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State of Washington

Air Monitoring Documentation, Data Review and Validation Procedure

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For more information contact:

Sarah Clouse
Air Quality Program
P.O. Box 47600
Olympia, WA 98504-7600

Washington State Department of Ecology — www.ecology.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Union Gap 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

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Air Monitoring Documentation, Data Review, and Validation Procedure

October 2019

Approved by:

Signature: Date:
Kathy Taylor, Air Quality Program Manager

Signature: Date:
Cullen Stephenson, Technical Services Section Manager

Signature: Date:
Jill Schulte, Air Monitoring Coordinator

Signature: Date:
Sean Lundblad, Quality Assurance Coordinator

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1. Introduction

This document details the procedure for the documentation and validation of data collected from automated ambient air monitors within the Washington State Ambient Air Monitoring Network (Washington Network).

The data collected by the Air Quality Program (AQP) will be used to make decisions that affect human and environmental health. High-quality data increases the likelihood that these decisions will be well-informed and that the data will withstand scrutiny, particularly in cases of litigation. Ultimately, consistent high-quality data will enable Ecology to better serve the public's charge and Ecology's mission to enhance and protect air quality in Washington State.

2. Data Quality Indicators

The EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Section 3 defines data quality in terms of several key indicators: precision, bias, detection limit, completeness, and comparability. In accordance with this guidance, it is Ecology's policy to provide for the collection, storage, and use of data that meet these indicators. EPA defines these indicators as follows:

2.1. Precision

Precision is a measure of the agreement among repeated measurements of the same property under identical or substantially similar conditions. This is the random component of error. Precision is estimated by various statistical techniques typically using some derivation of the standard deviation.

Ecology assesses individual automated method precision through routine quality control checks that must fall within predefined acceptance criteria (see section 4.1.1).

2.2. Bias

Bias is the systematic or persistent distortion of a measurement process which causes error in one direction. Bias is determined by estimating the positive and negative deviation from the true value as a percentage of the true value.

Network bias is assessed through routine quality control checks and performance audits.

2.3. Detection Limit

The detection limit is the lowest concentration or amount of the target analyte that can be determined to be different from zero by a single measurement at a stated level of probability.

Detection limits are generally not a concern for the majority of Ecology's monitors. However, detection limits are particularly important at National Core (NCore) sites, which require measurements at lower concentrations (e.g., trace gases).

2.4. Completeness

Completeness describes the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct, normal conditions. All of the completeness requirements for each type of monitor and program (NATTS, CSN, NCore) can be found in Table 1 below.

Table 1: Completeness goals and associated standards (highlighted) for ambient air monitoring data

Pollutants	1-hour	3-hour	8-hour	24-hour	Quarterly	Annual
CO	45, 1 min. values	NA	75% of hourly values	75% of hourly values	NA	75% of hourly values per quarter
O_3	45, 1 min. values	NA	75% of hourly values	13 of 17 8-hour periods	NA	75% of days within season**
SO_2	45, 1 min. values	All 3 hours 75% complete	NA	75% of hourly values	NA	75% of hourly values per quarter
NO2	45, 1 min. values	NA	NA	NA	NA	75% of hourly values per quarter
PM10 Cont.	45, 1 min. values	NA	NA	18 hours	NA	NA
PM2.5 Cont.	45, 1 min. values	NA	NA	18 hours	NA	NA
PM10 Manual	NA	NA	NA	23 hours*	NA	NA
PM2.5 Manual	NA	NA	NA	23 hours	75% of samples	NA
Pb	NA	NA	NA	23 hours	3 mo. avg. >75% of monthly means	NA
PAMS	NA	NA	NA	23 hours	NA	NA
NATTS	NA	NA	NA	23 hours	NA	NA
CSN	NA	NA	NA	23 hours	NA	NA

*Not defined in CFR

** For ozone the requirements are met for a 3-year period at a site if valid daily maximum 8-hour average O_3 concentrations are available for at least 90% of the days within the O_3 monitoring season, on average, for the 3-year period, with a minimum of at least 75% of the days within the O_3 monitoring season in any one year.

2.5. Comparability

Comparability is a measure of the confidence with which one dataset or method can be compared to another, considering the units of measurement and applicability to standard statistical techniques. Comparability of datasets is critical to evaluating their measurement uncertainty and usefulness.

3. Documentation

Detailed documentation is an important factor in ensuring high data quality because it provides an official record for all activities, allows for the thorough review of the monitoring and collection processes, facilitates troubleshooting of systematic or other sampling errors, and ensures the data stand up under scrutiny. This section details the procedures for proper documentation of air monitoring activities and data.

Documentation is accomplished primarily through the use of the data logger's electronic log book. For more information on parameter-specific documentation requirements, refer to the appropriate standard operating procedure (SOP). The minimum requirements for documenting log books are detailed in the following section.

3.1. Electronic log book

Each station must be equipped with a log book that is accessible from the monitoring site itself. All of the air monitoring stations in Ecology's network meet this requirement via an electronic log accessible through a PC-based data logger, hereafter referred to as an Envidas Ultimate data logger. These data loggers run software called the Envidas Ultimate Reporter that must be used to document monitoring activities. Washington Network data loggers are TCP-IP addressable so the electronic log books can be accessed and updated on site or remotely through an internet connection. Electronic log books offer distinct advantages over paper log books in that they allow for log entries and systematic and operational review from remote locations, facilitating instrument troubleshooting, data review and validation, and other activities. The electronic log book entry screen and an example entry for an ozone quality control check are shown in Figure 1 below.

