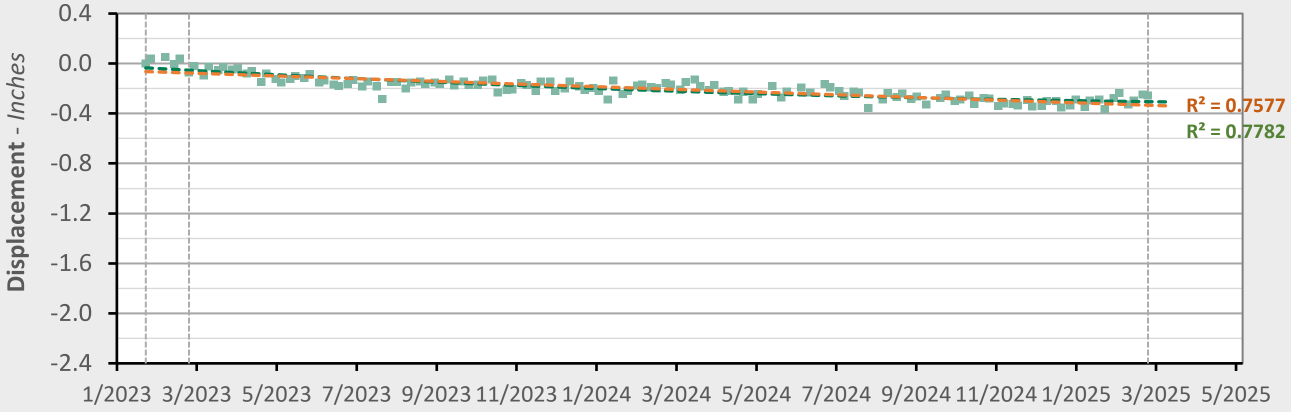
■ LOS Displacement Measurement
- - - - Nonlinear Trend Line (Quadratic Regression)
- - - - Linear Trend Line (Linear Regression)

AOI 4 - Location Map



AOI 4 - Displacement Time Series

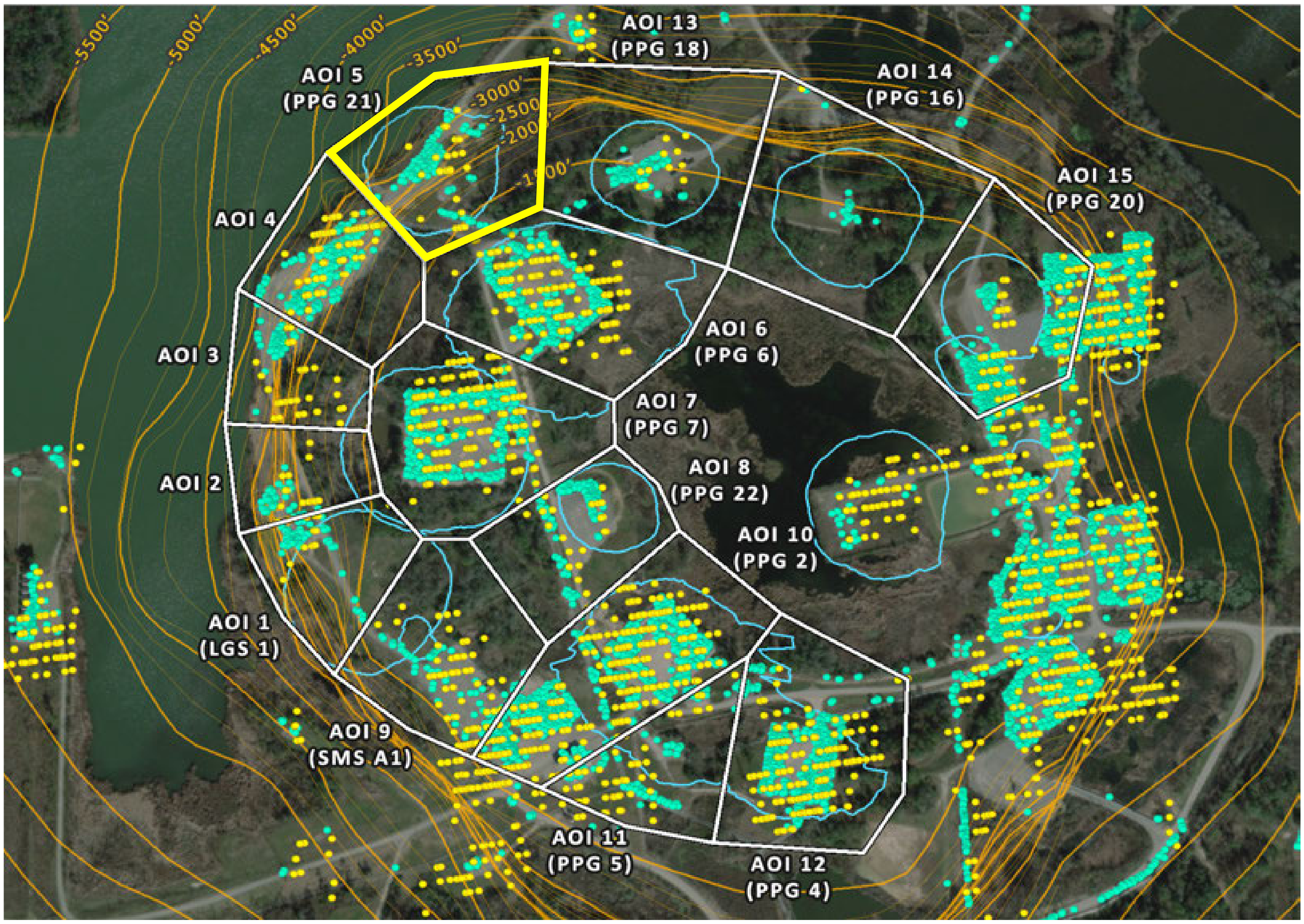
TSX/PAZ (2/25/2025) Point Count: **225**



	Nonlinear Trend		Linear Trend	
Velocity:	-0.05	in/yr	-0.13	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

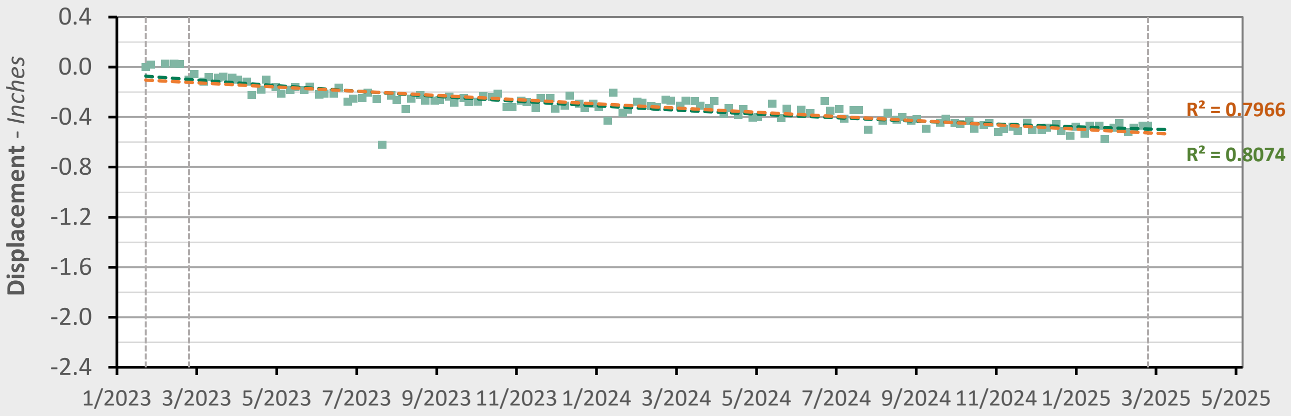
■ LOS Displacement Measurement   - - - - Nonlinear Trend Line (Quadratic Regression)   - - - - Linear Trend Line (Linear Regression)

AOI 5 *(PPG 21)* - Location Map



AOI 5 *(PPG 21)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **138**



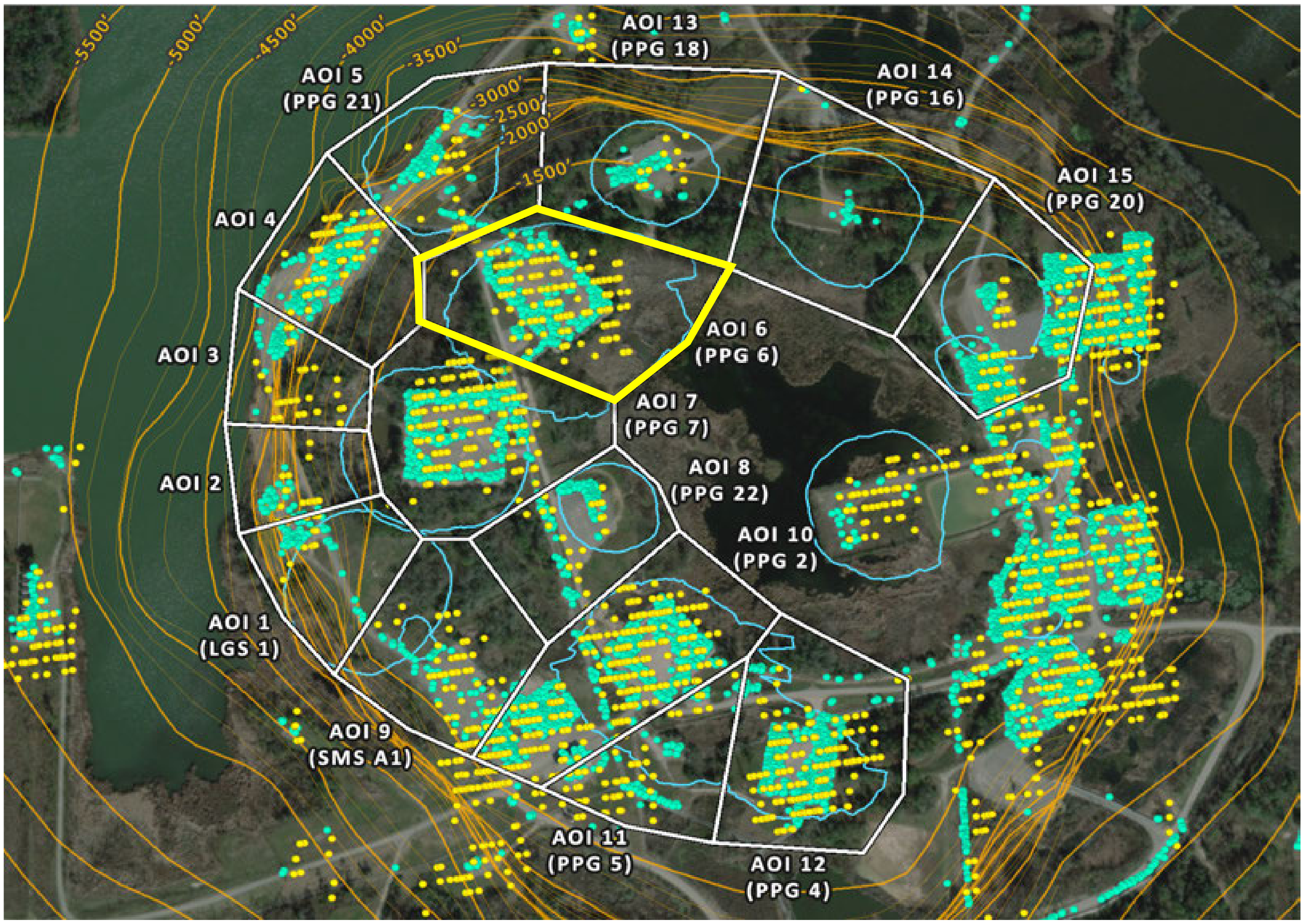
	Nonlinear Trend	Linear Trend
Velocity:	-0.11 in/yr	-0.20 in/yr
Acceleration:	+0.09 in/yr^2	0.00 in/yr^2

■ LOS Displacement Measurement

- - - - Nonlinear Trend Line (Quadratic Regression)

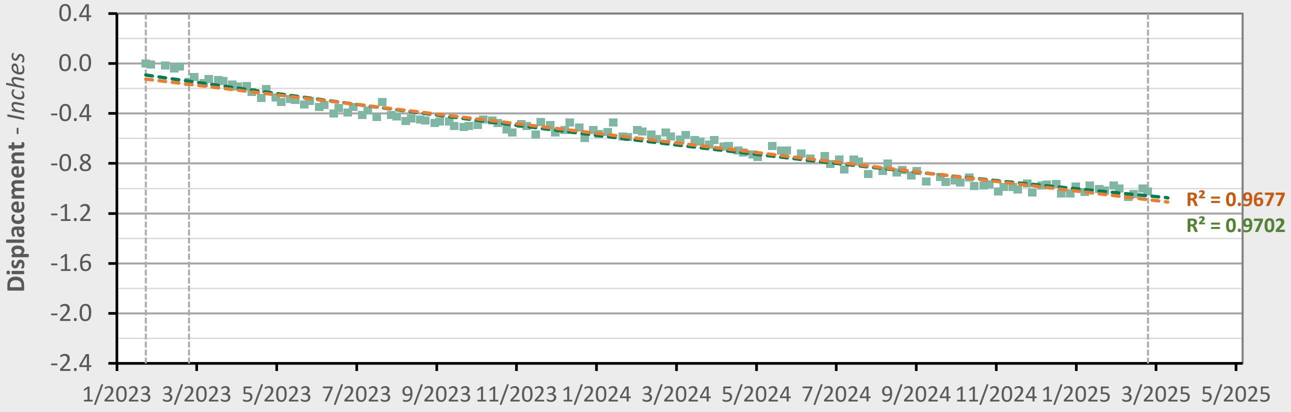
- - - - Linear Trend Line (Linear Regression)

AOI 6 *(PPG 6)* - Location Map



AOI 6 *(PPG 6)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: 355



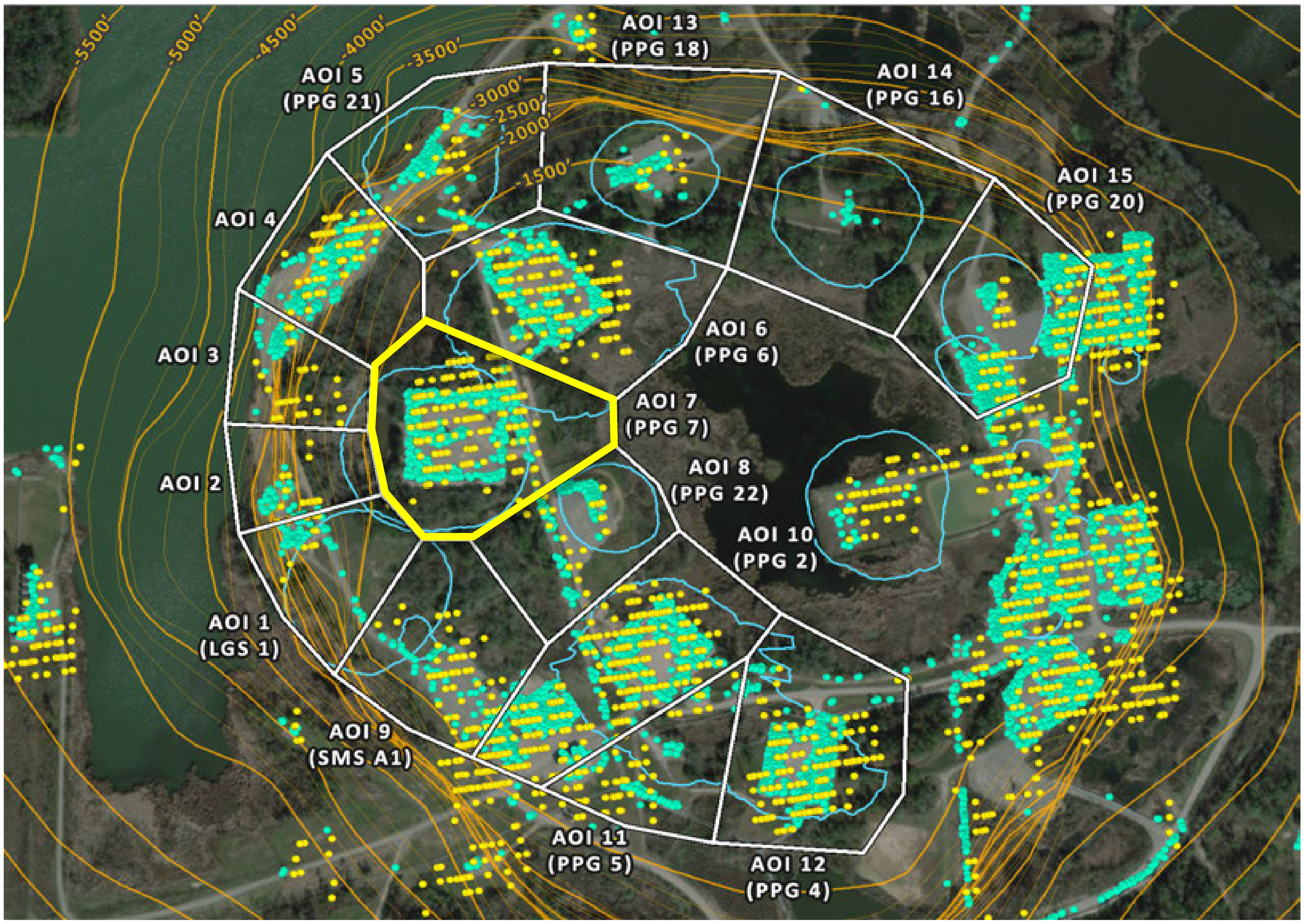
	Nonlinear Trend		Linear Trend	
Velocity:	-0.37	in/yr	-0.46	in/yr
Acceleration:	+0.09	in/yr^2	0.00	in/yr^2

🟩 LOS Displacement Measurement

Nonlinear Trend Line (Quadratic Regression)

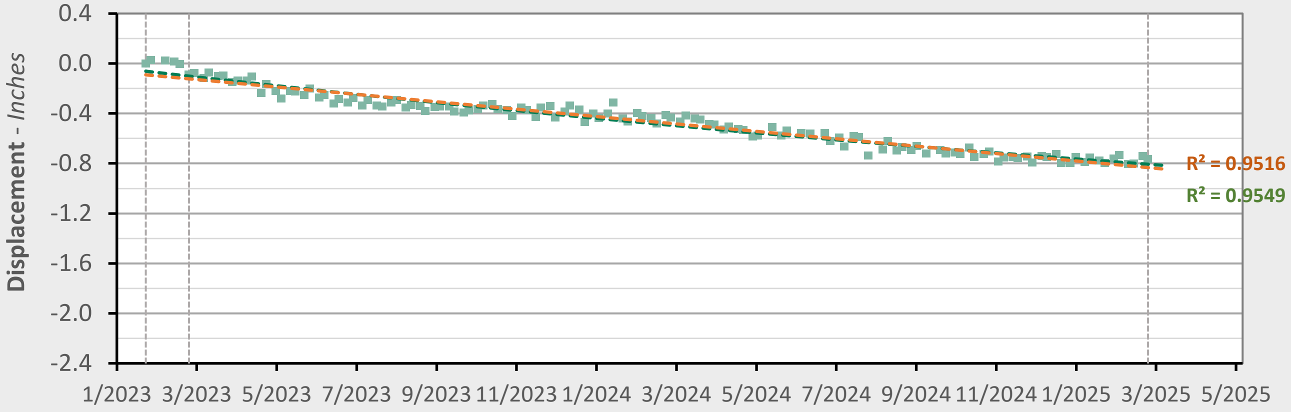
Linear Trend Line (Linear Regression)

AOI 7 *(PPG 7)* - Location Map



AOI 7 *(PPG 7)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **396**



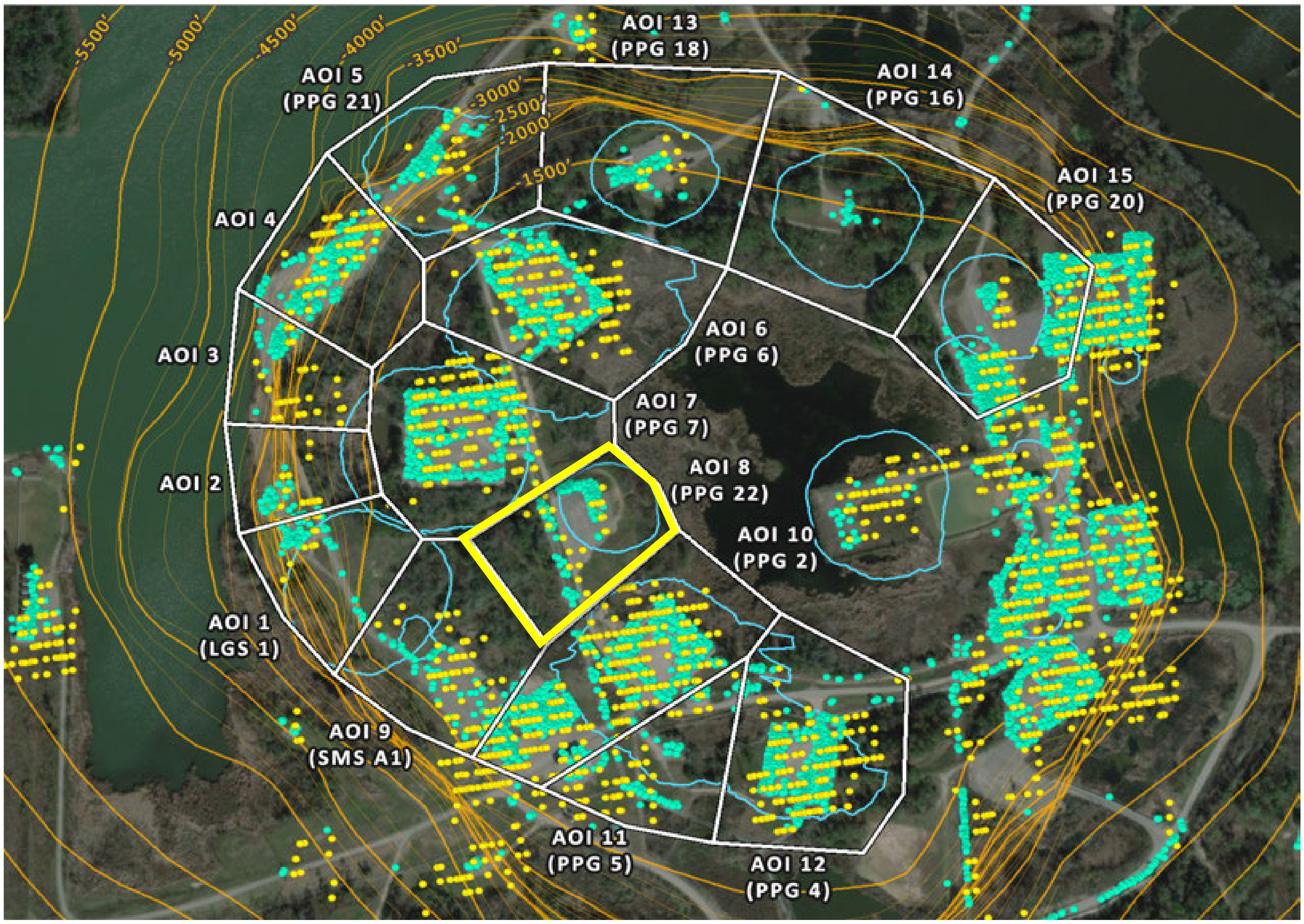
	Nonlinear Trend		Linear Trend	
Velocity:	-0.28	in/yr	-0.36	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

■ LOS Displacement Measurement

- - - - Nonlinear Trend Line (Quadratic Regression)

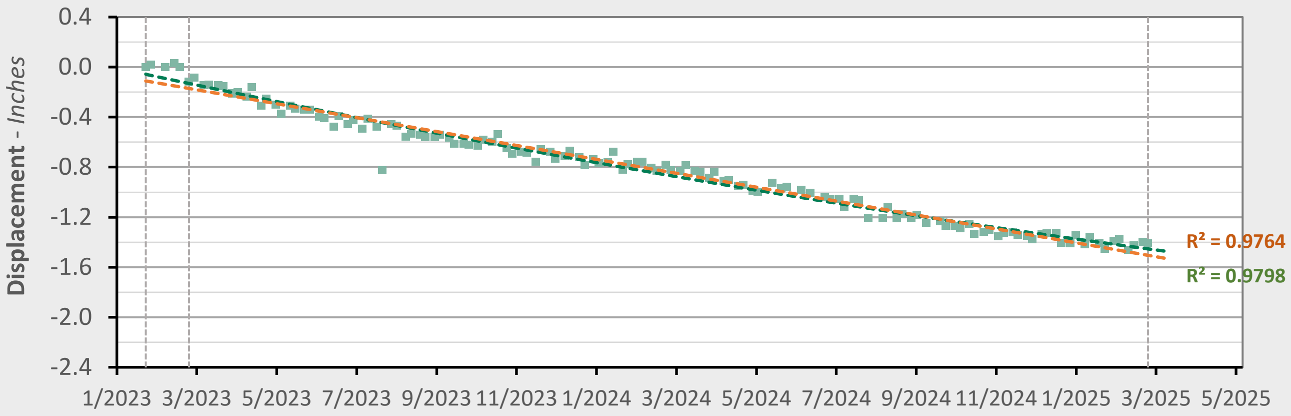
- - - - Linear Trend Line (Linear Regression)

AOI 8 *(PPG 22)* - Location Map



AOI 8 *(PPG 22)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **127**



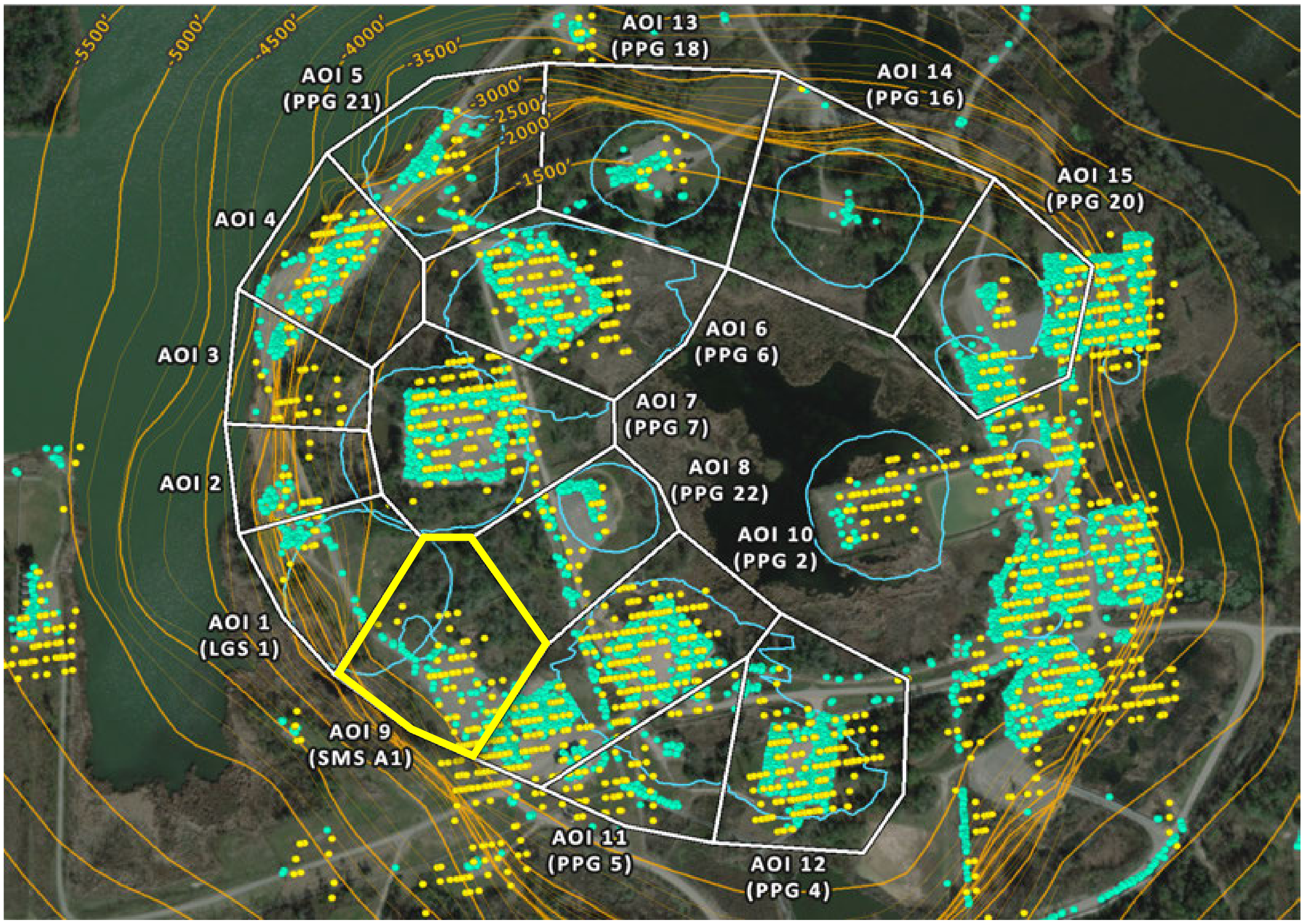
	Nonlinear Trend		Linear Trend	
Velocity:	-0.52	in/yr	-0.67	in/yr
Acceleration:	+0.15	in/yr^2	0.00	in/yr^2

🟩 LOS Displacement Measurement

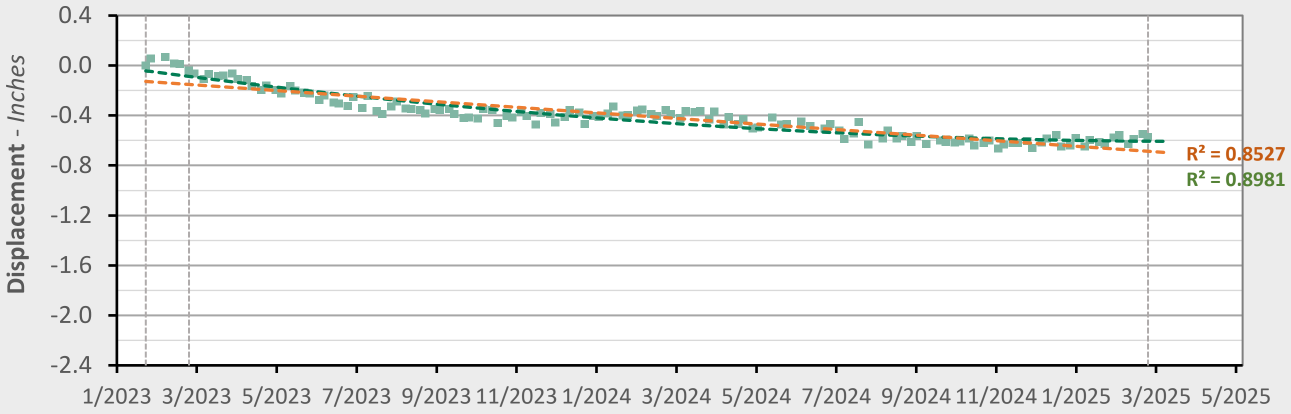
Nonlinear Trend Line (Quadratic Regression)

Linear Trend Line (Linear Regression)

AOI 9 *(PPG A1)* - Location Map



AOI 9 *(SMS A1)* - Displacement Time Series TSX/PAZ (2/25/2025) Point Count: 68



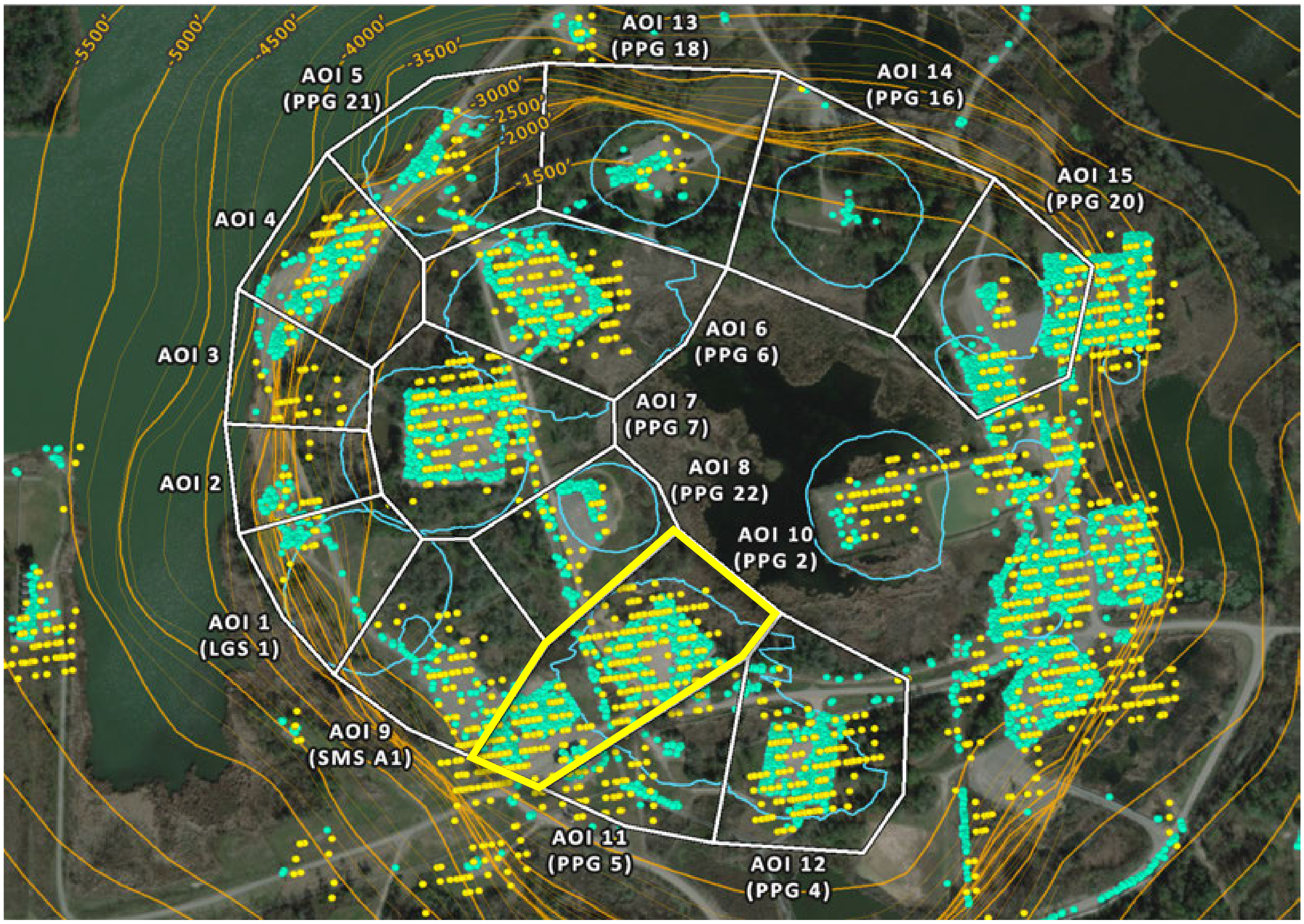
	Nonlinear Trend		Linear Trend	
Velocity:	-0.03	in/yr	-0.27	in/yr
Acceleration:	+0.23	in/yr^2	0.00	in/yr^2

🟩 LOS Displacement Measurement

\- - - - Nonlinear Trend Line (Quadratic Regression)

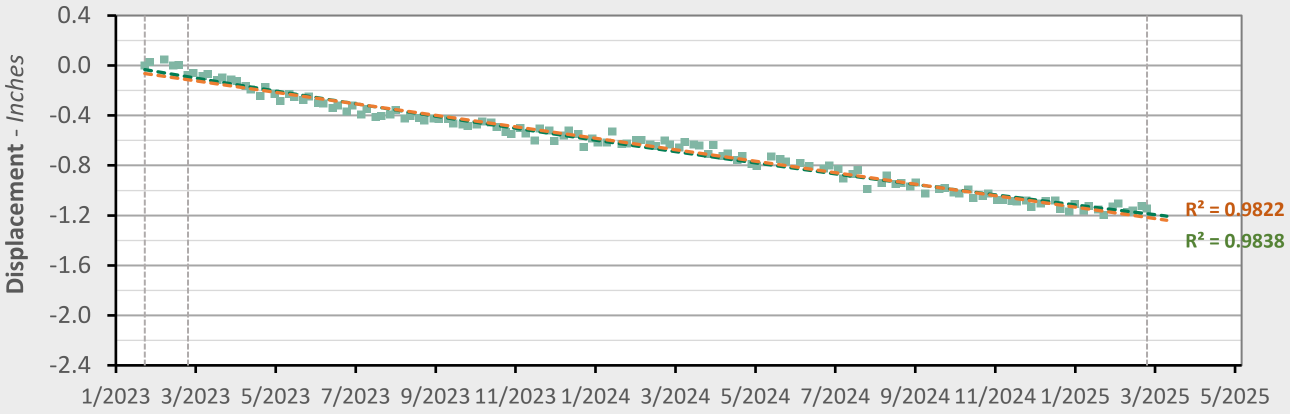
\- - - - Linear Trend Line (Linear Regression)

AOI 10 *(PPG 2)* - Location Map



AOI 10 *(PPG 2)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **811**



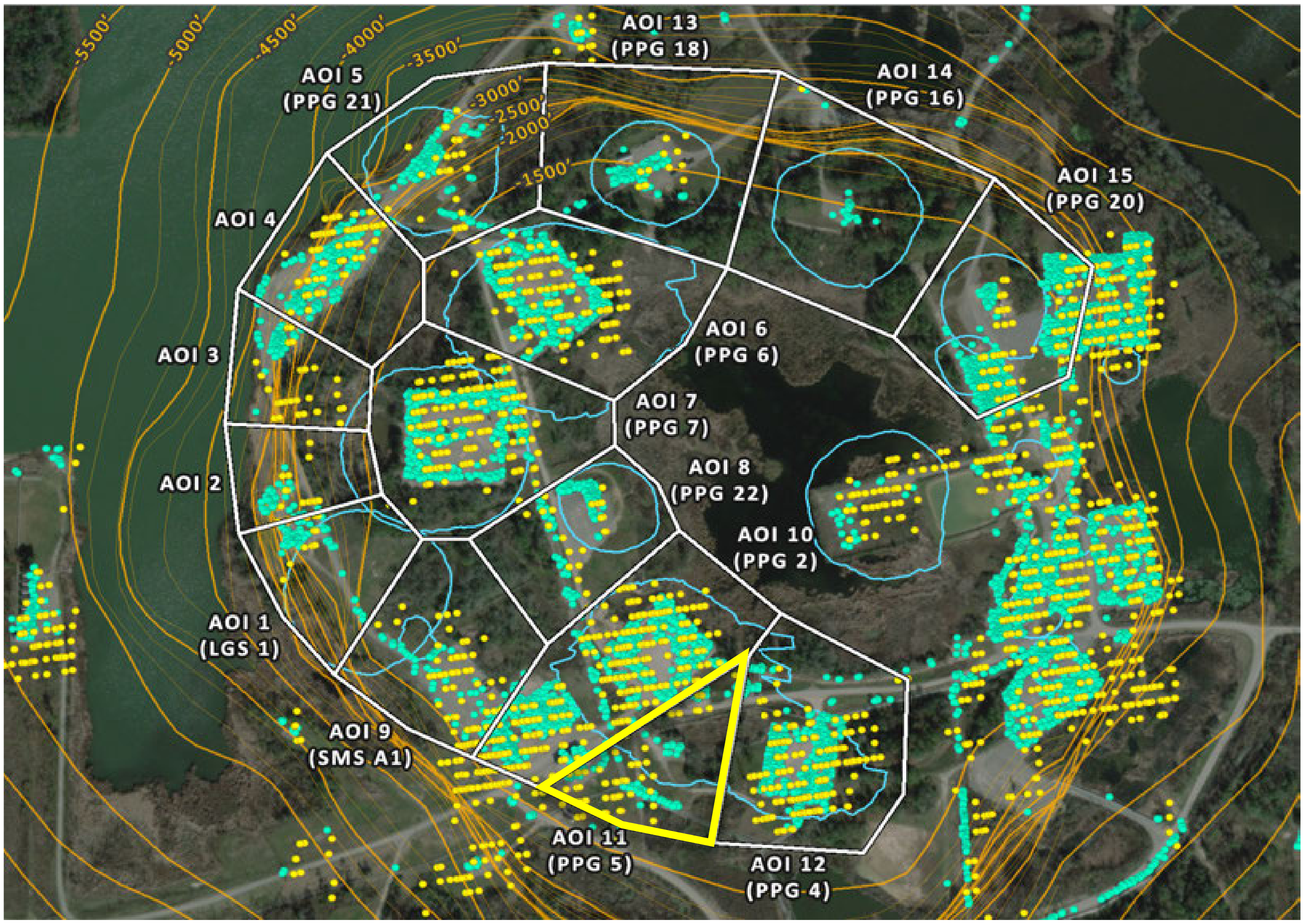
	Nonlinear Trend		Linear Trend	
Velocity:	-0.47	in/yr	-0.55	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

■ LOS Displacement Measurement

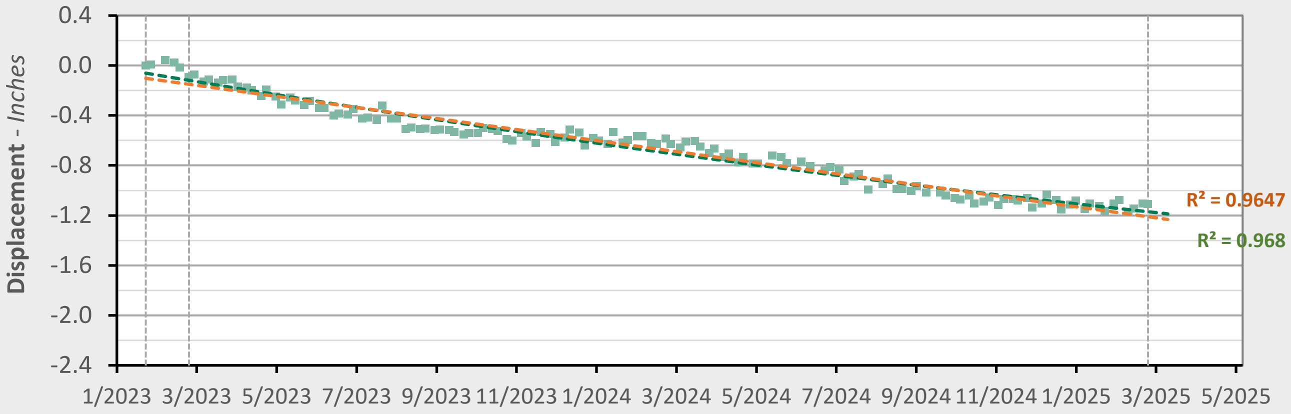
Nonlinear Trend Line (Quadratic Regression)

