Air Monitoring Plan for the Tesoro Refinery in Martinez, California

Submitted by Tesoro Martinez Refinery
Martinez, California

September 7, 2017

TESORO

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Air Monitoring Plan for the Tesoro Refinery in Martinez, California

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Air Monitoring Plan

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Prepared in consultation with Sonoma Technology, Inc.

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1. Introduction

Tesoro Refining & Marketing Co., LLC (Tesoro) plans to monitor fenceline concentrations of certain compounds at the Tesoro Martinez Refinery in Martinez, California, in compliance with the Bay Area Air Quality Management District's (BAAQMD) Regulation 12, Rule 15 (Rule 12-15) and consistent with the BAAQMD's Air Monitoring Guidelines for Petroleum Refineries.[1,2] Rule 12-15 requires refineries to monitor multiple species in a manner that achieves a minimum detection limit (MDL) in the parts-per-billion (ppb) concentration range, using measurement technology such as "open-path" or an equivalently sufficient method.[1] Rule 12-15 requires monitoring for benzene, toluene, ethylbenzene, xylenes (BTEX), and hydrogen sulfide (H_2S); in addition, the rule requires sulfur dioxide (SO_2), alkanes, 1,3-butadiene, other organics, ammonia (NH_3), oxides of nitrogen, and particulate matter (PM) to be considered for monitoring and ruled out only with justification. Rule 12-15 requires monitoring along fencelines where receptors (e.g., residences and businesses) are located within 1 mile downwind. As part of the planning process for monitoring and reporting, Tesoro's Air Monitoring Plan (Monitoring Plan; this document) was revised in response to comments from the BAAQMD and is hereby submitted to the BAAQMD for approval.

1.1 Plan Summary

1.1.1 General Principles of Proposed Measurement Techniques

The Tesoro Martinez Refinery will monitor concentrations of certain compounds using open-path instruments placed at or near the refinery's property fencelines. Open-path instruments operate based on the following principles of physics:

- Each gas species absorbs light energy at characteristic wavelengths; thus, a target gaseous species can be specifically identified by monitoring for light absorption at a specific wavelength.
- The extent of light absorption is proportional to the path-average concentration of the target gaseous species. The greater the absorption, the higher the concentration.

Open-path instruments transmit light or infrared energy across a long open path. Energy absorption relates to the average concentration of gases of interest along the path, according to the Beer-Lambert absorption law. Individual gases absorb most effectively at characteristic wavelengths; therefore, measurements of energy absorption at specific wavelengths can be used to infer

[1] Petroleum Refining Emission Tracking (Rule 12-15; approved by the BAAQMD on April 20, 2016).

[2] Bay Area Air Quality Management BAAQMD (2016) Air Monitoring Guidelines for Petroleum Refineries. April 2016. Available at baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.

path-average concentrations for species of interest. The transmitted energy signal is typically either detected remotely by a targeted detector or reflected for detection elsewhere. Often a combined transmitter-detector unit is positioned at one end of a path, and a retroreflector—a type of mirror with a geometric shape that gathers and re-focuses the transmitted energy—is positioned at the other end of the path. The retroreflector returns the transmitted energy to the transmitter-detector unit for detection. Figure 1 illustrates the basic concepts of open-path measurements.

Note that open-path instruments are not able to distinguish between a widely dispersed, low-concentration plume and a narrow, high-concentration plume. Rather, the instruments detect average concentrations across the entire distance from the transmitter to the detector (or the distance from the transmitter-detector to a retroreflector, and back again). Periods of poor visibility due to weather-related conditions (e.g., fog) are known to interfere with open-path measurements. Rule 12-15 anticipates some data loss due to poor visibility and allows for such data loss if supported by visibility measurements. The Refinery will monitor visibility using a standard light-scattering device to identify periods of poor visibility that may cause data loss.

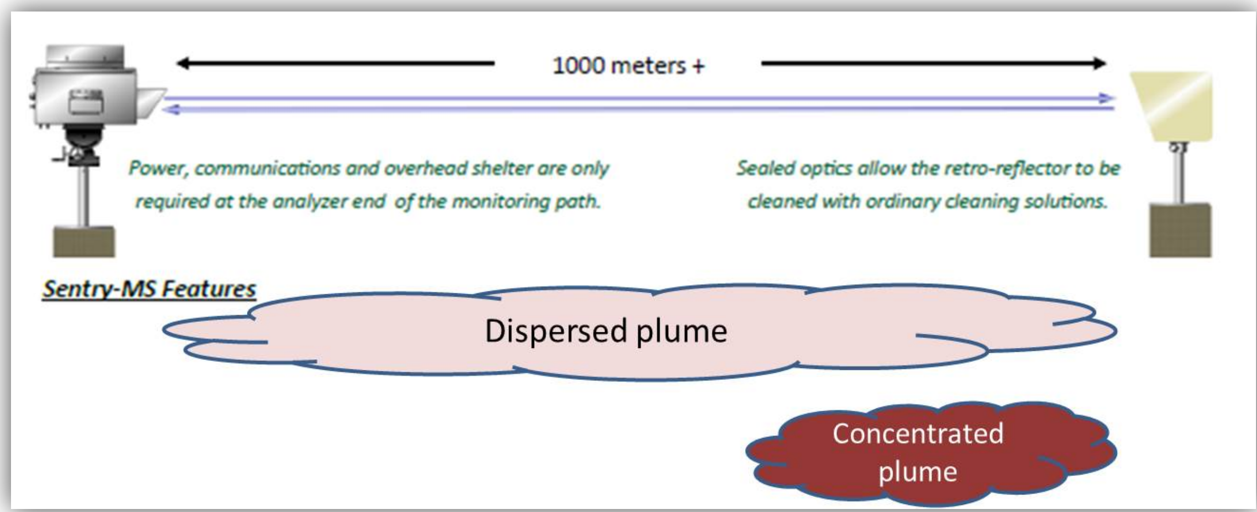

Figure 1. Basic premise for open-path instrument operation. Image from CEREX Sentry-MS monitoring brochure.

1.1.2 Proposed Measurement Sites

Tesoro proposes to monitor concentrations across four open paths (shown in Figure 2). The Refinery selected these locations after consideration of dominant wind patterns, sources of potential air emissions on the refinery property, nearby local receptors, and logistical feasibility. Transmitter-detectors will be located at sites 1s, 2e, 3n, and 4n (identified in Figure 2), and retroreflectors will be placed at the remaining identified sites at 1n, 2w, 3s, and 4s. Please note: the exact paths may need to be adjusted based on final site logistics and exact instrument capabilities, particularly in regard to the maximum path lengths for which the instruments can reliably measure the compounds of interest.

The following provides an explanation of the rationale that Tesoro used in selecting the open path monitoring locations identified in Figure 2. Additional information is provided in Section 2.2.2.

- Path 1 is positioned between the refinery's main processing block and the community of Clyde. Clyde is further than 1 mile from the eastern fenceline and even further from any emission sources, and therefore, Rule 12-15 requirements do not apply. However, Tesoro considers that the community is directly east and downwind from the refinery's main processing block during wind conditions that are predominate in the region (i.e., winds blowing from the west to the east). Thus, Tesoro proposes to include monitoring on Path 1.
- Path 2 is positioned between the refinery's main processing block, storage tanks, and the occupied areas of Concord towards the southeast: the Concord-Northwood residential community, the Sun Terrace neighborhood, and a zone of light industry and office parks that borders the south and eastern sides of the Mallard Reservoir. While wind blowing from the refinery in this direction is not frequent, Tesoro recognizes that these receptor areas are close to the refinery and proposes to establish monitoring on Path 2. Paths 3 and 4 are important during periods of time when winds blow from the northeast to southwest. Northeasterly winds are infrequent; however, they occasionally occur during the winter.
    - Path 3 lies between a battery of crude oil storage tanks and residential neighborhoods of Martinez off north Blum Road.
    - Path 4 lies between the refinery's main center of processing operations and the Vine Hill neighborhood of Martinez.

A visibility monitor will be located either on or near the GER meteorological station (Figure 2).

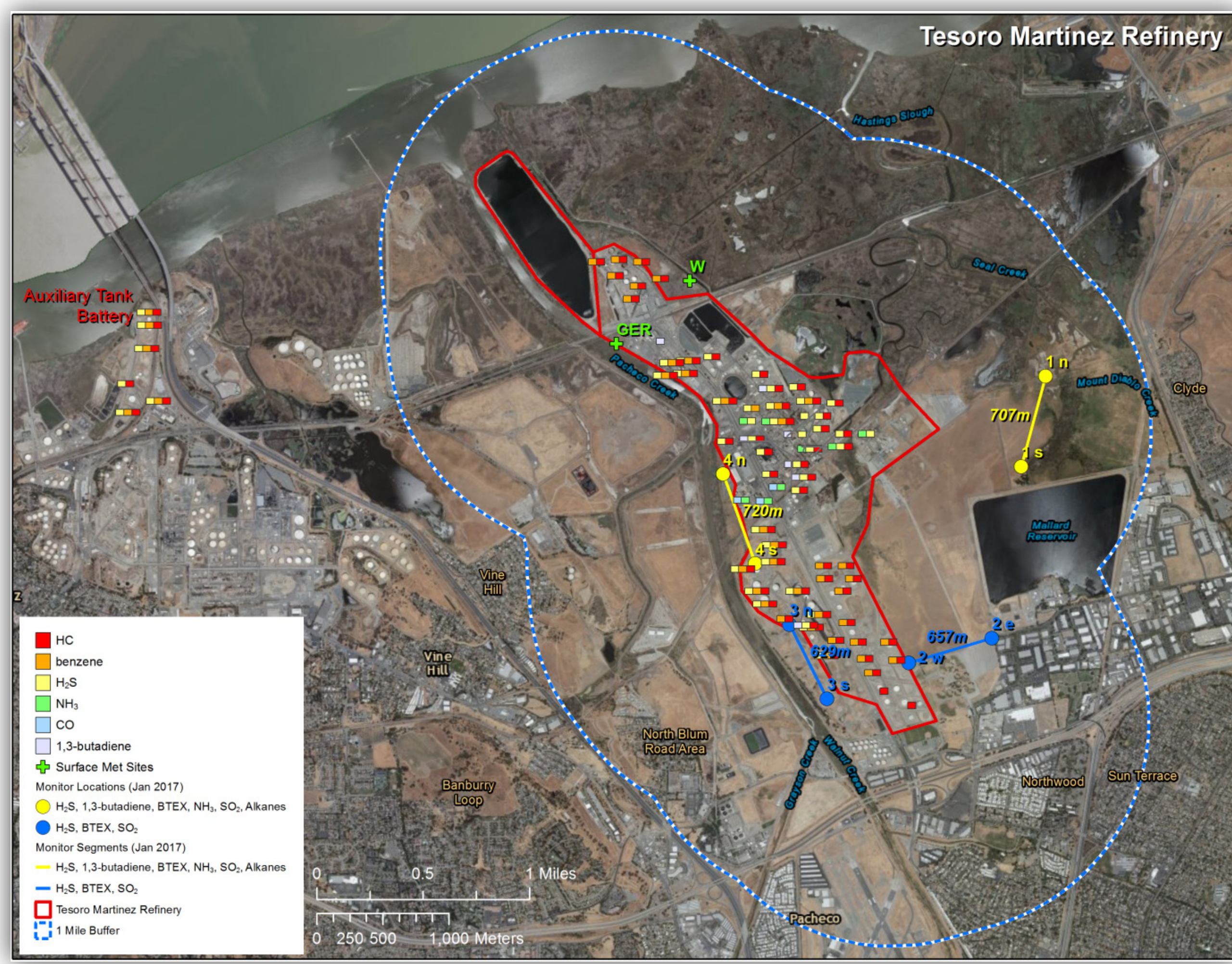

Figure 2. Proposed open-path monitoring sites for the Tesoro Martinez Refinery. (Four proposed paths are identified, labeled 1n-1s, 2e-2w, 3n-3s, and 4n-4s.)

1.1.3 Parameters and/or Species to Be Measured

Species to be measured include H_2S and BTEX (the required species), as well as 1,3-butadiene, hexane, SO_2, and NH_3. Other species are ruled out based on an understanding of the operations and materials existing at the Tesoro Martinez Refinery. H_2S and BTEX emissions are distributed across the refinery property, and these species will be measured along all four of the proposed open pathways. Sources of NH_3 and 1,3-butadiene are present only near the refinery's main processing block; therefore, given the annual and seasonal wind patterns, these species are proposed to be measured only along Path 1 and Path 4. Hexane will also be measured along Path 1 and Path 4 because hexane measurements will be available from the same instruments used to measure NH_3 and 1,3-butadiene, and hexane is a surrogate for alkanes.

1.1.4 Instrument Selection and Configuration

BTEX and SO_2 will be measured by monostatic Ultra Violet-Differential Optical Absorption Spectroscopy *(*UV-DOAS*)* with a xenon light source. H_2S will be measured by monostatic Tunable Diode Laser Absorption Spectroscopy (TDLAS) instruments. NH_3 and 1,3-butadiene will be measured with a Fourier Transform Infrared spectroscopy (FTIR) instrument. To the extent practicable, instruments will be installed and operated as follows:

- Instruments generally will be elevated about 5 ft above ground level (agl); the final height will be determined based on site logistics. While instruments will be located at the above elevations, along the light path, the height of the light beam above the ground will change due to terrain.
- Instruments will be configured and operated following manufacturers specifications, including necessary bump tests. A bump test challenges an instrument using known gas concentrations to confirm accurate instrument response.
- Instruments will be operated to strive for a minimum of 75% completeness by hour and day, and 90% completeness by 3-month calendar quarters. Appropriate completeness criteria will be calculated after removing periods when poor visibility conditions prevented measurement.
- Measurements will be collected at a time resolution of 5 minutes or less.

1.1.5 Data Management

Data collected by the fenceline monitors will be transmitted to a website where the near-real-time results can be viewed by the public.

Data generated by the fenceline monitors will undergo a review throughout the measurement and reporting process. Included in this process are automated QA/QC checks that will occur before data are reported on the public website. Under normal circumstances, a 5-minute average measurement will appear on the website within 10 minutes of the end of the measurement period. However, the data upload may be impacted by internet traffic. A rolling 24 hour trend of the 5 minute data for each gas reported will also be available on the website.

Once QA/QC of the final data is completed (within 60 days after the end of each calendar quarter), the refinery will provide 1-hr average concentration data in tabular format through a comma separated value data file to the BAAQMD. The BAAQMD may make the 1-hr average data available to the public through a BAAQMD website or through a public records request. The refinery will make data available to BAAQMD upon request prior to the report submittal.

The website will provide a mechanism for public comment.

Tesoro will maintain a data record for five years consistent with Rule 12-15-502.

1.2 Next Steps to Implementation

The expected next steps for the implementation of the Tesoro Martinez Refinery fenceline monitoring program are as follows.

- Gain BAAQMD's approval of the Monitoring Plan (this document).
- Finalize monitoring instrument selections (makes and models).
- Work with the BAAQMD to finalize the Quality Assurance Project Plan (QAPP) based on the acquired instruments. The QAPP is provided in Appendix A.
- Procure instruments and necessary ancillary equipment and supplies. Perform bench testing.
- Develop instrument infrastructure, including power, concrete pads, shelters, security fences, access paths, and communications.
- Install monitoring instruments and retroreflectors.
- Deploy the data management system.
- Develop and deploy a public data-display website for displaying data in real time.
- Operate and maintain instruments following the manufacturer's specifications.
- Operate and maintain the public website.

2. Monitoring Plan Design Considerations

Tesoro's Monitoring Plan was developed in consideration of the following elements.

- Rule 12-15 and related BAAQMD guidance documents.
- Monitoring objectives, which were established in consideration of Rule 12-15 and related guidance.
- The findings of a preliminary scoping study, which involved assessments of the geographic setting around Tesoro's Martinez Refinery and meteorological conditions that impact the area. The preliminary scoping study is discussed in Section 2.2.
- Technical and engineering feasibility related to available monitoring technologies and instrument siting.
- Data management and quality assurance/quality control (QA/QC) requirements.

Details on each of these elements are provided in the following subsections.

2.1 Key Elements of Rule 12-15 and Guidance

According to the Guidance Document,[3] the main goals of fenceline monitoring are to:

- "Provide continuous air quality concentration information on a short enough time scale to address changes in fence-line concentrations of compounds associated with refinery operations;
- "Provide data of sufficient accuracy to identify when concentrations of compounds associated with refinery operations are elevated as compared to other monitoring locations throughout the Bay Area;
- "Potentially aid in identifying corrective actions that will lower emissions."

