Fenceline Air Monitoring Plan

For BAAQMD Rule 12-15

Chevron Richmond Refinery

Revision 6

May 30, 2025

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Document Control

Document	Rev. No.	Rev. Date	Effective Date	Distribution	Description
AMP	0	12/7/2018	12/7/2018	Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Original submission.
AMP	1	6/1/2022		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Addressing BAAQMD comments, including addition of Tunable Diode Laser measurements of H_2S
AMP	2	2/16/2023		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Addressing BAAQMD comments on Revision 1; the original submission of Rev. 2 on 11/2/2022 was rescinded and modified
AMP	3	9/5/2023		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Revised in response to July 19, 2023, comments from BAAQMD
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AMP	6	5/30/2025		Program Manager, Project Manager, Data Manager, Field Technician Supervisor, Information Technology Manager, BAAQMD	Revised in response to May 7, 2025, comments received from BAAQMD

List of Acronyms

BAAQMD – Bay Area Air Quality Management District

BTEX – Benzene, Toluene, Ethylbenzene, Xylenes

CFR – Code of Federal Regulations

CHS – Contra Costa County Health Services

COES – California Governor's Office of Emergency Services

CWS – Contra Costa County Community Warning System

DMS – Data Management System

EBV – Emergency Block Valves

EPA – Environmental Protection Agency

FTIR – Fourier Transform Infrared

GC-PID – Gas Chromatograph followed by Photoionization Detector

GLM – Ground Level Monitor required by Rules 9-1 and 9-2

H_2S – Hydrogen Sulfide

IR – Infrared Light

LFL/LEL – Lower Flammability Limit/Lower Explosive Limit

OEHHA – California Office of Environmental Health Hazard Assessment

PMT - Photomultiplier Tube

ppb – Parts Per Billion

ppm – Parts Per Million

QA/QC – Quality Assurance / Quality Control

QAPP – Quality Assurance Project Plan

RCAMP – Richmond Community Air Monitoring Program

REL – Reference Exposure Level; RELs used are from OEHHA (http://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary)

RLOP – Richmond Lube Oil Project

SO_2 – Sulfur Dioxide

TDL – Tunable Diode Laser

TRI – Toxic Release Inventory

UV-DOAS – Ultraviolet Differential Optical Absorption Spectroscopy

UV – Ultraviolet

Section 1. Overview

On April 20, 2016, the Bay Area Air Quality Management District (BAAQMD) published guidelines containing criteria for an approvable Air Monitoring Plan, required by BAAQMD Rule 12-15 Section 403. On October 6, 2021, the BAAQMD provided updated requirements for refineries to conduct additional monitoring of hydrogen sulfide (H_2S) concentrations along refinery fenceline paths, and to implement this enhanced monitoring by January 1, 2023. On December 22, 2022, the BAAQMD revised the requirements for H_2S monitoring. The additional H_2S monitoring was operational on January 1, 2023. BAAQMD issued updated specifications on December 22, 2022, and Chevron's response to the updated specifications was submitted on February 17, 2023. This revision addresses feedback from BAAQMD received July 19, 2023, October 19, 2023, June 21, 2024, and May 7, 2025.

The Chevron Richmond Refinery (Chevron) has followed these guidelines to generate the Air Monitoring Plan (this document) in November of 2020, and has updated the Air Monitoring Plan and the Quality Assurance Project Plan (QAPP, located in Appendix B) to account for the H_2S requirements. As presented in "Air Monitoring Guidelines for Petroleum Refineries, AIR DISTRICT REGULATION 12, RULE 15: PETROLEUM REFINING EMISSIONS TRACKING," the key elements of the BAAQMD guidelines (Guidelines) are as follows (Bay Area Air Quality Management District, 2016):

Element #1 – Gases Requiring Monitoring

Refinery operators must measure benzene, toluene, ethylbenzene, and xylenes (BTEX) and H_2S concentrations at refinery fencelines with technology capable of measuring in the parts-per-billion (ppb) range.

Element #2 – Other Gases to Be Considered for Measurements

Measurement of sulfur dioxide (SO_2), alkanes, or other organic compound indicators, 1,3-butadiene, and ammonia concentrations are to be considered in the Air Monitoring Plan. Refinery operators must provide a rationale in the Air Monitoring Plan for not measuring all the above compounds. The rationale must address the following:

- Why these compounds are not contained in the compositional matrix of emissions
- Why these compounds are not at expected concentrations measured by available equipment
    - Address the technical or other considerations that make specific measurements inappropriate or unavailable.

Element #3 – Fenceline Coverage

For refineries that do not have open-path monitoring capabilities in place, measurements must cover populated areas within 1 mile of the refinery fenceline 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% 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, the monitoring plan should take into consideration seasonal and short-term meteorological events. Refineries that already have open-path monitoring capabilities in place need only provide verification that current systems adequately address population requirements.

Element #4 – Sample Time Resolution and Data Completeness

Open-path fenceline measurements must be continuously measured with a time resolution of five minutes. If this is not the case, refinery operators must provide rationale in the Air Monitoring Plan for lesser time resolutions based on equipment or other operational limitations. Instruments are operated to meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Atmospheric conditions beyond the control of the refinery that affect accurate measurements, such as dense fog, shall not be counted against data completeness calculations.

Element #5 – Data Presentation to the Public

Measurements must be provided to the public on a real-time basis, with appropriate Quality Assurance/Quality Control (QA/QC) measures taken to provide assurance of data accuracy.

Element #6 – Develop a Quality Assurance Project Plan

A QAPP that follows U.S. Environmental Protection Agency (EPA) guidelines must be developed that outlines QA/QC parameters.

Chevron's policy is to comply with all local and federal environmental regulations, including the fenceline monitoring provisions of BAAQMD Rule 12-15. In accordance with Rule 12-15-403, Chevron's goal is to provide the BAAQMD with an approvable Air Monitoring Plan (Plan) and QAPP, and then operate and install systems in accordance with the plans.

Section 2. Chevron's Existing Fenceline and Community Monitoring

As of the establishment of Rule 12-15, the Richmond refinery was operating 3 open-path fenceline monitors and 3 community monitors as part of the Richmond Community Air Monitoring Program (RCAMP). The fenceline monitors have been in operation since 2013 and the community monitors have been in operation since 2014. Siting of the fenceline and community monitors and the compounds to be monitored were subject to City of Richmond approval. Site locations for the fenceline equipment were selected to strategically position the fenceline monitors using predominant and variable meteorological conditions and topographical terrain features within and near the refinery.

The fenceline and community monitoring sites were selected with the following considerations, consistent with guidance from EPA and CARB. Environmental requirements were considered when selecting the monitors' placement with respect to on-site and off-site sources. The existing fenceline monitors do not have any large-scale sources between the monitor and the fenceline. Monitors were placed with consideration toward proximity to off-site emissions sources and sampling requirements were considered. Chevron aimed to make the horizontal distance from a point sampler to an obstacle, such as a building, at least twice the vertical distance that the obstacle protrudes above the sampler. Chevron aimed to make the horizontal distance from 90% of open-path to obstacles at least twice the vertical distance that the obstacles protrude above the path. For open-path monitors, a direct line of sight between light source and receiver must be available for the monitors to function. Logistical requirements were considered, such as proximity to power, capability to access the internet for real-time data reporting and on-line troubleshooting, and adequate security.

Chevron also met on multiple occasions between September 2011 and November 2012 with Shields-Reid, Point Richmond, and Atchison Village Neighborhood Councils for input on the locations of the air monitors. These are all the neighborhoods that border the refinery. The compounds to be monitored were selected with input from the City of Richmond, Chevron consultants, and community representatives. The compounds monitored by the fenceline system are considered to be common for refinery operations. The specific chemicals that require monitoring were evaluated for each source from emissions estimates based on available Toxic Release Inventory (TRI) reports. The compounds monitored by the community monitors represent a larger spectrum of compounds that can be attributed to many sources present in the Richmond community. The final siting locations and compounds to be monitored were approved by the City of Richmond in 2013. The fenceline and community monitoring data are made available to the public online at https://www.richmondairmonitoring.org/index.html. The following sections provide a summary of Chevron's Air Monitoring Plan in accordance with Rule 12-15 Section 403.

Section 3. Evaluation

Element #1 – Gases Requiring Measurements

In 2013, Chevron installed and began operating open-path air monitoring systems in cooperation with the City of Richmond. Chevron compared the BAAQMD Air Monitoring Guidelines with Chevron's existing monitoring system, which quantifies benzene, carbon disulfide, H_2S, ozone, SO_2, toluene, and xylene. Chevron has added capability to their open-path Ultraviolet Differential Optical Absorption Spectroscopy (UV-DOAS) system to measure ethylbenzene. Benzene, toluene, and xylene will continue to be detected and quantified by UV-DOAS. H_2S will temporarily be detected and quantified for informational purposes only using an open-path Tunable Diode Laser (TDL) air monitoring system pending deployment of more precise point monitors. The Castro Street ground level point monitor will be used for compliance with BAAQMD Rule 12-15, Rule 9-1 and Rule 9-2. Relevant equipment specifications are provided in Section 4 of this Plan.

