Odor Control Summer Monitoring Data

Annapolis Water Reclamation Facility

Odor Control Evaluations

December 10, 2024

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1 INTRODUCTION

The Annapolis Water Reclamation Facility (WRF) is a wastewater treatment plant, jointly owned by the City of Annapolis and Anne Arundel County. The County is responsible for the operation and maintenance of the facility. The facility employs an advanced activated sludge process with nitrification/de-nitrification for Enhanced Nutrient Removal (ENR) level treatment. The treated effluent is discharged into the Chesapeake Bay. The aerial view of the WRF and its surrounding neighborhoods is shown in Figure 1-1.

Figure 1-1: Aerial view of the Annapolis Water Reclamation Facility

Recent projects at the WRF have upgraded various portions of the treatment plant. However, the odor control facilities have not been evaluated. The County desired to complete a comprehensive odor control evaluation at the plant to identify sources of odor and potential capital improvements.

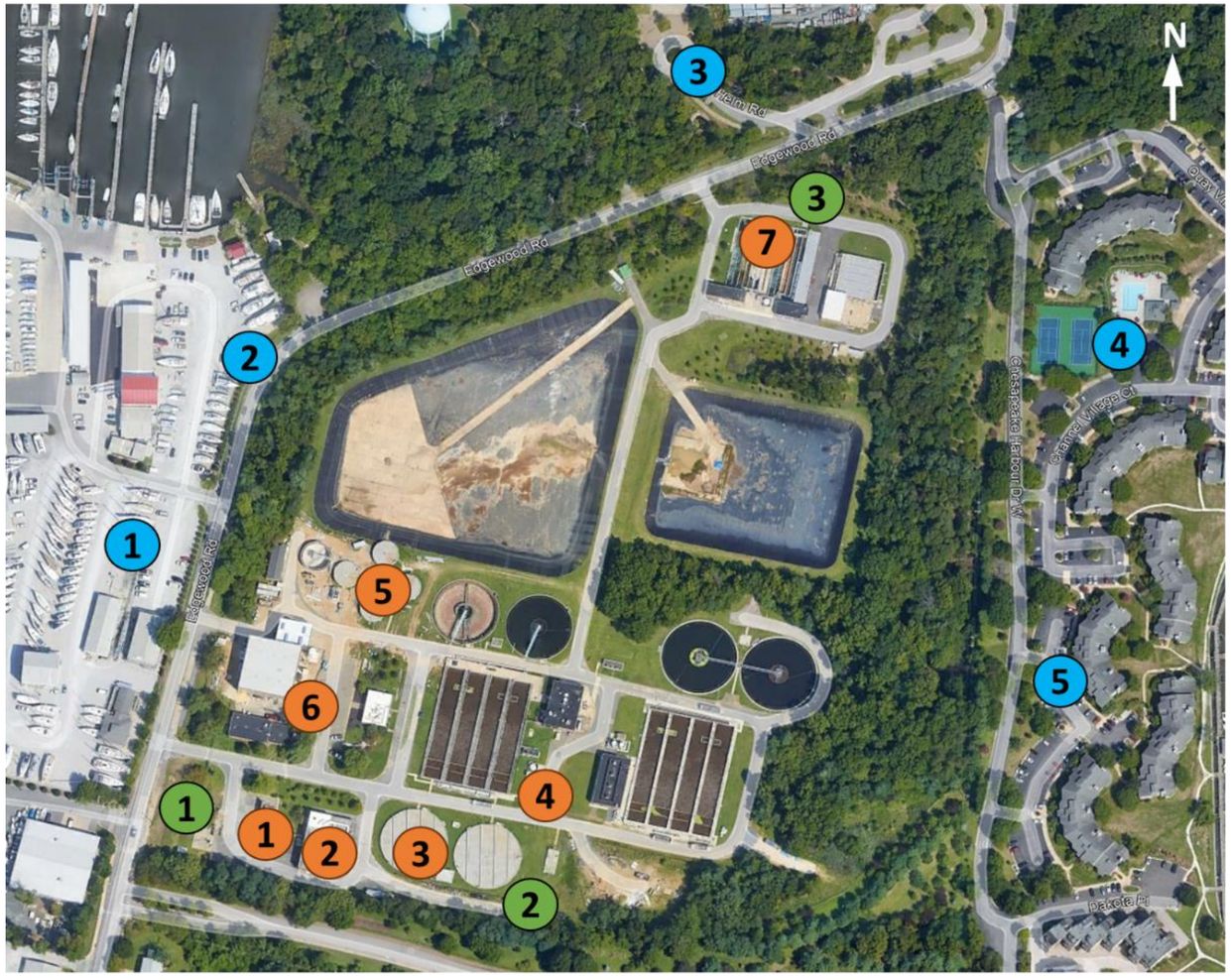
The overall goal of the project is to conduct a comprehensive odor evaluation including monitoring, data collection, data analysis, and air dispersion modeling to identify sources of odors and potential capital improvements needed to address them.

The purpose of this Technical Memo (TM) is to summarize the results of continuous monitoring conducted during the summer months within the facility and along the fenceline/neighborhood, in

accordance with the Odorous Air Monitoring Plan. The Odor Monitoring Plan and the previously developed winter monitoring data TM are provided in the Appendices for reference.

2 MONITORING LOCATIONS AND PERIOD

The summer monitoring included continuous hydrogen sulfide (H_2S) and temperature monitoring at a total of fifteen (15) locations over a six-week period, from July 1, 2024, to August 13, 2024. Seven (7) Acrulog™ hydrogen sulfide (H_2S) part-per-million (PPM) data loggers were used to monitor odors at the source of emissions within the WRF, while eight Acrulog™ (8) part-per-billion (PPB) monitors were used to monitor odor levels after the impacts of dispersion. The monitored locations are shown in Figure 2-1, orange circles denote interior source locations, green circles indicate fenceline locations, and blue circles indicate neighborhood locations. Further details on winter and summer monitoring locations can be found in Odor Monitoring Plan provided in Appendix A.



Legend:

Locations within WRF (PPM)

1. Wet well (Influent & Effluent (2))
2. Headworks (Building Space & Effluent (2))
3. Primary Clarifier Launders
4. Odor Control to Blowers
5. Gravity Sludge Thickeners
6. Solids Facility
7. Denite Filters Mudwell

Fenceline locations (PPB)

1. Septic Hauler Discharge/West
2. South
3. Denite Filter Backwash Area / North

Neighborhood Locations (PPB)

1. Marina- Store Front
2. Marina- Fenceline
3. Maritime Museum
4. Chesapeake Harbor - Near pool/tennis courts
5. Chesapeake Harbor along roadway - East

Figure 2-1: Summer Monitoring Locations

3 MONITORING DATA

After the odor monitors were deployed on July 1, 2024, weekly site visits were conducted to check the battery life of the monitors and extract data. These visits occurred on July 8, 15, 19, 29, and August 5, with the final visit on August 13. The data collected during this monitoring period are presented below.

3.1 Site Source H_2S Monitoring Findings

The changes in the measurable H_2S concentration distribution over the monitoring period for all the locations within the WRF are illustrated in Figure 3-1. Additionally, the measured the range of H_2S concentrations and the percent of detection events, are presented in Table 3-1.

Overall findings from the onsite source monitoring are presented below.

- Among all the monitored locations, the Headworks (screen and grit) building space had the highest detection frequency (refers to how often H_2S was detected by the logger during the monitoring period) and magnitude of measurable H2S concentrations, with detection frequency of 98% and concentrations ranging from 0.4 to 57.8 ppmv, with an average of 4.4 ppmv. The air from the Headworks building is being ventilated directly into the atmosphere through an inactive scrubber unit. However, the logger deployed at the effluent of the inactive scrubber measured relatively lower H_2S levels (0.4 to 12.5 ppmv at 89% detection frequency, with an average of 1.5 ppmv), indicating that the Headworks building's ventilation system is ineffective at removing odorous air from the building.
- Similar to the Headworks building space, the logger deployed at the mudwell recorded higher levels of H2S (0.4 to 60.0 ppmv, with an average of 0.2 ppmv); however, the detection frequency was much lower at 43% compared to Headworks. The solids buildup within the mudwell is likely the source of decay and odors. And the data suggests that the detection events may be linked to operational activities, such as active backwash events, which could be causing the release of H_2S from the mudwell. The County is actively flushing the tank and working on permanent covers and automatic flushing systems to help mitigate these odors.
- Ventilated air from the influent pump station had H_2S concentrations reaching up to 36.7 ppmv with an average of 5.1 ppmv and a detection frequency of 98%. This air is being directed to the existing biofilter for treatment. However, the effluent air from the biofilter still showed the presence of H_2S, with concentrations up to 15.3 ppmv with an average of 1.2 ppmv and a detection frequency of 81%. These results indicate that the current treatment system is not effectively mitigating the odorous air from the influent pump station.
- Primary clarifier logger recorded the next highest frequency and magnitude of measurable H_2S concentrations. The detection frequency was 93% with measurable H_2S concentrations ranging from 0.4 to 37.7 ppmv with an average of 4.5 ppmv. The odorous emissions in this area are being collected and sent to the existing aeration blowers for diffusion into the aeration tanks (not directly emitted to the atmosphere).
- The recorded H_2S detection frequency and magnitude at the gravity sludge thickeners (GSTs) were also relatively high, at 95% and 0.4 to 39.5 ppmv, respectively. The average

H_2S concentration was 3.4 ppmv. Odorous emissions in this area are being collected and sent to the existing aeration blowers for diffusion into the aeration tanks (not directly emitted to the atmosphere).

- The logger installed at the blower duct also measured the presence of H_2S for 82% of the monitoring time, with concentrations in the range of 0.4 to 37.2 ppmv and an average of 12.1 ppmv. This air is sent to the existing aeration blowers for diffusion into the aeration tanks (not directly emitted to the atmosphere).
- Previous monitoring at the aeration tanks and secondary clarifiers indicated that the diffusion into the aeration tanks (for the primary clarifiers and GSTs) is effective in odor reduction.
- H_2S levels at the solids facility ware not detectable, both in terms of concentration and detection frequency.

In general, summer H_2S levels at all locations were relatively high compared to the winter data, consistent with the reasoning that warmer temperatures increase biological activity, promote the volatilization of odorous compounds, and create anaerobic conditions, leading to higher H_2S production and release.

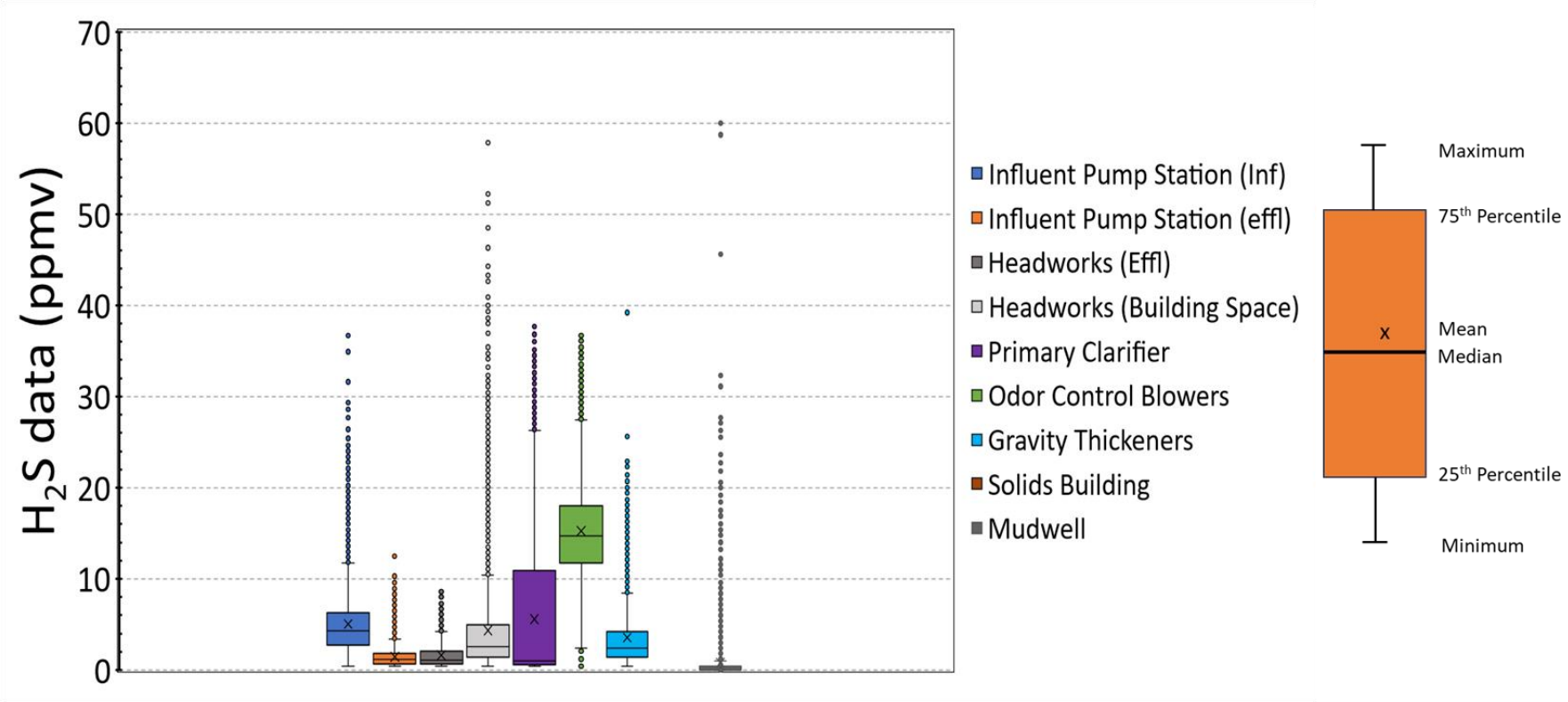


Figure 3-1: Box-And-Whisker Plots Showing the Change in Measurable H2S Concentration Distribution for the Locations Within the WRF (July 1 to August 13).

Table 3-1: Site Source H_2S Monitoring Findings (Winter and Summer)

Monitoring Locations	Winter			Summer		
	Average H_2S Concentration (including "Zero")	H_2S Concentration Range (PPM) Min/Max (Excluding "Zero" Readings)	Percent of Values Detected above "Zero"	Average H_2S Concentration (including "Zero")	H_2S Concentration Range (PPM) Min/Max (Excluding "Zero" Readings)	Percent of Values Detected above "Zero"
Uncontrolled Sources (Emitted Directly to Atmosphere)						
Influent Pump Station (effluent)	-	-	-	1.2	0.4 – 15.3	81%
Headworks (Building Space)	-	-	-	4.4	0.4 – 57.8	98%
Headworks (Effluent)	2.4	0.4 – 19.9	56%	1.5	0.4 – 12.5	89%
Solids Building	0.0	0.4 – 0.9	1%	0.0	0.0 – 0.0	0%
Aeration Tank	0.0	0.0	0%	-	-	-
Secondary Clarifier Launder	0.0	0.4	0.04%	-	-	-
Mudwell	-	-	-	0.2	0.4 – 60.0	43%
Controlled Sources (Sent to Odor Control Treatment)						
Influent Pump Station (influent)	2.3	0.4 – 13.8	96%	5.1	0.4 – 36.7	98%
Primary Clarifier Launder #1	3.0	0.4 – 27.5	79%	4.5	0.4 – 37.7	93%
Primary Clarifier Launder #2	6.2	0.4 – 26.3	96%	-	-	-
Odor Control Blowers	1.4	0.4 – 9.5	46%	12.1	0.4 – 37.2	82%
Gravity Sludge Thickener #1	0.2	0.4 – 3.5	32%	3.4	0.4 – 39.2	95%
Gravity Sludge Thickener #2	0.6	0.4 – 4.2	54%	-	-	-

The subsections below provide specific details of monitoring findings for individual locations.

3.1.1 Influent Pump Station Monitoring

Two PPM loggers were installed at the influent pump station: one at a pressurized location downstream of the fan, sampling ventilated air from the influent pump station before it enters the existing biofilter, and the second one after biofiltration, measuring treated effluent. The H_2S concentrations and ambient air temperatures recorded over the six-week period, from July 1 to August 13, are shown in Figure 3-2.

Compared to the winter data, summer monitoring at the influent pump station (particularly influent going to the existing biofilter) showed significantly higher H_2S concentrations, reaching up to 36.7 ppmv, compared to 13.8 ppmv during the winter months. The increase in ambient temperatures during the summer leads to greater production of odorous gases in the waste stream, resulting in elevated H_2S concentrations.

The H_2S readings at the influent pump station are not excessive and can be effectively treated with appropriate odor control technologies (evaluated in separate TM). Although the existing biofilter is currently used for treating these odors, the effluent data shown in Figure 3-2 indicate that the existing treatment system is not effective in addressing the odorous air from the influent pump station.

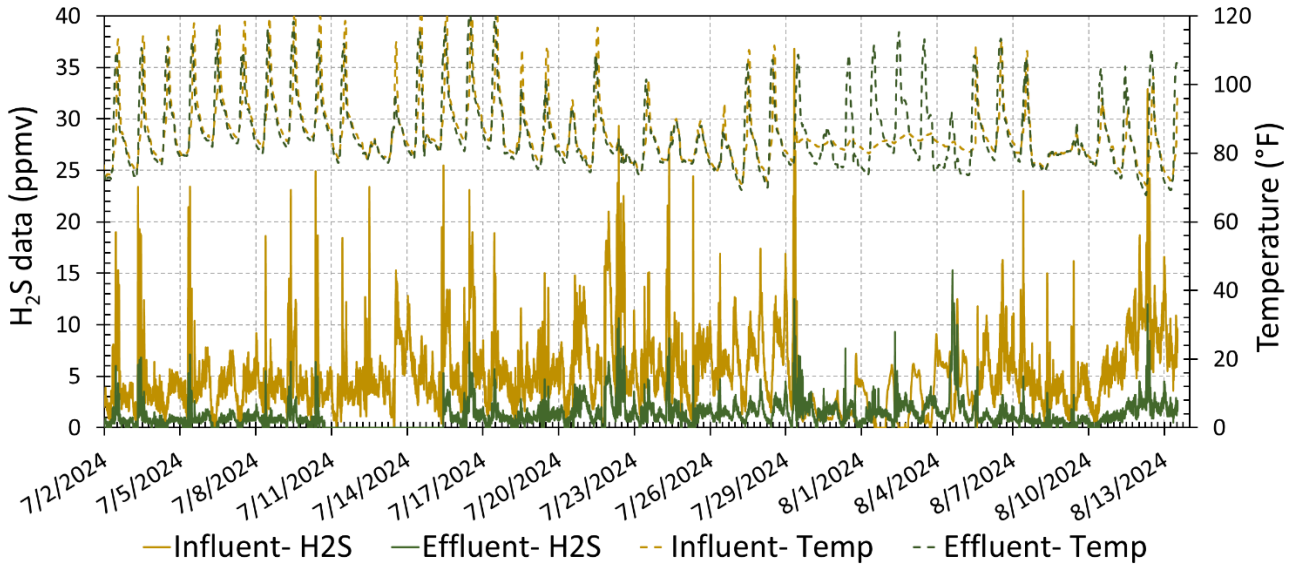


Figure 3-2: Results of Continuous Monitoring at Influent Pump Station (7/1/2024-8/13/2024)

3.1.2 Headworks (Screen and Grit Building) Monitoring

The space within the Headworks (screen and grit) building is ventilated through an inactive chemical odor scrubber. The monitoring setup involved hanging a ppm monitor inside the Headworks building to measure the air within the building space and tapping a sampling tube into a pressurized location downstream of the fan to measure the building's effluent air. During this summer monitoring, a feed

pump was utilized for the effluent logger to address the low airflow issue encountered during the winter sampling. The H_2S concentrations and ambient air temperature measured for the six-week period, spanning from July 1 to August 13, are shown in Figure 3-3.

The measured H_2S levels inside the headworks building reached as high as 57.8 ppmv at times, while the untreated effluent air had significantly lower H_2S levels at 12.5 ppmv. Note, the monitor was located directly above wastewater flows so the measurements may not reflect the actual concentration within the building space. However, the high readings could be an indication that the current ventilation system is ineffective in adequately ventilating the building. Potential upgrades to the ventilation system to address this issue are discussed in a separate TM.

During the winter sampling, H_2S levels at the Headworks effluent peaked at 19.9 ppmv, with an overall average of 2.1 ppmv for the monitoring period. These results show that winter odorous air readings were higher than the summer readings, despite the low flow rate issue during the winter sampling, which was mitigated during the summer by using a pump to feed air into the bucket setup.

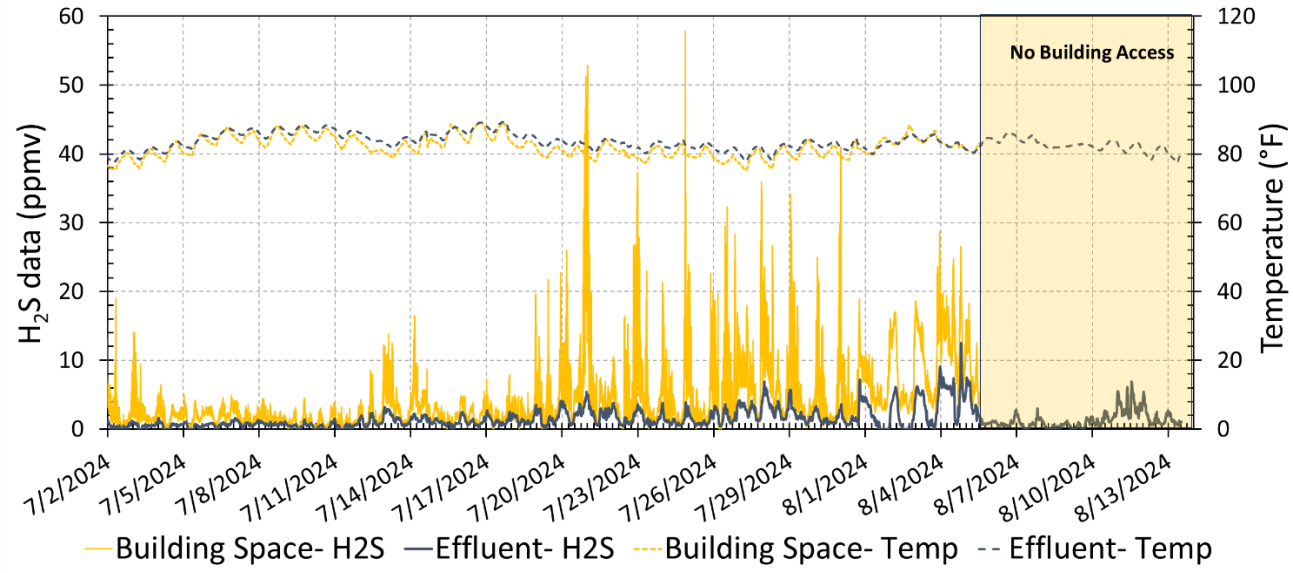


Figure 3-3: Results of Continuous Monitoring at Screen and Grit Building (7/1/2024-8/13/2024)

The H_2S readings at the screen and grit building are significant. As these are not being treated, it is likely that these emissions are contributing to offsite odors. Treatment recommendations are provided in a separate TM.

3.1.3 Primary Clarifier Monitoring

To monitor odorous air formed in the primary clarifiers, a PPM logger was placed in one of the primary clarifier launders– near the existing takeoff (PC1). This space is enclosed to effectively capture the odors and is not accessible to personnel. The H_2S concentration and ambient air temperature measured for the six-week period, spanning from July 1 to August 13, are shown in Figure 3-4. The presented data shows the continuous generation of H_2S in the primary clarifier launders. It was noticed that the logger was getting too close to the water level, and the splashing water was interfering with the data logging. As a result, the measured H_2S concentrations were lower after a few weeks of sampling (7/12 – 8/13).

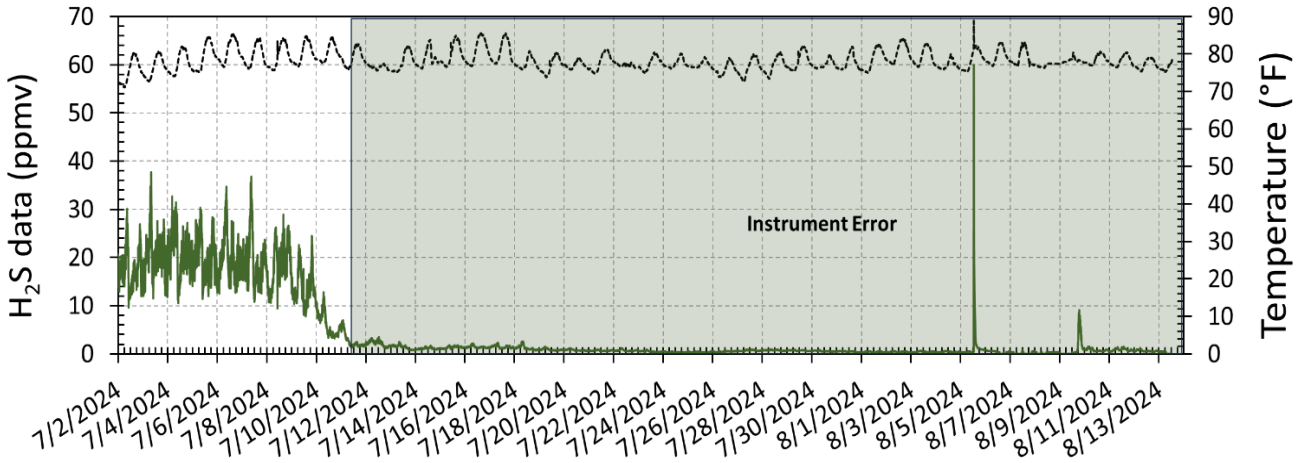


Figure 3-4: Results of Continuous Monitoring at Primary Clarifier Launders (7/1/2024-8/13/2024)

The measured concentrations are consistent with what might be expected from beneath covered primary clarifier launders and are similar to observations during the winter months (excluding data collected during periods of instrument error). Odors from this location are currently directed to the existing aeration blowers (see Section 3.1.5 below).