Key guidance for designing a monitoring plan to meet these goals is summarized below. The Tesoro monitoring program will achieve the goals listed above and meet the following provisions:

- Conduct "fenceline" measurements of BTEX and H_2S and consider measuring other compounds, including SO_2, alkanes, 1,3-butadiene, other organics, and NH_3. The term

[3] Bay Area Air Quality Management BAAQMD (2016) Air Monitoring Guidelines for Petroleum Refineries. April 2016. Available at baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.

"fenceline" in the guidance refers to a general boundary between refinery property and areas outside the refinery property, not necessarily to an actual fence.

- Conduct measurements in areas where emissions from the refinery could impact populated areas on a frequent basis. Specifically,
  - "Measurements must cover populated areas within one mile of the refinery fence-line likely to be affected when the annual mean wind direction lies in an arc within 22.5 degrees of a direct line from source to receptors 10 percent of the time, or greater, based on the most representative meteorological measurements for sources likely to emit the compounds listed above at the refinery."
  - In addition, "Meteorological measurements should also be used and addressed in the Monitoring Plan to ensure proper siting of fence-line systems, looking at long-term measurements such as annual average wind rose, but also taking into account more seasonal and recurring short term meteorological events."
- Provide measurements of the species at the ppb level or as technology allows.
- Conduct measurements using open-path instruments or an appropriate alternative.
- Provide rationale for the species to be measured and not measured.
- Provide rationale for the locations for the measurements.
- Provide rationale for the instruments to be used.
- Collect the measurements every five minutes.
- Process the data and display the data in near-real time to a public website.
- Meet data recovery and completeness criteria.
- Develop a QAPP for the measurement program and follow the QAPP.

2.2 Preliminary Scoping Study

2.2.1 Geographic Study Setting

Tesoro's Martinez Refinery is located east of the City of Martinez and north of the City of Concord in Contra Costa County, California (see Figure 3). Refinery operations occupy approximately 2,200 acres, including a 50-acre main block of processing operations, with the center of the facility located approximately at 38.025° latitude, -122.063° longitude (see Figure 4). The area surrounding the refinery includes:

- North – Wetlands, the Point Edith Wildlife Area, and Suisun Bay sit to the north of the refinery. There are no receptors within one mile of the Refinery in this direction. The Valero Benicia Refinery is about three miles north of Tesoro, across the Suisun Bay.

- **West –**The Shell Martinez Refinery is about two miles west of the Tesoro Martinez Refinery. The Vine Hill and Blum Road neighborhoods of Martinez are the nearest residential areas to the west and portions of these areas are within 1 mile of the refinery. Low coastal hills rise to elevations of 400 to 600 feet within 5 miles west of the refinery.

- **South –** Highway 4 passes by directly south of the refinery. Toward the southeast, the Concord-Northwood residential community and the Sun Terrace neighborhood are the nearest residential areas, and a zone of light industry and office parks sits just south of the Mallard Reservoir.

- **East –** Low coastal hills rise to elevations of 400 to 600 feet within 2.5 miles east of the refinery. Areas east of the refinery include former and current military lands, but aside from the community of Clyde (slightly beyond 1 mile east of the refinery), the lands within 5 miles to the east are only lightly populated.

The nearby populated public areas represent air quality “receptors” that may at times sit downwind from Tesoro’s Martinez Refinery. The positions of these receptors received careful consideration during the design of the Monitoring Plan.

Tesoro also maintains an auxiliary tank battery and a marine unloading terminal just west of the south end of the Benicia-Martinez Bridge across the Carquinez Strait, about 2.8 miles west of the refinery. Potential receptors near this facility were also considered for the Monitoring Plan.

Figure 3. Geographic setting of the Tesoro Martinez Refinery.

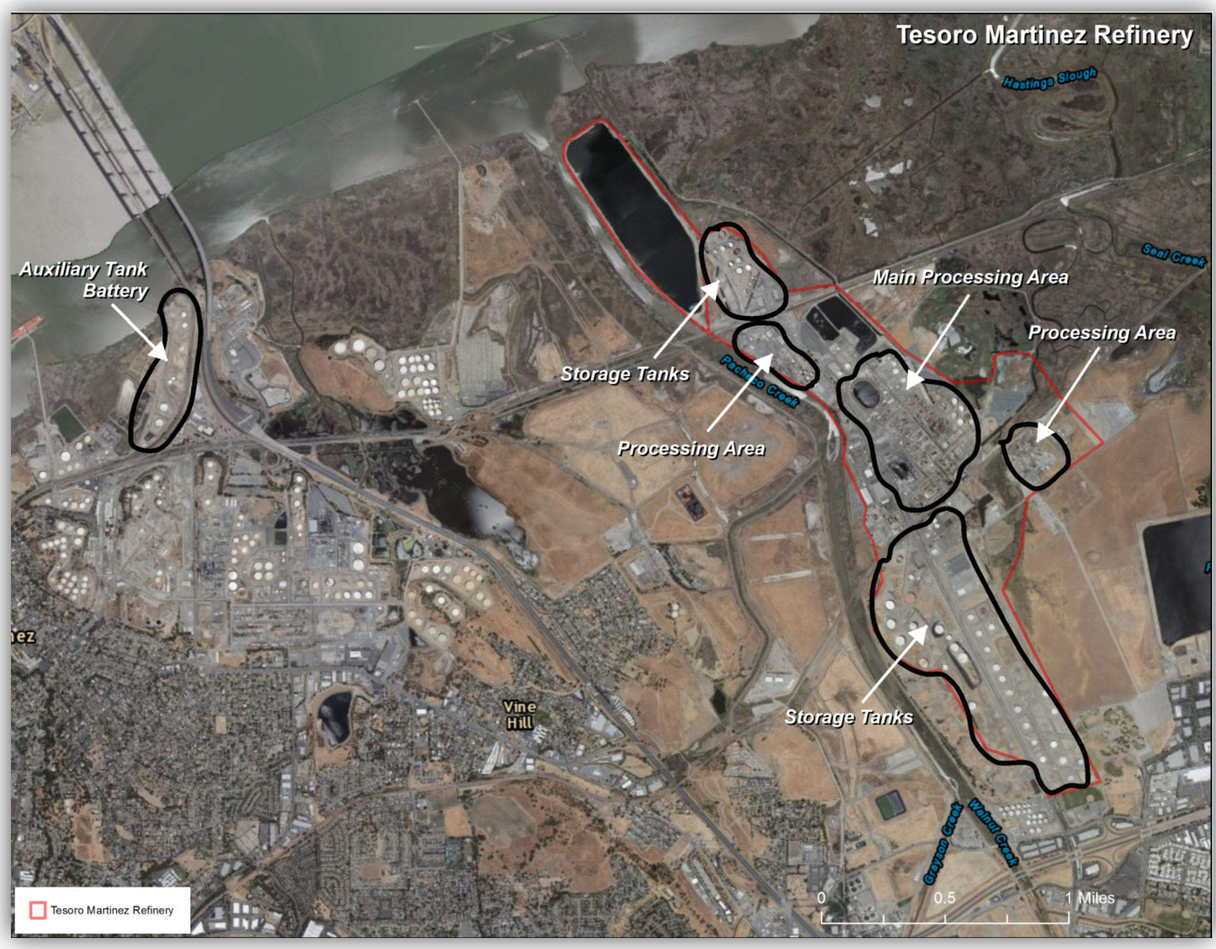

Figure 4. Layout of the Tesoro Martinez Refinery.

2.2.2 Local Meteorology

Tesoro's contracted meteorologist reviewed the refinery's routinely collected surface wind measurements in the context of expert knowledge about the Bay Area regional wind patterns. Tesoro's Martinez Refinery is positioned in a wind flow corridor between the San Francisco Bay and the Sacramento Valley. Wind flow through the corridor is driven by seasonally variable regional temperature gradients and large-scale meteorological systems. Figure 5 illustrates the predominant wind flow patterns: (1) winds occasionally blowing from the south (most often occurring during winter storms); (2) winds blowing from northeast to southwest (regional offshore flow, most often occurring in winter); (3) winds blowing from the northwest and west to southeast (onshore flow, most often occurring in spring, summer, and early fall).[4]

[4] Seasons were defined as follows: winter is December, January, February; spring is March, April, May; summer is June, July, August; and fall is September, October, November.

Figure 5. Typical wind flows influencing the Tesoro Martinez Refinery.

Radial histograms (wind roses) were prepared to determine the frequencies of wind speeds and directions as directed by Rule 12-15 Guidance (i.e., annual mean wind direction distributed by 22.5-degree arcs) and for other relevant data groupings (e.g., seasonal, monthly, and/or narrower arcs). Using data from 2011 through 2016, Figure 6 provides the annual wind roses recorded from the refinery's meteorological station, Golden Eagle Refinery, while Figure 7 provides seasonal wind roses. Key findings are summarized as follows:

- Onshore winds – westerly winds (from west to east) occur with frequencies greater than 10% on an annual basis. Winds from these directions are most common in spring, summer, and early fall. The town of Clyde is located more than one mile downwind of the refinery's process operations during westerly wind flow.
- Southerly winds – winds blowing from south to north occur about 10% of the time on an annual basis. However, there are no receptors downwind during southerly wind flow.
- Offshore winds – northeasterly winds do not occur with a frequency greater than 10% on an annual basis, but do occur with a frequency greater than 10% during the winter season. The

Vine Hill and north Blum Road neighborhoods of Martinez are the nearest residential areas to the west and are within one mile of the fenceline.

- **Southeasterly winds** – southeasterly winds (winds blowing from southeast to the northwest) do not occur with a frequency greater than 10% on an annual basis, but do occur more than 10% of the time during the winter; however, there are no receptors within one mile downwind of the refinery during southeasterly flows.
- **Other winds** – winds from other directions occur with lesser frequencies, whether data are grouped annually, monthly, or seasonally. While winds blowing from approximately northwest to southeast are very infrequent, the Concord-Northwood residential community, the Sun Terrace neighborhood, and a zone of light industry and office parks next to the Mallard Reservoir are downwind and within one mile of the fenceline under these conditions.

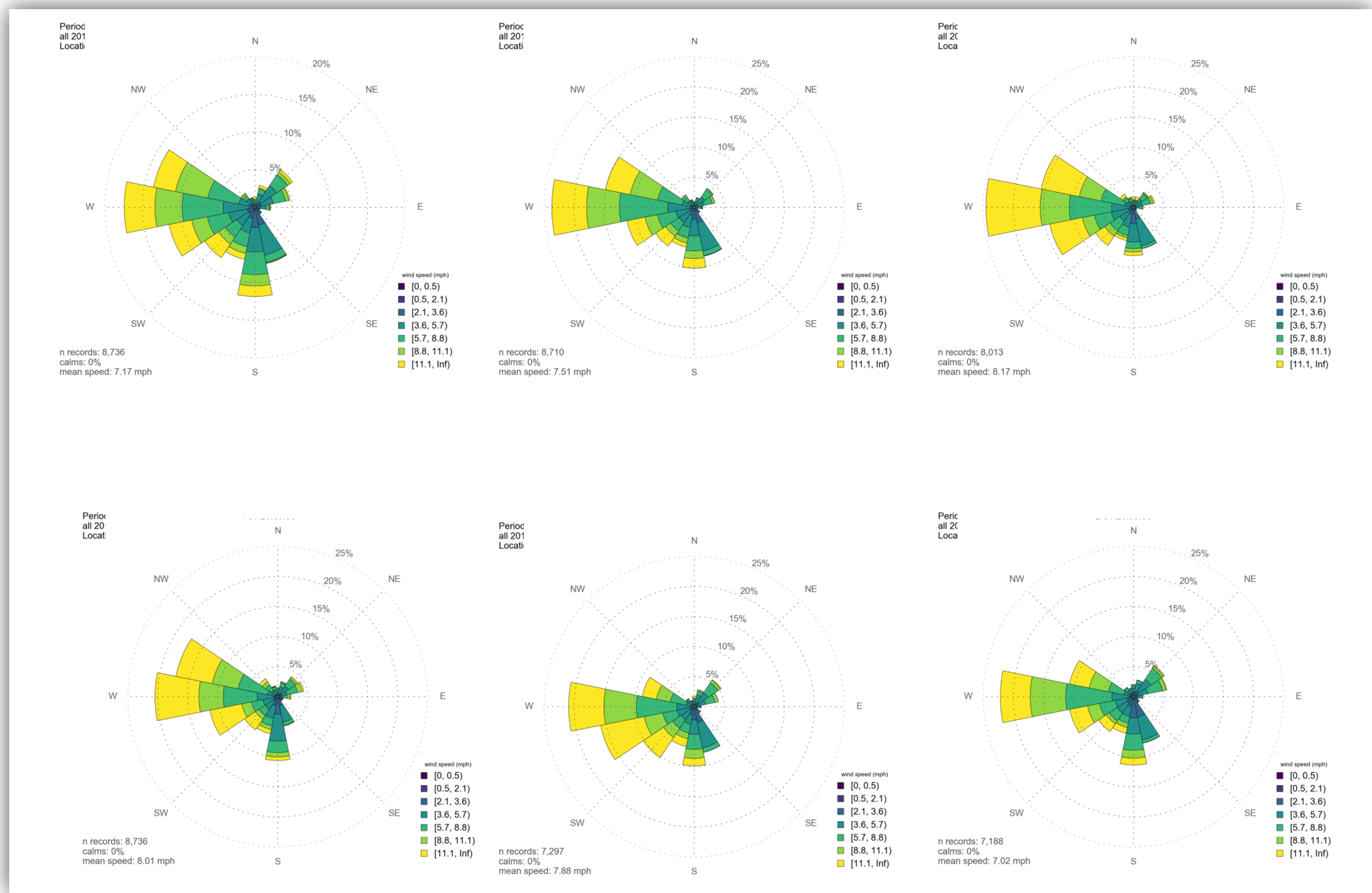

Figure 6. Annual wind roses plotted from the Tesoro Martinez Refinery's surface meteorological station, Golden Eagle Refinery, from 2011-2016 (top left to bottom right).

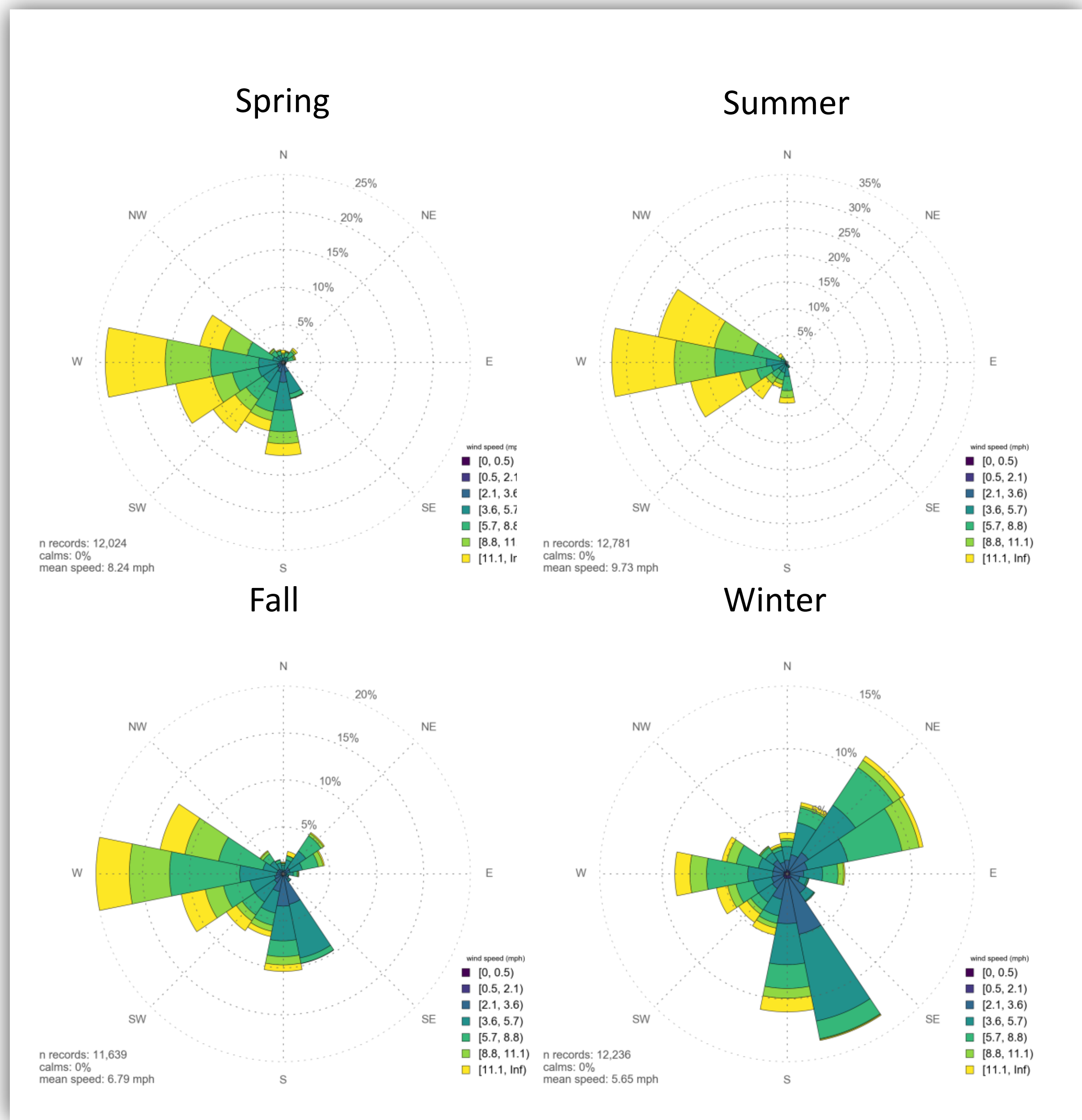

Figure 7. Seasonal wind roses plotted from the Tesoro Martinez Refinery's surface meteorological station, Golden Eagle Refinery, from spring, summer, fall, and winter of 2011 through 2016.

