Navy Closure Task Force

Soil Vapor Monitoring and Light Non-Aqueous Phase Liquid Gauging Reduction Justification Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM OAHU HI

December 2025

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Prepared for NCTF – Red Hill, Environment & Remediation by
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ACRONYMS AND ABBREVIATIONS

%	percent
ATS	Akritas-Theil-Sen
DSVMP	deep soil vapor monitoring point
ISVMP	intermediate soil vapor monitoring point
JP-5	Jet Propellant 5
LNAPL	light non-aqueous phase liquid
PID	photoionization detector
ppmv	part per million by volume
SK	Seasonal Kendall
SVMP	soil vapor monitoring point
VOC	volatile organic compound

1. Introduction

On November 20, 2021, Jet Propellant 5 (JP-5) was accidentally released from an overhead 14-inch polyvinyl chloride fire suppression recovery drain line approximately [redacted] of the water supply pump station for Navy Well 2254-01, also known as Red Hill Shaft (Figure 1). In response to this release, the Navy installed soil vapor monitoring points (SVMPs) and light non-aqueous phase liquid (LNAPL) gauging boreholes in the adjacent Red Hill Bulk Fuel Storage Facility tunnel system to monitor the nature and extent of the JP-5 that migrated below the tunnel floor (Figure 2). The purpose of monitoring is to evaluate changes in conditions at each location to support the assessment of JP-5 migration and degradation over time and the potential threat to human health and the environment.

Organic vapor and fixed gas vapor monitoring began on December 25, 2021, from 54 subslab SVMPs installed in the cement floor of the [redacted] tunnels in proximity to the release. The first phase of monitoring occurred weekly using semi-quantitative hand-held continuous read-out detectors (photoionization detectors [PIDs] and landfill gas meters) to assess the magnitude and mobility of the fuel product in the subsurface environment. In accordance with an agreement made with the State of Hawaii Department of Health (DON 2022) (Appendix A), the monitoring frequency from June 2022 onward was changed from weekly to monthly, and supplementary monitoring after significant rain events was added. Significant rain events are defined as precipitation equaling or exceeding 1 inch within a continuous 24-hour period, occurring at least 72 hours after the end of the previous significant rain event, as measured at a nearby National Oceanic and Atmospheric Administration weather station. In the agreement, each significant rain event will trigger two monitoring events: one conducted within five days of the significant rain event, and another conducted between five and seven days after the first monitoring event.

Since soil vapor monitoring began in December 2021, the SVMP network has expanded to include subslab SVMPs, deep SVMPs (DSVMPs), and intermediate SVMPs (ISVMPs). A table of all SVMPs installed and their depths can be found in Appendix A.

In addition to soil vapor monitoring, JP-5 product gauging as LNAPL has also been conducted since December 2021. Following the November 2021 release, several boreholes and temporary wells (not SVMPs) were installed from [redacted]+375 to [redacted]-350, 2S+025 to 2S+150, and along the 1S portion, which connects the [redacted] and 2S segments of the tunnel from approximately [redacted]-125 to 2S+100, of the [redacted] tunnel. These boreholes and temporary wells are utilized to monitor LNAPL presence in the perched water zone up to [redacted] below the [redacted] tunnel floor. Currently, there are 23 LNAPL gauging locations that are monitored weekly. More details can be found in Appendix A. Each monitoring event includes measuring volatile organic compounds (VOCs) in headspace at the location with a PID, determining depth to LNAPL (if applicable) and depth to water, and measuring the total depth of the boreholes.

The intent of this document is to present multiple lines of evidence supporting the reduction in the frequency of soil vapor monitoring and LNAPL gauging as a response to the November 20, 2021, JP-5 release in [redacted]. The data collected over the last 4 years, displayed in the figures and tables of this memorandum, show that changes in JP-5 concentrations are occurring at a much lower rate than was observed during 2021 and 2022, and can be monitored at a lower frequency without adding risk to human health and the environment. The United States Department of the Navy requests that:

- Soil vapor monitoring be changed to a quarterly frequency
- Additional soil vapor monitoring requirements after significant rain events be eliminated
- LNAPL gauging be reduced to a monthly frequency

2. Monthly Soil Vapor Monitoring Activities in [redacted] Tunnel

A statistical summary of the subslab SVMP data is presented in Table 1. This data verifies a significant reduction in organic vapor concentrations from 2021 to 2025.

As illustrated on Soil Vapor Monitoring Point Results, December 17, 2021, to October 21, 2025 (Figure 3a, Figure 3b, and Figure 3c), and the reduced standard deviation and variance (for concentrations >5 parts per million by volume [ppmv]) over time (Table 1, Figure 4), organic vapor concentrations at each subslab SVMP location have stabilized. Quantile-quantile plots were prepared for the SVMP data and are in Appendix C. As seen in the plots, data variability greatly decreased from year to year with a smaller range of recorded values and lower z-scores with time, indicating less deviation from the average measurement for each year.

Table 1: Statistical Summary for Concentrations in Subslab SVMPs from 2021 to 2025

Statistics	Year				
	2021	2022	2023	2024	2025
Number of measurements	426	1653	1243	1083	680
Number of points with concentrations >5 ppmv	409	1313	260	117	34
Percentage of concentrations >5 ppmv	96%	79%	21%	11%	5%
Maximum VOC concentration (ppmv)	785.4 (on 12/31/2021 at [redacted]+375)	862.0 (on 5/9/2022 at [redacted]+300)	112.9 (on 8/8/2023 at [redacted]-275)	87.0 (on 2/23/2024 at 2S+100)	123.2 (on 7/22/2025 at 2S+100)
Mean VOC concentration (ppmv)	114.1	92.0	5.5	2.7	1.2
Range (ppmv)	0.7-785.4	0.0-862.0	0.0-112.9	0.0-87.0	0.0-123.2
Mean VOC concentration (concentration >5 ppmv) (ppmv)	118.7	115.4	22.5	17.7	13.9
Standard deviation (concentrations >5 ppmv) (ppmv)	133.5	136.9	20.0	15.8	20.2
Variance (concentrations >5 ppmv)	17823.5	18731.9	401.7	250.2	406.2

% percent

A subset of data was used to conduct Akritas-Theil-Sen (ATS) and Seasonal Kendall (SK) trend tests for subslab SVMPs, DSVMPs, and LNAPL data sets (Appendix D). The ATS and SK trend tests are statistical methods often used to identify trends in time-series data. They are nonparametric techniques that do not assume a specific data distribution, which makes them more robust when managing environmental data that often includes outliers or seasonal variations.

Monitoring data were organized into subsets based on specific tunnel locations (e.g., [redacted] 1S, and 2S sections). Within each subset, only data points with sufficient monitoring coverage (i.e., greater than 80 measurements) were included to ensure the reliability and accuracy of statistical analyses. Results from ATS testing of subslab SVMPs demonstrated statistically significant trends, with negative slopes indicating a decline in concentrations over time. SK trend test results indicate no significant seasonal variation in the SVMP data subset, as evidenced by high chi-squared values and p-values exceeding 0.05. Statistically significant decreasing trends were identified within the same subset, supported by negative z-trend values and corresponding p-values, signifying a consistent decline in VOC concentrations over time. Graphical representation of the data shows a decreasing trend (Figure 4). A reduction in soil vapor monitoring events at subslab SVMPs from monthly to quarterly would continue to allow for evaluation of additional changes in organic vapor conditions.

Since the initial soil vapor monitoring locations were installed in December 2021, additional DSVMPs and ISVMPs have been installed to evaluate changes in subsurface conditions at varying depths. Appendix B provides monitoring point construction details. Soil vapor monitoring of the DSVMPs began in September 2022.

Due to the limited number of measurements in 2022 at vapor points in the DSVMP wells, 2022 DSVMP data are largely excluded for comparison purposes. A comparison of DSVMP organic vapor concentrations from 2023 to 2025 (Table 2) shows that average VOC concentration above 5 ppmv has decreased over time. Though the overall average VOC concentration and percentage of measured concentrations above 5 ppmv increased in 2024 compared to 2023, 2025 thus far has the lowest average VOC concentration and lowest percentage of concentrations measured above 5 ppmv than all other years in which measurements took place. Box plots (Figure 5) show reduced data variability in 2025 compared to 2023 and 2024, as evidenced by narrower boxes and shorter whiskers. The reduced variability over time indicates that conditions have reached stabilization. Quantile-quantile plots were also prepared for DSVMP data (Appendix C). These plots show a reduction in measurements greater than 100 ppmv from 2023 to 2025. The reduced range of z-scores for each year also show decreasing variability with time from 2023 to 2025.

Table 2: Statistical Summary for Concentrations in DSVMPs from 2022 to 2025

	Year			
Statistics	2022	2023	2024	2025
Number of measurements	67	356	471	387
Number of measurements with concentrations >5 ppmv	9	42	67	35
Percentage of concentrations >5 ppmv	13%	12%	14%	9%
Maximum VOC concentration (ppmv)	60.28 (on 12/19/2022 at [redacted]-375-DSVMP63.5)	154.1 (on 10/13/2023 at [redacted]-210-DSVMP69.25)	130.0 (on 1/19/2024 at [redacted]-210-DSVMP69.25)	98.34 (on 6/20/2025 at [redacted]-375-DSVMP63.5)
Mean VOC concentration (ppmv)	3.7	6.3	6.6	2.8
Range (ppmv)	0.0–60.28	0.0–154.1	0–130.0	0.0–98.34
Mean VOC concentration (concentration >5 ppmv) (ppmv)	23.5	47.6	40.0	26.4
Standard deviation (concentrations >5 ppmv) (ppmv)	20.5	45.5	29.1	19.8
Variance (concentrations >5 ppmv)	368.5	2068.1	846.5	393.1

ATS trend tests and corresponding plots for the DSVMP data subset reveal a slight, near-zero slope, indicating stable VOC concentrations over time with no significant upward or downward trend. Similarly, SK trend tests show no statistically significant seasonal patterns or overall trends, reinforcing the conclusion of stable subsurface conditions (Appendix D).

The ISVMPs [redacted]+215-ISVMP and [redacted]+315-ISVMP were completed in July 2025 and are not included in this evaluation due to the limited number of measurements.

A notable reduction in fluctuations of organic vapor concentrations was observed in the DSVMP data from 2023 to 2025 (Figure 5). This is also shown by the decreased standard deviation and variance for concentrations exceeding 5 ppmv when compared to previous years. Subsurface conditions have stabilized over time and the reduction in variability is shown by the lower standard deviation. Statistical analyses further confirm this trend, showing that the mean, standard deviation, and variance of VOC concentrations above 5 ppmv have decreased from 2023 to 2025. These findings confirm that conditions at the monitored locations have stabilized.

Given this trend toward reduced variability and consistent concentrations, transitioning soil vapor monitoring from a monthly to a quarterly schedule is appropriate and recommended. This adjusted frequency would continue to provide sufficient data to detect any future changes in organic vapor conditions at the DSVMPs.

3. Weekly LNAPL Gauging Activities in [redacted]

LNAPL gauging in temporary wells and boreholes in [redacted] has been conducted at a weekly frequency since March 2022 using a PID and oil/water interface probe. The purpose of the LNAPL gauging is to monitor the presence of LNAPL in the shallow perched water beneath the [redacted] tunnel floor.

The 2025 LNAPL gauging data (Table 3, Appendix D) document a declining trend in LNAPL occurrence when compared to the LNAPL gauging data. From 2023 to 2025, the number of locations containing LNAPL has decreased. The percentage of measurements containing LNAPL has also decreased with time, aside from 2022 in which less measurements were collected than in subsequent years. Four points were abandoned ([redacted]+200-BH, [redacted]-050-BH, PS+095 Initial, PS+095 Offset) and one new point was installed (2S+100-BH) during the monitoring period between 2022 and 2025. The points were abandoned as they were dry and not contributing to overall study goals. ATS trend tests were conducted on a subset of data and showed statistical significance results with a negative slope indicating a decreasing trend in headspace PID readings over time. Points chosen for ATS analysis had at least 140 readings over the entire monitoring period and were located in differing sections of the tunnel system to provide a representative data set of the entire area. Graphical representations of the data also show near-zero slopes in some locations, verifying stable conditions without notable increases or decreases. SK trend test results largely indicate no significant seasonal variation, while several locations exhibit statistically significant decreasing trends. Based on this evaluation, a transition to monthly gauging events would still allow for observation of decreasing trends within the monitoring points.

Table 3: Statistical Summary for LNAPL Gauging Events in [redacted] Temporary Wells and Boreholes in 2022–2025

Statistics	Year			
	2022	2023	2024	2025
Number of temporary wells/boreholes	26	25	23	23
Number of temporary wells/boreholes with LNAPL present (during any gauging event)	10	9	5	5
Number of measurements	481	1162	1149	966
Number of measurements with LNAPL present	51	177	75	56
Percentage of measurements with LNAPL present	11%	15%	7%	6%
Maximum LNAPL thickness (ft)	0.58 (9/7/2022 at [redacted]-040-TW)	0.50 (9/28/2023 at [redacted]-010-TW)	0.24 (12/23/2024 at [redacted]-100-BH)	0.37 (1/28/2025 at [redacted]-100-BH)
Average LNAPL thickness (ft)	0.13	0.06	0.04	0.07
Standard deviation of LNAPL thickness (ft)	0.17	0.08	0.06	0.08

BH borehole
ft foot or feet
TW temporary well

4. Conclusions and Recommendations

Statistically significant evidence of VOC concentrations and LNAPL thickness decreasing over time, coupled with ATS and SK trend tests results, confirm that conditions associated with the JP-5 release to the environment have stabilized in the [redacted] tunnels and high-frequency monitoring of the subsurface is no longer appropriate. Graphical and statistical data show that there are decreasing VOC concentrations, as well as increased stability, over time at both the subslab SVMPs and DSVMPs. Since temporal trends are either decreasing or stable, the United States Department of the Navy recommends reducing the frequency of soil vapor monitoring from weekly to monthly and that monitoring in response to significant rain events be eliminated. Based on the evaluation conducted in this memorandum, the modified soil vapor monitoring program will still allow for identification of potential outlier concentrations.

Over the past three years, the number of points containing LNAPL has shown a consistent decline. ATS and SK trend test results confirm the absence of significant seasonal variation, including during the rainy season. The overall reduction in data variability, along with stable or decreasing trends, confirm that monitoring results are becoming more consistent and reliable. Reducing LNAPL gauging to a monthly frequency would still provide sufficient resolution to detect changes in subsurface conditions.

5. References

Department of the Navy (DON). 2022. *Precipitation Monitoring Memorandum for Sub-Slab Soil Vapor Monitoring Points, Adit 3, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, Hawai‘i*. Naval Facilities Engineering Systems Command, Hawaii, JBPHH HI. July.

Figures

(b) (3) (B)

[redacted]

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(b) (3) (B)

[redacted]

Event No	Date	[redacted] +300	[redacted] +250	[redacted] +200	[redacted] +150	[redacted] +100	[redacted] +050	[redacted] +000	[redacted] +000	[redacted] 025	[redacted] -050	[redacted] -050	[redacted] 075	[redacted] 100	[redacted] -125	[redacted] 150	[redacted] -150
71	1/12/2024*	1	0	0	0	0	1	1	1	1	1	1	Tight	2	24	1	2
72	1/19/2024*	3	1	1	1	1	2	1	1	2	2	2	Tight	2	2	1	2
73	2/23/2024	6	1	1	0	0	0	0	0	0	0	0	Tight	1	1	1	1
74	3/5/2024*	3	1	1	1	0	1	1	1	1	2	2	Tight	4	4	Tight	3
75	3/12/2024*	1	0	0	0	0	0	0	0	0	0	0	Tight	1	0	0	0
76	4/9/2024*	2	0	0	0	0	0	0	1	0	0	0	Tight	1	1	1	1
77	4/16/2024*	1	1	0	1	1	1	1	1	1	1	1	Tight	1	1	1	1
78	4/23/2024*	2	1	1	1	1	1	1	1	1	1	1	Tight	1	1	1	1
79	4/29/2024*	1	1	1	1	1	1	1	1	1	1	1	Tight	1	1	1	1
80	5/6/2024*	3	1	0	2	0	0	1	2	1	0	1	Tight	1	1	0	0
81	5/17/2024*	3	1	1	0	0	0	0	0	0	0	0	Tight	0	1	0	0
82	5/24/2024*	NA	1	1	2	0	1	0	1	1	2	1	Tight	1	2	1	1
83	6/11/2024	1	1	1	1	0	1	0	1	1	1	1	Tight	1	1	1	1
84	7/9/2024	0	0	0	1	0	1	1	1	1	0	0	Tight	1	1	0	0
85	8/15/2024	2	0	1	0	0	0	0	2	1	1	1	Tight	2	2	1	1
86	9/12/2024	7	0	1	1	1	1	0	1	0	0	0	Tight	1	1	0	NA
87	10/9/2024	1	0	1	0	0	0	0	1	0	0	0	Tight	1	1	NA	0
88	10/30/2024*	1	0	0	0	0	0	0	0	0	NA	NA	Tight	0	0	0	0
89	11/5/2024*	1	0	0	0	0	0	0	0	0	NA	NA	Tight	1	1	0	0
90	11/8/2024*	1	0	0	0	0	0	NA	NA	0	0	0	Tight	0	1	0	0
91	11/14/2024*	1	0	0	1	0	0	NA	NA	0	0	0	Tight	1	1	0	0
92	12/17/2024	1	0	0	0	0	0	0	NA	0	0	0	Tight	0	1	0	NA
93	1/22/2025	0	0	0	0	0	0	0	NA	0	0	0	Tight	0	2	0	0
94	1/31/2025*	0	0	0	0	0	0	0	NA	0	0	0	Tight	0	1	0	NA
95	2/6/2025*	1	0	0	0	0	0	NA	NA	NA	NA	NA	Tight	1	1	0	0
96	3/12/2025*	0	0	0	0	0	0	0	NA	0	0	0	Tight	0	0	0	0
97	3/19/2025*	1	0	0	0	0	0	0	NA	0	0	0	Tight	1	1	0	0
98	4/25/2025	0	0	0	0	0	0	0	0	0	0	0	Tight	0	0	0	0
99	5/2/2025*	0	0	0	0	0	0	0	0	0	0	0	Tight	0	0	NA	NA
100	5/8/2025*	0	0	0	0	0	0	0	0	0	0	0	Tight	1	1	0	0
101	6/25/2025	NA	NA	NA	0	0	1	0	0	0	1	0	Tight	1	1	1	1
102	7/22/2025*	2	1	1	1	1	1	1	1	1	1	1	Tight	1	1	1	NA
103	7/29/2025*	0	0	0	0	0	0	0	0	NA	0	0	Tight	0	0	0	0
104	8/19/2025	0	0	0	0	0	0	0	0	0	0	0	Tight	0	0	0	0
105	9/16/2025	0	0	0	0	0	0	0	0	0	0	0	Tight	0	0	0	0
106	10/21/2025	1	0	0	0	0	0	0	0	1	1	NA	Tight	2	1	1	1

Event No	Date	[redacted] -175	[redacted] 200	[redacted] 200	[redacted] -225	[redacted] -250	[redacted] -275	[redacted] -300	[redacted] -300	[redacted] -325	[redacted] -350	[redacted] -350	[redacted] -375	[redacted] 375-05.0	[redacted] 400	[redacted] 425	[redacted] -450
71	1/12/2024*	1	2	4	Tight	32	62	1	2	22	20	40	9	17	0	1	0
72	1/19/2024*	1	4	2	Tight	14	6	2	3	8	5	28	1	1	1	1	1
73	2/23/2024	1	2	4	4	59	81	2	3	28	11	32	7	6	1	2	3
74	3/5/2024*	2	4	6	Tight	37	53	3	2	29	11	29	6	4	0	0	0
75	3/12/2024*	0	1	1	Tight	13	11	0	1	6	3	3	1	1	0	0	0
76	4/9/2024*	1	1	2	Tight	16	18	1	1	7	4	6	2	2	0	0	0
77	4/16/2024*	1	2	2	Tight	17	22	1	1	6	3	8	1	1	0	0	0
78	4/23/2024*	1	2	2	Tight	10	11	1	2	4	3	4	1	1	0	1	0
79	4/29/2024*	1	2	2	Tight	9	11	2	2	5	2	6	1	1	0	0	0
80	5/6/2024*	0	1	2	Tight	2	2	2	2	1	0	10	0	0	0	0	0
81	5/17/2024*	0	1	1	Tight	23	40	1	1	10	5	8	2	1	1	1	1
82	5/24/2024*	1	2	3	Tight	20	27	3	4	10	9	12	4	4	2	2	2
83	6/11/2024	1	1	2	Tight	9	14	1	1	3	3	6	1	1	0	0	0
84	7/9/2024	0	1	1	Tight	6	10	1	1	2	2	3	1	1	0	0	0
85	8/15/2024	1	2	2	1	0	24	0	0	7	5	13	2	2	0	1	3
86	9/12/2024	1	1	1	NA	12	14	1	1	2	2	5	1	1	0	0	0
87	10/9/2024	0	1	1	Tight	10	11	0	1	3	NA	3	2	0	0	0	0
88	10/30/2024*	0	0	1	Tight	8	12	0	1	2	1	2	1	0	0	0	0
89	11/5/2024*	0	1	1	Tight	6	12	0	1	2	2	2	0	0	0	0	0
90	11/8/2024*	0	0	1	Tight	7	11	1	1	2	2	3	1	0	0	0	0
91	11/14/2024*	0	1	1	Tight	6	9	1	1	2	1	2	0	0	0	0	0
92	12/17/2024	0	0	1	Tight	4	5	0	1	2	1	1	0	0	0	0	0
93	1/22/2025	0	0	1	Tight	NA	NA	NA	NA	2	1	2	0	0	0	0	0
94	1/31/2025*	0	0	1	Tight	5	7	NA	NA	2	1	3	0	0	0	0	0
95	2/6/2025*	0	1	1	Tight	7	14	1	1	3	2	4	0	0	0	0	0
96	3/12/2025*	0	0	0	Tight	4	9	0	1	1	1	1	0	0	0	0	0
97	3/19/2025*	0	1	1	Tight	9	15	1	1	3	2	3	0	0	0	0	0
98	4/25/2025	0	0	NA	Tight	1	2	0	0	0	0	0	0	0	0	0	0
99	5/2/2025*	0	0	0	Tight	1	2	0	0	1	0	0	0	0	0	0	0
100	5/8/2025*	0	0	NA	Tight	4	10	1	1	3	2	4	0	0	0	0	0
101	6/25/2025	1	1	1	Tight	4	29	1	1	3	2	4	1	0	0	0	0
102	7/22/2025*	1	1	2	Tight	6	28	1	1	6	3	7	1	1	0	0	0
103	7/29/2025*	0	0	0	Tight	1	5	0	0	1	1	1	0	0	0	0	0
104	8/19/2025	0	1	0	Tight	2	9	1	1	2	1	1	0	0	0	0	0
105	9/16/2025	0	0	0	Tight	2	8	0	0	1	1	1	0	0	0	0	0
106	10/21/2025	2	2	2	Tight	6	25	1	2	5	4	4	1	1	0	0	0

[redacted]

Event No.	Date	[redacted] +500	[redacted] +475	[redacted] +450	[redacted] +425	[redacted] +400	[redacted] +375	[redacted] +375
71	1/12/2024*	0	0	0	0	0	0	0
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73	2/23/2024	1	1	1	1	1	1	1
74	3/5/2024*	1	1	1	1	0	1	1
75	3/12/2024*	1	0	0	0	0	0	0
76	4/9/2024*	0	0	0	0	0	0	0
77	4/16/2024*	1	1	1	1	0	0	1
78	4/23/2024*	1	1	1	1	1	1	1
79	4/29/2024*	1	1	1	1	1	1	1
80	5/6/2024*	0	0	0	2	2	1	0
81	5/17/2024*	1	1	1	1	1	1	1
82	5/24/2024*	1	1	1	0	0	0	0
83	6/11/2024	1	1	15	0	0	0	1
84	7/9/2024	0	0	0	0	0	0	0
85	8/15/2024	0	0	0	0	0	0	0
86	9/12/2024	0	0	0	0	0	0	1
87	10/9/2024	0	0	0	0	0	0	0
88	10/30/2024*	NA	0	0	0	0	0	0
89	11/5/2024*	NA	0	0	0	0	0	0
90	11/8/2024*	NA	0	0	0	0	0	0
91	11/14/2024*	0	0	0	0	0	0	0
92	12/17/2024	0	0	0	0	0	0	0
93	1/22/2025	0	0	0	0	0	0	0
94	1/31/2025*	0	0	0	0	0	0	0
95	2/6/2025*	0	0	0	0	0	0	0
96	3/12/2025*	0	0	0	0	0	0	0
97	3/19/2025*	2	0	0	0	0	0	0
98	4/25/2025	0	0	0	0	0	0	0
99	5/2/2025*	1	0	0	0	0	0	0
100	5/8/2025*	0	0	0	0	0	0	0
101	6/25/2025	0	0	0	0	0	0	0
102	7/22/2025*	1	0	0	0	0	1	0
103	7/29/2025*	0	0	0	0	0	0	0
104	8/19/2025	0	0	0	0	0	0	0
105	9/16/2025	0	0	0	0	0	0	0
106	10/21/2025	0	0	0	0	0	0	0

Date	2S+300	2S+275	2S+250	2S+225	2S+200	2S+175	2S+150	2S+125	2S+100	1S+038	1S+068	2S+075	2S+075-05.0	2S+050	2S+025
1/12/2024*	0	0	0	0	0	0	0	0	70	0	0	54	8	0	0
1/19/2024*	2	1	1	2	1	2	2	3	28	1	1	12	3	2	3
2/23/2024	1	1	0	1	1	2	1	2	87	1	1	35	12	2	3
3/5/2024*	1	2	2	2	Tight	3	2	4	54	2	2	27	10	3	3
3/12/2024*	0	0	0	0	0	0	0	0	20	0	0	12	2	0	0
4/9/2024*	1	1	1	1	1	1	1	2	20	1	1	3	15	2	1
4/16/2024*	1	1	0	0	2	1	1	2	21	1	1	18	3	1	1
4/23/2024*	1	1	1	1	1	1	2	4	12	1	2	10	3	1	1
4/29/2024*	1	1	1	1	1	2	2	4	10	2	2	10	3	1	2
5/6/2024*	1	1	1	1	1	1	1	2	1	1	1	2	2	1	1
5/17/2024*	0	0	0	0	0	0	1	1	4	0	1	NA	NA	NA	0
5/24/2024*	2	2	2	2	3	3	3	5	23	3	3	20	NA	NA	2
6/11/2024	1	1	1	1	1	1	1	2	13	1	2	NA	2	NA	NA
7/9/2024	0	0	0	0	1	1	1	1	9	1	1	6	2	1	1
8/15/2024	0	1	1	1	1	0	2	1	42	1	2	21	9	0	NA
9/12/2024	0	0	0	0	1	1	1	NA	20	1	1	NA	NA	NA	NA
10/9/2024	0	0	0	1	1	1	1	4	27	NA	NA	11	2	1	1
10/30/2024*	0	0	0	0	0	0	0	1	NA	0	1	NA	NA	NA	NA
11/5/2024*	0	0	0	0	0	0	0	1	NA	0	1	6	1	NA	NA
11/8/2024*	NA	NA	0	0	0	0	0	1	8	0	0	7	1	NA	NA
11/14/2024*	NA	NA	1	1	1	1	1	1	7	1	1	6	1	NA	NA
12/17/2024	0	0	0	0	0	0	0	1	7	0	0	5	1	0	0
1/22/2025	0	0	0	0	0	1	1	1	9	0	0	8	1	1	1
1/31/2025*	0	0	0	0	0	0	0	1	5	0	0	4	1	0	0
2/6/2025*	0	0	0	0	1	1	1	2	10	0	1	8	2	1	1
3/12/2025*	0	0	0	0	0	0	NA	NA	6	NA	NA	5	1	0	1
3/19/2025*	1	1	2	1	1	2	NA	NA	11	NA	NA	10	2	0	1
4/25/2025	0	0	0	0	0	0	0	0	1	NA	NA	1	0	0	0
5/2/2025*	0	0	0	0	0	0	0	1	2	0	NA	2	0	0	0
5/8/2025*	0	0	1	0	0	0	0	1	8	NA	NA	8	1	0	0
6/25/2025	0	0	0	0	Tight	1	1	1	12	NA	NA	9	NA	1	1
7/22/2025*	1	1	1	1	1	1	1	1	123	1	1	11	3	1	1
7/29/2025*	0	0	0	0	0	0	0	1	5	0	0	4	1	0	0
8/19/2025	0	0	0	0	0	0	0	1	8	0	NA	5	1	0	0
9/16/2025	0	0	0	0	0	0	0	1	6	0	NA	4	0	0	0
10/21/2025	0	0	0	1	1	1	1	3	16	NA	NA	10	2	NA	1

