SETTLEMENT AGREEMENT
BY AND BETWEEN
THE BAY AREA AIR QUALITY MANAGEMENT DISTRICT
AND
VALERO REFINING COMPANY – CALIFORNIA
(Notices of Violation described in Appendix A)

I. **Background: Parties and Allegations**

1. The Bay Area Air Quality Management District ("Air District") is the regional governmental agency charged with the primary responsibility for maintaining healthy air quality in the San Francisco Bay Area. (Health & Saf. Code, §§ 39002, 40000 & 40200.)

2. Valero Refining Company – California ("Valero") owns and operates a petroleum refinery located at 3400 East Second Street, Benicia, California ("Facility").

3. The Air District alleges that, at all relevant times, Valero was subject to and violated Air District regulations as described in the Notices of Violation listed in Appendix A ("the App. A NOVs"), which are, by this reference, incorporated into this Settlement Agreement ("Agreement").

4. Valero is entering into this Agreement to avoid the cost of litigation and does not admit or agree with the allegations of the Air District or agree that Valero's actions constituted a violation, and does not admit any liability arising out of or in connection with the occurrences alleged in the App. A NOVs.

II. **Terms and Conditions**

5. In consideration of the foregoing, and of the promises set forth herein, the Air District and Valero (collectively, the "Parties," and individually, "Party") desire to settle and resolve all claims, allegations, disputes, and obligations relating to or arising from the facts and circumstances alleged in the App. A NOVs, (collectively, the "Claims"), and voluntarily agree to resolve the Claims by means of this Agreement. Therefore, in order to settle the Claims, Valero has taken, or agrees to take, the actions enumerated in this Agreement, including the civil penalty payment described in Paragraph 6 below and the actions associated with Valero's fenceline air

monitoring plan described in Paragraphs 7 and 8 below; the Air District agrees to accept this Agreement in termination and full settlement of the Claims, and not to file a legal action against Valero and its beneficiaries, predecessors, successors, assigns, partners, partnerships, parent companies, subsidiaries, affiliates and related entities, officers, directors, principals, agents, employees, and representatives regarding the Claims; and the Parties agree to the terms in this Agreement.

6. Civil Penalty. Valero shall pay the Air District a civil penalty in the amount of $3,250,000 no later than 30 days after the full execution of this Agreement ("Effective Date"). Valero shall pay the civil penalty by wire, in accordance with wiring instructions provided by the Air District, with "2026 Global Valero Settlement" in the memo.

Upon wiring the payment, Valero shall notify the Air District via email. If the Air District does not receive the payment, the Air District shall notify Valero via email, and Valero shall, within 3 business days of the date such notice is sent, re-send the payment according to this Paragraph 6, and this process shall be repeated as needed until the Air District receives the payment. Valero shall be responsible for all payment processing, check cancellation, and other fees or costs associated with carrying out this Paragraph.

If Valero fails to timely pay the civil penalty in this Paragraph 6, Valero shall pay the Air District $2,000 for each day on which it fails to pay the civil penalty.

7. Fenceline Air Monitoring Plan Approval and Hydrogen Sulfide Monitoring Compliance Measures.

a) The Air Monitoring Plan (AMP), Quality Assurance Project Plan (QAPP), and Standard Operating Procedures (SOP) (collectively, the Fenceline Air Monitoring Plan, or FAMP), attached hereto as Appendix B, is hereby approved as Valero's Plan for purposes of Air District Regulation 12-15-403.

b) With respect to hydrogen sulfide air monitoring at the Facility, Valero shall utilize point monitors in lieu of open path monitors for purposes of compliance with Rule 12-15, in accordance with the following provisions:

i) Valero shall operate a minimum of six point monitors at or near the fenceline of the Facility. Each point monitor operated pursuant to this provision shall meet a minimum detection limit of less than or equal to 5 ppb and shall have a measurement error no greater than 20% at a concentration of 50 ppb. Valero may meet this requirement by doing one of the following:

1) Incorporating the Ground Level Monitors (GLMs) it currently operates pursuant to Rule 9-2 into its fenceline monitoring program, in which case those GLMs shall be counted toward meeting the minimum of six point monitors required under Paragraph 7.b.i, and purchasing, installing, and operating one additional point monitor in close proximity to measurement path 1-1" (see Figure 2 on page 3 of the FAMP approved under Paragraph 7.a), one additional point monitor in close proximity to measurement path 2-2', and one additional point monitor in close proximity to measurement path 3-3'; or

2) Purchasing, installing, and operating six new point monitors at or near the fenceline of the Facility. Three of those monitors shall be located in close proximity to measurement paths 1-1", 2-2', and 3-3' (see Figure 2 on page 3 of the FAMP approved under Paragraph 7.a). The other three monitors shall be placed at locations approved by the Air District pursuant to Paragraph 7.b.ii and demonstrated by Valero to maximize the likelihood of detecting hydrogen sulfide plumes that may cross the Facility fenceline into the surrounding communities.

ii) Valero and the Air District shall comply with the following timelines:

1) No later than 7 days after the full execution of this Agreement, Valero shall notify the Air District, in writing, which option it

selects from Paragraph 7.b.i. Valero may not change its option selection after this submission.

2) No later than 60 days after the full execution of this Agreement, and before purchasing new monitoring equipment to comply with Paragraph 7.b.i, Valero shall submit to the Air District for approval a written description of the proposed equipment and proposed precise monitoring locations. If Valero elects to satisfy the minimum monitoring requirement according to the provisions of Paragraph 7.b.i.2, this written submittal shall also include a demonstration that the proposed monitoring locations maximize the likelihood of detecting hydrogen sulfide plumes that may cross the Facility fenceline into the surrounding communities.

3) No later than 90 days after the Air District approves the written description submitted in Paragraph 7.b.ii.2, Valero shall submit a revised FAMP to the Air District, in writing, for review and approval, that incorporates the monitors required under Paragraph 7.b in Valero's revised FAMP. Review and approval of the revised FAMP submitted under this Paragraph 7.b.ii.3 shall be conducted in accordance with this Agreement in lieu of Air District Regulation 12-15-404. Within 120 days of receipt of the revised FAMP, the Air District will either approve the revised FAMP or notify Valero in writing of any deficiency and may provide a redline specifying what changes Valero should incorporate to make the revised FAMP approvable. Upon receipt of the Air District's written notice of any deficiency, Valero will have 30 days to correct the revised FAMP to address the Air District's comments. If Valero fails to correct the revised FAMP to address the Air District's comments, Valero and the Air District shall meet and confer within 30 days, and Valero shall make all changes required and submit the final revised FAMP to the Air District within 30 days of this

meeting. The Air District shall then notify Valero of its final determination to approve or disapprove the final revised FAMP within 120 days of the submission of the final revised FAMP. If the Air District does not approve the final revised FAMP, the Parties will proceed to the dispute resolution process under paragraph 11 to resolve the remaining disputed issues and finalize the FAMP.

4) No later than 240 days after receiving the Air District's approval of the revised FAMP, Valero shall install and begin operating the point monitors at the monitoring locations approved by the Air District.

8. Additional Voluntary Measures. No later than 180 days after the full execution of this Agreement, Valero shall implement all of the measures in this Paragraph 8.

a) Data Public Access Improvements. Valero shall provide the public, via https://beniciarefineryairmonitors.org/measurements.html ("Website"), open access to all of the data in Paragraph 8.a.i, both by manual download and through an application programming interface (API).

i) Data required to be provided in accordance with Paragraph 8.a.:

1) Preliminary 5-minute average concentration data and final quality-assured historical 5-minute average concentration data from the fenceline monitoring systems subject to Rule 12-15, including all of the point monitors when installed and operated pursuant to Paragraph 7.b of this Agreement, for all pollutants covered by the FAMPs approved pursuant to Paragraphs 7.a and 7.b.ii.3 of this Agreement (Fenceline Monitoring Data);

2) Preliminary and final quality-assured 5-minute average concentration data collected by Valero's ground level monitors (GLMs) for purposes of compliance with Air District Rules 9-1 and 9-2 (GLM Data); and

3) Geospatial data representing:

a. The refinery property boundary,

b. The locations of all analyzers, reflectors, meteorological stations, and other monitors covered by the FAMPs approved pursuant to Paragraphs 7.a and 7.b.ii, and

c. The location of all GLMs installed and operated pursuant to Rules 9-1 and 9-2.

ii) The data required under Paragraph 8.a.i, above, shall be provided under Paragraph 8.a.i as described below, as applicable:

1) For all Fenceline Monitoring Data, GLM data, and geospatial data, Valero shall provide:

a. A data dictionary that identifies and describes each field and its data type, and also identifies the API field name (if different than the display name or label), and

b. API documentation that explains how to use the API and its services.

2) For preliminary and final 5-minute average concentration data:

a. Preliminary 5-minute average concentration data shall be made available in near real time, consistent with the procedures in the FAMPs approved pursuant to Paragraphs 7.a and 7.b.ii, and shall be updated at least every five minutes,

b. Final quality-assured data for each calendar quarter shall be made available no later than 90 days following the end of each respective quarter,

c. The preliminary and final quality-assured Fenceline Monitoring Data shall be provided together in a single data set such that once the final quality assured data are available for a given calendar quarter, the final quality assured data will replace the corresponding preliminary data records, and

d. Notwithstanding the replacement of preliminary data with final quality assured data as described in Paragraph 8.a.ii.2.c, all Fenceline Monitoring Data and GLM Data made publicly available on the Website shall remain available for no less than five years,

e. Manually downloaded concentration data must be made available in at least comma separated value (CSV) and extensible markup language (XML) formats, and,

f. Concentration data accessed through an API endpoint must be made available in at least CSV and JavaScript Object Notation (JSON) formats.

3) For Geospatial data:

a. Geospatial data shall be updated as necessary to maintain consistency with all installed equipment,

b. Manually downloaded geospatial data must be made available in at least CSV, shapefile, and GeoJSON formats, and

c. Geospatial data accessed through an API must be made available in at least CSV, JSON, and GeoJSON formats.

iii) For each type of data required, Valero shall provide the information outlined below, as applicable:

1) For Fenceline Monitoring Data, Valero shall provide the following information for each instrument/parameter combination:

a. facility_name – the name of the facility where the equipment is located,

b. instrument_id – a unique identification number assigned to a given instrument,

c. instrument – a short descriptive name for the instrument associated with the specified instrument identification number,

d. parameter – the name of the pollutant being measured and reported,

e. date – the date of measurement, reported in Pacific Standard Time and formatted as "yyyy-mm-dd",

f. time – the hour of the day and the beginning of the five-minute period over which measurements were collected and averaged, reported in Pacific Standard Time (without any adjustments for daylight savings time) and formatted as "hh:mm" using 24-hour notation,

g. mean concentration – the arithmetic mean pollutant concentration measured over the corresponding averaging period; for measurements below the minimum detection limit, the mean concentration must be reported as a numeric value based on the actual values returned by the instrument during the corresponding averaging period,

h. units_of_measure – the units of measure corresponding to reported mean concentration,

i. averaging_period – the averaging period (in minutes) for the reported mean pollutant concentration,

j. observation_count – the number of values that comprise the reported mean concentration,

k. validity_indicator – an indicator ("Y" or "N") representing whether the reported mean concentration represents a valid air measurement,

l. QC_code – the QC code (as described in the QAPP) assigned to the corresponding measurement,

m. OP_code – the OP code (as described in the QAPP) assigned to the corresponding measurement,

n. max_value – the maximum individual concentration measured during the corresponding averaging period, reported in the same units of measure as the mean concentration,

o. mdl – the real-time minimum detection limit for the equipment for the TDLAS open-path data only,

p. signal – the average measured light signal for the corresponding averaging period,

q. signal_units – the units of measure for the corresponding light signal measurement,

r. final_data – an indicator ("Y" or "N") indicating wither the data record reflects final quality assured data, and

s. change_log – a text field describing any changes made to the corresponding data record and the dates of any such changes.

2) For GLM Data and Fenceline Monitoring Data from point monitors, Valero shall provide all of the information specified in Paragraph 8.a.iii.1. except for the "mdl," "signal," and "signal_units" fields.

3) For geospatial data representing fenceline monitoring or GLM equipment, Valero shall provide the following information:

a. facility_name – the name of the facility where the equipment is located,

b. instrument_id – a unique identification number assigned to a given instrument,

c. instrument – a short descriptive name for the instrument associated with the specified instrument identification number, including whether points represent an open path analyzer or reflector,

d. parameters – the name of the pollutants being measured and reported by the instrument,

e. latitude – (for point data) the latitude of the location in decimal degrees, and

f. longitude – (for point data) the longitude of the location in decimal degrees.

iv) Subject to Paragraph 8.a.iii, above, for records in the Fenceline Monitoring Data and GLM Data with missing pollutant concentrations, Valero shall populate the following fields with their respective values and all remaining fields shall be populated with a value of "NA":

a. facility_name,

b. instrument_id,

c. instrument,

d. parameter,

e. date,

f. time,

g. QC_code, and

h. OP_code.

b) Public Quarterly Reports. Valero shall, within 90 days of the close of each calendar quarter, post quarterly summary reports to https://www.beniciarefineryairmonitors.org/index.html (the "Website") that include a narrative description of the observed concentration data in comparison to historical observations and health-based thresholds, the results of any QA/QC activities or checks, and summaries of all instrument downtime and other periods without valid concentration data. The first quarterly report shall be posted by June 30, 2026. Valero shall maintain on the Website the quarterly summary reports for at least three years from the June 30, 2026, and the reports shall be made available to the public for manual download during that time.

9. Stipulated Penalties. Valero shall pay the Air District stipulated penalties, as applicable, as laid out in this Paragraph 9.

a) In the event that Valero discovers an instance of noncompliance with the settlement, it shall notify the District of that noncompliance in writing within 10 days of its discovery, and shall take immediate steps to cure the noncompliance.

b) If the Air District determines that Valero is subject to stipulated penalties under this Paragraph and the Air District wishes to seek stipulated penalties, the Air District will provide written notice to Valero with an opportunity for Valero to cure any such noncompliance. The cure period shall not exceed thirty (30) days from the date of the notice, except for documented good cause based on factors beyond the reasonable control of Valero, such as and including, but not limited to, delays in securing parts, equipment, authorizations, etc. If Valero identifies such a basis for an extension, it will promptly notify the Air District. In such a circumstance, Valero and the Air District will confer in good faith and document in writing an appropriate and reasonable extension, determined in the sole discretion of the Air District, based on the factors provided by Valero. If Valero does not know how to cure the identified noncompliance, Valero may seek guidance from the Air District. When Valero cures an identified noncompliance, whether within the cure period, agreed extension, or otherwise, Valero shall notify the Air District of the cure, and provide supporting documentation, within 10 days after the cure period or, if the cure is completed outside of the cure period, within 10 days of the completion of the cure. If Valero fails to cure a noncompliance by the end of the cure period, including any agreed-upon extension, Valero shall pay the Air District the stipulated penalties specified in Paragraphs 9.c-9.f, as applicable, for each day on which Valero failed to comply with the specified measure as determined by the Air District, excluding any time of noncompliance prior to, and during, the cure period, including any agreed-upon extension.

c) If Valero fails to submit to the Air District information as required in Paragraphs 7.b.ii.1 or 7.b.ii.2, and does not cure the failure in the cure period provided in subparagraph (b), Valero shall pay the Air District $1,000 for each day of noncompliance up to 15 days following the cure period, and $2,000 for each day of noncompliance thereafter, on which Valero fails to submit information as required by Paragraphs 7.b.ii.1 or 7.b.ii.2

d) If Valero fails to submit a revised FAMP pursuant to 7.b.ii.3, and does not cure the failure in the cure period provided in subparagraph (b), Valero shall pay the Air District $1,000 for each day of noncompliance up to 15 days following the cure period, and $2,000 for each day of noncompliance thereafter, on which it fails to submit a revised FAMP in accordance with Paragraph 7.b.ii.3.

e) If Valero fails to provide the data on the Website pursuant to Paragraph 8.a and in accordance with the data completeness requirement in the approved FAMP, and does not cure the failure in the cure period provided in subparagraph (b), Valero shall pay the Air District $1,000 for each day of noncompliance following the cure period on which it fails to provide the missing data on the Website as required under Paragraph 8.a, provided, however, that no such stipulated penalty shall be due in the event that the inability to establish or maintain the Website is due to an act of God or is otherwise outside of Valero's control, including, but not limited to, technical difficulties associated with the server or domain that is hosting the Website, the cloud host for the data management system (DMS), the DMS itself and any associated web application (WebApp) that presents data on the website, and/or unavailability of internet connectivity.

f) If Valero fails to post quarterly summary reports pursuant to Paragraph 8.b, and does not cure the failure in the cure period provided in subparagraph (b), Valero shall pay the Air District $1,000 for each day of noncompliance following the cure period on which it fails to post quarterly summary reports required under Paragraph 8.b.

g) Valero may dispute the assertion of any noncompliance in Valero's implementation of the specified measures required under this Settlement Agreement which the Air District believes subjects Valero to stipulated penalties, through the Dispute Resolution process provided under Paragraph 11.

h) Stipulated penalties shall be paid by wire, in accordance with wiring instructions provided by the Air District, with "2026 Global Valero Settlement" in the memo. Upon wiring the payment, Valero shall notify the Air District via email. If the Air District does not receive the payment, the Air District shall notify Valero via email and Valero shall, within 3 business days of the date such notice is sent, re-send the payment according to this Paragraph 9, and this process shall be repeated as needed until the Air District receives the payment. Valero shall be responsible for all payment processing, check cancellation, and other fees or costs associated with carrying out this Paragraph 9. Each stipulated penalty is cumulative and in addition to any other applicable stipulated penalty and any other payment required by this Agreement.

10. Force Majeure. Valero shall not be deemed to be in noncompliance with this Agreement for any delay in the performance of the work described in this Agreement that is caused by, or results from, an event that falls under this Paragraph. To qualify as a force majeure event, an event must have the effect of either significantly delaying labor or materials necessary for work required by this Agreement from accessing or reaching the Facility such that the work or part of the work cannot be performed, or otherwise preventing Valero from complying with this Agreement at the Facility. Such force majeure events include, but are not limited to, the following: acts of God; enemy or hostile governmental action; uncontrolled pandemics where the State of California declares an emergency; civil commotion (e.g. public protest or riot); fires or other casualties; delay in the delivery of equipment that is not attributable to action or inaction by Valero; and delivery of damaged or off-specification equipment, through no fault of Valero, provided Valero demonstrates it acted in good faith and took all reasonable steps to avoid the delay. Financial hardship to Valero, by itself, is not a force majeure event. To qualify for relief under this

Paragraph for any event, Valero must notify the Air District of the force majeure event within 72 hours following the deadline for the requirement, must provide evidence of the force majeure event, and must demonstrate that it has taken and/or is taking all reasonable action to mitigate any adverse consequences resulting from the delay. In such case, Valero shall not be deemed in noncompliance with the Agreement for the length of the delay attributable to the force majeure event. Delays that are due to Valero's own action or inaction are not force majeure events.

11. Dispute Resolution. Unless otherwise expressly provided for in this Agreement, the dispute resolution procedures of this Paragraph shall be the exclusive mechanism to resolve disputes arising between the Parties under or with respect to this Agreement. The dispute resolution procedures in this Paragraph 11 do not apply to any failure by Valero to pay the settlement amount due pursuant to Paragraph 6. Valero's failure to seek resolution of a dispute under this Paragraph concerning an issue of which it had notice and an opportunity to dispute under this Paragraph 11 prior to an action by the Air District to enforce any obligation of Valero arising under this Agreement precludes Valero from raising any such issue as a defense to any such enforcement action.

a. Types of Dispute Resolution.

i. *Informal Dispute Resolution*. Any dispute subject to dispute resolution under this Agreement shall first be the subject of informal negotiations. The dispute shall be considered to have arisen when a Party sends the other Party a written Notice of Dispute in accordance with Paragraph 13. Such Notice of Dispute shall state clearly the matter in dispute. The period of informal negotiations shall not exceed 45 calendar days from the date the Party sent its/their Notice of Dispute, unless that period is modified by a written agreement of the Parties. If the Parties cannot resolve a dispute by informal negotiations, then the position advanced by the Air District shall be binding and contractually enforceable unless, within 45 calendar days after the conclusion of the informal negotiation period, Valero invokes the Mediated Dispute Resolution process set forth below.

ii. *Mediated Dispute Resolution*. Valero shall invoke the Mediated Dispute Resolution process set forth in this Sub-Paragraph, within the time period provided in the preceding Sub-Paragraph, by sending the Air District written Notice of Intent to invoke this Mediated Dispute Resolution process. Within 30 calendar days of receipt of Valero's Notice of Intent, the Parties shall jointly select a mutually acceptable mediator and schedule a non-binding mediation session. The mediation session shall occur within 45 calendar days of the District's receipt of Valero's Notice of Intent unless the Parties agree in writing to a different date. At least 15 calendar days prior to the date of the mediation session, Valero shall send the Air District and the mediator a Statement of Position regarding the matter in dispute. As to the Air District, Valero's Statement of Position shall be sent in accordance with Paragraph 13. The Statement of Position shall include, but need not be limited to, any factual data, analysis, or opinion supporting Valero's position and any supporting documentation relied upon by Valero. The Air District shall send Valero and the mediator a Statement of Position at least 5 calendar days prior to the date of the mediation session. As to Valero, the Air District's Statement of Position shall be sent in accordance with Paragraph 13. The Air District Statement of Position shall include, but need not be limited to, any factual data, analysis, or opinion supporting that position and any supporting documentation relied upon by the Air District. After the conclusion of the mediation session, the mediator shall make a non-binding recommendation regarding the appropriate resolution of the dispute(s). If any Party does not accept the mediator's non-binding recommendation, that Party may file a complaint in accordance with the following Sub-Paragraph. The cost of the mediation session (i.e. mediator fees and facility costs) required by this Sub-Paragraph shall be borne by Valero; other than the cost of the mediation session, the Parties shall pay their own costs of such mediation, including their attorneys' fees associated with preparing for and participating in the mediation.

iii. *Judicial Dispute Resolution*. A Party or Parties may seek judicial review of the dispute by filing a complaint with the Superior Court of California, located in the County of Solano, and serving it on the other Party. The complaint must be filed within the earlier of 45 calendar days of the Parties' receipt of the mediator's non-binding recommendation regarding the appropriate resolution of the dispute(s) issued pursuant to the preceding Sub-Paragraph, or within 60 calendar days of the date of the mediation session held pursuant to the preceding Sub-Paragraph. The complaint may not raise any issue the Party filing the complaint did not raise in informal dispute resolution pursuant to Paragraph 11.a.i unless the issue was first raised by another Party's Statement of Position pursuant to Paragraph 11.a.ii. The complaint shall assert the filing Party's position on the matter in dispute. The non-filing Party shall respond to the complaint in accordance with California law.

12. The failure to enforce any provision of this Agreement shall not be construed as a waiver of any such provision, nor prevent such Party thereafter from enforcing such provision or any other provision of this Agreement. The rights and remedies granted all Parties herein are cumulative and the election of one right or remedy by a Party shall not constitute a waiver of such Party's right to assert all other legal remedies available under this Agreement or otherwise provided by law.

13. Unless otherwise specified in this Agreement, whenever notice, submissions, or communications are required by or related to this Agreement, they shall be submitted in writing to the address or email below, as applicable:

As to the Air District:
Bay Area Air Quality Management District
Somerset Perry
Assistant Counsel
375 Beale Street, Suite 600
San Francisco, CA 94105
sperry@baaqmd.gov

With a copy to, from April 17, 2026 through September 13, 2026:
Bay Area Air Quality Management District
Jamie Jefferson
Assistant Counsel
375 Beale Street, Suite 600
San Francisco, CA 94105
jjefferson@baaqmd.gov

As to Valero:
Lisa Hodges
Senior Advisory Counsel
The Valero Companies
One Valero Way
San Antonio, TX 78249
Lisa.Hodges@valero.com

With a copy to:
Julie Cress
Baker Botts L.L.P.
101 California Street, Suite 3600
San Francisco, CA 94111-5802
Julie.Cress@bakerbotts.com

Each of the Parties may, by advance written notice to the other Party, change its designated notice recipient or notice address provided above. Notices submitted pursuant to this section shall be deemed submitted upon emailing, or five days from mailing, as applicable.

14. In consideration of full payment of the civil penalty and the completion of all other requirements in this Agreement, this Agreement resolves, and the Air District hereby releases, Valero and its beneficiaries, partners, partnerships, affiliates and related entities, directors, agents, employees, representatives, principals, officers, receivers, trustees, predecessors, successors and assignees, subsidiaries and parent companies from the Claims, except that the Air District reserves the right to:

a) Take action to enforce this Agreement;

b) Take enforcement actions arising out of future violations not covered by this Agreement;

c) Demand increased penalties in connection with any future alleged violations, as appropriate based on a consideration of all the facts and circumstances; and

d) Rely upon the alleged violations described in the App. A NOVs and offer proof thereof in connection with any other administrative or judicial proceeding not related to this proceeding solely for the purpose of showing a history of violation.

15. Valero reserves the right to challenge an increase in penalties in connection with any future alleged violations, and to contest any offers of proof and present any evidence disputing the events or allegations described in Paragraph 3 above. Valero further reserves the right to challenge the disapproval of any future FAMP based on Valero's inability to meet air pollution specifications in any Air District interpretive letter, to the extent allowed by California law. The Air District may not assert or maintain that this Agreement constitutes a waiver or determination of, or otherwise obviates, any claim or defense whatsoever, or that this Agreement constitutes acceptance by Valero of any interpretation or guidance issued by the Air District related to Regulation 12-15. Notwithstanding the foregoing, the Air District reserves the right to interpret and enforce the laws and regulations it is charged with implementing in any matter whatsoever, consistent with law.

16. Except for the reservations of rights in Paragraphs 14 and 15 of this Agreement, the pieces of this Agreement shall terminate as follows:

a) This Agreement, except for the FAMP approved under Paragraph 7.a. or 7.b.ii of this Agreement, whichever is later, shall terminate upon the earlier of: (a) three years from the Effective Date, or (b) the date on which the Air District approves the revised FAMP submitted by Valero in response to the Air District adopting a new or revised rule or guidelines.

b) The FAMP approved under Paragraph 7.a or 7.b.ii of this Agreement, whichever is later, shall remain in effect and Valero shall continue operating the monitors required under Paragraph 7.b and reporting the data in accordance with Paragraph 8 until the Air District approves a revised FAMP submitted by Valero in response to the Air District adopting a new or revised rule or Guidelines, or until the Air District approves a revised FAMP submitted by Valero as otherwise required by Air District Regulation 12-

15 or the Guidelines adopted pursuant thereto, including prior to adoption of a new or revised rule or Guidelines.

c) Notwithstanding anything to the contrary in subparagraphs (a) or (b) above, this Agreement shall terminate when Valero ceases operating the Facility as a refinery and relinquishes its Air District permits that are necessary to operate the Facility as a refinery. Valero shall provide at least 30 days' advance notice to the Air District of this clause being triggered. The dispute resolution (para.11), stipulated penalty (para. 9), force majeure (para. 10), and forum (para. 24) provisions of this Agreement shall survive termination, up to and including any dispute or claim for stipulated penalties made within 30 days following termination. No dispute or claim for stipulated penalties shall be allowed under this agreement if brought more than 30 days following termination of the Agreement.

17. Any rule of construction to the effect that ambiguities are to be resolved against the drafting party shall not be applied in interpreting this Agreement.

18. This Agreement is not a permit or modification of any permit under any federal, State, or local laws or regulations. Valero is responsible for achieving and maintaining compliance with all applicable federal, State, and local laws, regulations, and permits, including, but not limited to, any new or additional monitoring requirements that may become applicable through future rulemakings; and, except as provided herein, Valero's compliance with this Agreement shall not be a defense to any action commenced pursuant to any such laws, regulations, or permits. The Air District does not, by its execution of this Agreement, warrant or aver in any manner that Valero's compliance with any aspect of this Agreement will result in compliance with any provisions of federal, State, or local laws, regulations, or permits, except as otherwise explicitly provided in this Agreement.

19. The settlement of the allegations in the App. A NOVs without further litigation is fair, reasonable, and in the interests of the Parties and the public. The Parties have participated fully in the review and drafting of this Agreement; understand and accept all terms; enter into this

Agreement freely and voluntarily; have had an opportunity to consult with legal counsel; are fully informed of the terms and effect of this Agreement; have agreed to this Agreement after independent investigation and agree it was not arrived at through fraud, duress, or undue influence; and knowingly and voluntarily intend to be legally bound by this Agreement.

20. Each provision of this Agreement is severable, and in the event that any provision, or part thereof, of this Agreement is held to be illegal, invalid or unenforceable in any jurisdiction, the remainder of this Agreement remains in full force and effect.

21. This Agreement constitutes the entire agreement and understanding between the Parties, and fully supersedes and replaces any and all prior negotiations and agreements of any kind or nature, whether written or oral, between the Parties, concerning the allegations in the App. A NOVs.

22. No agreement to modify, amend, extend, supersede, terminate, or discharge this Agreement, or any portion thereof, shall be valid or enforceable unless it is in writing, signed by all the Parties, and dated after the date of the full execution of this Agreement.

23. This Agreement may be executed in counterparts. Electronic, facsimile, and photocopied signatures shall be considered as valid signatures.

24. The Superior Court of California, County of San Francisco, shall hear any dispute between the Parties arising from this Agreement.

25. This Agreement shall be interpreted and enforced in accordance with the laws of the State of California, without regard to California's choice-of-law rules.

26. Upon execution by both Parties, this Agreement shall become final and binding upon Valero and any of its principals, officers, receivers, trustees, successors and assignees, subsidiary and parent companies and upon the Air District and any successor agency that may have responsibility for and jurisdiction over the subject matter of this Agreement. In the event of a sale of the Facility, the purchaser of the Facility will be subject to this Agreement and it shall no longer be binding on Valero or any of its principals, officers, receivers, trustees, successors and assignees, subsidiary or parent companies. Within 30 days of such a sale, the Purchaser and the Air District

shall confer in good faith, and document, in writing, an appropriate and reasonable extension of time, if needed, for the Purchaser to comply with the requirements of Paragraph 7 of this Agreement.

27. Each of the undersigned expressly represents that he or she is authorized to execute this Agreement on behalf of, and to bind, the Party for whom he or she signs below.

SO AGREED, STIPULATED AND EXECUTED:

BAY AREA AIR QUALITY MANAGEMENT DISTRICT
375 Beale Street, Suite 600
San Francisco, California 94105

By: Signed by: [signature] 98506AF9981D4CC...
Philip M. Fine
EXECUTIVE OFFICER/APCO

Date: 4/27/2026

VALERO REFINING COMPANY - CALIFORNIA
3400 East Second Street
Benicia, California, 94510-1097

By: [signature]
Richard J. Walsh
EXECUTIVE VICE PRESIDENT AND GENERAL COUNSEL

EKH

Date: 4/27/2026

APPROVED AS TO FORM BY:
BAY AREA AIR QUALITY MANAGEMENT DISTRICT
375 Beale Street, Suite 600
San Francisco, California 94105

By: Signed by: Alexander Crockett 6DC7110552B5451...
ALEXANDER CROCKETT
GENERAL COUNSEL
ALEXANDRA KAMEL
SENIOR ASSISTANT COUNSEL
SOMERSET PERRY
ASSISTANT COUNSEL

Date: 4/27/2026

Appendix A
Notices of Violation

Notices of Violation resolved pursuant to this Agreement.

57351	59000	59619	60820
57352	59001	59620	60821
58454	59038	59621	60822
58455	59506	59624	60823
58456	59507	59625	60824
58457	59508	59626	60825
58458	59509	60578	60826
58459	59511	60579	60827
58460	59515	60580	62178
58461	59516	60581	62179
58462	59517	60582	62180
58464	59518	60583	62181
58466	59519	60584	62182
58467	59522	60585	62183
58468	59523	60586	62184
58469	59525	60587	62185
58470	59527	60589	62186
58610	59603	60591	62187
58986	59604	60592	62189
58987	59605	60593	62191
58989	59606	60804	62192
58990	59607	60807	62195
58991	59608	60809	62197
58992	59610	60810	62198
58993	59612	60813	62199
58995	59613	60814	62201
58996	59614	60815	62202
58997	59615	60816	62577
58998	59617	60818	
58999	59618	60819	

Appendix B
Fenceline Air Monitoring Plan (FAMP)

Air Monitoring Plan for the Valero Refinery in Benicia, California

Prepared for
Valero Refining Company - CA
Benicia Refinery
Benicia, CA

Updated: April 14, 2026
Original: September 7, 2017

This document contains blank pages to accommodate two-sided printing.

Air Monitoring Plan for the Valero Refinery in Benicia, California

Prepared by

Sonoma Technology
1450 N. McDowell Blvd., Suite 200
Petaluma, CA 94954-6515
Ph 707.665.9900 | F 707.665.9800
sonomatech.com

Prepared for

Taryn Wier
Valero Refining Company - CA
Benicia Refinery
3400 E 2nd St.
Benicia, CA 94510
Ph 707.745.7990
valero.com

Air Monitoring Plan, Rev 10
STI-1922002-6601

Updated: April 14, 2026
Original: September 7, 2017

Contents

Figures

Tables

Document Control

Doc No.	Rev No.	Rev Date	Distribution	Description
AMP	1	4/14/2017	BAAQMD, Refinery Project Manager, QA Manager	Initial Submission
AMP	2	7/24/2017	BAAQMD, Refinery Project Manager, QA Manager	Revised in response to BAAQMD comments
AMP	3	9/7/2017	BAAQMD, Refinery Project Manager, QA Manager	Revised in response to BAAQMD comments
AMP	4	7/23/2018	BAAQMD, Refinery Project Manager, QA Manager	Updated per District requests to (1) include chemical species data collected by sorbent tubes on the southeast corner of the refinery and (2) to reflect that hydrogen sulfide (H_2S) monitoring will be implemented on a different schedule due to unproven H_2S open-path measurement technology at this time
AMP	5	6/1/2022	Refinery Project Manager, Routine Operations Project Manager, QA Manager, Field Staff Manager, Instrument Contractors, Data Manager, Website/Data System Manager, BAAQMD	Revised in response to BAAQMD comments; revised TDLAS measurement
AMP	6	2/3/2023	Refinery Project Manager, Routine Operations Project Manager, QA Manager, Field Staff Manager, Instrument Contractors, Data Manager, Website/Data System Manager, BAAQMD	Revised in response to BAAQMD comments; revised TDLAS measurement
AMP	7	9/5/2023	Refinery Project Manager, Routine Operations Project Manager, QA Manager, Field Staff Manager, Instrument Contractors, Data Manager, Website/Data System Manager, BAAQMD	Revised in response to BAAQMD comments
AMP	8	1/5/2024	Refinery Project Manager, Routine Operations Project Manager, QA Manager, Field Staff Manager, Instrument Contractors, Data Manager, Website/Data System Manager, BAAQMD	Revised in response to BAAQMD comments
AMP	9	10/31/2024	Refinery Project Manager, Routine Operations Project Manager, QA Manager, Field Staff Manager, Instrument Contractors, Data Manager, Website/Data System Manager, BAAQMD	Revised in response to BAAQMD comments
AMP	10	4/14/2026	Refinery Project Manager, Routine Operations Project Manager, QA Manager, Field Staff Manager, Instrument Contractors, Data Manager, Website/Data System Manager, BAAQMD	Revised in response to BAAQMD comments

1. Introduction

1.1 Background

The Valero Refining Company (Valero) conducts air quality monitoring at its Benicia, CA, refinery in response to the Bay Area Air Quality Management District's (BAAQMD) Regulation 12, Rule 15 (Rule 12-15).[1] The monitoring follows a facility-specific air monitoring plan (AMP) consistent with the BAAQMD's Air Monitoring Guidelines for Petroleum Refineries.[2] Rule 12-15 requires routine monitoring near the fencelines of all San Francisco Bay Area refineries for specific air compounds, with data reported to the public. The rule also requires that refineries submit AMPs to BAAQMD for approval. This AMP was approved on June 8, 2018, with conditions to: (1) update the Quality Assurance Project Plan (QAPP, attached as **Appendix A**) and (2) select hydrogen sulfide (H_2S) monitoring technology. On October 6, 2021, BAAQMD provided updated requirements for refineries to (1) conduct additional H_2S monitoring along refinery fenceline paths, and (2) implement this enhanced monitoring by January 1, 2023. On December 8, 2022, Valero implemented H_2S monitoring. BAAQMD issued updated specifications on December 22, 2022, and Valero's response to the updated specifications was submitted on February 23, 2023. This revision addresses feedback from BAAQMD received July 19, 2023, October 19, 2023, June 11, 2024, and April 6, 2026.

The remainder of Section 1 gives an overview of this AMP and outlines the steps that will be taken to maintain approval.

1.2 Plan Summary

This section provides an overview of this AMP, and subsequent sections provide additional plan details and associated justifications for the monitoring program design.

BAAQMD Guidelines for Rule 12-15 require fenceline monitoring of multiple compounds using "open-path technology capable of measuring in the parts-per-billion range regardless of path length" or an alternative measurement technology.[2] The required compounds to be measured include benzene, toluene, ethylbenzene, xylenes (BTEX), and H_2S. In addition, sulfur dioxide (SO_2), alkanes, 1,3-butadiene, other organics, and ammonia should be considered for measurements.

For the Valero fenceline monitoring program, open-path instruments are used to measure the required compounds (BTEX and H_2S) along three paths. H_2S measurements are used for

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

[2] Bay Area Air Quality Management air monitoring guidelines for petroleum refineries. April 2016. Available at **baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en**.

informational purposes only. The three measurement paths, composed of two segments each, are implemented to cover Valero's fencelines in consideration of nearby local receptors (e.g., residences and businesses), dominant winds that blow from west to east, and infrequent winds that blow from northeast to southwest to portions of populated areas in Benicia. As shown in Figure 1, the business park east of Valero is the only populated area influenced by the dominant winds, as winds blow from other directions less than 10% of the time for 22.5-degree wind direction segments.

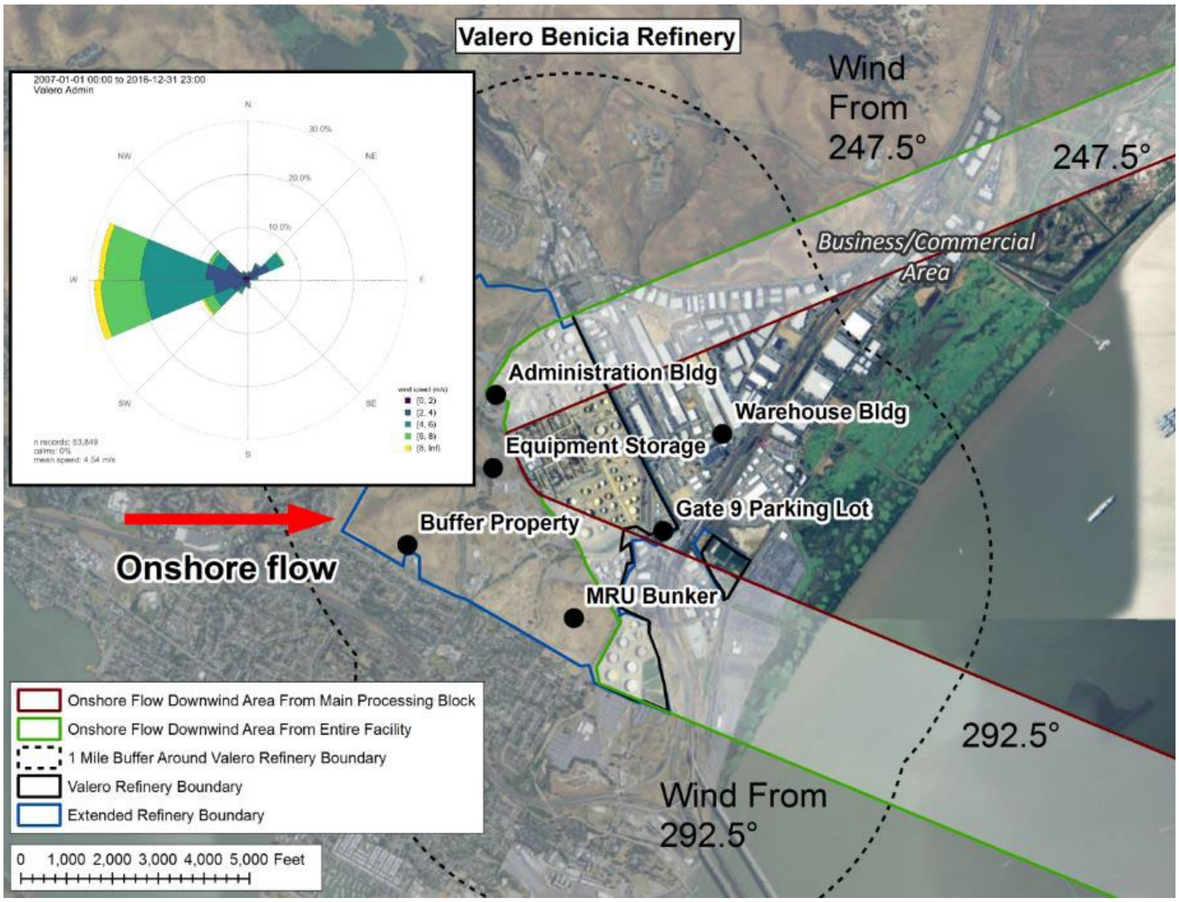

Figure 1. Areas downwind of the Valero Benicia Refinery property boundaries for wind directions that occur more than 10% of the time on an annual basis. The only populated area impacted by the dominant wind direction is the business park to the east of the Valero refinery.

