Washington Ambient Air Monitoring Network Quality Assurance Plan

Air Quality Program

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Publication and Contact Information

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Introduction

The Air Monitoring Quality Assurance Plan describes Ecology's Air Quality Program quality system governing the Washington Ambient Air Monitoring Network (Washington Network). This plan describes the organizational structure, functional responsibilities of management and staff, lines of authority, and required information exchange for those planning, implementing, and assessing activities involving environmental data collected in the Washington Network. The Washington Network is designed and maintained to collect vital air data for the purposes of fulfilling the program's mission and carrying out the provisions of the Clean Air Act.

The Air Quality Program's mission is to protect public health and the environment by preventing and reducing air pollution.

The federal Clean Air Act requires EPA to set National Ambient Air Quality Standards (NAAQS) for widespread pollutants considered harmful to public health and the environment. The federal Clean Air Act sets limits to protect public health, including the health of at-risk populations such as people with pre-existing heart or lung disease (for example, asthma), children, and older adults.

The 1990 Amendments to the federal Clean Air Act describe the "e*stablishment of a national network to monitor, collect, and compile data with quantification of uncertainty in the status and trends of air emissions, deposition, air quality, surface water quality, forest condition, and visibility impairment and to ensure the comparability of air quality data collected in different states and obtained from different nations."* The data collected in the Washington Network provides critical information that is used by the public, government agencies, tribes, and other organizations concerned about human health and the welfare of communities and ecosystems. This data informs decisions regarding air pollution control strategies, environmental and community planning, policy, and is used also in research applications. Therefore, it is critical that the ambient air data collected in the Washington Network is of known, acceptable, and comparable quality.

The quality assurance (QA) regulations (40 CFR Part 58, Appendix A) have been developed to ensure that ambient air monitoring programs are well planned, so that it is known what data quality is needed, that checks are included to assess data quality, and corrective actions are in place to improve quality systems when needed. The Washington Network quality system is designed to adhere to the specifications in 40 CFR Part 58, Appendix A and follow guidance outlined in the Quality Assurance Handbook so that data collected in the network is comparable with that collected by other organizations around the nation and is of sufficient quality for use in decision-making.

This plan is written using guidance from *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations (EPA QA/R5)* (http://www.epa.gov/quality/epa-qar-5-epa-requirements-quality-assurance-project-plans) and *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program* (QA Handbook) (http://www3.epa.gov/ttn/amtic/qalist.html).

Washington State Department of Ecology
Air Quality Program

Ambient Air Monitoring Quality Assurance Plan

Prepared by: Sean Lundblad

The Quality Assurance Plan for the Washington State Ambient Air Monitoring Network is recommended for approval and commits the State of Washington, Department of Ecology to follow the elements described within.

Chris Hall, US EPA Region 10 Quality Assurance Officer

Signature_____ Date 12/3/15

William Kammin, Ecology Quality Assurance Officer Date_____

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This plan has been distributed to the individuals currently working in the organizational roles listed in **Table 1.**

Table 1: Washington Network Quality Assurance Plan Distribution List

Washington State Department of Ecology
Program Manager Headquarters
Northwest Regional Office Section Manager Bellevue
Program Development Section Manager Headquarters
Science and Engineering Section Manager Headquarters
Technical Services Section Manager Headquarters
Eastern Regional Office Section Manager Spokane
Central Regional Office Section Manager Yakima
Ecology Quality Assurance Officer Headquarters
EPA Region 10
Quality Assurance Administrator
Air Monitoring Administrator

1. Project/Task Organization

The Washington State Department of Ecology is a state agency that is broadly organized into 10 environmental programs that carry out the agency's mission to protect, preserve, and enhance Washington's environment, and to promote the wise management of our air, land, and water for the benefit of current and future generations. Ecology relies on its Environmental Assessment Program (EAP) to monitor quality assurance practices within the entire agency and improve its scientific practices, especially those involving the generation and assessment of environmental data. Ecology's quality system is based on requirements established by EPA, and incorporates guidance and methodology from many standards-setting organizations world-wide.

Ecology's Executive Policy 22-01 establishes quality assurance requirements for all environmental data collection activities conducted or funded by Ecology. This policy ensures the consistent application of quality assurance principles to the planning and execution of all activities that acquire and use environmental measurement data and establishes Ecology's Quality Management Plan (QMP) (https://fortress.wa.gov/ecy/publications/summarypages/0503031.html) to implement, document, and assess the effectiveness of Ecology's quality system supporting environmental data operations.

Figure 1 shows the general organizational structure of the Washington Network as described in detail in this section.

1.1 Ecology quality assurance officer

Ecology's Quality Assurance (QA) Officer regularly reports to the EAP Manager regarding QA accomplishments and issues throughout Ecology. The QA Officer also brings issues related to QA directly to individual environmental program managers and designated QA coordinators within each program.

1.2 Air Quality Program organization

Ecology's Director administers the 10 environmental programs within Ecology. The Deputy Director assists in the direction of the environmental programs and is responsible for the oversight of program managers. The EAP Manager ensures that a satisfactory monitoring and quality assurance program is implemented for the field, laboratory, and data processing phases of each monitoring program, with assistance from the Ecology Quality Assurance Officer.

The Air Quality Program (AQP) Manager is located at Ecology Headquarters (HQ) in Lacey, with section managers located at HQ and at regional offices in Bellevue, Lacey, Spokane, and Yakima. Section managers oversee units of staff with specific expertise in their fields and assigned duties.

The Northwest Regional Office (NWRO) Section Manager is responsible for setting ambient air monitoring policy direction for the AQP. This position supervises the AQP Monitoring Coordinator and, along with the Technical Services Section (TSS) Manager, is the AQP co-lead for the Monitoring Action Committee.

The TSS Manager is responsible for oversight of AQP monitoring operations and supervises the AQP Quality Assurance Coordinator.

1.3 Monitoring action committee

The Monitoring Action Committee (MAC) is Ecology's decision-making body for Washington Network monitoring efforts. Issues regarding network monitoring policy and operational direction are discussed and evaluated during bi-monthly meetings. The MAC is comprised of AQP managers and staff, and is charged with assessing current and future monitoring, identifying communities where monitoring may be needed, identifying data quality objectives, and reviewing collected data to determine if intended monitoring objectives are being met.

MAC
Executive sponsor: AQP Program Manager
AQP co-leads: NWRO and TSS Section Managers
MAC meeting lead: AQP Monitoring Coordinator
Team members:
- AQP Quality Assurance Coordinator
- Toxics/Speciation Monitoring Project Manager
- Smoke Management Program Representative
- State Implementation Plan Lead
- TSS Section Manager
- CRO or ERO Section Manager (rotating every 2 years)
- Modeling/Meteorology Scientist

1.4 Air Quality Program leadership team

Monitoring decisions that cannot be addressed by the MAC, or that may result in significant financial, political, or resources impacts are brought before the Air Quality Program Leadership Team (AQPLT) for resolution.

AQPLT
Budget Manager
Central Regional Office Manager
Communications Manager
Eastern Regional Office Manager
Northwest Regional Office Manager
Policy Analyst
Program Development Section Manager

Program Manager
Science and Engineering Section Manager
Technical Services Manager

The AQP Manager has the final approval authority for any proposal in the Washington Network.

1.5 Air Quality Program quality assurance coordinator

The AQP Quality Assurance Coordinator serves as the representative for quality assurance activities for the Washington Network. A Quality Assurance Coordinator is defined by EPA as "the person responsible for quality management – that aspect of the overall management system of the organization that determines and implements the quality policy. Quality management includes strategic planning, allocation of resources and other systematic planning activities (e.g., planning, implementation, assessment, and reporting) pertaining to the quality system."

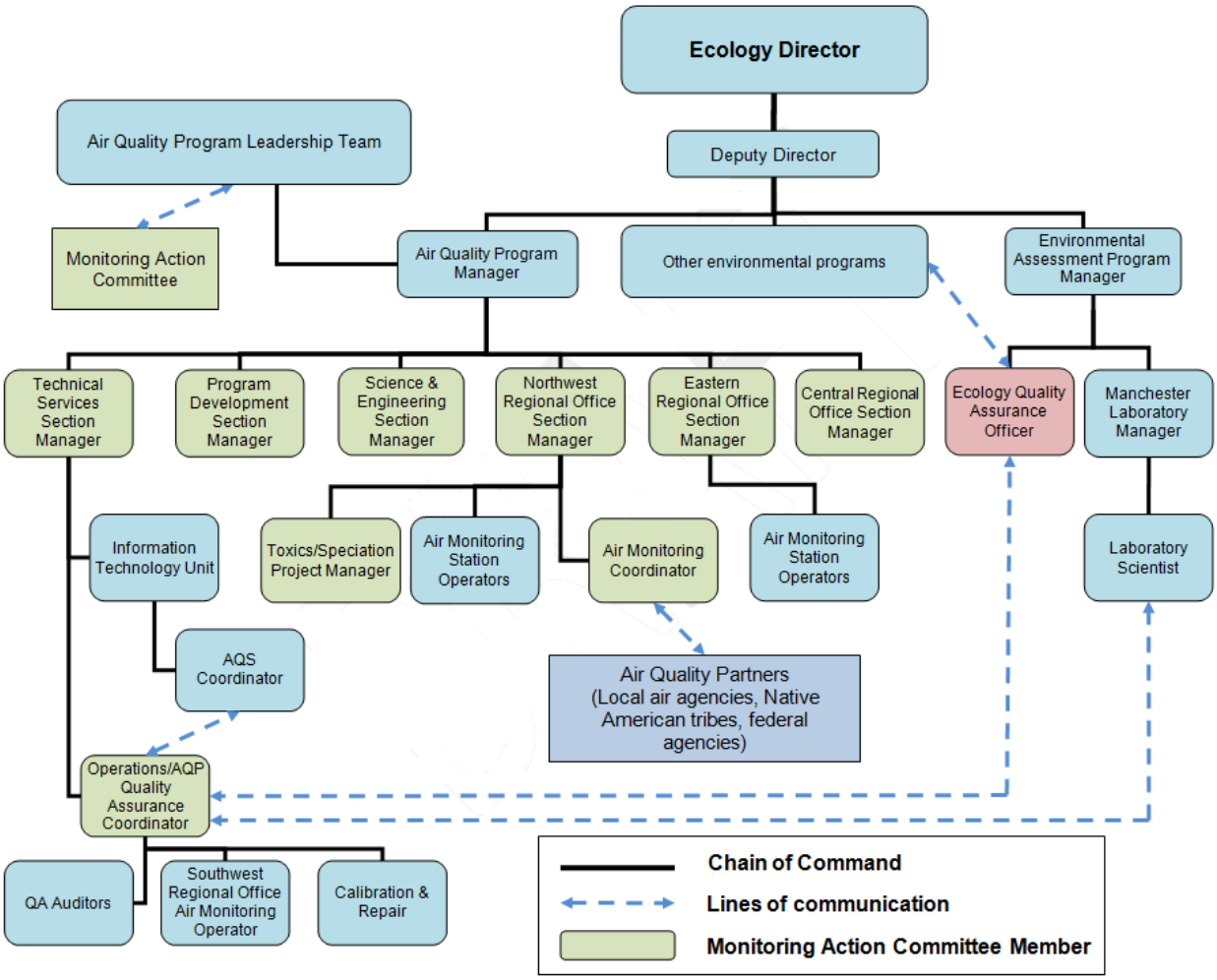

Figure 1: Air Quality Program and Washington Network Organizational Structure

2. Organizational Responsibilities

The organizational structure of Ecology's Air Quality Program is made up of units within sections located in different regions of the state. Responsibility for the collection of air quality data and the implementation of monitoring efforts are assigned to specific individuals within the Air Quality Program or are carried out by the AQP's Washington Network partner agencies. Washington Network partners collect data in accordance with the Washington Network Quality Assurance Plan and SOPs.

2.1 Washington network partners

The Washington Network includes federal, state, and local clean air agencies and tribes. These partners operate monitors and collect vital air quality information for a wide variety of applications across the state. A list of Washington Network partners is shown in **Table 2**.

Table 2: Washington Network Partners

Washington Network Partners			
Local Clean Air Agencies	**Tribes**	**Federal Agencies**	**State Agency**
Benton Clean Air Agency	Confederated Tribes of the Colville Reservation	U.S. Dept. of Agriculture Forest Service	Dept. of Ecology
Northwest Clean Air Agency	Makah Tribe	U.S. Dept. of Interior Park Service	
Olympic Region Clean Air Agency	Quinault Indian Nation	EPA	
Puget Sound Clean Air Agency	Spokane Tribe of Indians		
Southwest Clean Air Agency	Yakama Nation		
Spokane Regional Clean Air Agency			
Yakima Regional Clean Air Agency			

The collection of air monitoring data in the Washington Network requires a great degree of cooperation between the partners. Good communication and strong relationships are critical to a clear and mutual understanding of monitoring objectives, roles and responsibilities, and the collection of data sufficient to meet intended use. **Table 3** shows the basic roles and responsibilities within the Washington Network.

