
# Fence Line Air Monitoring Plan

## For BAAQMD Rule 12-15

## Chevron Richmond Refinery

**September 7, 2017**

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# List of Acronyms

BAAQMD – Bay Area Air Quality Management District

BTEX – Benzene, Toluene, Ethylbenzene, Xylenes

CFR – Code of Federal Regulations

CWS – Contra Costa County Community Warning System

DMS – Data Management System

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

Guidelines – BAAQMD Air Monitoring Guidelines for Petroleum Refineries, AIR DISTRICT REGULATION 12, RULE 15: PETROLEUM REFINING EMISSIONS TRACKING

H2S – Hydrogen Sulfide

LFL – Lower Flammability Limit/Lower Explosive Limit

OEHHA – Office of Environmental Health Hazard Assessment

PPB - Parts Per Billion

PPM – Parts Per Millioin

QA/QC – Quality Assurance / Quality Control

RCAMP – Richmond Community Air Monitoring Program

REL – Reference Exposure Level from http://oehha.ca.gov/air/general-info/oehha-acute-8-hour-and-chronic-reference-exposure-level-rel-summary

SO2 – Sulfur Dioxide

TDL – Tunable Diode Laser

TRI – Toxic Release Inventory

UV-DOAS – Ultraviolet Differential Optical Absorption Spectroscopy

# 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. The Chevron Richmond Refinery (Chevron) has followed these guidelines to generate this Air Monitoring Plan for submission to BAAQMD. 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:

**Element #1 – Gases Requiring Monitoring**

Refinery operators must measure benzene, toluene, ethyl benzene, and xylenes (BTEX) and hydrogen sulfide (H2S) concentrations at refinery fence-lines 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 (SO2), 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: why these compounds are not contained in the compositional matrix of emissions; are not at expected concentrations measured by available equipment; and/or address the technical or other considerations that make specific measurements inappropriate or unavailable.

**Element #3 – Fence-line Coverage**

For refineries that do not have open path monitoring capability in place, measurements must cover populated areas within 1 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% 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 those current systems adequately address population requirements.

**Element #4 – Sample Time Resolution and Data Completeness**

Open path fence-line 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. Instrumentation must 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 affects 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 Quality Assurance Project Plan (QAPP) that follows EPA guidelines must be developed that outlines the QA/QC parameters.

Chevron's policy is to comply with all local and federal environmental regulations including the fence-line 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 Fence Line and Community Monitoring

The Richmond Refinery currently operates three open-path fence line monitors and three community monitors as part of the Richmond Community Air Monitoring Program (RCAMP). The fence line monitors have been in operation since 2013. The community monitors have been in operation since 2014. Siting of the fence line and community monitors and the compounds to be monitored were subject to City of Richmond approval. Site locations for the fence-line equipment were selected to strategically position the fence-line monitors using the predominant and variable meteorological conditions and topographical terrain features within the refinery.

The fence line and community monitoring sites were selected with the following considerations, consistent with guidance from EPA and CARB. Environmental requirements were considered in the monitors' placement with respect to on-site and off-site sources. The existing fence line monitors do not have any large-scale sources between the monitor and the fence line. The monitors were placed with consideration toward proximity to off-site emissions sources. 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 the 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 with Shields-Reid, Point Richmond, and Atchison Village Neighborhood Councils, who provided input on the locations of the air monitors between September 2011 and November 2012. These are all the neighborhoods that border the refinery. The compounds to be monitored were selected with input from the City of Richmond, Argos Scientific, and community representatives. The compounds monitored by the fence line system are considered to be common of refinery operations. The specific chemicals that require monitoring were evaluated for each source from

emissions estimates based on available TRI (Toxic Release Report) information. 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 fence line and community monitoring data is made available to the public online at http://fenceline.org/richmond/index.htm. 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, H2S, ozone, SO2, toluene, and xylene. Chevron plans to add capability to our existing 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. H2S will continue to be detected and quantified using an open-path Tunable Diode Laser (TDL) air monitoring system and the Castro Street ground level point monitor, which is used to demonstrate compliance with BAAQMD Rule 9-2-301. 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 sulfur dioxide (SO2), alkanes or other organic compound indicators, 1,3-butadiene, and ammonia for inclusion in the Air Monitoring Plan. Chevron plans to continue fence line monitoring SO2 and add fence line monitoring of alkanes. Chevron does not plan to add fence line monitors for 1,3-butadiene and ammonia.

**SO2**

SO2 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 plans to monitor alkanes at the 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. The analyzers would be installed to provide indication of emissions from process units, which do not emit BTEX compounds, namely the Alkylation Unit, Liquid Petroleum Gas spheres and loading racks, and hydrogen plant.

The alkanes to be monitored will be methane, ethane, propane, butane, and pentane. Methane and total alkane (C2 through C5) concentration would be reported on the website. C6 and greater would not be 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 would like to install open path Fourier Transform Infrared (FTIR) monitors for monitoring alkanes as long as it can be demonstrated that an open-path FTIR is capable of measuring alkanes (C1 through C5) at a minimum of 500 meters path length while achieving greater than 90% data completeness. Chevron would like 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 to capture a possible plume that may cross the fence line. However, FTIR manufacturers have not demonstrated that an open-path FTIR could measure individual alkane species at 500 meters path length at the refinery's design conditions, which are 82% relative humidity at 96 degrees Fahrenheit. FTIR accuracy at design conditions is important for ensuring data availability. If an open-path FTIR is capable of meeting both the following conditions, then Chevron plans to install open-path FTIRs along the same paths as the TDL and UV-DOAS paths.

1. Equipment is capable of measuring 200 ppb of each alkane (C2-C5) with at least 75% accuracy at a minimum path length of 500 meters when water vapor concentration is equivalent to the refinery's design conditions, and

2. Minimum detection limits of alkanes at 500 meters path length are lower than extractive FTIR minimum detection limits.