Along all paths, BTEX and SO_2 are measured by monostatic Ultraviolet-Differential Optical Absorption Spectroscopy (UV-DOAS) with a xenon light source. For open-path measurements, "monostatic" refers to a configuration where the light source and detector are at the same location, and the light from the source is reflected along a path then back to the detector using a special mirror called a retroreflector. H_2S is measured by a monostatic Tunable Diode Laser Absorption Spectroscopy (TDLAS) instrument for informational purposes only. These open-path instruments transmit light across a given path and detect the amount of energy absorption at a particular wavelength of light to determine the average concentration of a particular pollutant along the path. The three primary monitoring paths, composed of six total segments, are shown in Figure 2. GPS coordinates, elevations, and an instrument inventory at each open-path sampling site are shown in Table 1.

In addition, as requested by the BAAQMD, monitoring between Paths 2 and 3 occurs at sample locations 10, 11, and 12 (Figure 2). The sorbent tubes at these point locations will be replaced and analyzed for BTEX approximately every 14 days in accordance with the 40 CFR Subpart CC Fenceline Monitoring program. Please note, all additional monitoring discussions in this document, unless otherwise noted, refer to the open-path monitoring and not the sorbent tubes.

Figure 2. Open-path monitoring network for Valero's Benicia Refinery. Each path is numbered and contains segments that are labeled with the path number and a prime (′) or double prime (′′) symbol. Main wind flow directions are also shown.

Table 1. GPS coordinates, elevation above ground level (AGL) and equipment for each site.

Site	GPS Coordinates	Elevation (ft)	Equipment
1″	38.069404, -122.153003	13	1 UV-DOAS Retroreflector
		8	1 TDLAS Retroreflector
1	38.065527, -122.150574	6.5	2 UV-DOAS Analyzers
		6.5	2 TDLAS Analyzers
1′	38.063530, -122.147851	14	1 UV-DOAS Retroreflector
		7	1 TDLAS Retroreflector
2″	38.061956, -122.144872	14.5	1 UV-DOAS Retroreflector
		8	1 TDLAS Retroreflector
2	38.059251, -122.138816	6.5	2 UV-DOAS Analyzers
		6.5	2 TDLAS Analyzers
2′	38.056332, -122.133499	14	1 UV-DOAS Retroreflector
		8	1 TDLAS Retroreflector
3″	38.069889, -122.132245	16.5	1 UV-DOAS Analyzer
		11.5	1 TDLAS Analyzer
3	38.074329, -122.134956	12	2 UV-DOAS Retroreflectors
		12	2 TDLAS Retroreflectors
3′	38.079025, -122.137809	16.5	1 UV-DOAS Analyzer
		12	1 TDLAS Analyzer

Paths 1 and 2 cover the southwest fenceline to assess potential transport toward the city of Benicia. This transport direction is infrequent and only occurs on an occasional basis in the winter when wind sometimes blows from the northeast toward the southwest. Over the course of a year, these northeast winds occur less than ~7% of the time. Because of terrain effects and the orientation of the Carquinez Strait, the northeasterly wind direction is well-defined and has little directional variability; therefore, the downwind areas that could be affected under these wind conditions are very narrow.

Path 3 covers the eastern fenceline to assess potential transport toward the business/commercial area east of the refinery. This transport direction is common in the spring, summer, and early fall, when winds often blow from west to east. Monitoring between Paths 2 and 3 is not needed, as there are no significantly populated areas downwind of this space between the monitors. In addition, a release that might travel between Paths 2 and 3 would likely be seen on Path 2 or 3 monitors because of dispersion. Also, it is not feasible to add monitors between Paths 2 and 3 because of road, rail track, and terrain issues.

Open-path analyzers are located at sites 1, 2, 3′, and 3″. Sites 1 and 2 each have 2 UV-DOAS and

2 TDLAS analyzers. Each pair of analyzers at each site points roughly 180 degrees from each other. The remaining numbered sites (1′, 1″, 2′, 2″, and 3) have retroreflectors (i.e., mirrors). This setup provides maximum spatial coverage along the critical paths.

Visibility instruments are placed at sites 1 and 3′ to measure visibility conditions at different locations and elevations. The visibility measurements are used as evidence of low visibility conditions that result in missing measurements on open-path instruments. Two sites have been selected because visibility can vary spatially across the refinery. In addition, these locations were selected for ease of access.

All instruments are installed and operated following manufacturer specifications, including necessary bump tests, which challenge instruments with known gas concentrations to confirm accurate response.

Instruments are operated to meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Appropriate completeness criteria are calculated after removing time periods when atmospheric conditions prevented measurement.

Measurements are collected at a time resolution of 5-min. Data from the fenceline monitors are transmitted to an internet website where the near-real-time results can be viewed by the public. The website also provides a mechanism for public comment, which is monitored by a designated consultant. Data generated by the fenceline monitoring equipment undergoes review throughout the measurement and reporting process. Included in this process are automated QA/QC checks that occur before data are reported on the real-time website. Under normal circumstances, a 5-min average measurement appears on the website within 10–15 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 (QA) checks before data are reported to the website, which also makes available a rolling 1-hr trend of the 5-min data for each gas reported. Final data sets are compiled quarterly and will be provided to 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 refinery will make data available to BAAQMD upon request prior to report submittal.

All data are retained by the facility for a period of 5 years, consistent with Regulation 12-15-502.

2. Monitoring Plan Design Considerations

This Monitoring Plan was developed in consideration of the following elements:

- Rule 12-15 and related guidance.
- Monitoring objectives, which were established in consideration of Rule 12-15 and related guidance.
- The findings of a scoping study, which involved assessments of (1) geographic setting around Valero's Benicia Refinery, (2) relevant meteorological conditions, and (3) air quality monitoring and dispersion modeling results.
- Technical and engineering feasibility related to available monitoring technologies and instrument siting.
- Data management and QA/QC (quality control) requirements.

Details on each of these elements are provided below.

2.1 Key Elements of Rule 12-15 and Guidance

According to the BAAQMD's April 2016 guidelines, the main goals of fenceline monitoring are to:

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

Key considerations provided in the Guidance Document for designing a monitoring plan to address BAAQMD's goals are summarized below.

- Conduct "fenceline" measurements of BTEX and H_2S. Consider measuring other compounds, including SO_2, alkanes, 1,3-butadiene, other organics, and ammonia. The term "fenceline" in the guidance refers to a general boundary between refinery property and areas outside the refinery property, not necessarily to an actual fence.

- Conduct measurements in areas where emissions from the refinery could frequently impact populated areas. Specifically, this includes the following:
  - "Measurements must cover populated areas within one mile of the refinery fence-line likely to be affected when the annual mean wind direction lies in an arc within 22.5 degrees of a direct line from source to receptors 10% of the time, or greater, based on the most representative meteorological measurements for sources likely to emit the compounds listed above at the refinery."
  - In addition, "Meteorological measurements should also be used and addressed in the Air Monitoring Plan to ensure proper siting of fence-line systems, looking at long-term measurements such as annual average wind rose, but also taking into account more seasonal and recurring short term meteorological events."
- Provide measurements of the compounds at the parts-per-billion (ppb) level or as technology allows.
- Conduct measurements using open-path instruments or an appropriate alternative.
- Provide rationale for the compounds to be measured and not measured.
- Provide rationale for measurement locations.
- Provide rationale for the instruments to be used.
- Collect the measurements every 5 minutes.
- Process and display the data in near-real time to a public website.
- Meet data recovery and completeness criteria.
- Develop a QAPP for the measurement program and follow the QAPP.

2.2 Scoping Study

2.2.1 Assessment of the Geographic Study Setting

Valero's Benicia Refinery is located at 3400 East 2nd Street in the eastern part of the city of Benicia, Solano County, California (Figure 3). The refinery is bordered by Suisun Bay and by the Carquinez Strait on the east and south sides of the property. Low coastal hills rise to elevations of 400 to 1,000 feet on the west and north sides of the refinery. Valero's 800-acre property is largely undeveloped and provides a useful area for air monitoring. Valero's Refinery operations occupy approximately 330 acres, including a 46-acre process block that lies between East 2nd Street and Park Road and a 50-acre crude oil tank farm that lies between Park Road and Interstate 680 (Figure 4). The PBF Energy Martinez and Tesoro Golden Eagle refineries are located to the south and southeast across the Carquinez Strait.

Figure 3. Geographic setting of the Valero Benicia Refinery.

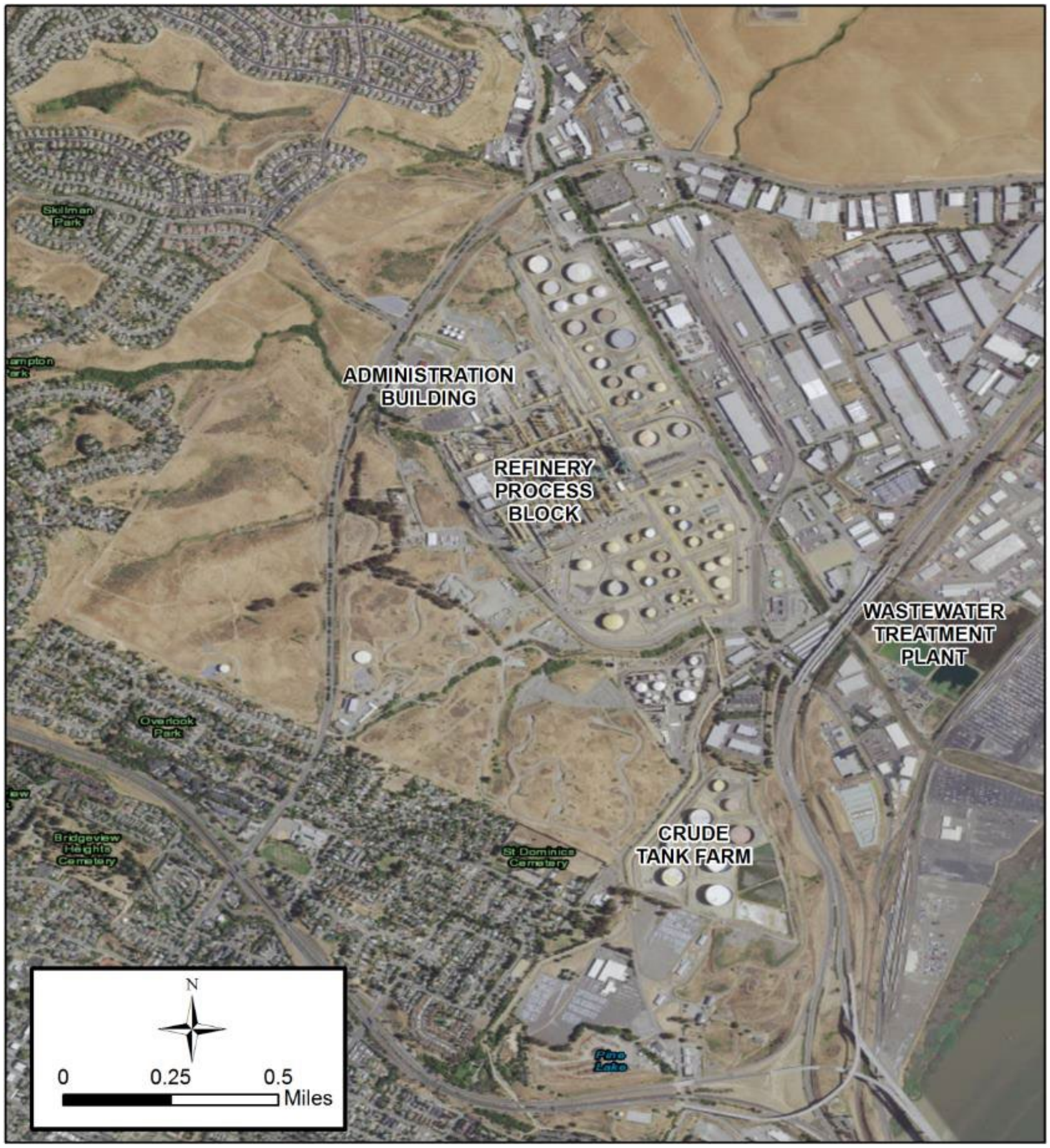

Figure 4. Layout of the Valero Benicia Refinery (Source: Valero Improvement Project Environmental Impact Report, June 2008).

Residential areas are located to the southwest, west, and northwest of the facility, and most are at least 1,500 feet away from the refinery plant and storage tanks. Businesses are located east and northeast of the refinery, and the business/commercial area begins a short distance from the refinery property. Interstate 680 is adjacent to the eastern side of the refinery and Interstate 780 is located to the south, with residences between Interstate 780 and the refinery. The nearby public-access areas (e.g., residences, businesses, and public roadways) represent air quality "receptors" that are nearest and at times downwind from Valero's Benicia Refinery. The positions of these receptors received careful consideration during the design of this AMP.

2.2.2 Assessment of Valero Processes

Valero's Benicia Refinery is a petroleum refinery producing fuel products, such as liquefied petroleum gas (LPG), gasoline, jet fuels, diesel fuels, and residual fuel oils through distillation of crude oil, including cracking, alkylation, and reforming. In light of Valero's products, processes, and associated potential emissions, the rationale in Table 2 was used to determine which compounds need to be measured or not measured:

1. Benzene measurements are a good qualitative indicator for other Hazardous Air Pollutant (HAP) emissions[3]
2. Compound is not a HAP (this is not the sole reason for exclusion, but is provided for completeness)
3. Alerting systems already in place at the refinery
4. Compound is not manufactured as a product of the refinery and not used in routine processing.

Table 2. Compounds and the rationale for their exclusion from the fenceline monitoring program.

Compound	Required by the BAAQMD	To Be Measured	Rationale for Exclusion
Benzene	Yes	Yes	N/A
Toluene	Yes	Yes	N/A
Ethylbenzene	Yes	Yes	N/A
Xylenes	Yes	Yes	N/A
H_2S[a]	Yes	Yes	N/A
SO_2	No, if justified	Yes	N/A
Alkanes	No, if justified	No	1 (for hexane) 2 (except for hexane) 3
1,3-Butadiene	No, if justified	No	4
Other organics	No, if justified	No	1
Ammonia	No, if justified	No	3, 4

[a] H_2S will temporarily be measured for informational purposes only using an open-path TDLAS system.

[3] Background section of Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards.

Exclusion of alkanes. Valero does not include alkanes in its fenceline monitoring program. During normal operations, there is no potential for alkanes to be released at the fenceline without a corresponding benzene release, and as noted in Table 2 above, benzene is included in the fenceline monitoring program. Alkanes are used within the refinery process units; however, the Benicia refinery is unique in its design of integrated process units. This design, intended to maximize energy efficiency and minimize the storage of intermediate products, essentially causes the entire refinery to function as one integrated unit. This means that a release of alkanes from a process unit that *does not* emit BTEX compounds would coincide with a release from a process unit that *does* emit BTEX compounds. Therefore, the proposed fenceline BTEX monitoring would serve as the alert in the event of a release of alkanes used in the process units.

The only location where alkanes could potentially be released without a corresponding benzene release is at tank storage (LPG spheres, 1 pressurized tank, and 2 LPG loading racks). However, fenceline monitoring of these alkanes would not serve as a first alert of an alkane leak: any release from one of these sources would be a significant event with refinery alarms that would activate refinery emergency response procedures and evacuation of people downwind. The LPG storage area, including the loading racks, has open-path total hydrocarbon detectors that alarm in the Control House in the event of a release. The pressurized tank is equipped with pressure relief valves (PRVs). These existing open-path analyzers and PRVs serve as the first alert for an alkane release that would activate emergency response procedures; a fenceline monitor would not be used as a first alert of a release in this situation.

Exclusion of 1,3-butadiene. Valero does not include measurements of 1,3-butadiene in its fenceline monitoring program. This is because 1,3-butadiene is not manufactured as an intermediate product or end product of the refinery and is only present in trace quantities.

Exclusion of other organics. Valero does not include measurements of other organics in its fenceline monitoring program. Other organics, with the exception of alkanes, are coincident with BTEX; therefore, the BTEX measurements serve as an excellent surrogate for other organics. The exclusion of alkanes is discussed above.

Exclusion of anhydrous ammonia. Valero does not include measurements of anhydrous ammonia in its fenceline monitoring program because anhydrous ammonia is used in air pollution control devices and is not used in routine processing at the refinery. Anhydrous ammonia is present in only one location, in two 3.5′ x 14′ drums that have high temp/pressure/level alarms for detection of release at the source. There are also excess flow shutoff valves on the drum, fixed fire monitors around the perimeter, and bollards and elevated foundations to protect the drums.

2.2.3 Assessment of Local Meteorology

Valero's Benicia Refinery is positioned in a wind flow corridor between the San Francisco Bay and the Sacramento Valley. Wind flow through the corridor is driven by seasonally variable regional temperature gradients and large-scale meteorological systems.

To characterize meteorological processes, wind, mixing height, and visibility were measured and assessed at several sites (**Figure 5**). Items investigated included the monthly, annual, seasonal, and spatial wind patterns; the low-level vertical structure of winds and how that structure might impact the transport of elevated sources versus surface sources; and the presence of fog and low clouds (as related to the ability of open-path sensors to obtain measurements). The primary data used in this analysis included:

- **Routine surface winds** – collected at Valero's Administration building and an offsite warehouse from 2007–2016.
- **Special-study surface winds** – collected at MRU Bunker in 2015.
- **Special-study 1-min visibility measurements** – collected using a Belfort visibility instrument at the facility's Equipment Storage (ES) site from January 14 – July 9, 2015.

Surface wind data collected at the special-study Buffer Property (BP) site in winter 2015 were compared to data from the Administration site. It was determined that the wind data collected at BP were very similar to the data collected at the Administration site; thus, the BP data were not included in the detailed analysis summarized in this report. Also, the Administration meteorological site is appropriate for understanding movement of air from the refinery to the city of Benicia because (1) it is located between the refinery and the community to the west and thus better represents transport directions to the community; (2) it is at an elevation that is more representative of winds that blow into the community; and (3) it is not influenced by nearby buildings.

General meteorological patterns were also discussed with experts in meteorological processes in the North Bay Area.

For this analysis, seasons were defined as follows: winter is December, January, and February; spring is March, April, and May; summer is June, July, and August; and fall is September, October, and November.

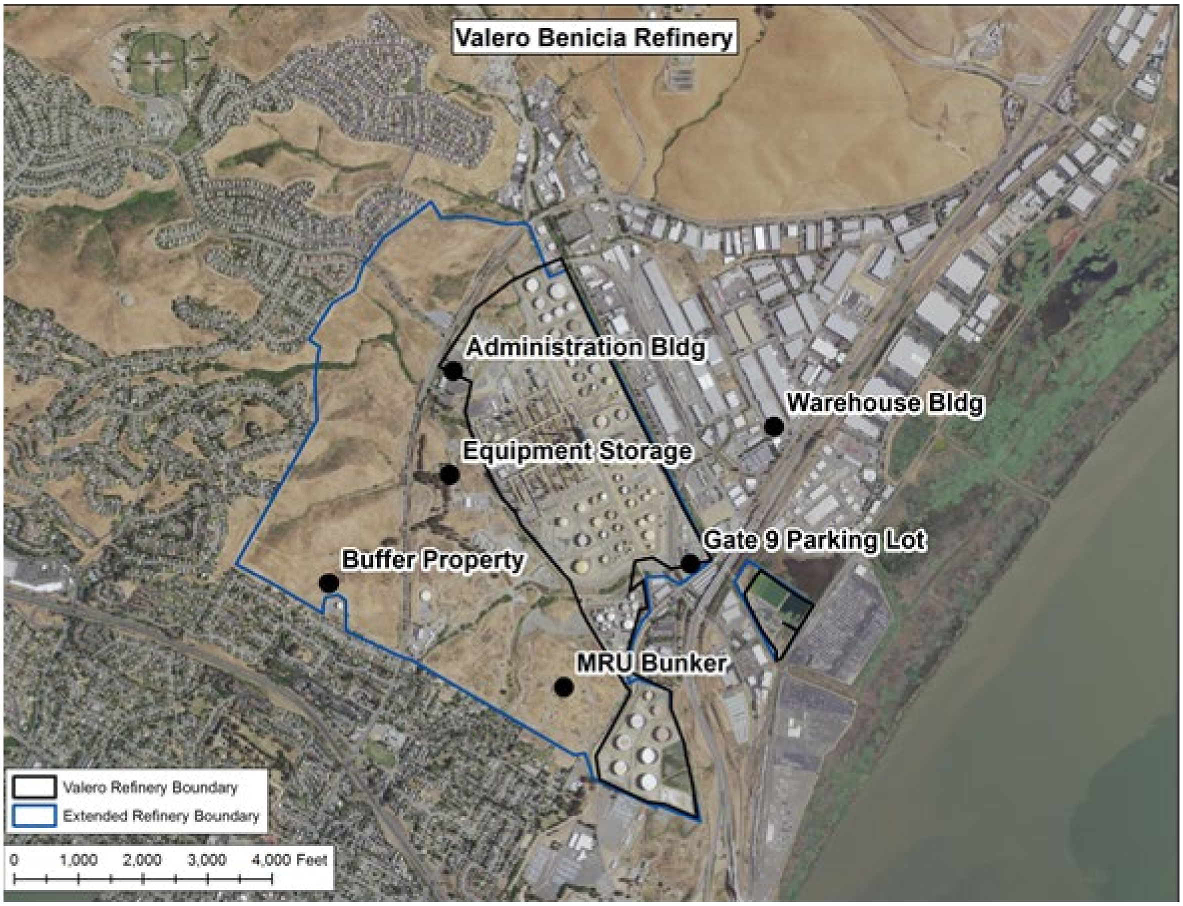

Figure 5. Meteorological monitoring locations.

General Flow Patterns

Figure 6 illustrates the predominant wind flow patterns (1) winds blowing from northwest and west to east and southeast (onshore flow, most often occurring in spring, summer, and early fall); and (2) winds blowing from northeast to southwest (regional offshore flow, most often occurring in winter).

Figure 6. Typical wind flows around Valero's Benicia Refinery.

Wind Roses

Wind roses were created to determine the frequency of wind speed and direction for various time periods. To evaluate the actual winds against the wind direction requirement stated in BAAQMD Guidance document, wind roses showing annual mean wind direction in 22.5-degree segments were created and reviewed. To evaluate seasonal and recurring short-term meteorological events, seasonal and monthly wind roses were created.

The petals of a wind rose show the direction from which the wind is blowing, and reveal that:

- **Onshore winds** – Winds blowing from northwest to southeast, west to east, and southwest to northeast are in excess of 10% per year (Figure 7). Winds from these directions are most common in spring, summer, and early fall.
- **Offshore winds** – Winds blowing from the refinery toward the city of Benicia (i.e., winds blowing from northeast to southwest) are infrequent and occur on an occasional basis that totals less than 7% of the time throughout the year (Figures 8 and 9). Although northeasterly winds occur less than 10% of the time annually, they are included for consideration in this AMP because portions of the city of Benicia are downwind of the refinery under these conditions and the winds may occur more than 10% of the time *during the winter season only*. Winds from other directions occur a negligible amount of the time.

To better illustrate the downwind areas impacted by the onshore and offshore winds, maps that highlight the areas downwind of the Valero Benicia Refinery property were created. For offshore winds, more precise modeling was performed because this wind direction is from the refinery toward the residences of Benicia. Details on the modeling are discussed in Section 2.2.4. The downwind areas of influence for onshore flow are shown in Figure 1 and offshore flow in Figure 10. These analyses show that:

- During dominant onshore (southwesterly through northwesterly) winds, the main area downwind of the refinery is the business/commercial area just to the east.
- During infrequent offshore (northeasterly) winds, the main area downwind of the refinery is the city of Benicia, excluding west and northwest Benicia. The offshore wind direction is well defined and has little directional variability because of terrain effects and the orientation of the Carquinez Strait. Therefore, the downwind areas that could be affected under these conditions are very narrow.

The results of these wind and modeling analyses indicate that air quality measurements are needed along the southwest (Paths 1 and 2) and eastern (Path 3) fencelines of the Valero Benicia Refinery (Figure 2). Monitoring between Paths 2 and 3 is not feasible because of road, rail track, and terrain issues. However, monitoring between Paths 2 and 3 is not needed, as there are no significantly populated areas downwind of this space between the monitors. Monitoring north of Path 1 is not needed because it is outside of the area of influence.

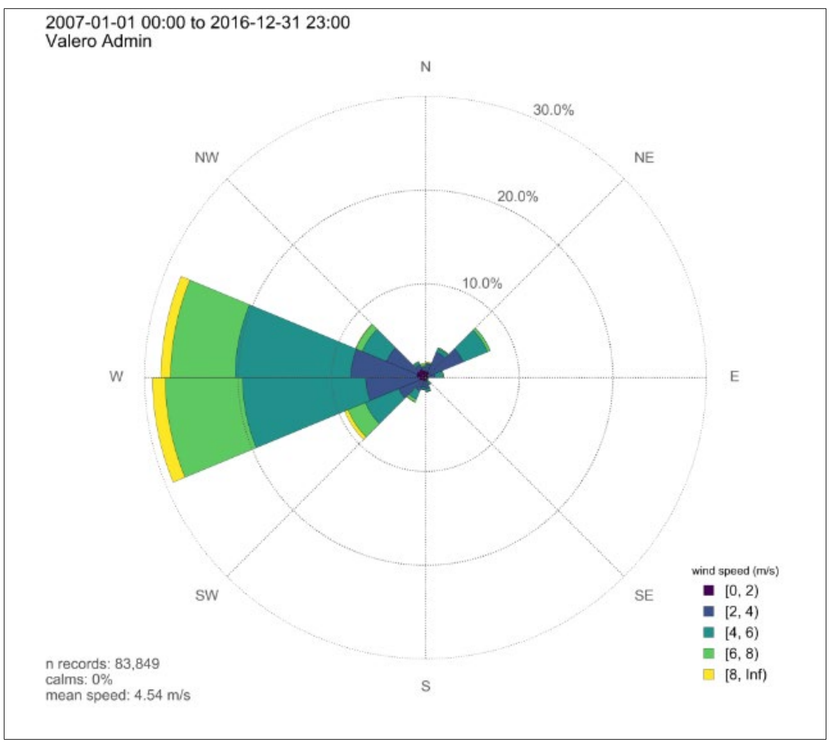

Figure 7. Wind rose for the Administration site showing near-surface wind directions for data collected from 2007 – 2016.

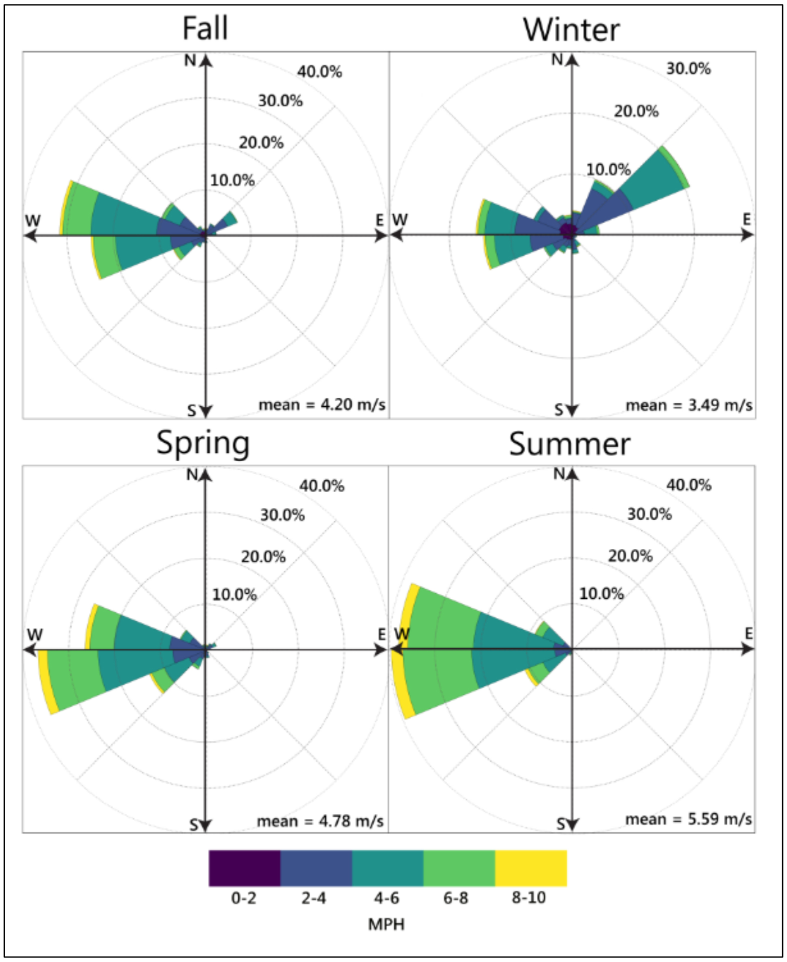

Figure 8. Wind roses at the Administration building (surface winds) by season for data collected from 2007 – 2016.

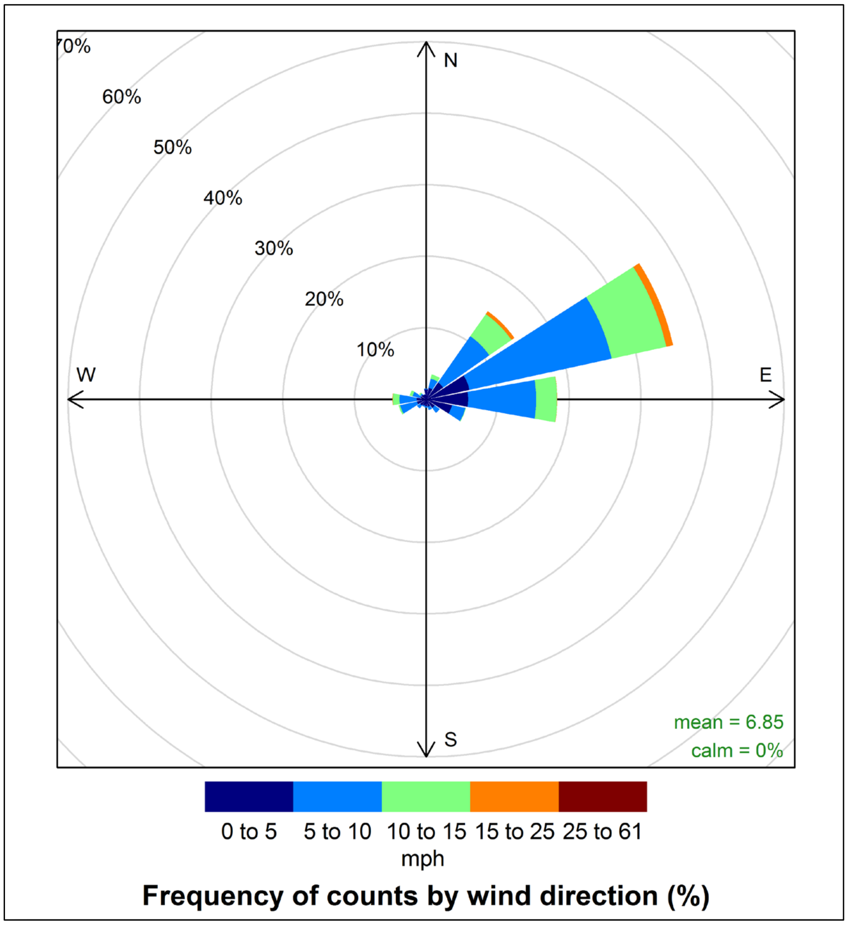

Figure 9. Wind roses at the MRU Bunker for January 2015.

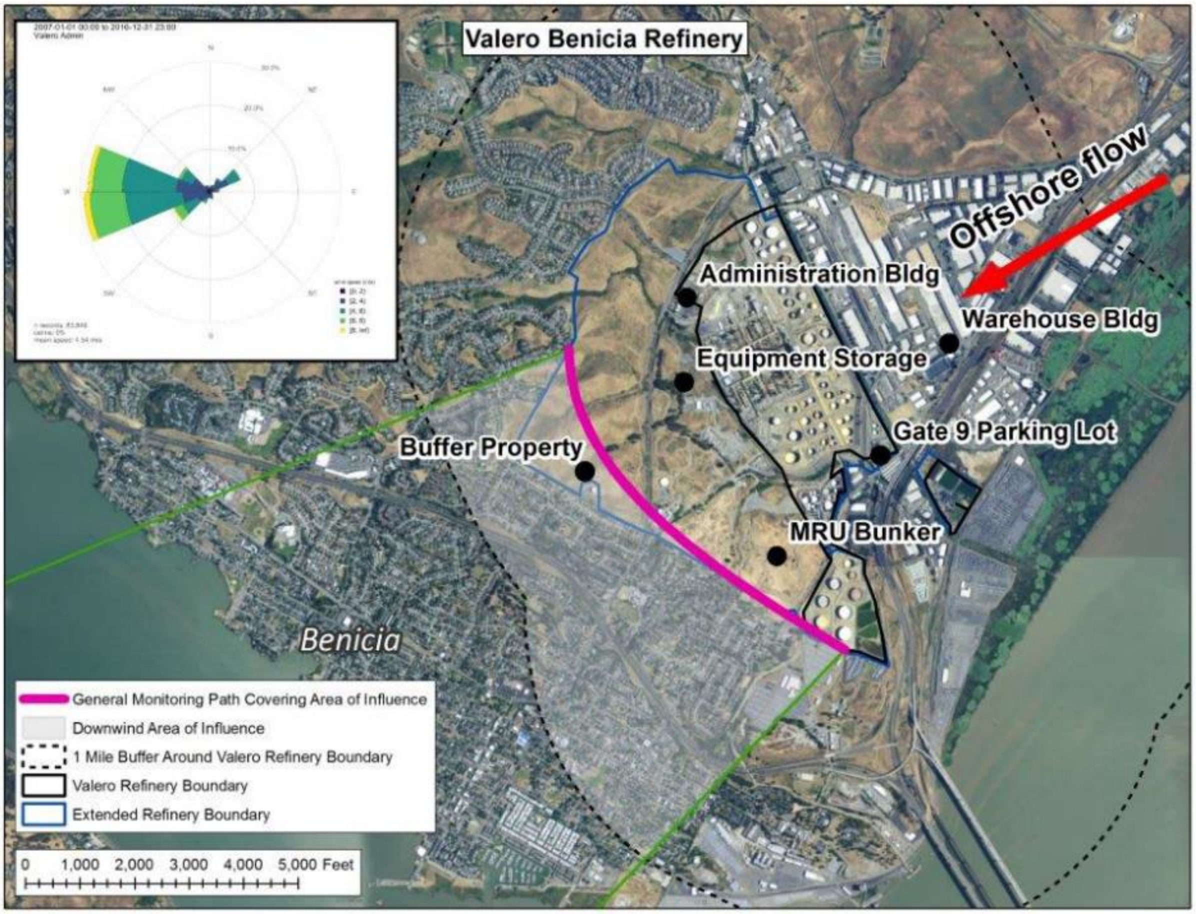

Figure 10. Areas downwind of the Valero Benicia Refinery property boundaries during offshore (northeast to southwest) winds.

2.2.4 Winter Offshore-Flow Dispersion Modeling

Because of terrain effects and the orientation of the Carquinez Strait, the northeasterly wind direction is well-defined and has little directional variability; therefore, the downwind areas that could be affected under these wind conditions are very narrow. To provide further evidence that monitoring Paths 1 and 2 upwind of Benicia during winter months are in the correct locations to capture the narrow area of the offshore flow, air pollutant dispersion modeling was performed using the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD, Version 15181).[4] AERMOD is a steady-state Gaussian plume dispersion model. The advantage of dispersion modeling over wind rose analysis is that it combines winds, topography, atmospheric stability, emissions, and dispersion processes to estimate areas of peak concentrations across the entire downwind area. Importantly, dispersion modeling accounts for the time variability in meteorology to create a more accurate assessment of the locations where fenceline monitoring is needed.

[4] https://www3.epa.gov/scram001/dispersion_prefrec.htm

AERMOD uses hourly meteorological data to assess the dispersion of emission plumes from several point, area, or volume sources in flat and complex terrain.

Special meteorological measurements were conducted from January 15, 2015, through late spring of 2015 to support the development of this AMP. The data collected during this study were used to support the air pollutant dispersion modeling. Due to the infrequent nature of northeasterly wind events (the meteorological conditions of importance for transport to Benicia and the focus of the modeling), there were only a few days to model, which included January 24, 2015, January 25, 2015, and January 26, 2015. Meteorological data collected on these days used in the model included sodar winds (continuous winds from about 20 m to 600 m above ground level), ceilometer mixing heights (roughly the height to which any emissions will mix), and surface winds.

Sources of benzene emissions at Valero's Benicia Refinery[5] were identified, and dispersion was modeled for three representative case-study days. Benzene measurement is a reasonable surrogate for other HAP emissions.[6] Maps of the 24-hr accumulative concentrations of benzene were produced for each of the days.

Figures 11 through 13 provide the model results for these case study days. The results predict very low benzene levels downwind of the refinery. The concentrations fields provide further evidence that the monitoring paths (Paths 1 and 2) upwind of the city of Benicia are in the correct location and that monitoring along the western/northwestern fenceline is not required. Any emission that would pass just north of Path 1 would also be captured by Path 1 monitors because of pollutant dispersion.

Because the east boundary that is upwind of the business/commercial area is covered by Monitoring Path 3, we did not perform modeling for the onshore westerly wind events.

As noted in Figure 2, there is a small gap in coverage between monitoring Paths 1 and 2 over East 2nd Street because it was not logistically feasible to measure in this area. However, the horizontal dispersion of any material released from the refinery would create a wide enough plume by the time it reached this gap, such that monitoring along both Paths 1 and 2 would capture any material.

[5] Based on 2010 EPA ICR data adjusted for the flue gas scrubber.
[6] Background section of Petroleum Refinery Sector Risk and Technology Review and New Source Performance Standards.