Figure 3a. Soil Vapor Monitoring Point Results
January 12, 2024 - October 21, 2025
[redacted] Tunnel and Pearl Harbor Tunnel

Notes
* denotes out-of-frequency sampling events that were conducted in response to a significant rain event that exceeded 1 inch in 24 hours. An additional follow-up sampling event is conducted 7 days after the initial event.
NA = not analyzed

Scale
ppmv
862
650
550
450
350
250
150
50
0

Event No	Date	[redacted] +300	[redacted] +250	[redacted] +200	[redacted] +150	[redacted] +100	[redacted] +050	[redacted] +000	[redacted] +000	[redacted] 025	[redacted] -050	[redacted] -050	[redacted] 075	[redacted] 100	[redacted] -125
44	1/9/2023	1	0	1	20	0	0	5	95	0	0	3	Tight	31	Tight
45	2/1/2023 *	11	2	2	34	1	2	0	126	0	1	1	Tight	28	Tight
46	2/6/2023 *	2	2	3	10	1	9	1	46	1	1	2	Tight	10	Tight
47	2/13/2023 *	4	3	4	10	5	9	1	42	1	1	2	Tight	9	Tight
48	2/23/2023*	4	1	1	10	1	1	1	64	0	0	0	Tight	10	Tight
49	2/27/2023*	4	1	1	10	2	2	0	72	0	0	0	Tight	9	Tight
50	3/3/2023*	2	0	0	9	1	1	0	81	0	0	0	Tight	9	Tight
51	3/7/2023*	1	0	0	4	0	0	0	55	0	0	0	Tight	6	Tight
52	3/13/2023	1	0	0	3	0	0	0	41	0	0	0	Tight	NA	Tight
53	4/6/2023*	1	0	0	2	0	1	0	47	0	0	0	Tight	4	Tight
54	4/10/2023*	1	0	0	3	0	0	0	53	0	0	0	Tight	3	Tight
55	4/24/2023*	1	0	1	1	1	1	0	22	0	0	0	Tight	1	Tight
56	4/28/2023*	1	0	0	1	1	1	0	26	0	0	0	Tight	1	Tight
57	5/9/2023	1	0	0	1	0	0	0	21	N/A	0	0	Tight	1	Tight
58	5/15/2023*	1	0	0	1	0	1	1	1	0	0	0	Tight	0	Tight
59	5/22/2023*	1	0	0	1	1	1	0	22	0	0	0	Tight	1	Tight
60	6/15/2023	0	0	0	0	0	0	0	3	0	0	0	Tight	0	Tight
61	7/14/2023	2	1	1	1	1	1	1	21	1	0	0	Tight	2	NA
62	8/8/2023	3	0	0	0	0	0	0	15	NA	NA	NA	NA	2	7
63	9/14/2023	4	0	0	0	0	0	0	8	1	0	0	Tight	2	Tight
64	10/10/2023	6	0	0	1	1	0	0	2	1	0	0	Tight	2	Tight
65	11/7/2023	7	1	1	1	1	1	1	3	1	1	1	Tight	2	2
66	12/1/2023*	3	0	0	0	0	1	0	0	0	0	1	Tight	1	2
67	12/8/2023*	0	0	0	0	0	1	0	0	0	0	0	Tight	0	1
68	12/15/2023*	2	0	0	0	0	0	0	1	0	1	1	Tight	1	2
69	12/22/2023*	5	1	1	1	1	1	1	2	1	1	1	Tight	2	3
70	12/29/2023*	4	1	1	2	1	1	1	2	1	1	1	Tight	3	4

Event No	Date	[redacted] 150	[redacted] -150	[redacted] -175	[redacted] 200	[redacted] 200	[redacted] -225	[redacted] -250	[redacted] -275	[redacted] -300	[redacted] -300	[redacted] -325	[redacted] -350	[redacted] -350	[redacted] -375	[redacted] 375-05.0	[redacted] 400	[redacted] 425	[redacted] -450
44	1/9/2023	3	3	0	1	4	Tight	14	95	6	6	26	18	22	15	8	0	0	0
45	2/1/2023 *	2	4	0	1	5	Tight	9	70	2	2	12	11	24	32	12	0	0	0
46	2/6/2023 *	2	2	1	2	3	Tight	10	36	3	2	10	6	13	13	5	0	0	0
47	2/13/2023 *	2	2	1	2	2	Tight	12	37	4	3	7	5	11	10	4	0	0	0
48	2/23/2023*	3	2	0	1	4	Tight	15	60	1	2	14	9	21	13	4	0	0	0
49	2/27/2023*	3	2	0	1	3	Tight	9	41	0	1	9	5	23	12	4	0	0	0
50	3/3/2023*	2	3	0	1	3	Tight	6	31	0	1	6	4	11	10	5	0	0	0
51	3/7/2023*	1	1	0	0	2	Tight	4	31	1	1	7	4	9	8	3	0	0	0
52	3/13/2023	1	1	0	2	0	Tight	8	46	2	2	11	21	6	15	5	0	0	0
53	4/6/2023*	2	1	2	2	11	Tight	9	37	1	1	7	3	10	5	2	0	0	0
54	4/10/2023*	2	1	0	1	2	Tight	8	52	1	1	8	4	9	8	3	0	0	0
55	4/24/2023*	1	1	0	1	1	Tight	5	23	1	1	6	3	10	4	1	0	0	0
56	4/28/2023*	1	0	0	1	1	Tight	6	26	1	1	7	3	12	7	4	0	0	0
57	5/9/2023	0	0	0	0	1	Tight	4	23	1	1	6	3	11	6	4	0	0	0
58	5/15/2023*	N/A	N/A	0	1	1	Tight	1	4	0	0	4	2	9	4	2	0	0	0
59	5/22/2023*	1	0	0	0	1	Tight	6	30	1	1	5	3	10	3	2	0	0	0
60	6/15/2023	0	0	0	NA	NA	Tight	1	0	0	0	1	1	3	2	1	0	0	0
61	7/14/2023	NA	NA	NA	NA	NA	Tight	16	65	2	2	13	10	27	19	14	0	0	0
62	8/8/2023	2	1	0	1	4	Tight	31	113	3	5	21	18	55	20	12	0	0	0
63	9/14/2023	2	1	0	1	4	Tight	28	99	3	2	23	18	47	18	9	0	0	0
64	10/10/2023	2	2	0	2	4	Tight	32	76	3	4	25	14	44	19	7	0	0	0
65	11/7/2023	2	3	1	3	6	Tight	40	63	3	3	30	16	39	9	3	1	1	1
66	12/1/2023*	1	1	1	2	2	Tight	23	44	2	2	14	11	25	4	4	0	0	0
67	12/8/2023*	0	0	0	0	2	Tight	18	47	2	3	19	11	29	4	3	0	0	0
68	12/15/2023*	1	1	1	2	2	Tight	35	58	2	3	20	15	22	4	3	1	1	1
69	12/22/2023*	2	1	1	4	2	Tight	31	45	3	4	21	16	29	20	6	2	2	2
70	12/29/2023*	3	3	3	6	6	Tight	37	69	5	5	22	16	30	7	5	1	1	1

[redacted]

Event No.	Date	[redacted] +500	[redacted] +475	[redacted] +450	[redacted] +425	[redacted] +400	[redacted] +375	[redacted] +375
44	1/9/2023	1	0	0	0	0	1	0
45	2/1/2023 *	3	0	0	1	1	4	1
46	2/6/2023 *	1	1	1	1	1	2	1
47	2/13/2023 *	2	1	1	1	2	3	2
48	2/23/2023*	1	0	0	0	0	2	1
49	2/27/2023*	2	1	1	1	1	2	1
50	3/3/2023*	1	0	0	0	0	2	0
51	3/7/2023*	0	0	0	0	0	0	0
52	3/13/2023	0	0	0	0	0	0	0
53	4/6/2023*	0	1	0	0	0	0	0
54	4/10/2023*	0	0	0	0	0	0	0
55	4/24/2023*	0	0	0	0	0	1	0
56	4/28/2023*	0	0	0	0	0	1	0
57	5/9/2023	0	0	0	0	0	0	0
58	5/15/2023*	0	0	0	0	0	0	0
59	5/22/2023*	0	0	0	0	0	0	0
60	6/15/2023	0	0	0	0	0	0	0
61	7/14/2023	0	0	0	0	0	1	1
62	8/8/2023	0	0	0	0	0	0	0
63	9/14/2023	0	0	0	0	0	0	0
64	10/10/2023	1	0	0	0	0	0	0
65	11/7/2023	3	1	1	2	1	0	1
66	12/1/2023*	1	0	1	1	0	1	0
67	12/8/2023*	0	0	0	0	0	0	0
68	12/15/2023*	1	0	0	0	0	0	0
69	12/22/2023*	2	1	1	1	1	1	1
70	12/29/2023*	1	1	1	1	1	1	1

Date	2S+300	2S+275	2S+250	2S+225	2S+200	2S+175	2S+150	2S+125	2S+100	1S+038	1S+068	2S+075	2S+075-05.0	2S+050	2S+025
1/9/2023	0	0	0	0	0	0	0	5	31	0	0	50	10	18	8
2/1/2023 *	0	0	0	1	1	1	1	3	27	0	0	37	4	8	5
2/6/2023 *	0	1	1	1	1	2	2	5	20	1	1	21	6	7	5
2/13/2023 *	0	0	0	1	1	2	2	9	20	1	1	21	5	6	5
2/23/2023*	0	0	0	0	0	1	1	2	30	1	0	4	37	9	4
2/27/2023*	0	0	0	0	0	0	0	1	19	0	1	20	4	7	4
3/3/2023*	0	0	0	0	0	0	0	1	4	0	0	19	3	6	2
3/7/2023*	0	0	0	0	0	0	0	1	11	0	0	14	3	5	3
3/13/2023	0	0	0	0	0	0	0	0	22	0	0	11	6	10	5
4/6/2023*	0	0	0	0	0	0	0	2	25	1	1	25	4	7	4
4/10/2023*	0	0	0	0	0	0	1	1	NA	0	0	27	4	7	4
4/24/2023*	0	0	0	0	0	1	1	2	13	0	0	11	2	3	1
4/28/2023*	0	0	0	0	1	1	1	1	14	0	0	14	2	3	2
5/9/2023	0	0	0	0	0	1	1	1	13	0	0	12	N/A	3	1
5/15/2023*	0	0	0	0	1	1	1	1	9	0	0	1	2	2	1
5/22/2023*	0	0	0	0	1	1	1	2	15	0	0	N/A	2	3	2
6/15/2023	0	0	0	0	0	0	0	0	NA	0	0	3	1	0	0
7/14/2023	1	0	0	1	1	1	0	NA	54	0	0	34	8	4	4
8/8/2023	1	1	2	2	3	2	3	5	89	1	1	33	16	6	7
9/14/2023	0	0	0	1	0	1	0	4	75	1	1	33	13	6	6
10/10/2023	1	1	1	2	2	2	2	3	79	1	1	NA	14	3	5
11/7/2023	1	1	1	1	2	2	2	2	70	2	2	27	6	3	6
12/1/2023*	0	0	1	1	1	1	1	3	43	1	1	21	7	1	1
12/8/2023*	0	0	0	0	0	0	0	1	53	0	0	26	7	2	3
12/15/2023*	2	2	2	2	2	3	3	4	87	2	1	33	11	2	3
12/22/2023*	3	3	3	3	4	4	5	7	62	3	4	30	11	2	3
12/29/2023*	2	2	2	2	3	4	2	4	53	2	2	34	9	4	3

Figure 3b. **Soil Vapor Monitoring Point Results**
January 9, 2023 - December 29, 2023
[redacted] Tunnel and Pearl Harbor Tunnel

Notes
* denotes out-of-frequency sampling events that were conducted in response to a significant rain event that exceeded 1 inch in 24 hours. An additional follow-up sampling event is conducted 7 days after the initial event.
NA = not analyzed

Scale
ppmv
862
650
550
450
350
250
150
50
0

Event No	Date	[redacted]+300	[redacted]+250	[redacted]+200	[redacted]+150	[redacted]+100	[redacted]+050	[redacted] +000	[redacted] +000	[redacted]-025	[redacted] -050	[redacted] 050	[redacted]-075	[redacted]-100	[redacted]-125	[redacted] -150	[redacted] -150
1	12/17/2021	67	101	55	43	39	40	24	33	28	24	35	36	44	29	83	95
2	12/20/2021	235	178	88	96	67	85	65	79	57	54	69	NT	65	32	92	108
3	12/21/2021	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
4	12/22/2021	55	106	51	62	62	37	45	60	42	56	45	12	92	16	69	85
5	12/23/2021	106	350	192	233	205	138	215	203	151	258	101	9.3	302	9	257	321
6	12/24/2021	120	281	282	131	462	101	448	471	105	423	208	NT	407	NT	475	490
7	12/27/2021	NT	240	79	160	141	99	180	181	106	160	118	NT	264	NT	265	157
8	12/29/2021	Wet	Wet	76	117	103	45	101	110	65	97	83	NT	203	NT	180	181
9	12/30/2021	Wet	Wet	74	109	85	45	87	87	47	86	73	Wet	142	Wet	155	153
10	12/31/2021	Wet	Wet	175	341	278	65	342	387	111	227	110	Wet	679	Wet	617	682
11	1/6/2022	Wet	614	238	426	415	95	497	544	133	118	139	Tight	618	Wet	527	627
12	1/12/2022	628	550	184	386	350	64	398	410	98	239	108	Tight	416	Tight	466	547
13	1/19/2022	654	531	148	313	343	65	316	344	89	177	108	Tight	439	Tight	597	622
14	1/26/2022	Wet	667	157	335	320	64	334	386	96	364	99	Tight	624	Tight	538	669
15	2/2/2022	Wet	598	159	391	389	41	400	414	75	219	78	Tight	673	Tight	432	701
16	2/9/2022	664	498	135	298	341	50	293	325	77	167	103	Tight	474	Tight	457	535
17	2/18/2022	369	295	77	187	181	30	186	180	35	181	60	Tight	254	Tight	230	259
18	2/23/2022	442	383	104	220	236	41	253	255	53	126	63	Tight	362	Tight	353	396
19	3/2/2022	508	424	125	290	298	37	307	330	66	142	72	Tight	437	Tight	401	440
20	3/16/2022	295	213	60	103	108	15	112	57	22	55	31	Tight	238	Tight	125	175
21	3/23/2022	169	150	45	129	77	31	97	123	34	37	24	Tight	158	Tight	81	120
22	3/30/2022	245	181	42	157	68	17	62	123	13	38	29	Tight	173	Tight	78	119
23	4/6/2022	192	89	32	83	57	15	88	133	17	61	23	Tight	171	Tight	96	139
24	4/13/2022	236	163	36	152	66	17	74	110	15	57	22	Tight	162	Tight	110	140
25	4/20/2022	227	136	34	139	59	14	80	101	16	42	13	Tight	146	Tight	97	135
26	4/27/2022	234	131	34	133	58	14	78	104	17	41	15	Tight	151	Tight	97	141
27	5/4/2022	272	147	30	134	53	35	78	118	42	55	37	Tight	157	Tight	92	119
28	5/9/2022	862	283	53	259	142	64	95	199	71	83	55	Tight	300	Tight	152	196
29	5/16/2022	254	145	19	143	72	30	37	99	30	37	29	Tight	158	Tight	77	88
30	5/23/2022	278	137	10	141	71	21	26	111	25	32	29	Tight	155	Tight	72	85
31	5/31/2022	244	116	11	116	48	17	12	94	18	28	19	Tight	124	Tight	50	66
32	6/6/2022	303	164	11	158	68	18	16	152	26	47	31	Tight	206	Tight	78	107
33	6/13/2022	350	156	16	175	87	14	6	129	19	26	14	Tight	160	Tight	78	90
34	6/20/2022	325	160	15	136	57	16	76	151	21	44	29	Tight	190	Tight	55	73
35	7/11/2022	435	262	95	289	61	6	164	330	14	47	23	Tight	437	Tight	94	124
36	8/8/2022	613	253	10	38	65	0	52	NA	14	82	34	Tight	504	Tight	140	124
37	9/12/2022	342	101	4	236	19	2	88	402	0	25	0	Tight	406	Tight	61	99
38	11/7/2022 *	80	13	13	124	6	10	17	307	2	23	6	Tight	202	Tight	35	39
39	11/14/2022 *	74	7	6	111	3	8	22	350	8	13	11	Tight	193	Tight	38	31
40	11/21/2022 *	62	9	7	100	7	20	4.1	325	7	26	10	Tight	176	Tight	25	27
41	11/28/2022 *	65	9	9	91	8	11	23	249	1	9	5	Tight	155	Tight	25	26
42	12/19/2022 *	31	6	4	78	6	5	0	334	14	24	18	Tight	136	Tight	24	18
43	12/27/2022 *	31	10	12	108	6	8	12	192	3	6	6	Tight	73	Tight	16	13

Event No	Date	[redacted]-175	[redacted] 200	[redacted] -200	[redacted]-225	[redacted] 250	[redacted]-275	[redacted] -300	[redacted] 300	[redacted]-325	[redacted] -350	[redacted] 350	[redacted]-375	[redacted]-375-05.0	[redacted] 400	[redacted] 425	[redacted]-450
1	12/17/2021	69	56	51	13	27	36	56	51	47	36	47	288	NA	2.3	NA	NA
2	12/20/2021	42	57	69	7	38	58	43	75	142	275	246	290	NA	15	NA	NA
3	12/21/2021	NT	71	78	15	66	68	66	76	72	76	87	181	NA	17	NA	NA
4	12/22/2021	36	36	45	7	30	50	23	35	49	41	49	96	NA	18	NA	NA
5	12/23/2021	112	73	157	4	102	121	85	120	163	228	196	407	NA	24	NA	NA
6	12/24/2021	71	116	374	NT	97	408	197	73	139	409	155	450	NA	17	NA	NA
7	12/27/2021	66	49	53	NT	36	52	24	36	38	58	26	443	NA	14	NA	NA
8	12/29/2021	53	37	85	Wet	52	68	28	14.2	86	125	81	128	NA	2	NA	NA
9	12/30/2021	52	46	82	Wet	56	62	41	54	73	66	88	82	NA	2	NA	NA
10	12/31/2021	114	146	403	Wet	228	308	80	135	377	365	408	444	NA	14	NA	NA
11	1/6/2022	358	158	422	Wet	196	370	74	167	399	342	381	410	NA	8	NA	NA
12	1/12/2022	74	105	342	Tight	174	338	51	132	328	318	401	396	NA	1	1	1
13	1/19/2022	89	138	312	Tight	160	277	66	134	338	349	450	408	NA	69	55	52
14	1/26/2022	93	81	336	Tight	151	291	53	123	339	352	367	416	NA	3	1	1
15	2/2/2022	109	105	362	Tight	152	365	61	105	374	400	392	399	NA	1	1	2
16	2/9/2022	85	71	283	Tight	151	268	42	127	312	251	399	397	NA	1	1	1
17	2/18/2022	21	33	140	Tight	49	69	16	41	80	81	115	91	NA	1	1	1
18	2/23/2022	22	221	213	Tight	68	113	34	68	138	133	157	152	NA	1	1	1
19	3/2/2022	53	48	235	Tight	113	147	34	90	219	188	245	248	NA	2	2	2
20	3/16/2022	56	28	134	Tight	63	145	42	72	115	95	98	79	124	1	1	1
21	3/23/2022	27	30	99	Tight	53	112	22	67	114	76	100	59	106	1	1	1
22	3/30/2022	46	21	101	Tight	53	78	19	54	114	89	125	57	123	0	0	0
23	4/6/2022	14	20	87	Tight	59	96	21	65	121	87	120	51	117	1	1	1
24	4/13/2022	13	19	83	Tight	50	86	18	58	121	91	97	66	100	0	0	0
25	4/20/2022	17	18	83	Tight	41	68	20	47	103	85	98	52	108	1	1	1
26	4/27/2022	18	17	79	Tight	44	76	15	44	92	79	104	56	113	0	0	0
27	5/4/2022	12	14	69	Tight	35	47	17	38	90	59	86	69	107	1	1	1
28	5/9/2022	18	24	130	Tight	56	75	24	62	156	102	137	129	189	2	2	2
29	5/16/2022	3	6	65	Tight	25	35	15	34	77	54	76	66	95	0	0	0
30	5/23/2022	3	4	58	Tight	23	31	10	26	70	53	79	71	92	0	0	0
31	5/31/2022	2	4	47	Tight	17	22	10	21	63	48	70	70	83	0	0	0
32	6/6/2022	6	9	59	Tight	19	24	12	25	77	30	53	34	47	0	0	0
33	6/13/2022	5	8	62	Tight	18	23	7	25	79	58	80	53	81	0	0	1
34	6/20/2022	6	7	58	Tight	14	17	6	19	61	38	43	85	89	1	1	1
35	7/11/2022	0	0	74	Tight	20	23	15	27	134	96	149	176	210	0	0	0
36	8/8/2022	0	5	90	Tight	24	24	20	41	166	138	56	300	320	0	0	0
37	9/12/2022	0	3	45	Tight	53	9	8	24	78	80	132	137	NA	0	0	0
38	11/7/2022 *	0	2	23	Tight	26	222	2	14	69	53	79	82	NA	0	0	0
39	11/14/2022 *	4	5	24	Tight	19	210	12	15	81	60	91	89	78	1	1	1
40	11/21/2022 *	6	7	27	Tight	14	156	4	7	39	44	15	54	26	1	0	1
41	11/28/2022 *	0	2	14	Tight	10	100	5	5	40	24	39	52	22	0	0	0
42	12/19/2022 *	6	3	17	Tight	11	124	3	4	37	27	55	68	22	1	0	1
43	12/27/2022 *	5	4	17	Tight	9	113	3	5	30	22	50	37	19	0	0	0

[redacted]

Event No.	Date	[redacted]+500	[redacted]+475	[redacted]+450	[redacted]+425	[redacted]+400	[redacted] +375	[redacted]+375
1	12/17/2021	33	4	3	20	55	120	92
2	12/20/2021	96	56	54	86	244	350	269
3	12/21/2021	NT	NT	NT	NT	NT	NT	NT
4	12/22/2021	56	41	43	50	64	115	114
5	12/23/2021	193	145	160	178	215	405	408
6	12/24/2021	122	76	82	96	101	201	244
7	12/27/2021	NT	90	113	159	134	239	281
8	12/29/2021	Wet	39	44	48	81	196	193
9	12/30/2021	Wet	43	47	55	63	109	157
10	12/31/2021	Wet	38	45	62	85	785	673
11	1/6/2022	Wet	45	53	70	97	560	474
12	1/12/2022	107	38	45	57	72	486	263
13	1/19/2022	Wet	42	54	59	72	458	163
14	1/26/2022	291	30	37	50	64	683	225
15	2/2/2022	444	17	21	27	36	438	144
16	2/9/2022	112	26	31	42	67	384	169
17	2/18/2022	118	27	33	40	55	239	136
18	2/23/2022	70	25	30	40	50	323	124
19	3/2/2022	148	36	40	49	73	405	187
20	3/16/2022	83	9	9	12	15	193	82
21	3/23/2022	28	9	12	15	21	151	58
22	3/30/2022	75	7	8	9	13	151	53
23	4/6/2022	46	14	17	21	26	85	49
24	4/13/2022	76	9	11	12	17	141	53
25	4/20/2022	70	8	9	10	12	129	51
26	4/27/2022	68	9	12	15	18	126	52
27	5/4/2022	12	8	10	11	16	128	57
28	5/9/2022	20	19	24	23	29	249	102
29	5/16/2022	4	6	5	7	10	146	49
30	5/23/2022	0	3	4	6	7	143	42
31	5/31/2022	1	3	4	7	10	123	35
32	6/6/2022	4	4	7	9	15	180	49
33	6/13/2022	8	9	12	13	16	179	44
34	6/20/2022	13	9	10	13	15	153	46
35	7/11/2022	1	1	4	6	11	280	43
36	8/8/2022	0	4	66	6	13	376	41
37	9/12/2022	0	0	0	0	0	159	85
38	11/7/2022 *	0	0	0	0	5	37	8
39	11/14/2022 *	21	7	7	8	10	51	14
40	11/21/2022 *	9	0	0	6	6	39	10
41	11/28/2022 *	17	1	2	6	5	36	7
42	12/19/2022 *	8	5	4	3	4	12	5
43	12/27/2022 *	17	2	3	3	7	23	5

Date	2S+300	2S+275	2S+250	2S+225	2S+200	2S+175	2S+150	2S+125	2S+100	1S+038	1S+068	2S+075	2S+075-05.0	2S+050	2S+025
12/17/2021	NA	NA	NA	33	20	40	79	69	49	13	33	89	NA	90	59
12/20/2021	NA	NA	NA	37	39	82	84	83	473	16	21	525	NA	135	110
12/21/2021	NA	NA	NA	42	40	68	43	86	189	NT	NT	238	NA	86	94
12/22/2021	NA	NA	NA	25	28	35	38	38	83	20	28	81	NA	65	39
12/23/2021	NA	NA	NA	82	87	133	132	142	241	81	92	252	NA	192	205
12/24/2021	NA	NA	NA	39	76	127	133	57	260	58	76	577	NA	269	42
12/27/2021	NA	NA	NA	6	35	66	70	67	128	42	43	158	NA	68	39
12/29/2021	NA	NA	NA	23	29	23	29	16	146	27	Wet	143	NA	151	119
12/30/2021	NA	NA	NA	40	36	36	33	32	138	68	58	144	NA	137	103
12/31/2021	NA	NA	NA	58	45	120	99	39	485	65	95	577	NA	536	402
1/6/2022	NA	NA	NA	70	50	112	103	39	521	65	92	607	NA	531	488
1/12/2022	12	12	15	34	41	94	102	84	435	17	19	490	NA	400	376
1/19/2022	1	1	1	1	2	30	43	10	395	79	103	457	NA	378	402
1/26/2022	18	20	20	26	34	66	78	80	444	22	22	510	NA	421	354
2/2/2022	6	5	5	6	12	13	33	31	454	8	9	569	NA	490	56
2/9/2022	11	12	3	15	26	43	54	59	448	15	15	496	NA	394	309
2/18/2022	6	6	7	9	13	17	24	28	149	9	9	281	NA	118	84
2/23/2022	7	7	8	11	17	17	23	32	227	11	11	316	NA	172	121
3/2/2022	11	11	14	17	22	36	49	55	338	16	16	422	NA	260	217
3/16/2022	3	3	4	8	10	14	19	21	236	5	7	249	55	174	126
3/23/2022	4	4	6	6	9	14	19	26	219	7	7	369	67	117	86
3/30/2022	3	3	4	6	8	13	17	21	218	5	6	290	50	121	100
4/6/2022	3	3	4	6	9	12	15	22	248	5	5	411	52	130	96
4/13/2022	3	3	4	5	8	12	14	20	228	5	5	358	43	131	90
4/20/2022	3	4	4	6	9	12	14	28	207	6	5	302	36	103	74
4/27/2022	3	3	4	5	8	11	13	20	194	6	5	333	39	105	73
5/4/2022	5	4	8	6	6	11	12	17	155	5	5	278	71	91	68
5/9/2022	6	6	7	9	11	21	22	36	326	8	9	460	120	169	116
5/16/2022	0	0	0	0	1	5	4	8	146	0	1	238	52	74	53
5/23/2022	0	0	0	0	1	4	5	14	150	0	0	229	55	93	56
5/31/2022	0	0	0	0	1	4	5	9	124	0	0	192	48	74	48
6/6/2022	0	0	0	0	4	7	7	8	130	0	0	177	63	101	63
6/13/2022	2	2	2	4	3	7	8	8	118	3	3	170	66	102	57
6/20/2022	2	2	2	3	4	6	6	13	125	4	4	175	48	67	38
7/11/2022	0	0	0	0	0	0	0	12	188	0	0	286	96	161	68
8/8/2022	0	0	0	0	0	5	7	16	273	0	0	334	114	188	90
9/12/2022	0	0	0	0	0	0	0	4	137	0	0	182	50	102	36
11/7/2022 *	0	0	0	0	1	3	4	11	102	0	0	121	33	62	29
11/14/2022 *	0	0	0	0	0	3	4	8	97	0	0	89	35	55	26
11/21/2022 *	2	2	2	2	3	4	5	9	85	4	3	80	25	43	17
11/28/2022 *	0	0	0	0	1	2	4	16	97	0	0	48	14	27	11
12/19/2022 *	0	0	0	0	1	1	3	6	84	0	2	51	16	29	11
12/27/2022 *	3	3	3	3	5	6	7	10	60	3	2	59	17	27	11