If an open path FTIR cannot meet the two conditions above, then Chevron plans to install five extractive FTIRs. Accordingly, an FTIR manufacturer will field test an open-path FTIR with a contracted Chevron representative observing the test. The largest interferent in FTIR measurements is water vapor from humidity. The test would chart relative humidity, temperature, and path length where humidity causes signal extinction in the wavelength range that alkanes are measured. Based on the chart, the manufacturer will recommend a path length for the refinery's design conditions. If the manufacturer's recommended path length is greater or equal to 500 meters, then minimum and upper detection limits will be determined for each alkane species (C1 through C5) at the manufacturer's recommended path length. Accuracy of each alkane (C2 through C5) measurement in comparison with a 200 ppb standard concentration will also be determined at the manufacturer's recommended path length.

In all cases, Chevron's selection of the particular FTIR monitoring technology will have less than 1.1 part per million detection limit for methane and part per billion detection limits for C2 through C5 alkanes. Since methane is present in ambient air at greater than 1.7 ppm[1], methane readings will always be higher than the minimum detection limit. The FTIRs will also be designed to operate at least 90% of time based on annual quarters consistent with the Guidelines. Relevant equipment specifications are provided in Section 4 of this plan.

Existing measures for monitoring alkane and organic compound leaks

The systems would 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

[1] Fairley, D., Fischer, M.L., Top-Down Methane Emissions Estimates for the San Francisco Bay Area from 1990 to 2012, *Atmospheric Environment* (2015), doi: 10.1016/j.atmosenv.2015.01.065. http://calgem.lbl.gov/Fairley-2015-Atm-Env-1990-2010-SFBayArea-CH4-SK76R4HS2.pdf

individuals are monitoring background hydrocarbon concentrations and components in the refinery using Method 21. Method 21 is described in 40 Code of Federal Regulations Subpart 60 Appendix A-7. In accordance with Rule 8-18, Chevron repairs any source of a leak causing background concentration higher than 50 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. Floating roof tank seals are inspected at least semiannually. In 2016, one third of regulated tank seals were inspected quarterly. 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. Starting October 2017, all contractors entering Chevron process units will be required to wear personal LFL monitors that 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 lbs per year of 1,3 butadiene emissions to the Environmental Protection Agency (EPA) in its annual Toxic Release Inventory Report. Chevron does not expect 1,3 butadiene to be present in measurable concentrations at the fence line.

**Ammonia**

Chevron proposes to exclude ammonia from fence line monitoring because it is not emitted in measurable amounts at the fence line as anhydrous ammonia, which is BAAQMD's primary toxicity concern. Sources of ammonia leaks are not as prevalent as alkanes. Ammonia is produced at 8 and 18 plant, but 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, FCC, 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 percent. Redundant high level alarms sound at 41 percent and emergency alarms sound at 43 percent to ensure operators do not fill the ammonia storage vessels past 45 percent. Ammonia pumps are protected from cavitation by ensuring the ammonia storage vessels

are at least 10 percent filled. Redundant low level alarms sound at 15 percent and emergency low level alarms sound at 10 percent. 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, 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 would occur. If more than 100 lbs of ammonia is released in a 24-hour 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 the Bay Area Air Quality Management District, 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 on three community monitors. The monitors collect five-minute average concentration data similar to fence line monitors and post the five minute 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. Figure 3.1 shows that the maximum one hour average concentration was less than four percent of the acute health standard. To determine the maximum one hour average concentrations for comparison with the acute health standard, 60 minute averages were calculated for every five minutes of data from the community monitor's start of operation in 2014 through December 31, 2016. During periods that a chemical was not detected, one ppb was substituted for calculating the average concentration. The average concentration measured at each community monitoring station was less than two percent of the chronic health standard. 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 the existing fence line monitors, of which ammonia was not selected.

**Figure 3.1: Comparison of Richmond Community Monitors One Hour Average Concentrations with Acute (One-hour Average) OEHHA Health Standard**

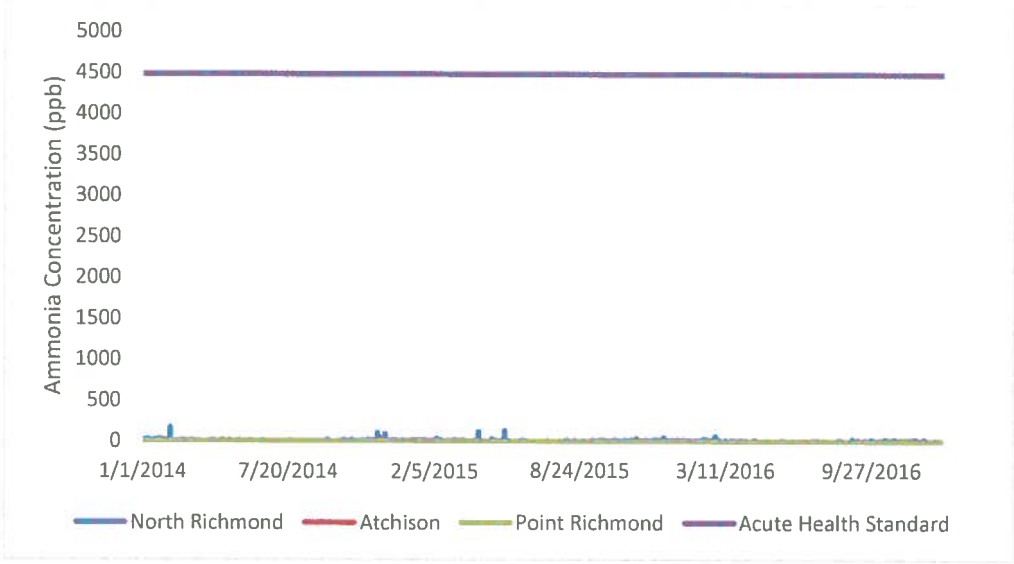



Table 3.1 summarizes the gases to be included in the Rule 12-15 fence-line air monitoring program and the equipment to be used to detect them.