To better identify and illustrate the areas located downwind from the refinery during onshore and offshore winds, maps highlighting these areas were created (**Figures 8 and 9**). The edges of the refinery boundaries were coupled with leeward projections of onshore and offshore winds to highlight any areas sitting downwind from the Tesoro Martinez Refinery during the wind conditions of interest. In addition, the outline of the refinery boundary was projected outwards to a distance of one mile. The illustrations confirm the above findings and show that:

- During infrequent offshore winds, portions of Martinez are downwind, but only a few Martinez neighborhoods are within one mile.
- During infrequent northwesterly winds, a few neighborhoods of Concord sit within one mile downwind of the refinery.
- During dominant westerly winds, the community of Clyde is downwind, but more than one mile downwind of refinery process areas.

In consideration of the above, general paths for monitoring were considered and are shown in Figures 8 and 9 as black bold lines. These general paths were then refined based on detailed wind data, population areas, and emission locations to develop the final monitoring paths shown in Figure 2.

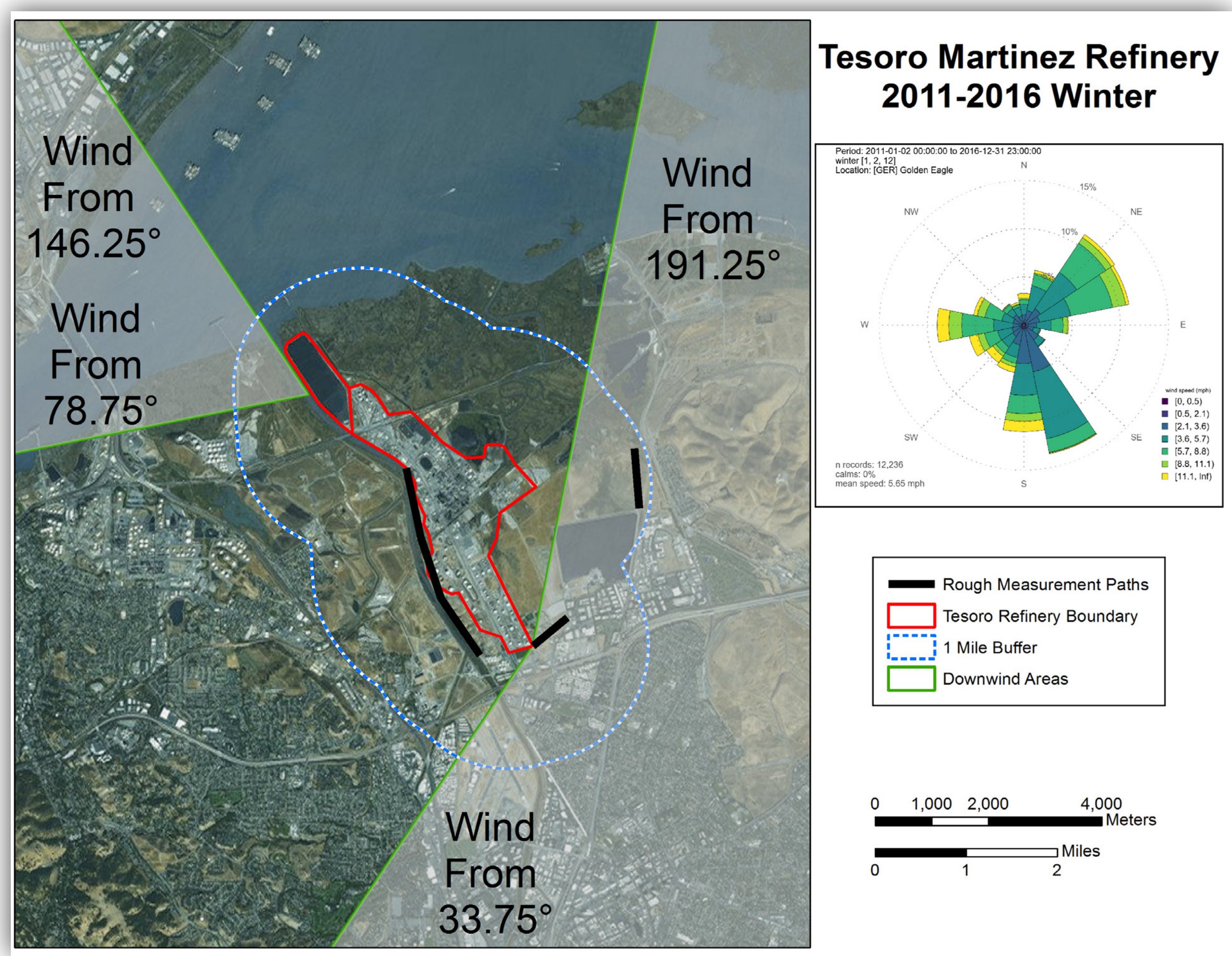

Figure 8. Areas downwind of the Tesoro Martinez Refinery property boundaries during infrequent offshore and southerly winds. Black lines are the initial monitoring paths that were considered.

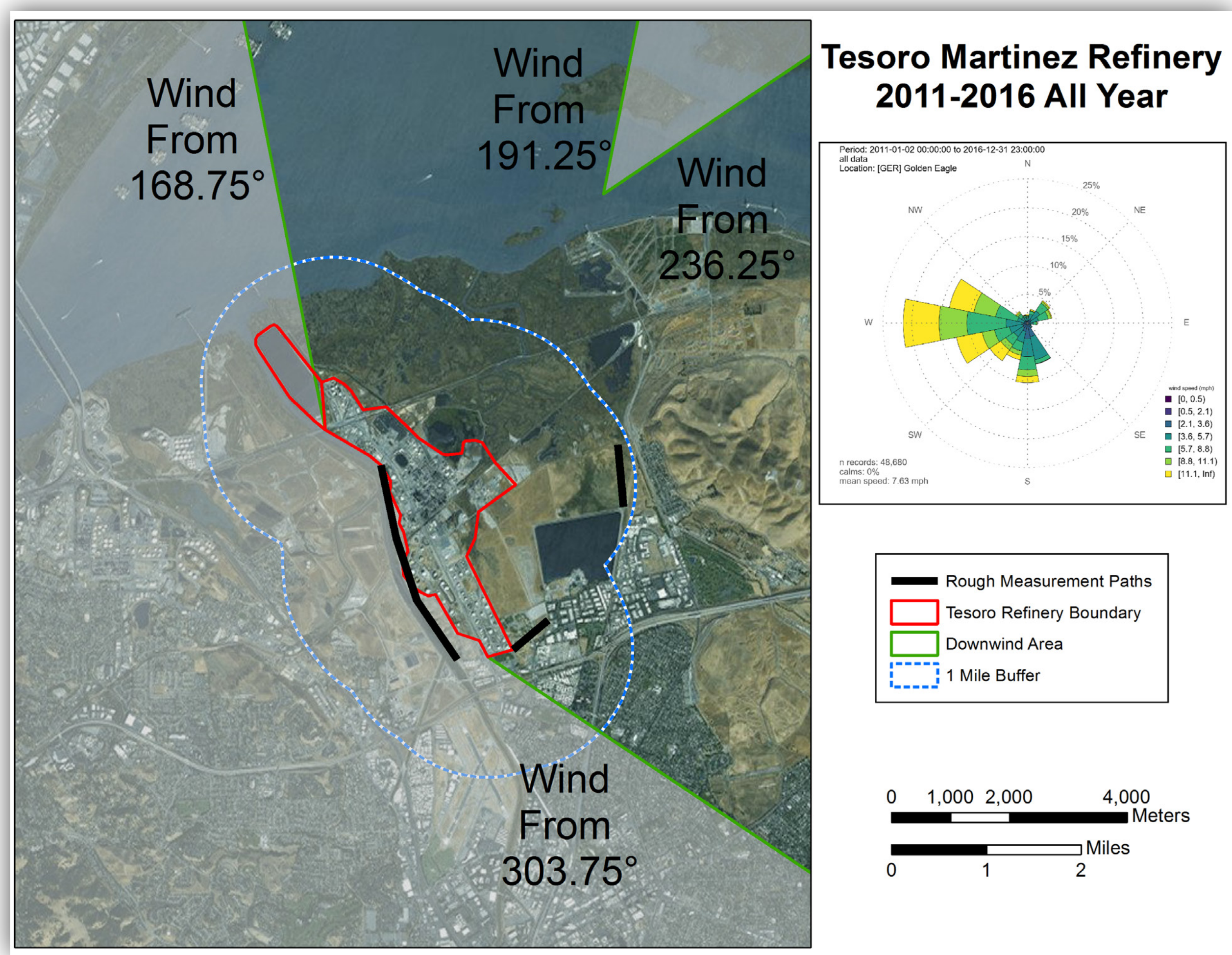

Figure 9. Areas downwind of the Tesoro Martinez Refinery property boundaries during onshore winds. Black lines are the initial monitoring paths that were considered.

As shown in Figure 2, monitoring Path 1 upwind of Clyde is proposed to address the scenarios of onshore winds. Monitoring Path 2 is proposed to address the few neighborhoods of Concord that are located to the south within one mile downwind of the refinery.

Optimally, the refinery had hoped that Path 2 would cover the very southern end of the refinery; however, the location was not logistically feasible for a number of reasons, including the presence of large trees and several public baseball fields. Although Path 2 is north of a few storage tanks, these tanks contain diesel, which is a finished product that is inherently low in emissions: it has very low vapor pressure and only trace amounts of BTEX, H_2S, and other compounds of relevance to this rule. The gap in monitoring between Path 1 and 2 exists because there are no nearby populated areas downwind of the refinery in this direction; thus, measurements are not needed.

To further refine the paths west of the refinery, one-mile pie segments that encompass the northeasterly wind segments were created and overlaid at various points on the western refinery boundary – these pie segments are shown in **Figure 10**. Based on this analysis, proposed monitoring Paths 3 and 4 capture the needed monitoring paths for the areas to the west of the refinery.

A small gap necessarily exists between Paths 3 and 4 because of steep terrain to the west, making it logistically infeasible to monitor between these two paths.

While not required by Rule 12-15 because there is no population downwind within a mile of the refinery, consideration was given to extending Path 4 north by a few hundred yards. However, due to terrain, infrastructure, and trees, it is not feasible to extend the monitoring north. Importantly, any emissions leaving the refinery from this area are very unlikely to impact populated areas because winds from the northeast to the southwest are infrequent. Furthermore, given the terrain and distances from the refinery to populated areas, any emissions that moved toward the southwest would be well-diluted.

Similar illustrations were prepared for Tesoro's auxiliary tank battery near the Martinez-Benicia Bridge (**Figure 11**). Figure 11 shows one-mile pie segments that encompass the northeasterly wind segments. The transparent pie segment uses the wind data from the meteorological station located in the main refinery area. The green pie segments illustrate the probable wind pattern in this area as the winds follow the terrain through Carquinez Strait. As observed in Figure 11, there are no downwind areas of concern near Tesoro's auxiliary tank battery; thus, no open path monitoring in this area is proposed. (As previously discussed in Section 1.2, passive benzene fenceline monitoring will be performed around Tesoro's auxiliary tank battery).

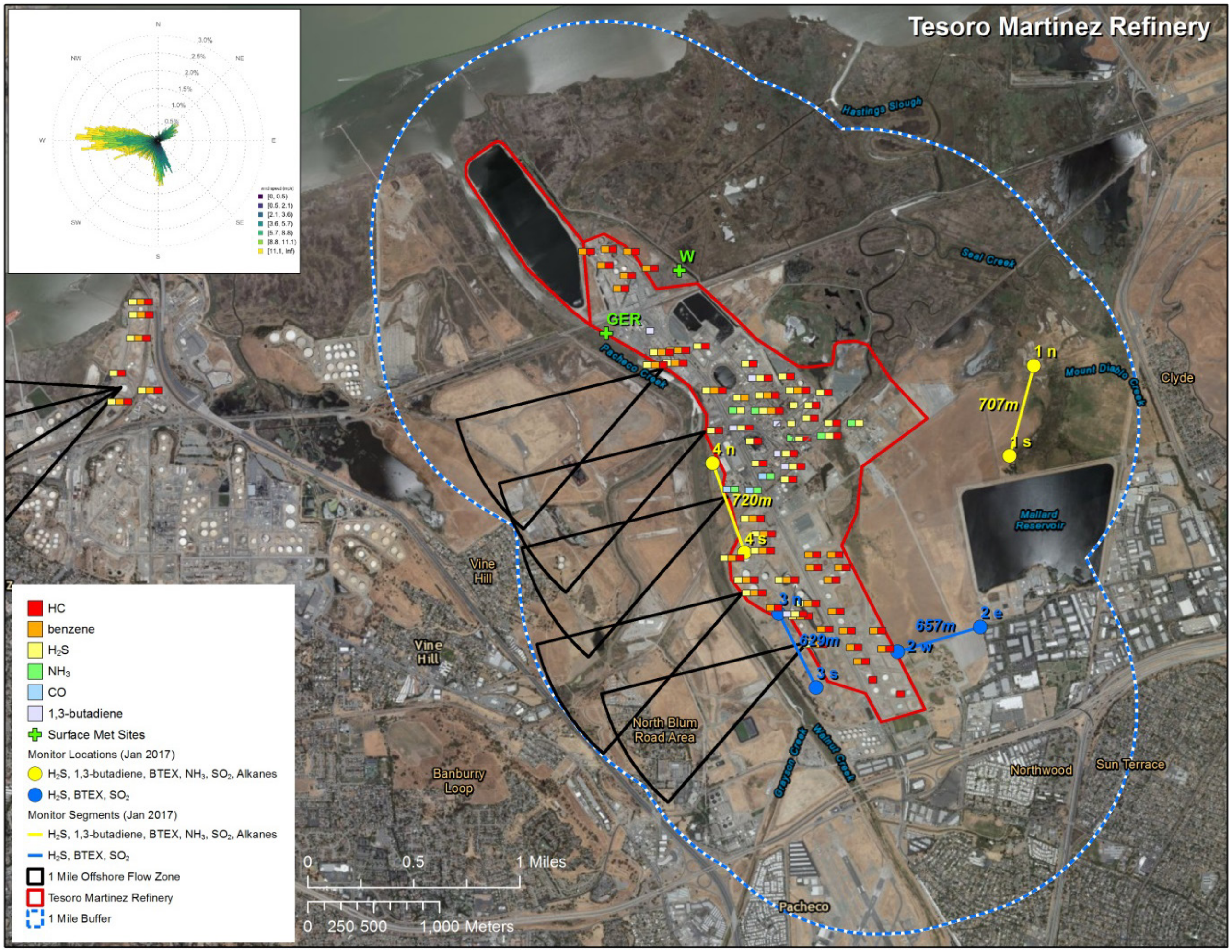

Figure 10. Proposed open-path monitoring sites for the Tesoro Martinez Refinery. Four proposed paths are identified, labeled 1n-1s, 2e-2w, 3n-3s, and 4n-4s. The annual wind rose is shown in the top left.