3.1.4 Gravity Sludge Thickeners Monitoring

During this monitoring period, one H_2S PPM monitor was installed beneath the covers of GST. This space is enclosed to effectively capture the odors and is not accessible to personnel. The H_2S concentrations and ambient air temperature measured for the six-week period, spanning from July 1 to August 13, are shown in Figure 3-5. The presented data shows the continuous generation of H_2S in the GST. Overall, the recorded H_2S detection frequency and magnitude at the GST were also relatively high, at 95% and 0.4 to 39.5 ppmv, respectively.

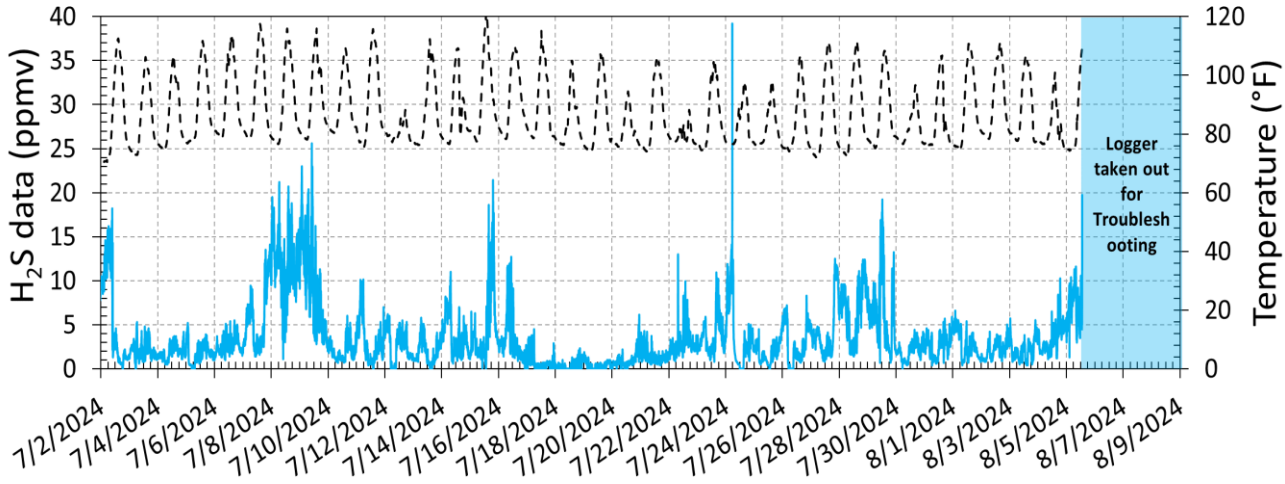


Figure 3-5: Results of Continuous Monitoring at Gravity Sludge Thickeners (7/1/2024-8/13/2024)

The measured concentrations are significantly higher than those observed during the winter months (0.4 – 4.2 ppmv), which is expected with the effects of higher summer temperatures. Odors from this location are directed to the existing aeration blowers (see Section 3.1.5 below).

3.1.5 Odor Control to Blowers

Air supply for the existing aeration blowers currently is provided by the odorous air ventilated from the primary clarifiers and GSTs. A PPM logger was employed to tap into the pressurized location downstream of the fan to collect H_2S sample measurements. The H_2S concentrations and ambient air temperature measured for the five-week period, spanning from July 1 to August 13, are shown in Figure 3-6. The recorded H_2S levels were continuous, except for the periods when the blowers were turned off.

The measurable H_2S concentration was as high as 39.2 ppmv at times, with a detection frequency of 95%. These values are consistent with the combined odor measurements from the primary clarifiers and GSTs. However, during the winter months, H_2S levels measured at the blowers were significantly lower, ranging from 0.4 to 9.3 ppm. Despite this, the levels were still consistent with the combined odor measurements from the primary clarifiers and GSTs observed during winter monitoring.

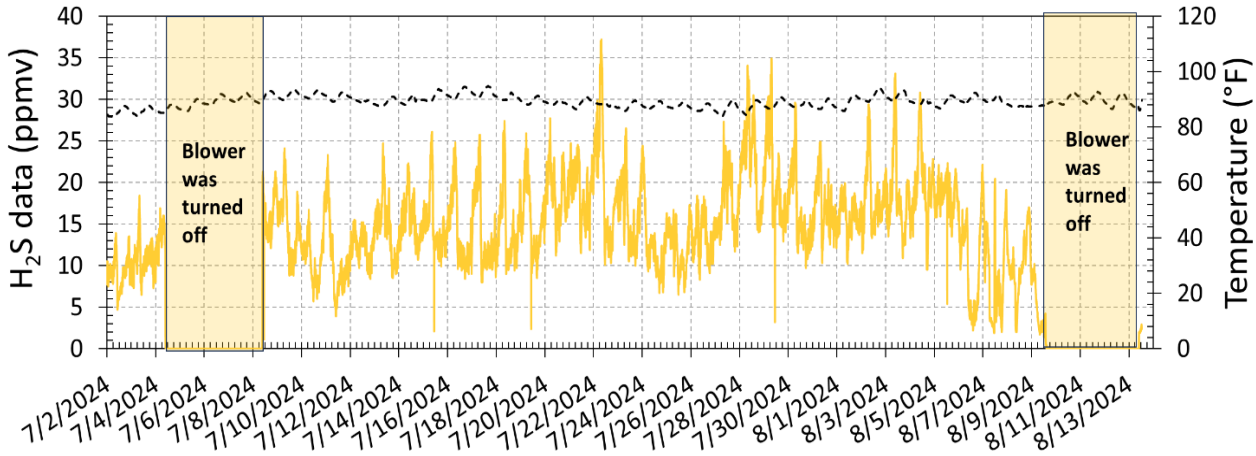


Figure 3-6: Results of Continuous Monitoring at Odor Control Blowers (7/1/2024-8/13/2024)

While the current treatment scheme for the primary clarifiers and GSTs is effective, the County is undertaking a project to replace the aeration blowers with new blowers that are incompatible with the levels of H_2S expected from this odorous air stream. Therefore, a new odor control system will be required. Evaluation of odor technologies for these odorous air stream is discussed in a separate TM.

3.1.6 Solids Facility Monitoring

A PPM H_2S monitor was installed at the solids facility scrubber to assess H_2S levels in the carbon scrubber discharge and evaluate potential impacts on the surrounding community. Since the air had passed through a carbon scrubber, significant H_2S detection was not expected at this location. As anticipated, the monitor did not detect H_2S gas in the treated effluent, indicating that the existing scrubber is effectively treating the odorous gas generated within the solids facility.

3.1.7 Mudwell Monitoring

During the winter monitoring it was noticed that the fenceline loggers close to the mudwell were measuring infrequent high H_2S levels. As a result, a ppm logger was deployed at the mudwell to identify the odorous gas emissions. The H_2S concentrations and ambient air temperature measured for the six-week period, spanning from July 1 to August 13, are shown in Figure 3-7.

The logger deployed at the mudwell recorded H_2S levels ranging from 0.4 to 60.0 ppmv and a detection frequency of 43%. The buildup of solids within the mudwell is likely contributing to decay and odors. Additionally, the data suggests that detection events may be linked to operational activities, such as active backwash events, which could be causing the release of H_2S from the mudwell. The County is actively flushing the tank and working on permanent covers and automatic flushing systems to help mitigate these odors.

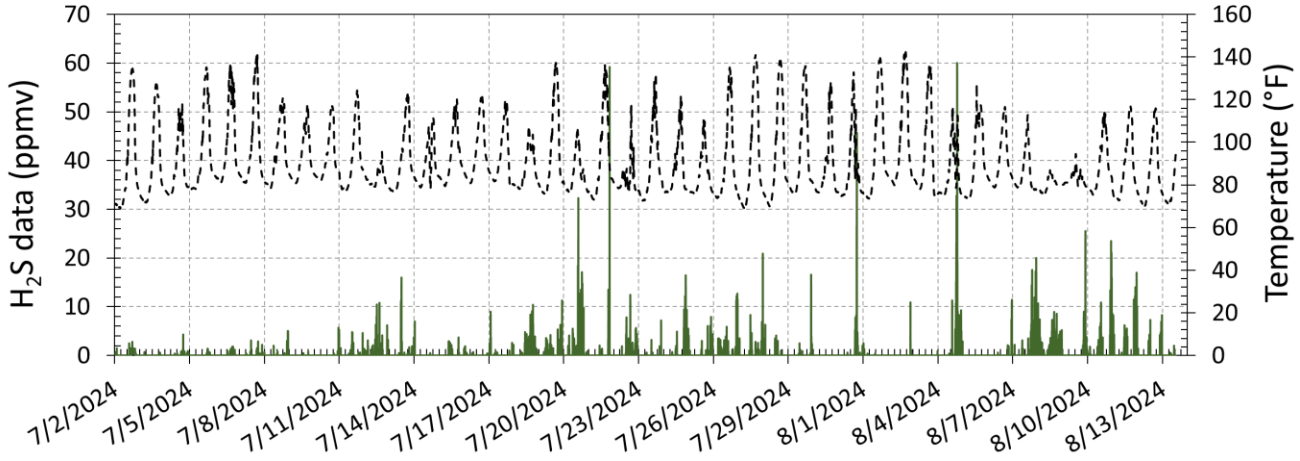


Figure 3-7: Results of Continuous Monitoring at Mudwell (7/1/2024- 8/13/2024)

The logger was located outside. Temperatures were measured in excess of 140 °F, which was likely caused by exposure to direct sunlight. This could impact overall accuracy. The peaks in the detected H_2S values seem to align with the ambient temperature peaks recorded by the logger, so a correlation plot was developed to verify this relationship. However, as seen in Figure 3-8, the hourly time-averaged H_2S emissions plotted against the hourly time-averaged temperature data did not show any clear correlation, indicating that odor emission at the mudwell is not temperature dependent.

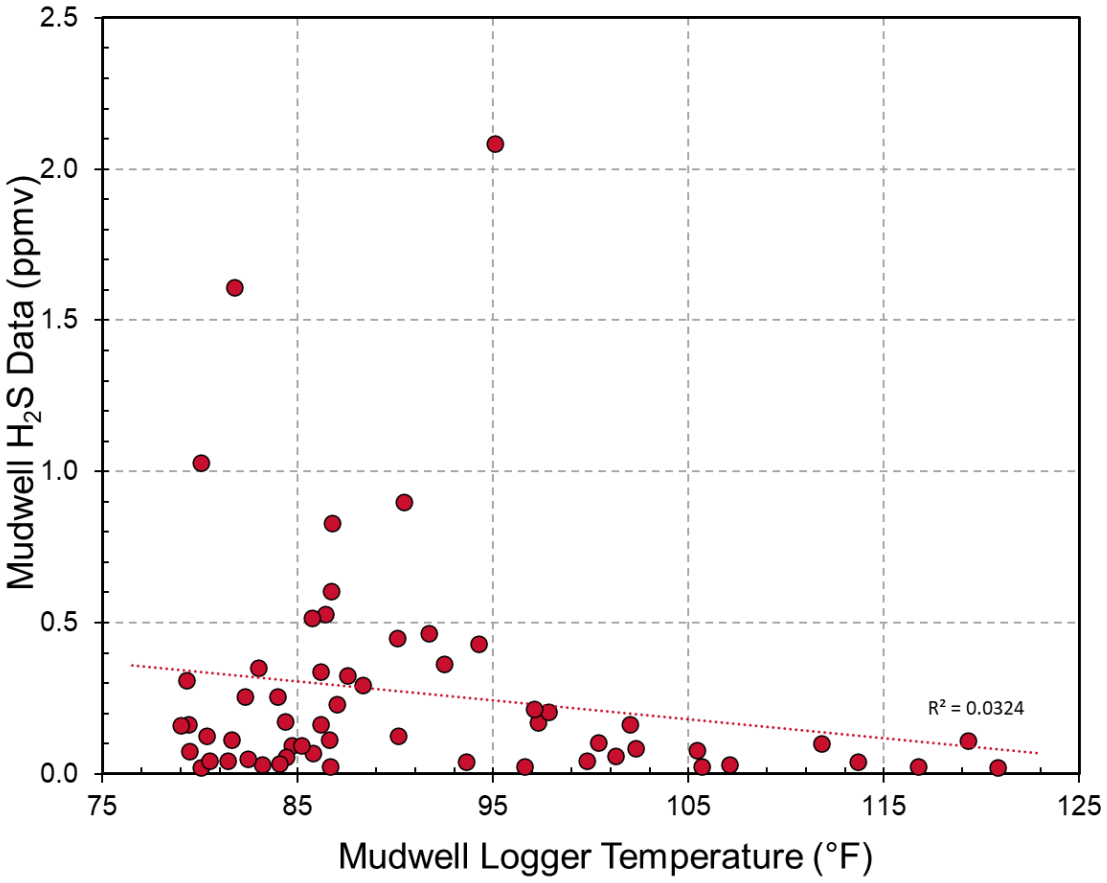


Figure 3-8 Hourly Time-Averaged Mudwell H_2S Data Plotted against Ambient Temperature Data Recorded by the Logger

3.2 Fenceline Monitoring Findings

As shown in Figure 3-9, a total of three PPB loggers were installed to monitor the fenceline: one to the west (at the septage hauler discharge), one to the south (near the primary clarifier distribution box), and one to the north (near the denitrification filters) of the WRF. Figure 3-9 presents the H_2S concentrations and ambient air temperatures measured by the three fenceline PPB loggers deployed over the six-week monitoring periods. Note that the PPB data has been converted to PPM for easier comparison with all other data presented above.

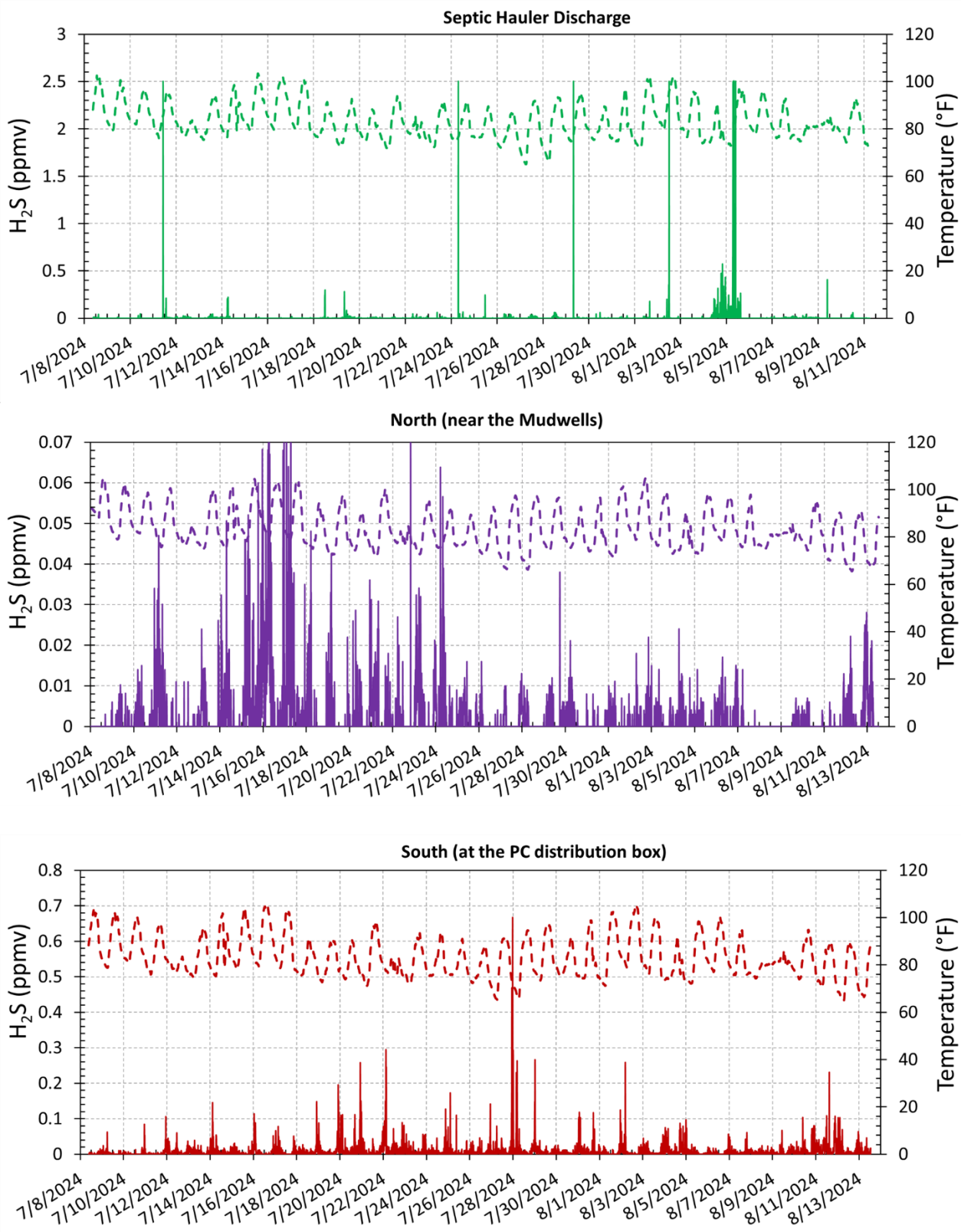


Figure 3-9: Results of Continuous Monitoring at the Fenceline (7/8/2024- 8/13/2024).

The changes in the measurable H_2S concentration distribution over the monitoring period for the fenceline locations are illustrated in Figure 3-10. Additionally, the measured range of H_2S concentrations, as well as the percent of detection events, are presented in Table 3-2.

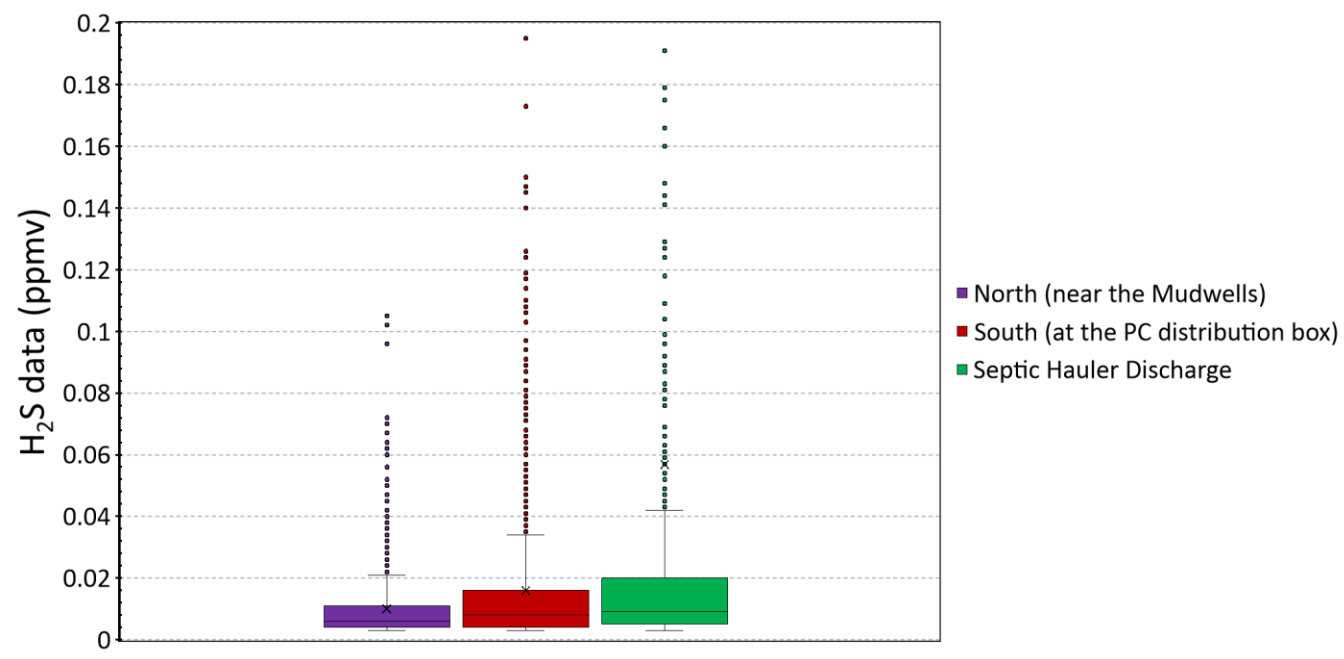


Figure 3-10: Box-And-Whisker Plots Showing the Change in Measurable H2S Concentration Distribution for the Fenceline Locations (July 8 to August 13).

Note that while the data for the septic hauler discharge location extends up to 2.5 ppmv (the instrument's maximum detection limit), it is displayed only up to 0.2 ppmv to maximize the visibility of data from other locations.

Table 3-2: Fenceline H_2S Monitoring Findings

Monitoring Locations	H_2S Concentration Range Min/Max (Excluding "Zero" Readings)	Percent of Values Detected above "Zero"
Septic Hauler Discharge	0.003 – 2.5	15%
South (at the PC Distribution Box)	0.003 – 0.7	51%
North (Near the Mudwells)	0.003 – 0.1	24%

H_2S levels at the septic hauler discharge were measurable 15% of the time during the five weeks of monitoring, with concentrations reaching up to 2.5 ppmv (the instrument's maximum detection limit). The spikes are likely occurring when septic unloading is occurring. Considerations should be given to making sure covers are in place during unloading operations.

On the east side of the plant, H_2S was detected 51% of the time at lower levels, ranging from 0.003 to 0.7 ppmv. To the north of the facility, near the mudwell, H_2S was detected intermittently at a frequency of 25%, with concentrations ranging from 0.003 to 0.1 ppmv. On a population basis, the

average odor detection threshold is about 0.03 to 0.05 ppmv[1], although some individuals can detect H_2S at lower concentrations. The maximum detectable H_2S levels at these fenceline locations exceed this threshold, contributing to odor nuisances within the fenceline. (Note that these average detection thresholds are based on the information published by the California Air Resources Board.)

3.3 Neighborhood Monitoring Findings

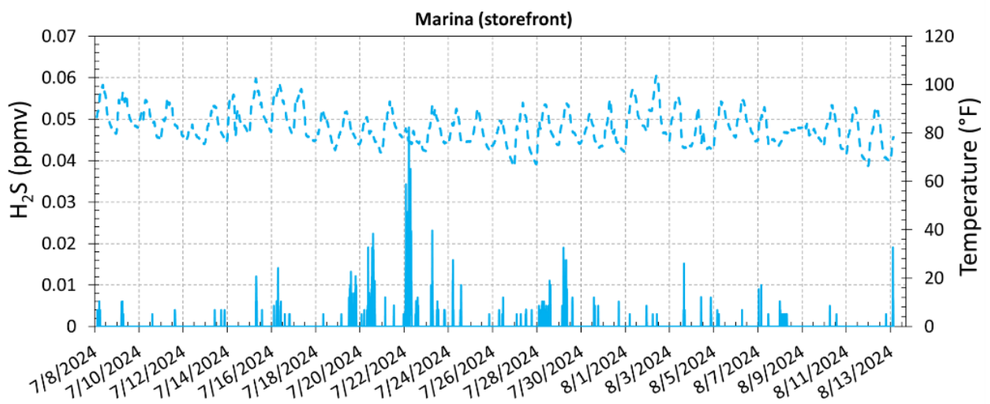
As shown in Figure 2-1, a total of five PPB loggers were installed to monitor odorous air dispersion into the neighboring communities: two at the Marina west of the WRF, one at the Maritime Museum, and two within the Chesapeake Harbor Community. Figure 3-9 presents the H_2S concentrations and ambient air temperatures measured by the five neighborhood PPB loggers deployed over the six-week monitoring periods. Note that the PPB data has been converted to PPM for easier comparison with all other data presented above.

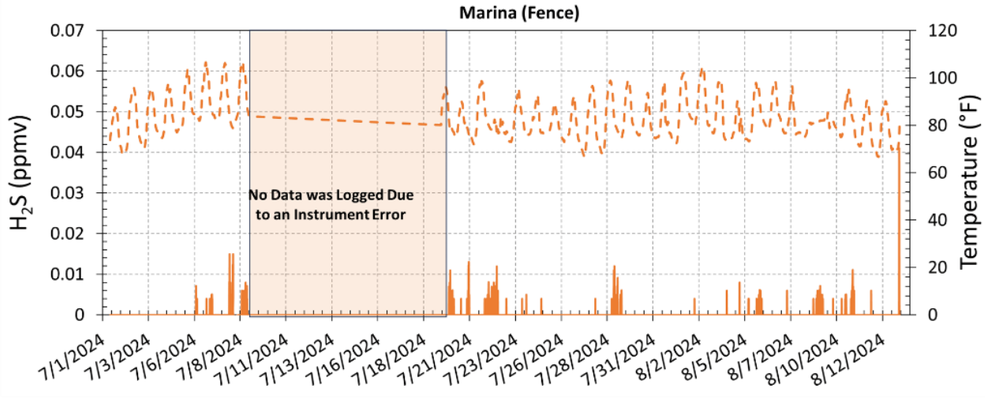
The changes in the measurable H_2S concentration distribution over the monitoring period for the fenceline locations are illustrated in Figure 3-10. Additionally, the measured range of H_2S concentrations, as well as the percent of detection events, are presented in Table 3-3.