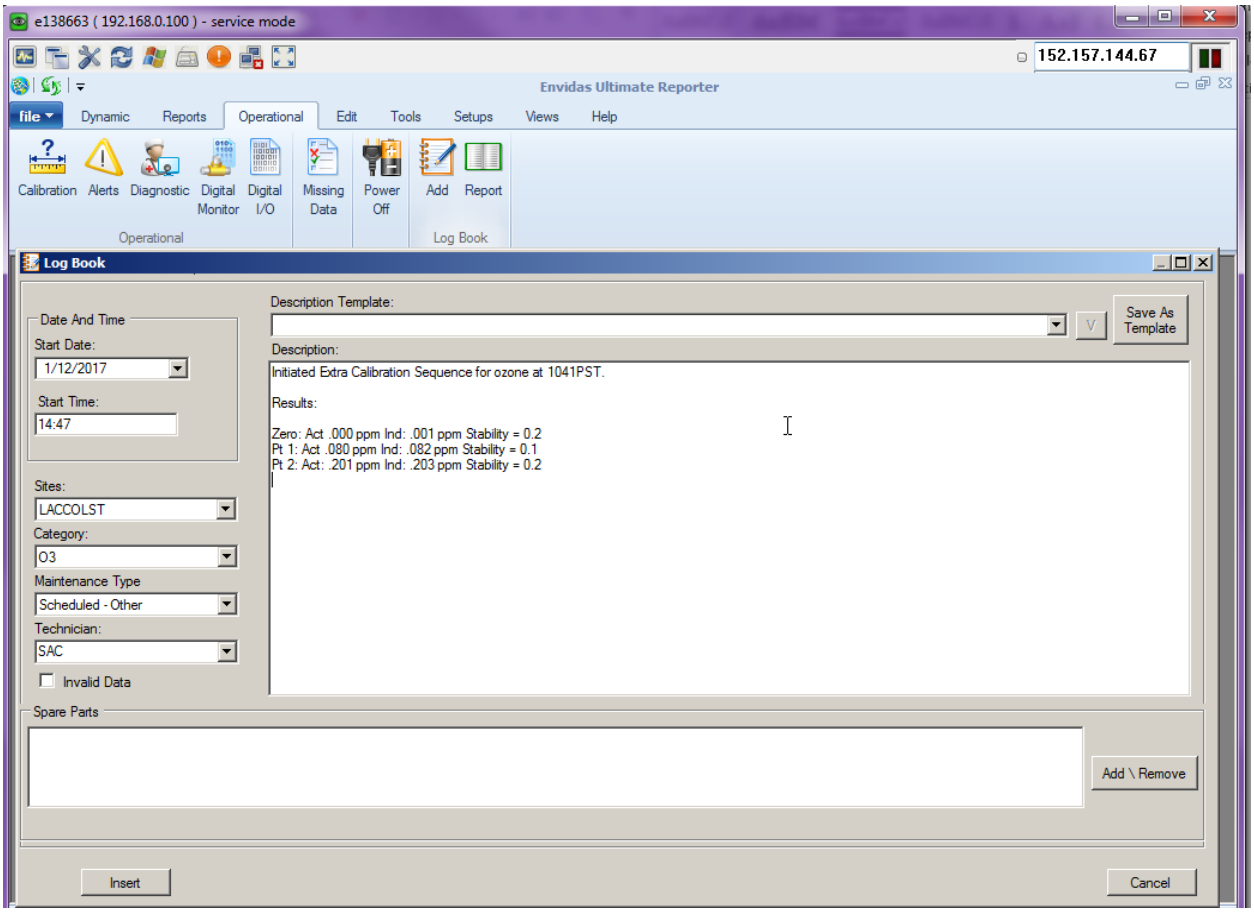


Figure 1: Electronic Log Book Entry Screen

3.2. Documenting electronic log books

The electronic log book functions as a legal record and is the repository for detailed documentation regarding station operation. Electronic log book entries must be made in Envidas Reporter on the site data logger and not in Envidas ARM. Log book entries can be viewed in Envidas ARM. At a minimum the log book should fully document the following:

- Dates and times of all station activities (in PST military time – e.g., “0835 PST”). Electronic log book entries are automatically date/time stamped by the logger
- All maintenance activities such as analyzer or instrument replacements, shelter upgrades or changes, filter changes, cylinder changes, and probe cleaning and replacement
- All quality control check activities and results
- Unusual events and station conditions such as incidences of vandalism, smoke and weather events, shelter leaks, and insect or vermin intrusions
- Performance audits and results including assessment (actual) and monitor (indicated) results

- Other activities or information that may affect monitored readings or data collection

3.2.1. Documenting quality control checks

All instruments must be checked for proper calibration at regular pre-defined intervals. Please refer to the parameter-specific SOPs for a full description of quality control check requirements. Quality control checks for gaseous instruments (CO, NOx, O3, SO2) and nephelometers are performed both automatically and manually. Automated 1-point and multipoint quality control checks are pre-programmed on the Envidas Ultimate data logger to occur at pre-determined intervals as defined in the parameter-specific SOPs. The results of automated quality control check results are recorded by Envidas Ultimate. Manual checks for gaseous instruments and nephelometers are initiated by the station operator via the Initiate Sequence feature of the Envidas Ultimate Viewer software.

Quality control checks for manual methods (such as filter-based PM2.5 FRMs, Chemical Speciation Network, National Air Toxics Trends Station parameters, etc.) and continuous particulate monitors (such as the FDMS TEOM and BAM 1020) cannot be triggered automatically via the data logger. Therefore, quality control results from these instruments are not recorded by the data logger and should be recorded in the electronic log book. All manual method quality control check results must be documented on the appropriate quality control check forms found in the parameter-specific SOPs.

3.2.1.1. Extra Calibration (Initiate Sequence) feature of Envidas Ultimate

The Extra Calibration (Initiate Sequence) feature allows an operator to perform a manual quality control check on demand while at the monitoring site or from a remote location. The Envidas Ultimate data logger records the date, time and actual and indicated results of these checks. The results are then polled by the central telemetry system and saved to a SQL database. The data can then be accessed via Ecology's public air monitoring website and through the Envista Air Resources Manager (EnvistaARM). The capture of quality control check information by the data logger facilitates Level 1 operator data review and Level 2 quality assurance personnel data review and validation as all manual and automated quality control check results are readily available through the data loggers' Envidas Ultimate Reporter and EnvistaARM software. **It is for these reasons that operators are required to use the Extra Calibration (initiate sequence) feature when performing a manual quality control check.** To initiate a sequence from the Envidas Ultimate Viewer, select Operational tab > Sequence > choose which sequence you want to run > Initiate Sequence.

3.2.1.2. Documenting manual quality control checks

At a minimum, manual quality control checks for air monitoring instruments must be documented on the QC check forms provided in the parameter-specific SOPs. Station operators should also record as much information as practical in the electronic log book to ensure a record of activities onsite and to help facilitate data review and validation. QC check forms must be completely filled out and sent in electronic form (Excel, pdf, etc.) via email. Typically, QC

forms for air monitoring instruments operated within the Washington Network will contain the following information:

- Instrument state tag or ID number
- Transfer standard serial number and/or remaining pounds per square inch (PSI) values for calibration gas cylinders
- Traceability information of standards used in the QC checks to national standards.
- Indicated (monitor) and actual (assessment) values for flow rates or zero, precision, and span values

Many Washington Network electronic forms are created in Excel and will calculate the percent difference automatically. However, operators should know how to calculate percent difference and will need to do so for those instruments without an Excel version of the QC form. To calculate the percent difference, use the following equation:

$$\left(\frac{Indicated - Actual}{Actual}\right) * 100 = \%difference$$

Upon completing the QC check, the station operator is responsible for:

- Determining whether the acceptance criteria for the appropriate pollutant is within required range and taking recalibrating the instrument if necessary. For current action and acceptance limits, please refer to the parameter-specific SOPs.
- Adjusting the instrument if action levels have been exceeded. Do not make any instrument adjustments until the entire quality control check has been completed and been verified as executing correctly. An "as left" QC check form must be filled documenting post-calibration results. Both "as-found" and "as-left" QC forms must be submitted to the Ecology AQP Quality Assurance Coordinator (QAC).
- Recording any corrective action taken as well as "as-left" results in the log book.

3.2.1.3. Documenting automated quality control checks

Station operators do not need to document automated quality control checks in the station log book as the critical information is collected and recorded by the logger automatically and subsequently polled and stored by the central telemetry system. However, in the event of a quality control check failure, operators must record any corrective action taken.

3.2.1.4. Documenting failed quality control checks

In the event of a manual QC check failure, operators must document any corrective action taken in the electronic station log book. If for any reason the operator determines that a quality control check failed for reasons that shouldn't result in data invalidation, the operator must document the reason(s) the data should be considered valid in the log book.

3.3. Other required documentation

Depending on the parameter, additional documentation of quality control checks and other maintenance activities may be required. Please refer to the parameter-specific SOPs to determine additional documentation requirements.