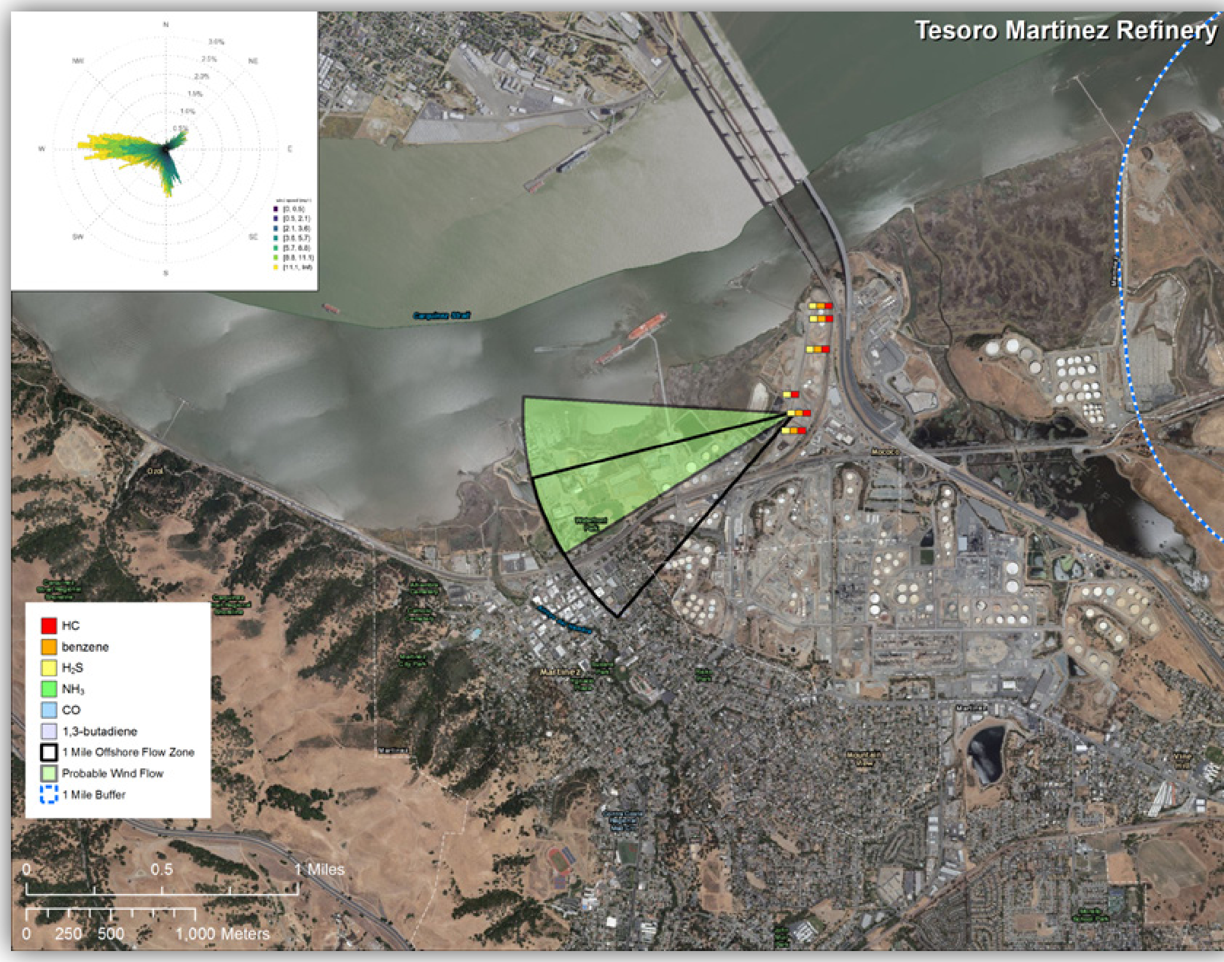

Figure 11. Areas downwind of Tesoro's auxiliary tank battery during offshore flow.

2.3 Instrument Selection

Tesoro's Martinez Refinery is a petroleum refinery producing fuel products—primarily gasoline, diesel, liquefied petroleum gas (LPG), residual fuel oils, and petroleum coke—through distillation of crude oil, including cracking, alkylation, and reforming processes. The refinery also has a chemical plant, where salable sulfuric acids, molten sulfur, and liquid ammonia are produced. In consideration of the refinery's products, processes, and potential emissions sources, the rationales summarized in Table 1 were applied to determine which species would be proposed for inclusion in the Monitoring Plan. Literature reviews, site surveys, and interviews with instrument manufacturers were performed to determine the instruments needed to meet Rule 12-15 requirements. Both fixed-site and open-path instruments were investigated. Based on the distances that need to be covered by measurements (hundreds of meters), data time-resolution requirements (5 minutes), and current measurement technology, various open-path instruments were selected to best measure the target species.

Table 1. Summary of rationale supporting selection of species for inclusion in the Monitoring Plan.

	Required by the BAAQMD	To Be Measured (paths)	Instrument(s)	Rationale for Inclusion or Exclusion if Not Required
Benzene	Yes	Yes (1,2,3,4)	UVDOAS with Xenon	Required
Toluene	Yes	Yes (1,2,3,4)	UVDOAS with Xenon	Required
Ethylbenzene	Yes	Yes (1,2,3,4)	UVDOAS with Xenon	Required
Xylenes	Yes	Yes (1,2,3,4)	UVDOAS with Xenon	Required
H_2S	Yes	Yes (1,2,3,4)	TDLAS (FTIR yields poor detection, false positives)	Required
SO_2	No, if justified	Yes (1,2,3,4)	UVDOAS with Xenon	Included
NH_3	No, if justified	Yes (1,4)	FTIR	Impact unlikely other than on Paths 1 and 4 because NH_3 is only located in the main processing area.
1,3-butadiene	No, if justified	Yes (1,4)	FTIR	Although not needed due to coincident with benzene and low concentrations, will report 1,3-butadiene, since FTIRs will be implemented for NH_3.
Alkanes	No, if justified	Yes (1,4)	FTIR	Will report hexane since FTIRs will be implemented for NH_3 and hexane is a reasonable surrogate for alkanes. On paths without FTIR, benzene will be measured and is a good surrogate for hexane except for diesel tanks. For diesel tanks, any emissions would be negligible due to low vapor pressure.
Other organics	No, if justified	No	NA	Benzene measurement is reasonable surrogate.

Along all paths, BTEX and SO_2 will be measured using a monostatic UV-DOAS with a xenon light source. The xenon light is required to achieve MDL for BTEX and collect measurements over paths that are about 300 to 600 meters long. H_2S will be measured using monostatic TDLAS instruments. The basic principle of TDLAS is to measure the absorption of a single absorption line for the target species. A tunable diode laser can emit light at a very specific wavelength, which allows the measurement to avoid potential interferents. For H_2S, manufacturers report that the TDLAS has detection limits on the order of 200 ppb for path lengths of about 500 meters; however, its actual minimum detection limit will depend on atmospheric conditions and on the specific instrument used. In theory, one can monitor H_2S using UV-DOAS, but its absorption spectra overlaps with BTEX and will generate false positives. While FTIR technology was considered for measurements of BTEX and H_2S, instrument manufacturers informed Tesoro that FTIR is not suitable for these species because of poor detection limits and overlap in absorption with other species (such as carbon dioxide [CO_2] with benzene). NH_3, 1,3 butadiene, and alkanes will be measured using FTIRs.

Table 2 summarizes the MDLs and upper detection limits (UDLs) by instrument expected for Tesoro's monitoring program. Detection limits are approximate and are based on the theoretical capabilities of the instruments; however, they are supported by manufacturers' lab tests and real-world applications. Again, actual detection limits will depend on atmospheric conditions and on the specific instrument used. The detection limits are for the average species concentration along a path; narrow plumes that only cover a portion of the path would need to have a higher concentration than the MDL to be detected.

Monostatic (as opposed to bistatic) instruments have been selected to reduce the need for substantial power at the mirror sites and improve minimum detection limits by increasing effective path lengths. Thus, substantial power, communications, and shelter are required at the light-source/detector end of the monitoring path only. Limited power is needed at the retroreflectors. The retroreflector needs to be aligned at the other end of the path for maximum performance and should be cleaned regularly. An example of a UV-DOAS analyzer and receiver in a shelter is shown in **Figure 12**, and a retroreflector is shown in **Figure 13.**

Table 2. Anticipated open-path instrument detection limits by technology, species, and path length. TDLAS MDLs for H_2S are less certain; thus, only an estimate of MDL is provided.

Open Path Analyzer Technology Summary: Approximate Detection Limits									
Path		Path 1		Path 2		Path 3		Path 4	
Approximate Distance		707 meters		657 meters		629 meters		720 meters	
Technology	Compound	MDL PPB	UDL PPB	MDL PPB	UDL PPB	MDL PPB	UDL PPB	MDL PPB	UDL PPB
FTIR	1,3-Butadiene	2.6	873.1	2.8	939.5	2.9	979.8	2.6	857.3
	Ammonia	0.2	707.2	0.2	761.0	0.2	793.7	0.2	694.4
	Hexane	2.1	693.3	2.1	711.5	2.0	661.5	2.5	833.7
TDLAS	Hydrogen Sulfide	200	70721.4	200.0	76103.5	200	79365.1	200	69444.4
UVDOAS	Benzene	0.2	10866.8	0.2	11693.8	0.2	12194.9	0.2	10670.6
	Toluene	1.7	6168.5	1.8	6637.9	1.9	6922.4	1.7	6057.1
	Ethylbenzene	1.3	1311.6	1.4	1411.4	1.5	1471.9	1.3	1287.9
	Total Xylenes	3.3	4997.6	3.6	5378.0	3.7	5608.5	3.2	4907.4
	Sulfur Dioxide	4.7	3079	4.9	3159	4.5	2937.5	5.7	3701.8

Notes: Actual detection limits will depend on ambient conditions and final selection of instrument vendor. A lower MDL TDLAS for monitoring H_2S is being developed by a manufacturer and may be available in late summer 2017.

Figure 12. A UV-DOAS analyzer.

Figure 13. A UV-DOAS retroreflector.

2.4 Data Management Requirements

2.4.1 Data Recovery

BAAQMD guidance for open-path measurement data recovery requirements are shown in Table 3. Because open-path measurements are affected by atmospheric conditions that create low-visibility (such as dense fog), missing or questionable data during low-visibility conditions do not count against completeness requirements. Visibility measurements will be made at one location to document the time periods of poor visibility. The threshold for impairment of the open-path measurements is not well established. For example, on a path of 500 meters between transmitter-detector to retroreflector, the effective path length is 1,000 meters; therefore, visibility of less than 1,000 meters will likely affect data quality. This threshold will be refined based on final instrument selection, path length, manufacturer specifications, and review of the actual data signal (e.g., signal to noise ratio) once the equipment is installed and operating. Visibility measurements will be made at least every five minutes to coincide with the open-path measurements.

Table 3. Data recovery requirements.

Completeness Requirement	Relevant to	Minimum No. of Values Needed
75% per hour; 75% per day	5-minute average data; 1-hr average data	9 per hour; 18 per day
90% per calendar quarter	Daily data	81 days per 90-day quarter [a]

[a] The exact number of days in the quarter will be used; this example is for illustration only.

Percent data recovery (or data capture) for 1-hr data is the percentage of valid 5-minute data values that were collected divided by 12. Percent data recovery for the day is the number of valid 1-hr values that were collected divided by 24. Percent data recovery for the calendar quarter is the number of valid daily data values that were collected divided by the total number of expected 1-hr data values in the date range (e.g., 90 days in the quarter). The 1-hr values must meet the 75% data completeness requirement to be included in the computation for quarterly completeness. For communication purposes, the Percent Data Valid—the percentage of data values that are valid divided by the number of captured data values, corrected for low-visibility conditions—will also be computed.

Other factors that affect data availability include instrument bump tests (approximately every quarter for a few hours), other maintenance (e.g., replacement of UV bulbs for the UV-DOAS after every 2,000 hours of use, roughly quarterly, replacement of the FTIR cryocoolers every 3 years), and annual maintenance. For the TDL, a backup system will be used when each of the primary TDL instruments is returned to the manufacturer every two years for maintenance. Regular maintenance and careful, responsive operation will minimize instrument downtime.

2.4.2 Data Quality Assurance/Quality Control

A key goal of the QA/QC plan is to ensure high-quality data that are representative and defensible. Clear definitions and procedures for QA/QC are also necessary to inform the public on why some data are missing, suspect, or invalid.

Details regarding the QA/QC process can be found in Section 3.2.1 and in the QAPP located in Appendix A.

3. Routine Operations

Instrument operations, maintenance, and bump tests include daily checks to ensure that data are flowing consistently, as well as monthly, quarterly, and annual maintenance activities. Further details are provided in the following sections, which describe routine instrument and data management operations. Additional details and documentation, including standard operating procedures (SOPs), for example, are included in the QAPP. Modest adjustments to the operation plans may be needed based on the brand of instruments that are ultimately selected.

3.1 Instrument Operations

3.1.1 UV-DOAS

The UV-DOAS system is designed to require only modest service and maintenance. **Table 4** summarizes typical UV-DOAS maintenance activities as recommended by a manufacturer. Preventive maintenance frequency depends on the operating environment and may need to be adjusted beyond manufacturers' recommendations once the instruments are deployed in the field. On an as-needed basis, system status alarms will alert operators to specific issues needing to be addressed.

Table 4. Schedule of maintenance activities for the UV-DOAS.

Activity	Monthly	Quarterly	Annually
Visually inspect the system.	✓	✓	✓
Inspect optics on detector and retroreflector; clean if necessary.	✓	✓	✓
Inspect system filters.	✓	✓	✓
Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.	✓	✓	✓
Download data from detector hard drive and delete old files to free space, if needed.	✓	✓	✓
Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).	✓	✓	✓
Change out the UV source.		✓	
Replace ventilation exit and intake filters.		✓	
Clean optics on detector and retroreflector.		✓	
Realign system after service.		✓	✓
Check system performance indicators.		✓	✓
Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit.		✓	
Review and test light and signal levels. Check average light intensity to establish baseline for bulb change frequency.		✓	✓
Verify system settings.			✓

3.1.2 TDLAS

The TDLAS has similar maintenance activities to the UV-DOAS. The TDLAS system is also designed to require only modest service and maintenance. Table 5 summarizes TDLAS maintenance activities, as recommended by a typical manufacturer. Preventative maintenance frequency depends on the operating environment and may need to be adjusted. On an as-needed basis, system status alarms may alert operators to specific issues that need to be immediately addressed. Calibration is typically done at the factory, and field calibration is not required because these instruments do not suffer span drift; however, bump tests will be performed.

Table 5. Schedule of maintenance activities for the TDLAS.

Activity	Monthly	Quarterly	Annually
Visually inspect the system.	✓	✓	✓
Inspect optics on detector, clean if necessary.	✓	✓	✓
Check the alignment to verify there has not been significant physical movement.	✓	✓	✓
Download data from detector hard drive and delete old files to free space, if needed.	✓	✓	✓
Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).	✓	✓	✓
Check system performance indicators.		✓	✓
Perform bump test.		✓	
Review and test light and signal levels.		✓	✓
Verify system settings.			✓

3.1.3 FTIR

The FTIR has similar maintenance activities to the UV-DOAS. The FTIR system is also designed to require only modest service and maintenance. Table 6 summarizes FTIR maintenance activities, as recommended by a typical manufacturer. Preventative maintenance frequency depends on the operating environment and may need to be adjusted. On an as-needed basis, system status alarms may alert operators to specific issues that need to be addressed. Bump tests are performed on site.

Table 6. Schedule of maintenance activities for the FTIR.

Activity	Monthly	Quarterly	Semi-Annually	Annually	Three Years	Five Years
Visually inspect the system.	✓	✓		✓		
Inspect and clean AC system exterior heat sink.			✓			
Inspect and clean AC system interior heat sink.				✓		

Activity	Monthly	Quarterly	Semi-Annually	Annually	Three Years	Five Years
Confirm the alignment to verify there has not been significant physical movement. *Note: this is automatically monitored as well.*	✓	✓		✓		
Download data from detector hard drive and delete old files to free space, if needed.	✓	✓		✓		
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓	✓		✓		
Change out the IR source.						✓
Realign system after service.		✓		✓		
Check system performance indicators.		✓		✓		
Perform bump test.		✓				
Review and test light and signal levels. Check average light intensity to establish baseline for IR Source change frequency and retroreflector wear.				✓		
Verify system settings.		✓				
Replace cryocooler or swap detector module assembly.					✓	

3.1.4 Visibility Instruments

For the visibility instruments, monthly maintenance includes inspecting the sensor for dirt, spider webs, birds' nests, or other obstructions. If the sensor is dirty, the glass windows can be cleaned with glass cleaner. There are no serviceable components in the sensor.

The sensors are calibrated in the field using a manufacturer-specific calibration kit. A calibration kit consists of a blocking plate or block for checking the sensor zero and a scatter plate for checking the sensor span. The calibration fixture is assigned a factory-traceable extinction coefficient (EXCO) used to calculate the expected values during calibrations. Calibrations will be performed every six months or as specified by a manufacturer.

3.2 Data Management Operations

Raw data management occurs on a daily, monthly, quarterly, and annual basis. On a daily basis, data are transferred from infield instruments through a data acquisition system (DAS) to a Data Management System (DMS) using cell modem in real-time. Data are also stored onsite on instrument computers in case of cell modem failure.