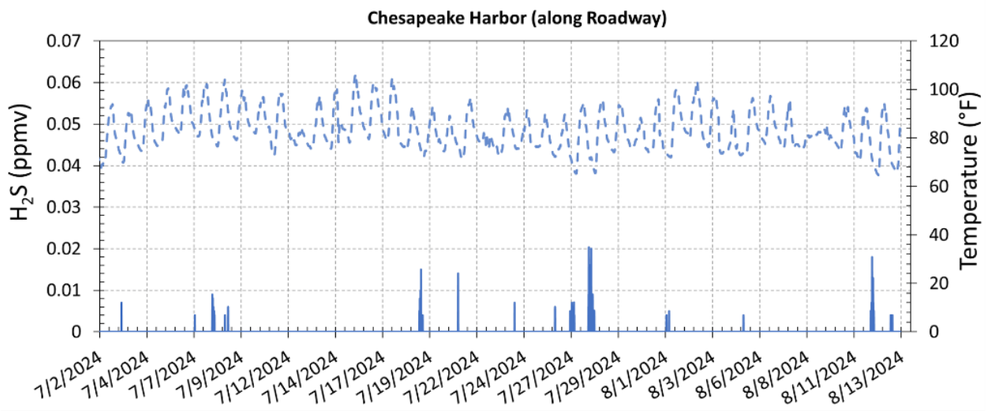
Overall findings from the onsite source monitoring are presented below.

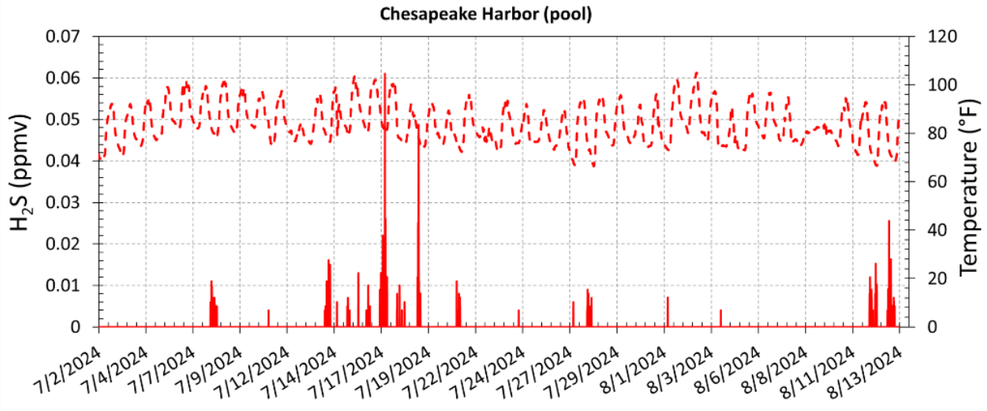
- The loggers deployed at the Marina detected the presence of odorous air infrequently, with a detection frequency of only 4%. The H_2S levels detected ranged from 0.003 to 0.048 ppmv, near the average odor detection threshold.
- The loggers within the Chesapeake Harbor Community also detected H_2S infrequently, with very low detection frequencies of 2% to 3% during the six-week monitoring period. The detected H_2S levels ranged from 0.003 to 0.061 ppmv, slightly exceeding the average odor detection threshold.
- Of all the loggers, the one deployed at the Maritime Museum had the lowest detection frequency and magnitude, with a 1% detection frequency and H_2S levels ranging from 0.003 to 0.013 ppmv. These levels are very low and fall below the reported average odor detection threshold of 0.03 to 0.05 ppmv.

[1] https://ww2.arb.ca.gov/resources/hydrogen-sulfide-and-health









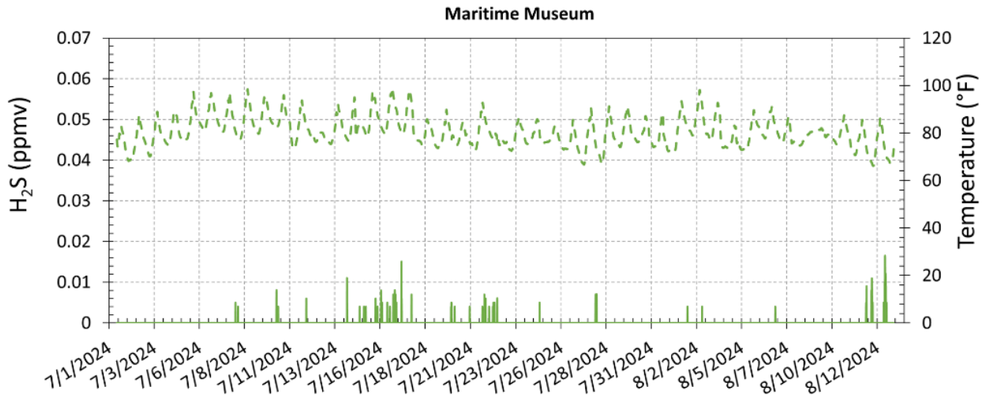


Figure 3-11: Results of Continuous Monitoring around the Neighborhood (7/1/2024- 8/13/2024).

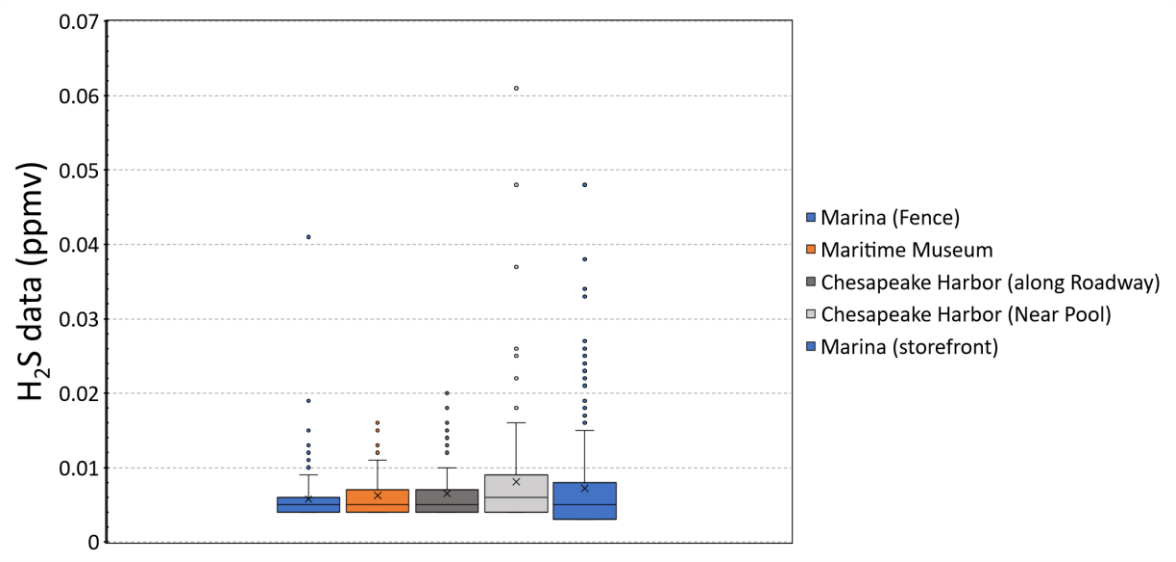


Figure 3-12: Box-And-Whisker Plots Showing the Change in Measurable H2S Concentration Distribution for the Neighborhood Locations (July 1 to August 13).

Table 3-3: Neighborhood H2S Monitoring Findings

Monitoring Locations	H_2S Concentration Range Min/Max (Excluding "Zero" Readings)	Percent of Values Detected above "Zero"
Marina (Store Front)	0.004 – 0.048	4%
Marina (Fence)	0.004 – 0.041	4%
Chesapeake Harbor (along Roadway)	0.004 – 0.020	2%
Chesapeake Harbor (near pool)	0.004 – 0.061	3%
Maritime Museum	0.004 – 0.016	1%

3.3.1 Odor Data Correlations

Time-averaged hourly concentrations from the fenceline and neighborhood monitors were plotted against time-averaged hourly concentrations from the septic hauler discharge, influent pump station effluent, grit and screen building, and mudwell individually to determine if there was any correlation between odorous emissions from these sources and the observed H_2S concentrations at the fenceline and neighborhood locations. Additionally, emissions from the plant were plotted directly against neighborhood emissions to see if a visual correlation could be drawn. Neighborhood readings are influenced strongly by meteorological conditions, so finding direct correlations is unlikely.

Septic Hauler Discharge Data with Other PPB Loggers' Data

Figure 3-13 shows the correlation plot for the septic hauler discharge data with the other PPB loggers' data.

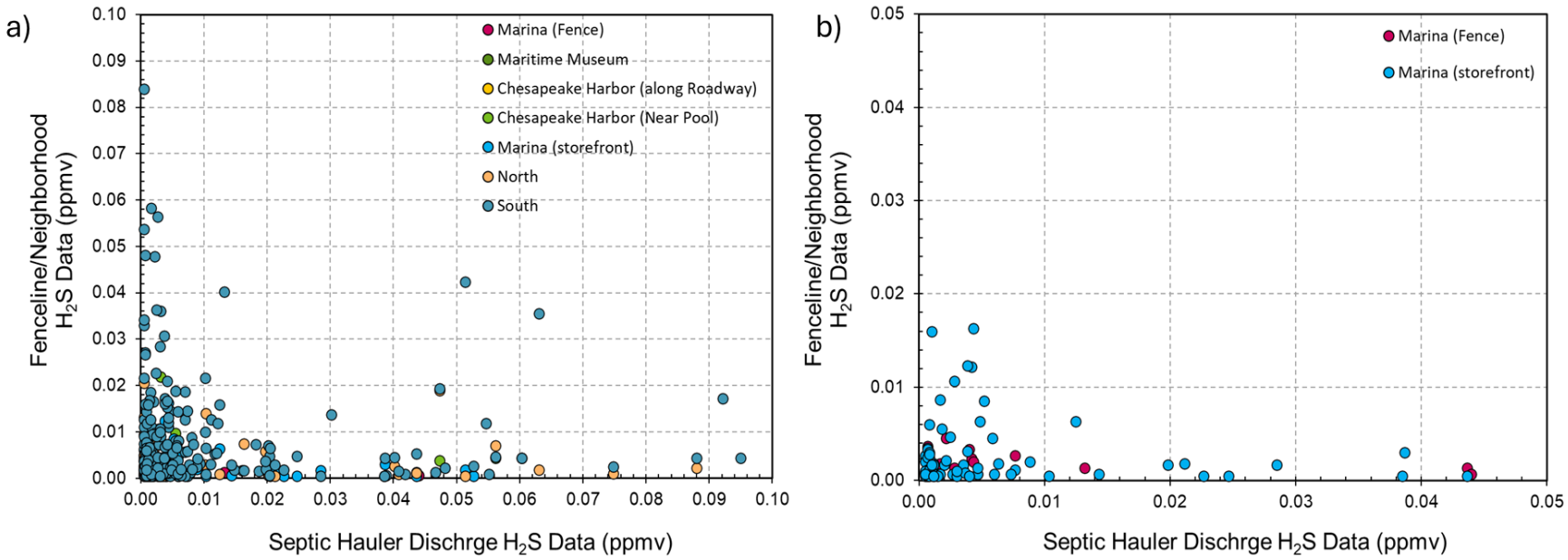


Figure 3-13: Hourly Time-Averaged Concentrations: a) Fenceline and Neighborhood Data Plotted against Septic Hauler Discharge Data; b) Marina Data Plotted against Septic Hauler Discharge Data

No direct correlation was observed between the odor emissions from the Septic Hauler Discharge and any of the fenceline or neighborhood locations during this round of odor monitoring.

As the Septic Hauler Discharge is closest to the marina, a comparison was made between the Septic Hauler Discharge H_2S and the monitors at the marina, as shown in Figure 3-14 below.

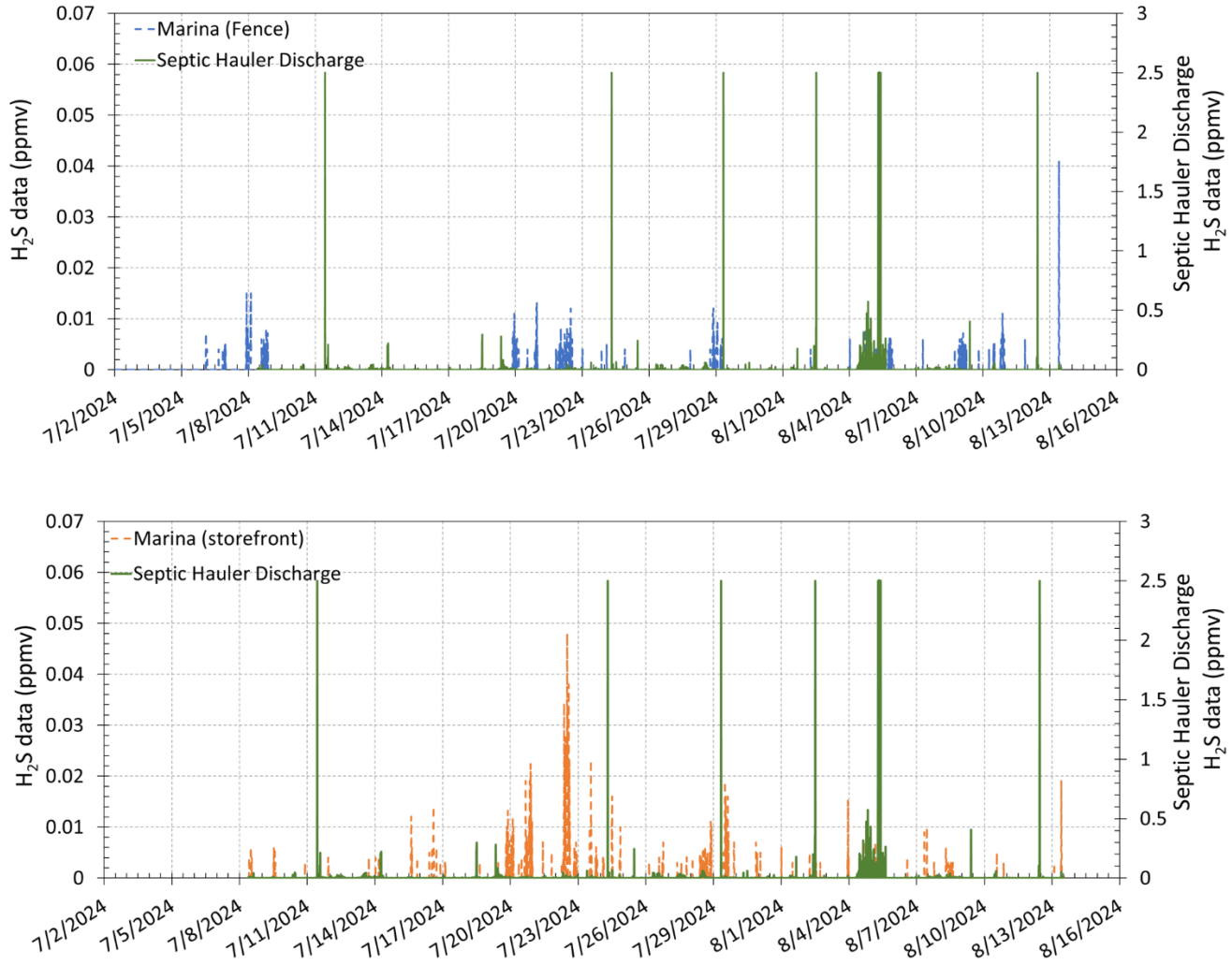


Figure 3-14: Continuous Monitoring data from Septic Hauler Discharge Plotted against the Data measured at the Marina

As with above, no direct correlation is evident. There are times when concentrations are observed at the marina but not at the Septic Hauler Discharge location.

Influent Pump Station Effluent Data with Other PPB Loggers' Data

Figure 3-15 shows the correlation plot for the influent pump station effluent data with the other PPB loggers' data. No strong correlation was observed between the odor emissions from the IPS effluent and any of the fenceline or neighborhood locations during this round of odor monitoring, except for the data collected at the marina storefront. The odor data from the marina storefront closely correlated with the influent pump station effluent data.

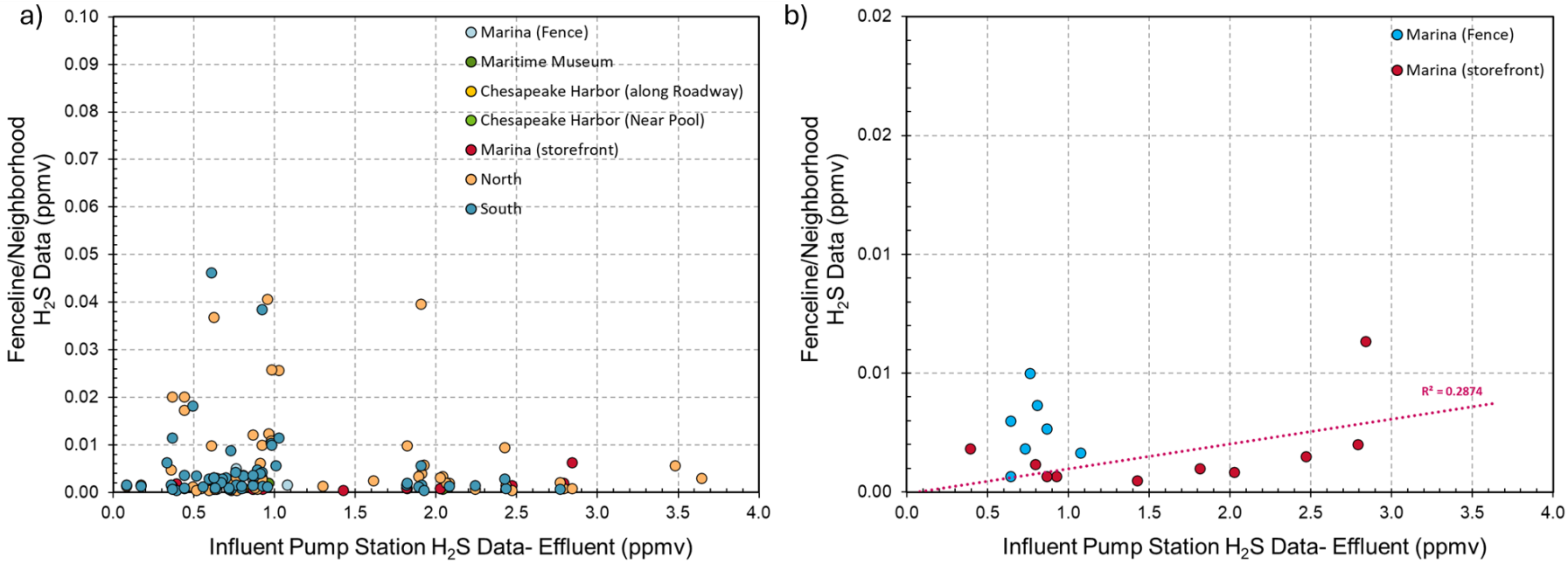


Figure 3-15: Hourly Time-Averaged Concentrations: a) Fenceline and Neighborhood Data Plotted against Influent Pump Station Effluent Data; b) Marina Data Plotted against Influent Pump Station Effluent Data

As the Influent Pump Station is closest to the marina, a comparison was made between Influent Pump Station effluent H_2S and the monitors at the marina, as shown in Figure 3-16 below.

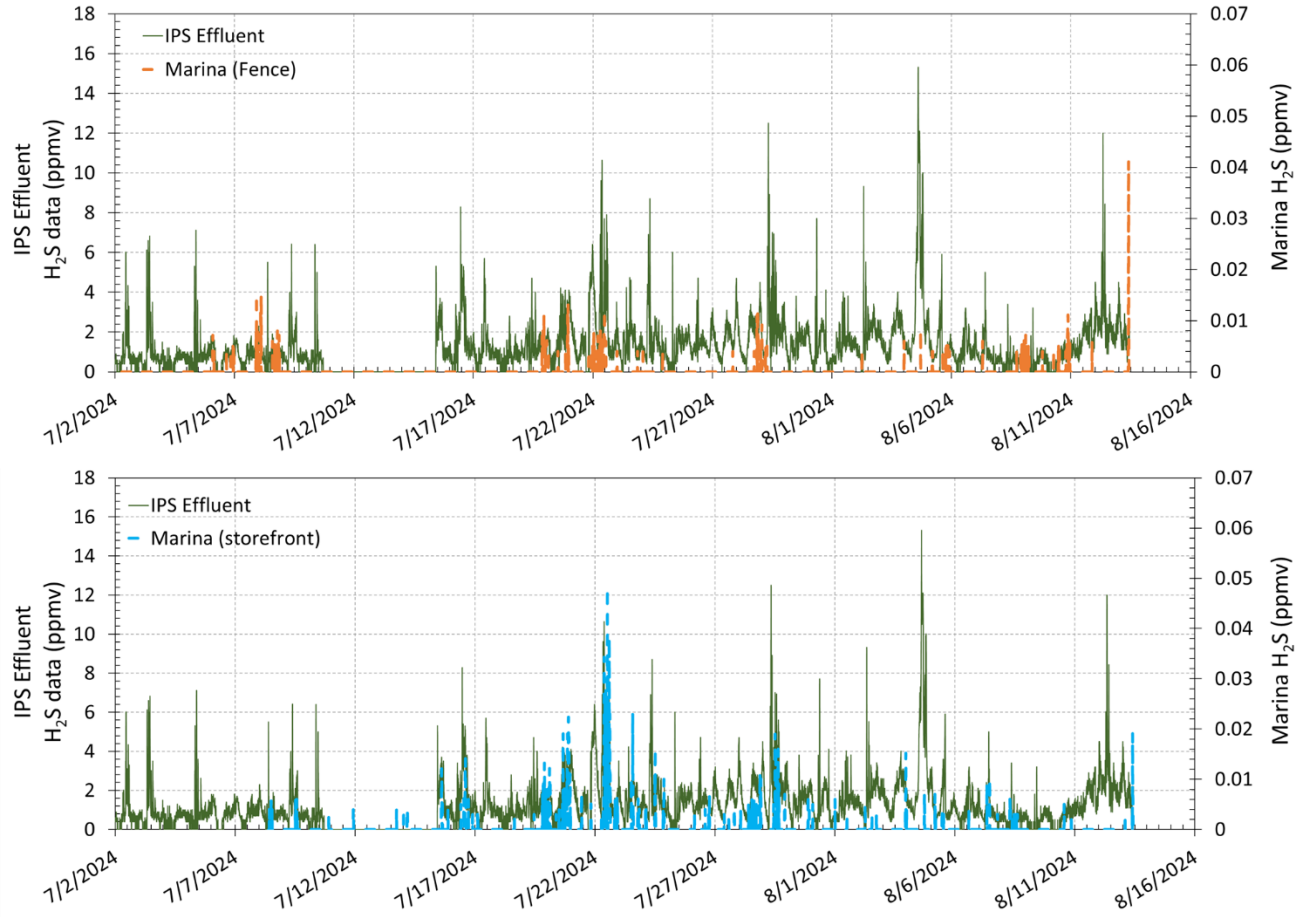


Figure 3-16: Continuous Monitoring Data from Influent Pump Station Effluent Plotted against the Data measured at the Marina

Given the frequency of emissions, comparisons were also made between the Influent Pump Station effluent H_2S and the monitors at Chesapeake Harbor, as shown in Figure 3-17 below.