Element #2 – Other Gases to Be Considered for Open-Path Measurements

Chevron considered the measurement of SO_2, alkanes, or other organic compound indicators, 1,3-butadiene, and ammonia for inclusion in this Air Monitoring Plan. Chevron continues to perform fenceline monitoring for SO_2, and has added fenceline monitoring of alkanes. Chevron does not plan to add fenceline monitors for 1,3-butadiene and ammonia.

SO_2

SO_2 will continue to be monitored by the existing UV-DOAS monitoring system and the Castro Street ground level monitor.

Alkanes or other organic compound indicators

Chevron has added monitoring for alkanes at BAAQMD's suggestion for measuring refinery fugitive leak emissions from process units that do not emit BTEX compounds detectable on the UV-DOAS monitors. Chevron does not expect refinery alkane emissions to be regularly detected, and rare detections will contain some ambient alkanes (Stephens and Burleson, 1969). The installed analyzers provide indication

of emissions from process units that do not emit BTEX compounds, namely the Alkylation Unit, Liquid Petroleum Gas spheres and loading racks, and Hydrogen Plant.

The alkanes being monitored include methane, ethane, propane, butane, and pentane. Methane and alkane (C2 through C5) concentrations are reported on the website. C6 and greater are not measured because process streams, such as gasoline, naphtha, and crude containing C6 and greater also contain BTEX compounds, which are measured on the UV-DOAS monitors. Chevron has installed open-path Fourier Transform Infrared (FTIR) monitors for monitoring alkanes to accommodate the public's preference for open-path monitors. Chevron appreciates that open-path monitors span long distances around a refinery and are more likely than point monitors to capture a possible plume that may cross the fenceline. Chevron received a manufacturer's guarantee based on results of a study conducted in Atlanta, GA, in December 2017 that an open-path FTIR with a 500-meter path length will measure alkanes C2 through C4 at 200 ppb concentration with 75% accuracy at 2 vol% water vapor in ambient air. In the Atlanta study, at 800 meters path length and 1.1 vol% water in ambient air, water vapor did not cause interference in alkane measurements. Interpolation of data justifies the manufacturer's guarantee.

The FTIR monitoring technology has the ability to detect ambient methane and ppb detection limits for C2 through C5 alkanes. Relevant equipment specifications are provided in Section 4 of this plan.

Existing measures for monitoring alkane and organic compound leaks

The systems do not serve as a first alert to Chevron of an alkane leak because Chevron has numerous systems in place for detecting an alkane leak. On most days, seven contracted individuals are monitoring background hydrocarbon concentrations and components in the refinery using Method 21, which is described in 40 Code of Federal Regulations Subpart 60 Appendix A-7. In accordance with Rule 8-18, Chevron repairs any leak source causing background concentration higher than 50 parts per million by volume (ppmv). Chevron Method 21 monitors light liquid pumps monthly, valves and pressure relief devices quarterly, and connectors annually. Leaks are typically repaired within 24 hours of discovery. Tank floating roof seals are inspected on a quarterly, semiannual, or annual basis per the requirements of BAAQMD Regulation 8, Rule 5. The liquid petroleum gas sphere area has five lower flammability limit (LFL) analyzers that alarm operators inside and outside the console when 5% of the LFL is detected. Chevron employees also wear personal LFL monitors while inside the process units that alarm at 5% of the LFL. All contractors entering Chevron process units are required to wear personal LFL monitors that sound an alarm at 5% of the LFL.

1,3-Butadiene

1,3-Butadiene is not produced as an intermediate or end product and is only present in trace quantities at the refinery. Chevron reports about 100 lb. per year of 1,3 butadiene emissions to the EPA in its annual TRI Report. Chevron does not expect 1,3-butadiene to be present in measurable concentrations at the fenceline.

Ammonia

Chevron excludes ammonia from fenceline monitoring because it is not emitted in measurable amounts at the fenceline as anhydrous ammonia, which is BAAQMD's primary toxicity concern. Sources of ammonia leaks are not as prevalent as alkanes. Ammonia is produced at refinery plants 8 and 18;

however, it is otherwise isolated to three anhydrous ammonia vessels for storage/loading or use in small streams in process units, primarily for pollution control devices. Anhydrous ammonia is sold as a by-product. Anhydrous ammonia loading points are tightly sealed and closely monitored by operators as explained below. Chevron's aqueous ammonia emission rates are already monitored through direct measurement in source tests submitted to BAAQMD. Aqueous ammonia reduces nitrogen oxide emissions from furnace stacks and filterable particulate emissions from the fluidized catalytic cracking unit (FCCU). Ammonia slip emissions from the FCCU have dramatically decreased following Regulation 6-5 compliance implementation.

Additionally, Chevron already has numerous systems in place, developed in cooperation with the City of Richmond, for preventing, detecting, and mitigating an anhydrous ammonia leak. The bulk of the refinery's anhydrous ammonia is kept in storage vessels near the ammonia loading rack and rail cars. Anhydrous ammonia is produced at 8 and 18 plants and consumed at the cogeneration units, FCCU, hydrogen plant, and Richmond Lube Oil Project (RLOP). The ammonia storage vessels are elevated above normal vehicle height and surrounded by steel barricades to prevent a motor vehicle from puncturing a vessel. Chevron also documented in its Risk Management Plan that the ammonia storage vessels will not be filled more than 45% full. Redundant high-level alarms sound at 41% and emergency alarms sound at 43% to ensure operators do not fill the ammonia storage vessels past 45%. Ammonia pumps are protected from cavitation by ensuring the ammonia storage vessels are at least 10% filled. Redundant low-level alarms sound at 15% and emergency low level alarms sound at 10%. As shown in Appendix A, anhydrous ammonia storage is located away from the refinery perimeter to minimize the effect on the public in the event of a release.

The ammonia storage area is equipped with excess flow valves and emergency block valves (EBV) to prevent or limit the severity of a release. EBVs are installed at the train loading racks' liquid and vapor lines, suction lines on the ammonia storage vessels, and on the common header. EBVs close with emergency shutdown switches, hand activation, and fusible plugs. When an EBV closes, the associated pumps are interlocked to shut down as well. Operators routinely test the EBVs.

In the event of a fire, each storage vessel is equipped with a firewater deluge system to scrub vapor from the atmosphere and cool the vessel. The fusible plugs on the EBVs cause the EBVs to close in the event of a fire. The ammonia storage area is encircled by a firewater-monitor fog system. One large water fog spray can be remotely operated. In the case of a leak, operators wearing air-supplying respirators immediately begin mitigation by isolating the line where the leak is located, applying water spray, and/or shutting down the process unit.

Any significant release of ammonia would be detected by the refinery, and if off-site impacts are possible, this would be communicated by Chevron to the community via the Contra Costa County Community Warning System (CWS). Numerous ammonia sensors located throughout the refinery would alert operators if a leak were to occur. If more than 100 lb. of ammonia are released in a 24-hr period, Chevron would immediately notify the Contra Costa County Health Services (CHS) Department on-call pager via the CWS as Level 1 and would call BAAQMD, the National Response Center, and the California Governor's Office of Emergency Services (COES). In the case of possible off-site health impacts, CHS would alert the community with sirens.

Lastly, Chevron voluntarily measures ammonia with three community monitors. The monitors collect 5-min average concentration data similar to fenceline monitors and post the 5-min average concentrations to a website. Since measurement began in 2014, ammonia concentration data through December 31, 2016, has been consistently well below the California health standards at all three community locations. **Figure 3.1** compares the community monitor data with health standards and shows that the maximum 1-hr average concentration was less than 4% of the acute health standard. To determine the maximum 1-hr average concentrations for comparison with the acute health standard, 60-min averages were calculated for every 5 minutes of data from the community monitor's start of operation in 2014 through December 31, 2016. During periods when a chemical was not detected, 1 ppb was substituted for calculating the average concentration. The average concentration measured at each community monitoring station was less than 2% of the chronic health standard. The California Office of Environmental Health Hazard Assessment (OEHHA) publishes reference exposure levels (REL), which are health standards, at https://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary. Lastly, as described in Section 2, compounds expected to be commonly emitted by refinery operations were required to be monitored at existing fenceline monitors, of which ammonia was not selected.

