Los Alamos National Laboratory

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U.S. Environmental Protection Agency, Region 6
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Subject: FTWC Radioactive Air Emissions Summary, Volume 2
Environmental Sampling & Expanded Plume Modeling

Dear Mr. Brozowski:

This letter serves to transmit the second volume of the Radioactive Air Emissions Summary addressing the Flanged Tritium Waste Container (FTWC) operation at Los Alamos National Laboratory (LANL). This volume summarizes downwind environmental sampling results and explores different plume modeling scenarios that were performed after FTWC operations concluded.

The report summarizes results of the FTWC environmental sampling activities, addresses requests from Environmental Protection Agency (EPA) staff, responds to questions raised at FTWC public meetings, and fulfills criteria established by the New Mexico Environment Department on FTWC operations.

As stated in the Conclusions of the attached report,

> There were no measurable environmental effects from FTWC operations. There was no soil deposition measured, no change in tritium vapor concentrations measured at Airnet stations, and no measurable conversion of HT gas to HTO vapor in the area.
>
> Comparing different plume models and evaluation scenarios, it is demonstrated that the EPA's compliance model CAP88 provides a conservative, bounding assessment of public dose from airborne releases of radionuclides. No model indicated any health effects or regulatory issues from FTWC operations. Questions about age-dependent dose calculations were examined in this report. Under all scenarios examined, for all receptor ages, public dose from FTWC emissions was less than 0.1 millirem. The FTWC project was safely performed in compliance with all applicable laws and in a manner protective of human health and the environment.

This report completes the special analyses for the FTWC project. The information will be included in the annual report to EPA addressing 2025 operations at LANL, which will be submitted in June 2026. If you have questions or comments, please contact David Fuehne of my staff. David can be reached by email at davef@lanl.gov or by phone at (505) 699-5619.

Sincerely,

SARAH HOLCOMB (Affiliate)

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Sarah S. Holcomb
Group Leader
Environmental Compliance Programs

Attachment: TA-54 Flanged Tritium Waste Container Operations, Radioactive Air Emissions Summary, Volume 2: Environmental Sampling & Expanded Plume Modeling; LA-UR: 26-20967.

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Attachment 1

TA-54 Flanged Tritium Waste Container Operations
Radioactive Air Emissions Summary
Volume 2: Environmental Sampling
& Expanded Plume Modeling

LA-UR: 26-20967

EPC-DO: 26-033

Date: February 17, 2026

TA-54 Flanged Tritium Waste Container Operations
Radioactive Air Emissions Summary
Volume 2: Environmental Sampling & Expanded Plume Modeling

Executive Summary

Volume 1 of this report[1] discussed in detail the execution of the Flanged Tritium Waste Container (FTWC) pressure mitigation project. This report, the FTWC Radioactive Air Emissions Summary Volume 2, examines downwind air and soil sampling measurements that were conducted to support the FTWC operations and presents expanded plume modeling scenarios, looking at different time frames of evaluation, different plume models, and different age range scenarios.

As described in Volume 1, total radionuclide air emissions were 123 curies of tritium, primarily elemental tritium gas (HT). These low levels of emissions did not result in measurable soil concentrations or significant deviations from normal ambient air tritium measurements at downwind locations. While different plume models and modeling scenarios resulted in slightly different hypothetical exposures, the end results all showed that off-site public dose consequences were well below any regulatory limits and far below any levels that would have any sort of human health impacts. The EPA's mandated plume model, CAP88, is conservative and bounding relative to other commonly used plume models.

Introduction

The FTWC pressure mitigation project was performed in September and October 2025. In late October and early November 2025, the four FTWC drums were then shipped off-site for final disposal at Waste Characterization Specialists in Andrews, Texas. The work was continuously monitored for airborne tritium releases to meet Environmental Protection Agency regulations[2]. At Los Alamos National Laboratory (LANL or the Laboratory), compliance with these regulations is managed by the Radioactive Air Emissions Management (RAEM) team within the Environmental Protection and Compliance Division, Compliance Programs Group (EPC-CP).

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[1] EPC-DO:25-331, "FTWC Radioactive Air Emissions Summary, Volume 1. Stack Emissions & Off-Site Dose Consequence." Letter to George Brozowski, United States Environmental Protection Agency Region 6, November 14, 2025. Transmittal of report LA-UR-25-31093. On the LANL external web site at
https://cdn.lanl.gov/files/epc-do-25-331-ftwc-rad-air-emissions-summary-volume-1_b0cbd.pdf

[2] National Emissions Standards for Hazardous Air Pollutants – Radionuclides. Title 40 of the Code of Federal Regulations, Part 61, Subpart H. "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities." Referred to as the Radionuclide NESHAP or Rad-NESHAP.

Volume 1 of this Radioactive Air Emissions Summary was published in mid-November 2025, detailing operations and daily emissions from the project. Volume 1 also included information on downwind air sampling that was performed with specialized "field bubblers" which were analyzed on-site at LANL. Volume 2 addresses environmental analyses with longer turnaround times, as well as plume modeling using different exposure parameters and different software packages.

Drivers

There were several motivating factors to develop this report. They include:

- The Environmental Sampling Plan[3], developed in conjunction with EPA Region 6, is intended to perform measurements of tritium concentration in soil and air downwind of the FTWC operations site to evaluate environmental effects of the project. Analytical results from these analyses are included here in Volume 2. Stack emissions and field bubbler data were already presented in Volume 1.
- One field bubbler sample presented in Volume 1 had a positive detection of tritium gas in a downwind sample. Expanded plume modeling was performed to examine that result and to see if additional model data could explain that single result when other samplers were non-detects.
- During discussions in 2022 with EPA Region 6 and EPA Headquarters personnel, the EPA staff requested that LANL evaluate the FTWC releases under multiple scenarios. While they agreed the "sum-of-days" methods described in Volume 1 would be used to track emissions and dose during the project's operational phase, EPA staff asked for additional evaluations after-the-fact to examine consequences of longer-duration runs, different input parameters, etc.
- Questions were raised in the FTWC public meetings that addressed the dose calculation process, specifically the use of age-dependent dose factors and the general appropriateness of use of the CAP88 model in the complex terrain of Northern New Mexico. These questions are explored in Volume 2.
- In the letter approving the Temporary Authorization[4] for FTWC operations, the New Mexico Environment Department required that LANL "publish a final report documenting the treatment process and all analytical results, including summaries of activities, lessons learned, and photographic documentation of the process" and make this available to the public. Collectively, Volumes 1 and 2 of the Radioactive Air

[3] LA-UR-21-30596, "Proposed Environmental Sampling Plan for the FTWC Remediation Project." October 25, 2021.

[4] "Approval with Modifications of Temporary Authorization Request, Class 2 Permit Modification for Waste Treatment, Storage, and Repackaging of Four Flanged Tritium Waste Containers, HWB-LANL-19-033." New Mexico Environment Department letter to Theodore Wyka and Steven Coleman, September 4, 2025.

Emissions Summary, in conjunction with other closure reports prepared by LANL's Waste Management Programs group, will address this requirement.

Soil Data

As part of the Environmental Sampling Plan, certain downwind locations were selected for evaluating deposition of tritium onto soil surfaces. These four locations are collocated with ambient air monitoring stations (Airnet stations) to allow comparison between air concentrations and soil deposition. These locations represent the projected maximally exposed Individual (MEI) location as well as other downwind locations that would be likely to see emitted tritium. Sampling locations are shown in Figure 1.

The LANL Environmental Stewardship group (EPC-ES) performed soil sampling activities and coordinated analysis of these samples. Sampling and analytical processes were performed per EPC-ES procedures. Samples were pulled early in the summer of 2025 to represent pre-operational conditions, then each week during operations. A final set of samples were taken after operations were concluded.   A report[5] on the sampling processes and results was finalized on December 8, 2025, and sent to RAEM staff. None of the samples showed detectable tritium in the soil. Results are summarized in Table 1.

[5] "Flanged Tritium Waste Container (FTWC) Soil Monitoring Methods and Results." Gaukler, Shannon et al., December 8, 2025.

Figure 1: FTWC Downwind Soil Sampling Locations

Table 1: FTWC Soil Sample Results						
Sample Date & Description	**@ Airnet Station**	**Sample ID**	**Tritium Result (pCi/g)**	**1-Std Dev. Uncertainty (pCi/g)**	**Minimum Detectable Activity (pCi/g)**	**Tritium Detected?**
June 3, 2025 Pre-Operational Background	137	SFB-25-367045	0.023	0.663	2.60	No
	207	SFB-25-367030	0.437	0.722	2.65	No
	208	SFB-25-367036	0.396	0.690	2.54	No
	392	SFB-25-367040	0.581	0.724	2.60	No
September 22, 2025 After Week 1 of operations	137	SFB-25-367046	0.591	0.934	3.37	No
	207	SFB-25-367031	0.422	0.922	3.40	No
	208	SFB-25-367035	0.652	0.945	3.40	No
	392	SFB-25-367041	0.976	0.976	3.40	No
September 30, 2025 After Week 2 of operations	137	SFB-25-367047	0.525	0.842	3.13	No
	207	SFB-25-367032	-0.135	0.776	3.17	No
	208	SFB-25-367037	1.15	0.867	2.93	No
	392	SFB-25-367042	-0.232	0.759	3.16	No
October 16, 2025 Post-Op	137	SFB-25-367048	0.401	0.771	2.87	No
	207	SFB-25-367033	-0.330	0.724	3.00	No
	208	SFB-25-367038	0.136	0.744	2.86	No
	392	SFB-25-367043	-0.318	0.767	3.19	No

In all samples, the analytical result was less than the counting uncertainty and/or the minimum detectable activity. Therefore, these results are not considered to be positive detections of tritium in the soil at these downwind locations. Given the nature of the FTWC stack emissions as predominantly tritium in elemental gas phase, this lack of soil deposition is understandable.