Linear Trend Line (Linear Regression)

AOI 11 *(PPG 5)* - Location Map



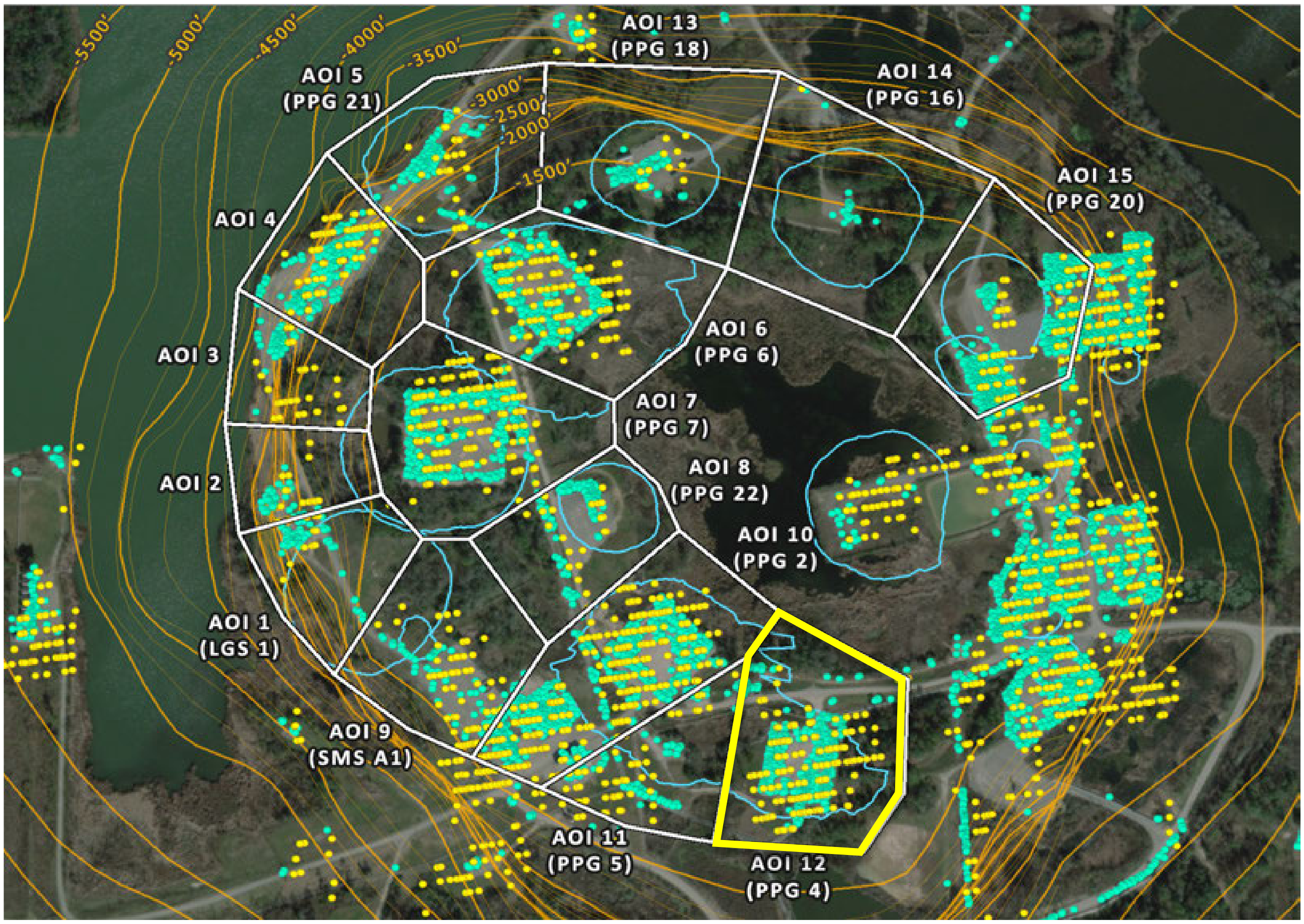
AOI 11 *(PPG 5)* - Displacement Time Series TSX/PAZ (2/25/2025) Point Count: 127



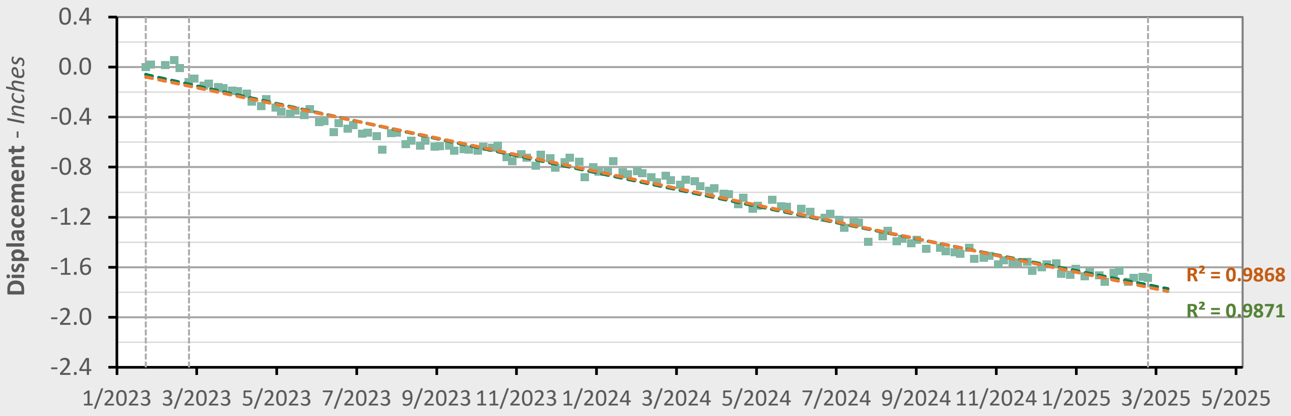
	Nonlinear Trend		Linear Trend	
Velocity:	-0.41	in/yr	-0.53	in/yr
Acceleration:	+0.11	in/yr^2	0.00	in/yr^2

- 🟩 LOS Displacement Measurement
- Nonlinear Trend Line (Quadratic Regression)
- Linear Trend Line (Linear Regression)

AOI 12 *(PPG 4)* - Location Map



AOI 12 *(PPG 4)* - Displacement Time Series TSX/PAZ (2/25/2025) Point Count: 552



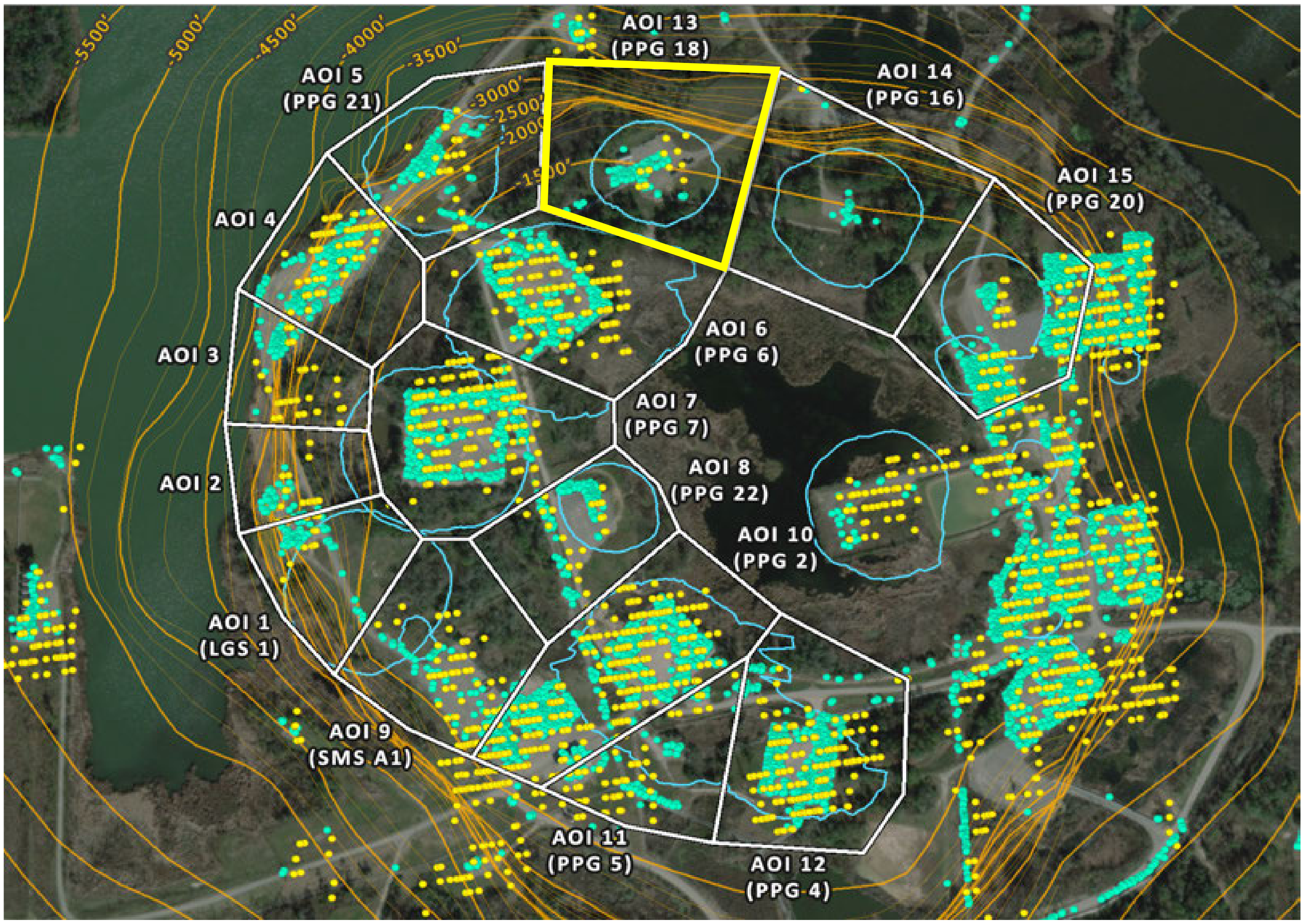
	Nonlinear Trend		Linear Trend	
Velocity:	-0.75	in/yr	-0.80	in/yr
Acceleration:	+0.05	in/yr^2	0.00	in/yr^2

🟩 LOS Displacement Measurement

- - - - Nonlinear Trend Line (Quadratic Regression)

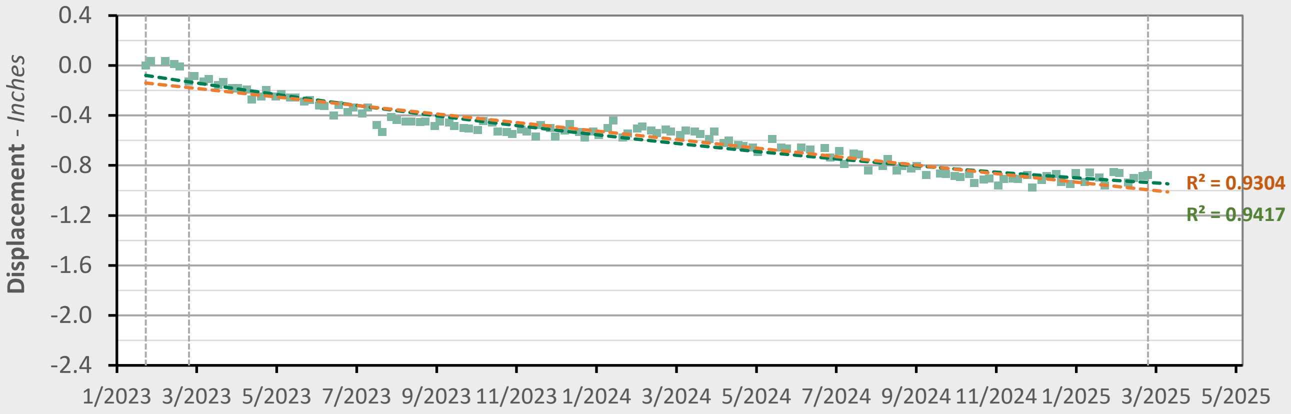
- - - - Linear Trend Line (Linear Regression)

AOI 13 *(PPG 18)* - Location Map



AOI 13 *(PPG 18)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **108**



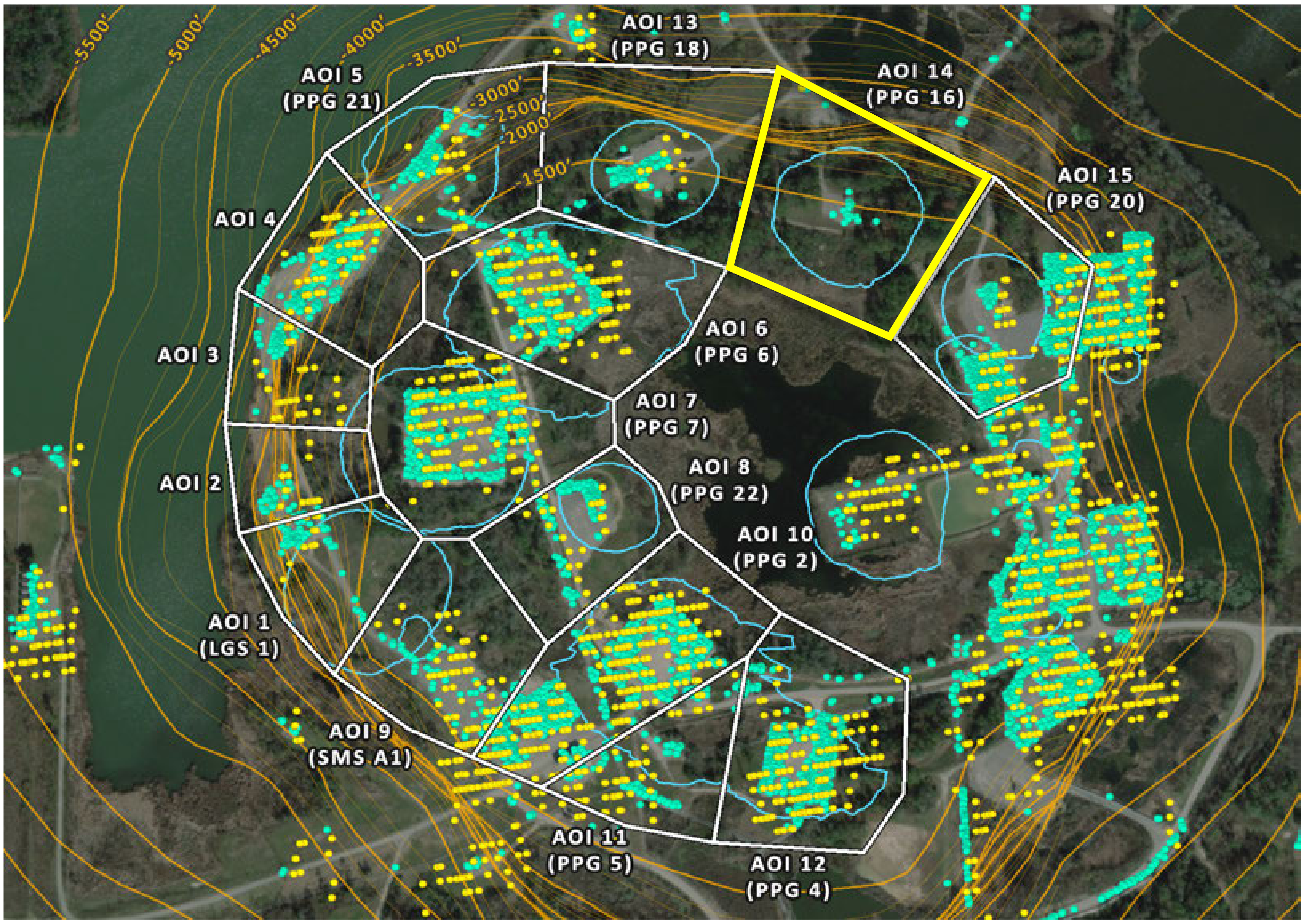
	Nonlinear Trend		Linear Trend	
Velocity:	-0.24	in/yr	-0.41	in/yr
Acceleration:	+0.17	in/yr^2	0.00	in/yr^2

🟩 LOS Displacement Measurement

\- - - - Nonlinear Trend Line (Quadratic Regression)

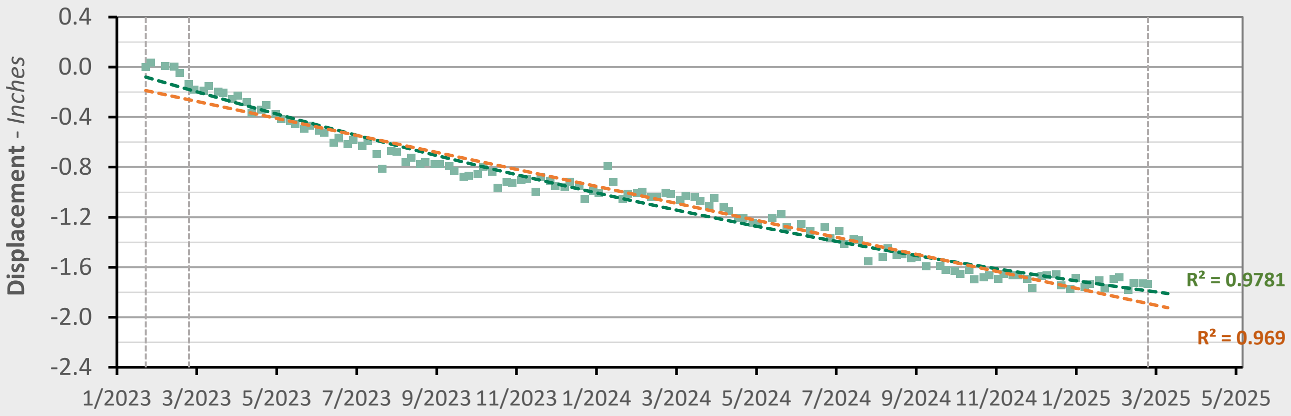
\- - - - Linear Trend Line (Linear Regression)

AOI 14 *(PPG 16)* - Location Map



AOI 14 *(PPG 16)* - Displacement Time Series

TSX/PAZ (2/25/2025) Point Count: **22**



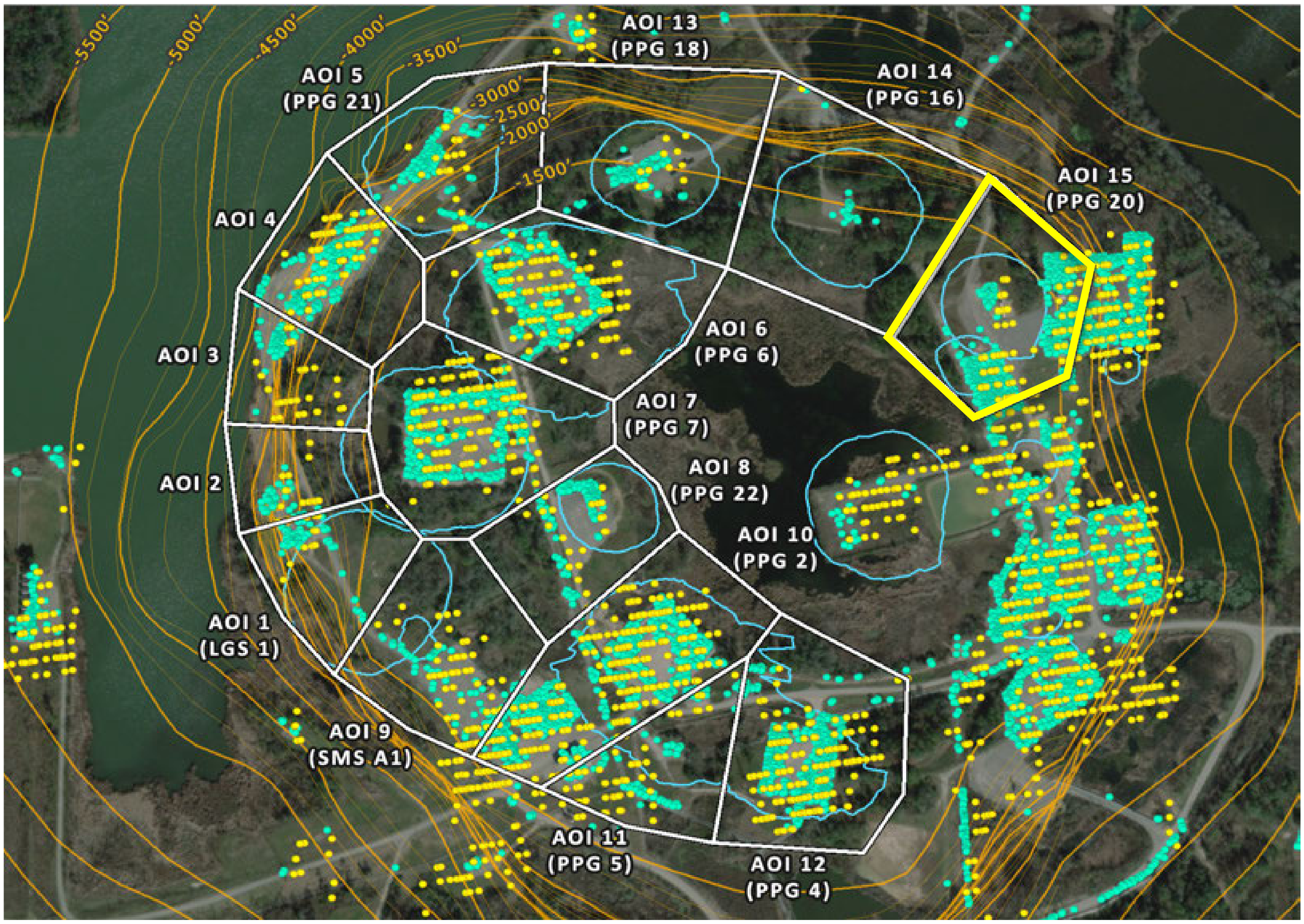
	Nonlinear Trend	Linear Trend
Velocity:	-0.51 in/yr	-0.82 in/yr
Acceleration:	+0.29 in/yr^2	0.00 in/yr^2

■ LOS Displacement Measurement

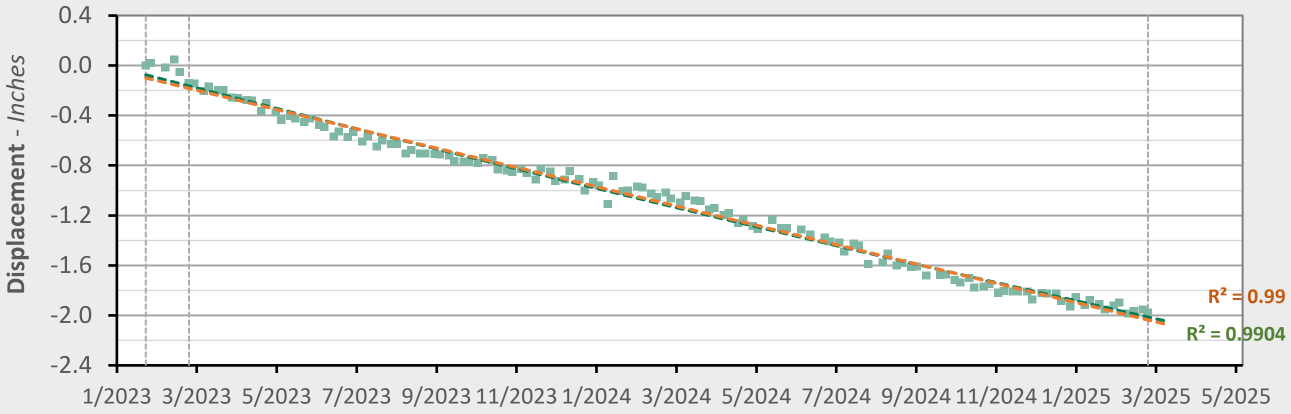
- - - Nonlinear Trend Line (Quadratic Regression)

- - - Linear Trend Line (Linear Regression)

AOI 15 *(PPG 20)* - Location Map



AOI 15 *(PPG 20)* - Displacement Time Series TSX/PAZ (2/25/2025) Point Count: 742



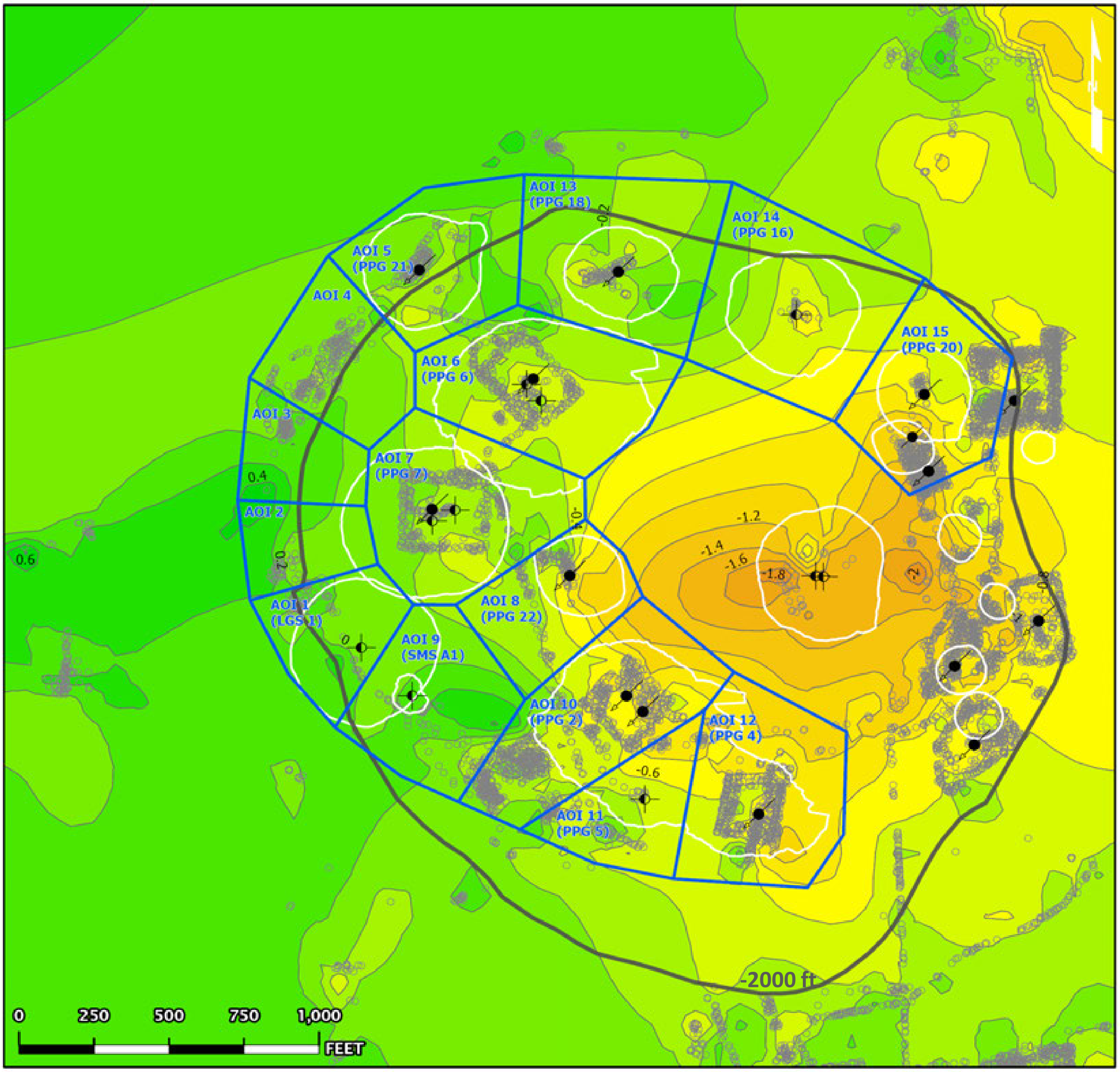
	Nonlinear Trend		Linear Trend	
Velocity:	-0.86	in/yr	-0.93	in/yr
Acceleration:	+0.06	in/yr^2	0.00	in/yr^2

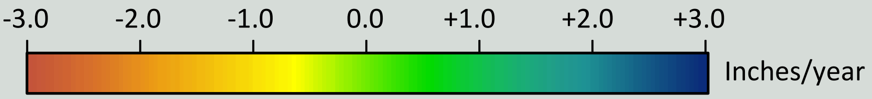
■ LOS Displacement Measurement — Nonlinear Trend Line (Quadratic Regression) — Linear Trend Line (Linear Regression)

TSX/PAZ Data (01/24/2023 - 02/25/2025)

Nonlinear Velocity Contours

As of date: 02/25/2025





🟦 AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.2)

⬜ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

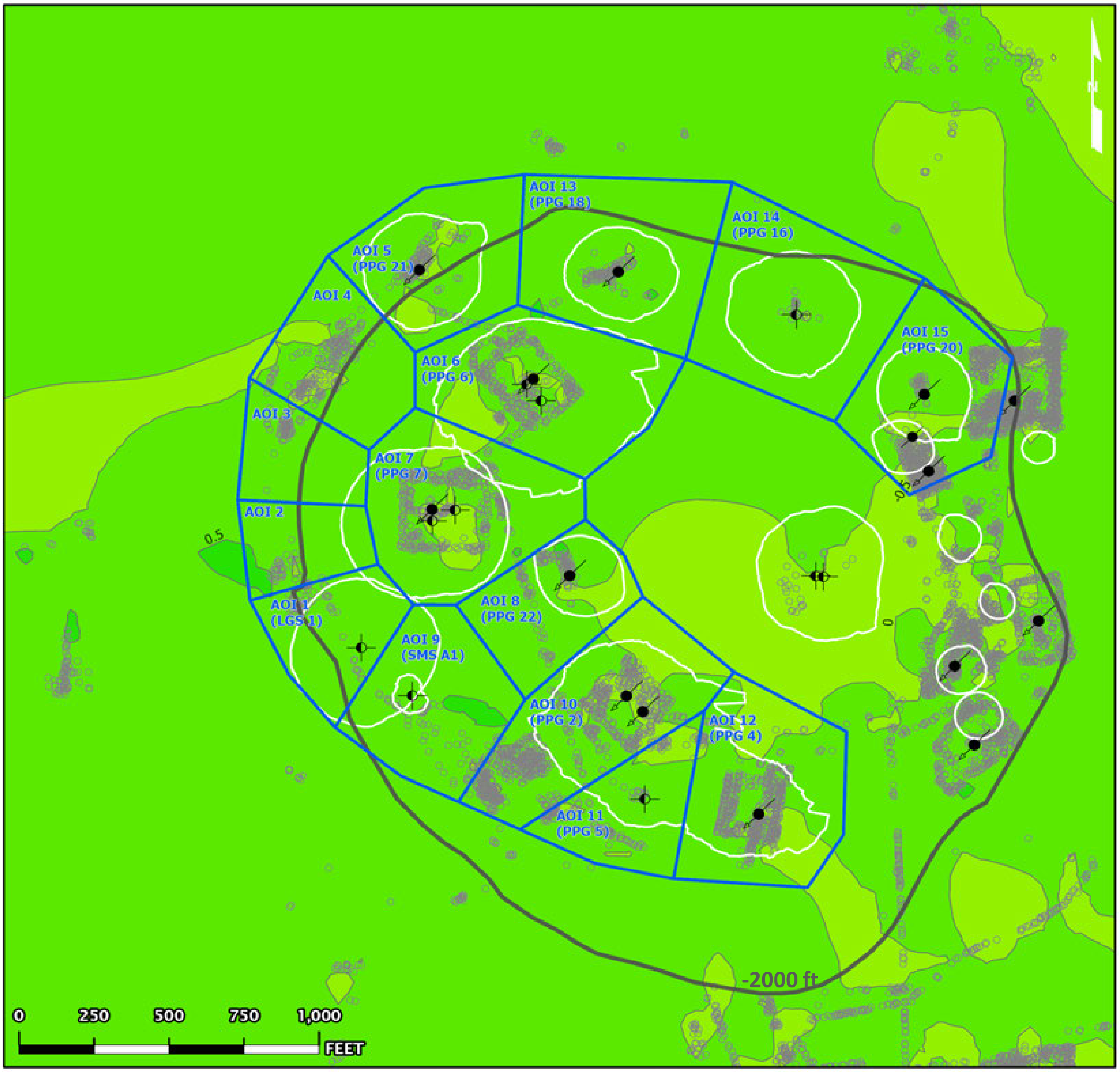
Cavern Well Surface Locations

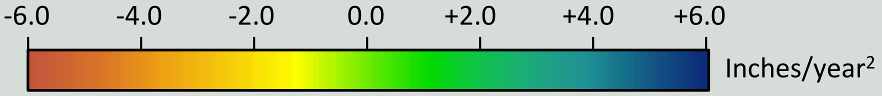
09 - Active - Injection 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 02/25/2025)

Nonlinear Acceleration Contours

Date range: 01/24/2023 - 02/25/2025





AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.5)

Historical Cavern Extent Top of Dome (-2000 ft Contour)

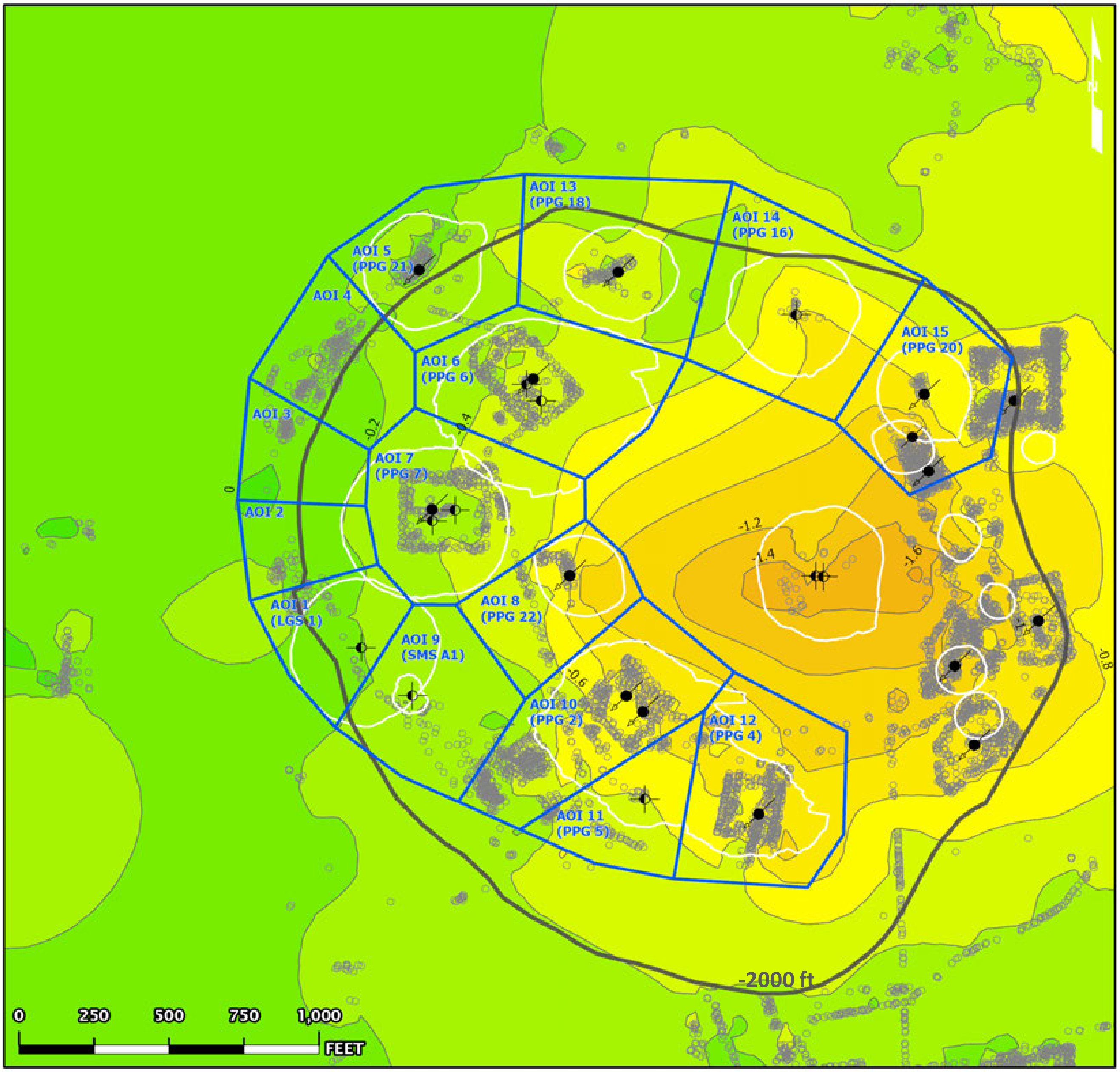
Cavern Well Surface Locations

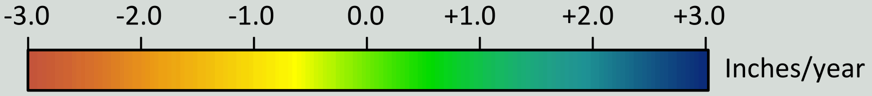
09 - Active - Injection 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 02/25/2025)

Linear Velocity Contours

Date range: 01/24/2023 - 02/25/2025





▭ AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.2)
▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

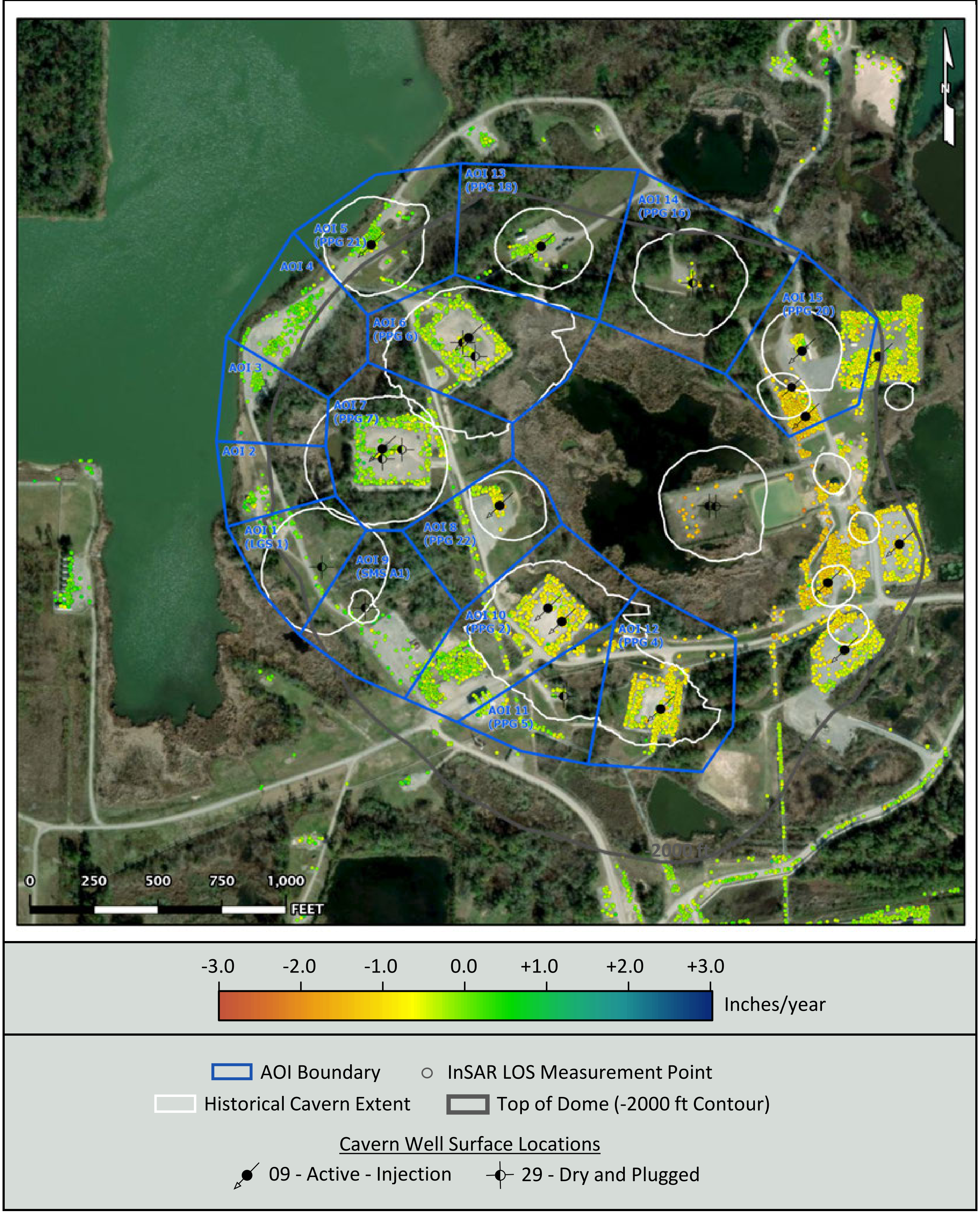
Cavern Well Surface Locations

● 09 - Active - Injection ⊕ 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 02/25/2025)