Figure 3.1 – Comparison of Richmond Community Monitors 1-Hr Average Concentrations with Acute (1-Hr Average) OEHHA Health Standard

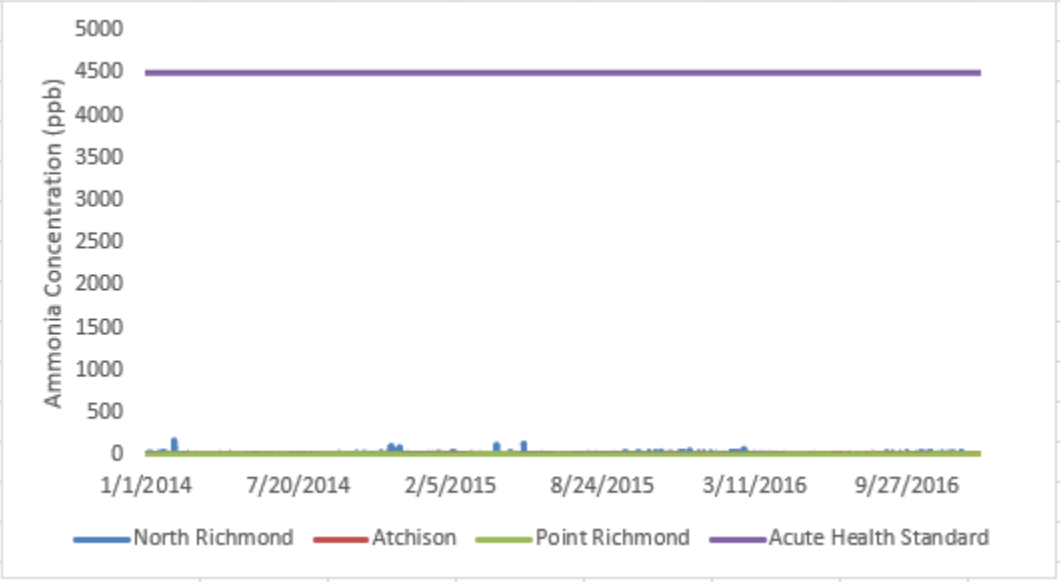


Table 3.1 summarizes the gases included in the Rule 12-15 fenceline AMP and the equipment to be used to detect them.

Table 3.1 – Gases Included in the Fenceline Air Monitoring Plan

Gas	Equipment
Alkanes (C2 through C5)	5 open-path FTIRs
Benzene	3 open-path UV-DOAS instruments North Richmond community monitor Sorbent tubes at sample stations 6 and 7*
Ethylbenzene	3 open-path UV-DOAS instruments North Richmond community monitor
Hydrogen Sulfide	3 open-path TDLs along 5 monitoring paths** Castro Street ground level monitor
Methane	5 Open-path FTIRs
Sulfur Dioxide	3 open-path UV-DOAS instruments Castro Street ground level monitor
Toluene	3 open-path UV-DOAS instruments North Richmond community monitor
Xylene	3 open-path UV-DOAS instruments North Richmond community monitor

*Sampled and analyzed in accordance with 40 CFR 63.658.
** H2S will temporarily be detected and quantified for informational purposes only using an open-path TDL air monitoring system pending deployment of more precise point monitors..

Element #3 – Fenceline Coverage

This section describes the process used to determine where fenceline air monitoring equipment are installed and/or made part of the Rule 12-15 fenceline monitoring compliance program. In accordance with the Guidelines, wind rose analyses were completed to determine monitor locations needed to cover populated areas within 1 mile of the refinery fenceline 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% of the time or greater, given site topography.

Meteorological data collected from January 1, 2012, through December 31, 2016, from the Gertrude Meteorological Station, associated with the Rules 9-1 and 9-2 ground level monitors, were used to generate the wind roses in **Figures 3.2 and 3.3** and the summary in **Table 3.2**. Figure 3.2 compares the 2016 wind rose with the 5-yr wind rose to show a consistent wind pattern with wind primarily blowing from the south. Wind occurred greater than 10% of the time from 0 degrees north and from 135 degrees to 225 degrees. Thus, the Guidelines suggest monitoring for Rule 12-15 in the arc from 292.5 degrees to 67.5 degrees and in the arc from 157.5 degrees to 202.5 degrees if there are receptors downwind of sources within 1 mile of the refinery fenceline, depending upon site topography.

Figure 3.2 – Wind Rose (1/1/12 – 12/31/16) Consistent Wind Pattern Primarily from South

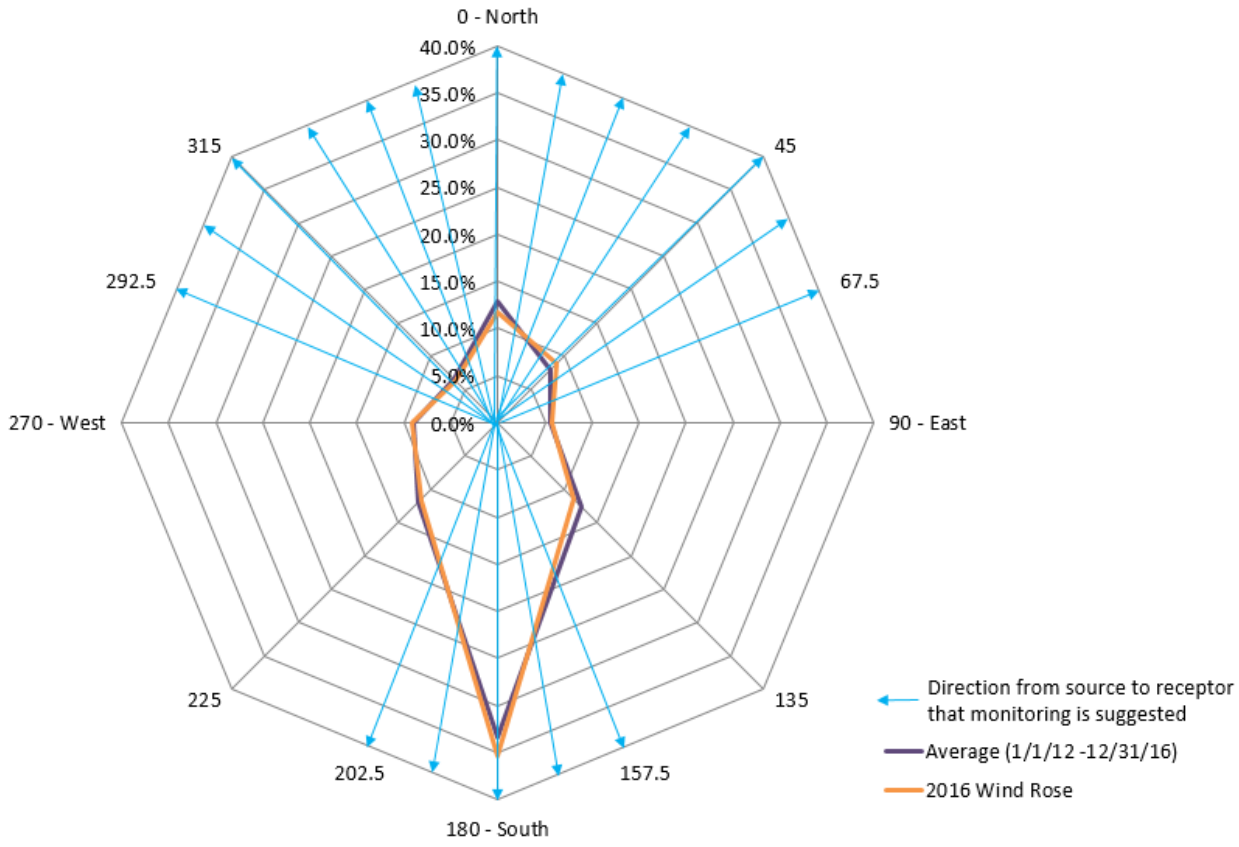
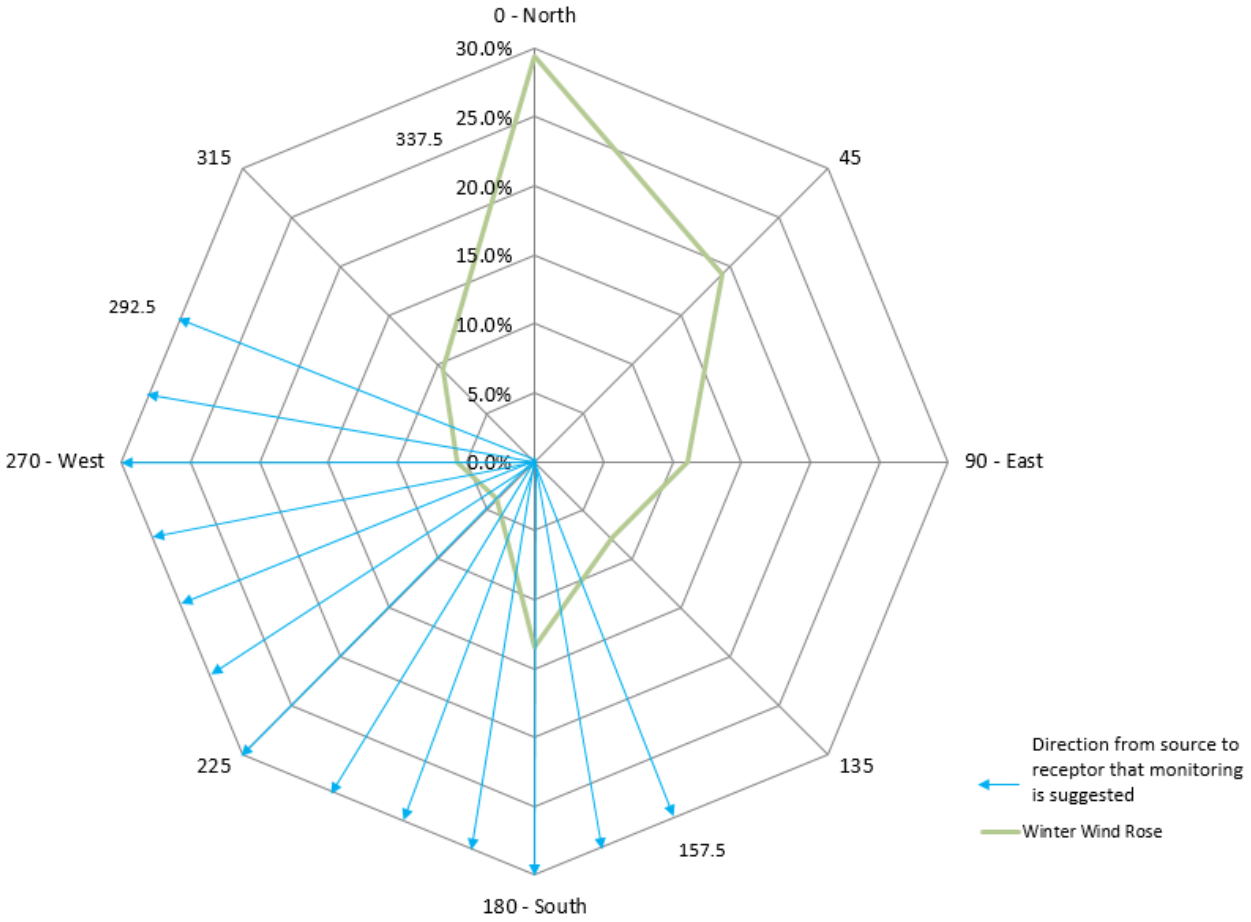