Airnet Data

LANL has over 30 locations where ambient air is continuously measured for the presence of airborne radionuclides. These air samplers, called Airnet stations, measure air concentrations of particulate radionuclides and tritium water vapor. A map of the Airnet stations is available on the LANL public web site.[6] Eight of these stations are a dedicated sub-network surrounding the TA-54 Area G waste disposal site. Most stations are located along the Laboratory perimeter, in public locations in the Los Alamos or White Rock town sites. Additional stations are located further away from LANL at regional locations, and others are in certain Pueblo locations operated in conjunction with these Pueblo governments. Figure 2 is a map of Airnet stations surrounding Area G, and their relationship to the FTWC operations location.

Figure 2: Map of Airnet Stations near TA-54 Area G

[6] Map of Regional Airnet Stations. On the LANL public web site at: *https://cdn.lanl.gov/files/regional-airnet-stations-la-ur-25-25297-01fad_89a51.pdf*

These air samplers run continuously throughout the year, with samples being exchanged every two weeks. Samples are designated by the week of the sample removal. For example, the "250915" sample event had samples running from the week of September 1, 2025, through the week of September 15, 2025. Samples are changed out during the given week. Individual stations are collected in geographically-consistent groups for sample exchange; for example, Area G samples are changed out on Tuesdays of the exchange week.

The FTWC operations at Area G with potential tritium emissions started on Monday, September 15, 2025, and concluded on Monday, September 29, 2025. Drum movement activities, which occurred after this time period, did not have any tritium releases. This operational window corresponds to the sample events 250915 (samples ending the week of 9/15/2025) and 250929 (samples ending the week of 9/29/25). The majority of air emissions during the FTWC operations corresponded to the Airnet 250929 sample event.

Airnet does not measure tritium in elemental gas form; it only measures tritium in the form of tritiated water vapor (referred to as HTO). Since the dominant emission from the FTWC operations was elemental gas (HT), these emissions are not likely to affect Airnet measurement unless there is in-flight conversion from HT gas to HTO vapor. Evaluation of this potential for in-flight conversion was one goal of the RAEM team during FTWC environmental monitoring.

During these sample events, only a few stations showed positive detections of HTO. The eight Area G stations showed detections, and three other stations showed positive measurements. For this evaluation, a positive detection is considered one in which the measured concentration result exceeds the uncertainty of the concentration. All of these detections were consistent with measured air concentrations at that location before and after the FTWC operational window.

Table 2 shows the measured air concentrations and uncertainty for the stations showing positive detections during the 250929 sample event, as that period was most representative of FTWC emissions. Along with the data for sample event 250929, Table 2 also provides the annual average and averaged uncertainty for 2025, excluding obvious outlier data points. For more complete information, plots showing measured air concentrations for summer and fall 2025 for Airnet stations of interest are shown in Appendix 1. Plots in Appendix 1 include the eight Airnet stations at TA-54 Area G, the three regional background stations, four stations in the White Rock area, three stations that are operated in collaboration with nearby Pueblos, and other select stations.

Table 2: Airnet Tritium Detections *Sample period ending week of 9/29/2025; all other stations were non-detects*				
Station ID	**Station Name**	**HTO Air Concentration (pCi/m3)**	**2025 HTO Annual Average Conc[(a)] (pCi/m3)**	**Evaluation**
159	TA-54 Area G North 6	3.81 ± 2.71	6.26 ± 4.17	Consistent with annual data
160	TA-54 Area G South	297.42 ± 16.45	392.62 ± 27.40	Consistent with annual data
161	TA-54 Area G North 1	3.55 ± 2.70	2.73 ± 3.50	Consistent with annual data
170	TA-54 Area G North 4	11.31 ± 2.73	14.24 ± 3.24	Consistent with annual data
189	TA-54 Area G East	5.83 ± 2.77	10.27 ± 4.85	Consistent with annual data
191	TA-54 Area G North 5	6.74 ± 2.69	7.12 ± 3.75	Consistent with annual data
207	TA-54 Area G North 3	5.58 ± 2.60	4.93 ± 2.80	Consistent with annual data
208	TA-54 Area G North 2	13.75 ± 2.82	5.17 ± 2.91	See plot; consistent with pre-operational data points
248	Jemez Pueblo Village	2.70 ± 2.42	0.62 ± 3.11	Within annual uncertainty value
293	San Ildefonso Sacred Area	2.98 ± 2.60	2.69 ± 2.89	Consistent with annual data
297	LANL TA-50 MDA-C	6.98 ± 2.67	5.69 ± 3.05	Consistent with annual data
(a) 2025 averages and uncertainties exclude obvious outlier data points. Also, annual uncertainty is a simple average of the biweekly uncertainties, not a fully propagated uncertainty.				

Note that Station 160 is immediately adjacent to the tritium waste storage shafts at Area G, resulting in consistently higher air concentrations of HTO relative to other Airnet stations.

An evaluation statement is included in each detection shown in Table 2. When evaluating Station 208's readings, the concentration measured during event 250929 were similar with results from routine Airnet sampling events earlier in 2025 and very similar to readings measured during the same relative time period a year earlier, in September 2024. Overall, there were no measurable impacts on measured air concentrations of tritiated water vapor resulting from FTWC operations.

Expanded Plume Modeling

For this Volume 2 report, RAEM staff explored several different scenarios and used different modeling tools to evaluate the FTWC air emissions. These are described in more detail below.

1. Analysis Time Frame: comparing the sum of daily evaluations vs. single CAP88 evaluation over a longer duration
    a. Operational time period, Sep 15-29
    b. Annual evaluation, 2025 full year wind data
2. Age dependency of receptors; use of “composite receptor”
3. Comparison of different plume models – CAP88 vs NARAC vs AERMOD
4. Comparison of plume model data with downwind environmental sampling results

Analysis Time Frame

The process for measuring and reporting daily emissions and calculating subsequent off-site dose consequences during the FTWC remediation project was described in Volume 1 of this report. The final totals of that analysis are shown in Table 3. Table 3 also shows the results of modeling these emissions under different parameters using CAP88, with more details on these different analyses after the Table.

Table 3: FTWC Emissions & Dose Assessment using CAP88		
Tritium Vapor (HTO)	12.7 curies	*Includes 12.2 curies of suspected HT, but chemical form determination was not possible on 9/17/25.*
Tritium Gas (HT)	110.1 curies	
Total Tritium Emissions (HT+HTO)	122.9 Ci	*Rounded total*
Sum of daily doses	0.0123 mrem	This is the reported dose from Volume 1. *Sum of nine operational days; max dose to one of 16 possible MEI locations; 2308m SE (Karen Cir).*
Two-week run; Single dose calc, Sep 15 – 29 wind file	0.0189 mrem	*Max of 16 possible MEI locations; 2308m SE (Karen Cir). Single analysis, using time-specific humidity, precipitation, temperature, etc.*
Single dose calc, annual 2025 data	0.0300 mrem	*Max of 16 possible MEI locations; 2080m ESE (Confianza St). Annual meteorological data from new TA-54B tower, plus standard LANL humidity/temperature/precipitation*

The EPA’s CAP88 plume model and dose assessment code is designed for longer-term chronic releases, typically performed on annual emissions data sets. However, FTWC operations were performed during discrete time periods, with only 9 operational days and with the exhaust fan shut down and capped between operations. To calculate potential public doses during operations, we ran CAP88 for each day of work, with time-specific wind and precipitation parameters, as described in Volume 1. In this Volume 2 report, we compare the sum of these daily assessments with a longer-term run that represents the full scope of FTWC emissions (September 15 through September 29, 2025), as well as with an annual run that mimics how LANL calculates doses from other major sources, using a full year's wind file representing 24/7 operations and average meteorological data.

The single assessment, covering two weeks (September 15 through September 29, 2025), resulted in a maximally exposed individual (MEI) dose of 0.0189 mrem at the MEI location in the SE compass sector, a residence on Karen Circle in White Rock. This is the same MEI location as the sum of daily CAP88 runs. The slightly larger magnitude of the dose is likely due to the single wind file including nighttime canyon drainage winds, which tend to direct the plume more towards the White Rock town site. Overall, the longer-term wind file calculated a larger fraction of the emissions being "pushed" towards this White Rock receptor location, resulting in a slightly larger dose to the MEI.

For the annual assessment, we ran a calculation using the full 2025 meteorological data file from the new TA-54B meteorological tower. The TA-54B tower began full operations in 2024, and it is approved for plume modeling of emissions from Area G sources.

The annual assessment used historical average data for precipitation, humidity, and temperature per LANL procedure[7], as opposed to the September 2025 time-specific parameters used for the other evaluations shown in Table 3. Using the annual average humidity in particular will increase the reported off-site doses of tritium emissions; the LANL average humidity (4.3 grams per cubic meter) is lower than what was measured during September 2025 operations (7 grams per cubic meter). A higher absolute humidity results in a lower dose, while lower humidity results in higher doses. This is due to the more abundant moisture in humid air diluting the plume's tritium contents, resulting in lower radiological intake by receptors. Less humid air will concentrate the tritium, delivering more radioactivity to the receptor. That humidity change alone accounts for the difference between the reported doses in the annual assessment and the dose in the September-specific analysis. Other criteria such as wind speed and direction can also affect the reported doses between the different analyses.

While the different CAP88 scenarios are not direct apples-to-apples comparisons, the models all agree that the off-site dose consequence from FTWC operations is well below any regulatory or administrative limits. For balancing conservatism and accuracy, the RAEM team is using the result of the single two-week run (September 15 through September 29, 2025, corresponding to

[7] EPC-CP-QP-0501, *Dose Assessment Using CAP88,* Revision 0. Effective date 11/30/2021. Describes process steps and LANL-specific parameters for performing plume modeling and dose calculations using the EPA's CAP88 code.

0.0189 millirem) as the baseline comparison point for further analysis in this report. The longer analysis time makes this run more suited for CAP88's design than the individual daily runs, and using time-specific humidity and other meteorological parameters make it more accurate than the annual assessment.