Nonlinear Velocity Data Points

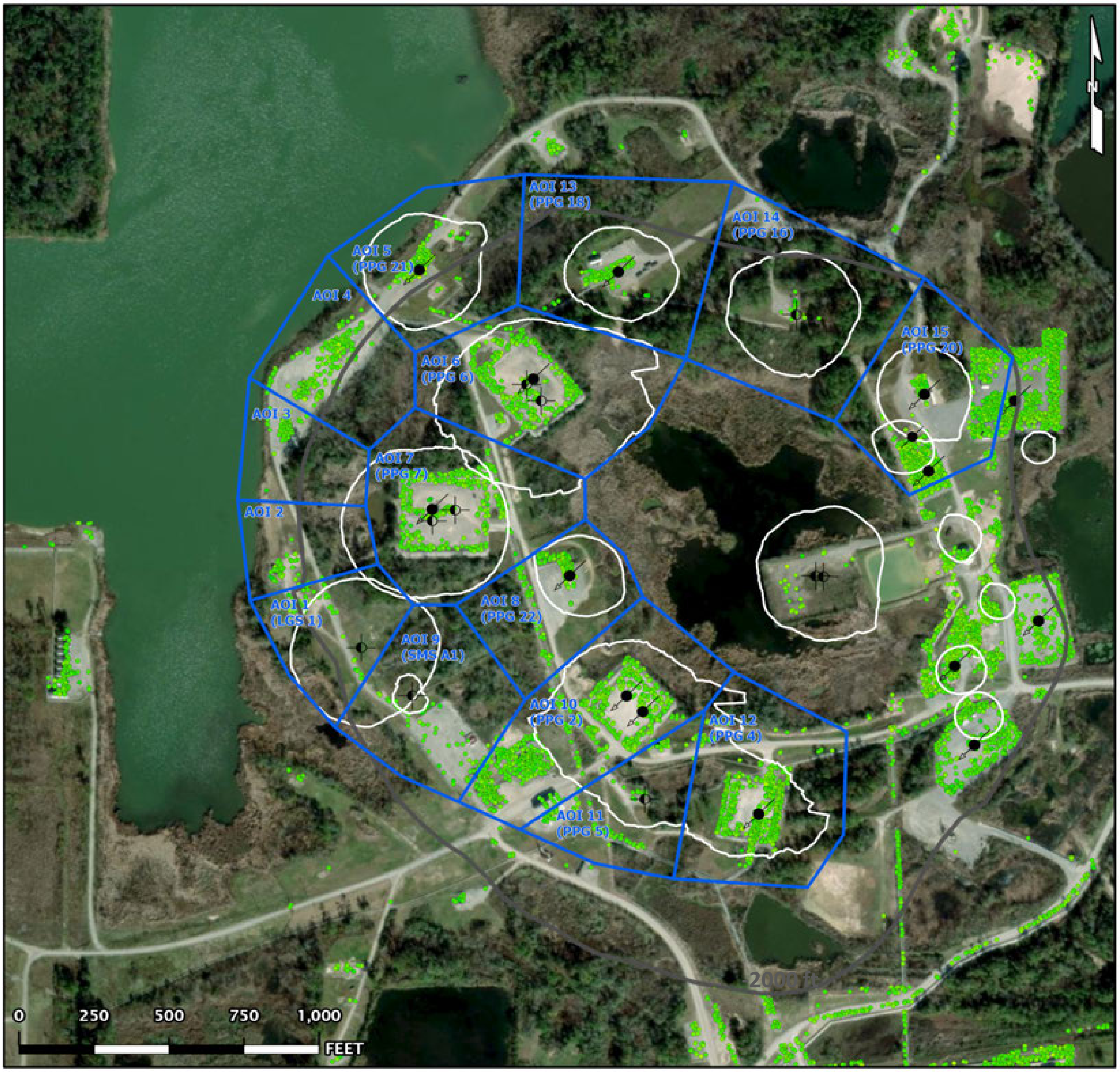
As of date: 02/25/2025

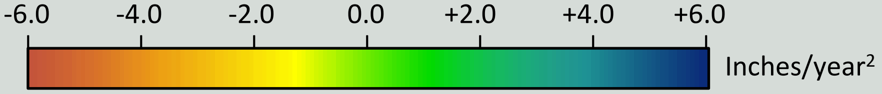


TSX/PAZ Data (01/24/2023 - 02/25/2025)

Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 02/25/2025





▭ AOI Boundary ○ InSAR LOS Measurement Point

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

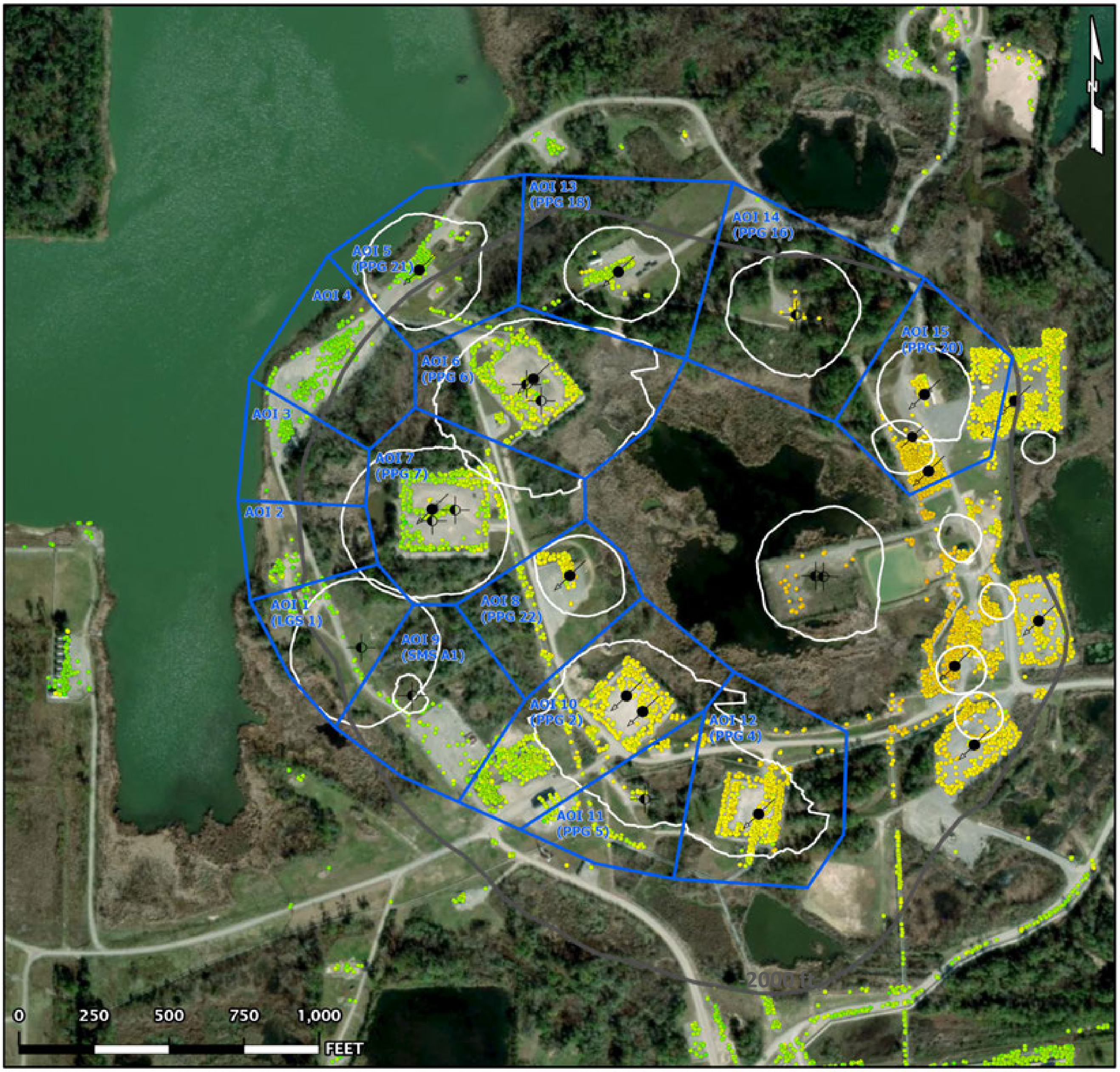
Cavern Well Surface Locations

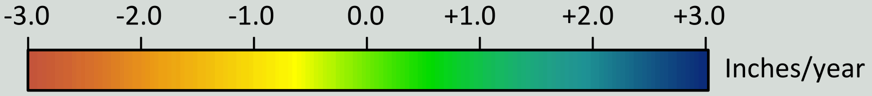
09 - Active - Injection 29 - Dry and Plugged

TSX/PAZ Data (01/24/2023 - 02/25/2025)

Linear Velocity Data Points

Date range: 01/24/2023 - 02/25/2025





▭ AOI Boundary ○ InSAR LOS Measurement Point

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection 29 - Dry and Plugged

ATTACHMENT D

Vertical & East-West 2D InSAR report - February 25, 2025

Vertical & E-W 2D Update

Continuous InSAR Monitoring of Ground Displacement At Westlake Caverns and Western Dome Flank

Sulphur Mines Salt Dome

Prepared for:
Westlake Chemical

Prepared by:
Lonquist Field Service, LLC
8591 United Plaza Blvd., Suite 280
Baton Rouge, LA 70809

Dataset
Satellite Source
Sentinel-1 & TerraSAR-X - PAZ Constellation
Most Recent Image Date
Tuesday, February 25, 2025

Analysis Report Date:

March 7, 2025

Dataset Information

Satellite Source	Sentinel-1 & TerraSAR-X - PAZ Constellation
Update Frequency	12 days
Most Recent Image Date	Tuesday, February 25, 2025
Dataset Image Count	173
Dataset Time Range	January 24, 2023 - February 25, 2025
Dataset Length	2.09 Years
Measurement Directions	Vertical and East-West

Analysis Methodology

Time Series Charts

Trend lines were calculated for the averaged vertical and east-west displacement values within each AOI. Both a nonlinear (quadratic) and linear regression were applied to each AOI point group to identify rates of change in LOS displacement. These trends are displayed in the Time Series section of this report.

Contour Maps

A nonlinear (quadratic) and linear trend was also calculated for each individual measurement point across the analysis region. Nonlinear trend values for each point were used to generate Velocity and Acceleration contour maps to convey the spatial distribution of the calculated movement. The linear trend values for each point (which lack an acceleration component) were used to generate an additional Velocity contour map. Maps depicting the individual data points colored by these trend values are included after the contour maps.

Rate Interpretation

For the vertical data, positive velocity values indicate uplift and negative velocity values indicate subsidence. Positive acceleration values indicate increasing rates of uplift or slowing rates of subsidence, while negative acceleration values indicate slowing rates of uplift or increasing rates of subsidence. For the east-west data, positive velocity values indicate eastward horizontal movement and negative velocity values indicate horizontal westward movement. Positive acceleration values indicate increasing rates of eastward movement or decreasing rates of westward movement, while negative acceleration values indicate increasing rates of westward movement or decreasing rates of eastward movement.

Observations

To-date there have been no acute deviations from established subsidence trends in the areas investigated.

The calculated vertical displacement values indicate that subsidence is occurring with near-linear trends in all AOIs where data is present, with the greatest rates occurring in the central portions of the dome. Minor positive acceleration (slowing subsidence) is present in all of the nonlinear AOI trends.

The calculated east-west displacement values generally indicate near-linear horizontal movement toward the dome center with the greatest rates of eastward movement occurring in the western AOIs and the greatest rate of westward movement occurring in the easternmost AOI. Slight positive and negative east-west acceleration values are evenly distributed among the AOIs.

NATHANIEL L. BYARS
License No. 40697

Nathaniel Byars

Date Signed: March 7, 2025
Austin, Texas

Nathaniel L. Byars, P.E.
Principal Engineer
Louisiana License No. 40697

InSAR Data Sources

InSAR Data

Interferometric Synthetic Aperture Radar (InSAR) is the most well established method to continually evaluate small, normally undetectable, ground movement over a large area. Radar imagery collected via satellites over successive orbital passes is used to identify and define measurement points on the ground. Objects or ground features providing a stable reflection of radar energy such as buildings, roads, and infrastructure produce the highest quality measurement points. InSAR analysis identifies the change in distance between the satellite and each measurement point over time relative to a stable reference point within the imaged area.

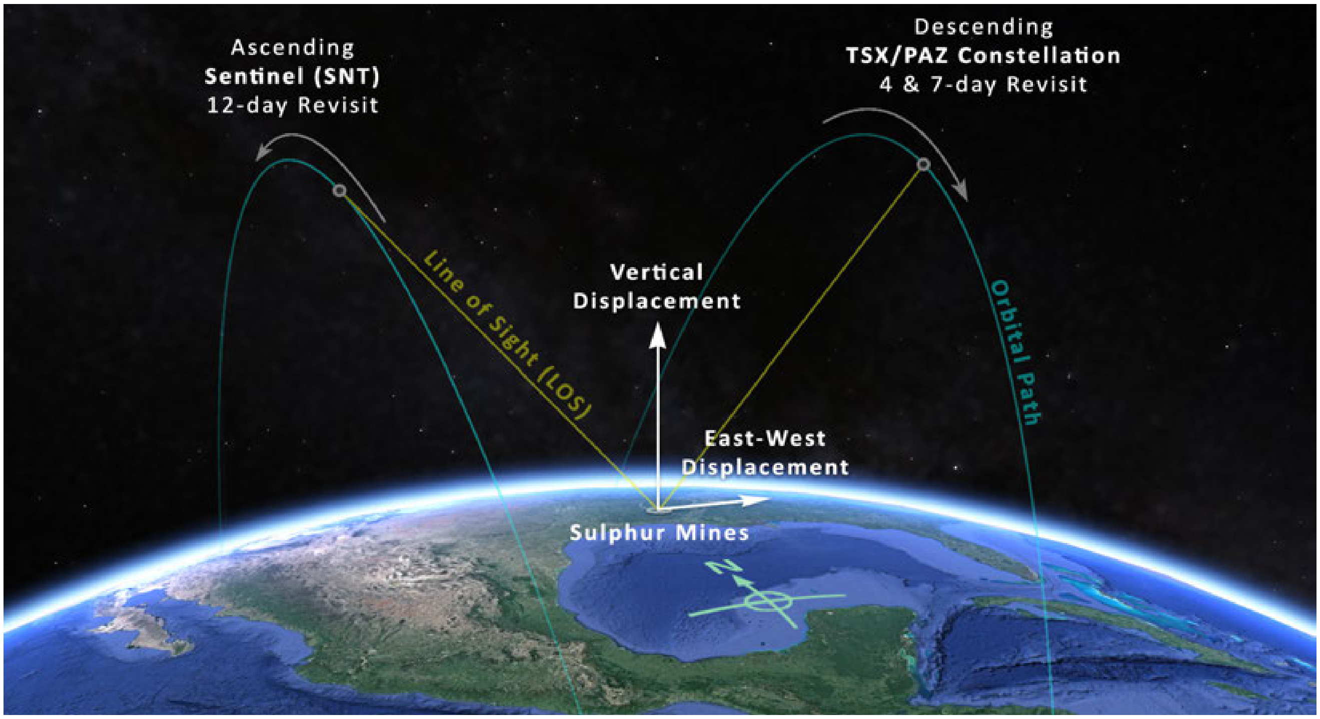
Satellite Sources

Two InSAR datasets are being used to evaluate subsidence over the Sulphur Mines Salt Dome. These datasets provide Line-of-Sight (LOS) displacment measurements from both ascending and descending orbits. An ascending orbit denotes the satellite's longitudinal course from south to north as it passes over the site, while a descending orbit denotes the satellite is moving from north to south.

The first dataset comes from a low-resolution Sentinel-1 (SNT) satellite on an ascending orbit that captures data from the west of the site on a 12-day frequency. The second comes from a pair of high resolution satellites that share the same descending orbit and capture data from east of the site. These are a TSX satellite and the PAZ satellite (TSX/PAZ constellation), both with an 11-day revisit frequency. Their orbits are offset with the PAZ satellite passing over the site 4 days after the TSX satellite.

Each instance of data capture in either the SNT or TSX/PAZ constellation is used to generate 2D (two-dimensional) displacement values in the vertical and east-west directions for each measurement point within the 2D data grid. The image below depicts the orbital paths of the satellites in relation to the Sulphur Mines Salt Dome as well as the 2D components of the calculated displacement.

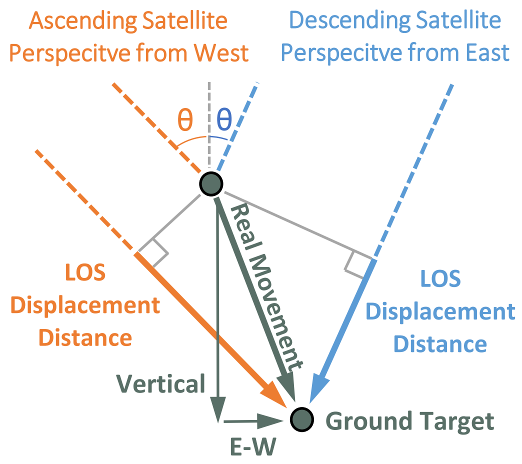
Satellite Orbital Diagram



InSAR 2D Vertical and East-West Data

LOS (line-of-sight) displacement measurements, which refer to a change in distance between the satellite sensor and the ground target, are used to triangulate the real movement along the 2D plane defined by the satellite positions and the ground target. The diagram to the right illustrates the geometric relationship between the Real Movement of a ground target, the LOS displacement measurements from two different satellite viewing directions, and the resulting vertical and east-west components of calculated 2D displacement. Ground targets are not consistent between LOS datasets so these calculations are performed on averaged LOS data within 82-ft square cells. One 2D measurement point is generated within each cell where data from both LOS sources are present.

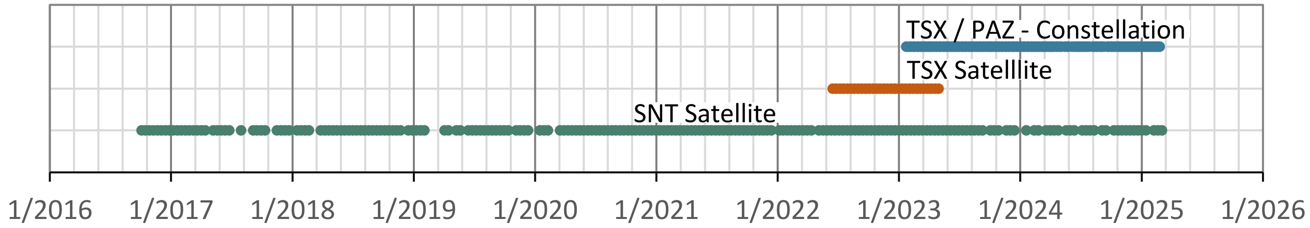
<-- West **Side View** East-->



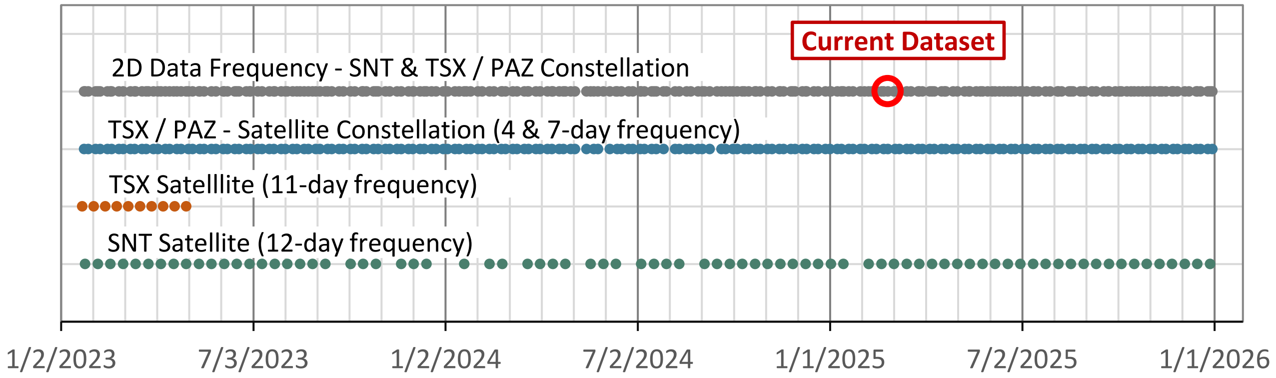
Satellite Properties & Image Frequency

Satellite and Data Properties	SNT	TSX/PAZ Constellation
Band (Wavelength)	C-band (2.20 in)	X-band (1.22 in)
Track	T136	T67 & T120
Pixel resolution	65 x 16 ft	3 x 3 ft
Revisit frequency	12 days	4 & 7 days
Orbit (LOS Angle, θ)	Ascending (43^{o})	Descending (37^{o})
Data Start Date	10/4/2016	1/24/2023
Measurement error range	± 0.20 in	± 0.03 in

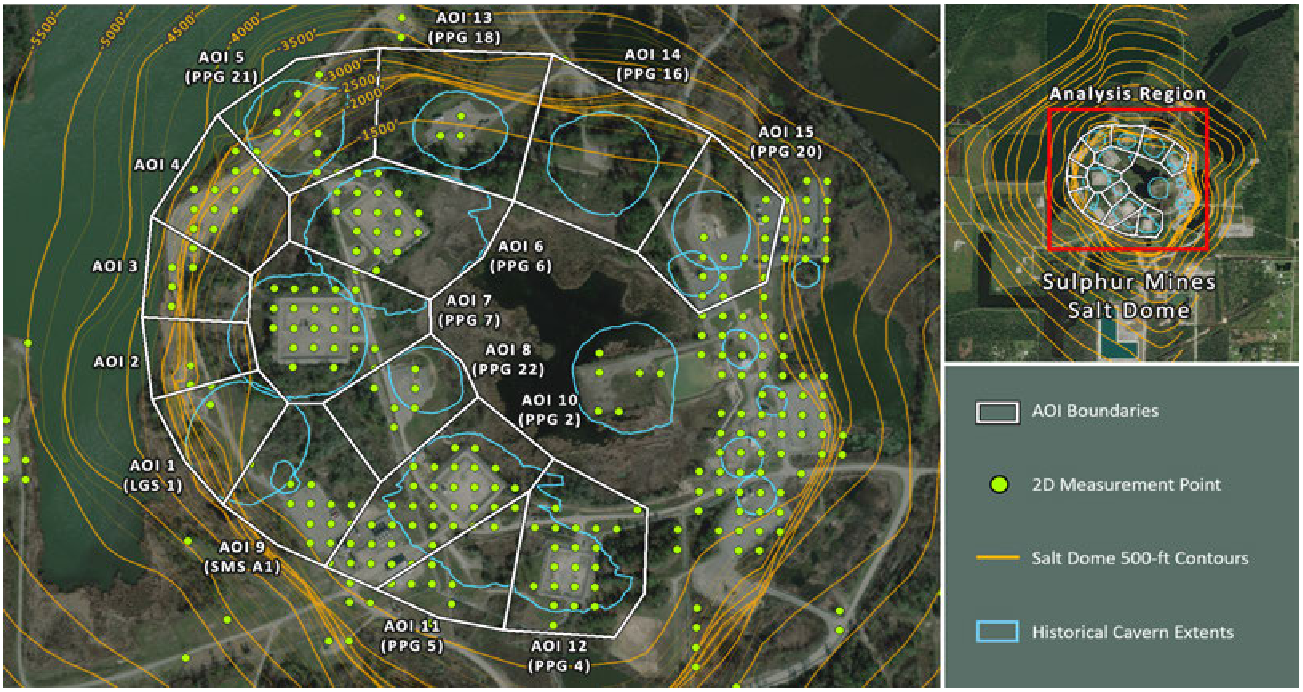
LOS Measurement History



2D Measurement Frequency



AOI Boundaries & 2D InSAR Measurement Points

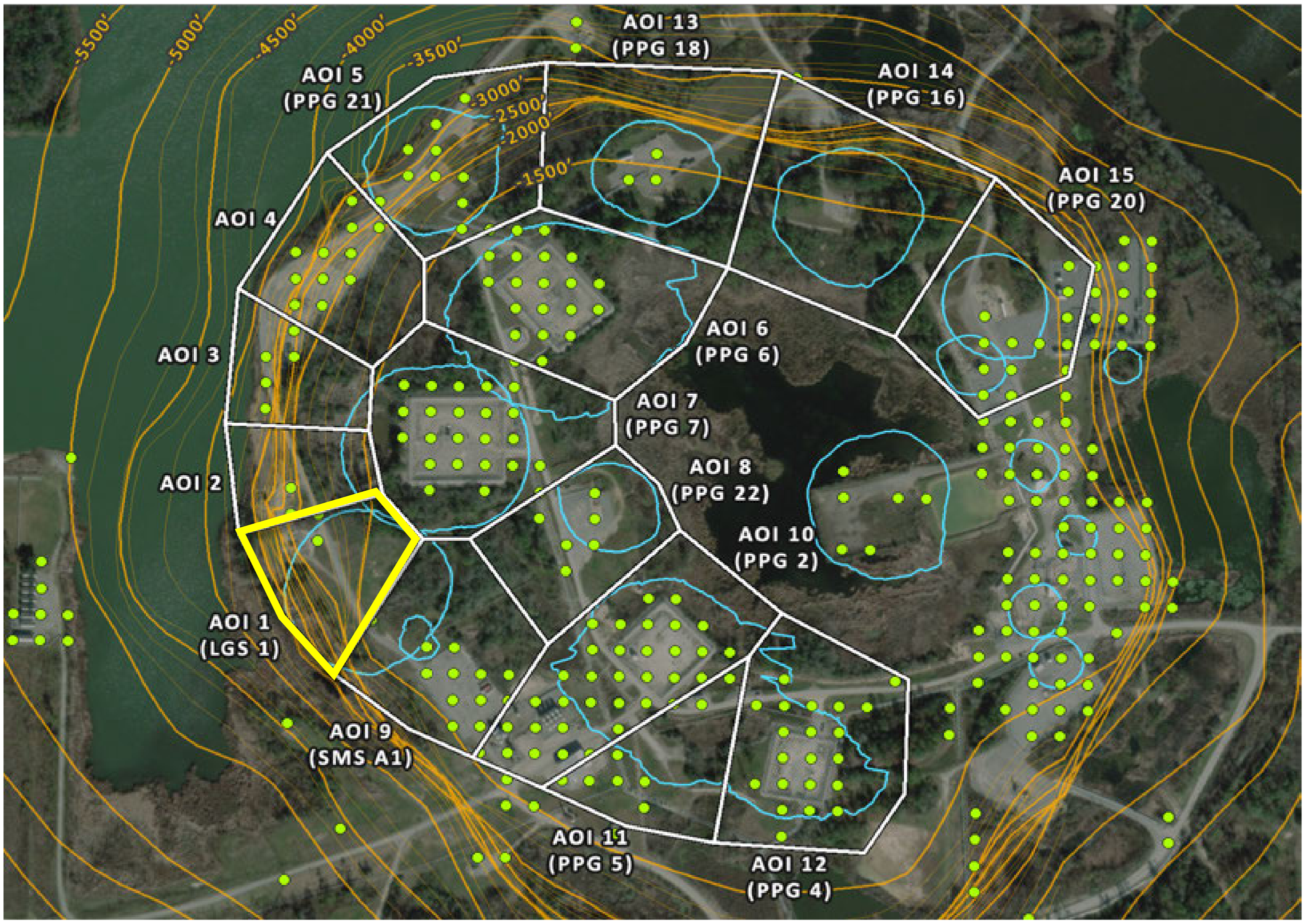


Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the Vertical displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the Vertical trend values calculated in each AOI for the dataset evaluated in this report.

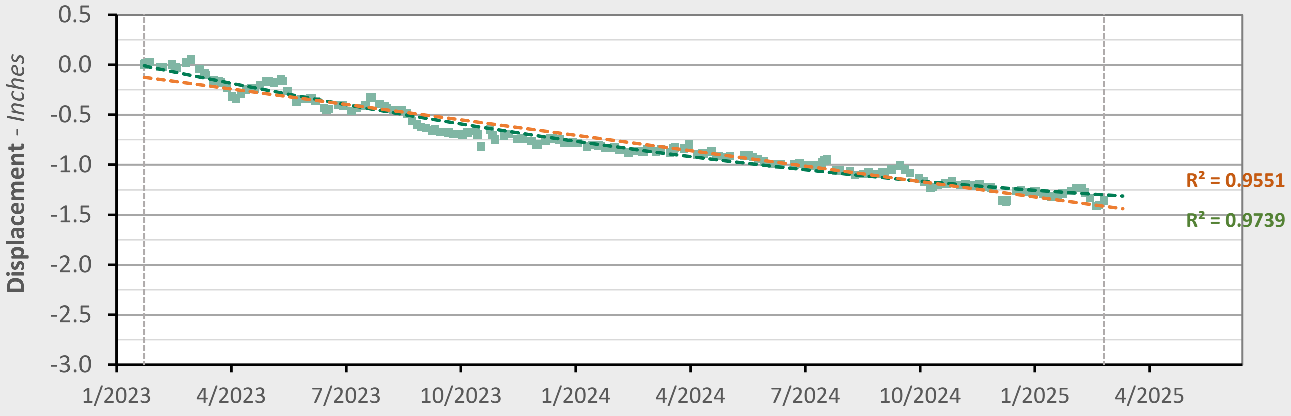
AOI Name	Vertical (2/25/2025)	Vertical Velocity (in/yr)		Vertical Acceleration (in/yr^2)	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
AOI 1 *(LGS 1)*	3	-0.28	-0.62	+0.32	0.00
AOI 2	2	-0.33	-0.62	+0.28	0.00
AOI 3	5	-0.20	-0.48	+0.26	0.00
AOI 4	11	-0.47	-0.56	+0.08	0.00
AOI 5 *(PPG 21)*	10	-0.45	-0.52	+0.07	0.00
AOI 6 *(PPG 6)*	20	-0.74	-0.84	+0.09	0.00
AOI 7 *(PPG 7)*	24	-0.79	-0.91	+0.12	0.00
AOI 8 *(PPG 22)*	6	-0.96	-1.19	+0.22	0.00
AOI 9 *(SMS A1)*	12	-0.43	-0.75	+0.30	0.00
AOI 10 *(PPG 2)*	33	-0.91	-1.04	+0.13	0.00
AOI 11 *(PPG 5)*	9	-0.90	-0.97	+0.08	0.00
AOI 12 *(PPG 4)*	21	-0.89	-0.98	+0.08	0.00
AOI 13 *(PPG 18)*	3	-0.57	-0.66	+0.08	0.00
AOI 14 *(PPG 16)*	0	N/A	N/A	N/A	N/A
AOI 15 *(PPG 20)*	12	-0.77	-0.82	+0.05	0.00

AOI 1 *(LGS 1)* - Location Map



AOI 1 *(LGS 1)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **3**



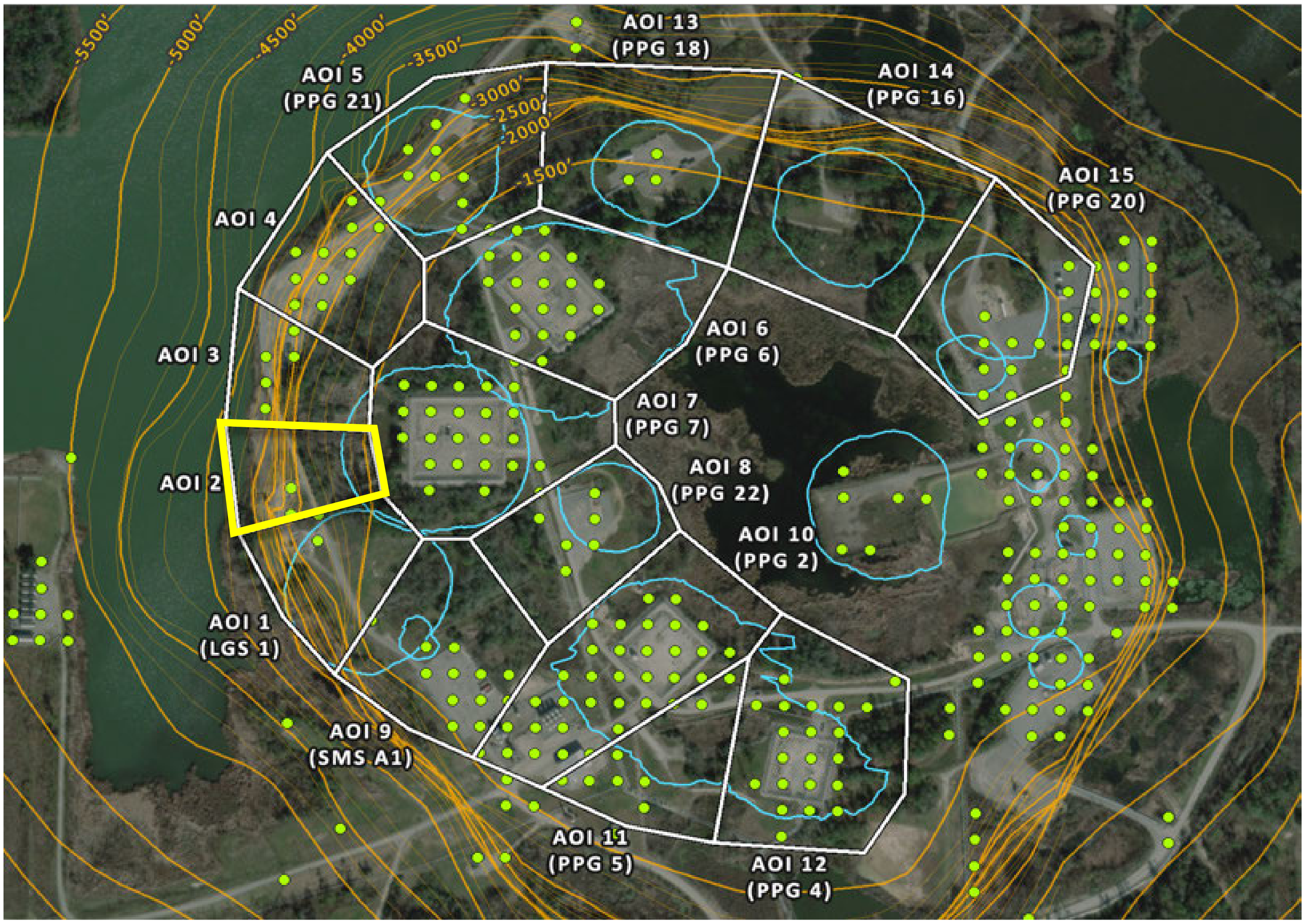
	Nonlinear Trend	Linear Trend
Velocity:	-0.28 in/yr	-0.62 in/yr
Acceleration:	+0.32 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

- - - Nonlinear Trend Line (Quadratic Regression)

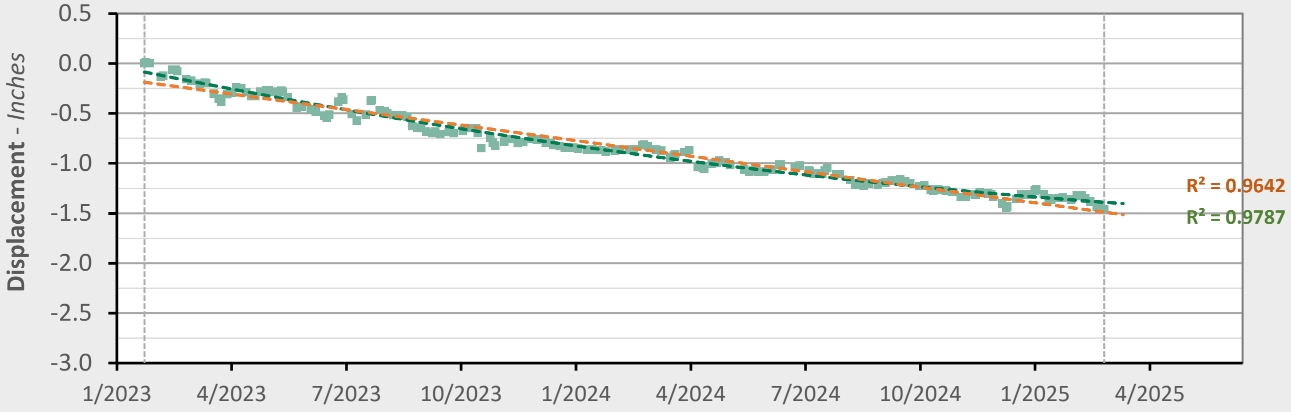
- - - Linear Trend Line (Linear Regression)

AOI 2 - Location Map



AOI 2 - Vertical Time Series

Vertical (2/25/2025) Point Count: 2



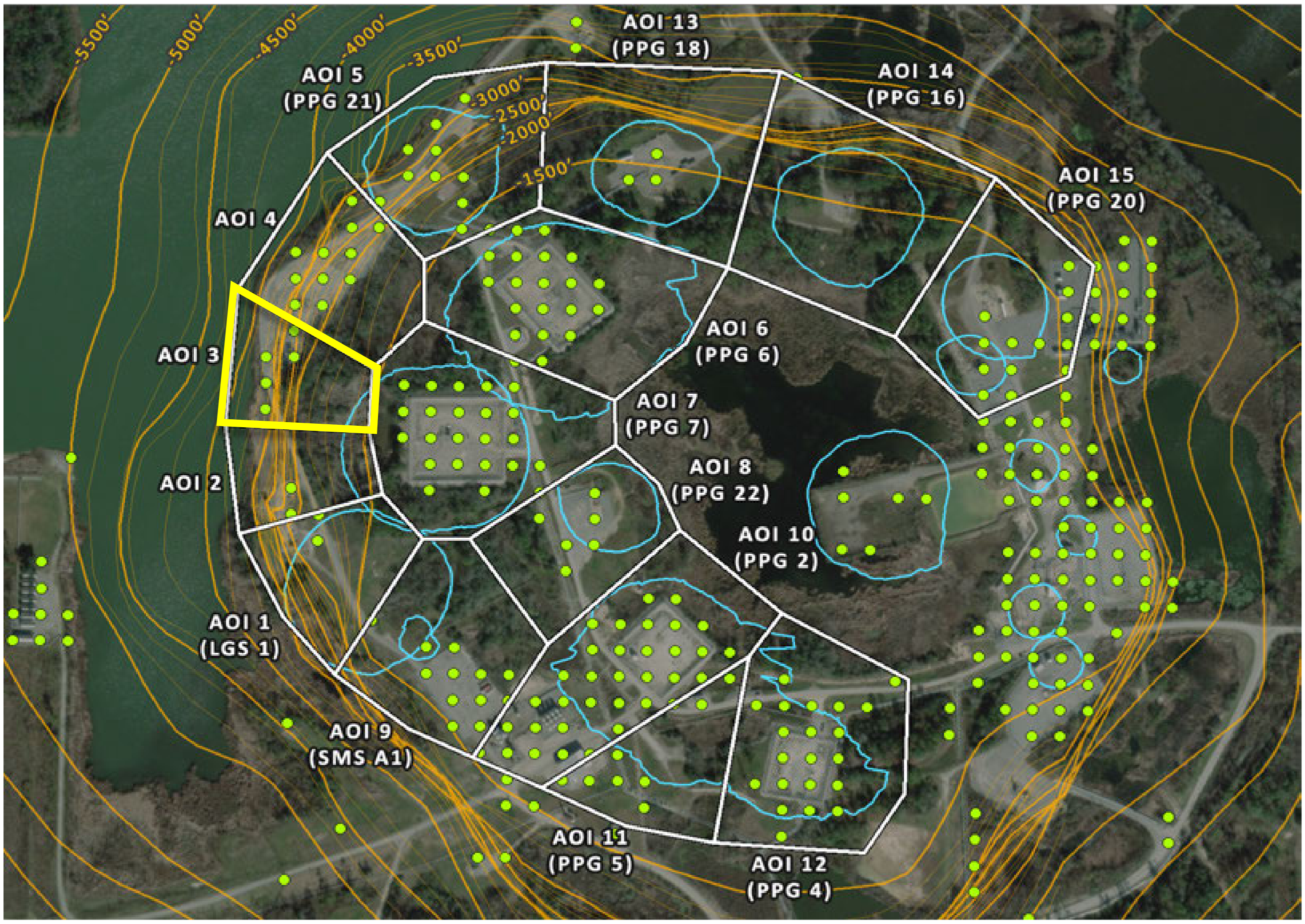
	Nonlinear Trend		Linear Trend	
Velocity:	-0.33	in/yr	-0.62	in/yr
Acceleration:	+0.28	in/yr^2	0.00	in/yr^2

■ 2D Displacement Measurement

--- Nonlinear Trend Line (Quadratic Regression)

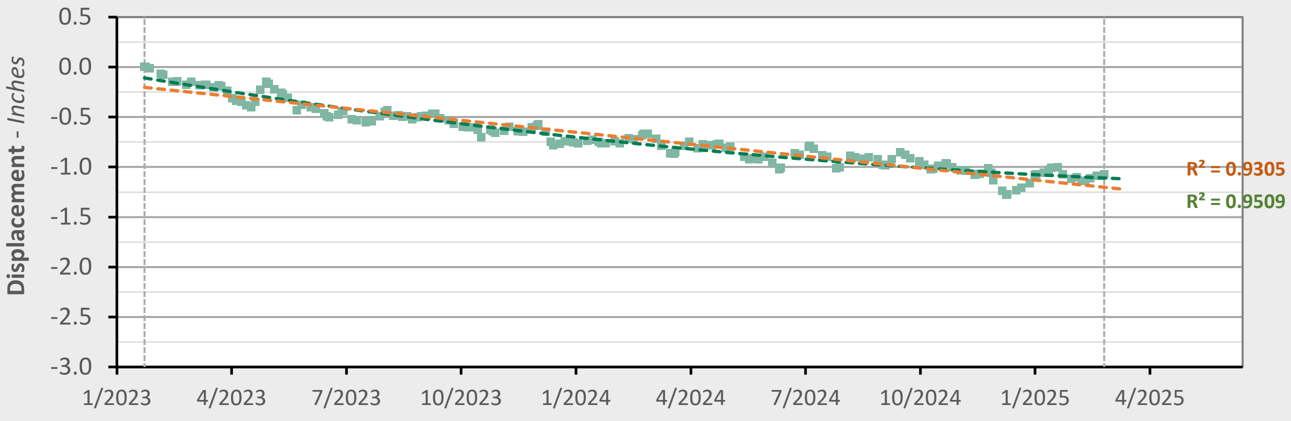
--- Linear Trend Line (Linear Regression)