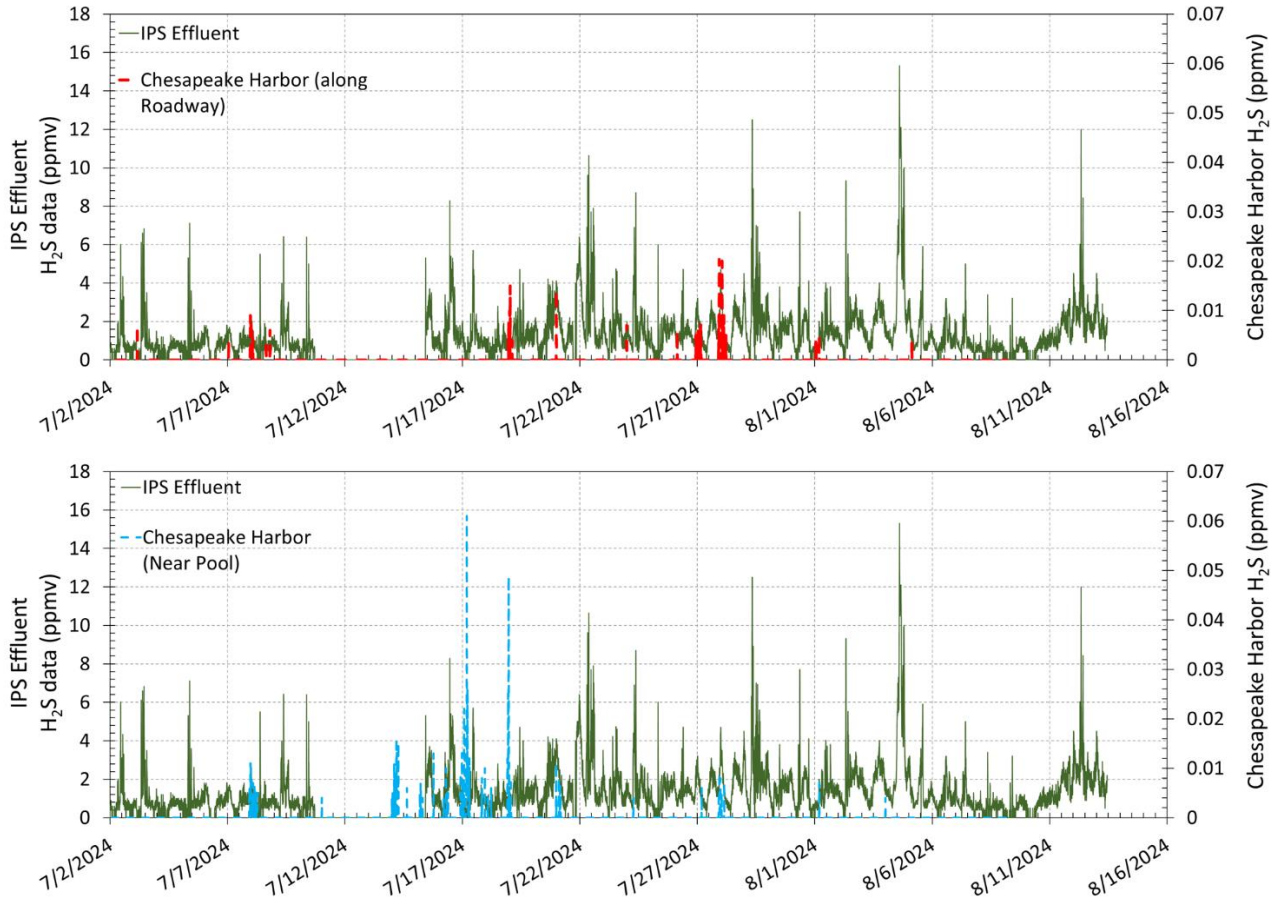
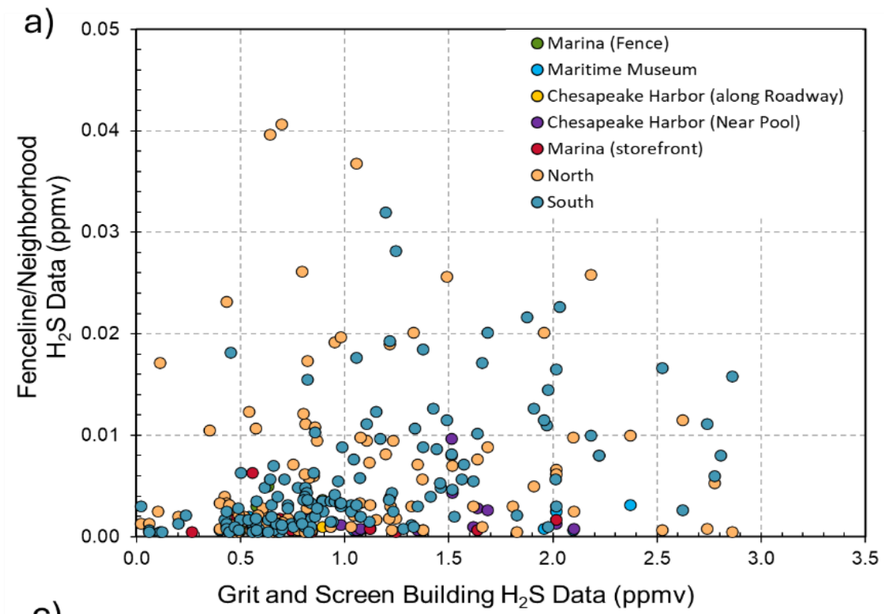


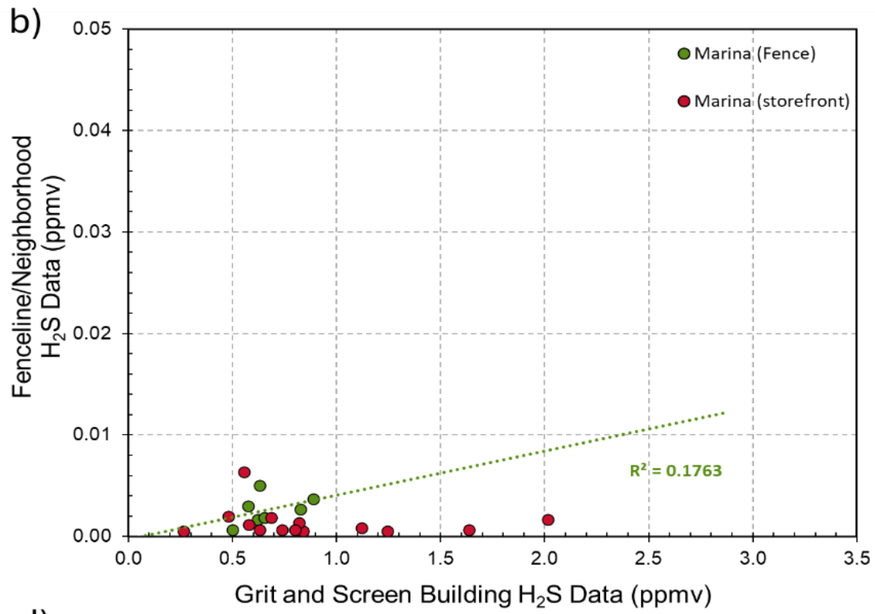
Figure 3-17: Continuous Monitoring Data from Influent Pump Station Effluent Plotted against the Data measured at the Chesapeake Harbor Community

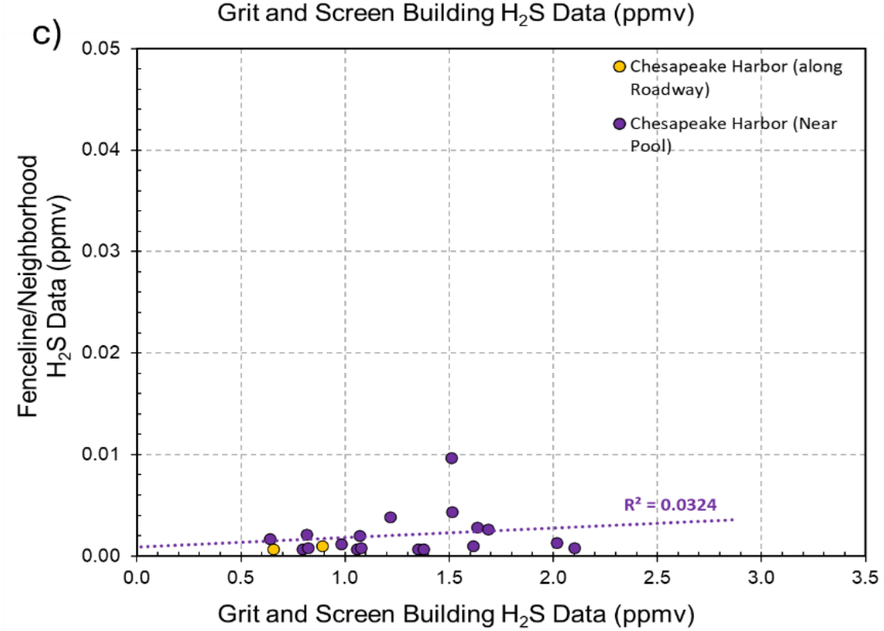
As with above, no direct correlation is evident. Spikes in Chesapeake Harbor do not appear to directly correlate with spikes at the Influent Pump Station.

Headworks (Grit and Screen Building) with Other PPB Loggers' Data

Figure 3-18 shows the correlation plot for the grit and screen building effluent data with the other PPB loggers' data. No strong correlation was observed between the odor emissions from the IPS effluent and any of the fenceline or neighborhood locations during this round of odor monitoring. Even though the marina fenceline and the maritime museum are slightly farther from the grit and screen building, a slight correlation was found between the data from these locations and the grit and screen building effluent data. Therefore, meteorological data should be examined in conjunction with the H_2S logger data to better understand the dispersion of odorous air into the neighboring areas.







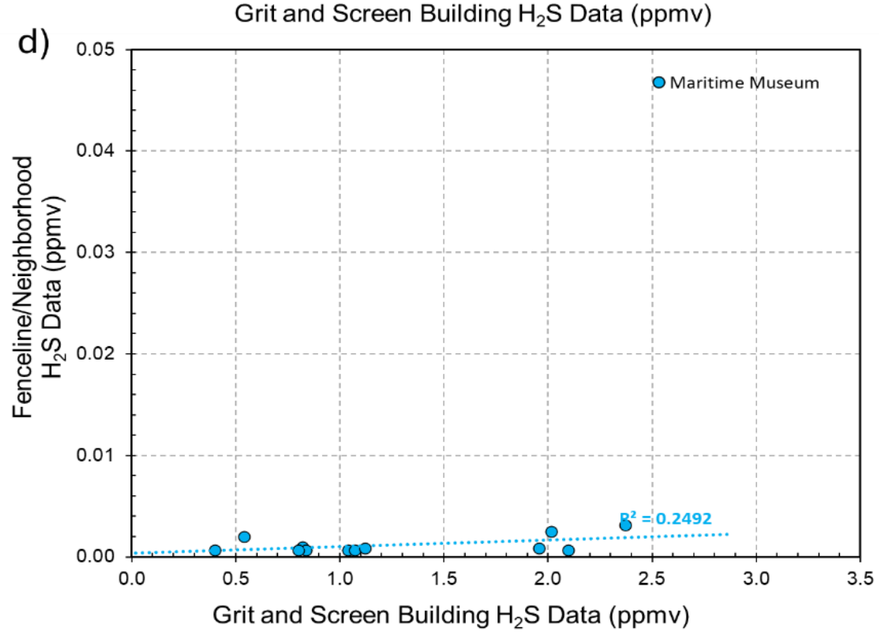
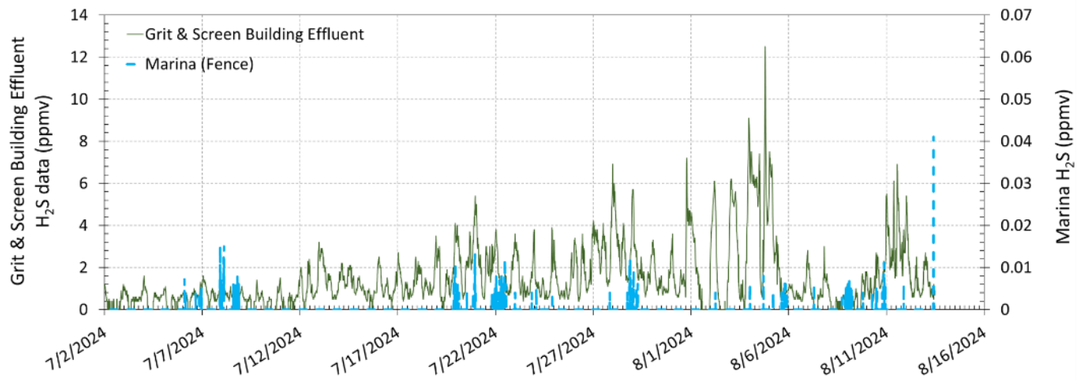


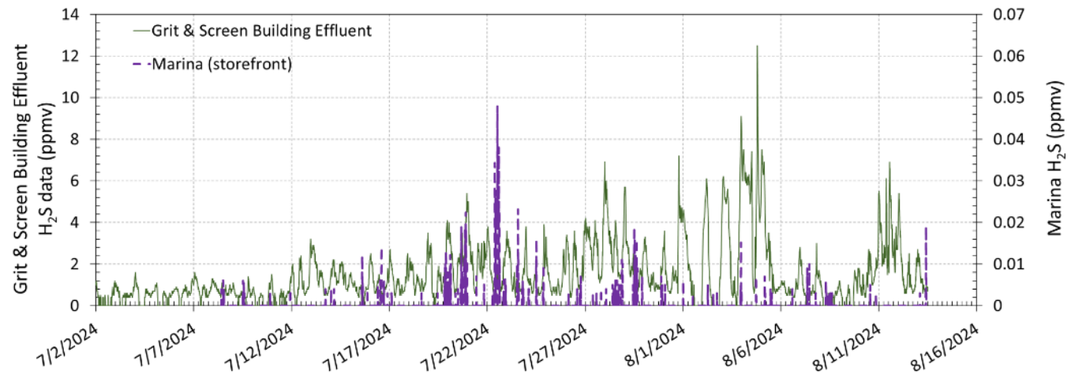
Figure 3-18: Hourly Time-Averaged Concentrations: a) Fenceline and Neighborhood Data Plotted against Grit and Screen Building Effluent Data; b) Marina Data Plotted against Grit and Screen Building Data; c) Chesapeake Harbor Community Data Plotted against Grit and Screen Building Data; d) Maritime Museum Data Plotted against Grit and Screen Building Data.

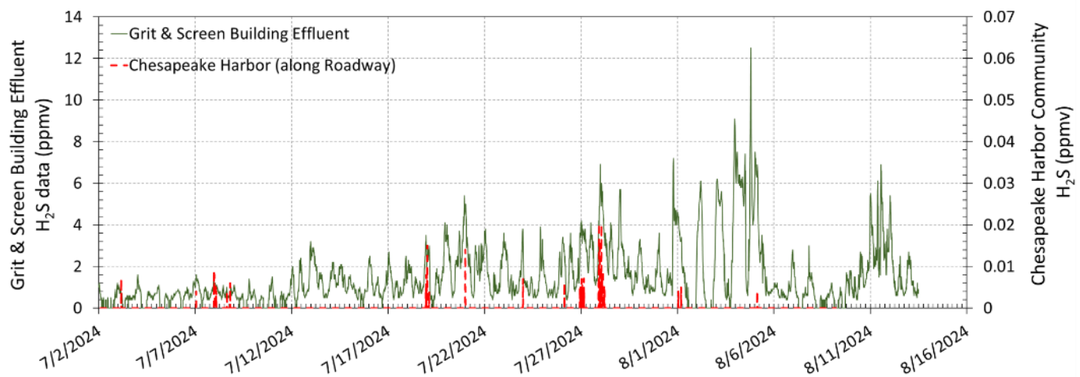
Given the large H_2S load from the Screen and Grit Building, comparisons were also made between the Grit and Screen Building H_2S and all neighborhood monitors, as shown in Figure 3-19 below.As with others, no direct correlation is evident.

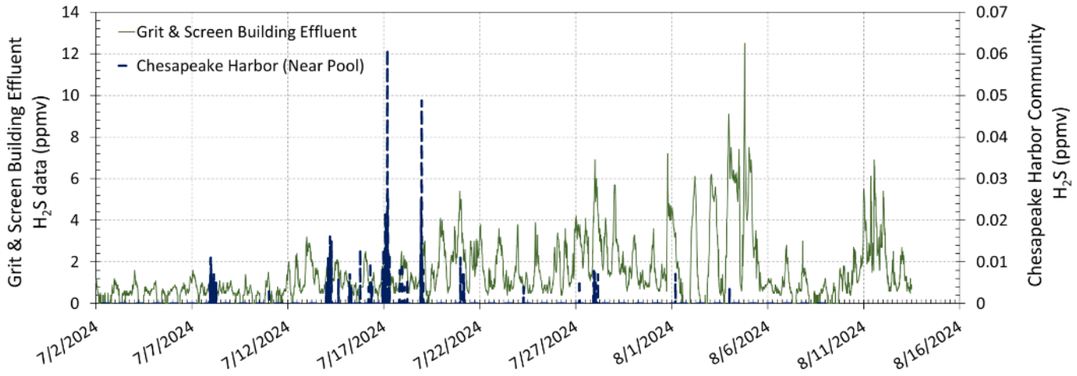
Mudwell Data with Other PPB Loggers' Data

Figure 3-20 shows the correlation plot for the mudwell data with the other PPB loggers' data. Similar to the above findings, no direct correlation was observed between the odor emissions from the mudwell and any of the fenceline or neighborhood locations during this round of odor monitoring.









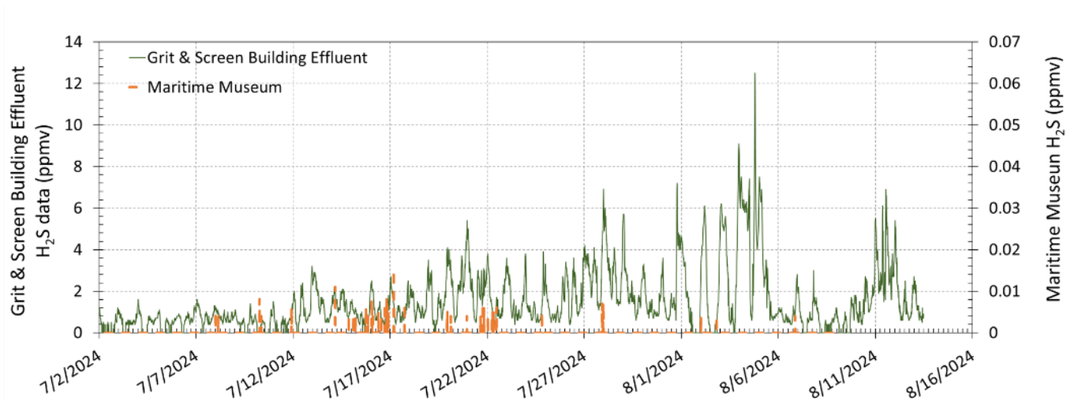
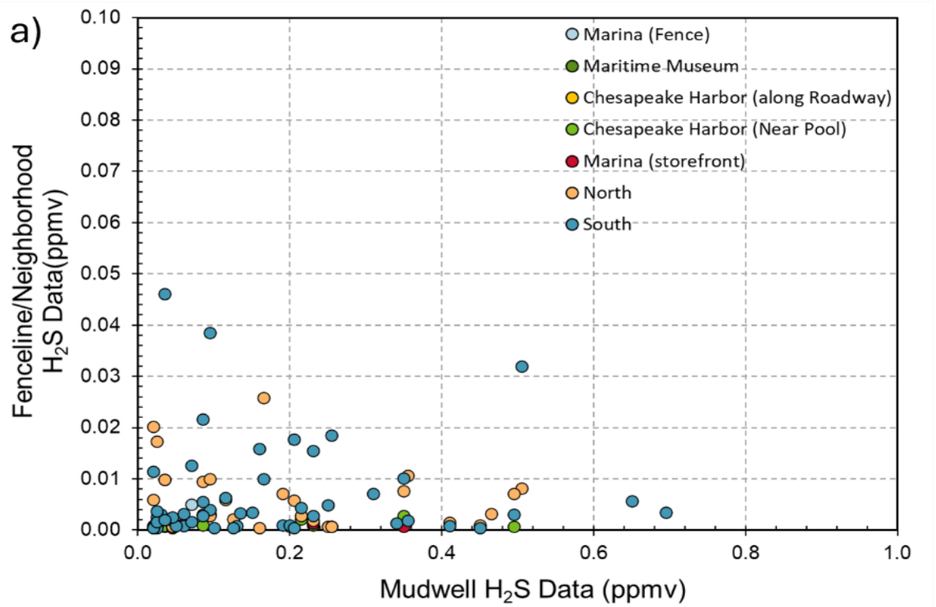
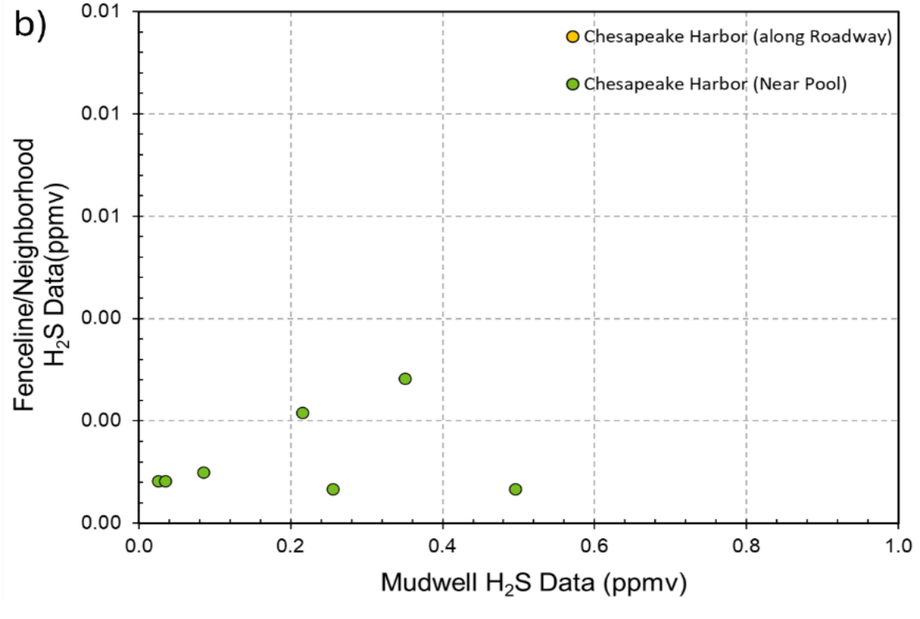


Figure 3-19: Continuous Monitoring Data from Grit and Screen Building Effluent Compared with Data Measured at Neighborhood Location





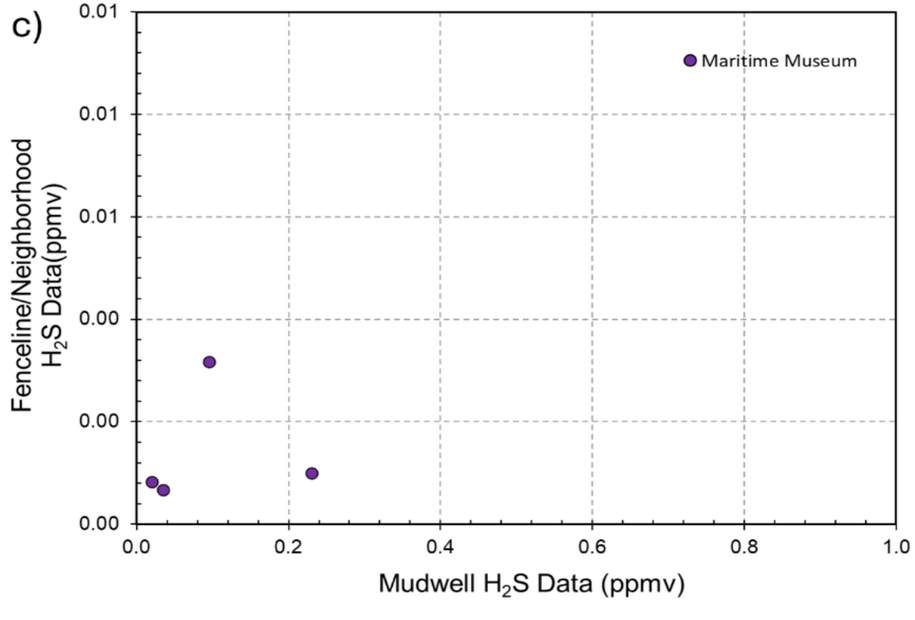


Figure 3-20: Hourly Time-Averaged Concentrations: Fenceline and Neighborhood Data Plotted against Mudwell Data

Comparisons were also made between the mudwell and the monitor at the Maritime Museum, as shown in Figure 3-21 below.

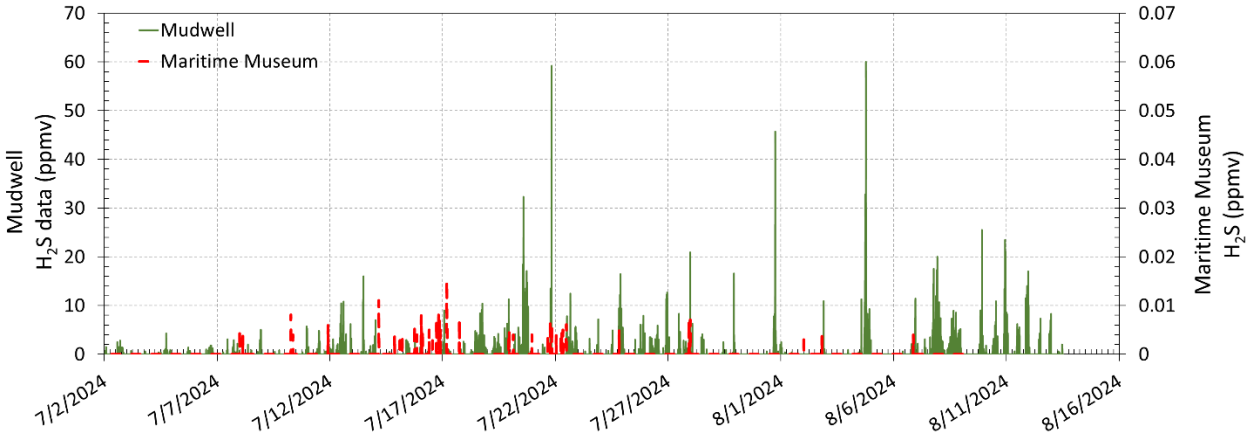


Figure 3-21: Continuous Monitoring Data from Mudwell Compared with Data from the Maritime Museum

As with above, no direct correlation is evident. There are times when concentrations are observed at the Maritime Museum but not at the mudwell location.