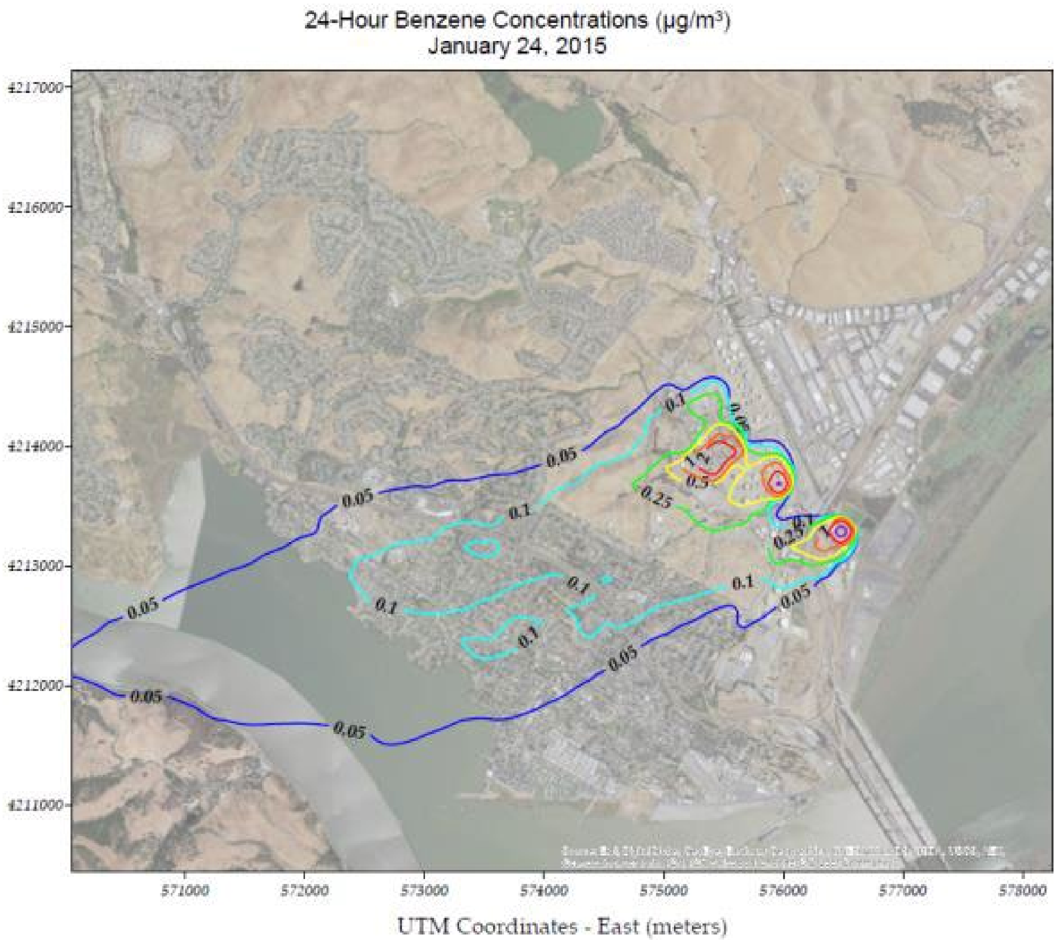

Figure 11. Dispersion modeling results using meteorological data from January 24, 2015, showing predicted 24-hr average benzene concentrations (µg/m^3). Note: 1 ppb = 3.2 µg/m^3 for benzene at 20°C and 1013 mb.

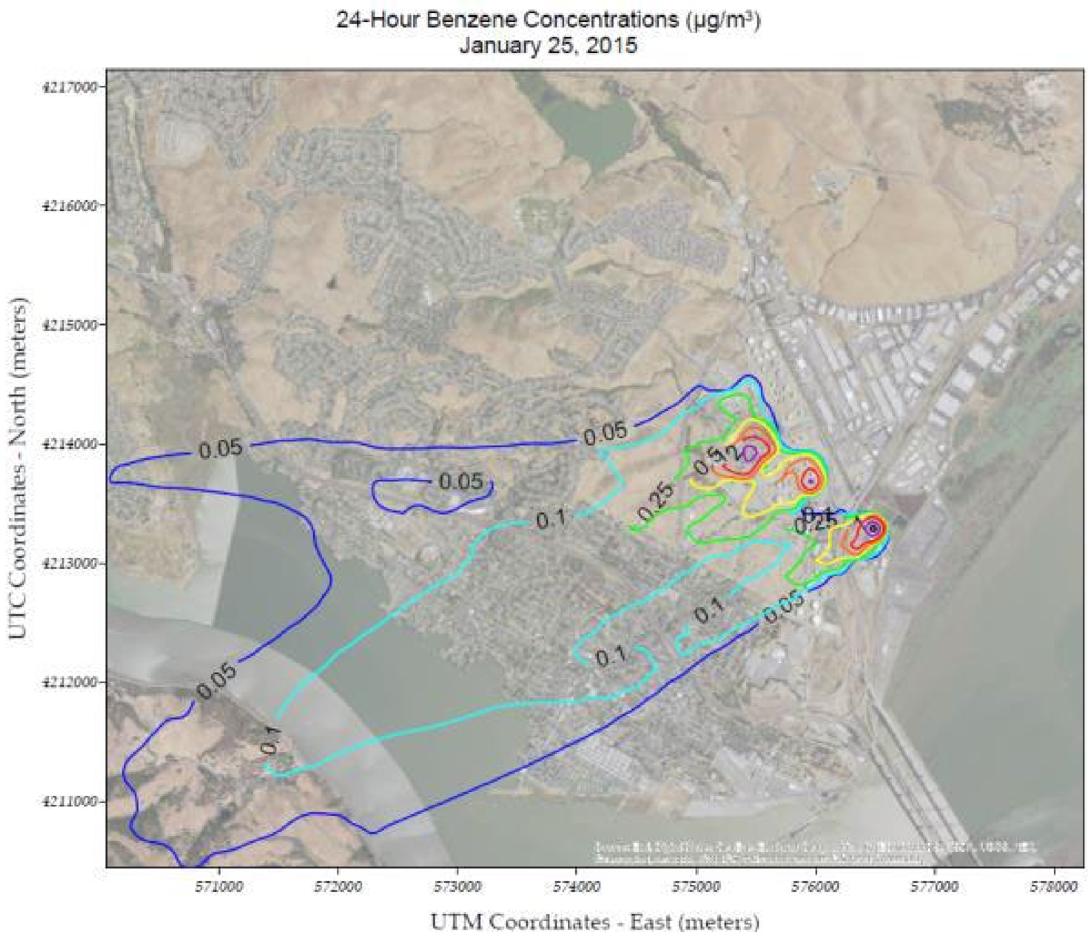

Figure 12. Dispersion modeling results using meteorological data from January 25, 2015, showing predicted 24-hr average benzene concentrations (µg/m^3). Note: 1 ppb = 3.2 µg/m^3 for benzene at 20°C and 1013 mb.

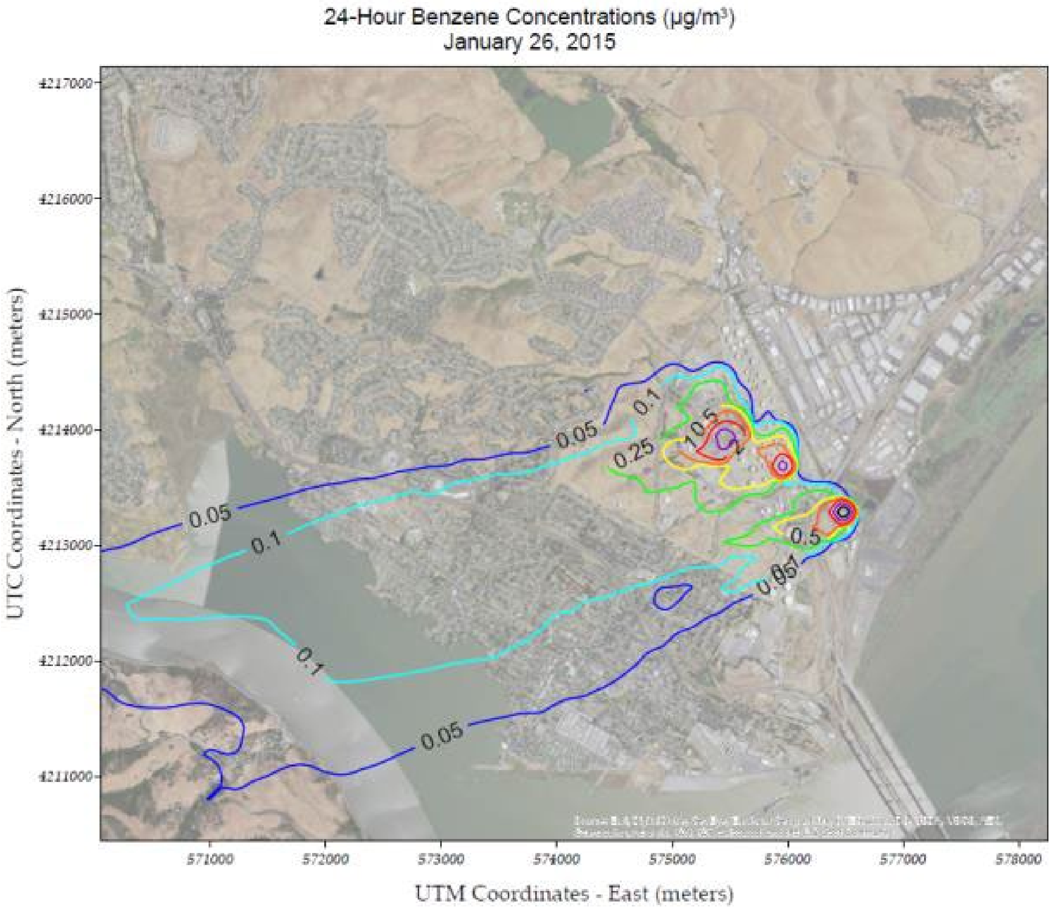

Figure 13. Dispersion modeling results using meteorological data from January 26, 2015, showing predicted 24-hr average benzene concentrations (µg/m³). Note: 1 ppb = 3.2 µg/m³ for benzene at 20°C and 1013 mb.

2.2.5 Visibility Conditions

Tule fog forms when there is high relative humidity (typically after rain), light wind, and rapid cooling. Tule fogs typically form in the California Central Valley, extending into the marshlands along the Sacramento and San Joaquin Rivers and into the Carquinez Strait, especially during the rainy season from late fall through early spring. Heavy fog may entirely block the signal from an open-path instrument and prevent data collection; however, even light fog can absorb the signal partially and interfere with measurements. Tule fogs may occur during periods when pollutant measurements are most critical because (1) the stable atmospheric conditions associated with Tule fogs are unfavorable for pollutant dispersal, and (2) they are most likely to occur during northeasterly wind events when residential receptors in Benicia are downwind from the refinery. Figure 14 shows an example of the Tule fog at the refinery. To investigate visibility, a visibility monitor was operated at the refinery from January 14 through July 9, 2015.

Figure 14. Tule fog at the Valero Benicia refinery.

Figure 15 shows that 617 5-min periods were recorded with visibility below 500 m, and 839 periods were recorded with visibility below 1,000 m. Based on these observations, if signal strength drops below the threshold value and the visibility is less than 2.5 miles, then data from open-path analyzers are flagged as invalid due to weather. Assuming that the frequency of low visibility observed during mid-January to mid-July is representative of visibility from mid-July through mid-January, and that 2015 is representative of other years, we expect fog to impact open-path measurements about 5% of the time over the course of a year. Rule 12-15 allows for missing or invalid data due to adverse environmental conditions, where supported by meteorological measurements and a narrative description. For this reason, visibility measurements are taken as part of the measurement program.

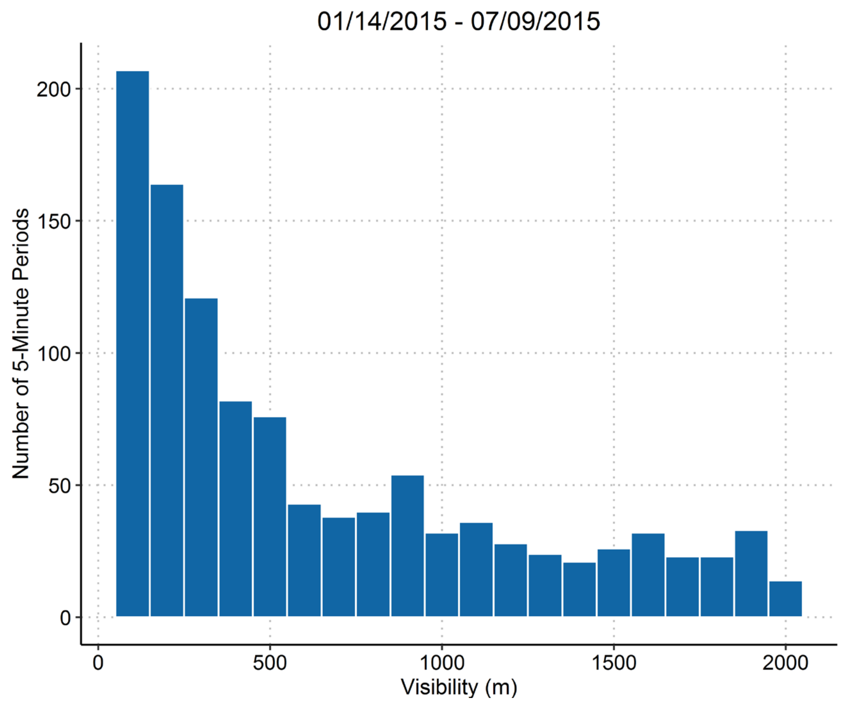

Figure 15. Histogram of 5-min visibility values less than 2,000 m from January 14 – July 9, 2015.

2.3 Instrument Selection

Literature reviews, site surveys, and interviews with instrument manufacturers were performed to determine the instruments needed to meet Rule 12-15 requirements. Both point and open-path instruments were investigated. Based on the distances that need to be covered by measurements (hundreds of meters), data time-resolution requirements (5-min), and current measurement technology, open-path instruments were selected.

Monostatic open-path instruments transmit light across a long, open path, which is reflected back by a targeted mirror ("retroreflector") for detection by a sensor located within the same housing as the light source. Energy absorption at different wavelengths is measured and recorded by the detector. Energy absorption relates to the average concentrations of gases of interest along the light path, according to Beer-Lambert's absorption law, with individual gases having characteristic wavelengths at which they absorb most effectively. Therefore, measurements of absorption between the transmitter and detector can be used to infer average concentrations across the length of the path for species of interest. Figure 16 illustrates the basic concepts of open-path measurements. Note that open-path measurements cannot distinguish between a widely dispersed, low-concentration plume and a narrow, high-concentration plume; they detect average concentrations across the entire distance from transmitter to detectors.

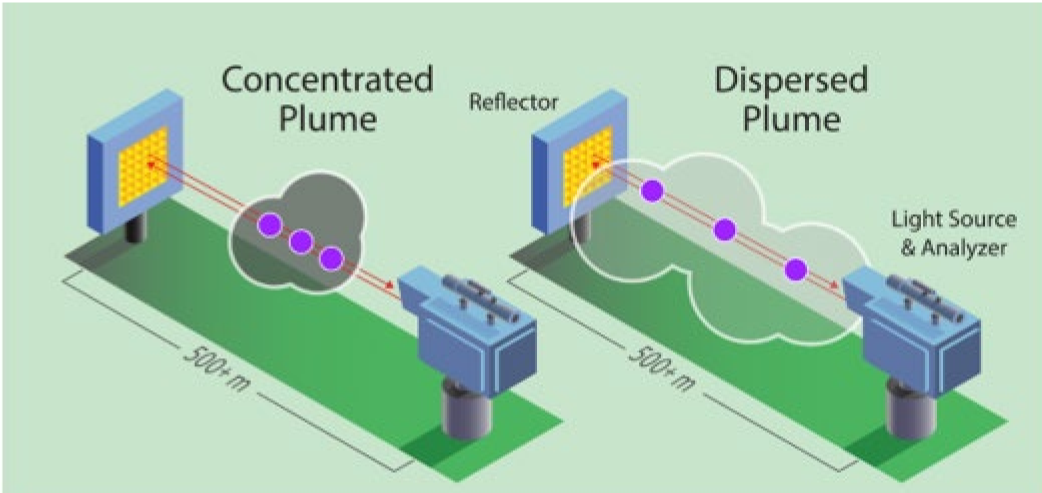

Figure 16. Schematic illustrating the basic premise for open-path instrument operation.

Along all paths, BTEX compounds and SO_2 are measured using monostatic UV-DOAS analyzers with xenon light sources. The xenon light is required to achieve (1) measurements over paths that are about 300 to 600 m long, and (2) the minimum detection limits (MDL) for BTEX compounds. H_2S is measured using monostatic TDLAS instruments for informational monitoring purposes. The basic principle of TDLAS is to measure a single absorption line for the target pollutant. A tunable diode laser can emit light over a small range of very specific wavelengths, which allows spectral measurement over a narrow wavelength range. In theory, one can monitor H_2S using a UV-DOAS analyzer, but its absorption spectra overlaps with BTEX and generates false positives. While Fourier Transform Infrared Technology spectroscopy (FTIR) technology was considered for measurements of BTEX and H_2S, instrument manufacturers informed Valero that FTIR is not suitable for these compounds because of poor detection limits and overlap in absorption with other compounds (such as carbon dioxide [CO_2] with benzene).

MDLs and upper detection limits (UDLs) are the lowest and highest concentrations of each species that can be measured by each instrument and sampling path. Additional details, including estimated values at each sampling path as reported by instrument manufacturers are provided in Section B.2 of the QAPP.

For the Unisearch TDLAS, a real-time MDL is calculated continuously using the standard deviation of the last seven 5-min average concentration values containing no measurable analyte (as determined by the correlation coefficient). The resulting MDL is reported alongside every 5-min average concentration value. The MDL may be higher if there is poor atmospheric visibility (e.g., heavy fog, rain, smoke, or dust), the instrument is misaligned, there are hardware problems, or an interferant is present. MDLs at the lower end of the specified range are expected under the opposite conditions.

Monostatic (as opposed to bistatic) instruments use mirrors to reflect sensor light; monostatic instruments have been selected to reduce the need for substantial power at the mirror sites and to improve MDLs by increasing effective path lengths. Power, communications, and shelter are required at the light-source/detector end of the monitoring path only. The retroreflector needs only to be aligned for maximum performance at the other end of the path and to be cleaned regularly. An example of a UV-DOAS analyzer and receiver in a shelter is shown in **Figure 17**. The retroreflector is shown in **Figure 18**. For Path 3, the instruments and retroreflectors are placed on an elevated platform to avoid interference with passing vehicles (see the example in **Figure 19**).

Figure 17. Example of a UV-DOAS analyzer installation.

Figure 18. Example of a UV-DOAS retroreflector installation.

Figure 19. Example of a UV-DOAS analyzer installation on an elevated platform.

2.4 Data Analysis

2.4.1 Completeness

BAAQMD guidance for open-path measurement data recovery is that instrumentation must meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Because open-path measurements are affected by atmospheric conditions such as dense fog, invalid data during low-visibility conditions do not count against completeness requirements. Visibility measurements are made using a forward scattering optical visibility sensor to document the time periods of reduced visibility, as described in Section 2.2.5. Visibility measurements are made at least every 5 minutes to coincide with the open-path measurements.

Other factors that affect data availability include instrument bump tests (monthly for a few hours), other maintenance (e.g., replacement of UV bulbs for the UV-DOAS after every 2,000 hours of use, roughly on a quarterly basis), and annual maintenance. For both UV-DOAS and TDLAS instruments, a backup system will be used when each of the primary instruments are returned to the manufacturer for extended maintenance. Regular maintenance and careful, responsive operation will minimize instrument downtime.

2.4.2 Quality Assurance/Quality Control (QA/QC)

A key goal of the QA/QC plan is to ensure high-quality data that are representative and defensible. Clear definitions and procedures for QA/QC are also necessary to inform the public on why some data are missing, flagged as questionable, or invalid. Data review processes are detailed in Section D of the QAPP as well as the standard operating procedure (SOP) for Data Validation (Attachment 5).

3. Routine Operations

For this monitoring program, 6 UV-DOAS, 6 TDLAS, and 2 visibility instruments have been installed and are currently collecting measurements. Instrument operations, maintenance, and bump tests include daily checks to ensure that data are flowing from all instruments, as well as monthly, quarterly, and annual maintenance activities. Full details and documentation are included throughout the QAPP, and individual instrument SOPs are provided as Attachments 1–4 to the QAPP.

In addition, as requested by BAAQMD, sorbent tubes are used at three locations (labeled 10, 11, and 12 in Figure 2). The sorbent tubes at these locations are replaced and analyzed for BTEX approximately every 14 days in accordance with the 40 CFR Subpart CC Fenceline Monitoring program. Valero reviews the BTEX results and submits them to BAAQMD in an approved formatted spreadsheet within 30 days of receiving the results. Because the 2-week monitoring period results in 26 samples per calendar year, the availability of laboratory results is not expected to align with calendar months. Therefore, Valero submits the results within 30 days of receipt and verification.

Should three or more sampling events in one year exceed 9.0 $\mu g/m^3$ of benzene at an individual location (site 10, 11, or 12), Valero will increase the submittal frequency to BAAQMD to within two weeks of receiving the results from the laboratory. Once there is a 12-month period with no benzene results greater than 9.0 $\mu g/m^3$, the results will resume being submitted to BAAQMD within one month of receiving the results.

In the event the annual rolling average benzene concentration (deltaC) at sample locations 10, 11, or 12 exceeds the 9.0 $\mu g/m^3$ action level (as defined in 40 CFR 63.658), Valero will work with BAAQMD to consider installation of a UV-DOAS open-path monitor at this monitoring point location.

3.1 Instrument Operations

System status indicators will alert data reviewers to operational issues. A comprehensive summary of status indicators and data flagging is included in Section D.2 of the QAPP. Sonoma Technology's after-hours on-call staff additionally respond to alerts for operational issues, as discussed in Section B.6 of the QAPP. Routine maintenance activities and schedules are detailed in Section B.6 of the QAPP and in the instrument SOPs provided as Attachments 1–4 to the QAPP.

3.2 Data Management

A Data Acquisition System (DAS) or data logger at each sampling site performs basic 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 quality control (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 SOP for Data Validation (Attachment 5 to the QAPP).

3.2.1 Public Display

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 for the public to build understanding surrounding 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 Data Verification and Validation SOP (Attachment 5 to the QAPP). Figure 20 shows a screenshot of the Valero Benicia Refinery public website.

In the event that high concentration levels occur, Valero will follow its existing event protocol and the city of Benicia will decide when it is appropriate to activate its emergency alert program. Episodic data will be provided to the BAAQMD upon request, consistent with other regulatory measurements.

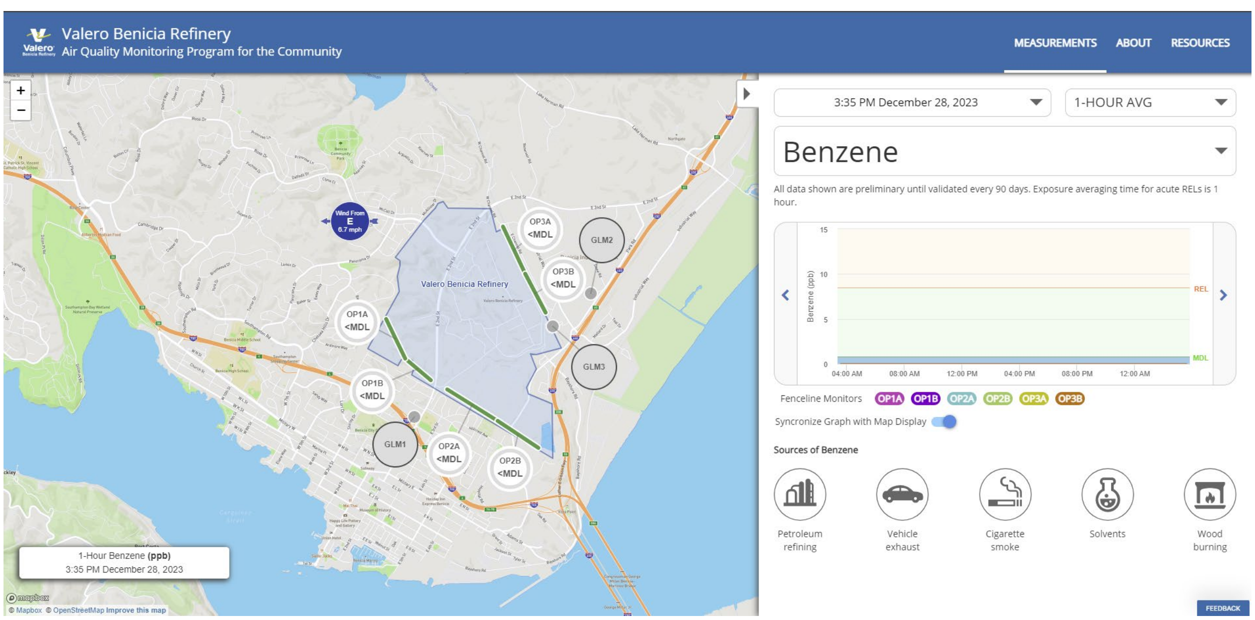

Figure 20. Screenshot of the Valero Benicia fenceline monitoring public website.

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

- Information about the species measured and the measurement techniques.
- Discussion of levels of concern, with links to third-party sources such as the Office of Environmental Health Hazard Assessment (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 MDL.
- Definition of data flags and their meaning.
- Frequently asked questions (FAQs).

To facilitate public feedback, a feedback mechanism is provided on the web page. This allows users to submit questions or comments about the website. An email is delivered to a Valero contact and the website host, who are responsible for deciding how to respond to the 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.

Appendix A: Quality Assurance Project Plan

Quality Assurance Project Plan for the Valero Benicia Refinery in Benicia, CA.

Quality Assurance Project Plan

Prepared by

Sonoma Technology, Inc.
1450 N. McDowell Blvd. Suite 200
Petaluma, CA 94954
Ph 707.665.9900 | F 707.665.9800
sonomatech.com

Prepared for

Valero Refining Company–CA
Benicia Refinery
3400 E 2nd St.
Benicia, CA 94510
valero.com

April 14, 2026
Revision 9

STI-922002-6990

This document contains blank pages to accommodate double-sided printing.

A. Project Management

A.1 Title and Approval Page

Quality Assurance Project Plan
Fenceline Monitoring for the Valero Refinery in Benicia, California

Signature	Date
Name Valero Benicia Refinery	Title
Signature	Date
Name Sonoma Technology, Inc.	Title

The attached Quality Assurance Project Plan (QAPP) is hereby recommended for approval and commits Valero to follow the elements described within.

A.2 Table of Contents

Figures

Tables

Review and Revision History

Revision Number	Date	Responsible Party	Description of Change
0	December 7, 2018	Valero	Initial Submission to BAAQMD
1	March 4, 2019	Valero	Submission to BAAQMD; Addressed comments on initial submission and added TDLAS measurement for H_2S
2	August 23, 2019	Valero	Submission to BAAQMD; addressed comments from BAAQMD on March 2019 submission
3	January 8, 2020	Valero	Submission to BAAQMD; addressed comments from BAAQMD on August 2019 submission
4	June 1, 2022	Valero	Submission to BAAQMD; revised TDLAS measurement information
5	February 3, 2023	Valero	Submission to BAAQMD; addressed comments from BAAQMD on June 2022 submission, revised TDLAS measurement information
6	September 5, 2023	Valero	Submission to BAAQMD; addressed comments from BAAQMD on February 2023 submission
7	December 11, 2023	Valero	Submission for redline comments to BAAQMD; addressed comments from BAAQMD on September 2023 submission
8	October 31, 2024	Valero	Submission to BAAQMD; addressed comments from BAAQMD on December 2023 submission
9	April 14, 2026	Valero	Submission to BAAQMD; addressed comments from BAAQMD on October 2024 submission

This QAPP is a living document, meaning it will undergo regular review to ensure that data quality assurance practices are robust and current. The QAPP will be reviewed at least annually and any proposed updates will be submitted for approval to the Bay Area Air Quality Management District (BAAQMD). The official version of this QAPP is maintained by Valero in Benicia, CA. This QAPP contains all critical documents for this program, including Standard Operating Procedures (SOPs) and blank data entry forms.

A.3 Distribution List

Name	Organization	Role
Asha Noorullah	Valero	Refinery Contact
Taryn Goodwin	Valero	Refinery Contact
Director, Meteorology & Measurement Division	BAAQMD	BAAQMD Contact
Director, Compliance & Enforcement Division	BAAQMD	BAAQMD Contact
Neil Fernandez	Sonoma Technology	Project Manager
Hilary Hafner	Sonoma Technology	Quality Assurance Manager
All Project Personnel	Sonoma Technology	Various

Personnel included in above list will be provided with revisions of all critical documentation.

A.4 Project Organization

This QAPP details the specifications for operating the monitoring network and outlines the operation and maintenance of all instrumentation and equipment, data management and quality control (QC) procedures, and public reporting via a publicly accessible website.

Refinery staff work with a designated contractor to achieve the goals of the fenceline monitoring network. An organization chart (**Figure 1**) and various project roles are detailed below. Contact information for key personnel is provided in **Table 1**.

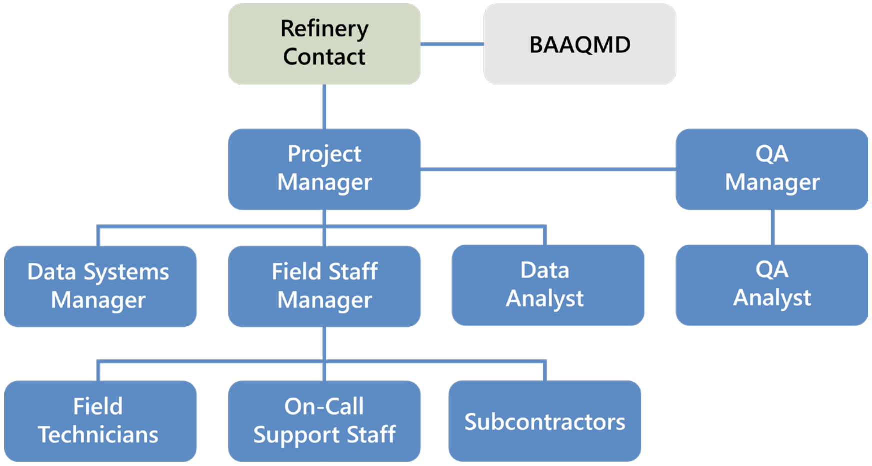

Figure 1. Organization chart for the refinery's fenceline monitoring project.

Refinery Contact. The Refinery Contact is responsible for project oversight and serves as the primary point of contact for the refinery. They facilitate communication between the refinery and BAAQMD.

Project Manager. The Project Manager is responsible for the successful execution of the fenceline monitoring project and serves as the primary point of contact for the contractor. The Project Manager oversees day-to-day monitoring operations, coordinates with all project personnel, and reports to the Refinery Contact. They also work closely with the Quality Assurance Manager (QA Manager) to ensure the QAPP and SOPs are followed, and oversee corrective action plans when needed.

Quality Assurance Manager. The QA Manager provides overall guidance for the evaluation of data, and is responsible for evaluating data for adherence to project specifications and ensuring that QA activities remain independent from data collection. If deviations are discovered, the QA Manager coordinates with the Project Manager to determine and implement necessary corrective actions.

Field Staff Manager. The Field Staff Manager oversees the team responsible for operating and maintaining all instrumentation and equipment at the refinery fenceline monitoring sites. They work closely with Field Technicians and Subcontractors, coordinate staff coverage and additional science support as needed, and regularly provide updates to the Project Manager.

Field Technicians. Field Technicians are responsible for the successful operation of instrumentation and equipment, providing routine maintenance according to SOPs. They are qualified to work on refinery property and with all scientific instrumentation. They also perform the required quality checks according to this QAPP while documenting work in site logs.

On-Call Support Staff. On-Call Support Staff are responsible for responding to automated system alerts outside of normal business hours, including remotely troubleshooting data flow outages and validating potential detection events. They are trained in the theories of operation for all field instrumentation and equipment, and conduct abbreviated data checks to identify operational issues requiring field support.

Subcontractors. Subcontractors may be used to provide additional technical support for instrumentation and equipment. They are overseen by the Field Staff Manager and adhere to all project requirements.

Quality Assurance Analyst. The Quality Assurance Analyst (QA Analyst) conducts independent reviews of data products to confirm data analysis activities have been conducted according to the QAPP. The QA Analyst works closely with the QA Manager and Data Analysts.

Data Analysts. Data Analysts conduct routine daily data checks to ensure accuracy of real-time reporting on the public website, and relay issues to the Field Staff Manager as needed. They also conduct an extended analysis every calendar quarter to generate data products for regulatory reporting efforts, including the assembly of final data sets.

Data System Manager. The Data System Manager is responsible for continuous real-time data flow, routine operation of the automated alerting system, and proper data display on the public website. They work closely with Field Technicians, Data Analysts, and the Project Manager to ensure the system is operational and real-time data is reported to the public.

Table 1. Contact information for key project personnel.

Name	Organization	Role	Contact Information
Asha Noorullah	Valero Benicia Refinery	Refinery Contact	asha.noorullah@valero.com 707-745-7212
Neil Fernandez	Sonoma Technology	Project Manager	nfernandez@sonomatech.com 707-665-9900
Hilary Hafner	Sonoma Technology	QA Manager	hilary@sonomatech.com 707-665-9900

A.5 Problem Definition and Background

The Valero Refining Company (Valero) conducts air quality monitoring at its refinery in Benicia, CA, in response to BAAQMD Regulation 12, Rule 15 (Rule 12-15).[1] Measurements are collected according to an Air Monitoring Plan (AMP) consistent with BAAQMD Air Monitoring Guidelines for Petroleum Refineries,[2] and data are reported in real time on a publicly accessible website.

[1] Petroleum Refining Emission Tracking (Rule 12-15; approved by the BAAQMD on April 20, 2016).
[2] Bay Area Air Quality Management, Air monitoring guidelines for petroleum refineries. April 2016. Available at baaqmd.gov/~/media/files/planning-and-research/public-hearings/2016/9-14-and-12-15/042016-hearing/1215-amg-041416-pdf.pdf?la=en.

Rule 12-15 Guidelines from BAAQMD require fenceline monitoring with "open path technology capable of measuring in the parts per billion range regardless of path length," or an alternative measurement technology.[2] The required compounds to be measured include benzene, toluene, ethylbenzene, xylenes (BTEX), and hydrogen sulfide (H_2S). As described in the facility's AMP, sulfur dioxide (SO_2) was also included in the list of compounds to be measured.

The California Environmental Protection Agency (EPA) Office of Environmental Health Hazard Assessment's (OEHHA) acute 1-hr reference exposure limits (REL) are used as a reference for fenceline monitoring because they represent the concentration threshold above which compounds are considered hazardous to human health. Table 2 lists the RELs for the compounds included in this fenceline monitoring program, for which sampling methods capable of measuring below these values were selected. For clarity, the California Ambient Air Quality Standards (CAAQS; California EPA) and National Ambient Air Quality Standards (NAAQS; U.S. EPA) are also included. Detailed information regarding monitoring methods is provided in Section B of this document.

Table 2. Acute 1-hr RELs from OEHHA.

Compound	1-Hr REL (ppb)	1-Hr CAAQS (ppb)	1-Hr NAAQS (ppb)
Benzene	8.5	--	--
Ethylbenzene	--	--	--
H_2S	30	30	--
SO_2	252	250	75
Toluene	1,327	--	--
Xylenes	5,066	--	--

A.6 Project Description

Valero currently conducts open-path monitoring of BTEX compounds, H_2S, and SO_2 along three fenceline paths at the Benicia refinery, in accordance with BAAQMD Rule 12-15 and the facility's AMP. Sampling sites were selected in consideration of nearby local receptors (e.g., residences and businesses), dominant winds that blow from west to east, and infrequent winds that blow from northeast to southwest towards areas in Benicia.

Preliminary data from fenceline monitors are quality controlled and reported in real time to a publicly accessible website, and final quarterly data sets are provided to BAAQMD. Additional details are provided in the AMP and Section B of this document.

A.7 Quality Objectives and Criteria

Data Quality Objectives

Data quality objectives (DQOs) outline the major question(s) to be answered by a monitoring project and ensure that collected data are of sufficient quality to support project goals. The U.S. EPA provides a seven-step process to establish DQOs:

1. **Problem Statement**: The goal of this monitoring program is to meet the requirements of BAAQMD Rule 12-15, which was established to provide the public with information regarding concentrations of target compounds at the fenceline of refining facilities.
2. **Decision**: The refinery provides information to the public regarding concentrations of target compounds consistent with BAAQMD Rule 12-15 and the facility's AMP.
3. **Information Inputs**: Concentration data from open-path monitors are provided as 5-min and 1-hr rolling average concentrations. Data are reviewed with respect to representativeness and comparability, and measurements from other available sources in similar geographic locations serve as a basis of comparison.
4. **Study Boundaries**: Concentration measurements are collected along the refinery fenceline in accordance with BAAQMD Rule 12-15 and the facility's AMP.
5. **Decision Rule**: Measurements are collected and reported in real time in accordance with BAAQMD Rule 12-15 and the facility's AMP.
6. **Acceptance Criteria**: Data will be considered acceptable for reporting provided they meet the defined performance criteria for the project.
7. **Data Collection**: Raw data are collected at various frequencies (depending on the instrumentation and equipment), 24 hours a day, 7 days a week, and aggregated into 5-min averages. Automated quality control logic (AutoQC) and DMS-level screening checks are performed in real time before data are posted to a publicly accessible website.

Data Quality Indicators

Data quality indicators (DQIs) are the quantitative statistics and qualitative descriptors used to interpret the degree of data's acceptability or utility in consideration of the project's DQOs. The DQIs for BAAQMD Rule 12-15 fenceline monitoring projects are defined below. Accuracy and precision are quantitative metrics, representativeness and comparability are qualitative metrics, and completeness combines quantitative and qualitative metrics.

Accuracy is the metric of agreement between an observed value and an accepted reference value. Accuracy is calculated using some derivation of error or recovery from data sets collected during bump tests and calibration checks. Additional details are provided in Section B.7 of this document.

Precision is the metric of mutual agreement among individual measurements of the same parameter, otherwise known as the random component of error. Precision is calculated using some derivation of the standard deviation of data sets collected during bump tests and calibration checks. Additional details are provided in Section B.7 of this document.

Representativeness refers to the degree to which data collected by the monitoring project broadly represent ambient conditions, variations between sampling sites, and potential detection events. Representativeness is primarily controlled by the sampling locations, which are detailed in the facility's AMP.

Concentrations of target compounds will be reported in parts per billion (ppb), consistent with the requirements of Rule 12-15 Guidelines from BAAQMD. Routine bump tests and calibration checks with NIST-traceable reference gases ensure that concentrations reported by open-path analyzers are comparable to other available measurements.

Completeness is a measure of the amount of usable data obtained by the monitoring project compared to the potential amount expected to be obtained. The goal of the monitoring project is to maximize system uptime through robust analyzer maintenance, routine data review and short response times for addressing system issues. Quantitative metrics for calculating completeness are detailed further within this section, consistent with BAAQMD guidance.

Measurement Quality Objectives

Measurement quality objectives (MQOs) are individual performance or acceptance goals that directly translate each DQI into discrete analytical performance criteria. The MQOs for this fenceline monitoring project are detailed below.

Accuracy and Precision

Accuracy and precision are assessed for the Ultraviolet-Differential Optical Absorption Spectroscopy (UV-DOAS) open-path systems through routine bump tests with NIST-traceable reference gases. The acceptance criteria shown in **Table 3** are used for periodic testing (i.e., monthly, quarterly, annually), as well as for continuous, AutoQC of real-time data. Test gases were identified based on which compounds are required for monitoring by Rule 12-15, and concentrations were selected to be representative of potential detection events and near or below health thresholds of concern. Regarding accuracy and precision of open-path bump tests, warning levels are defined as 5% less than the acceptance criteria and are further discussed in the individual instrument SOPs (Attachments 1-3). Bump tests and calibration checks on the Tunable Diode Laser Absorption Spectroscopy (TDLAS) open-path system are performed for information purposes only.

An appropriate manufacturer-specific calibration kit is used to assess accuracy of the visibility sensor and generally consists of a blocking plate (sensor zero) and scatter plate (span). The calibration fixture is assigned a factory-traceable extinction coefficient, which is compared to the value reported by the sensor.

Additional details regarding instrument calibration and frequency are shown in Section B.7, and step-by-step procedures are provided in the relevant instrument SOPs (Attachments 1–3).

Table 3. Acceptance criteria for instrumentation and equipment.