AOI 3 - Location Map



AOI 3 - Vertical Time Series

Vertical (2/25/2025) Point Count: **5**



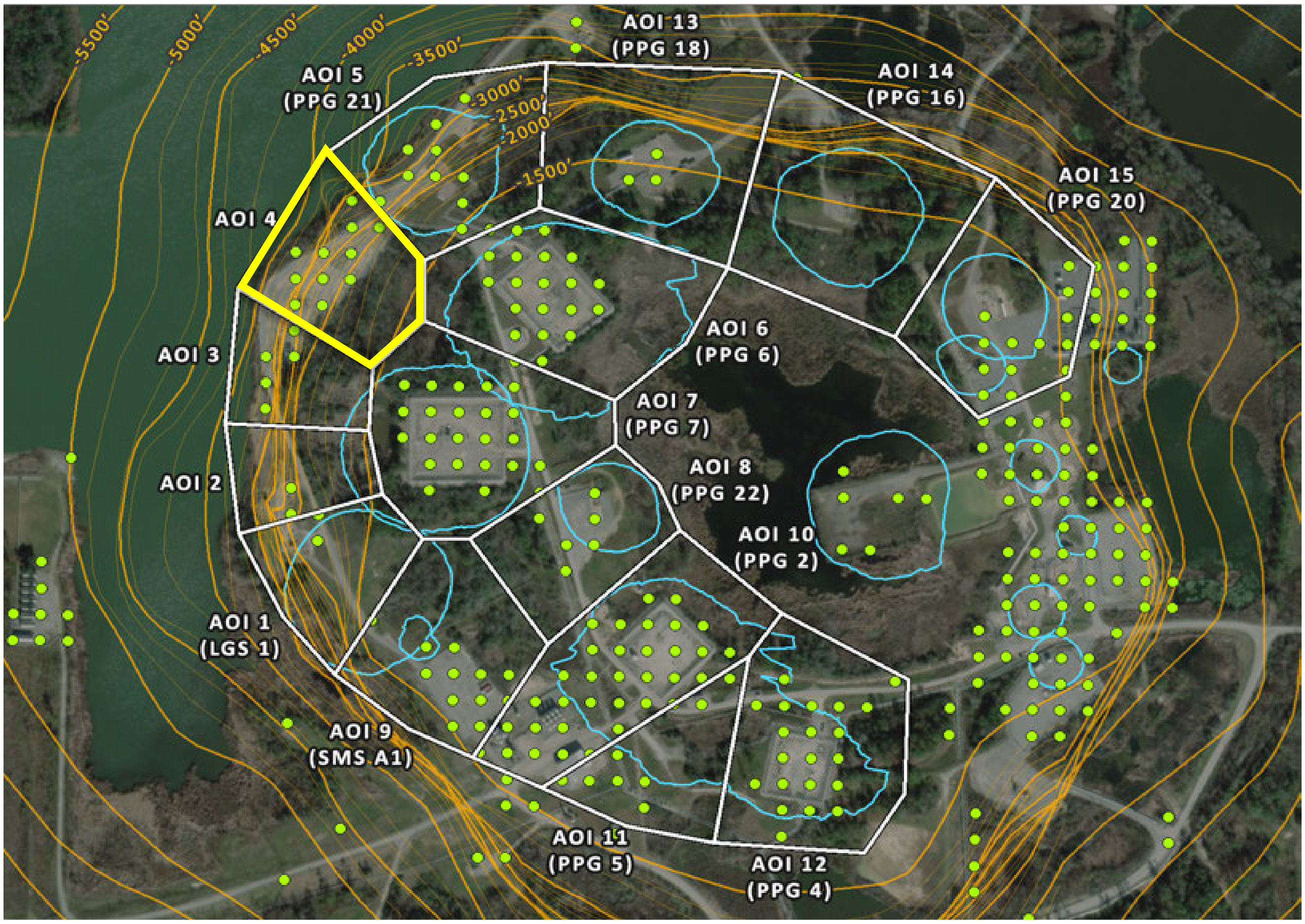
	Nonlinear Trend		Linear Trend	
Velocity:	-0.20	in/yr	-0.48	in/yr
Acceleration:	+0.26	in/yr^2	0.00	in/yr^2

🟩 2D Displacement Measurement

- - - Nonlinear Trend Line (Quadratic Regression)

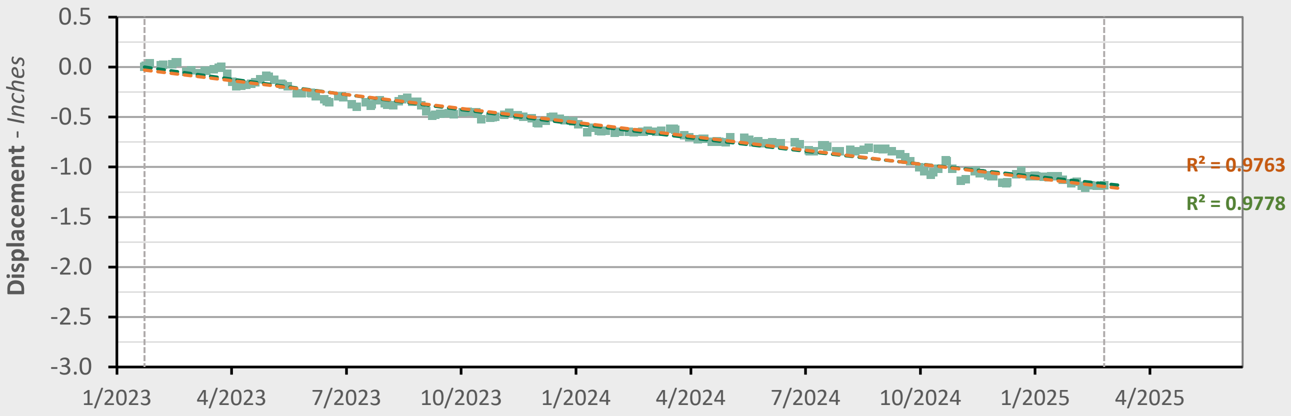
- - - Linear Trend Line (Linear Regression)

AOI 4 - Location Map



AOI 4 - Vertical Time Series

Vertical (2/25/2025) Point Count: **11**



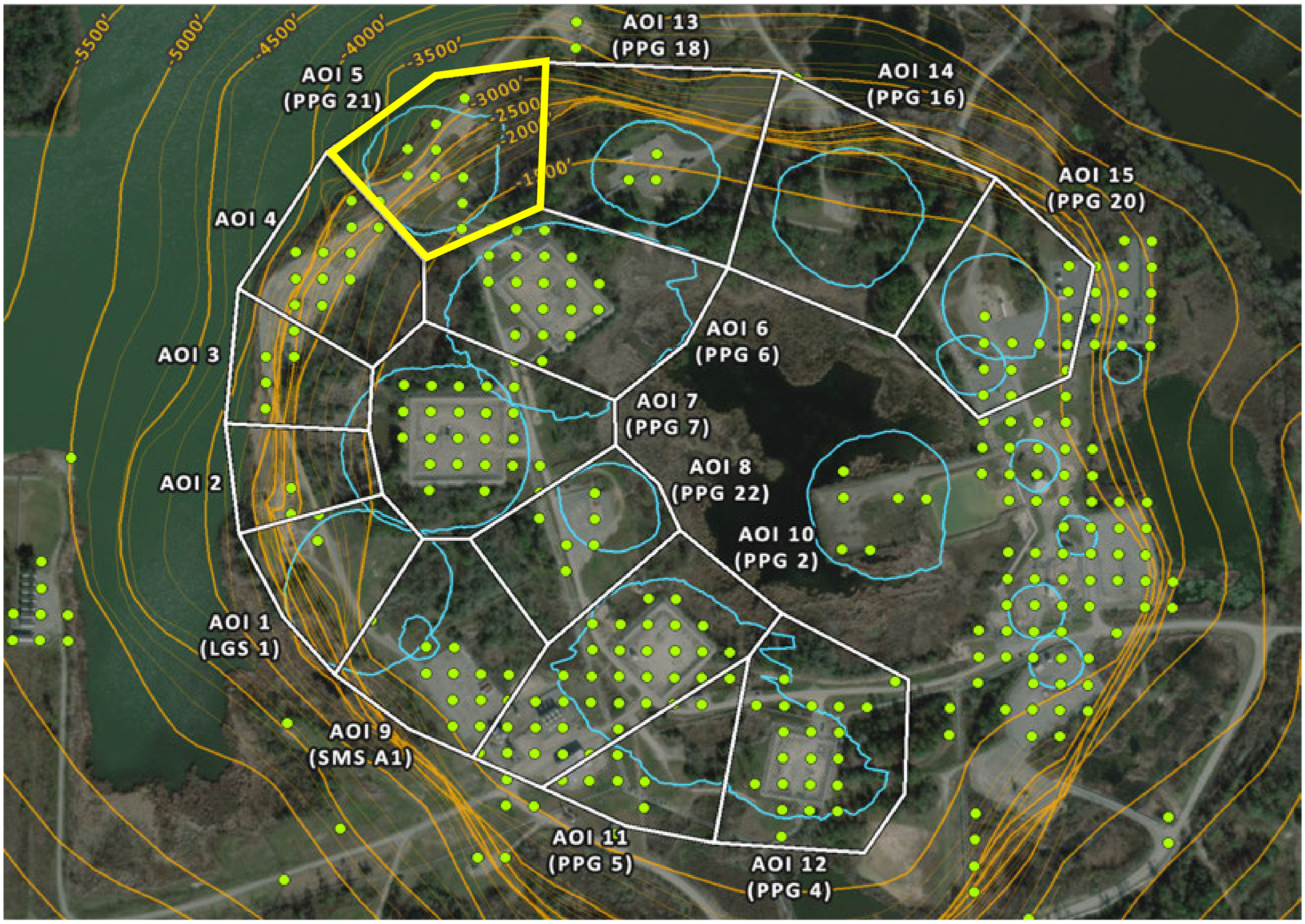
	Nonlinear Trend		Linear Trend	
Velocity:	-0.47	in/yr	-0.56	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

▪ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

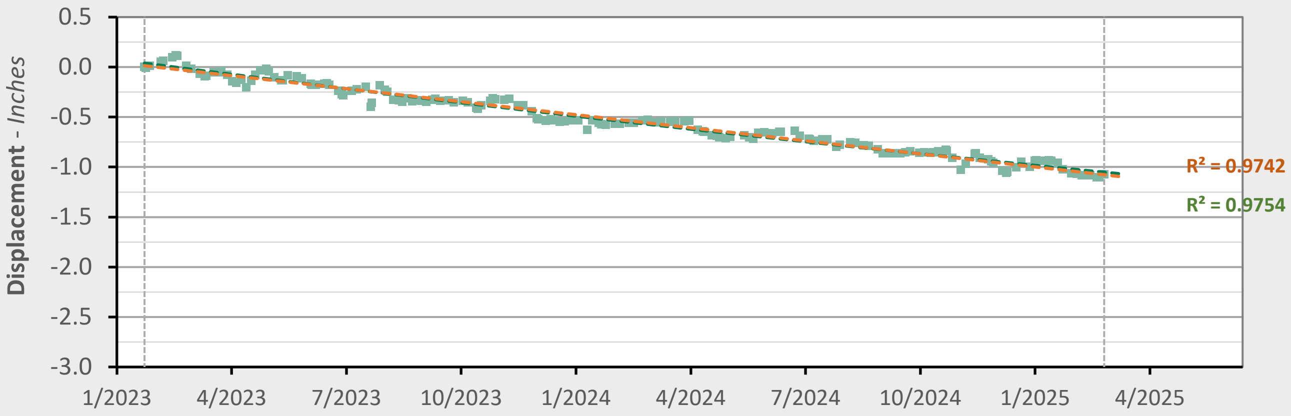
---- Linear Trend Line (Linear Regression)

AOI 5 *(PPG 21)* - Location Map



AOI 5 *(PPG 21)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **10**



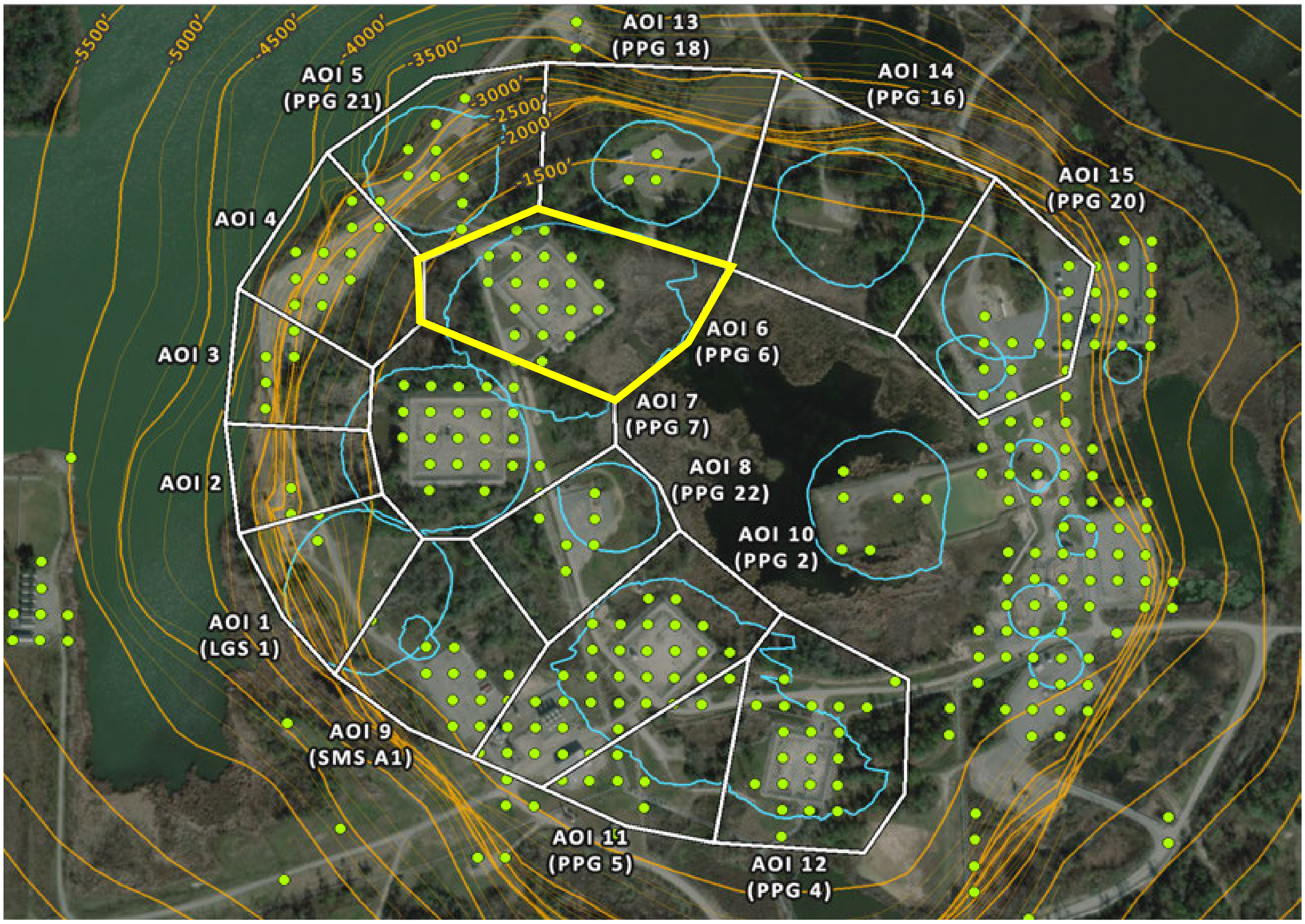
	Nonlinear Trend		Linear Trend	
Velocity:	-0.45	in/yr	-0.52	in/yr
Acceleration:	+0.07	in/yr^2	0.00	in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

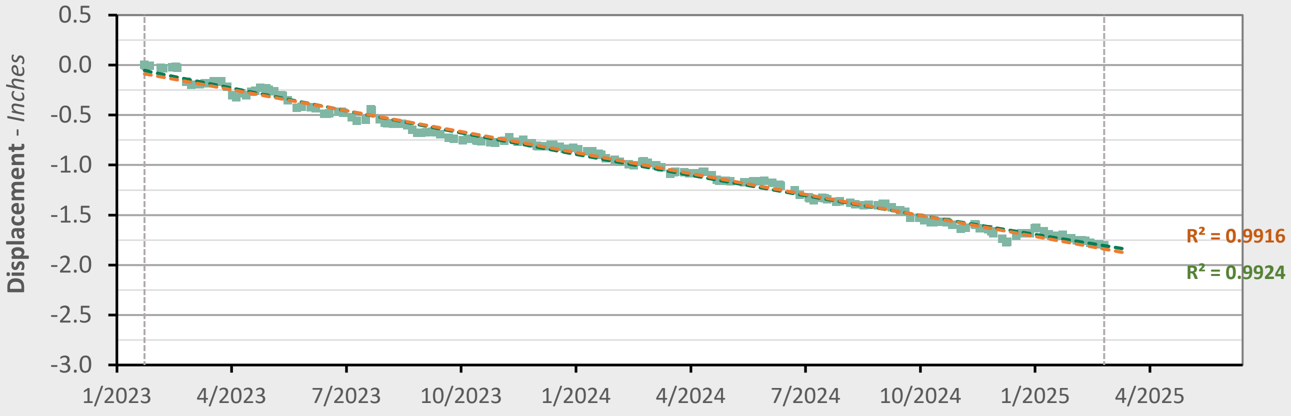
---- Linear Trend Line (Linear Regression)

AOI 6 *(PPG 6)* - Location Map



AOI 6 *(PPG 6)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **20**



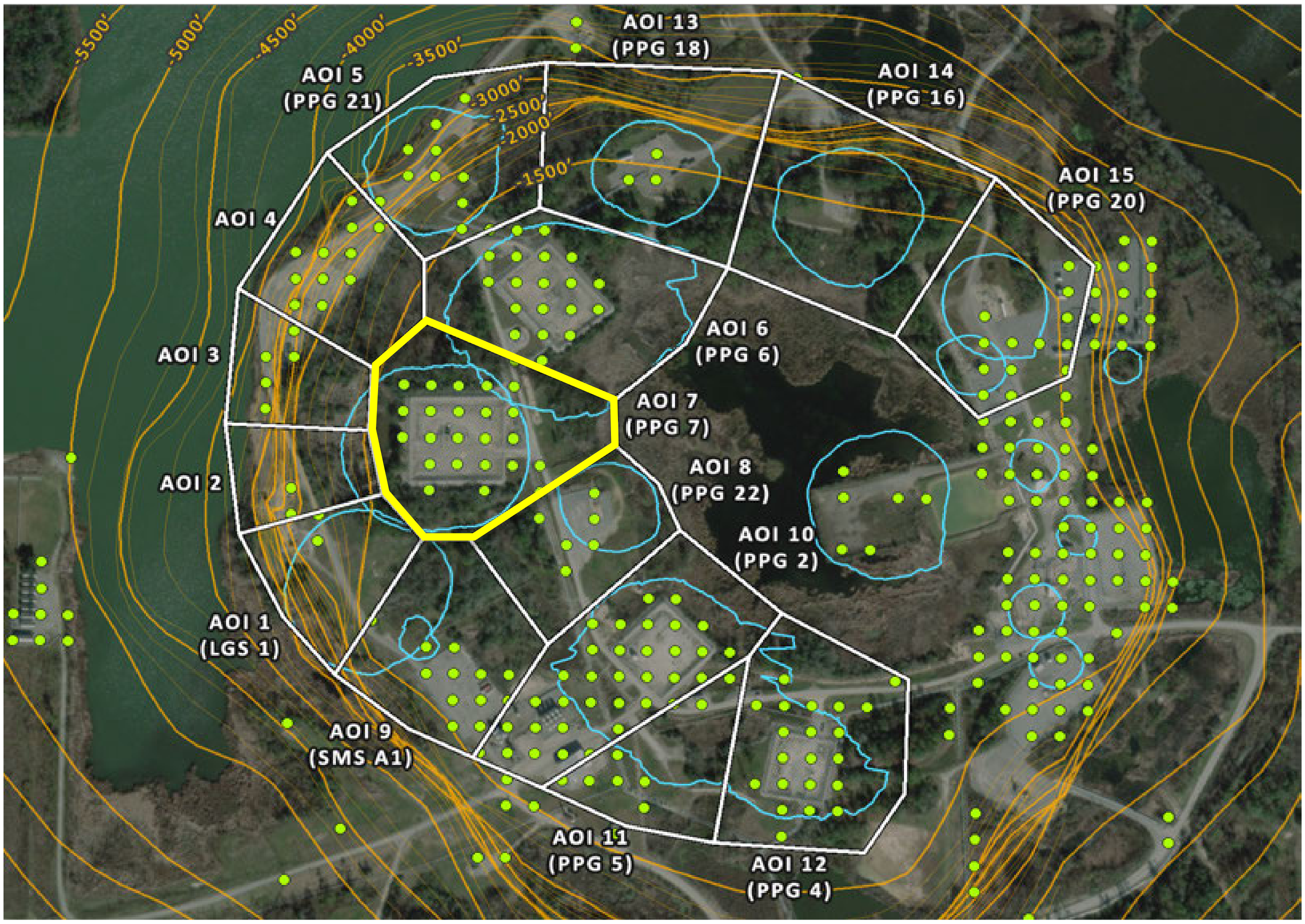
	Nonlinear Trend	Linear Trend
Velocity:	-0.74 in/yr	-0.84 in/yr
Acceleration:	+0.09 in/yr^2	0.00 in/yr^2

🟩 2D Displacement Measurement

Nonlinear Trend Line (Quadratic Regression)

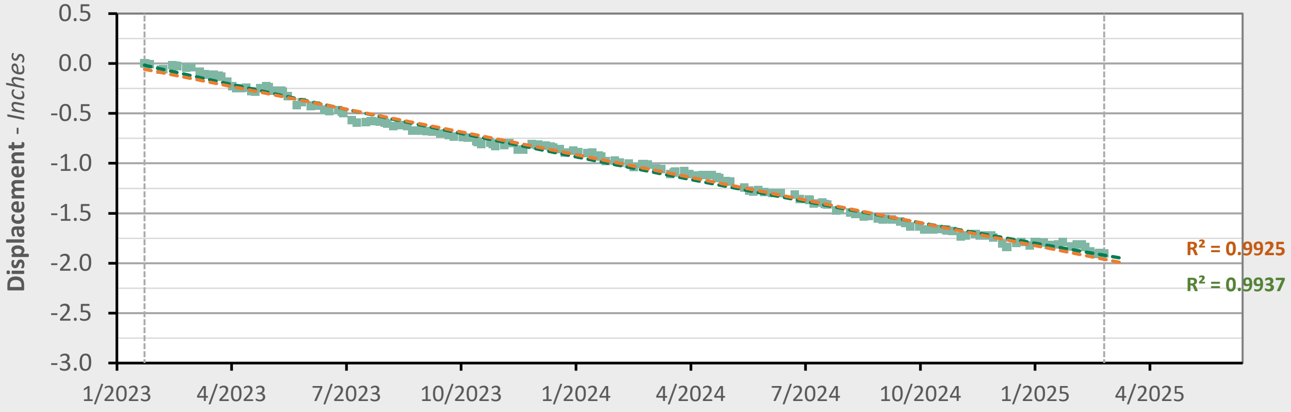
Linear Trend Line (Linear Regression)

AOI 7 *(PPG 7)* - Location Map



AOI 7 *(PPG 7)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **24**



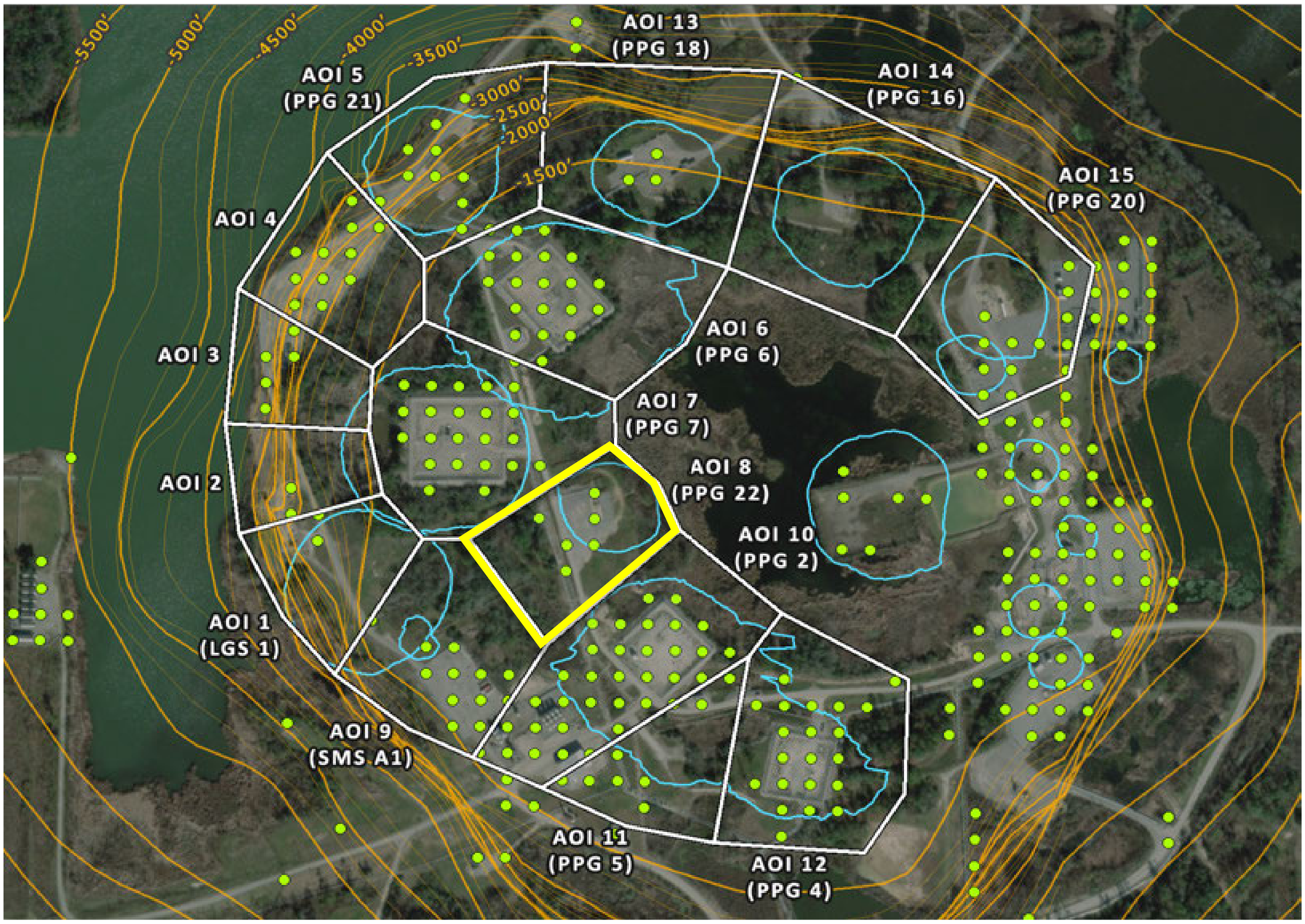
	Nonlinear Trend	Linear Trend
Velocity:	-0.79 in/yr	-0.91 in/yr
Acceleration:	+0.12 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

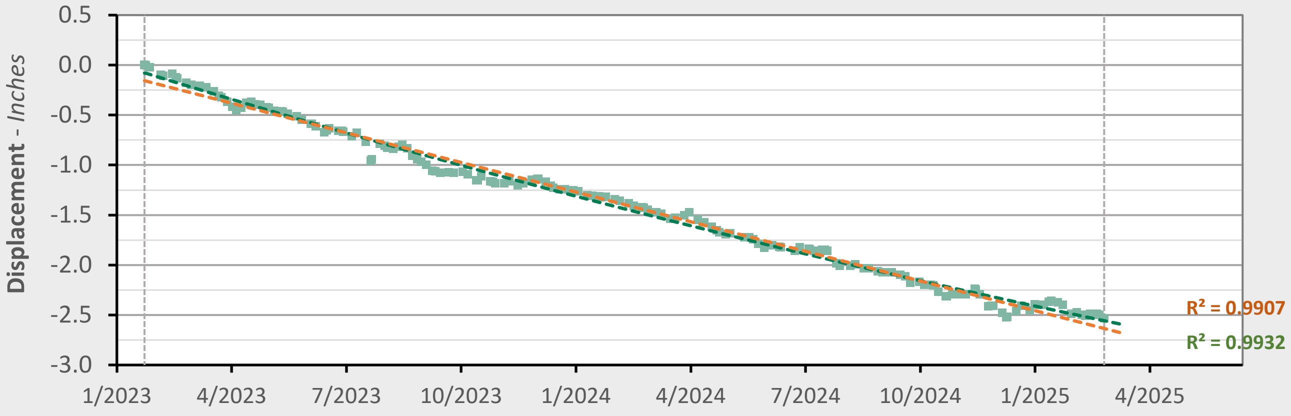
---- Linear Trend Line (Linear Regression)

AOI 8 *(PPG 22)* - Location Map



AOI 8 *(PPG 22)* - Vertical Time Series

Vertical (2/25/2025) Point Count: 6



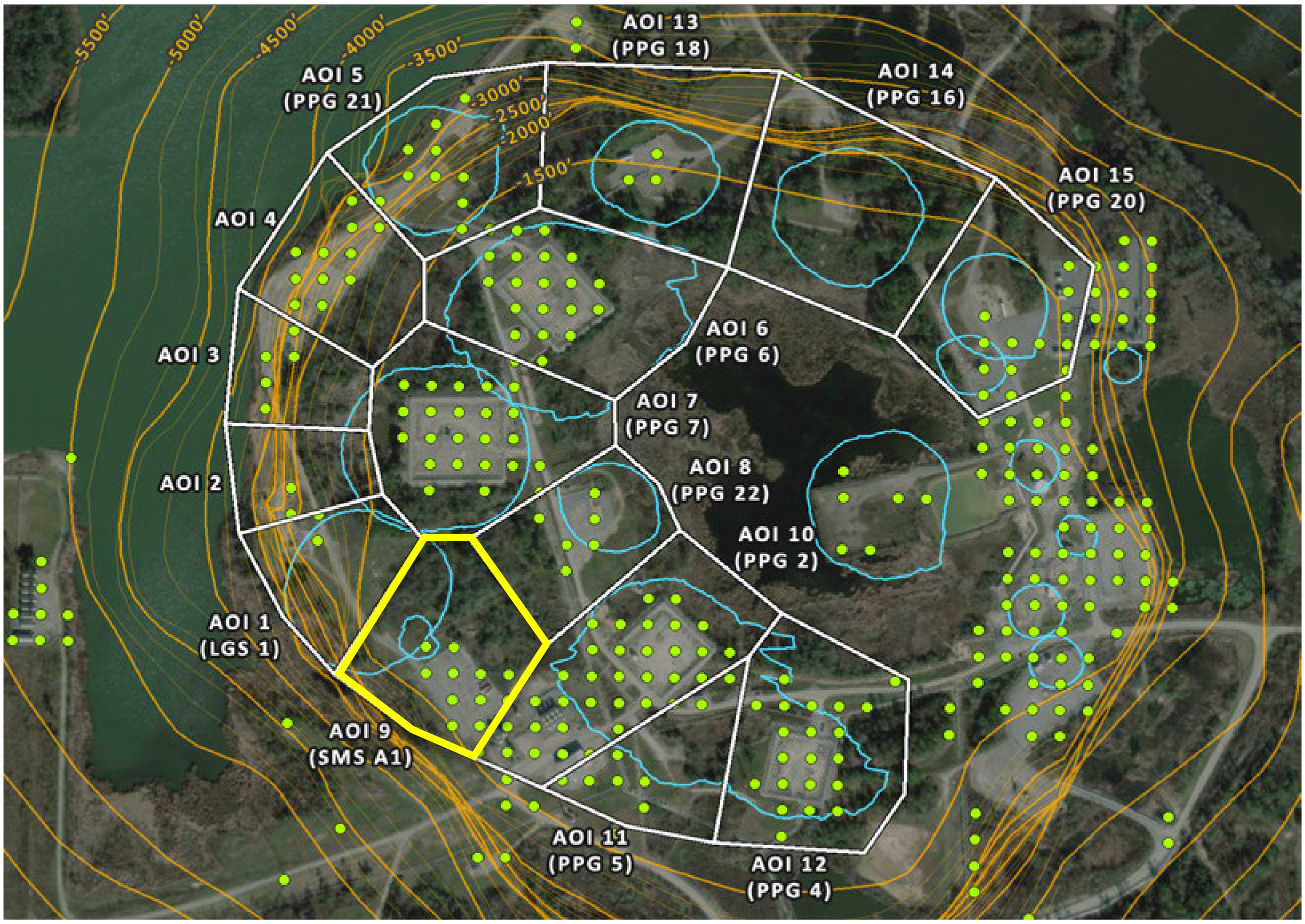
	Nonlinear Trend	Linear Trend
Velocity:	-0.96 in/yr	-1.19 in/yr
Acceleration:	+0.22 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

Nonlinear Trend Line (Quadratic Regression)

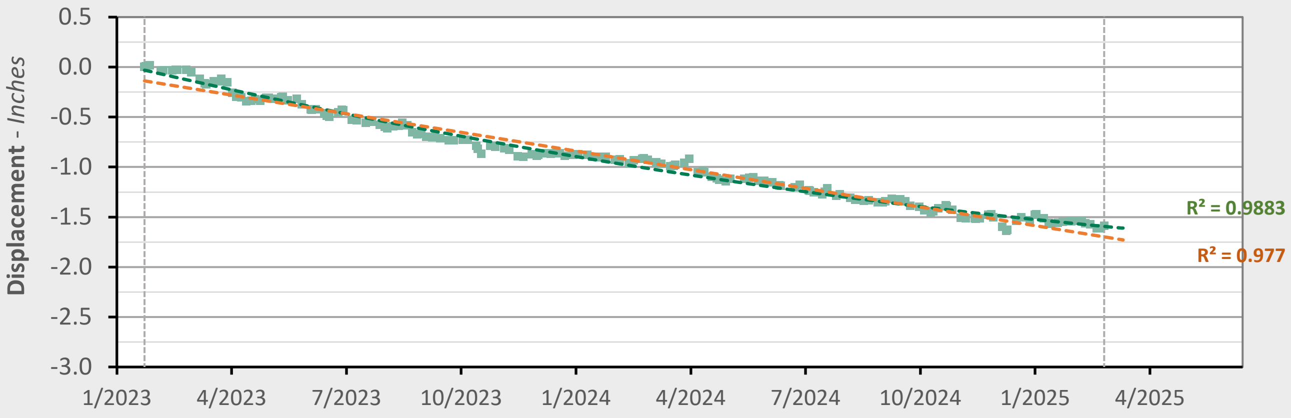
Linear Trend Line (Linear Regression)

AOI 9 *(PPG A1)* - Location Map



AOI 9 *(SMS A1)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **12**



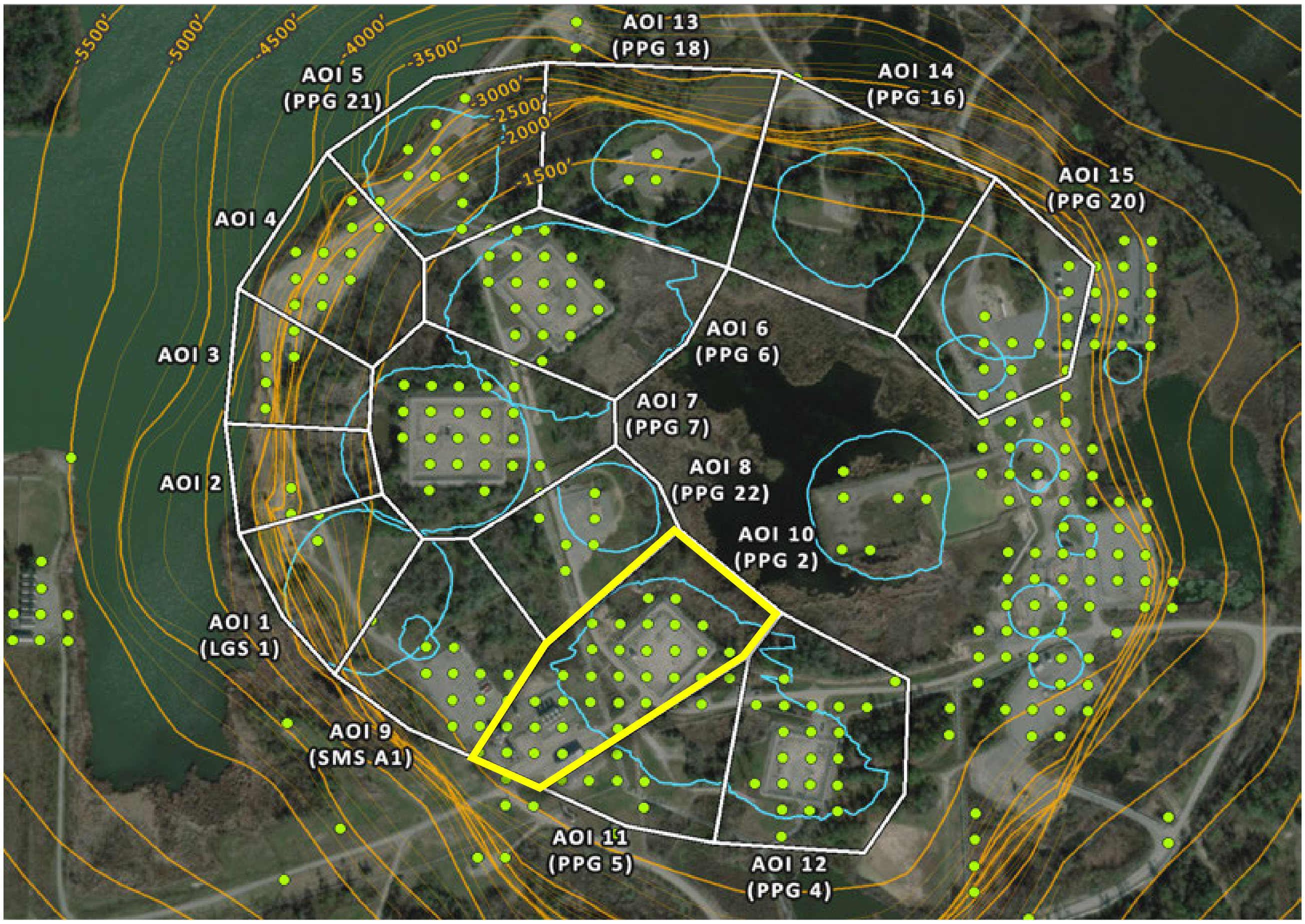
	Nonlinear Trend		Linear Trend	
Velocity:	-0.43	in/yr	-0.75	in/yr
Acceleration:	+0.30	in/yr^2	0.00	in/yr^2

▪ 2D Displacement Measurement

\- - - - Nonlinear Trend Line (Quadratic Regression)

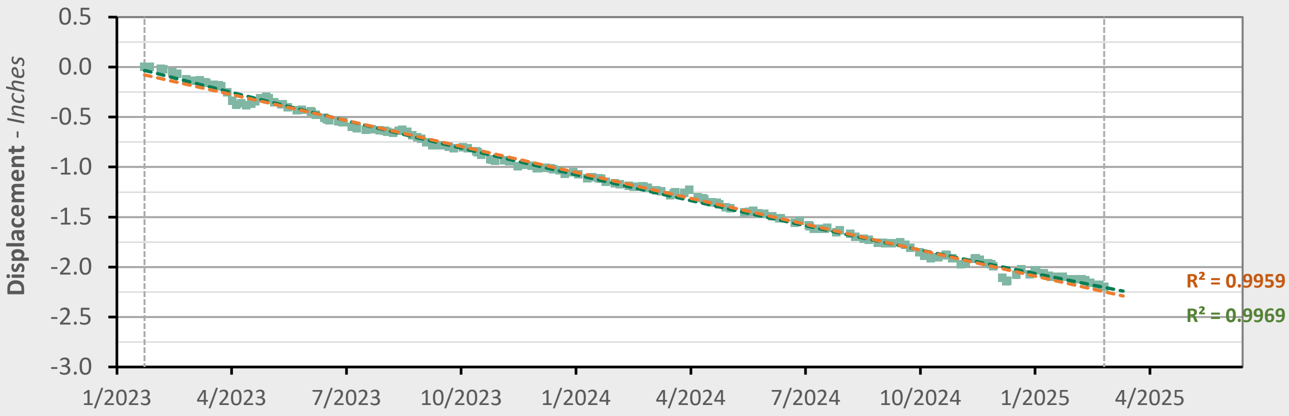
\- - - - Linear Trend Line (Linear Regression)

AOI 10 *(PPG 2)* - Location Map



AOI 10 *(PPG 2)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **33**



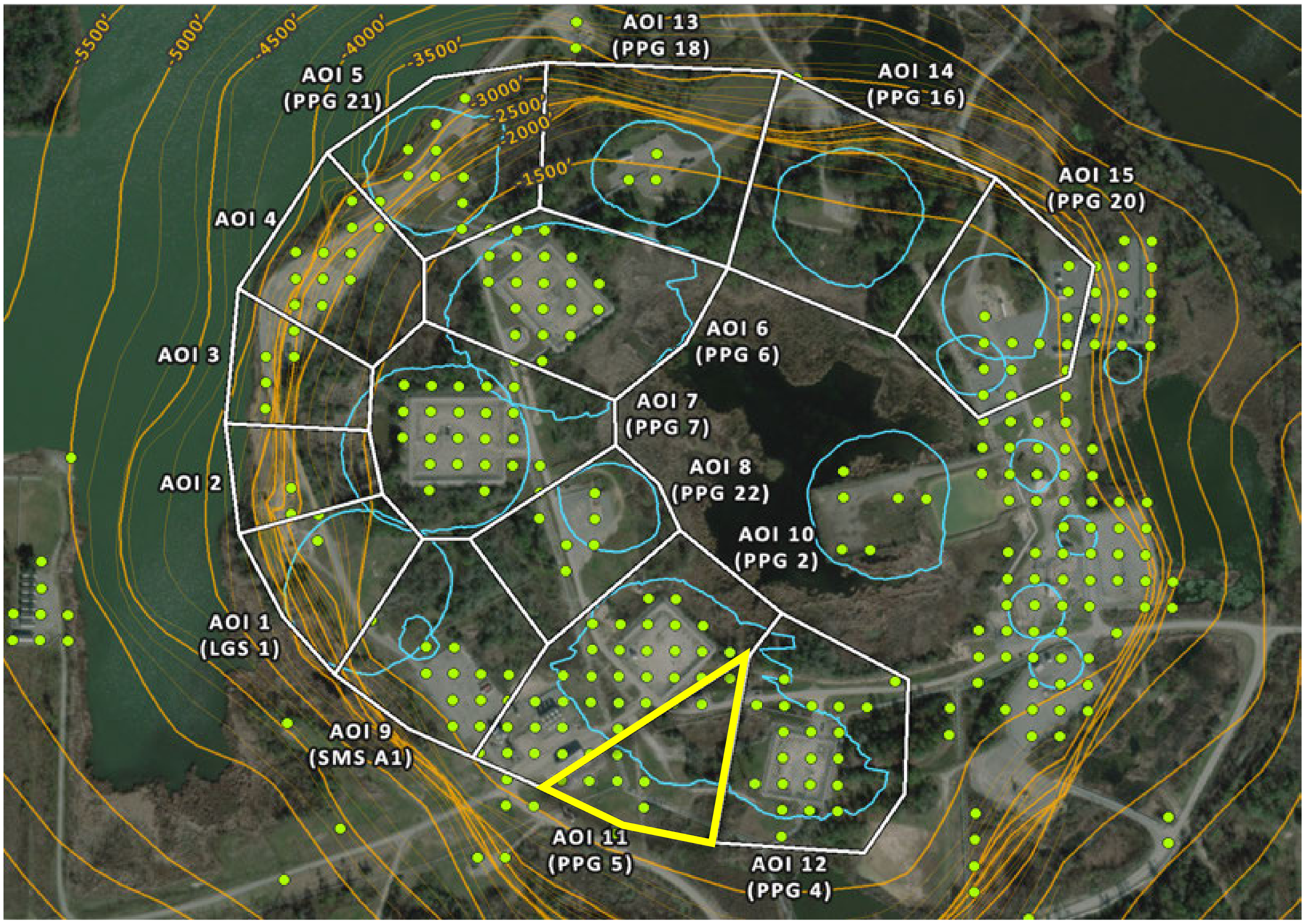
	Nonlinear Trend		Linear Trend	
Velocity:	-0.91	in/yr	-1.04	in/yr
Acceleration:	+0.13	in/yr^2	0.00	in/yr^2