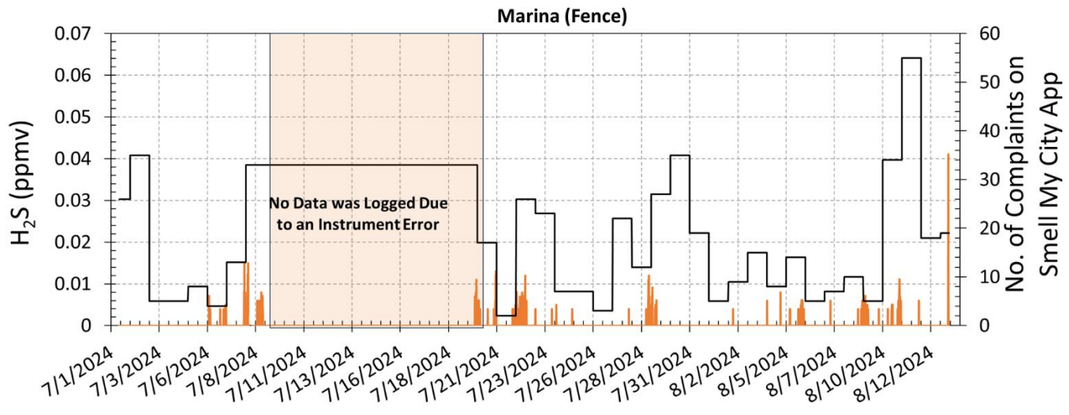
3.3.2 Correlating Neighborhood Data to Odor Nuisance Complaints

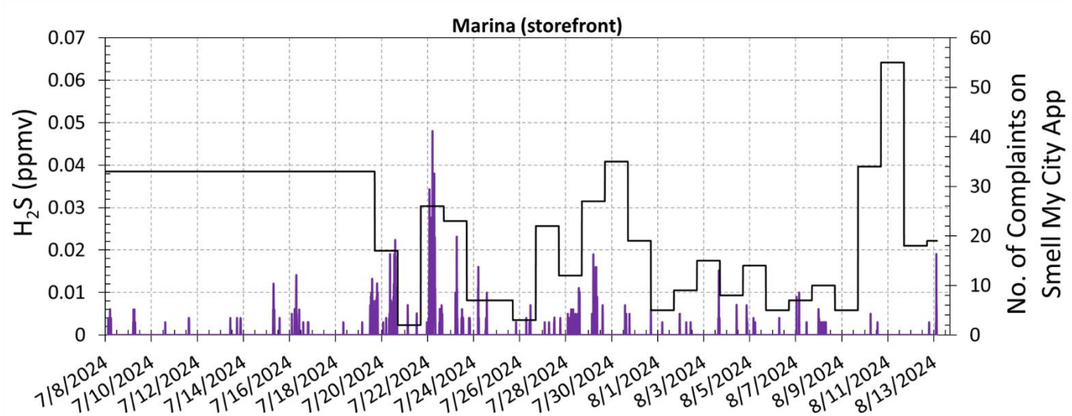
Local residents have been using the “Smell MyCity” app to document odor nuisance complaints. The team gathered information from the Smell MyCity app to evaluate and correlate the odor nuisance complaints with the data recorded by the loggers. Figure 3-22 presents a heat map and a scatterplot showing where the majority of complaints were reported during the sampling period from July 1 to August 16. During the summer monitoring period, the complaints were concentrated around the WRF, while in the winter monitoring period, most complaints originated from the east of the WRF. Figure 3-23 shows the number of odor complaints per day for the sampling duration (July 1 - August 16) overlaid on H_2S data recorded from the neighborhood monitors. Although it appears that complaints were logged when the monitors recorded H_2S spikes, a clear correlation was not observed between the two, as a considerable number of complaints were logged even when the loggers recorded negligible levels of H_2S.

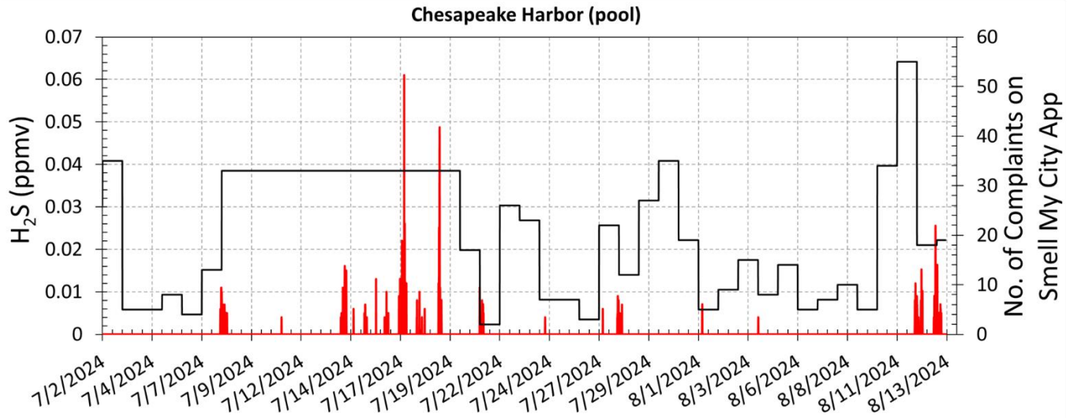
Heat map showing where most of the complaints are coming from.

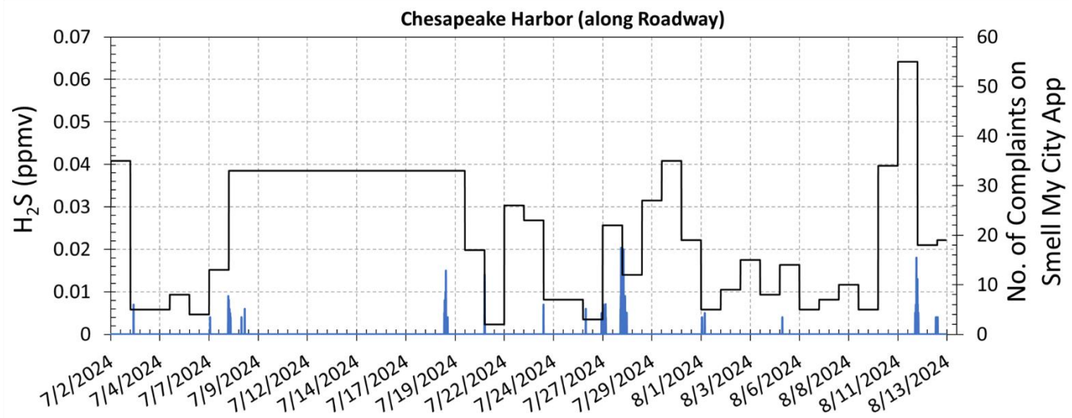
Scatter plot showing the locations of individual complaints (same data shown differently)

Figure 3-22 Odor Complaints Logged on Smell My City App During July 1 to August 16.









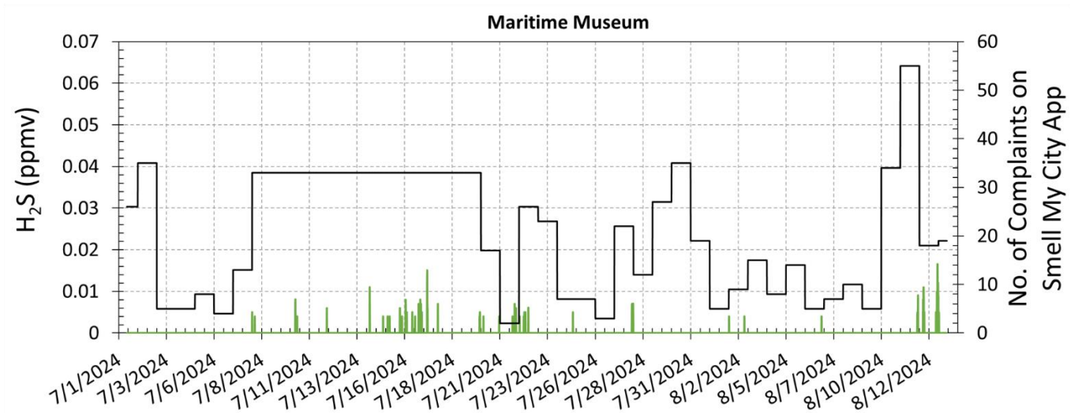


Figure 3-23 Number of Odor Complaints per Day for the Sampling Duration (July 1-August 16) Overlayed on H2S Data Recorded from the Fenceline Monitors

4 OVERALL SUMMARY FINDINGS

The overall summary finding from Summer of monitoring include:

- Odorous H2S is frequently detected at the onsite monitoring locations, and as expected, the main contributors to H2S generation were found to be the primary clarifiers, screen and grit building, influent pump station, and GSTs.
- Of these odorous air sources, only the screen and grit building is not currently treated for odor control. The influent pump station odor control system does not appear to be fully functional.
- Fenceline loggers at the north and south of the WRF showed relatively low H_2S detection frequencies compared to onsite locations, with average levels ranging from 0.11 to 0.67 ppmv. In contrast, H_2S concentrations at the septic hauler discharge reached up to 2.5 ppmv, significantly exceeding the suggested human detection limits of 0.03 to 0.05 ppmv.
- The loggers in the Marina, Chesapeake Harbor Community, and Maritime Museum detected H_2S infrequently, with levels ranging from below to slightly above the average odor detection threshold, indicating minimal odor nuisance in these areas.

The results from the sampling analysis inform air dispersion modeling, ventilation recommendations, and technology recommendations presented in separate TMs.

5 APPENDIX A- ANNAPOLIS ODOR MONITORING PLAN

Odor Control Monitoring Plan

Annapolis Water Reclamation Facility

Odor Control Evaluations

January 18, 2024

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1 INTRODUCTION

The Annapolis Water Reclamation Facility (WRF) is a wastewater treatment plant, jointly owned by the City of Annapolis and Anne Arundel County. The County is responsible for the operation and maintenance of the facility. The facility employs an advanced activated sludge process with nitrification/de-nitrification for Enhanced Nutrient Removal (ENR) level treatment. The treated effluent is discharged into the Chesapeake Bay. The arial view of the WRF and its surrounding neighborhoods is shown in Figure 1-1.

Figure 1-1 Aerial view of the Annapolis Water Reclamation Facility

Recent projects at the WRF have upgraded various portions of the treatment plant. However, the odor control facilities have not been evaluated. The County desires to complete a comprehensive odor control evaluation at the plant to identify sources of odor and potential capital improvements.

The overall goal of the project is to conduct a comprehensive odor evaluation including monitoring, data collection, data analysis, and air dispersion modeling to identify sources of odors and potential capital improvements needed to address them. Final recommendation will be made after the long-term evaluation, which includes summertime monitoring and data analysis.

The purpose of this Technical Memo (TM) is to detail the identified locations for monitoring odorous air within the facility and along the fence line/neighborhood. These selected sites will offer valuable insights into the sources of odor and types of odor control strategies, if any, that need to be implemented.

2 MONITORING PLAN

2.1 Hydrogen Sulfide Monitoring

The monitoring plan includes continuous hydrogen sulfide (H_2S) and temperature monitoring at a total of ten locations, over two separate one-month periods – one in February, 2024 and one in the summer of 2024 - to capture the seasonal impact on odor emissions. In addition to continuous online monitoring, HDR will use colorimetric tubes for periodic measurements of organic sulfur compounds and ammonia, when deemed necessary.

The County will purchase (through HDR) ten H_2S data loggers for this odor evaluation study. Six of the loggers are Parts Per Million (PPM) monitors, preferred for source locations within the plant, while the remaining four are Parts Per Billion (PPB) monitors, preferred for fence line locations where the concentrations are lower than those at source locations. An example of Acrulog™ H_2S PPM and PPB monitors are shown in Figure 2-1.

Figure 2-1 Photos of Acrulog H_2S Gas Monitors: Parts Per Million (left) and Part Per Billion (right)

These H_2S gas monitors are portable data-loggers, designed to track continuous data for extended periods of time and to withstand the harsh environments typically found within the wastewater industry. These monitors can be attached directly to the fence or structure with zip ties or other forms of connection. The collected data is easily downloadable via Bluetooth wireless technology. HDR, in collaboration with County staff, will install the data logging monitors. Additionally, HDR will be responsible for the weekly tasks of data collection and battery replacement.

2.2 Monitoring Locations

Six of the H_2S data loggers will be deployed at locations within the WRF, while four loggers will be positioned at the fence line/neighborhood locations. The proposed locations for the monitoring are shown in Figure 2-2, orange stars denote interior WRF locations, and green stars indicate proposed fence line locations. The specific locations for the remaining two fence line/neighborhood positions are yet to be determined (TBD).

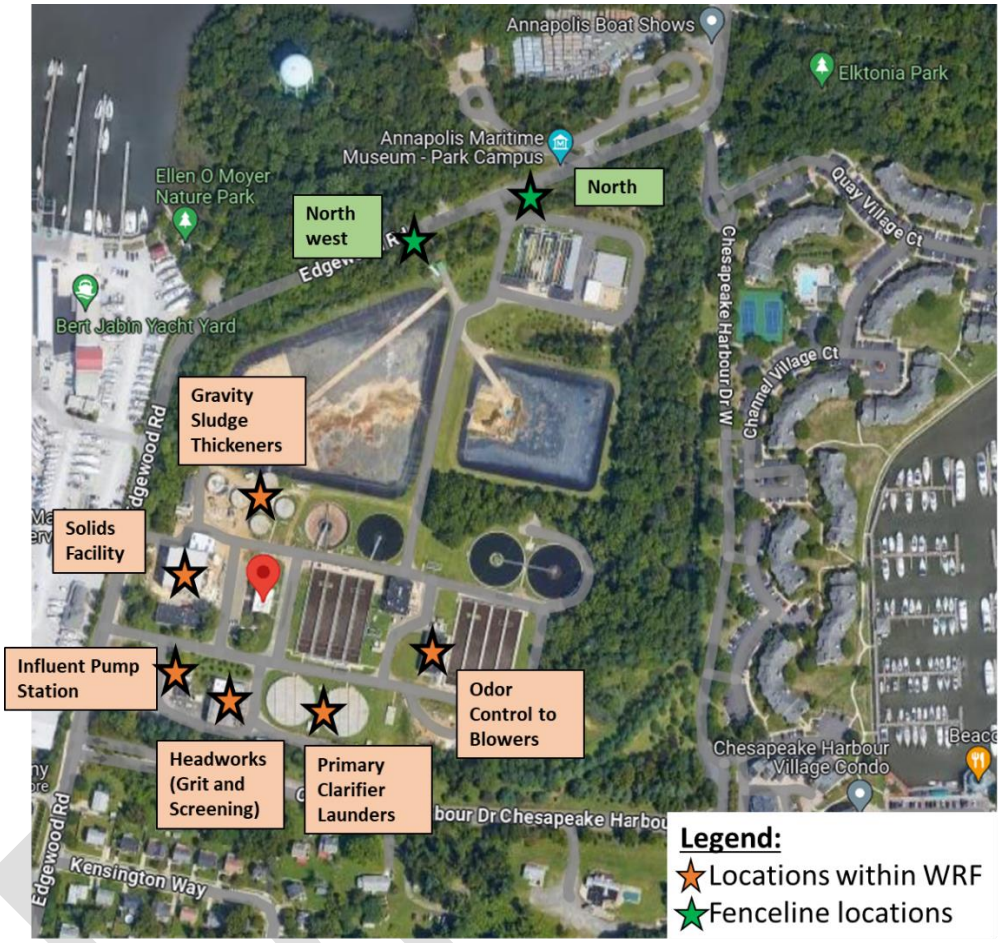

Figure 2-2 Proposed H_2S logger monitoring locations

2.2.1 H_2S Data Logger Locations Within The WRF

Influent Pump Station

A portion of the incoming wastewater to the Annapolis WRF flows through the influent pump station. The influent pump station is configured with a small wet well and a dry well with four influent pumps. The wet well is ventilated to a biofilter for odor control. To evaluate potential odor impacts from the influent pump station and appropriate design criteria for a new odor control system, a PPM monitor will be positioned at the wet well to assess H_2S levels at the influent pump station. The monitoring approach involves utilizing a "bucket method," where the monitor is placed within a closed 5-gallon bucket. The bucket features an inlet port for introducing the source gas and an outlet port to eliminate any positive pressure within the container. As shown in Figure 2-3, inlet tube will be tapped

into pressurized location downstream of fan. During the site walk conducted on December 21, it was confirmed that both potential locations indicated in the Figure 2-3 have sampling ports available for utilization.

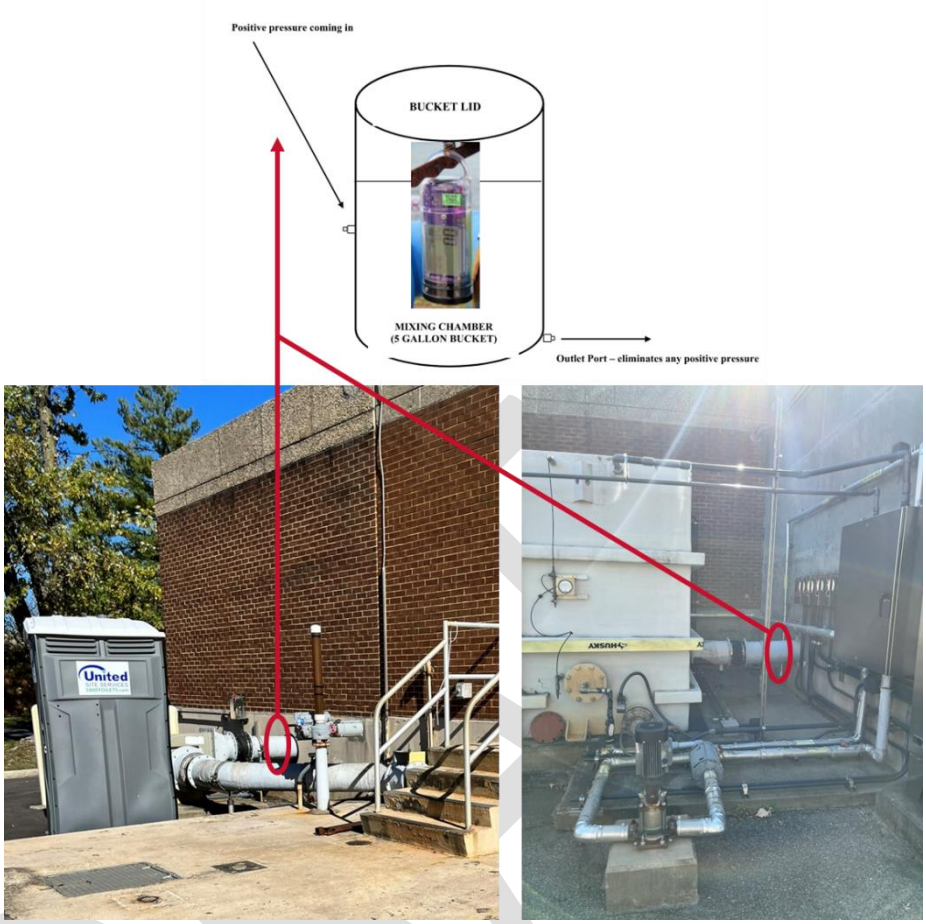

Figure 2-3 Proposed locations to install PPM monitor at the influent pump station.

Screen and Grit Building

The preliminary treatment systems at the Annapolis WRF were recently upgraded. There are two fine screens, a fine screen bypass channel, and two grit detritors. All preliminary treatment facilities are located within the screen and grit building. All channels within the building are covered with open grating and the detritors are open tanks. The space within the screen and grit building is ventilated through an inactive chemical odor scrubber. To evaluate potential odor impacts from the screen and grit building and appropriate design criteria for a new odor control system, a PPM monitor will be installed. The monitoring setup, as depicted in the Figure 2-4, involves tapping a sampling tube into a pressurized location downstream of the fan, and the monitoring will be conducted using the bucket method. During the site walk conducted on December 21, it was confirmed that an existing sampling port can be used for monitoring.

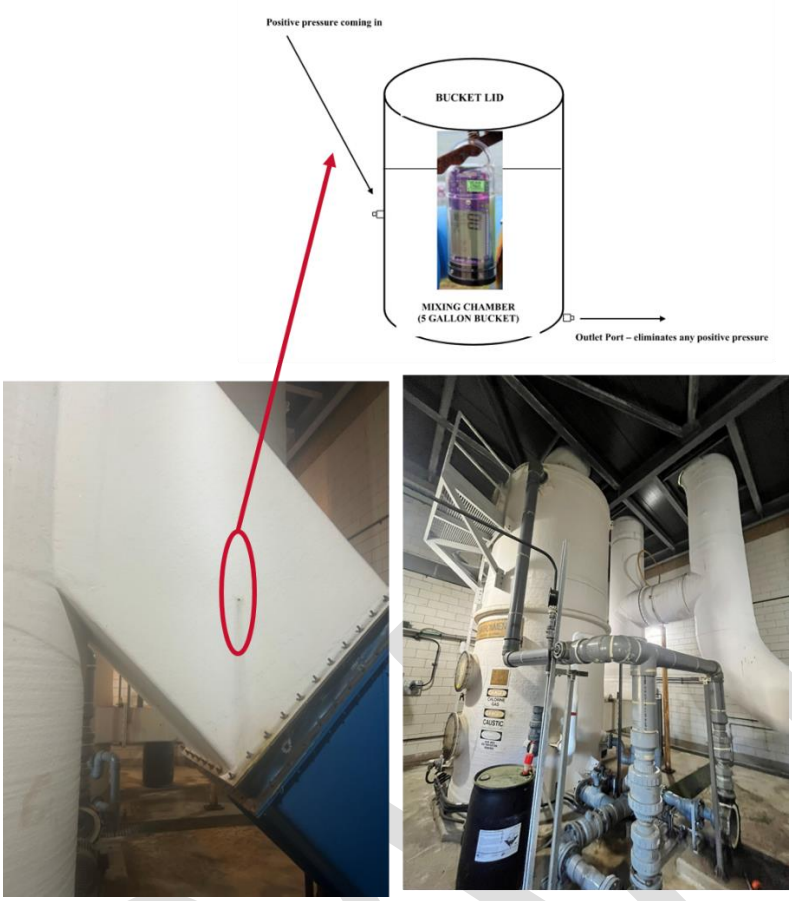

Figure 2-4 Existing non-operational scrubber and the proposed location to install H_2S monitor.

Primary Clarifier Launders

There are two primary clarifiers at the Annapolis WRF. The primary clarifier launders are covered and ventilated to the aeration blowers for odor treatment through the activated sludge system. However, the existing aeration blowers are being replaced with high-speed turbo blowers, and it has been noted by at least one vendor that using odorous air at the blower intakes is not advisable. To identify design criteria for a future odor control system, an H_2S PPM monitor will be installed beneath the launders cover to measure H_2S levels. During the site walk on December 21, it was confirmed that the monitor can be secured to a rope or chain and suspended from the cover. This arrangement ensures easy access to the monitor for data collection and battery replacement. Two monitors will be placed in one primary clarifier – one near the existing takeoff and one in between the fresh air intake and an existing takeoff. This will help confirm the ventilation is working appropriately.

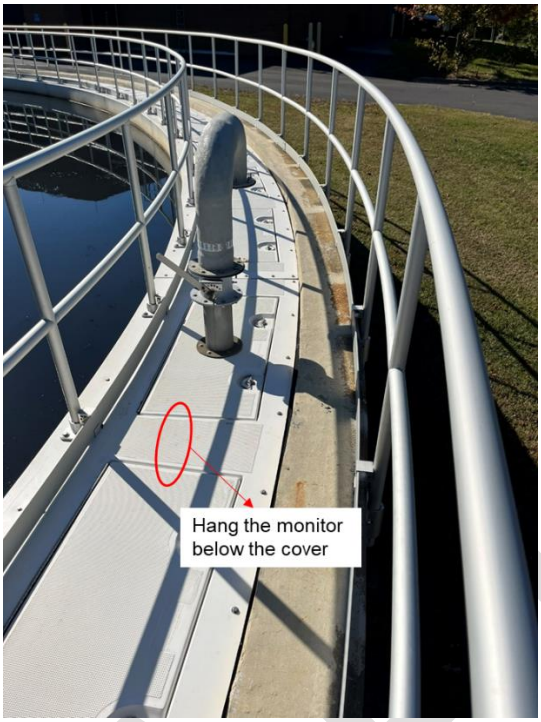

Figure 2-5 Proposed monitoring location at the primary clarifier.

Gravity Sludge Thickeners

There are five gravity sludge thickeners (GSTs) at the Annapolis WRF. Each GST is completely covered and (similar to the primary clarifiers) ventilated to the aeration blowers for odor treatment through the activated sludge system. To identify design criteria for a future odor control system, an H_2S PPM monitor will be installed beneath the covers during the monitoring period. It is advisable to keep the covers closed to obtain representative data. Alongside continuous H_2S monitoring, colorimetric tubes will be employed for periodic measurements of organic sulfur compounds and ammonia. During the site walk conducted on December 21, it was identified that the monitor can be hung from the covers using existing penetrations (see Figure 2-6).

Figure 2-6 Gravity sludge thickener PPM monitor location

Odor Control to Blowers

Supply air for the existing aeration blowers currently is provided by the odorous air ventilated from the primary clarifiers and GSTs. To identify design criteria for a future odor control system, an H_2S PPM monitor will be installed on the discharge of the existing odor control fans (providing the supply air to the aeration blowers) downstream of the fan as shown in Figure 2-7. The bucket method will be employed to tap into the pressurized location downstream of the fan. During the site walk, it was observed that there are no existing sample taps in the blower building. A new sample tap will be drilled at the proposed location shown in the Figure 2-7. The County confirmed they could keep one blower in operation during the study period.