**Table 3.1- Gases Included in the Fence-Line Air Monitoring Plan**

| Gas | Equipment |
|---|---|
| Alkanes (C2 through C5) | Open path FTIRs or five extractive FTIRs |
| Benzene | Three open path UV-DOAS<br>Sorbent tubes at sample stations 6 and 7* |
| Ethyl Benzene | Three open path UV-DOAS<br>North Richmond community monitor |
| Hydrogen Sulfide | Three open path TDLs<br>Castro Street ground level monitor |
| Methane | Open path FTIRs or five extractive FTIRs |
| $SO_2$ | Three open path UV-DOAS<br>Castro Street ground level monitor |
| Toluene | Three open path UV-DOAS<br>North Richmond community monitor |
| Xylene | Three open path UV-DOAS<br>North Richmond community monitor |

*Sampled and analyzed in accordance with 40 CFR 63.658

## Element #3 – Fence-line Coverage

This section describes the process used to determine where fence-line air monitoring equipment would be installed and/or made part of the Rule 12-15 fence line monitoring compliance program. In accordance with the Guidelines, wind rose analyses were completed to determine the monitor locations needed to cover populated areas within 1 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% 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 summary in Table 3.2. Figure 3.2 compares the 2016 wind rose with the five-year 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 at 292.5 degrees to 67.5 degrees and at 157.5 degrees to 202.5 degrees downwind of sources within 1 mile of the refinery fence line depending upon site topography.

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

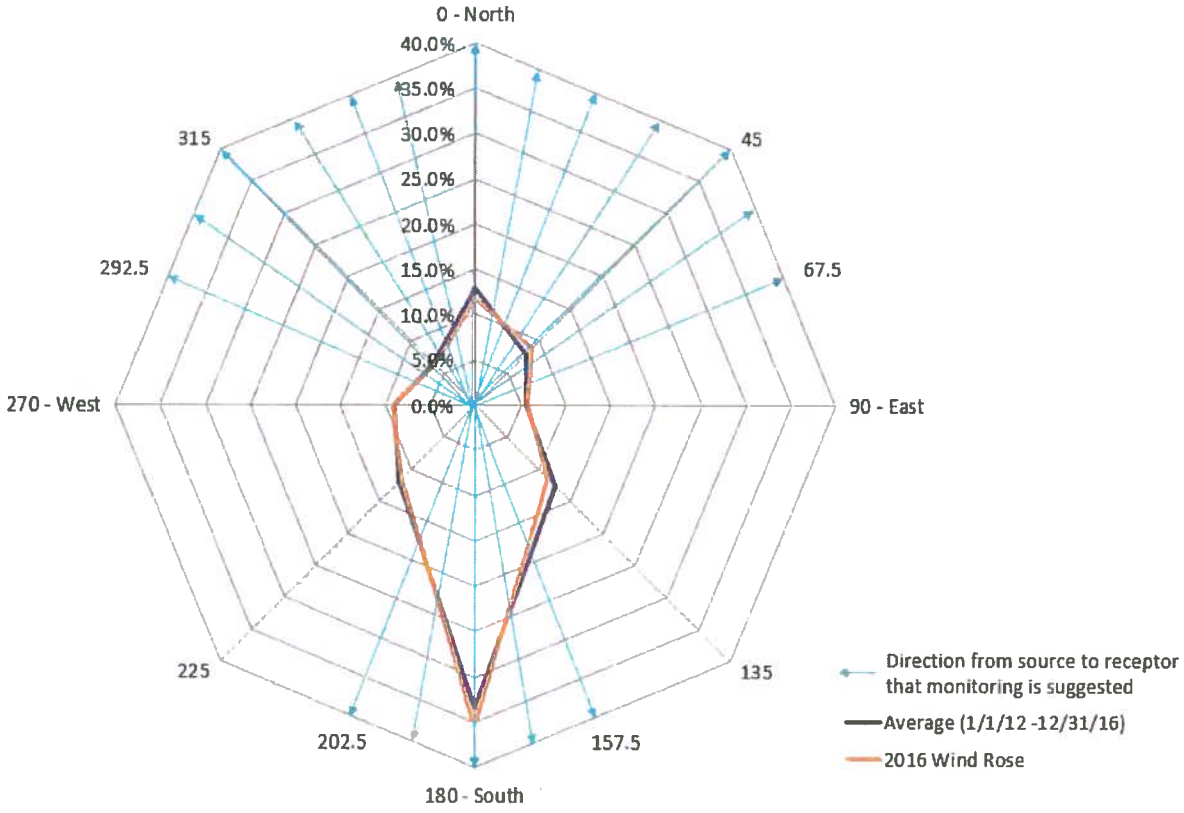
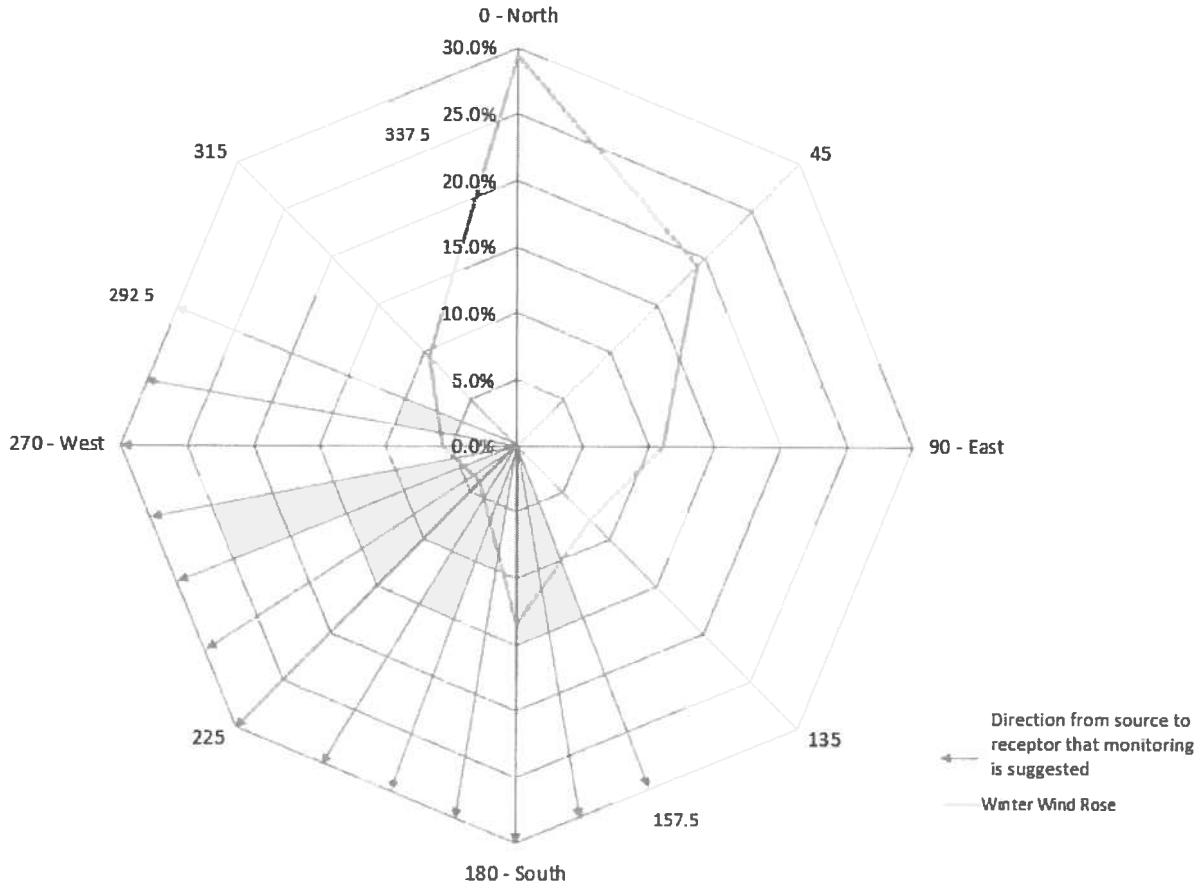