Figure 3.3 contains a wind rose of winter winds from November 1 through February 15 for the years 2012 through 2016. This figure shows winds blowing primarily from the north and northeast during winter months. The wind direction is from 0 degrees north through 90 degrees east more than 10% of the time during winter months. Per the guidelines, fenceline monitoring coverage should be considered in the arc between 157.5 and 292.5 degrees if there are receptors downwind from sources within one mile of a receptor, depending upon site topography.

Figure 3.3 – Winter Wind Rose (2012-2016): Wind Primarily from North/Northeast



Based on the wind rose analyses, the Guidelines suggest some additional fenceline monitor coverage beyond the pre-existing RCAMP fenceline monitors. As described in Section 2, the existing fenceline monitor open-path locations were already agreed upon with the City of Richmond and developed in cooperation with local neighborhood councils. In adhering to this agreement, Chevron aims to either keep the monitors in the same locations or expand the path to capture more sources. Table 3.2 shows the percentage of time that wind blew from each wind rose sector.

Table 3.2 – Additional Monitors Based on Wind Rose Analyses. Sectors where wind blows in that quadrant greater than 10% of the time are highlighted in blue.

Direction From	Range (Degrees)	Percent of Time	Coverage on Existing Public Website
North	337.5-22.5	12.61%	Partial coverage by Point Richmond open-path UV-DOAS, FTIR, and TDL monitors
Northeast	22.5-67.5	7.68%	Southwest refinery perimeter is not populated
East	67.5-112.5	5.49%	West refinery perimeter is not populated
Southeast	112.5-157.5	12.68%	Northwest refinery perimeter is not populated
South	157.5-202.5	33.74%	North refinery perimeter is not populated
Southwest	202.5-247.5	12.18%	• Atchison Village and North Richmond open-path UV-DOAS, FTIR, and TDL monitors • North Richmond community monitor • Benzene sorbent tube sample at stations 6 and 7 • Castro Street ground level monitor
West	247.5-292.5	9.04%	• Atchison Village and North Richmond open-path UV-DOAS, FTIR, and TDL monitors • North Richmond community monitor • Benzene sorbent tube sample at stations 6, 6D, and 7 • Castro Street ground level monitor
Northwest	292.5-337.5	6.59%	Atchison Village and Point Richmond open-path UV-DOAS, FTIR, and TDL monitors

Based on the 2012 through 2016 wind rose analysis, the monitors cover populated areas within 1 mile of the refinery fenceline 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% of the time or greater, given site topography. Refinery emission sources, and existing air monitoring equipment, are shown on a map of the refinery in Appendix A. The open-path monitors are located south, east, and northeast of refinery processes in between the processes and populated areas. The North Richmond open-path monitors are located northeast of the refinery. The Atchison Village open-path monitors are located east of the refinery. The Point Richmond open-path monitors are located south/southeast of the refinery. The map shows that the refinery is surrounded on the north, west, and southwest parts of the refinery by large bodies of water, which are not populated.

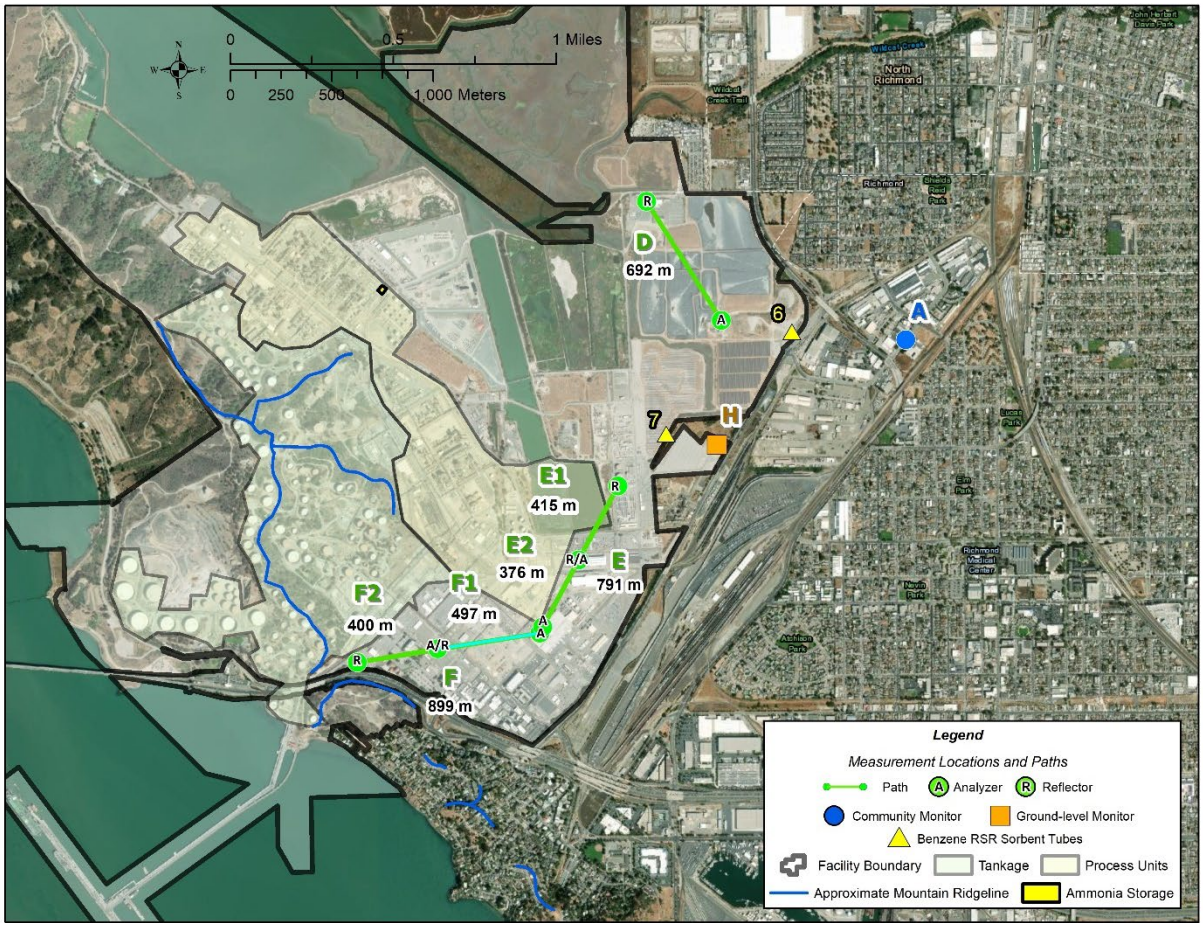
Chevron has installed open-path FTIR, UV-DOAS, and TDL analyzers and retroreflectors along the North Richmond, Point Richmond, and Atchison paths. The path lengths for the UV-DOAS, TDL, and FTIR open-path monitors are provided in **Table 3.3**. Because intermediate paths (e.g., F1 and F2) are close to but not exactly the same as the overall path (e.g., path F), the distances may not be exactly the same.

Table 3.3 – Fenceline Open-Path Lengths

Fenceline[1]	Path Designation	Open-Path Equipment	Approximate Path Length (meters)
North Richmond	D	UV-DOAS, TDL, FTIR	692
Atchison	E	UV-DOAS	791
Atchison (North)	E1	FTIR, TDL	415
Atchison (South)	E2	FTIR, TDL	376
Point Richmond	F	UV-DOAS	899
Point Richmond (East)	F1	FTIR, TDL	497
Point Richmond (West)	F2	FTIR, TDL	400

Chevron has included measurements from benzene sample stations 6 and 7, the Castro Street ground level monitors, and the North Richmond community monitor BTEX measurements in the Rule 12-15 program. **Figure 3.4** provides a visual summary of the monitoring locations that are part of Rule 12-15 compliance.