3.4. Submitting required documentation

Operators are required to email electronic versions of all QC and maintenance forms as well as any other parameter-specific information regarding data validity to the Ecology AQP's Quality Assurance Coordinator (QAC).

It is recommended that operators email their completed forms to the Ecology AQP QAC immediately after completing manual QC checks. Timely submittal of QC results helps expedite review of data and ensure that erroneous data are identified and removed from the publicly available dataset as quickly as possible.

At a minimum, all quality control forms and supporting documentation must be emailed to the Ecology AQP QAC by the 10th of the month following the check. Quality Assurance personnel will proceed with final data validation regardless of whether the required documentation is submitted on time or not. If no documentation is submitted, the data in question may be considered invalid.

4. Data Verification and Validation

Data review, verification and validation are techniques used to accept, reject, or qualify data in an objective and consistent manner. Verification can be defined as confirmation, through provision of objective evidence, that specified requirements have been fulfilled. Validation can be defined as confirmation, through objective evidence, that specific requirements for an identified intended use are fulfilled. For example, one could verify that all 1-point QC checks for a given monitor were performed every 14 days as required. However, if the checks were outside the quality control acceptance limits as defined by the SOP, the validation process would determine that the data are not valid.

Thorough data validation ensures that Ecology's data quality and measurement objectives are met and that the data generated can be used to inform policy and protect public and environmental health. In addition, a thorough review and validation process will help detect collection system errors and facilitate subsequent improvements.

Data validation consists of two separate activities: initial review and final validation. Initial review is conducted by station operators during and after data collection but prior to final validation. Final validation is conducted by Quality Assurance personnel and involves a separate, thorough, qualitative and quantitative system and data review.

Data that have been through the entire validation process are sent electronically to the EPA's Air Quality System (AQS). Among other uses, validated data will be utilized by AQP management to inform program policy and evaluate pollution control strategies. Criteria pollutant data will be used by EPA to make attainment/nonattainment determinations regarding the National Ambient Air Quality Standards (NAAQS).

Data satisfying the criteria in Section 4.1 below will be considered valid. Data not satisfying these criteria will be invalidated back to the time of the last QC check that was within Ecology's acceptance criteria and forward to the point of the next QC check or performance audit documenting that the parameter is within acceptance criteria.

4.1. Data validation criteria

Data will only be considered valid when the following criteria have been satisfied:

1. The air monitoring instrumentation has been calibrated and operated in accordance with 40 CFR Part 58, Appendix A and Ecology's SOPs

2. The instrument has been operating within acceptance limits as defined by the parameter-specific SOP during the period of data collection as determined by the results of manual and automated quality control checks and performance audits

3. All quality control checks have been performed within the required time intervals as defined in 40 CFR Part 58, Appendix A and the parameter-specific SOPs and have been sufficiently documented

4. The data are consistently free of excessive drift, noise, spiking, and statistical outliers

4.1.1. Acceptance criteria

Quality Assurance personnel review monitoring data, QC and QA results, electronic logbooks, diagnostic parameters and other supporting information to ensure that all data collection processes adhere to the requirements of 40 CFR Part 58, Appendix A and Ecology's parameter-specific SOPs. Quality Assurance personnel also consult EPA guidance and use a weight of evidence approach to determining validity of data, especially in cases where the CFR and AQP SOPs allow for flexibility. Following the acceptance criteria set forth by EPA and Ecology ensures data collected within the Washington Network are of sufficiently high quality for intended uses and will withstand scrutiny. Acceptance criteria for the Washington Network air monitors are derived from 40 CFR Part 58, Appendix A, the EPA's Quality Assurance Handbooks, and are described in Ecology's parameter-specific SOPs. The following sections contain references to these sources and describe, by monitor category, how each source is used.

4.1.1.1. Federal Reference Method (FRM) and Federal Equivalent Method (FEM) monitors

Federal Reference Method (FRM) and Federal Equivalent Method (FEM) monitors operated within the Washington Network must comply with the acceptance criteria described in 40 CFR Part 58, Appendix A (Appendix A) and Ecology's SOPs. Where Appendix A and Ecology's SOPs differ, operators must comply with the requirements described SOPs. The SOP will never be less stringent than Appendix A.

Appendix A acceptance criteria are summarized in the most current version of EPA's Validation Templates. A link to the Validation Templates can be found in the Quality Assurance Guidance Documents section of the EPA's Ambient Monitoring Technology Information Center (AMTIC) website.

Ecology's SOPs can be found on Ecology's website.

4.1.1.2. Meteorological monitors

Meteorological monitors operated in the Washington Network must comply with the PSD-quality acceptance criteria described in EPA's Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD). Additional guidance on the review validation of meteorological data can be found in Ecology's Meteorological Standard Operating Procedure and also in the Quality Assurance Guidance Documents section of the EPA's Ambient Monitoring Technology Information Center (AMTIC) website.

4.1.1.3. Non-FRM/FEM monitors

Non-FRM/FEM monitors (such as nephelometers) operated within the Washington Network must comply with the acceptance criteria as described in Ecology's parameter-specific SOPs.

In addition to the acceptance criteria, Ecology uses a weight of evidence approach, including but not limited to logbook entries, power failure and site-to-site data comparisons, to determine data validity.

4.2. Manual method verification and validation

Manual methods are those that involve the use of sample media (filters, canisters, etc.) that must be installed and retrieved by the site operator as well as post-sample collection analysis to derive pollution concentrations, which is typically conducted by an accredited laboratory. In contrast to continuous method monitoring, manual method sampling does not provide a real-time resultant pollution concentration.

4.2.1. Filter-based FRM/Class I FEM $PM_{2.5}$ and PM_{10} samplers

Gravimetric analysis, including pre- and post- conditioning and weighing, of Washington Network filter-based PM2.5 and PM10 samples is conducted by the Manchester Environmental Lab (MEL). The MEL gravimetric lab analyst uses the Gravimetric Laboratory Information Management System (GLIMS) software to automatically calculate 24-hour sample mass concentrations based upon pre- and post-sample filter net mass and associated 24-hour environmental (pressure, temperature, flow) and flow data. GLIMS mass concentration calculations are verified by the lab analyst using a calculator and then verified again by another trained MEL employee. The full lab verification and validation process is described in MEL's Gravimetric Analysis Standard Operating Procedure (SOP).

Following laboratory verification and validation, the lab analyst uses a software script to create a re-engineered AIRS file containing a given calendar month of sample mass concentrations, corresponding 24-hour average ambient temperature and ambient pressure readings, as well as field blank records. The re-engineered AIRS file and corresponding Adobe pdf reports of all laboratory-validated sample and field blank data are sent electronically each month to the Air Quality Program Quality Assurance team for final level review and validation.