Figure 3.3 contains a wind rose of winter winds from November 1 through February 15 in the years 2012 through 2016. This figure shows winds blowing primarily from the north and north east during winter months. The wind direction is from 0 degrees north through 90 degrees east more than 10% of the time during winter months. Per the Guidelines, fence line monitoring coverage should be considered between 157.5 and 292.5 degrees 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 fence line monitor coverage beyond the existing RCAMP fence line monitors. As described in Section 2, the existing fence line 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. Sectors where wind blows in that quadrant greater than 10% of the time are highlighted in blue. Table 3.2 lists the additional monitors that will have data posted to the public RCAMP website for Rule 12-15 compliance.

**Table 3.2 – Additional Monitors Based On Wind Rose Analyses**

| Direction From | Range | Percent | Coverage on Existing Public Website | Proposed Additional Coverage for Rule 12-15 |
|---|---|---|---|---|
| | | | | |
| North | 337.5-22.5 | 12.61% | Partial coverage by Point Richmond open-path UV-DOAS and TDL | • Extending Point Richmond UV-DOAS and TDL path lengths to ~910 meters<br>• Adding point or open-path FTIR 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 and TDL<br>• North Richmond community monitor | • Adding point or open-path FTIR monitors<br>• Including benzene sorbent tube sample stations 6 and 7<br>• Including Castro Street ground level monitor |
| West | 247.5-292.5 | 9.04% | • Atchison Village and North Richmond open-path UV-DOAS and TDLs<br>• North Richmond community monitor | • Including benzene sorbent tube sample stations 6 and 7<br>• Including Castro Street ground level monitor |
| Northwest | 292.5-337.5 | 6.59% | Atchison Village and Point Richmond UV-DOAS and TDL open-path monitors | Adding point or open-path FTIRs |

Based on the 2012 through 2016 wind rose analysis, the proposed monitors cover populated areas within 1 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% of the time or greater, given site topography. Refinery emission sources, and existing and proposed air monitoring equipment, including the option of point or open path FTIRs, 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 UV-DOAS and TDL open path monitors are located northeast of the refinery. The Atchison Village UV-DOAS and TDL open path monitors are located east of the refinery. The Point Richmond UV-DOAS and TDL 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 water bodies, which are not populated.

As explained in Section 3 Element #2, if the open-path FTIR study demonstrates that an open path FTIR is capable of measuring alkanes (C1 through C5) accurately at refinery design conditions and with MDLs lower than extractive FTIRs, then Chevron plans to install open-path FTIRs along the same total paths as the UV-DOAS and TDL open path monitors. Otherwise Chevron plans to install five extractive or point FTIRs. Chevron plans to include 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.

Figures 3.4 and 3.5 provide a visual summary of the proposed monitoring locations that will be part of Rule 12-15 compliance.

**Figure 3.4 Proposed Locations of Rule 12-15 Monitors With Open Path FTIR Option**

**Figure 3.5 Proposed Locations of Rule 12-15 Monitors with Point FTIR Monitor Option**

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 plans to move the Point Richmond monitor to a lower elevation so that fugitive emissions are primarily measured. Argos Scientific, who is experienced with operating and maintaining the monitors, indicated that the current minimum detection limits for BTEX, SO2, and H2S should be achievable at the planned path length, which is less than 920 meters. 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 fence line monitors. Thus, the BAAQMD is primarily interested in using the fence line 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 north west 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 fence line monitor. Also, the tanks are compliant with Rule 8-5 storage vessel requirements, which limits 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 planned 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 would be fulfilled with point monitors. The following point monitors will become part of the Rule 12-15 compliance program.

- Castro Street ground level monitor fulfills H2S and SO2 monitoring
- One sorbent tube at each sample station 6 and 7 fulfills suggested benzene monitoring
- North Richmond community monitor fulfills benzene, ethylbenzene, toluene and xylene monitoring

The two sorbent tube samples would continue to be analyzed for benzene at frequencies specified in 40 CFR 63 Subpart CC. Starting around April 2018, the Environmental Protection Agency (EPA) plans to report benzene sorbent tube data over a public website approximately quarterly. Chevron will provide a link to the EPA website. Five-minute average Castro Street GLM data and five-minute average North Richmond community monitor data will be 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 North Richmond open path monitor typically catches 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 ten years of GLM reports showed that Chevron has not caused exceedence of the sulfur dioxide ground level concentration limits in Rule 9-1-301 or the hydrogen sulfide 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 H2S detection limit is about 0.5 ppb versus an open path monitor detection limit is over 100 ppb. The GLM's SO2 detection limit is also about 0.5 ppb versus an open path monitor's detection limit is about 4 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 fence line between the North Richmond and Atchison open path monitors are much lower than the OEHHA chronic health standard of 3 ug/$m^3$. 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 3.3. 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, Castro, 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 intersection or nearby off-site excavation of contaminated soil.