QA/QC Checks	Frequency	Gas/Concentration	Acceptance Criteria
UV-DOAS			
Bump test (accuracy and precision)	Monthly (and after major service)	Benzene 1–20 ppb	±20%
Spectral match (r^2)	Continuous	--	0.8–1.0
Integration time	Continuous	--	≤250 ms
Signal intensity	Continuous	--	≥70% (if integration time >250 ms)
TDLAS			
Bump test (informational purposes)	Monthly (and after major service)	Not applicable – temporary informational monitoring	
3-point calibration (informational purposes)	Quarterly	Not applicable – temporary informational monitoring	
H_2S spectral match (r)	Continuous	--	0.72–1.0
Signal power	Continuous	--	≥0.1 mW (corresponds to <1% transmission)
H_2O spectral match (r)	Continuous	--	0.95–1.0
CO_2 spectral match (r) (in the presence of dry air masses)	Continuous	--	0.95–1.0
Visibility Sensor			
Extinction coefficient (accuracy)	Annually	--	±25%

Completeness

Data completeness is assessed after reviewing the data flags assigned for each 5-min average data point (see Section B.5). BAAQMD guidance for open-path measurement data recovery is that instrumentation must meet a minimum of 75% completeness on an hourly basis, 90% of the time based on annual quarters. Completeness is therefore calculated as follows:

$$Quarterly\ \%\ Completeness = \left(\frac{Count\ of\ hours\ in\ the\ calendar\ quarter\ where\ hourly\ completeness > 75\%}{Count\ of\ all\ hours\ in\ the\ calendar\ quarter}\right) x\ 100$$

Additional data completeness definitions are included below.

- **Possible**. Maximum number of 5-min average concentrations that can be measured in a given hour and logged in the data management system (DMS)
- **Captured.** Actual number of 5-min average concentrations that were measured in a given hour and logged in the DMS
- **Missing.** Number of 5-min average concentrations not measured or logged in the DMS in a given hour

  Missing = Possible – Captured

- **% Missing.** Percentage of missing 5-min average concentrations in a given hour relative to the possible number 5-min average concentrations

  % Missing = (Missing / Possible) x 100

- **Invalid Total.** Number of invalid 5-min average concentrations measured and logged in the DMS in a given hour
- **% Invalid Total**. Percentage of invalid 5-min average concentrations in a given hour relative to the possible number of 5-min average concentrations

  % Invalid Total = (Invalid Total / Possible) x 100

- **Invalid Environmental.** Number of invalid 5-min average concentrations in a given hour due to adverse atmospheric or environmental conditions
- **Invalid Other.** Number of invalid 5-min average concentrations in a given hour due to anything other than adverse atmospheric or environmental conditions
- **% Invalid Other.** Percentage of invalid 5-min average concentrations in a given hour due to anything other than adverse atmospheric or environmental conditions relative to the possible number of 5-min average concentrations

  % Invalid Other = (Invalid Other / Possible) x 100

- **Expected.** Number of possible 5-min average concentrations in a given hour, adjusted for periods of low visibility during adverse atmospheric or environmental conditions

  Expected = Possible – Invalid Environmental

- **Valid.** Number of valid 5-min average concentrations in a given hour
- **% Valid.** Percentage of valid 5-min average concentrations in a given hour relative to the possible number of 5-min average concentrations

  % Valid = (Valid / Possible) x 100

- **% Hourly Completeness.** Percentage of valid 5-min average concentrations in a given hour relative to the expected number of 5-min average concentrations

  % Hourly Completeness = (Valid / Expected) x 100

A.8 Special Training and Certifications

All project personnel are provided with necessary training and oversight, including:

1. Safety courses administered through the Occupational Safety Councils of America (OSCA)
2. Instrument-specific training from vendors
3. Data validation training from experienced Data Analysts
4. Routine operations and maintenance training from experienced Field Technicians

Training is conducted by senior staff with at least 1 year of experience operating refinery fenceline monitoring systems, and analyzer manufacturers. Project personnel are provided with copies of the QAPP and SOPs, and receive updated versions when available. Initial training is provided prior to personnel performing work on the system, and refresher trainings are conducted on an annual basis. The QA Manager will identify specific training requirements for all project personnel and will determine when trainees are qualified to work independently. Training records will be maintained by the Field Staff Manager. Additional details regarding training and certification are provided in the individual SOPs included as attachments.

A.9 Documents and Records

Quality System documentation, including the AMP, QAPP, and SOPs, are frequently revised to reflect current best practices, improvements to available technology and data control practices, and fenceline monitoring program changes. Revisions (and new SOPs) are undertaken at the direction of the QA Manager. In addition to Quality System documentation, quarterly reports are produced that provide a summary of system performance over each calendar quarter, which may include data summaries, statistical analyses, and results of QC tests. These reports are generated by relevant project staff, overseen by the QA Manager, and delivered to BAAQMD along with quarterly data deliveries.

The fenceline contractor (Sonoma Technology) achieves work product quality through a series of internal review-and-correction cycles and an external review by the client. Documents undergo at least two internal reviews—the first by a senior technical staff member who is knowledgeable about the subject matter but is not the primary author of the work, and the second by a technical editor who is skilled in English mechanics and writing style. Before any document (draft or final) is delivered to the refinery, the lead author or Project Manager conducts a final quality review and approves it for delivery. Final approved versions in PDF format are distributed to the refinery and/or appropriate project personnel via email. The refinery reviews the report for accuracy and any changes are jointly discussed between the refinery and the fenceline contractor prior to finalization and submission.

Sonoma Technology employs a robust, systematic approach to version tracking and file maintenance. Each document is stored by project number on a shared fileserver. Only the most recent version is stored in the top-level folder, and each draft version is tracked by a timestamp as well as all reviewers' initials in a subfolder. A unique Master File Number is assigned to each document and all versions of that document retain that number.

Sonoma Technology's proprietary Deliverables Organizer and Tracking System (DOTS) is used to track progress and facilitate management of all quality documentation and work products. The web-based system retains information on document versions, including the dates and names of employees who edited, reviewed, and revised each document. DOTS also contains standard reports for tracking deliverables through the QA/QC and delivery process and ensures that document information can be easily retrieved. A lead author or Project Manager creates a DOTS entry for each upcoming deliverable and a technical editor maintains the DOTS record as each deliverable progresses through the update, review, delivery, and disposition process. Microsoft Word and PDF versions of all final approved documents are preserved on Sonoma Technology's fileserver in a secured Master File Library.

All staff involved in fenceline monitoring have been provided with electronic copies of the SOPs. Revised versions of the QAPP and SOPs will be distributed to both refinery and contractor staff via email and will be stored on a shared drive. Additionally, hard copies of the SOPs and analyzer user manuals are kept in the analyzer shelters and replaced when revisions are completed. By updating digital and hard copies of the QAPP, SOPs, and other QC documents, we ensure that staff only use the most recent versions to meet measurement and DQOs.

The analyzer shelters also contain logbooks where all onsite activities related to the fenceline monitoring system are recorded. This includes planned maintenance activities and emergency site visits. The field logbooks are scanned monthly to generate electronic copies.

Any corrections that are made to hard-copy documents will be indicated by (1) a cross out of the previous entry, (2) the addition of a new entry, (3) the date of correction, and (4) the initials or name of the individual making the correction. Electronic documents (reports and data) are stored on a password-protected server at Sonoma Technology, with current and previous versions stored by project and document.

The document retention policy for the fenceline monitoring network is shown below in **Table 4**.

Table 4. Document management procedures for the Valero Benicia refinery fenceline monitoring project.

Document	Retention Policy
AMP	Fenceline Project Manager to retain all versions for project duration
QAPP	Fenceline Project Manager to retain all versions for project duration
Maintenance Forms	QA Manager to retain all documents for 5 years
Audit Forms	QA Manager to retain all documents for 5 years
Corrective Action Report	QA Manager to retain all documents for 5 years
Calibration Standard Certifications	QA Manager to retain all documents for 5 years
Daily Data Check Logs	QA Manager to retain all documents for 5 years
Logbooks	Field Staff Manager to retain all versions for 5 years at Valero (or electronically)
Training Documents	QA Manager to retain all documents for 5 years

B. Data Generation and Acquisition

B.1 Sampling Process Design

Open-path analyzers were selected after consideration of all Rule 12-15 requirements and BAAQMD guidelines, including (1) spatial coverage necessary to monitor hundreds of meters of refinery fencelines, (2) 5-min resolution for real-time data, and (3) required detection limits, accuracy, and precision of target compounds. Additional details about open-path analyzers are provided in Section B.2.

Heavy fog, rain, or smoke may block the signal from an open-path instrument and prevent data collection, but even light fog can partially absorb the signal and interfere with measurements. Tule fog forms when there is high relative humidity (typically after rain), light wind, and rapid cooling. This fog is characteristic of the California Central Valley and extends into the marshlands along the Sacramento River, San Joaquin River, Carquinez Strait, and into the San Francisco Bay, especially during the winter season from late fall through early spring. Tule fog is most likely to occur during northeasterly wind events. Visibility sensors are installed at two locations – one at a low elevation and one at a higher elevation – to confirm when low-visibility conditions result in invalid data from open-path instruments.

Three sampling paths, composed of six segments in total, are shown in **Figure 2**.

Figure 2. Siting of the monitoring network at the Valero refinery in Benicia, CA.

Paths 1 and 2 cover the southwest fenceline to assess potential transport toward the city of Benicia. This transport direction is infrequent and only occurs approximately 7% of the time over the course of the year, usually in the winter when winds occasionally blow towards the southwest (referred to as northeasterly winds). Due to terrain effects and the orientation of the Carquinez Strait, the northeasterly wind direction is well defined and has little directional variability. Therefore, the affected areas downwind under these wind conditions are very narrow. Analyzer shelters for Paths 1 and 2 each have 2 UV-DOAS and 2 TDLAS instruments, which point roughly 180° from each other and are installed approximately 7 ft above ground level (AGL).

Path 3 covers the eastern fenceline to assess potential transport toward the business/commercial area located east of the refinery. This transport direction is common in spring, summer, and early fall, when winds often blow towards the east (known as westerly winds). Analyzer shelters at Site 3′ and 3′′ each have 1 UV-DOAS and 1 TDLAS analyzer, which are installed approximately 15 ft AGL so that vehicle traffic does not block the sampling path and prohibit data collection.

Visibility sensors are installed at Sites 1 and 3′ to collect measurements at different elevations and capture the spatial variability in environmental conditions at the refinery.

B.2 Sampling Methods

BTEX and SO_2 are measured by monostatic UV-DOAS instruments with a xenon light source. The xenon light source is required to achieve sufficient detection limits for target compounds over the approximately 500-m (one-way) sampling paths. Each target UV-absorbing compound has a unique absorbance spectrum, meaning they absorb different amounts of light at discrete wavelengths. This is measured by the analyzer, which then compares regions of a sample absorbance spectra to the same regions of a reference absorbance spectra.

A classic least squares regression analysis provides a spectral match parameter (r^2) which is used to identify potential interferents present in the sample path. The primary means of avoiding absorbance due to interfering gases is to select regions of the absorbance spectrum that are specific to the target compounds and free of absorbance due to other gases. Spectral subtraction is used in cases with overlapping absorbance features, and the subtraction technique is proprietary to the instrument manufacturer. Spectral matching is used to identify the target compounds, and Beer's Law is used to report the concentration. This approach is comparable to U.S. EPA's TO-16 Methodology,[3] though TO-16 was not written specifically for UV-DOAS.

H_2S will temporarily be measured by monostatic TDLAS for informational purposes only. A tunable diode laser emits light at a very small range of wavelengths, which allows spectral measurement of an H_2S absorption peak. The Unisearch TDLAS operates in a wavelength range that also contains an absorbance feature for water vapor and carbon dioxide (CO_2), both of which are present in Earth's atmosphere, so the spectral match of those gases can be used as additional performance metrics. If the water vapor spectral match drops below a threshold value, the CO_2 spectral match is examined. If the CO_2 spectral match also drops below a threshold value, data are flagged as invalid. The signal strength of the light transmitted through the atmosphere is recorded using a photodiode detector and recorded in the data file. Together with an independent visibility measurement, the signal strength can be used to evaluate the impact of atmospheric conditions or misalignment on data quality.

Table 5 summarizes the estimated minimum detection limits (MDLs) and upper detection limits (UDLs), which are the lowest and highest concentrations of each species that can be measured by each instrument and sampling path, as reported by instrument manufacturers. Values are presented as the average concentration along the sampling path. The MDL may be higher than those listed in Table 5 if there is poor atmospheric visibility (e.g., fog, rain, smoke, or dust), misalignment of the light source with the retroreflectors, hardware problems, or interfering gases. MDLs at the lower end of the specified range are expected under the opposite conditions.

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[3] U.S. Environmental Protection Agency (1999) Compendium of methods for the determination of toxic organic compounds in ambient air: compendium method TO-16. Second edition, prepared by the U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati, OH, EPA/625/R-96/010b, January. Available at https://www3.epa.gov/ttnamti1/files/ambient/airtox/tocomp99.pdf.

Additional information regarding instrument operations and maintenance, emergency site visits, and corrective actions are detailed in Section B.6.

Table 5. Open-path instruments and approximate detection limits by pollutant and path. Actual detection limits will differ and depend on ambient conditions. H_2S MDLs will be evaluated in real-time and used for informational purposes only.

Path		1-1'		1-1"		2-2''		2-2'		3-3'		3-3"	
Distance (one-way; meters)		326		481		609		567		578		549	
Technology	Compound	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)	MDL (ppb)	UDL (ppb)
UV-DOAS (Xenon)	Benzene	0.4	23,900	0.3	14,700	0.2	12,800	0.2	13,400	0.2	13,400	0.3	14,600
	Toluene	1.3	13,600	0.8	8,300	0.7	7,300	0.7	7,600	0.7	7,600	0.8	8,300
	Ethylbenzene	0.5	2,900	0.3	1,800	0.3	1,600	0.3	1,600	0.3	1,600	0.3	1,800
	Xylenes	5.9	7,300	3.6	4,500	3.2	3,900	3.3	4,100	3.3	4,100	3.6	4,400
	SO_2	1.1	6,800	0.7	4,200	0.6	3,600	0.6	3,800	0.6	3,800	0.9	4,100
TDLAS[a]	H_2S	N/A[(a)]	12,000	N/A[(a)]	7,200	N/A[(a)]	6,300	N/A[(a)]	6,500	N/A[(a)]	6,500	N/A[(a)]	7,100

[a] H_2S will temporarily be measured using an open-path TDLAS system for informational purposes only.

B.3 Sample Handling and Custody

Analyzers are located in secured sites to prohibit tampering or handling by anyone other than authorized personnel. Technicians keep sampling shelters clean and routinely check analyzers for any debris or residue during site visits.

Real-time data are transmitted to the DMS by cellular modem and can only be accessed by authorized personnel. All changes to data within the DMS are tracked through chain-of-custody logs.

As discussed in the AMP, benzene is measured at select sites utilizing an absorbent tube deployed inside a sampling shelter. Sampling and analysis are performed following EPA 325 B methodology. Sample tubes are conditioned and blank checked at the laboratory, and subsequently sent to the fenceline contractor. The fenceline contractor assigns each tube to a sample site by serial number and records this information in an electronic chain-of-custody log in the lab. Tubes are deployed and retrieved every 14 days using separate “retrieval” and “deployment” carriers, and chain-of-custody logs are updated at each deployment and retrieval.

B.4 Analytical Methods

Refer to Section B.2 for information regarding real-time sampling methods.

Sampling and analysis for the benzene sorbent tubes are performed following EPA 325 B methodology. Sorbent tube samples received in the laboratory for analysis are thermally desorbed and analyzed by gas chromatography/mass spectrometry (GC/MS) for trace-level benzene. Critical steps included in the process of thermal desorption are described below:

- Leak testing under stop flow
- Recording ambient conditions
- Internal standard addition
- Tube purging
- Thermal desorption of the sample tube
- Refocusing on a cold trap
- Secondary desorption of the cold trap with transfer/injection of the sample to the capillary GC column for analysis of the analytes of interest

B.5 Quality Control Requirements

Real-time data from open-path analyzers undergo several rounds of QC, including AutoQC logic, which flags data before they are posted on the public website. Additional details on analysis and QC of real-time and final data are described in Section D.2. No laboratory analyses are required for this monitoring project.

Field blanks for the benzene sorbent tubes are deployed in the same manner as samples, except that the long-term storage caps remain on both ends of the tube and are placed in the sample shelter alongside the field sample. One field blank is required per sampling event. Two co-located duplicates are collected for every sampling event following the normal deployment procedure.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Routine Maintenance

The UV-DOAS and TDLAS open-path analyzers are designed to require only modest service and maintenance. Tables 6 and 7 summarize the routine maintenance activities as recommended by instrument manufacturers, and additional details are provided in the instrument SOPs (see Attachments 1–3). Preventive maintenance frequency depends on the operating environment and may need to be adjusted depending on field conditions.

Table 6. Schedule of routine maintenance activities for UV-DOAS open-path analyzers.

Activity	Monthly	Quarterly	Annually
Visually inspect the system	✓		
Inspect detector and retroreflector optics; clean if necessary	✓		
Inspect and clean system filters	✓		
Inspect all electrical cables for wear; replace as needed	✓		
Confirm the alignment of the light source/detector and retroreflector	✓		
Ensure that there are no obstructions between the light source/detector and retroreflector (e.g., refinery equipment, vegetation, or vehicles)	✓		
Document signal levels to establish a baseline for light source replacement frequency	✓		
Archive historical data and remove from analyzer computer	✓		
Perform bump test	✓		
Replace light source if diagnostics are outside the acceptable range		✓	
Replace ventilation exit and intake filters		✓	
Clean detector and retroreflector optics		✓	
Confirm the alignment of the light source/detector and retroreflector		✓	
Verify system settings			✓

Table 7. Schedule of routine maintenance activities for TDLAS open-path analyzers.

Activity	Monthly	Quarterly	Annually
Visually inspect the system	✓		
Inspect detector and retroreflector optics; clean if necessary	✓		
Inspect all electrical cables for wear; replace as needed	✓		
Confirm the alignment of the light source/detector and retroreflector	✓		
Ensure that there are no obstructions between the light source/detector and retroreflector (e.g. refinery equipment, vegetation, or vehicles)	✓		

Activity	Monthly	Quarterly	Annually
Archive historical data and remove from analyzer computer	✓		
Perform bump test	✓		
Document signal levels*		✓	
Perform 3-point calibration check		✓	
Verify system settings as described in the SOP			✓

* Although signal strength is recorded in real time, long-term trends are necessary to evaluate the status of optical components, effects of cleaning optical components, and noise characteristics of the spectral data.

Routine monthly maintenance of the visibility sensors includes inspecting for dirt, spiderwebs, birds' nests, and other obstructions (Table 8). Obstructions are removed and the glass windows are cleaned if the sensor is dirty. There are no serviceable components in the sensor. Calibration is performed annually per the manufacturer's recommendation.

Table 8. Schedule of routine maintenance activities for visibility sensors.

Activity	Monthly	Annually
Visually inspect the system, including all cables	✓	
Inspect detector optics; clean if necessary	✓	
Perform calibration (extinction coefficient)		✓

Emergency Maintenance and Corrective Actions

Emergency maintenance occurs when problems are identified with the fenceline monitoring network. Two teams of after-hours (on-call) support personnel remotely monitor the status of the instrumentation and the data pipeline (acquisition, DMS, public website) 24 hours a day, 7 days a week. Automated alerts are sent if potential issues are identified, such as:

1. Missing data
2. Reported concentrations are outside of an expected range
3. Instrument diagnostics indicate a potential malfunction

The Sonoma Technology field operations team (Field Ops) is led by the Field Staff Manager, and the data pipeline team, or information systems team (IS Ops), is led by the Data Systems Manager. The nature of the potential issue determines which team receives the automated alert. On-call personnel are required to acknowledge alerts within 30 minutes of receipt and attempt to resolve potential issues remotely. This approach ensures that issues are identified and addressed in a timely manner, which maximizes the uptime of the fenceline monitoring network.

The Field Ops team addresses most issues pertaining to instrumentation and equipment. In the case of missing data, the refinery is notified if the cause of the alert cannot be resolved remotely, a maintenance message is posted on the public website at the direction of the refinery, and BAAQMD is notified of monitoring downtime with a duration over 24 hours according to Regulation 1-530.[4] Spare instrumentation or equipment may be installed if an extended outage is anticipated. In the case of elevated concentrations, data are reviewed and the refinery is notified whether the detection is legitimate or due to a potential instrument malfunction. Data flags are updated on the public website during daily data checks to ensure accuracy, including for potential after-hours events. Any required field site visits occur on the next business day, and all corrective actions performed are documented in on-site logbooks.

The IS Ops team addresses most issues pertaining to data flow and the public website. Table 9 outlines examples of automated screening, which the IS Ops team may review to troubleshoot potential issues.

Table 9. Examples of automated screening pertaining to the data pipeline and public website.

Target	Test	Frequency	Threshold
Website Availability	HTTP test of the public and internal websites	300 sec	Pass/Fail
DMS	CPU utilization	300 sec	>60%
	Memory use		>75%
	Disk space used		>75%
Data Flow	Time since last datum received	30 min	Pass/Fail
Data Processing Errors	Process scheduler	300 sec	Pass/Fail

B.7 Instrument Calibration and Frequency

As discussed in Section A.7, DQIs for open-path analyzers are assessed through completion of bump tests and calibrations. These are part of the routine operations and maintenance of the system, which are further detailed in Section B.6 and in the instrument SOPs (Attachments 1–3).

Bump and span testing verify open-path analyzer detection capability, accuracy, and precision. Concentrations are selected such that they are well above the level of quantitation, but near or below levels of concern for target compounds. Accordingly, path-average concentrations for benzene are typically on the order of 10 ppb. Bump tests are performed when the atmospheric influence on sample variability is assumed to be minimal, so tests are not conducted in rain, fog, or when ambient concentrations of target compounds or interfering gases (e.g., ozone) are changing rapidly.

[4] Area Monitoring Downtime (BAAQMD Rule 1-530), available at http://www.baaqmd.gov/~/media/dotgov/files/rules/reg-1-general-provisions--definitions/documents/rg0100.pdf?la=en.

Temperature control is accomplished by systems within the instrument enclosure itself, so instrument shelters are ventilated but not temperature-controlled. Retroreflector housings include a heater/fan system designed to mitigate the effects of condensation and particulates on the retroreflector surface.

Bump tests are performed by introducing NIST-traceable reference gases into the open sampling path using a test cell. During the test, light from the analyzer source passes through the test cell and entire atmospheric path length to the retroreflector, which reflects it back through the sampling path, test cell, and detector. Because the light travels through the ambient atmosphere, which includes other gases and particles as it would during a normal measurement, this test is a representative assessment of the instrument's capabilities under the influence of environmental conditions. During bump tests, a number (N) of replicated, raw time resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) are measured. An acceptable number of trials is defined as 7≤N≤15, and a subset of test data which meet the acceptance criteria (Section A.7) are used for subsequent calculations. The average value of these measurements is calculated as:

$$\bar{x} = \frac{\sum_i x_i}{N}$$

The standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}.$$

From these definitions, accuracy (as % error) is defined as:

$$\%\ error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\%$$

Precision (as the % coefficient of variation, CV) is defined as:

$$Precision \equiv \%\ CV = \frac{\sigma}{\bar{x}} \times 100\%$$

B.8 Inspection/Acceptance of Supplies and Consumables

The Field Staff Manager is responsible for inspecting and accepting all supplies and consumables for the monitoring project. A certification of reference gases used for routine bump tests will be requested from the gas supplier, and standards will not be used past their expiration date.

B.9 Non-Direct Measurements

Part of the data validation methods detailed in Section D.2 includes comparison of fenceline monitoring data to remote background and average urban concentrations, with the goal of determining overall data reasonableness. This comparison includes a combination of qualitative and quantitative assessments of general spatial or temporal trends in target compound concentrations, such that measurements from this monitoring program may be compared against other external data sources. Though no direct quantitative data product is generated from this comparison effort, comparisons to external data sources generally increase the confidence in data products and, by extension, the overall value of the monitoring project.

External sources of data used for comparison may include the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), BAAQMD, and the U.S. EPA. Common target compounds may include smoke or ozone, depending on available data sets. Data used for comparison will include quality controlled final data where available, though preliminary data may be considered for qualitative assessments.

Importantly, because these data sets are external and were not collected, verified, or validated by this project's personnel, they will not serve as an independent benchmark for data validation or invalidation. They will only be used as secondary references to gauge overall reasonableness of data once all QC has been completed. Additional information regarding data verification and validation methods is provided in Section D.2 and the SOP in Attachment 4.

B.10 Data Management

Raw data collected at each monitoring site are stored on the analyzer computer and only reviewed if data validation efforts identify potential issues that require additional investigation. A Data Acquisition System (DAS), or data logger, performs basic QC, averages to 5-min resolution, and aggregates data into a desired file format. This data containing 5-min concentration data, diagnostic parameters, and quality control and operational (QC/OP) codes assigned by the DAS are then transmitted from each sampling site to a cloud-based file storage service via cellular modems, where they are stored and available for retrieval as needed. Data from the cloud are ingested into Sonoma Technology's Insight© DMS where a robust AutoQC logic assigns data flags in real time based on instrument diagnostics and local meteorological measurements. Subsequent, automated DMS-level screening checks are performed according to Section D.2. From this point forward, data are persisted within the DMS and any changes to data are recorded via chain-of-custody logs.

These preliminary data are displayed on the public website within 10–15 minutes of collection. Data are reviewed daily by air quality data analysts to assess system operations, confirm the automated data flagging is correct, and ensure any corrections to data flagging are propagated to the public website immediately. Extended analyses are performed every calendar quarter and reviewed by the project QA Manager. **Figure 3** illustrates the general data flow and QC schematic. Additional details regarding data verification and validation are provided in Section D.2 and the SOP in Attachment 4.

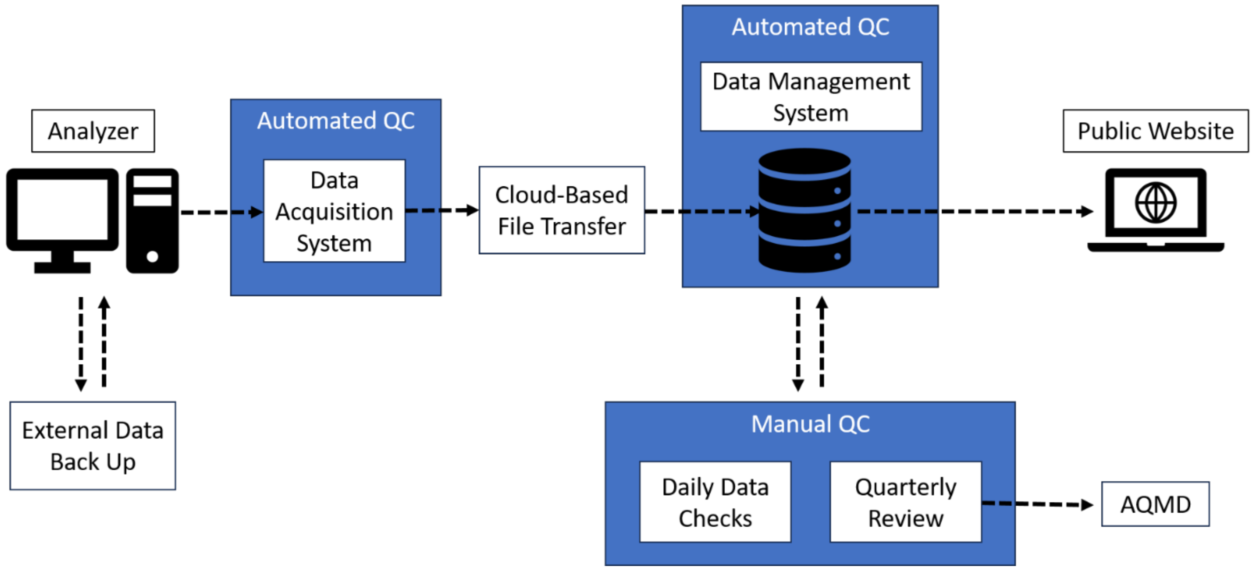

Figure 3. Data flow and QC schematic.

As described in Section B.6, data archival and management on the analyzer computers is part of routine operations and maintenance. Data are copied to external hard drives either manually or via an automated copy script and deleted from analyzer computers after confirmation that copy efforts were successful. Old files are deleted from the analyzer computer to allow continued data collection.

All ingested data are retained in the DMS. During quarterly analysis, data are downloaded from the database, analyzed, validated, and then backfilled into the DMS as final data sets. Redundancy of DMS data is maintained on a cloud-based system and will be stored for 5 years after sampling.

In addition to the AutoQC and DMS-level screening checks, individual absorbance spectra from open-path measurements are available for additional review when automated processes identify either an anomaly or a detection event. This manual validation process relies on analytic software packages provided by the instrument manufacturers. Reference libraries and runtime settings are copied from analyzers in the field onto the auxiliary system where analysis is performed. This process is typically performed when detection events are observed, and doing so ensures accuracy of spectral information, and allows qualified Data Analysts to view individual absorbance spectra and associated fits. The ability to retain absorbance spectra and independently validate spectral matches and reported concentrations is a key part of the data validation process for open-path analyzers. Raw spectral data is manually backed up to external hard drives and retained for 5 years and will be made available to BAAQMD upon request.

C. Assessment and Oversight

C.1 Assessments and Response Actions

On an annual basis, the refinery will work with the fenceline monitoring contractor to assess the performance of the network through:

1. Review of data completeness by monitoring path, instrument, and compound
2. Comparison of bump test results via control charting
3. Analysis of reported concentrations in the context of refinery operations
4. Analysis of reported concentrations with respect to meteorological conditions
5. Review of QC/OP codes that led to invalid data, including potential repeating combinations
6. Determination of whether any measures could be taken to reduce future occurrences of repeating invalid QC/OP code combinations, and implementation of those measures as necessary and appropriate
7. Verification that data are realistically achievable and not beyond the limits of what can be measured by the instrument

Using analyses similar to those used to support the network design, the contractor will further evaluate the overall performance of the network to ensure it is meeting project objectives. The contractor will also prepare an internal technical memorandum summarizing findings for the refinery, which will be submitted to BAAQMD along with the next quarterly report submission following completion of the memorandum. Following the assessment of the monitoring network, any necessary changes will be reflected as an update to the AMP, QAPP, or SOPs, which will be submitted to BAAQMD for approval prior to implementing any changes.

C.2 Reports to Management

Public Website

Posting data to a public website constitutes the most immediate and frequent reporting effort. Preliminary data collected by the fenceline monitoring network are displayed on a public website (usually within 10–15 minutes of acquisition) with time series plots and map marker visualizations of 5-min and rolling hourly concentration values. Data are quality controlled in real time with AutoQC logic, and the resulting data flags (QC/OP codes) assigned to each data point determine how they appear on the website. Additional information regarding website data display on the public website is provided in Section D.2.

The website is operated and maintained by the refinery's fenceline monitoring contractor, and the general public is the intended user of the preliminary data. Accordingly, the public website contains supplemental information written at a public-friendly level about the monitoring network, target compounds, how to interpret data visualizations, and frequently asked questions (FAQs).

Quarterly Data Delivery to BAAQMD

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. Outside of the normal quarterly delivery, data will be made available to BAAQMD within 30 days of a request. Consistent with BAAQMD guidance, quarterly data deliveries will include:

- Data for all instrument and parameter combinations in the comma separated value (.csv). Data will contain:
    - The name of the facility where the equipment is located
    - A unique identification number assigned to each instrument or system
    - A short descriptive name for the instrument associated with the reported unique ID (e.g., TDLAS, UV-DOAS)
    - The name of the compound being measured
    - The date of measurement, formatted as "yyyy-mm-dd"
    - The hour of the day and the beginning of the 5-min period over which measurements were collected and averaged, reported in Pacific Standard Time (PST) and formatted as "hh:mm" using 24-hr notation
    - The mean 5-min concentration, reported as numeric values for detection events above and below the LOQ
    - The unit of measure corresponding to the reported mean concentration
    - The averaging period duration (in minutes) for the reported mean concentration
    - The number of values that comprise the reported mean concentration
    - An indicator representing whether the reported mean concentration represents a legitimate air measurement ("Y") or one that has been affected ("N") by an instrument malfunction, adverse environmental conditions, maintenance events, etc.
    - Error codes explaining the reason for invalid or missing data, with multiple codes separated by a semicolon without spaces and the field left blank for valid data
    - The maximum concentration measured during the averaging period, reported in the same units of measure as the mean concentration
    - The required LOQ for the corresponding instrument, reported in the same units of measure as the mean concentration

  - The real-time LOQ for the averaging period, reported in the same units of measure as the mean concentration
  - The average measured light signal for the corresponding averaging period
  - The units of measure for the corresponding light signal
- A record for each 5-min period of the quarter for all instrument and parameter combinations. Records corresponding to missing data will include the facility name, instrument ID, instrument descriptor, parameter, date, time, and error codes with their respective values, and remaining fields will be populated with a value of "NA."
- An assessment of data completeness, as described in Section A.7.
- A summary of bump tests and calibration checks performed according to the QAPP, including the instrument or system, the type of test or check, the start and end date and time of the test or check, and the date and time that the instrument or system resumed normal operations. Potential failed bump tests or calibration checks will be included.
- The results of bump tests and calibration checks performed according to the QAPP, including accuracy and precision. Root cause analysis and a narrative description of maintenance or repairs performed to return the system to proper operations will be included for potential bump tests or calibration checks with accuracy and precision results that are not within the acceptance criteria.
- Data corrections accounting for the operational setup of bump tests and calibration checks, when they differ from ambient conditions.
- Meteorological data and a narrative explanation sufficient to justify where data have been excluded due to adverse atmospheric or environmental conditions.
- A summary of each instance of data invalidated for a reason other than failed acceptance criteria, including a brief statement of the cause.

D. Data Validation

D.1 Data Review, Verification, and Validation

Data verification is a process of comparing how the data were gathered to the procedures established by the project QAPP and SOPs. It is a data review technique that evaluates the conformance of data collection practices to established methods, procedures, or specifications. Data verification usually consists of checking that SOPs were followed and QC activities were performed.[5]

Data validation is a process of confirming that reported values meet the DQOs of the project. It is a data review technique that examines whether the particular requirements for a specific, intended use are fulfilled. Data validation examines whether acceptance criteria outlined in the QAPP were achieved.[6]

To produce defensible, quality environmental information for its intended use, Valero shall:

- Meet regulatory requirements
  - Monitor in accordance with the AMP
  - Achieve the acceptance criteria outlined in the QAPP
  - Follow the procedures outlined in the relevant SOPs
- Maintain scientific robustness
  - Use validated methods and accepted practices for scientific quality
  - Use standard materials traceable to an authoritative source (NIST or equivalent)
  - Verify that the electronic output signals from instrumentation are representative of atmospheric conditions and real concentrations (vs. instrument noise)
- Ensure defensibility
  - Document all data collection steps and retain associated raw data
  - Maintain data integrity and reliability through chain-of-custody logging
  - Ensure ethical practices in achieving all project objectives

D.2 Verification and Validation Methods

Data collected at each monitoring site receives five rounds of QC between the point of collection and final data set submission to the regulatory agency. A detailed process flow diagram of the data pipeline is provided in Section B.10, and additional details are provided in the Data Validation SOP (Attachment 4).

[5] EPA Quality Assurance Handbook Vol II.

Tiered Data Quality Control

Data proceed through a tiered order at each point of the data flow and QC schematic.

Level 0. Raw data collected on analyzer computers are referred to as Level 0 data. They do not receive any QC but are retained for future review as needed.

Level 0.5. These data have been logged by the DAS and received only the most basic, AutoQC. This stage of QC includes checking basic instrument diagnostic thresholds and whether a sufficient number of raw analyzer data points were collected to generate a 5-min average, which results in the data preliminarily being flagged as valid or invalid. Maintenance and calibration periods are commonly flagged at this stage, which do not receive additional QC because they are not representative of ambient monitoring data. Level 0.5 data are retained at least through the completion of quarterly analysis and generation of final data sets.

Level 1. Upon ingest to the DMS, AutoQC further assesses data quality and subsequent DMS-level screening checks are performed, resulting in revised QC/OP codes for each individual data point in real time. The QC codes categorize data as valid, suspect/questionable, or invalid, and the OP codes provide additional context relevant to the assigned data flag. Unique AutoQC logic trees are developed for each piece of instrumentation and equipment by air quality scientists with input from instrument manufacturers where needed. Level 1 data are displayed on the public website within 10–15 minutes of collection by the analyzer.

Level 2. Daily review by Data Analysts allows system operations assessment and ensures that automated data flagging is correct. Data Analysts may adjust the QC/OP codes to reflect recent operational issues and have the ability to adjust data values if an independent validation of the raw data requires this action. Any and all changes to QC/OP codes or data values are made according to processes outlined in the SOPs and QAPP, recorded by the DMS via the chain-of-custody logs, and immediately reflected on the public website.

Level 3. Extended analyses are performed by Data Analysts every calendar quarter to verify and validate data as described in Attachment 4. As with Level 1 data, any and all changes to QC codes, OP codes, or data values are recorded by the DMS via the chain-of-custody logs and are made according to processes outlined in the SOPs and QAPP.

Level 4. The final stage of QC is an independent review of data by the QA Analyst to confirm that analysis activities have been conducted according to the QAPP. Final data sets are prepared for submission to the regulatory agency and in support of quarterly reporting activities.

Data flags within the Insight DMS are composed of QC/OP codes, which are shown in **Table 10**.

Table 10. QC/OP codes assigned in the Sonoma Technology Insight DMS.

QC/OP Codes	
QC Codes	
0	Valid
5	Suspect/Questionable
7	Insufficient Data
8	Missing
9	Invalid
OP Codes	
0	Valid
5	Suspect
7	Insufficient Data
9	Invalid
17	Below MDL
28	Planned Instrument Maintenance
29	Unplanned Instrument Maintenance
70	Instrument Malfunction
72	Marginal Operating Conditions (Good Spectral Match)
73	Low-Visibility Conditions
74	Poor Spectral Match
76	Marginal Operating Conditions (Poor Spectral Match)
100	Manual Data Review
101	Range Check
102	Rate-of-Change Check
103	Sticking Check
108	Real-Time MDL Outside of Required Range

QC codes are defined as follows:

- **Valid (QC=0).** Data that meet all defined thresholds for acceptance are considered valid and flagged with this QC code.

- **Suspect/Questionable (QC=5).** Data which meet the defined thresholds for acceptance but indicate marginal operating conditions based on secondary review criteria are flagged with this QC code. For example, elevated integration time reported by the UV-DOAS analyzer that coincides with elevated signal strength may indicate that the data require additional review but are likely accurate. Other causes of suspect/questionable data include concentrations out of a specified range, concentrations exceeding a defined rate-of-change, or stuck data values.
- **Insufficient Data (QC=7).** If insufficient data to generate an hourly average are received by the DMS, rolling hourly data is flagged with this QC code.
- **Missing (QC=8).** The DMS does not contain records for missing data that were not received by the DAS, but null records are created manually during the quarterly reporting process and included in final data sets.
- **Invalid (QC=9).** Data that do not meet defined thresholds for acceptance are flagged with this QC code in the DMS. Causes of invalid data include low visibility conditions, maintenance and calibration, open-path analyzer misalignment, and instrument malfunction. Data are only invalidated if acceptance criteria are not met or if a clear cause is identified that warrants invalidation. If data are anomalous but no clear cause is identified, data are flagged as suspect/questionable.

OP codes are defined as follows:

- **Valid (OP=0).** Data that meet all defined thresholds for acceptance are considered valid and flagged with this OP code.
- **Suspect/Questionable (OP=5).** This OP code is used as a fallback condition for aggregated hourly data to indicate data which meet the defined thresholds for acceptance but indicate marginal operating conditions based on secondary review criteria.
- **Insufficient Data (OP=7).** If insufficient data to generate an hourly average are received by the DMS, rolling hourly data is flagged with this OP code.
- **Missing (OP=8).** The DMS does not contain records for missing data that were not received by the DAS, but null records are created manually during the quarterly reporting process and included in final data sets.
- **Invalid (OP=9).** This OP code is used as a fallback condition for aggregated hourly data to indicate data that do not meet defined thresholds for acceptance.
- **Below MDL (OP=17).** Data that meet the spectral match criteria but are associated with concentrations below the defined MDL are flagged with this OP code. Concentration values with this OP code are shown as reported and included in statistical analysis.
- **Planned Instrument Maintenance (OP=28).** Data that are not representative of ambient conditions because planned maintenance is being performed on the system are flagged with this OP code.