Upon receipt from MEL, Quality Assurance personnel upload the re-engineered AIRS file into the Envidas SQL Server database via the EnvistaARM software. QA personnel then review and verify that concentrations and field blanks loaded into the EnvistaARM accurately reflect the information contained in the final reports (i.e., sample dates, site information, mass concentrations, and field blank weights match the report) to confirm that the laboratory-validated sample and field blank data were correctly loaded. QA personnel investigate and attempt to resolve any discrepancies with the lab analyst and field operators. QA personnel compare mass concentrations, 24-hour average temperatures and pressures data with collocated and nearby site monitors for reasonable consistency. Field operator quality control checks, maintenance, and electronic logbook entries are reviewed for completeness, accuracy (i.e., consistency between logbook entries and QC records), and adherence to Appendix A and SOP requirements to ensure proper operational activity. QA personnel notify field operators and the QA Coordinator when operational deviations from Appendix A or the SOP are discovered. Data that are deemed

comparable and representative and meet Appendix A and SOP requirements are considered valid, flagged with Final Level Validation in the EnvistaARM and submitted to EPA's Air Quality System. Data failing to meet these criteria, or otherwise deemed unacceptable through a weight of evidence approach, are invalidated and not sent to EPA.

4.2.2. Chemical Speciation Network (CSM) samplers

Site operators and QA personnel use Sonoma Technology online Data Analysis and Reporting Tool (DART) to validate and approve monthly PM2.5 Chemical Speciation Network (CSN) and supplemental CSN data following sample collection and the national contract laboratory (AMEC/Wood/UC Davis) analysis. Site operators are responsible for preliminary review which involves assessing that data are consistent with field logs and flags assigned by the lab. Quality assurance personnel conduct a further independent review to assess flags and null codes, invalid samples, sampling anomalies and outliers, operational parameters, field blanks, and consistency with historical data. CSN and supplemental CSN sample data are only invalidated by QA personnel when measurements are known to be invalid, such as due to a lack of sample air flow, filter damage, or contamination.

4.2.3. Air toxics samplers

Using monthly data summaries supplied by the contract laboratory, operators and QA personnel conduct an independent review of air toxics data. This review includes assessment of flags and null codes as well as sampling anomalies and outliers. Field blanks, duplicates, and comparison to historical data is also used to assess data validity.

4.3. Continuous method validation

Continuous method monitors conduct analysis of samples internally and therefore provide real-time pollution concentrations. The validation of these data involve the use of a series of tools and actions.

Site operators are responsible for ensuring that the data they collect have been thoroughly reviewed. The primary tools for reviewing data are the Envidas Ultimate Reporter (on the data logger) and the Envista Air Resource Manager (EnvistaARM). These software tools allow for a variety of graphical and tabular analyses that, when thoroughly inspected, reveal the great majority of instrument problems and suspect data.

In an effort to ensure that collected data meet the data validation criteria (see section 4.1 above), operators should thoroughly review continuous method monitoring data as frequently as possible. At a minimum, operators should review their data on a weekly basis (i.e., review the previous week's data during the current week).

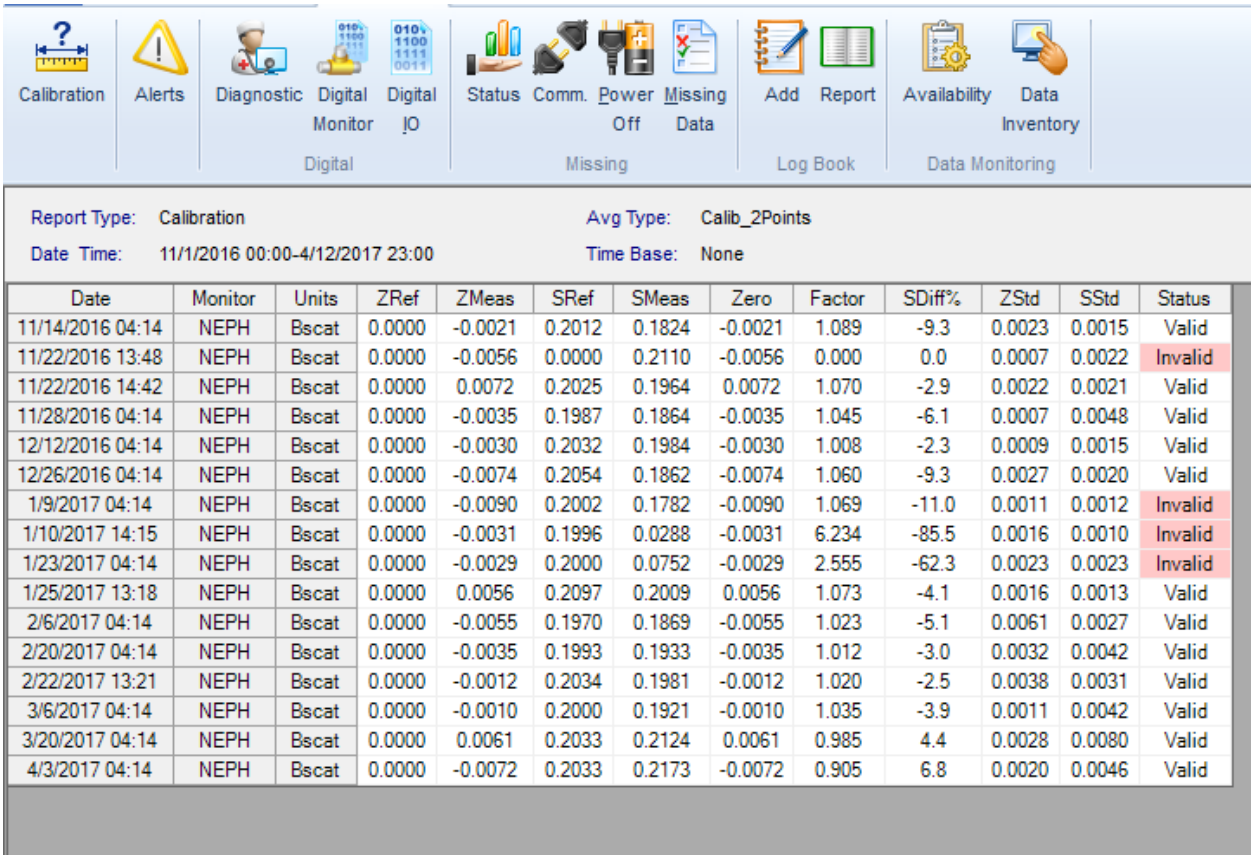
At a minimum, a thorough review of the data includes:

- Review of calibration results (Calibration Report)
- Review of graphical data (1-minute and 1-hour average Station Reports)

- Comparison to collocated and nearby monitors (Multi-station and Group reports)
- Review of diagnostic data (Diagnostic Report)

4.3.1. Calibration report review

The Calibration Report contains results from automated and manually initiated Envidas Ultimate quality control check sequences. The Calibration Report should be reviewed on a weekly basis. An optimal time to review the Calibration Report is Monday morning as many quality control checks occur early on Monday mornings (before business hours). Doing so should provide operators with ample lead time to plan their schedules to ensure that any failed QC checks and instrument malfunctions can be investigated and addressed as soon as possible. Figure 2 below presents a monthly Calibration Report for a nephelometer. In the event of a quality control check failure such as those in red below, operators should investigate the failure, take any necessary corrective action, and alert Quality Assurance of any erroneous or suspect data. Any calibration check failures and any subsequent action taken should be documented in the electronic station log book. In the event of an instrument recalibration or other adjustment, a pre-adjustment "as-found" and post-adjustment "as-left" QC check must be completed and submitted to the Ecology AQP QAC.