■ 2D Displacement Measurement

- - - Nonlinear Trend Line (Quadratic Regression)

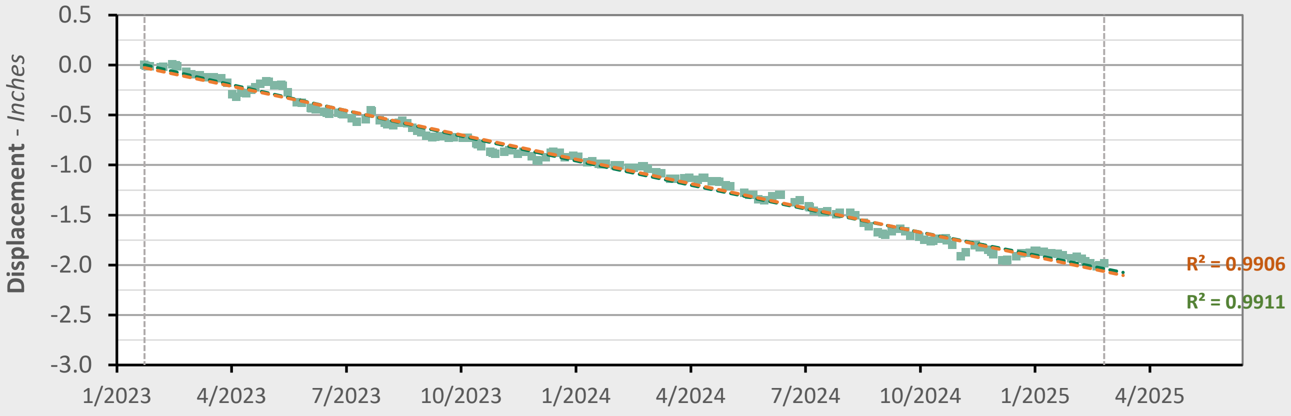
- - - Linear Trend Line (Linear Regression)

AOI 11 *(PPG 5)* - Location Map



AOI 11 *(PPG 5)* - Vertical Time Series

Vertical (2/25/2025) Point Count: 9



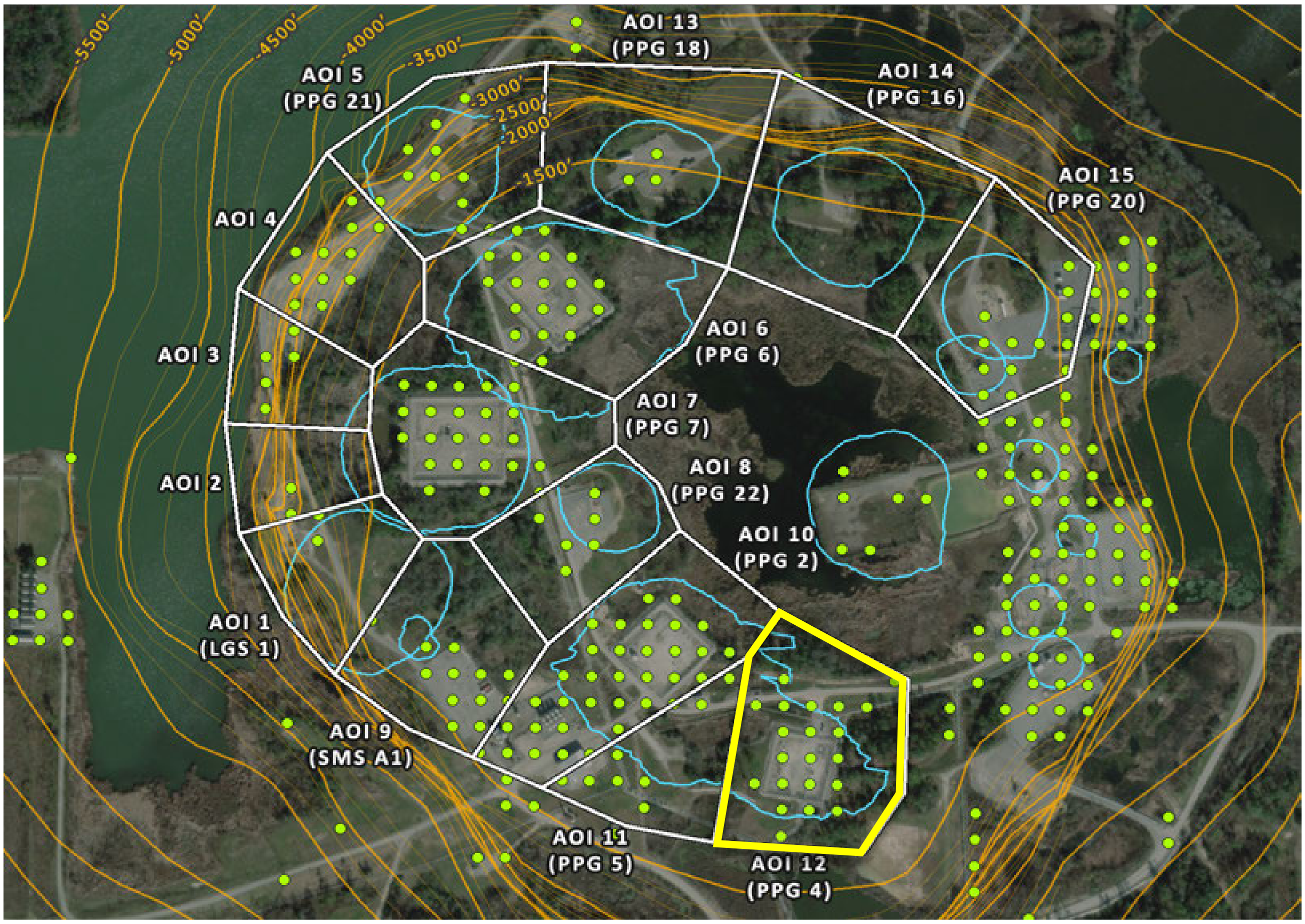
	Nonlinear Trend		Linear Trend	
Velocity:	-0.90	in/yr	-0.97	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

🟩 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

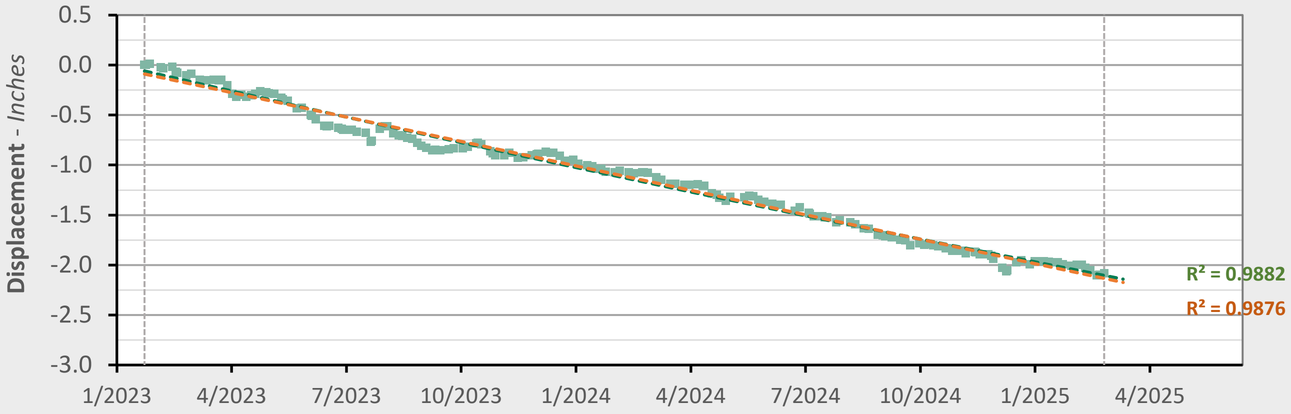
---- Linear Trend Line (Linear Regression)

AOI 12 *(PPG 4)* - Location Map



AOI 12 *(PPG 4)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **21**



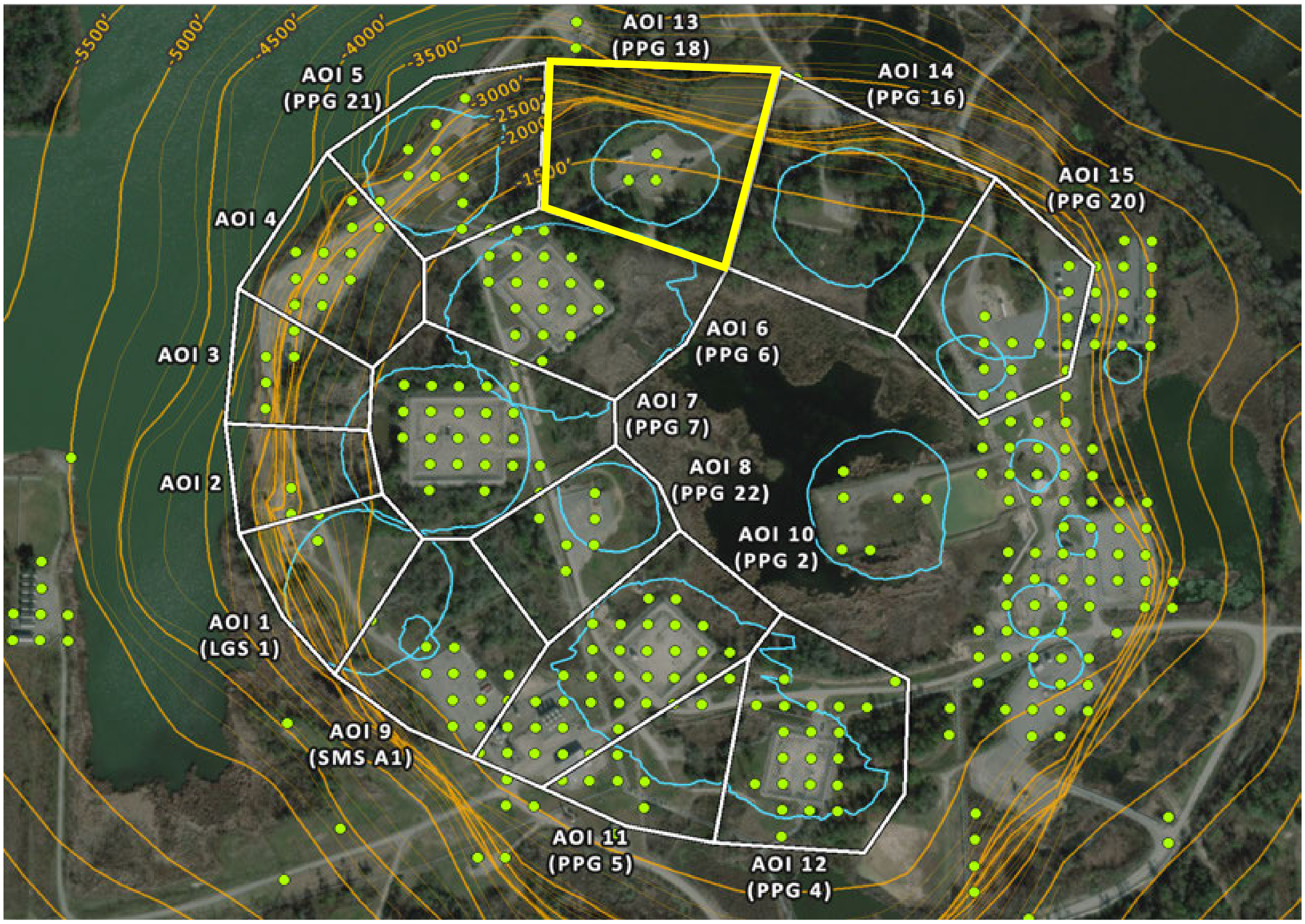
	Nonlinear Trend		Linear Trend	
Velocity:	-0.89	in/yr	-0.98	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

🟩 2D Displacement Measurement

Nonlinear Trend Line (Quadratic Regression)

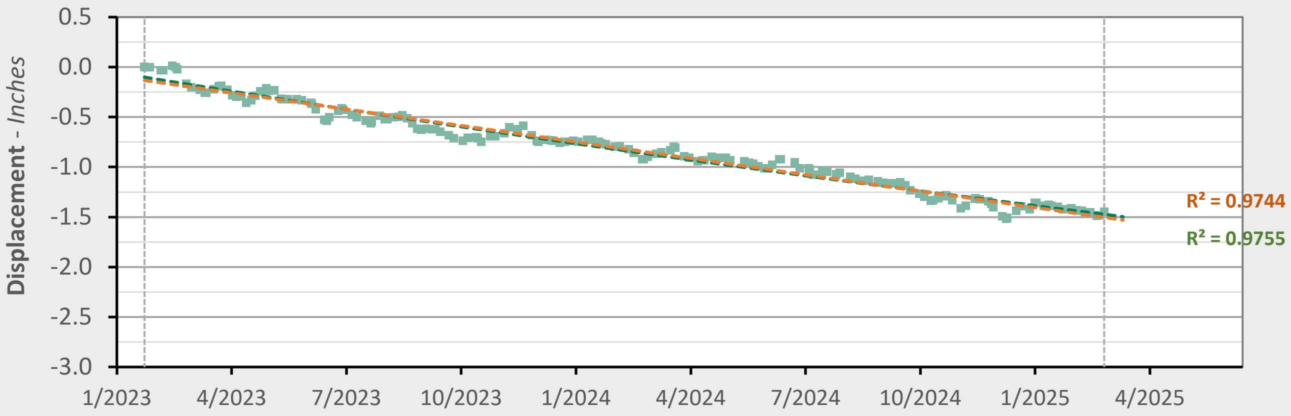
Linear Trend Line (Linear Regression)

AOI 13 *(PPG 18)* - Location Map



AOI 13 *(PPG 18)* - Vertical Time Series

Vertical (2/25/2025) Point Count: 3



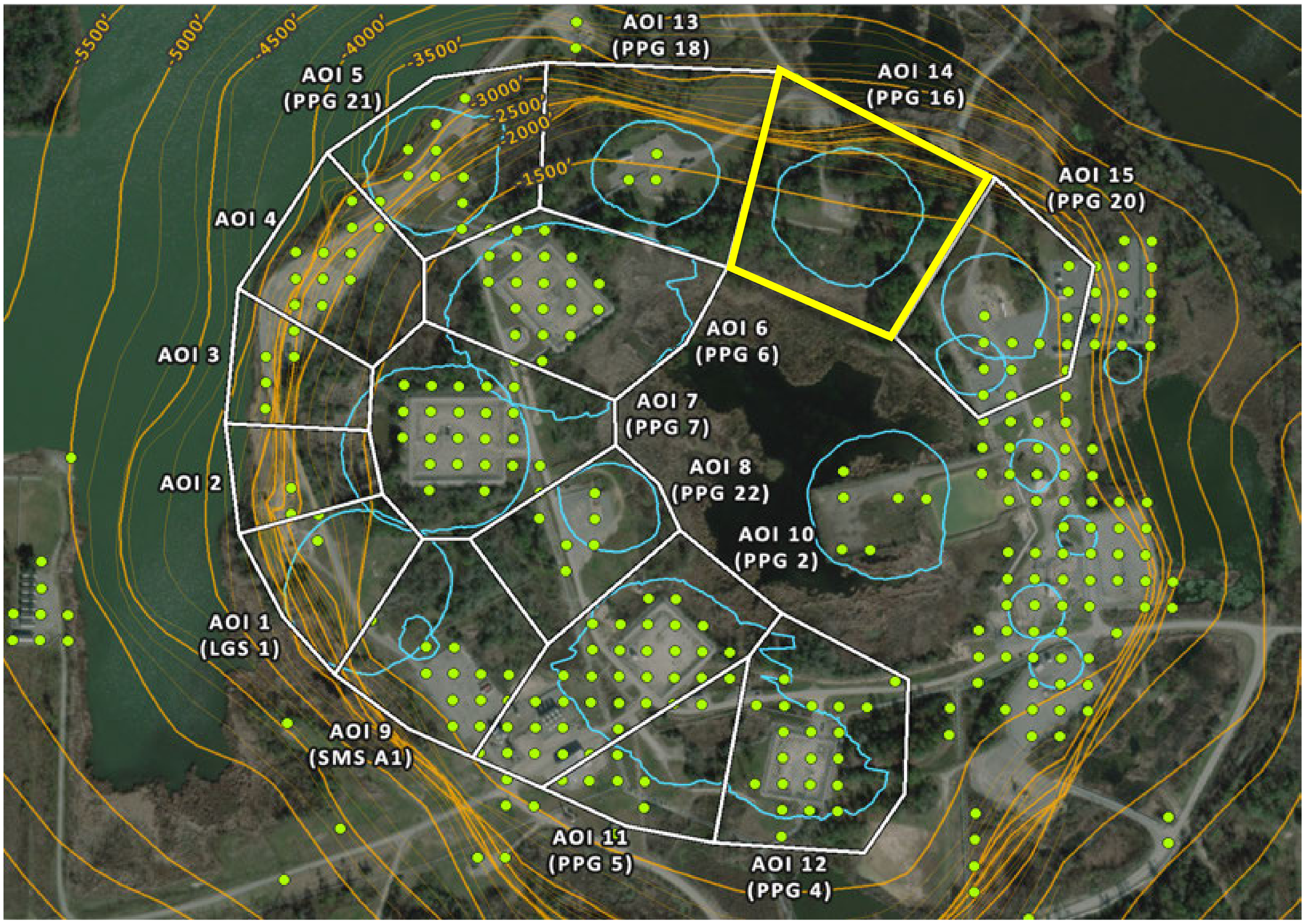
	Nonlinear Trend		Linear Trend	
Velocity:	-0.57	in/yr	-0.66	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

🟩 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

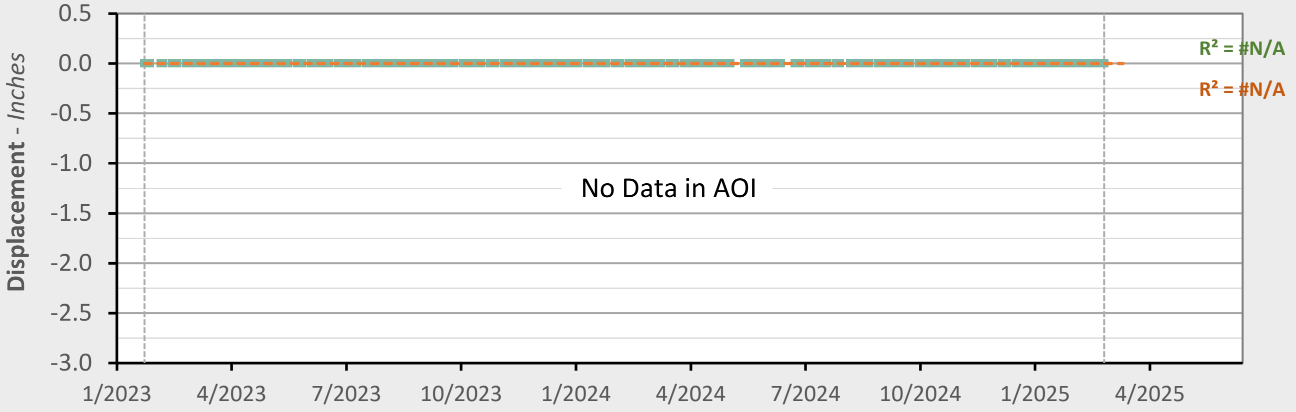
---- Linear Trend Line (Linear Regression)

AOI 14 *(PPG 16)* - Location Map



AOI 14 *(PPG 16)* - Vertical Time Series

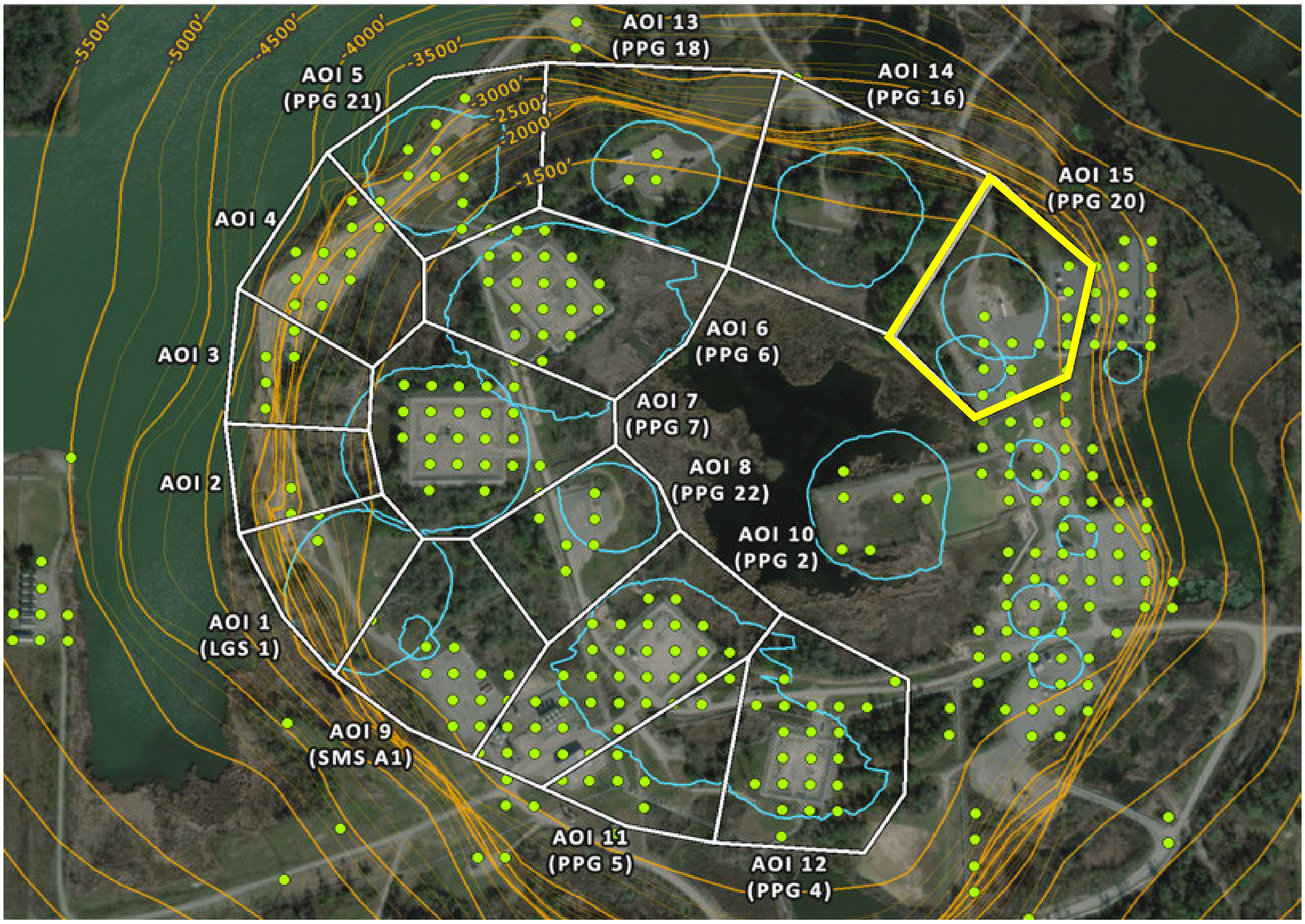
Vertical (2/25/2025) Point Count: **0**



	Nonlinear Trend		Linear Trend	
Velocity:	N/A	in/yr	N/A	in/yr
Acceleration:	N/A	in/yr^2	N/A	in/yr^2

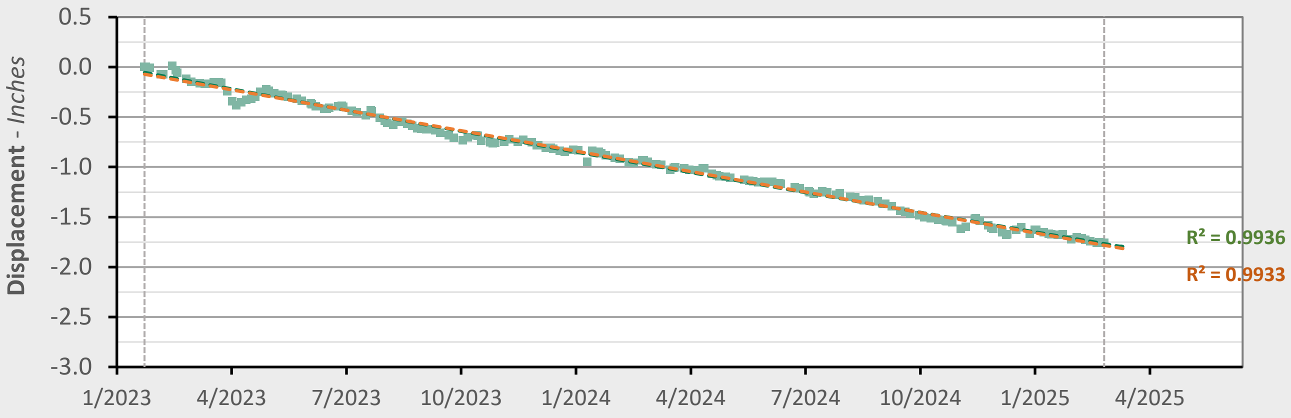
🟩 2D Displacement Measurement ---- Nonlinear Trend Line (Quadratic Regression) ---- Linear Trend Line (Linear Regression)

AOI 15 *(PPG 20)* - Location Map



AOI 15 *(PPG 20)* - Vertical Time Series

Vertical (2/25/2025) Point Count: **12**



	Nonlinear Trend		Linear Trend	
Velocity:	-0.77	in/yr	-0.82	in/yr
Acceleration:	+0.05	in/yr^2	0.00	in/yr^2

▨ 2D Displacement Measurement

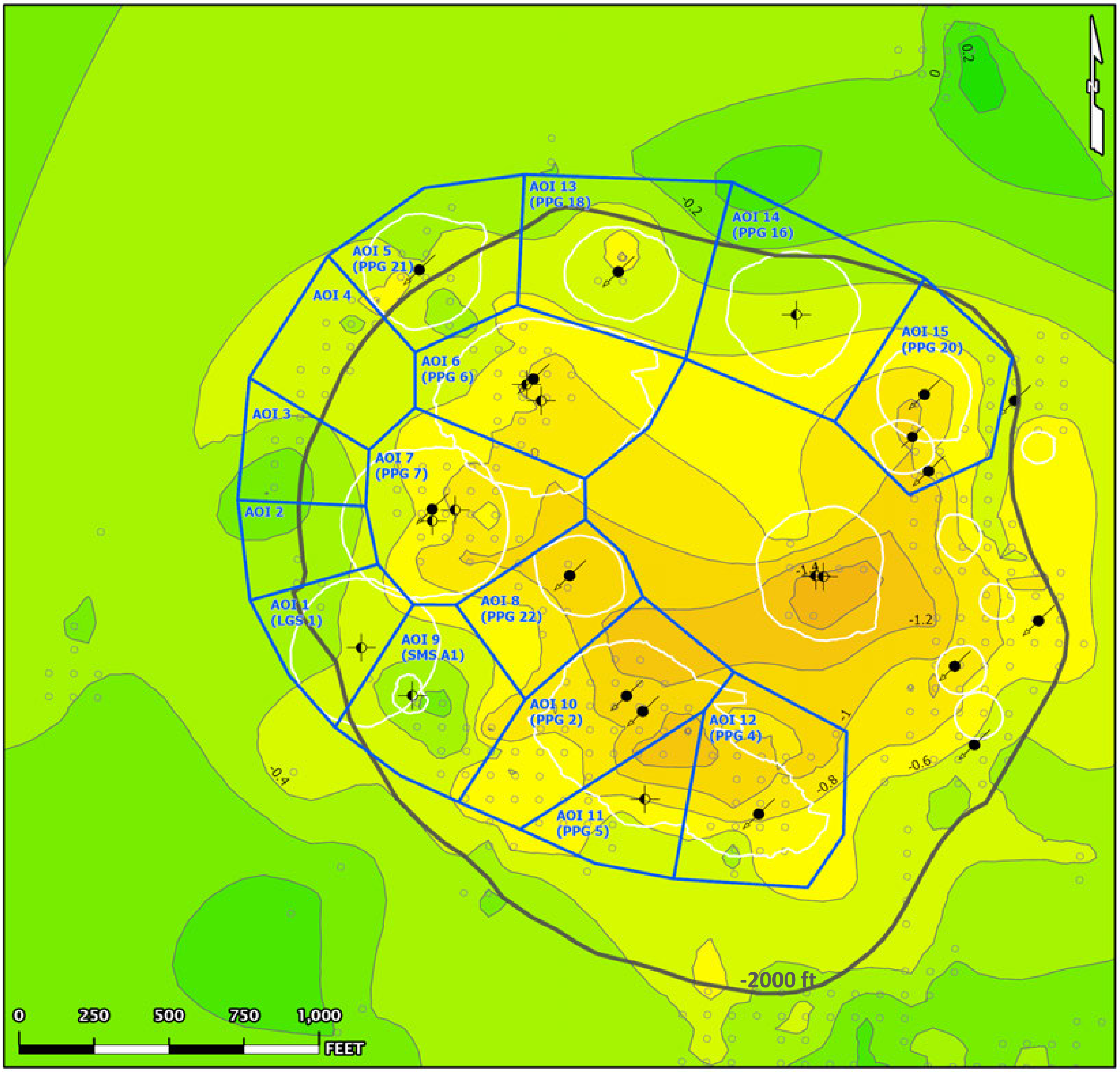
---- Nonlinear Trend Line (Quadratic Regression)

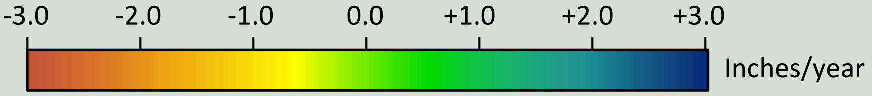
---- Linear Trend Line (Linear Regression)

Vertical Data (01/24/2023 - 02/25/2025)

Nonlinear Velocity Contours

As of date: 02/25/2025





▭ AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.2)

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

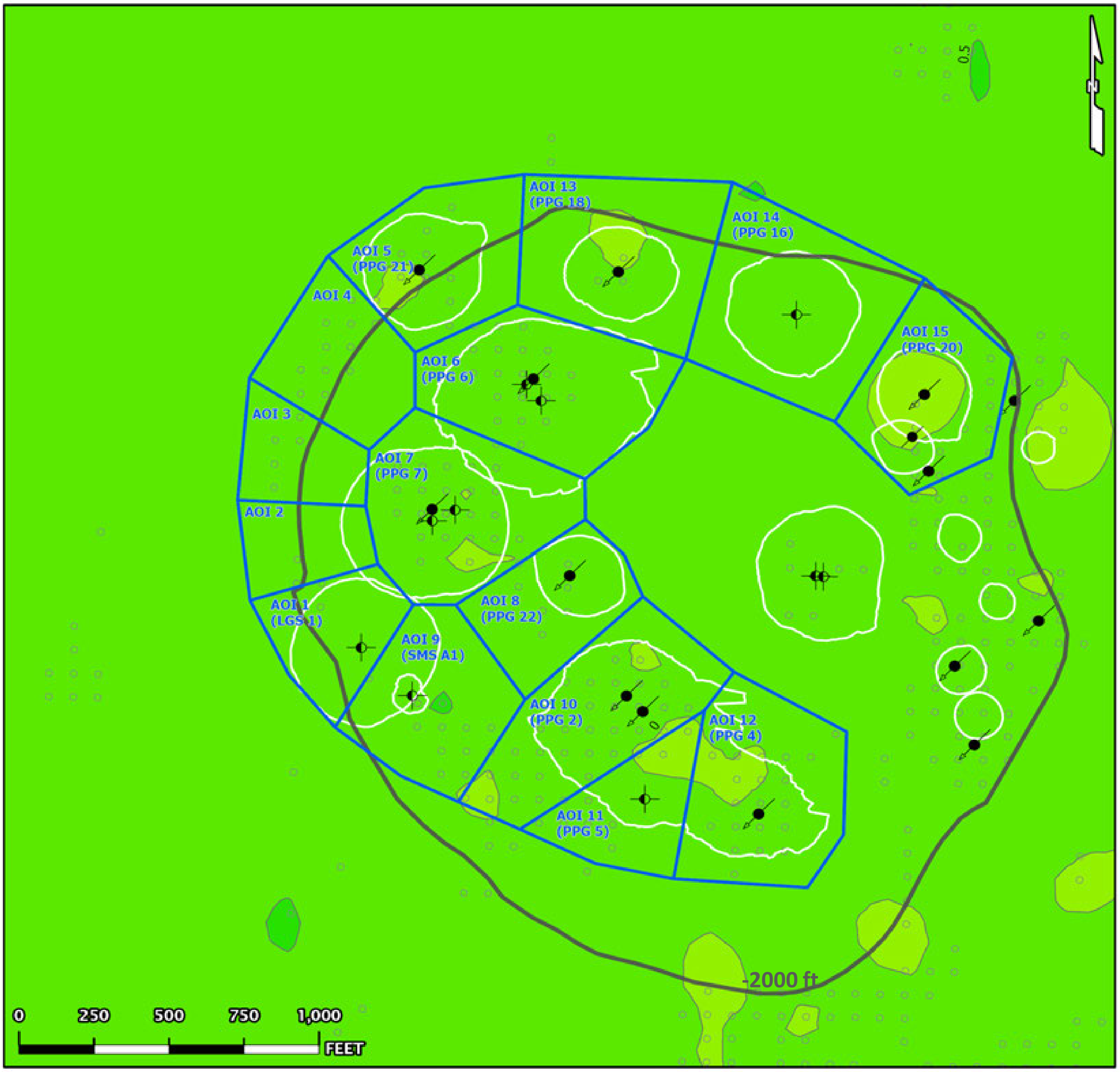
Cavern Well Surface Locations

● 09 - Active - Injection ⊕ 29 - Dry and Plugged

Vertical Data (01/24/2023 - 02/25/2025)

Nonlinear Acceleration Contours

Date range: 01/24/2023 - 02/25/2025



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0 Inches/year^2

- AOI Boundary
- ○ InSAR LOS Measurement Point
- Contour (0.5)
- Historical Cavern Extent
- Top of Dome (-2000 ft Contour)

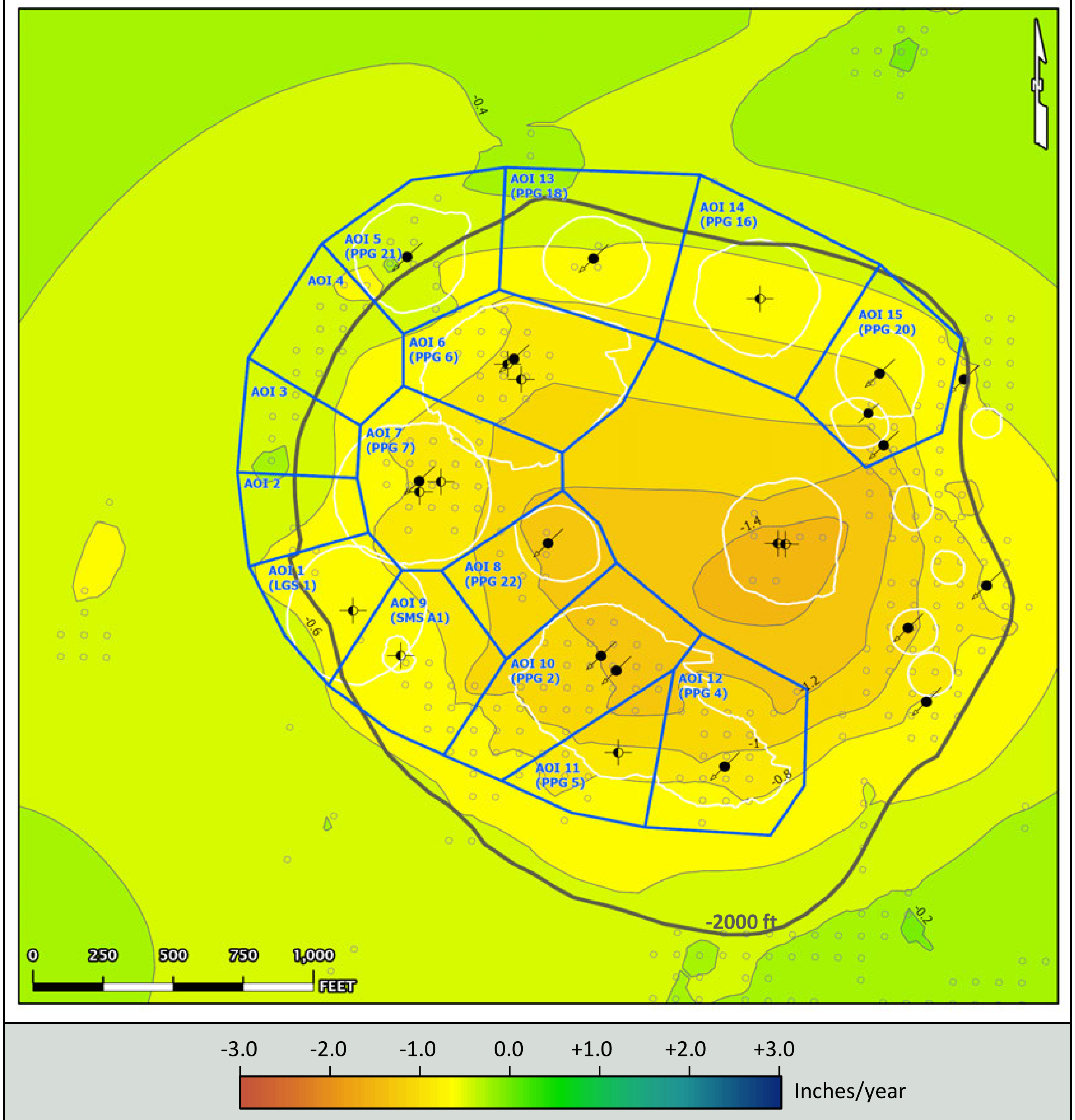
Cavern Well Surface Locations

- 09 - Active - Injection
- 29 - Dry and Plugged

Vertical Data (01/24/2023 - 02/25/2025)

Linear Velocity Contours

Date range: 01/24/2023 - 02/25/2025



▭ AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.2)

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

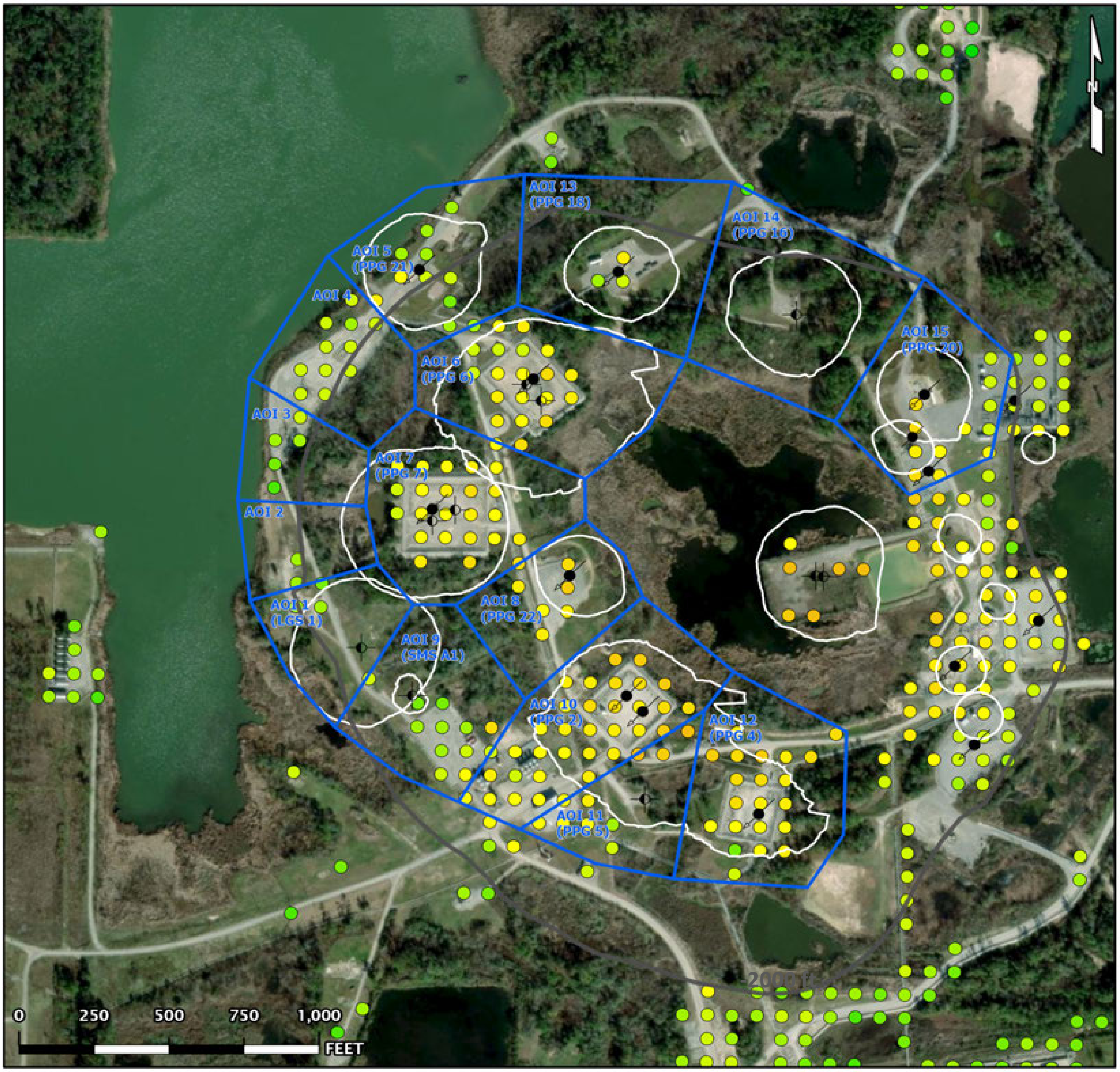
Cavern Well Surface Locations

● 09 - Active - Injection ⊕ 29 - Dry and Plugged

Vertical Data (01/24/2023 - 02/25/2025)