Table 3: Washington Network Roles and Responsibilities

Position	Responsibility
HQ Managers/Staff	
Air Quality Program Manager	• Ensures Ecology AQP policies are in place and effective, so that state and federal clean air objectives are achieved • Responsible for overall program leadership • Guides AQP decisions • Executive sponsor for MAC
Ecology Quality Assurance Officer	• Ensures Ecology quality assurance policies are maintained statewide, including Manchester Environmental Lab • Reviews individual program quality assurance plans
Technical Services Section Manager	• Supervises IT, SWRO, and Operations unit supervisors • AQLPT member • MAC member
Program Development Section Manager	• Oversees development of plans, policies, and rules that ensure air quality meets health and environmental objectives (diesel reduction strategies, toxics inventory, SIP programs) • AQPLT member
Information Technology Unit Supervisor	• Supervises AQS Coordinator, telemetry staff • Oversees telemetry equipment evaluation, procurement, and acceptance testing • Oversees telemetry system operation and maintenance
Air Monitoring Coordinator	• Meeting lead for MAC • Air monitoring evaluation, design, budget, and reports • Air monitoring equipment amortization and procurement approval • Station installation and operation coordination and status assessment • Site, shelter, and utility contracts
Science and Engineering Section Manager	• Supervises meteorologists, toxicologists, and engineers • MAC member • AQPLT member
AQS Coordinator	• Coordinates data collection from PQAO members • Loads environmental data to AQS
SWRO and Air Quality Operations Unit Supervisor/Quality Assurance Coordinator	• Responsible for AQP quality assurance activities and oversees QA lab • Supervises instrument repair and calibration laboratory staff, SWRO air monitoring station operator, quality assurance auditors • Oversees instrument procurement and acceptance testing
Regional Managers	
Northwest Regional Office Manager (Bellevue)	• Monitoring policy lead • Supervises air monitoring coordinator, toxics/speciation project manager, air monitoring station operators • Coordinates monitoring efforts in Northwest Washington • AQLPT member
Central Regional Office Manager (Yakima)	• Works with NWRO and Technical Services Section Managers to coordinate monitoring efforts in Central Washington • MAC member • AQLPT member

Eastern Regional Office Manager (Spokane)	• Coordinates monitoring efforts in Eastern Washington • Supervises air monitoring station operators • MAC member • AQLPT member
Air Monitoring Site Operator	
Staff from federal and local clean air agencies, tribes, and Ecology's SWRO, NWRO, ERO	• Selects sites; installs sites and monitors • Site/monitor maintenance and repair in the field • Quality control checks • Collect monitored data • Initial data review and validation

2.2 EPA national exposure research laboratory

EPA's National Exposure Research Laboratory (NERL) conducts research and development that leads to improved methods, measurements, and models to assess and predict human and ecosystem exposures to harmful pollutants and other conditions in air, water, soil, and food. NERL provides the following activities relative to ambient air monitoring networks:

- Develops, improves, and validates methods and instruments for measuring gaseous, semi-volatile, and non-volatile pollutants in source emissions and in ambient air
- Supports multi-media approaches to assessing human exposure to toxic contaminated media, and analytical and method support for special monitoring projects for trace elements and other inorganic and organic constituents and pollutants
- Develops standards and systems needed for assuring and controlling data quality
- Assesses whether candidate sampling methods conform to accepted reference method specifications and are capable of providing data of acceptable quality and completeness for determining compliance with applicable National Ambient Air Quality Standards
- Assesses whether emerging methods for monitoring criteria pollutants are "equivalent" to accepted Federal Reference Methods and are capable of addressing EPA's research and regulatory objectives
- Provides an independent audit and review function on data collected by NERL or other appropriate clients

2.3 EPA's Office of Air Quality Planning and Standards

Under the federal Clean Air Act (CAA) as amended in 1990, EPA's responsibility includes:

- Sets National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to the public health and environment
- Ensures that these air quality standards are met or attained through national programs and strategies to control air emissions from sources
- Ensures that sources of toxic air pollutants are well controlled

EPA's Office of Air Quality Planning and Standards (OAQPS) is responsible to protect and enhance the quality of the nation's air resources. OAQPS:

- Evaluates the need to regulate potential air pollutants
- Develops NAAQS
- Works with state and local clean air agencies and tribes to develop plans to meet NAAQS
- Monitors national air quality trends
- Maintains a database of information about air pollution and controls

- Provides technical guidance and training on air pollution control strategies
- Monitors compliance with the NAAQS

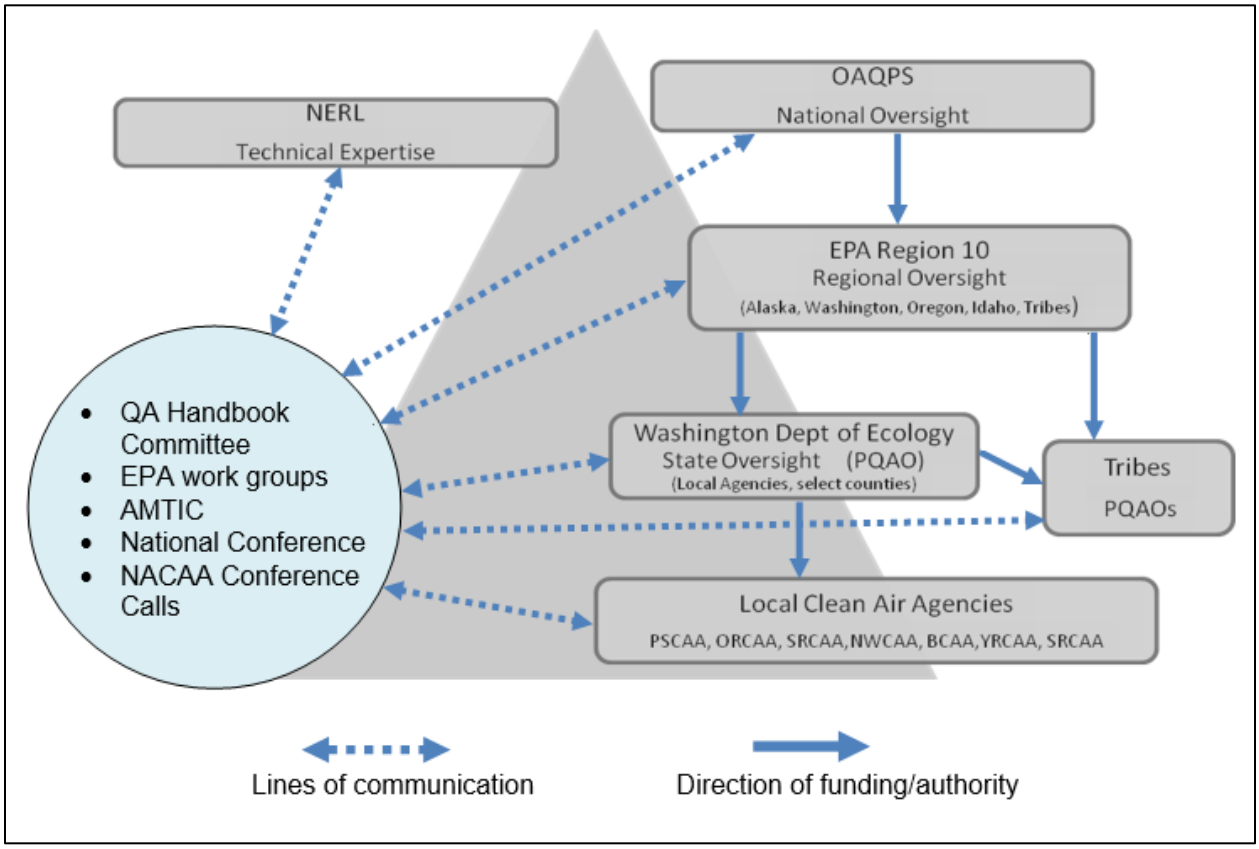

Figure 2: Organizational Oversight and Input to Decisions

Within the OAQPS Air Quality Assessment Division, the Ambient Air Monitoring Group (AAMG) is responsible to implement the National Air Monitoring Strategy and its quality assurance program. AAMG:

- Develops a quality system for the national Ambient Air Quality Monitoring Network
- Ensures that the methods and procedures used in making air pollution measurements are adequate to meet the programs objectives and that the resulting data is of appropriate quality
- Manages the National Performance Evaluation Program (NPEP)
- Performs data quality assessments of organizations making air pollution measurements of importance to the regulatory process
- Ensures that guidance related to the quality assurance aspects of the national Ambient Air Quality Program are written and revised as necessary
- Provides technical assistance to EPA regional offices and the air pollution monitoring community

2.4 EPA Region 10

EPA Region 10 plays a critical role in addressing environmental issues related to air monitoring in Washington by overseeing regulatory and congressionally-mandated programs.

The major quality assurance responsibility of EPA Region 10 regarding the National Air Monitoring Strategy is the coordination of quality assurance matters between EPA Region 10 and the Air Quality Program Quality Assurance Coordinator for the Washington Network. This role requires that EPA Region 10:

- Distributes and explains technical and quality assurance information to the Air Quality Program Quality Assurance Coordinator
- Identifies quality assurance needs of the Air Quality Program to the Office of Air Quality Planning and Standards that are national in scope
- Provides the infrastructure to implement NPEP programs
- Knows the QA regulations and possesses adequate technical expertise to address ambient air monitoring and QA issues
- Ensures Ecology has an approved quality management plan (QMPs) and that the Air Quality Program has quality assurance project plans (QAPPs) before routine monitoring
- Conducts network reviews and technical systems audits (TSA) to evaluate the capabilities of the Air Quality Program and Washington Network partners to measure criteria air pollutants
- Assesses Washington Network data quality
- Assists state, local, and tribal clean air agencies to define Primary Quality Assurance Organizations (PQAO) within their jurisdiction and to assign sites to a PQAO

2.5 Washington State Department of Ecology

Ecology is the principal environmental management agency for Washington. Ecology was established in 1970 under Chapter 43.21A RCW (http://app.leg.wa.gov/rcw/default.aspx?cite=43.21A) and is headquartered in Lacey.

Ecology's mission is to protect, preserve, and enhance Washington's environment, and to promote the wise management of our air, land, and water for the benefit of current and future generations.

2.6 Ecology regional offices

Ecology has four regional offices. Air Quality Program staff provide information and address air quality issues in counties where there is no local clean air agency. **Table 4** shows these counties.

Table 4: Counties Regulated by Ecology

Ecology Regional Office	Counties in each region
Central Regional Office (CRO)	Chelan, Douglas, Kittitas, Klickitat, Okanagan
Eastern Regional Office (ERO)	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Stevens, Walla Walla, Whitman
Northwest Regional Office (NWRO)	San Juan
Southwest Regional Office (SWRO)	N/A

2.7 Washington clean air agencies

In many Washington counties, the provisions of the federal and state clean air act are carried out by local clean air agencies havng jurisdiction over one or more counties. Local clean air agencies are largely funded by fees collected on air pollution sources within their jurisdictions, and are lesser funded by federal and state grants. These agencies partner with Ecology to conduct air monitoring as part of the Washington Network and to achieve specific goals that are mutually beneficial for their jurisdictions, Ecology, EPA, and the public. Local clean air agencies also conduct local air monitoring that is not part of the Washington Network yet still provides valuable information. The seven local clean air agencies in Washington are:

- Benton Clean Air Agency – Benton County
- Northwest Clean Air Agency – Island, Skagit, and Whatcom Counties
- Olympic Region Clean Air Agency – Clallam, Grays Harbor, Jefferson, Mason, Pacific, and Thurston Counties
- Puget Sound Clean Air Agency – King, Kitsap, Pierce, and Snohomish Counties
- Southwest Clean Air Agency – Clark, Cowlitz, Lewis, Skamania, and Wahkiakum Counties
- Spokane Regional Clean Air Agency – Spokane County
- Yakima Regional Clean Agency – Yakima County

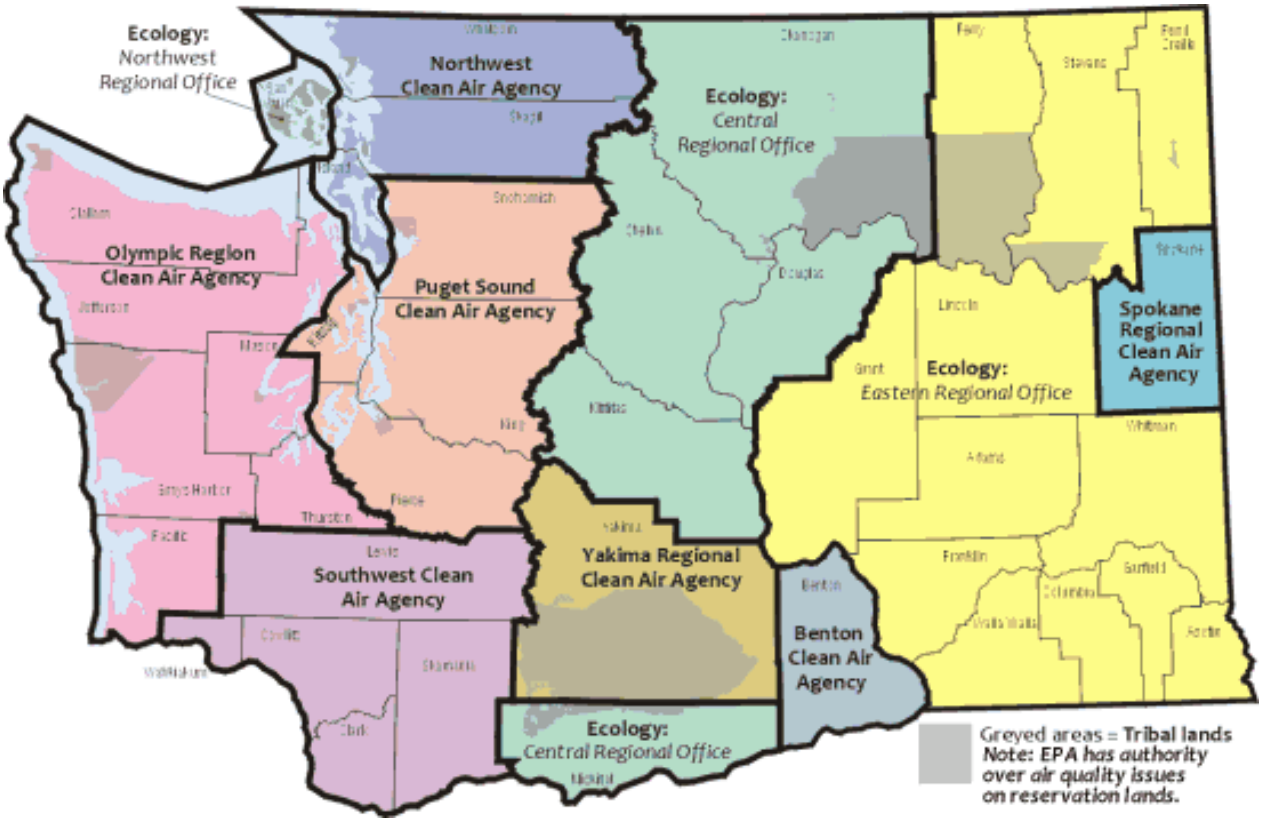

Figure 3: Washington Clean Air Agencies

2.8 Air monitoring on tribal lands

The Federal Air Rules for Indian Reservations (FARR) apply within the boundaries of 39 Indian reservations in Idaho, Oregon, and Washington. Tribes have authority for air quality issues on their lands and several tribes conduct air monitoring programs within these boundaries. Ecology contracts with EPA to provide technical assistance and support of air monitoring efforts on tribal lands for several tribes. Ecology's assistance includes site installation, instrument operation or operational assistance, quality assurance performance audits, and reporting data to AQS. Contract tribal sites receive the same level of quality assurance and support as other sites supported by the Air Quality Program and are therefore treated as part of the Washington Network.

2.9 Primary quality assurance organization

A Primary Quality Assurance Organization (PQAO) is a monitoring organization or a group of monitoring organizations that share a number of common quality assurance factors. Ecology's Air Quality Program is recognized by EPA Region 10 as the PQAO for Washington. As a PQAO, the Air Quality Program prioritizes maintaining a consistent network in order to reduce statewide measurement variability and uncertainty, and ensure comparability of monitored data throughout the state and with the national network. This is achieved by:

- Operate by a common team of field operators according to a common set of procedures
- Adhere to a common Quality Assurance Plan
- Follow common calibration facilities and standards
- Use common makes and models of instruments
- Overseen by a common quality assurance organization
- Support by a common management, laboratory, and headquarters

EPA compiles many of its data quality assessments at the PQAO level, aggregating data completeness, precision, and bias based on PQAO. Monitoring organization QAPPs must also refer to the PQAO that the monitoring organization is affiliated with and EPA Region 10 must have documentation about this.

Several Washington Network air monitoring station operators work for federal, state, and local clean air agencies and tribes. In addition, Ecology contracts with EPA, local clean air agencies, and tribes to provide operational and quality assurance support and technical assistance for ambient air monitoring activities. Ecology treats all contract site ambient air monitoring as part of the Washington Network. Further, all air monitoring that is conducted as part of the Washington Network is required to be conducted in accordance with this Quality Assurance Plan and the Ecology-approved Washington Network standard operating procedures.