**Table 3.3 – Benzene Sorbent Tube Results Are Within OEHHA Chronic Health Standard**

| Sample Start Date | Sample End Date | Sample Point / Benzene Concentration* (ug/m3) | | | | |
|---|---|---|---|---|---|---|
| | | 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, which measures BTEX, H2S, ammonia, several alkanes, trimethylbenzenes, 3-methylpentane, 2,2,4-trimethylpentanes, PM2.5 and black carbon, located at Richmond fire station 62 on 7th Street. The North Richmond community monitor is located downwind of the refinery when wind is from the west or southwest. Data

from the North Richmond community monitoring station is posted at http://www.fenceline.org/Richmond/data.php.

Table 3.4 shows that BTEX concentrations measured at the North Richmond community monitor for any wind direction are far below California Office of Environmental Health Hazard Assessment (OEHHA) acute health standards. The North Richmond community monitor collects five-minute average concentration data and posts the five-minute averages to the website similar to fence line monitors. To determine the maximum one hour average concentrations for comparison with the acute health standard, 60 minute averages were calculated for every five minutes of data from January 1, 2014 through December 31, 2016. During periods that 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 one hour average concentration was equal to 34% (2.75 ppb one hour average/8 ppb acute health standard) of a health standard.

Table 3.4 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 five-minute average data was averaged from January 1, 2014 through December 31, 2016. During periods that 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 health standard) of a chronic health standard.

Given the data in Table 3.4, Chevron does not expect BTEX to be regularly detectable by an open path fence line monitor between the North Richmond and Atchison open path monitors and does not expect any exceedence of a health standard. The community monitor is more sensitive than open path fence line monitors, and only half a mile downwind (westerly wind) from the N. Richmond fence line. The BTEX detection limit of the community monitor is 0.5 ppb versus the detection limit of an open path monitor is about an order of magnitude higher.

**Table 3.4 – North Richmond Community Monitor Data Is Within Health Standards (1/1/2014 – 12/31/2016)**

| Chemicals | Maximum One Hour Average Concentration (ppb) | Acute OEHHA REL (ppb) | Average Concentration (ppb) | Chronic OEHHA REL (ppb) |
|---|---|---|---|---|
| benzene | 2.75 | 8 | 0.25 | 1 |
| ethylbenzene | 12 | None published | 0.25 | 400 |
| toluene | 111 | 9,800 | 0.30 | 70 |
| xylenes | 65 | 5,000 | 0.57 | 200 |

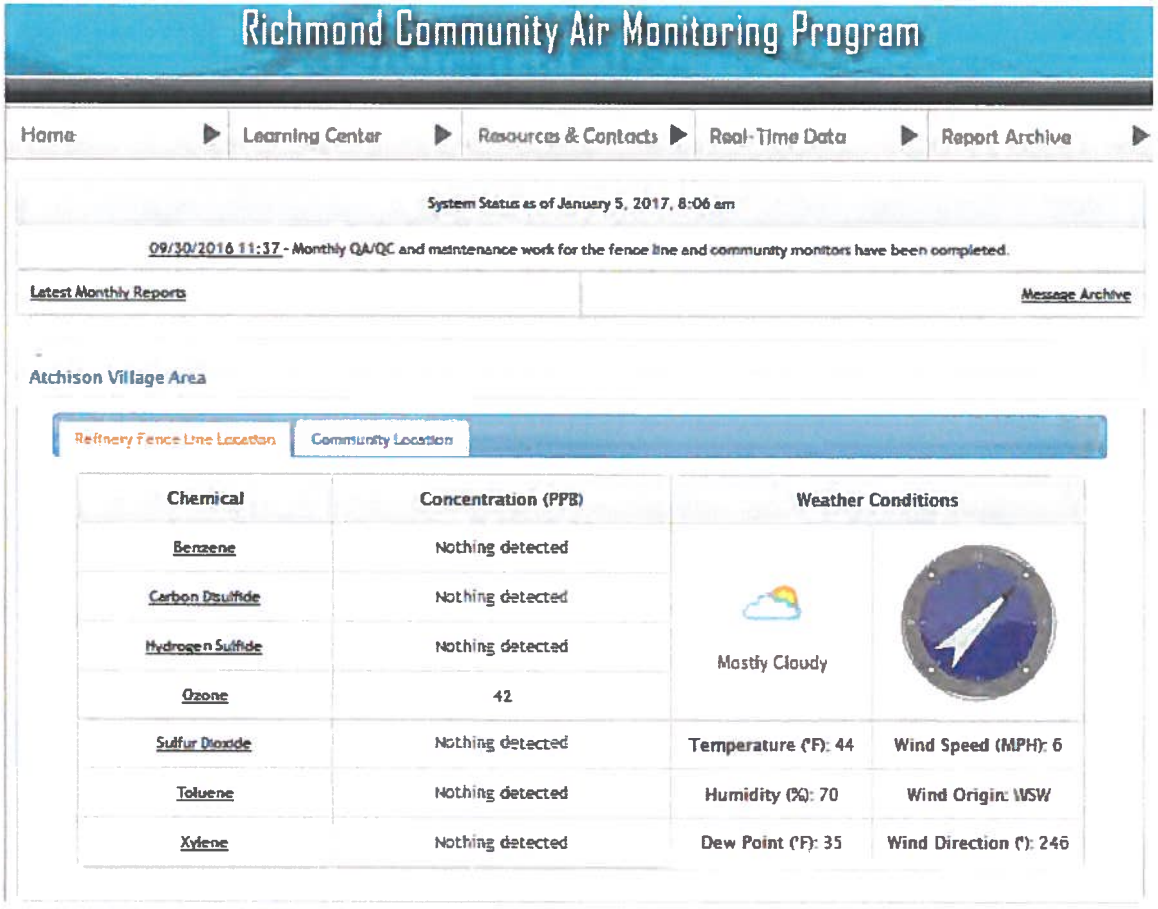
## Element #4 – Sample Time Resolution and Data Completeness

Fence-line continuous monitoring equipment specified for the Chevron fence-line system will collect data on five minute averages and report the five-minute averages. Chevron will aim 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 affects accurate measurements, such as dense fog, will not be 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' ability to provide accurate measurements. In the event that signal drops on two of either the UV-DOAS, the TDL, and/or the FTIR in the same proximity simultaneously, the data may be flagged as weather related and will not be counted as instrument down time.