Figure 2-7 Proposed H_2S monitoring location at the aeration blower facility

Solids Facility

The Solids Facility at the Annapolis WRF was recently upgraded with new belt filter presses, lime stabilization systems, conveyors, and enclosed truck loading. Odorous air from inside the building is collected and ventilated through an ammonia packed tower scrubber and a carbon vessel. A PPM H_2S monitor will be installed at the solids facility scrubber to assess the level of H_2S in the discharge of the carbon scrubber, evaluating potential impacts on the surrounding community. The bucket method will be utilized to install the monitor, and the inlet tube will be tapped into the existing sample line at one of the proposed locations shown in the Figure 2-8. Periodic colorimetric samples will also be taken as deemed necessary to assess for organic sulfides, ammonia, or other odorants.

Annapolis WRF staff should monitor the positioning of the doors and note times where doors are open during truck filling operations.

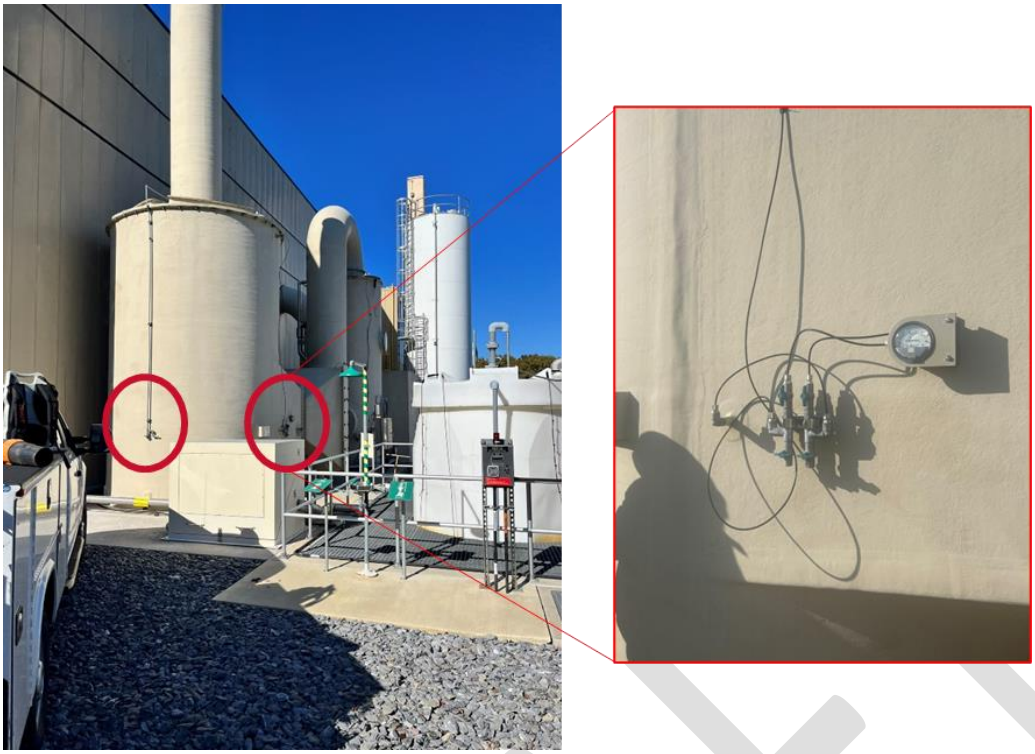

Figure 2-8 Proposed H_2S monitor locations at the solids facility scrubber.

2.2.2 Fenceline/Neighborhood Monitoring Locations

At the kickoff meeting on December 21, 2023, HDR suggested selecting fence line monitoring locations based on the majority of neighboring resident complaints and wind rose directions. Following the County's input, two locations (north and northwest of the WRF) shown in Figure 2-2 were preliminarily selected as fence line locations for H_2S monitoring.

Additionally, the County proposed two other neighborhood locations— a pump station near the Chesapeake Harbor community and the Annapolis Maritime Museum and Park—as potential sites for neighborhood monitoring. These locations were suggested due to a few odor complaints reported from these areas. However, the specific locations for the remaining two fence line/neighborhood positions are yet to be determined (TBD).

3 MONITORING SCHEDULE

The proposed monitoring schedule, as outlined in the Table 3-1, involves continuous data collection during each monitoring period, lasting for one month. In the event of unplanned process changes or impacts that affect monitoring locations during the scheduled monitoring, the project team will document and address these changes as needed.

Table 3-1 Proposed Monitoring Schedule

Month	WRF Locations	Fenceline/ Neighborhood Locations
February, 2024	PPM Monitors • Influent Pump Station • Headworks (Grit and Screening) • Primary Clarifier Launders • Odor Control to Blowers • Gravity Sludge Thickeners • Solids Facility Scrubber	PPB Monitors • North fence line • Northwest fence line • Pump station near the Chesapeake Harbor community (TBD, may require a PPM monitor) • Annapolis Maritime Museum and Park (TBD)
Mid-June, 2024	PPM Monitors • Influent Pump Station • Headworks (Grit and Screening) • Primary Clarifier Launders • Odor Control to Blowers • Gravity Sludge Thickeners • Solids Facility Scrubber	PPB Monitors • North fence line • Northwest fence line • Pump station near the Chesapeake Harbor community (TBD, may require a PPM monitor) • Annapolis Maritime Museum and Park (TBD)

4 MONITORING PLAN CONTACTS

The HDR contacts for the monitoring part of the project are as follows:

1. Mamatha Hopanna – Project Engineer, Mamatha.Hopanna@hdrinc.com, 443.345.7367
2. Brian Balchunas – Task Lead, Brian.Balchunas@hdrinc.com, 301.289.7209

6 APPENDIX B- ODOR CONTROL SUMMER MONITORING DATA (WINTER)

Odor Control Monitoring Data

Annapolis Water Reclamation Facility

Odor Control Evaluations

May 20, 2024

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1 INTRODUCTION

The Annapolis Water Reclamation Facility (WRF) is a wastewater treatment plant, jointly owned by the City of Annapolis and Anne Arundel County. The County is responsible for the operation and maintenance of the facility. The facility employs an advanced activated sludge process with nitrification/de-nitrification for Enhanced Nutrient Removal (ENR) level treatment. The treated effluent is discharged into the Chesapeake Bay. The aerial view of the WRF and its surrounding neighborhoods is shown in Figure 1-1.

Figure 1-1 Aerial view of the Annapolis Water Reclamation Facility

Recent projects at the WRF have upgraded various portions of the treatment plant. However, the odor control facilities have not been evaluated. The County desired to complete a comprehensive odor control evaluation at the plant to identify sources of odor and potential capital improvements.

The overall goal of the project is to conduct a comprehensive odor evaluation including monitoring, data collection, data analysis, and air dispersion modeling to identify sources of odors and potential capital improvements needed to address them. Final recommendation will be made after the long-term evaluation, which includes summertime monitoring and data analysis.

The purpose of this Technical Memo (TM) is to provide a summary of the results of the continuous monitoring conducted within the facility and along the fenceline/neighborhood in accordance with the odorous air monitoring plan. The Odor Monitoring Plan, previously developed, is provided in Appendix for reference.

2 MONITORING LOCATIONS AND PERIOD

The first round of monitoring included continuous monitoring of hydrogen sulfide (H_2S) levels and temperature at a total of fourteen (14) locations over a four-week period, from March 19, 2024, to April 22, 2024. Initially, eight H_2S part-per-million (PPM) data loggers were deployed at locations within the WRF, while four (4) part-per-billion (PPB) loggers were positioned at fenceline/neighborhood locations. PPM data loggers are used to monitor H_2S at the source of emissions, while PPB monitors are used to monitor H_2S levels after the impacts of dispersion. Midway through the monitoring period (April 1, 2024), two (2) additional PPM data loggers were added to collect data from the aeration tank and secondary clarifier launders. The monitored locations are shown in Figure 2-1, orange stars denote interior WRF locations, and green stars indicate fenceline locations. Further details on monitoring locations can be found in Odor Monitoring Plan provided in Appendix.

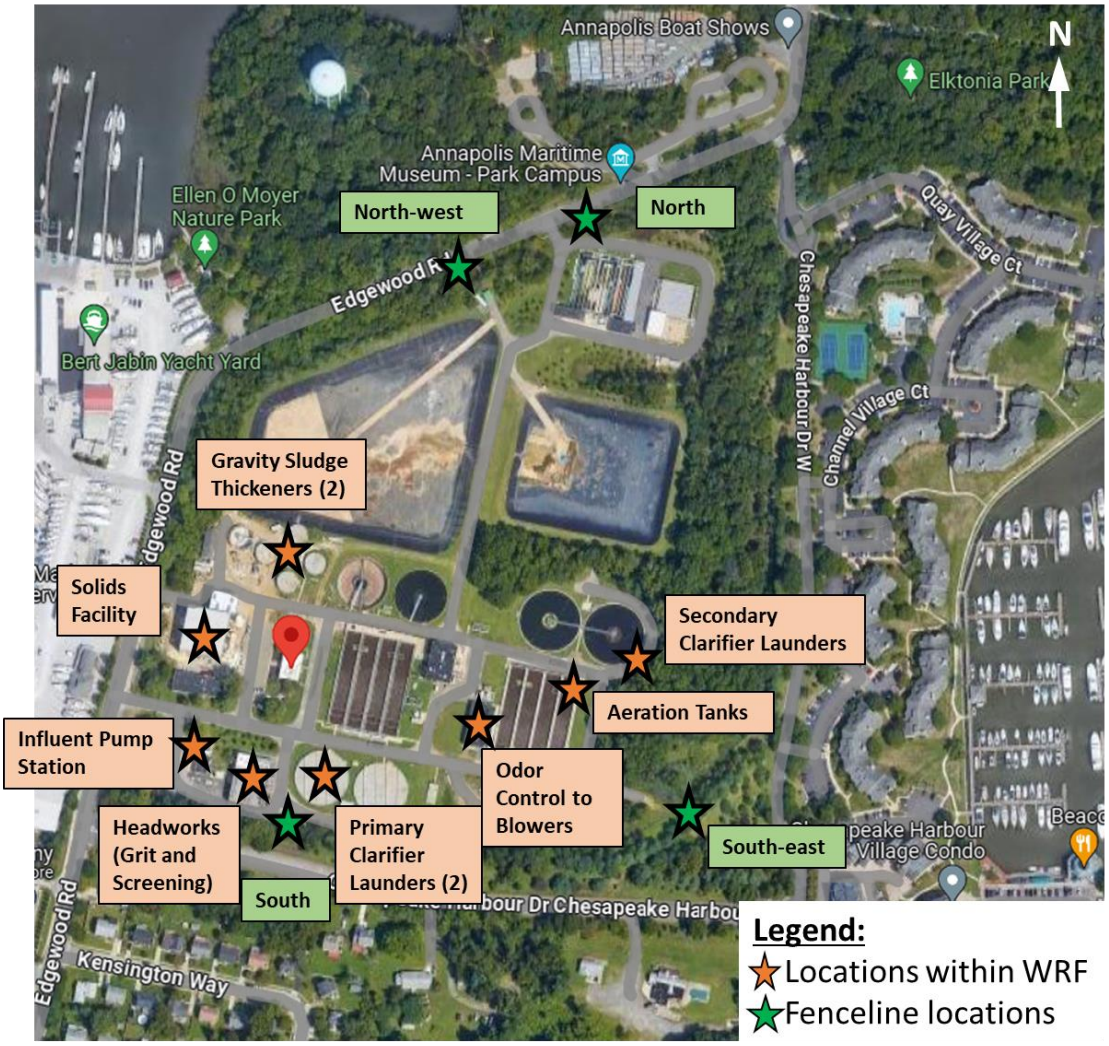


Figure 2-1 H_2S Logger Monitoring Locations

Based on input from the Chesapeake Harbor Homeowners Association meeting with the County, the County suggested moving the northwest PPB monitor to the west of the WRF, closer to the solids facility. The relocation of the data logger was carried out on April 14, 2024, and the location is shown in the Figure 2-2.

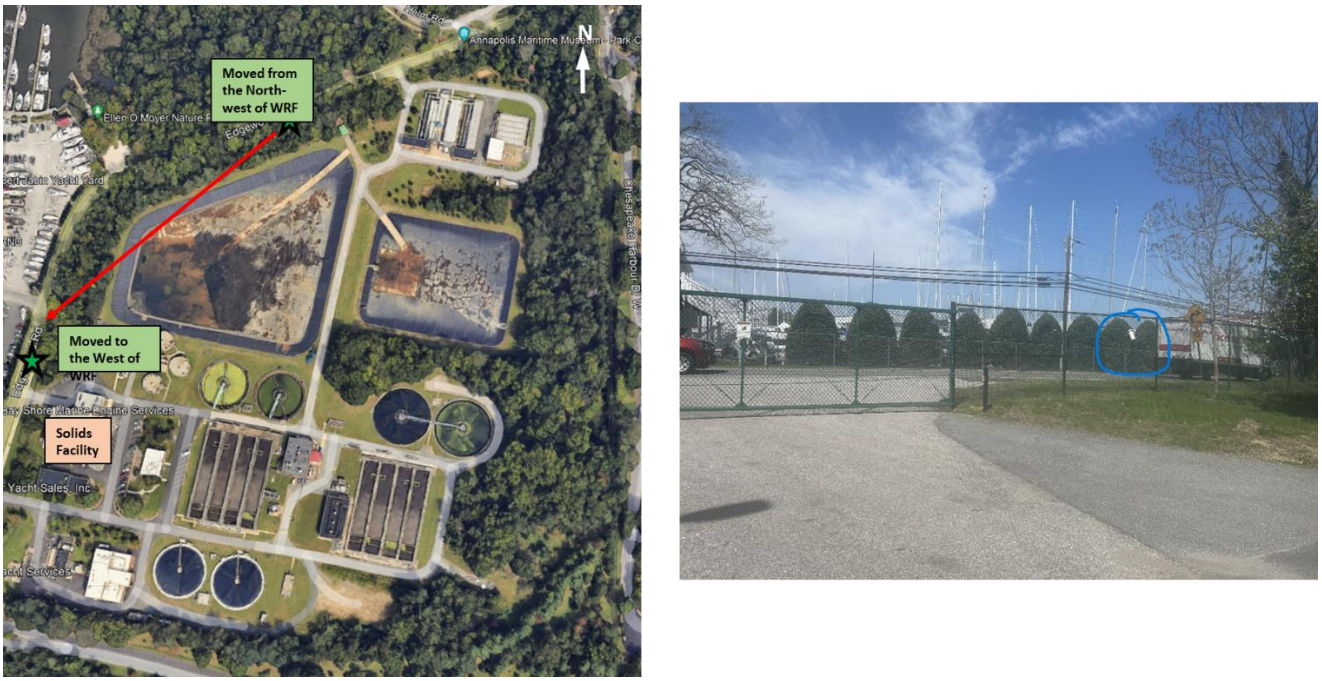


Figure 2-2 Relocated PPB Monitor Location (to the West of WRF, Close to Solids Facility)

3 MONITORING DATA

Once the Acrulog data loggers were deployed on March 19, 2024, weekly site visits were conducted to check the battery life of the monitors and extract data from the loggers. These visits occurred on March 22, April 1, 8, 15, and 22 (the last day of data collection). The collected data from this monitoring period are presented below.

3.1 Site Source H_2S Monitoring Findings

The changes in the measurable H_2S concentration distribution over the monitoring period for all the locations within the WRF are illustrated in Figure 3-1. Additionally, the measured averages and the range of H2S concentrations, as well as the percent of detection events, are presented in Table 3-1.

Overall findings from the onsite source monitoring are presented below (note: the H_2S concentrations presented below are calculated after excluding all the “zero” readings from the data):

- Out of all the locations monitored, primary clarifier loggers recorded the highest frequency and magnitude of measurable H_2S concentrations. The detection frequency ranged between 79% and 96%, with measurable H_2S concentrations ranging from 0.4 to 27.5 ppmv. The odorous emissions in this area are being collected and sent to the existing aeration blowers for diffusion into the aeration tanks.
- Screen and Grit Building air had the next highest H_2S concentrations, ranging between 0.4 and 19.9 ppmv, with a detection frequency of 56%. The air ventilated from the Screen and Grit Building is being ventilated directly to the atmosphere.
- Ventilated air from the influent pump station had H_2S concentrations measuring up to 13.8 ppmv, with a detection frequency of 96%. However, two weeks of data were recorded as

"zero" due to sampling errors mentioned in section 3.1.2, which skewed the reported detection frequency and magnitude. The air ventilated from the influent pump station is being sent to the existing biofilter.

- The logger installed at the blower duct also measured the presence of H_2S for 46% of the monitoring time, with concentrations in the range of 0.4 to 9.5 ppmv. This air is sent to the existing aeration blowers for diffusion into the aeration tanks.
- Although the recorded H_2S detection frequencies at GSTs were high (32%-54%), the magnitudes of H_2S concentrations were relatively low (0.4 – 4.2 ppmv). The odorous emissions in this area are being collected and sent to the existing aeration blowers for diffusion into the aeration tanks.
- The measurable H_2S levels and frequency were low at the solids facility, ranging from 0.4 to 0.9 ppmv and 1%, respectively.

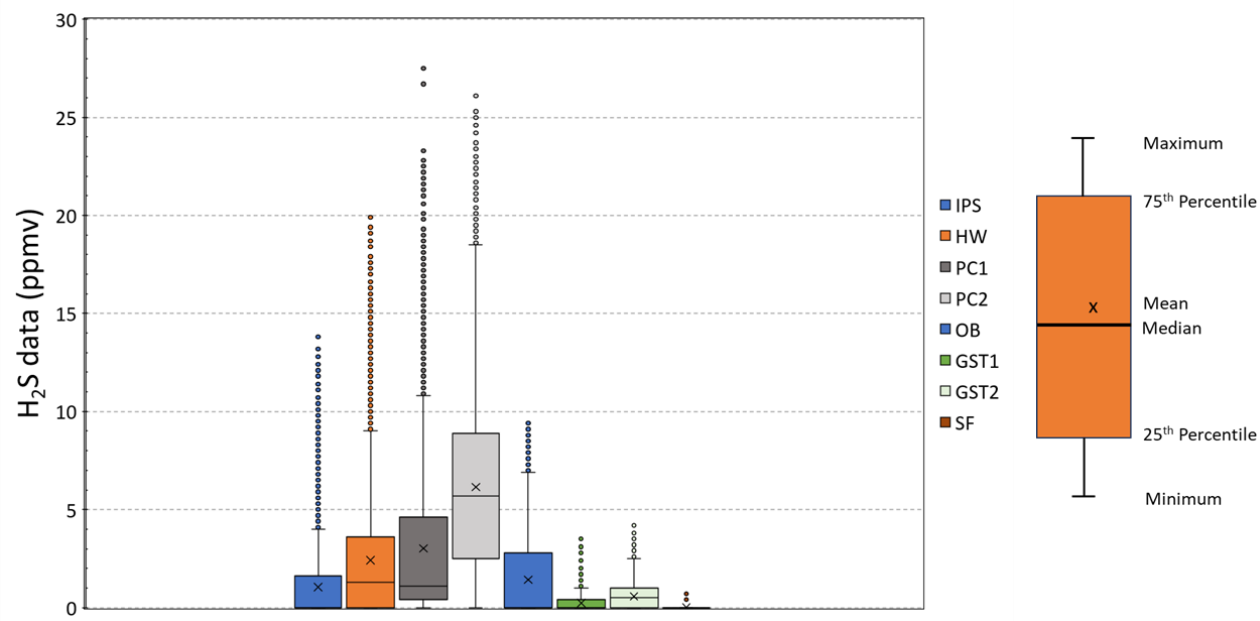


Figure 3-1 Box-And-Whisker Plots Showing the Change in Measurable H_2S Concentration Distribution for the Locations Within the WRF (March 19 to April 22).

[Legend: IPS- Influent Pump Station; HW- Screen and Grit Building; PC1 & PC2- Primary Clarifier Launder; OB- Odor Control to Blowers; GST1 & GST2- Gravity Sludge Thickeners; and SF- Solids Facility.]

Table 3-1 Site Source H_2S Monitoring Findings

Monitoring Locations	Average H_2S Concentration (PPM)		H_2S Concentration Range (PPM)	Percent of Values Detected above "Zero"
	Including "Zero" readings	Excluding "Zero" readings	Min/Max (Excluding "Zero" Readings)	
Influent Pump Station[1]	2.30	2.39	0.4 – 13.8	96%
Screen & Grit Building[2]	3.95	4.26	0.4 – 19.9	56%
Primary Clarifier Launder #1	3.01	3.84	0.4 – 27.5	79%
Primary Clarifier Launder #2	6.15	6.40	0.4 – 26.3	96%
Odor Control Blowers	1.43	3.12	0.4 – 9.5	46%
Gravity Sludge Thickener #1	0.23	0.74	0.4 – 3.5	32%
Gravity Sludge Thickener #2	0.57	1.05	0.4 – 4.2	54%
Solids Facility	0.0	0.53	0.4 – 0.9	1%
Aeration Tank	-	-	-	-
Secondary Clarifier Launder	0	0.4	0.4	0.04%

Notes:

1. **Data collected during the sampling error period caused by condensate in the sampling tube was excluded when calculating both averages and frequency.**
2. **Data collected during low air flow conditions has been excluded from the calculations of averages and frequency to prevent underestimation of values.**

The subsections below provide specific details of monitoring findings for individual locations.

3.1.1 Influent Pump Station Monitoring

The PPM logger was installed at a pressurized location downstream of the fan for sampling the ventilated air from the influent pump station prior to the existing biofilter. The H_2S concentrations and ambient air temperature measured for the five-week period, spanning from March 19 to April 22, are shown in Figure 3-2. During the initial week (3/19 – 3/22) and the final two weeks (4/8 – 4/15 and 4/15 – 4/22), the PPM logger recorded the presence of H_2S in the ventilated air. However, during the weeks of 3/22 – 4/1 and 4/1 – 4/8, all recorded readings indicated a H_2S level of "zero". Subsequently, it was discovered that moisture in the sampled air had condensed in the sampling tube, obstructing airflow into the logger. Therefore, the zero results from these two weeks do not indicate the absence of H_2S in the sampled air, but rather a sampling error. The sampling error will be mitigated in the next round of sampling by frequently inspecting and clearing the sampling tube of any condensation.

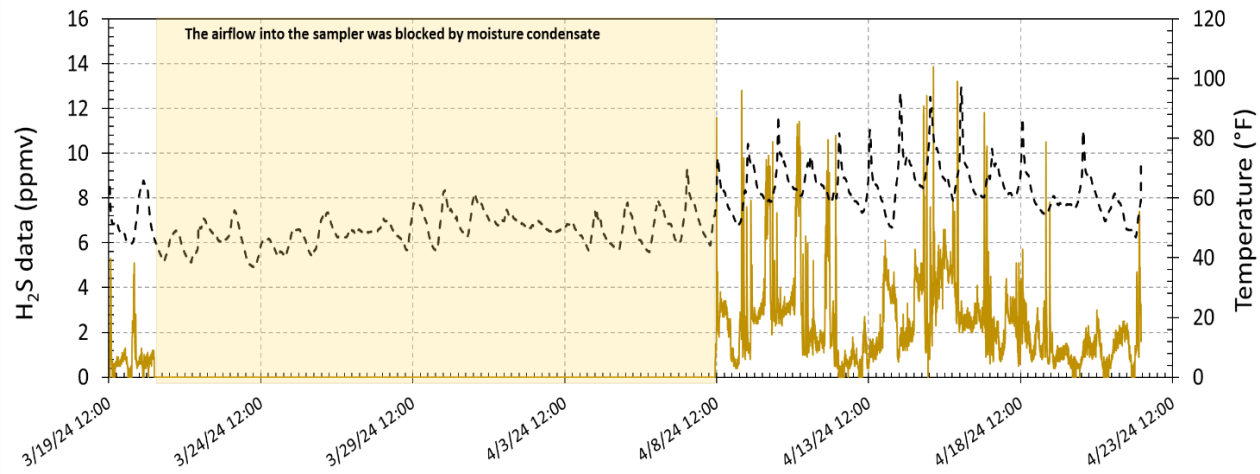


Figure 3-2 Results of Continuous Monitoring at Influent Pump Station (3/19/2024-4/22/2024)

In comparison, both the frequency and magnitude of measurable H_2S levels were higher during the weeks of 4/8 – 4/22. With two weeks of data missing, it is difficult to pinpoint a single cause that could have resulted in this observation. However, a probable cause could be the increase in temperature during these last two weeks. Higher ambient and wastewater temperatures could lead to higher measured concentrations of H_2S. The time-averaged temperatures, recorded by the logger are presented in Table 3-2. The spikes in H_2S concentration do not exhibit a diurnal pattern that correlates with the influent flow patterns.

Table 3-2 Time-Averaged Temperatures Measured at the Influent Pump Station

Monitoring Week	Air Temperature, °F (Time-Averaged)
3/19 – 3/22	48.0
3/22 – 4/1	49.0
4/1 – 4/8	50.0
4/8 – 4/15	64
4/15 – 4/22	63

The H_2S readings at the Influent Pump Station are not excessive and can effectively be treated with appropriate odor control technologies (to be evaluated in subsequent TMs). These odors are currently treated with the existing biofilter.