The DMS can handle the large volumes of data that will be generated in this project. DMS will be used to automatically quality control data, detect outliers and problems, and create alerts. The auto-screening and graphical capabilities will be used for continuous examination of data quality. The DMS will feed auto-screened data to the field operations website and notification system to inform project and facility staff. The operations website will show maps and time series plots of the pollutants, winds, and visibility data. The auto-QC'd air quality data will be fed to the public website (see Section 3.2.2) in near-real time. The DMS data will be backed up on a daily basis.

3.2.1 QA/QC

All data values that are not associated with bump tests or other instrument maintenance will be displayed to the public in near-real time (i.e., about 10 minutes or less). If data are subsequently proven to be invalid, they will be removed from the public display, and the rationale for data removal will be provided.

A non-public field operations website will be used for daily graphical review of the data (an example is provided in Figure 14). Common data problems include flat signal/constant values, no signal/missing data, extremely noisy signal, rapid changes (spikes or dips), and negative concentrations (see annotated Figure 15 for some examples). An initial review, typically of a three-to five-day running time-series plot of selected parameters for each instrument, allows the analyst to see common problems and verify instruments are operational. If it appears that an instrument is not operating, or the data are missing, the field operator will be notified and further investigation and corrective action, if needed, will be taken.

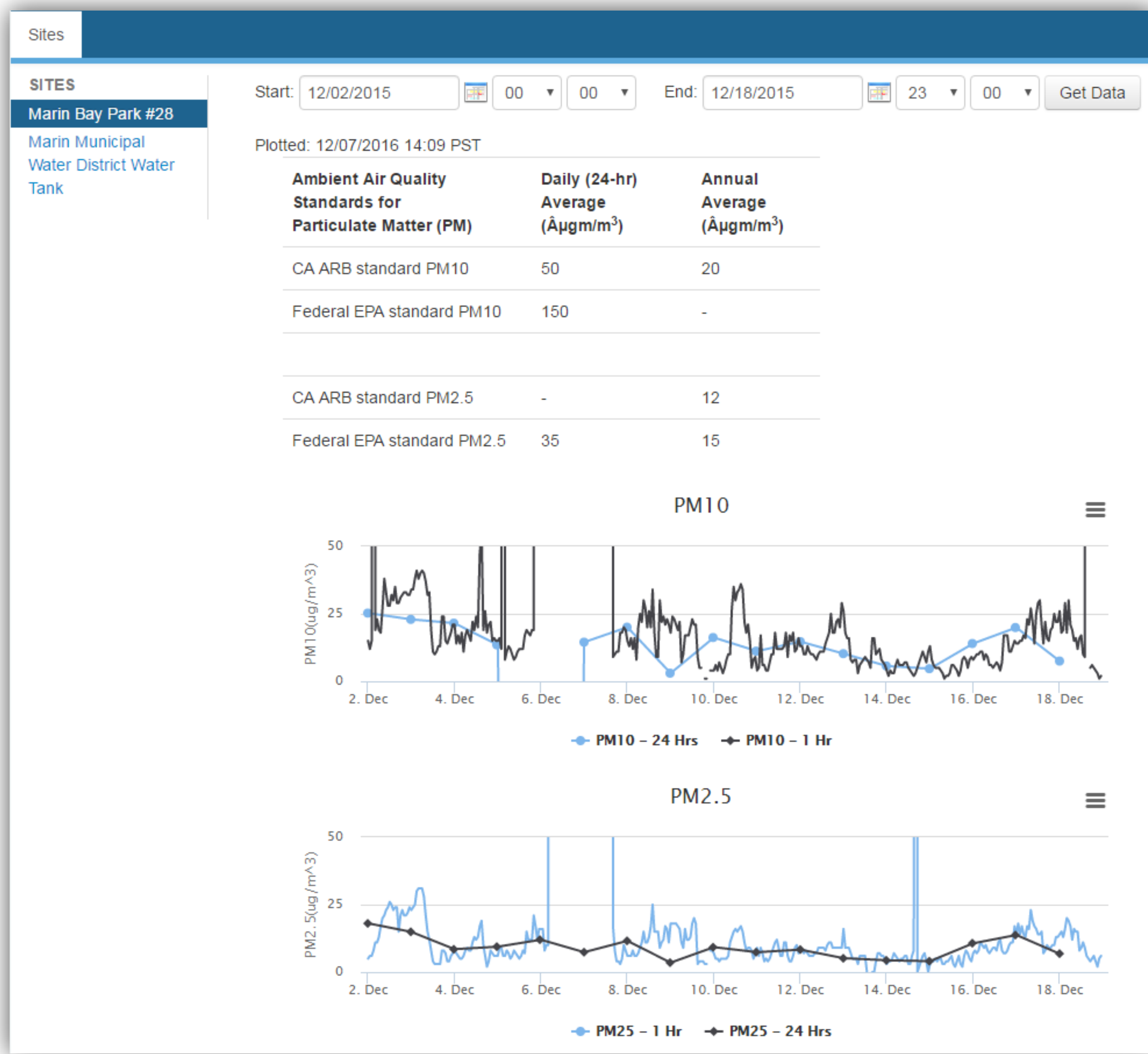

Figure 14. Example of a non-public field operations website used for daily review of instrument operations.

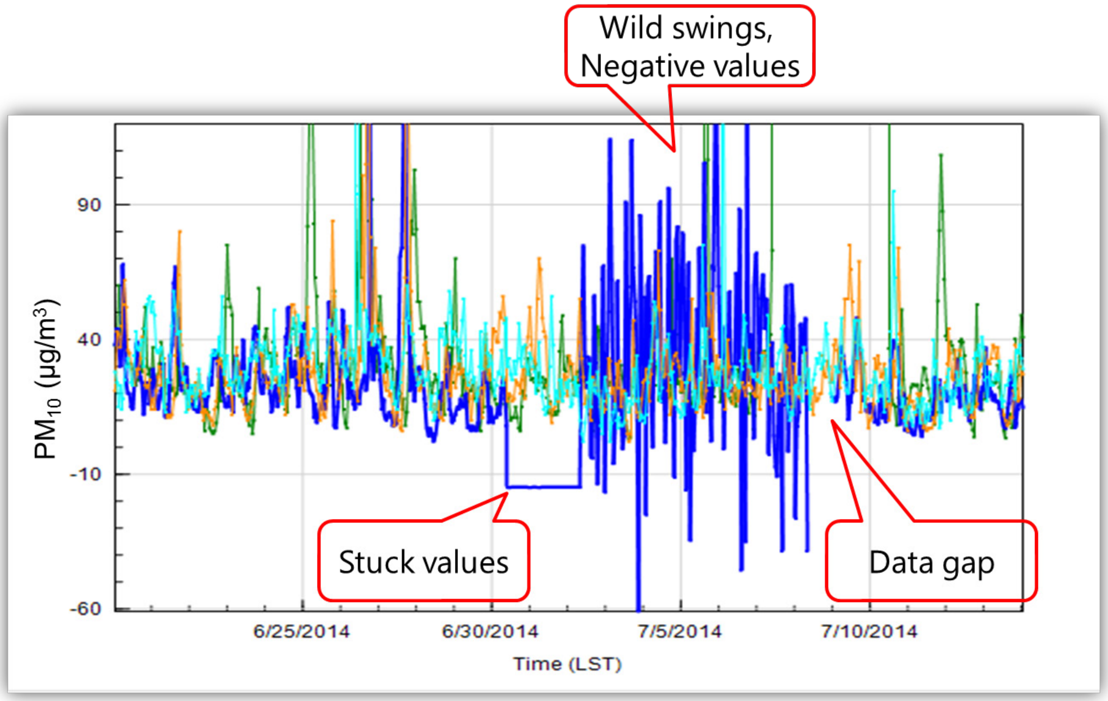

Figure 15. Example of species concentration time series showing stuck values, wild swings, large negative values, and a data gap. Such features in the data indicate instrument issues.

Once it is clear that instruments are operational, the next step will be to review whether the species concentration patterns are reasonable with respect to the time of day, season, meteorology, facility operations, and concentrations are expected and observed at other sites. If anomalies are observed, additional analysis will be conducted to determine whether there is an instrument malfunction or the data are truly anomalous, but explainable and valid.

Visual review of data will be augmented by automated data screening within the DMS upon data ingest. Automated screening checks of data feeds are helpful to focus the analyst's efforts on the data that need the most attention and are used to screen out invalid data. Initial screening checks, along with actions to be taken, are summarized in Table 7. Please note, some screening criteria are below the expected MDL of the instruments, in which case the MDL will be used. The screening check concentration criteria are based on an analysis of expected instrument performance, concentration levels of concern by species, and typical ambient concentrations by species. Screening criteria (flags and rates of change) are preliminary and will be refined during the project based on actual observations and instrument performance. In summary, the DMS auto-screening checks that will be used include:

- Range – These checks will ensure the instrument is not reporting values outside of reasonable minimum and maximum concentrations.
- Sticking – If values are repeated for a number of sampling intervals, data will be reviewed for validity. Typically, four or more intervals of sticking values are a reasonable time span to

indicate that investigation is needed. Sticking checks will not be applied to data below the instrument detection limit.

- **Rate of Change –** Values that change rapidly without reasonable cause will be flagged as suspect and reviewed.
- **Missing –** If data are missing, data during those time periods will be marked as missing.
- **Sensor OP codes and alarms –** If the instrument assigns operation (OP) codes to data automatically (e.g., for bump tests, internal flow rate checks), the data will be reviewed, op codes confirmed, and data flags checked.

Additional QC checks for the instruments are summarized in **Table 8**. Data that fail checks will be flagged in the DMS and brought to the attention of the reviewer. Data are invalidated only if a known reason can be found for the anomaly or automated screening check failure. If the data are anomalous or fail screening, but no reason can be found to invalidate the data, the data are flagged as suspect. Additional analysis may be needed to deem data valid or invalid. Common reasons for invalidation include instrument malfunction, power failure, and bump test data that were not identified as such. As the measurements progress over time, Tesoro will update and refine the screening checks. Screening checks are typically specific to the site, instrument, time of day, and season, and adjusted over time as more data are collected.

Table 7. Initial screening checks for 5-minute data. Valid and suspect data values will be displayed to the public in real time. If they are subsequently proven invalid, they will be removed from the public display. Screening values (flags and rates of change) presented herein should be considered as preliminary and may be refined either during the project implementation or after the instruments have been deployed.

Measurement (units)	MDL	Range	Checks				
			Sticking	Rate of Change Between Intervals	Missing	Sensor OP Code or Alarm	Visibility
Benzene (ppb)	If below MDL, flag as below MDL	If above 24 ppb, flag as suspect and conduct investigation on validity	If same value observed for four or more intervals, flag as suspect and conduct investigation on validity (SAME FOR ALL POLLUTANTS)	If value changes by more than 12 ppb, flag as suspect and conduct investigation on validity	If data are missing, flag as missing and investigate cause (SAME FOR ALL POLLUTANTS)	If sensor indicates malfunction or bump test data, flag as appropriate (SAME FOR ALL POLLUTANTS)	If visibility is less than 1,000 m and data are missing, flag as appropriate (SAME FOR ALL POLLUTANTS)
Toluene (ppb)		If above 100 ppb, flag as suspect and conduct investigation on validity		If value changes by more than 50 ppb, flag as suspect and conduct investigation on validity			
Ethylbenzene (ppb)		If above 100 ppb, flag as suspect and conduct investigation on validity		If value changes by more than 50 ppb, flag as suspect and conduct investigation on validity			
Total Xylene (ppb)		If above 100 ppb, flag as suspect and conduct investigation on validity		If value changes by more than 50 ppb, flag as suspect and conduct investigation on validity			

Measurement (units)	MDL	Range	Checks				
			Sticking	Rate of Change Between Intervals	Missing	Sensor OP Code or Alarm	Visibility
H_2S (ppb)	If below MDL, flag as below MDL	If value above 30 ppb, flag as suspect and conduct investigation on validity[a]	If same value observed for four or more intervals, flag as suspect and conduct investigation on validity (SAME FOR ALL POLLUTANTS)	If value changes by more than 8 ppb, flag as suspect and conduct investigation on validity	If data are missing, flag as missing and investigate cause (SAME FOR ALL POLLUTANTS)	If sensor indicates malfunction or bump test data, flag as appropriate (SAME FOR ALL POLLUTANTS)	If visibility is less than 1,000 m and data are missing, flag as appropriate (SAME FOR ALL POLLUTANTS)
SO_2 (ppb)		If value above 37.5 ppb, flag as suspect and conduct investigation on validity		If value changes by more than 19 ppb, flag as suspect and conduct investigation on validity			
NH_3 (ppb)		If value above 50 ppb, flag as suspect and conduct investigation on validity		If value changes by more than 25 ppb, flag as suspect and conduct investigation on validity			

Measurement (units)	MDL	Range	Checks				
			Sticking	Rate of Change Between Intervals	Missing	Sensor OP Code or Alarm	Visibility
1,3 – Butadiene (ppb)	If below MDL, flag as below MDL	If value above 9 ppb, flag as suspect and conduct investigation on validity	If same value observed for four or more intervals, flag as suspect and conduct investigation on validity (SAME FOR ALL POLLUTANTS)	If value changes by more than 4.5 ppb, flag as suspect and conduct investigation on validity	If data are missing, flag as missing and investigate cause (SAME FOR ALL POLLUTANTS)	If sensor indicates malfunction or bump test data, flag as appropriate (SAME FOR ALL POLLUTANTS)	If visibility is less than 1,000 m and data are missing, flag as appropriate (SAME FOR ALL POLLUTANTS)
Hexane (ppb)		If value is above 200 ppb, flag as suspect and conduct investigation on validity		If value changes by more than 100 ppb, flag as suspect and conduct investigation on validity			
Visibility (meters)	If value less than 0, flag as suspect		Not applicable	Not applicable			Not applicable

[a] If the MDL is higher than 30 ppb, the MDL will be used as the screening criterion; the currently available measurement technology for H_2S has an MDL greater than 30 ppb.

Table 8. Instrument QA/QC checks.

QA/QC Checks	Frequency	Acceptance Criteria
UV-DOAS		
Bump test (accuracy)	Quarterly and after major service	±20%
Baseline stability	Continuous	±5%
Single beam ratio test (strength of UV source)	Real-time	*To be determined*
Single point bump test in field	Quarterly	±20%
Measurement quality (R2)	Continuous	0.7 to 1.0
Integration time	Continuous	80-200 mS *400 mS integration time results in a warning notification*
Signal intensity	Continuous	>30% *Signal intensity below 30 results in a warning notification*
TDLAS		
Multi-point bump test	Quarterly	±20%
FTIR		
Bump test	Quarterly and after major service	±20%
Baseline stability	Continuous	±5%
IR single beam ratio test (background vs. sample intensity)	Real-time	*To be determined*
Measurement quality (R2)	Continuous	0.7 to 1.0
Signal intensity	Continuous	>5% *Signal intensity below 5 results in a warning notification*

In addition to auto-screening and daily visual checks, data will be subjected to more in-depth review on a quarterly basis and when data fail screening. Final data sets will be compiled quarterly, 60 days after each quarter's end and will be provided to the BAAQMD. Tesoro will maintain a data record for five years consistent with Rule 12-15-502.

Any corrections or updates will be copied to the website. Validation checks will include:

- Looking for statistical anomalies and outliers in the data.
- Inspecting several sampling intervals before and after data issues, bump tests, or repairs.
- Evaluating monthly summaries of minimum, maximum, and average values.
- Ensuring data reasonableness by comparing to remote background concentrations and average urban concentrations.
- Referring to site and operator logbooks to see whether some values may be unusual or questionable based on observations by site operator.
- Ensuring that data are realistically achievable, i.e., not outside the limits of what can be measured by the instrument.
- Confirming that bump tests were conducted and were within specifications.

These in-depth analyses typically require data that are not available in real time and ensure that the data on the website are updated.

On a quarterly basis, to ensure daily QC tasks are complete, analysts will:

- Review any instrument bump test results.
- Verify that daily instrument checks were acceptable.
- Review manual changes to operations/data, and verify that the changes were logged and appropriately flagged.
- Ensure that daily bump tests or instrument checks have the appropriate QC codes applied.

On a quarterly basis, analysts will subject the data to final QC including filling in missing records with null values, and adding Null Codes.

- If a record is not created for a particular site/date/time/parameter combination, a null record will be created for data completeness purposes.
- Invalid data will have a Null Code, or in other words, a reason for being invalid.
- Inspect data consistency over three months.
- Review ranges of values for consistency—ranges should remain consistent over months of monitoring.
- Check bump test values for consistency.
- Review data completeness.