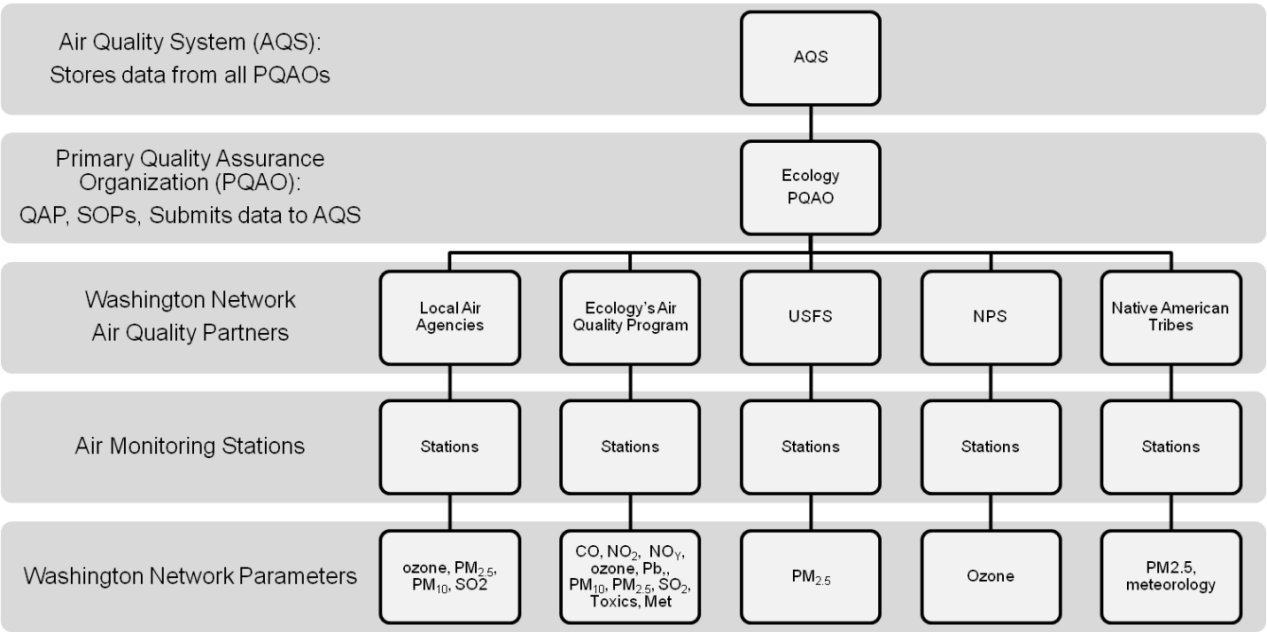

Figure 4: Washington Network PQAO Hierarchy

3. Problem Definition and Background

The federal Clean Air Act (CAA) requires EPA to develop and enforce regulations to protect the general public from exposure to airborne contaminants that are known to be hazardous to human health.

The CAA, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (40 CFR part 50). The CAA established two types of NAAQS:

- Primary standards – air pollution limits established to protect public health, including the health of sensitive populations (such as those with asthma), children, and the elderly
- Secondary standards – air pollution limits established to protect the public, including protection against decreased visibility, damage to animals and crops, vegetation, and buildings

EPA's Office of Air Quality Planning and Standards (OAQPS) has set NAAQS for six principal air pollutants, known as "criteria" pollutants. The criteria air pollutants are:

- Carbon Monoxide (CO)
- Lead (Pb)
- Nitrogen Dioxide (NO_2)
- Ground-Level Ozone (O_3)
- Particulate Matter (PM)
  - $PM_{2.5}$
  - PM_{10}
- Sulfur Dioxide (SO_2)

A list of the current level and form of the NAAQS, by pollutant, can be found in 40 CFR Part 50.

EPA is responsible for enforcing the CAA, but delegates implementation of the CAA to individual states in exchange for funding. In order to receive delegation, states must write and submit a State Implementation Plan (SIP) to EPA for approval. To achieve EPA approval, a SIP must meet minimum criteria. An EPA-approved SIP becomes the state's legal guide for local enforcement of the CAA.

Areas that violate the NAAQS may be designated by EPA as nonattainment areas. The CAA requires additional air pollution controls in these areas. EPA declares nonattainment areas for only a single pollutant. However, nonattainment areas for different pollutants may overlap each other or share common boundaries.

In the past, EPA designated 14 areas in Washington as nonattainment areas, based on air monitoring data. All of the 14 nonattainment areas have been reclassified as attainment areas (i.e., no longer violating the NAAQS). These reclassifications resulted from control measures that led to measurable decreases in pollution levels at monitoring sites over time.

While Washington is currently in attainment with the NAAQS, air pollution is still a concern in many communities. In addition, EPA reviews the most recent epidemiological and scientific studies regarding the criteria air pollutants at 5-year intervals. These rigorous reviews increase

understanding of health effects associated with air pollution and sometimes lead to revisions of the NAAQS to ensure they remain protective of human health.

3.1 Quality system requirements for EPA-funded programs

EPA's national quality system requirements can be found in EPA Order CIO2105. This order requires organizations that receive funding for collecting environmental data must develop, implement, and maintain a quality system that conforms to the minimum specifications of ANSI/ASQC E4-1994. These requirements and how Ecology satisfies them are discussed below.

3.2 Ecology's quality assurance officer

Ecology performs many environmental data collection activities for air, water, and solid waste. Ambient air monitoring is only one area of the environmental data collection work. Ecology's Quality Assurance Officer is responsible for the oversight of all agency data collection activities and is responsible for the data.

3.2.1 Ecology's quality management plan

EPA's QA/R-2 requires the implementation of a comprehensive Quality Management Plan (QMP). A QMP documents an organization's quality policy, describes its quality system, and identifies the environmental programs the quality system applies to. The QMP is necessary to ensure that sufficiently accurate environmental data is available to inform decision-making. If inaccurate data is used, erroneous conclusions may be drawn, leading to poor decisions. Other problems that may occur from the use of inaccurate data include wasted resources, legal liability, increased risks to human health and the environment, inadequate understanding of the state of the environment, and loss of credibility. It is the responsibility of the agency to have a QMP that demonstrates an acceptable quality system that is approved by EPA Region 10.

Ecology is committed to developing sound quality assurance and quality control practices, and applying them to its environmental studies and activities. Further, Ecology Executive Policy and Procedure 22-01 requires the consistent application of quality assurance principles to the planning and execution of all activities that acquire and use environmental measurement data. The development, practice, and review of a QMP are critical in meeting these goals. Ecology has an EPA-approved Quality Management Plan that is available on Ecology's QA web page. Ecology's QMP is reviewed at 3-year intervals and delegates air pollution monitoring Quality Assurance Project Plan (see next section) review and approval authority to the Air Quality Program's Quality Assurance Coordinator.

The SIP submitted to EPA by Ecology is a strategy designed to prevent pollution, clean up pollution, and support sustainable communities and natural resources. Some of Ecology's environmental data collection efforts are not for SIP purposes and therefore may have different quality objectives depending on the use and nature of the data. However, all data must have some degree of quality control consistent with its intended use.

3.2.2 Quality assurance project plans

EPA requires that all projects involving the generation, acquisition, and use of environmental data are planned, documented, and have an agency-approved Quality Assurance Project Plan (QAPP). The QAPP is the critical planning document for any environmental data collection operation since it documents how quality assurance and quality control activities will be implemented during the project's life cycle. It serves as a "blueprint" for operators, project officers, and program managers responsible for implementing, designing, and coordinating air pollution monitoring projects, and provides the foundation to ensure that the data collected during the project will be the correct type and of adequate quality for data users.

QAPPs describe, in comprehensive detail, the necessary QA/QC and other technical activities that must be implemented to ensure that the results of work performed will satisfy the stated performance criteria, which may be in the form of a data quality objective (DQO). EPA's quality assurance policy requires that every Environmental Data Organization (EDO) funded by EPA must have an approved QAPP before the start of monitoring.

All ambient air monitoring projects outside the scope of typical Washington Network monitoring operations require project-specific QAPPs. If the AQP QA Coordinator gives permission to proceed without an approved QAPP, he/she assumes all responsibility.

3.2.2.1 Graded approach to quality assurance project plans

The term "graded approach" appears in the EPA Quality Manual where it states that the level of detail in the QMP should be "based on a common sense, graded approach that establishes QA and QC activities commensurate with the importance of the work, the available resources, and the unique needs of the organization." The Quality Manual also states that monitoring organizations may tailor QAPP specifications in their own implementation documents to better fit their specific needs.

EPA Region 10 allows the Air Quality Program flexibility in writing a detailed QAPP for every project, allowing the use of a graded approach. The four-tiered project category approach to designing a QAPP is provided in order to effectively focus QA activities. The categories are listed in **Table 5** below.

Category 1 involves the most stringent QA approach, using all QAPP elements as described in EPA QA/R-5; whereas Category 4 is the least stringent, using fewer elements. The amount of detail or specificity required for each element will be less from Category 1 to 4. Each type of EDO will be associated with one of these categories. The comment area of the table indicates whether QMP and QAPP can be combined. The DQO field identifies the type of data quality objectives (DQOs) required. DQOs are defined in detail in Section 5 (Quality) of this document. EPA QA/R-5 provides more detail about which specific QAPP elements are required for each category QAPP. Based upon a specific project, the AQP Quality Assurance Coordinator may add/delete elements for a particular category as it relates to the project.

Table 5: QAPP/QMP Project Categories

Category	Program	QAPP/QMP Comments	DQO
Category 1: Projects include EDOs that directly support rulemaking, enforcement, regulatory, or policy decisions. They also include research projects of significant national interest, such as those typically monitored by the administrator. Category 1 projects require the most detailed and rigorous QA and QC for legal and scientific defensibility. Category 1 projects are typically stand-alone; that is, the results from such projects are sufficient to make the needed decision without input from other projects.	SLAMS PSD NCore IMPROVE CastNet	Most agencies implementing ambient air monitoring networks will have separate QMPs and QAPPs. However, a region has the discretion to approve combining QMP/QAPP for small monitoring organizations (i.e., tribes)	Formal DQOs
Category 2: Projects include EDOs that complement other projects in support of rulemaking, regulatory, or policy decisions. Such projects are of sufficient scope and substance that their results could be combined with those from other projects of similar scope to provide necessary information for decisions. Category 2 projects may also include certain high visibility projects as defined by EPA.	Speciation Trends Toxics Monitoring	Most agencies implementing ambient air monitoring networks will have separate QMPs and QAPPs. However, a region has the discretion to approve combining QMP/QAPP for small monitoring organizations (i.e., tribes).	Formal DQOs for national objective
Category 3: Projects include EDOs performed as interim steps in a larger group of operations. Such projects include those producing results that are used to evaluate and select options for interim decisions, or to perform feasibility studies or preliminary assessments of unexplored areas for possible future work.	SPM One-Time Studies Local Scale Air Toxics Grants	EDOs of short duration. QMP and QAPP can be combined.	Flexible DQOs
Category 4: Projects involving	Education/		Project

EDOs to study basic phenomena or issues, including proof of concepts, screening for particular analytical species, etc. Such projects generally do not require detailed QA/QC activities and documentation.	outreach		objectives or goals

3.2.2.2 Flexibility in the systematic planning process

Table 5 describes four QAPP/QMP categories which require some type of statement about the program or project objectives. Three of the categories use the term data quality objectives (DQOs), but there is flexibility within the systematic planning process about how these DQOs are developed based on the particular category. For example, a Category 1 project would have formal DQOs. EPA's Office of Air Quality Planning and Standards (OAQPS) develops DQOs for Category 1 projects, such as the State and Local Monitoring Stations (SLAMS). Formal DQOs may apply to Category 2 QAPPS if there are national implications to the data (e.g., Chemical Speciation Network). For projects that are local in scope, organizations may develop less formal DQOs. Categories 3 and 4 would require less formal DQOs to a point that only project goals (Category 4) may be necessary.

4. Project/Task Description

Criteria air pollutant levels in Washington declined dramatically after implementation of the CAA and associated amendments. Monitoring data collected in the Washington Network reveal this decrease and show the effectiveness of implemented control measures over time (**Figure 5**).

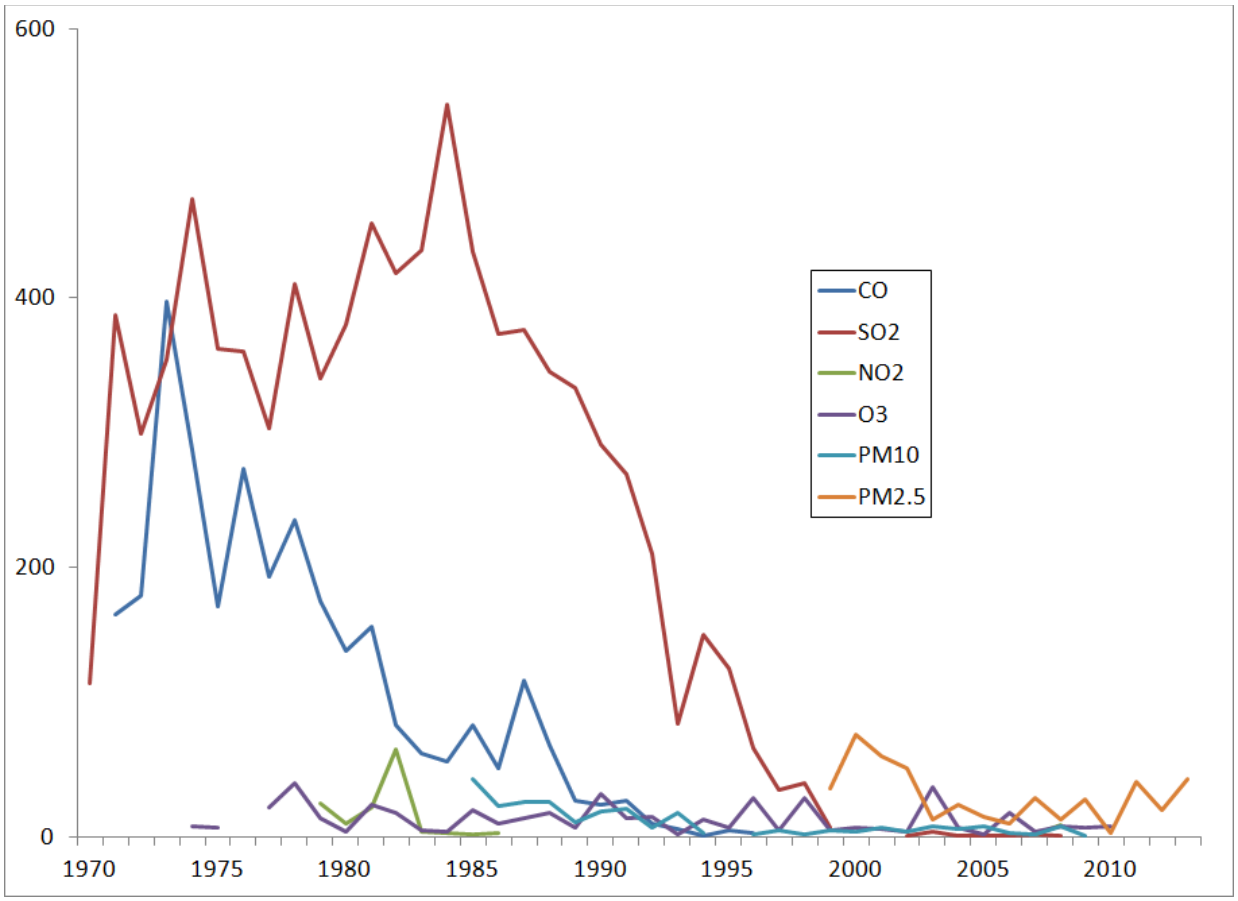

Figure 5: Number of Exceedances in Washington (using current NAAQS)

While air quality for some of the criteria pollutants has improved dramatically, other criteria pollutants have remained relatively constant and have even increased in some areas. In addition, scientific understanding of the adverse health and environmental impacts associated with the criteria and other air pollutants (such as air toxics) has also dramatically improved. As mentioned earlier in this document, EPA conducts NAAQS reviews at 5-year intervals, reviewing the latest scientific epidemiological studies to ensure that the NAAQS continue to protect human health. Recent epidemiological studies show that adverse health effects from fine particle ($PM_{2.5}$), ozone, NO_2, and SO_2 occur at lower levels than previously thought. These studies provided the basis for EPA to revise the NAAQS for these pollutants.