Report Type: Calibration
Avg Type: Calib_2Points
Date Time: 11/1/2016 00:00-4/12/2017 23:00
Time Base: None

Date	Monitor	Units	ZRef	ZMeas	SRef	SMeas	Zero	Factor	SDiff%	ZStd	SStd	Status
11/14/2016 04:14	NEPH	Bscat	0.0000	-0.0021	0.2012	0.1824	-0.0021	1.089	-9.3	0.0023	0.0015	Valid
11/22/2016 13:48	NEPH	Bscat	0.0000	-0.0056	0.0000	0.2110	-0.0056	0.000	0.0	0.0007	0.0022	Invalid
11/22/2016 14:42	NEPH	Bscat	0.0000	0.0072	0.2025	0.1964	0.0072	1.070	-2.9	0.0022	0.0021	Valid
11/28/2016 04:14	NEPH	Bscat	0.0000	-0.0035	0.1987	0.1864	-0.0035	1.045	-6.1	0.0007	0.0048	Valid
12/12/2016 04:14	NEPH	Bscat	0.0000	-0.0030	0.2032	0.1984	-0.0030	1.008	-2.3	0.0009	0.0015	Valid
12/26/2016 04:14	NEPH	Bscat	0.0000	-0.0074	0.2054	0.1862	-0.0074	1.060	-9.3	0.0027	0.0020	Valid
1/9/2017 04:14	NEPH	Bscat	0.0000	-0.0090	0.2002	0.1782	-0.0090	1.069	-11.0	0.0011	0.0012	Invalid
1/10/2017 14:15	NEPH	Bscat	0.0000	-0.0031	0.1996	0.0288	-0.0031	6.234	-85.5	0.0016	0.0010	Invalid
1/23/2017 04:14	NEPH	Bscat	0.0000	-0.0029	0.2000	0.0752	-0.0029	2.555	-62.3	0.0023	0.0023	Invalid
1/25/2017 13:18	NEPH	Bscat	0.0000	0.0056	0.2097	0.2009	0.0056	1.073	-4.1	0.0016	0.0013	Valid
2/6/2017 04:14	NEPH	Bscat	0.0000	-0.0055	0.1970	0.1869	-0.0055	1.023	-5.1	0.0061	0.0027	Valid
2/20/2017 04:14	NEPH	Bscat	0.0000	-0.0035	0.1993	0.1933	-0.0035	1.012	-3.0	0.0032	0.0042	Valid
2/22/2017 13:21	NEPH	Bscat	0.0000	-0.0012	0.2034	0.1981	-0.0012	1.020	-2.5	0.0038	0.0031	Valid
3/6/2017 04:14	NEPH	Bscat	0.0000	-0.0010	0.2000	0.1921	-0.0010	1.035	-3.9	0.0011	0.0042	Valid
3/20/2017 04:14	NEPH	Bscat	0.0000	0.0061	0.2033	0.2124	0.0061	0.985	4.4	0.0028	0.0080	Valid
4/3/2017 04:14	NEPH	Bscat	0.0000	-0.0072	0.2033	0.2173	-0.0072	0.905	6.8	0.0020	0.0046	Valid

Figure 2: EnvistaARM Calibration Report

4.3.2. Graphical data review

In many cases, viewing data graphically is superior to viewing data in tabular form as instrument malfunctions tend to be obvious when data is displayed graphically. Nevertheless, tabular data can prove useful in identifying minimum and maximum values (e.g., using the Station Report). Maximum and minimum values outside of normal instrument operation are indications of a problem and should be investigated and resolved.

At a minimum, operators should review the following graphical data on a weekly basis:

4.3.2.1. Station report: 1-hour averages

Operators should review similar parameters from the same site or from different sites in the same airshed using one or several of the following reports: Station Report, Group Report, Multi-Station Report. Figure 3 below presents a Station Report hourly average comparison of NPM25, TPM25, and the black carbon portion of PM2.5 collected by an Aethalometer (AETH BC) at the Seattle, Beacon Hill station. These parameters compare fairly well with the exception of the Aethalometer. It appears to stop tracking on the 4th of June, possibly an indication of an instrument problem that should be investigated further.