Actions will be documented to retain the raw data and support traceability of actions taken to produce the data on the website. Additional details on the final QC process are provided in the QAPP (Appendix A).

On an annual basis, Tesoro or its designated contractor will review the performance of the network by reviewing the data completeness by monitoring path, instrument, and species; by reviewing results of bump tests; by analyzing the reported values in the context of refinery operations; and by analyzing the data in the context of the meteorology. The results will be summarized in a technical memorandum and provided to the BAAQMD upon request.

Data flagged through auto-screening checks (discussed in Section 3.2.1) will be graphically reviewed, and QC flags will be updated as needed with daily, monthly, and quarterly actions (see Figure 16) and the QC flags will be updated on the public website as needed. DMS keeps track of data QC changes.

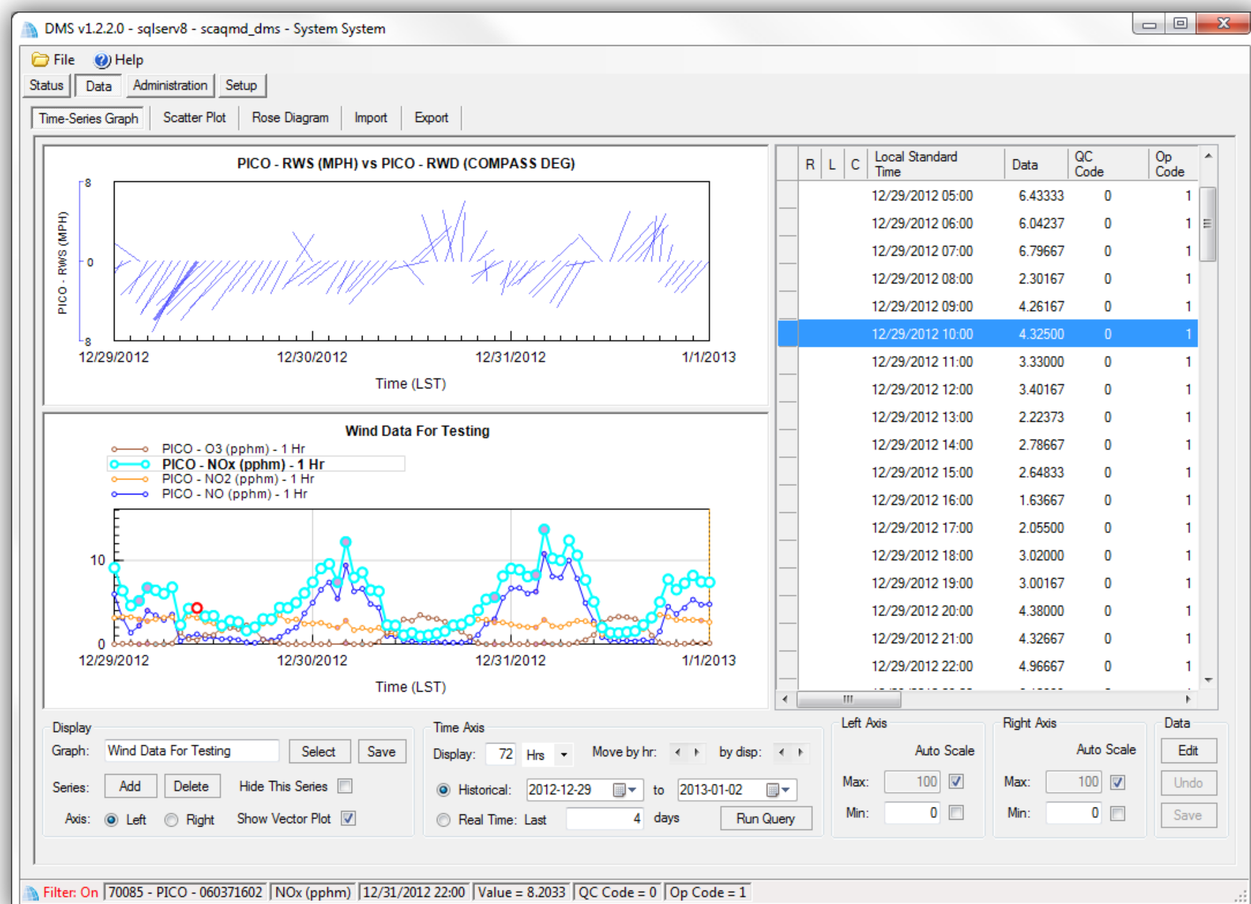

Figure 16. Screenshot of a typical DMS showing winds and species concentrations. Actual screen(s) may vary.

3.2.2 Public Data Availability and Display

Data are screened in real time upon upload into the DMS, as described in previous sections. Automated procedures will be used to ensure that data are properly uploaded, stored, processed, and quality-assured, and that products are delivered to a public-facing website in near-real time, defined here as 10 minutes or less after data collection.

For the public website, key components include visual display of data in near-real time, context for the public to better understand the concentrations displayed, a mechanism for feedback on the website, and a mechanism for requesting data for further exploration.

The preliminary quality-controlled data will be presented as time series of species concentrations, visibility, and wind speed and direction. Data will be provided as 5-minute averages. Data will be color-coded and annotated for quality (valid, invalid, suspect, missing). In the event that high concentration levels occur, Tesoro will follow its existing procedures to determine whether any additional information needs to be provided to the public.

An example of a public-facing website that allows users to explore 1-minute data is shown in Figure 17. It may also be useful to show the data in a map format showing wind direction, which further helps to explain observed concentrations. Web design will be finalized at a later date.

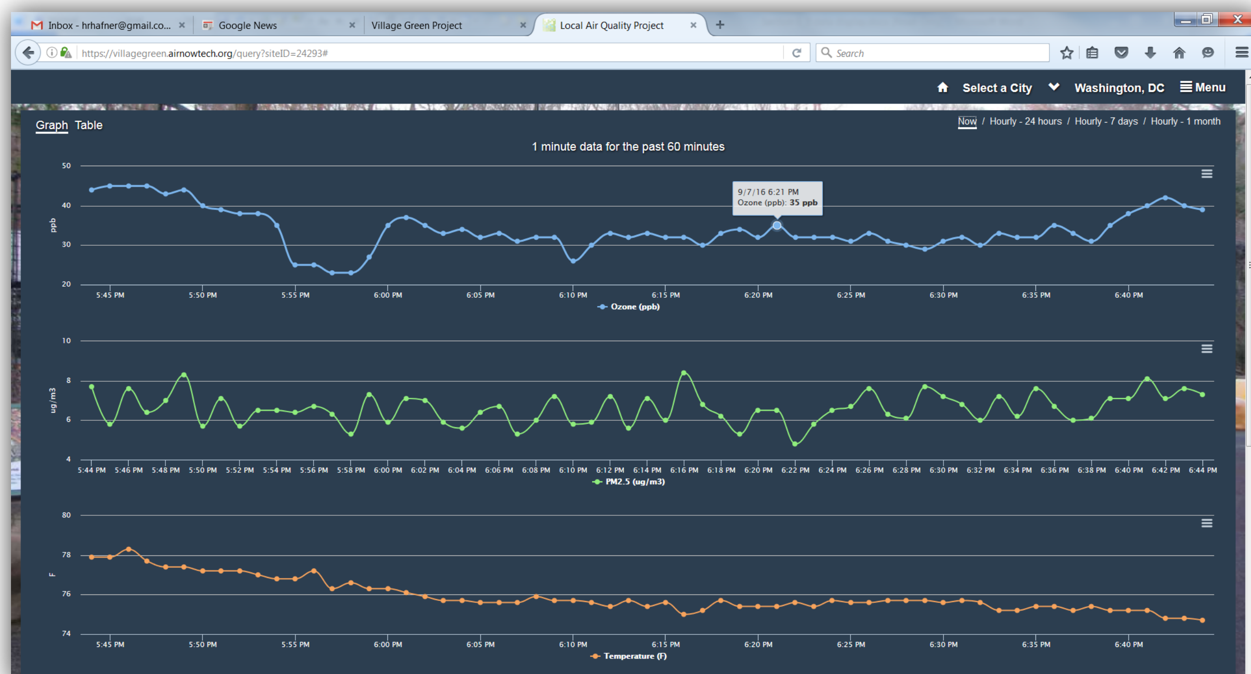

Figure 17. Example of a typical public-facing web page.

The data to be collected are high time resolution, spatially variable, and chemically complex. To provide context to this complex data set for the public, the following information will be included through a combination of links, graphics, or captions:

- Information about the species measured and the measurement techniques.
- Context of what fenceline measurements represent as compared to other regional air quality measurements. This will include a discussion of: (1) species that are measured at the fenceline vs. regional monitors; (2) near-source vs. regional ambient air measurements; (3) the difference between open-path and point measurements; (4) 5-minute fenceline data versus longer time-averaged data that are collected by regional monitors; and (5) discussion of typical background concentrations.
- Discussion of levels of concern, with links to third-party sources such as the Office of Environmental Health Hazard Assessment website on the health effects of each species.
- Discussion of non-refinery sources that could affect the measured concentrations.
- Definitions of abbreviations.
- Discussion of data below MDL.
- Definition of data QC flags and their meaning.
- Frequently asked questions (FAQs; *to be developed over time).*
- Quality procedures.

Information will be written at a public-friendly level with links to additional resources for members of the public who want to delve deeper into the science. Clarity and thoroughness will help to reduce the number of questions that arise.

To facilitate public feedback, a feedback button will be provided on the web page. When a user clicks on the button, an email form will pop up for the user to submit comments about the website. The email will be delivered to a Tesoro contact responsible for deciding how to respond to the public comments. The emails received through the website will be archived. Although not all comments have to be addressed, they will be made available to BAAQMD upon request. Some of the comments will aid in the creation of FAQs.

Appendix A
Quality Assurance Project Plan

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1. Project Background and Management

1.1 Background

1.1.1 Purpose

Tesoro Refining & Marketing Co., LLC (Tesoro) plans to monitor fenceline concentrations of certain compounds at the Tesoro Martinez Refinery in Martinez, California, in compliance with the Bay Area Air Quality Management District's (BAAQMD) Regulation 12, Rule 15 (Rule 12-15) and consistent with the BAAQMD's Air Monitoring Guidelines for Petroleum Refineries.[1,2] Rule 12-15 requires monitoring for specific air compounds, with data reported to the public.[3]

1.1.2 Rationale

Rule 12-15 requires fenceline monitoring of multiple compounds using "open-path technology capable of measuring in the parts-per-billion range regardless of path length" or an alternative measurement technology.[2] Tesoro has proposed to conduct open-path pollutant monitoring, in addition to visibility and meteorological measurements, to meet the regulations.

This document is a quality assurance project plan (QAPP), which documents the actions that the project team will take to ensure that the data collected are of the highest quality.

1.2 Roles and Responsibilities

This project combines refinery staff, contractors, and quality-assurance, field, and website personnel. Figure 1 shows an organization chart for the project.

[1] Petroleum Refining Emission Tracking (Rule 12-15; approved by the BAAQMD on April 20, 2016).
[2] Bay Area Air Quality Management BAAQMD (2016) Air Monitoring Guidelines for Petroleum Refineries. April 2016. Available at baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.
[3] The exact timing for the start of fenceline monitoring depends on when this monitoring plan is approved by the BAAQMD.

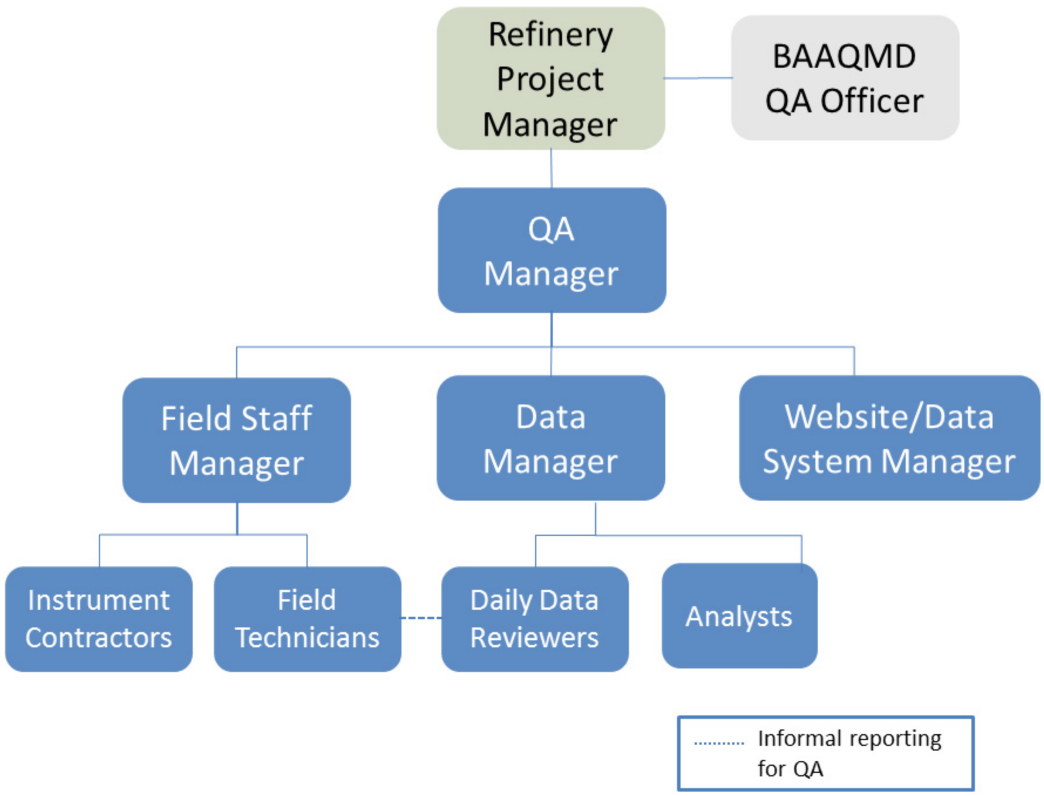

Figure 1. Organizational chart for this project.

The overall project will be run by a **Project Manager** appointed by the refinery. This PM acts as the central point of contact for the BAAQMD and the QA manager. The PM is responsible for overseeing the project and reporting directly to the BAAQMD.

The **QA Manager** is responsible for ensuring the quality of data collected in this project. The QA Manager oversees data collection and review, provides QA oversight during the study, and oversees and reports on QA activities to the Refinery PM and BAAQMD QA Manager. The QA Manager oversees daily data review and data management, works with the Field Staff Manager to ensure that any data issues are addressed by the field technicians promptly, and works with the Website Manager to ensure that data provided to the public are of high quality.

The **Field Staff Manager** ensures that field technicians (site operators) are meeting the requirements of the project. The Field Staff Manager coordinates staff coverage and serves as a technical resource for site measurements.

Field Technicians/Site Operators perform instrument maintenance. The technicians ensure that all measurements are collected in accordance with SOPs, standard methods, and regulations, where applicable. Technicians perform the required quality checks on instruments and document all work in site logs.

The **Instrument Contractors** provide technical support for the instruments deployed in the field.

The **Data Manager** is responsible for ensuring that daily data review is conducted, data that fail auto-screening are inspected, and data validation follows the proper schedule and procedures. The Data Manager is also responsible for delivering the validated data to the PM.

Daily data review and data validation are conducted by experienced air quality analysts. The **Data Reviewers** communicate with the Data Manager when there are issues and may also interact with the Field Technicians when they notice an issue that needs to be addressed.

The **Website/Data System Manager** is responsible for properly displaying data on the website, managing inquiries from the public, and ensuring that validated data graphs are available for download on a quarterly basis. Automated alerting will notify the Website/Data System Manager when the real-time data are not available on the website. This manager will be responsible for assessing and fixing data communication and other information technology–related issues concerning the website and data system.

2. Measurements

2.1 Instrument Selection and Descriptions

The compounds to be measured are benzene, toluene, ethylbenzene, xylenes (BTEX), and H_2S, as well as 1,3-butadiene, hexane, SO_2, and NH_3. These compounds will be measured at a 5-minute resolution. Because of the distances that need to be covered by measurements (hundreds of meters), data time-resolution requirements (5 minutes), and current measurement technology, open-path instruments (UV-DOAS, TDLAS, and FTIR) were selected.