Figure 3c. **Soil Vapor Monitoring Point Results**
December 17, 2021 - December 27, 2022
[redacted] Tunnel and Pearl Harbor Tunnel

Notes
* denotes out-of-frequency sampling events that were conducted in response to a significant rain event that exceeded 1 inch in 24 hours. An additional follow-up sampling event is conducted 7 days after the initial event.
NA = not analyzed

Scale
ppmv
862
650
550
450
350
250
150
50
0

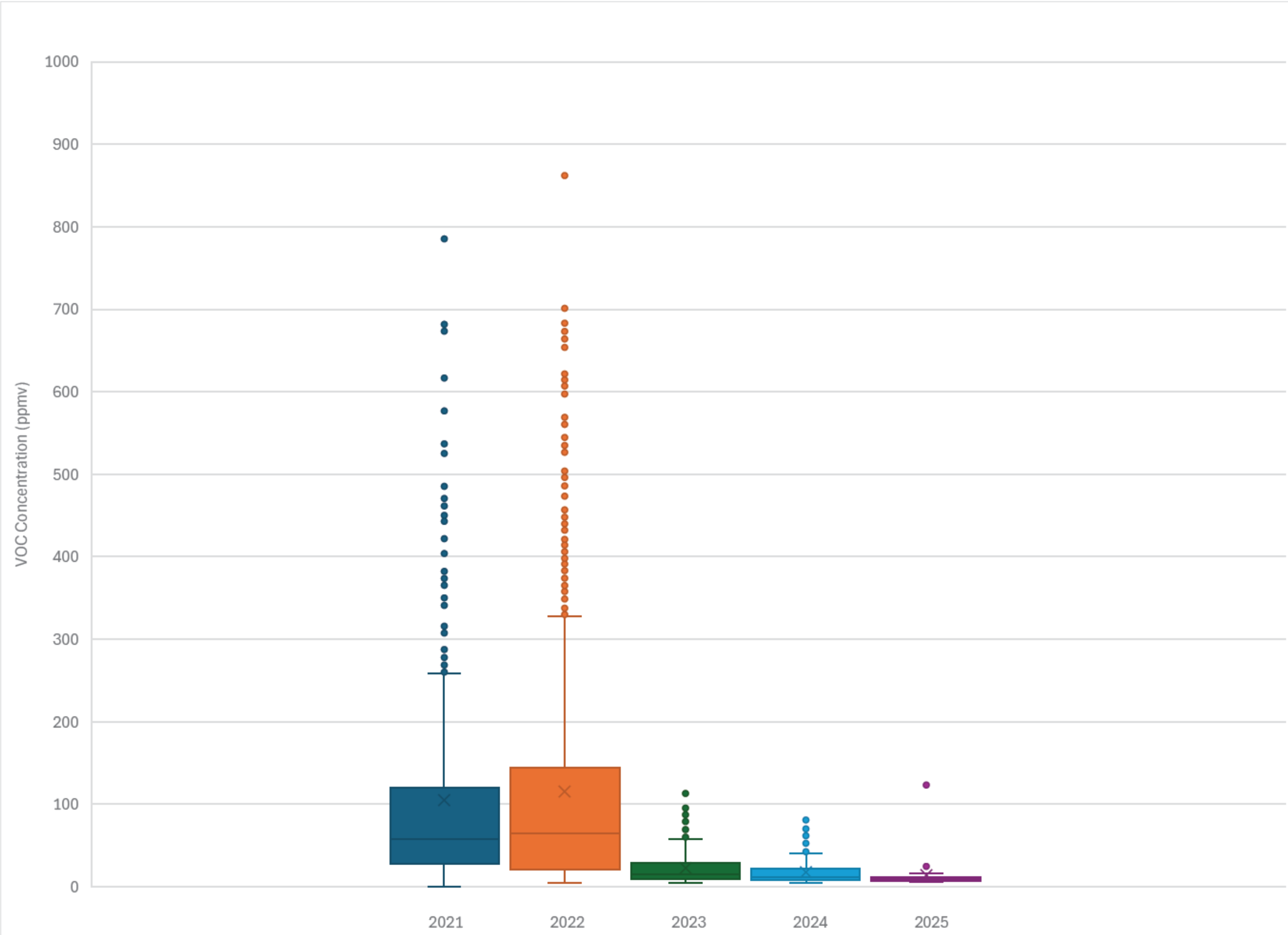


Figure 4
Subslab SVMP Concentrations above 5 ppmv
Soil Vapor Monitoring and LNAPL Gauging Reduction
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

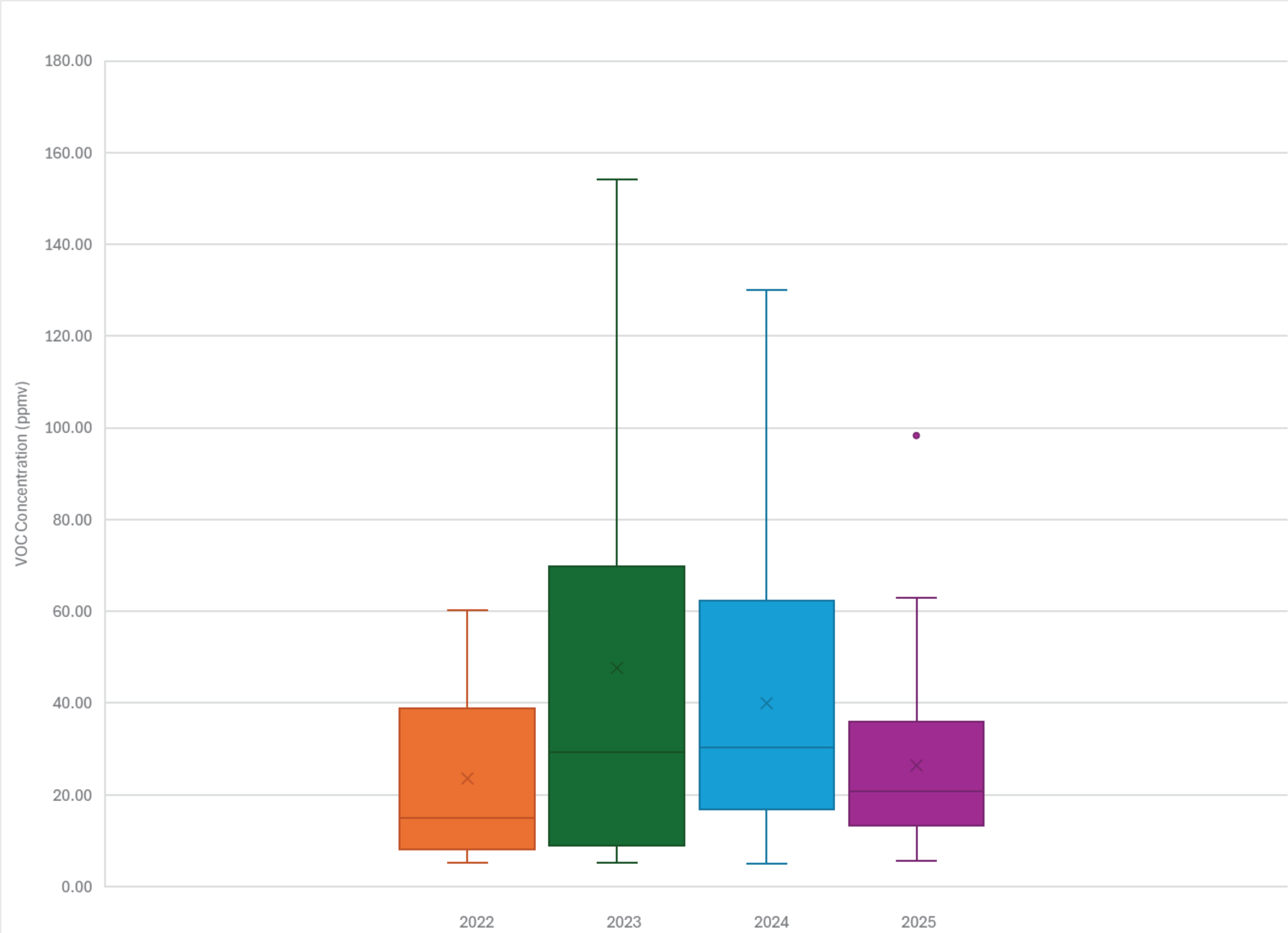


Figure 5
DSVMP VOC Concentrations above 5 ppmv
Soil Vapor Monitoring and LNAPL Gauging Reduction
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

Appendix A:
Precipitation Monitoring Memorandum for Subslab Soil Vapor Monitoring Points

Precipitation Monitoring Memorandum for Sub-Slab Soil Vapor Monitoring Points

[redacted] Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, Hawai‘i

Naval Facilities Engineering Command, Hawaii, JBPHH HI, July 2022

1. Background & Purpose

Sub-slab soil vapor monitoring points (SVMPs) were installed to provide a long-term trend evaluation tool to help identify significant changes in the location and concentration of Jet Propellant No. 5 (JP-5) directly below the impacted areas of the [redacted] tunnels. Semi-quantitative hand-held continuous read-out detectors (photoionization detectors [PIDs]) are used to measure these organic vapor concentrations resulting from the November 2021 release. SVMPs can be monitored over time to evaluate changes in conditions at each location, which can support assessment of light nonaqueous-phase liquid (LNAPL) migration and degradation over time (contaminant fate and transport), which in turn can be used for modeling.

Subslab SVMP PID readings were collected weekly between December 25, 2021, and June 20, 2022 at the SVMPs shown on Figure 1. Based on a collaborative agreement with the Hawai‘i Department of Health (DOH), the Navy reduced the monitoring frequency to monthly in June 2022. This agreement included the requirement for out-of-frequency subslab SVMP sampling whose conduct would be determined by significant rain events, with criteria and sampling requirements described below.

[redacted]

Figure 1: [redacted] Tunnels SVMP Locations

The purpose of conducting out-of-frequency subslab SVMP sampling based on the occurrence of a significant rain event is to allow the Navy and regulatory agencies to assess the effect of precipitation and infiltration of meteoric water through the stratigraphy surrounding the portions of the tunnels that were impacted by the November 20, 2021 JP-5 release. An extended rain event in the study area in late December 2021 and early January 2022 coincided with observable changes in the SVMP organic vapor concentrations, which has been deemed worthy of additional assessment.

1.1 Qualified Significant Rain Event

The agreement between the Navy and DOH defines a qualified significant rain event as a rain event that:

- Is monitored using National Oceanic and Atmospheric Administration (NOAA)/ National Weather Service (NWS) rain gauge MOAH1 (HI19), location identification (ID) Moanalua 2N (Figure 2);
- Equals or exceeds 1 inch of precipitation within a continuous 24-hour period; and
- Occurs at least 72 hours from the end of a previous significant rain event.

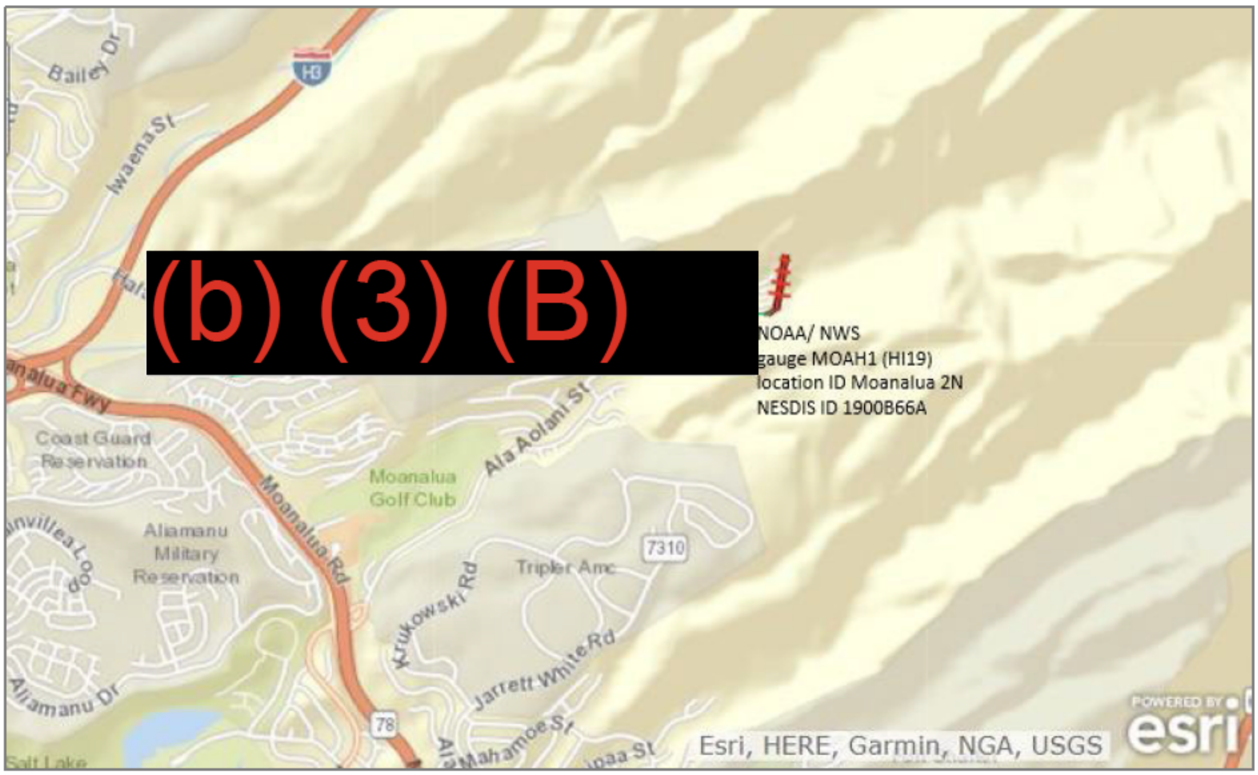


Figure 2: Rain Gauge MOAH1 Location

The NOAA/ NWS MOAH1 rain gauge was chosen based on its proximity to the study area, similar elevation, distance from the coast, and from the adjacent Ko'olau summit. The rain gauge will be monitored every weekday, Monday through Friday, except on holidays.

1.2 Monitoring Criteria

The agreement between the Navy and DOH included specific requirements associated with out-of-frequency sampling events that determine when the sampling event will occur. After a qualified significant rain event is documented, two sampling events will be conducted:

- The first sampling event will occur within 5 days of the qualified significant rain event (as dictated by weekend/holiday dates) with preference for sampling within 48 hours of the 1-inch exceedance.
- The second sampling event will occur between 5 and 7 days following the first sampling event.
- Sampling will occur during normal business hours (between 7:00 AM and 5:00 PM Hawaii Time, Monday through Friday).
- Sampling will not be required during holidays, weekends, after hours, or any time that professional judgement deems the task unsafe.
- When a qualified significant rain event has been identified:
  - AECOM will communicate with the field team to set up the collection event as soon as possible, not to exceed 5 days from the initial exceedance of the associated rain event.
  - An email correspondence will be delivered to the Navy indicating a soil vapor monitoring event has been initiated.
  - Results will be submitted with the regular monthly reporting of the sub-slab SVMP measurements.
  - AECOM will conduct the soil vapor monitoring from the following locations:
    - Sub-slab SVMPs
    - Installed near-surface SVMPs (2S+75, [redacted]-375)
    - Other SVMPs not currently installed, as determined by the Navy

1.3 RAIN GAUGE DATA COLLECTION AND REDUCTION

An analyst will download the most recent precipitation data from the NOAA/ NWS website NOAA/ NWS Rain Gauge MOAH1 (Figure 3), and the data will be uploaded into an Excel spreadsheet managed by AECOM. The Excel spreadsheet will be updated Monday thru Friday and viewed to determine if a significant rain event occurred since the previous data set was obtained.

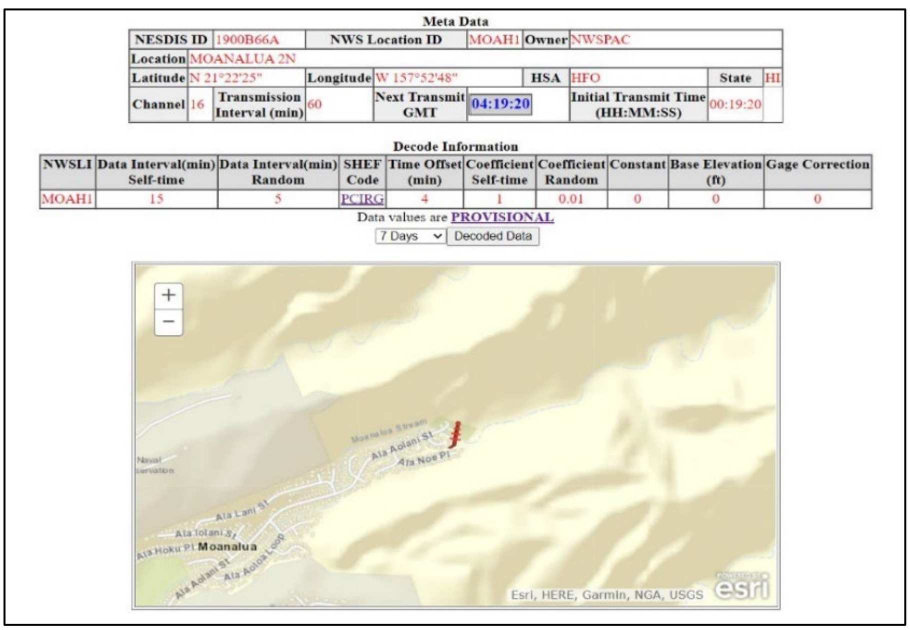


Figure 3: Screen Shot Example of Gauge Webpage

2. Data Collection Procedure

The data are retrieved from a table located on the NOAA/ NWS website by selecting the quantity of data previously recorded from the drop-down menu then pressing the "Decoded Data" button.

The data table (Figure 4) reports observed time as (Observation Time) in Greenwich Mean Time (GMT) and annual accumulated precipitation in inches (AnnualAccumPrecip) as PC (MOAHI).

Data values are PROVISIONAL and have not been reviewed.

1900B66A
MOANALUA 2N

Observation Time Reverse Order	**PC** (MOAH1) Graph
2022-07-08 00:20	26.28 R
2022-07-08 00:30	26.28
2022-07-08 00:45	26.28
2022-07-08 01:00	26.28
2022-07-08 01:15	26.28
2022-07-08 01:30	26.28
2022-07-08 01:45	26.28
2022-07-08 02:00	26.28
2022-07-08 02:15	26.28
2022-07-08 02:30	26.28
2022-07-08 02:45	26.28
2022-07-08 03:00	26.28
2022-07-08 03:15	26.28

**R - Random data message*
**P - Parity error in data*
**Q - Data are questionable. Use best judgement*

Figure 4: Screen Shot Data Table Example

1. A table with the data populates and is available for copy and paste commands.
2. After the data are transferred into the Excel spreadsheet (NOAA/ NWS MOAH1 Rain Gauge Spreadsheet), a quality assurance check will be performed to validate the precipitation values:
   a. If a value is highlighted, flagged, and recorded outside the expected 15-minute interval, the value needs to be deleted.
   b. If the reading is flagged on the expected time record and fits with the anticipated data set, the value needs to be preserved.
3. The observed time GMT is converted to Honolulu Standard Time (HST) using the equation:

$$GMT - (10/24)$$

4. The accumulated precipitation is used to calculate the rolling total precipitation in a 24-hour period (24-hrAccumPrecip) with the equation:

$$24\text{-}hrAccumPrecip = AnnualAccumPrecip_{(i+24hr)} - AnnualAccumPrecip_{(i)},$$

Where:

$AnnualAccumPrecip_{(i)}$ is the annual accumulated rain recorded on the rain gauge at time i, and

$AnnualAccumPrecip_{(i+24hr)}$ is the annual accumulated rain recorded on the rain gauge at time i+24 hours.

5. Within the Excel spreadsheet, a chart has been developed to track the inches of rain accumulated in a 24-hour period and the total annual accumulated precipitation in inches versus time (see Figure 5).
6. If the blue line in Figure 5 exceeds the value of 1 on the left axis (Rolling Total Precipitation (in/24-hrs), the 1-inch/24 hour significant storm event threshold has been exceeded:
   a. The AECOM Project Manager and field team will be informed and will prepare for sampling.
   b. The AECOM Project Manager will inform the Navy Point of Contact.

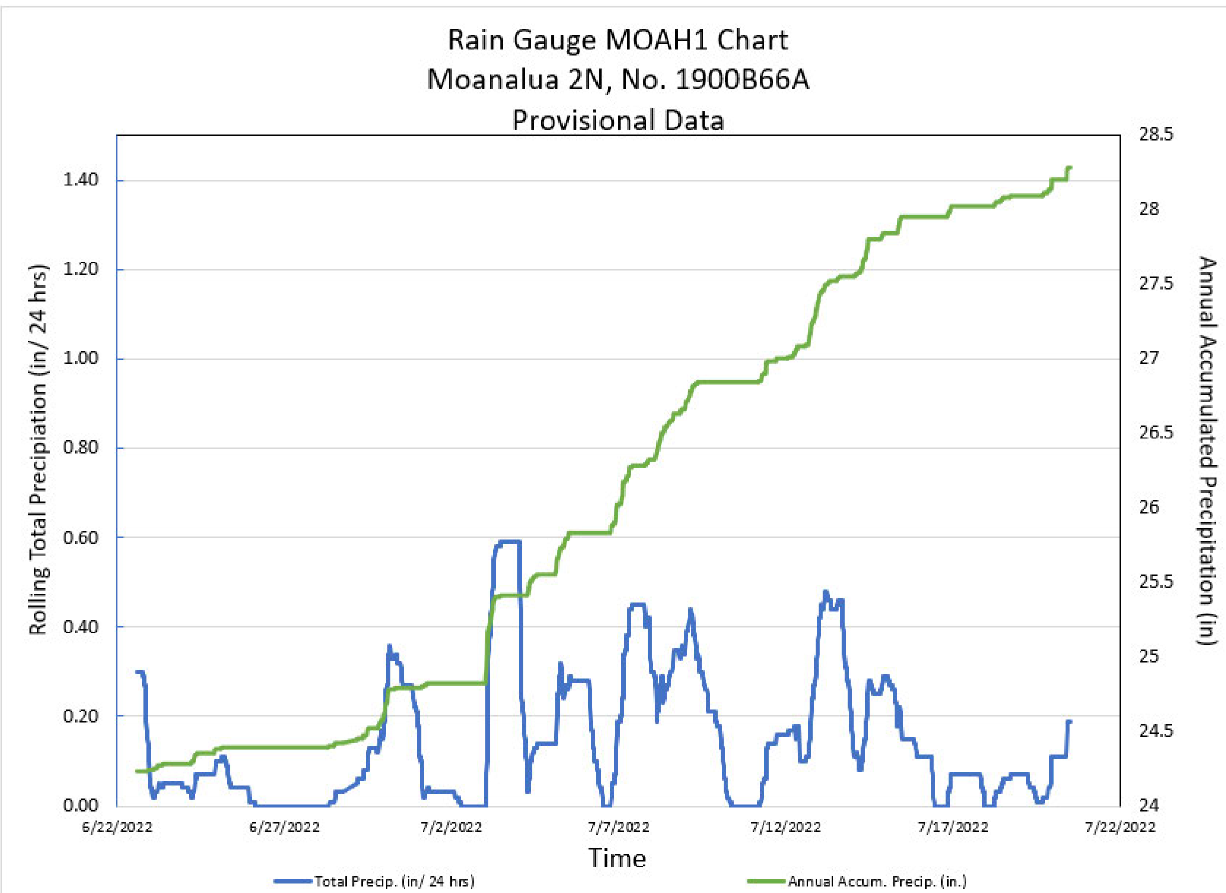


Figure 5: Rain Gauge Accumulation Chart, 24-hour and Annual Accumulation

Appendix B:
Soil Vapor Monitoring and
LNAPL Gauging Point Construction

Table B-1: Current Deep and Intermediate Soil Vapor Monitoring Locations as of October 2025

Point Name	Total Vapor Screens Installed	Vapor Screen Depths (ft btf)	Coordinates		
			X SP (ft)	Y SP (ft)	Elevation (ft amsl)
1S+075-DSVMP	4	12.6	[redacted]		
		29.0			
		39.0			
		57.8			
2S+040-DSVMP	5	12.45			
		27.75			
		41.25			
		51.25			
		60.25			
[redacted]-010-DSVMP	3	40.0			
		48.5			
		62.0			
[redacted]-075-DSVMP	6	17.25			
		26.75			
		35.25			
		43.75			
		53.75			
		70.47			
[redacted]-110-DSVMP	6	18.75			
		23.75			
		28.75			
		35.75			
		40.25			
		45.35			
[redacted]-175-DSVMP	6	20.25			
		26.75			
		42.25			
		52.75			
		63.25			
		69.25			
[redacted]-210-DSVMP	6	19.25			
		25.25			
		44.25			
		55.25			
		69.25			
		73.25			
[redacted]-290-DSVMP	5	17.25			
		26.75			
		47.25			
		60.25			
		71.25			

Point Name	Total Vapor Screens Installed	Vapor Screen Depths (ft btf)	Coordinates		
			X SP (ft)	Y SP (ft)	Elevation (ft amsl)
[redacted]-375-DSVMP	4	12.5	[redacted]	[redacted]	[redacted]
		34.5			
		47.5			
		63.5			
[redacted]+215-ISVMP	1	26.3	[redacted]	[redacted]	[redacted]
[redacted]+315-ISVMP	2	27.3	[redacted]	[redacted]	[redacted]
		37.6			

amsl above mean sea level
btf below tunnel floor
DSVMP deep soil vapor monitoring point
ft foot or feet
ISVMP intermediate soil vapor monitoring point
X SP horizontal coordinate in the state plane system
Y SP vertical coordinate in the state plane system