$PM_{2.5}$ and ozone occasionally reach unhealthy levels in Washington communities. Therefore, where levels begin to approach the NAAQS, monitoring for these criteria pollutants and their constituent species and precursors is a primary focus of monitoring efforts in the Washington Network.

4.1 Fine particle pollution

Several communities in Washington are close to violating 24-hour NAAQS for fine particles ($PM_{2.5}$). $PM_{2.5}$ pollution in Washington communities comes from a variety of sources related to

incomplete combustion. In general, $PM_{2.5}$ pollution on the west side of the Cascade Mountains is mostly from home heating and mobile sources. The same is true on the east side of the Cascade Mountains, but due to the more rural nature, agricultural and silvicultural burning play a larger role. In many communities on both sides of the Cascades, smoke from residential home heating is a major contributor to unhealthy $PM_{2.5}$ levels during the winter.

4.2 Ozone

The Air Quality Program began monitoring ozone in Western Washington in the 1970s and found that ozone levels were highest in the rural areas near the foothills of the Cascade Mountains. It is now understood that precursor pollutants, largely generated by sources in the heavily-populated Interstate 5 corridor, drift on prevailing winds and form ozone on hot summer days. Several communities downwind of Seattle, Tacoma, and Vancouver experience elevated ozone concentrations from May through September when temperatures rise above 30°C. Ozone levels also reach unhealthy levels in Spokane and Benton Counties, east of the Cascades.

Ozone is known to be a threat to human health, but it is also harmful to the natural environment. The U.S. Forest Service and National Park Service have conducted studies that show ozone has damaged trees, moss, and lichens in Mt. Rainier National Park and in Cascade forest and wilderness areas.

Climate change is expected to increase the occurrence of wildfires in the Pacific Northwest which may lead to corresponding increases in ozone pollution. Many sites in the Washington Network provide long-term datasets with which to track such changes and better characterize health and environmental implications associated with ozone pollution.

4.3 Monitoring goals of the Air Quality Program

The Air Quality Program's mission is to protect public health and the environment by preventing and reducing air pollution. A key QAP strategic goal is to understand air pollution and its health consequences. In keeping with the program's mission and the AQP's strategic goal, the Washington Network's goal is to provide data of sufficient quality to:

- Determine if air quality is meeting the NAAQS
- Provide near real-time air quality information to protect public health
- Forecast air quality
- Make daily burn decisions and curtailment calls
- Assist permitting activities
- Evaluate the effectiveness of air pollution control programs
- Evaluate the effects of air pollution on public health
- Determine air quality trends
- Identify and develop responsible and cost-effective pollution control strategies
- Evaluate air quality models

4.4 National ambient air monitoring network participation

Through the process of implementing the CAA, EPA has identified several major categories of monitoring stations or networks that apply to the measurement of the criteria air pollutants. The Washington Network is comprised of stations that are part of national monitoring network program efforts as well as an interagency program.

4.5 State and local air monitoring stations

State and Local Air Monitoring Stations (SLAMS) comprise the majority of monitoring sites within the Washington Network. The majority of these sites support measurements of criteria pollutant measurements for particulates and/or ozone for NAAQS compliance and the satisfaction of SIP requirements. Additional SLAMS operations within the Washington Network are described below. A complete list of the current Washington Network SLAMS sites can be found in the most recent version of Ecology's annual Ambient Air Monitoring Network Report, available on Ecology's web site.

4.5.1 $PM_{2.5}$ chemical speciation network

The $PM_{2.5}$ Chemical Speciation Network (CSN) is an EPA-funded national network of monitors which are used to determine the chemical makeup of $PM_{2.5}$. Trends in concentration levels of selected ions, metals, carbon species, and organic compounds that make up $PM_{2.5}$ are determined over several years at fixed monitoring sites. Ecology and its partners often use CSN data to conduct source apportionment studies at locations recording $PM_{2.5}$ pollution levels near the NAAQS. The results from these studies are used to guide the development of effective control strategies.

CSN monitoring is conducted at the NCore station in Seattle – Beacon Hill and a handful of supplemental chemical speciation sites in the Washington Network. A list of the CSN sites is available in the current version of the annual Ambient Air Monitoring Network Report, available on Ecology's web site.

The CSN is a component of the National $PM_{2.5}$ SLAMS network. Although the CSN network is intended to complement SLAMS activities, CSN data is not used for determining NAAQS compliance. The objectives of the CSN network are:

- Determine the chemical makeup of $PM_{2.5}$
- Understand which sources contribute to $PM_{2.5}$ at each site
- Determine the spatial and temporal differences of $PM_{2.5}$ composition between geographical areas
- Provide representative $PM_{2.5}$ speciation data to support exposure assessments (i.e., determine health risks)
- Provide data for source apportionment

4.5.2 Near-road monitoring

Near-road monitoring for NO_2 in the Washington Network is also part of the SLAMS network. In 2009, EPA published a technical assistance document describing new minimum monitoring requirements and guidance in support of the 2009 NO_2 NAAQS revision. The NO_2 NAAQS was revised to include a 1-hour standard with a 98th percentile form and a maximum allowable NO_2 concentration of 100 ppb anywhere in an area, while retaining the annual standard of 53 ppb. EPA's NO_2 Risk and Exposure Assessment recognized that roadway-associated exposures account for a majority of ambient exposures to peak NO_2 concentrations. Near-road monitoring for NO_2 began in Seattle at the 10th and Weller location in 2014. The Seattle location is a Phase 1 near-road location. As such, it is a multi-pollutant site with measurements of carbon monoxide, continuous $PM_{2.5}$, and meteorology. A second Phase 2 (NO_2 and meteorology only) location in Tacoma is expected to begin operation in 2016.

4.5.3 National air toxics trend stations

EPA developed the National Air Toxics Trends Station (NATTS) Network to fulfill the need for long-term Hazardous Air Pollutant (HAP) monitoring data of consistent quality. Among the principle objectives are assessing trends and emission reduction program effectiveness, assessing and verifying air quality models (e.g., exposure assessments, emission control strategy development, etc.), and as direct input to source-receptor models. The current network configuration includes 27 sites (20 urban, 7 rural) across the United States; 13 sites were established in 2003, 10 sites in 2004, and 2 sites each in 2007 and 2008. There are typically over 100 pollutants (although only 19 of those are required) monitored at each NATTS, including VOCs, carbonyls, PM_{10} metals, and PAHs. There is currently a single site in the Washington Network in Seattle (Beacon Hill).

Grants to conduct additional toxic monitoring are awarded by EPA Region 10. Past air toxics monitoring has been conducted in Vancouver, Spokane, Seattle, and Tacoma.

For each NATTS study, a separate QAPP is required and must be submitted by the Project Manager to the Air Quality Program's Quality Assurance Coordinator before the project begins. The QAPP must provide clear monitoring objectives and a detailed description of the quality control activities in keeping with satisfying those objectives.

4.5.4 National core monitoring network

National Core Monitoring (NCore) is a multi-pollutant network that integrates several advanced measurement systems for particles, gaseous pollutants, and meteorology.

The NCore Network addresses the following objectives:

- Timely reporting of data to the public by supporting AirNow, air quality forecasting, and other public reporting mechanisms

- Support for development of emission strategies through air quality model evaluation and other observational methods
- Accountability of emission strategy progress through tracking long-term trends of criteria and non-criteria pollutants and their precursors
- Support for long-term health assessments that contribute to ongoing reviews of the NAAQS
- Compliance through establishing nonattainment/attainment areas through comparison with the NAAQS
- Support to scientific studies ranging across technological, health, and atmospheric process disciplines
- Support to ecosystem assessments recognizing that national air quality networks benefit ecosystem assessments and, in turn, benefit from data specifically designed to address ecosystem analyses

There are two NCore stations within the Washington Network: Seattle-Beacon Hill and Cheeka Peak. Beacon Hill is designated as Urban NCore while Cheeka Peak, which is located on the western tip of the Olympic Peninsula, is designated a rural NCore station. The Cheeka Peak site is funded by EPA, and operated by the Olympic Region Clean Air Agency and the Makah Tribe Air Quality Program. The Ecology Air Quality Program is contracted to provide air quality system (AQS) and quality assurance support.

4.5.5 Other SLAMS monitoring

Ecology conducts NAAQS compliance monitoring for carbon monoxide at a single location in Spokane which is operated to satisfy maintenance plan requirements.

Ecology also monitors lead for NAAQS compliance purposes at the NCore site in Seattle – Beacon Hill.

4.6 Special purpose monitoring stations

Special Purpose Monitoring Stations (SPMS) are designed to meet discrete, typically shorter-term goals and are designated as such in Ecology's annual Ambient Air Monitoring Network Report and AQS. Monitoring activities at these stations are designed to supplement the longer-term SLAMS network, report near real-time pollution information for EPA's AQI and Ecology's WAQA, and be flexible enough to accommodate changing program needs and priorities. Examples of SPMS sites in the Washington Network include the agricultural burning sites in Eastern Washington. Data from SPMS must meet all Washington Network quality control, quality assurance, siting, and methodology requirements as described in this Quality Assurance Plan and the Ecology-approved Washington Network standard operating procedures.

SPMS data collected within the Washington Network via a federal reference method (FRM) or federal equivalent method (FEM) instrument must be operated in accordance with the requirements of 40 CFR Part 58.11, 58.12 and the QA requirements in 40 CFR Part 58, Appendix A. Compliance with the probe and monitoring path siting criteria in 40 CFR Part 58,

Appendix E must also be followed. All Washington Network SPMS data collected using a FRM/FEM and meeting the requirements of Appendix A is reported to AQS in accordance with the requirements of 40 CFR Part 58.16. The Air Quality Program identifies whether each SPM meets the requirements of Appendices A and E in AQS.

Contract-supported special purpose monitoring stations - The Air Quality Program contracts with EPA, the U.S. Forest Service, and local clean air agencies for operational and quality assurance support for various monitoring activities around the state. Contract-supported sites are usually Special Purpose Monitoring Stations (SPMS) and are considered part of the Washington Network. All contract-supported monitoring activities are conducted in accordance with this Quality Assurance Plan and Washington Network Standard Operating Procedures. Data collected from these stations that are found to meet all data quality requirements are validated and submitted to AQS. A list of the current contract sites can be obtained in the most recent version of Ecology's annual Ambient Air Monitoring Network Report, available on Ecology's web site.

4.7 Interagency monitoring of protected visual environments

The Air Quality Program operates an Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring site at Beacon Hill in Seattle.

The IMPROVE program is a cooperative measurement effort governed by a steering committee made up of representatives from federal and regional state organizations. The IMPROVE monitoring program was established in 1985 to aid the creation of federal and state implementation plans to protect visibility in Class I areas as specified in the 1977 amendments to the Clean Air Act.

The objectives of IMPROVE are to:

- Establish current visibility and aerosol conditions in mandatory Class I areas
- Identify chemical species and emission sources responsible for existing man-made visibility impairment
- Document long-term trends for assessing progress toward the national visibility goal
- Provide regional haze monitoring representing all visibility-protected federal Class I areas where practical

5. Quality Objectives and Criteria for Measuring Data

Data are never completely error free. Therefore, it is critical that those involved in making decisions using air monitoring data understand the inherent error (uncertainty) of those data. Various metrics of data quality guide the level of confidence associated with such decisions and can help inform changes to data collection processes that may reduce future uncertainty. Decision makers must establish acceptable limits on these data quality metrics and understand the quality of collected data in order to reduce the risk of poor decision-making.

EPA is responsible for developing the NAAQS, defining the quality of the data necessary to make comparisons to the NAAQS, and identifying the minimum amount and nature of quality control activities from which to evaluate data quality. The Air Quality Program is responsible for developing and implementing a quality system to ensure data quality requirements within the Washington Network are met. The Air Quality Program assesses the quality of collected data and takes corrective action when necessary.

5.1 Data quality objectives and the data quality objective process

The EPA Quality Assurance Handbook, Volume II, defines data quality objectives (DQOs) as qualitative and quantitative statements that:

- Clarify the purpose of the study
- Define the most appropriate type of information to collect
- Determine the most appropriate conditions from which to collect that information
- Specify tolerable levels of potential decision errors

EPA developed the DQO process in the 1980s to help ensure data quality and data collection efficiency regarding monitoring for NAAQS compliance. The process has evolved to reflect best scientific principles and project management. It can best be thought of as a systematic planning process for efficiently generating environmental data that will be sufficient for their intended use and for managing decision errors. The underlying principles of the DQO process are:

- All collected data contain some amount of error.
- No organization can afford absolute certainty (completely error-free data).
- The DQO process defines tolerable error rates.
- Without DQOs, decisions are uninformed.
- Uninformed decisions tend to be conservative and expensive.

The DQO process identifies the allowable population and measurement uncertainty for a given objective. The monitoring program is then developed, and quality control samples are identified and implemented to evaluate data quality (through data quality assessments) to ensure that it is maintained within the established acceptance criteria.

Data collected in the Washington Network are used to make very specific decisions that can have health and economic impacts on the area represented by the monitor. The MAC and AQPLT must have confidence that the data used to make environmental decisions are of sufficient quality. Therefore, the DQO process is used within the Washington Network and applied to all monitoring projects.