Figure 3.4 – Locations of Rule 12-15 Monitors



[1] FTIR and TDL instruments cover paths E and F via subpaths E1, E2, F1, and F2.

The City of Richmond was interested in capturing emissions from as many refinery sources as possible, including elevated sources, such as flares and furnaces. At BAAQMD's suggestion, Chevron moved the Point Richmond open-path monitors to a lower elevation so that fugitive emissions are primarily measured. The manufacturers of the open-path analyzers (Cerex for the UV-DOAS and FTIR), who are experienced with operating and maintaining the monitors, indicated that the current minimum detection limits (MDLs) for BTEX and SO_2 should be achievable at the path lengths installed. Flare and furnace stack emissions are already measured continuously with sampling systems, flow meters, and stack analyzers. Most fugitive emissions are measured at each component periodically using Method 21, but site-wide fugitive emissions can only be measured continuously with fenceline monitors. Thus, BAAQMD is primarily interested in using the fenceline monitors to measure fugitive emissions, which occur near ground level.

During winter winds from the north, the Point Richmond and Atchison Village open-path monitors provide the suggested monitoring coverage when terrain is considered. Due to the mountainous terrain and presence of the Interstate 580 freeway, it is not practicable to install an open-path monitor west of the Point Richmond monitor. Appendix A shows a mountain ridge line southwest of the Point Richmond open-path monitor that is expected to direct wind from refinery tanks away from receptors. It is expected that for the tanks located northwest of the Point Richmond open-path monitor and to the west of the mountain ridge that runs north-south, the mountains would cause wind across the tanks to move westward away from the community. It is expected that for the tanks located northwest of the Point Richmond open-path monitor and to the east of the mountain ridge that runs north-south, the mountains would cause wind across the tanks to pass through the Point Richmond open-path fenceline monitor. Also, the tanks are compliant with Rule 8-5 storage-vessel requirements, which limit organic compound emissions. The seals are inspected at least semiannually to verify proper function of the emission control technology. It is expected that a potential seal leak from a tank located northwest of the Point Richmond open-path monitor would be detected on the Point Richmond open-path monitor because wind direction varies throughout the day.

Monitoring coverage is not needed for wind directions from the northeast, east, southeast, and south, because the downwind areas are not populated.

Monitoring coverage between the North Richmond and Atchison open-path monitors are fulfilled with point monitors. The following point monitors are part of the Rule 12-15 compliance program.

- Castro Street ground level monitor fulfills H_2S and SO_2 monitoring
- One sorbent tube at each sample station 6 and 7 fulfills suggested benzene monitoring
- North Richmond community monitor fulfills BTEX monitoring

The two sorbent tube samples will continue to be analyzed for benzene every two weeks as specified in 40 CFR 63 Subpart CC. In April 2019, the EPA began reporting benzene sorbent tube data over a public website on a quarterly basis. The EPA website link is: https://cfpub.epa.gov/webfire/reports/eSearchResults.cfm. To access the Chevron Richmond data, enter or select the following search criteria:

- Report Type: All, then click Submit
- Facility Name: Chevron
- Facility Location: California, Contra Costa County, Richmond

- Regulatory Part and Subpart:
    - CFR Part: 63-NESHAP
    - CFR Subpart: NESHAP-CC: Petroleum Refineries

Next, submit the search. Once the search results appear, select the row with the submission date of interest and download the file in the document column.

Five-min average Castro Street ground-level monitor (GLM) data and 5-min average North Richmond community monitor data are posted to the public website.

The only sources located within one mile upwind of a receptor greater than 10% of the time that are between the North Richmond and Atchison monitors are the bioreactor and two recovered oil storage tanks. We expect that the Atchison open-path monitor, which crosses the bioreactor, or the North Richmond open-path monitor, typically catch any possible plumes from these sources. However, in the rare instance when wind direction is between the North Richmond and Atchison open-path monitors, it is expected that the previously mentioned point monitors will measure possible emissions.

A review of 10 years of GLM reports showed that Chevron has not caused exceedance of the SO_2 ground level concentration limits in Rule 9-1-301, or the H_2S limits in Rule 9-2-301 at the Castro Street GLM. Additionally, the GLM has much lower detection limits than open-path monitors. The GLM's MDL for H_2S and SO_2 is about 0.5 ppb.

Analyses of sorbent tubes installed in preparation for compliance with 40 CFR 63.658 indicate that benzene concentrations at sample stations 6 and 7 along the fenceline between the North Richmond and Atchison open-path monitors are much lower than the OEHHA chronic health standard of 3 $\mu g/m^3$. Sorbent tubes were replaced and analyzed for benzene approximately every 14 days. Sorbent tube data available to date for sample points 5 through 8 located between and nearby the North Richmond and Atchison open-path monitors are provided in **Table 3.4**. The refinery map in Appendix A shows the sorbent tube locations. Sample point 5A located on refinery property near the heavy-traffic intersection of Gertrude Avenue, Castro Street, and Richmond Parkway had the highest readings of all the sample points in the refinery. The benzene concentrations decreased when the sample station was moved closer to the refinery processes around March 7, 2017. The current location is labeled as sample point 5. The elevated results at sample point 5A were attributed to off-site sources, likely traffic congestion at the Gertrude Avenue intersection or nearby off-site excavation of contaminated soil.

Table 3.4 – Benzene Sorbent Tube Results Are Within OEHHA Chronic Health Standard

Sample Start Date	Sample End Date	Sample Point / Benzene Concentration* (ug/m^3)				
		5A	5	6	7	8
7/27/2016	8/10/2016	0.19		Not Detectable	0.18	Not Detectable
8/10/2016	8/24/2016	0.18		0.24	0.25	0.20
8/24/2016	9/7/2016	0.36		0.38	0.29	0.40
9/7/2016	9/21/2016	0.52		0.34	0.38	0.29
9/21/2016	10/5/2016	0.69		0.52	0.51	0.52
10/5/2016	10/19/2016	0.68		0.44	0.46	0.41
10/19/2016	11/2/2016	0.97		0.57	0.60	0.55
11/2/2016	11/16/2016	2.41		0.96	0.75	0.77
11/16/2016	11/30/2016	1.34		0.67	0.79	0.76
11/30/2016	12/14/2016	1.44		0.65	0.64	0.71
12/14/2016	12/28/2016	0.94		0.63	0.63	0.58
12/28/2016	1/11/2017	1.03		0.85	0.48	0.50
1/11/2017	1/25/2017	1.09		0.62	0.64	0.60
1/25/2017	2/8/2017	1.07		0.65	0.58	0.59
2/8/2017	2/22/2017	0.86		0.49	0.44	0.55
2/22/2017	3/8/2017	1.04		0.51	0.49	0.55
3/8/2017	3/22/2017		0.44	0.46	0.40	0.41
3/22/2017	4/5/2017		0.38	0.34	0.31	0.44
4/5/2017	4/19/2017		0.34	0.33	0.30	0.38
4/19/2017	5/3/2017		0.26	0.28	0.28	0.29
5/3/2017	5/17/2017		0.21	0.20	0.21	0.23
5/17/2017	5/31/2017		0.17	0.21	0.18	0.22
5/31/2017	6/14/2017		0.20	0.18	0.19	0.25

* Values less than 0.37 are less than the analytical reporting limit, but greater than the method detection limit.

Lastly, Chevron continues to operate the existing North Richmond community monitor, located at Richmond Fire Station 62 on 7th Street, to deliver BTEX data to meet Rule 12-15 needs. The North Richmond community monitor is located downwind of the refinery when wind is from the west or southwest. The monitor also measures H_2S, ammonia, several alkanes, trimethylbenzenes, 3-methylpentane, 2,2,4-trimethylpentanes, $PM_{2.5}$, and black carbon. All data from the North Richmond community monitoring station is posted at https://www.richmondairmonitoring.org/index.html.

The North Richmond community monitor collects 5-min average concentration data and posts the 5-min averages to the website similar to fenceline monitors. To determine the maximum 1-hr average concentrations for comparison with the acute health standard, 60-min averages were calculated for every 5 minutes of data from January 1, 2014, through December 31, 2016. During periods when a chemical was not detected, one half the detection limit of 0.25 ppb was substituted for calculating the average concentration. The table shows that the maximum 1-hr average concentration was equal to 34% (2.75 ppb 1-hr average/8 ppb acute health standard) of a health standard.

Table 3.5 shows that BTEX concentrations measured at the North Richmond community monitor for any wind direction are far below OEHHA chronic health standards. To determine the average concentration for comparison with the chronic health standard, all 5-min average data was averaged from January 1, 2014, through December 31, 2016. During periods when a chemical was not detected, one half the detection limit of 0.25 ppb was substituted for calculating the average concentration. The table shows that for the worst-case chemical (benzene), the average concentration was about 25% (0.25 ppb average/1 ppb benzene of the chronic health standard) of a chronic health standard.

Given the data in Table 3.5, Chevron does not expect BTEX compounds to be regularly detectable by an open-path fenceline monitor between the North Richmond and Atchison open-path monitors and does not expect any exceedance of a health standard. The community monitor is more sensitive than open-path fenceline monitors, and only half a mile downwind (westerly wind) from the North Richmond fenceline.