Age Dependency

When the Radionuclide NESHAP was first promulgated in 1989, the required dose assessment plume models, CAP88 and AIRDOSE, only used adult dose conversion factors to determine radiological doses from air emissions. No other options existed in these original models. As later versions of CAP88 were developed, options for calculating doses to different age groups became available. For Subpart H compliance purposes, LANL and other DOE sites have consistently used adult dose conversion factors. The Environmental Protection Agency (EPA) has accepted this practice without issue and, in recent years, has approved Applications for Pre-Construction Approval which used adult dose factors. In addition, EPA doesn't specify which version of CAP88 must be used to meet compliance. Therefore, sites using older versions of the model software would only have access to adult dose conversion factors.

During FTWC public meetings, questions were raised about using infant or other age groups for evaluating bounding doses. The Radionuclide NESHAP states that emissions of airborne radionuclides cannot exceed levels which would give "any member of the public" a dose of 10 millirem per year.[8] Public questions centered around this point.

The RAEM team has investigated the effects of age-dependency on doses in CAP88. Relative doses between age groups will vary depending on intake rates (e.g., breathing rates and food consumption) and on chemical behavior of different compounds within the body. For some nuclide types, such as plutonium and uranium, dose factors for infants and youths are lower than those for adults. For other nuclides, the dose factors for infants are higher than for adults. The most bounding case is for tritium, in which the dose for infants is a factor of 3.32 higher than the dose for adults for a given stack release.

The FTWC source term shown in Table 3 was evaluated in CAP88, using different age groups. For consistency, the single two-week evaluation (September 15 through September 29, 2025) was run for all age groups. The results of these analyses are shown in Table 4.

Taking things a step further, the RAEM team also examined United States Census data and New Mexico state population data; in both cases, the "Adult" age group (over age 15) made up about 75% of the population. Other groupings in these age demographic reports were 0-5, 5-10, and

[8] 40 CFR 61.92, "Standard"

10-15 years. We explored the concept of using a "bounding composite" resident of New Mexico, using a dose factor ratio of 75% adult and 25% infant (the bounding case for tritium). The CAP88 dose from FTWC operations using this "composite New Mexican" is 0.0299 mrem and is shown in Table 4 as a separate scenario.

Table 4: FTWC Dose Assessment with Different CAP88 Age Groups
(single 2-week CAP88 evaluation, September 15 through September 29, 2025)

Scenario	CAP88 Age Group	CAP88 Dose (mrem)	Ratio to Adult dose
FTWC_Adult	Adult	0.0189 mrem	100%
FTWC_Infant	Infant	0.0630 mrem	3.32x higher than adult
FTWC_Age01	Age 1	0.0600 mrem	3.16x higher
FTWC_Age05	Age 5	0.0320 mrem	1.68x higher
FTWC_Age10	Age 10	0.0250 mrem	1.32x higher
FTWC_Age15	Age 15	0.0200 mrem	1.05x higher
Composite NM	75% Adult, 25% Infant	0.0299 mrem	1.58x higher

All runs used the wind file & humidity conditions, and operational parameters from Sep 15-29, and the HT/HTO mix shown in Table 3. The "FTWC_Adult" scenario is identical to that shown in Table 3.

The RAEM team has performed the different assessments shown in Table 4, looking back at the specific FTWC operations scenario with well understood receptor locations and a discrete operational timeframe. In summary, even if we were required to apply the 3.32x multiplier for infants, all doses from FTWC operations were very low. Applying that 3.32x factor to all of the dose scenarios shown in Table 3 still results in a public dose consequence of less than 0.1 millirem for all modeling scenarios.

The question about using age-dependent dose factors was raised during the public meetings. There has been no requirement for using age-dependent analyses for regulatory compliance purposes. Moving forward, the RAEM team will continue to evaluate new projects and report annual doses using the adult dose conversion factors, in accordance with EPA standard practice.

Comparison of Different Plume Models

Another question that is frequently raised is the appropriateness of using CAP88, a flat-terrain Gaussian-plume model, for the complex terrain and frequently changing winds of the Los Alamos region. To explore this issue, RAEM staff performed analyses of specific FTWC operational days using the NARAC[9] code and the AERMOD[10] plume model. NARAC is the standard plume model used for evaluating emergencies and short-term releases, while AERMOD is an industry-standard plume model widely used for regulatory permitting and impact analysis.

The biggest difference between CAP88 and these other models is the incorporation of complex terrain. CAP88 assumes a flat-terrain release scenario, with very little dilution of the plume from ground surface interactions. NARAC and AERMOD incorporate terrain effects, which scavenge pollutants from the plume and dilute the plume when there are changes in elevation, buildings, or other terrain effects.

When comparing the models, single day releases were selected. NARAC will not run longer-term releases (more than 24 hours), and AERMOD worked best with discrete releases and wind files. We selected Monday, September 29, 2025, as the comparison day, since it had the single largest release during FTWC operations (69.3 curies of HT gas). The modeling time was extended past the cessation of operations to allow the more advanced models to track the plume as it moved with the changes in wind direction. Rather than looking at public receptor locations, these analyses were performed to evaluate air concentrations and doses at the three downwind field bubbler locations, as described in the Volume 1 report. These field bubblers were collocated with Airnet stations 207, 137, and 392, as shown in Figure 3 below. Later analyses combined multiple NARAC runs to give a multi-day evaluation that could be compared with the 2-week long CAP88 run presented in Table 3. Again, we used the 2-week CAP88 run (September 15 through September 29, 2025) as the baseline since the extended-time wind file more closely matches the wind parameters used for NARAC calculations than the daily CAP88 runs.

[9] National Atmospheric Release Advisory Center, plume model maintained by Lawrence Livermore National Laboratory. More information on the web at: https://narac.llnl.gov

[10] AERMOD Modeling System, the EPA's preferred plume dispersion model for industrial sources. More information is online at https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

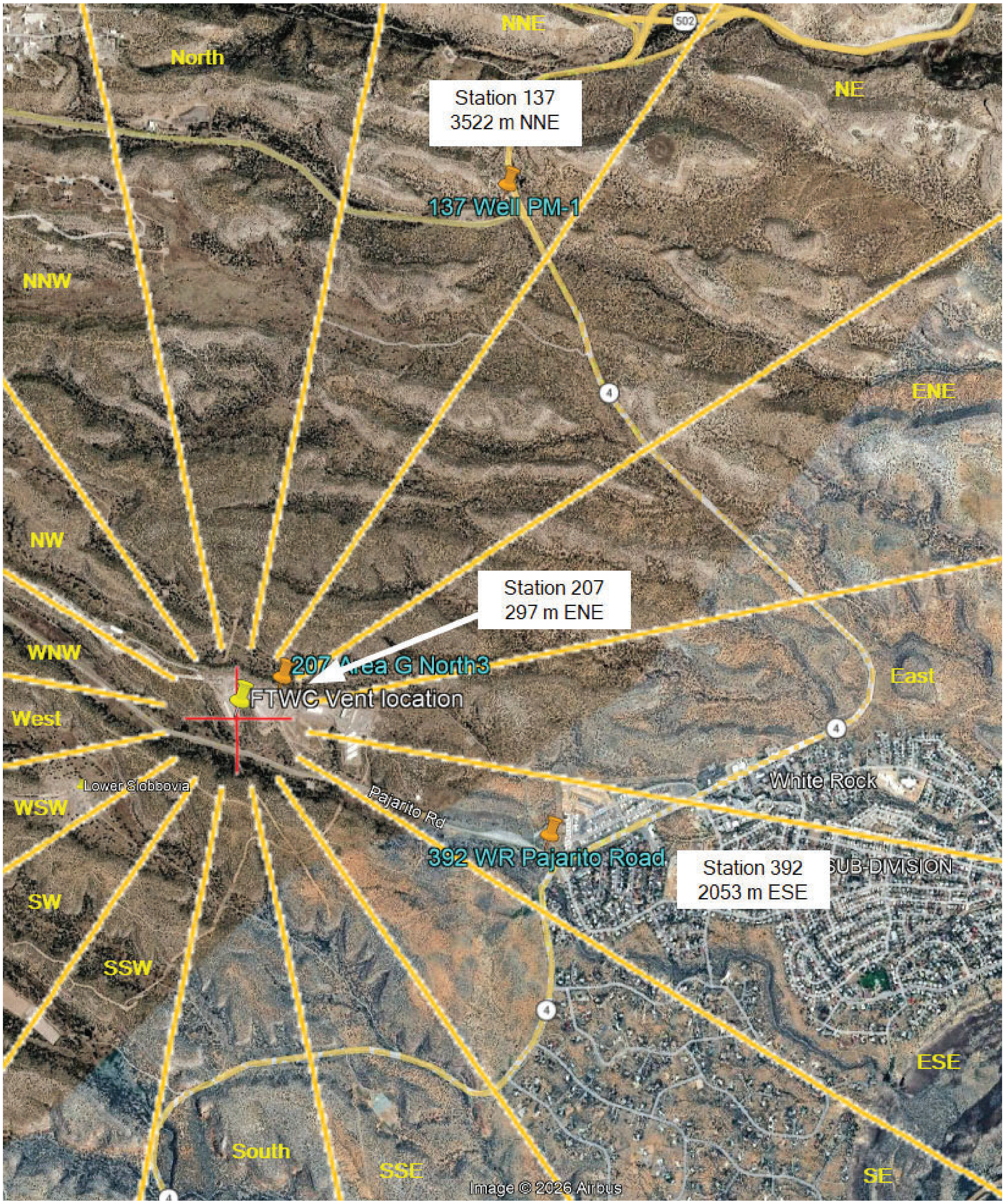


Figure 3: Field Bubbler & Plume Modeling Assessment Locations

Both NARAC and CAP88 will provide dose calculation in millirem. AERMOD will only provide air concentrations. For comparisons with AERMOD, we extracted concentration data from NARAC and from CAP88.