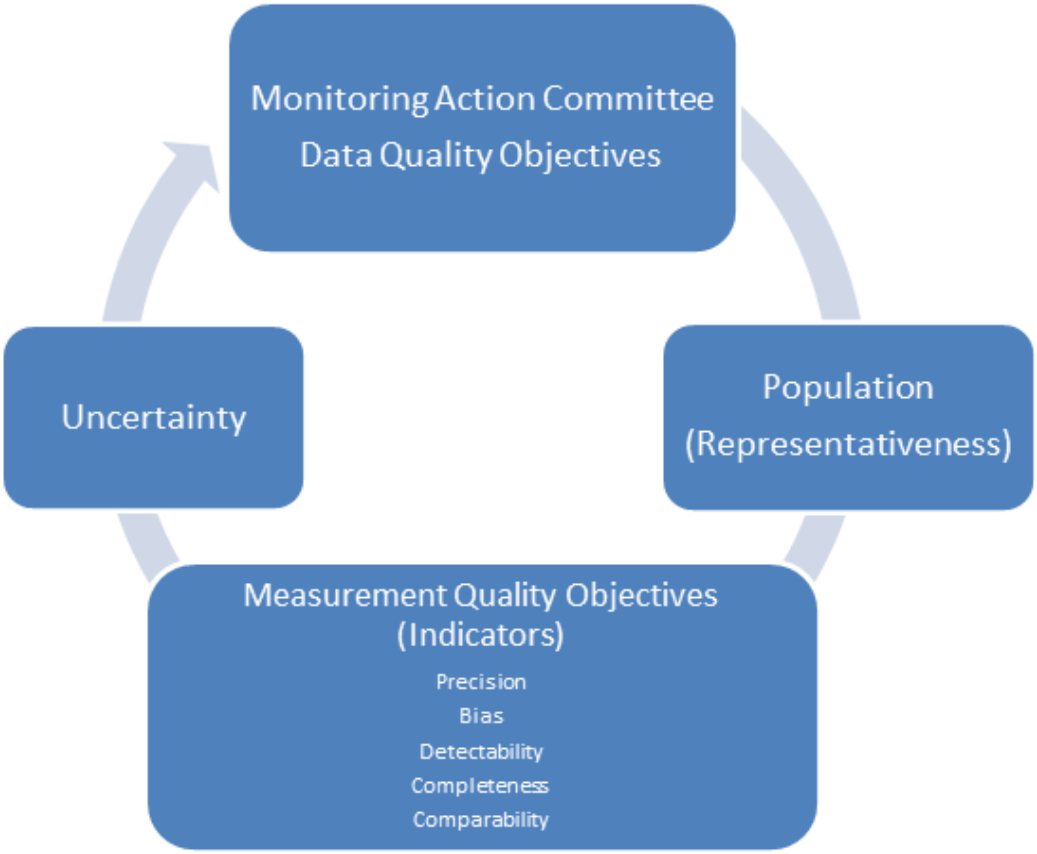

Figure 6: The Data Quality Objective Process

Before any monitoring begins, the MAC determines the DQOs for a given project or study in order to:

- Clarify the study objective
- Identify the target population(s) of the monitoring study
- Define the most appropriate type of data to collect
- Determine the most appropriate conditions/times of year to collect data
- Specify limits on decision errors which will be used to establish the quantity and quality of data needed to support the decision

The Air Quality Program's Quality Assurance staff routinely evaluate the DQOs, particularly when pollution levels are near NAAQS violations. Uncertainty or error in the measurements may falsely indicate a NAAQS violation when pollution levels are actually below the NAAQS or vice versa. Such uncertainties may require changes in monitoring systems or processes in order to reduce error, and provide the program and our partners with greater confidence that attainment designation recommendations are defensible and correct. If any of the DQOs are not met, the Quality Assurance Coordinator advises the MAC in identifying and implementing adjustments to the project to reduce uncertainty to acceptable levels.

5.1.1 Measurement quality objectives

Measurement quality objectives (MQOs) are identified as the various quality control (QC) samples or QC activities undertaken to ensure DQOs are met. Data verification/validation is the process of reviewing information to ensure that data of unacceptable quality are identified and appropriately handled in order not to adversely impact the decision-making process.

MQOs are designed to evaluate and control various phases (e.g., sampling, transportation, preparation, and analysis) of the measurement process to ensure that total measurement uncertainty is within the range prescribed by the DQOs. MQOs can be defined in terms of the following data quality indicators (DQI):

- Precision
- Bias
- Representativeness
- Detection limit
- Completeness
- Comparability

The AQP Quality Assurance Coordinator assists the MAC in determining appropriate MQOs for proposed monitoring projects.

5.1.2 Data quality assessments

Air Quality Program Quality Assurance staff rely on the AQS AMP256 QA Data Quality Indicator Report to compile summary information about whether the Washington Network is meeting its MQOs. This information is used to prepare quarterly and annual Ambient Air Monitoring Data Quality Assessment Reports for the AQPLT, MAC, and our partners. The Data Quality Assessments describe how well the Washington Network is meeting its MQOs. The AQP Quality Assurance Coordinator also provides updates to the MAC at bi-monthly meetings about MQOs for the Washington Network and keeps decision makers informed about whether the quality of collected data is sufficient for decision-making.

5.2 Ecology Air Program data quality goals

A primary goal of the Air Quality Program is to collect data within the Washington Network that is of sufficient quality and quantity to meet the program requirements and objectives consistent with its intended use. The MAC, AQPLT, and Ecology's partners recognize that good decisions depend on high quality data collected for a well-defined, specific purpose.

The Washington Network quality system developed by Ecology's Air Quality Program is designed to produce results that will:

- Meet a well-defined use or purpose
- Satisfy the strategic goals of the Air Quality Program

- Comply with federal/state requirements and specifications
- Consider cost and resources
- Match data quality needs to intended uses

5.3 Monitoring project proposals

Before any monitoring begins, the MAC reviews Washington Network monitoring proposals to determine if proposed projects meet Air Quality Program objectives. Monitoring project proposals are approved at the MAC level, but the Air Quality Program Manager has final approval about any monitoring project within the Washington Network.

6. Personnel Qualification and Training

Ambient air monitoring personnel must have sufficient education, training, and skills in order to properly operate a variety of complex air sampling instrumentation and associated gear. Basic knowledge of ambient air monitoring principles, meteorology, chemistry, statistics, and physics are important to ensure competency. Personnel involved in air monitoring activities often interact with the public and staff from other federal and state agencies and tribes. Therefore, good interpersonal, verbal, and written communication skills are also critical to successfully carry out assignments. The physical ability to travel to and from monitoring sites by vehicle, travel overnight, climb ladders, and carry equipment up to 50 pounds is necessary to perform the duties of an ambient air monitoring station operator.

6.1 Qualifications

All of Ecology's air monitoring personnel are hired through a competitive process and must meet minimum qualifications defined by the State of Washington and Ecology Human Resources. External partner agencies and tribes within the Washington Network have their own minimum requirements for air monitoring personnel. However, there is a basic set of knowledge, skills, and abilities necessary to be a successful air monitoring operator in the Washington Network. Air monitoring personnel must be capable of performing the following basic functions independently or with assistance from Ecology staff:

- Install, operate, and maintain environmental monitoring/sampling equipment
- Calibrate environmental monitoring/sampling equipment, in accordance with manufacturer specifications and standard operating procedures
- Review basic sampling data to ensure data validity
- Maintain basic databases or inventories
- Review monitoring plans for technical accuracy
- Conduct routine sampling and testing
- Analyze, evaluate, and interpret data
- Write reports
- Maintain and use databases related to monitoring projects

6.2 Ecology training

Ecology Calibration and Repair and Quality Assurance staff provide periodic training to station operators on the proper calibration, operation, quality control, and maintenance activities for instruments used in the Washington Network. These activities are also described in detail in the instrument-specific standard operating procedures (SOPs). To the extent possible, Ecology provides training in advance on equipment that has not been previously used in the Washington Network.

In addition, Ecology's Environmental Assessment Program Quality Assurance Program provides additional information about fundamental quality assurance principals.

6.3 External training

Training is also provided through EPA and other external organizations. Instructional seminars and training may be provided as DVDs, online presentations, webinars, and in-person classroom instruction. Several training opportunities are offered by the Air Pollution Training Institute (APTI) (http://www.apti-learn.net/LMS/EPAHomePage.aspx).

Air Quality Program QA staff responsible for auditing the $PM_{2.5}$ Chemical Speciation Network and supplemental sites are required to take training and be currently certified by Office of Air Quality Planning and Standards (OAQPS) (http://www3.epa.gov/ttn/amtic/specguid.html). Courses are provided by OAQPS staff on a recurring basis.

Air Quality System training (AQS training) is available online through EPA's Technology Transfer Network (TTN).

The Institute for Tribal Environmental Professionals (ITEP) and Tribal Air Monitoring Support (TAMS) Center provide a series of courses for tribal air monitoring operators.

Table 6 below presents a list of Ecology-recommended training for ambient air monitoring laboratory, field, and quality assurance staff as well as managers overseeing the work.

Table 6: Recommended Training for Ambient Air Monitoring Personnel

APTI COURSES (SI = ONLINE ONLY)		LAB/FIELD	QA	MANAGERS
INTRODUCTION TO AIR POLLUTION CONTROL				
APTI SI-422	Air Pollution Control Orientation Course	X	X	X
APTI SI-105	Introduction to Air Pollution Control	X	X	X
APTI 452	Principles and Practices of Air Pollution	X	X	X
AMBIENT MONITORING, INCLUDING QA/QC AND DATA ANALYSIS				
APTI SI-434	Introduction to Ambient Air Monitoring	X	X	X
APTI SI-473A	Beginning Environmental Statistical Techniques	X	X	X

APTI 435	Atmospheric Sampling (1983) (PM 2.5 Monitoring Update - 1998)	X	X	X
APTI SI-471	General Quality Assurance Consideration for Ambient Air Monitoring	X	X	X
APTI SI-474	Introduction to Environmental Statistics	X	X	
APTI 464	Analytical Methods for Air Quality Standards	X	X	
APTI 470	Quality Assurance for Air Pollution Measurement Systems	X	X	X
APTI SI-433	Network Design and Site Selection for Monitoring PM2.5 and PM10 in Ambient Air			X
APTI SI-436	Site Selection for Monitoring PM2.5 and PM10 in Ambient Air	X	X	X
MODELING, FORCASTING, AND DATA ANALYSIS				
APTI SI-409	Basic Air Pollution Meteorology			
EPA QUALITY ASSURANCE COURSES		**LAB/FIELD**	**QA**	**MANAGERS**
Assessing Quality Systems				X
Detecting Improper Laboratory Practices				X
Introduction to Data Quality Assessment			X	X
Introduction to Data Quality Objectives			X	X
Introduction to EPA Quality System Requirements			X	X
Introduction to Quality Assurance Project Plans			X	X

6.4 Conferences and professional organizations

Air monitoring and quality assurance personnel are strongly encouraged to attend and contribute input to professional conferences in order to benefit from the many opportunities these venues provide. Active participation and networking opportunities with colleagues from other agencies, organizations, and businesses maximize professional growth and benefit the Washington Network.

Several organizations provide information and professional development opportunities for staff to pursue. Some of these include: The Western States Air Resource Council (WESTAR), the National Association of Clean Air Agencies (NACAA), and the Air and Waste Management Association (AWMA).

6.5 Vendor training

Several vendors of air monitoring equipment offer specialized training. Many of these courses are instrument-specific (e.g., Teledyne Advanced Pollution Instrumentation) and provide technicians hands-on instruction. Several offer custom training classes and off-site training for specific needs.

6.6 Other learning resources for air monitoring professionals

Monitoring objectives can differ greatly between individual states, tribes, and local agencies. EPA's Office of Air Quality Planning and Standards provides national oversight with limited resources and invites agencies to participate in policy-making activities. Ecology's Air Quality Program encourages staff to participate in OAQPS-sponsored committees, work groups, and conferences in order to share perspectives with others performing similar work around the nation, as well as to improve their understanding of how policy decisions are made.

The Ambient Monitoring Technology Information Center (AMTIC) is operated by EPA's Ambient Air Monitoring Group (AAMG). AMTIC is an excellent source of information about ambient air quality monitoring programs, monitoring methods including QAPPs and SOPs, relevant documents and articles, air quality trends and nonattainment areas, and federal regulations related to ambient air quality monitoring.

7. Documentation and Records

By May 1 of each year, the Air Quality Program is required to submit an annual Data Certification Report (AMP600) to the EPA Administrator, through the Region 10 Office. This report certifies the validity of all Washington Network SLAMS, meteorological, and SPMS data in AQS for the previous calendar year. The report and associated letter from the Air Quality Program Manager certifies that the given year's data are accurate to the best of his/her knowledge. The certifications are based on the various data quality assessments and validation process performed by the organization.

7.1 Electronic records

Most of the data collected by the Air Quality Program is collected and stored electronically. These electronic records are stored in databases, shared network drives, and other locations in a logical order for ease of access. Raw and edited ambient air quality and most quality control data are securely stored on computer servers. Incremental backups are done daily and full backups weekly. For historical reasons, hourly ambient air monitoring data is kept in perpetuity, while 1-minute data (largely used for quality assurance purposes) is retained for about 9 months.

Table 7: Washington Network Record Storage Locations

Categories	Record	File Location
Management and Organization	State Implementation Plan Reporting agency information Organizational structure Personnel qualification and training Training certification Quality management plan EPA directives Grant allocations Support contracts	Headquarters-Lacey
Site Information	Network description Site Information Management System Site maps Site pictures	Headquarters-Lacey
Environmental Data Operations	QA project plans Standard Operating Procedures Electronic field notes Inspection/maintenance records	Headquarters-Lacey
Environmental Data Operations	Laboratory notebooks Sampling handling/custody records	Manchester Laboratory
Raw and Edited Data	Lab results (tare/gross weights) Lab QC results	Manchester Laboratory
Raw and Edited Data	Any ambient monitoring data (including QC data) QC data entry forms	Headquarter-Lacey
Data Reporting	Washington Air Quality Advisory Report Annual Data Certification Reports	Headquarters-Lacey
Data Management	Nephelometer-$PM_{2.5}$ correlations/models Data management plans/flowcharts Data Acquisition/Management Systems	Headquarters-Lacey
Air Monitoring Coordination	Network reviews	Headquarters-Lacey
Quality Assurance	Data quality assessments QA reports System audits Response/corrective action reports Performance audits	Headquarters-Lacey

7.2 Data acquisition system

The Air Quality Program uses the Envitech Ltd./DR DAS (Envidas) Environmental Data Acquisition System software for electronic data collection, review, verification, validation, and submittal to AQS (see Section 17). A customized off-the-shelf Envidas web site is used for near real-time display of continuous monitoring data as well as site information. All collected data is stored in an Envidas database housed on a Microsoft SQL server physically located at Ecology's headquarters building in Lacey.

7.3 Record retention

The Air Quality Program retains air monitoring records for a minimum period (years) as required by federal rule and/or Washington and Ecology retention schedules. As stated in 40 CFR Part 31.42, all information considered as documentation and records must be retained for 3 years from the date the grantee submits its final expenditure report unless otherwise noted in the funding agreement. However, if any litigation, claim, negotiation, audit, or other action involving the records has been started before the expiration of the 3-year period, the records will be retained until completion of the action and resolution of all issues that arise from it, or until the end of the regular 3-year period, whichever is later. The retention of samples produced as a result of required monitoring may be different depending on the program and/or purpose samples were collected.