## Element #5– Data Presentation to the Public

Data from the fence line monitors will be transmitted to an Internet website where near-real-time results can be viewed by the public. Figure 3.6 shows an example webpage of real-time data. The actual website design can be customized and may differ from the image shown in Figure 3.6.

**Figure 3.6 – Sample Real-time Community Air Monitoring Webpage**



Data generated by the fence line monitoring equipment undergoes review throughout the measurement and reporting process. Included in this process is automated QA/QC checks that occur before data is reported on the real-time 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 uploaded may be impacted by Internet traffic. An automated system conducts the Quality Assurance checks listed in Table 3.5 before the data is reported to the website. The website will also make available a rolling 24-hour trend of the 5 minute data for each gas reported.

Once QA/QC of the final data is completed within 60 days after the end of each calendar quarter, the refinery will provide one hour average concentration data in tabular format through a comma separated value data file to the BAAQMD. The BAAQMD may make the one hour 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. All data will be retained by Chevron for a period of five years, consistent with Regulation 12-15-302.

**Table 3.5 - Real-time Data Quality Assurance**

| Real-Time Check | System Check | Follow-up Activities |
|---|---|---|
| **Low Signal** | Signal Threshold Test for UV, TDL or FTIR | If signal is below the threshold value the real-time website reports "Low Signal" for the specific analyzers. In addition, an automated email is sent to the Program Manager and Field Technician who will determine if the loss of signal is due to weather or other issues. |
| **Instrument Error Code** | Instrument Error Code | When an instrument reports an error code, the Real-time website will report an "off-line" message for the specific analyzer, and no additional data will be reported to the website. An email will be sent to the Program Manager and Field Technician notifying them of the situation. |
| **Internet Connection Lost** | Internet Connection | If internet connection is lost, an email will be sent to Field Technician and Program Manager to restore the internet connection. An "internet unavailable" message for the specific analyzer will appear on the web site. |

Figure 3.7 shows an example website, subject to change, that appears when a person clicks a chemical name on the page in Figure 3.6. The web page describes the chemical properties, common sources of the chemical, and OEHHA health standards. A click on an ambient air quality standard displays the OEHHA website that describes the basis for the health standard.

## Figure 3.7 – Example Website Display of Ambient Air Quality Standards

**Fenceline Monitoring Chemical Definitions**

| Chemical | Description | Ambient Air Quality Standards |
|---|---|---|
| Benzene | Benzene is a volatile organic compound (VOC) that is an important solvent and used in the production of drugs, plastics, synthetic rubber and dyes.<br>... more | Short-term (acute) Toxicity Summary (for a 8-hour exposure) 8 PPB<br>Long-term (chronic) Toxicity Summary 1 PPB<br>... more |
| Carbon Disulfide | Carbon Disulfide is a volatile organic compound (VOC) that is often found in industrial processes.<br>... more | Short-term (acute) Toxicity Summary (for a 6-hour exposure) 2000 PPB<br>Long-term (chronic) Toxicity Summary 300 PPB<br>... more |
| Hydrogen Sulfide | Hydrogen sulfide occurs naturally in petroleum, natural gas, volcanic gases, and hot springs. It is also found in many waste streams and is easily identified by its distinctive "rotten egg" odor.<br>... more | Short-term (acute) Toxicity Summary (for a 1-hour exposure) 30 PPB<br>Long-term (chronic) Toxicity Summary 8 PPB<br>... more |
| Ozone | Ozone is a colorless, odorless reactive gas comprised of three oxygen atoms. It occurs naturally in the earth's stratosphere, where it is beneficial as it absorbs the ultraviolet component of incoming solar radiation that could be harmful to life on earth. However, ozone is also found near the earth's surface where pollutants such as nitrogen oxides (NOx) and volatile organic compounds (VOCs) combine with carbon monoxide (CO).<br>... more | Currently there are no standards set for evaluating risks of exposure to Ozone. |
| Sulfur Dioxide | Sulfur dioxide is a product of combustion from coal and other fuel burning. There are natural sources of atmospheric SO2, including volcanoes. Sulfur dioxide is used as a food preservative for some fruits and vegetables; as a disinfectant; for bleaching flour, fruit, grain, wood pulp, wool, textile fibers, gelatin, and glue; and for making other chemicals.<br>... more | Short-term (acute) Toxicity Summary (for a 1-hour exposure) 250 PPB<br>... more |
| Toluene | Toluene occurs naturally as a component of petroleum and is produced in petroleum refining and coke oven operations. Toluene is commonly found in household aerosols, nail polish, paints and paint thinners, lacquers, rust inhibitor, adhesives and solvent based cleaning agents.<br>... more | Short-term (acute) Toxicity Summary (for a 1-hour exposure) 9800 PPB<br>Long-term (chronic) Toxicity Summary 70 PPB<br>... more |
| Xylene | Xylenes are a clear, colorless, sweet-smelling liquid. Xylenes are found naturally in petroleum, coal tar, and wildfires. Xylenes are commonly used in industrial solvents, paints, varnishes, dyes, adhesives, detergents, and pharmaceuticals.<br>... more | Short-term (acute) Toxicity Summary (for a 1-hour exposure) 5000 PPB<br>Long-term (chronic) Toxicity Summary 200 PPB<br>... more |

Additional information will be made available on the website to help the public understand how the fence line monitoring system works and to help explain the data. Fence line monitor locations, how the locations were selected, and descriptions of equipment used will be published. Context of what fence line measurements represent as compared to other regional air quality measurements, as outlined by BAAQMD, will be provided on the website.

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 Chevron contact or a designated consultant 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, all comments will be made available to BAAQMD upon request. Some of the comments will aid in the creation of frequently asked questions to be published on the website.

### Element #6– Quality Assurance Project Plan

A Quality Assurance Project Plan is provided in Appendix B.