- **Unplanned Instrument Maintenance (OP=29).** Data that are not representative of ambient conditions because unplanned maintenance is being performed on the system are flagged with this OP code.
- **Instrument Malfunction (OP=70).** Invalid data that are not coincident with low-visibility conditions are flagged with this OP code.
- **Marginal Operating Conditions; Good Spectral Match (OP=72).** This OP code is assigned to data that meet the spectral match criteria but have been flagged with a QC code of 5. Concentration values with this OP code are shown as reported and included in statistical analysis.
- **Low-Visibility Conditions (OP=73).** Invalid data that are coincident with low-visibility conditions are flagged with this OP code.
- **Poor Spectral Match (OP=74).** This OP code is assigned to valid data that do not meet the spectral match criteria. These data are considered non-detections because the concentration of the target compound was so low that the analyzer did not determine it was present. In this scenario, the numerical output of the analyzer usually represents instrument noise but can occasionally range in magnitude depending on the result of the analytical fitting routine to the reference spectra. To reflect the status as a non-detection, data with poor spectral matches are adjusted to 0 ppb and subsequently shown on the public website.
- **Marginal Operating Conditions; Poor Spectral Match (OP=76).** This OP code is assigned to data flagged with a QC code of 5, that also do not meet the spectral match criteria. These data are considered non-detections because the concentration of the target compound was so low that the analyzer did not determine it was present. In this scenario, the numerical output of the analyzer usually represents instrument noise, but can occasionally range in magnitude depending on the result of the analytical fitting routine to the reference spectra. To reflect the status as a non-detection, data with poor spectral matches are adjusted to 0 ppb.
- **Manual Data Review (OP=100).** This OP code is used as a fallback condition to indicate data that have undergone additional manual review and are not readily categorized by the AutoQC logic. If this OP code is used, an accompanying explanation will be provided in the quarterly report explaining why.
- **Range Check (OP=101).** This OP code is assigned when data are flagged by the associated DMS-level screening check for additional review.
- **Rate-of-Change Check (OP=102).** This OP code is assigned when data are flagged by the associated DMS-level screening check for additional review.
- **Sticking Check (OP=103).** This OP code is assigned when data are flagged by the associated DMS-level screening check for additional review.
- **Real-Time MDL Outside of Required Range (OP=108).** TDLAS data with real-time MDL values outside of the required range are flagged with this OP code.

Automated DMS-Level Screening Checks

For open-path analyzers, the DAS determines if each raw data point should be included in the 5-min average based on whether real-time instrument diagnostics are above the defined thresholds shown in Table 2 (Section A.7), which include signal return and spectral fit metrics. For open-path analyzers with raw data resolutions on the order of 30 seconds (e.g., UV-DOAS), the DAS requires that six measurements with diagnostic parameters above the defined thresholds be collected for the 5-min average data point to be generated. TDLAS analyzers with raw data resolutions on the order of 8 seconds do not have a completeness requirement for the 5-min average data point to be generated, but 5-min periods with few raw acquisitions are reviewed during quarterly analysis as they may indicate disruptions to routine operations. Data are only invalidated if they do not meet defined acceptance criteria (Section A.7) or a clear and verifiable cause has been identified and documented. The number of data points used to calculate the 5-min average data point are reported in the final quarterly data sets.

In addition to the AutoQC logic conducted upon ingest to the DMS, **Table 11** summarizes DMS-level data screening checks, which help focus data review efforts on potentially anomalous data or where confirmation is otherwise needed that data values correctly reflect ambient conditions. These checks are based on expected instrument performance and expected concentrations of target compounds relative to ambient background. The DMS auto-screening checks include:

- **Range**: This check flags data outside of a specified range when 5-min concentration values are greater than the defined threshold. With the exception of negative outliers which are invalidated, this check does not alter the QC code and results in an OP code of 101.
- **Rate-of-Change**: Rapid changes between individual 5-min values are flagged for additional review as they may be anomalous. This check does not alter the QC code and results in an OP code of 102.
- **Sticking**: Stuck values are flagged for additional review as they may be indicative of an issue with the instrument and may not represent ambient data. Sticking checks are not applied to data that are below the instrument MDL (i.e., concentration values of 0). This check does not alter the QC code and results in an OP code of 103.

QC/OP codes are assigned through a combination of AutoQC and DMS-level screening checks, and result in Level 1 data.

Table 11. DMS-level screening checks for 5-min data.

Compound	Range (ppb)	Rate-of-Change (ppb)	Sticking
Benzene	24	12	Four or more stuck values
Toluene	100	50	
Ethylbenzene	100	50	
Total Xylene	100	50	
SO_2	37.5	19	
H_2S	30	30	

Daily Data Checks

Following AutoQC and DMS-level screening checks, Data Analysts review the Level 1 data from the fenceline monitoring network on an at least a daily basis to identify operational issues and maximize system uptime, typically with a one- to two-day running time series plot of select parameters on an internal field operations website. The Data Analyst assesses the current operational status of the monitoring network and whether concentration patterns are reasonable with respect to the time of day, season, current meteorological conditions, facility operations, and concentration levels measured at other sites. Data are also reviewed on the public website to confirm that data flow and visualizations are current, and to additionally identify any anomalous behavior. Findings are documented after each check and made available to the Project Management, Field Staff, Data Analysts performing quarterly analysis, and the QA Manager.

Examples of observations requiring additional review include low signal strength or high integration time; spikes or dips in diagnostic parameters or reported concentrations; stuck or missing data; negative concentrations; and concentrations that are outside of a specified range based on nearby measurements or known atmospheric chemistry. Data are only invalidated if they do not meet defined acceptance criteria (Section A.7) or a clear and verifiable cause has been identified and documented. This documentation is part of the daily data check logs and will be retained for a period of 5 years, in accordance with Section 502 of Rule 12-15. Common reasons for invalidation include instrument malfunction, power failure, and bump test data that were incorrectly flagged.

Data flagged as suspect or invalid by AutoQC and DMS-level screening checks may also be validated during daily data checks if appropriate, meaning that temporary data flags are typically resolved within one to two business days. Following the daily data check, data are considered Level 2.

Unusual Observations

If unusual data are observed during daily data checks, the Data Analyst investigates whether an instrument malfunction occurred or if the anomalous data are explainable and therefore correct. Any need for corrective action is communicated to the Project Manager and Field Staff for further coordination. Technical staff may remotely access analyzers in the field to perform basic troubleshooting, and site visits are conducted as required.

When elevated concentrations (i.e., concentrations greater than routine background observations) are reported by open-path analyzers, a visual review of individual absorption spectra is performed using data processing software provided by the instrument manufacturer. Additional information regarding spectral validation of open-path data is provided in the SOPs attached to this document (see Attachments 1–2). If this additional review proves data to be invalid, they are flagged accordingly and may be removed from the public display. The rationale for data invalidation is maintained in the chain-of-custody logs, and corrective action is overseen by the Field Staff Manager usually within one to two business days. If extended instrument downtime is necessary to address a data quality issue, BAAQMD personnel will be notified in accordance with Regulation 1-530.

On-Call Response

Similar review processes are completed outside of business hours by after-hours support staff in the event of missing data alerts or an exceedance of defined concentration thresholds. This helps to maximize system uptime and ensure the accuracy of data reported to the public website in real time.

Quarterly Review and Reporting

Data undergo an extended analysis every 90 days in alignment with quarterly reporting requirements, after which they are considered Level 3. Where possible, quarterly analysis is conducted by the same analysts that have been completing daily data checks to ensure consistency and familiarity with the monitoring network. Any and all changes to QC/OP codes or data values are recorded by the DMS via the chain-of-custody logs and are made according to processes outlined in the SOPs and QAPP.

Analysts verify that SOPs were followed, and QC activities were performed according to the QAPP. Examples of quarterly data verification may include:

- Review of daily data check documentation and routine instrument maintenance records to ensure consistency
- Confirmation that routine maintenance, calibrations, and bump and span tests were conducted according to schedule
- Review of instrument logbooks to assess whether data flagged as invalid or suspect/questionable are explainable based on recorded observations

- Review of site operator logbooks to assess whether observations by Field Technicians require additional examination of data
- Review of changes to data QC/OP codes or data values, and confirmation that they were appropriately recorded

Data Validation

Analysts validate data by exporting quarterly data sets from the DMS and analyzing them with a robust QC analysis code. Analysis code is maintained through an internal code repository, reviewed regularly, updated as requirements evolve, and shared with all analysts. The primary goal of quarterly data validation is to ensure reported values meet the DQOs of the project and the acceptance criteria outlined in the QAPP were achieved. Quarterly data validation typically includes:

- Generation of monthly and quarterly summaries of data statistics (including concentration minimums, maximums, averages, and standard deviations)
- Identification and review of statistical outliers; negative outliers are defined as concentration values below –3 * MDL, and positive outliers are usually identified with DMS-level screening checks (range)
- Inspection of measurements before and after unusual data, missing data, instrument bump tests, and maintenance activities
- Review of data flagged as suspect/questionable, and flag adjustment to valid or invalid status as appropriate
- Confirmation bump and span test results are within acceptance criteria detailed in the QAPP
- Comparison of data to remote background concentrations and average urban concentrations, including assessment of data consistency over longer time periods; as described in Section B.9, this comparison will not serve as an independent benchmark for data validation or invalidation and will only be used as secondary references to gauge overall reasonableness of data
- Verification that data are realistically achievable and not beyond the limits of what can be measured by the instrument
- Review of data completeness as detailed in Section A.7

Independent Review

An independent review of post-QC quarterly data sets ensures that data are reasonable, and analysis activities were conducted according to the QAPP. This independent review is conducted using similar methods to those described for quarterly analysis by the QA Analyst. Daily data check documentation and routine instrument maintenance records are also reviewed to ensure that the appropriate QC checks were applied. After this review, data are considered Level 4 (final).

Final data sets are prepared as a part of quarterly data review and reporting and are submitted to BAAQMD as discussed in Section C.2.

Public Website Display

Invalid Data (QC=9) are not representative of ambient conditions and are therefore omitted from the public website display. As noted above, causes of invalid data include low visibility conditions, maintenance and calibration, open-path analyzer misalignment, and instrument malfunction. On the time series plot and associated "tooltip" detail pane, no concentration value is shown and data are labeled "Invalid." The map marker behavior is similar, but provides an extended message with additional information, such as the identification of maintenance periods, instrument malfunctions, or low-visibility conditions. Concentration values and diagnostic information for invalid data are retained within the DMS and included in final data deliveries to the regulatory agency.

Missing Data (QC=8) are not displayed on the website. Tooltip detail panes on the time series and map markers indicate where data are missing for each 5-min record. Null record indicators are created for these periods as a part of quarterly analysis and are included in final data deliveries to the regulatory agency.

Insufficient Data (QC=7) only applies to the rolling hourly average concentrations, and the public website display behavior is the same as described for missing data.

Suspect/Questionable Data (QC=5) and **Valid Data (QC=0)** are displayed on the time series and map marker visualizations. Because suspect/questionable data do not coincide with failed acceptance criteria and merely indicate marginal operating conditions or the need for further manual review, concentration values are included in completeness calculations and statistical analyses. The suspect/questionable QC/OP code(s) may rarely remain following quarterly validation if they are unresolvable, but these data are considered valid despite unresolved questions. As such, they are also displayed on the public website.

Open-path data with a poor spectral match are considered **non-detections** because the concentration of the target compound is so low that the analyzer did not determine it was present. In this scenario, the numerical output of the analyzer usually represents instrument noise, but can occasionally range in magnitude depending on the result of the analytical fitting routine to the reference spectra. To reflect the status as a non-detection, data with poor spectral matches are adjusted to "0 ppb" and subsequently shown on the public website. Tooltip detail panes on the time series and map markers show "<MDL" or "BD" (below detection) for non-detections. Unadjusted concentration values for these non-detections are retained by the DMS.

Open-path data with a spectral match greater than the acceptance criteria (Table 2 in Section A.7) are considered **detections**, and the concentrations are displayed on the public website time series plots as recorded. If the recorded concentration is less than the defined instrument MDL, the tooltip detail panes on the time series and map markers show "<MDL" or "BD." If the recorded concentrations are

greater than the defined instrument MDL, the tooltip detail panes on the time series and map markers show the recorded concentration.

Concentration data are always reported on the public website as recorded, unless the spectral match criteria are not met, or the data are invalid or missing. A summary of public website display behavior according to QC/OP codes is shown in Table 12. Additional details regarding QC/OP codes are provided in Section D.2.

Table 12. Summary of public website display behavior according to QC/OP codes.

QC Code	OP Code	Concentration	Flag
0	74	0	Below Detection (BD or <MDL)
	17	As Recorded	Below Detection (BD or <MDL)
	0, 100, 101, 102, 108	As Recorded	Valid
5	76	0	Below Detection (BD or <MDL)
	17	As Recorded	Below Detection (BD or <MDL)
	0, 5, 72, 100, 101, 102, 103, 108	As Recorded	Suspect (Questionable)
7	7	None	Missing
8	8	None	Missing
9	28, 29, 70, 73	None	Invalid

D.3 Reconciliation with User Requirements

As discussed in Section C.2, the public website constitutes the primary, real-time reporting effort of preliminary data to the general public. Changes to data concentrations or data flags affect how data are displayed on the website, and are immediately propagated to the public website. In this manner, the refinery routinely provides the public with information regarding concentrations of target compounds at the fencelines of refining facilities, consistent with Rule 12-15 requirements.

Key components of the public website intended to meet user requirements of BAAQMD Rule 12-15 include visual display of data in real time, context for the public to better understand the concentrations displayed, and a mechanism for feedback. The website also includes a functionality to notify the public with custom messaging about instrument maintenance activities, potential issues with the monitoring network, or any other relevant information affecting the use of data.

E. Standard Operating Procedures

Instrument-specific SOPs for the systems listed below are provided as attachments to this document.

- **Attachment 1:** Standard Operating Procedures for UV-DOAS
- **Attachment 2:** Standard Operating Procedures for TDLAS
- **Attachment 3:** Standard Operating Procedures for Visibility Sensor
- **Attachment 4:** Standard Operating Procedure for Data Validation

Standard Operating Procedures for the CEREX UV Sentry UV-DOAS

October 31, 2024

STI-7024

APPROVED:

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Sonoma Technology date

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Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Application

This SOP covers the use of the CEREX UV Sentry UV-DOAS analyzer in a fenceline monitoring application. This document addresses routine maintenance activities including visual inspections, instrument checks, data management, bump testing, and data validation. The maintenance forms are provided in Section 9.

2. Introduction and Overview

The CEREX UV Sentry ultraviolet differential absorption spectrometer (UV-DOAS, shown in **Figure 1**) is an instrument that is used to detect BTEX, SO_2, NO_2, and a number of other gases in the ultraviolet (UV) region of the electromagnetic spectrum. The instrument consists of a Xenon light source and several optical elements, including a spectrometer. UV-DOAS instruments may be configured so that the spectrometer and source are in one location (monostatic) or at opposite ends of the path (bistatic). For a monostatic configuration, the light from the light source is collimated with the primary mirror and directed along a path length of about 500 m. At the other end of the path is an array of corner-cube reflectors called retroreflectors that direct the light directly back into the analyzer where the light is dispersed and measured using a spectrometer. The working range of the spectrometer is from about 200 to 400 nm. This document addresses the routine operations and maintenance procedures for the CEREX Monitoring Solutions UV Sentry units. The procedure is intended to guide the field technician in ensuring and verifying that the equipment is performing to expectations. As required, hard copies of this procedure and the associated test forms will be kept on site and a copy of the test form showing the results will be sent to the Refinery Project Manager upon completion of the test procedure.

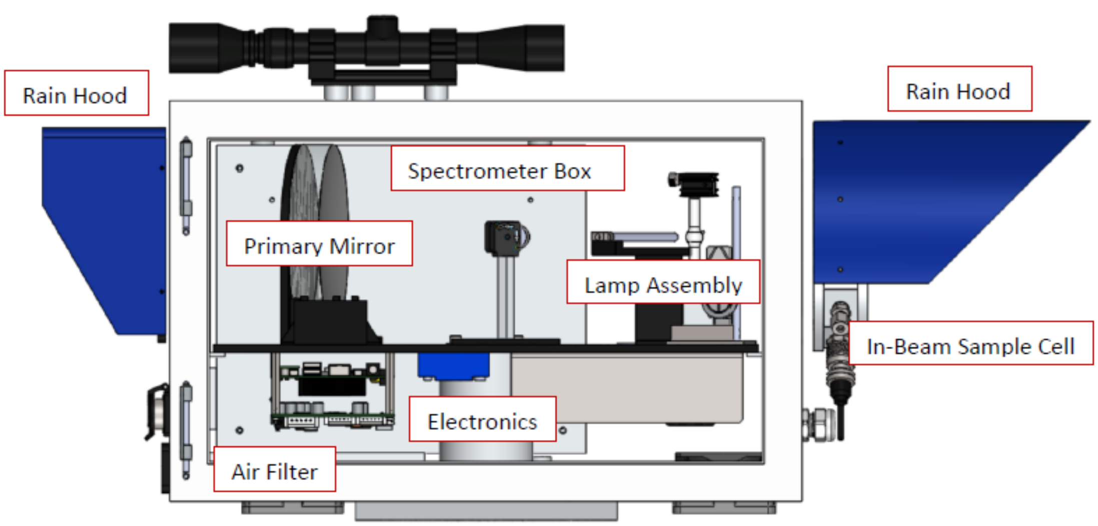


Figure 1. Schematic of the monostatic UV Sentry UV-DOAS analyzer.

The purpose of field maintenance is to ensure that the instrument is operated within specification and for field verification of the factory calibration of the UV Sentry. The QA Test process challenges the instrument using known concentrations of select BTEX reference gases and/or SO_2 to verify proper detection and quantification under field conditions.

3. Definitions

Table 1. Definitions of terms and acronyms used in this document.

Term/Acronym	Definition
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes (Xylenes are composed of ortho, meta and para isomers)
Bump Test	Test where gas of a known concentration is introduced to the analyzer to check for response accuracy and precision
CMS	Continuous Monitoring Software
Coefficent of Determination (R^2)	The square of the correlation coefficient. R^2 ranges from 0 (not correlated) to 1 (perfect correlation).
Correlation Coefficient (r)	A coefficient that measures the linear correlation between two sets of data. In the case of the UV-DOAS, it measures the correlation between the modeled and measured spectral data. It ranges from -1 (perfect anticorrelation) to 1 (perfect correlation).
Integration Time	The amount of time the spectrometer detector collects light for (typically 20 to 300 ms)
Intensity	A measure of how much light was collected
Percent Match	The coefficient of determination multiplied by 100. (R^2 x 100).
PPE	Personal Protective Equipment
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
SOP	Standard Operating Procedure
UV-DOAS	Ultraviolet Differential Absorption Spectroscopy

4. Safe Work, Hazard Identification, and Precautions

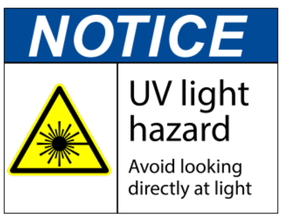
The following information is intended to provide guidance in ensuring a safe work environment.

Operator Qualifications

Installing, operating, and servicing CEREX UV Sentry analyzers should only be performed by personnel trained in the operation of the system components, familiar with the potential hazards associated with the deployment site, and familiar with the handling of gas delivery and testing equipment.

Work should conform to the manufacturer guidance and site health and safety practices.

The CEREX Monitoring Solutions UV Sentry Series Analyzers are not rated for safe operation in hazardous or explosive environments (not intrinsically safe). Any use in an area that may contain flammable mixtures or highly corrosive vapors requires special preparation to ensure operator safety and safe operation of the equipment.



WARNING – Eye hazard. Risk of eye injury. CEREX UV-DOAS Analyzers contain an ultra-violet light source that may cause eye injury after prolonged exposure. Always wear UVA/B/C eye protection when working on or near the operating equipment.

Procedure Warnings

The procedure contained within this document requires the handling of toxic substances including but not limited to benzene, aromatic hydrocarbons, and sulfur dioxide gas, and it requires the operation of equipment designed for toxic gas containment and dispensation. Improper handling of materials or hardware may result in serious injury, destruction of property, or damage to the UV Sentry. Only qualified individuals should attempt or perform analyzer operation or testing activities.

Safe Operating Precautions

Ensure that a clear escape path is identified.

Standard site personal protective equipment (PPE) is appropriate. If gloves are required for work on optics, nitrile or latex should be used.

Please check off the following steps before conducting maintenance. Doing so reduces the chances of false notifications to the public and clients.

- ❒ Notify the client and project manager of maintenance tasks.
- ❒ Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
- ❒ Confirm that the data is invalidated on the public website before proceeding with maintenance.
- ❒ When maintenance is complete check the public site for at least 15 min to ensure proper reporting (no missing data, no bump test data, etc.).
- ❒ Take out of maintenance mode
- ❒ Notify the project manager and client when maintenance is complete.

5. Routine Operations

To set the UV-DOAS instrument to acquire data for normal operations, the instrument CMS must be operating and the instrument must be aligned. These actions are detailed in the steps below.

1. Start the CMS software (if not already initiated). You should see a window similar to the one shown below in Figure 2.

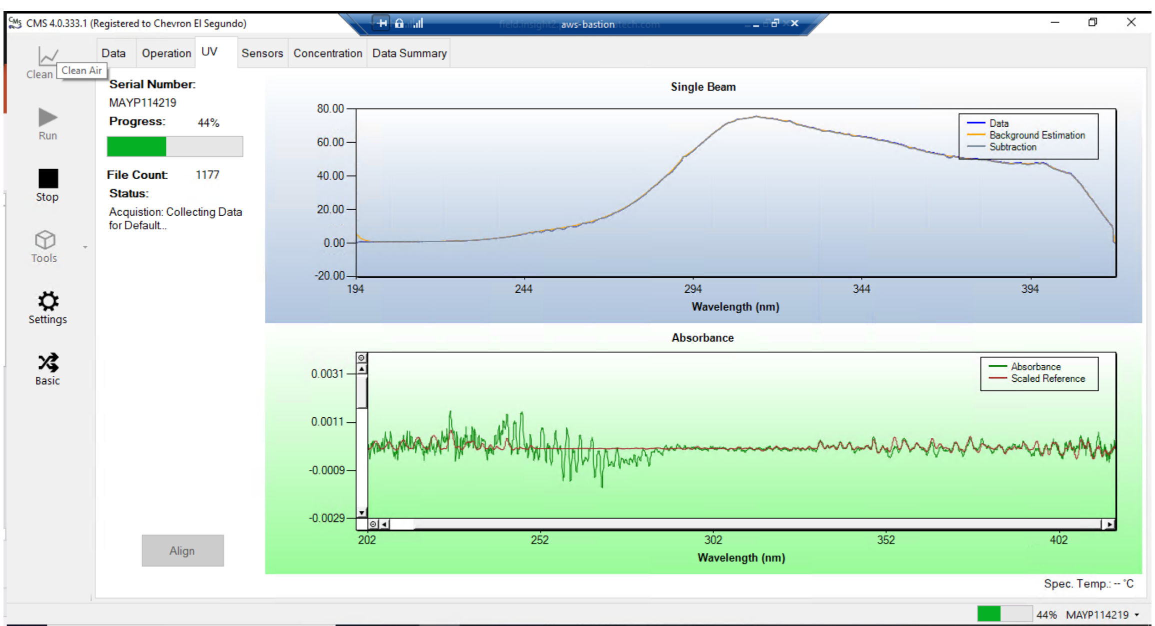


Figure 2. Screenshot showing the **UV** tab of the CMS software. Note that the **Align** button is grayed out because the instrument is in run mode (the **Run** button is also grayed out because the instrument is in run mode).

2. Under the **UV** tab, left-click on the **Align** button. This action brings up a new screen showing the instantaneous single beam plot (intensity vs wavelength). If the **Align** button is not active, you may need to press **Stop**. The **Align** mode is shown in Figure 3.

Figure 3. Screenshot for **Align** mode. The integration time can be entered in the upper right of the screen. In this particular screenshot, the integration time is 38 ms.

3. Enter an integration time of 25 ms and optimize the signal intensity by adjusting the pan-tilt head of the UV-DOAS unit to adjust the position of the UV beam on the retroreflector.

   NOTE: Make sure not to saturate the peak of the spectrum when at 25 ms integration time. An example of a saturated spectrum is shown in Figure 4; note that the spectrum is flattened out starting at about 290 nm. Also, ensure there is sufficient intensity at 250 nm compared to the stray light intensity. If there is more than 10% stray light, advanced optical adjustment or bulb change may be necessary. To measure stray light, block the beam from exiting the analyzer with an opaque object (such as a black cloth) and measure the intensity at the wavelength of interest.

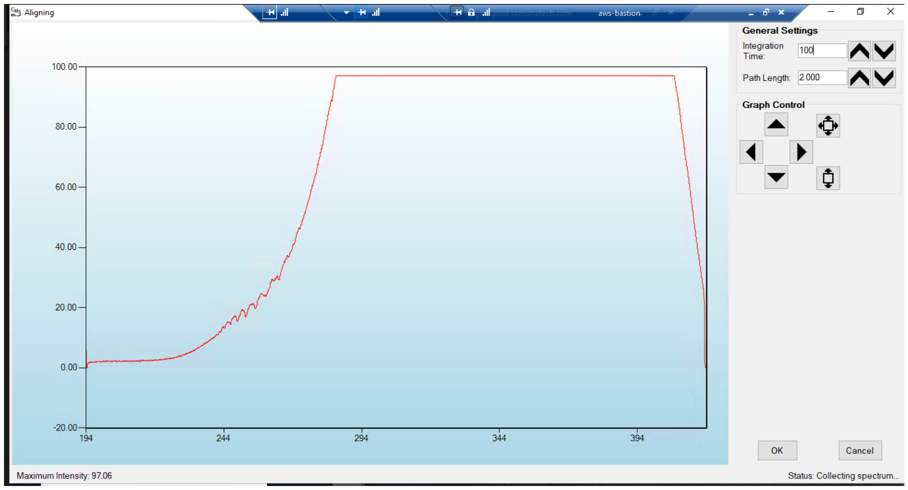


Figure 4. An example of a saturated spectrum when in **Align** mode. Note the "flat top" profile of the spectrum. The spectrum flattens out because the detector has saturated at those wavelengths and cannot quantitatively measure additional light.

4. Once sufficient alignment is obtained, exit the align mode by pressing **Cancel**.

5. Verify settings by left-clicking **Settings**.

   Note: If you need to change any setting back to the original configuration, you must go to **File** and **Save** and **Save As Default.** If you change settings, record why they were changed and what they were changed to in the instrument logbook. If settings are changed, they are automatically saved under the directory: C:\Users\CMS-USER\Documents\Cerex\CMS.

- RunTime
  - General
    - Operator Name: **Default** (these will change based on the path and site you are working on)
    - Sitename: **Cerex** (these will change based on the path and site you are working on)
    - Auto Run: **ON**
    - Auto Run Delay (s): **15**
  - File
    - File Type: **.CSV**
    - Primary Data Logging File: **ON**
      - C:\Users\CMS-USER\Documents\Cerex\Data
    - Secondary Data File Logging: **ON**
      - \\OPT1-PC1\VLOData\OPT1_Path1\UVSentry_POC1
        - Note this path will change based on the different computer and path you are working on. This is just a basic file writing path to show you what it should look like.

        - Single Data Folder: **OFF**
        - Primary Summary File Logging: **ON**
            - C:\Users\CMS-USER\Documents\Cerex\Data
        - Secondary Summary File Logging: **ON**
            - \\OPT1-PC1\VLOData\OPT1_Path1\UVSentry_POC1
                - Note this path will change based on the different computer and path you are working on. This is just a basic file writing path to show you what it should look like
        - Single Summary File: **OFF**
    - Library
        - Library File: C:\Users\CMS-USER\Documents\Cerex\Library\
    - UI
        - Sort Column: Compound Name
        - Data Summary Chart: **OFF**
        - Concentration Chart: **OFF**
        - Password Protection Settings: **ON**
        - Pump Control: **OFF**
        - Status Control: **OFF**
        - Testing Control: **OFF**
- <u>Analysis</u>
    - General
        - Moving Average Interval: **12**
        - Display Units: **PPM**
    - Concentration
        - Zero Readings on Non-Detect: **OFF**
        - Zero Readings on Negative concentrations: **OFF**
        - Display BDL: **OFF**
        - Quick Analysis MDL Wave length Range: **276-280 (The range doesn't matter)**
        - Temperature/ Pressure Concentration: **OFF**
    - Filters
        - Absorbance Savitzhy-Golay: **ON**
        - Baseline Correction Savitzky-Golay: **OFF**
- <u>Instruments</u>
    - UV
        - Operation
            - UV: **ON**
            - Acquisition Time (s): **30 (this is the "averaging time" of the instrument)**
            - Integration Time (ms): **Always will change if Auto integration is turned on**. This is the amount of time that the instrument will collect light.

- Path Length (m): **2 (2 for monostatic, 1 for bistatic)**
- Trigger Mode: **Normal**

- Auto Routine
  - Auto Integration: **ON (the software will determine the integration time)**
  - Intervals (s): **300**
  - Wavenumber Range: **300-310 (This is the range where the intensity will be measured for autointegration determination. This is different on all instruments due to Spectral Background and Intensity Range)**
  - Intensity Range **75-85 (This is the target intensity range for the autointegration routine)**
  - Maximum Integration: **300**
  - Auto Background: **ON**
  - Interval (Acquisitions): **5**
  - Wavenumber Range: **266-270**
- Verification
  - Verification: **OFF (This inactivates all inputs)**

- Controller
  - General
    - Serial Port: **n/a**
    - Sensor Refresh Interval (s): **15**
  - Sensors
    - **Don't Touch Anything**
  - Alarms
    - **Don't Touch Anything**
- Email
  - General
    - Data Recipient: **Blank**
    - Email Sender: **Blank**
    - Email Periods (s): **60 (doesn't matter the time, we don't use this setting)**
    - Send Data: **OFF**
  - SMTP
    - Server: **smtp.gmail.com**
    - Port: **587**
    - Username: **Blank**
    - Password: **Blank**
    - Timeout (s): **100**
    - SSL Authentication: **ON**
- Auxiliary Coms
  - Modbus
    - Modbus: **ON**

- System Type: **Ethernet**
- TCP Port: **502**
- Unit ID: **2**
- 16-bit unsigned int to: **OFF**

6. After settings are verified and the instrument is aligned, you can place the instrument in run mode.

6. Equipment and Supplies

1. Field notebook
2. Tool kit, especially including: 7/64 hex driver, complete set of combination wrenches, adjustable wrenches, screwdrivers, etc.
3. Cleaning supplies designated to be safe for use on a CEREX UV-DOAS – especially lens paper
4. All relevant PPE, hardware, and procedural guidance per SOP, Safety Plan, and Safe Work Permit
5. Local or remote network link device (as required).
6. External laptop computer with network interface device to the Sentry unit (as required)
7. CEREX UV Sentry Unit equipped with CMS software
8. CEREX UV-DOAS 8" x 8" x 1" pleated filter
9. Isopropyl alcohol (≥80%)
10. Distilled water
11. Pressurized sprayers
12. CEREX UV-DOAS UV source bulb
13. Nitrile gloves
14. Cell bump test apparatus (including panels, regulators, valves, meters, etc.)
15. Tubing as required: 1/4" PTFE tubing for gas supply from the bottle to the QA cell
16. Tubing as required: 3/8" PTFE tubing with inline flow indicator from the QA cell to the scrubber
17. Flow regulation system capable of delivering gas 0.1 to 5 L/min at a total system pressure of 3 psig or less
18. Gas scrubber appropriate for gas used. Activated carbon may be used for benzene.
19. Reference standard traceable zero compressed air purge gas
20. Reference standard traceable gas blend in nitrogen for detection at about five times the

instrument's theoretical detection limit or higher

21. CEREX UV Sentry Unit equipped with CMS software
22. Spare reflector for alignment

7. Maintenance Activities

The following sections outline the routine performance indicator checks and maintenance activities to be carried out for each analyzer and sensor, followed by maintenance forms (see Section 9) used to indicate when the checks are completed and document any corrective actions taken. These activities are also expected, based upon the project plan, to be logged in a site logbook either in hard copy or electronic form and can reference this SOP and associated forms.

The following UV-DOAS maintenance activities and performance checks are recommended by the manufacturer:

- Visually inspect the system.
- Inspect optics on detector and retroreflector; clean if necessary.
- Inspect system filters on the optics and retroreflectors.
- Confirm the alignment to verify there has not been significant physical movement. Note: this is automatically monitored as well.
- Download data from detector hard drive and delete old files to free space, if needed. Ensure data are backed up on external drive.
- Ensure there are no obstructions between the detector and the retroreflector (such as equipment, vegetation, vehicles).
- Change out the UV source.
- Replace ventilation exit and intake filters.
- Clean optics on detector and retroreflector.
- Realign system after service.
- Perform bump test (simulates system-observed gas content at the required path average concentration) to verify the system can detect at or below a lower alarm limit.
- Review and test light and signal levels.
- Verify system software settings.
- Deliver previous years data to client and remove from brick and analyzer.

7.1 Visual Inspections

1. Ensure that the instrument is running and the data look reasonable.
2. Clean and correct any obvious problems with the system (cobwebs, rodent nests, broken optics, etc.).
3. Inspect all electrical cables for wear; replace as needed.
4. Indicate that these visual checks are complete on the form included at the end of this document.
5. Document any changes to the system in the course of these checks in the site logbook.

7.2 Filter Inspection and Replacement

Filters are present on both the instrument and the retroreflector fans. Some DOAS units may have two filters on the analyzer to mitigate salt intrusion and subsequent corrosion. Ensure all system filters are visually inspected and replaced if dirty.

Remove and inspect instrument filters following the procedure described here. Replace if necessary. Ensure fans are running (they should make an audible sound) when the system is turned back on.

NOTICE

The UV Sentry should be powered down prior to changing the filter. When powering down, adhere to the recommended shut-down procedure, which includes properly shutting down all applications, and then shut down the instrument PC.

When the PC has been successfully shut down, remove the power cord from the unit.

The UV Sentry contains a filter that must be changed on a periodic basis. Good airflow through the filter is directly related to the ability of the instrument to properly regulate internal temperature. If the filter is allowed to become clogged (through lack of maintenance), the system can overheat, and go into thermal shutdown. In extreme cases, damage may occur to the internal electronics.

The main filter is a custom size 8″ x 8″ x 1″ pleated filter, which is stocked at the CEREX factory. If a large number of replacement filters are ordered, the lead time could be several weeks.

7.2.1 Filter Installation Procedure

1. Power down the instrument—you cannot replace the filter with the instrument running. First,

close the software and shut down the onboard PC. Next, disconnect the power.

2. The filter is accessible by removing the black plate located beneath the instrument touchscreen. The plate has the words “Filter Access” imprinted on it (**Figure 5**).
3. Use a 7/64 hex driver to remove the six socket-head cap screws that retain the filter access panel.

Figure 5. Location of filter access plate.

4. Once the access plate is removed, the filter can be accessed for removal and replacement. Old filters should be discarded and not re-used. Insert the new filter with the “Airflow” arrow pointing in the “UP” direction (**Figures 6 and 7**).
5. When inserting the new filter, do not force the filter into the slot. If you encounter any unusual resistance, open the side door, and ensure no wires have fallen into the filter slot.
6. When fully inserted, the filter should be flush with the instrument case.

Figure 6. Filter access plate removed and filter partially removed.

Figure 7. Filter completely removed.

7. Re-attach the black filter access panel using the same driver and six screws.
8. Power up the instrument, make sure CMS software has started, and realign the instrument.

7.3 Light Level Check

For good visibility conditions, signal strength is normally >90% and integration time is normally <50 ms. If it is determined that these values are out of range, re-alignment may be needed.

Check and record signal strength at 250 nm. With an integration time of less than 125 ms, minimum signal intensity at 250 nm should be greater than 5%.

7.3.1 Check for Stray Light

Ensure there is sufficient intensity at 250 nm compared to the stray light intensity. If there is more than 10-20% stray light, advanced optical cleaning, replacement, alignment, or a bulb change may be necessary. To measure stray light, block the beam from exiting the analyzer with an opaque object (such as a black cloth) and measure the intensity at the wavelength of interest. Calculate stray light by dividing the intensity of the beam while blocked by the intensity of the unblocked beam and multiplying by 100:

$$\%stray\ light = \frac{Intensity\ of\ blocked\ beam\ (\%)}{Intensity\ of\ unblocked\ beam(\%)} \times 100\%$$

Note the result of this stray light calculation in the form at the end of this document.

7.4 System Settings

Check the system settings and compare them to those documented in Section 5 (Routine Operations); if any settings do not match those listed in Section 5, provide any explanation for the changes. If you change any settings, document how the settings were changed in the instrument logbook present at the site. Note that all instrument settings are saved by the analyzer on a daily basis.

7.5 Data Management

7.5.1 Archiving and Deleting Older Data

Note: Data older than twelve months should be deleted from the instrument each month to prevent the instrument from filling its 125 GB internal hard drive.

Raw instrument data are stored on the analyzer computer, the site PC, and the hard drive attached to the site PC. Data consists of spectral data containing two columns: one for wavelength, and the other for intensity. There are also two types of “summary” files that contain data resulting from the classical least squares analysis of the spectral data as a function of time. These file formats are described in the CMS Software User Manual.[1] Spectral data and summary files are automatically written to the site PC and moved to the external hard drive after a regular interval. Deliver the external hard drive to the client with the frequency indicated in the QAPP.

As noted above, data on the instrument must be deleted at monthly intervals. Details on the proper procedure for deleting data files from the instrument are as follows.

1. Confirm that the data files have been successfully written to site PC and the external hard drive attached to the site PC.
2. Make a note of the amount of available space on the instrument's internal drive on the maintenance form.
3. Locate files older than 12 months on the instrument file directory here: C:\Users\CMS-USER\Documents\Cerex\Data\.

   Note: This procedure excludes the Bump Test folder, which should always remain on the instrument computer.
4. Log into the brick PC located in the instrument shelter and locate the data files written from the instrument onto the external hard drive.
5. Confirm all Complete Data Summary files and Simple Data Summary files for the desired month have been transferred over completely to the external hard drive attached to the brick PC.
6. Once you have confirmed that those files have transferred over to the external hard drive, delete those exact Complete Data Summary and Simple Data Summary files from the instrument data folders.
7. For each individual day of single beam folders, ensure that the amount of single beam files are the same on both the external hard drive located on the brick pc and the internal hard of the instrument.
8. If both folder locations match and you have ensured proper file download, you may permanently delete the Single Beam folders from the instrument computer.
9. After all data older than 12 months have been deleted, note how much free space is now available on the instrument's internal drive. If removal of the files does not result in enough free disk space, the disk drive may need to be reindexed (see Section 7.4.2).

7.5.2 Rebuilding the Instruments Indexing Preferences

If deleting data from the instrument does not seem to increase free instrument disk space, you may need to re-index the files. To rebuild the index preferences, follow these steps.

1. Under the **Control Panel Menu**, use the search function in the lower left-hand corner of the

[1] CMS Software User Manual Rev 4. CMS Version 4.0.298.1, CEREX Monitoring Solutions, December 5, 2017.

task bar to search for "Indexing Options."

2. Click on the **Advanced** tab with the shield logo.
3. Click **Rebuild**.

   Note: Once "Rebuild" has been selected, a message will appear saying that it might slow user activity. This will not affect the instruments' ability to perform data collection. On the original indexing option screen, the magnifying glass in the upper right-hand corner will move and the number of items indexed will slowly increase. Take note of the available space on the instrument's internal drive once the indexing has been completed.

7.6 Clean Optics on Detector and Retroreflector

Cleaning the retroreflector is an important part of the maintenance plan. Over time, the retroreflector will collect debris that can alter the performance of the instrument. Caution should be taken as there are electric fan heaters that are used to keep moisture and particulates from collecting on the retroreflectors.

Optic Cleaning

If light levels are low or visual inspection reveals soiled optics, cleaning optical surfaces with lens paper and solvent can improve light throughput. This applies to the primary mirror, secondary mirror, and quartz windows. In general, if the optic is not dirty, don't clean it, as excessive cleaning of optics can result in scratches and wear over time. If the optic is obviously soiled and is affecting performance, take the following steps. Mirrors with metallic coatings should be treated with extra care because these surfaces are easily damaged on contact.