Table B-2: Current Subslab Soil Vapor Monitoring Locations as of October 2025

Point Name	Approximate SVMP Depth (ft btf)	Coordinates		
		X SP (ft)	Y SP (ft)	Elevation (ft amsl)
1S+038-SVMP	0.5	(b) (3) (B) [redacted]		
1S+068-SVMP	0.5			
2S+025-SVMP	0.5			
2S+050-SVMP	0.5			
2S+075-SVMP	0.5			
2S+075-05.0-SVMP	5.0			
2S+100-SVMP	0.5			
2S+125-SVMP	0.5			
2S+150-SVMP	0.5			
2S+175-SVMP	0.5			
2S+200-SVMP	0.5			
2S+225-SVMP	0.5			
2S+250-SVMP	0.5			
2S+275-SVMP	0.5			
2S+300-SVMP	0.5			
(b) (3) (B) [redacted]050-SVMP	0.5			
[redacted]100-SVMP	0.5			
[redacted]150-SVMP	0.5			
[redacted]200-SVMP	0.5			
[redacted]250-SVMP	0.5			
[redacted]300-SVMP	0.5			
[redacted]400-SVMP	0.5			
[redacted]425-SVMP	0.5			
[redacted]450-SVMP	0.5			
[redacted]475-SVMP	0.5			
[redacted]500-SVMP	0.5			
[redacted]025-SVMP	0.5			
[redacted]075-SVMP	0.5			
[redacted]100-SVMP	0.5			
[redacted]125-SVMP	0.5			
[redacted]175-SVMP	0.5			
[redacted]225-SVMP	0.5			
[redacted]250-SVMP	0.5			
[redacted]275-SVMP	0.5			
[redacted]325-SVMP	0.5			
[redacted]375-SVMP	0.5			
[redacted]375-05.0-SVMP	5.0			
[redacted]400-SVMP	0.5			
[redacted]425-SVMP	0.5			
[redacted]450-SVMP	0.5			
[redacted]+000-SVMP	0.5			
[redacted]+375-SVMP	0.5			
[redacted]-050-SVMP	0.5			

Point Name	Approximate SVMP Depth (ft btf)	Coordinates		
		X SP (ft)	Y SP (ft)	Elevation (ft amsl)
[redacted]-150-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-200-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-300-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-350-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]+000-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]+375-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-050-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-150-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-200-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-300-SVMP	0.5	[redacted]	[redacted]	[redacted]
[redacted]-350-SVMP	0.5	[redacted]	[redacted]	[redacted]

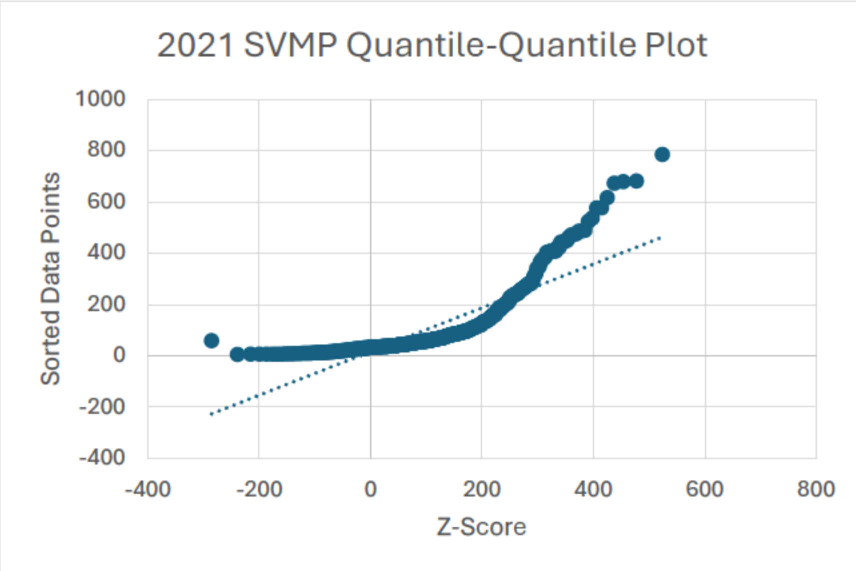
amsl above mean sea level
btf below tunnel floor
ft foot or feet
SVMP soil vapor monitoring point
X SP horizontal coordinate in the state plane system
Y SP vertical coordinate in the state plane system

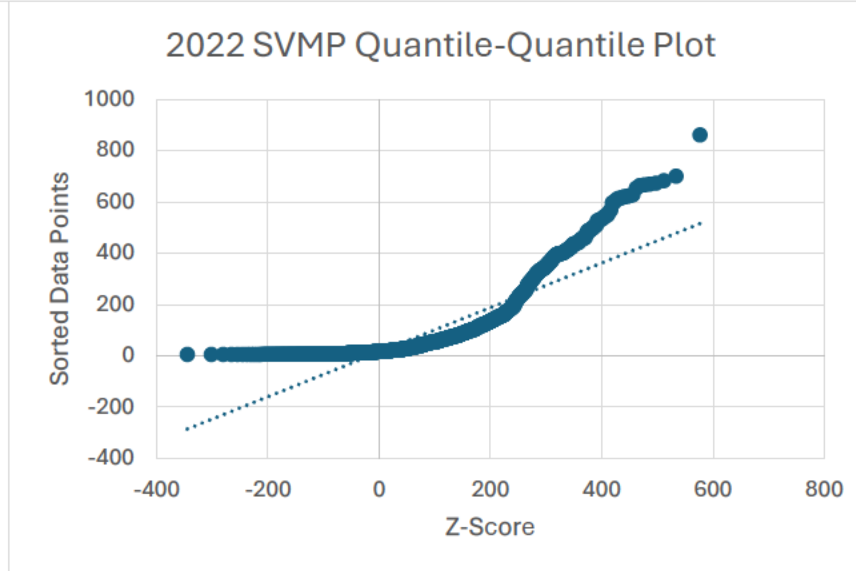
Table B-3: Current LNAPL Gauging Locations as of October 2025

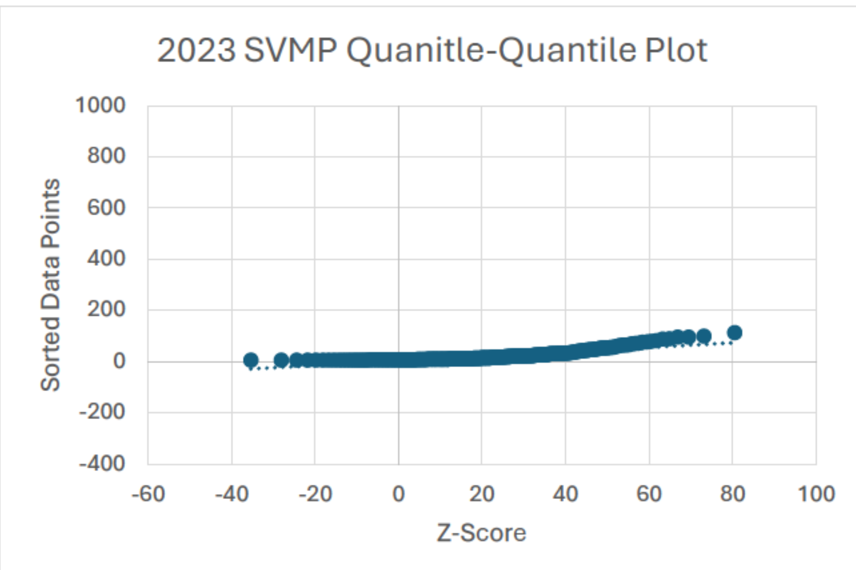
Location	Location Type	Approximate Depth (ft btf)	Coordinates		
			X SP (ft)	Y SP (ft)	Elevation (ft amsl)
1S+025-BH	Borehole	1.1	(b) (3) (B) [redacted]	[redacted]	[redacted]
2S+025-BH	Borehole	5.3	[redacted]	[redacted]	[redacted]
2S+100-BH	Borehole	1.5	[redacted]	[redacted]	[redacted]
2S+150-BH	Borehole	5.4	[redacted]	[redacted]	[redacted]
(b) (3) (B) [redacted]+015-TW	Temporary Well	6.1	[redacted]	[redacted]	[redacted]
[redacted]+050-TW	Temporary Well	6.0	[redacted]	[redacted]	[redacted]
[redacted]+087-BH	Borehole	5.9	[redacted]	[redacted]	[redacted]
[redacted]+150-BH	Borehole	4.2	[redacted]	[redacted]	[redacted]
[redacted]+210-TW	Temporary Well	6.2	[redacted]	[redacted]	[redacted]
[redacted]+325-TW	Temporary Well	6.3	[redacted]	[redacted]	[redacted]
[redacted]+375-TW	Temporary Well	6.4	[redacted]	[redacted]	[redacted]
[redacted]-010-TW	Temporary Well	5.9	[redacted]	[redacted]	[redacted]
[redacted]-040-TW	Temporary Well	6.1	[redacted]	[redacted]	[redacted]
[redacted]-050-BHO	Borehole	5.6	[redacted]	[redacted]	[redacted]
[redacted]-090-BH	Borehole	5.5	[redacted]	[redacted]	[redacted]
[redacted]-100-BH	Borehole	5.3	[redacted]	[redacted]	[redacted]
[redacted]-110-BH	Borehole	5.5	[redacted]	[redacted]	[redacted]
[redacted]-150-BH	Borehole	4.8	[redacted]	[redacted]	[redacted]
[redacted]-200-BH	Borehole	5.6	[redacted]	[redacted]	[redacted]
[redacted]-240-BH	Borehole	5.3	[redacted]	[redacted]	[redacted]
[redacted]-250-BH	Borehole	5.6	[redacted]	[redacted]	[redacted]
[redacted]-300-BH	Borehole	4.9	[redacted]	[redacted]	[redacted]
[redacted]-350-BH	Borehole	1.6	[redacted]	[redacted]	[redacted]

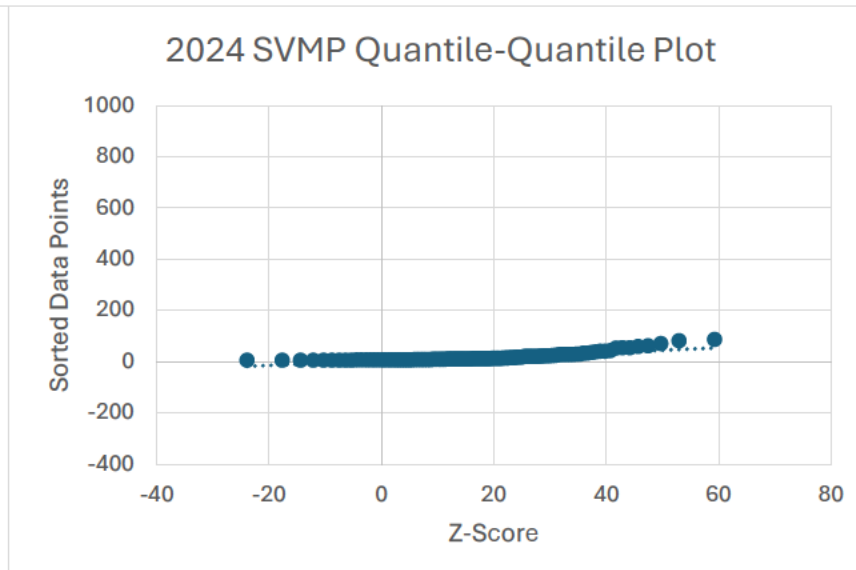
amsl above mean sea level
BH borehole
BHO borehole offset
btf below tunnel floor
ft foot or feet
TW temporary well
X SP horizontal coordinate in the state plane system
Y SP vertical coordinate in the state plane system

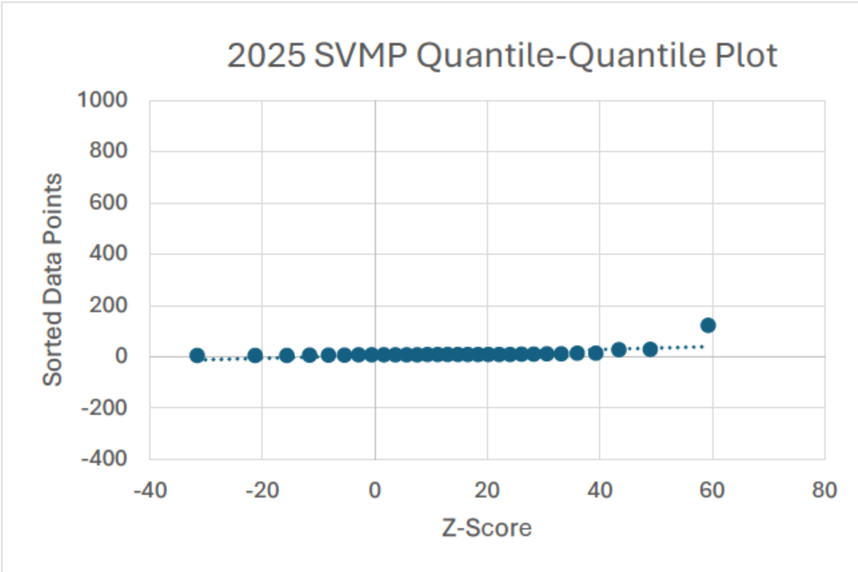
Appendix C:
Soil Vapor Monitoring Quantile-Quantile Plots

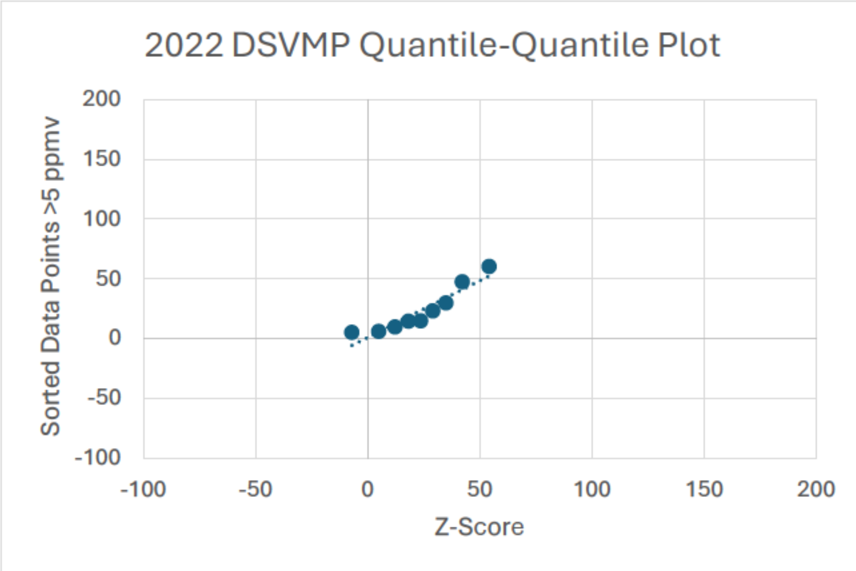

2021 SVMP Quantile-Quantile Plot
Sorted Data Points
Z-Score
1000
800
600
400
200
0
-200
-400
-400
-200
0
200
400
600
800

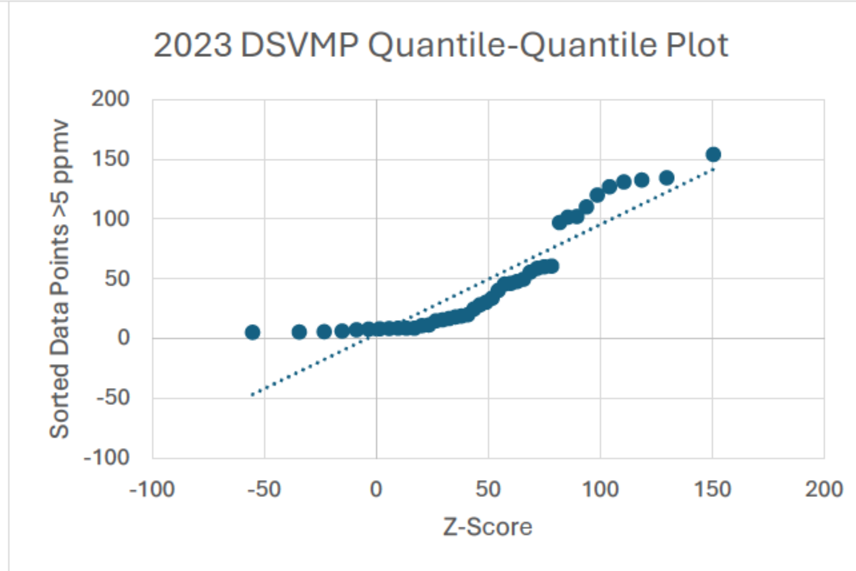

2022 SVMP Quantile-Quantile Plot
Sorted Data Points
Z-Score
1000
800
600
400
200
0
-200
-400
-400
-200
0
200
400
600
800

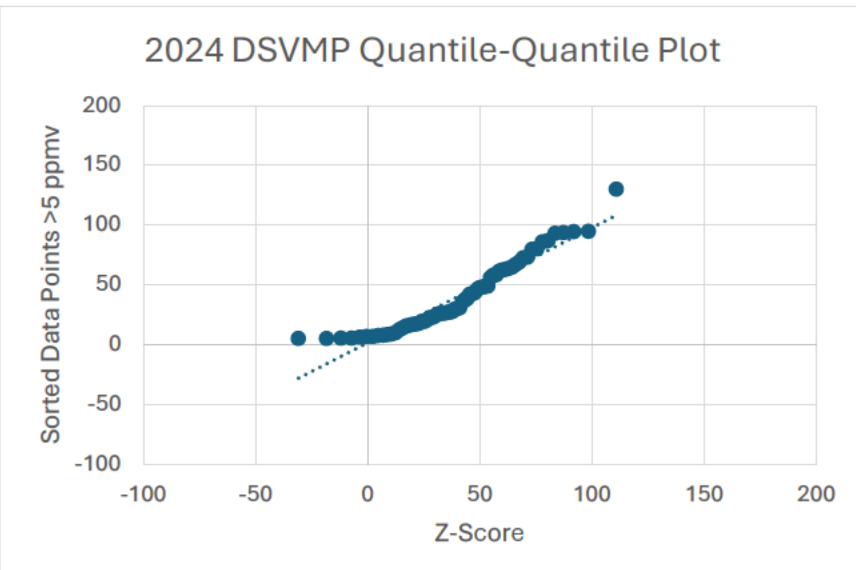

2023 SVMP Quanitle-Quantile Plot
Sorted Data Points
Z-Score
1000
800
600
400
200
0
-200
-400
-60
-40
-20
0
20
40
60
80
100

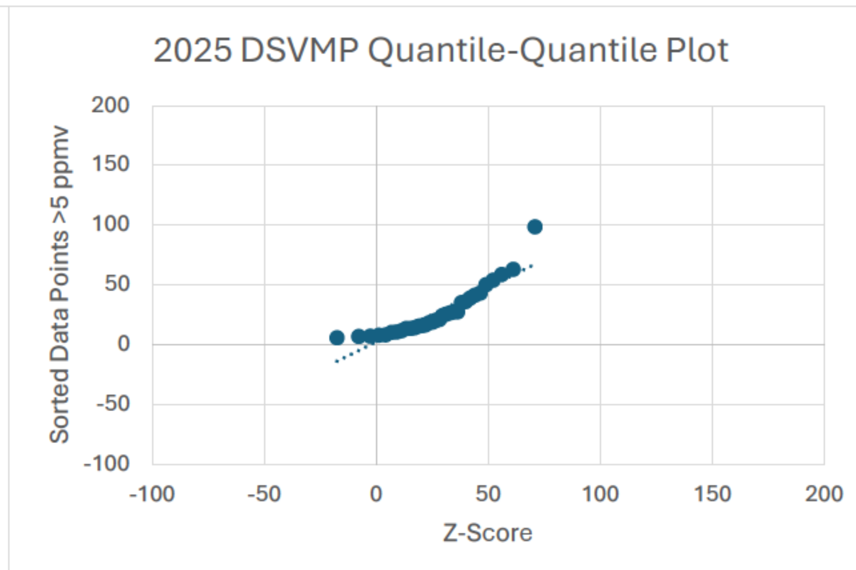

2024 SVMP Quantile-Quantile Plot
Sorted Data Points
Z-Score
1000
800
600
400
200
0
-200
-400
-40
-20
0
20
40
60
80


2025 SVMP Quantile-Quantile Plot
Sorted Data Points
1000
800
600
400
200
0
-200
-400
-40
-20
0
20
40
60
80
Z-Score


2022 DSVMP Quantile-Quantile Plot
Sorted Data Points >5 ppmv
Z-Score
200
150
100
50
0
-50
-100
-100
-50
0
50
100
150
200


2023 DSVMP Quantile-Quantile Plot
Sorted Data Points >5 ppmv
Z-Score
200
150
100
50
0
-50
-100
-100
-50
0
50
100
150
200


2024 DSVMP Quantile-Quantile Plot
Sorted Data Points >5 ppmv
Z-Score
200
150
100
50
0
-50
-100
-100
-50
0
50
100
150
200


2025 DSVMP Quantile-Quantile Plot
Sorted Data Points >5 ppmv
Z-Score
200
150
100
50
0
-50
-100
-100
-50
0
50
100
150
200

Appendix D:
Akritas-Theil-Sen Trend Test Results

Appendix D.1:
SVMP Akritas-Theil-Sen Trend Test Results

CTO 24F0224_SV 1S+038-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-02

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for 1S+038-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

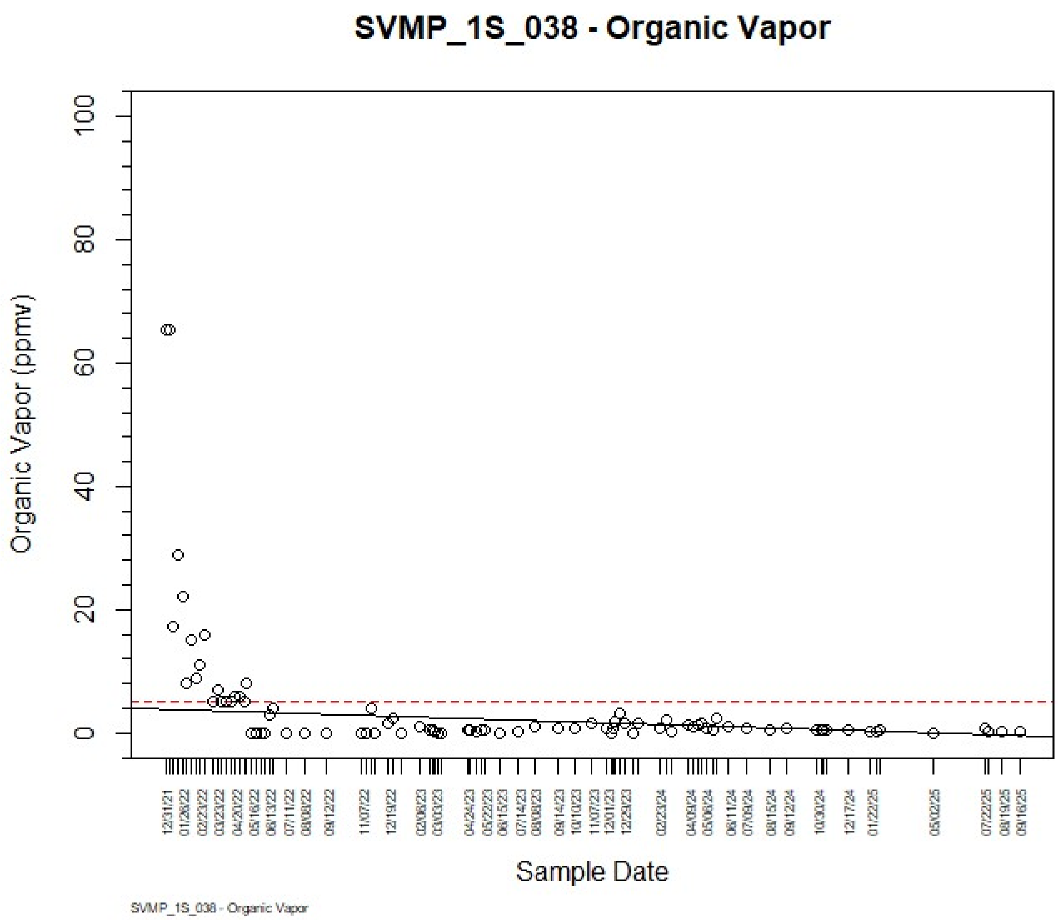
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

SVMP_1S_038 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.00314	143	-0.315	0.0000151



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 1S+038-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
16.9	0.11	-2.61	0.00916

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 1S+038-SVMP

tau	**slope**	**intercept**
-0.207	-1.36	1,259

2.2.3 Seasonal Kendall Sample Size per Season

```
##        kendall_out.sample.size
## 1                            9
## 2                            9
## 3                            9
## 4                           10
## 5                           12
## 6                            5
## 7                            5
## 8                            4
## 9                            4
## 10                           2
## 11                           8
## 12                          10
## Total                       87
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -17
## 2                     -21
## 3                     -14
## 4                     -16
## 5                      10
## 6                      -1
## 7                       5
## 8                       0
## 9                       0
## 10                     -1
## 11                      5
## 12                    -21
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       80.56
## 2                       79.67
## 3                       77.22
## 4                      105.24
## 5                      185.76
## 6                       13.00
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       1.00
## 11                      50.36
## 12                      95.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau   slope intercept
## 1  -0.472 -9.0790     18368
## 2  -0.583 -5.1230     10365
## 3  -0.389 -4.8000      9713
## 4  -0.356 -2.1335      4317
## 5   0.152  0.1500      -303
## 6  -0.100 -0.9540      1930
## 7   0.500  0.2770      -560
## 8   0.000 -0.0767       156
## 9   0.000 -0.0733       149
## 10 -1.000 -0.2900       587
## 11  0.179  0.1805      -365
## 12 -0.467 -1.5290      3095
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 1S+038-SVMP

Parameter	Limits	Confidence
slope	-2.382	0.95
slope	-0.246	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1 End of 1S+038 -SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV 2S+025-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for 2S+025-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

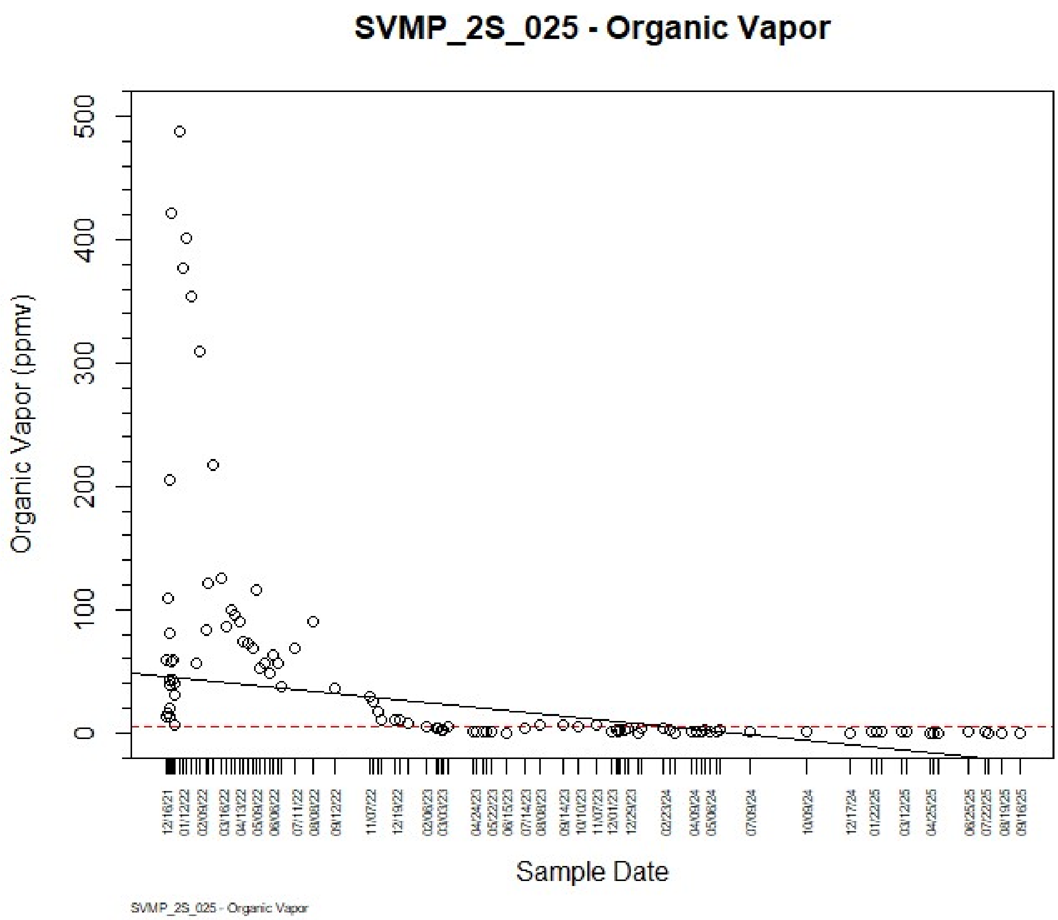
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

SVMP_2S_025 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0508	2,309	-0.67	0



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 2S+025-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
11.5	0.406	-7.72	0.0000000000000118

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 2S+025-SVMP

tau	***slope***	***intercept***
-0.64	-23.2	44,579

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           9
## 3                          11
## 4                          11
## 5                          13
## 6                           5
## 7                           5
## 8                           3
## 9                           3
## 10                          2
## 11                          5
## 12                         28
## Total                     104
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                      -24
## 2                      -27
## 3                      -38
## 4                      -36
## 5                      -51
## 6                       -5
## 7                       -9
## 8                       -3
## 9                       -3
## 10                      -1
## 11                      -4
## 12                    -183
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                    8.13e+01
## 2                    7.97e+01
## 3                    1.51e+02
## 4                    1.47e+02
## 5                    2.44e+02
## 6                    1.30e+01
## 7                    1.57e+01
## 8                    3.67e+00
## 9                    3.67e+00
## 10                   1.00e+00
## 11                   8.00e+00
## 12                   1.72e+03
```