Table 3.5 – North Richmond Community Monitor Data Are Within Health Standards (1/1/2014 – 12/31/2016)

Chemicals	Maximum 1-Hr Average Concentration (ppb)	Acute OEHHA REL (ppb)	Average Concentration (ppb)	Chronic OEHHA REL (ppb)
Benzene	2.75	8.6	0.25	1
Ethylbenzene	12	None published	0.25	400
Toluene	111	1,328	0.30	70
Xylenes	65	5,000	0.57	200

Element #4 – Sample Time Resolution and Data Completeness

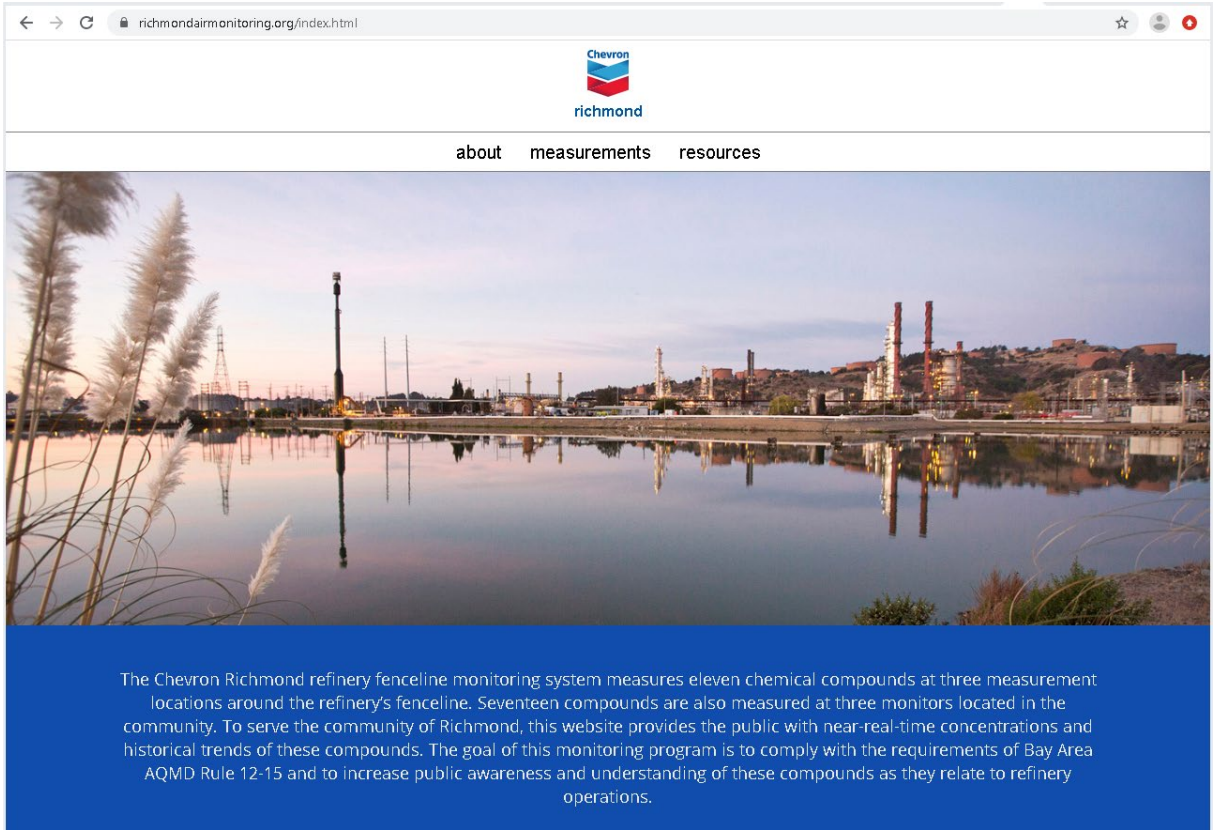
Continuous monitoring equipment specified for the Chevron fenceline system collects data on 5-min averages and reports the 5-min averages. Instruments are operated to meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Atmospheric conditions beyond the control of the refinery that affect accurate measurements, such as dense fog, are not counted against data completeness requirements. In addition to rain and fog, other types of environmental conditions beyond the control of the refinery can occur. These environmental factors include, but are not limited to, strong winds, dust, and earthquakes, which can impact the ability of open-path instruments to provide accurate measurements.

Element #5 – Data Presentation to the Public

A Data Acquisition System (DAS) or data logger at each sampling site performs basic quality control (QC) and averages raw analyzer data to 5-min resolution. Data are then transmitted to Sonoma Technology's Data Management System (DMS), where a robust automated QC (AutoQC) logic assigns data flags in real time based on instrument diagnostics and local meteorological measurements. These preliminary data are displayed on the public website, usually within approximately 10–15 minutes of collection. Additional details regarding data flow and QC processes are described in Sections B.10 and D.2 of the QAPP, as well as the Standard Operating Procedure (SOP) for Data Verification and Validation (Attachment 7).

Preliminary data collected by the fenceline monitoring network are displayed on a public website in real time. Key components of the public website include visual display of real-time and historical data, contextual information to help the public understand the concentrations displayed, and a feedback mechanism. The public website includes time-series plots and map marker visualizations of preliminary 5-min and rolling hourly concentration values in real time. Data quality information is also included, and is described further in the SOP for Data Verification and Validation (Attachment 7). **Figure 3.5** shows the home page of the fenceline webpage, located at https://www.richmondairmonitoring.org/index.html.

Figure 3.5 – Sample Real-Time Fenceline and Community Air Monitoring Webpage



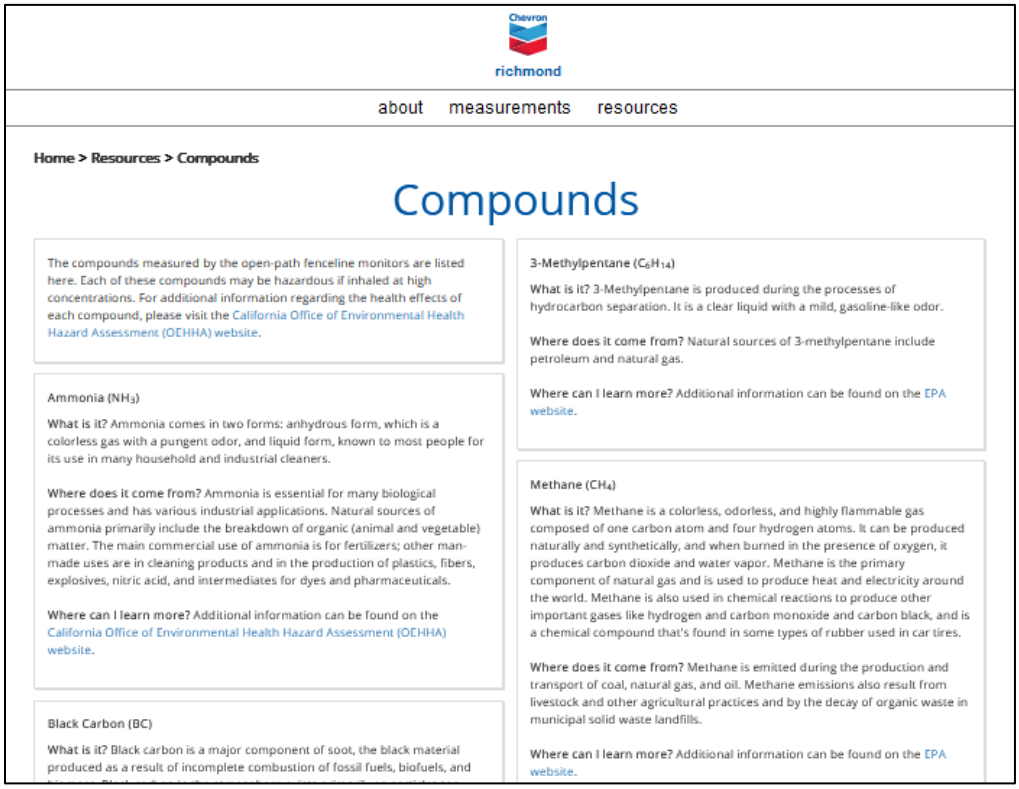
The data collected are high-time-resolution, spatially variable, and chemically complex. To provide context to this multifaceted data set for the public, the following information is included through a combination of links, graphics, and captions:

- Information about the species measured and the measurement techniques
- Discussion of levels of concern with links to third-party sources, such as the OEHHA website on the health effects of each species
- Discussion of non-refinery sources that could affect the measured concentrations
- Definitions for abbreviations
- Discussion of data below the MDL
- Definitions of data flags and their meanings
- Frequently asked questions (FAQs)

To facilitate public input, a feedback mechanism is provided on the web page to allow users to submit questions or comments about the website. An email is delivered to a Chevron contact and the website host, who are responsible for deciding how to respond to public comments. The emails received through the website are archived. Although not all comments have to be addressed, they can be made available to BAAQMD upon request.

Figure 3.6 shows an example page from the website that appears when a person clicks the Compounds page of the Resources section on the website. The web page describes the chemical's properties, common sources of the chemical, and links to the OEHHA health standards.