The models had varying results, which related to the mechanisms by which each model calculates concentrations and doses, built-in dose conversions, and other assumptions inherent to each model. For example, the CAP88 model makes several very conservative assumptions about tritium conversion in-flight from HT gas to HTO vapor; these assumptions drive up the dose calculations for tritium, which are not reflected in other models.

Table 5 shows the comparison between analyses for CAP88, NARAC, and AERMOD dose calculations for the September 29, 2025, release. A discussion of the differences between models appears after the table. Overall, the CAP88 model required by EPA to evaluate compliance with the Radionuclide NESHAP is by far the most conservative/bounding of the three.

Table 5: Sample of Plume Model Comparison
(Single-day runs, September 29, 2025)

Air Concentration Comparison		*CAP88, NARAC, and AERMOD*	
Station 207 *297 m ENE*	NARAC	1.78E-3 microCi/m3	Average over 8-hour analysis
	AERMOD	9.36E-2 microCi/m3	Average over 14-hour analysis
	CAP88	Zero	CAP88 did not project the plume toward 207
Station 392 *2053 m ESE*	NARAC	4.73E-5 microCi/m3	Average over 8-hour analysis
	AERMOD	2.12E-3 microCi/m3	Average over 14-hour analysis
	CAP88	Zero	CAP88 did not project the plume toward 392
Station 137 *3522 m NNE*	NARAC	3.18E-4 microCi/m3	Average over 8-hour analysis
	AERMOD	9.90E-4 microCi/m3	Average over 14-hour analysis
	CAP88	7.70E-4 microCi/m3	Average, adjusted for 8-hour evaluation time
Dose Comparison		*CAP88 & NARAC only; Sum of daily NARAC runs 9/15-9/29*	
Station 207 *297 m ENE*	NARAC	4.04E-4 mrem	Sum of 9 operational days
	CAP88	3.6E-01 mrem	Single run covering 2-week time period
Station 392 *2053 m ESE*	NARAC	3.00E-5 mrem	Sum of 9 operational days
	CAP88	1.90E-2 mrem	Single run covering 2-week time period
Station 137 *3522 m NNE*	NARAC	2.03E-6 mrem	Sum of 9 operational days
	CAP88	3.40E-3 mrem	Single run covering 2-week time period

Some causes for the differences between the models as shown in Table 5.

- The air concentration analysis using the September 29 release was greatly affected by how the wind shifted directions that day. Early in the day, the wind blew directly towards the south; as the day went on, the wind direction rotated clockwise towards the north later in the day and then back around to the east. Appendix 2 shows multiple plots of the wind shifts. We extended the NARAC and AERMOD plots out for a longer time period than the original CAP88 run for that day. The NARAC and AERMOD models showed concentrations later in the day at Stations 207 and 392. Since the CAP88 wind file only extended through the end of FTWC operations, there were no wind frequencies in the ENE or ESE sectors and, therefore, no concentrations calculated at Stations 207 and 392. Only Station 137 had a concentration calculated by CAP88, as shown in Table 5.

- Doses reported by NARAC are summed across the nine individual runs for each of the 9 operational days. While these NARAC runs extended past the original operational hours and into the early evening, they did not include the full duration of nighttime winds that the single CAP88 run included. The nighttime drainage winds can increase the predicted dose to White Rock area receptors (e.g., around Station 392).
- As mentioned earlier, the tritium dose calculation process in CAP88 is very conservative. Doses calculated by CAP88 assume a great deal of HT -to-HTO conversion, as well as bounding factors for calculating dose from inhalation, skin absorption, and other pathways.
- CAP88 assumes flat-plain, with minimal ground effects on the plume. As shown with the other models, the complex terrain in the area will greatly reduce the downwind doses predicted in the model.
- Finally, the way each model handles terrain, plume loft, and other factors can vary . In general, the NARAC and AERMOD models show fairly good agreement, while CAP88 shows higher doses across the board for extended-duration modeling.

Comparing Plume Models with Downwind Environmental Sampling

The soil sampling data, described earlier in this document, showed no detectable tritium activity at the evaluated locations. Given the nature of the releases (almost pure HT gas) and the low level of emissions, these results are to be expected.

The Airnet data showed positive detections at some locations, but the measured levels were similar to measurements before and after FTWC operations. Since Airnet does not measure HT gas, only HTO vapor, the lack of impact is understandable. What the data do indicate is that there is <u>not</u> a significant level of in-flight conversion from HT gas to HTO vapor. Given the arid nature of Los Alamos County and the time of year that operations took place, the lack of HT-to-HTO conversion is to be expected.

Looking back at the downwind field bubbler measurements from Volume 1, there is one data point that merited further investigation. For the second week of operations, the field bubbler installed at Airnet Station 137 showed measurable quantities of HT gas. This was the only sample that had a measurement result that was above its pre-operational background levels.

The Week 2 HT concentration at Station 137 was 1175 pCi/m3, or about 1E-3 microcuries per cubic meter when pre-operational background is subtracted. This is slightly above the average air concentrations predicted in Table 5 for this station. The averaging time for the model evaluations was less than a day, whereas the bubbler data was averaged over a full week and included other operational days. There is general agreement between the modeled data and the sample result.

The RAEM team looked at many factors when evaluating this Station 137 HT measurement.

- As mentioned, the wind direction began in the morning blowing towards the south, then cycled clockwise around to the west and finally around towards the north. The NNE sector at 137 would get direct wind later in the day, when FTWC evacuation operations were taking place. The wind plots for September 29, 2025, are shown in Appendix 2, illustrating how the wind direction moved throughout the day.
- As shown in these wind direction plots in Appendix 2, the plume from FTWC operations did eventually make its way to Station 137, but it may not have impacted Stations 207 or 392 on that day.
- The wind rose for the time period around September 29, 2025, shows a higher-than-average wind velocity vector in the NNE direction; this wind rose is shown at the end of Appendix 2. This could contribute to the measurements at Station 137, pushing the plume towards the measurement location in the NNE sector.
- Station 207 did not measure any HT or HTO for Week 2; that could be explained by potential plume lofting over the station (less than 300 meters from the source) or by the fact that the wind direction never pointed towards station 207 when emissions were occurring. Emissions earlier in the day would have passed further out past 300 meters before the wind direction shifted around towards the ENE sector and Station 207.

Overall, the one detection of HT gas at Station 137 is understandable given the wind data and subsequent behavior of the tritium emissions plume during the FTWC operations. No measurable conversion of HT gas to HTO vapor was noted during these operations. The measured data point indicated trace levels of HT gas, well below regulatory limits.

Conclusions

As part of the FTWC project, the RAEM team investigated environmental behavior of tritium, the mechanics of CAP88 and other plume models, and identified operational lessons. Appendix 3 has a list of technical "Lessons Learned" from the FTWC project.

There were no measurable environmental effects from FTWC operations. There was no soil deposition measured, no change in tritium vapor concentrations measured at Airnet stations, and no measurable conversion of HT gas to HTO vapor in the area.

Comparing different plume models and evaluation scenarios, it is demonstrated that the EPA's compliance model CAP88 provides a conservative, bounding assessment of public dose from airborne releases of radionuclides. No model indicated any health effects or regulatory issues from FTWC operations. Questions about age-dependent dose calculations were examined in this report. Under all scenarios examined, for all receptor ages, public dose from FTWC emissions was less than 0.1 millirem. The FTWC project was safely performed in compliance with all applicable laws and in a manner protective of human health and the environment.

Appendices

1) Airnet data plots for summer/fall 2025, showing ambient air concentrations of tritium water vapor HTO
2) NARAC plots showing plume direction over time for September 29, 2025; and the wind rose for Sep 29-30 from the TA-54B meteorological tower.
3) Technical Lessons Learned

Appendix 1

Airnet Data

Ambient air concentrations of tritium water vapor HTO

Summer/Fall 2025

FTWC Operations correspond to the area under the red squares in the following plots.

Area G Airnet Stations
(8 stations, 2 pages)

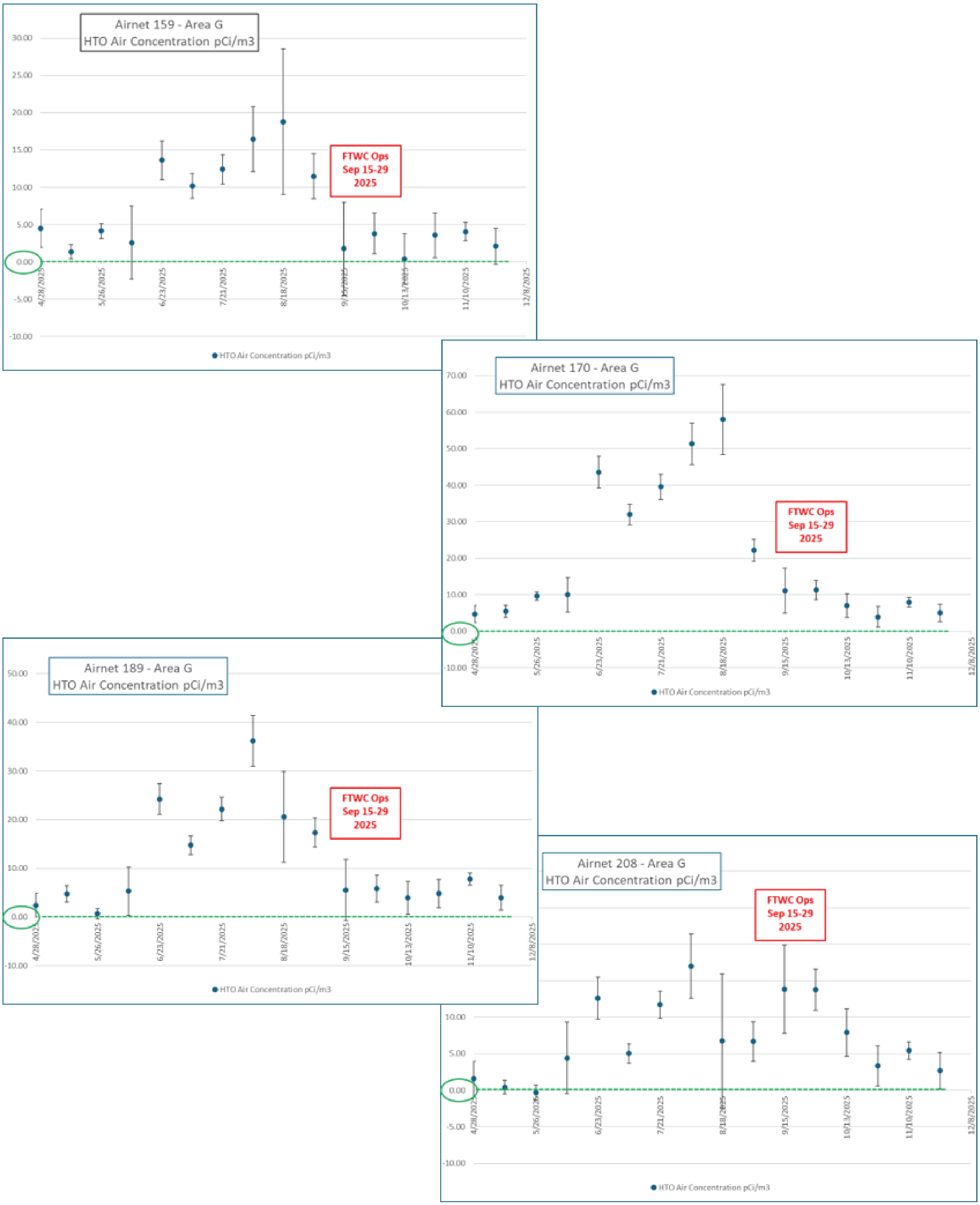
Northern New Mexico Regional Airnet Stations
(2 stations, 1 page)