2.2.6 Seasonal Kendall Estimates

```
##        tau   slope intercept
## 1  -0.667 -148.14    299691
## 2  -0.750  -52.35    105909
## 3  -0.691  -41.80     84568
## 4  -0.655  -35.83     72486
## 5  -0.654  -23.27     47086
## 6  -0.500  -20.79     42073
## 7  -0.900   -3.16      6395
## 8  -1.000  -29.94     60570
## 9  -1.000  -11.97     24216
## 10 -1.000   -3.99      8072
## 11 -0.400  -15.35     31055
## 12 -0.484  -19.10     38627
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 2S+025-SVMP

Parameter	***Limits***	***Confidence***
slope	-32.1	0.95
slope	-14.2	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 2S+025-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV 2S+150-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for 2S+150-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

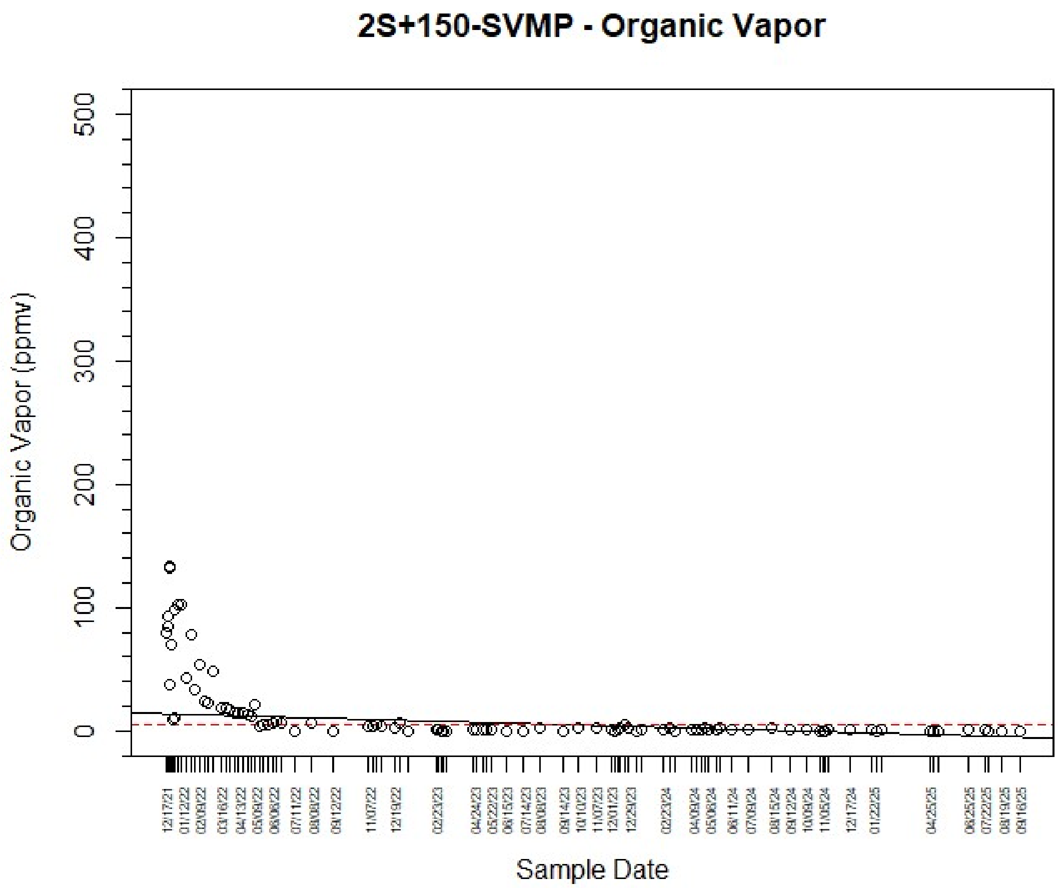
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

2S+150-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0134	609	-0.611	0



2S+150-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 2S+150-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
27.6	0.00374	-6.87	0.0000000000635

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 2S+150-SVMP

tau	***slope***	***intercept***
-0.481	-5.46	4,679

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           8
## 3                           9
## 4                          11
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         19
## Total                      99
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -18
## 2                     -11
## 3                     -20
## 4                     -26
## 5                     -49
## 6                      -8
## 7                       7
## 8                      -6
## 9                       2
## 10                     -2
## 11                    -19
## 12                   -106
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                        81.33
## 2                        55.67
## 3                        77.94
## 4                       145.90
## 5                       242.88
## 6                        24.67
## 7                        15.67
## 8                         8.67
## 9                         8.67
## 10                        2.67
## 11                       50.36
## 12                      662.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau   slope intercept
## 1  -0.500 -29.983     60657
## 2  -0.393 -16.145     32666
## 3  -0.556 -16.775     33938
## 4  -0.473  -5.908     11953
## 5  -0.628  -1.909      3862
## 6  -0.533  -2.516      5092
## 7   0.700   0.146      -295
## 8  -1.000  -2.107      4265
## 9   0.333   0.200      -405
## 10 -0.667  -1.407      2849
## 11 -0.679  -1.875      3796
## 12 -0.620 -34.559     69854
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 2S+150-SVMP

Parameter	Limits	Confidence
slope	-10.72	0.95
slope	-3.03	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 2S+150-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV 2S+275-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for 2S+275-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

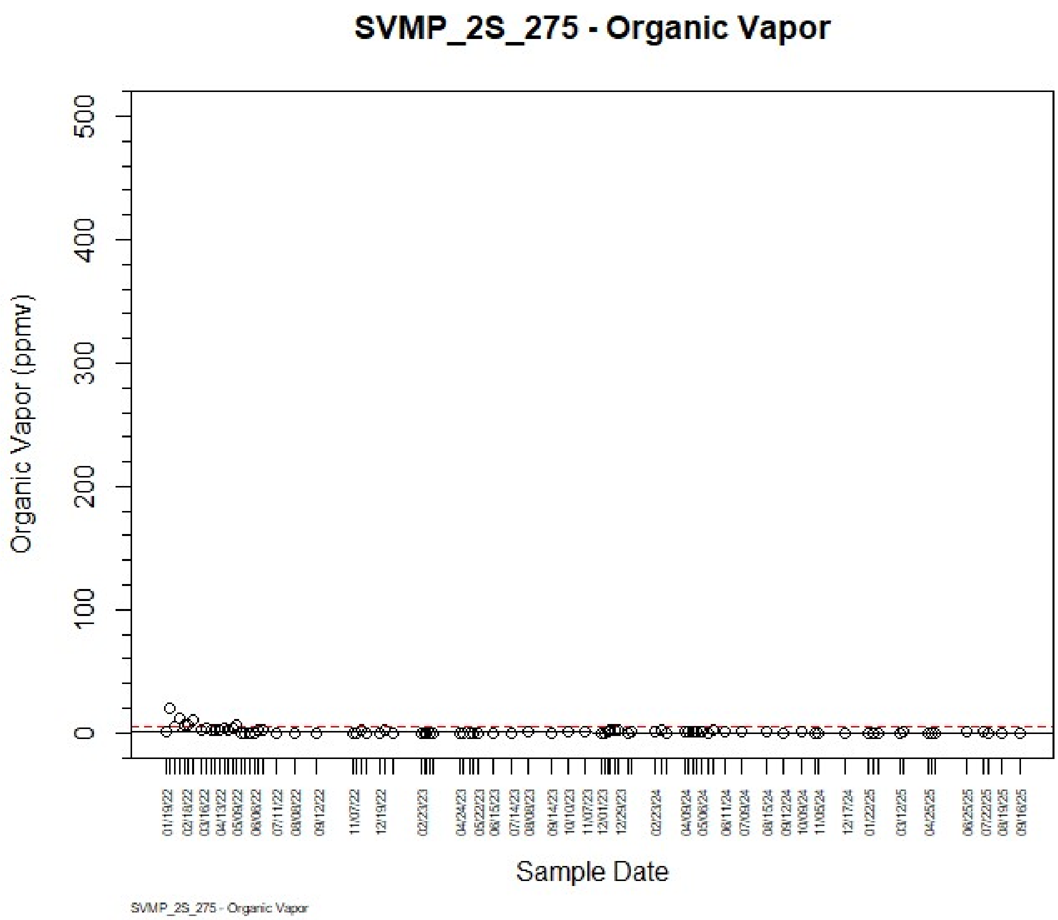
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

SVMP_2S_275 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.000944	43.4	-0.201	0.00543



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 2S+275-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
17.3	0.0992	-2.04	0.0417

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	Estimation
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 2S+275-SVMP

tau	slope	intercept
-0.132	-0.529	604

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           7
## 2                           8
## 3                          11
## 4                          11
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          6
## 12                          9
## Total                      87
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                      -7
## 2                     -13
## 3                     -19
## 4                     -26
## 5                       4
## 6                      -3
## 7                       7
## 8                       0
## 9                       4
## 10                     -2
## 11                      3
## 12                     -5
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       40.48
## 2                       54.92
## 3                      142.48
## 4                      143.74
## 5                      236.42
## 6                       23.07
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       2.67
## 11                      17.33
## 12                      62.11
```

2.2.6 Seasonal Kendall Estimates

```
##         tau     slope intercept
## 1  -0.3333 -4.44e-01    898.09
## 2  -0.4643 -3.18e+00   6441.45
## 3  -0.3455 -1.15e+00   2330.78
## 4  -0.4727 -1.18e+00   2384.75
## 5   0.0513  1.00e-03     -1.79
## 6  -0.2000 -4.07e-01    823.36
## 7   0.7000  2.20e-01   -443.97
## 8   0.0000  2.33e-03     -3.97
## 9   0.6667  3.75e-02    -75.82
## 10 -0.6667 -7.75e-01   1569.09
## 11  0.2000  1.47e-01   -298.10
## 12 -0.1389 -1.90e-01    384.86
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 2S+275-SVMP

Parameter	***Limits***	***Confidence***
slope	-1.1	0.95
slope	0.0	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 2S+275-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]+100-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]+100-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

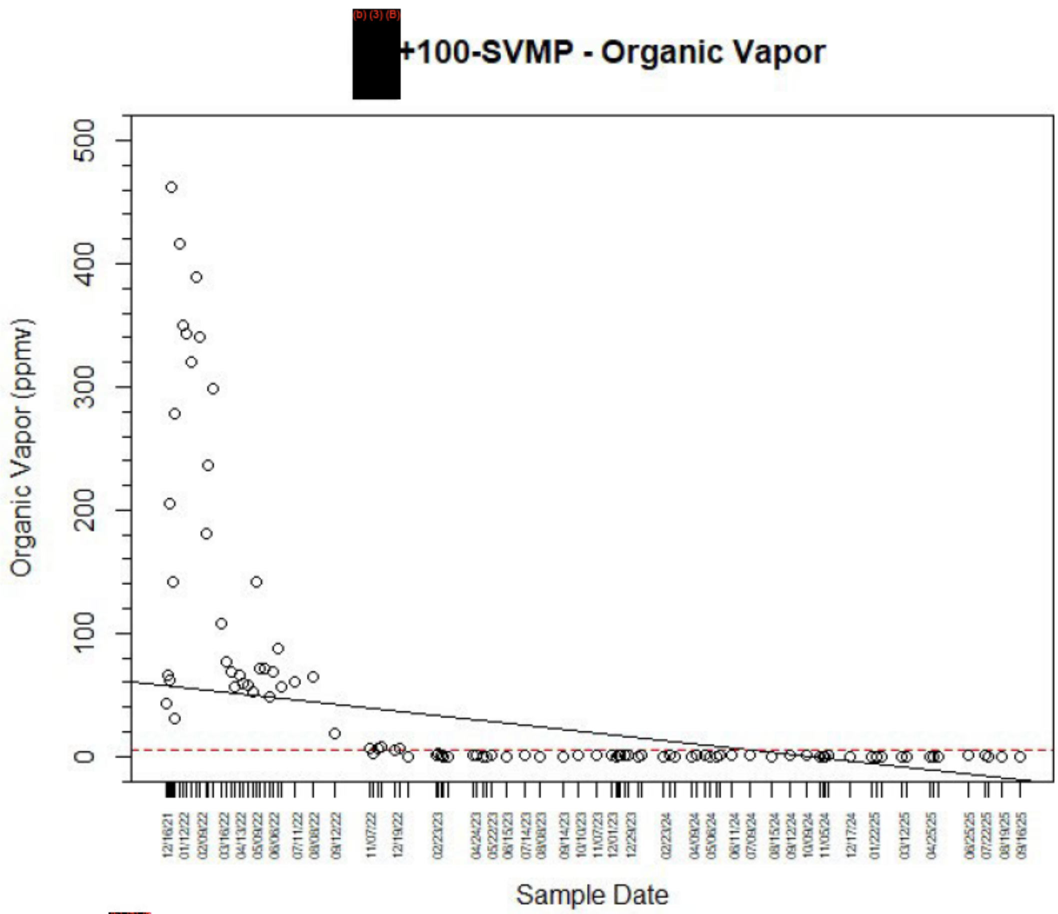
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]+100-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0554	2,527	-0.656	0



[redacted]+100-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]+100-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
11.6	0.394	-8.14	0.0000000000000000411

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted] +100-SVMP

tau	**slope**	**intercept**
-0.632	-26.4	52,979

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           8
## 3                          11
## 4                          10
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         18
## Total                      99
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -26
## 2                     -19
## 3                     -29
## 4                     -33
## 5                     -51
## 6                      -6
## 7                      -7
## 8                      -2
## 9                      -4
## 10                     -2
## 11                    -19
## 12                    -99
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                        81.33
## 2                        55.67
## 3                       143.28
## 4                       111.67
## 5                       242.88
## 6                        24.67
## 7                        15.67
## 8                         8.67
## 9                         8.67
## 10                        2.67
## 11                       53.00
## 12                      575.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau     slope intercept
## 1  -0.722 -1.28e+02    257942
## 2  -0.679 -1.30e+02    262166
## 3  -0.527 -3.49e+01     70697
## 4  -0.733 -2.84e+01     57405
## 5  -0.654 -2.40e+01     48552
## 6  -0.400 -2.86e+01     57782
## 7  -0.700 -5.88e-01      1191
## 8  -0.333 -1.09e+01     22097
## 9  -0.667 -3.41e+00      6903
## 10 -0.667 -3.42e-01       692
## 11 -0.679 -2.85e+00      5776
## 12 -0.647 -3.07e+01     62111
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]+100-SVMP

Parameter	***Limits***	***Confidence***
slope	-35.8	0.95
slope	-17.7	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

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Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1 End of [redacted] +100-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]+250-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]+250-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

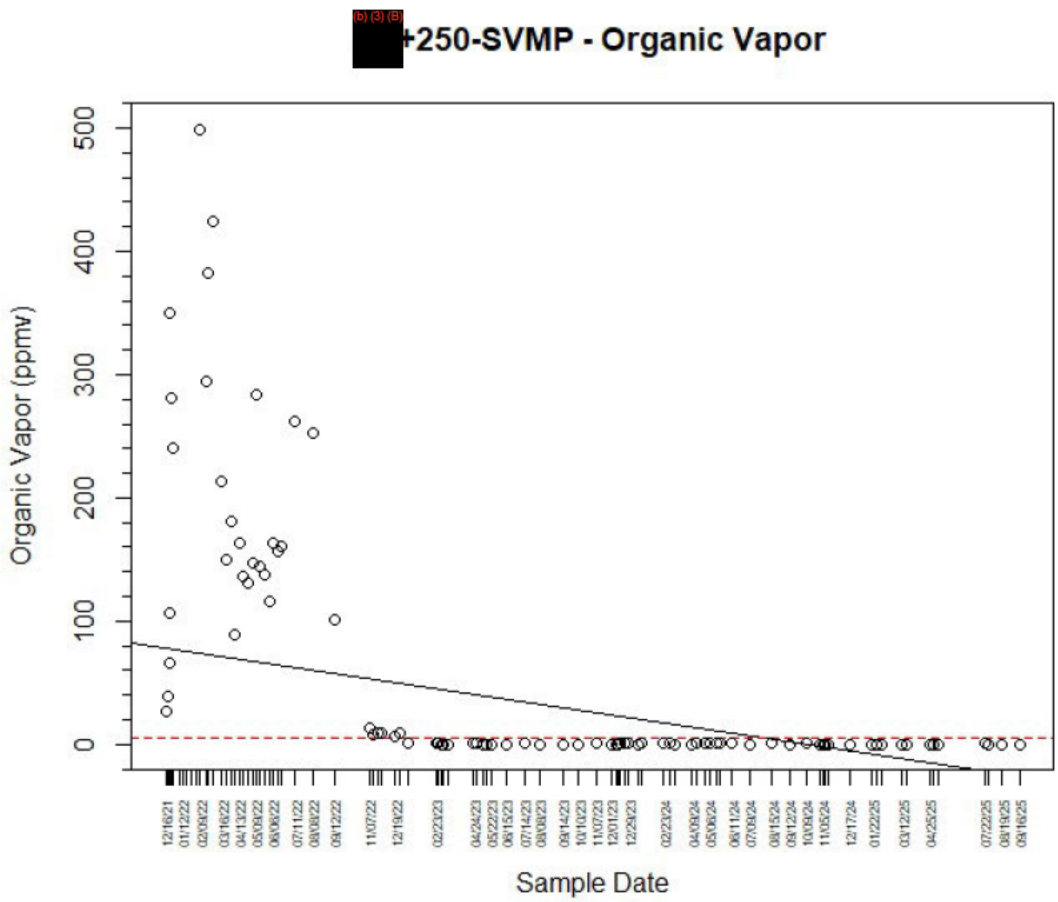
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]+250-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0761	3,469	-0.614	0



[redacted]+250-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]+250-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
18.2	0.0774	-7.26	0.000000000000391

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]+250-SVMP

tau	***slope***	***intercept***
-0.544	-49.9	97,809

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           8
## 3                          11
## 4                          10
## 5                          13
## 6                           5
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         17
## Total                      97
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -22
## 2                     -17
## 3                     -24
## 4                     -27
## 5                     -43
## 6                      -5
## 7                      -7
## 8                      -2
## 9                      -4
## 10                      2
## 11                    -19
## 12                    -88
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       81.33
## 2                       55.67
## 3                      147.62
## 4                      111.67
## 5                      242.88
## 6                       13.00
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       2.67
## 11                      53.00
## 12                     493.31
```

2.2.6 Seasonal Kendall Estimates

```
##       tau     slope intercept
## 1  -0.611 -2.14e+02    431977
## 2  -0.607 -1.99e+02    403101
## 3  -0.436 -7.28e+01    147371
## 4  -0.600 -5.43e+01    109917
## 5  -0.551 -5.77e+01    116744
## 6  -0.500 -8.17e+01    165391
## 7  -0.700 -2.68e-01       543
## 8  -0.333 -4.24e+01     85702
## 9  -0.667 -1.69e+01     34272
## 10  0.667  7.35e-02      -148
## 11 -0.679 -4.21e+00      8523
## 12 -0.647 -2.56e+01     51812
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]+250-SVMP

Parameter	***Limits***	***Confidence***
slope	-76.1	0.95
slope	-17.2	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1 End of [redacted] +250-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-325-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-325-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

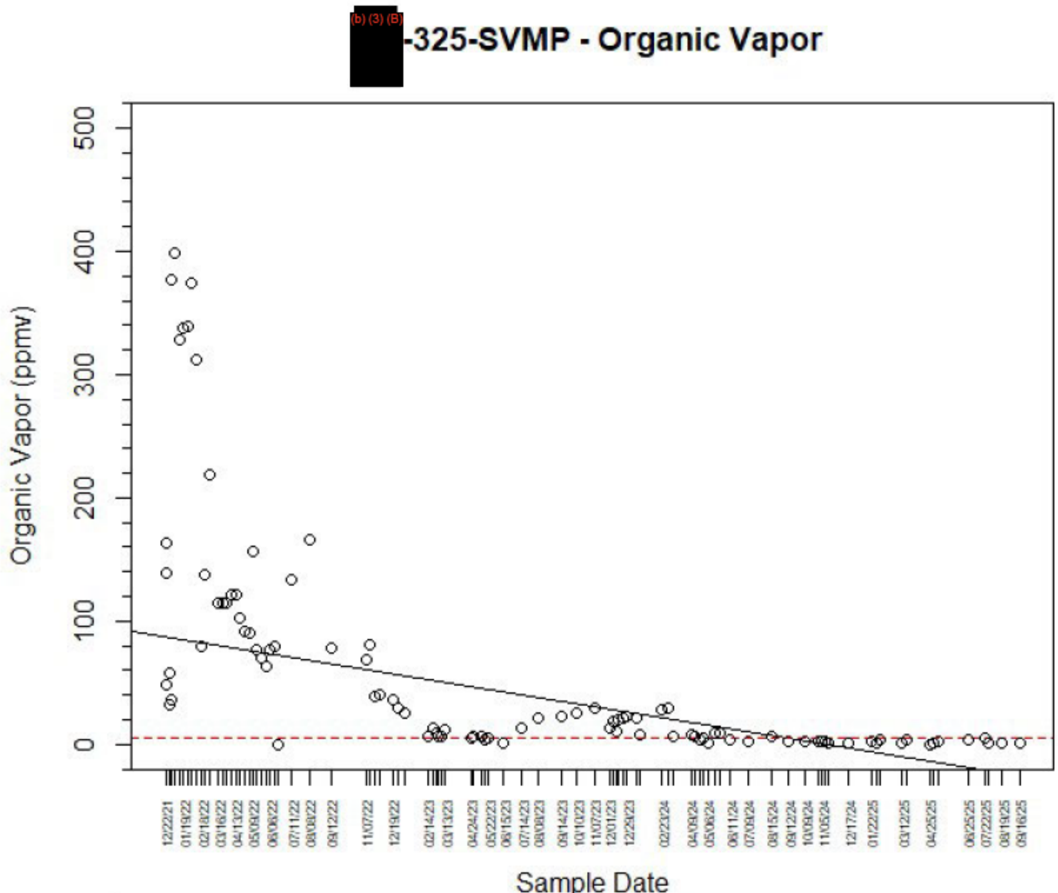
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-325-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0826	3,766	-0.688	0



[redacted]-325-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-325-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
11.4	0.41	-8.14	0.000000000000000384

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-325-SVMP

tau	***slope***	***intercept***
-0.646	-30.6	58,159

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           9
## 3                          11
## 4                          11
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         16
## Total                      99
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -28
## 2                     -21
## 3                     -36
## 4                     -36
## 5                     -47
## 6                       0
## 7                      -7
## 8                      -6
## 9                      -6
## 10                     -2
## 11                    -19
## 12                    -79
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       81.33
## 2                       79.67
## 3                      149.87
## 4                      145.90
## 5                      243.67
## 6                       24.67
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       2.67
## 11                      53.00
## 12                     419.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau  slope intercept
## 1  -0.778 -122.3    247464
## 2  -0.583  -72.9    147505
## 3  -0.655  -40.1     81179
## 4  -0.655  -43.8     88609
## 5  -0.603  -29.8     60325
## 6   0.000  -12.3     24790
## 7  -0.700  -10.2     20598
## 8  -1.000  -34.7     70287
## 9  -1.000  -23.0     46645
## 10 -0.667  -22.7     45884
## 11 -0.679  -27.7     55993
## 12 -0.658  -18.6     37640
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-325-SVMP

Parameter	***Limits***	***Confidence***
slope	-44.3	0.95
slope	-19.9	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1 End of [redacted]-325-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]+400-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]+400-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

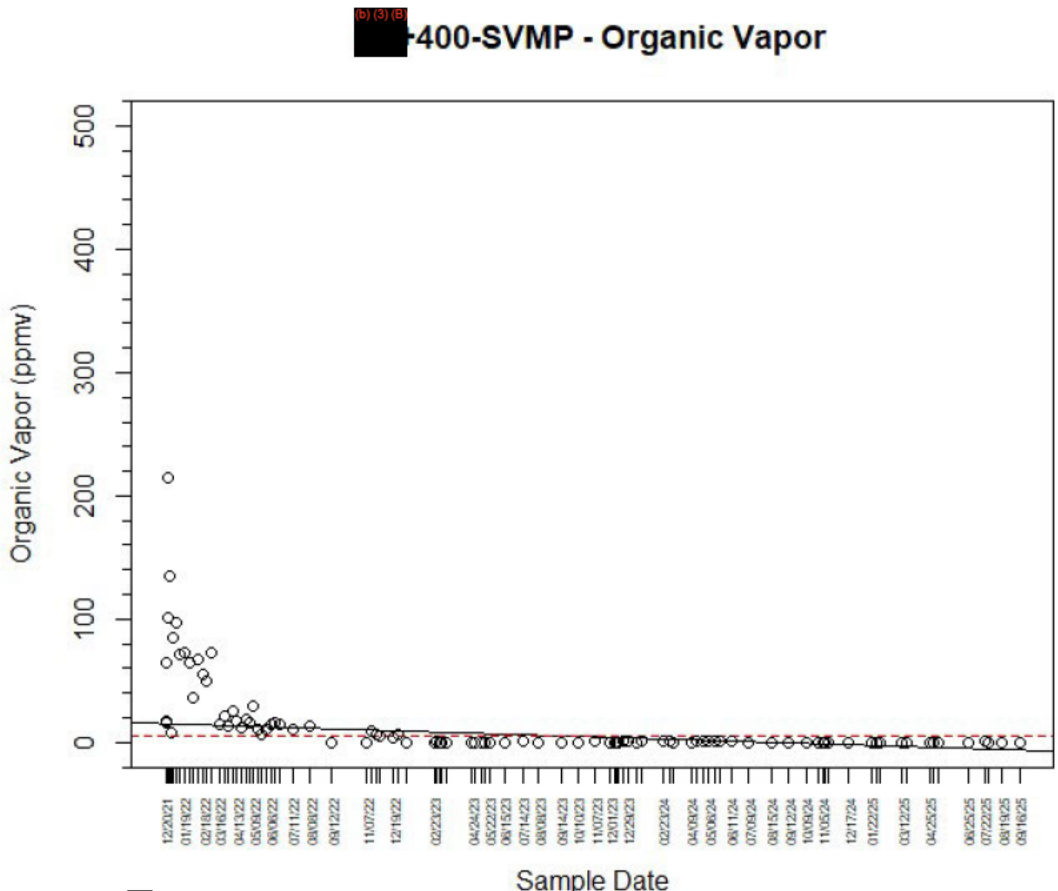
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]+400-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0152	690	-0.574	0



[redacted]400-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]+400-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
21.5	0.0282	-6.79	0.0000000000112

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted] +400-SVMP

tau	***slope***	***intercept***
-0.475	-6.91	10,620

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           8
## 3                          11
## 4                          10
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         17
## Total                      98
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -17
## 2                     -19
## 3                     -21
## 4                     -27
## 5                     -43
## 6                      -8
## 7                      -7
## 8                      -2
## 9                       1
## 10                      2
## 11                    -11
## 12                    -88
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                        80.56
## 2                        55.67
## 3                       143.28
## 4                       111.67
## 5                       242.10
## 6                        23.87
## 7                        15.67
## 8                         8.67
## 9                         7.67
## 10                        2.67
## 11                       53.00
## 12                      493.99
```