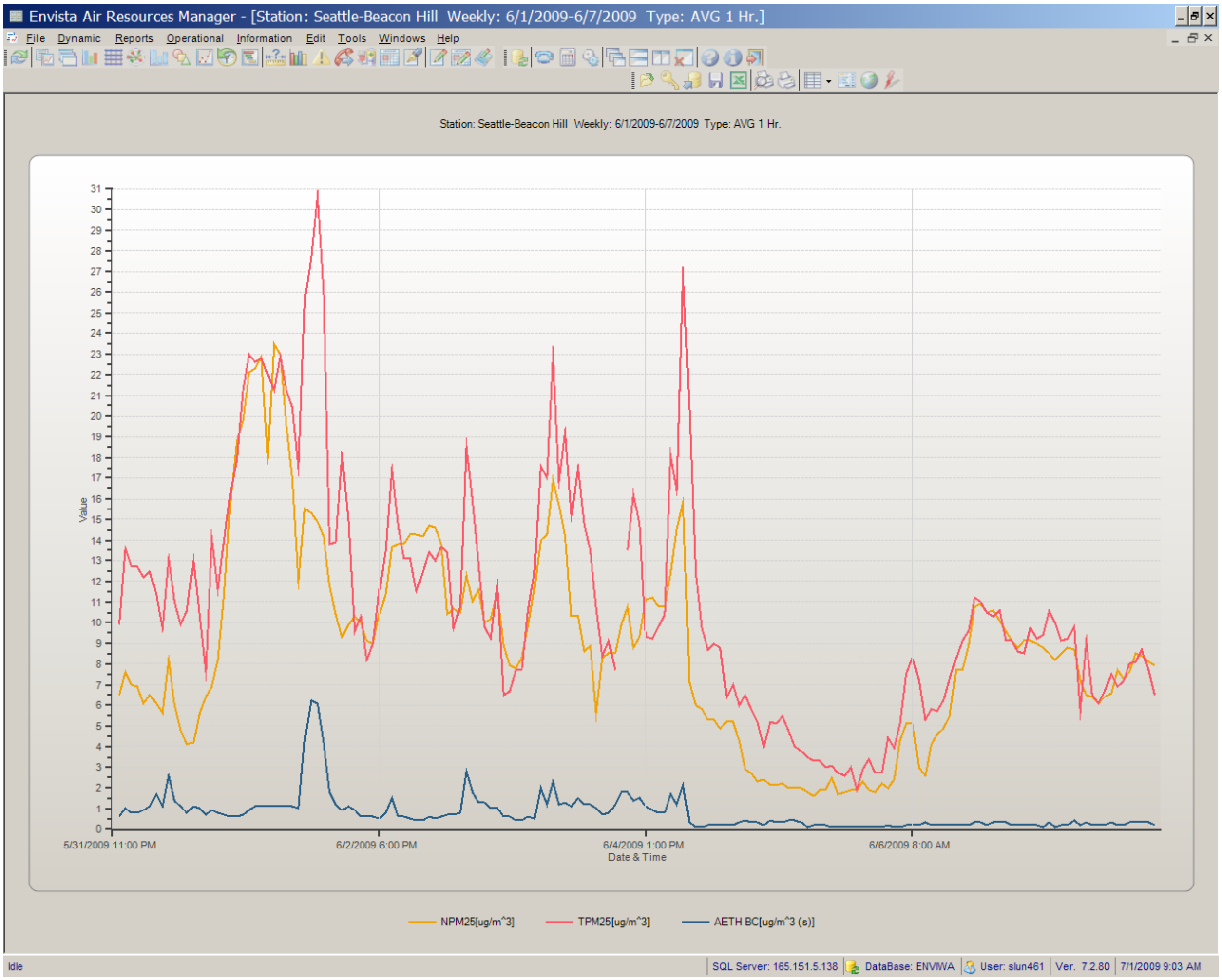


Figure 3: Station Report - multiple Parameter 1-Hour Averages

Below is another example of a one-hour average station report. Figure 4 shows nephelometer (NPM25) data that has at least one readily identifiable irregularity; a loss of data followed by a straight line at zero late in the day on 1/18/17 to early on 1/19/17. Operators must investigate the cause of such problems and take appropriate corrective action. In addition, operators should alert the QA team to all such problems so that any erroneous data can be invalidated.

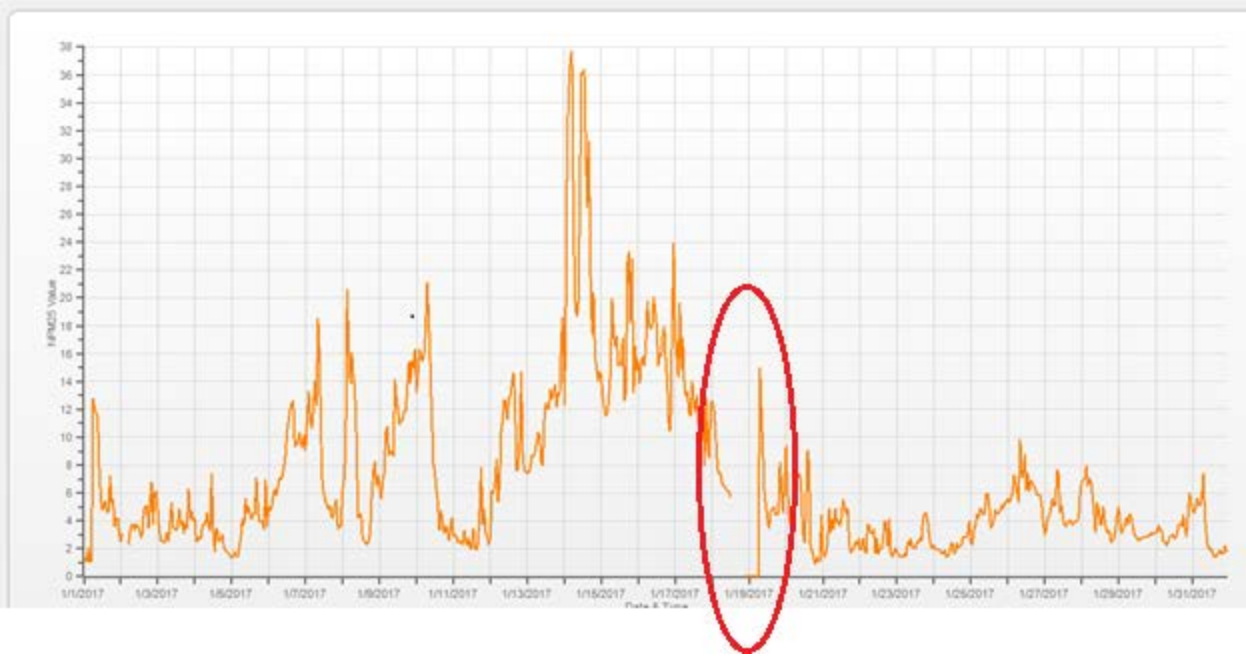


Figure 4: Station Report - 1-Hour Averages

4.3.2.2. Station report: 1-minute averages

Some problems may not be visible through viewing hourly averages. Therefore, operators should also review graphs of 1-minute data (1-minute averages). For example, the hourly wind data in Figure 5 might not look alarming except for the 80 mph wind during the early morning hours of 2/28. However, looking at the minute data in Figure 6 there is an obvious problem with the wind speed and wind direction from late evening on 2/27 to the afternoon of 2/28. In addition to more obvious errors like this one, other less obvious problems such as erratic instrument operation (i.e., spiking, noise, etc.) that may be smoothed out in 1-hour averages are readily identifiable in the 1-minute graph.