White Rock Area Airnet Stations
(4 stations, 1 page)

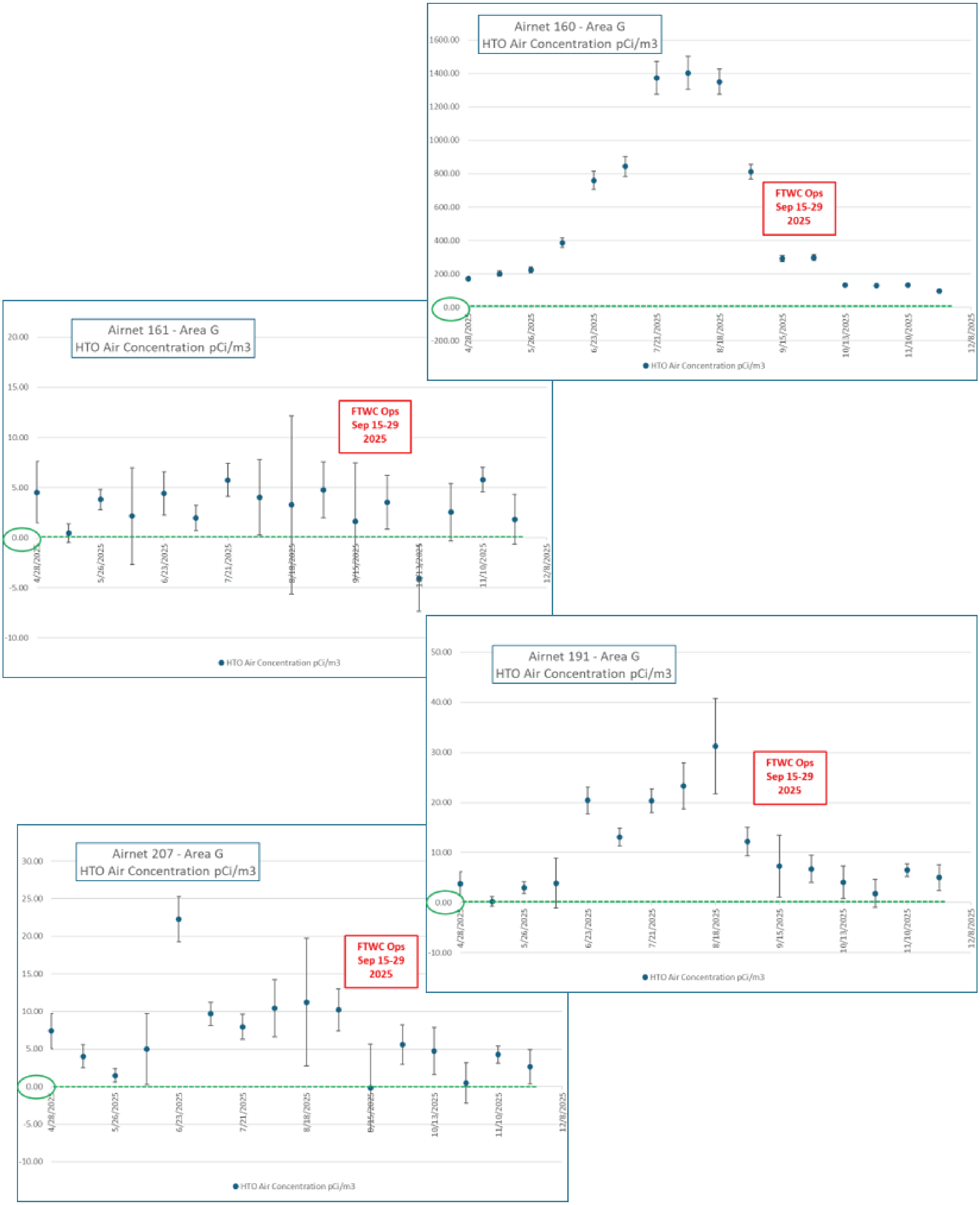
Pueblo Airnet Stations
(3 stations, 1 page)

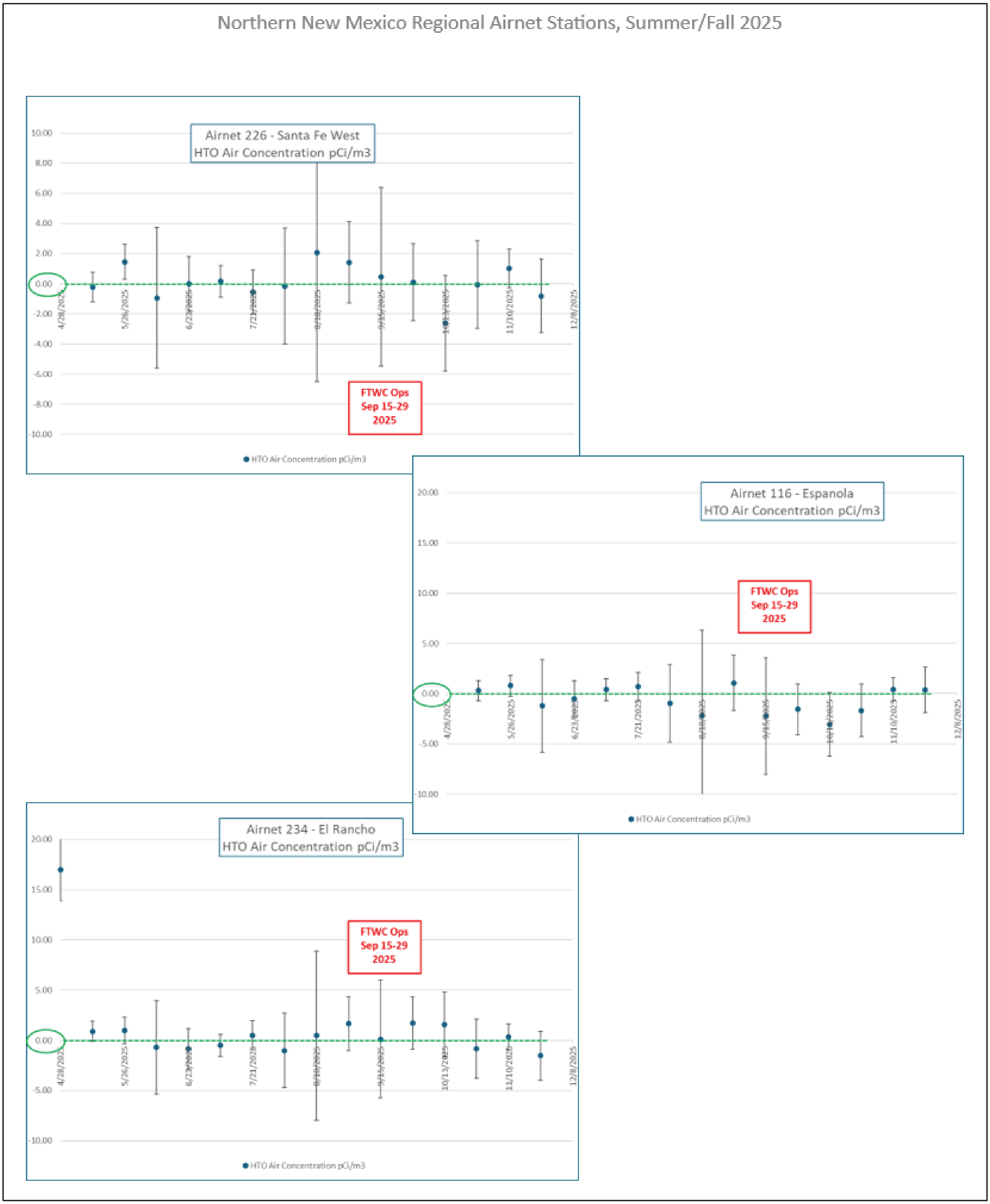
Other Select Airnet Stations
(7 stations, 2 pages)