2.2.6 Seasonal Kendall Estimates

```
##        tau     slope intercept
## 1  -0.472 -2.78e+01     56237
## 2  -0.679 -2.47e+01     49976
## 3  -0.382 -6.65e+00     13447
## 4  -0.600 -8.11e+00     16412
## 5  -0.551 -4.25e+00      8594
## 6  -0.533 -6.25e+00     12646
## 7  -0.700 -3.28e-01       664
## 8  -0.333 -2.31e+00      4675
## 9   0.167  6.10e-02      -123
## 10  0.667  9.15e-02      -185
## 11 -0.393 -2.27e+00      4599
## 12 -0.647 -1.26e+01     25383
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted] *+400-SVMP*

Parameter	***Limits***	***Confidence***
slope	-9.78	0.95
slope	-4.33	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

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Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted] +400-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-100-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-100-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

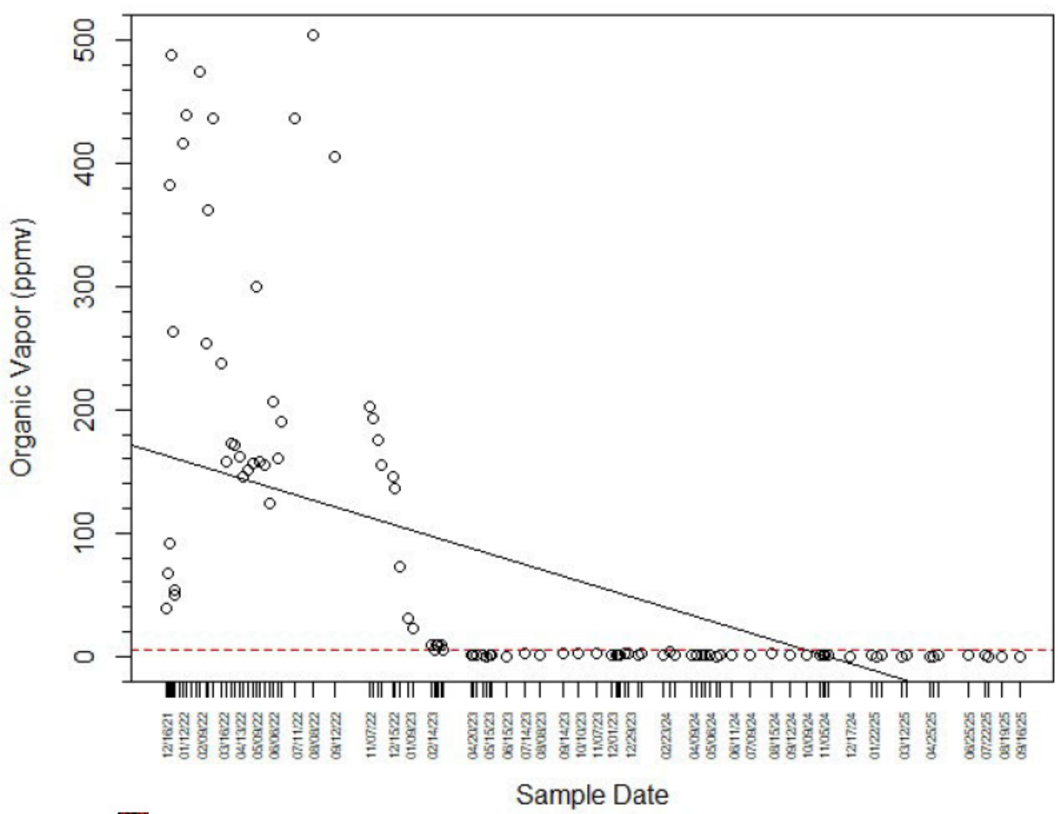
2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-100-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.154	7,010	-0.693	0

[redacted]-100-SVMP - Organic Vapor



[redacted] 100-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-100-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
7.97	0.716	-8.33	0.0000000000000000796

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-100-SVMP

tau	***slope***	***intercept***
-0.669	-77.6	148,196

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          10
## 2                          10
## 3                          10
## 4                          12
## 5                          14
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         19
## Total                     105
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -36
## 2                     -33
## 3                     -34
## 4                     -45
## 5                     -55
## 6                      -8
## 7                      -7
## 8                      -4
## 9                      -6
## 10                     -2
## 11                    -19
## 12                    -89
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                      113.33
## 2                      107.67
## 3                      113.33
## 4                      191.67
## 5                      303.67
## 6                       24.67
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       2.67
## 11                      53.00
## 12                     693.00
```

2.2.6 Seasonal Kendall Estimates

```
##       tau   slope intercept
## 1  -0.800 -206.51    417792
## 2  -0.733 -244.40    494431
## 3  -0.756  -78.88    159583
## 4  -0.682  -72.56    146795
## 5  -0.604  -61.73    124888
## 6  -0.533  -73.93    149596
## 7  -0.700   -1.30      2632
## 8  -0.667  -84.83    171658
## 9  -1.000  -68.26    138132
## 10 -0.667   -1.63      3306
## 11 -0.679  -96.43    195105
## 12 -0.520  -70.42    142443
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-100-SVMP

Parameter	Limits	Confidence
slope	-123.0	0.95
slope	-51.5	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-100-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-250-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-250-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

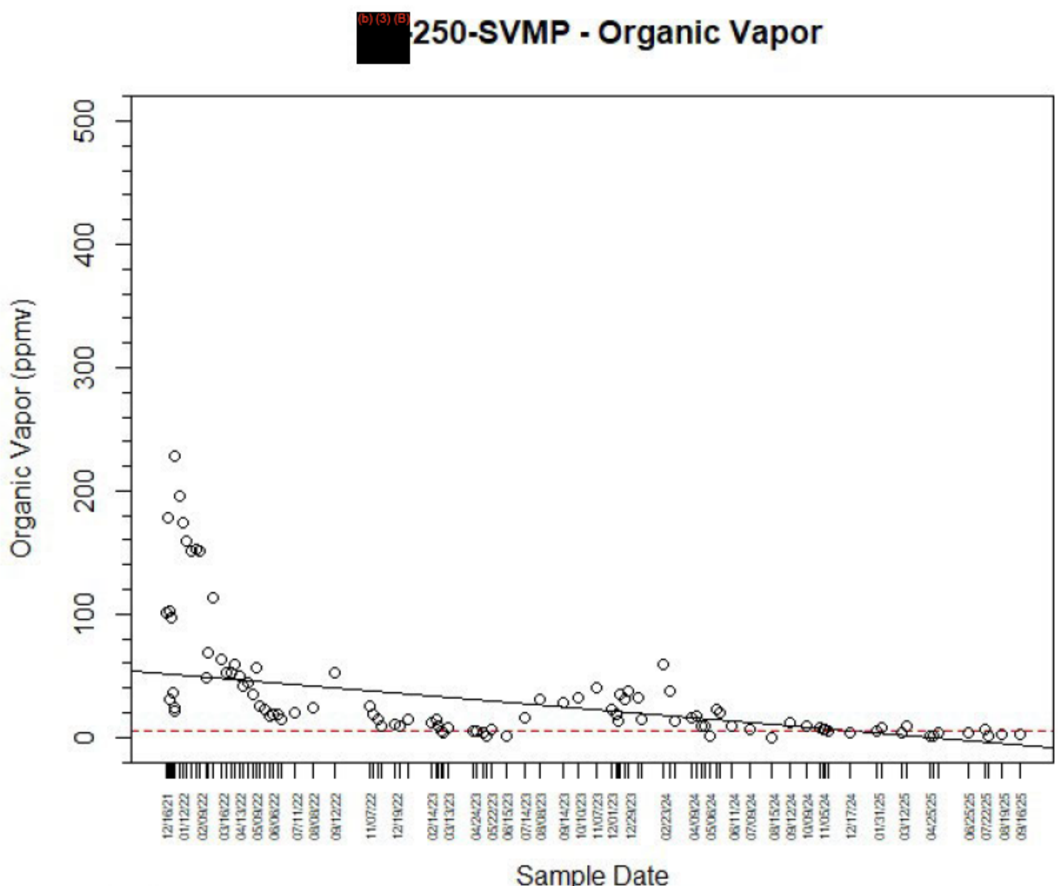
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-250-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0418	1,911	-0.58	0



[redacted]250-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-250-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
3.39	0.985	-5.93	0.00000000306

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-250-SVMP

tau	***slope***	***intercept***
-0.513	-14.6	32,240

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           8
## 2                           9
## 3                          11
## 4                          11
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         18
## Total                     100
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -19
## 2                     -19
## 3                     -24
## 4                     -26
## 5                     -39
## 6                      -8
## 7                      -9
## 8                      -2
## 9                      -6
## 10                     -2
## 11                    -11
## 12                    -55
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       55.67
## 2                       79.67
## 3                      149.87
## 4                      146.67
## 5                      243.67
## 6                       24.67
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       2.67
## 11                      53.00
## 12                     575.67
```

2.2.6 Seasonal Kendall Estimates

```
##       tau  slope intercept
## 1  -0.679 -63.93    129397
## 2  -0.528 -45.80     92702
## 3  -0.436 -18.84     38132
## 4  -0.473 -15.72     31822
## 5  -0.500  -7.65     15484
## 6  -0.533  -4.68      9470
## 7  -0.900  -5.10     10321
## 8  -0.333  -9.68     19597
## 9  -1.000 -16.13     32658
## 10 -0.667 -22.77     46101
## 11 -0.393  -4.38      8866
## 12 -0.359 -21.60     43695
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-250-SVMP

Parameter	**Limits**	**Confidence**
slope	-20.17	0.95
slope	-8.29	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

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Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

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Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1 End of [redacted]-250-SVMP Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-325-SVMP Organic Vapor Trend Analysis

[redacted]

2025-10-03

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-325-SVMP for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

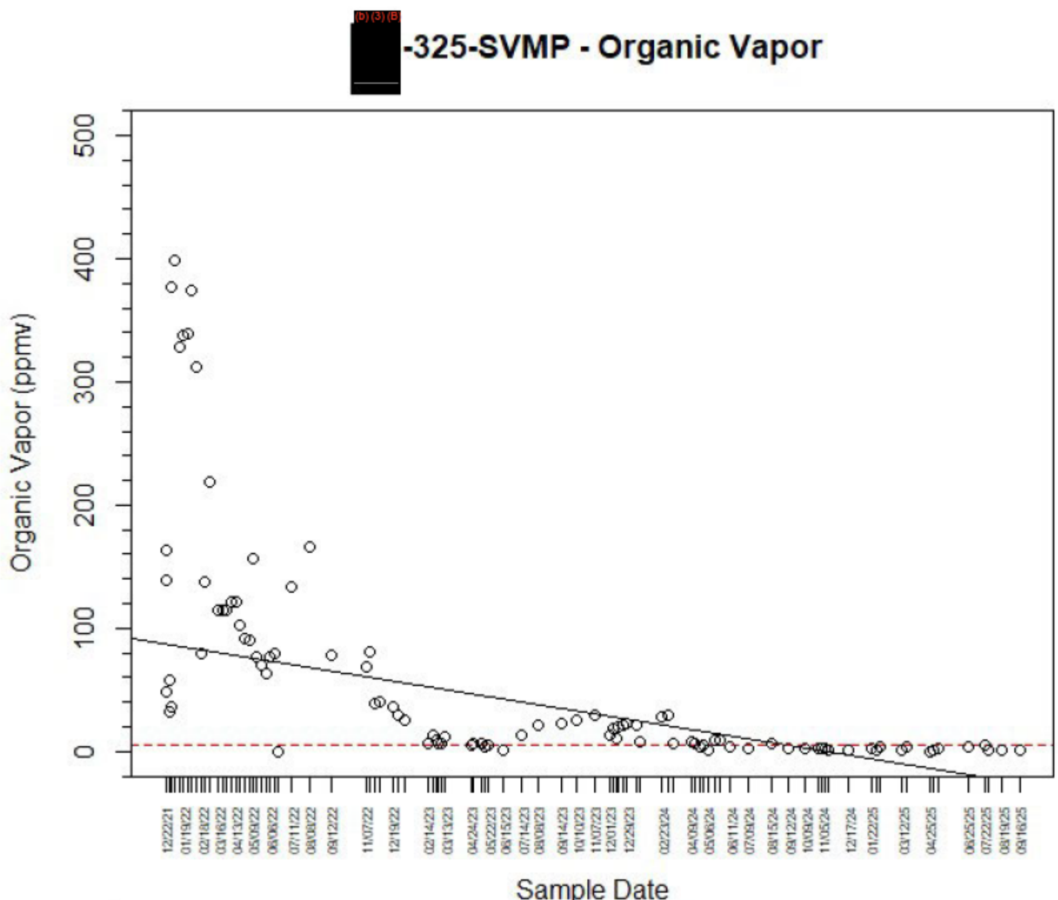
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-325-SVMP Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.0826	3,766	-0.688	0



[redacted]325-SVMP - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall’s Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-325-SVMP

Chi-Square	***p-value***	***z (trend)***	***p-value***
11.4	0.41	-8.14	0.000000000000000384

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-325-SVMP

tau	***slope***	***intercept***
-0.646	-30.6	58,159

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           9
## 2                           9
## 3                          11
## 4                          11
## 5                          13
## 6                           6
## 7                           5
## 8                           4
## 9                           4
## 10                          3
## 11                          8
## 12                         16
## Total                      99
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -28
## 2                     -21
## 3                     -36
## 4                     -36
## 5                     -47
## 6                       0
## 7                      -7
## 8                      -6
## 9                      -6
## 10                     -2
## 11                    -19
## 12                    -79
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       81.33
## 2                       79.67
## 3                      149.87
## 4                      145.90
## 5                      243.67
## 6                       24.67
## 7                       15.67
## 8                        8.67
## 9                        8.67
## 10                       2.67
## 11                      53.00
## 12                     419.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau  slope intercept
## 1  -0.778 -122.3    247464
## 2  -0.583  -72.9    147505
## 3  -0.655  -40.1     81179
## 4  -0.655  -43.8     88609
## 5  -0.603  -29.8     60325
## 6   0.000  -12.3     24790
## 7  -0.700  -10.2     20598
## 8  -1.000  -34.7     70287
## 9  -1.000  -23.0     46645
## 10 -0.667  -22.7     45884
## 11 -0.679  -27.7     55993
## 12 -0.658  -18.6     37640
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-325-SVMP

Parameter	***Limits***	***Confidence***
slope	-44.3	0.95
slope	-19.9	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-325-SVMP Organic Vapor Trend Analysis

Appendix D.2:
DSVMP Akritas-Theil-Sen Trend Test Results

CTO 24F0224_SV 1S+075-DSVMP29 Organic Vapor Trend Analysis

(b) (6) [redacted]

2025-10-04

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1 Introduction

This purpose of this document is to present the time-series and trend results for 1S+075-DSVMP29 for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

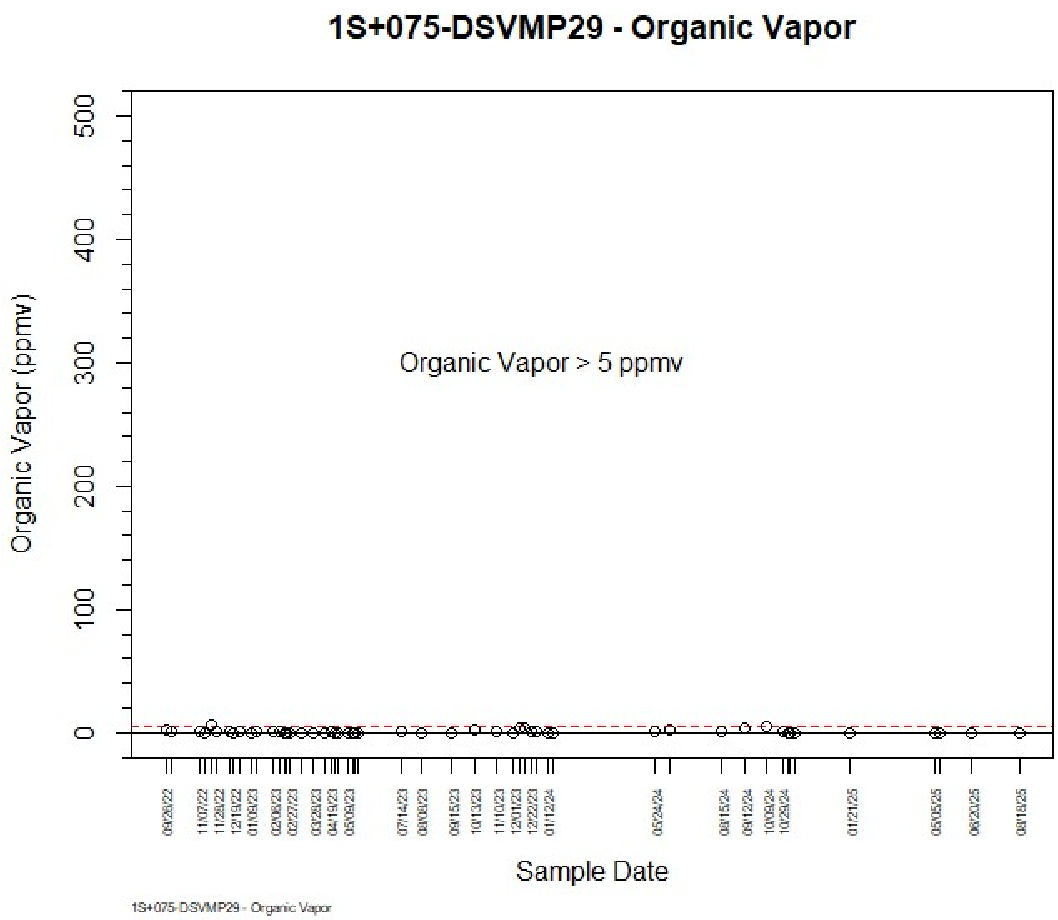
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

1S+075-DSVMP29 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
0.00000000213	0.373	-0.00603	0.956



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 1S+075-DSVMP29

Chi-Square	***p-value***	***z (trend)***	***p-value***
4.82	0.682	-0.158	0.875

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 1S+075-DSVMP29

tau	***slope***	***intercept***
-0.0208	-0.0168	-157

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           5
## 2                           5
## 3                           2
## 4                           4
## 5                           7
## 6                           2
## 7                           1
## 8                           3
## 9                           3
## 10                          4
## 11                          8
## 12                          8
## Total                      52
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                        1
## 2                       NA
## 3                       NA
## 4                       NA
## 5                       -6
## 6                       -1
## 7                       NA
## 8                        1
## 9                        1
## 10                       1
## 11                      -7
## 12                       7
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       13.87
## 2                          NA
## 3                          NA
## 4                          NA
## 5                       34.00
## 6                        1.00
## 7                          NA
## 8                        3.67
## 9                        3.67
## 10                       7.67
## 11                      52.32
## 12                      45.00
```

2.2.6 Seasonal Kendall Estimates

```
##        tau   slope intercept
## 1   0.100  0.0885      -179
## 2      NA      NA        NA
## 3      NA      NA        NA
## 4      NA      NA        NA
## 5  -0.286 -0.0405        82
## 6  -1.000 -2.8760      5824
## 7      NA      NA        NA
## 8   0.333  0.0665      -134
## 9   0.333  0.8590     -1736
## 10  0.167  0.4690      -947
## 11 -0.250 -0.0705       143
## 12  0.250  0.7800     -1577
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 1S+075-DSVMP29

Parameter	Limits	Confidence
slope	-0.189	0.95
slope	0.384	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 1S+075-DSVMP29 Organic Vapor Trend Analysis

CTO 24F0224_SV 1S+075-DSVMP12.6 Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for 1S+075-DSVMP12.6 for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

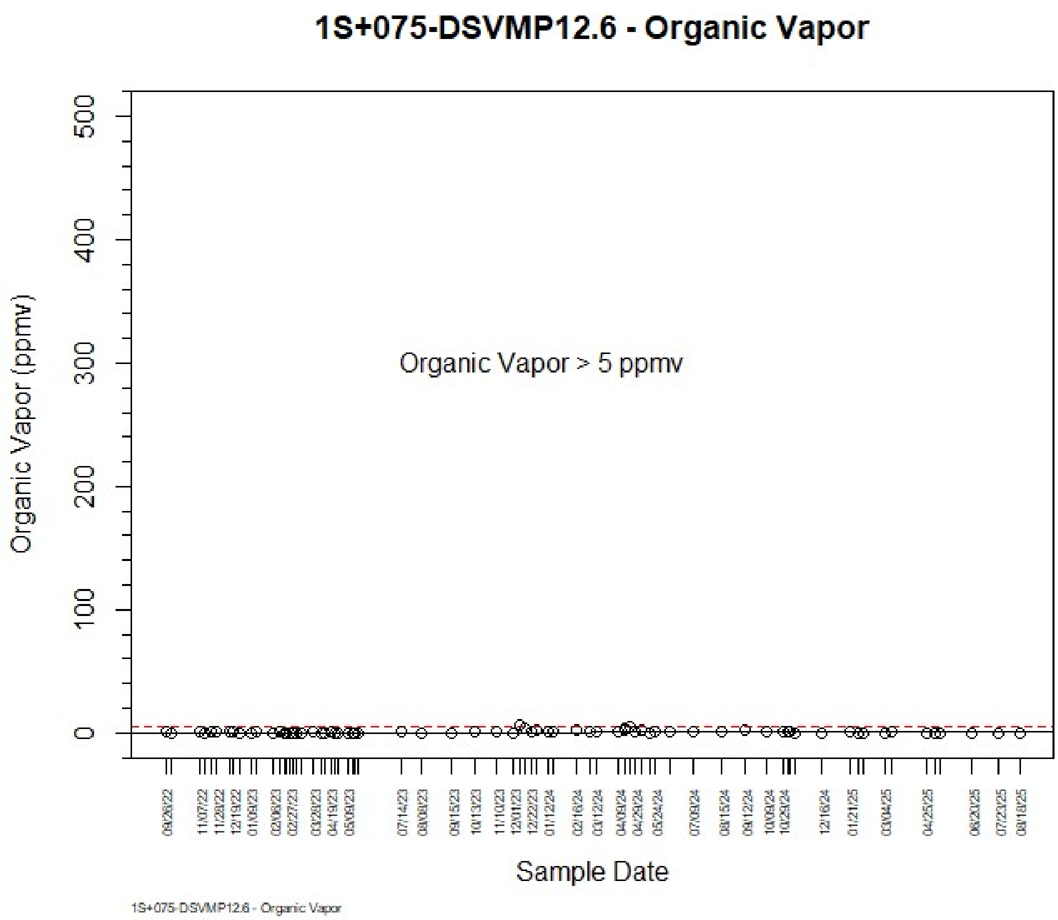
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

1S+075-DSVMP12.6 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
0.00022	-9.5	0.107	0.182



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 1S+075-DSVMP12.6

Chi-Square	***p-value***	***z (trend)***	***p-value***
9.36	0.589	1.68	0.0929

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 1S+075-DSVMP12.6

tau	***slope***	***intercept***
0.118	0.183	-290

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           6
## 2                           7
## 3                           8
## 4                          11
## 5                           9
## 6                           2
## 7                           3
## 8                           3
## 9                           3
## 10                          4
## 11                          8
## 12                          9
## Total                      73
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                      -2
## 2                       5
## 3                      10
## 4                      23
## 5                      -2
## 6                      -1
## 7                      -1
## 8                       1
## 9                       1
## 10                      3
## 11                     -5
## 12                      5
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       25.33
## 2                       27.14
## 3                       53.95
## 4                      131.03
## 5                       77.94
## 6                        1.00
## 7                        3.67
## 8                        3.67
## 9                        3.67
## 10                       7.67
## 11                      52.32
## 12                      71.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau   slope intercept
## 1  -0.1333 -0.0288      58.7
## 2   0.2381  0.1460    -295.1
## 3   0.3571  0.2495    -504.5
## 4   0.4182  0.9180   -1857.6
## 5  -0.0556 -0.0350      71.1
## 6  -1.0000 -1.1130    2253.8
## 7  -0.3333 -0.2080     421.6
## 8   0.3333  0.1410    -285.1
## 9   0.3333  1.1030   -2230.7
## 10  0.5000  0.2655    -536.5
## 11 -0.1786 -0.0670     136.1
## 12  0.1389  0.7130   -1441.7
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 1S+075-DSVMP12.6

Parameter	***Limits***	***Confidence***
slope	-0.0385	0.95
slope	0.6960	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

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Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 1S+075-DSVMP12.6 Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-110-DSVMP18.75 Organic Vapor Trend Analysis

[redacted]

2025-10-04

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-110-DSVMP18.75 for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

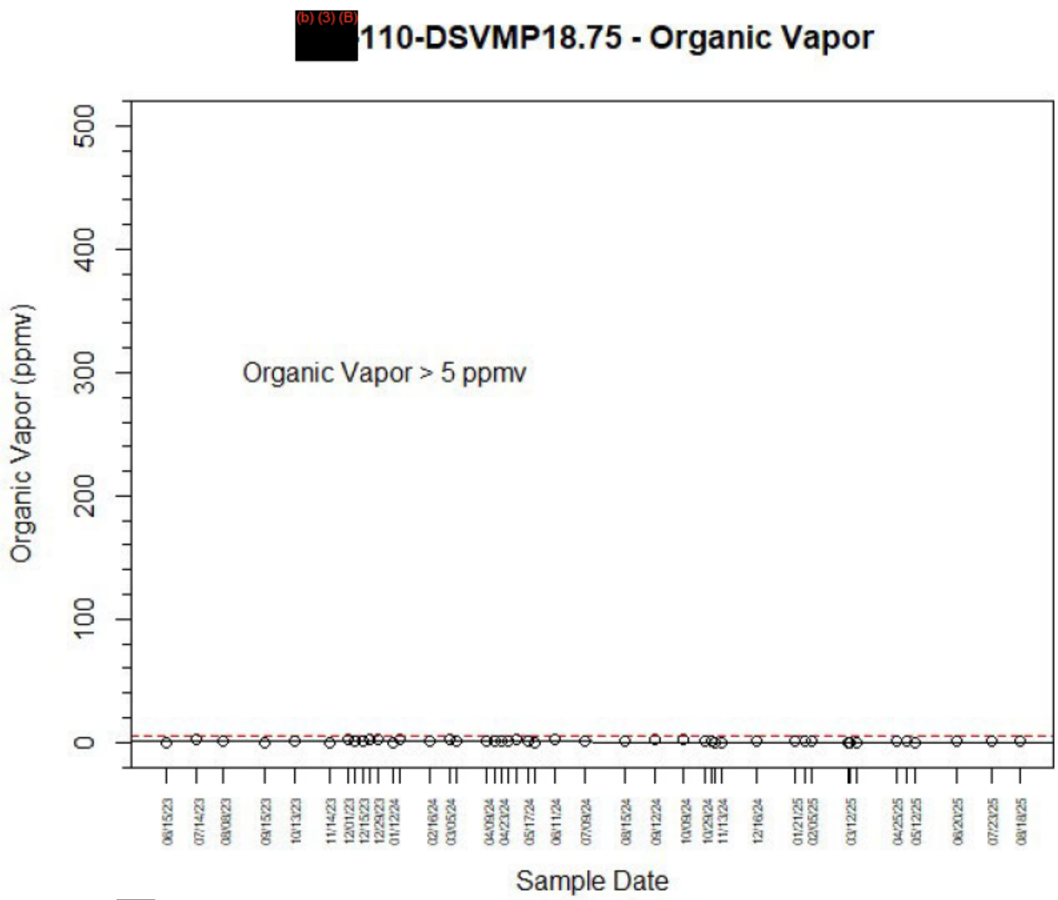
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-110-DSVMP18.75 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.00119	54.8	-0.218	0.0354



[redacted]10-DSVMP18.75 - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-110-DSVMP18.75

Chi-Square	***p-value***	***z (trend)***	***p-value***
10.1	0.52	-1.43	0.153

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-110-DSVMP18.75

tau	***slope***	***intercept***
-0.16	-0.363	356

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           4
## 2                           2
## 3                           5
## 4                           5
## 5                           5
## 6                           3
## 7                           3
## 8                           3
## 9                           2
## 10                          3
## 11                          4
## 12                          6
## Total                      45
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                       0
## 2                      -1
## 3                      -6
## 4                      -2
## 5                      -2
## 6                       1
## 7                      -3
## 8                      -1
## 9                       1
## 10                      0
## 11                      3
## 12                     -3
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                        6.67
## 2                        1.00
## 3                       11.40
## 4                        8.00
## 5                       12.00
## 6                        3.67
## 7                        3.67
## 8                        3.67
## 9                        1.00
## 10                       2.67
## 11                       5.00
## 12                      11.67
```