Nonlinear Velocity Data Points

As of date: 02/25/2025



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

▭ AOI Boundary ○ InSAR LOS Measurement Point

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

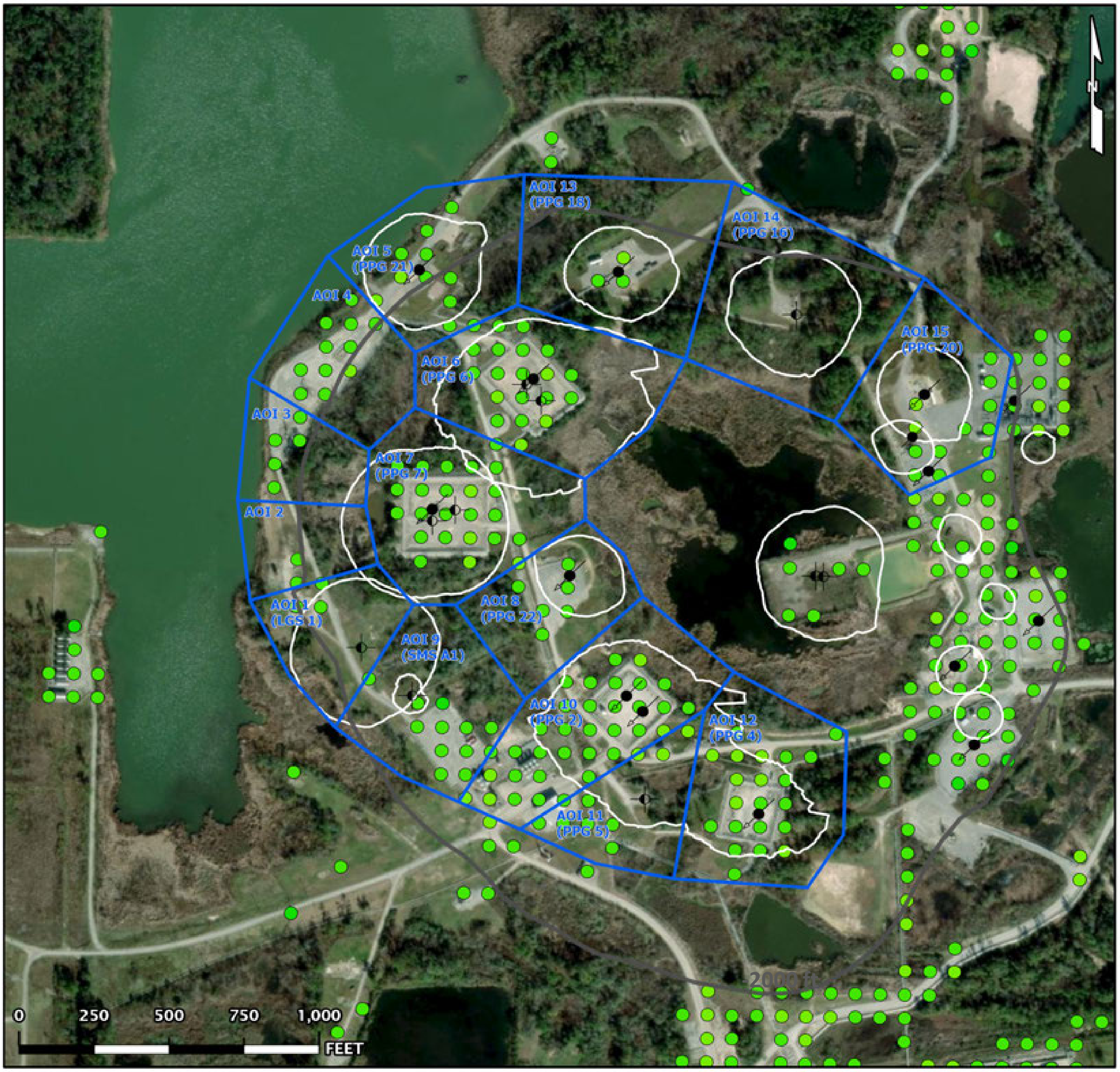
Cavern Well Surface Locations

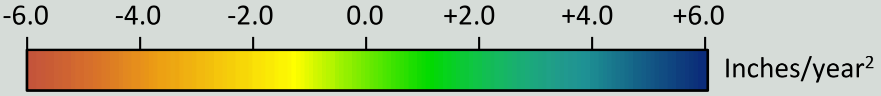
09 - Active - Injection 29 - Dry and Plugged

Vertical Data (01/24/2023 - 02/25/2025)

Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 02/25/2025





AOI Boundary ○ InSAR LOS Measurement Point

Historical Cavern Extent Top of Dome (-2000 ft Contour)

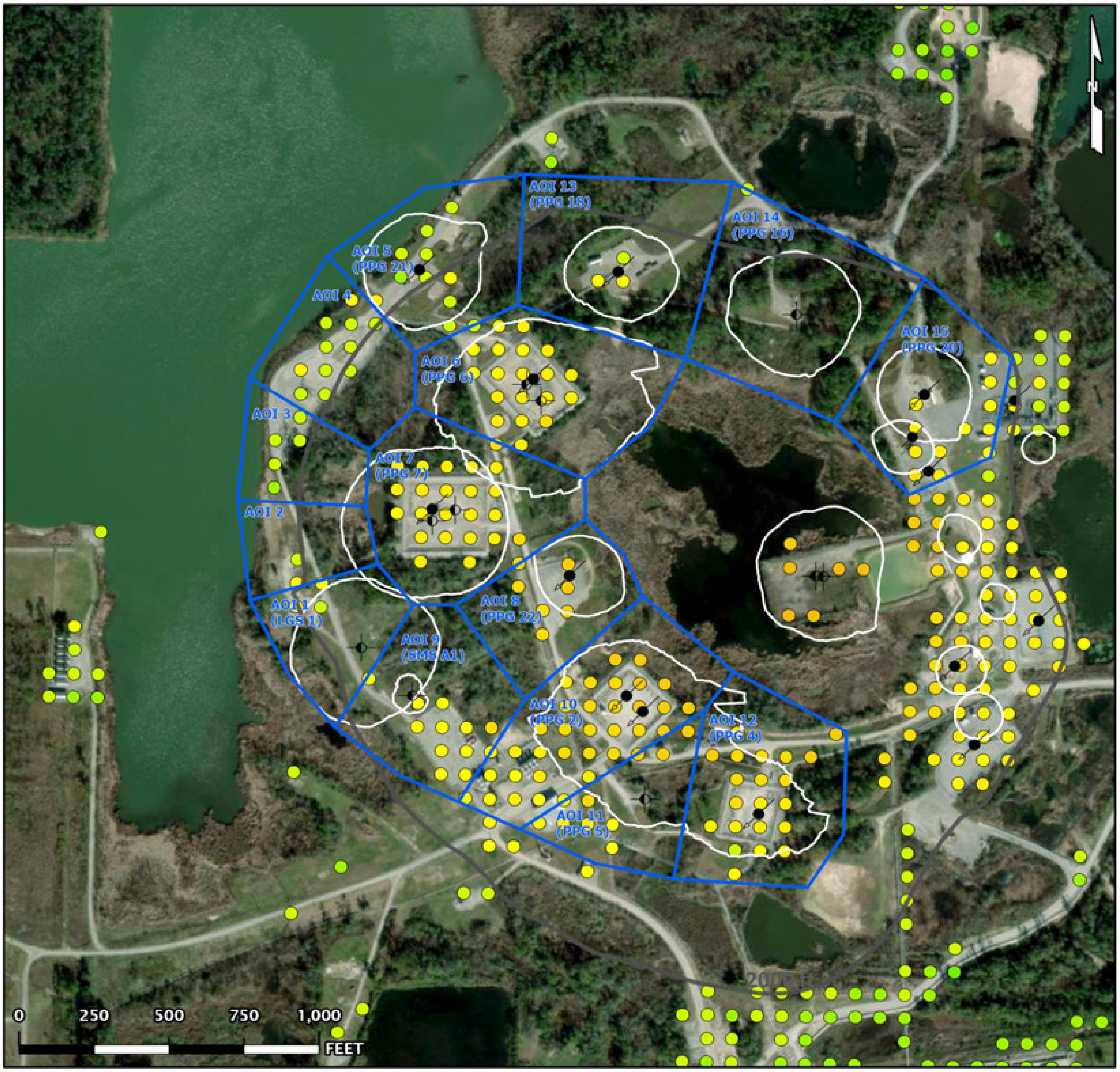
Cavern Well Surface Locations

09 - Active - Injection 29 - Dry and Plugged

Vertical Data (01/24/2023 - 02/25/2025)

Linear Velocity Data Points

Date range: 01/24/2023 - 02/25/2025



-3.0 -2.0 -1.0 0.0 +1.0 +2.0 +3.0

Inches/year

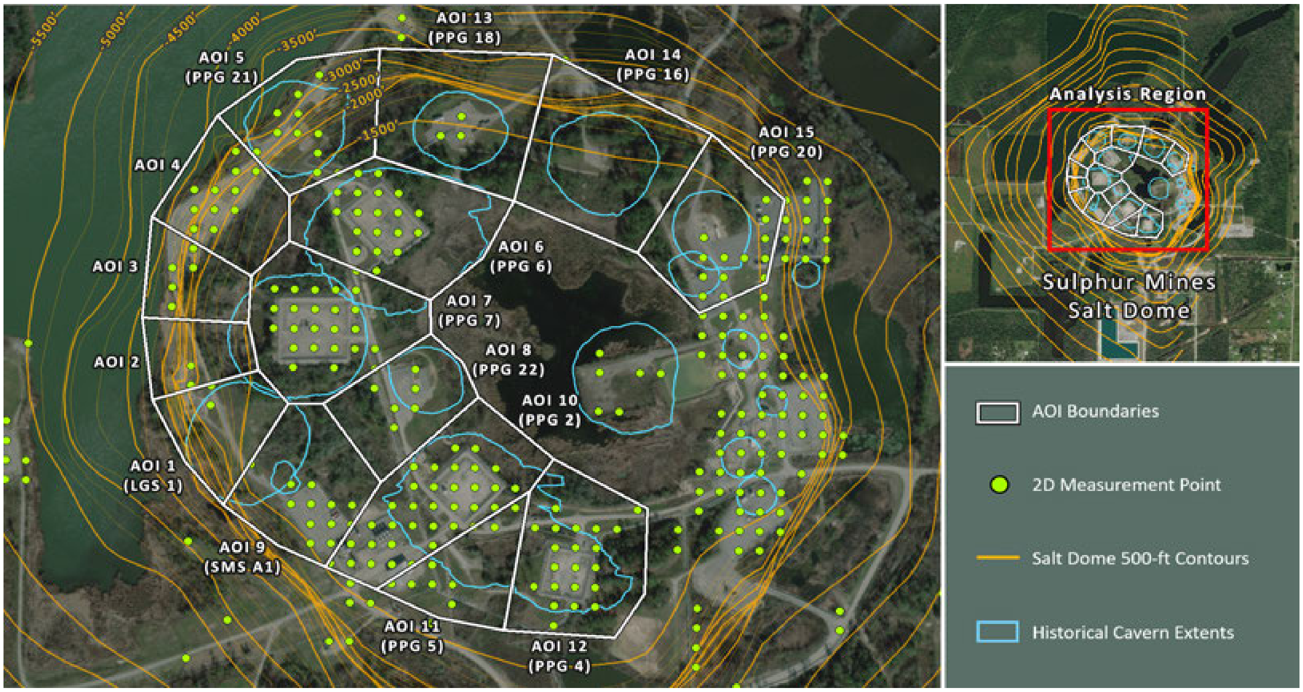
▭ AOI Boundary ○ InSAR LOS Measurement Point

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection 29 - Dry and Plugged

AOI Boundaries & 2D InSAR Measurement Points

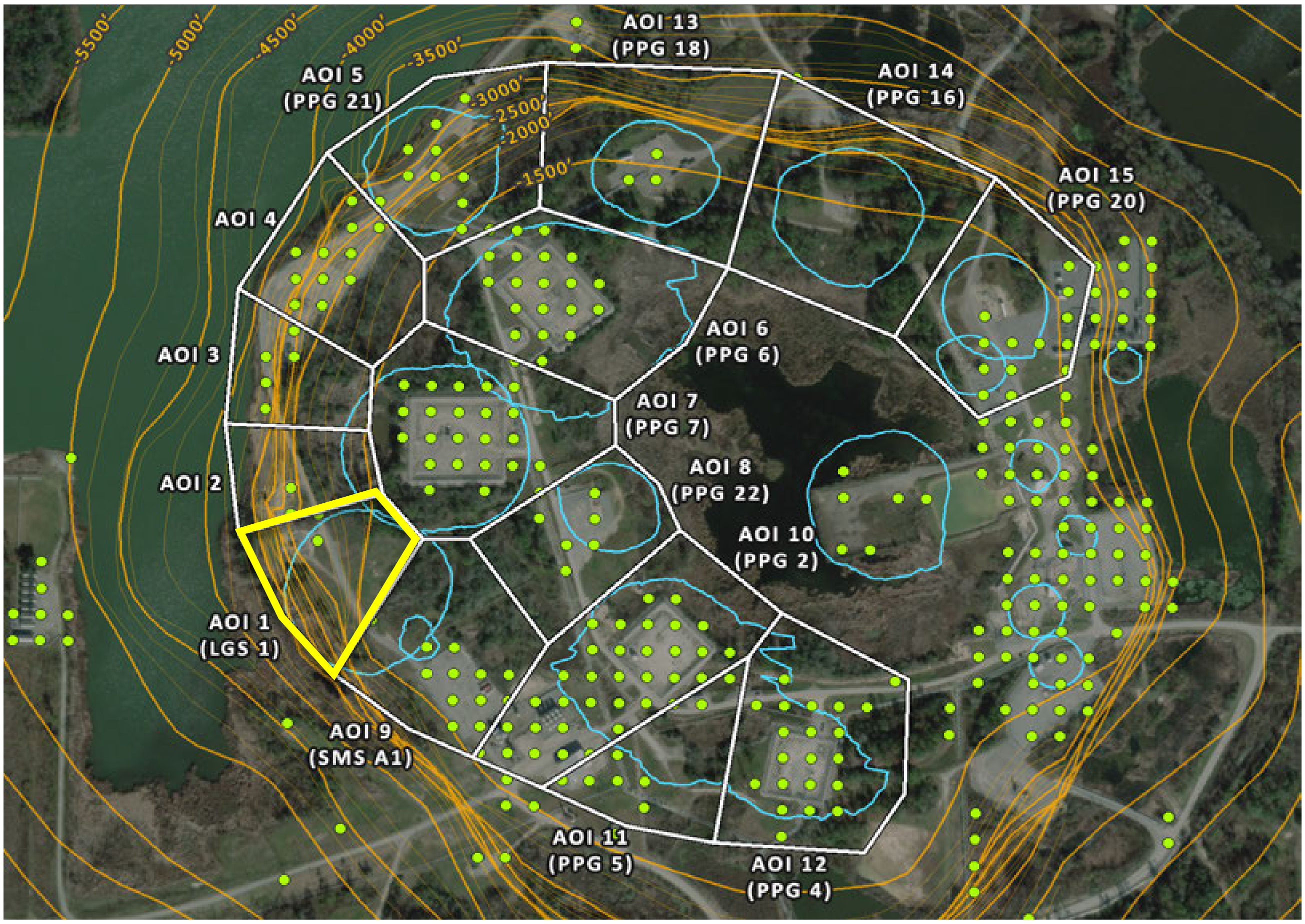


Subsidence Monitoring Areas of Interest (AOIs)

To visually convey and evaluate trend consistency for the East-West displacement time series of each ground target, measurment points were grouped and their displacement values were averaged. The point groups are referred to as Areas of Interest (AOIs) in this analysis and their boundaries are depicted on the above map. The below table lists the East-West trend values calculated in each AOI for the dataset evaluated in this report.

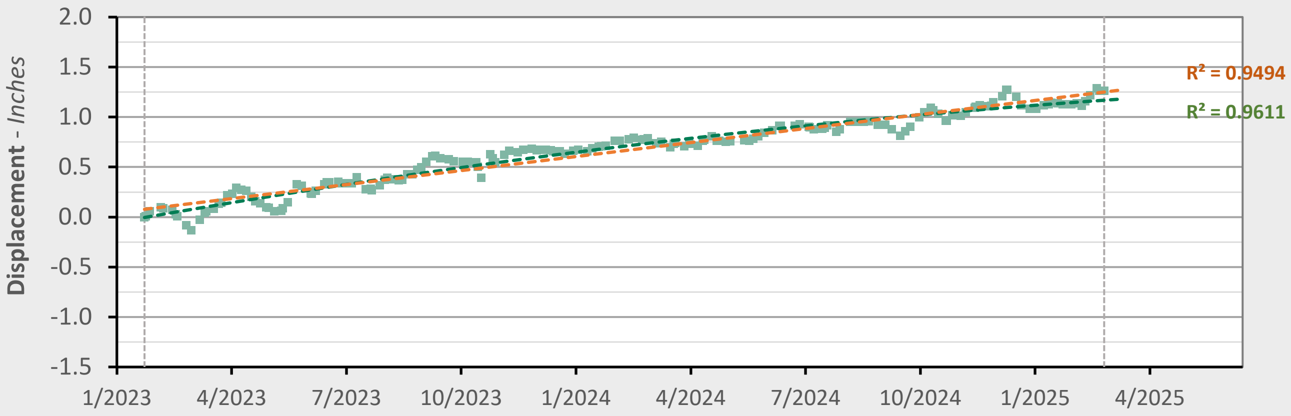
AOI Name	East-West (2/25/2025)	East-West Velocity (in/yr)		East-West Acceleration (in/yr²)	
	Point Count	Nonlinear	Linear	Nonlinear	Linear
AOI 1 *(LGS 1)*	3	+0.32	+0.56	-0.23	0.00
AOI 2	2	+0.41	+0.51	-0.10	0.00
AOI 3	5	+0.40	+0.51	-0.11	0.00
AOI 4	11	+0.54	+0.53	+0.01	0.00
AOI 5 *(PPG 21)*	10	+0.37	+0.28	+0.08	0.00
AOI 6 *(PPG 6)*	20	+0.40	+0.37	+0.04	0.00
AOI 7 *(PPG 7)*	24	+0.61	+0.61	+0.00	0.00
AOI 8 *(PPG 22)*	6	+0.45	+0.51	-0.06	0.00
AOI 9 *(SMS A1)*	12	+0.55	+0.53	+0.02	0.00
AOI 10 *(PPG 2)*	33	+0.36	+0.38	-0.02	0.00
AOI 11 *(PPG 5)*	9	+0.43	+0.33	+0.10	0.00
AOI 12 *(PPG 4)*	21	-0.03	-0.06	+0.03	0.00
AOI 13 *(PPG 18)*	3	+0.27	+0.23	+0.03	0.00
AOI 14 *(PPG 16)*	0	N/A	N/A	N/A	N/A
AOI 15 *(PPG 20)*	12	-0.36	-0.40	+0.05	0.00

AOI 1 *(LGS 1)* - Location Map



AOI 1 *(LGS 1)* - East-West Time Series

E-W (2/25/2025) Point Count: 3



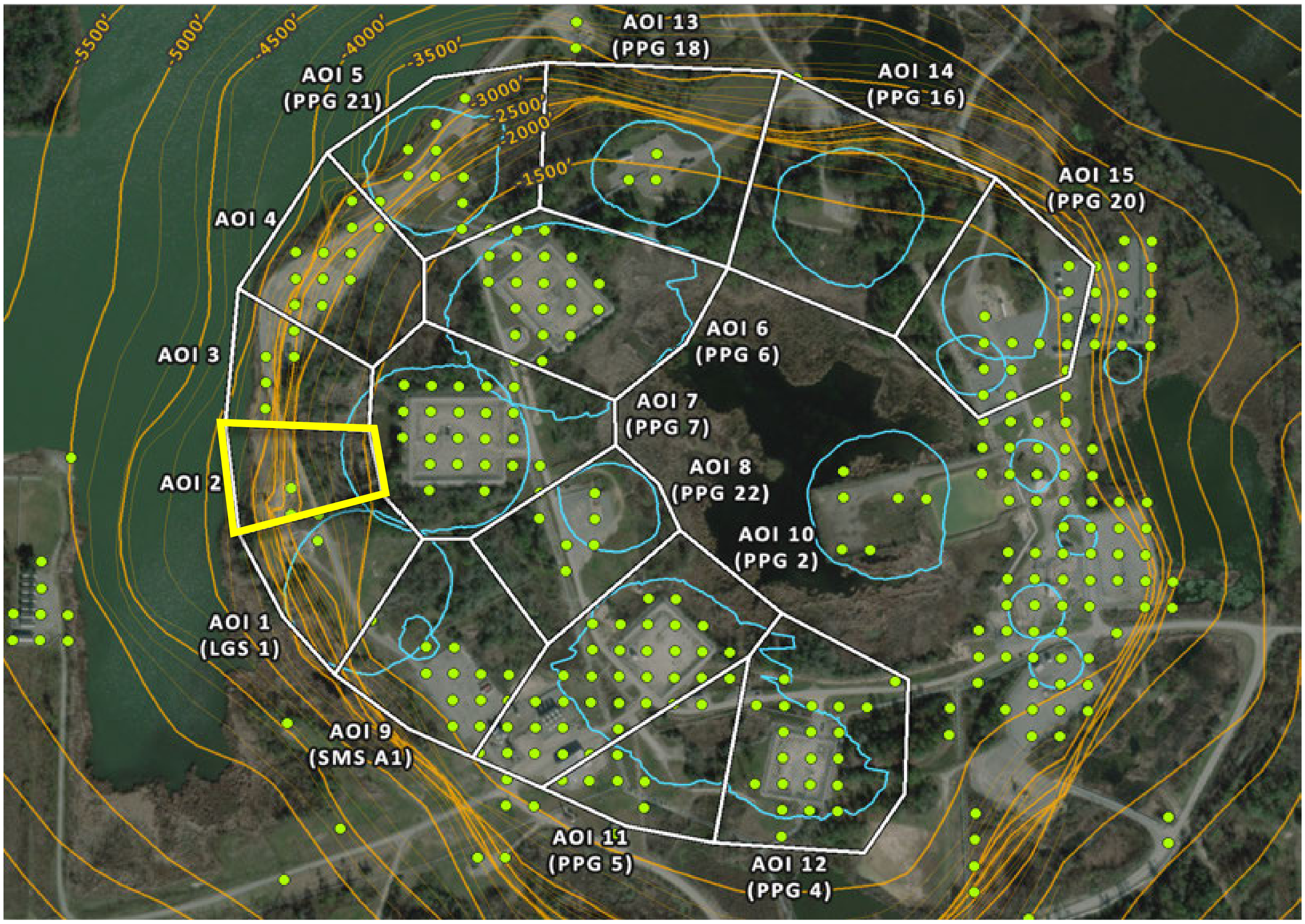
	Nonlinear Trend	Linear Trend
Velocity:	+0.32 in/yr	+0.56 in/yr
Acceleration:	-0.23 in/yr^2	0.00 in/yr^2

▪ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

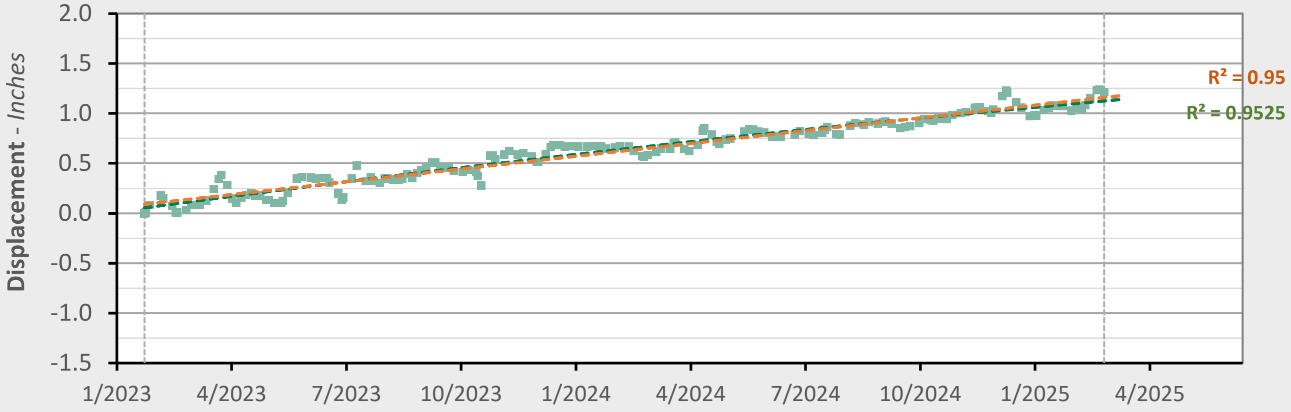
---- Linear Trend Line (Linear Regression)

AOI 2 - Location Map



AOI 2 - East-West Time Series

E-W (2/25/2025) Point Count: 2



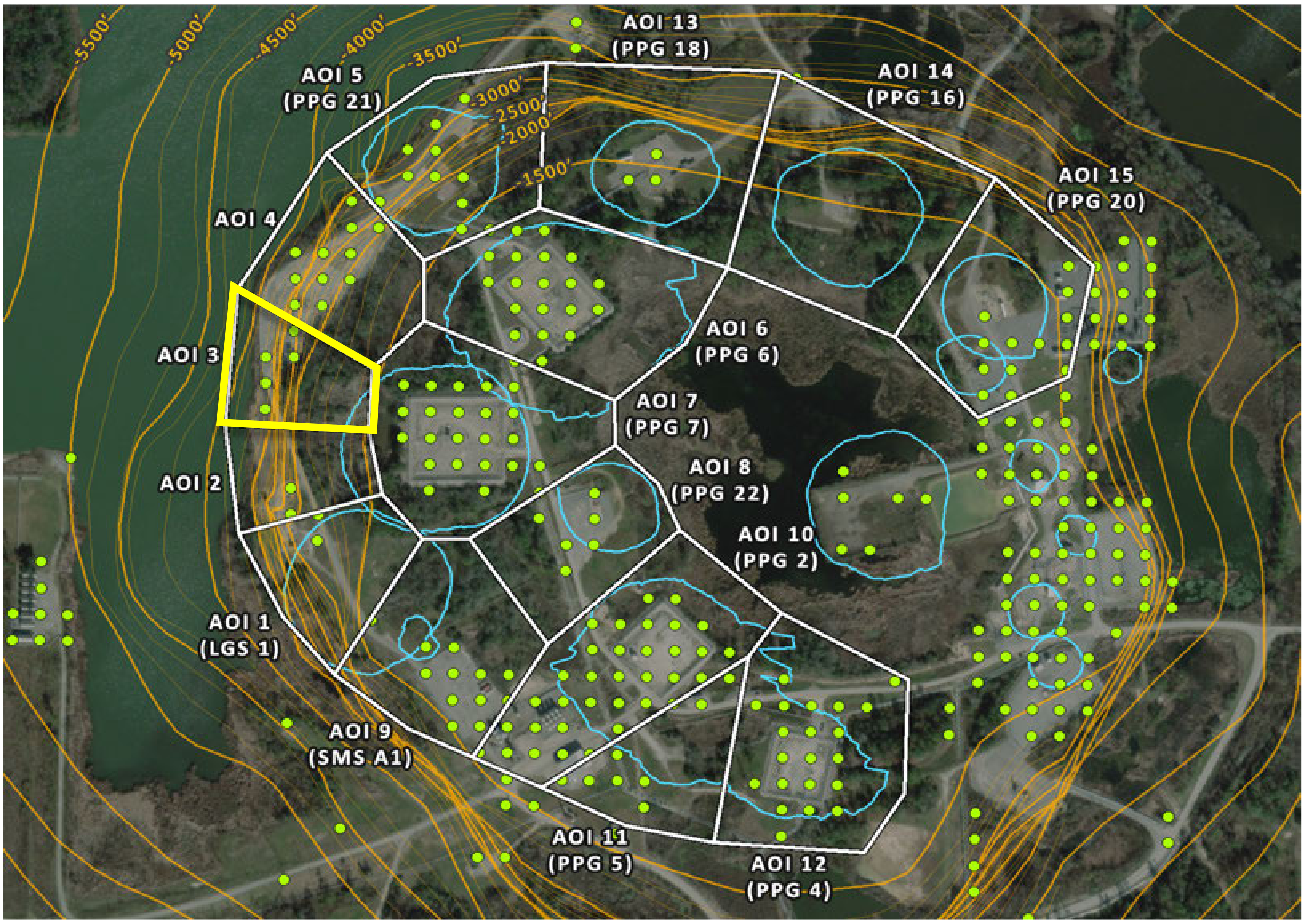
	Nonlinear Trend	Linear Trend
Velocity:	+0.41 in/yr	+0.51 in/yr
Acceleration:	-0.10 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

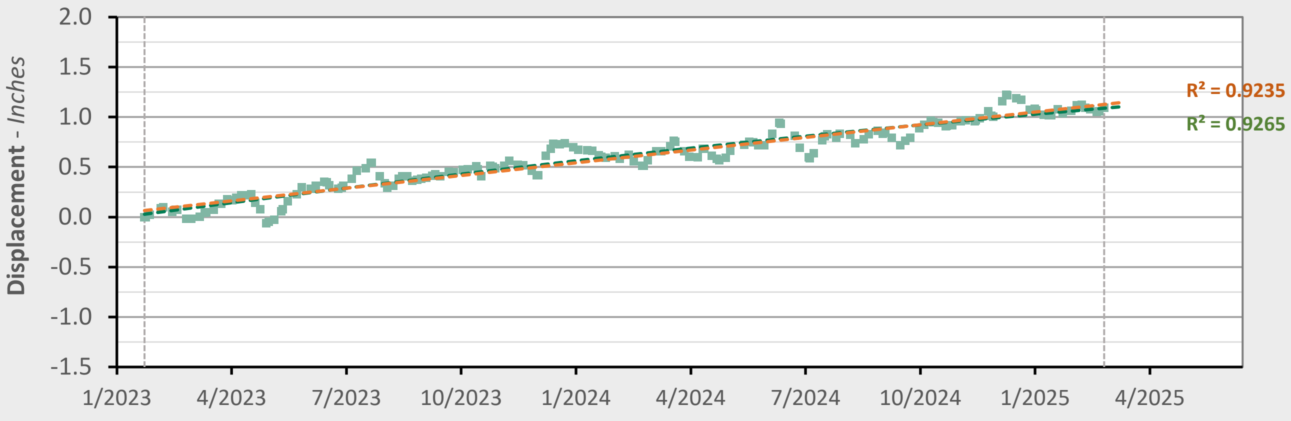
---- Linear Trend Line (Linear Regression)

AOI 3 - Location Map



AOI 3 - East-West Time Series

E-W (2/25/2025) Point Count: 5



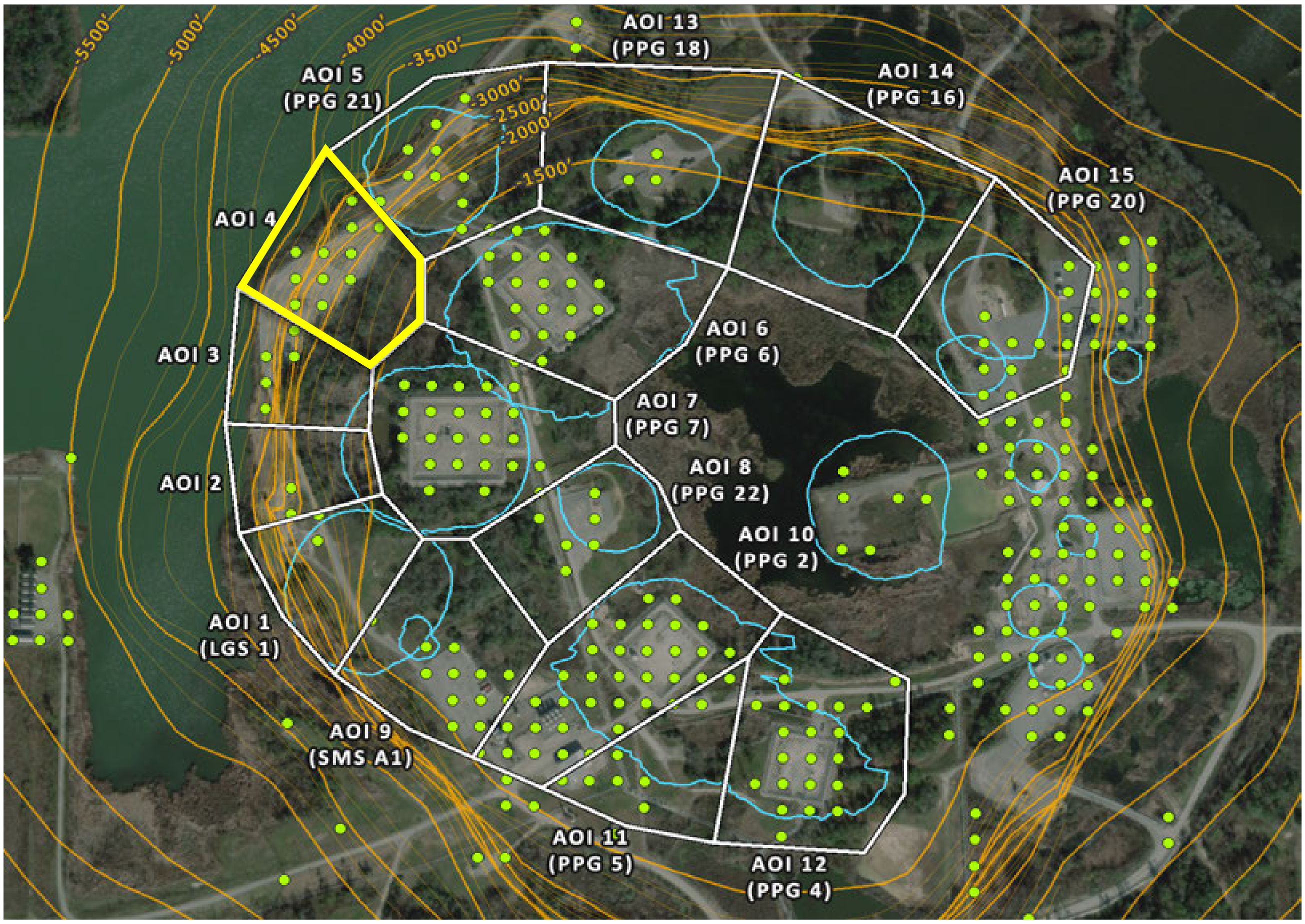
	Nonlinear Trend	Linear Trend
Velocity:	+0.40 in/yr	+0.51 in/yr
Acceleration:	-0.11 in/yr^2	0.00 in/yr^2

🟩 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

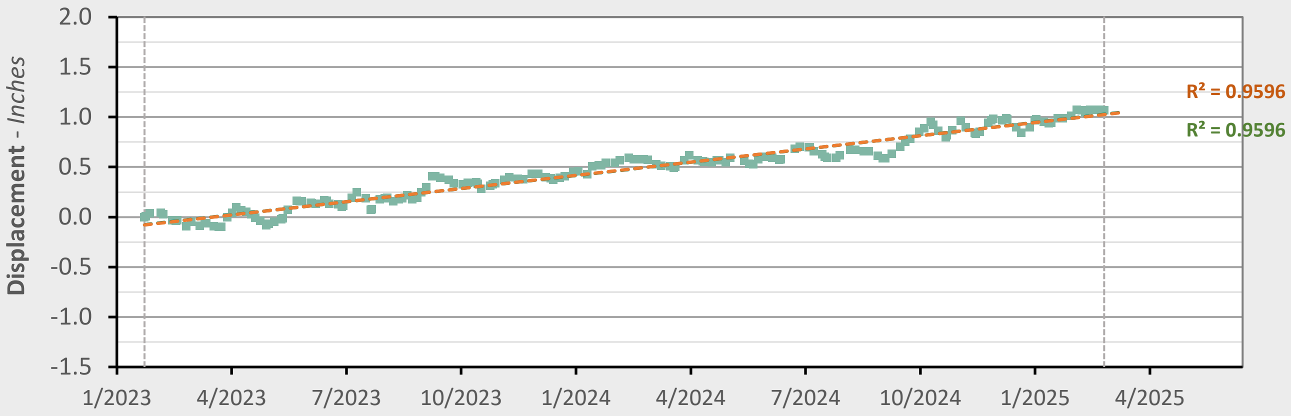
---- Linear Trend Line (Linear Regression)

AOI 4 - Location Map



AOI 4 - East-West Time Series

E-W (2/25/2025) Point Count: **11**



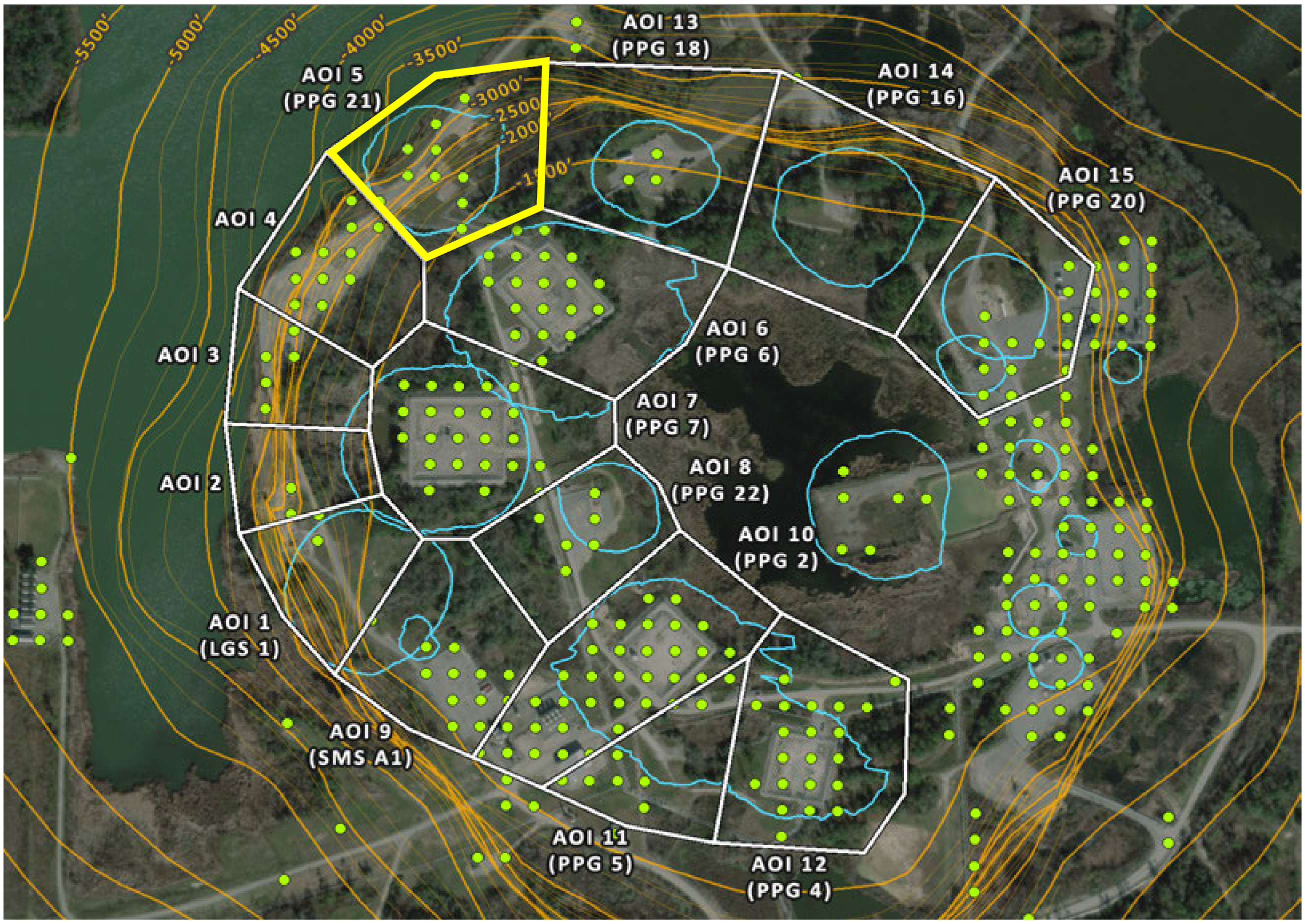
	Nonlinear Trend		Linear Trend	
Velocity:	+0.54	in/yr	+0.53	in/yr
Acceleration:	+0.01	in/yr^2	0.00	in/yr^2

■ 2D Displacement Measurement

Nonlinear Trend Line (Quadratic Regression)

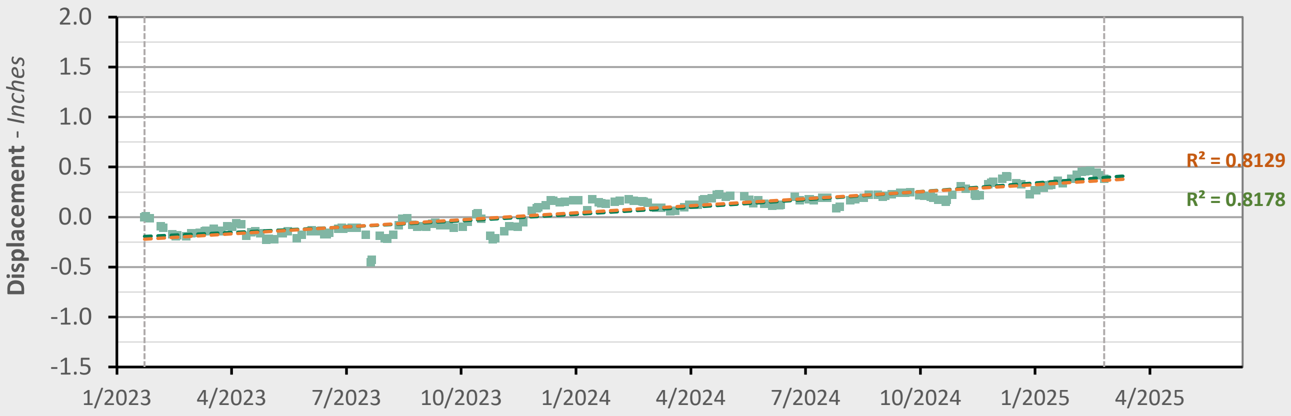
Linear Trend Line (Linear Regression)