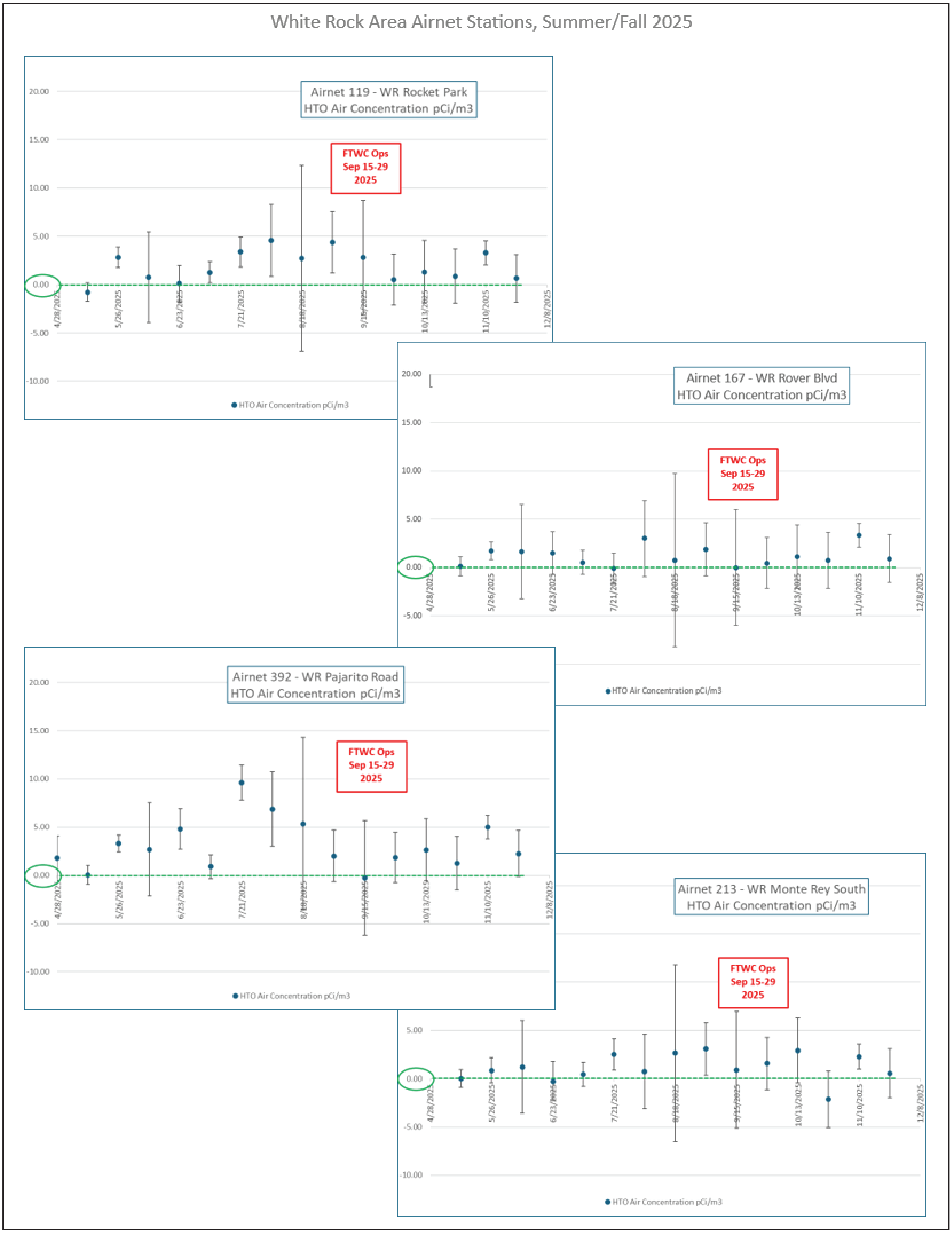
TA-54 Area G Airnet Stations, Summer/Fall 2025



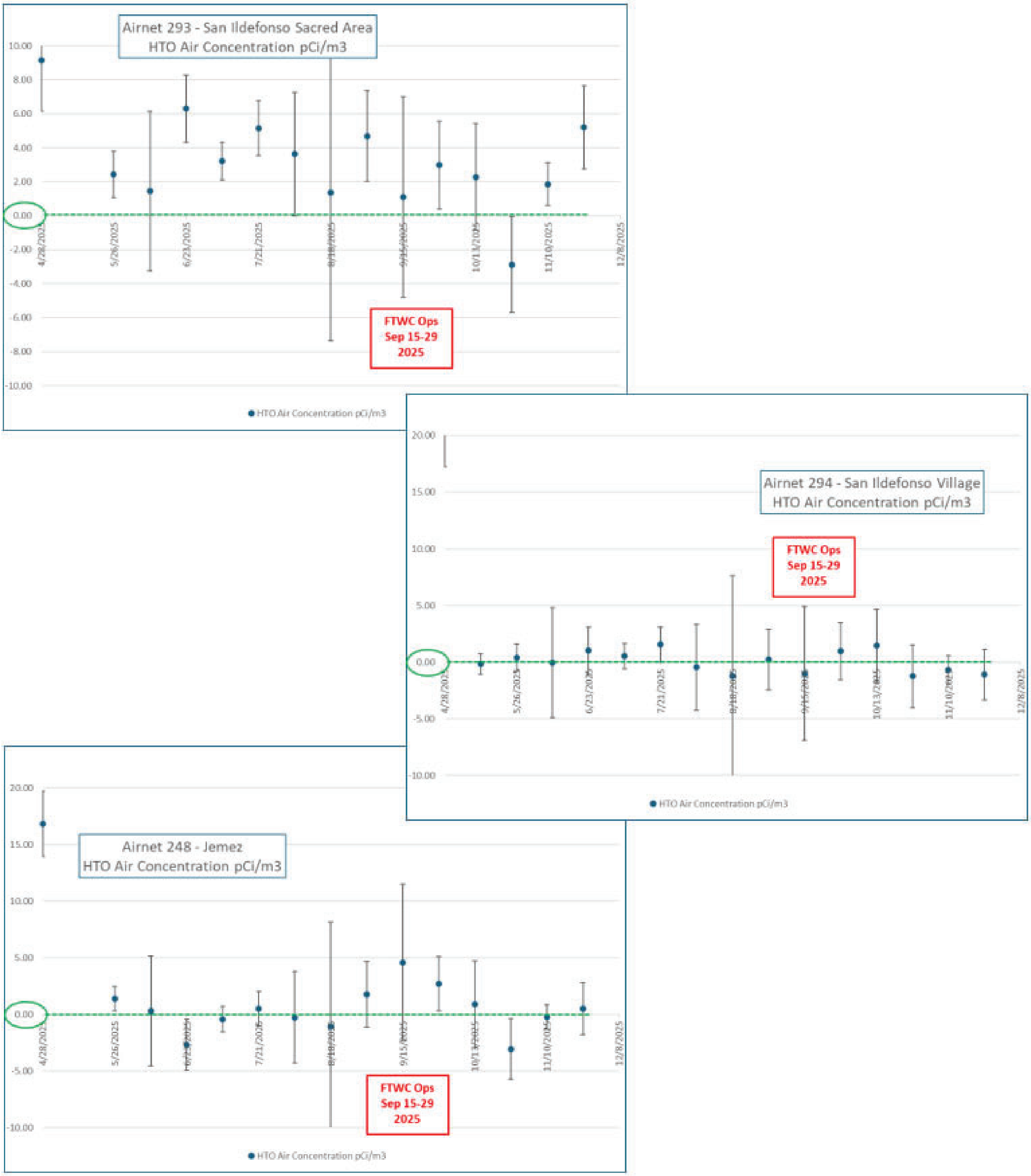
TA-54 Area G Airnet Stations, Summer/Fall 2025