Figure 3.6 – Example Website Display of Compound Descriptions and Resources



Final data sets are compiled quarterly and will be provided to the BAAQMD no later than 60 days after the end of each calendar quarter. Data deliveries are consistent with BAAQMD guidance and additional details are provided in Section C.2 of the QAPP. The BAAQMD may make data available to the public through a BAAQMD website or through public records requests. The refinery will make data available to BAAQMD upon request prior to the report submittal. All data are retained by Chevron for a period of 5 years, consistent with Regulation 12-15-502.

Element #6 – Quality Assurance Project Plan

An updated QAPP is included with this monitoring plan as Appendix B.

Section 4. Monitoring Equipment Description

The fenceline monitoring program for Rule 12-15 integrates the equipment currently used as part of RCAMP along with additional equipment to monitor additional target gases, namely alkanes, and extend spatial coverage. This equipment used to meet the monitoring requirements for Rule 12-15 are described below.

Section 4.1 – Fundamentals of Operation

The following paragraphs describe how the equipment measures compound concentrations. Open-path monitors report average concentration over the path length. Point monitors measure the concentration at the point of each monitor's intake line.

Castro Street Sulfur Dioxide and Hydrogen Sulfide Pulsed Fluorescence GLMs

The SO_2 and H_2S GLMs comply with the BAAQMD Manual of Procedures Volume VI. The SO_2 GLM is a trace-level pulsed fluorescence SO_2 analyzer, which operates by measuring the emitted fluorescence of SO_2 produced by the absorption of ultraviolet (UV) light. Pulsating UV light is focused through a narrow band-pass filter mirror, allowing only light wavelengths of 190 to 230 nm to pass into the fluorescence chamber. SO_2 absorbs light in this region without any quenching by air or most other molecules found in ambient air. The SO_2 molecules are excited by UV light and emit fluorescent light at a longer wavelength (lower energy). A second filter allows only this fluorescent light to contact a photomultiplier tube (PMT), which converts the optical signal from the fluorescent light into a voltage that is recorded and turned into a concentration value.

The H_2S GLM operates using similar technology to the GLM SO_2 analyzer. Continuous H_2S monitoring is accomplished by conversion of H_2S in the sample to SO_2 and its subsequent detection by the SO_2 analyzer.

North Richmond Community Monitor Auto Gas Chromatograph

Automated Gas Chromatographs (Auto GC) use point sampling technology. The systems work by inserting a sample of ambient air into a narrow tube known as the column. A carrier gas flows through the column and carries the sample through the column; depending on the chemical composition, the various sample gases exit the column at different times. As the chemicals exit the end of the column, they are detected using a photoionization detector. The major advantage of the Auto GC air monitoring system is its sensitivity in that it can measure gases, such as BTEX compounds, at very low concentrations in the air.

Open-Path FTIR

Open-path FTIR air monitoring systems use a beam of infrared (IR) light to detect and measure alkanes in the air. A beam of light passes across ambient air to a reflector that sends the light beam back to the light detector. If a gas is present that absorbs IR light, it can be identified by the specific wavelengths of light that were absorbed. The concentration of a gas can be determined by measuring the amount of each specific wavelength of light that was absorbed. The primary interferents associated with FTIR air monitoring systems are water vapor and carbon dioxide (CO_2). The two gases absorb light in the same

region as alkanes and can be mistaken for the target gas. Also, due to the similarity in chemical structure, the C1 through C5 alkanes absorb light in a similar region and may interfere with measurements of total alkanes. However, the presence of potentially interfering gases can be accounted for through the analytical software of the system.

Open-path FTIRs can theoretically achieve lower MDLs than extractive FTIRs because the beam path is much longer. The primary limitations for these systems are that the light signal cannot penetrate heavy fog or rain. Thus, they may not be effective during situations where dense fog or heavy rain are present.

Open-Path TDL

Open-path TDLs are similar to open-path FTIR air monitoring systems in that they use beams of infrared light to measure gases. The primary difference between the two systems is the TDL system uses a laser as its light source whereas the FTIR uses a broad-band beam of light as its source. TDL systems are designed to measure a limited number of gases, which, for this application, are H_2S, CO_2, and water vapor. The primary interferents for the H_2S measurement are water vapor and CO_2 because both absorb light in the same region as H_2S. The primary limitation for the system is that the light signal cannot penetrate heavy fog or rain.

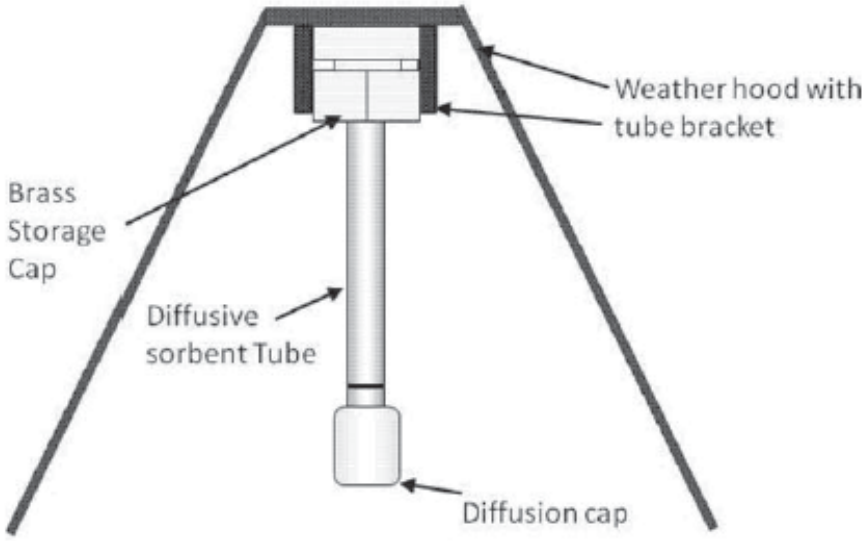
Open-Path UV-DOAS

The open-path UV-DOAS system differs from open-path FTIR and TDL systems in two major ways. First, the system has a light source at one end of the path that sends a beam directly to the light detector at the other end of the light beam. Second, the system uses UV light as a light source. The open-path UV-DOAS air monitoring system is used to detect BTEX and SO_2. The primary interferents associated with the UV-DOAS air monitoring systems are ozone and oxygen, because both absorb light in the same region as the target gases. However, the presence of these gases can be accounted for with the system's analytical software. The primary limitation for the systems is that the light signal cannot penetrate heavy fog or rain.

Sorbent Tubes

Sorbent tubes placed approximately six feet above ground level absorb benzene, if present, from the ambient air during the sampling period, which is about 14 days. The sorbent tubes are installed at locations along the refinery perimeter specified in 40 CFR 63 Appendix A Method 325A Section 8.2. The tubes are analyzed in a laboratory at the end of the sampling period in accordance with 40 CFR 63 Appendix A Method 325B. The sorbent tubes are placed in shelters similar to the one shown in **Figure 4.1** to protect them from rain. Thus, the tubes can provide average benzene concentrations in the ambient air during nearly all weather conditions, including fog, except for periods of extremely high winds with rain. The sorbent tube method also achieves benzene concentration measurements at concentrations lower than open-path monitor MDLs.

Figure 4.1 – Benzene Sorbent Tube and Shelter



Section 4.2 – Monitoring Equipment Capabilities

Table 4.1 summarizes monitoring equipment capabilities, interferences, limitations, and measurement errors.

Table 4.1 – Monitoring Technology Capabilities, Interferences, Limitations, Measurement Errors

Equipment	Capabilities	Interferences	Limitations	Measurement Errors
Sorbent tubes	Absorbs benzene from ambient air, if present, at a point over approximately 14-day periods; Lower MDLs than open-path monitors	Sorbent artifacts, water (rain)	Heavy rains with high winds; Continuous reporting not possible	Within 30% (Per 40 CFR 63 Appendix A Method 325B Section 9.7)
North Richmond Community Monitor Auto GC	Measures BTEX continuously at a point with lower MDLs than open-path monitors	--	Measures at point vs. open-path	Within 25%
Open-path FTIR	Continuously measures alkanes across an open path; Likely lower MDL than extractive FTIR	Water (humidity), CO_2, and C2-C5 alkanes may interfere with each other	Heavy fog and rain	Refer to Section A.7 of the QAPP.
Open-path UV-DOAS	Continuously measures BTEX and SO_2 across an open path	Ozone and oxygen	Heavy fog and rain	Refer to Section A.7 of the QAPP.
Open-path TDL	Continuously measures H_2S across an open path	H_2O and CO_2	Heavy fog and rain	Not applicable – temporary informational monitoring
Castro St. GLM H_2S and SO_2 Pulsed-Florescence Analyzers	Continuously measures H_2S and SO_2 at a point; Lower MDLs than open-path monitors	High concentrations of hydrocarbons; Mercaptans interfere with H_2S measurement	Measures at a point vs. open-path	Within 10% for SO_2, within 15% for H_2S (BAAQMD MOP Volume VI)

Section 4.3 – Detection Range

Table 6 in the QAPP summarizes the expected detection ranges of the open-path monitors. Alkane detection ranges are based on an initial study conducted in Atlanta, GA, in December 2017. The alkane detection ranges shown are accurate when multiple alkanes are present. The detection ranges are much wider if only an individual alkane is present. The FTIR should routinely report methane readings between 1,520 and 2,280 ppb (± 20% of a global average concentration of 1,900 ppb) due to the inherent presence of methane in ambient air.