AOI 5 *(PPG 21)* - Location Map



AOI 5 *(PPG 21)* - East-West Time Series

E-W (2/25/2025) Point Count: **10**



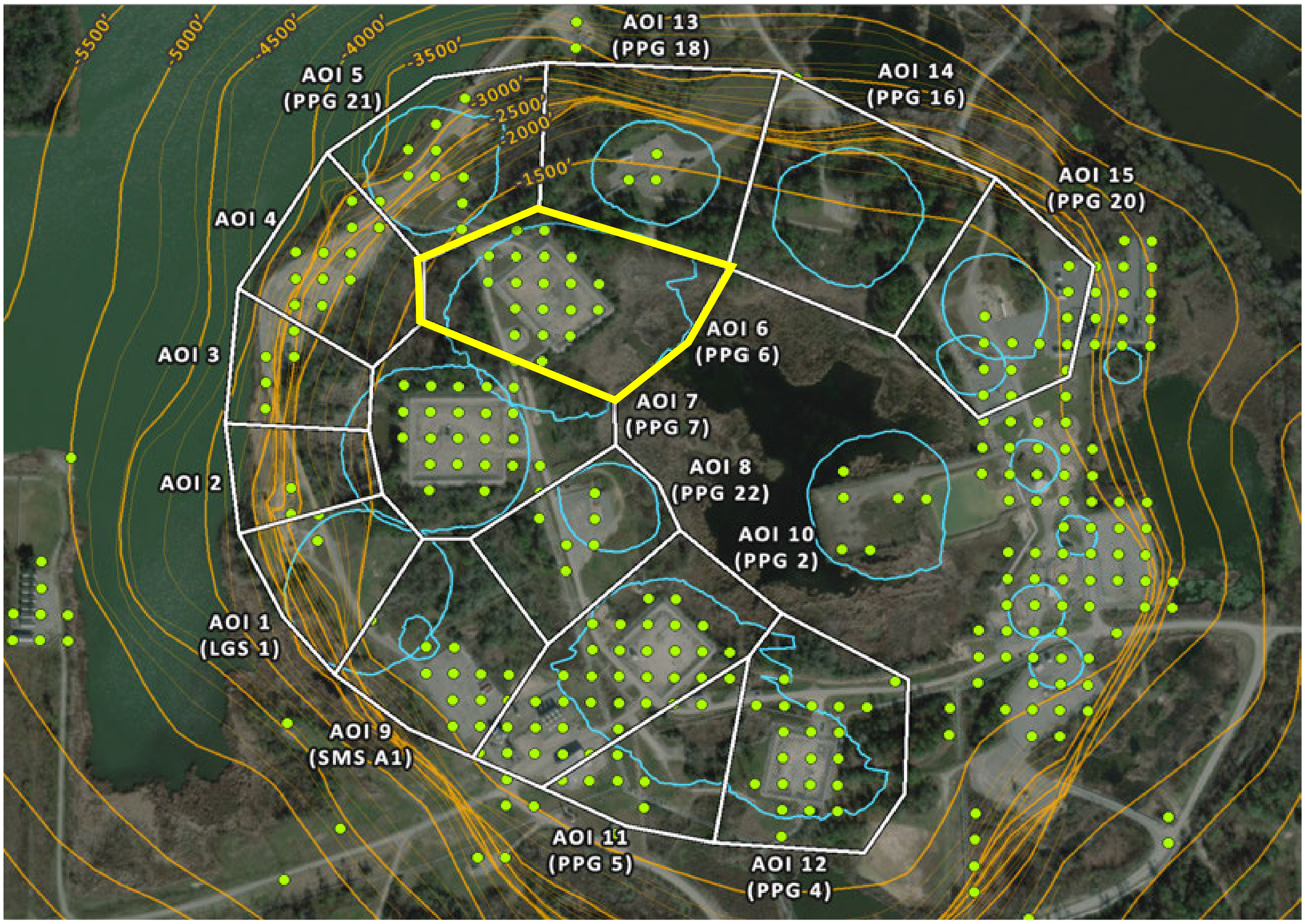
	Nonlinear Trend		Linear Trend	
Velocity:	+0.37	in/yr	+0.28	in/yr
Acceleration:	+0.08	in/yr^2	0.00	in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

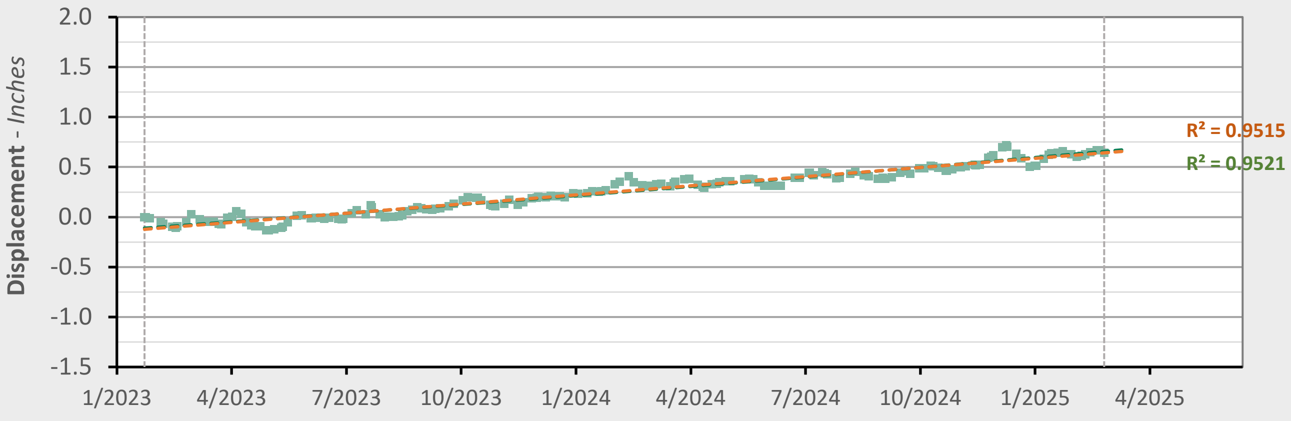
---- Linear Trend Line (Linear Regression)

AOI 6 *(PPG 6)* - Location Map



AOI 6 *(PPG 6)* - East-West Time Series

E-W (2/25/2025) Point Count: **20**



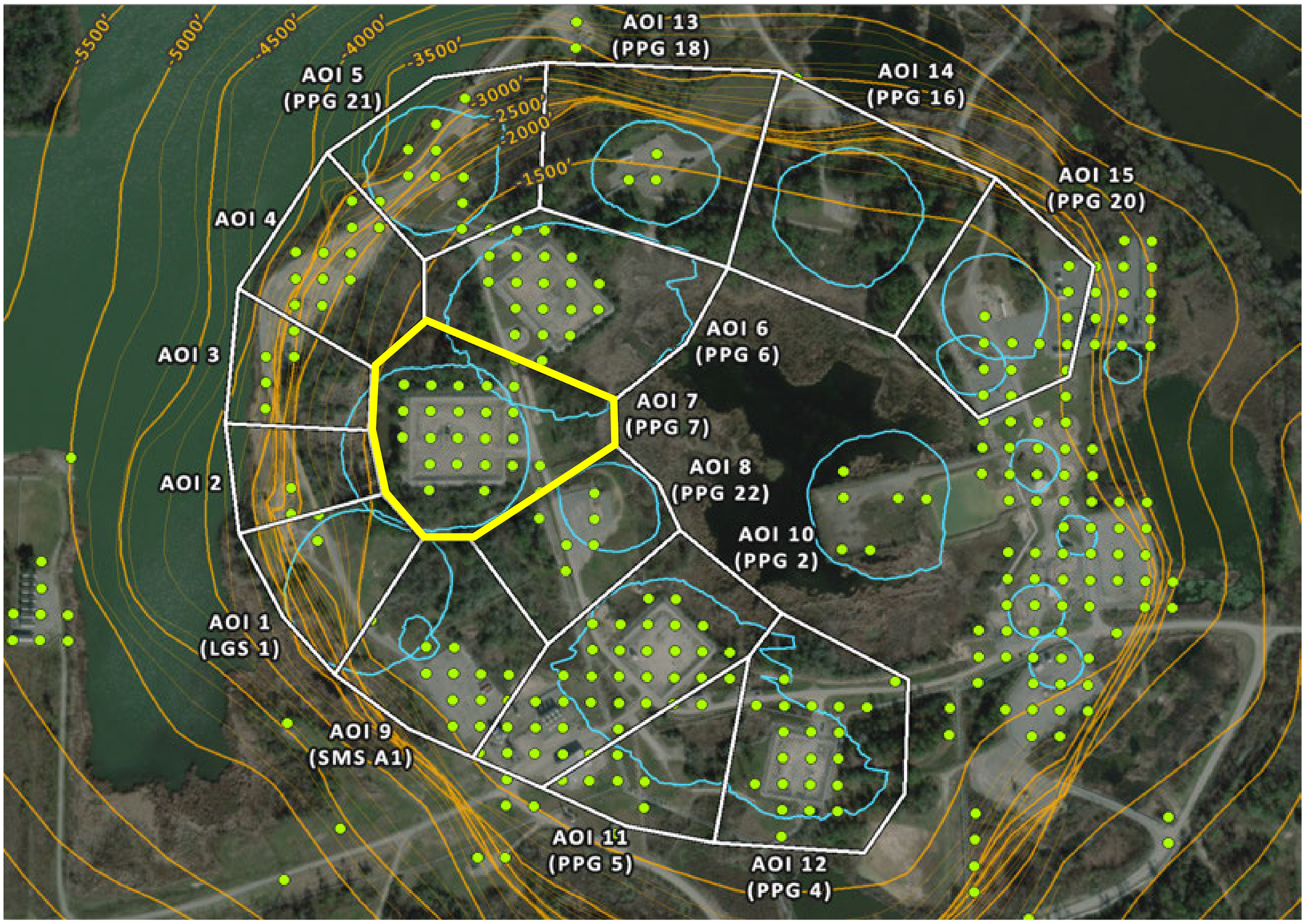
	Nonlinear Trend		Linear Trend	
Velocity:	+0.40	in/yr	+0.37	in/yr
Acceleration:	+0.04	in/yr^2	0.00	in/yr^2

▪ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

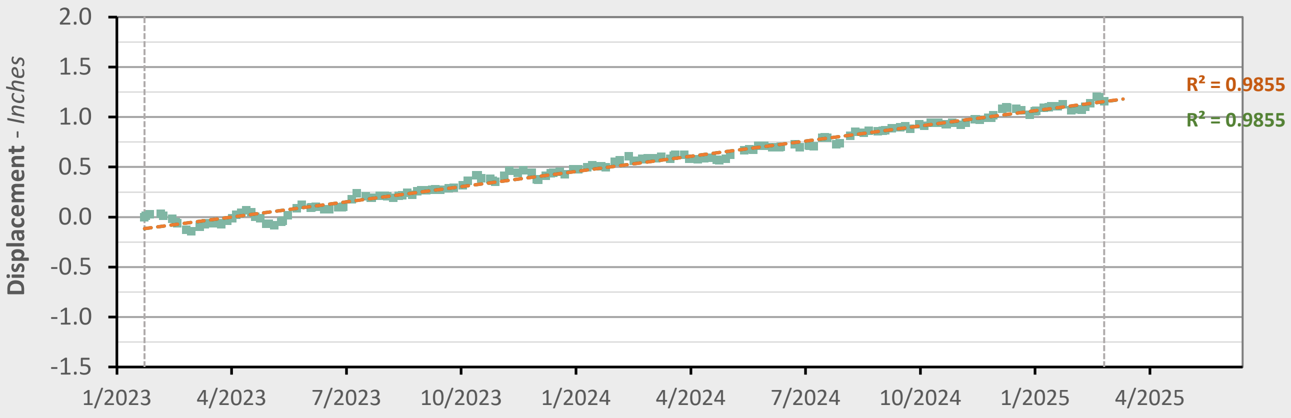
---- Linear Trend Line (Linear Regression)

AOI 7 *(PPG 7)* - Location Map



AOI 7 *(PPG 7)* - East-West Time Series

E-W (2/25/2025) Point Count: **24**



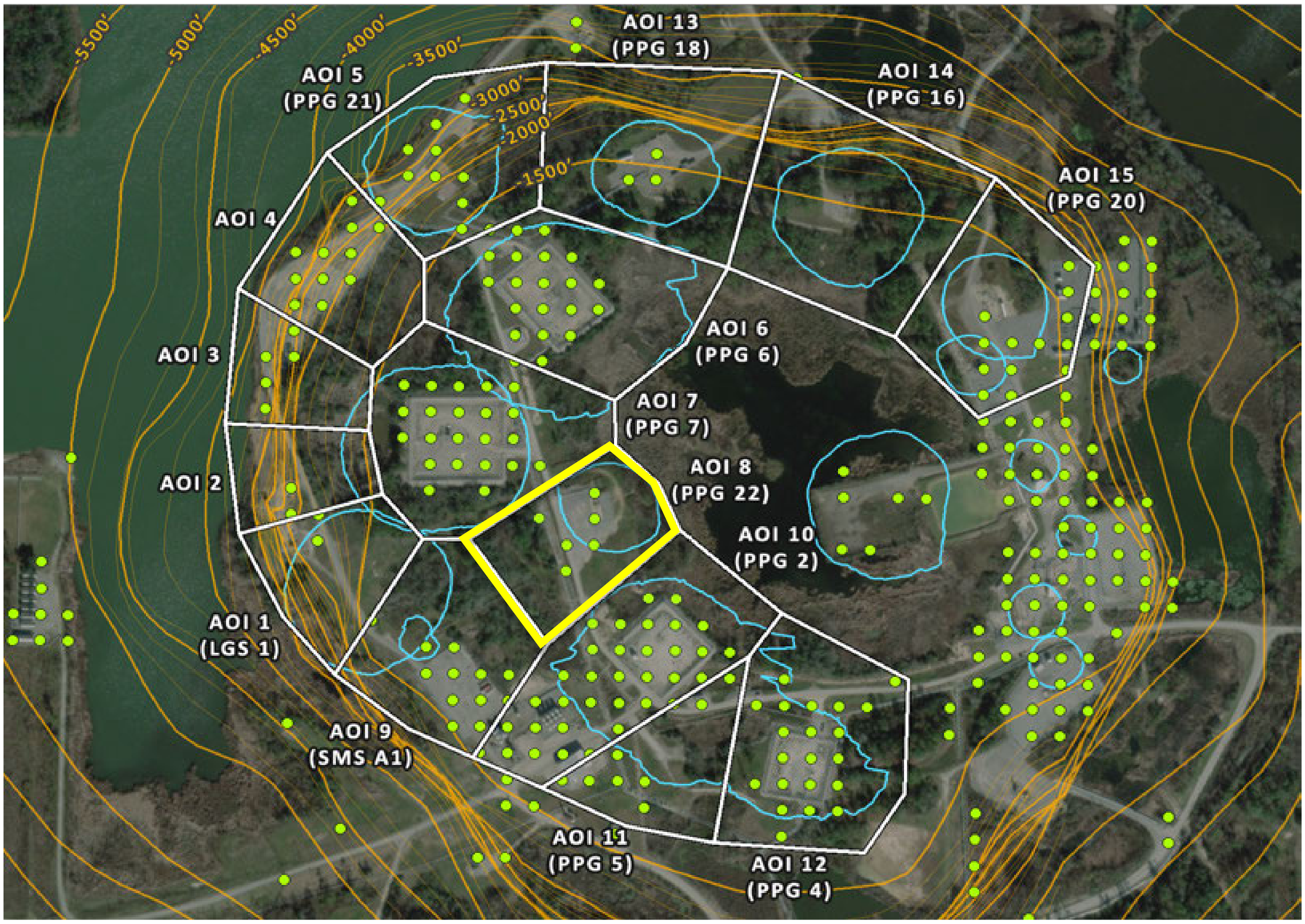
	Nonlinear Trend		Linear Trend	
Velocity:	+0.61	in/yr	+0.61	in/yr
Acceleration:	+0.00	in/yr^2	0.00	in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

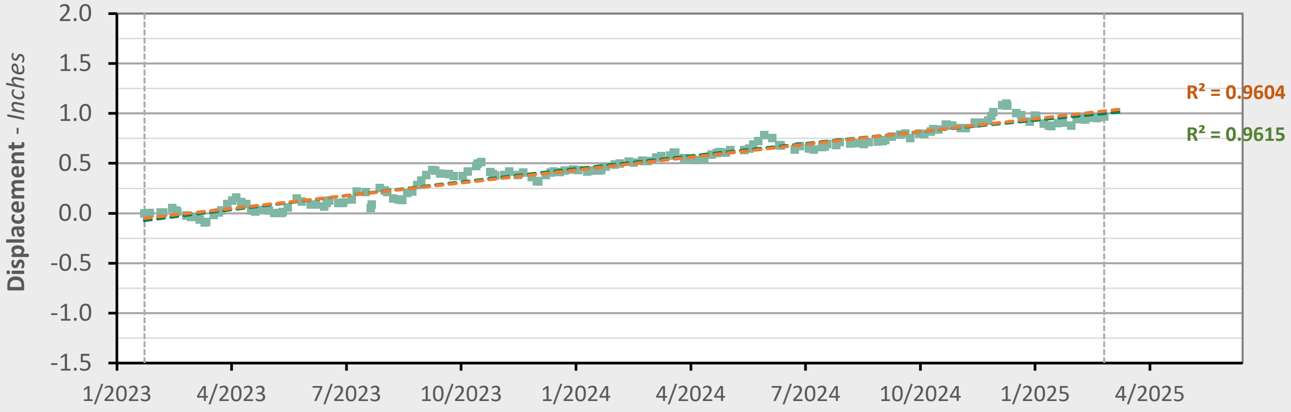
---- Linear Trend Line (Linear Regression)

AOI 8 *(PPG 22)* - Location Map



AOI 8 *(PPG 22)* - East-West Time Series

E-W (2/25/2025) Point Count: 6



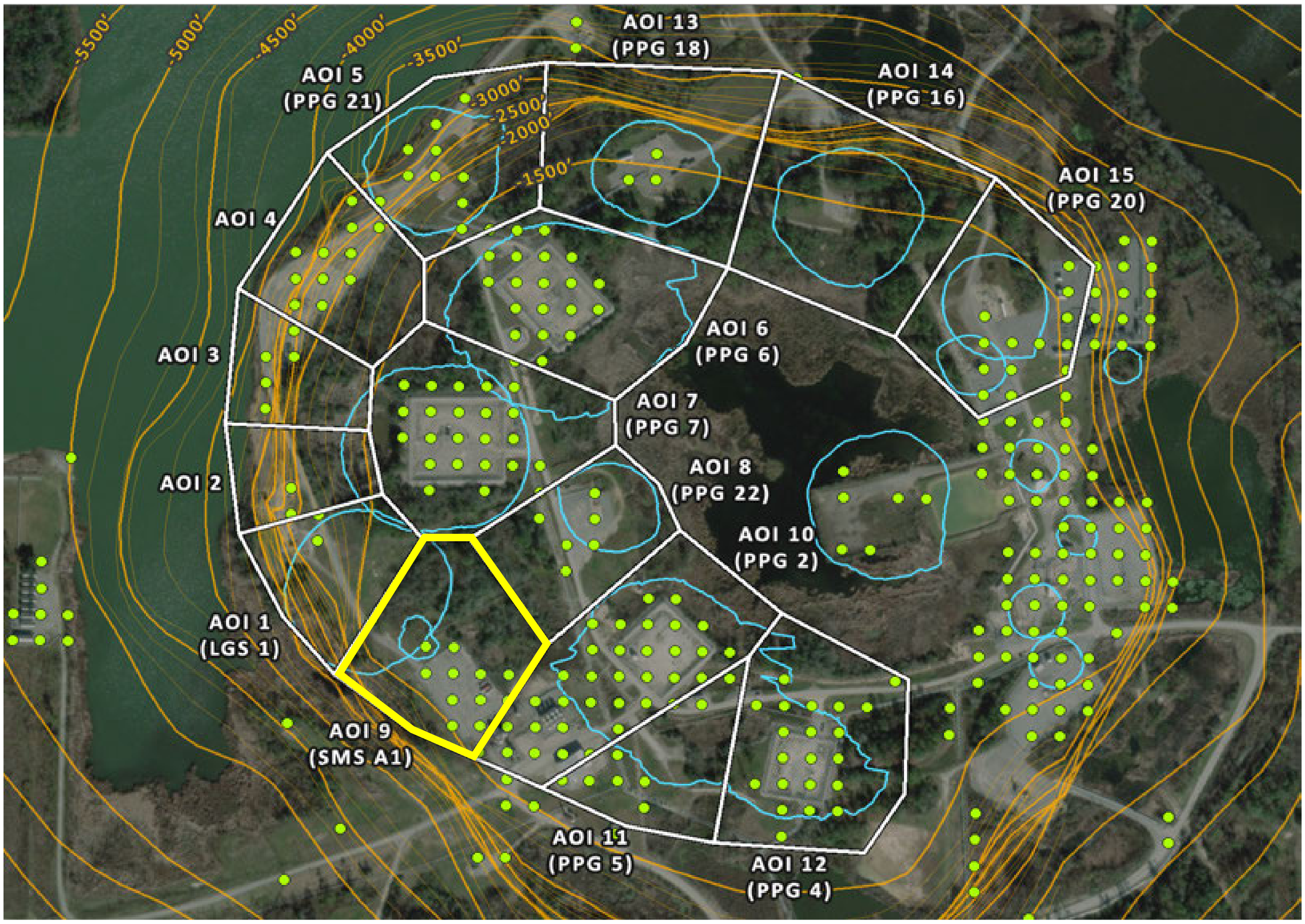
	Nonlinear Trend	Linear Trend
Velocity:	+0.45 in/yr	+0.51 in/yr
Acceleration:	-0.06 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

Nonlinear Trend Line (Quadratic Regression)

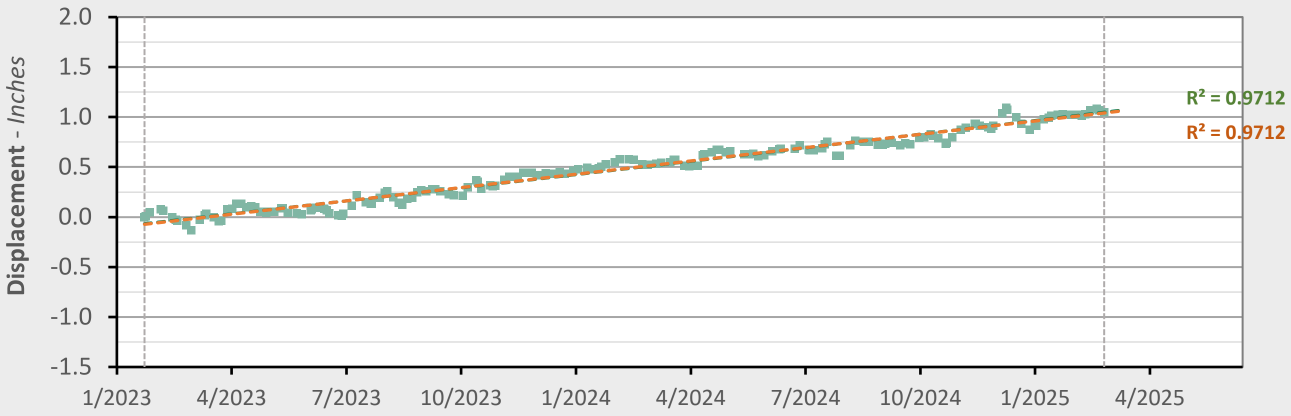
Linear Trend Line (Linear Regression)

AOI 9 *(PPG A1)* - Location Map



AOI 9 *(SMS A1)* - East-West Time Series

E-W (2/25/2025) Point Count: **12**



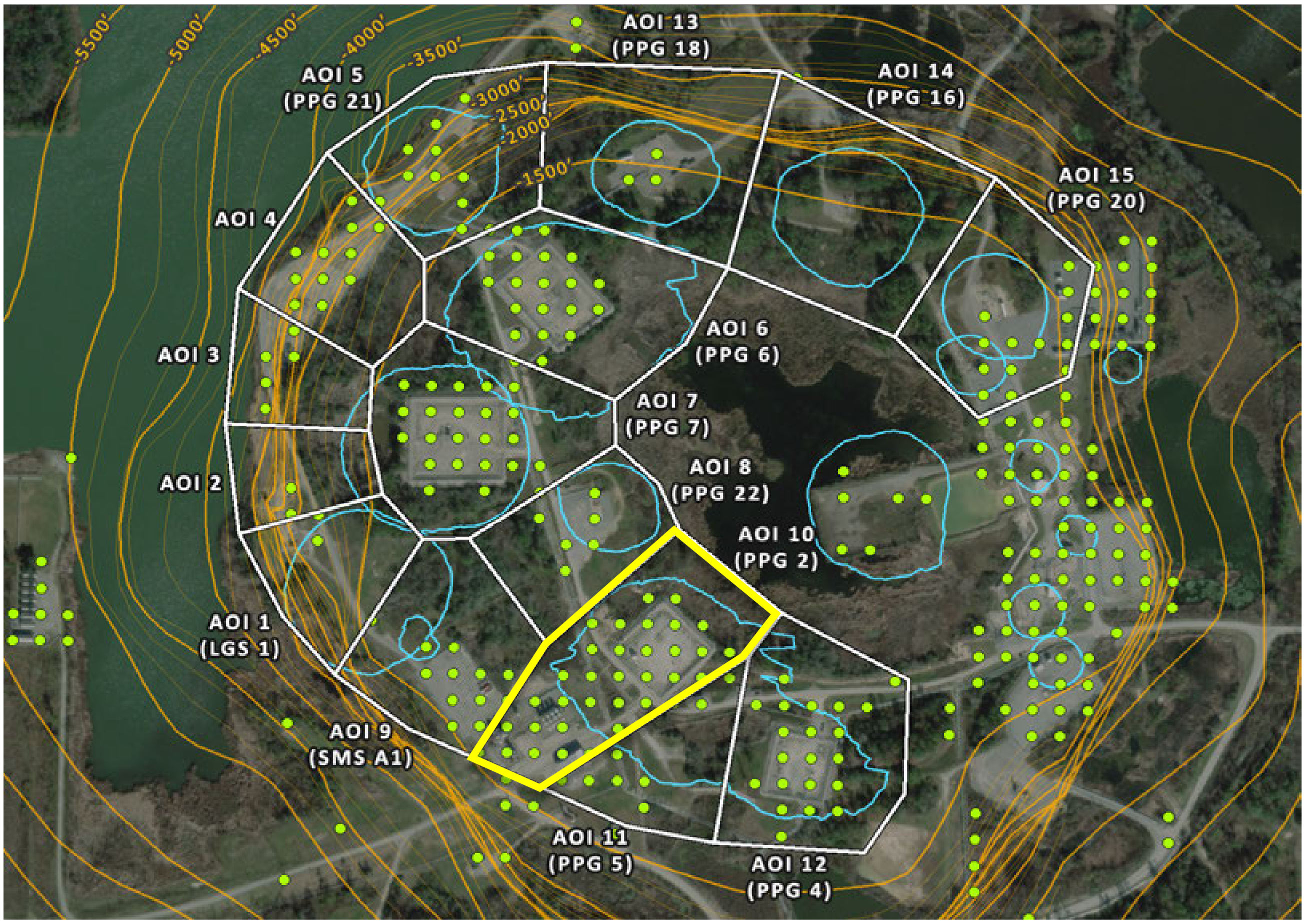
	Nonlinear Trend	Linear Trend
Velocity:	+0.55 in/yr	+0.53 in/yr
Acceleration:	+0.02 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

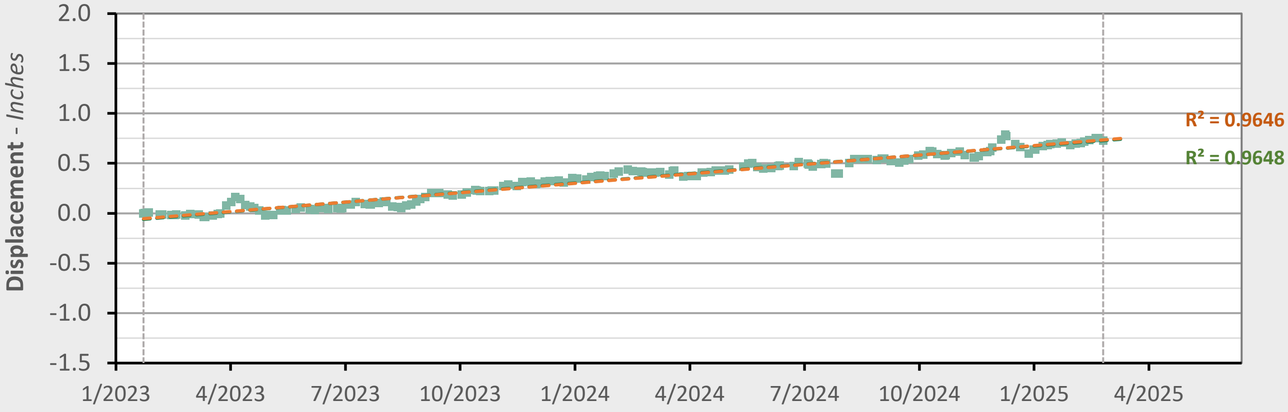
---- Linear Trend Line (Linear Regression)

AOI 10 *(PPG 2)* - Location Map



AOI 10 *(PPG 2)* - East-West Time Series

E-W (2/25/2025) Point Count: 33



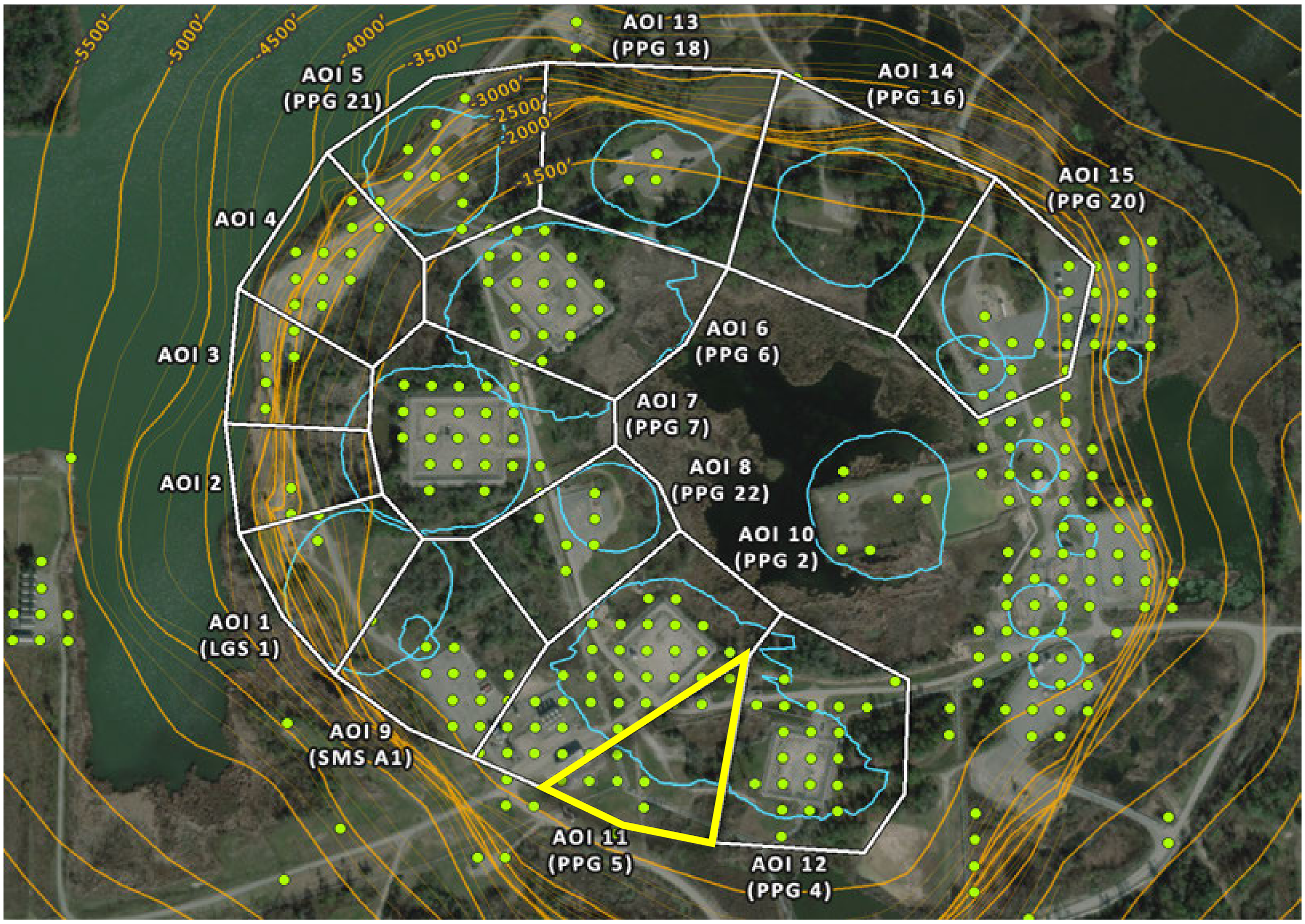
	Nonlinear Trend	Linear Trend
Velocity:	+0.36 in/yr	+0.38 in/yr
Acceleration:	-0.02 in/yr^2	0.00 in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

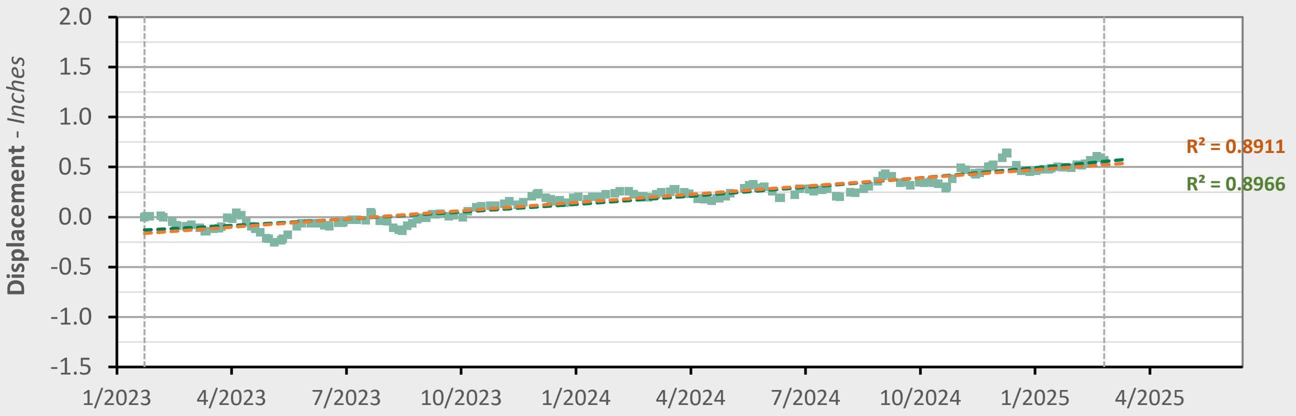
---- Linear Trend Line (Linear Regression)

AOI 11 *(PPG 5)* - Location Map



AOI 11 *(PPG 5)* - East-West Time Series

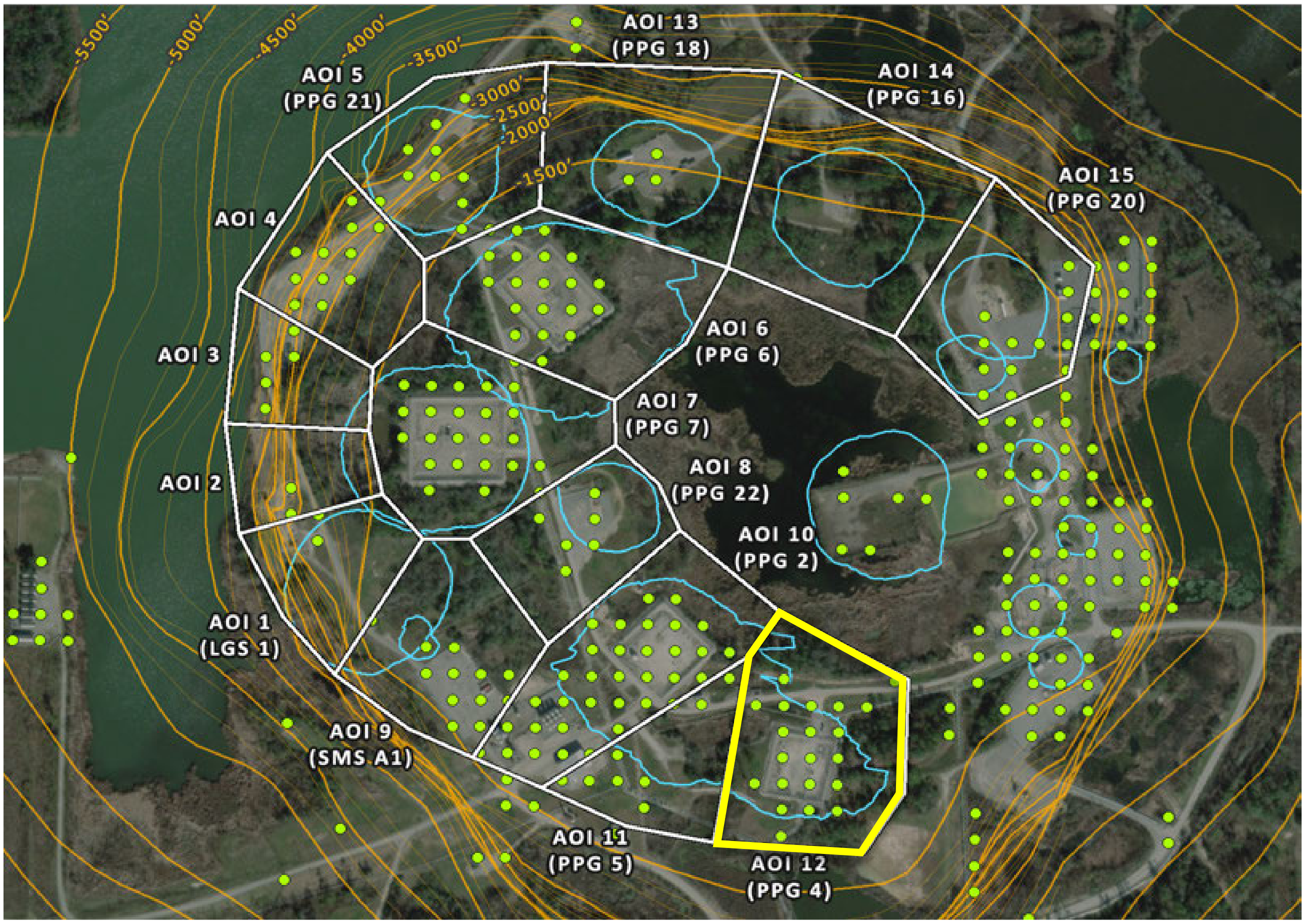
E-W (2/25/2025) Point Count: **9**



	Nonlinear Trend		Linear Trend	
Velocity:	+0.43	in/yr	+0.33	in/yr
Acceleration:	+0.10	in/yr^2	0.00	in/yr^2

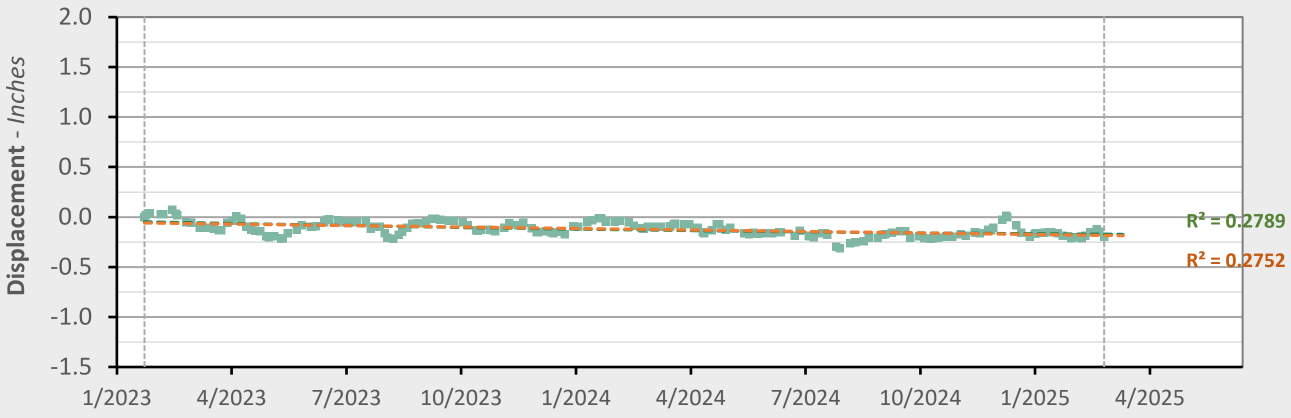
- ▪ 2D Displacement Measurement
- Nonlinear Trend Line (Quadratic Regression)
- Linear Trend Line (Linear Regression)