2.2.6 Seasonal Kendall Estimates

```
##       tau   slope intercept
## 1   0.000 -0.7875    1594.8
## 2  -1.000 -0.3870     784.3
## 3  -0.600 -1.7125    3468.0
## 4  -0.200 -0.0875     178.2
## 5  -0.200 -0.0805     163.4
## 6   0.333  0.2250    -455.0
## 7  -1.000 -0.8255    1672.5
## 8  -0.333 -0.0485      98.7
## 9   1.000  2.5490   -5156.5
## 10  0.000 -0.2625     532.9
## 11  0.500  0.3680    -744.6
## 12 -0.200 -1.1910    2410.8
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-110-DSVMP18.75

Parameter	***Limits***	***Confidence***
slope	-1.1402	0.95
slope	0.0838	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-110-DSVMP18.75 Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-110-DSVMP23.75 Organic Vapor Trend Analysis

[redacted]

2025-10-04

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-110-DSVMP23.75 for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

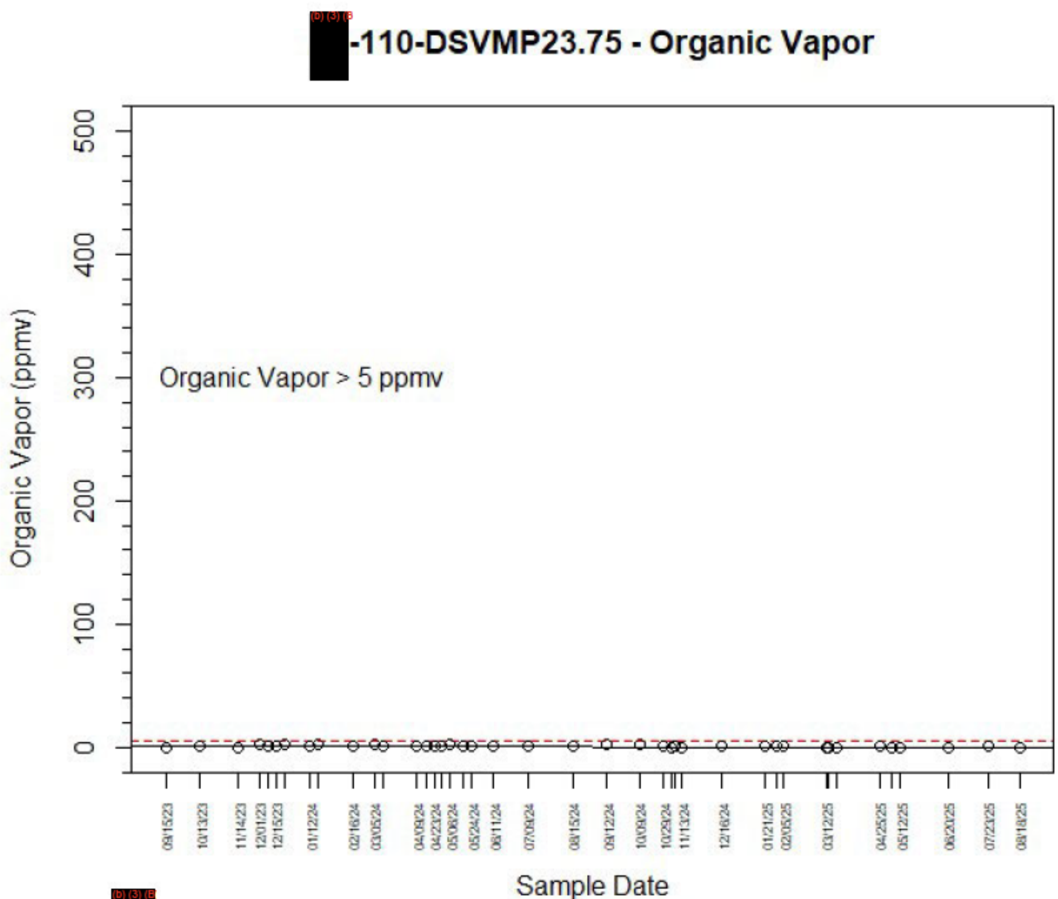
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-110-DSVMP23.75 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.00158	72.5	-0.335	0.00209



[redacted]10-DSVMP23.75 - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-110-DSVMP23.75

Chi-Square	***p-value***	***z (trend)***	***p-value***
8.97	0.625	-2.74	0.00614

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-110-DSVMP23.75

tau	***slope***	***intercept***
-0.39	-0.376	639

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           4
## 2                           2
## 3                           5
## 4                           5
## 5                           5
## 6                           2
## 7                           2
## 8                           2
## 9                           2
## 10                          3
## 11                          4
## 12                          5
## Total                      41
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                      -4
## 2                      -1
## 3                      -6
## 4                      -4
## 5                      -6
## 6                      -1
## 7                      -1
## 8                      -1
## 9                       1
## 10                      0
## 11                      1
## 12                      0
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                         6.67
## 2                         1.00
## 3                        11.40
## 4                         8.00
## 5                        12.00
## 6                         1.00
## 7                         1.00
## 8                         1.00
## 9                         1.00
## 10                        2.67
## 11                        5.00
## 12                        8.00
```

2.2.6 Seasonal Kendall Estimates

```
##        tau  slope intercept
## 1  -0.667 -1.208      2445
## 2  -1.000 -0.421       853
## 3  -0.600 -1.381      2797
## 4  -0.400 -0.180       364
## 5  -0.600 -0.212       429
## 6  -1.000 -1.078      2183
## 7  -1.000 -0.826      1673
## 8  -1.000 -0.380       770
## 9   1.000  2.215     -4481
## 10  0.000  0.074      -149
## 11  0.167  0.066      -133
## 12  0.000 -0.250       508
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-110-DSVMP23.75

Parameter	***Limits***	***Confidence***
slope	-1.109	0.95
slope	-0.113	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-110-DSVMP23.75 Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-110-DSVMP35.75 Organic Vapor Trend Analysis

[redacted]

2025-10-04

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-110-DSVMP35.75 for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

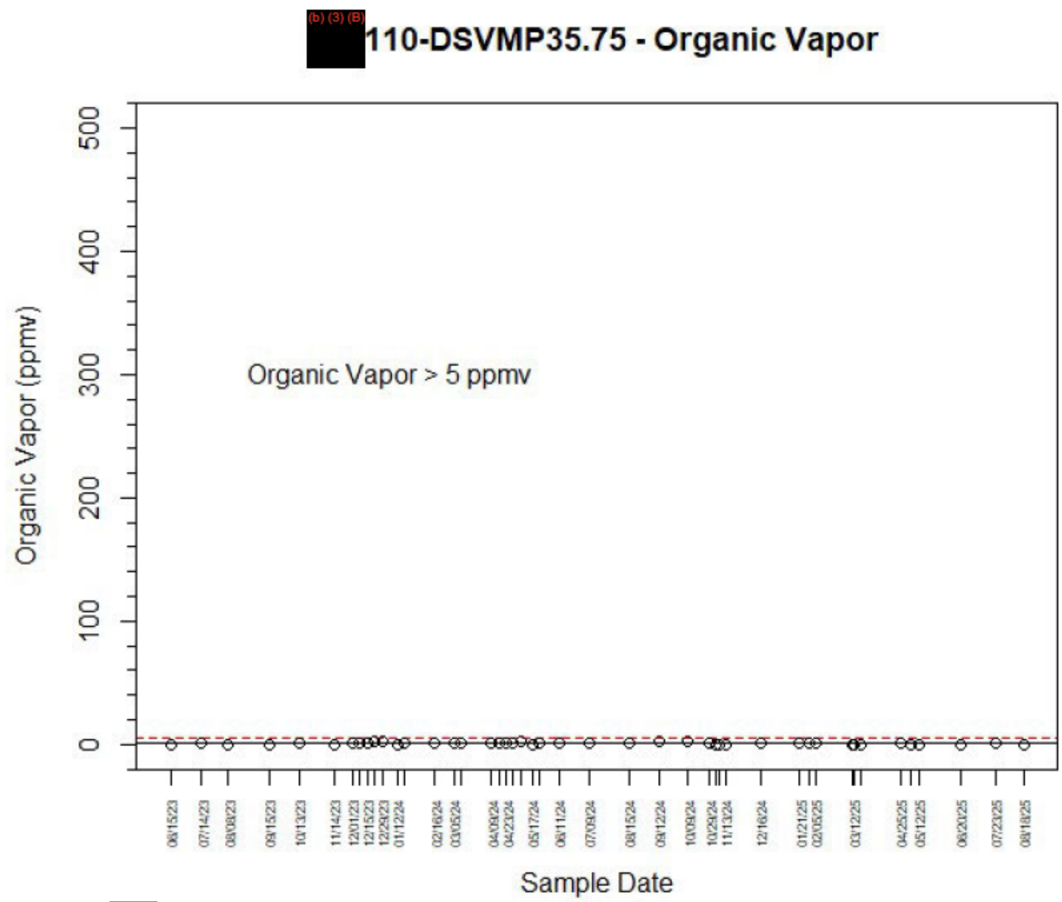
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-110-DSVMP35.75 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.000735	34.2	-0.187	0.0718



[redacted]110-DSVMP35.75 - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-110-DSVMP35.75

Chi-Square	*p-value*	*z (trend)*	*p-value*
10.7	0.47	-1.91	0.0565

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-110-DSVMP35.75

tau	**slope**	**intercept**
-0.221	-0.107	140

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           4
## 2                           2
## 3                           5
## 4                           5
## 5                           5
## 6                           3
## 7                           3
## 8                           3
## 9                           2
## 10                          3
## 11                          4
## 12                          6
## Total                      45
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                       0
## 2                      -1
## 3                      -6
## 4                      -4
## 5                      -6
## 6                       1
## 7                      -3
## 8                      -1
## 9                       1
## 10                      0
## 11                      1
## 12                      1
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                        6.67
## 2                        1.00
## 3                       11.40
## 4                        8.00
## 5                       12.00
## 6                        3.67
## 7                        3.67
## 8                        3.67
## 9                        1.00
## 10                       2.67
## 11                       5.00
## 12                      11.67
```

2.2.6 Seasonal Kendall Estimates

```
##          tau   slope intercept
## 1   0.0000 -0.0945     191.8
## 2  -1.0000 -0.0090      18.8
## 3  -0.6000 -1.1875    2404.9
## 4  -0.4000 -0.1040     211.4
## 5  -0.6000 -0.0915     185.6
## 6   0.3333  0.0885    -178.9
## 7  -1.0000 -0.3635     737.1
## 8  -0.3333 -0.1560     316.1
## 9   1.0000  2.5540   -5166.6
## 10  0.0000 -0.0460      94.6
## 11  0.1667  0.2170    -438.9
## 12  0.0667  0.0200     -39.6
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-110-DSVMP35.75

Parameter	***Limits***	***Confidence***
slope	-0.8251	0.95
slope	0.0131	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-110-DSVMP35.75 Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-110-DSVMP40.25 Organic Vapor Trend Analysis

[redacted]

2025-10-04

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-110-DSVMP40.25 for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

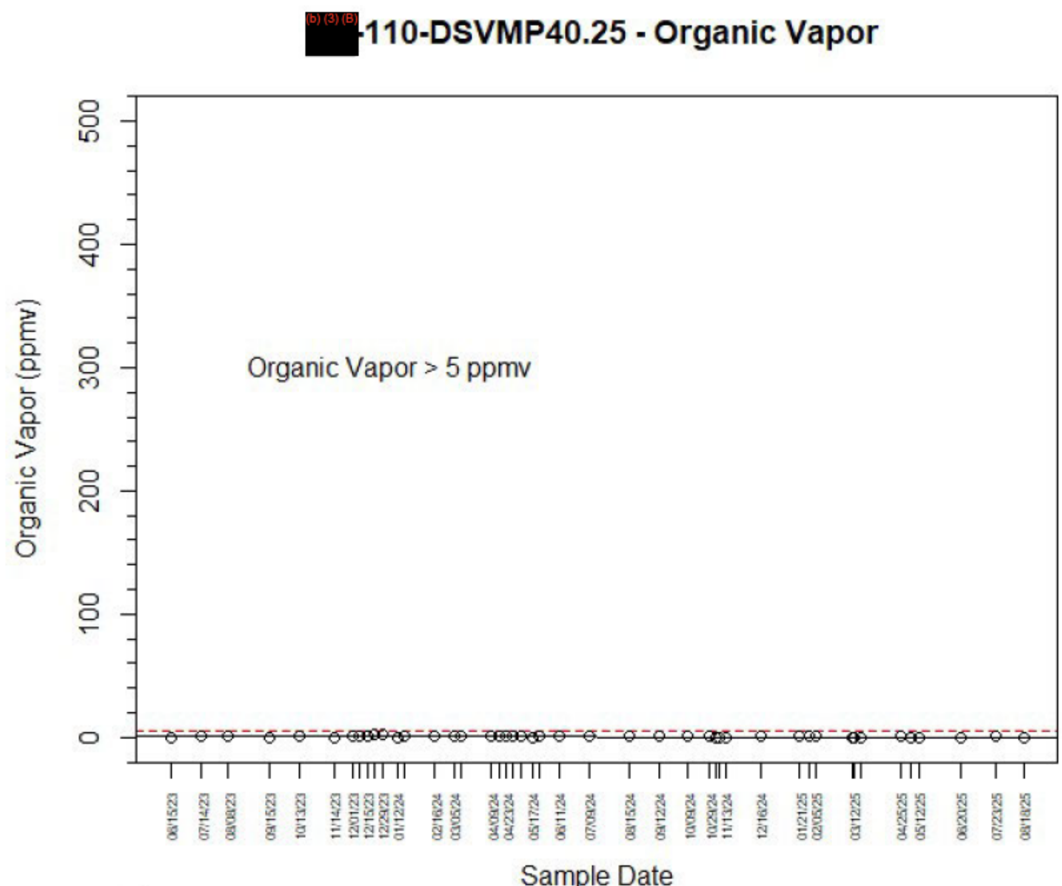
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-110-DSVMP40.25 Akritas-Theil-Sen Trend Test Results for Organic Vapor

Slope	Intercept	Tau	p-value
-0.00089	41.1	-0.225	0.0299



[redacted] 110-DSVMP40.25 - Organic Vapor

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-110-DSVMP40.25

Chi-Square	***p-value***	***z (trend)***	***p-value***
9.5	0.576	-1.43	0.153

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-110-DSVMP40.25

tau	**slope**	**intercept**
-0.105	-0.222	385

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                           4
## 2                           2
## 3                           5
## 4                           5
## 5                           5
## 6                           3
## 7                           3
## 8                           3
## 9                           2
## 10                          3
## 11                          4
## 12                          6
## Total                      45
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                       0
## 2                       1
## 3                      -6
## 4                      -2
## 5                      -4
## 6                       1
## 7                      -1
## 8                      -3
## 9                       1
## 10                      0
## 11                      1
## 12                     -1
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                        6.67
## 2                        1.00
## 3                       11.40
## 4                        8.00
## 5                       12.00
## 6                        3.67
## 7                        3.67
## 8                        3.67
## 9                        1.00
## 10                       2.67
## 11                       5.00
## 12                      11.67
```

2.2.6 Seasonal Kendall Estimates

```
##        tau   slope intercept
## 1   0.0000 -0.2245       455
## 2   1.0000  0.1390      -281
## 3  -0.6000 -0.9665      1957
## 4  -0.2000 -0.0735       150
## 5  -0.4000 -0.2680       543
## 6   0.3333  0.0705      -143
## 7  -0.3333 -0.3295       668
## 8  -1.0000 -0.2700       547
## 9   1.0000  1.6210     -3279
## 10  0.0000 -0.2020       410
## 11  0.1667  0.1760      -356
## 12 -0.0667 -0.1770       359
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-110-DSVMP40.25

Parameter	***Limits***	***Confidence***
slope	-0.7126	0.95
slope	0.0364	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-110-DSVMP40.25 Organic Vapor Trend Analysis

Appendix D.3:
LNAPL Akritas-Theil-Sen Trend Test Results

CTO 24F0224_SV 1S+025-BH Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for 1S+025-BH for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

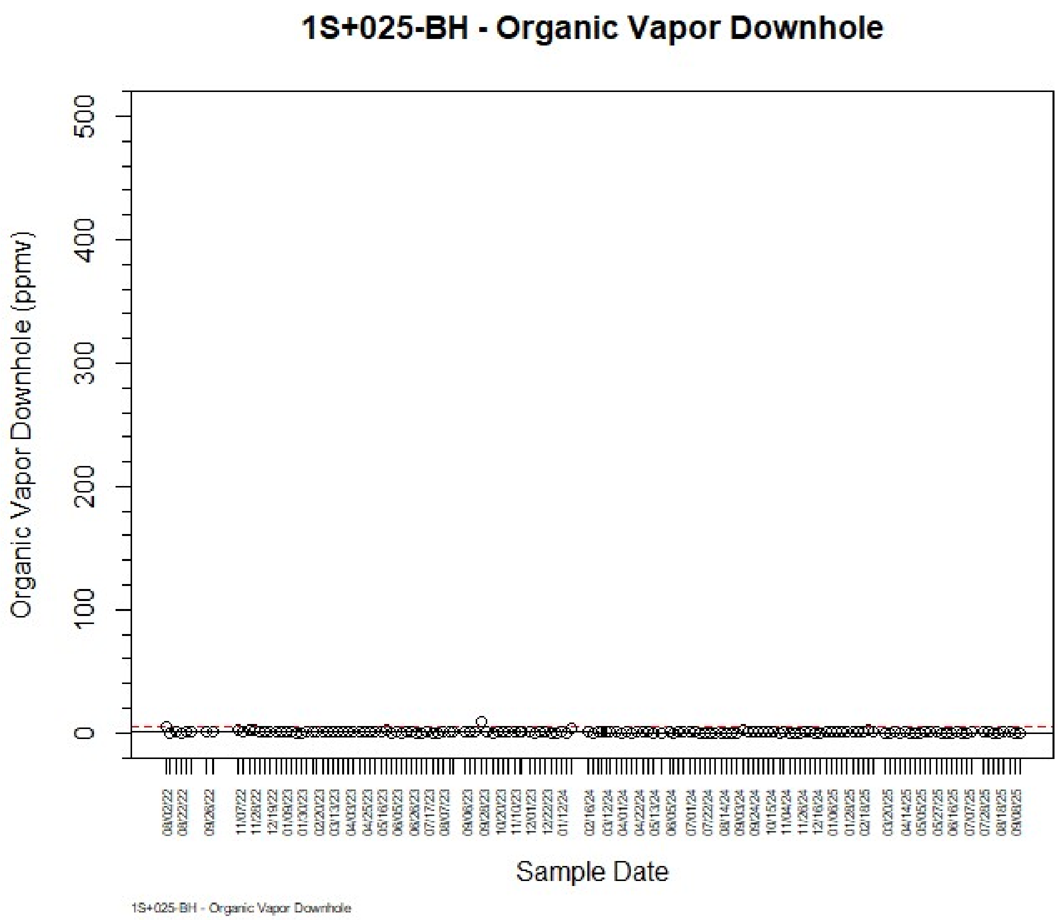
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

1S+025-BH Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.000278	13.1	-0.167	0.00214



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 1S+025-BH

Chi-Square	***p-value***	***z (trend)***	***p-value***
34	0.00036	-2.5	0.0125

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 1S+025-BH

tau	***slope***	***intercept***
-0.138	-0.1	220

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          13
## 2                          10
## 3                          12
## 4                          14
## 5                          12
## 6                          13
## 7                          13
## 8                          16
## 9                          13
## 10                         10
## 11                         12
## 12                         14
## Total                     152
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                        28
## 2                        16
## 3                       -38
## 4                       -33
## 5                       -15
## 6                       -21
## 7                        22
## 8                        -7
## 9                        -6
## 10                        4
## 11                      -48
## 12                      -32
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       231.2
## 2                       105.2
## 3                       180.8
## 4                       281.4
## 5                       182.2
## 6                       228.4
## 7                       217.0
## 8                       433.7
## 9                       243.6
## 10                       97.1
## 11                      185.9
## 12                      280.7
```

2.2.6 Seasonal Kendall Estimates

```
##         tau  slope intercept
## 1   0.3590  0.200   -404.20
## 2   0.3556  0.350   -707.60
## 3  -0.5758 -0.400    810.20
## 4  -0.3626 -0.200    405.35
## 5  -0.2273 -0.150    304.10
## 6  -0.2692 -0.100    202.80
## 7   0.2821  0.150   -303.40
## 8  -0.0583  0.000      0.35
## 9  -0.0769 -0.117    236.83
## 10  0.0889  0.100   -201.65
## 11 -0.7273 -0.900   1821.60
## 12 -0.3516 -0.200    405.00
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 1S+025-BH

Parameter	***Limits***	***Confidence***
slope	-0.2	0.95
slope	0.0	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 1S+025-BH Organic Vapor Trend Analysis

CTO 24F0224_SV 2S+100-BH Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for 2S+100-BH for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

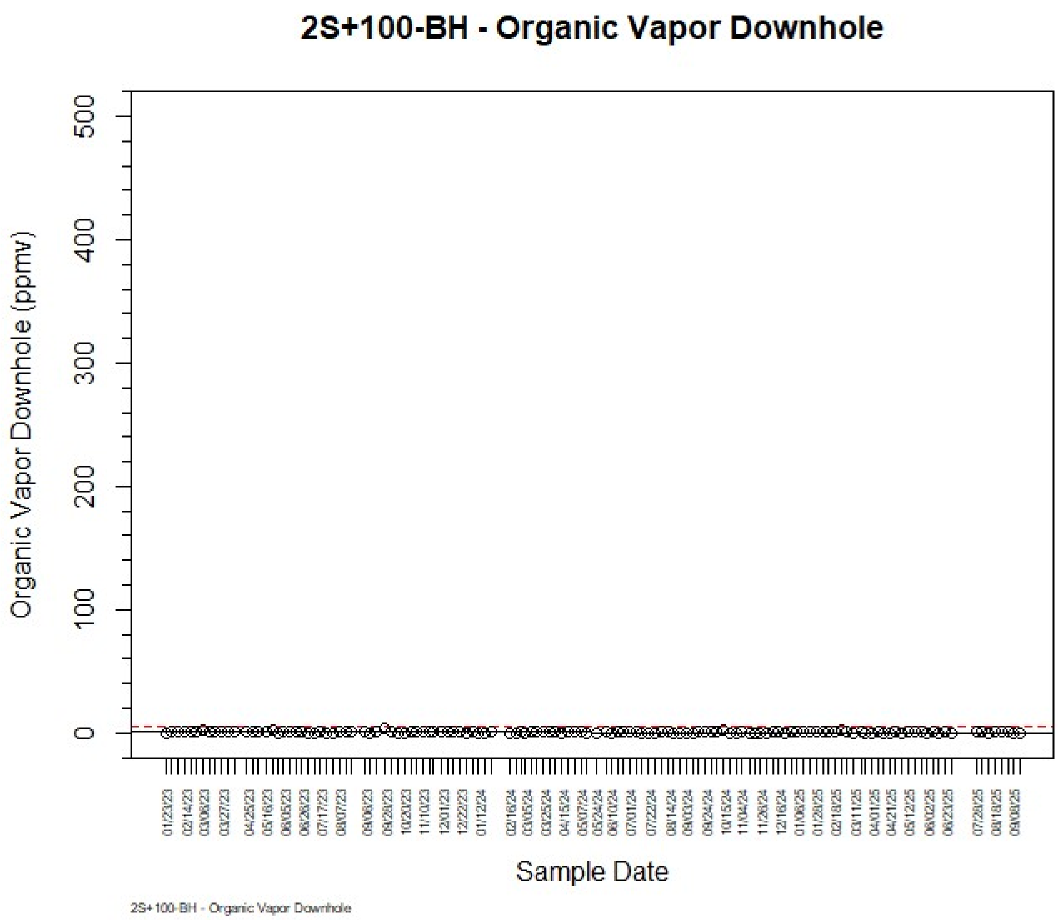
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

2S+100-BH Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.000116	5.72	-0.0937	0.11



2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend 2S+100-BH

Chi-Square	***p-value***	***z (trend)***	***p-value***
34.8	0.000263	-1.83	0.0669

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall 2S+100-BH

tau	slope	intercept
-0.0846	-0.1	25.7

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          10
## 2                          10
## 3                          13
## 4                          13
## 5                          12
## 6                          13
## 7                          11
## 8                          11
## 9                          11
## 10                          9
## 11                          8
## 12                         10
## Total                     131
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                       23
## 2                       14
## 3                      -42
## 4                      -45
## 5                      -13
## 6                      -25
## 7                       17
## 8                       -2
## 9                       -2
## 10                      11
## 11                     -15
## 12                       3
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       105.2
## 2                       106.7
## 3                       231.8
## 4                       225.5
## 5                       178.8
## 6                       227.7
## 7                       127.9
## 8                       139.7
## 9                       141.8
## 10                       66.1
## 11                       46.3
## 12                       78.3
```