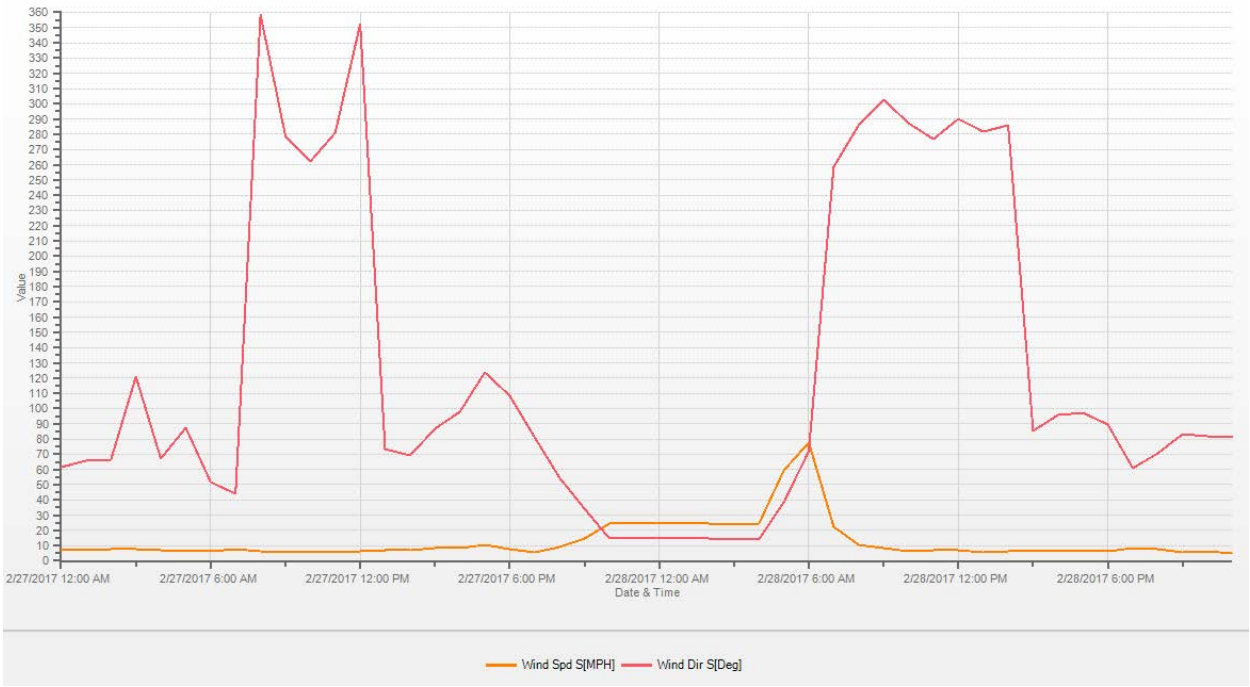


Figure 5: Station Report - 1-Hour Averages

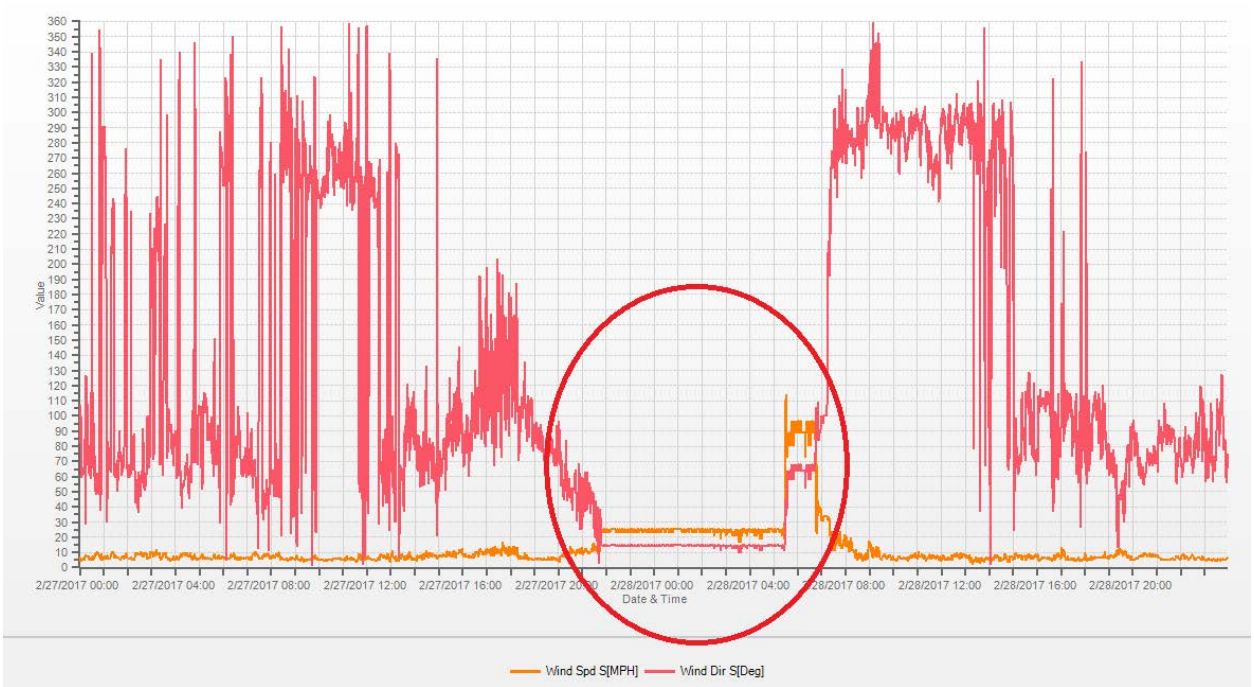


Figure 6: Station Report - 1-Minute Averages

4.3.2.3. Multi-station report: hourly averages

Graphical displays of data collected by instruments measuring the same pollutant in the same airshed should reasonably be expected to generally track each other – in other words, the data should be comparable. Comparing the graphical traces from several stations for the same parameter is an excellent way to identify suspect data. To do such comparisons, operators should generate a Multi-Station Report for several monitors in the same geographic area. The Multi-Station report is only available through the EnvistaARM and Ecology's website. Multi-Station reports cannot be generated at the logger level via the Reporter. Data that does not compare well to other area monitors should be examined more closely for instrument/sensor malfunction(s). Figure 7 presents an hourly Multi-Station Report for pressure data of nephelometer monitors in the Spokane area from 12/16/2014 – 1/5/2016. Pressure readings appear to compare well until sometime early in the day on December 29th when the Colville monitor drops and stops tracking with the other sites nearby. This is indicative of an instrument/equipment problem at the Colville site. Discrepancies warrant further investigation as soon as possible.

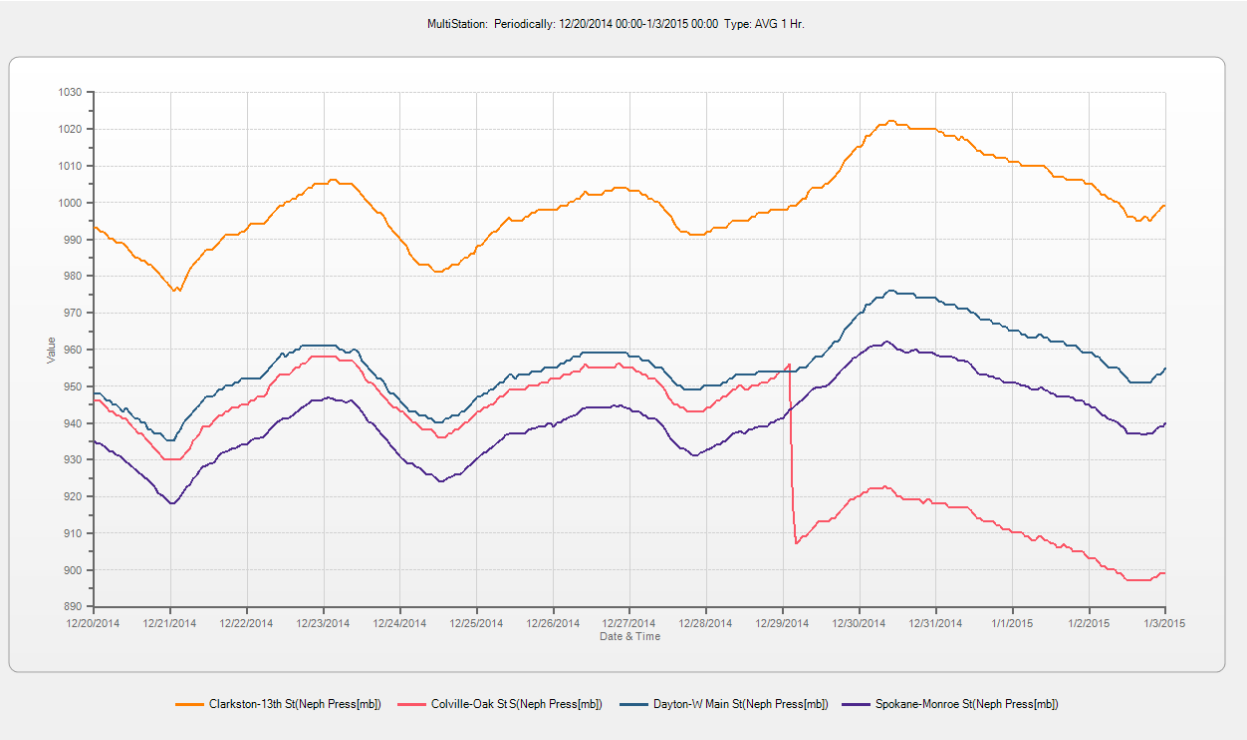


Figure 7: Multi-station report

4.3.3. Diagnostic report

Operators should review diagnostic data from their monitors via the Diagnostic Report. This report can be accessed through the data logger's Reporter or EnvistaARM software. Diagnostic parameter results outside the range of normal instrument operation as defined in the parameter-

specific SOPs should be investigated and corrective action taken as soon as possible. Figure 8 below is an example of a Diagnostic Graph for a PM2.5 FEM analyzer.