AOI 12 *(PPG 4)* - Location Map



AOI 12 *(PPG 4)* - East-West Time Series

E-W (2/25/2025) Point Count: **21**



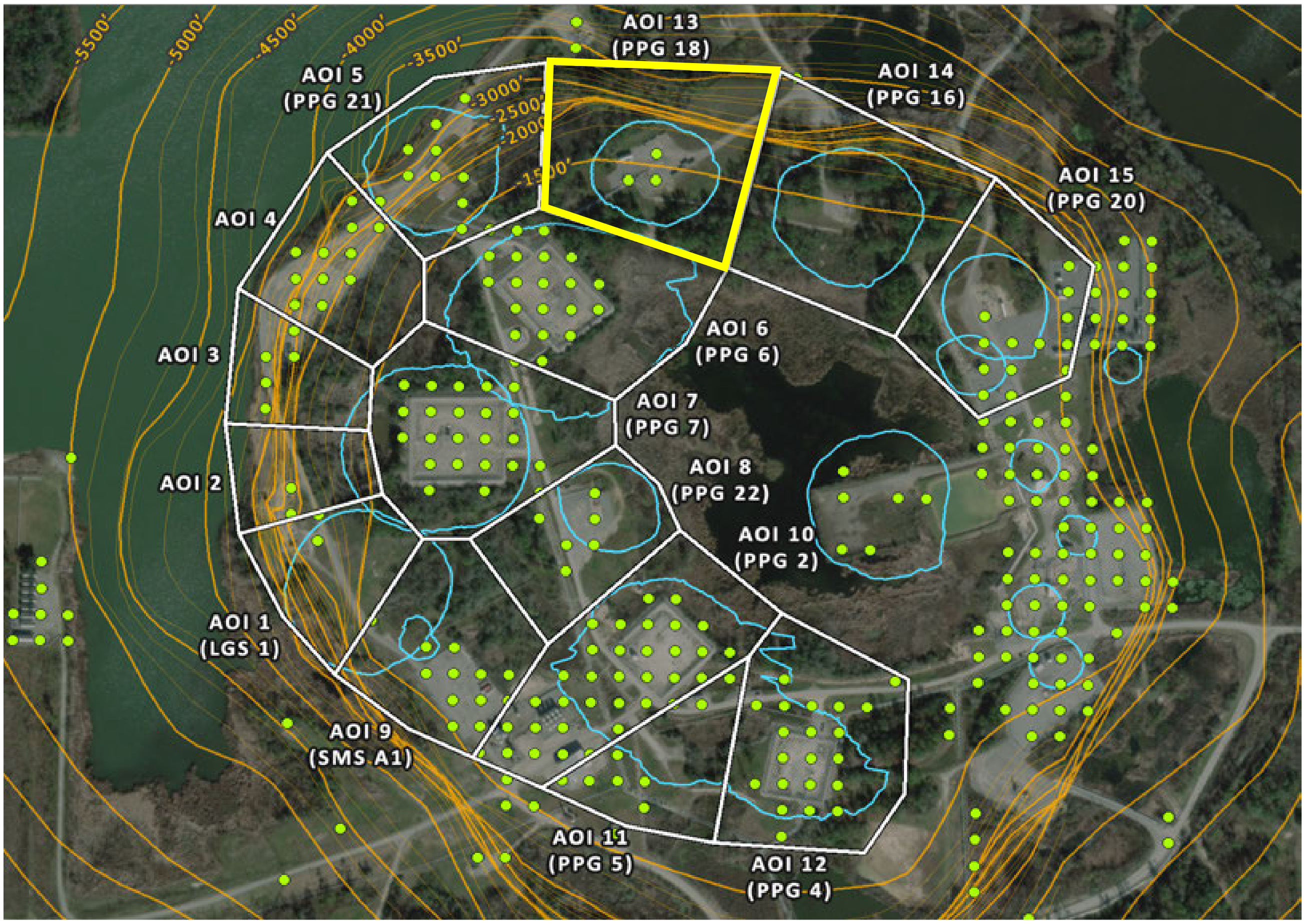
	Nonlinear Trend	Linear Trend
Velocity:	-0.03 in/yr	-0.06 in/yr
Acceleration:	+0.03 in/yr^2	0.00 in/yr^2

🟩 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

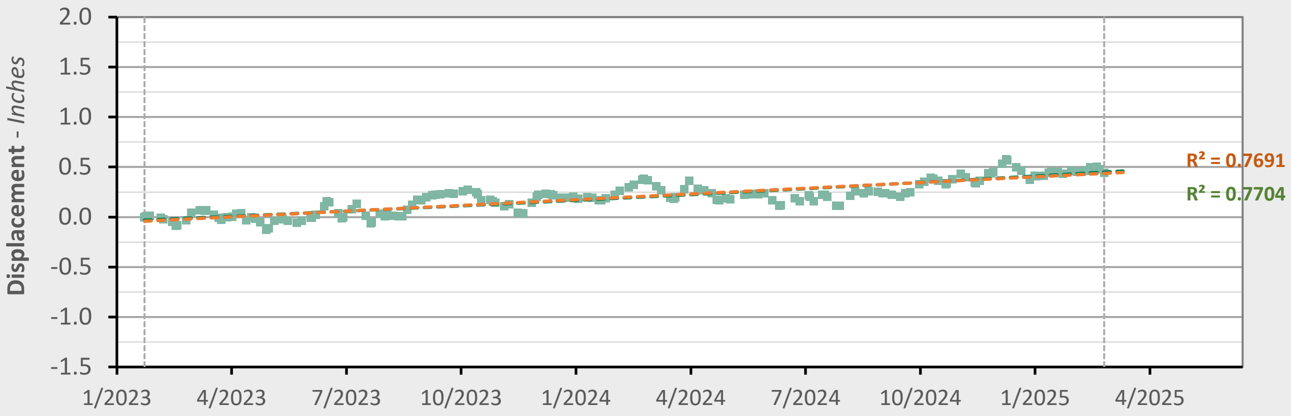
---- Linear Trend Line (Linear Regression)

AOI 13 *(PPG 18)* - Location Map



AOI 13 *(PPG 18)* - East-West Time Series

E-W (2/25/2025) Point Count: **3**



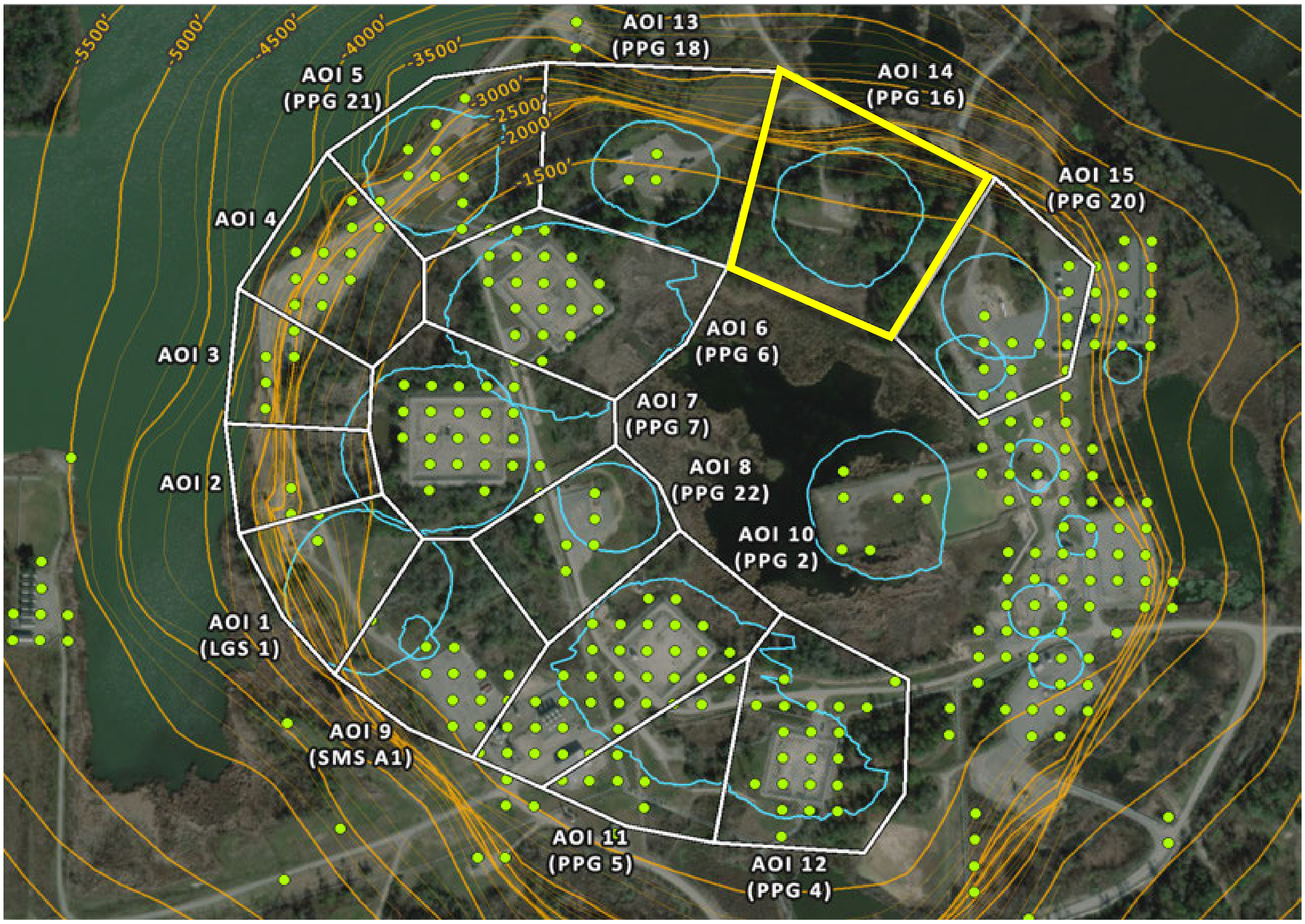
	Nonlinear Trend		Linear Trend	
Velocity:	+0.27	in/yr	+0.23	in/yr
Acceleration:	+0.03	in/yr^2	0.00	in/yr^2

🟩 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

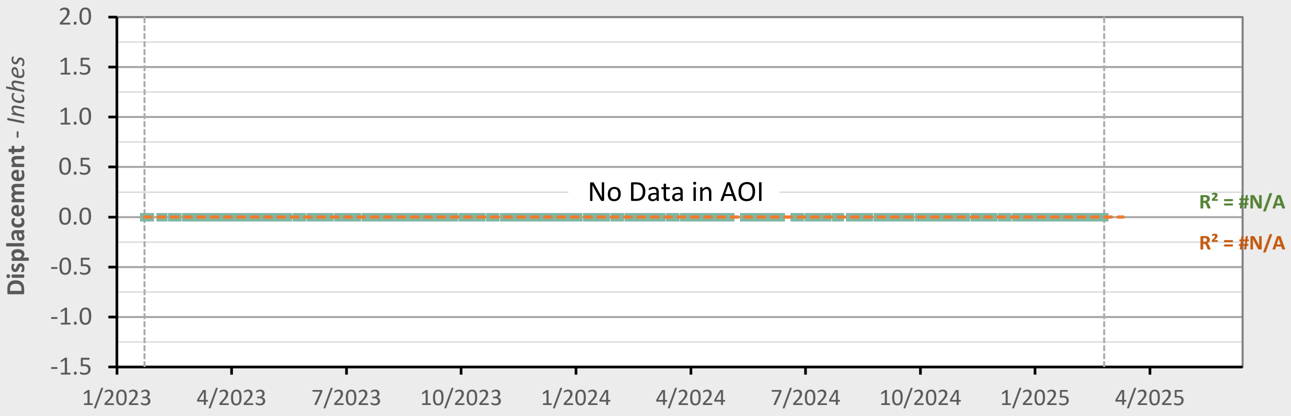
---- Linear Trend Line (Linear Regression)

AOI 14 *(PPG 16)* - Location Map



AOI 14 *(PPG 16)* - East-West Time Series

E-W (2/25/2025) Point Count: **0**



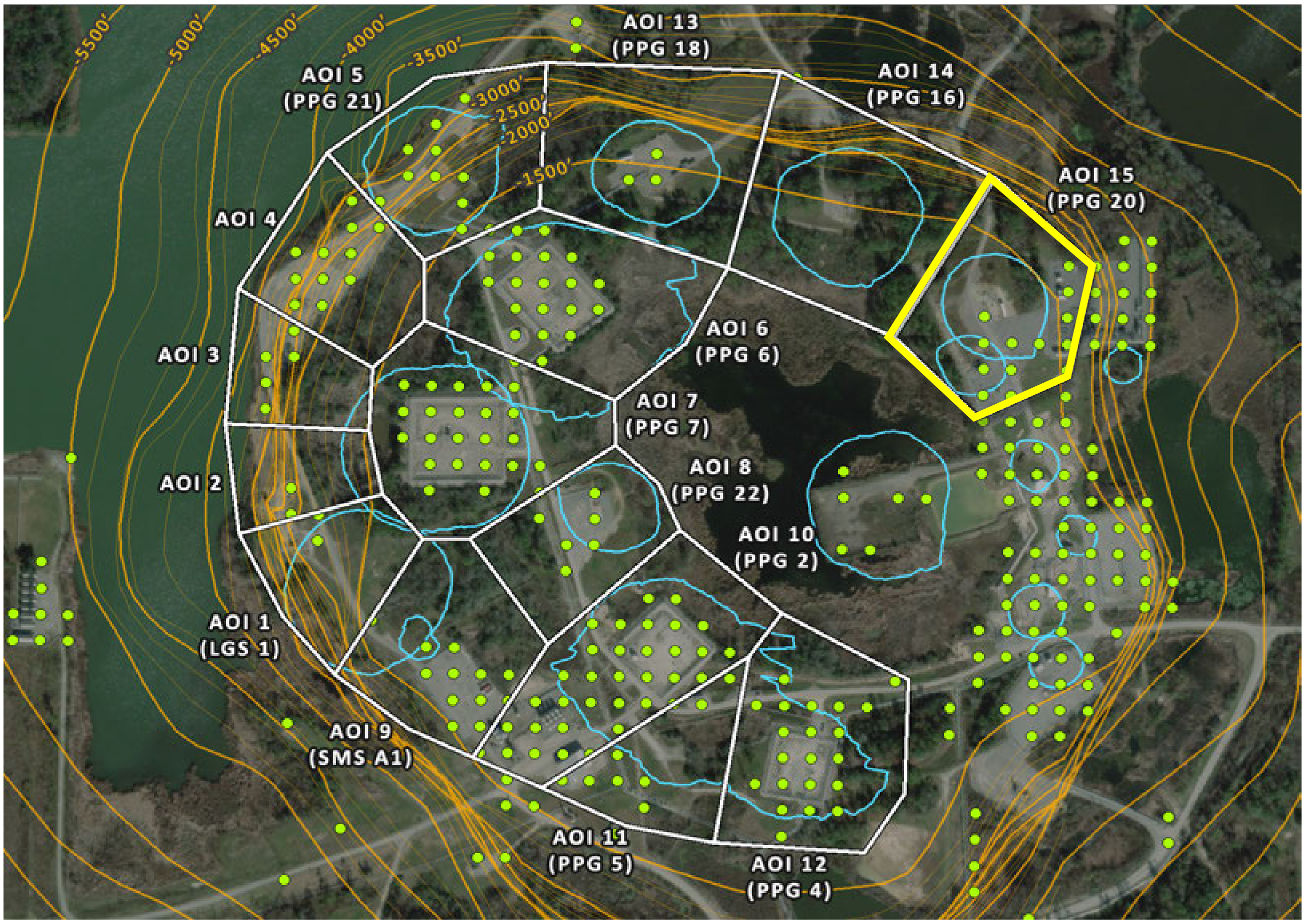
	Nonlinear Trend		Linear Trend	
Velocity:	N/A	in/yr	N/A	in/yr
Acceleration:	N/A	in/yr^2	N/A	in/yr^2

■ 2D Displacement Measurement

---- Nonlinear Trend Line (Quadratic Regression)

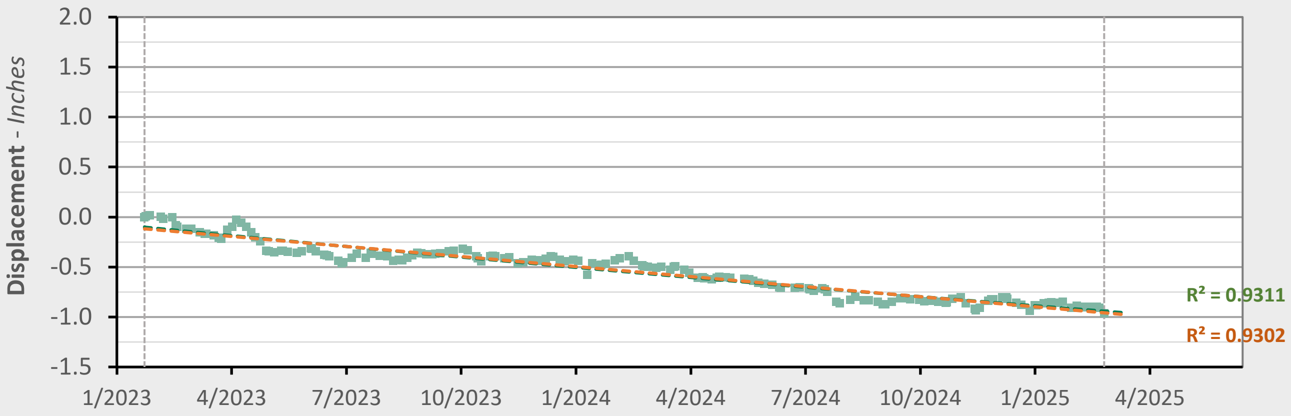
---- Linear Trend Line (Linear Regression)

AOI 15 *(PPG 20)* - Location Map



AOI 15 *(PPG 20)* - East-West Time Series

E-W (2/25/2025) Point Count: **12**



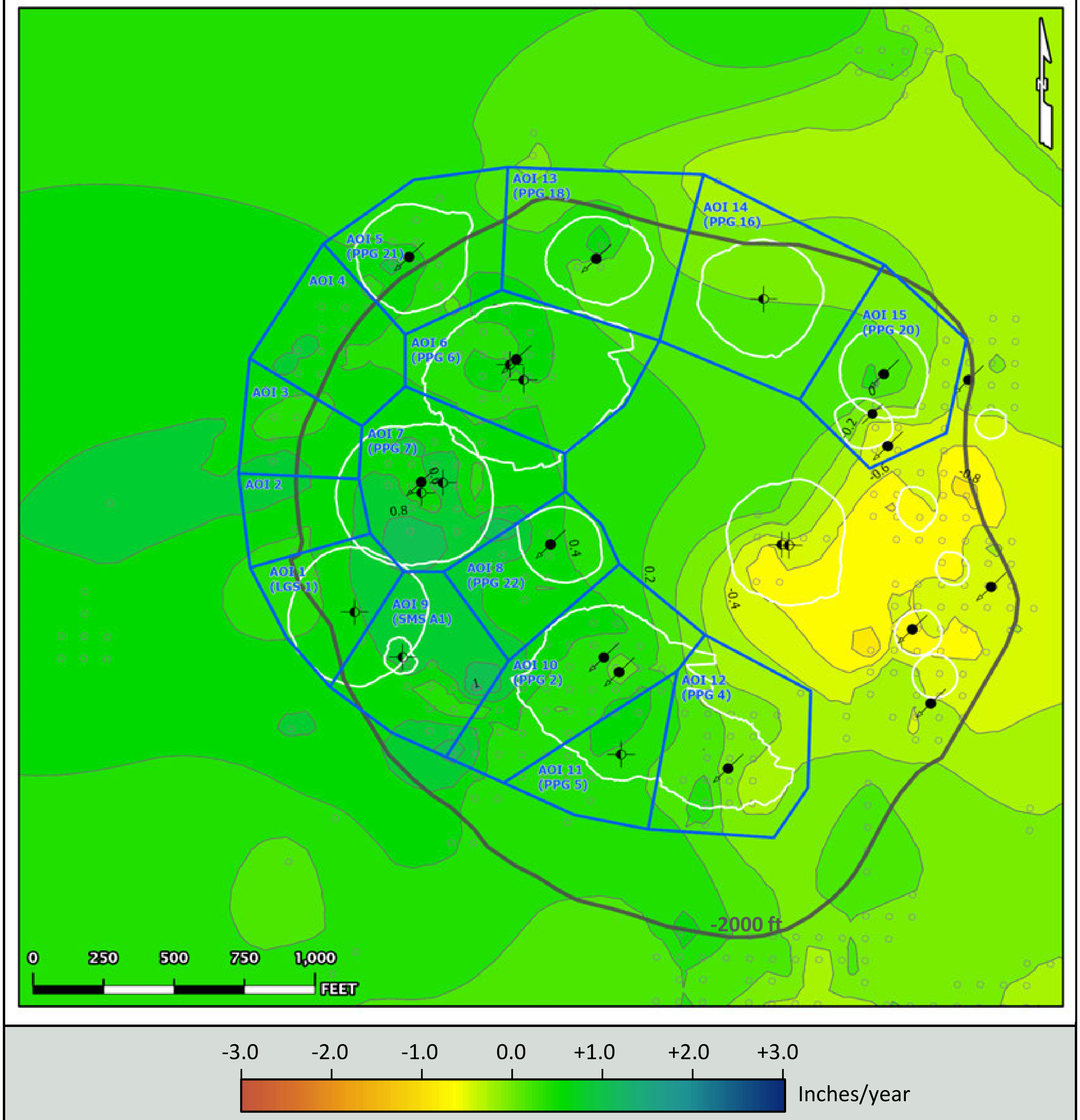
	Nonlinear Trend	Linear Trend
Velocity:	-0.36 in/yr	-0.40 in/yr
Acceleration:	+0.05 in/yr^2	0.00 in/yr^2

🟩 2D Displacement Measurement
Nonlinear Trend Line (Quadratic Regression)
Linear Trend Line (Linear Regression)

East-West Data (01/24/2023 - 02/25/2025)

Nonlinear Velocity Contours

As of date: 02/25/2025



▭ AOI Boundary
○ InSAR LOS Measurement Point
— Contour (0.2)
▭ Historical Cavern Extent
▭ Top of Dome (-2000 ft Contour)

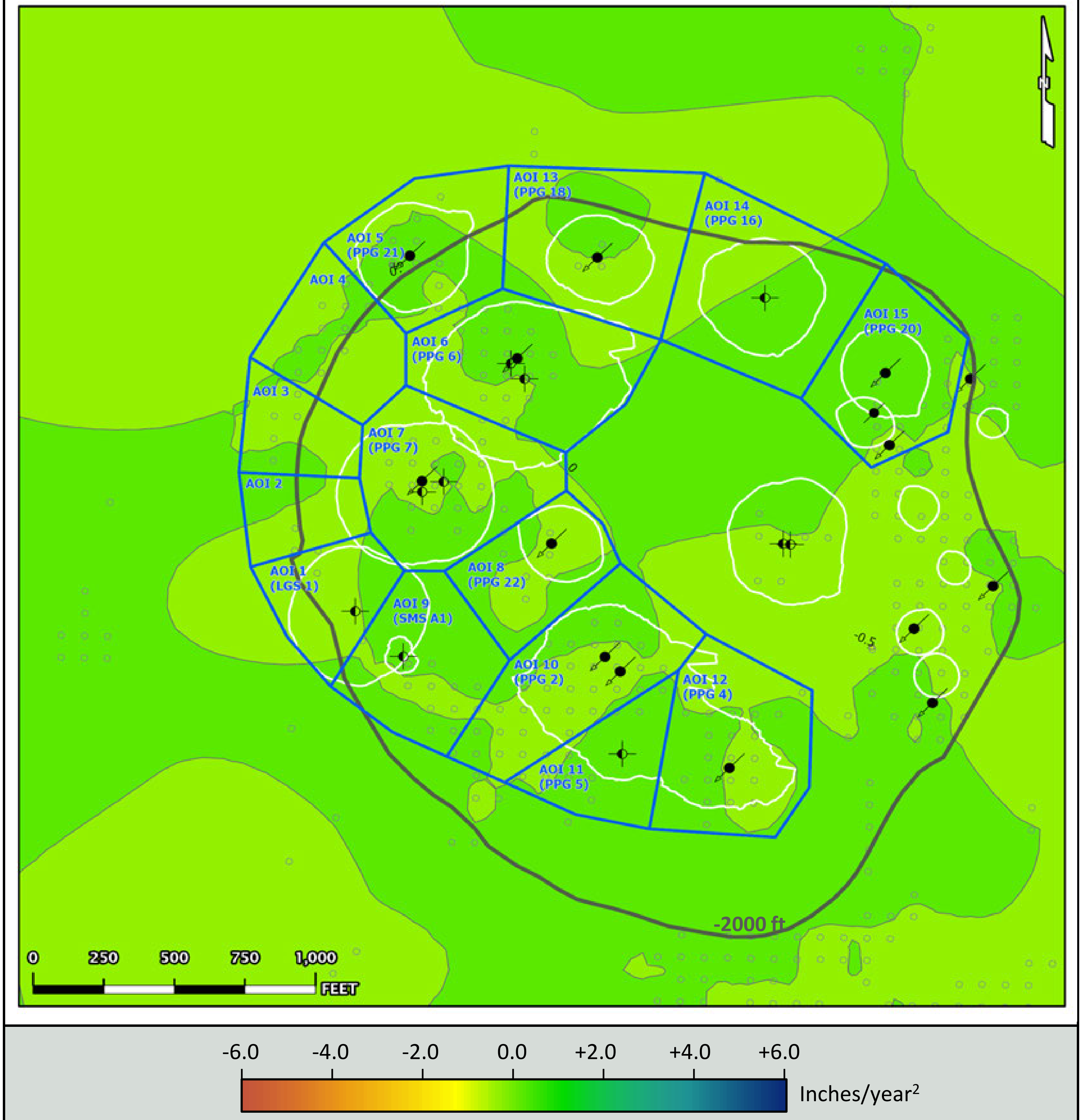
Cavern Well Surface Locations

● 09 - Active - Injection
⊕ 29 - Dry and Plugged

East-West Data (01/24/2023 - 02/25/2025)

Nonlinear Acceleration Contours

Date range: 01/24/2023 - 02/25/2025



🟦 AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.5)

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

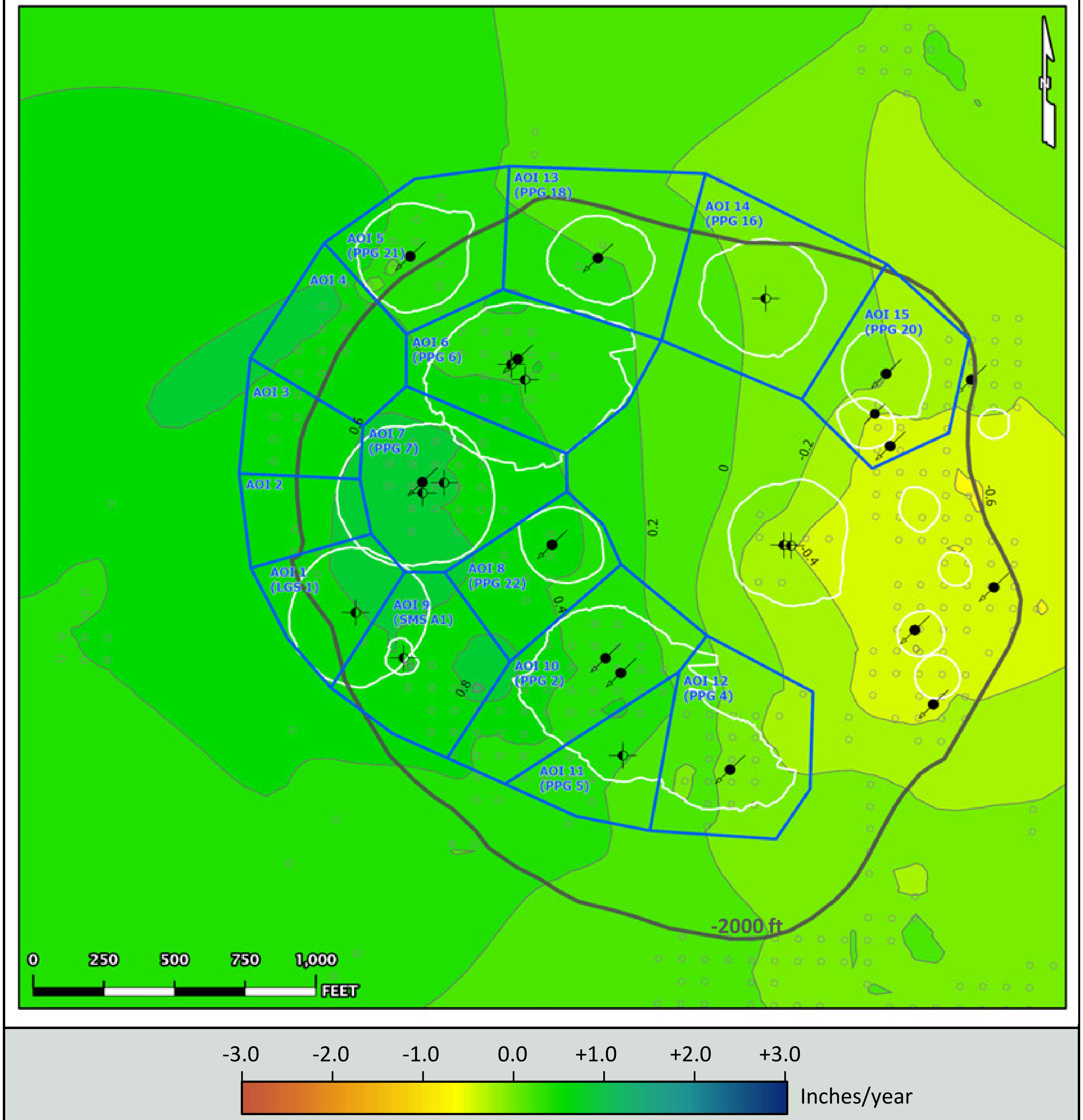
<u>Cavern Well Surface Locations</u>

● 09 - Active - Injection ⊕ 29 - Dry and Plugged

East-West Data (01/24/2023 - 02/25/2025)

Linear Velocity Contours

Date range: 01/24/2023 - 02/25/2025



▭ AOI Boundary ○ InSAR LOS Measurement Point — Contour (0.2)

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

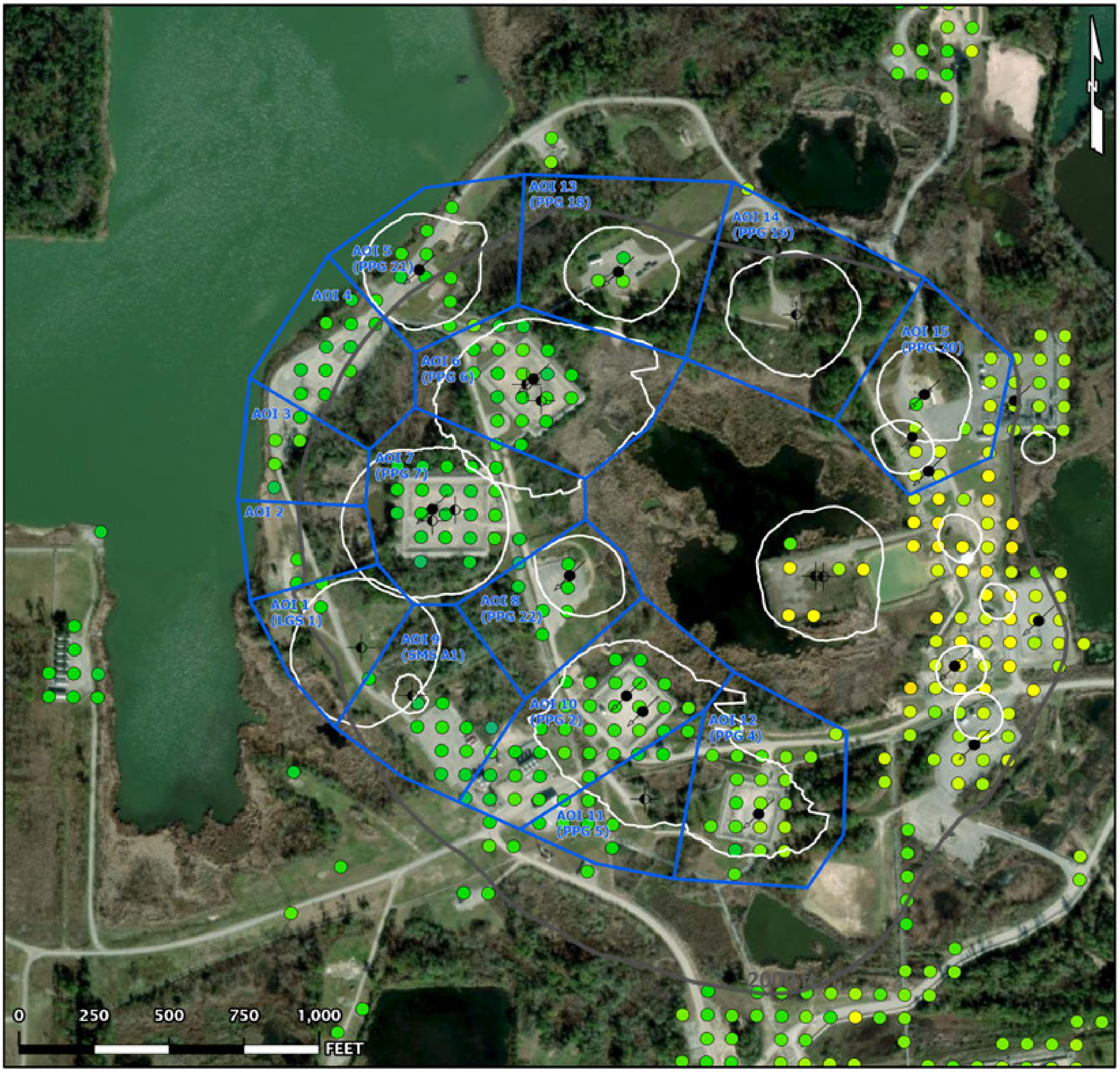
Cavern Well Surface Locations

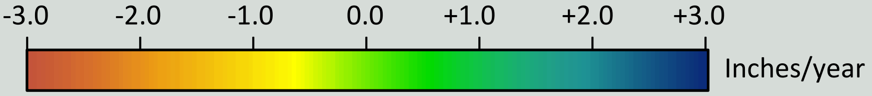
09 - Active - Injection 29 - Dry and Plugged

East-West Data (01/24/2023 - 02/25/2025)

Nonlinear Velocity Data Points

As of date: 02/25/2025





▭ AOI Boundary ○ InSAR LOS Measurement Point

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

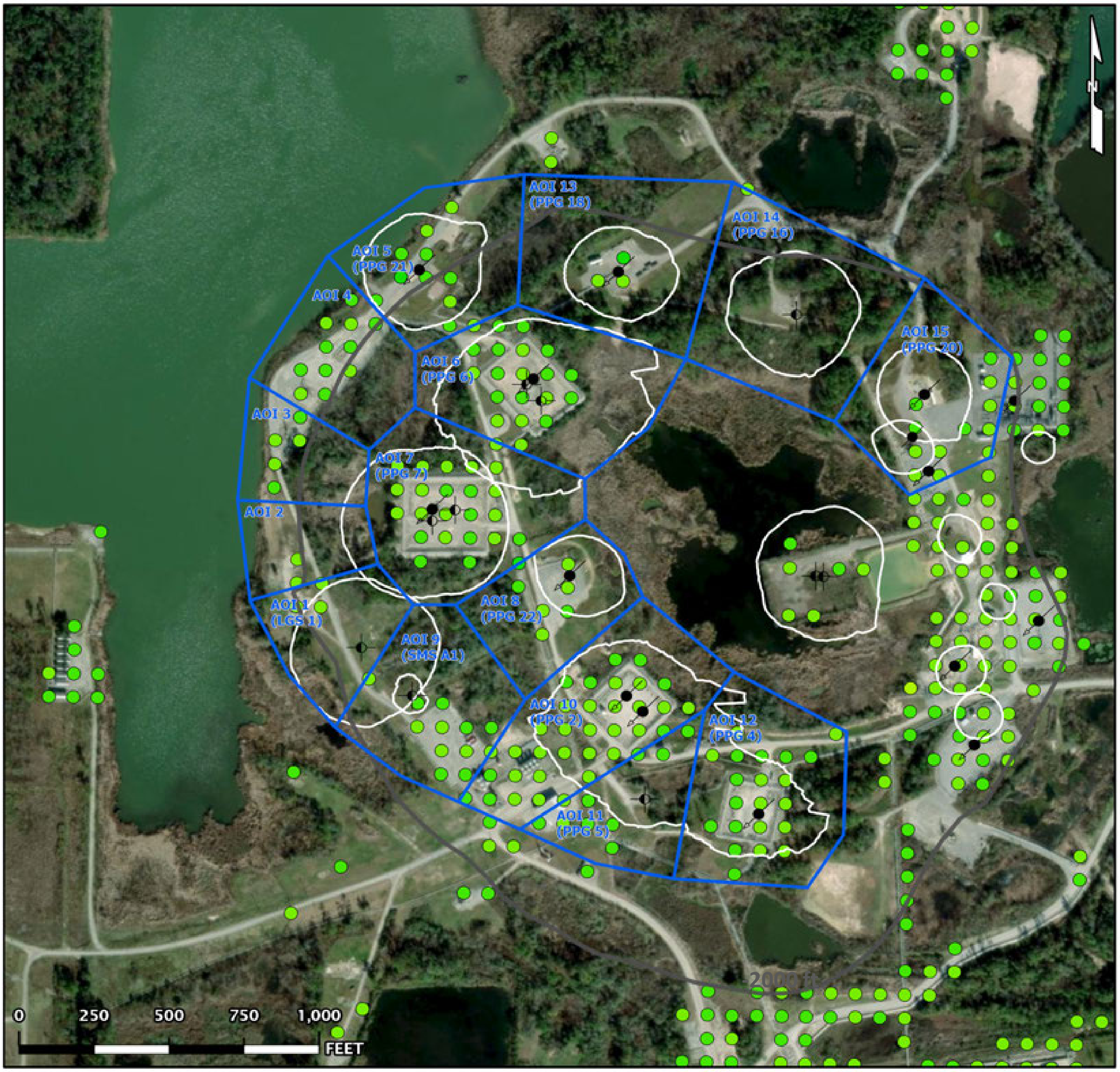
Cavern Well Surface Locations

● 09 - Active - Injection ⊕ 29 - Dry and Plugged

East-West Data (01/24/2023 - 02/25/2025)

Nonlinear Acceleration Data Points

Date range: 01/24/2023 - 02/25/2025



-6.0 -4.0 -2.0 0.0 +2.0 +4.0 +6.0 Inches/year^2

▭ AOI Boundary ○ InSAR LOS Measurement Point

▭ Historical Cavern Extent ▭ Top of Dome (-2000 ft Contour)

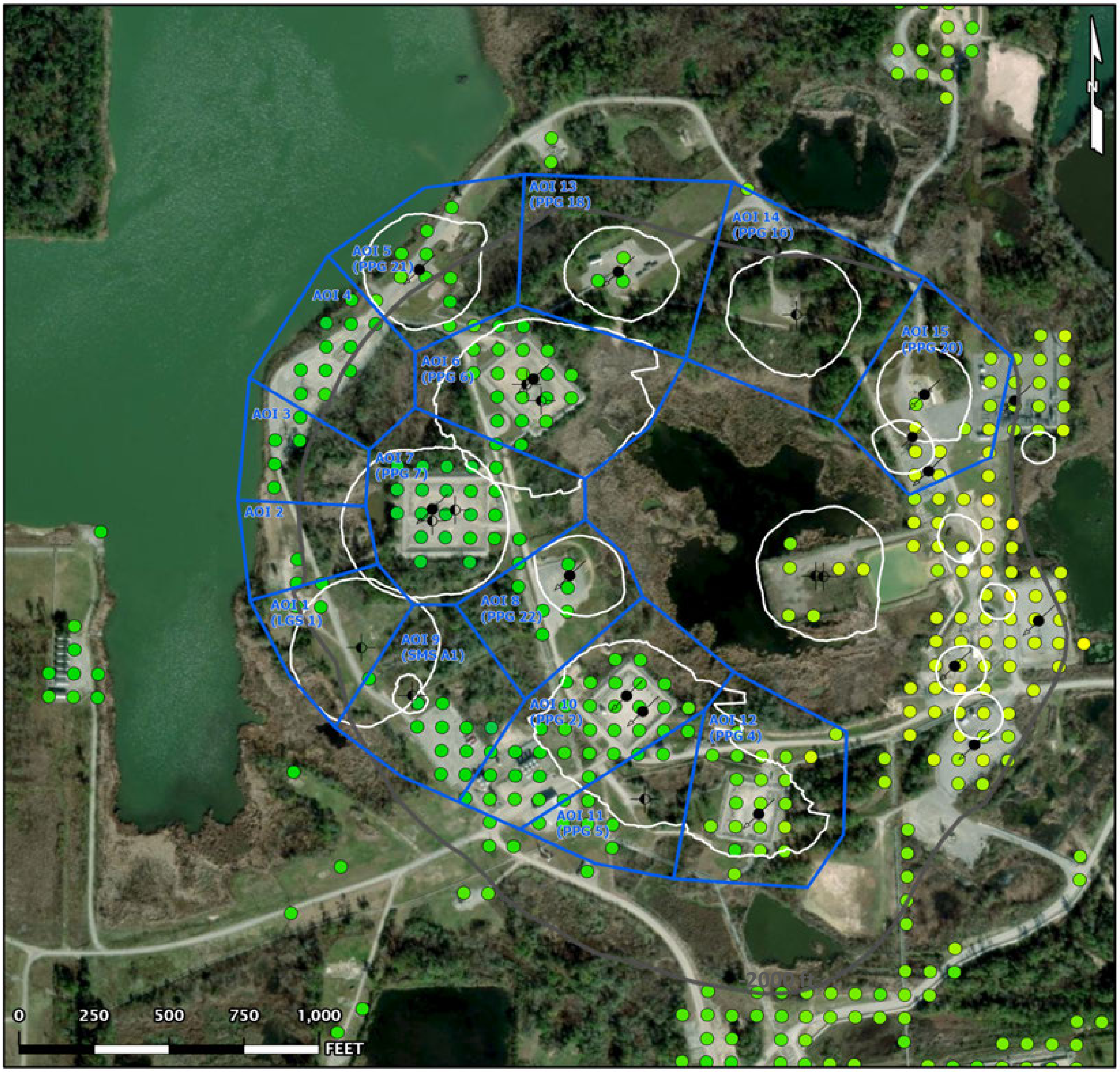
Cavern Well Surface Locations

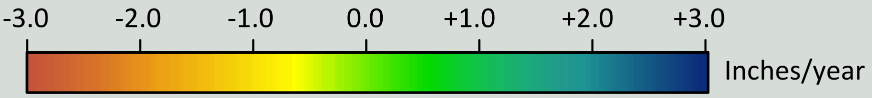
● 09 - Active - Injection ⊕ 29 - Dry and Plugged

East-West Data (01/24/2023 - 02/25/2025)

Linear Velocity Data Points

Date range: 01/24/2023 - 02/25/2025





AOI Boundary ○ InSAR LOS Measurement Point

Historical Cavern Extent Top of Dome (-2000 ft Contour)

Cavern Well Surface Locations

09 - Active - Injection 29 - Dry and Plugged