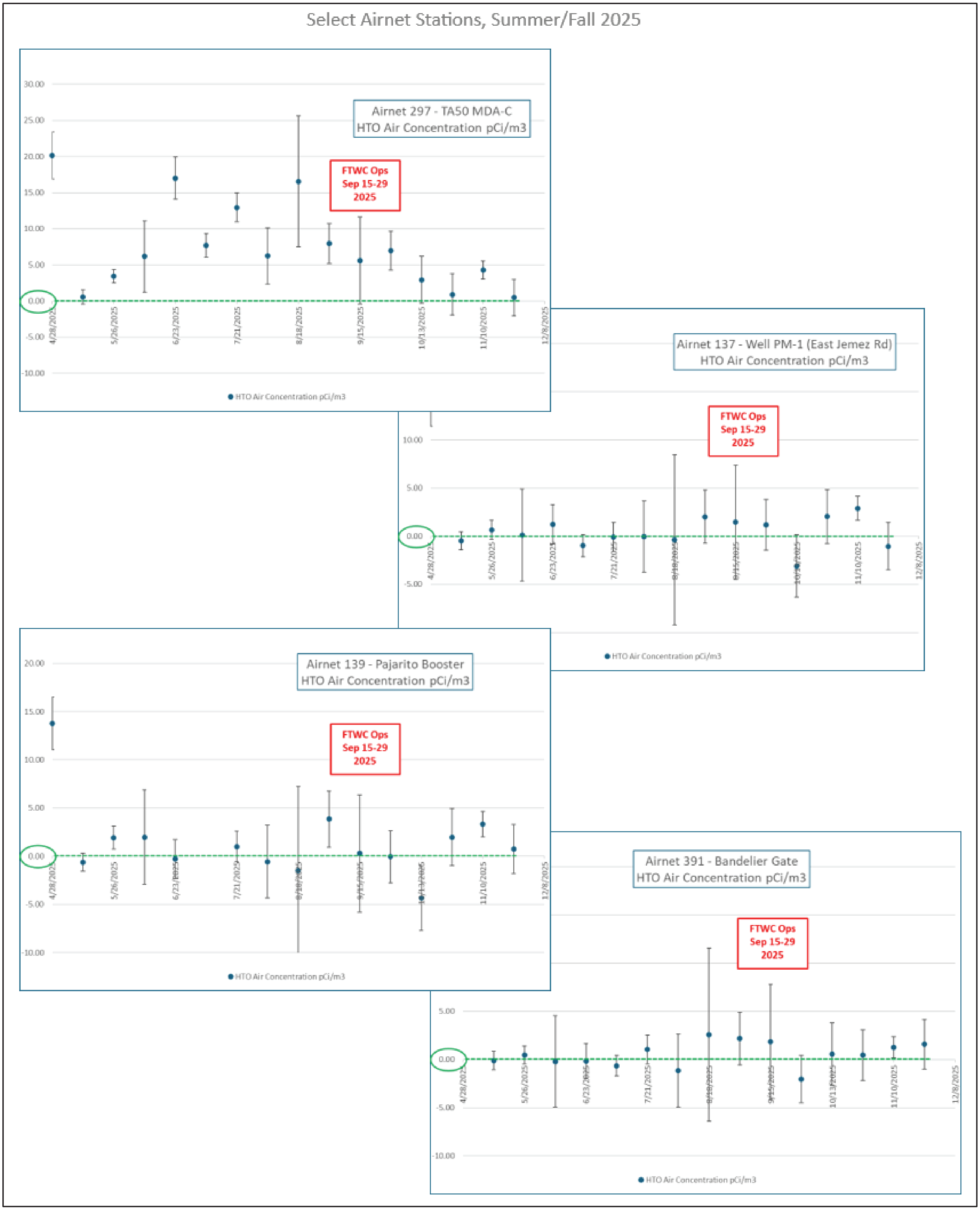



Northern New Mexico Regional Airnet Stations, Summer/Fall 2025
Airnet 226 - Santa Fe West
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 116 - Espanola
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 234 - El Rancho
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3

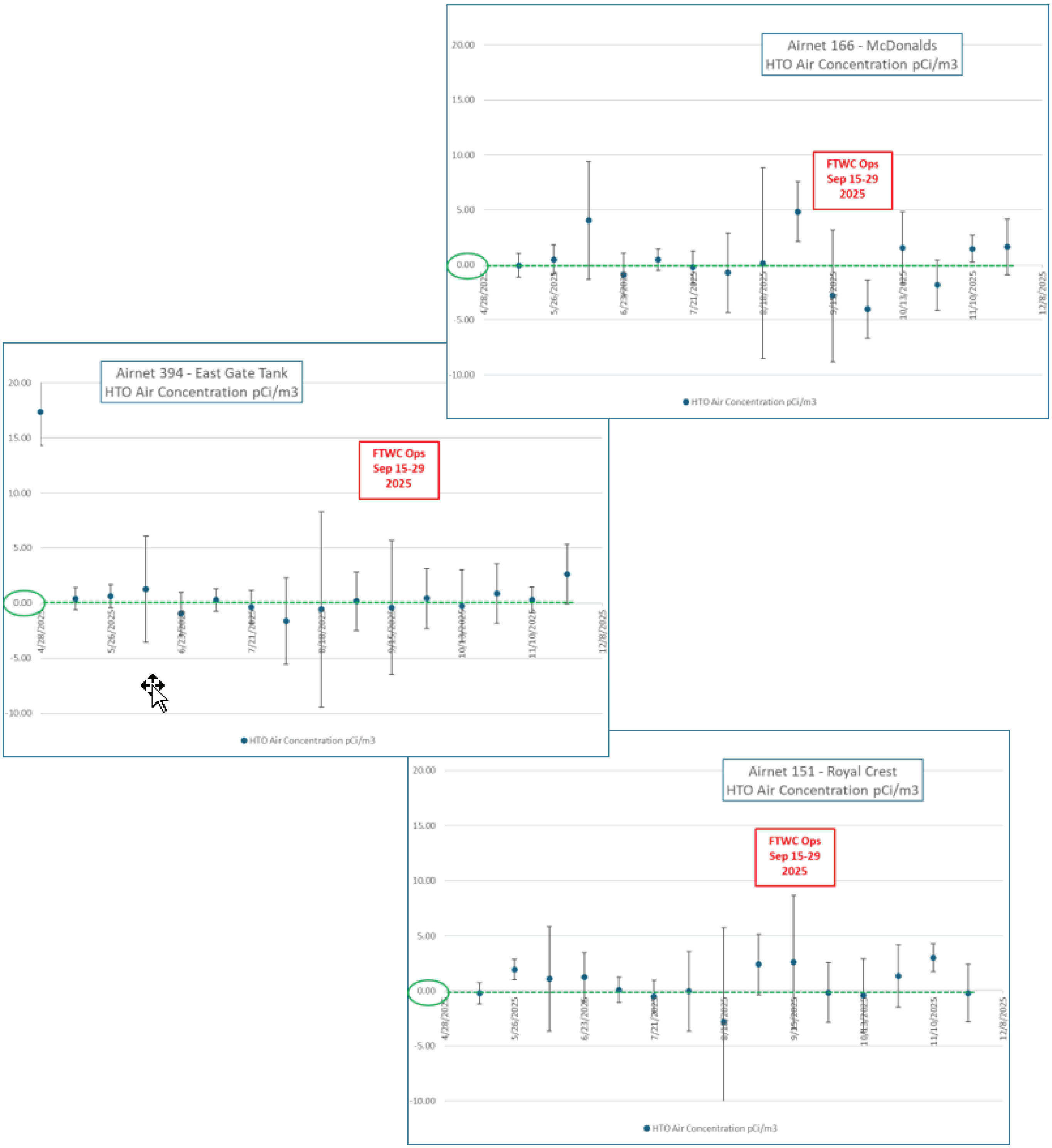

White Rock Area Airnet Stations, Summer/Fall 2025
Airnet 119 - WR Rocket Park
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 167 - WR Rover Blvd
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 392 - WR Pajarito Road
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 213 - WR Monte Rey South
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3

Pueblo Airnet Stations, Summer/Fall 2025




Select Airnet Stations, Summer/Fall 2025
Airnet 297 - TA50 MDA-C
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 137 - Well PM-1 (East Jemez Rd)
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 139 - Pajarito Booster
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3
Airnet 391 - Bandelier Gate
HTO Air Concentration pCi/m3
FTWC Ops
Sep 15-29
2025
HTO Air Concentration pCi/m3