7.4 Site information management system

Site information is retained by the Air Quality Program to record physical changes and characterize sites over time. The Air Quality Program's Site Information Management System (SIMS) and the Ecology ambient air monitoring data web site (https://fortress.wa.gov/ecy/enviwa/Default.htm) are used to capture, track changes, and retain site information. This information is updated by station operators as monitored parameters and/or physical conditions at the site change.

SIMS information includes:

- Monitoring objective (e.g., population exposure, highest concentration, etc.)
- Monitor/station type (SLAMS, SPMS, NCore, etc.)
- Instrumentation and methods (pollutant being measured, instrument manufacturer's make and model, etc.)
- Measurement scale (micro, middle, neighborhood, etc.)
- Land use (industrial, commercial, etc.)
- Location setting (urban, rural, etc.)
- Physical location and characteristics (address, latitude and longitude coordinates, elevation, etc.)
- Probe location (top of building, ground level, etc.)
- Equipment inventory

The Ecology air monitoring data web site includes:

- Site photos, including the monitoring shelter 8 compass cardinal point pictures
- A map showing the location of all monitoring locations in the state

7.5 Environmental data operations

The Air Quality Program and its Washington Network partners recognize that ambient air monitoring results and, in certain types of measurements, the sample itself may be essential elements in proving the validity of the data or the decisions made using the data. Data will not withstand scrutiny, particularly in the event of legal challenge, unless it can be shown that they are representative of the conditions that existed at the time that the data (or sample) were collected. Therefore, Washington Network partners follow several steps to ensure the evidence collection phase of the quality assurance process is preserved. Failure to include, follow, and document any of the following elements in the collection and analysis of ambient air monitoring data may render the results inadmissible as evidence or seriously undermine the credibility of any report based on the data.

- **Quality assurance project plans** – QAPPs document how environmental data operations are planned, implemented, and assessed during the life cycle of a program, project, or task.

- **Standard operating procedures (SOPs)** – SOPS are detailed documents that provide instruction about how Washington Network staff will perform daily tasks in the field, laboratory, and office. SOPs are a required element of a QAPP and therefore any EDO must include these.

- **Field and laboratory documentation** – Any documentation, electronic or hard copy, that provides additional information about the environmental data operation (e.g., calibration results, visual representations of data, temperature records, site notes, maintenance records**,** etc.).

- **Electronic logbook** – The Envidas for Windows or Ultimate Reporter Logbook is used to create an electronic record of activities and sampling comments for field and data personnel. Logbook entries provide a record of monitor and site maintenance and other activities and information about aspects of the monitoring operations that may impact data quality.

- **Sample handling records** – Records that trace sample and data handling from the lab, to the site, and through the analysis process. These are records of transportation to facilities, sample storage, and handling between individuals within facilities.

7.6 Standard operating procedures

Standard Operating Procedures are provided to all Washington Network personnel in order to ensure that sampling and analysis operations are carried out in a consistent manner, collection errors are minimized, and comparability of data across the various pollutant networks is maximized. The SOPs detail the method for each operation, required quality control, and preventive maintenance activities. All Washington Network monitoring is required to be carried in accordance with the SOP.

The Washington Network's instrument-specific SOPs are written in a step-by-step format to be readily understood by a person knowledgeable about the general concept of the procedure and help ensure consistent conformity with Washington Network practices. SOPs serve as training aids, provide ready reference and documentation of proper procedures, maximize operational efficiency and minimize costs, reduce error occurrences in data, and improve data comparability, credibility, and defensibility.

Procedures are revised on an as-needed basis, or when new methods or instruments are used. A list of the Washington Network SOPs are on Ecology's web site (http://www.ecy.wa.gov/programs/air/other/Air_Monitoring_Procedures.htm).

8. Monitoring Network Design

To meet the Air Quality Program objectives, Washington Network air monitoring sites have been established to:

- Determine if air quality is meeting the NAAQS
- Provide near real-time air quality information to protect public health
- Forecast air quality
- Make daily burn decisions and curtailment calls
- Assist with permitting activities
- Evaluate the effectiveness of air pollution control programs
- Evaluate the effects of air pollution on public health
- Determine air quality trends
- Identify and develop responsible and cost-effective pollution control strategies
- Evaluate air quality models

8.1 Air quality public reporting

40 CFR Part 58.50 requires the state or, where applicable, local agency, to report an air quality index (AQI) for any Metropolitan Statistical Areas (MSAs) with a population of 350,000 or greater. EPA's AQI is calculated from concentrations of five criteria pollutants: Ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Concentration data used in the calculation are from the SLAMS required under Part 58 of 40CFR. Ecology also submits its SPMS data to EPA's AQI.

8.2 National air quality index (AQI)

EPA, in conjunction with NOAA, National Park Service, tribal, state, and local agencies, developed AirNow (http://www.airnow.gov/) to provide the public with easy access to national air quality information. The web site offers daily air quality index forecasts for $PM_{2.5}$ and ozone, near real-time pollution conditions for over 300 cities across the U.S., and provides links to more detailed state and local air quality web sites.

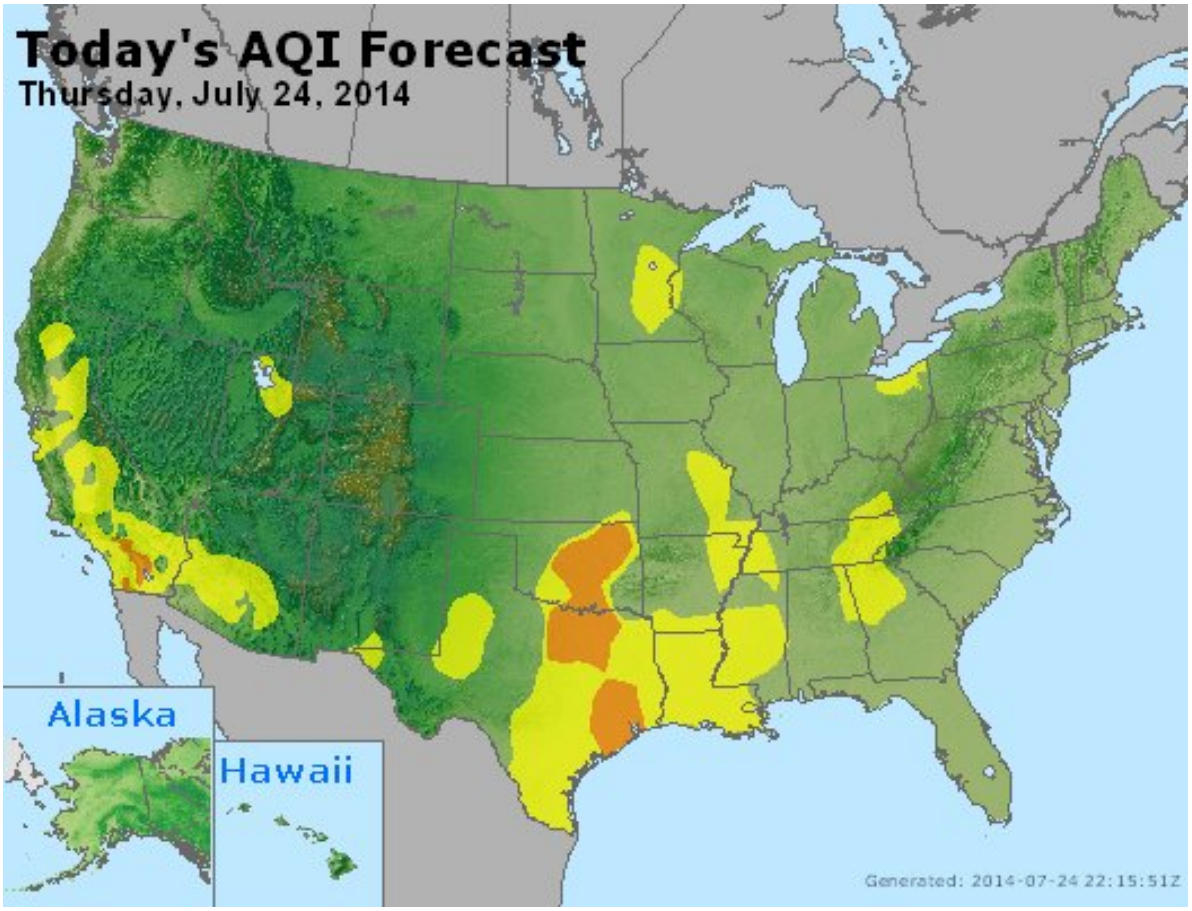

Figure 7: Example of an AirNow AQI Forecast

8.3 Washington air quality advisory

The Washington Air Quality Advisory (WAQA) is Ecology's information tool for relating current criteria pollutant levels with associated health messages. The WAQA is similar to EPA's AQI. The difference is that WAQA shows the adverse health effects of $PM_{2.5}$ pollution occurring at lower levels than the AQI. WAQA shows that air quality is unhealthy sooner – making WAQA more protective of public health in regard to $PM_{2.5}$ pollution. The WAQA is the same as the AQI for the other criteria pollutants.

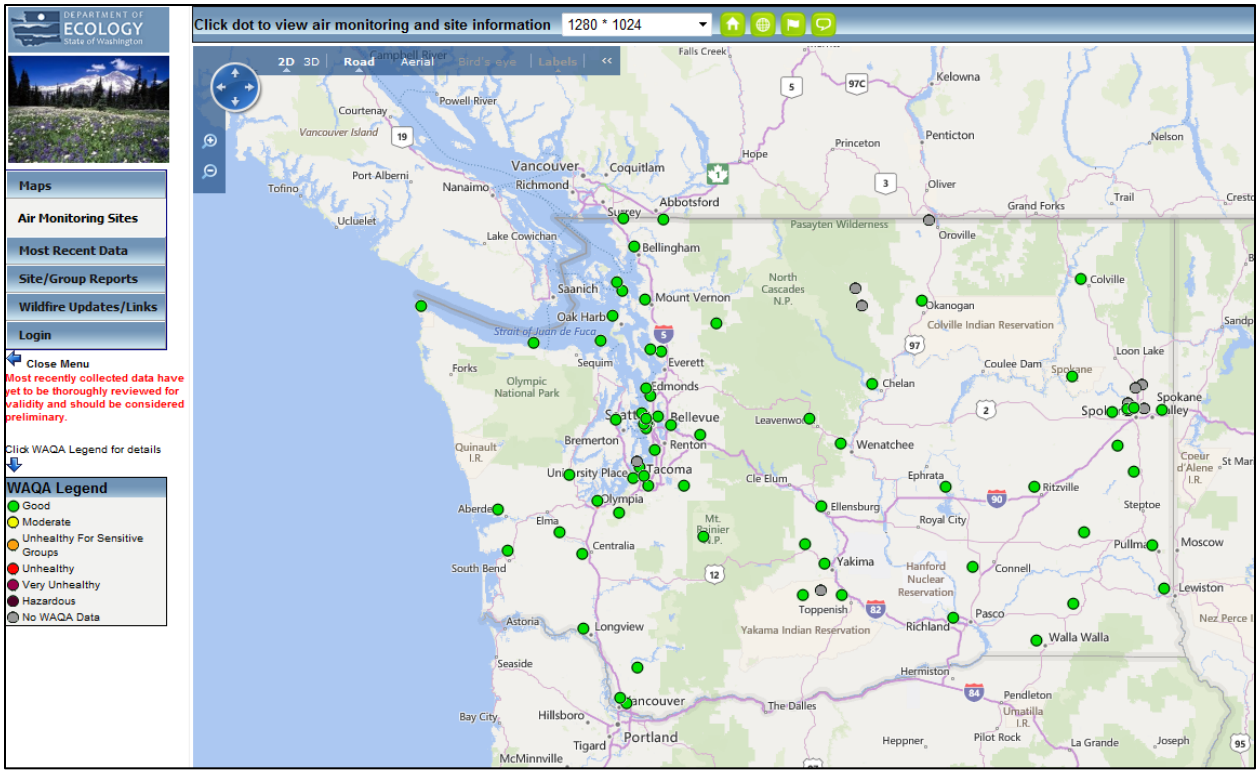

Figure 8: Example of Ecology's WAQA Map

Automated quality control checks are used within the Washington Network. However, the most recently collected data on the AirNow and WAQA web sites have not yet been fully verified and validated through the complete quality assurance process and is considered preliminary data.

8.4 Monitoring for NAAQS compliance

A major objective of the Air Quality Program is to monitor in areas where highest pollution exposures occur. Data from such monitors are used to determine compliance with and/or progress made towards meeting the NAAQS. Data collected in the Washington Network shows that:

- Many communities across Washington experience elevated levels of $PM_{2.5}$ pollution during the winter months due to wood burning for home heating.
- Washington is in attainment of both the annual and 24-hour $PM_{2.5}$ NAAQS.
- Two large communities in Washington (Tacoma, Yakima) are close to violating 24-hour $PM_{2.5}$ NAAQS.
- A few additional areas are at or near 80 percent of the 24-hour NAAQS.
- $PM_{2.5}$ pollution appears to be getting worse in some areas of the state, particularly in central Washington, and these areas may be at risk of a future 24-hour $PM_{2.5}$ NAAQS violation.
- Smoke from silvicultural and agricultural burning practices contribute to elevated $PM_{2.5}$ pollution levels in eastern Washington.

- Wildfires in eastern Washington occasionally result in extremely elevated, very unhealthy $PM_{2.5}$ pollution levels during the summer months.
- Ozone levels sometimes reach unhealthy levels in the Cascade Mountain foothill communities east of the densely-populated Puget Sound/I-5 corridor as well as in areas of eastern Washington, such as Spokane and Kennewick, during hot summer weather.
- At least one community, Enumclaw, is close to violating the 8-hour ozone NAAQS.

Ecology's analysis of the Health Effects and Economic Impacts of Fine Particle Pollution in Washington (https://fortress.wa.gov/ecy/publications/SummaryPages/0902021.html) shows that $PM_{2.5}$ pollution is extremely costly, leading to approximately 1,100 deaths and costing the state $200 million in direct and indirect costs each year. Furthermore, the Washington State Office of Financial Management estimates that the state population will continue to grow, potentially leading to increased pollution. Affects from climate change are expected to increase the occurrence of wildfires and may lead to associated increases in $PM_{2.5}$ and ozone pollution.

Because of these findings, $PM_{2.5}$ and ozone monitoring comprise the bulk of the NAAQS compliance monitoring activities in the Washington Network. However, monitoring is also conducted per federal requirements for CO, Pb, NO_2, PM_{10}, and SO_2.

Few of the Washington Network monitoring stations are capable of fulfilling more than a single monitoring objective. However, most stations are useful for determining population exposures, and many longer-term stations are useful for tracking changes in pollutant concentrations and evaluating the success of control strategies used in the area.

The Air Quality Program has designated monitoring sites in selected regions to determine the extent and nature of air pollutants in respect to geographical, socioeconomic, climatological, and other factors. The data are useful in planning epidemiological investigations and in providing the background against which more intensive regional and community studies of air pollution can be conducted.