1. Wear powder-free gloves to avoid transferring skin oils onto the optics.
2. Use compressed air/canned air to remove particles from the surface of the optic. If the optic is sufficiently clean after this step, stop here.
3. Use a solvent (isopropyl alcohol or methanol/acetone in a 60/40 ratio) and lens tissue to wipe the optic clean. If using acetone, make sure to use acetone-impenetrable gloves. Wipe slowly from the edges first with a solvent-soaked lens tissue. One technique is to drop solvent on the unfolded lens tissue and drag from one end to the other.

7.6.1 Retroreflector Cleaning

1. Power down any equipment to prevent electrical shock or damage to the system.
2. Use a gentle stream of distilled water, usually from a weed sprayer or other type of gentle delivery method, to remove any salt or dust built up on the retroreflector.
3. Use a gentle stream of 80% isopropyl alcohol, usually from a weed sprayer or other type of gentle delivery method, to remove any remaining salt or dust built up on the retroreflector.

4. Once the retroreflector has been cleaned and is dry, repower any electrical equipment you powered down and clean any spills you created while cleaning.

7.7 Inspect and Change Out UV Source If Intensity Spectrum Has Dropped Below Acceptable Range

NOTICE

Never power the UV Sentry without a properly installed Xenon UV Source obtained from CEREX.

Powering the system without a UV source may cause an electrical short, which will permanently damage the instrument.

Always remove the Xenon UV Source and secure the analyzer heat sink anode prior to transporting or shipping the UV Sentry.

Failure to remove the Xenon Source and secure the Heat Sink anode prior to transporting or shipping the UV Sentry may cause destruction of the source as well as the anode.

Always check the polarity of the Xenon UV Source for proper installation prior to powering the analyzer.

Installing the UV source with reverse polarity will permanently damage the UV Source and cause immediate failure. The Xenon UV Source is shipped from CEREX with Heat Shrink and labeling over the Anode (+) end of the Source. The UV Source must be installed so the Anode (+) end of the bulb mounts to the Anode Heat Sink. The UV Source will be oriented with the (+) end at the top.

7.7.1 Xenon UV Source Handling

The UV Sentry Xenon Source is shipped from CEREX in a protective plastic enclosure (see **Figure 8**). The (+) Anode end of the UV Source is labeled "UP." The UV Source must be installed with the (+) side UP. Always wear clean powder-free nitrile gloves when handling the UV Source. Oils from hands deposited on the UV Source glass bulb will cause damage in operation. Remove the "UP +" label from the UV Source prior to installation. If the glass bulb is touched with bare hands, clean the glass bulb with isopropyl alcohol or acetone prior to installation.

Figure 8. The ANODE end of the UV Source is marked (+). The CATHODE end of the UV Source is marked (-).

7.7.2 UV Sentry Xenon Source Removal

Prior to shipping or transporting the UV Sentry, remove the Xenon UV Source and secure the anode heat sink assembly.

1. Power off the analyzer and disconnect from power. Allow the analyzer to cool completely.
2. Use the provided key to remove the Source Access Panel (see **Figure 9**).

Figure 9. Opening the source access panel.

3. Wearing clean nitrile gloves, loosen the retaining thumbscrew on the Anode Heatsink at the top of the UV Source (see Figure 10).

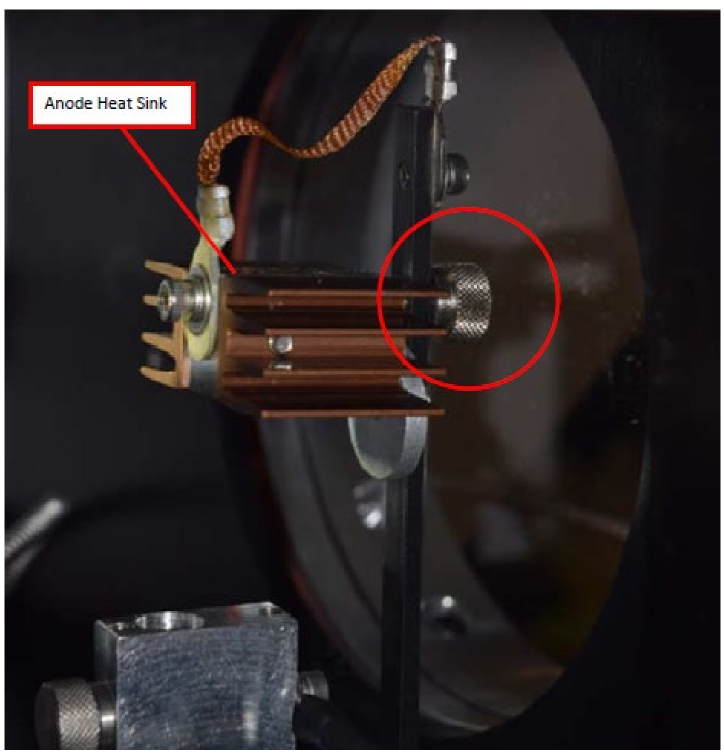


Figure 10. Anode heatsink at the top of the UV source.

4. Lift the Anode Heat Sink off the top of the UV Source. It is connected to the post by a cable. Gently let the heat sink dangle.
5. Loosen the retaining thumbscrew on the Cathode block at the bottom of the source (**Figure 11**).

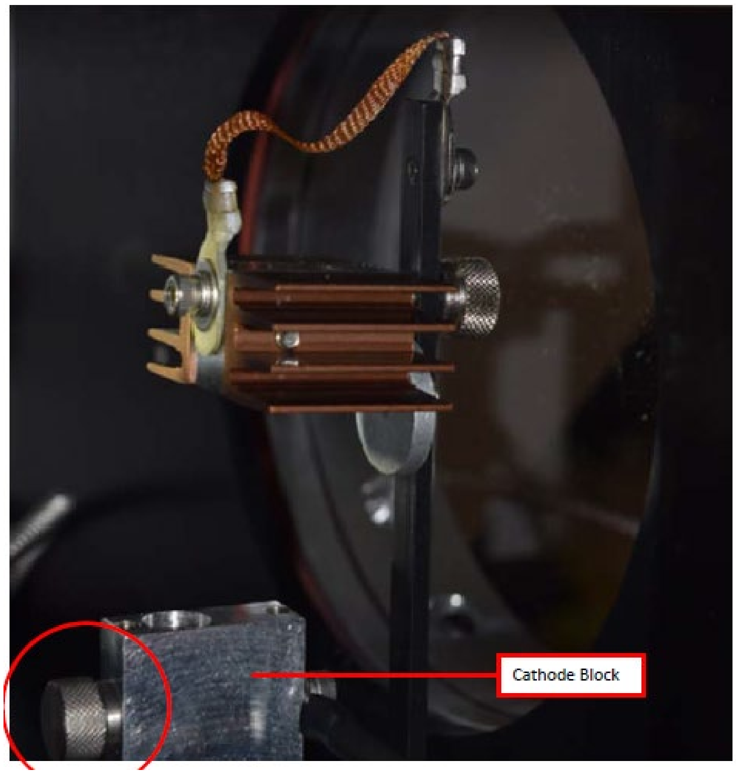


Figure 11. Loosen the thumbscrew on the Cathode block at the bottom of the UV source.

6. Lift the source lamp straight up and out of the mount.

7.7.3 UV Sentry Xenon UV Source Installation

1. Insert the Cathode (-) end of the Xenon UV Source into the Cathode Block (see **Figure 12**). The Cathode end of the UV Source is marked with (-).

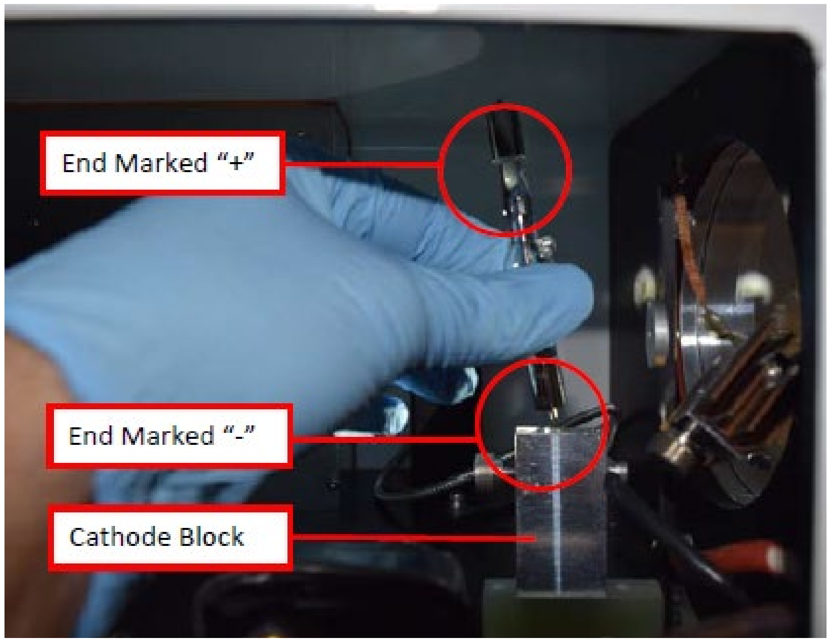


Figure 12. Inserting the Xenon UV Source into the Cathode block.

2. Rotate the UV Source so the nipple on the glass envelope faces the aluminum disc on the mounting post.
3. Tighten the Cathode block thumbscrew gently. Gently pull up on the Xenon UV Source to verify the thumbscrew has made contact with the nipple on the UV Source cathode.
4. Slide the Anode Heat Sink (+) over the top of the UV Source Anode. The Anode end of the UV Source is marked (+). Gently tighten the Anode Heat Sink thumbscrew to secure. Gently pull up on the heat sink to ensure the thumbscrew has made contact with the nipple on the UV Source anode.
5. Reinstall the Source Access Panel prior to powering on the analyzer.
6. Confirm signal strength through the remote desktop connection before leaving path.

7.7.4 Secondary Optic Alignment

If there is lower intensity than what was previously observed after the UV Source been replaced, an internal alignment of the secondary optic might be required. This should only be performed by a technician who has been properly trained to perform internal alignments.

Note: Proper PPE must be worn (glasses, sunblock) while performing a secondary alignment to prevent over-exposure to high intensity UV light from the UV Source within the instrument. Also, use an opaque object (such as cardboard or paper) to block as much of the light from the bulb as possible while still maintaining a view of the secondary mirror and fiber (if required).

1. Stop the CMS and navigate to the **Alignment** menu.
2. Properly align the instrument at 20 to 25 ms integration time, as shown in **Figure 3**. Make a note of the intensity at 254 nm and the overall shape of the UV signal return.
3. Open the side of the instrument to gain access to the secondary optic.
4. Ensure alignment achieves maximum signal return and is fully aligned to the retroreflector. This is achieved by maximizing signal intensity in align mode at an 8 ms integration time. If signal cannot be confirmed in align mode, this can be done visually by maximizing the visual return brightness on the retroreflector either by looking through the telescope or by placing your head next to the instrument and observing the returned reflection from the retroreflector.
5. If the entire spectrum is visible in the alignment menu, take note of the deep UV intensity at 254 nm. If the instrument is over saturation, as seen in **Figure 4**, take note of the wavelength at which the oversaturation starts.
6. Once the instrument is aligned, take care not to bump the instrument.
7. Adjust the first secondary mirror mount thumb screw to maximize the overall intensity.
8. Move on to the second mirror mount thumb screw and repeat the same process of adjustment to maximize the signal return.
9. In an iterative process, continue to adjust the optical mount screws to maximize intensity, one at a time, until no further gain in signal intensity is achieved.

   Note: Only adjust the two thumb screws of the secondary optic.
10. Set the integration time back to 20-25 ms and make sure the instrument is able to achieve a proper UV spectrum, as shown in Figure 3**.** If you are not able to achieve the proper UV spectrum, repeat steps 6-8.
11. Take note of the overall shape of the UV intensity and adjust secondary mirror to maximize intensity at 254 nm**.**
12. Close the access door of the instrument enclosure. Observe if having the access door closed has changed the internal alignment.
13. Return the instrument to its normal operation and observe the first few scans to ensure the UV spectra are acquired.

7.8 Perform Bump Test

7.8.1 Apparatus Setup

Bump tests of open-path analyzers require high concentration (~100 ppm) calibration gases. Standard refinery personal protective equipment (PPE) should be worn at all times, including safety glasses. This procedure requires the use of pressurized gas cylinders; training on proper handling of pressurized systems is required. The operator-supplied SOPs, approved by the End User and in compliance with the End User's Health and Safety Plan, is also required.

Verify the system is set up (minus the instrument connections) as depicted in Figure 13.

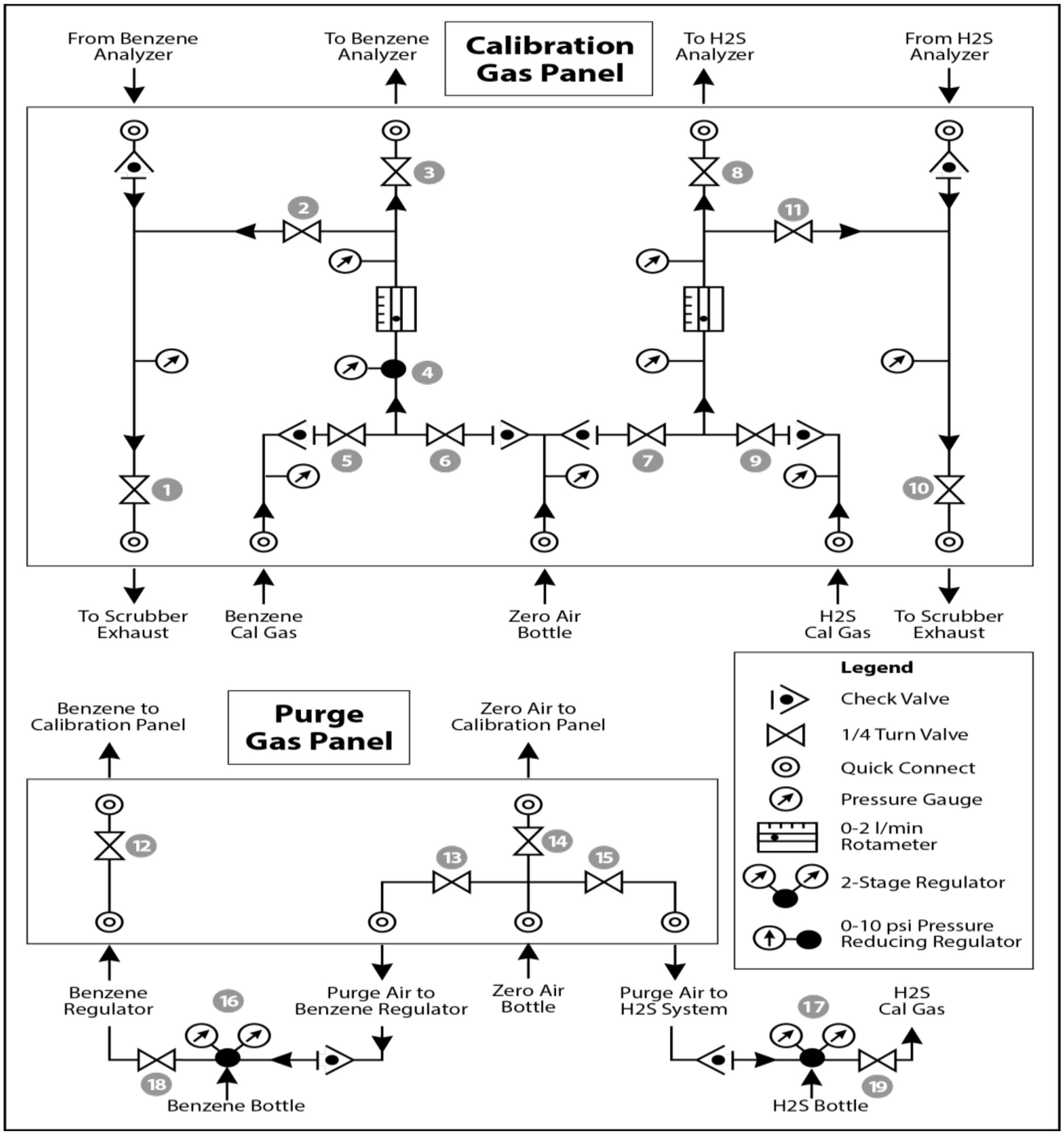


Figure 13. Diagram of the calibration gas panel (top) and purge gas panel (bottom) used for gas delivery.

7.8.2 Prepare CMS for Gas Testing

Note: There is a summary of system settings in Section 5 that can help you when you are changing any setting in the CEREX UV-DOAS instrument.

7.8.3 Configure CMS for Test (This may be concurrent with Gas Purge System setup)

1. The analyzer should be powered and running for **at least 30 minutes**.
2. Stop CMS data collection by pressing the **STOP** button.

7.8.4 Configure Test Files

1. Click **Advanced** on the left side of the CMS software window; the password can be provided by the Field Staff Manager.
2. Under **Advanced** -> **Settings** -> **Runtime -> File**, note the current file path so that it can be restored at the end of the test.
3. Under **Advanced** -> **Settings** -> **Runtime -> File**, turn off **Secondary Logging**.
4. Change the primary file logging paths (both of them) to: C:\Users\CMS-USER\Documents\Cerex\Data\bumptest. Then select **File** and select **Save**.

7.8.5 Leak Check

1. Ensure all the tubing from the purging panel is connected to the calibration panel. Ensure gas cylinders are connected to the purge panel as depicted in Figure 13. Then attach the calibration panel to the analyzer connection in the analyzer shelter.
2. Connect the PTFE tubing containing the activated carbon scrubber to the analyzer exhaust.
3. Close all valves on the calibration and purging panel.
4. Verify that the regulators on the zero air and benzene cylinders are completely closed (all the way to the left) to prevent any pressure buildup at the regulator.
5. Open high-pressure valves on both the benzene and zero air bottles.
6. Open valve (14) and slowly open the regulator on the zero air cylinder to a pressure of 5-10 psi, observed on the calibration panel zero gas pressure gauge. Do this by making small adjustments at the cylinder regulator and watching the pressure on the calibration panel.
7. Open valve (12) and slowly open the regulator on the benzene cylinder to a pressure of 5-10 psi on the pressure gauge on the benzene calibration gas channel of the panel. Do this by making small adjustments at the cylinder regulator and watching the pressure on the calibration panel.
8. Open the bypass valve (2).
9. Open zero air valve (6) and slowly open the regulator to a final pressure of about 2 psi (as

read on cell and exhaust pressure gauges). **DO NOT pressurize above 3 psi**.

10. Now pressurize cell: slowly open the valve going to the cell (valve 3) and close the bypass valve (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increases, just open the bypass valve (2) to relieve the pressure on the cell. Wait until the same pressure is reached on the pressure gauge of the exhaust side of the calibration panel.
11. Close the zero air valve (6) going to the benzene regulator on the panel so the system is now fully closed off to external pressure.
12. Watch the system for a minimum of 5 minutes to ensure there is no pressure drop and the system is leak free.
13. Open the leak check valve (1) to release the pressure from the system, and then close all the valves on both panels.
14. Record leak check.
15. Click the **ALIGN** button at the bottom left of the plot display.
16. Adjust the alignment until the signal intensity is optimized.
    a. **Target intensity is 70 – 90%.**
    b. **Target integration time is between 20 ms and 25 ms.**
17. **Record** the intensity and integration time.

7.8.6 Bump Test

This procedure was written assuming that the benzene and zero (purge) air side of the calibration panel has been pressurized according to the procedure above. At this point it is prudent to set up the instrument to start taking test measurements according to the UV-DOAS test procedure.

Background Measurement Using Zero (Purge) Gas

1. Close the secondary pressure regulator (4) on the panel by turning all the way to the left.
2. Open the leak check (1) and bypass valve (2).
3. Open Zero Air Valve (6).
4. Adjust the flow of purge air going through the bypass until the desired flow rate (1 lpm) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves [1] and [2]) is typically less than 1 psi.
5. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increases, just open the bypass valve (2) to relieve the pressure on the cell. Wait until the

desired flow rate has stayed the same and the pressure on the entire system has not increased.

6. Press **RUN** to start background acquisitions.
7. Flow compressed zero air purge gas at total flow of 1 L/min for ten 30-second acquisitions.
8. Monitor until a stable zero reading is reached and then allow the analyzer to run until an acceptable background is reached.
9. Close the zero gas valve (6).
10. Close all valves.
11. Close the secondary pressure regulator (4) on the panel.

7.8.7 Span Test

1. Open the leak check (1) and bypass valve (2).
2. Open the benzene valve (5).
3. Adjust the flow of benzene going through the bypass and scrubber until the desired flow rate (1 lpm) and pressure are achieved by slowly increasing the pressure on the secondary pressure regulator (4). The backpressure on the scrubber (measured between valves (1) and (2)) is typically less than 1 psi.
4. Open the valve going to the cell (3) and close the valve on the bypass (2) while carefully watching the cell pressure gauge after the regulator (4). If you note any sudden pressure increase, just open the bypass valve (2) to relieve the pressure on the cell. Ensure the desired flow rate has stayed the same and adjust as needed.
5. Wait 5 minutes to fill and condition lines and cell.
6. After 5 minutes of Check Gas flow, press **Start** in CMS.
7. Collect Check Gas data.
   a. Observe the concentration reported on the **DATA** tab.
   b. After the concentration becomes stable, allow the analyzer **to run until 7-15 stable measurements are made.**
   c. **Verify that the values meet the QA criteria. If the test fails QA criteria, follow the corrective actions listed at the end of this section (see: Data Evaluation, Reporting, and Corrective Action).**

7.8.8 Completion of Test and Purge of Benzene Regulator

1. Close the benzene cylinder. You will see benzene pressure increase and/or fluctuate as the pressure on the bottle regulator drops. This is normal - be patient and wait for the benzene pressure to zero out.

2. When pressure on cylinder and panel read zero, open the benzene purge valve (13).
3. **Verify that the target gas(es) concentration has returned to 0 ppm** with non-detect percent match.

   NOTE If not, ambient background target gas concentration has changed during the procedure; testing may need to be repeated to verify results.
4. Once zero reading is indicated on the UV-DOAS, close all valves.
5. Close the zero air cylinder and allow for all the pressure to be released from the system.
6. Close all valves and ensure there is zero pressure on the system.
7. Disconnect tubing to the analyzer and activated carbon scrubber.

7.8.9 Restore Normal Operation

1. **Restore** Normal Operation.

   Note: When restoring normal operation, you will change the file writing path in the settings menu back to the normal file writing path (this is slightly different for each unit, so make a note when first setting up the instrument for the QA test). Once you restart the CMS, you will see the file number located on the UV main menu of CMS. If the file count restarts and starts at file 1, you have the incorrect file writing path because it is starting a new folder for the entire day. Also, once you restart CMS, look at the single beam graph also located on the CMS UV main menu to ensure a good alignment and intensity in the lower UV wavelengths.
2. **STOP** CMS.
3. Click **Advanced** on the left side of the CMS software window; the password can be provided by the Field Staff Manager.
4. Under **Advanced** -> **Settings** -> **Runtime -> File**, turn On **Secondary Logging**. Change both of the primary file logging paths to: C:\Users\CMS-USER\Documents\Cerex\Data. Then select **File** and click **Save**.
5. Check the system alignment as previously described.
6. Press **RUN** to begin monitoring.

7.8.10 Test Suspension

In the event of a leak or plant alarm requiring the suspension of work, the process should be safely suspended.

1. If a plant or site alarm sounds during the validation, stop the test immediately as follows.
2. Close the reference gas bottle valve completely.
3. Allow the system to flow purge gas to the scrubber/vent.

7.8.11 Data Evaluation, Reporting and Corrective Action

During these tests, a number (N) of replicated, raw time resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) will be measured. Here, an acceptable number of trials will be defined as 7≤N≤15. The average value of these measurements is calculated as

$$\bar{x} = \frac{\sum_i x_i}{N} \tag{1}$$

and the sample standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}. \tag{2}$$

From these definitions, % error is defined as:

$$\%\ error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\% \tag{3}$$

and precision as the coefficient of variation expressed as a percentage (% CV):

$$Precision \equiv \%\ CV = \frac{\sigma}{\bar{x}} \times 100\% \tag{4}$$

1. Concentration
   a. Average the concentration of 15 consecutive stable measurements.
   b. Report the % error between the average and the certified value. The acceptable % error is listed in the QAPP.

      Note: To calculate the certified value that will be seen on the CEREX UV-DOAS from the actual certified instrument calibration gas concentration, you multiply the certified gas concentration by the calibration cell length (0.047 meters) and divide that answer by the path length set in the instrument software. For most CEREX instruments in operation by Sonoma Technology, the path length is set to 2 meters for monostatic instruments and 1 meter for bistatic instruments.
2. Calculate the Limits of Detection and Quantitation.
   a. Calculate the mean (average), sample standard deviation, and % error (sometimes also referred to as % difference) of the selected results.
   b. Report the Detection Limit as three times the standard deviation.
   c. Report the Quantitation Limit as five times the standard deviation.
3. Compile all configuration files, spectra files, and log files into a single folder.
   a. The folder should be named "CUS LOC QATest UV# YearMonDy" where CUS is a three-letter designator for the customer and LOC is a three-letter designator for the facility location.

The QAPP contains the acceptance criteria and warning levels to be used for the test.

Note:

- If the test produces an error or precision greater than the warning level: the test is considered passing if below the acceptance criteria, but corrective action should be taken so that the precision and error are below the warning levels.
- If the test produces an error or precision greater than the acceptance criteria: the test is not considered passing and corrective action should be taken so that the precision and error are below the warning levels. Equipment will not be placed into service (taken out of "maintenance mode") until it meets all measurement criteria.

If the measurements do not meet the data quality objectives listed in the QAPP, repeat the procedure without adjustment. If the instrument still fails to meet the QA criteria, retest the following day with no adjustment. If these repeated tests continue to fail, initiate corrective actions such as:

- Realign the system and perform the test again.
- Reviewing data for potential interferants, including a detailed check of absorbance spectra in the analysis regions configured for the analyte, noting any excessive noise or unexpected absorbance features.
- Consulting with the project technical lead to identify abnormal changes to the background
- Check wavelength calibration
- Checking for large changes in stray light since the last test and adjusting calibration factors as necessary
- Reviewing gas testing apparatus for leaks or other similar problems
- Review and confirm specifications of standard calibration equipment and gases (expiration dates, concentrations, etc.)

In the event of a failed test after following all steps outlined above, inform the Sonoma Technology Project Manager and Quality Assurance Manager who will review the instrument performance parameters in the list above.

If all parameters indicate that the instrument was performing properly since the last test, data since the last test will be flagged as suspect. If an issue with the instrument is identified, data since the date and time of the instrument issue will be flagged as invalid. All data flagging will be performed by Data Analysts in consultation with the Quality Assurance Manager.

8. Data Validation and Quality Control

Data for the fenceline monitoring network appears on both public and internal sites. The internal website allows for detailed quality control and flagging of the data. Data are checked daily and finalized quarterly as outlined in the QAPP. This section outlines how to perform daily and quarterly data validation.

8.1 Daily Checks

Both the public website and the admin website need to be checked twice daily (for example, before 10 a.m. and 10 p.m.).

1. Ensure that the site is operating properly by pointing your browser to the public website.
2. View the data display on the public website. Take note of any outages by selecting **All Compounds**" from the pollutant dropdown menu.
3. View the time series graphs for each compound by selecting each compound in the pollutant dropdown menu. Verify that pollutant concentrations are reasonable by using the guidance in Table 2. Notify the field operations team if anything seems erroneous.

Table 2. Parameters measured with the UV-DOAS and typical observations.

Parameter	Observational Notes
Visibility	~30 miles is the maximum measured by the sensor. Values are typically less than 30 miles due to smog and fog.
Integration Time	Should generally be <250 ms. Report values stuck at 300 ms to PM and fieldopsalerts. Should be anticorrelated with visibility for fog events.
Winds	Typically there is a sea breeze during the day, land breeze at night. Winds are stronger near the coast at met west.
Benzene	Typically below MDL (~1 ppb) – note any high values above REL or immediately visible on the public website (this is a toxic compound
Toluene	Typically below MDL (~1 ppb) – note any high values above REL.
Ethylbenzene	Typically below MDL (~1 ppb) – note any high values above REL.
o-xylene	Typically below MDL (~1 ppb)– note any high values above REL.
m-xylene	Typically below MDL (~1 ppb) – note any high values above REL.
p-xylene	Typically below MDL (~1 ppb) – note any high values above REL.
SO_2	0 to 100 ppb, usually zero. Refineries are a local source – note any high values above REL.
NO_2	Typically 0 to 200 ppb. Values typically peak at night; sunlight destroys it, traffic and combustion produce it. Some instruments may not detect NO_2 if they are saturated.

8.2 Quarterly Validation

Quarterly validation activities involve looking at the data over a longer time period (3 months) than the daily checks (typically a time range of a few days). To validate the data:

1. Plot time series and look for statistical anomalies. If problems are found they may be flagged using the DMS.
2. Review any instrument bump test results.
3. Verify that daily instrument checks were acceptable.
4. Review manual changes to operations/data, and verify that the changes were logged and appropriately flagged; ensure that logged information is complete and understandable.
5. Ensure that instrument checks have the appropriate Quality Control (QC) codes applied.
6. Assign invalid data a Null Code, providing a reason for data being invalid.
7. If a record is not created for a particular site/date/time/parameter combination, create a null record for data completeness.
8. Inspect data consistency.
9. Review collected data ranges for consistency – ranges should remain within expected values over months of monitoring.
10. Check bump test values for completeness; ensure they meet acceptance criteria.
11. Review quarterly data completeness.

9. Maintenance Forms

Path:______________________________

Technician:________________________

Date:______________________________

Instructions: complete checks described below and enter data or initial next to each one once complete. Make note of any corrective action.

- ❒ Notify the client and project manager of maintenance tasks.
- ❒ Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
- ❒ Confirm that the data is invalidated on the public website before proceeding with maintenance.
- ❒ When maintenance is complete check the public site for at least 15 min to ensure proper reporting (no missing data, no bump test data, etc.).
- ❒ Take out of maintenance mode
- ❒ Notify the project manager and client when maintenance is complete.

Upon completion sign and date:______________________________

Checklist of maintenance activities and performance indicator checks for the UV-DOAS.

Table 3. Maintenance activities and performance indicator checks for the UV-DOAS.

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

[a] UV bulbs will be changed depending on deep UV performance.

Corrective Actions for UV-DOAS:

UV Sentry Fenceline Detection System

DATE: __________________ Location: __________________________________

Test Technician 1:_______________________________ 2:_______________________________

Physical one-way path length_______________ m Instrument Configuration (mono/bistatic)_______________

Sentry Alignment and Light Levels

Integration time ____________________________ Target 20-24 ms
300 nm Intensity ____________________________ Target 80-120%
254 nm Intensity ____________________________ Target >5%
Blocked Beam Intensity at 254 nm __________________
% Stray Light ____________________________

Gas Purge System

Flow purge gas Start Time ______________________

Prepare CMS

Path length in the CMS Configuration (typically 1 m for monostatic and 2 m for bistatic)______________________ m

Configure Test Files

Site File (i.e., Bump Test UV# YearMoDy) ____
Baseline Check ______________________ init

Reference Gas

Concentration ______________________ ppm
Source ____
Date ______________________
Cylinder Pressure ______________________

NOTES:

Bump Test Record - UV Sentry Detection System - Page 2

Purge Flow Conditions

Start Time ______________________

Purge Gas flow ______________________ L/min

NOTES: Around 1 LPM

Check Gas Test

Initial Gas flow ______________________ L/min

Around 1 LPM

Start Time ______________________

Collect Check Gas Data Start Time ______________________

Data Record:

TIME	PPM	R2
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________
____________________	__________	_________

Verify Client ______________________ Init

Stop Time ______________________ Init

Open the **PURGE** gas Time ______________________

Reference Concentration __________ ppm

Average Concentration __________ ppm

% error __________ %

Std Deviation __________ ppm

% CV __________ ppm

Restore Normal Operation

Restore running data file ______________________ Init

Press **RUN** to begin monitoring. ______________________ Init

Unisearch LasIR Tunable Diode Laser System (TDLAS) Maintenance and Test Procedures

October 31, 2024

STI-7801

APPROVED:

Sonoma Technology	date
Fenceline Monitoring Refinery Representative	date

Contents

Definitions

Term/Acronym	Definition
Bump Test	Test where gas of a known concentration is introduced to the analyzer to check for response accuracy and precision.
Calibration	Procedure by which a series of standards are used to perform an instrument calibration.
Correlation coefficient	A statistical measure of the strength of the relationship between two variables (e.g., measured vs. theory).
FRC	Fire-retardant clothing
IDLH	Immediately dangerous to life or health
laser	A device that emits Light Amplified by Stimulated Emission of Radiation. The resultant light is often very bright, coherent, and monochromatic.
OAP	Off Axis Parabolic reflector. For the TDLAS, the OAP serves as the collection optic for the return beam after it has traversed the atmosphere. The OAP directs and focuses the return light onto the detector.
OEHHA	Office of Environmental Health Hazard Assessment
NIOSH	National Institute for Occupational Safety & Health
Power	A measure of the energy delivered by the laser beam per unit time. The units of power are typically expressed in watts, milliwatts (mW), or microwatts (µW).
PPE	Personal protective equipment
QA	Quality assurance
QC	Quality control
QAPP	Quality Assurance Project Plan
REL	Reference Exposure Level
Retroreflector	An array of reflective corner-cube optics that reflect light back in the direction of the light source.
SOP	Standard Operating Procedure
TAS	Terra Applied Systems
TDLAS	Tunable Diode Laser Absorption Spectroscopy
Transmission (%)	The ratio of return beam strength to the source beam strength, expressed as a percentage.

1. Applicability/Scope

This SOP includes procedures for the routine maintenance, and gas testing for Unisearch Tunable Diode Laser System (TDLAS) open-path analyzers. This document provides procedures that enable technicians to verify that equipment is performing to expectations and detection and communication links are functioning correctly. This SOP has the steps to conduct routine maintenance and quality control checks and calibrations, while the QAPP or other specific SOPs should be referenced for other related quality assurance (QA) system requirements including the required frequency of these QA activities (**Section B.6** of the QAPP), criteria that must be met (**Section A.7** of the QAPP), management of the data (**Section B.10** of the QAPP), or corrective actions needed, depending on the outcome of the maintenance activities or QC checks.

***NOTE ***

This procedure should only be used by personnel with experience in the safe use of the analyzer and test equipment.

A number of these maintenance procedures closely follow the manuals provided by Unisearch.[1] Field staff should obtain access to and read these. The QA) bump test procedure ensures field verification and calibration of the TDLAS by challenging the instrument with a known concentration of hydrogen sulfide (H_2S) and verifying proper detection and quantification under field conditions.

2. Summary

The Unisearch LasIR H_2S monitoring system (**Figure 1**) is a monostatic open-path remote sensor that uses direct absorption technique. The LasIR sensor consists of an analyzer, transmitter/receiver, and retro-reflector array. The tunable infrared (IR) laser for the LasIR system is housed in the analyzer box and scanned over a small range of wavelengths at high frequency. A fiber optic cable guides the laser light to the transmitter/receiver telescope where it is collimated and sent across the atmospheric path. The retroreflector array at the other end of the path returns the signal to an off-axis parabolic mirror that focuses the light onto a photodiode detector. The electrical signal from the photodiode detector is amplified and returned to the analyzer box where the absorption spectrum is analyzed to produce concentration data.

Classical least squares fitting of the absorption spectrum allows elucidation of low-H_2S concentrations by simultaneously accounting for overlapping water (H_2O) and carbon dioxide (CO_2)

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[1] Unisearch Associates: A. Preinstallation Manual, B. Installation Manual, C. Networking Manual, D. Remote Sensing Optics Manual, E. Operations Manual, H. Troubleshooting Manual, I. Laser Safety Manual, J. Maintenance Manual, LasIRView 2015 Manual, 2018.

absorbance bands. As a result, concentration data for H_2S, H_2O, and CO_2 are provided with correlation coefficients that indicate the "goodness of fit."

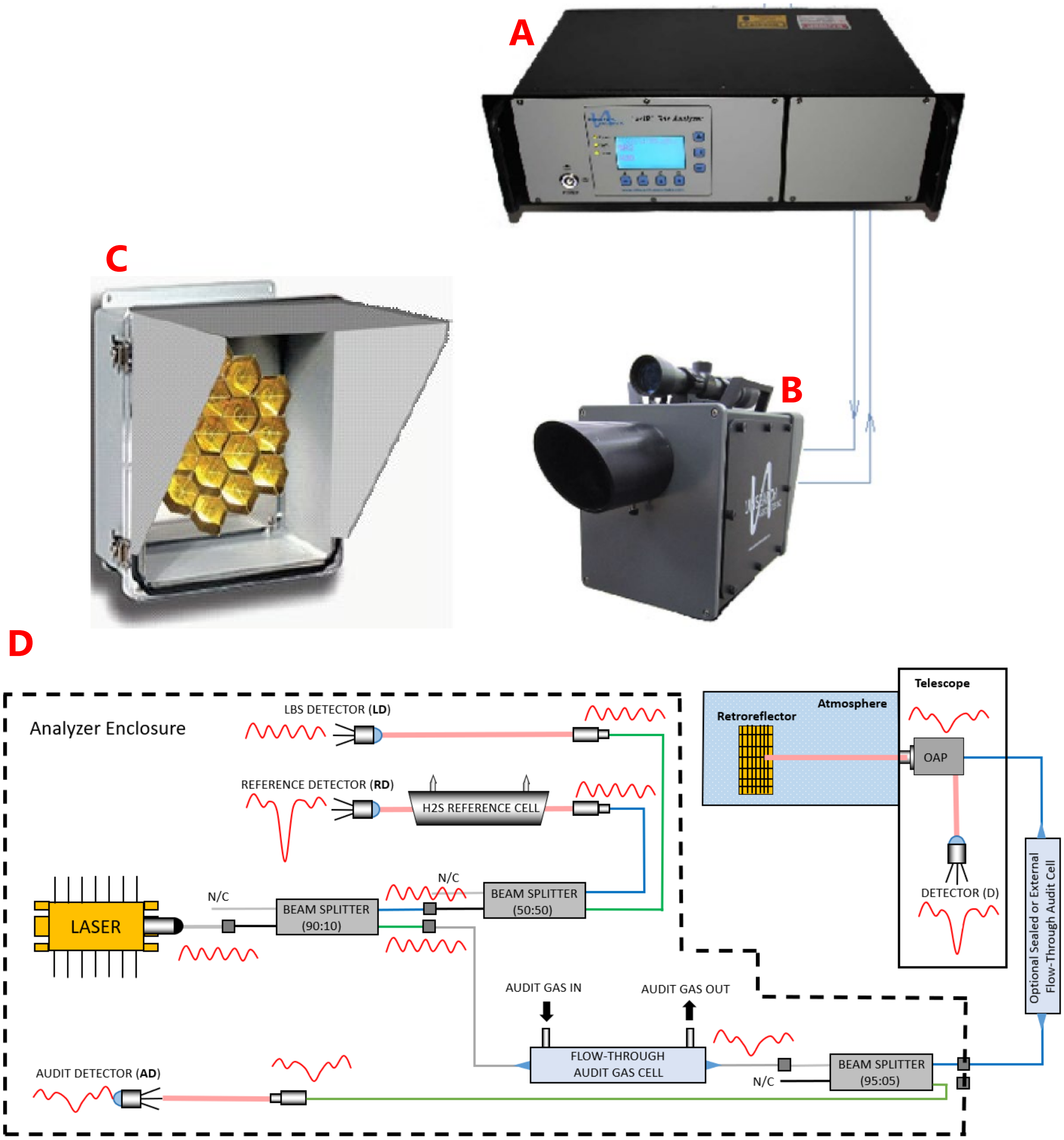
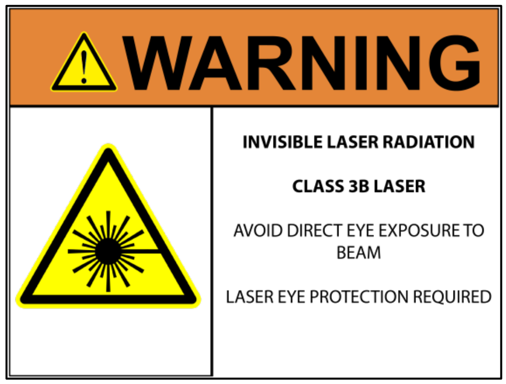


Figure 1. (A) Unisearch TDLAS Analyzer box, (B) telescope, (C) retroreflector, and (D) schematic diagram showing the optical fiber paths and detection points.