## Section 4 – Monitoring Equipment Description

The fence-line monitoring program for Rule 12-15 will integrate 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 the monitor's intake line.

**Castro Street Sulfur Dioxide and Hydrogen Sulfide GLMs**

The sulfur dioxide and hydrogen sulfide GLMs comply with the BAAQMD Manual of Procedures Volume VI. The sulfur dioxide GLM is a trace level pulsed fluorescence sulfur dioxide analyzer. The analyzer operates by measuring the emitted fluorescence of SO2 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 fluorescent chamber. SO2 absorbs light in this region without any quenching by air or most other molecules found in ambient air. The SO2 molecules are excited by UV light and emit a characteristic decay radiation. A second filter allows only this decay radiation to contact a photomultiplier tube (PMT). Electronic signal processing transfers the light energy impinging on the PMT into a voltage which is directly analyzed.

The hydrogen sulfide GLM operates using similar technology as the SO2 analyzer. The analyzer converts H2S to SO2, then analyzes the concentration similar to the SO2 GLM.

**Extractive or Point FTIR:**

Extractive or point FTIR air monitoring systems use a beams of infrared (IR) light to detect and measure alkanes in the air. A beam of light passes through the air sample inside a chamber to multiple reflectors that then send the light beam back to a light detector. FTIRs with larger beam paths and associated sample chamber can achieve lower detection limits than FTIRs with shorter beam paths. For this project, if an open path monitor is not viable, Chevron plans to install extractive FTIRs with the lowest

demonstrated alkane detection limit available from the selected manufacturer. 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 gas. These 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 C2 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 systems. Unlike the open-path FTIR, an extractive FTIR is capable of operating during heavy fog or rain.

**North Richmond Community Monitor Auto Gas Chromatograph:**

Automated Gas Chromatographs are point sampling technologies. 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 gases that were in the sample through the column at different rates depending on their various chemical and physical properties. As the chemicals exit the end of the column, they are detected and identified 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 at very low concentrations in the air.

**Open-path FTIRs:**

Open-path FTIR air monitoring systems operate in a similar fashion as extractive FTIRs. Instead of measurement inside a sample chamber, a beam of IR light is sent across ambient air to a reflector that sends the light beam back to the light detector. The concentration of the gas is determined by measuring the amount of each specific wavelength of light that was absorbed. Open-path FTIRs can theoretically achieve lower detection limits than extractive FTIRs because the beam path is much longer. This system will be studied for viability of measuring alkanes. The primary limitations for the 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 TDLs:**

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 a FTIR uses a broad band beam of light as its source. TDL systems are designed to measure single gases which, for this application, is hydrogen sulfide. The primary interferents of the TDL air monitoring systems are water vapor and carbon dioxide, because both absorb light in the same region as hydrogen sulfide. The primary limitation for the system is that the light signal cannot penetrate heavy fog or rain.

**Open-Path UVs:**

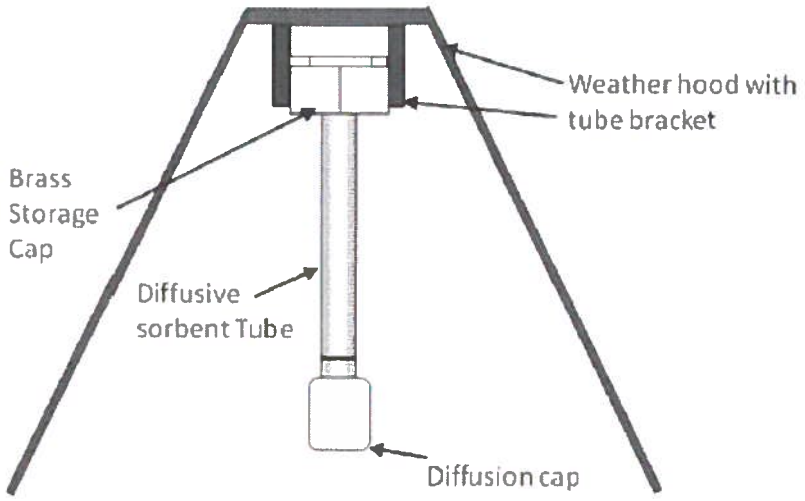
The open-path UV system differs from the open-path FTIR and TDL systems in two ways. First the system has a light source at one end of the path that sends a beam directly to the light detector at the other end of the light beam. The other difference is that the system uses ultra violet light as a light

source. The Open-path UV air monitoring system is used to detect BTEX as well as sulfur dioxide. The primary interferents associated with the UV air monitoring systems are ozone and oxygen gas, 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 Figure 4.1 to protect them from rain. Thus, the tubes are capable of providing average benzene concentrations in the ambient air during nearly all weather conditions (with the exception of extremely high winds with rain), including fog. The sorbent tube method also achieves benzene concentration measurements at concentrations lower than open path monitor minimum detection levels.

**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 detection limit 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 Gas Chromatograph | Measures BTEX continuously at a point with lower detection limit than open-path monitors | | Measures at point vs. open-path | Within 25% |
| Extractive or Point FTIR Option | Measures alkanes continuously at a point | Water (humidity), CO2, and C2-C5 alkanes may interfere with each other | Expected higher minimum detection limit than open-path FTIR | Within 25%; Uses regression analysis to quantify data |
| Open-path FTIR Option | Measures alkanes across an open path continuously; Likely lower detection limit than extractive FTIR | Water (humidity), $CO_2$, and C2-C5 alkanes may interfere with each other | Heavy Fog and Rain | Quantitative error is to be determined; Uses regression analysis to quantify data |
| Open-path UV | Measures BTEX and SO2 across an open path continuously | Ozone and oxygen | Heavy Fog and Rain | Within 25%; Uses Partial Least Square (PLS) analysis to quantify data |
| Open-path TDL | Measures H2S continuously across an open path | Water (humidity) and $CO_2$ | Heavy Fog and Rain | Within 25%; Uses Single Regression Analysis to quantify data |
| Castro St. H2S and SO2 GLM | Measures H2S and SO2 at a point continuously; Lower detection limit than open path monitors | High concentrations of hydrocarbons; Mercaptans interfere with H2S measurement | Measures at a point vs. open path | Within 10% for SO2, within 15% for H2S (BAAQMD MOP Volume VI) |

## Section 4.3 – Detection Range

Table 4.2 shows the expected detection range of methane and alkanes (C2 through C5) for an extractive FTIR. The FTIR should always show methane readings greater than 1,700 ppb due to the inherent presence of methane in the ambient air. Minimum and upper detection limits will be determined for open path FTIRs during the study.