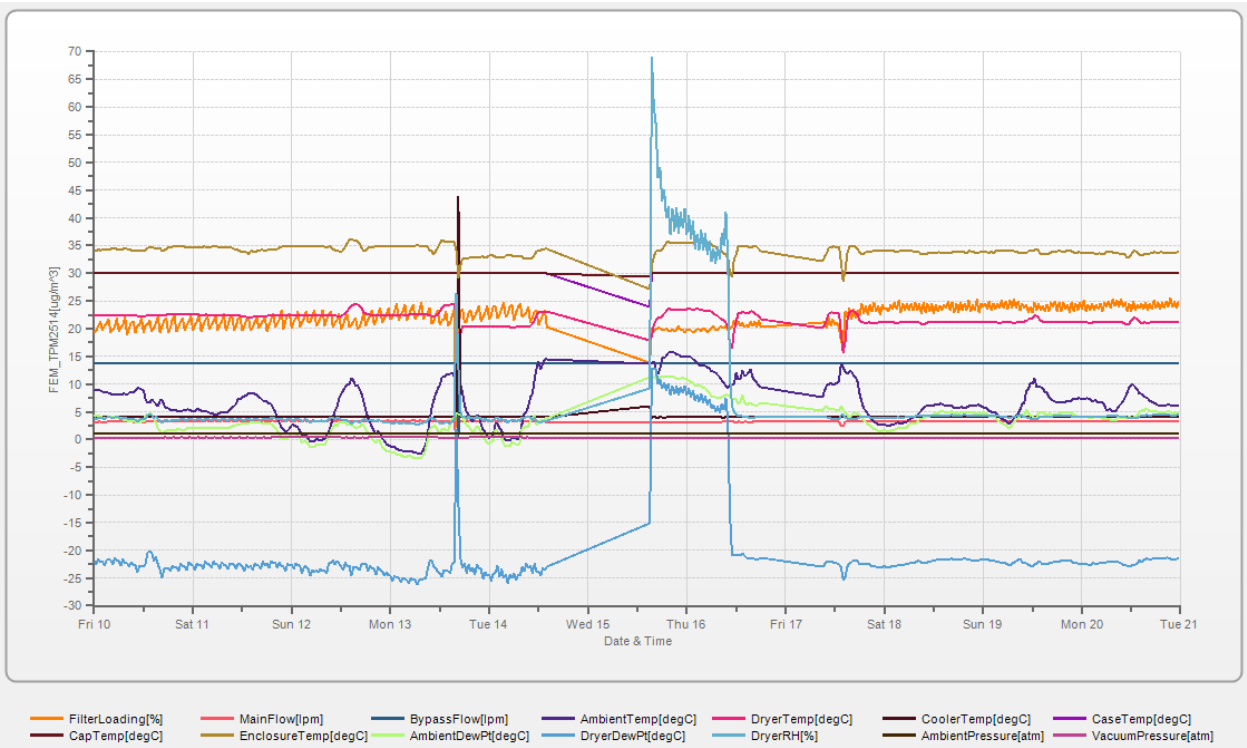


Figure 8: Diagnostic graph for a $PM_{2.5}$ FEM analyzer

4.4. Final data validation

Final data validation is conducted by Quality Assurance personnel and is an independent, thorough review of the data. Quality Assurance personnel rely heavily on the EnvistaARM for review and validation of data. The EnvistaARM is similar to the Ultimate Reporter in many ways and features additional options, such as Multi-Station Report and Final Data Validation. However, edits made in the EnvistaARM will not appear on the site logger.

Quality Assurance personnel will conduct a thorough qualitative and quantitative review of the station log book entries, quality control check results, performance audit results, operator documentation, and collected data that will include, but is not limited to, the following activities:

- **Assessment of Data Completeness** – contact operator if data is missing or flagged for extended period without supplementary information provided in the QC form or electronic log book
- **Assessment and Review of Documentation** – ensure all station log books and required forms are properly and thoroughly documented

- **Quality control and quality assurance activities** – ensure all required precision checks and performance audits are within acceptance criteria via the EnvistaARM Calibration Report, operator documentation, and performance audit results
- **Proper operation and maintenance of instrument** – verify that all maintenance activities have been completed
- **Comparability** – using the EnvistaARM, review Station, Group, and Multi-Station Reports to ensure comparability of monitored data
- **Edit data** – invalidate erroneous data and data that does not meet data quality objectives or correct values or flags based on evidence they were captured incorrectly.
- **Lock data per Final Validation** – after thorough review of all data, set the Final Validation designation in the EnvistaARM, locking all validated data from further edits
- **Notify AQS Coordinator** –Conduct timely review and notify AQS Coordinator as soon as data have been validated and are ready for submittal to EPA. This will ensure that Ecology complies with the reporting requirements described in section 58.16 of the most recent version of 40 CFR Part 58

Below, in Figure 9 is an example of a spreadsheet that the Quality Assurance personnel use when validating FEM PM2.5 data.

	A	C	D	E	F	G	H	I	J	K	L
1	Site Name	AQS ID	Group report	Station Report	Diagnostics	Logbook	QC	QA	Final Validation Set	PARS Nouveau	Notes
2	Seattle-Beacon Hill	530330080									
3	Bellingham-Yew St	530730015									
4	Wenatchee-Fifth St	530070011									
5	Ellensburg-Ruby St	530370002									
6	Anacortes-202 Ave	530570011									
7	Vancouver-NE 84th	530110024									
8	Tacoma-S 36th St	530530024									
9	Spokane-Augusta	530630021									
10	Toppenish-Yakama Tribe	530770015									
11	Omak-Colville Tribe	530470013									
12	Yakima-4th Ave S	530770009									
13	Bremerton-Spruce Ave	530350007									
14	Darrington-Fir St	530610020									
15	Kent-James	530332004									
16	Lynnwood-212	530610005									
17	Marysville-7th Ave	530611007									
18	Marysville-7th Ave (collocated)	530611007									
19	Seattle-10th and Weller	530330030									
20	Seattle-Duwamish	530330057									
21	Tacoma-L Street	530530029									
22											
23											
24											
25	Jill's TEOMs										
26	Jill's BAMs										
27	Sean's Sites										

Figure 9: FEM $PM_{2.5}$ Data Validation Spreadsheet

5. References

"Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I – A Field Guide to Environmental Quality Assurance." EPA-600/R-94/038a. April, 1994.

“Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II – Ambient Air Quality Monitoring Program.” EPA-454/B-17-001. January, 2017.

“Quality Assurance Handbook for air Pollution Measurement Systems, Volume IV – Meteorological Measurements.” EPA-454/B-08-002. March, 2008

Code of Federal Regulations, Title 40, Part 58 (40 CFR 58).

“Envista ARM Air Resources Manager”. Envitech Ltd. Envista ARM Ver. 7.7.14. September, 2014.

U.S. Environmental Protection Agency. Office of Air Quality Planning and Standards. “Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD).” Research Triangle Park, 1987 (EPA-450/4-87-007). https://www.epa.gov/sites/production/files/2015-07/documents/monguide.pdf