8.5 Monitoring boundaries for criteria pollutants

The federal Office of Management and Budget defines several categories of geographical statistical areas for use by the U.S. Census Bureau in collecting, tabulating, and publishing federal statistics on a wide variety of subject matter (e.g., population growth, income distribution, etc.). In general, statistical areas consist of a county or counties associated with at least one urbanized area/urban cluster having at least a population of 10,000.

EPA uses these statistical areas to set minimum monitoring requirements (i.e., the number of monitors required) for the criteria pollutants. The two types of areas commonly used for determining minimum monitoring requirements are:

- Metropolitan Statistical Areas (MSAs) (https://en.wikipedia.org/wiki/Metropolitan_statistical_area)

- Core-Based Statistical Areas (CBSAs) (https://en.wikipedia.org/wiki/Core-based_statistical_area)

These statistical areas (shown below) are used to identify the borders of areas in which monitors will be sited for the purposes of compliance with the NAAQS.

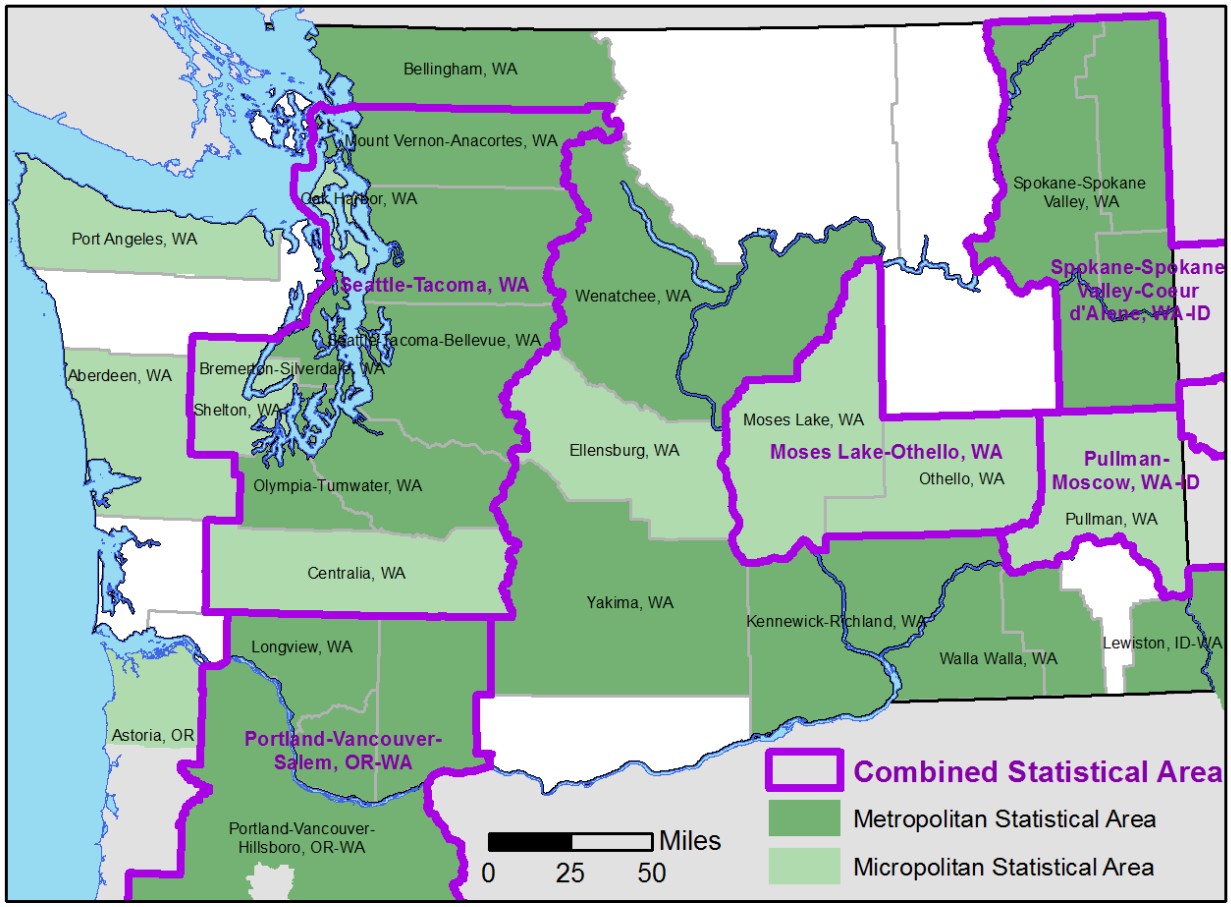

Figure 9: Washington Statistical Areas (2010)

8.6 Minimum network requirements

EPA sets minimum monitoring requirements for each criteria pollutant in 40 CFR Part 58, Appendix D 12. These requirements detail the minimum number and location (by statistical area) of monitors for determining NAAQS compliance. The minimum monitoring requirements are subject to periodic change as part of EPA's 5-year review cycle of the NAAQS. 40 CFR Part 58, Appendix D 12 contains the current minimum monitoring network requirements, and is regularly reviewed and referenced by Ecology and its local clean air agency partners to ensure that the requirements are being met in the Washington Network.

8.7 Design values

EPA defines a design value as “a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS).” The calculation of design values is often referred to as the *form of the standard*. The calculation of NAAQS design values is described in detail in CFR Part 50.

Design values are:

- Used to determine compliance with the NAAQS
- Identify nonattainment boundaries for areas in violation
- Assess progress toward meeting the NAAQS
- Develop control strategies

Design values are computed and published annually by EPA's OAQPS and reviewed in conjunction with EPA regional offices. Design values can be downloaded from EPA’s AQS’s list of standard reports (see Section 19.2.4).

8.8 Five-year network assessments

EPA finalized an amendment to the ambient air monitoring regulations in October 2006. As part of this amendment, EPA added the following requirement for state, or where applicable**,** local monitoring agencies to conduct a network assessments once every five years [40 CFR 58.10(e)]. The first 5-year assessment was due in 2010 and at 5-year intervals thereafter.

This 5-year network assessment requirement is an outcome of implementing the National Ambient Air Monitoring Strategy (NAAMS), the purpose of which is to optimize national air monitoring networks to use a finite set of resources to achieve the best possible scientific value and protection of public and environmental health.

The 5-year network assessments include:

- Re-evaluation of the objectives and budget for air monitoring
- Evaluation of the network’s effectiveness and efficiency relative to its objectives and costs
- Development of recommendations for network reconfigurations and improvements

8.9 Federal reference method and federal equivalent method monitors

EPA requires the use of an approved Federal Reference Method (FRM), Federal Equivalent Method (FEM), or Approved Regional Method (ARM) monitor in order to determine compliance with the NAAQS (40 CFR 58, Appendix C 2.1). The use of FRM and FEM instruments helps ensure the reliability and credibility of air quality measurements and comparability between monitoring locations throughout the national network. However, designation as a reference or

equivalent method by itself does not guarantee that a particular analyzer will always operate properly.

All reference and equivalent methods must be officially designated as such by EPA under the provisions of 40 CFR Parts 50 and 53. Notice of each designated method is published in the CFR at the time of designation. A current list of all designated reference and equivalent methods is maintained and updated by EPA whenever a new method is designated. This list can be found on AMTIC (https://www3.epa.gov/ttn/amtic/files/ambient/criteria/reference-equivalent-methods-list.pdf). Moreover, any analyzer offered for sale as a reference or equivalent method after April 16, 1976 must bear a label or sticker indicating that the analyzer has been designated as a reference or equivalent method by EPA.

All reference and equivalent method instruments used in the Washington Network are sited in accordance with the requirements of 40 CFR Part 58, Appendix E. Siting of monitors is discussed in detail in Section 9.1 of this document.

8.10 $PM_{2.5}$ NAAQS compliance monitoring

EPA Region 10 recommends that $PM_{2.5}$ FRM/FEM samplers operate only in locations where design values are greater than 80 percent of the NAAQS. Past monitoring has demonstrated that few areas in Washington approach NAAQS levels. Therefore, the number of FRM/FEM $PM_{2.5}$ samplers in the Washington Network has declined since the early 2000s. In addition, due to the benefits of near real-time data collection, Ecology and its partners have made a concerted effort to employ continuous FEMs in favor of the more labor-intensive, FRM daily samplers.

FRM/FEM monitoring occurs in several cities in Washington as part of the Washington Network. The monitors in these communities have design values that are close to violating 24-hour $PM_{2.5}$ NAAQS.

A list of the current Washington Network $PM_{2.5}$ NAAQS compliance sites/monitors can be found in the current version of Ecology's annual Ambient Air Monitoring Network Report.

8.11 PM_{10} NAAQS compliance monitoring

PM_{10} NAAQS compliance monitoring is conducted at 4 locations in the Washington Network. This monitoring is largely to satisfy maintenance plan requirements, as with the notable exception of wind-blown dust storms (i.e., exceptional events), concentrations have been well below the NAAQS. PM_{10} monitoring for NAAQS compliance in the Washington Network is conducted exclusively via continuous methods.

8.12 Lead NAAQS compliance monitoring

Per federal NCore requirements, lead monitoring is conducted at the Seattle-Beacon Hill NCore station. This monitor records concentrations well below the NAAQS.

8.13 Ozone NAAQS compliance monitoring

NAAQS compliance monitoring for ozone in the Washington Network occurs at over a dozen locations around the state. Ecology and its partners employ continuous FEMs at all network ozone sites. A list of the current Washington Network ozone sites can be found in the current version of Ecology's annual Ambient Air Monitoring Network Report.

Ozone levels sometimes reach unhealthy levels in the Cascade Mountain foothill communities east of the densely-populated Puget Sound/I-5 corridor as well as in areas of eastern Washington, such as Spokane and Kennewick, during hot summer weather. One community, Enumclaw, is close to violating the 8-hour ozone NAAQS.

Seattle-Tacoma CSA
Past monitoring efforts in Washington show that the highest ozone concentrations occur in at the Enumclaw-Mud Mountain monitoring station, which is part of the Seattle-Tacoma Combined Statistical Area. Ozone measurements from this and neighboring sites are used for evaluating area-wide trends and the success of control strategies. The Enumclaw monitor typically records the highest ozone design value in the state. It is located approximately 30 miles downwind of Seattle's urban core where the highest precursor emissions originate.

Spokane-Spokane Valley-Coeur d'Alene CSA
Ozone monitors are also located in Spokane County. The site locations were established to capture ozone concentrations during the summer and fulfill minimum SLAMS requirements for ozone.

Portland-Vancouver-Salem CSA
The Portland–Vancouver airshed crosses the Oregon/Washington border. Ecology and the Oregon Department of Environmental Quality operate ozone monitors on their respective sides of the border in this MSA.

8.14 Carbon monoxide NAAQS compliance monitoring

Carbon Monoxide (CO) levels have declined dramatically over the last two decades. However, in order to satisfy a SIP maintenance plan requirement, Ecology operates a single monitor in Spokane. An additional CO monitor was added in Seattle to satisfy near-road monitoring requirements.

8.15 NO_2 NAAQS compliance monitoring

Per the most recent NO_2 NAAQS revision, there are two NO_2 monitors currently operating in the Washington Network. These satisfy requirements for an area-wide monitor (Seattle-Beacon Hill) and near-road monitoring (Seattle-10th and Weller). A third monitor was added in 2015 at a second near-road site in Tacoma.

8.16 Trace gas monitoring

Precursor (trace) gas monitoring is a suite of continuous instruments (CO, NO_Y, SO_2) that operate year-round to provide valuable information for the national effort to support advanced multiple pollutant monitoring in urban and rural areas for the National Ambient Air Monitoring Strategy. The NCore multi-pollutant stations at Seattle-Beacon Hill (NCore) and Cheeka Peak (Rural NCore) are part of this overall strategy.

Though concentrations from these two stations' CO and SO_2 monitors are far below health standards, the data are used to develop emission control strategies relating to air quality model evaluation, rural monitoring of precursors for background transport, source apportionment, and other observation-based models. These monitoring efforts also support long-term health and epidemiological studies.

NAAQS SO_2 monitoring occurs at one contract-supported site in Anacortes. Concentrations measured at this site are well below the NAAQS. Because concentrations are very low, for the purposes of quality control/quality assurance, it is treated like a trace gas monitor.

8.17 Meteorological measurements

PSD-quality meteorological monitoring for wind speed, wind direction, and ambient temperature is conducted at over a dozen Washington Network meteorological stations. At the Seattle-Beacon Hill and Cheeka Peak NCore locations, relative humidity and ambient pressure are also monitored. Meteorological measurements are typically co-located at ozone monitoring locations in order to support modeling and forecasting efforts. Air Quality Program Quality Assurance staff routinely assess the accuracy of meteorological data collected at Washington Network sites and conduct annual performance audits for temperature, pressure, and relative humidity according to the methodology prescribed in the Quality Assurance Handbook for Air Pollution Measurement Systems - Volume IV: Meteorological Measurements Version 2.0. Ultrasonic anemometers for the measurement of wind speed and wind direction are used exclusively in the Washington Network. While there is currently no available method for conducting in-the-field quality control checks and performance audits on ultrasonic anemometers, the sensors are sent back to the manufacturer for recertification on an annual basis.

Further information on meteorological monitoring within the Washington Network can be found in the standard operating procedure available on Ecology's web site.

8.18 Manual method operating schedules

Station operators are required to follow the every 3rd, 6th, or 12th day monitoring schedule for manual method pollutant sampling for $PM_{2.5}$ (including CSN) and air toxics.