3.1.2 Screen and Grit Building Monitoring

The space within the screen and grit building is ventilated through an inactive chemical odor scrubber. The monitoring setup involved tapping a sampling tube into a pressurized location downstream of the fan. The H_2S concentrations and ambient air temperature measured for the five-week period, spanning from March 19 to April 22, are shown in Figure 3-3. During the first monitoring week, it was observed that the airflow rate to the logger was relatively low, necessitating a direct sampler plug and tube connection to the sampling port of the logger, which was implemented from the second week onward. Consequently, the measurable H_2S concentrations

were appreciably lower during the week of 3/19 – 3/22 compared to other weeks. Additionally, during the week of 4/15 – 4/22, it was noted that the sampler plug had detached from the logger, causing the logger to measure the low-flow-rate air entering the bucket, resulting in lower magnitude H_2S levels.

Once the sample line was connected directly to the sampler, near continuous H_2S presence was detected by the logger. The measured H_2S data were as high as 19.9 ppmv at times, with an overall average of 4.3 ppmv during this monitoring period. Note that the present average excludes all the zero readings recorded by the logger. During the next sampling event, the team will connect the sampler tube directly to the logger and take steps to secure the sample tube in place, so the sampling error from this round can be avoided.

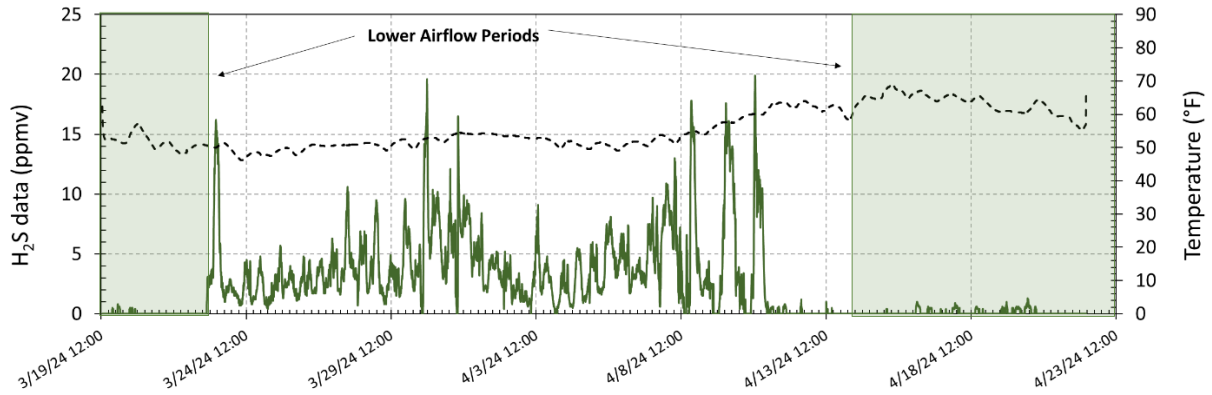


Figure 3-3 Results of Continuous Monitoring at Screen and Grit Building (3/19/2024-4/22/2024)

The H_2S readings at the screen and grit Building are significant. As these are not being treated, it is likely that these emissions are contributing to offsite odors. This will be evaluated further in subsequent TMs.

3.1.3 Primary Clarifier Monitoring

To monitor odorous air formed in the primary clarifiers, two PPM loggers were placed in one primary clarifier launders– one near the existing takeoff (PC1) and one in between the fresh air intake and an existing takeoff (PC2). The H_2S concentrations and ambient air temperature measured for the five-week period, spanning from March 19 to April 22, are shown in Figure 3-4. The presented data shows the continuous generation of H_2S in the primary clarifier launders, and the detected levels were comparable at both locations except for the last two weeks. It was noticed that the PC1 logger was getting too close to the water level, and the splashing water was interfering with the data logging. After the logger was removed from the sampling location, it continued to register higher levels of H_2S, indicating logger malfunction requiring thorough cleaning before the next round of sampling deployment. As a result, the measured H_2S concentrations from the PC1 logger were lower than those of PC2 for the last two weeks (4/8 – 4/22).

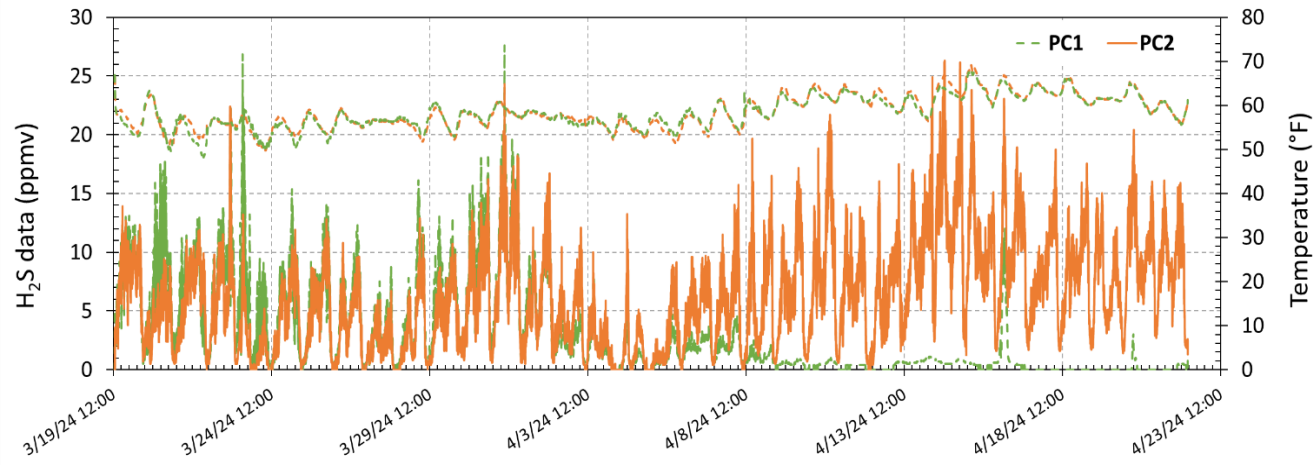


Figure 3-4 Results of Continuous Monitoring at Primary Clarifier Launders (3/19/2024-4/22/2024).

The H_2S detection frequencies at PC1 and PC2 were 79% and 96%, respectively. The maximum measurable H2S concentration in the primary clarifier was as high as 27.3 ppmv, and the average concentration ranged from 3.8 to 6.4 ppmv. The two locations tracked consistently with each other, indicating good air movement below the covers. The measured concentrations are consistent with what might be expected from beneath covered primary clarifier launders. The odors from this location are sent to the existing aeration blowers (see Section 3.1.5 below). Treatment of these odors will be considered further in subsequent TMs.

3.1.4 Gravity Sludge Thickeners Monitoring

During this monitoring period, two H_2S PPM monitors were installed beneath the covers of gravity sludge thickeners (GSTs). The H_2S concentrations and ambient air temperature measured for the five-week period, spanning from March 19 to April 22, are shown in Figure 3-5. The presented data shows the continuous generation of H_2S in the GSTs (except for the weeks of 3/22 – 4/1 and 4/1 – 4/8), with detected levels comparable at both locations except for the last two weeks. During data collection on 4/1, it was noticed that both loggers, GST1 and GST2, were displaced from their locations (cause unknown), which explains the missing data observed in Figure 3-5.

Overall, the magnitude and frequency of measurable H_2S were slightly higher at GST2 compared to GST1. At GST1, the maximum and average concentrations of H2S were 3.5 and 0.74 ppmv, respectively, with a detection frequency of 32%. For GST2, the maximum and average concentrations were 4.2 and 1.05 ppmv, respectively, with a slightly higher detection frequency of 54%.

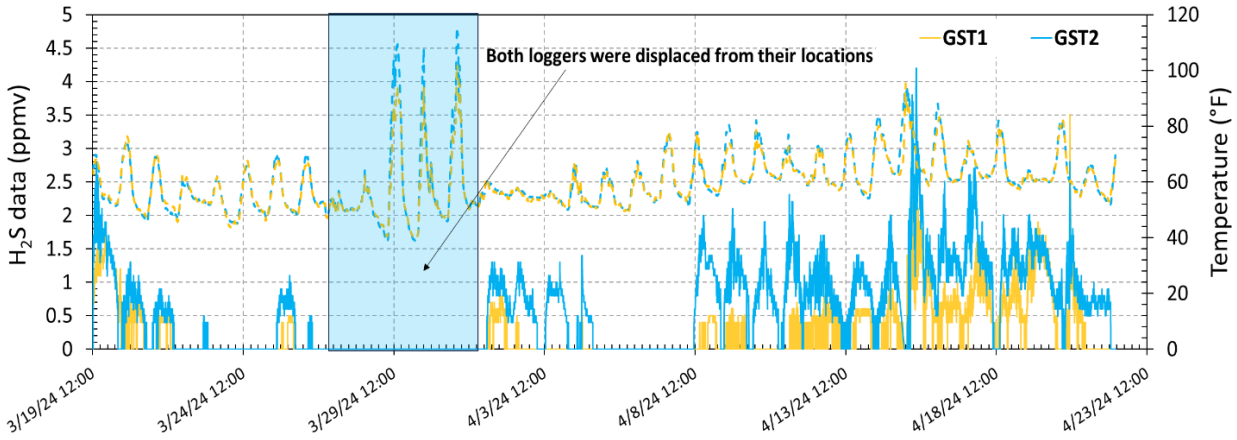


Figure 3-5 Results of Continuous Monitoring at Gravity Sludge Thickeners (3/19/2024-4/22/2024).

The measured concentrations are consistent with what might be expected from beneath covered GSTs. The odors from this location are sent to the existing aeration blowers (see Section 3.1.5 below). Treatment of these odors will be considered further in subsequent TMs.

3.1.5 Odor Control to Blowers

Air supply for the existing aeration blowers currently is provided by the odorous air ventilated from the primary clarifiers and GSTs. A PPM logger was employed to tap into the pressurized location downstream of the fan to collect H_2S sample measurements. The H_2S concentrations and ambient air temperature measured for the five-week period, spanning from March 19 to April 22, are shown in Figure 3-6. The recorded H_2S levels were not continuous, and periodic peaks were observed. No clear trend can be discerned between the temperature and the H_2S concentration or among the sampled weeks.

The measurable H_2S concentration was as high as 9.5 ppmv at times, with an average value of 3.1 ppmv and a detection frequency of 46%. These values are consistent with the combined odor measurements from the primary clarifiers and GSTs.

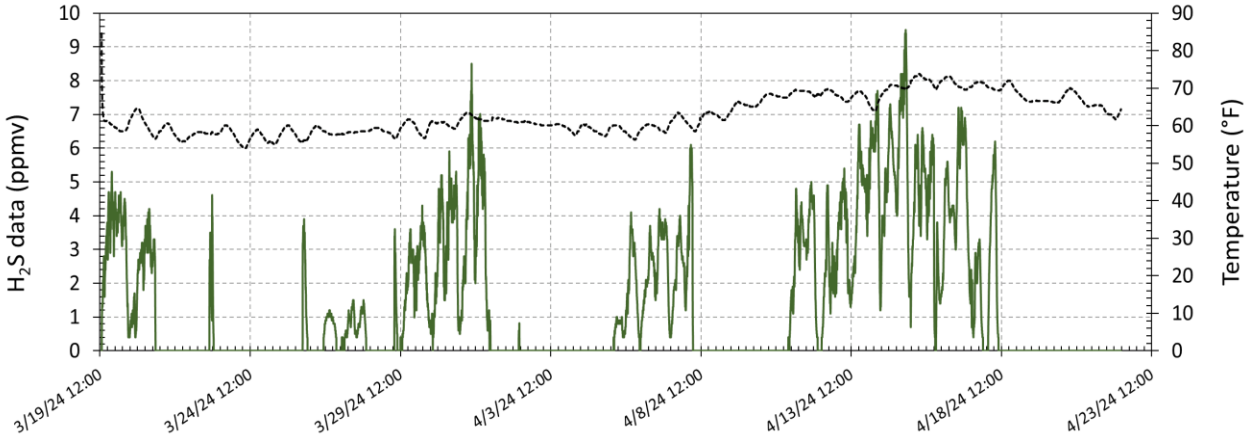


Figure 3-6 Results of Continuous Monitoring at Odor Control Blowers (3/19/2024- 4/22/2024).

A future technology evaluation will be completed for these odorous air sources in subsequent TMs. It is likely that new odor control technology will be required, as the future high-speed turbo blowers likely will not be compatible with the expected level of hydrogen sulfide concentrations.

3.1.6 Solids Facility Monitoring

A PPM H_2S monitor was installed at the solids facility scrubber to assess the level of H_2S in the discharge of the carbon scrubber, evaluating potential impacts on the surrounding community. Considering that the air has passed through a carbon scrubber, significant H2S detection was not expected from this location. As anticipated, only a few detection events (130) were recorded by the logger in the last week of sampling, as shown in Figure 3-7. These detections appear to coincide with temperature spikes during the day, with an average H_2S concentration of 0.53 ppmv.

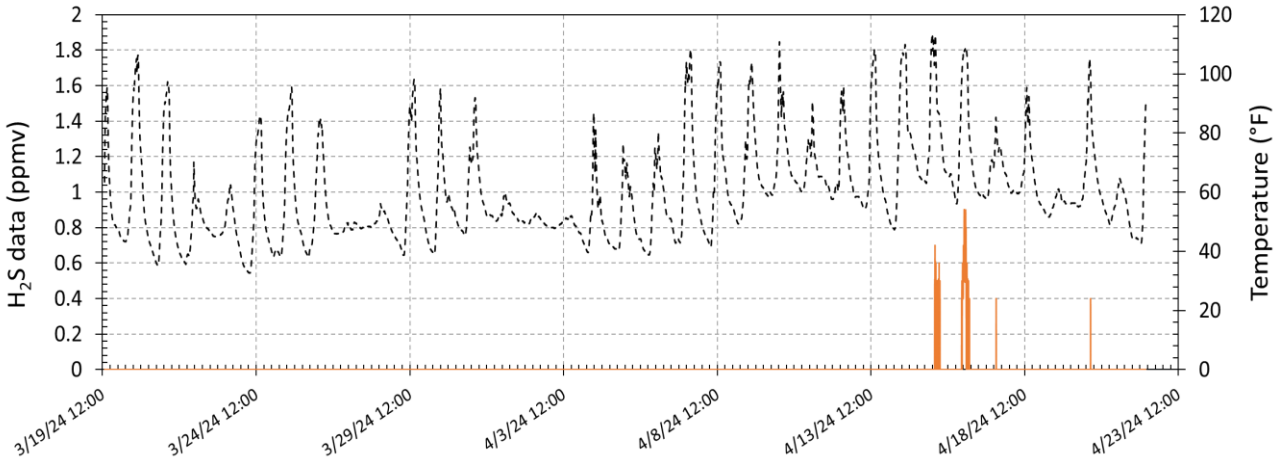


Figure 3-7 Results of Continuous Monitoring at Solids Facility (3/19/2024- 4/22/2024).

The existing solids odor control system appears to be functioning appropriately. However, future monitoring will be completed to confirm.

3.1.7 Aeration Tanks & Secondary Clarifier Launders

Midway through the monitoring period, one PPM logger was installed at each of the aeration tank and secondary clarifier launder to capture odorous H_2S data from these locations. The monitoring was conducted from 4/1 to 4/22. During this period, no H_2S detection was recorded by the logger installed at the aeration tanks (indicating effective removal of the H_2S from the primary clarifiers and GSTs through diffusion), while only two (2) detection events were recorded at the secondary clarifier, with H_2S concentration measuring at 0.4 ppmv.

3.2 Fenceline/Neighborhood Monitoring Findings

As shown in Figure 2-1, a total of four (4) PPB loggers, to the northwest, north, southeast, and south of the WRF were installed to monitor the fenceline. Figure 3-8 presents the H_2S concentrations and ambient air temperatures measured by the four fenceline PPB loggers deployed over the 5-week monitoring periods.

The results indicate that fugitive H_2S odors are reaching the fenceline. While H_2S concentrations measured at all of the locations were below the non-detect level the majority of the time, at times, measured concentrations reached as high as 276 ppbv. On a population basis, the average odor detection threshold is about 30 to 50 ppbv[1], although some individuals can detect H_2S at lower concentrations.

[1] https://ww2.arb.ca.gov/resources/hydrogen-sulfide-and-health

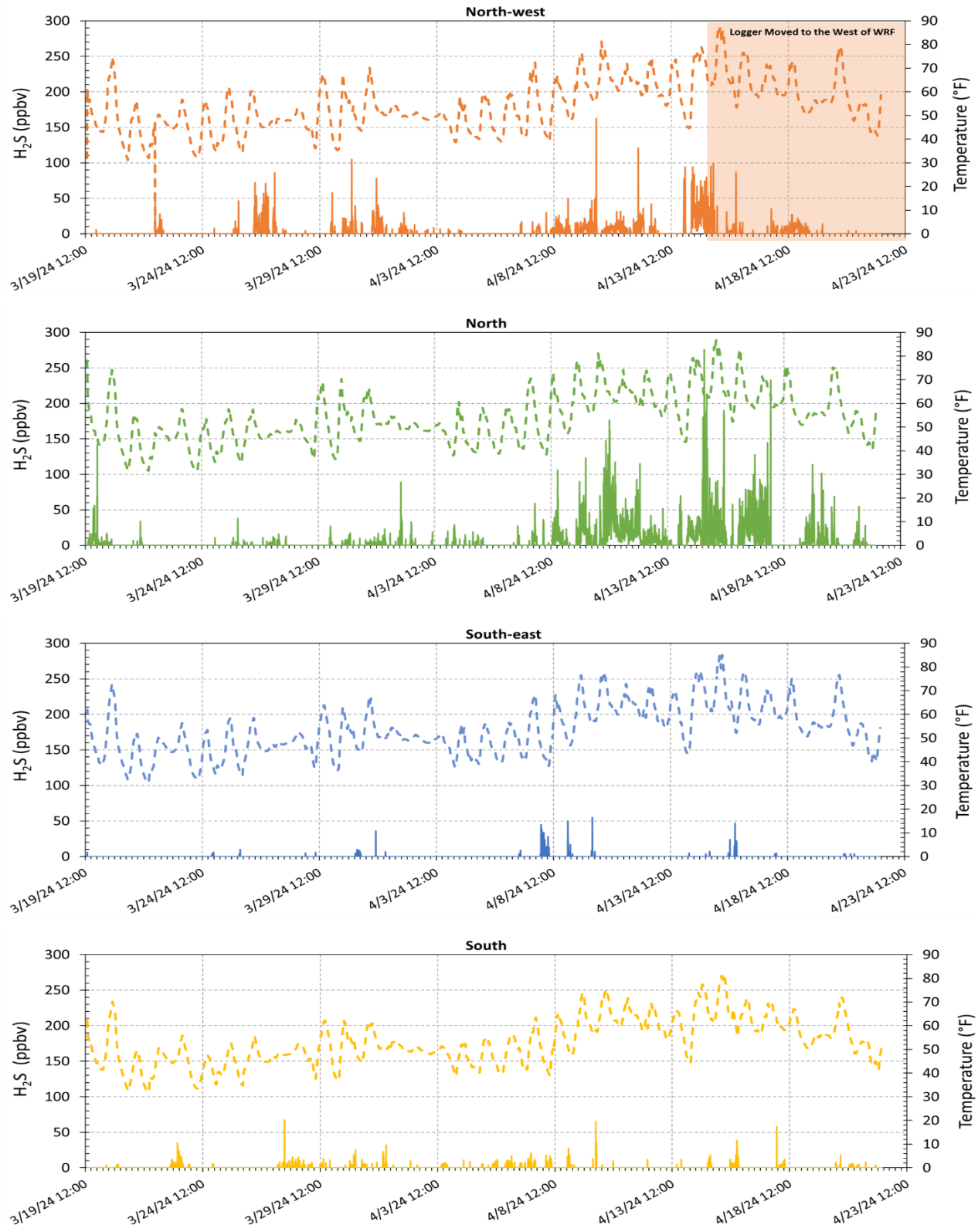


Figure 3-8 Results of Continuous Monitoring at the Fenceline (3/19/2024- 4/22/2024).

The changes in the measurable H_2S concentration distribution over the monitoring period for all the locations within the WRF are illustrated in Figure 3-9 Additionally, the measured averages and the range of H_2S concentrations, as well as the percent of detection events, are presented in Table 3-3.

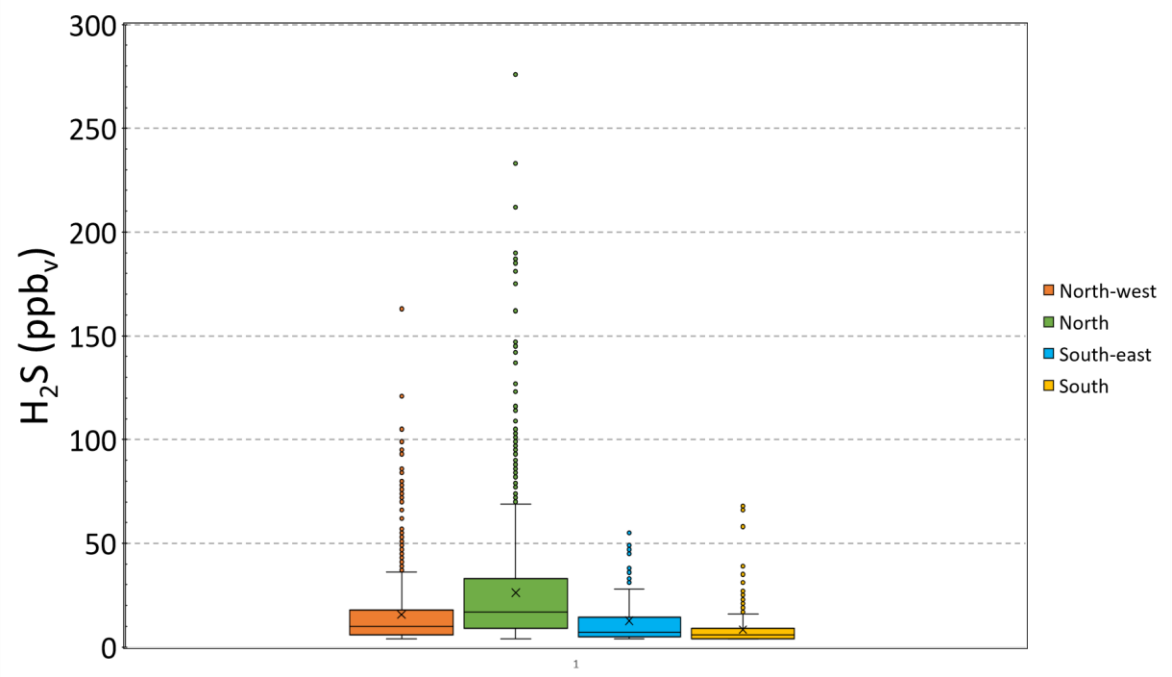


Figure 3-9 Box-And-Whisker Plots Showing the Change in Measurable H_2S Concentration Distribution for the Locations around the Fence-line (3/19/2024- 4/22/2024).

Table 3-3 Site Source H_2S Monitoring Findings

Monitoring Locations	Average H_2S Concentration		H_2S Concentration Range	Percent of Values Detected above "Zero"
	Including "Zero" readings	Excluding "Zero" readings	Min/Max (Excluding "Zero" Readings)	
Northwest	3	16	4 - 163	19%
North	6	26	4 - 276	24%
Southeast	0	13	4 - 55	2%
South	1	8	4 - 68	7%

Time-averaged hourly concentrations for the fenceline monitors were plotted against time-averaged hourly concentrations for the grit and screen building to see if there was a correlation between odorous emissions at the grit and screen building and observed H_2S concentrations at the fenceline. This correlation plot is shown in Figure 3-10 below. The south and southeast monitors showed the strongest correlation, while the north and northeast monitors showed weak correlation.