Along all measurement paths (see Section 2.2.1), BTEX and SO_2 will be measured by monostatic *Ultra Violet-Differential Optical Absorption Spectroscopy* (*UV-DOAS*) with a xenon light source. The xenon light is required to achieve measurements over paths that are about 300 to 600 meters long and to achieve the minimum detection limits (MDL) for BTEX. The analyzer records the intensity of light at discrete wavelengths. Any UV-absorbing gas that is present in the beam absorbs at a specific wavelength of light. Each species of gas has a unique absorbance fingerprint (i.e., the ratios between the absorbance at several different wavelengths are unique to that gas). The analyzer compares regions within the sample absorbance spectra to the same regions within the reference absorbance spectra. The analyzer uses a classical least squares regression analysis to compare the measured absorption spectrum to calibrated reference absorption spectra files. Beer's Law is used to report gas concentrations. Though not written specifically for UV-DOAS, this approach is the same as that specified in the Environmental Protection Agency's (EPA) TO-16 Methodology.[4] Closeness of fit is indicated by the correlation coefficient (R^2) of agreement between the measured spectra and the reference spectra. The R^2 is provided with each concentration so that interference can be detected if it is present. Selection of regions of analysis that are free of absorbance due to other gases within the sample is the primary means of avoiding cross-interference. Spectral subtraction is used in cases with overlapping absorbance features; the subtraction technique is proprietary to the instrument manufacturer.

Along all measurement paths, H_2S will be measured by monostatic *Tunable Diode Laser Absorption Spectroscopy (TDLAS)* instruments. For H_2S, manufacturers report that the TDLAS has detection limits on the order of 200 ppb for path lengths of about 500 meters; however, its actual minimum detection limit will depend on atmospheric conditions and on the specific instrument used.

Hexane, NH_3, and 1,3-butadiene will be measured with a *Fourier Transform Infrared spectroscopy (FTIR)* instrument. The FTIR operates by sending a beam of infrared light through the open air. The IR beam is reflected back to the analyzer by a retro-reflector array (monostatic), where the absorption due to target gases is measured and recorded. The analyzer uses a classical least squares regression

[4] Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Compendium Method TO-16. Long-Path Open-Path Fourier Transform Infrared Monitoring Of Atmospheric Gases (1999) EPA/625/R-96/010b.

analysis to compare the measured absorption spectrum to calibrated reference absorption spectra files according to the EPA's TO-16 Methodology. Beer's Law is used to report accurate gas concentrations. The FTIR operates on a similar premise as the UV-DOAS by using reference spectra. There are a variety of industry standard methods to mitigate interference from both water vapor and interference gases, including spectral subtraction, path length adjustments, and selecting isolated absorbance peaks for the gases of interest. Proprietary methods include multi-peak analytics.

Heavy fog may entirely block the signal from an open-path instrument and prevent data collection; however, even light fog can absorb the signal partially and interfere with measurements. Tule fog forms when there is high relative humidity (typically after rain), light wind, and rapid cooling. Visibility measurements will be made at one representative location.

Table 1 summarizes the MDL and upper detection limits (UDL) for each species by instrument. The MDL is the lowest path-average concentration that can be measured at the path length, and the UDL is the highest path-average concentration that can be measured at that path length. Detection limits are approximate and are based on the theoretical capabilities of the instruments; however, they are supported by manufacturers' lab tests and real-world applications. Again, actual detection limits will depend on atmospheric conditions and on the specific instrument used. The detection limits are for the average species concentration along a path; narrow plumes that only cover a portion of the path would need to have a higher concentration than the MDL to be detected.

Table 1. Anticipated open-path instrument detection limits by technology, species, and path length. TDLAS MDLs for H_2S are less certain; thus, only an estimate of MDL is provided.

Open Path Analyzer Technology Summary: Approximate Detection Limits									
Path		Path 1		Path 2		Path 3		Path 4	
Approximate Distance		707 meters		657 meters		629 meters		720 meters	
Technology	Compound	MDL PPB	UDL PPB	MDL PPB	UDL PPB	MDL PPB	UDL PPB	MDL PPB	UDL PPB
FTIR	1,3-Butadiene	2.6	873.1	2.8	939.5	2.9	979.8	2.6	857.3
	Ammonia	0.2	707.2	0.2	761.0	0.2	793.7	0.2	694.4
	Hexane	2.1	693.3	2.1	711.5	2.0	661.5	2.5	833.7
TDLAS	Hydrogen Sulfide	200	70721.4	200	76103.5	200	79365.1	200	69444.4
UV-DOAS	Benzene	0.2	10866.8	0.2	11693.8	0.2	12194.9	0.2	10670.6
	Toluene	1.7	6168.5	1.8	6637.9	1.9	6922.4	1.7	6057.1
	Ethylbenzene	1.3	1311.6	1.4	1411.4	1.5	1471.9	1.3	1287.9
	Total Xylenes	3.3	4997.6	3.6	5378.0	3.7	5608.5	3.2	4907.4
	Sulfur Dioxide	4.7	3079	4.9	3159	4.5	2937.5	5.7	3701.8

Notes: Actual detection limits will depend on ambient conditions and final selection of instrument vendor. A lower MDL TDLAS for monitoring of H_2S is being developed by a manufacturer and may be available in late summer 2017.

2.2 Monitor Siting Overview

2.2.1 Rationale

Tesoro proposes to monitor concentrations across four open paths (shown in **Figure 2**). The refinery selected these locations after consideration of dominant wind patterns, sources of potential air emissions on the refinery property, nearby local receptors, and logistical feasibility. Transmitter-detectors will be located at sites 1s, 2e, 3n, and 4n (identified in Figure 2), and retro-reflectors will be placed at the remaining identified sites at 1n, 2w, 3s, and 4s. The following explanation provides the rationale that Tesoro used in selecting the open-path monitoring locations identified in Figure 2:

- Path 1 is positioned between the refinery's main processing block and the community of Clyde. Clyde is further than 1 mile from the eastern fenceline and even further from any emission sources, and Rule 12-15 requirements therefore do not apply. However, Tesoro considers that the community is directly east and downwind from the refinery's main processing block during wind conditions that predominate in the region (i.e., winds blowing from the west to the east).
- Path 2 is positioned between the refinery's main processing block, storage tanks, and the occupied areas of Concord toward the southeast: the Concord-Northwood residential community, the Sun Terrace neighborhood, and a zone of light industry and office parks that borders the south and eastern sides of the Mallard Reservoir. While wind blowing from the refinery in this direction is infrequent, Tesoro recognizes that these receptor areas are close to the refinery and proposes to establish monitoring on Path 2.
- Paths 3 and 4 are important when winds blow from the northeast to southwest. Northeasterly winds are infrequent; however, they occasionally occur during the winter.
  - Path 3 lies between a battery of crude oil storage tanks and residential neighborhoods of Martinez off north Blum Road.
  - Path 4 lies between the refinery's main center of processing operations and the Vine Hill neighborhood of Martinez.

A visibility monitor will be located either on or near the GER meteorological station (Figure 2).

H_2S and BTEX emissions are distributed across the refinery property, and these species will be measured along all four of the proposed open pathways. Sources of NH_3 and 1,3-butadiene are present only near the refinery's main processing block; therefore, given the annual and seasonal wind patterns, measurements of these species are proposed only along Path 1 and Path 4. Hexane will also be measured along Path 1 and Path 4 because hexane measurements will be available from the same instruments used to measure NH_3 and 1,3-butadiene, and hexane is a good surrogate for all alkanes.

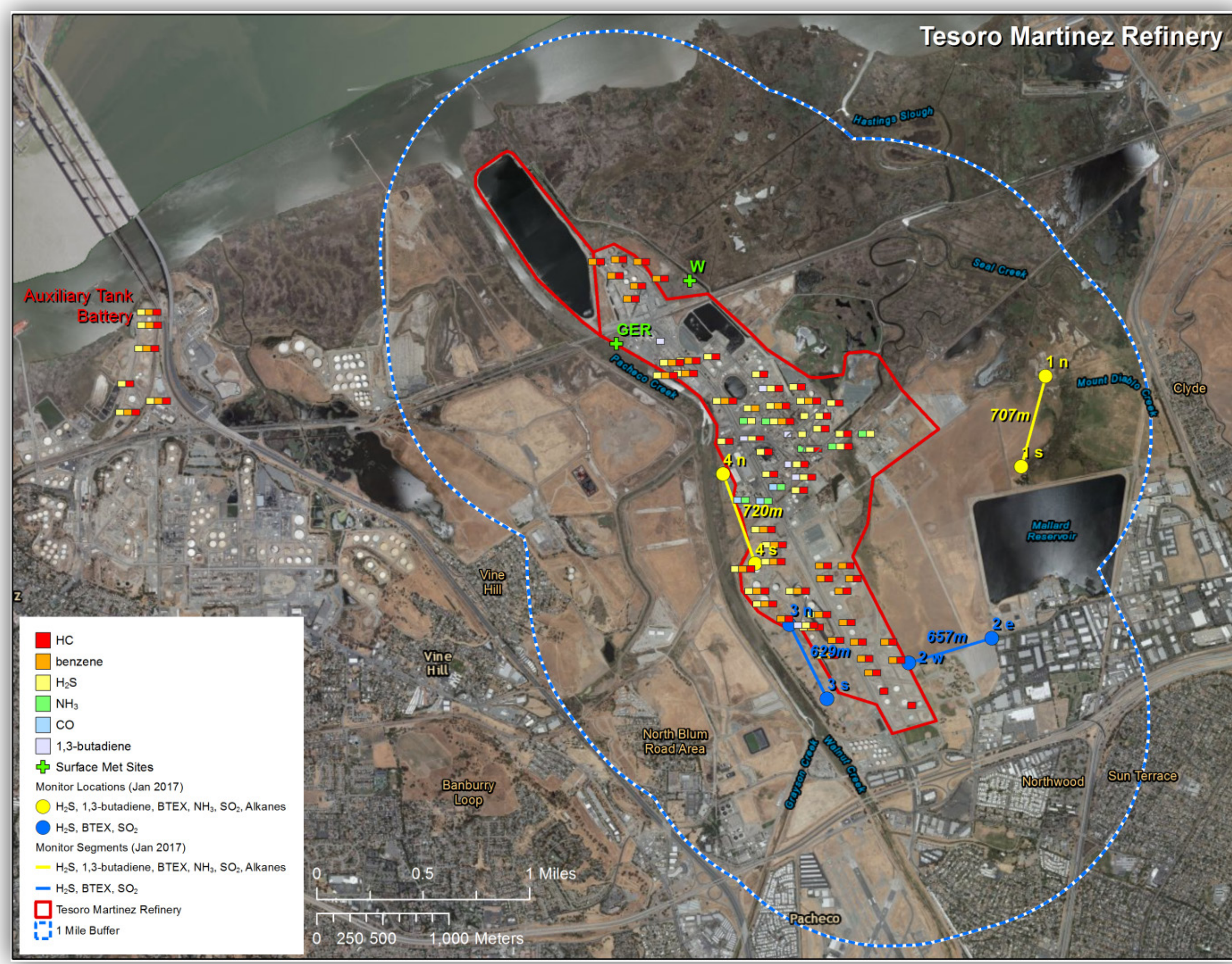

Figure 2. Proposed open-path monitoring sites for the Tesoro Martinez Refinery. (Four proposed paths are identified, labeled 1n-1s, 2e-2w, 3n-3s, and 4n-4s.)

2.3 Instrument Operations and Maintenance

Four instrument systems are included in this project: UV-DOAS, TDLAS, FTIR, and visibility measurements. Other meteorological data will be obtained from existing measurements at the refinery. Quality assurance is built into operations and maintenance. For all instruments, scheduled maintenance will occur monthly, quarterly, and/or annually. Emergency maintenance will occur as needed when problems are identified during daily data review and auto-screening of real-time data.

2.3.1 UV-DOAS

The UV-DOAS system is designed to require only modest service and maintenance. Table 2 summarizes typical UV-DOAS maintenance activities as recommended by the manufacturer. These actions help ensure data integrity and maximize up-time.

Table 2. Schedule of maintenance activities for the UV-DOAS.

Activity	Monthly	Quarterly	Annually
Visually inspect the system.	✓	✓	✓
Inspect optics on detector and retro-reflector; clean if necessary.	✓	✓	✓
Inspect system filters.	✓	✓	✓
Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.	✓	✓	✓
Download data from detector hard drive and delete old files to free space, if needed.	✓	✓	✓
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓	✓	✓
Change out the UV source.		✓	
Replace ventilation exit and intake filters.		✓	
Clean optics on detector and retro-reflector.		✓	
Realign system after service.		✓	✓
Check system performance indicators .		✓	✓
Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit.		✓	
Review and test light and signal levels. Check average light intensity to establish baseline for bulb change frequency.		✓	✓
Verify system settings.			✓

2.3.2 TDLAS

Maintenance activities for the TDLAS and the UV-DOAS are similar. The TDLAS system is also designed to require only modest service and maintenance. Table 3 summarizes TDLAS maintenance activities, as recommended by the manufacturer. Depending on the TDLAS brand, bi-annual calibration at the factory may be performed.

Table 3. Schedule of maintenance activities for the TDLAS.

Activity	Monthly	Quarterly	Annually
Visually inspect the system.	✓	✓	✓
Inspect optics on detector, clean if necessary.	✓	✓	✓
Check the alignment to verify there has not been significant physical movement.	✓	✓	✓
Download data from detector hard drive and delete old files to free space, if needed.	✓	✓	✓
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓	✓	✓
Check system performance indicators.		✓	✓
Perform bump test.		✓	
Review and test light and signal levels.		✓	✓
Verify system settings.			✓

2.3.3 FTIR

Maintenance activities for the FTIR and the UV-DOAS are similar. The FTIR system is also designed to require only modest service and maintenance. Table 4 summarizes FTIR maintenance activities, as recommended by a typical manufacturer. Preventative maintenance frequency depends on the operating environment and may need to be adjusted. On an as-needed basis, system status alarms may alert operators to specific issues that need to be addressed. Bump tests are performed on site.

Table 4. Schedule of maintenance activities for the FTIR.

Activity	Monthly	Quarterly	Semi-Annually	Annually	Three Years	Five Years
Visually inspect the system.	✓	✓		✓		
Inspect and clean AC system exterior heat sink.			✓			
Inspect and clean AC system interior heat sink.				✓		
Confirm the alignment to verify there has been no significant physical movement. [a]	✓	✓		✓		
Download data from detector hard drive and delete old files to free space, if needed.	✓	✓		✓		
Ensure there are no obstructions between the detector and the retro-reflector (such as equipment, vegetation, vehicles).	✓	✓		✓		
Change out the IR source.						✓
Realign system after service.		✓		✓		
Check system performance indicators.		✓		✓		

Activity	Monthly	Quarterly	Semi-Annually	Annually	Three Years	Five Years
Perform bump test.		✓				
Review and test light and signal levels. Check average light intensity to establish baseline for IR Source change frequency and retro-reflector wear.				✓		
Verify system settings.		✓				
Replace cryocooler or swap detector module assembly.					✓	

[a] Note: this is automatically monitored as well.

2.3.4 Visibility

For the visibility instruments, monthly maintenance includes inspecting the sensor for dirt, spider webs, birds' nests, or other obstructions. If the sensor is dirty, the glass windows are cleaned with glass cleaner. There are no serviceable components in the sensor. Calibration will be performed semi-annually.

2.4 System Corrective Actions

Corrective action will be taken to ensure that data quality objectives are met. Table 5 lists the types of issues that require corrective actions. (This table is not all-inclusive; additional checks may be added as the project progresses.) The daily data reviewers will review data to identify issues and will work with the field technicians and instrument contractors to resolve issues that need to be addressed on site.

Table 5. Potential sampling and data reporting problems and corrective actions.

Item	Problem	Action	Notification	Person Responsible
Erratic data	Possible instrument malfunction	Contact Field Manager and Instrument Contractor	Document in logbook, notify Field Manager	Field technician
Power	Power interruptions	Check line voltage, reset or restart instruments	Document in logbook, notify Field Manager	Field technician
Data downloading	Data will not transfer to the DMS	Contact Field Manager and Instrument Contractor	Document in logbook, notify Field Manager and Website/Data System Manager	Field technician
Supplies and consumables	Essential supplies run low	Contact Field Manager	Document in logbook, notify Field Manager	Field technician
Access to sites	Technician cannot access the sites	Contact Project Manager	Document in logbook, notify Project Manager	Field technician
Instrument Light level	A low light level alert is observed	Contact Instrument Manufacturer, replace bulb	Document in logbook, notify Field Manager	Field Technician
Website	Website is down	Contact Website/Data System Manager	Notify Project Manager	Website/Data System Manager

3. Quality Objectives and Criteria

3.1 Data and Measurement Quality Objectives

3.1.1 Discussion

To ensure success of field measurements, measurement performance or acceptance criteria are established as part of the monitoring design. These criteria specify the data quality needed to minimize decision errors based on the data. Data quality is defined in terms of the degree of precision, accuracy, representativeness, comparability, and completeness needed for the monitoring. Of these five data quality indicators, precision and accuracy are quantitative measures, representativeness and comparability are qualitative, and completeness is a combination of quantitative and qualitative measures.

To ensure appropriate spatial coverage of measurements, a thorough meteorological analysis was performed, as documented in the monitoring plan.