2.2.6 Seasonal Kendall Estimates

```
##         tau  slope intercept
## 1   0.5111  0.375    -758.4
## 2   0.3111  0.400    -808.7
## 3  -0.5385 -0.300     607.8
## 4  -0.5769 -0.300     607.6
## 5  -0.1970 -0.100     202.8
## 6  -0.3205 -0.100     202.8
## 7   0.3091  0.200    -404.5
## 8  -0.0364  0.000       0.4
## 9  -0.0364 -0.025      51.0
## 10  0.3056  0.500   -1011.6
## 11 -0.5357 -0.600    1214.5
## 12  0.0667  0.000       0.4
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope 2S+100-BH

Parameter	***Limits***	***Confidence***
slope	-0.15	0.95
slope	0.00	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of 2S+100-BH Organic Vapor Trend Analysis

CTO 24F0224_SV [redacted] +015-TW Organic Vapor Trend Analysis

[redacted]

2025-10-03

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted] +015-TW for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

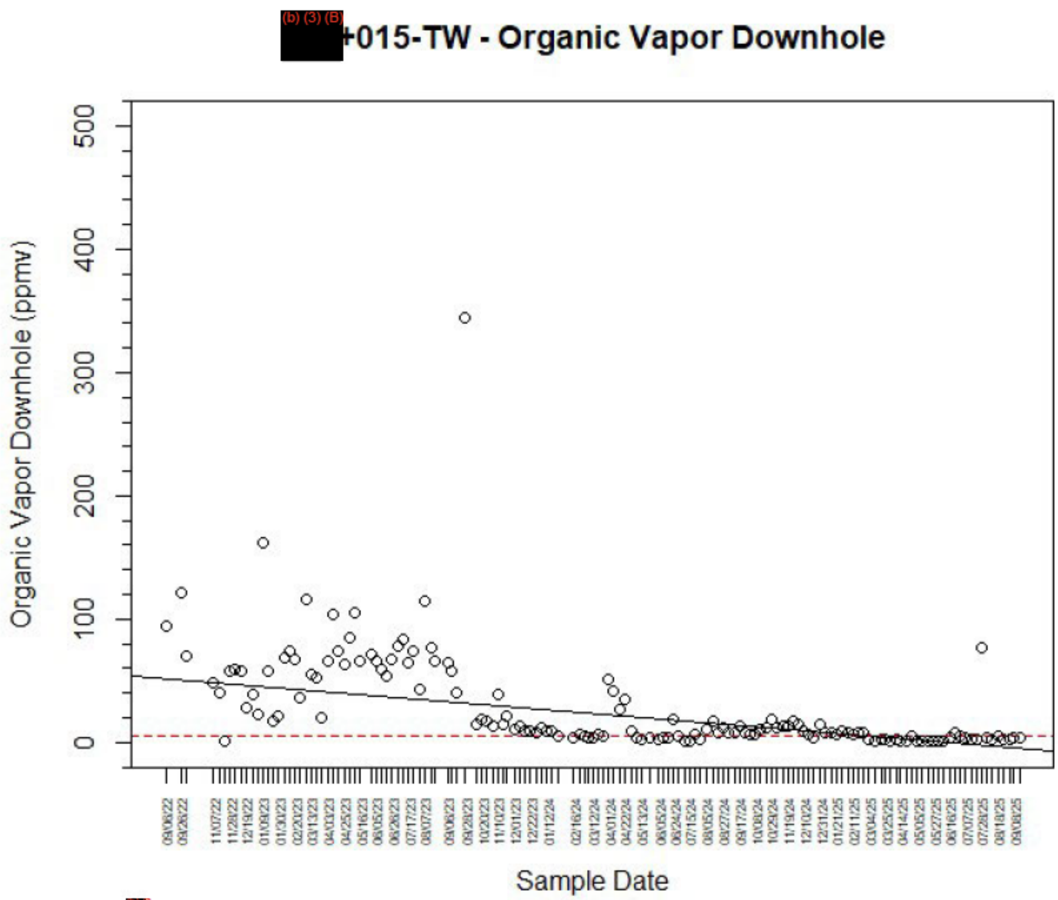
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]+015-TW Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.0509	2,331	-0.559	0



[redacted]+015-TW - Organic Vapor Downhole

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]+015-TW

Chi-Square	***p-value***	***z (trend)***	***p-value***
6.8	0.815	-9.57	0.0000000000000000000111

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted] +015-TW

tau	***slope***	***intercept***
-0.567	-25.9	58,753

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          13
## 2                          10
## 3                          13
## 4                          14
## 5                          11
## 6                          13
## 7                          14
## 8                          11
## 9                          13
## 10                          9
## 11                         12
## 12                         14
## Total                     147
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -45
## 2                     -18
## 3                     -56
## 4                     -65
## 5                     -40
## 6                     -38
## 7                     -31
## 8                     -40
## 9                     -58
## 10                    -19
## 11                    -24
## 12                    -43
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                         234
## 2                         107
## 3                         235
## 4                         292
## 5                         143
## 6                         235
## 7                         292
## 8                         144
## 9                         246
## 10                         71
## 11                        187
## 12                        292
```

2.2.6 Seasonal Kendall Estimates

```
##       tau slope intercept
## 1  -0.577  -7.6     15392
## 2  -0.400 -30.1     60981
## 3  -0.718 -15.6     31478
## 4  -0.714 -33.3     67430
## 5  -0.727 -38.5     77978
## 6  -0.487 -27.9     56525
## 7  -0.341 -35.8     72465
## 8  -0.727 -33.8     68321
## 9  -0.744 -34.6     70145
## 10 -0.528 -11.4     23088
## 11 -0.364 -13.3     26871
## 12 -0.473 -13.9     28132
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]+015-TW

Parameter	***Limits***	***Confidence***
slope	-30.7	0.95
slope	-17.6	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted] +015-TW Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]+150-BH Organic Vapor Trend Analysis

[redacted]

2025-10-03

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]+150-BH for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

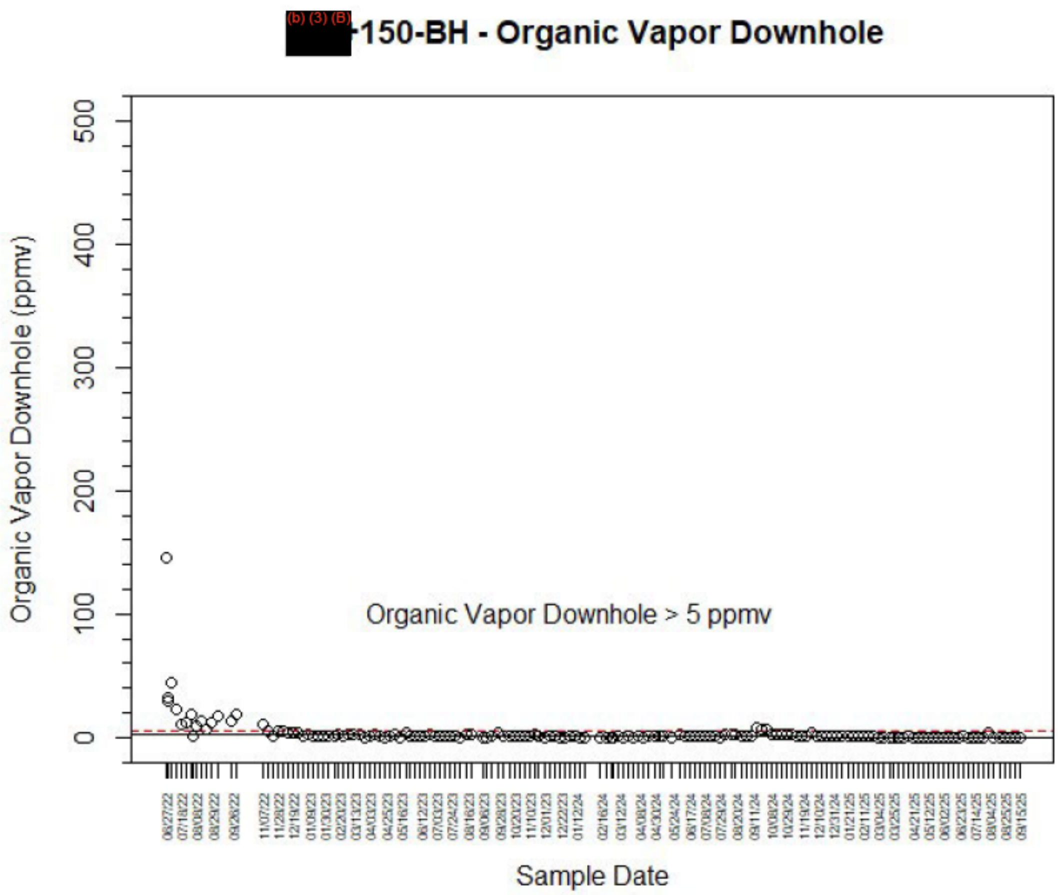
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]+150-BH Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.00204	93.6	-0.407	0.0000000000000144



[redacted]+150-BH - Organic Vapor Downhole

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]+150-BH

Chi-Square	***p-value***	***z (trend)***	***p-value***
23.6	0.0147	-6.86	0.0000000000686

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted] *+150-BH*

tau	***slope***	***intercept***
-0.354	-0.75	1,696

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          13
## 2                          10
## 3                          13
## 4                          14
## 5                          12
## 6                          15
## 7                          19
## 8                          17
## 9                          13
## 10                         10
## 11                         12
## 12                         14
## Total                     162
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                      -4
## 2                      -8
## 3                     -37
## 4                     -35
## 5                     -32
## 6                     -58
## 7                    -122
## 8                     -61
## 9                     -26
## 10                     11
## 11                    -26
## 12                     -9
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                          228
## 2                          107
## 3                          225
## 4                          287
## 5                          170
## 6                          372
## 7                          753
## 8                          539
## 9                          245
## 10                          99
## 11                         187
## 12                         290
```

2.2.6 Seasonal Kendall Estimates

```
##        tau  slope intercept
## 1  -0.0513 -0.050       102
## 2  -0.1778 -0.200       406
## 3  -0.4744 -0.550      1114
## 4  -0.3846 -0.300       608
## 5  -0.4848 -0.750      1518
## 6  -0.5524 -0.925      1873
## 7  -0.7135 -3.400      6879
## 8  -0.4485 -2.300      4655
## 9  -0.3333 -1.575      3189
## 10  0.2444  1.500     -3033
## 11 -0.3939 -1.650      3339
## 12 -0.0989 -1.000      2024
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]+150-BH

Parameter	***Limits***	***Confidence***
slope	-1.10	0.95
slope	-0.45	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted] +150-BH Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]+325-TW Organic Vapor Trend Analysis

[redacted]

2025-10-03

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1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]+325-TW for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

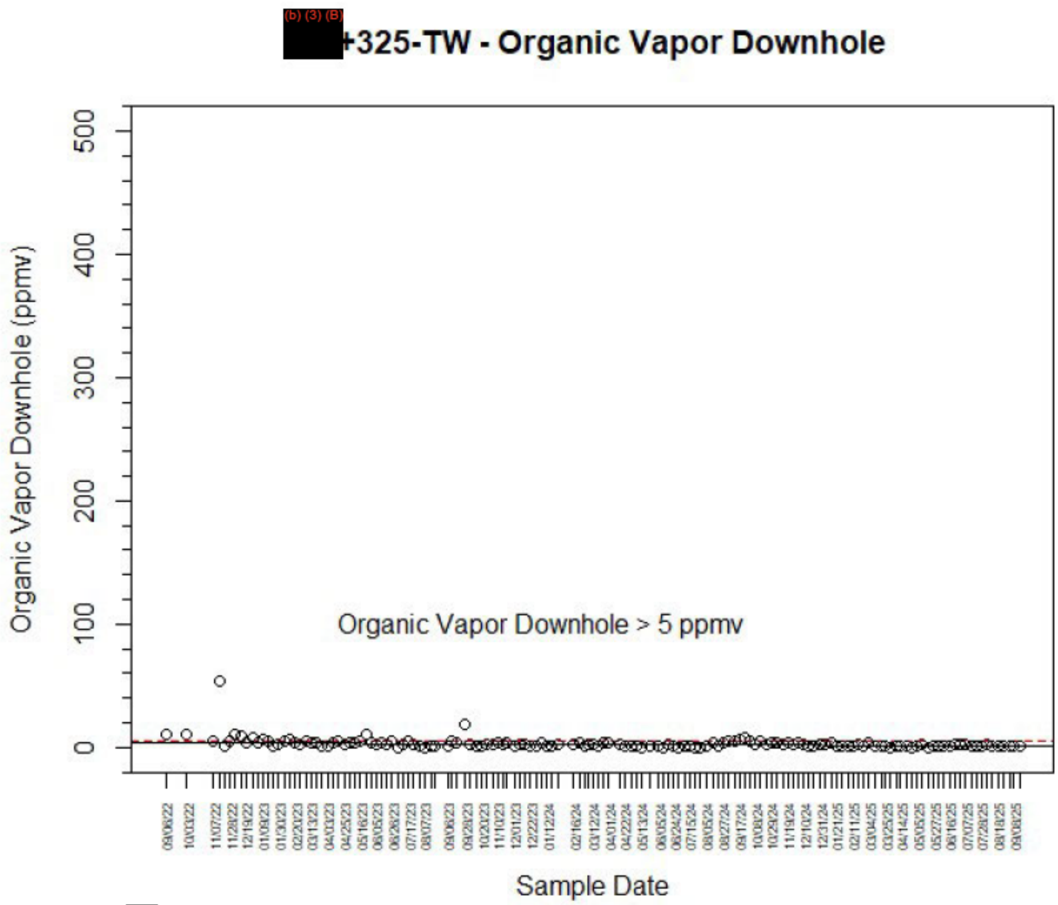
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]+325-TW Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.00304	141	-0.343	0.000000000685



[redacted]25-TW - Organic Vapor Downhole

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]+325-TW

Chi-Square	***p-value***	***z (trend)***	***p-value***
13.4	0.268	-4.37	0.0000123

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted] +325-TW

tau	***slope***	***intercept***
-0.257	-1	2,152

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          13
## 2                          10
## 3                          13
## 4                          13
## 5                          12
## 6                          13
## 7                          14
## 8                          11
## 9                          12
## 10                         10
## 11                         12
## 12                         14
## Total                     147
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -14
## 2                     -30
## 3                     -24
## 4                     -36
## 5                     -30
## 6                     -23
## 7                      -3
## 8                       4
## 9                     -25
## 10                      7
## 11                    -12
## 12                    -30
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       233.2
## 2                       106.0
## 3                       233.2
## 4                       231.9
## 5                       183.0
## 6                       231.2
## 7                       288.2
## 8                       142.5
## 9                       191.7
## 10                       99.7
## 11                      185.9
## 12                      291.0
```

2.2.6 Seasonal Kendall Estimates

```
##          tau  slope intercept
## 1  -0.1795 -0.425       863
## 2  -0.6667 -1.500      3039
## 3  -0.3077 -1.100      2228
## 4  -0.4615 -1.100      2228
## 5  -0.4545 -1.950      3948
## 6  -0.2949 -0.875      1773
## 7  -0.0330 -0.050       103
## 8   0.0727  0.100      -201
## 9  -0.3788 -2.750      5571
## 10  0.1556  0.900     -1818
## 11 -0.1818 -1.025      2077
## 12 -0.3297 -1.800      3644
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]+325-TW

Parameter	Limits	Confidence
slope	-1.3	0.95
slope	-0.6	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]+325-TW Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-100-BH Organic Vapor Trend Analysis

[redacted]

2025-10-03

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-100-BH for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

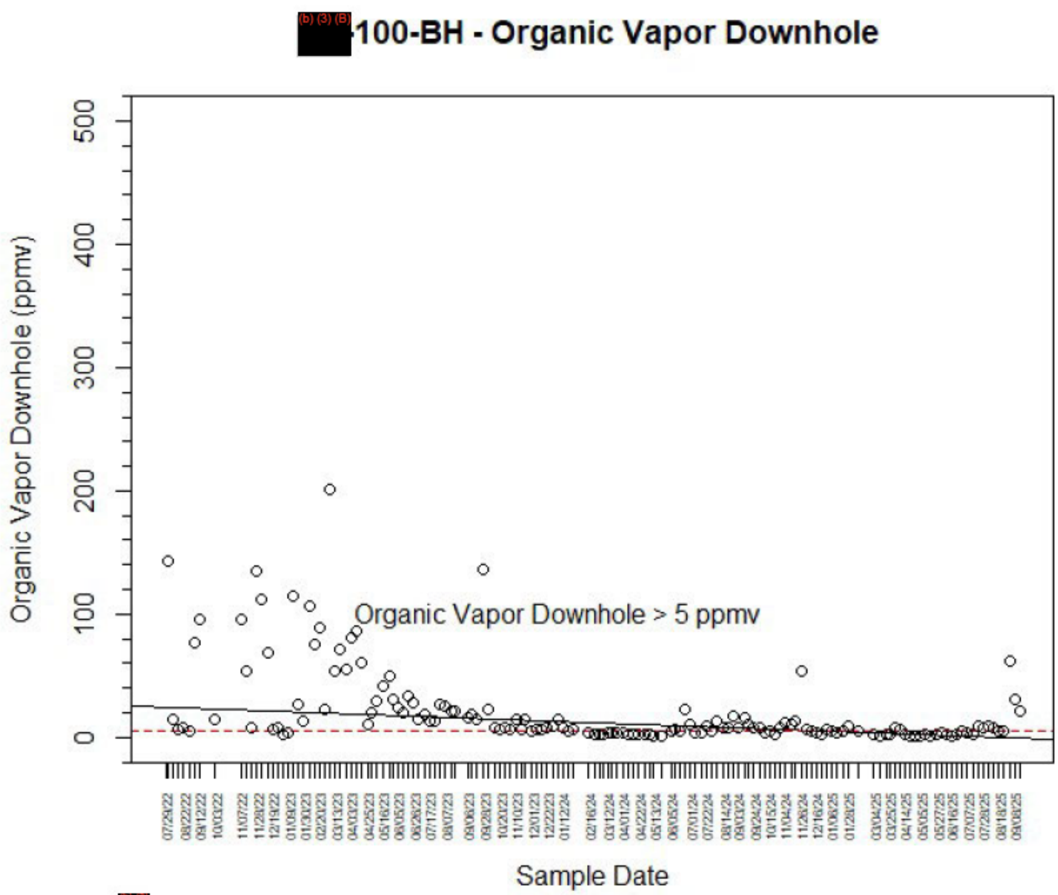
The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-100-BH Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.022	1,008	-0.435	0.000000000000002



[redacted]100-BH - Organic Vapor Downhole

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-100-BH

Chi-Square	***p-value***	***z (trend)***	***p-value***
10.8	0.459	-7.15	0.00000000000879

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	**Estimation**
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-100-BH

tau	**slope**	**intercept**
-0.42	-6.85	15,953

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          13
## 2                           7
## 3                          13
## 4                          14
## 5                          12
## 6                          13
## 7                          15
## 8                          16
## 9                          13
## 10                         10
## 11                         12
## 12                         14
## Total                     152
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                     -14
## 2                     -10
## 3                     -54
## 4                     -37
## 5                     -32
## 6                     -54
## 7                     -63
## 8                     -27
## 9                     -12
## 10                    -19
## 11                    -16
## 12                    -45
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                       234.7
## 2                        34.7
## 3                       234.7
## 4                       291.0
## 5                       182.2
## 6                       234.7
## 7                       366.3
## 8                       455.7
## 9                       246.7
## 10                       99.7
## 11                      186.7
## 12                      288.9
```

2.2.6 Seasonal Kendall Estimates

```
##        tau  slope intercept
## 1  -0.179  -2.95      5978
## 2  -0.476 -46.45     93990
## 3  -0.692 -30.58     61887
## 4  -0.407  -8.60     17409
## 5  -0.485 -14.65     29654
## 6  -0.692 -11.43     23129
## 7  -0.600  -7.60     15392
## 8  -0.225  -3.10      6282
## 9  -0.154  -8.15     16514
## 10 -0.422  -3.90      7899
## 11 -0.242  -4.00      8106
## 12 -0.495  -2.40      4862
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-100-BH

Parameter	***Limits***	***Confidence***
slope	-9.72	0.95
slope	-3.63	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

3.0.0.1End of [redacted]-100-BH Organic Vapor Trend Analysis

CTO 24F0224_SV[redacted]-300-BH Organic Vapor Trend Analysis

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2025-10-03

Table of Contents

1 Introduction

This purpose of this document is to present the time-series and trend results for [redacted]-300-BH for Organic Vapor.

The SVMP data was analyzed for trends using the NADA Version 1.6-1.1 (2020-03-22) (Helsel 2012) Akritas-Theil-Sen slope and Kendall's tau methods.

The SVMP data was analyzed for seasonal trends using the EnvStats Package 3.1.0 (2025-04-17) Kendall Seasonal Trend Test method (Hirsch et al. 1982, van Belle and Hughes 1984, Hirsch and Slack 1984).

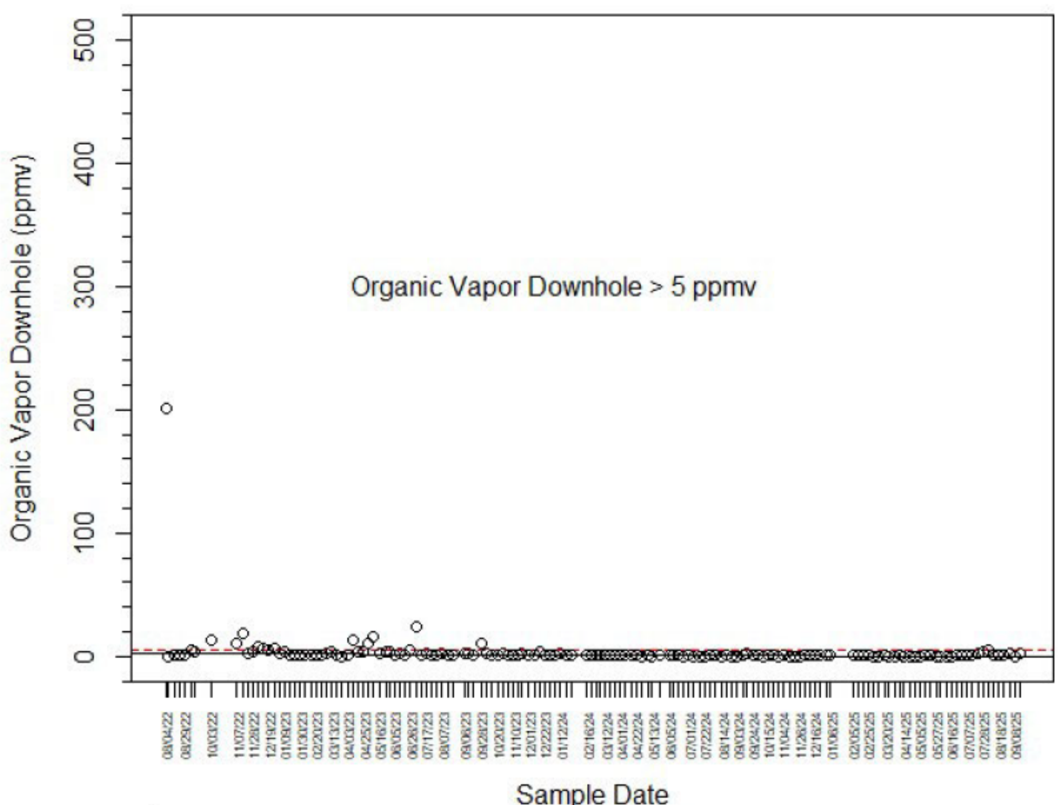
2 Compute Trend Statistics for SVMP

2.1 Aktritas-Theil-Sen Trend Test Organic Vapor (USGS NADA Method)

[redacted]-300-BH Akritas-Theil-Sen Trend Test Results for Organic Vapor Downhole

Slope	Intercept	Tau	p-value
-0.0016	73.7	-0.397	0.000000000000415

[redacted]-300-BH - Organic Vapor Downhole



[redacted]00-BH - Organic Vapor Downhole

2.2 Nonparametric Test for Monotonic Trend Within Each Season Based on Kendall's Tau Statistic Organic Vapor (ENVSTATS USGS Method)

Seasonal Kendall Trend [redacted]-300-BH

Chi-Square	*p-value*	*z (trend)*	*p-value*
17.3	0.1	-6.83	0.0000000000869

2.2.1 Seasonal Kendall Method

Seasonal Kendall Method

Method	***Estimation***
Seasonal Kendall Test for Trend (with continuity correction)	tau: Weighted Average of Seasonal Estimates slope: Hirsch et al.'s Modification of Thiel/Sen Estimator intercept: Median of Seasonal Estimates

2.2.2 Seasonal Kendall Results

Seasonal Kendall [redacted]-300-BH

tau	***slope***	***intercept***
-0.405	-0.6	1,417

2.2.3 Seasonal Kendall Sample Size per Season

```
##       kendall_out.sample.size
## 1                          10
## 2                          10
## 3                          13
## 4                          14
## 5                          12
## 6                          13
## 7                          14
## 8                          16
## 9                          13
## 10                         10
## 11                         12
## 12                         14
## Total                     151
```

2.2.4 Seasonal Kendall S per Season

```
##    kendall_out.seasonal.S
## 1                       0
## 2                     -15
## 3                     -35
## 4                     -52
## 5                     -35
## 6                     -47
## 7                      -6
## 8                      -4
## 9                     -31
## 10                    -29
## 11                    -45
## 12                    -56
```

2.2.5 Seasonal Kendall Variance per Season

```
##    kendall_out.var.seasonal.S
## 1                          99
## 2                         102
## 3                         233
## 4                         290
## 5                         182
## 6                         225
## 7                         290
## 8                         447
## 9                         246
## 10                         99
## 11                        185
## 12                        290
```

2.2.6 Seasonal Kendall Estimates

```
##        tau slope intercept
## 1   0.0000  0.00       1.5
## 2  -0.3333 -0.15     304.4
## 3  -0.4487 -0.50    1012.7
## 4  -0.5714 -0.80    1619.8
## 5  -0.5303 -2.00    4048.7
## 6  -0.6026 -0.60    1214.8
## 7  -0.0659 -0.10     203.1
## 8  -0.0333  0.00       0.6
## 9  -0.3974 -0.80    1621.2
## 10 -0.6444 -1.80    3643.2
## 11 -0.6818 -1.50    3035.9
## 12 -0.6154 -2.70    5463.1
```

2.2.7 Seasonal Kendall Confidence Interval on Slope

Seasonal Kendall Confidence Interval on Slope [redacted]-300-BH

Parameter	***Limits***	***Confidence***
slope	-1.0	0.95
slope	-0.4	0.95

3 REFERENCES

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York, NY.

Helsel, D.R., 2004. Nondetects and Data Analysis: Statistics for Censored Environmental Data, 1st edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., 2011. Statistics for Censored Environmental Data Using Minitab© and R, 2nd edition. ed. Wiley-Interscience, Hoboken, N.J.

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources: U.S. Geological Survey Techniques and Methods, book 4, chapter A3, 458 p., https://doi.org/10.3133/tm4a3. [Supersedes USGS Techniques of Water-Resources Investigations, book 4, chapter A3, version 1.1.]

Helsel, D.R., Hirsch, R.M., Ryberg, K.R., Archfield, S.A., and Gilroy, E.J., 2020, Statistical methods in water resources—Supporting materials: U.S. Geological Survey data release, https://doi.org/10.5066/P9JWL6XR.

Julian, P. and Helsel, D. (2024). NADA2: Data Analysis for Censored Environmental Data. R package version 1.1.8. https://github.com/SwampThingPaul/NADA2

Lee, L. 2020. NADA Nondetects and Data Analysis for Environmental Data. R package version 1.6-1.1. CRAN - Package NADA (r-project.org).

Millard SP (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4, https://www.springer.com.

R-4.5.1 for Windows: Download R-4.5.1 for Windows. The R-project for statistical computing. R Core Team (2025). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

RStudio Team (2025). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA URL http://www.rstudio.com/ Ver. 2025.09.0 Build 387

U.S. EPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007.

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