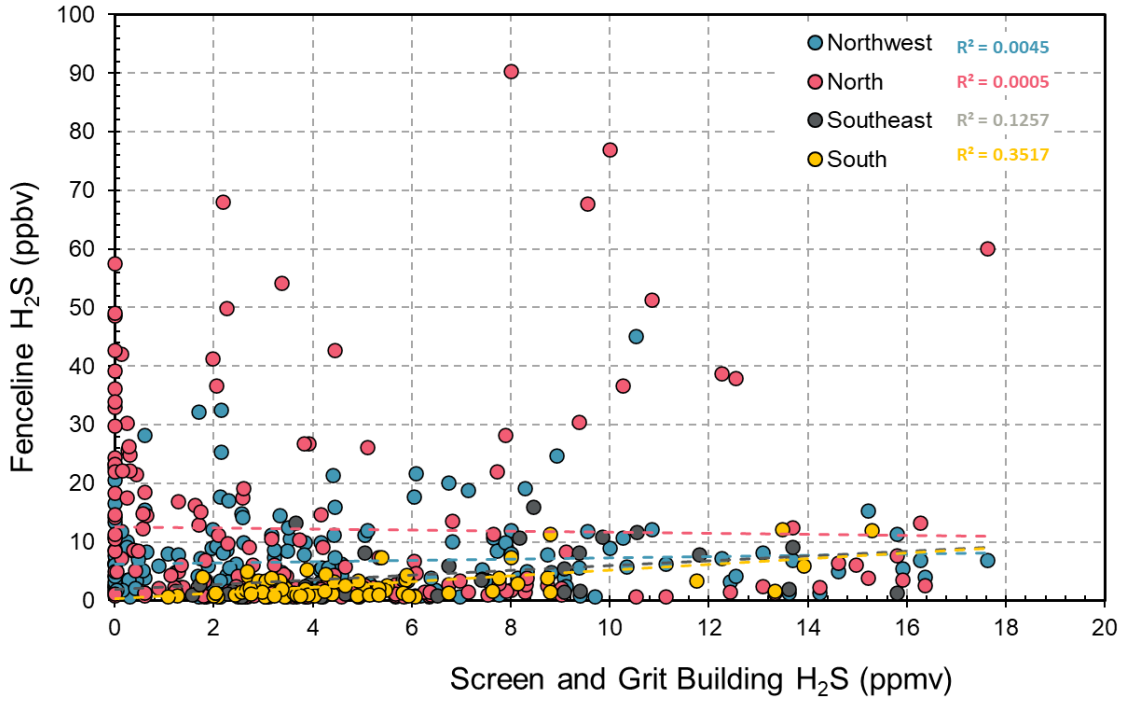
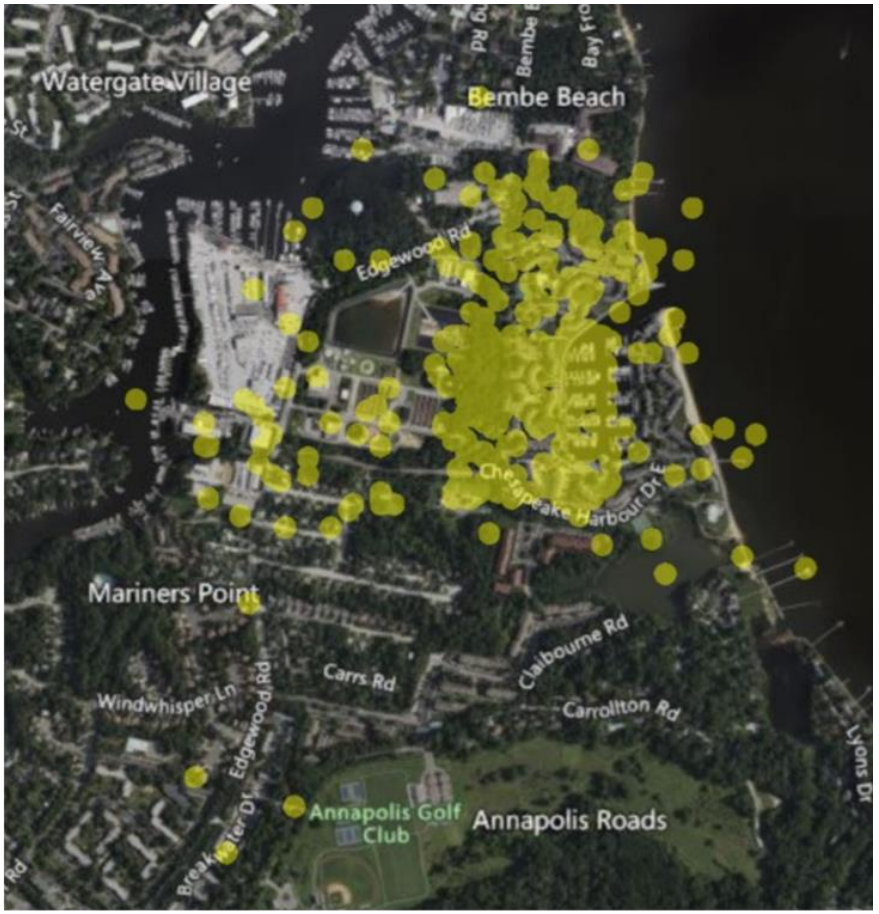


Figure 3-10 Hourly Time-Averaged Concentrations: Fenceline Data Plotted against Screen and Grit Building Air Data

3.2.1 Correlating Fenceline Data to Odor Nuisance Complaints

Local residents have been using the “Smell MyCity” app to document odor nuisance complaints. The team gathered information from the Smell MyCity app to evaluate and correlate the odor nuisance complaints with the data recorded by the loggers. Figure 3-11 presents a heat map and a scatterplot showing where the majority of complaints were reported during the sampling period from March 19 to April 22. Most of the complaints came from east of the WRF. Figure 3-12 shows the number of odor complaints per day for the sampling duration (March 19 - April 22) overlaid on H_2S data recorded from the fenceline monitors. The fenceline loggers to the north and northwest of the facility recorded higher frequency and magnitude of H_2S levels. Although it appears that complaints were logged when the monitors recorded H_2S spikes, a clear correlation was not observed between the two, as a considerable number of complaints were logged even when the loggers recorded negligible levels of H_2S. The south and southeast loggers recorded relatively lower frequency and magnitude of H_2S levels, and no correlation could be made with the odor complaint data either.

Heat map showing where most of the complaints are coming from.



Scatter plot showing the locations of individual complaints (same data shown differently)

Figure 3-11 Odor Complaints Logged on Smell My City App During March 19- April 22.

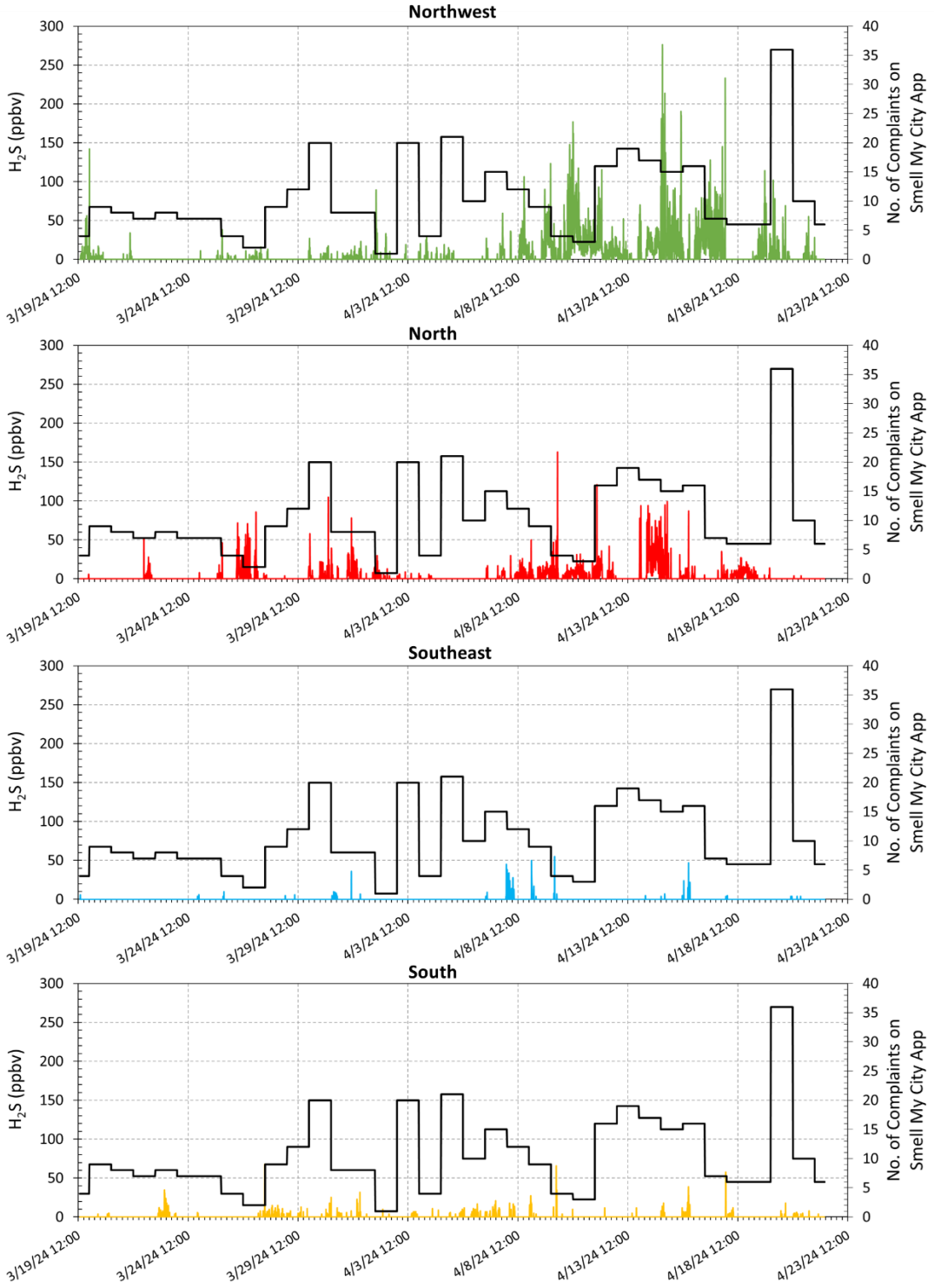


Figure 3-12 Number of Odor Complaints per Day for the Sampling Duration (March 19-April 22) Overlayed on H2S Data Recorded from the Fenceline Monitors

3.2.2 Correlating Fenceline Data to Weather

The wind speed and wind direction data were collected from the United States Naval Academy Weather Station in Annapolis for the H_2S sampling duration from March 19 to April 22. These data were plotted alongside the H_2S monitoring data to identify which sources within the WRF are generating odors that are carried by the prevailing wind and affecting neighboring communities. The H_2S data overlaid with the wind data for Northwest and North fenceline locations, with high-magnitude regions highlighted to understand the influence of local meteorological conditions on the odor issue, is shown in Figure 3-13 and Figure 3-14. The Southeast and South fenceline data with the wind data are presented in Figure 3-15 and Figure 3-16. During the sampling event, the wind speed ranged between 5-20 mph, and most of the time, the wind was blowing from north to south or east to west of the WRF. However, a clear correlation cannot be drawn between the wind data and the fenceline detections or the odor complaints. Wind data and source odor emission impacts on fenceline concentrations will be evaluated further with air dispersion modeling to understand the correlation between these factors in the next phase of the project.

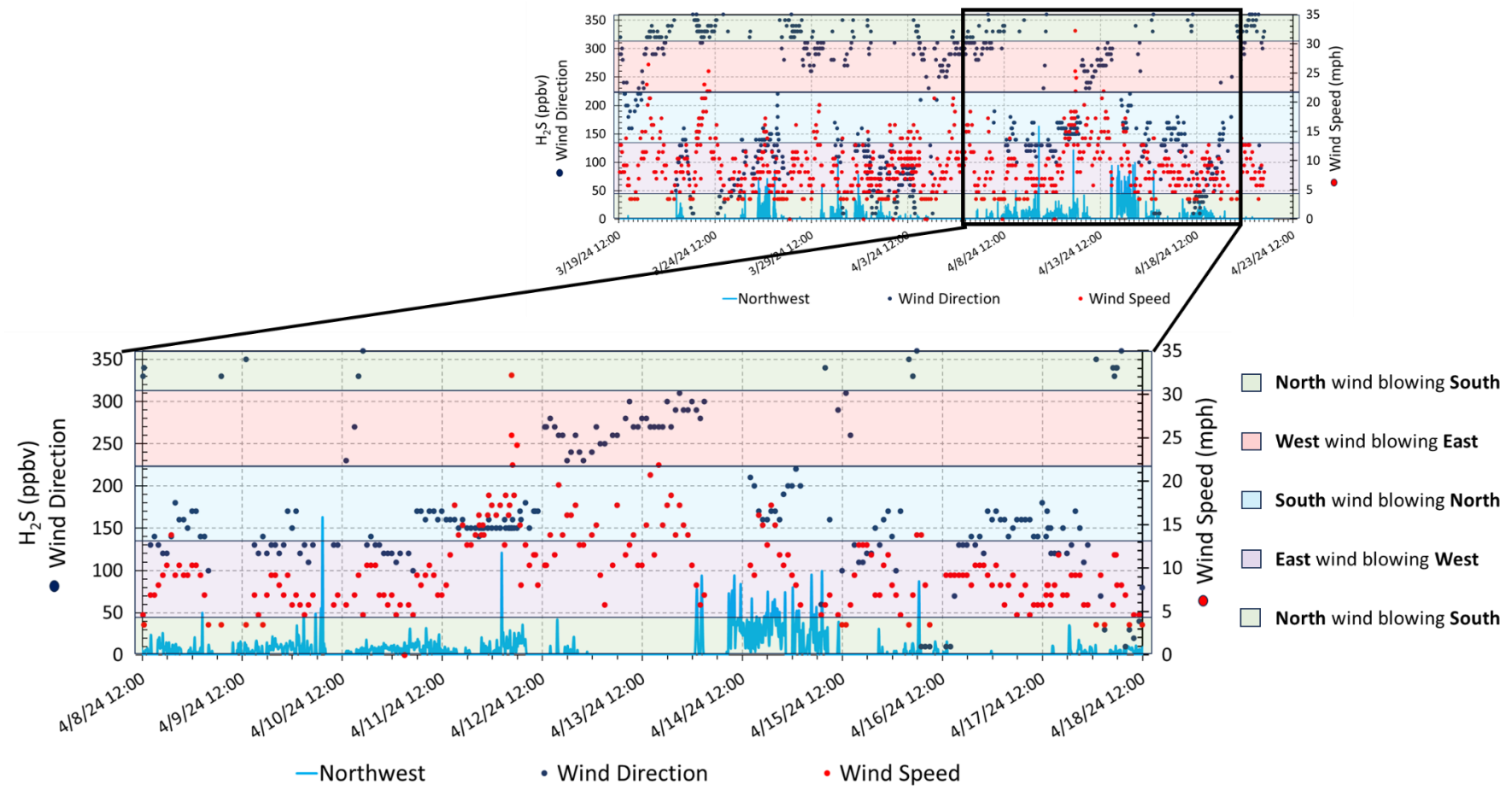


Figure 3-13 Wind Direction and Speed Data for the Days the Odor Data Was Collected, along with the H_2S Data from the Northwest Fenceline Monitor.

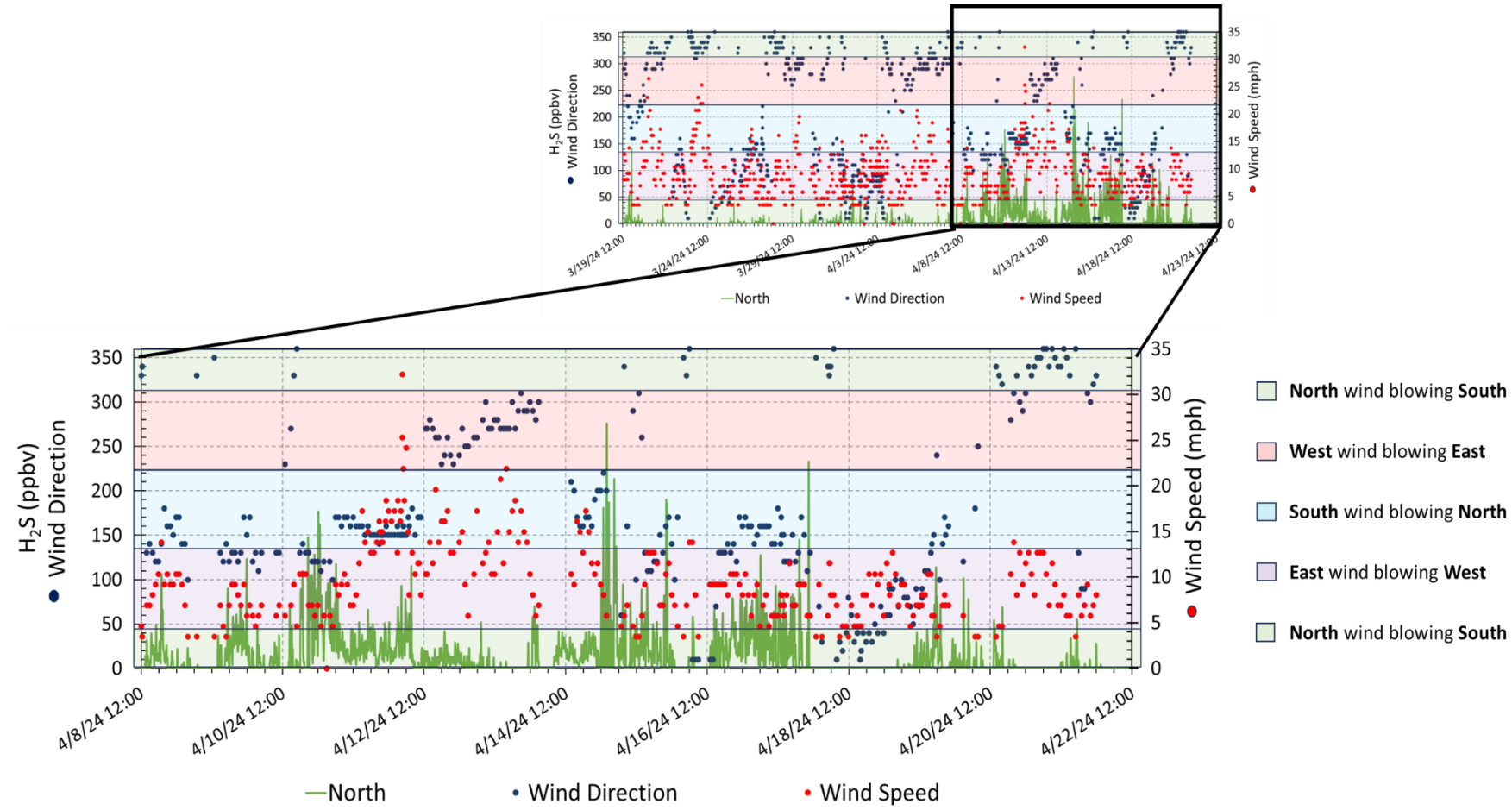


Figure 3-14 Wind Direction and Speed Data for the Days the Odor Data Was Collected, along with the H2S Data from the North Fenceline Monitor.

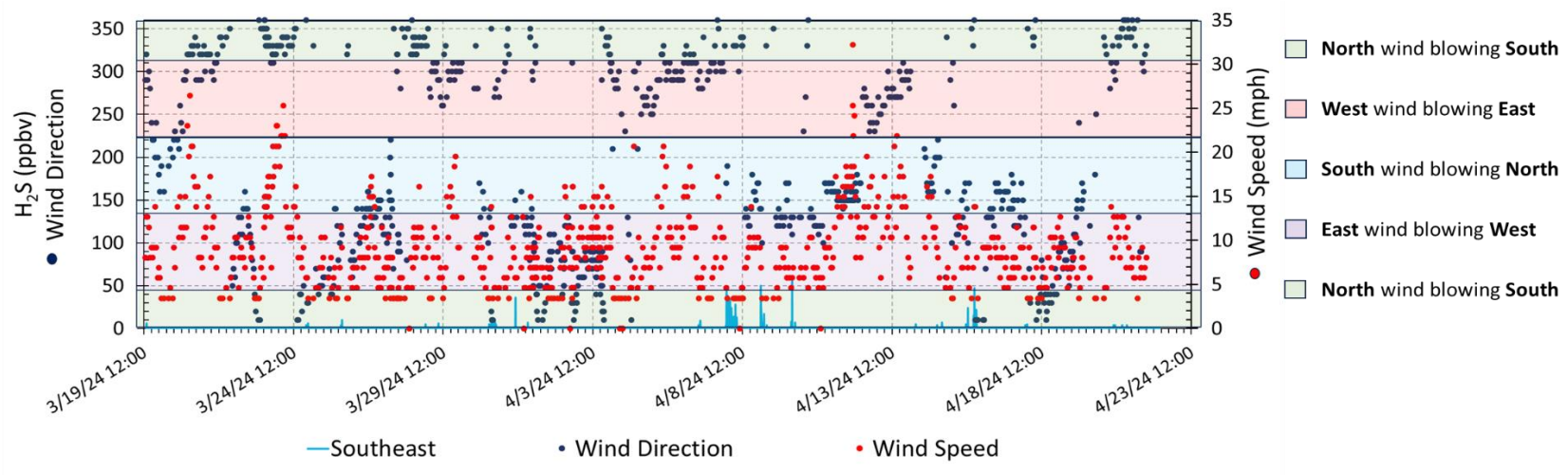


Figure 3-15 Wind Direction and Speed Data for the Days the Odor Data was Collected, along with the H_2S Data from the Southeast Fenceline Monitor.

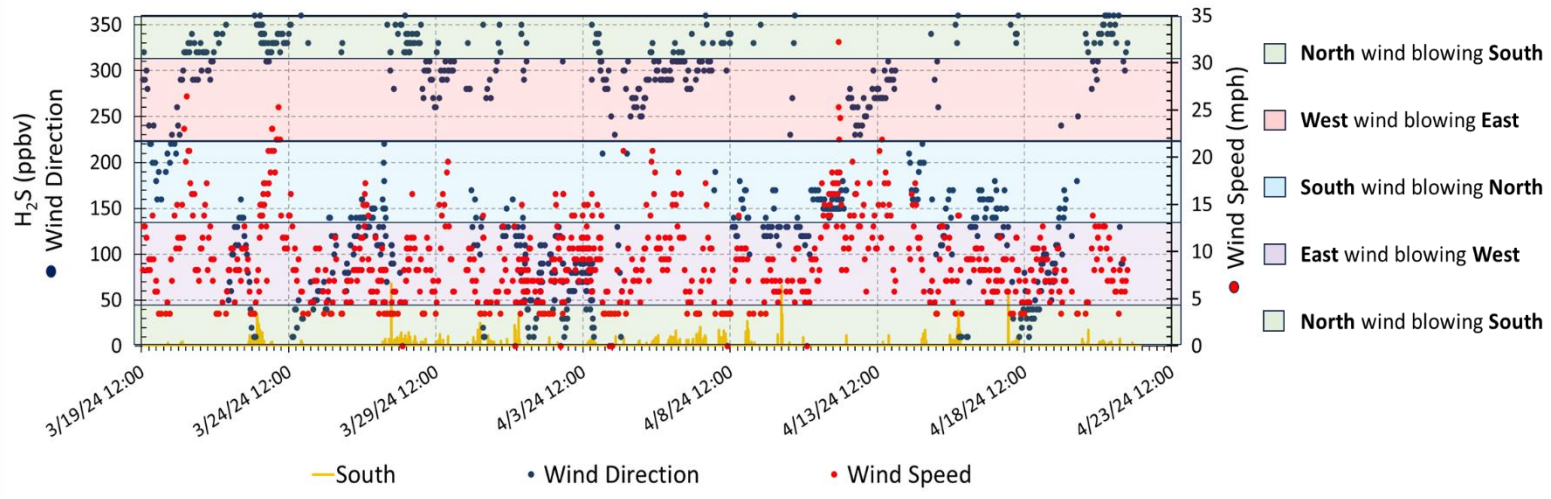


Figure 3-16 Wind Direction and Speed Data for the Days the Odor Data was Collected, along with the H2S Data from the South Fenceline Monitor.

Overall findings from the fenceline monitoring are presented below (note: the H_2S concentrations presented below are calculated after excluding all the "zero" readings from the data):

- The logger deployed at the north fenceline, location closer to the Annapolis Maritime Museum and Park, recorded the highest H_2S concentration with relatively high detection frequency of 24%. During these detection events, the measured H_2S concentrations ranged from 4 ppbv to 276 ppbv.
- The logger at northwest fenceline measured the next highest H_2S levels at 19% detection frequency. The measured concentrations were in the 4 -163 ppbv range.
- Southeast and south fenceline loggers had relatively lower detection frequencies of 2% and 7%, respectively, and concentration ranges of 4 – 55 ppbv and 4- 68 ppbv, respectively.
- The higher concentrations and detection frequencies to the north and northwest are likely influenced by prevailing winds. The north and northwest fenceline readings are not correlated to the grit and screen building exhaust.
- Emission impacts and fenceline concentrations will be evaluated further with air dispersion modeling.

Subsequent to finishing the initial round of modeling, the denitrification filter backwash holding tank was identified as a potential source of odors that may be causing offsite impacts. There appears to be some biological growth in the tank that could be releasing odors and impacting areas to the north of the plant (as observed on the fenceline monitors). HDR and Anne Arundel County are currently evaluating ways to monitor this area for odors, and further conclusions will be discussed in subsequent TMs.

4 OVERALL SUMMARY FINDINGS

The overall summary finding from this round of monitoring include:

- Odorous H_2S is frequently detected at the onsite monitoring locations, and as expected, the main contributors to H_2S generation were found to be the primary clarifiers, screen and grit building, and influent pump station. Of these odorous air sources, only the screen and grit building is not currently treated for odor control.
- Loggers at the primary clarifier launders indicated that H_2S is present most of the time (up to 96% of the monitored time), with concentrations reaching up to 27.6 ppmv.
- Similarly, screen and grit building, and influent pump station produce the next highest H_2S levels, with maximum levels recorded at 19.9 ppmv and 13.9 ppmv, respectively.
- Fenceline loggers indicated that H_2S detection frequency is relatively low compared to onsite locations. However, when detected, the average H_2S levels ranged from 8 – 26 ppbv.
- At times, fenceline H_2S concentrations were as high as 276 ppbv, significantly higher than the suggested human detection limits of 30-50 ppbv.
- North and northwest fenceline locations detected the highest H_2S frequency and magnitude.

HDR will use the results of this sampling analysis to inform air dispersion modeling, ventilation recommendations, and technology recommendations. These analyses and recommendations will be presented in future TMs.