For all instrument/parameter combinations, data completeness requirements are provided in **Table 6**. Percent data recovery (or data capture) for 1-hr data is the percentage of valid 5-minute data values that were collected divided by 12. Percent data recovery for the day is the number of valid 1-hr values collected divided by 24. Percent data recovery for the calendar quarter is the number of days of valid data collected divided by the total number of days in the date range. For communication purposes, the Percent Data Valid—the percentage of data values that are valid divided by the number of captured data values, corrected for low-visibility conditions—will also be computed. The Rule allows for omission of time periods from the completeness calculation when atmospheric conditions prevented measurement, as proven using an independent measure of visibility.

Table 6. Data recovery requirements.

Completeness Requirement	Relevant to	Minimum No. of Values Needed
75% per hour	5-minute average data	9 per hour
75% per day	1-hr average data	18 per day
90% per calendar quarter	Daily data	81 days per 90-day quarter [a]

[a] The exact number of days in the quarter will be used; this example is for illustration only.

Other factors that affect data availability include instrument bump tests (approximately every quarter for a few hours), annual maintenance, and other maintenance (e.g., replacement of UV bulbs for the UV-DOAS after every 2,000 hours of use, roughly quarterly, replacement of the FTIR cryocoolers every 3 years). For the TDLAS, a backup system may be used (depending on brand) when each of the primary TDLAS instruments is returned to the manufacturer for factory calibration every two years. Regular maintenance and careful, responsive operation will minimize instrument downtime.

3.2 Precision Checks, Bump Tests, and Verification

For the UV-DOAS system, a bump test will be performed quarterly the first year or so and semi-annually in later years as high-quality, reliable system performance is confirmed. In the field, a bump test (simulates system-observed gas content at the required path average concentration) is used to verify that the system can detect at or below a set level of concern.

TDLAS calibration will be done at the factory before deployment. In the field, a bump test will be performed quarterly for the first year or so and semi-annually in later years as high-quality, reliable system performance is confirmed. During factory calibration, a back-up instrument may be used so that measurements continue.

For the FTIR, bump tests will be performed onsite quarterly the first year or so and semi-annually in later years as high-quality, reliable system performance is confirmed.

For the visibility instruments, the sensors are calibrated in the field using a manufacturer-specific calibration kit. A calibration kit consists of a blocking plate or block for checking the sensor zero and a scatter plate for checking the sensor span. The calibration fixture is assigned a factory-traceable extinction coefficient (EXCO) used to calculate the expected values during calibrations. Calibrations will be performed every six months or as specified by a manufacturer.

For the open-path systems, precision will be measured by evaluating the variance of pollutant concentrations during a period of low variability, when atmospheric influence on variability is assumed to be minimal. Five-minute data will be selected during periods of low variability, but when concentrations are well above the MDL. The precision can then be evaluated by calculating the coefficient of variation (CV) during the period of low variability, as shown in **Equation 1**. If there are no periods of low variability with concentrations above the MDL, bump test data will be used to calculate precision.

$$Precision \approx CV = \frac{\sigma_{measured}}{\overline{[conc]}_{measured}} \times 100\% \qquad \textbf{(1)}$$

where:

$$\sigma_{measured} = \sqrt{\frac{\sum\left([conc]_{measured} - \overline{[conc]}_{measured}\right)^2}{N-1}}$$

3.2.1 Instrument or Standards Certifications

For factory calibrations, upon initial purchase a certification of the standard gases used will be requested from the manufacturer. Also, the spectra background file version number used for signal processing will be documented.

4. Data Management

Data quality criteria are evaluated through (1) automatic data checks conducted through the data management system and (2) data review by trained analysts (daily data review and periodic, more thorough validation).

4.1 Data Acquisition and Communications

Raw data management occurs on a real-time, daily, monthly, quarterly, and annual basis. In near-real time, data are transferred from infield instruments through a data acquisition system (DAS) to a Data Management System (DMS) using cell modem. Data are also stored onsite on instrument computers in case of cell modem failure. The DMS uses a Microsoft SQL relational database with stored procedures. These raw data are not yet intended for the public website.

The DMS automatically quality-controls data, detects outliers and problems, generates reports, and creates alerts. The auto-screening and graphical capabilities will be used for continuous examination of data quality. The DMS will feed auto-screened data to the field operations website and notification system to inform/alert project and facility staff. The operations website will show maps and time series plots of BTEX, H_2S, 1,3-butadiene, hexane, and NH_3, winds, and visibility data.

The automatically QC'd air quality data will be fed to the public website ten minutes after collection.

4.2 Automated Data Screening

Automated data screening is conducted within the DMS upon data ingest. Automated screening checks of data feeds are used to screen out invalid data for public display and are helpful to focus the data reviewer's efforts on the data that need the most attention. Initial screening checks, along with actions to be taken, are summarized in Table 7. The screening check concentration criteria are based on an analysis of expected instrument performance, concentration levels of concern by compound, and typical ambient concentrations by compound. All screening criteria (flags and rates of change) are preliminary and will be refined during the project based on actual observations. The DMS auto-screening checks that will be used include:

- **Range.** These checks will verify that the instrument is not reporting values outside of reasonable minimum and maximum concentrations.
- **Sticking.** If values are repeated for a number of sampling intervals, data will be reviewed for validity. Typically, four or more intervals of sticking values are a reasonable time span to indicate that investigation is needed. Sticking checks will not be applied to data below the instrument detection limit.

- **Rate of Change.** Values that change rapidly without reasonable cause will be flagged and reviewed.
- **Missing.** If data are missing, data during those time periods will be coded as missing.
- **Sensor OP codes and alarms**. If the instrument assigns operation (OP) codes to data automatically (e.g., for bump tests or internal flow rate checks), the data will be reviewed, codes confirmed, and data flags checked.
- **Visibility impairment.** While the exact relationship between visibility and open-path measurements is not established, the expectation is that there would be no measurements when visibility is less than the twice the path length (two times the path length is used because the open-path sensor light travels to the mirror and back to the analyzer).

Additional parameters that may be monitored as indicators of data quality include data quality value for each concentration as reported by the instrument (i.e., correlation between measured and reference spectra), signal strength, wavelength versus intensity, and visual review of peaks. There are no previously set data quality objectives for these parameters; we will need to develop objectives for these parameters if we find that they are useful indicators for automated data quality screening or for data validation.

Data flags identified through auto-screening will be graphically reviewed during data validation (i.e., not in real time), and QC flags will be updated with daily and quarterly actions. DMS keeps track of data changes in its chain-of-custody feature—i.e., raw data are preserved as well as all changes.

Table 7. Initial screening checks for 5-minute data. All valid and flagged data values will be displayed to the public in real-time. If data are invalid, they will not be included in the public display. All screening values below (flags and rates of change) are preliminary and will be refined during the project. During data validation, flagged data will be further investigated.

Measurement (units)	MDL	Range	Checks				
			Sticking	Rate of Change Between Intervals	Missing	Sensor OP Code or Alarm	Visibility
Benzene (ppb)	If below MDL, flag as below MDL	If above 24 ppb, flag as suspect	If same value observed for four or more intervals, flag as suspect *(Same for all pollutants)*	If value changes by more than 12 ppb, flag as suspect	If data are missing, flag as missing *(Same for all pollutants)*	If sensor indicates malfunction or bump test data, flag as appropriate *(Same for all pollutants)*	If visibility is less than 1,000 m and data are missing, flag as appropriate *(Same for all pollutants)*
Toluene (ppb)		If above 100 ppb, flag as suspect		If value changes by more than 50 ppb, flag as suspect			
Ethylbenzene (ppb)		If above 100 ppb, flag as suspect		If value changes by more than 50 ppb, flag as suspect			
Total Xylene (ppb)		If above 100 ppb, flag as suspect		If value changes by more than 50 ppb, flag as suspect			
H_2S (ppb)		If value above 30 ppb or the MDL, flag data as suspect[a]		If value changes by more than 8 ppb, flag as suspect			
SO_2 (ppb)		If value above 37.5 ppb, flag as suspect		If value changes by more than 19 ppb, flag as suspect			

Measurement (units)	MDL	Range	Checks				
			Sticking	Rate of Change Between Intervals	Missing	Sensor OP Code or Alarm	Visibility
NH_3 (ppb)		If value above 50 ppb, flag as suspect	If same value observed for four or more intervals, flag as suspect *(Same for all pollutants)*	If value changes by more than 25 ppb, flag as suspect	If data are missing, flag as missing *(Same for all pollutants)*	If sensor indicates malfunction or bump test data, flag as appropriate *(Same for all pollutants)*	If visibility is less than 1,000 m and data are missing, flag as appropriate *(Same for all pollutants)*
1,3 – Butadiene (ppb)		If value above 9 ppb, flag as suspect		If value changes by more than 4.5 ppb, flag as suspect			
Hexane (ppb)		If value is above 200 ppb, flag as suspect		If value changes by more than 100 ppb, flag as suspect			
Visibility (meters)	If value less than 0, flag as suspect		Not applicable	Not applicable			Not applicable

[a] If the MDL is higher than 30 ppb, the MDL will be used as the screening criterion; the currently available measurement technology for H_2S has an MDL greater than 30 ppb.

4.3 Data Verification

4.3.1 Confirm Daily Operation

Operationally, data are reviewed daily by a data reviewer to assess instrument operation. This initial review, typically of a three- to five-day time-series plot of selected parameters for each instrument, allows the analyst to see common problems and verify instruments are operational. If it appears that an instrument is not operating, or the data are missing, the field operator will be notified and further investigation and corrective action, if needed, will be taken.

In addition to daily checks of the field website, an automated alerting system will let technicians and managers know when data have been missing for a specified period of time. Missing data may indicate a power issue, an instrument problem, or a data communication problem. The time period allowed for missing data will likely be adjusted as the project proceeds to reduce false or excessive alerting. The alerting will likely be set initially for 6 to 12 missing 5-minute values (i.e., 30 to 60 minutes).

4.3.2 Assess Data Reasonableness

Also operationally, the data reviewer quickly assesses whether the pollutant concentrations are reasonable with respect to the time of day, season, meteorology, and concentrations expected and observed along other paths. If anomalies are observed, additional analysis will be conducted to determine whether there is an instrument malfunction or the data are truly anomalous but explainable. Data reasonableness is also assessed more thoroughly during the data validation process.

4.4 Data Validation

4.4.1 Approach

On a monthly (at first) to quarterly schedule, an experienced air quality analyst will validate data by building on the automated screening results. This process starts with an in-depth review of the data, a review that includes statistical tests to ensure the data are valid for the intended end use. The QA Manager will evaluate QA/QC procedures and ensure adherence to the methods for meeting data quality objectives. Data validation activities will be reviewed and approved by the QA Manager.

Data validation activities include:

- Looking for statistical anomalies and outliers in the data and investigating them
- Ensuring there are not several continuous 5-minute averages of the same number
- Evaluating monthly summaries of the minimum, maximum, and average values
- Ensuring the data are not biased by exceptional conditions or events occurring off refinery property
- Ensuring data reasonableness by comparing to remote background concentrations and average urban concentrations
- Ensuring the data or measurements are realistically achievable and not outside the limits of what can be measured[5]
- Inspecting several sampling intervals before and after data issues or instrument bump tests or repairs to ensure all affected data have been properly flagged
- Referring to site and operator logbooks to see if some values may be unusual or questionable based on observations by site operator
- Assessing instrument meta-data to confirm reasonableness
- Assessing visibility measurements to ensure adequate signal was obtained to quantify pollutant concentrations
- Confirming that bump tests were conducted and were within specifications

General criteria for suspecting or invalidating data include:

- Monitor appears to have malfunctioned (acting erratic, spiking, or showing other evidence of questionable operation)
- Data are outside of plausible values (indicating a calculation error, averaging error, or instrument malfunction)

Additional QC checks for the instruments are summarized in **Table 8**. Data that fail checks will be flagged in the DMS and brought to the attention of the reviewer by color coding in the graphic summaries. Common reasons for invalidation include instrument malfunction, power failure, and bump test data that were not identified as such. As the measurements progress, we will update and refine the screening checks. Screening checks are typically specific to the site, instrument, time of day, and season and adjusted over time as more data are collected.

[5] Measurements below the method detection limit will be flagged in the DMS for review by an analyst

Table 8. Instrument QA/QC checks.

QA/QC Checks	Frequency	Acceptance Criteria
UV-DOAS		
Bump test (accuracy)	Quarterly and after major service	±20%
Baseline stability	Continuous	±5%
Single beam ratio test (strength of UV source)	Real-time	*To be determined*
Measurement quality – R^2	Continuous	0.7 to 1.0
Integration time	Continuous	80-200 mS *400 mS integration time results in a warning notification*
Signal intensity	Continuous	>30% *Signal intensity below 30 results in a warning notification*
TDLAS		
Bump test	Quarterly	±20%
FTIR		
Bump test	Quarterly	±20%
Baseline stability	Continuous	±5%
IR single beam ratio test (background vs. sample intensity	Real-time	*To be determined*
Signal intensity	Continuous	>5% *Signal intensity below 5 results in a warning notification*
Measurement quality (R^2)	Continuous	0.7 to 1.0

Data are invalidated only if a reason can be found for the anomaly or automated screening check failure. If the data are anomalous or fail screening, but no reason can be found to invalidate the data, the data are flagged. Additional analysis may be needed to deem data valid or invalid. Voided data will be flagged as invalid in the database. A summary of issues leading to invalidated data will be documented in the data file.

On a quarterly basis, to ensure all the daily QC tasks are complete, analysts will:

- Review any instrument bump test results.
- Verify that daily instrument checks were acceptable.
- Review manual changes to operations/data, and verify that the changes were logged and appropriately flagged.
- Ensure that instrument checks have the appropriate QC codes applied.

On a quarterly basis, analysts will subject the data to final QC by filling in missing records with null values, and add Null Codes:

- Assign invalid data a Null Code, or in other words, a reason for being invalid.
- If a record is not created for a particular site/date/time/parameter combination, create a null record for data completeness purposes.
- Inspect data consistency over three months.
- Review ranges of values for consistency—ranges should remain consistent over months of monitoring.
- Check bump test values for consistency.
- Review quarterly data completeness.

All actions will be documented in the DMS, which retains raw data and traceability of all actions that result in the final data.

On an annual basis, the refinery or its designated contractor will review the performance of the network by reviewing the data completeness by monitoring path, instrument, and species; by reviewing results of bump test; by analyzing the reported values in context of refinery operations; and by analyzing the data in context of the meteorology. The contractor will also evaluate overall network performance to ensure it is meeting overall objectives, using analyses similar to those used to support the network design. The results will be summarized in a technical memorandum and provided to the BAAQMD upon request.

4.5 Data Storage and Processing

The DMS data will be backed up on a daily basis. Backup media will be moved weekly to a secure offsite facility. The data will be stored for a period of five years after sampling.

4.6 Data Delivery

QA/QC of the final data will be completed within 60 days after the end of each calendar quarter. The refinery will then provide hourly average concentration data in tabular format through a comma separated value data file to the BAAQMD. The BAAQMD may make the hourly average data available to the public through a BAAQMD website or through public records request. The refinery will make data available to BAAQMD upon request prior to the report submittal.

4.7 Data Flow to Website

4.7.1 Auto-Screening and Alert Review

All data values that are not associated with bump tests, other instrument maintenance, or instrument problems will be displayed to the public in near-real time. If data are subsequently proven to be invalid, they will be removed from the public display.

A non-public field operations website will be used for daily graphical review of the data. Common problems include flat signal/constant values, no signal/missing data, extremely noisy signal, rapid changes (spikes or dips), and negative values. An initial review, typically of a three- to five-day time-series plot of selected parameters for each instrument, allows the analyst to see common problems and verify instruments are operational. If it appears that an instrument is not operating, or the data are missing, the field operator will be notified and further investigation and corrective action, if needed, will be taken.

Data are screened in real time upon ingest into the DMS, as described in previous sections. Automated procedures will be used to ensure that data are properly ingested, stored, processed, and quality-assured, and that products are delivered to a public-facing website in real time, defined here as 10 minutes or less after the data are collected.

The preliminary QC'd data will be presented in a time series of benzene, toluene, ethylbenzene, total xylenes, 1,3-butadiene, hexane, SO_2, NH_3, and H_2S concentrations; and visibility, wind speed, and wind direction. Data will be provided as 5-minute averages. Data will be color-coded and annotated for quality (valid, invalid, flagged, missing).

4.7.2 Data Backfill Process and Schedule

Prescreened, raw data will be replaced with validated data within 60 days after the calendar quarter. All data, raw and validated, will be retained in the DMS.

5. Standard Operating Procedures

Instrument-specific SOPs will be provided after instrument brand selection.