**Table 4.2 Detection Range of Extractive FTIR**

| Gas | Lower Detection Limit* (ppb) | Upper Detection Limit* (ppb) |
|---|---|---|
| Methane | 1,070 | 356,000 |
| Alkanes (C2 - C5), If present as: | | |
| Ethane | 350 | 116,000 |
| Propane | 530 | 175,000 |
| Butane | 450 | 149,000 |
| Pentane | 350 | 116,000 |

Tables 4.3 through 4.5 summarize the detection ranges for the open path TDL and UV-DOAS monitors.

**Table 4.3 North Richmond Open-Path Monitors**

| Gas | Lower Detection Limit (ppb) | Upper Detection Limit (ppb) |
|---|---|---|
| Benzene | 4.7 | 6,100 |
| Ethyl Benzene | 25.6 | 6,100 |
| $H_2S$ | 720 | 93,123 |
| $SO_2$ | 4.7 | 2,450 |
| Toluene | 4.7 | 3,050 |
| Xylene | 4.7 | 3,050 |

**Table 4.4 Atchison Open-Path Monitors**

| Gas | Lower Detection Limit (ppb) | Upper Detection Limit (ppb) |
|---|---|---|
| Benzene | 4 | 6,100 |
| Ethyl Benzene | 21.9 | 6,100 |
| $H_2S$ | 610 | 79,462 |
| $SO_2$ | 4 | 2,450 |
| Toluene | 4 | 3,050 |
| Xylene | 4 | 3,050 |

**Table 4.5 Point Richmond Open-Path Monitors**

| Gas | Lower Detection Limit (ppb) | Upper Detection Limit (ppb) |
|---|---|---|
| Benzene | 3.6 | 6,100 |
| Ethyl Benzene | 19.5 | 6,100 |
| $H_2S$ | 550 | 71,038 |
| $SO_2$ | 3.6 | 2,450 |
| Toluene | 3.6 | 3,050 |
| Xylene | 3.6 | 3,050 |

The minimum detection limit of the sorbent tubes are dependent upon several analytical factors, including the presence of moisture. The typical minimum detection limit for benzene is typically 0.07 ug/m$^3$, 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 minimum detection limit 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 4.6 lists the proposed locations of the fence-line monitoring equipment.

**Table 4.6 Monitoring Equipment Locations**

| Monitor* | Fence Line | Approximate Elevation Above Ground Level | Location |
|---|---|---|---|
| UV, TDL, and FTIR Receivers | North Richmond | 18 | Maintenance Building |
| UV source, TDL reflector, and FTIR Source or FTIR Point | North Richmond | 18 | Next to Gertrude GLM |
| North Richmond Workstation | North Richmond | Not applicable | Maintenance Bldg. |
| Sorbent tube sample station 6 | North Richmond | 5.5 | Reclamation Yard Gate to Castro |
| North Richmond Community Monitor | North Richmond | 10 | Fire Station #62 |
| Sorbent tube sample station 7 | Atchison Village | 5.5 | Solar panel field |
| Castro GLM | Atchison Village | 8 | Gate 91 |
| UV, TDL, and open path FTIR source or FTIR Point | Atchison Village | 40 | Water Tank |
| FTIR Point Monitor | Atchison Village | 8 | Gate 91 Security |
| UV, TDL, and FTIR Receivers or FTIR Point | Atchison Village | 65 | North end of Lube Plant |
| Atchison Village Workstation | Atchison Village | Not applicable | Lube Plant Elevator Room |
| Point Richmond Workstation | Point Richmond | Not applicable | Lube Plant Elevator Room |
| UV, TDL, and FTIR Receivers or FTIR Point | Point Richmond | 35 | South West Corner Lube Plant |
| UV source, TDL reflector, and FTIR source or FTIR Point | Point Richmond | 11 | Hill Southwest of Chevron Fire Department |

*FTIR open-path monitor locations are subject to change depending upon the results of the study.

## Section 5 - Timing

Chevron already reports real time data over a website from open-path monitors that measure hydrogen sulfide, sulfur dioxide, benzene, toluene and xylenes. An FTIR manufacturer plans to begin a field study near its Atlanta office of an open path FTIR by November 2017 once manufacture of the FTIR is completed. Chevron would like the manufacturer to collect sufficient data to measure the effect of humidity on the FTIR's alkane readings to ensure that the system achieves at least 90% data availability. The test duration is expected to be about one week. An additional week will be needed for data analysis. If adverse weather occurs or water vapor in the atmosphere is too low in Atlanta to extrapolate alkane measurement capability at 82 percent relative humidity at 96 degrees Fahrenheit, more time may be needed to setup the FTIR in another location. In any case, Chevron expects to update

this Plan by December 29, 2017 with the selected alkane monitoring technology, which is either extractive or open-path FTIR. This plan already contains equipment specifications and locations of the extractive FTIR option. If open path FTIR is selected, then MDLs, UDLs, locations of the monitors and retroreflectors, and path lengths of the open-path FTIRs will be provided in the Plan update.

Chevron can begin implementing compliance with portions of the plan that BAAQMD approves upon receipt of the approval. Chevron intends to install FTIR analyzers, relocate the Point Richmond monitors, and begin operating in accordance with this Plan within one year of approval as required by Rule 12-15-501. However, the following list describes some of the circumstances outside of Chevron's control that could cause delay.

- Significant design changes to accommodate comments from BAAQMD and the public
- City of Richmond permitting delays
- Delays in manufacturing/delivery by suppliers
- Construction delays due to rain

If the implementation schedule is delayed, Chevron will notify the BAAQMD of the cause of delay and provide an expected project schedule.

# APPENDIX A

## Wind Roses and Refinery Map of Fence Line Monitoring Equipment

# APPENDIX B

## Quality Assurance Project Plan