3. Health and Safety Warnings

The following information should be noted when preparing work plans and permits for safe work practices.

3.1 Laser Safety



The Unisearch TDLAS produces a class IIIB LASER EMISSION that is INVISIBLE. The laser can cause eye damage if the laser is viewed directly. Unisearch recommends the use of safety procedures consistent with Class II and IIIA lasers. **PROTECTIVE EYEWEAR SHOULD BE WORN WHEN WORKING WITH THE SYSTEM**. Always avoid looking directly into any part of the instrument that can produce laser light, including the transceiver head. Make sure to read the laser safety manual and all other manuals provided with the Unisearch TDLAS instrument.

3.2 Operator Qualifications

Installing, operating, and servicing Unisearch analyzers should only be performed by personnel who are trained in the operation of the system components and are familiar with handling gas delivery and testing equipment. These procedures should not be performed by personnel who do not understand the system, technology, or hazards of the materials involved.

3.3 Safe Work and Hazardous Environment Operation

Work should conform to manufacturer guidance and site health and safety practices. Standard refinery personal protective equipment (PPE) should be worn at all times, including laser safety glasses with side shields, a hard hat, goggles, steel-toed boots, hearing protection, fire-retardant clothing (FRC), an H_2S monitor, and appropriate gloves that are adequate for this procedure. For testing with the flow-through cell using H_2S concentrations in excess of 100 ppm, a second person should always be present as a safety monitor. H_2S levels should be monitored inside the enclosure. Two self-contained breathing apparatuses should be on standby.

The Unisearch TDLAS are not rated for safe operation in hazardous or explosive environments. Using the TDLAS in an area that may contain flammable mixtures or highly corrosive vapors requires special preparation to ensure human safety and safe operation of the equipment.

H_2S is a colorless gas that has an odor of rotten eggs. It is hazardous at low concentrations (the immediately dangerous to life or health [IDLH] level is 100 ppm, the National Institute for Occupational Safety & Health [NIOSH] 10-min Reference Exposure Level [REL] is 10 ppm, and the California Office of Environmental Health Hazard Assessment [OEHHA] 1-hr REL is 30 ppb). Odor is not a reliable indicator of the presence of hazardous concentrations of H_2S because olfactory senses may be deadened by exposure to concentrations below safe exposure levels. A system for scrubbing H_2S gas from a test apparatus vent is used to prevent release and worker exposure.

This procedure has been written to limit exposure potential and mitigate the hazards of accidental release of the reference gas. Only personnel experienced with handling this material who are familiar with the test procedures and apparatus should perform these testing procedures.


WARNING – Toxic Gas and Eye Hazard. This procedure requires the use of H_2S concentrations as high as 3,000 ppm for the span check. This procedure must be conducted in a well-ventilated area and requires gas monitors, respirators, and the use of fume scrubbers. Make sure you and others fully understand the safety procedures and gas-handling systems required. Always wear proper eye protection having OD>4 above 900 nm. Improper handling of materials or hardware may result in death, serious injury, destruction of property, or damage to the TDLAS. Only qualified individuals should perform analyzer quality assurance testing.

4. Routine Maintenance

The TDLAS system is designed to require only modest service and maintenance. **Table 1** summarizes the TDLAS maintenance activities, as recommended by the manufacturer. The frequency of activities may vary from site to site, so always check the QAPP for facility-specific maintenance schedules and acceptance criteria.

Table 1. List of maintenance activities and performance indicator checks for the TDLAS.

Activity	SOP Section(s)
Visually inspect the system. Inspect electrical and optical cables for wear.	4.2
Inspect optics and clean if necessary	4.3, 4.4
Check the alignment to verify there has not been significant physical movement; note that this is automatically monitored as well	4.5
Download data from detector hard drive and delete old files to free space, if needed	4.6
Ensure there are no obstructions in the beam path	4.7
Review and test light and signal levels	4.7
Verify system settings	4.8
Perform bump test and take corrective action as needed	5 (flow-through) 6 (sealed cell)
3-point calibration check	5 (flow-through) 6 (sealed cell)

NOTICE

Perform the following steps before conducting maintenance. Doing so reduces the chances of false notifications to the public and/or clients.

1. Notify the client and project manager of maintenance tasks.
2. Using the field tech tool at ftt.sonomatechmonitor.com, place the equipment into planned or unplanned maintenance mode.
3. Confirm that the data is invalidated on the public website before proceeding with maintenance.
4. When maintenance is complete check the public site for at least 15 min to ensure proper reporting (no calibration data present; data is no longer invalid due to planned maintenance).
5. Take the equipment out of maintenance mode
6. Notify the project manager and client when maintenance is complete.

4.1 List of Equipment

1. Field notebook
2. Tool kit, especially including: hex drivers, complete set of combination wrenches, adjustable wrenches, screwdrivers, etc.
3. Cleaning supplies designated to be safe for use on a Unisearch TDLAS – especially lens paper
4. All relevant PPE, hardware, and procedural guidance per SOP, Safety Plan, and Safe Work Permit
5. Local or remote network link device (as required)
6. External laptop computer with network interface device to the Sentry unit (as required)
7. Unisearch TDLAS equipped with LasIRView software
8. Isopropyl alcohol (≥80%)
9. Distilled water
10. Pressurized sprayers
11. Nitrile gloves
12. Cell bump test apparatus (including panels, regulators, valves, meters, flow controllers etc.)
13. Tubing as required: 1/4″ PTFE tubing for gas supply from the bottle to the QA cell
14. Tubing as required: 3/8″ PTFE tubing with inline flow indicator from the QA cell to the scrubber
15. Flow regulation system capable of delivering gas 0.1 to 5 L/min at a total system pressure of 3 psig or less
16. Gas scrubber appropriate for gas used. Activated carbon may be used for benzene
17. Zero air supply
18. Reference standard traceable gas blend in nitrogen for detection at about 5X instrument theoretical detection limit or higher
19. Spare reflector for alignment

Related spare parts and equipment are available from Unisearch Associates and are detailed in the Unisearch manuals.

4.2 Visual Inspection

For each measurement site (includes both analyzer and any retroreflectors), complete the visual checks listed below on the form in **Section 10**. When maintenance is complete, file the forms from the "maintenance folder" in the main project folder on the company's shared drive. During visual inspection of the analyzer, complete the following checks.

1. Note and clean any excessive dust buildup on the equipment or analyzers. Use a damp rag to clean dust from surfaces.
2. Eliminate any pests from the sample site, including birds, spiders, rodents, etc., and remove cobwebs. Plug any holes that may serve as entry points for rodents. Work with the Project Manager and client to eliminate more extensive rodent issues.
3. Note the internal condition of the analyzer cabinet. Check for signs of condensation below the HVAC. Note other signs of water damage.
4. Inspect wiring and note and correct any corrosion or cracking insulation. Replace wires that have been chewed-through or show signs of imminent failure.
5. Check HVAC for proper operation by checking for cool air and reviewing cabinet temperature records, if available.
6. Check for corrosion. Common places to check are on top of the cabinet, various components of the instrument mount, nuts, and bolts. Mitigate corrosion by using oil or similar product designed to prevent corrosion.
7. Note and mitigate any condensation or water issues that may adversely affect equipment.
8. Check the door operation.
9. Note anything that may result in eventual degradation of the LasIR system.

For items that cannot be immediately corrected, notify the Project Manager to initiate corrective actions. If it is suspected that any issues that required corrective actions might have adversely affected data quality, note this in the form in **Section 10** and notify the project manager and QA Analyst assigned to the project.

4.3 Cleaning the Transmitter/Receiver Optics

Only the front surface of the window on the telescope assembly may need to be cleaned on a monthly basis. Use a clean cloth to lightly wipe the front surface of the window. Normal lens cleaning solution can be used if necessary, but dust can usually be wiped away with a dry cloth. Be careful not to scratch the window surface by pressing too hard. The shroud protecting the window from the elements may be removed for cleaning. If necessary, loosen the locking screw on the bottom of the shroud and pull the shroud away from the window housing.

If the inside of the window gets dirty, it is best to remove the window from the housing and clean it rather than open the telescope side covers, as access from these points is limited. You may either remove the shroud and unscrew the locking ring that holds the window in place, or remove the entire front cover by loosening the four screws in the corners. In either case be careful to keep the O-ring seals properly seated. Improper seating may result in leaks if rain falls on the telescope, which could damage sensitive electronic components inside.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.4 Cleaning Retroreflector Array

Only the front surface of the acrylic protective window for the retro-reflector needs to be cleaned on a monthly basis. Use a clean cloth to lightly wipe the front surface of the window. A lens cleaner solution can be used if necessary, but dust can usually be wiped away with a dry cloth. Be careful not to scratch the window surface by pressing too hard. If, for some reason, the inside of the window gets dirty, this can be cleaned by opening the enclosure front cover.

Reflector elements may also be cleaned if necessary, but this should be done with extreme care to prevent damage to their gold-coated surfaces. To clean retroreflector cubes:

1. Power down any equipment to prevent electrical shock or damage to the system.
2. Use a gentle stream of distilled water, usually from a weed sprayer or other type of gentle delivery method, to remove any salt or dust build-up on the retroreflector.
3. Repeat step 2 with a gentle stream of 80% isopropyl alcohol.
4. Once the retroreflector has been cleaned and dried, repower any electrical equipment you powered down and clean any spills created while cleaning.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.5 Optical Alignment

Adjust the vertical and horizontal adjustment knobs to maximize signal return power as reported on the OPM-15 power meter. Lock the adjustment knobs (**Figure 2**) in place. Once signal return power is optimized, push on the telescope top and side. If the optical configuration is optimal, this action should not result in a fluctuation in return signal power as measured with the OPM-15; the laser beam size at the retro-reflector should be 2-3 times the diameter of the retro-reflector for this to be true. If a drop in signal return power is observed when pushing on the telescope, it may be necessary to adjust the collimator (see below) to obtain the best beam size and return power. If the beam is smaller than twice the retroreflector size, variation in the power will be observed, which may affect the alignment over time due to flexing of the mounting structure. When the vertical alignment is correct, tighten the locking thumbscrew. For the horizontal sweep, loosen the 5/8" locking nut located underneath the mount base and use the thumbscrew on the right hand side of the mount base (looking from the back) to adjust the horizontal position. When adjustment is complete, tighten the locking nut. Slight adjustment of the vertical alignment may be required after tightening the horizontal alignment-locking nut, as this tightens the rear end of the telescope to the mount, which affects the tilt.

Adjusting the collimator is an iterative process. The collimator affects the size of the beam that illuminates the retroreflector. If the beam size at the retroreflector is too small, the signal return power will be too large and can saturate the detector and result in alignment instability. Conversely, if the collimation results in a beam size that is too large, the beam power will be spread over too large of an area at the retroreflector and will not allow enough light to be reflected back to the detector for an acceptable measurement.

To adjust the collimation:

1. Rotate the collimator either clockwise or counterclockwise 1/16 of a turn and note the change in signal power on the OPM-15. There is wobble in the collimator lens assembly, so the alignment will need to be optimized after each turn.
2. After turning the collimator, optimize the horizontal and vertical alignment.
3. Check the alignment stability by pressing on the top and side of the telescope – if the collimation is adjusted correctly, this will not result in significant power fluctuations. Also check the signal return on the OPM-15 to ensure that enough light is reaching the detector.
4. If necessary, repeat steps 1-3 until the signal return is sufficient.

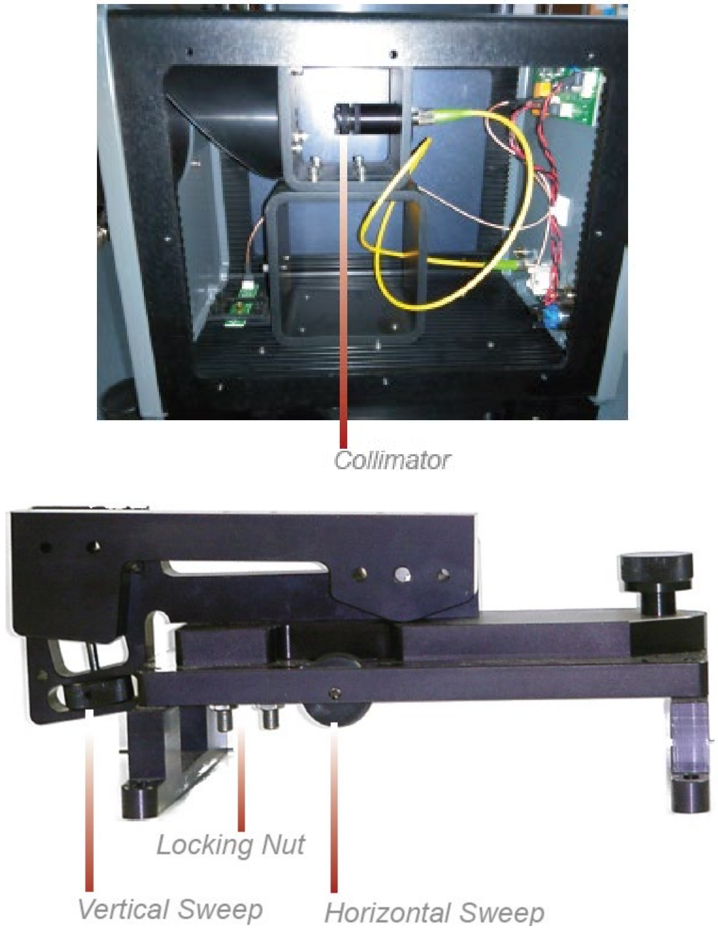


Figure 2. Location of adjustment knobs used for alignment of the Unisearch TDLAS.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.6 Data Management

Under normal operations, the LasIR system works together with a separate program called the TASDAcc to acquire and process raw TDLAS data, and reports 5-min data to the Sonoma Technology-operated data system. The TASDAcc software is developed and maintained by Terra Applied Systems (TAS), the integrator of the Unisearch TDLAS. As depicted in **Figure 3**, the LasIR, TASDAcc, and cellular modem are all connected through a network switch located in the same cabinet as the Unisearch analyzer box. The TASDAcc software handles four main data types: (1) raw data tables from the LasIR Analyzer (as .txt files for each species), (2) spectral data from the LasIR Analyzer (.spectrum), (3) 5-min data for ingestion to the Sonoma Technology data system and display on the public-facing website, and (4) configuration files that archive instrument settings (as either .xml or .cfg).

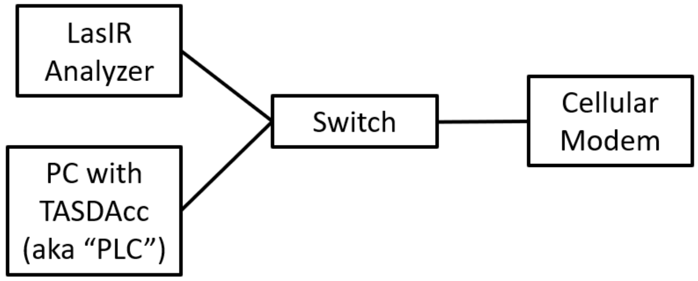


Figure 3. Diagram of local network configuration for the LasIR system.

On a routine basis, all TDLAS data from the PC running the TASDAcc software needs to be backed up on an external drive attached to the PC. To perform this task:

1. Transfer TDLAS files from the PC to the external hard drive (this may be accomplished on a continual basis using a .bat file).
2. Check to ensure all data have been backed up on the external drive for at least the previous quarter.

On an annual basis, the external storage device should be removed and transferred to the client. To perform this task:

1. Ensure the previous year’s data has been transferred to the removable storage device.
2. Remove the storage device and replace it with new (empty) one.
3. Deliver the removable storage device with the previous year’s data to the client for permanent redundant storage.
4. After data delivery to the client, confirm that all data from the previous year has undergone final QC and that the client has backed it up.
5. Delete the previous year’s data from the PC.
6. If enough free space cannot be created on the PC by transferring it to the external drive, take corrective action with support from the IT department.

Document completion of this task using the Maintenance Task Checklist in **Section 8**.

4.7 Test Light Levels

Although the return light level is monitored continuously and reported with the 5-min data, it is important to verify and document observations of light levels during routine maintenance. Daily observations regarding light levels are documented by Sonoma Technology’s analysts. Monitoring light levels over several days allows for the determination of root-cause for problems involving low signal return (e.g. thermal expansion). Field technicians are expected to review historical trends in light levels by utilizing the custom dashboards provided by the data management system. The effect of cleaning on light levels should be noted. Testing light levels at various points in the system can help troubleshoot damaged optical components, such as fibers.

To check light levels in the field, observe the power bar (S) in the scope display or the bar at the bottom of the "Main Running" display (Figure 4) on the analyzer. It should be green in the host trend display. The scope display will turn yellow if the power is low, and will turn purple if the power is very low and the instrument has stopped recording data. On the analyzer, the bar is normally between 25% and 75%. You may also check the percent (P) values on the analyzer display (Figure 4) by cycling to the "Species Information Screen." It should be greater than 5% for proper operation. Low power generally indicates a need for maintenance, such as cleaning the optics, or may also result from low visibility conditions (fog).

If light levels are not adequate, follow the procedure in Section 4.5 (optical alignment) to correct the issue. If low signal return is still observed after optical alignment, test the power at various points in the system using the OPM-15 to identify bad optical fibers or connections. If the source of the low signal strength still cannot be traced, contact Unisearch for further guidance.

Document completion of this task using the Maintenance Task Checklist in Section 8, and document results of this test in the LasIR Response Test Form in Section 9.

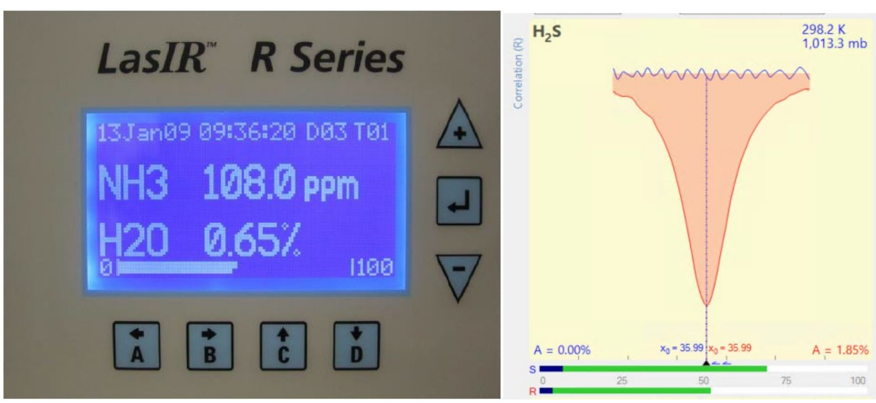


Figure 4. Main running window on instrument front panel (left) and scope display in LasIR View software (right).

4.7.1 Signal Strength Measurements

Light power measured at the detector can occur at several points in the system. There are two gains associated with these measurement points, as indicated in Table 2. The "signal gain" is the amplification placed on the signal itself through electronic hardware, and the "IO gain" is a multiplicative modification of the input-output data streams. Using this table together with the method-appropriate use case, the actual light power at the detector can be determined.

For example, if the signal gain is 2 (signal multiplier of 2), the IO gain stage is 3 (multiplier of 5), and the peak power at the detector is 0.12 mW, then the power displayed via RS232 data stream is:

RS232 **SignalPower** = Signal Multiplier x IO Multiplier x Peak Power = (2)(5)(0.12 mW) = 1.2

The ratio of MODBUS to RS232 signal powers is always 2.5, so in this case the **SignalPower** transmitted via MODBUS is: (1.2) (2.5) = 3

Following this example, by ratioing the power at the detector to the power of the laser (say, 18 mW for this example, can be obtained from instrument data sheets), a %transmission may be calculated.

%transmission = (0.12 mW / 18 mW) 100% = 0.67%

However, if the gains are set to "auto," as they are during normal operations, it is impossible to know what gain settings are applied and, therefore, what the actual power at the detector is. Therefore, %transmission can only be assessed during routine maintenance.

Table 2. Multiplicative factors associated with gain stages and how they are translated to the Unisearch data files (SignalPower) and through the MODBUS data connection. Note that the ratio of MODBUS to RS232 is 2.5. The ratio of RMS power to peak power is 0.83.

Signal Gain	Signal Multiplier	IO Gain Stage	IO Multiplier	Power at Detector (mA or mW)	Peak Power at Detector (mA or mW)	MODBUS/ Display Power	RS232/TXT Signal Power
1	1	2	1	1	1.2	3	1.2
2	2	2	1	0.5	0.6	3	1.2
2	2	3	5	0.1	0.12	3	1.2
2	2	4	25	0.02	0.024	3	1.2
1	1	3	5	0.32	0.4	5	2
2	2	3	5	0.2	0.24	6	2.4
3	4	3	5	0.25	0.3	15 (or 1.0 if not in Fast gain with error)	6 (or 2.5 if not in Fast gain with error)
4	8	3	5	0.1	0.12	12 (or 1.0 if not in Fast gain with error)	4.8 (or 2.5 if not in Fast gain with error)
2	2	4	25	0.05	0.06	7.5 (or 1.0 if not in Fast gain with error)	3 (or 2.5 if not in Fast gain with error)
3	4	4	25	0.015	0.018	4.5	1.8

Using the OPM-15 Power Meter: When working with the laser power meter (OPM-15, provided with the analyzer, shown in Figure 5) plugged into the back of the telescope “coax out” port, the units the meter provides are in mA, which has a 1:1 conversion to laser power in mW. If a triangle appears on the screen, units will be in µA or µW. If the IO Gain is configured, the power reading will need to be adjusted by that amount, according to Table 2.

Figure 5. Measuring laser power with the OPM-15 meter provided.

Power reported in Unisearch files: The units for "Signal Power" reported in the raw data files downloaded from the LasIR analyzer are in units of mW. If the signal gain is configured to have a multiplier, the reading will need to be divided with that multiplier (Table 2) in order to get the signal power in mW.

Power reported in TASDAcc files: The power reported in the TASDAcc files are pulled from the MODBUS data stream provided by the instrument. Table 2 shows how this power is related to laser power elsewhere in the system.

4.8 System Settings

In the LasIR instrument software, select File > Configure Analyzer. Select "Expert" on the upper right corner of the Configure Analyzer window. View the settings for H_2S, CO_2, and H_2O, and compare these settings with historical settings and provide any explanation for change. For a complete description of the settings and their typical ranges, consult the LasIRView software manual[2]. If you change any settings, document how the settings were changed in the instrument logbook present at the site. Note that all instrument settings are saved on the analyzer on a daily basis.

5. Flow-Through Response Test

The purpose of this procedure is to check the system for expected H_2S response under the installed operating conditions. H_2S standard reference gas is introduced into the optical path by means of a flow-through cell, meaning the entire sample path is included at the time of testing.

[2] Mackay, K., Chanda, A., Mackay, G. Software Manual: LasIRView2015, Application Software for LasIR Analyzers. Rev. 2015-10-01

The Unisearch analyzer enclosure comes equipped with a flow-through cell for use in response testing the LasIR units. This setup requires high-concentration compressed gases to flow through the analyzer. An alternate way to response-test the analyzers is to use sealed cells as described in **Section 6**.

5.1 Supplies

1. Nitrogen gas
2. H_2S reference gas blend
    - Note that the H_2S reference gas tank and as much of the gas lines as possible should be outside the shelter in the open air. All gas lines should be tested for leaks while filled with nitrogen gas.
3. 1/8″ PTFE tubing for the reference and purge gas lines into the quality assurance (QA) cell
4. 1/8″ PTFE Swagelok tee union to couple the reference and purge gas feed lines into the QA cell
5. 1/4″ PTFE tubing for gas flow lines on the outlet of the QA cell
6. Unisearch external 0.167-m flow cell
7. Acquire raw measurements as defined by the QAPP.
8. Length of PTFE tubing to go from external flow cell to scrubbing system
9. A scrubbing system consisting of ½″ ID PTFE tubing, 6″ long, filled with GC Sulfursorb Plus activated carbon absorbent, or equivalent; this volume of absorbent has a minimum capacity of 38 grams of H_2S, which is approximately 1,000 times the amount of H_2S existing in 750 ppm H_2S gas flowing at 0.3 l/min for 100 minutes
10. A max 5 l/min rotameter attached at the exhaust line to view that flow is occurring

5.2 Test Preparation

Depending on the requirements in the QAPP, the path-average concentration will need to be determined using the flow-through cell length, the concentration of standard gas, and the length of the open path. Note that because this is a monostatic system, the total optical pathlength is twice the distance between the telescope and the retroreflector. For example, a 750-ppm blend of H_2S (in nitrogen or air) delivered to the optical path through the 0.167-m flow-through cell and a total path length of 1,000 m provide an approximate 125-ppb path average concentration of H_2S. An example calculation of this is as follows:

$$(H_2S \text{ concentration in cylinder})\ (\text{flow cell length}) = \text{Path Integrated Concentration ppm-m}$$

$$(750 \text{ ppm})\ (0.167 \text{ m}) = 125.25 \text{ ppm-m}$$

Path Integrated Concentration divided by the total optical path length = Path Average Concentration (ppm)

125.25 ppm-m / 1,000 m = **0.125 ppm or 125 ppb H_2S**

5.3 Gas Testing Procedure

1. Flow nitrogen gas and perform an internal zero test with nitrogen. Gas delivery should be about 5-10 psi from the regulator/cylinder, at a flow rate of 0.25 to 0.5 L/min.
2. Assemble test configuration with the Unisearch short flow-through cell (0.167 m) in the path.
3. Assemble the H_2S gas scrubbing system, with gas flow coming from the external flow cell into the column packed with appropriate scrubbing media for H_2S (e.g., Sulfursorb Plus).
4. Flow nitrogen to a stable baseline, typically about five volumes of the cell. The flow of nitrogen can be verified by viewing the rotameter at the exhaust.
5. Monitor readings until a stable zero reading is reached.
6. Flow the H_2S reference gas. The H_2S should flow at 0.3 L/min.
7. Acquire replicated, raw time resolution measurements, as described in Section 7.
8. Verify that the values meet the QA criteria. If the test fails QA criteria, follow the corrective actions listed at the end of this section (see Section 7).
9. Stop the H_2S flow and flow nitrogen to purge the H_2S gas to a stable baseline, typically about five volumes of the cell.
10. Disconnect H_2S and nitrogen gases and remove the external flow cell to return the TDLAS system to open-path monitoring of ambient air.

5.3.1 Clean-Up

1. Dispose of the waste PTFE tube filled with GC Sulfursorb Plus appropriately.
2. Download the .cfg and .spectrum files and save them along with the form at the end of this document.

6. Sealed-Cell Response Testing

The purpose of this procedure is to check the system for the expected H_2S response under the installed operating conditions. H_2S standard reference gas is introduced into the optical path by means of a sealed cell, meaning the entire sample path is included at the time of testing.

Sealed cells filled with a known concentration of H_2S are used for response testing the LasIR analyzers. These sealed cells are fiber coupled and may be connected into the light path as indicated in Figure 1.

6.1 Test Preparation

To meet the testing requirements, you must determine the path average concentrations using the certified cell concentration and the pathlength. An example calculation of expected path average concentration for a 250 ppm-m sealed cell together with a 500 m one-way path is as follows:

$$Path\ Average\ Concentration = (\frac{250\ ppm - m}{(2 * 500\ m)})(\frac{1000\ ppb}{ppm}) = 250\ ppb$$

Prior to testing, you will need to ensure that the cells you have will satisfy the testing requirements of the QAPP.

6.2 Single-Point Bump Test

1. Disable alerts on Sonoma Technology Field Tech Tool (FTT) and put instrument into planned maintenance mode.
2. Disconnect the optical fiber from the instrument “Fiber In” port.
3. Connect the optical fiber from Step 2 to the sealed cell inlet.
4. Connect the optical fiber from the sealed cell outlet to the instrument “Fiber In” port.
5. Wait for response to stabilize before collecting data.
6. Acquire replicated, raw time resolution measurements as described in **Section 7**.
7. Calculate the average, %error, standard deviation, %CV, and average detection r. Record these values in the test form (**Section 9**).
8. **Verify that the values meet the QA criteria. If the test fails QA criteria, follow the corrective actions listed at the end of this section (see: Data Evaluation, Reporting, and Corrective Action).**
9. Disconnect the sealed cell outlet optical fiber from the instrument and reconnect the optical fiber from Step 2 to the instrument “Fiber In” port.
10. Verify the instrument baseline and turn alerts back on in FTT. Take the instrument out of planned maintenance mode.
11. Download .cfg and .spectrum files and save along with the form in **Section 9**.

6.3 Three-Point Calibration

1. For the three-point calibration test, repeat the measurements described in Section 6.1 for the remaining concentrations using additional sealed cells.
2. Plot a curve of measured concentration vs. expected concentration. Then record the r^2, slope, and intercept.
3. Download .cfg and .spectrum files and save along with the form at the end of this document.

7. Data Evaluation, Reporting, and Corrective Action

During these tests, a number (N) of replicated, raw time resolution measurements (x_i) of a standard reference material of known magnitude (x_{std}) will be measured. Here, an acceptable number of trials will be defined as 7 ≤ N ≤ 15. For purposes of this SOP, a "trial" is considered one raw concentration value that is reported at the interval specified by the instrument. The average value of these measurements is calculated as:

$$\bar{x} = \frac{\sum_i x_i}{N} \quad (1)$$

and the sample standard deviation (σ) as:

$$\sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{N-1}}. \quad (2)$$

From these definitions, %error is defined as:

$$\%error = \left|\frac{\bar{x} - x_{std}}{x_{std}}\right| \times 100\% \quad (3)$$

and precision as the coefficient of variation expressed as a percentage (%CV):

$$Precision \equiv \%CV = \frac{\sigma}{\bar{x}} \times 100\% \quad (4)$$

Calculate the concentration.

- Average the concentration of "N" stable measurements.
- Report the %error between the average and the certified value. The acceptable %error is listed in the QAPP.

  Note: To calculate the certified value that will be seen on the TDLAS from the actual certified instrument calibration gas concentration, you multiply the certified gas concentration by the calibration cell length (0.167 meters) and divide that answer by the path length set in the instrument software. For all TDLAS instruments in operation by Sonoma Technology, the path length is set to 2 meters.

Calculate the Limits of Detection and Quantitation.

- Calculate the mean (average), sample standard deviation, and %error (sometimes also referred to as %difference) of the selected results.
- Report the Detection Limit as two times the standard deviation.
- Report the Quantitation Limit as equal to the detection limit.[3]

Compile all configuration files, spectra files, and log files into a single folder in the maintenance folder for the project on Sonoma Technology's shared drive.

- The folder should be named "CUS LOC QATest TDL# YearMonDy" where CUS is a 3-letter designator for the customer and LOC is a three-letter designator for the facility location.

The QAPP contains the acceptance criteria to be used for the test.

Note:

- **If the test produces an error or precision greater than the warning level**: the test is considered passing if below the acceptance criteria, but corrective action should be taken so that the precision and error are below the warning levels.
- **If the test produces an error or precision greater than the acceptance criteria**: the test is not considered passing and corrective action should be taken so that the precision and error are below the warning levels. Equipment will not be placed into service (taken out of "maintenance mode") until it meets all measurement criteria.

If the measurements do not meet the data quality objectives listed in the QAPP, repeat the procedure without adjustment. If the instrument still fails to meet the QA criteria, retest the following day with no adjustment. Confirm that atmospheric conditions were acceptable for bump testing. If these repeated tests continue to fail under acceptable atmospheric conditions, initiate corrective action to include the following:

- Realign the system and perform the test again.
- Review data for potential interferants, including a detailed check of absorbance spectra in the analysis regions configured for the analyte, noting any excessive noise or unexpected absorbance features.
- Consult with the project technical lead to identify abnormal changes to the background.
- Examine wavelength calibration.
- Investigate any large changes in stray light since the last test and adjust calibration factors as necessary.
- Review gas testing apparatus for leaks or other similar problems.

[3] In accordance with guidance from BAAQMD in their letters to refineries dated December 22, 2022, and in subsequent statements that the December 2022 specification (requiring LOQ of 3-25 ppb) was not a significant change from – and was no more stringent than – the October 2021 specification (which required a detection limit of 3-25 ppb).

- Review and confirm specifications of standard calibration equipment and gases (expiration dates, concentrations, etc.)

In the event of a failed test after following all steps outlined above, inform the Sonoma Technology Project Manager and Quality Assurance Manager, who will review the instrument performance parameters in the list above.

If all parameters indicate that the instrument was performing properly since the last test, data since the last test will be flagged as suspect. If an issue with the instrument is identified, data since the date and time of the instrument issue will be flagged as invalid. All data flagging will be performed by Data Analysts in consultation with the Quality Assurance Manager.

8. Maintenance Task Checklist

File this checklist, along with other maintenance documents, in the "maintenance" folder in the main project folder on Sonoma Technology's shared drive.

Activity	SOP Section(s)	Complete?
Visually inspect the system. Inspect electrical and optical cables for wear.	4.2	
Inspect optics and clean if necessary	4.3, 4.4	
Check the alignment to verify there has not been significant physical movement; note that this is automatically monitored as well	4.5	
Download data from detector hard drive and delete old files to free space, if needed	4.6	
Ensure there are no obstructions in the beam path	4.7	
Review and test light and signal levels	4.7	
Verify system settings	4.8	
Perform bump test and take corrective action as needed	5 (flow-through) 6 (sealed cell)	
3-point calibration check	5 (flow-through) 6 (sealed cell)	

9. LasIR Response Test Form

Technician(s): ____________________________ Date: ___________________________________

Site Name: ______________________________ Pathlength: ____________________________________

Reference ID: ____________________________ Reference Cylinder Concentration (ppm):____________

Test Cell Pathlength (m): __________________ Path Average Concentration (ppb):__________

Return Power (mW): _____________________ %Transmission: __________________________

Replicate	Time	Analyzer Concentration (ppm)	Concentration (ppb)	Correlation
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
Average				
Standard Deviation				

%Error: ________________ **%CV:** ___________________

Signature: ____

Notes:

10. Visual Inspection Checklist

- ❒ Note and clean any excessive dust buildup on the equipment or analyzers.
- ❒ Eliminate any pests from the sample site, including birds, spiders, rodents, etc.
- ❒ Note the condition of the analyzer cabinet internals.
- ❒ Inspect wiring and note and correct any corrosion or cracking insulation.
- ❒ Check HVAC for proper operation by checking for cool air and reviewing cabinet temperature records (if available).
- ❒ Check for corrosion, note anything that needs to be addressed.
- ❒ Note and mitigate any condensation or water issues that may adversely affect equipment.
- ❒ Check for door operation.
- ❒ Note anything that may result in eventual degradation of the LasIR system.

Notes:

Belfort Model 6400 Visibility Sensor Maintenance and Audit Standard Operating Procedure

October 31, 2024

STI-6991

APPROVED:

Sonoma Technology date

Fenceline Monitoring Refinery Representative date

Contents

Summary

This document describes the steps necessary to calibrate and maintain the Belfort Instrument Visibility Sensor Model 6400. The procedure is intended to verify that the equipment is performing to expectations and the detection and communication links are functioning correctly. Hard copies of this procedure and associated audit forms will be kept on site. Upon completion of the audit procedure, a copy of the audit form showing the results will be sent to the Refinery Project Manager.

Safety

Work should conform to manufacturer guidance and site health and safety practices. Standard refinery personal protective equipment (PPE) should be worn at all times, including laser safety glasses with side shields, a hard hat, goggles, steel-toed boots, hearing protection, fire-retardant clothing (FRC), an H_2S monitor, and appropriate gloves that are adequate for this procedure.

Personnel Qualifications

Installing, operating, and servicing Belfort visibility sensors should only be performed by personnel who are trained in the operation of the system components and are familiar with handling the testing equipment. These procedures should not be performed by personnel who do not understand the system, technology, or hazards of the materials involved.

General Maintenance

Belfort Instrument Company suggests conducting the initial visibility sensor maintenance three months after installation. The technician will need to adjust this time frame based on the individual site environment where the instrument is installed. Factors may include but are not limited to insects at the site, weather conditions, dust, blowing debris, and deposits from water spray. **Table 1** provides a schedule of maintenance activities for the sensor.

The technician should periodically inspect the sensor for dirt, spider webs, bird nests, and other obstructions. When necessary, carefully clean the protective glass windows in the Receiver and Transmitter with a commercially available glass cleaner. When maintenance is complete, the maintenance forms on page 8 of this document should be saved in the maintenance folder for the project located on Sonoma Technology's shared drive.

There are no user serviceable components in the sensor. Should a failure occur, return the sensor to Belfort Instrument for repair. Data will be flagged in a manner consistent with the QAPP if there are issues that cannot be immediately corrected. In the case of extended down time, the sensor should be replaced with a working sensor.

Table 1. Schedule of maintenance activities for the Belfort Model 6400 Visibility Sensor.

Activity	Monthly	Annually
Visually inspect the system, including all cables.	✓	
Inspect optics on detector and clean if necessary.	✓	
Check calibration.		✓

Contact Belfort Instruments or Sonoma Technology to receive a digital copy of the user manual.

Prepare for Calibration

Before beginning the calibration, make sure you have these materials:

- Serial cable with hook or alligator clips
- Opaque filter
- Scatter plate
- Laptop with terminal emulator

If the calibration is being performed in the field, select a clear day with low wind speeds (less than 10 knots). Fog will also affect calibration results, so choose a day that isn't foggy. For calibration to be valid, visibility must be at least 1 mile. The sensor needs to have been powered on for at least 45 minutes before beginning calibration. Check that the sensor windows are clean and clear of any noticeable dirt, spider webs, or other obstructions before getting started.

The technician will need to set up a serial connection with the sensor, perform a zero calibration, and complete a span calibration (in that order).

Set Up the Serial Connection

1. Disconnect the three serial wires connected to the CR310 data logger's terminals and reconnect them to the serial cable with hooks (or alligator clips). Note: the red wire is RX, the brown wire is TX, and the bare wire is the ground. Next, connect the serial cable to a laptop.
2. Use **Device Manager** to check the com port you are connected to under the **Ports** section.
3. Open a terminal emulator, such as **Tera Term**, and set it to the com port you have connected to. Make sure the serial settings match that of the Belfort 6400 (baud rate 9600, 8 bit, no parity, 1 stop bit, no flow control).
4. Test the connection by typing the **FL** command into the terminal without pressing Enter. Immediately, a list of values should be returned similar to this:

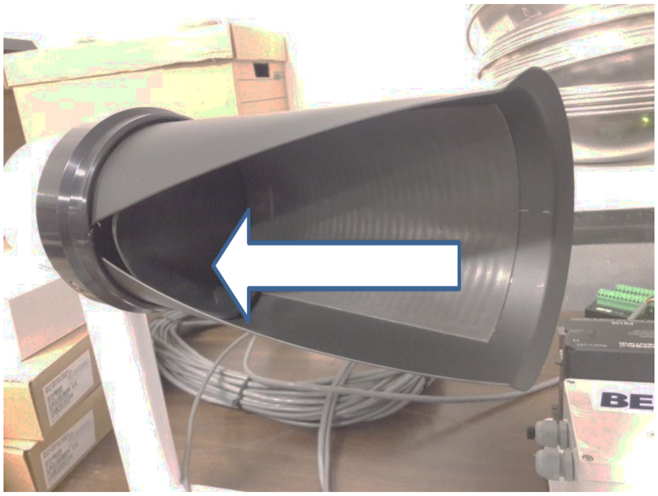
   P,00223, 1, 0.19333965, 40.33408642, 1.45484,Mi, 1.281314 0000

If nothing is returned, try swapping the red and brown wires. If it still doesn't work, check the serial settings to make sure they are correct.

5. Before the calibration commands can be entered, the terminal must be given super user privilege. Hold down the **Ctrl** key and press the **V** key. Then type in the password (which can be provided by the Field Staff Manager) and press **Enter**. You should see the message, "Password accepted, Operator is now Super User." To stop being a super user at any time, press **Ctrl-V** and then **Enter** again without entering the password. Turning the sensor off and on will also end super user status. **DO NOT USE ANY COMMANDS NOT STATED IN THIS SOP WHILE IN SUPER USER MODE**. Doing so could compromise the sensor's functionality.