Select Airnet Stations, Summer/Fall 2025



Appendix 2

Plume Dispersion Charts

September 29, 2025

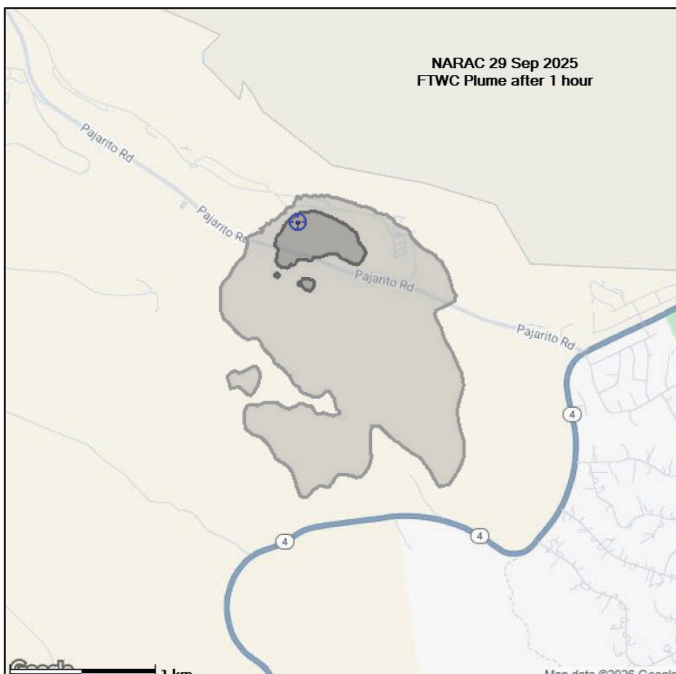
And

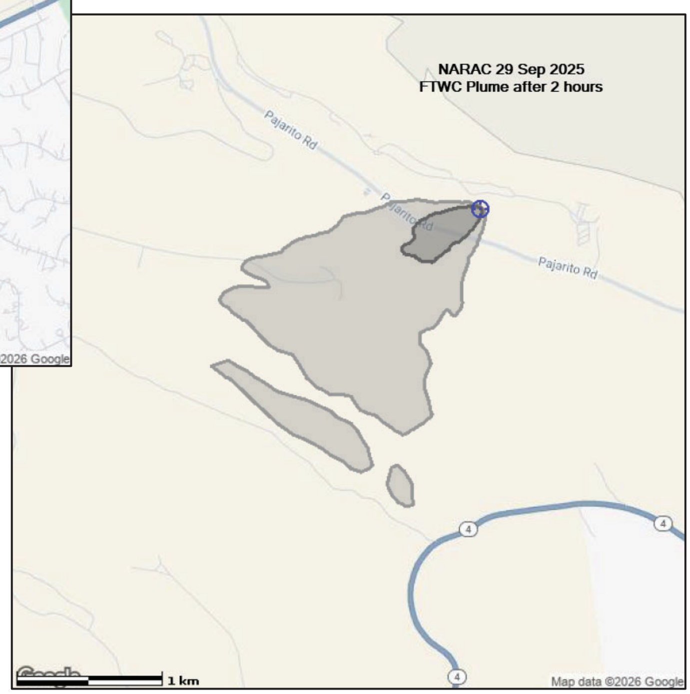
Wind Rose from TA-54B Tower

September 28-30, 2025

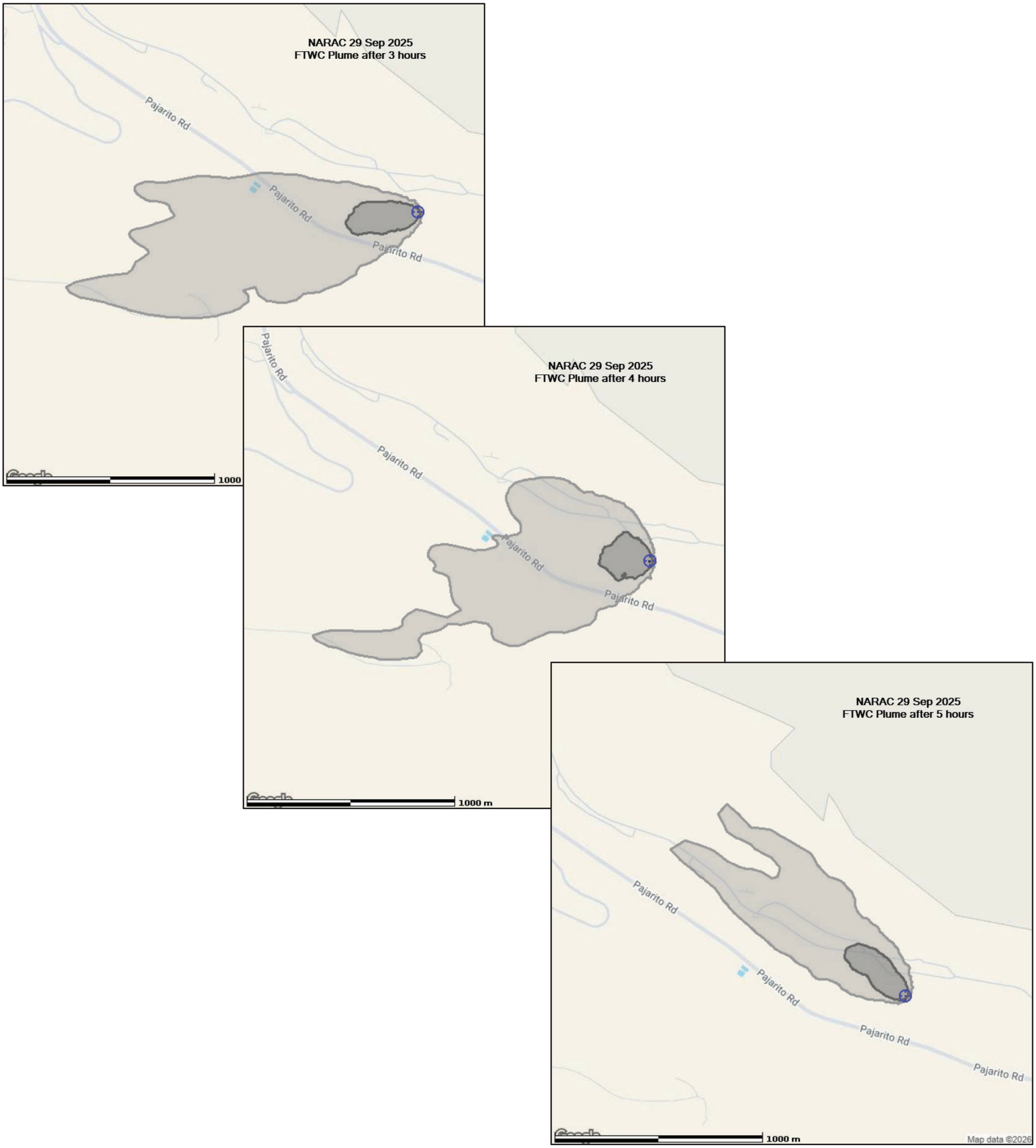
The emissions plume from the FTWC operations site started out the morning of September 29, 2025, by going to the south or southeasterly direction. As the day progressed, the winds shifted in a clockwise manner towards the west then around to the north. After 8 hours, the plume would be going to the north from the FTWC operations location. The attached plume maps are from the NARAC run for 29 Sep 2025. In the plots, the dark grey zone indicates concentrations over 1E-7 curies per cubic meter (>0.1 microCi/m^3) and the light grey is 1E-8 curies per cubic meter (>0.01 microCi/m^3).

Hours 1 and 2 after the start of operations, 9/29/2025.





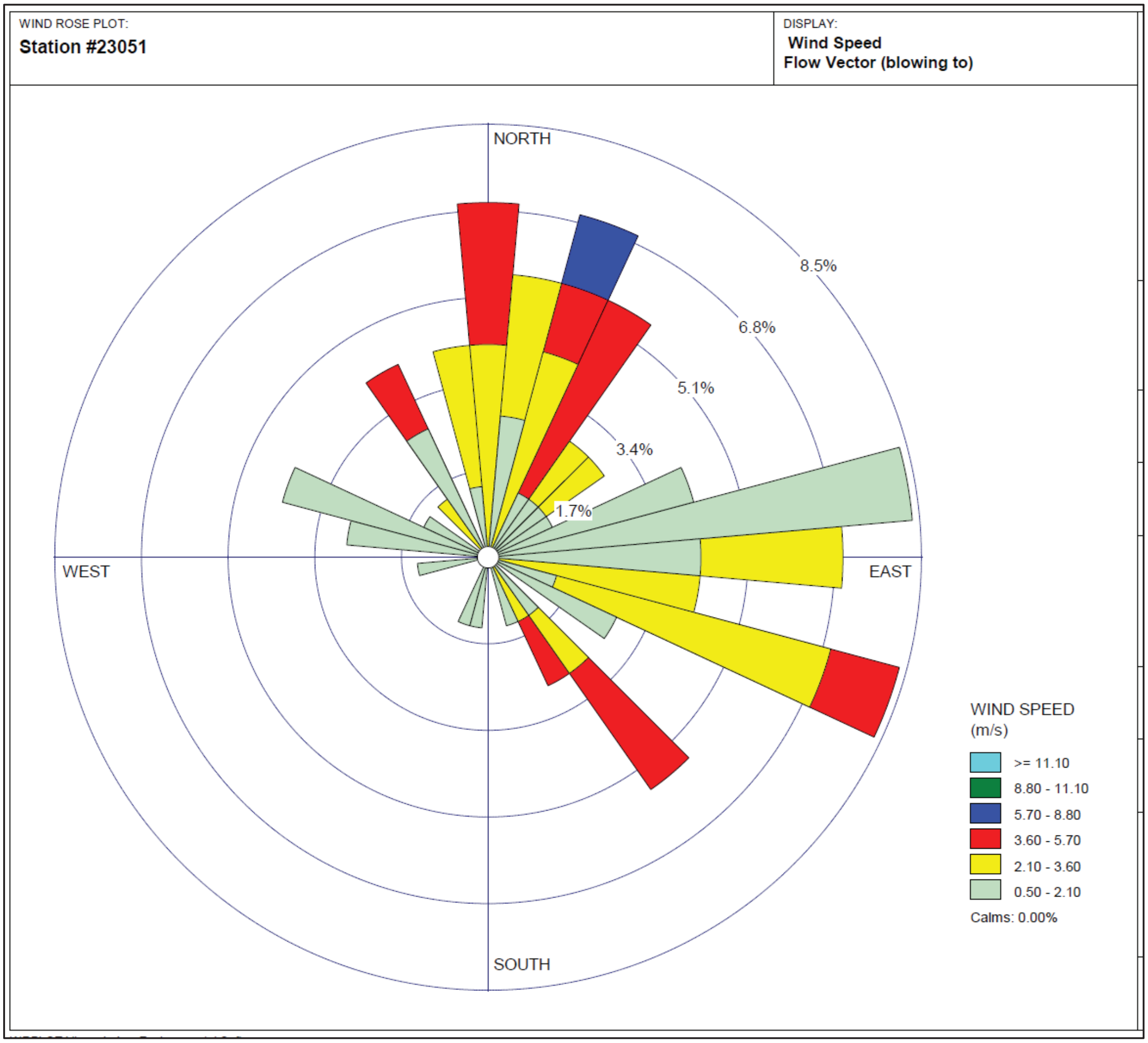
Hours 3-4-5 after the start of operations, 9/29/2025.



Hours 6-7-8 after the start of operations, 9/29/2025.

TA-54B Meteorological Tower Wind Rose, Sep 28-30

Intended to illustrate the higher-speed wind going from the FTWC operations site to the East Northeast sector towards Airnet Station 137



Appendix 3

Technical Lessons Learned During FTWC Operations

Radioactive Air Emissions Monitoring & Associated Areas

Operational Area	Topic / Lesson
Bubbler Operations	Discussed in Volume 1; • Using water in Vial C instead of glycol for short-duration operations will re-hydrate the air stream prior to HT-to-HTO conversion in the bubbler's catalyst; this will minimize plate-out in the bubbler internal components. This was done at the FTWC stack to ensure complete collection of HTO in vials D-E-F. • However, in longer-term operations (> 3 days) in an arid environment, the water in Vial C will likely evaporate. In multi-day operations (e.g. field bubblers), use glycol in all six vials.
Flow rate – standard conditions vs actual conditions	Need to performance-test instruments with built-in sample pumps & automated concentration calculations in order to verify flow rates and volumes in actual conditions (e.g., at elevation). This issue complicated the comparison of measurements from different instruments and interpreting reported air concentration data.
Receptor/MEI locations can change over time	The original FTWC receptor analysis was performed in 2020-2022, identifying the nearest receptor in each compass sector. As time went on, more residential development took place in White Rock, NM, and we had to adjust our receptor locations slightly to accommodate the new construction. For long-lead-time operations near the Laboratory perimeter, plan to re-evaluate receptor locations periodically.
CAP88 multi-receptor analysis	The FTWC project was the first time that the RAEM team used CAP88's multiple receptor capability. • Reported doses have only two significant digits rather than the usual three digits in single-receptor analyses. • Software/macros are useful to extract specific location information from tables in the "Summary" file.
CAP88 sensitivity analysis	The RAEM team also performed many evaluations to examine the effects of input parameters in CAP88; temperature, humidity, atmospheric mixing height, etc.

Operational Area	Topic / Lesson
Timing / Duration	The original direction in May 2019 was to complete pressure relief operations in 45 days. As time went on, we were still told to maintain readiness for imminent operations. • Many design decisions were made based on equipment availability or delivery time. • Operational processes were selected in part due to known methods and past experiences. • The COVID-19 pandemic presented additional challenges and delays.