Table 4.2 lists the messages displayed on the public website that outline the conditions and detection limits for the pollutants measured in this program.

Table 4.2 – Messages Displayed on the Website with Each Compound and Data Value (Hover Over the Data Point to View the Message)

Condition	Message
Valid	X ppb of Compound Y were measured at this location
Below detection	The concentration of the compound is so low that the instrument cannot accurately detect it.
Questionable	No additional information available. Pending further review.
Missing	A problem (such as power failure, calibration, etc.) prevented the instrument from collecting or reporting the data.
Invalid	No additional information available. Pending further review.
Not Measured	There is no instrumentation at the given site to measure this chemical.

The MDL of the sorbent tubes is dependent upon several analytical factors, including the presence of moisture. The MDL for benzene is typically 0.07 $^{\mu g/m3}$ (equivalent to 0.02 ppb), while the minimum reporting limit, which is the lowest end of the calibration range, is typically 0.37 ug/m^3 (equivalent to 0.12 ppb). The MDL of the Castro Street GLMs and North Richmond BTEX community monitor is 0.5 ppb for each compound.

Section 4.4 – Monitoring Equipment Locations

Table 4.3 lists the locations of the fenceline monitoring equipment.

Table 4.3 – Monitoring Equipment Locations

ID	Fenceline Name	Equipment	Approx. Elevation (ft agl)	Location
D	North Richmond	UV-DOAS analyzer; TDL & FTIR analyzers (D)	28.5	Next to Gertrude Ave. GLM
D	North Richmond	UV-DOAS source; TDL & FTIR reflectors (D)	23	Near maintenance building
6	North Richmond	Sorbent tube site 6	5	Reclamation yard gate to Castro St.
6D	North Richmond	Sorbent tube site 6D	5	Reclamation yard gate to Castro St.
A	North Richmond Community Monitor	Auto GC	13	Fire Station #62
7	Atchison Village	Sorbent tube site 7	5	Solar-panel field
H	Atchison Village - Castro GLM	Pulsed fluorescence analyzers	8	Gate 91
E	Atchison Village	UV-DOAS source (E)	38.5	Parking lot south of RARE Plant

ID	Fenceline Name	Equipment	Approx. Elevation (ft agl)	Location
E1	Atchison Village	FTIR & TDL reflectors (E1)	38.5	Parking lot south of RARE Plant
E1/E2	Atchison Village	FTIR & TDL analyzers (E1); FTIR & TDL reflectors (E2)	37	Next to warehouse 8
E2	Atchison Village	FTIR & TDL analyzers (E2)	64.5	Top level roof of Lube Plant
E	Atchison Village	UV-DOAS analyzer (E)	64.5	Top level roof of Lube Plant
F	Point Richmond	UV-DOAS analyzer (F)	31.5	Near SW corner of Lube Plant roof
F1	Point Richmond	FTIR & TDL analyzers (F1)	31.5	Near SW corner of Lube Plant roof
F1/F2	Point Richmond	FTIR & TDL reflectors (F1); FTIR & TDL analyzers (F2)	37.5	Next to permits office
F2	Point Richmond	FTIR & TDL reflectors (F2)	23.5	Hill SW of Chevron Fire Department
F	Point Richmond	UV-DOAS source (F)	23.5	Hill SW of Chevron Fire Department

Section 5. Timing

Chevron reports near real-time data over a website from open-path TDL, UV-DOAS, and FTIR monitors. The operation of these instruments will be conducted in accordance with this Plan pursuant to the timing requirements in Rule 12-15.

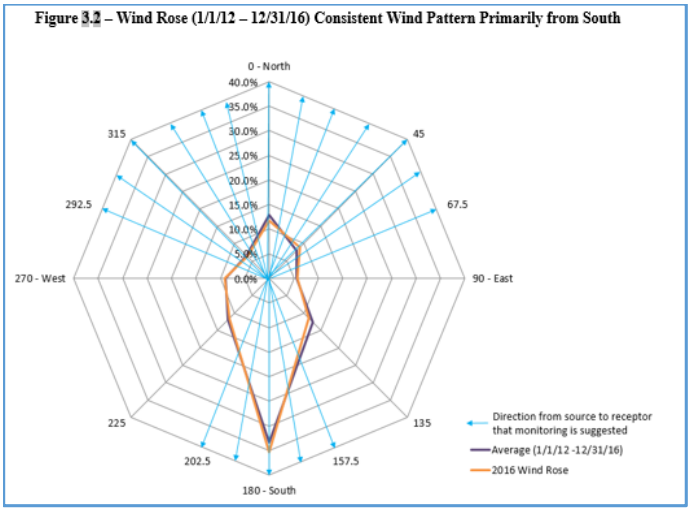
Section 6. References

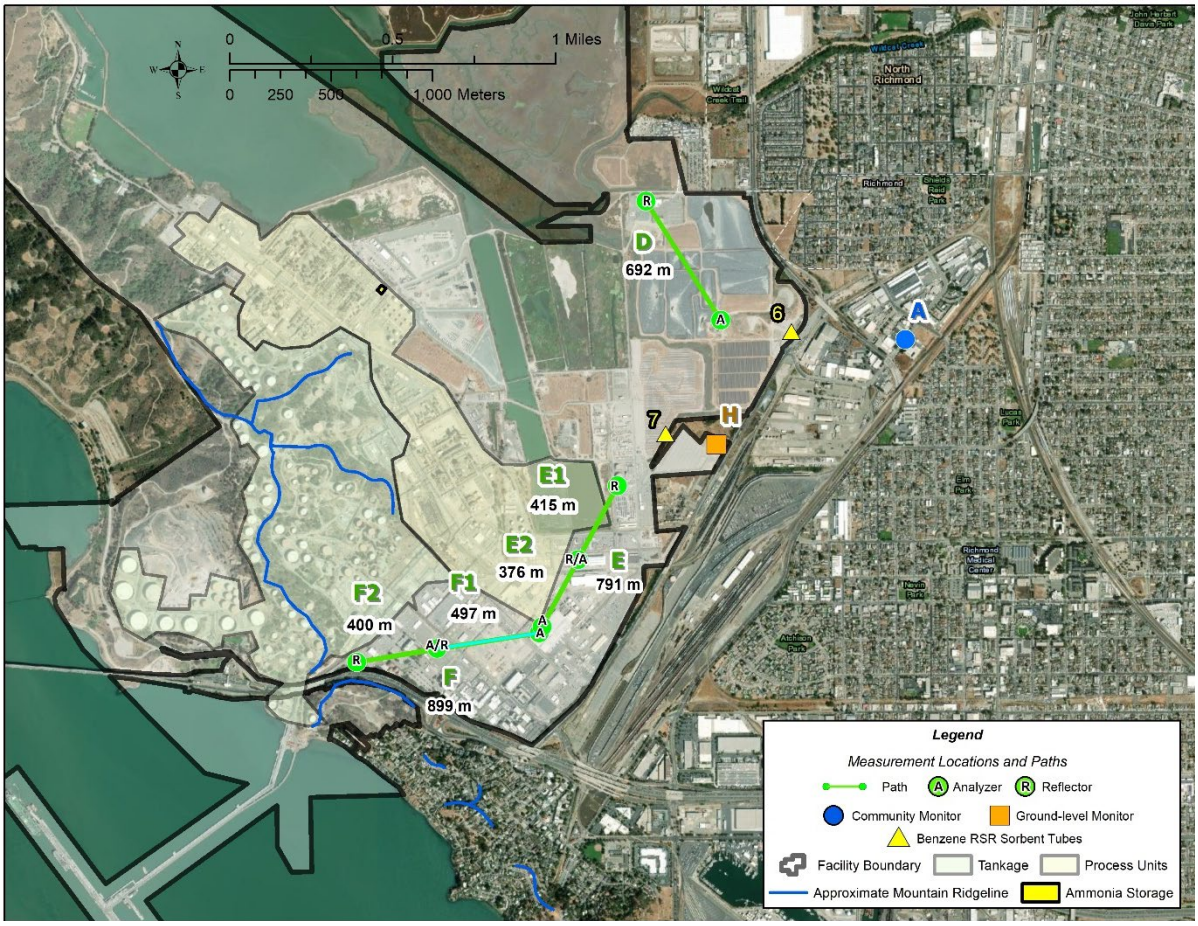
Bay Area Air Quality Management District (2016) Air monitoring guidelines for petroleum refineries: Air District Regulation 12, Rule 15: Petroleum Refining Emissions Tracking; April. Available at http://www.baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.

APPENDIX A

Wind Roses and Refinery Map of Fenceline Monitoring Equipment

Figure 3.2 – Wind Rose (1/1/12 – 12/31/16) Consistent Wind Pattern Primarily from South





APPENDIX B

Quality Assurance Project Plan for the
Chevron Richmond Refinery Fenceline Air Monitoring Program