Zero Calibration

1. Push the black foam opaque filter into the receiver hood, which is the hood on the left when facing the front of the sensor (see **Figure 1**). You are facing the front when you can see the "Belfort" logo on the device. Make sure the filter is completely blocking the receiver window. *Warning:* the hood might be hot to the touch if the heaters are on.
2. In the terminal emulator, enter the command **FZ**. The sensor will ask for verification before starting the calibration routine. Type the letter **Y** to accept (or **Esc** to abort).
3. The zero calibration routine will run for 3 minutes, allowing the sensor to reach a stable zero state, after which it will run for 2 more minutes while taking an average of the zero offset.
4. At the end of the zero calibration routine, the operator will be prompted to accept the new zero offset value. If the operator does not respond within 3 minutes, the sensor aborts the calibration (discarding the value generated). After accepting the new value, record it along with the previous value in eSIMS or a laboratory/field notebook.
5. Do not forget to remove the opaque filter after doing the zero calibration, as failure to do so will result in constant high visibility readings regardless of actual conditions.



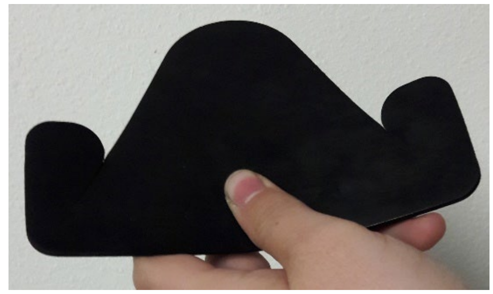


Figure 1. Inserting the opaque filter.

Span Calibration

1. Make sure the opaque filter has been removed from the receiver hood. Check the scatter plate for smudges and scratches. Clean off any smudges with a commercial glass cleaner (**do not use harsh solvents, as they will melt the plastic on the scatter plate**). If the scatter plate is badly scratched, contact the manufacturer before use.

2. Carefully hang the scatter plate on the sensor by hooking the top bracket over the top of the sensor's cross arm. Center the scatter plate on the cross arm an equal distance from the edge of each hood to the plate. Make sure the plate is secure and not swinging or rotating on the sensor's cross arm (see **Figure 2**).

3. In the terminal emulator, enter the command **FN**. A list of configuration parameters will be returned. Verify that the value of **Cal_ExtCo** (Calibration Extinction Coefficient) is equal to the value marked on the scatter plate's label. If they do not match, enter the command **FC**. A similar list of parameters will appear, followed by a prompt to change them. The prompt will go through each parameter one by one. Press **Enter** to go to the next parameter until you reach the **Cal_ExtCo** parameter. Enter the value found on the scatter plate's label and press **Enter**. Then press **Esc**. **DO NOT CHANGE ANY OTHER PARAMETERS**. Doing so could compromise the sensor's functionality.

4. Enter the **FS** command. When the sensor asks for verification before starting the calibration routine, type the letter **Y** to accept (or **Esc** to abort).

5. The span calibration routine will run for 3 minutes, allowing the sensor to reach a stable span state, after which it will run for 2 more minutes making periodic adjustments to the slope as it attempts to minimize the error.

6. At the end of the span calibration routine, the operator will be prompted to accept the new span factor value. If the operator does not respond within 3 minutes, the sensor aborts the

calibration (discarding the value generated). After accepting the new value, record it along with the previous value in eSIMS or a laboratory/field notebook.

7. Do not forget to remove the scatter plate from the sensor and carefully put it away in a safe place.
8. Record the procedure details, results, date, operator name, etc., in eSIMS or a laboratory notebook.

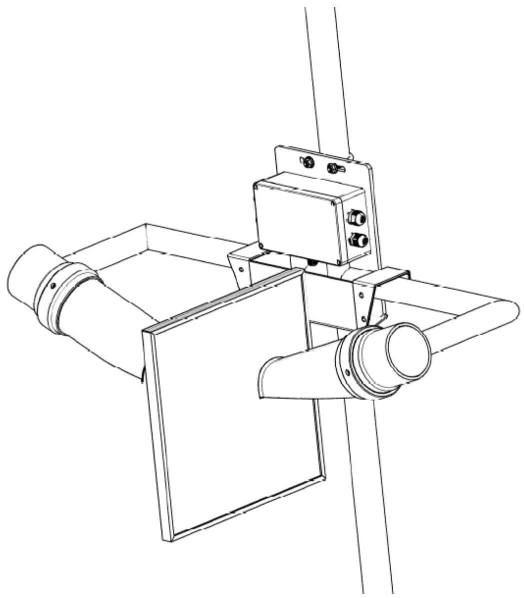


Figure 2. Scatter plate mounting.

Completing the Process

1. Disconnect the serial cable from the laptop, disconnect the Belfort 6400's three serial wires from the cable, and reconnect them to the CR310 data logger. The red wire goes to the **C1** terminal of the CR310, the brown wire goes to the **C2** terminal, and the bare wire goes to the **G** terminal.
2. Connect to the CR310 through Loggernet (either via a micro-USB cable connected to a field laptop or via the DMZ server connection) and check to see if values are coming in and if they make sense. Note: the values might initially be lower than expected, so wait 5 to 10 minutes for the sensor to adjust.

Belfort Model 6400 Visibility Sensor Audit Record

DATE:_______________ Location: ____________________________

Test Technician 1 :_________________________
Test Technician 2 :_________________________

Zero State Calibration

Start Time: __________________________________

Previous Zero Offset: _________________________

New Zero Offset: _____________________________

Stop Time: ___________________________________

Notes:

Span Calibration

Start Time: ___________________________

Scatter Plate ExCo: ____________________

Span Factor: _________________________

New Span Factor: ______________________

Stop Time: ___________________________

Notes:

Standard Operating Procedure for Data Verification and Validation

October 31, 2024

STI-7982

APPROVED:

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Sonoma Technology date

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Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Application

This standard operating procedure (SOP) describes the verification and validation of fenceline monitoring data, including daily checks and quarterly analyses. Additional information is provided in the corresponding air monitoring plan (AMP) and Section D.2 of the quality assurance project plan (QAPP).

2. Introduction and Overview

At all fenceline monitoring sites, a Data Acquisition System (DAS), or data logger, performs basic quality control (QC), averages data to 5-min resolution, and aggregates data into a desired file format. Data are then transmitted from each sampling site to a cloud-based file storage service via cellular modem, where they are stored and available for retrieval as needed. Data from the cloud are ingested into Sonoma Technology's Insight© data management system (DMS), where a robust automated QC (AutoQC) logic and subsequent DMS-level screening checks assign data flags in real time based on instrument diagnostics, local meteorological measurements, and concentrations of target compounds. Data are stored within the DMS and any changes to data are recorded via chain-of-custody logs. These preliminary data are displayed on the public website within 10–15 minutes of raw data collection.

Data are reviewed daily by air quality data analysts to assess system operations, confirm the automated data flagging is correct, and ensure any corrections to data flagging are propagated to the public website immediately. Extended analyses are performed every calendar quarter and reviewed by the project Quality Assurance (QA) Manager. Figure 1 illustrates the general data flow and QC schematic.

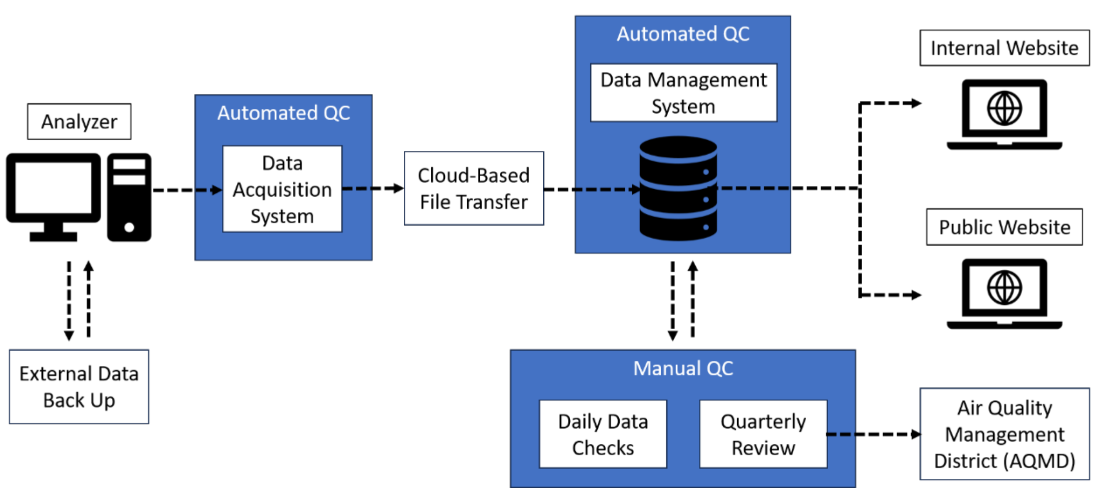

Figure 1. Data flow and QC schematic.

3. Definitions

Data verification is a process of comparing how the data were gathered with the procedures established by the project QAPP and SOPs. It is a data review technique that evaluates the conformance of data collection practices with established methods, procedures, or specifications. Data verification consists of checking that SOPs were followed and that the QC activities were performed.[1]

Data validation is a process of confirming that reported values meet the quality objectives of the project. It is a data review technique that examines whether the particular requirements for a specific, intended use are fulfilled. Data validation examines whether acceptance criteria outlined in the QAPP were achieved.[1]

Acceptance criteria are the defined performance criteria for the project that data must meet to be considered acceptable for reporting. Additional information regarding acceptance criteria is provided in Section A.7 of the QAPP.

Data flags are assigned to each data point based on instrument diagnostics and local meteorological measurements. Within the Sonoma Technology Insight DMS, data flags are composed of QC and operational (OP) codes. Additional information regarding data flags is provided in Section D.2 of the QAPP.

The **minimum detection limit (MDL)** is the lowest concentration of each parameter that can be measured by each analyzer at each sampling path. Additional information regarding MDLs is provided in Section B.2 of the QAPP.

Spectral data refers to the individual absorbance spectra collected at each open-path monitoring site. The analytic software evaluates raw spectral data in real time to report concentration data, and can be reviewed if data-validation efforts identify potential issues that require investigation. Additional information regarding spectral data is provided in Section B.10 of the QAPP.

A **spectral match parameter** is used to identify parameters of interest and potential interferences present with open-path sampling. Spectral subtraction is used in cases with overlapping absorbance features, and the subtraction technique is proprietary to the instrument manufacturer. Additional information regarding spectral match parameters is provided in Section B.2 of the QAPP.

4. Safe Work, Hazard Identification, and Training for Data Review

Data verification and validation is performed remotely in an office environment away from field sampling sites. Common office hazards include slips and trips, sprains and strains, poor workstation

[1] EPA Quality Assurance Handbook Vol II, https://www.epa.gov/sites/default/files/2020-10/documents/final_handbook_document_1_17.pdf.

ergonomics, indoor air-quality problems, insufficient or excessive lighting, noise, and electrical hazards. These hazards are identified and mitigated through safety walkthroughs, formal reporting of unsafe conditions, and regular training sessions on correcting safety hazards.

Training for data review is conducted by senior staff with at least one year of experience with refinery fenceline monitoring systems, as well as analyzer manufacturers. Project personnel are provided copies of the QAPP and SOPs, and receive updated versions when available. Initial training is provided prior to personnel performing work, and refresher trainings are conducted on an annual basis. The QA Manager will identify specific training requirements for all project personnel and will determine when trainees are qualified to work independently. Training records will be maintained by the Field Staff Manager.

5. Data Review and Quality Control

Data for the fenceline monitoring network appears on both public and internal websites (see Figure 1 in Section 2). The internal website allows for detailed QC and flagging of the data, which are checked daily and finalized quarterly as outlined in Section D.2 of the QAPP. The following text describes how to perform daily and quarterly data verification and validation.

5.1 Daily Checks

Data are manually reviewed on a daily basis by qualified analysts. An internal, non-public field operations website (Sonoma Technology's Insight DMS) is used for customized data queries and visualizations, and the public-facing website is reviewed to ensure the real-time display is current and accurate. Instrument performance issues or data gaps are escalated to the field operations team, and the Project Manager determines the appropriate actions to resolve issues in a timely manner.

Data analysts are qualified to perform daily checks after a training period of at least two weeks. Training includes education on monitoring rules and requirements, instrumentation, automated QC processing, expected concentration ranges, diagnostic thresholds, and internal procedures to escalate a data issue. Trainees shadow an experienced data analyst during daily checks for a week, and are then overseen by an experienced analyst while they perform their first week of data checks.

This daily data review allows the analyst to visualize fenceline concentrations and instrument diagnostics, thereby identifying potential instrument performance issues and confirming the current operational status of the network. Instances of missing or invalid data, instrument signal strength below defined thresholds, repeated (stuck) data values, rapid changes (spikes or dips) in data values, or negative concentrations are recorded in a spreadsheet that tracks observations across a calendar quarter. This form provides a template for data analysts to check relevant parameters against acceptance criteria and commonly expected values for routine reference. Daily data check spreadsheets from past quarters are maintained in an archive with other project documentation.

The following procedure details the daily data check for an individual monitoring network:

1. Log in to the Sonoma Technology Insight DMS with the facility-specific credentials for the check being performed. Credentials are stored in a secure password management software.
2. Navigate to the Dashboard, which contains configurable widgets showing time series plots of relevant parameters.
3. Record any periods of **missing data** and verify that (1) missing data alerts were sent and (2) resolution is being pursued by the field operations team. If this cannot be verified, escalate the finding to the Project Manager.
4. Review any **detection events** and confirm the validity determination made by the after-hours on-call team through review of instrument diagnostic parameters and spectral validation (see Section 5.3 of this SOP).
5. Review recent **visibility measurements** and note any periods with visibility <2.5 miles on the spreadsheet.
    a. Periods with visibility <2.5 miles may impact the performance of open-path analyzers and often correlate with observations of invalid data at multiple sampling paths.
6. Check that the **meteorological instrumentation** is functional and that measured values are within reason (e.g., directional measurements are between 0–360 degrees, speeds generally match local weather conditions). Record any instances of missing or abnormal meteorological measurements in the daily observation spreadsheet and escalate to the field operations team.
7. Compare the current **open-path analyzer diagnostic parameters** to the acceptance criteria (see Section A.7 of the QAPP) to assess the operational status of the monitoring network.
    a. Periods with diagnostic parameters (e.g., signal strength, integration time) outside of acceptance criteria will result in invalid data and may result from open-path analyzer misalignment. Record these periods in the spreadsheet and escalate to the field operations team for necessary site visits.
8. Because data flagging for each compound is determined by the analyzer diagnostic parameters, review one **representative compound concentration time series** for each analyzer at each sampling site, and note the following information:
    a. Any periods of missing or invalid data.
    b. Any periods of data flagged for additional review (i.e. automated checks for range, rate-of-change, and sticking).
    c. For periods where data were flagged as invalid due to environmental conditions, confirm that (1) analyzer diagnostic parameters are outside of acceptance criteria, and (2) visibility is <2.5 miles.

d. Any QC and OP codes that are inconsistent with the expected values, based on analyzer diagnostic parameters.

e. Instances of apparent baseline drift.

f. Reported concentrations (valid data) not within the specified range for each compound.

    i. Verify that concentration patterns are reasonable with respect to the time of day, season, and current meteorological conditions, and whether they correlate across multiple sampling sites. This check is for information purposes only and should not itself result in invalidation of data

    ii. Verify that concentrations are within the limits of what can be measured by the instrument.

9. Perform any edits to QC and OP codes to reflect the findings of the daily data check. Additional information regarding propagation of these changes to the public website is provided in Section D.3 of the QAPP.

    a. Changes to **concentration values** are extremely infrequent and should only be made if a problem with the analytical concentration determination or the averaging scheme is discovered. Changes to QC and OP codes are often sufficient to correctly reflect data quality.

    b. Changes to **QC and OP codes** are infrequent, and are only made if a clear reason to do so is discovered.

        i. For example, invalidate data if there was a violation of the acceptance criteria that was not captured by AutoQC logic.

        ii. Similarly, validate data that was flagged for additional review if it meets acceptance criteria.

    c. All edits to data and data quality flags are captured by chain-of-custody logs within the DMS.

10. Verify detection events with elevated concentrations (>5–10 times the MDL) by performing spectral validation according to Section 5.3 of this SOP.

11. Navigate to the public website for the facility, review the 5-min time series plot for each individual compound, and verify that:

    a. Data displayed on the public site matches the data viewed in the non-public data review website (Sonoma Technology's Insight DMS). Note any discrepancies in the spreadsheet and escalate to the Project Manager.

    b. Periods of missing or invalid data are correctly reflected on the public website.

    c. Detection events are correctly reflected on the public website, where suspect/questionable data flags are not shown for legitimate detection events.

12. Report any observed anomalies to the field operations team and Project Manager, and update the daily data check spreadsheet in the project documentation archive. Additional information regarding project documentation is provided in Section A.9 of the QAPP.

Typical observations for common compounds are shown in **Table 1**. The full list of measured compounds is provided in Section A.5 of the QAPP.

Table 1. Typical observations for select compounds monitored under BAAQMD Rule 12-15.

Parameter	Observational Notes
Visibility	The maximum value measured by the sensor is 30 miles. Values <10 miles may affect instrument performance, and values <2.5 miles may result in invalid data due to environmental conditions if analyzer diagnostics are also not within acceptance criteria.
Integration Time	This parameter is commonly between 20–250 ms for most sampling sites. Values stuck at 300 ms should be recorded and escalated to the field operations team. A pattern of elevated integration time and low signal strength can indicate poor instrument alignment. This parameter should be anticorrelated with visibility during fog events.
Signal Strength	This parameter is commonly >70%. A pattern of elevated integration time and low signal strength can indicate poor instrument alignment.
Winds	Wind speeds are typically 1-20 mph, and wind direction should generally follow expected patterns due to local terrain (e.g., sea and land breezes along the coast).
Benzene	This parameter is typically below the detection limit of the instrument.
Toluene	This parameter is typically below the detection limit of the instrument.
Ethylbenzene	This parameter is typically below the detection limit of the instrument.
o-xylene	This parameter is typically below the detection limit of the instrument.
m-xylene	This parameter is typically below the detection limit of the instrument.
p-xylene	This parameter is typically below the detection limit of the instrument.
SO_2	This parameter is typically below the detection limit of the instrument, but ambient background concentration are detected occasionally.
H_2S	This parameter is typically below the detection limit of the instrument.

5.2 Quarterly Validation

Quarterly validation is performed after each calendar quarter to ensure quality and in accordance with BAAQMD Rule 12-15 requirements. The 5-min resolution data for all relevant parameters are exported from the Sonoma Technology Insight DMS and imported into an R analysis workbook. Here, analysts perform additional analyses, visualizations, and assessments to verify AutoQC, confirm determinations made during daily data checks, and perform completeness calculations (see Section A.7 of the QAPP).

Data analysts are qualified to perform quarterly analysis after a training period of at least three months. Training includes the daily data check steps outlined in Section 5.1, experience conducting daily data checks for a period of three months, and shadowing an experienced data analyst during at least one complete quarterly analysis process. The trainee's work is reviewed by the experienced analyst while they perform their first round of quarterly analysis, and they are released for independent work during their second round.

The following procedure details the quarterly analysis process for an individual monitoring network:

1. Log in to the Sonoma Technology Insight DMS with the facility-specific credentials for the check being performed. Credentials are stored in a secure password management software.
2. Navigate to the Data Export page, where configurable export queries can be programmed and executed. Export all relevant parameters collected during the quarter as ".csv" files.
3. Import these exported data files into an R workspace using the most recent quarterly analysis script(s), maintained in the Sonoma Technology Bitbucket code repository.
4. Execute the quarterly analysis script(s), which performs the following tasks:
    a. Assign data flags using the same AutoQC logic as real-time data flagging (see Sections B.10 and D.2 of the QAPP).
    b. Flag negative outliers as invalid, using "–3 x MDL" as the threshold for comparison.
    c. Generate a series of output tables, figures, and ".csv" files for additional review.
5. Review the quarterly data set in detail. Note that findings pertaining to missing or invalid data are usually identified and corrected during the quarter, meaning the quarterly analysis process is commonly a redundant check on previously identified issues and resolutions. Any new findings identified during quarterly analysis must be escalated to the Project Manager for investigation, and proposed resolutions must be approved by the QA Manager.
    a. If >5% of diagnostic parameters (signal strength, integration time, spectral match) are missing, escalate the finding to the Project Manager for additional investigation.
    b. If >25% of missing or invalid data are associated with one analyzer or sampling site, escalate the finding to the Project Manager for additional investigation.

c. If concentration data were collected but coincident diagnostic information was missing or outside of the expected range, AutoQC determinations are manually inspected to ensure accurate data flagging.

   i. If visibility data are missing during a period of invalid concentration data, manual data review confirms that concentration data **are not** flagged as "invalid due to environmental conditions." In the absence of visibility data to confirm low-visibility conditions, data count against completeness (see Section A.7 of the QAPP).

   ii. If instrument diagnostic parameters are missing but concentration data are reported, a malfunction of the analyzer software (which reports both fields simultaneously) has occurred and data are flagged as invalid.

   iii. If spectral match parameters are reported outside of the expected range (e.g. <0 or >100 for percent match), a malfunction of the data acquisition script has occurred and data are flagged as invalid.

d. Review periods where visibility data is <2.5 miles, ensuring that **only** concentration data with diagnostic parameters outside of acceptance criteria are flagged as "invalid due to environmental conditions" and are not counted against completeness.

e. Review periods of invalid or missing data lasting longer than two hours and escalate findings to the Project Manager. Create null records in the place of missing data according to Section C.2 of the QAPP.

f. Review periods of planned and unplanned maintenance and compare them to field logbooks and maintenance records. Ensure that routine maintenance was performed as scheduled, logs reflect a sufficient level of detail, and all bump tests results are within acceptance criteria.

   i. Any failed bump tests should have been followed by additional maintenance and retesting as outlined in the individual instrument SOPs.

   ii. Maintenance logs may explain data anomalies and justify adjustments to QC and OP Codes, following discussion with the Project Manager.

g. If applicable, review any suspect/questionable data for which investigation was not performed and QC and OP codes were not adjusted during the daily data checks. Adjust QC and OP codes according to Section D.2 of the QAPP and escalate the finding(s) to the Project Manager.

h. Review any and all changes to QC and OP codes, including their justification, with the Project Manager.

6. Assess the data reasonableness through statistical analyses, review of exceptional conditions off-refinery, and comparisons to outside data.

a. For all sampling sites and parameters, calculate the monthly and quarterly 5-min concentration mean, standard deviation, and minimum and maximum values. Non-detections are assigned a value of "0 ppb" for statistical analysis.

   i. Compare observations to previous quarters and typical observations (Table 1) and escalate any anomalies to the Project Manager.

   ii. Confirm that known detection events observed during the quarter are correctly reflected in the calculated monthly and quarterly maxima.

   iii. Verify that the calculated monthly and quarterly minima are > "–3 x MDL," and escalate the finding of any negative outliers to the Project Manager.

b. In the event of anomalous data, review exceptional conditions off-refinery in conjunction with meteorological data to assess potential impacts to fenceline measurements. Data should not be invalidated based on the potential emission source being identified as off refinery property.

c. In the event of anomalous data, retrieve available outside data sources for comparison according to Section B.9 of the QAPP.

7. Review any detection events and periods where reported concentrations are >5–10 times the MDL, according to Section 5.3 of this SOP.

8. For all sites and compounds, calculate data completeness according to Section A.7 of the QAPP.

   a. Review the resulting completeness tables and compare against logbooks and maintenance logs.

   b. Escalate findings of data completeness <95% to the Project Manager for additional investigation.

9. For all sites and compounds, manually calculate the rolling hourly average data from quality-controlled 5-min data, following the same logic used in real-time by the public website.

   a. Investigate the cause of any discrepancies between hourly values reported on the website and hourly values calculated during quarterly analysis, and escalate findings to the Project Manager.

5.3 Spectral Validation

Measurements made in real time by open-path analyzers can be replicated with manufacturer-provided data processing software. This enables analysts to visualize and confirm each real-time analytic determination made by the analyzer during daily and quarterly analysis, to ensure data accuracy and quality.

The following procedure details the spectral validation process:

1. Retrieve the relevant (raw) data files from the analyzer of interest, which correspond to the event requiring spectral validation.
    a. This consists of:
        i. The daily data summary file corresponding to the day of interest.
        ii. Individual absorbance spectra (including applicable background spectra) corresponding to the time period of interest.
        iii. Instrument libraries from the analyzer of interest.
        iv. The analytic software configuration file from the analyzer of interest.
2. Open the manufacturer-provided data processing software and adjust the analysis parameters to match the configuration file retrieved from the analyzer of interest.
3. Where applicable, load the instrument libraries and verify that the available compounds match the expected values for the monitoring network.
4. Since this is a differential measurement, concentrations are reported by comparing observations in detection to observations of clean air. Examine the daily data summary file from the date and time period of interest to determine which individual absorbance spectra are of interest, and (where applicable) which dynamic background was loaded for each absorbance spectrum.
5. Load the applicable background and absorbance spectra. The software will automatically duplicate the analysis, according to the configuration parameters (see Step 2 above), and generate a differential absorbance spectrum overlaid with the applicable instrument library.
6. Select the compound of interest and visually inspect the plot, confirming the curve fitting to the library reference spectrum, and associated spectral match determination relative to the programmed analysis regions.
7. Report any discrepancies or incorrect peak fits to the Project Manager for additional investigation.

5.4 Quality Assurance Management

Following the completion of quarterly analysis, the QA Analyst completes an independent review of post-QC quarterly data sets. This independent review is conducted on a representative sub-set of data using similar methods to those described in Section 5.2 of this SOP. Data are reviewed without input from the data analyst who prepared the post-QC quarterly data set.

Findings of the independent review are compared to those of the quarterly analysis in a joint meeting between the Data Analyst, QA Analyst, and QA Manager. The QA Manager conducts an informal interview process to ensure that quarterly analysis was conducted according to the QAPP, and that field documentation reflects the procedures outlined by the QAPP. New findings or deviations are reported to the Project Manager by the QA Manager for additional investigation, and any necessary resolutions must be approved by the QA Manager before quarterly data are submitted (see Section C.2 of the QAPP).

6. Public Website Display

Data is displayed on the public website according to the data flags (QC and OP codes) for each record. Data flags are assigned by the AutoQC logic and further evaluated according to Section D.2 of the QAPP. Display behavior is the same for both 5-min data and rolling hourly average data.

Valid detections (e.g. QC=0, OP=0) are shown on the website (**Figure 2**). Concentrations are reported as recorded by the analyzer, with numeric values shown in the time series detail panel (left), the map detail panel (middle), and the map marker (right). For valid detections with concentrations below the MDL (e.g. QC=0, OP=17), numeric values are shown but data are flagged as "<MDL." For hourly data only, the outer ring of the map marker visualizes the concentration relative to an hourly threshold, with green indicating values below the threshold and orange indicating values above the threshold.

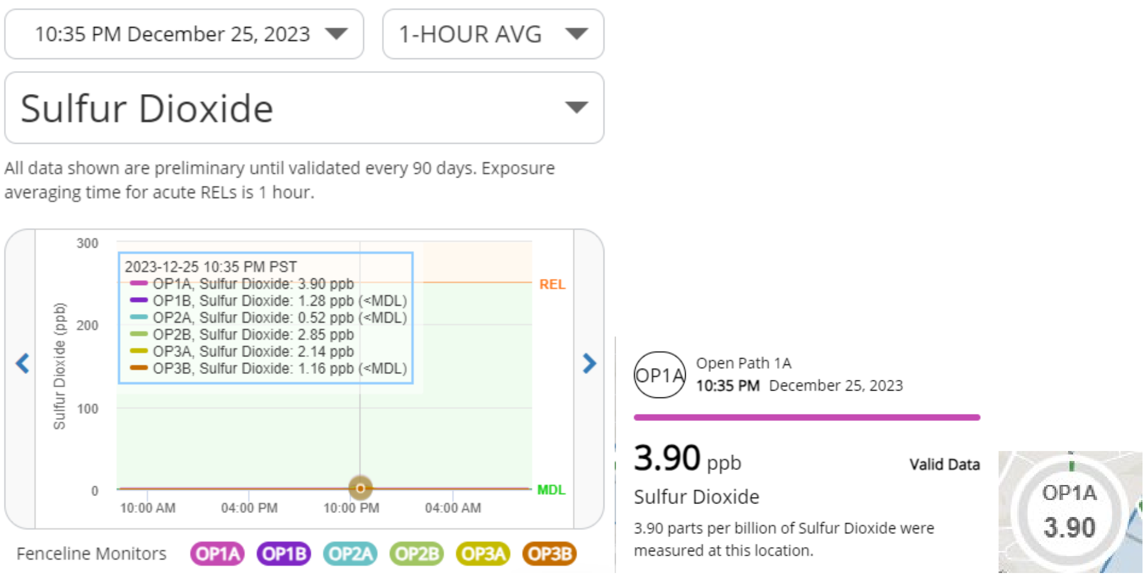

Figure 2: Example of valid detections as displayed on the public website.

Valid non-detections (e.g. QC=0, OP=74) are shown on the website (**Figure 3**). Concentrations are reported as "0 ppb" on the time series detail panel (left) according to Section D.2 of the QAPP. On the map detail panel (middle) and map marker (right), valid non-detections are flagged as "<MDL."

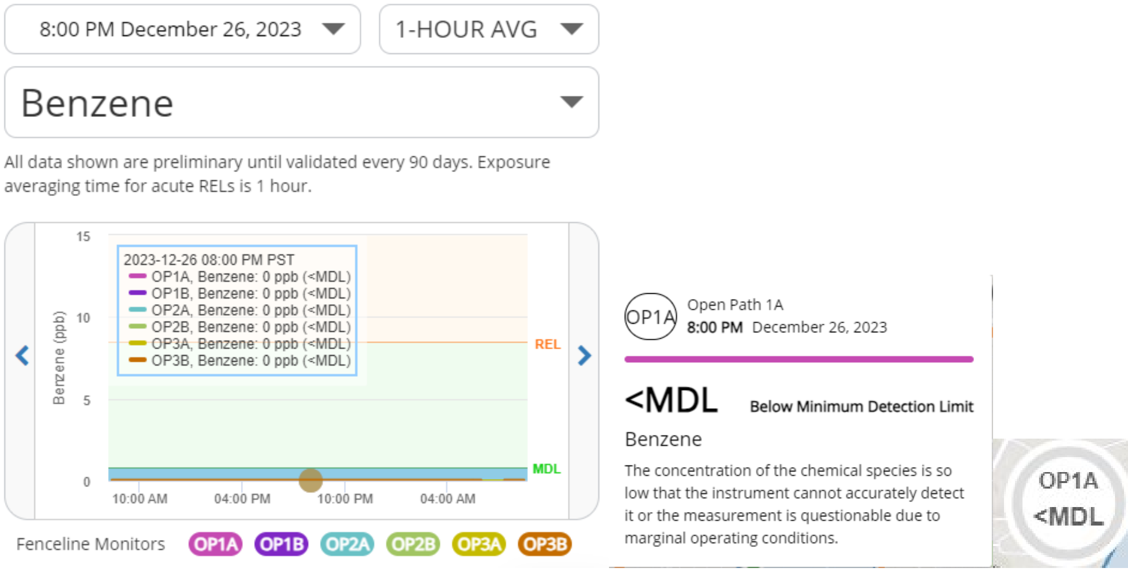

Figure 3: Example of valid non-detections as displayed on the public website.

Suspect/Questionable data (e.g. QC=5) are shown on the website (Figure 4). Concentration values are reported on the time series detail panel (left), either as recorded (e.g. OP=72) or as "0 ppb" (e.g. OP=76), depending on whether or not they correspond to detection events. The map detail panel (middle) and map marker (right) do not display these values and indicate that further review is needed. This additional review is completed according to Section D.2 of the QAPP.

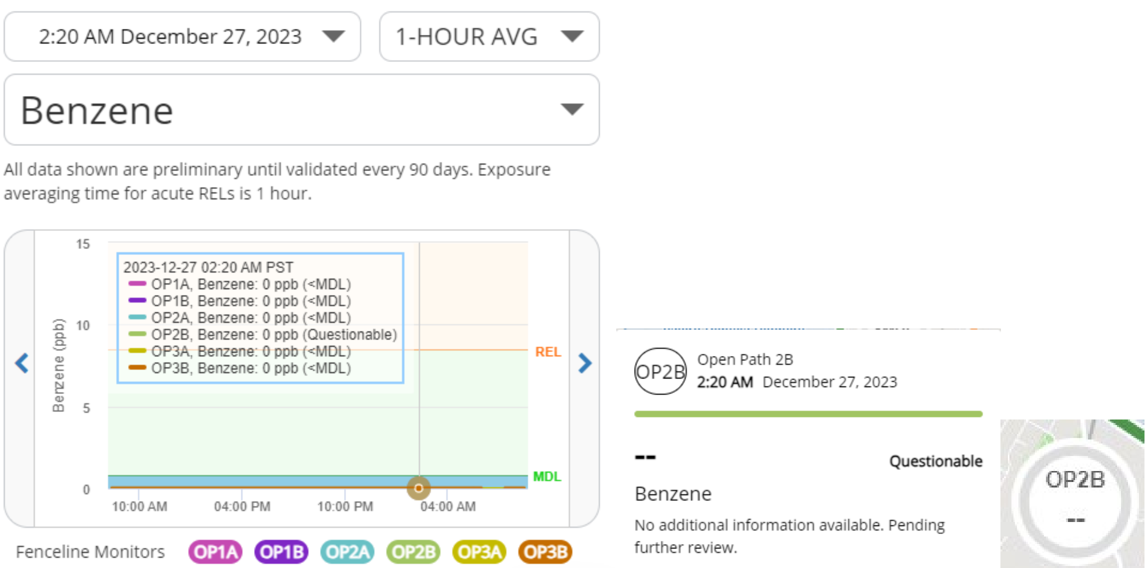

Figure 4: Example of questionable data as displayed on the public website.

Invalid data (e.g. QC=9) are not shown on the website (Figure 5). Concentration values are not reported on the time series detail panel (left), the map detail panel (middle), or the map marker (right), because the data do not meet acceptance criteria.

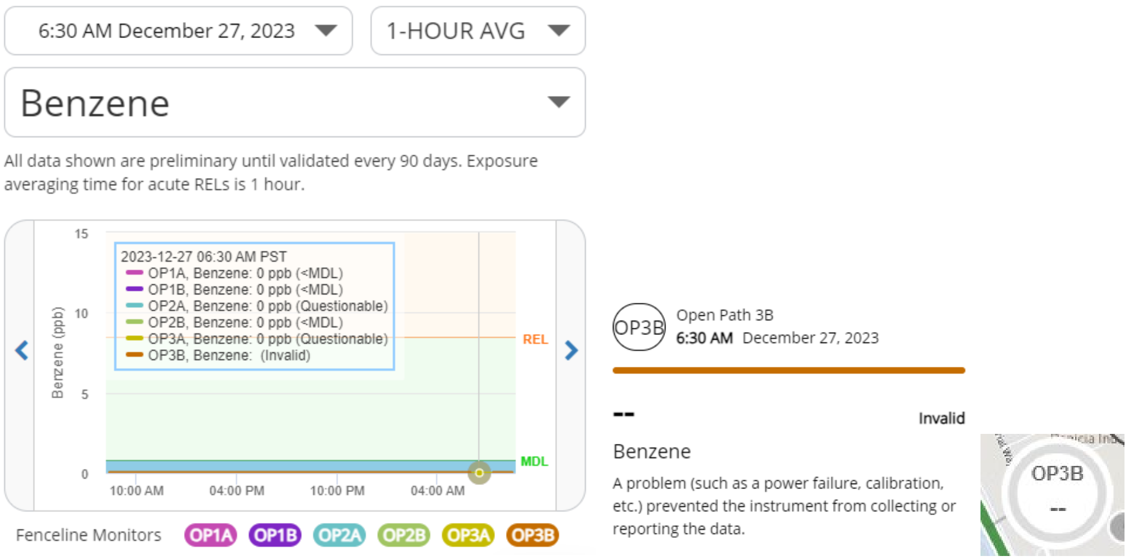

Figure 5: Example of invalid data as displayed on the public website.

Missing data (e.g. QC=8) are not shown on the website (Figure 6). Concentration values are not reported on the time series detail panel (left), the map detail panel (middle), or the map marker (right), because data were not collected. Missing data results in internal alerts to the project team (see Section B.6 of the QAPP).

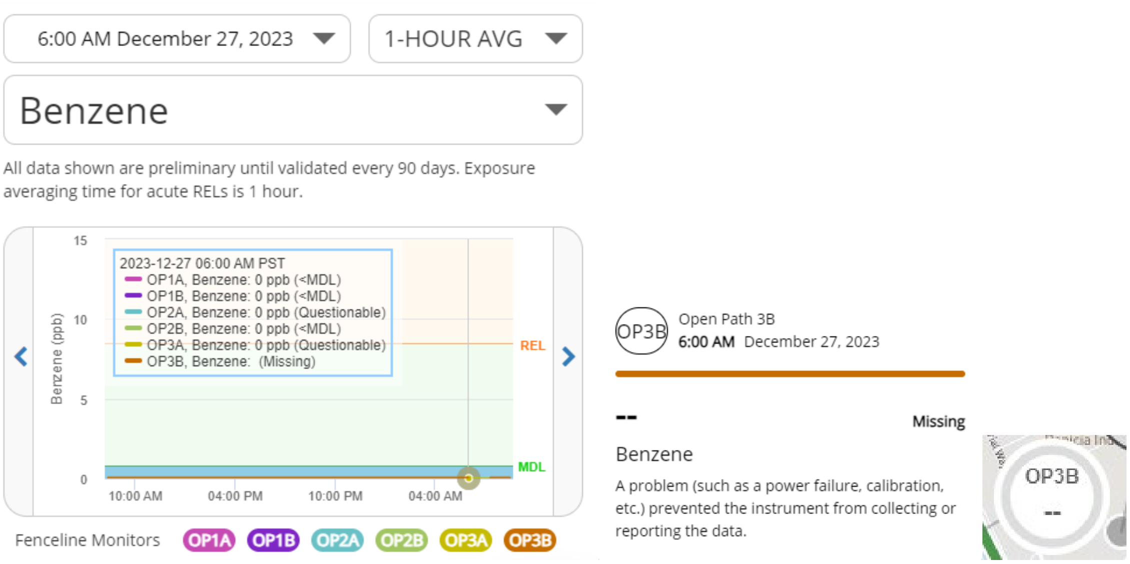

Figure 6: Example of missing data as displayed on the public website.

7. Daily Data Check Spreadsheet

Complete the checks described below and record observations in the space provided. Note any corrective action or issues that were escalated to the field operations team or Project Manager. Additional information regarding acceptance criteria is provided in Section A.7 of the QAPP.

Data Analyst: ______________________ Date and Time: ______________________

Parameter	Reference	Observations
Internal Website Review (5-min data)		
UV-DOAS		
Signal Intensity	Confirm that values ≥70%	
Integration Time	Confirm that values ≤250 ms	
Representative Parameter (e.g., benzene)	Record any instances of invalid data	
	Record any instances of missing data	
	Record maximum concentration	
TDLAS		
Signal Power	Confirm that values ≥0.1 mW	
H_2O Spectral Match	Confirm that values >0.95	
Real-Time MDL (rtMDL)	Record any instances of rtMDL >25 ppb	
Representative Parameter (e.g., H_2S)	Record any instances of invalid data	
	Record any instances of missing data	
	Record maximum concentration	
Met		
Visibility	Confirm that values >2.5 mi	
Wind Direction	Confirm that values are reasonable (0-360 deg)	
Wind Speed	Confirm that values are within typical values for this site	
Public Website Review (5-min data)		
TDLAS	Record any instances of invalid data	
	Record any instances of missing data	
	Record any H_2S detection events	
UV-DOAS	Record any instances of invalid data	
	Record any instances of missing data	
	Record any benzene detection events	
	Record any toluene detection events	
	Record any ethylbenzene detection events	
	Record any m-xylene detection events	
	Record any o-xylene detection events	
	Record any p-xylene detection events	
	Record any SO_2 detection events	
All Compounds	Record any instances of missing data	