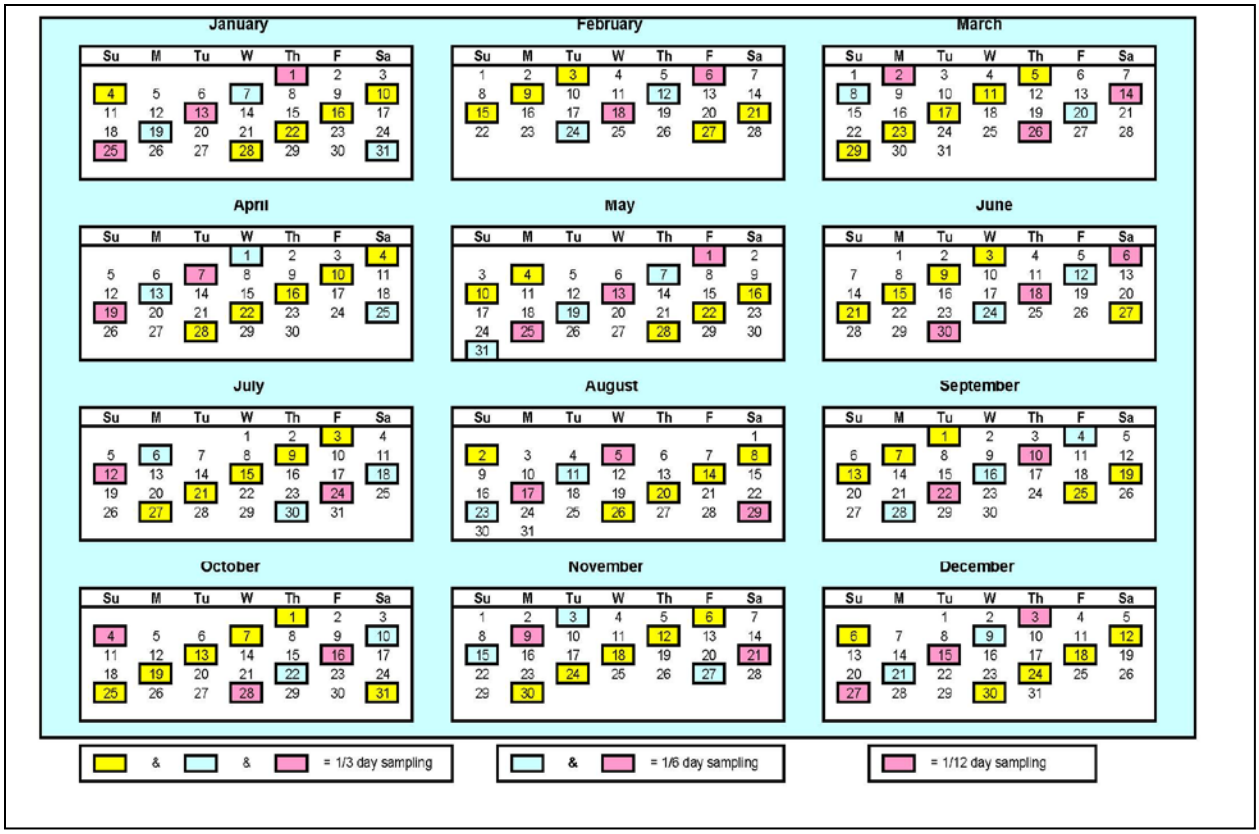

Figure 10: Example of Daily Sampler Run Schedule

8.19 Data completeness requirements/goals

Data that are used for comparison to the NAAQS have specific completeness requirements/ goals as identified in 40 CFR 50 and its associated appendices as well as in the Quality Assurance Handbook, Volume II. Collecting sufficiently complete data is critical to attaining representative individual samples and ensuring that averages compiled from aggregate samples accurately represent pollution concentrations during the given period. Completeness requirements typically start at the lowest level of aggregation, but also may apply to subsequently higher levels of aggregation. Although completeness requirements/goals vary according to the pollutant-specific method for calculating design values, the general rule is that EPA requires data to be 75 percent complete. For example, for continuous monitors, 1-hour pollution concentrations are valid only when there are at least 75 percent of valid minutes within the hour (i.e., at least 45 valid 1-minute concentrations). NAAQS compliance determinations also include completeness requirements for other levels of aggregation, including multiple-year levels of aggregation. With very few exceptions, Washington Network continuous monitor data are treated as valid only when the 75 percent completeness for each hour is met. In addition, Ecology has established a goal for all Washington Network monitors (including non-NAAQS compliance monitors) of 80 percent completeness as calculated at the quarterly and annual aggregate level.

The NAAQS and the associated forms occasionally change. For this reason, it is best to refer to the current CFR for determining data completeness requirements when calculating design values for NAAQS compliance determinations.

It is also important to note that 40 CFR 50 provides additional detail on how EPA may calculate design values even when completeness requirements are not met.

9. Sampling Methods

9.1 Monitoring site location

Washington Network monitors that are used for the purposes of determining compliance with the NAAQS, as well as SPMS that measure criteria pollutants with non-FRM/FEM instruments, are sited in accordance with the criteria described in detail in 40 CFR 58, Appendix E. EPA also provides technical assistance documents on NAAQS compliance monitoring.

When selecting a monitoring location, special attention should be given to the following:

- Economics of the installation (with the goal being a cost-effective installation)
- Safety of the site operator and QA personnel
- Security of the site/monitor
- Logistics (ensuring adequate site access, power availability, telecommunications)
- Atmospheric conditions (wind movements around the site, etc.)
- Topography (how might terrain or man-made obstructions affect concentrations)
- Pollutant considerations (such as undue influence of nearby sources)

In order to prevent sampling bias, air flow around the monitor must be such that collected data is representative of the general air flow in the area and the monitor inlet is toward the direction of predominant winds. Nearby sources that might unduly impact the sample (e.g., a rooftop air inlet near a stack or a ground-level inlet near an unpaved road) are avoided.

Due to the various physical and meteorological constraints, particularly in urban environments, tradeoffs may have to be made in choosing a site location. Consideration should include categorization of sites relative to their local placements. Suggested categories relating to sample site placement for measuring a corresponding pollution impact are identified below. Specifics on probe locations are described in 40 CFR 58, Appendix E and Washington Network SOPs.

Table 8: Station/pollutant Considerations for Site Installation

Station Category	Characterization
A (ground level)	Heavy pollutant concentrations, high potential for pollutant buildup. A site 3-5 m. (10-16 ft.) from major traffic artery, with local terrain features restricting ventilation. A sampler probe that is 3-6 m. (10-20 ft.) above ground.
B (ground level)	Heavy pollutant concentrations, minimal potential for a pollutant buildup. A site 3-15 m. (15-50 ft.) from a major traffic artery, with good natural ventilation. A sampler probe that is 3-6 m. (10-20 ft.) above ground.
C (ground level)	Moderate pollutant concentrations. A site 15-60 m. (5-200 ft.) from a major traffic artery. A sampler probe that is 3-6 m. (10-20 ft.) above ground.
D (ground level)	Low pollutant concentrations. A site more than 60 m. (more than 200 ft.) from a traffic artery. A sampler probe that is 3-6 m. (10-20 ft.) above ground.
E (air mass)	Sampler probe that is 6-45 m. (20-150 ft.) above ground. Two subclasses: (1) good exposure from all sides (e.g., on top of building) or (2) directionally-biased exposure (probe extended from window).
F (source-oriented)	A sampler that is adjacent to a point source. Monitoring that yields data directly relatable to the emission source.

The MAC evaluates the monitoring and sampling objectives in deciding where to locate sites. Typically, the MAC defines the monitoring objective and delegates the responsibility to select a corresponding location to the site operator. Sites are established to measure any one of the following:

- Impacts of known pollutant emission categories on air quality
- Population density relative to receptor-dose levels, both short- and long-term
- Impacts of known pollutant emission sources (area and point) on air quality
- Representative of area-wide air quality

The process of determining the correct type, number, and proper location of monitoring sites in order to satisfy these criteria and federal requirements can be complex. In order to make these determinations, it is necessary to have detailed information on the location of emission sources, geographical features, ambient pollutant concentrations, meteorological conditions, and population density.

Monitoring sites should be chosen to ensure the safety and unrestricted access for monitoring personnel. Sites with safety or access issues should be avoided.

A majority of the sites are enclosed in stand-alone shelters, trailers, buildings (i.e., rooms in schools and fire stations), or on the rooftops of structures. **Figure 11** below shows examples of the various types of shelters used within the Washington Network. Shelter temperatures should be recorded and consistently maintained at operating temperatures as specified by Ecology's instrument-specific standard operating procedures and the equipment (including monitoring instruments, data loggers, etc.) manufacturers' manuals.

Figure 11: Examples of Washington Network Monitor Shelters

While many monitoring instruments used within the Washington Network are capable of operating outside this temperature range, extreme shelter temperatures will occasionally lead to erratic instrument operation and may result in loss of data.

9.2 Sampling probes and manifolds

Sampling probes and manifolds should be chosen carefully to ensure that samples are preserved through the sample train and interactions between air samples and probe/sample train material are avoided.

The instrument manufacturer's manual and Washington Network SOPs must be followed to ensure that the proper material is used.

FEP Teflon® is used exclusively for gaseous criteria pollutant sample probes at air monitoring stations measuring except at the Seattle-Beacon Hill NCore site, where Pyrex® glass is used in a combination with FEP Teflon®. Teflon reduces the likelihood of oxidation of gases as they enter the sampling train and pass through the tubing to the analyzer. This preserves the sample until it reaches the detector inside the monitor. The glass manifold is used to facilitate a volumetrically large sample of ambient air from which several gas analyzers draw samples.

9.3 Residence time determination

Per 40 CFR 58, Appendix E, Part 9, all gaseous pollutant monitors in the Washington Network are required to have a residence time of less than 20 seconds, but operators should aim for a residence time under 10 seconds. Residence time is defined as the amount of time that it takes for a sample of air to travel from the opening of the sample probe to the inlet of the instrument.

$$RT = \frac{\pi * (d/2)^2 \ * 6 * L}{q}$$

Where:

RT = residence time in seconds
π = 3.14159
d = inside diameter of probe in centimeters (0.47752 cm is the inside diameter of the Teflon® probe material commonly used)
L = length of the probe line in meters
q = analyzer/instrument flow rate in liters per minute

9.4 Placement of probes and manifolds

Correct probe location is critical in preventing the introduction of bias to the sample. Important considerations are probe height above the ground, probe length, and physical influences near the probe. Some general guidelines for probe and manifold placement are:

- Probes should not be placed next to air outlets such as exhaust fan openings.
- Horizontal probes must extend beyond building overhangs.
- Probes should not be located near physical obstructions such as chimneys which can affect the air flow in the vicinity of the probe.
- Height of the probe above the ground depends on the pollutant being measured.

Detailed requirements for the placement of probes can be found in 40 CFR Part 58, Appendix E.

10. Analytical Methods

10.1 $PM_{2.5}$ monitoring

10.1.1 Federal reference method $PM_{2.5}$ monitoring

Federal Reference Method $PM_{2.5}$ monitoring is conducted at a handful of sites in the Washington Network using the Thermo/Rupprecht & Patashnick Partisol®-Plus Model 2025 Sequential Air Sampler (Manual Reference Method: RFPS-0498-118).

The 2025 draws a measured quantity of ambient air at a constant volumetric flow rate through a specially-designed particle-size discrimination inlet. Particles in the 2.5 µm and smaller size range are collected on a 46.2 mm diameter Teflon filter over a 24-hour sampling period. Each filter is weighed before use and after sampling. From these measurements, the mass of the collected PM sample can be calculated. The total volume of air sampled is determined from the measured volumetric flow rate and the sampling time. The mass concentration is calculated by taking the total mass of collected particles in the $PM_{2.5}$ size range and dividing by the total volume of air sampled under ambient conditions for temperature and pressure. The PM concentration is expressed as $\mu g/m^3$ of air. All Washington Network $PM_{2.5}$ FRMs are operated

in accordance with the SOP, manufacturer's manual, and requirements specified in 40 CFR Part 50, Appendix L.

To the extent possible, use of the Model 2025 is being phased out within the Washington Network in favor of FEM $PM_{2.5}$ monitors which provide a continuous (hourly) data output that can be used to communicate air pollution levels to the public in near real-time and inform burning curtailment decisions.

A list of the current FRM $PM_{2.5}$ monitoring locations can be found in the current version of the Washington Annual Ambient Air Monitoring Network Report, available on Ecology's web site.

10.1.2 Federal equivalent method $PM_{2.5}$ monitoring

Three types of continuous Federal Equivalent Method (FEM) continuous $PM_{2.5}$ monitors are used at over a dozen sites within the Washington Network. Two of the FEMs (1405F and 8500 models) are Filter Dynamic Measurement System (FDMS) Tapered Element Oscillating Microbalance (TEOM) instruments made by Thermo Scientific. EPA has designated the FDMS TEOM instruments as the same Federal Equivalent Method (Automated Equivalent Method: EQPM-0609-181) for $PM_{2.5}$ monitoring as the operational principle is the same. The third FEM used within the Washington Network is the Met One Beta Attenuation Monitor (BAM) model 1020 (Automated Equivalent Method: EQPM-0308-170).

The FDMS TEOMs are configured for $PM_{2.5}$ monitoring: An EPA PM_{10} inlet specified in 40 CFR 50, Appendix L, Figures L-2 thru L-19, is followed by a BGI Inc. Very Sharp Cut Cyclone (VSCC™) particle size separator, operated with a total actual flow of 16.67 L/min., loaded with Series FDMS® 8500 module operating software and an FDMS® kit. TEOM® 1400a with Series 8500C FDMS® operated with firmware version 3.20 and later and TEOM® 1405-F with FDMS® operated with version 1.55 or later.

The TEOM 1405-F Monitor is a true "gravimetric" instrument that draws ambient air through a sample filter at constant flow rate, continuously weighing the filter and calculating the near real-time mass concentration of the collected particulate matter. The Filter Dynamic Measurement System (FDMS) unit generates mass concentration measurements ($\mu g/m^3$) that account for both nonvolatile and volatile PM components. To accomplish this, the FDMS unit constantly samples ambient air and, using a switching valve to change the path of the sample flow, automatically compensates for the semi-volatile faction of the collected sample. Every six minutes, the switching valve alternates the sample flows between the base and reference sample periods. During the base period, the sample is collected normally and the base mass concentration is determined. During the reference period, the flow is diverted through a chilled filter to remove and retain the non-volatile and volatile PM. Under normal operation, the chiller is maintained at a temperature of 4° C. The weighing principle used is that of the Tapered Element Oscillating Microbalance (TEOM) mass transducer (see section below on Federal Equivalent Method PM_{10} monitoring).

The Met One BAM-1020 instruments used within the Washington Network are configured according to the requirements in 40 CFR 50, Appendix L specifications and operated in accordance with Ecology's standard operating procedure and the manufacturer's operation manual, revision F or later.

At the beginning of each sample hour, the Met One BAM-1020's small 14C (carbon-14) element emits a constant source of high-energy electrons (known as beta rays) through a spot of clean filter tape. These beta rays are detected and counted by a sensitive scintillation detector to determine a zero reading. The BAM-1020 then advances this spot of tape to the sample nozzle, where a vacuum pump pulls a measured and controlled amount of outside air through the filter tape, loading it with ambient dust. At the end of the sample hour, this dust spot is placed back between the beta source and the detector, thereby causing an attenuation of the beta ray signal which is used to determine the mass of the particulate matter on the filter tape. This mass is used to calculate the volumetric concentration of particulate matter in ambient air.

10.1.3 Nephelometer-$PM_{2.5}$ monitoring

Ecology uses cost-effective, reliable, and easy-to-operate nephelometers to report $PM_{2.5}$ concentrations at over 50 locations throughout Washington. Nephelometer-$PM_{2.5}$ monitoring provides a very cost-effective alternative to resource-intensive FRM and FEM monitoring, thereby facilitating greater spatial coverage while providing for near real-time data collection.

Nephelometers measure back scattering of light (BSCAT) and are not considered a Federal Reference or Equivalent Method (FRM/FEM) for $PM_{2.5}$ monitoring. Ecology has implemented EPA guidance for mathematically relating (correlating) BSCAT to $PM_{2.5}$ concentrations from a FRM/FEM $PM_{2.5}$ instrument via site-specific relationships. In order to establish a correlation, Ecology requires each nephelometer to FRM/FEM relationship to have a correlation coefficient (r^2) of 0.85 or above. When the 0.85 criteria is met, the resulting slope and intercept equation is applied to the nephelometer BSCAT data via a calculated channel on the data logger to produce FRM-like $PM_{2.5}$ concentrations. Using this method at over 50 sites across the state, Ecology and its partners maximize spatial coverage of $PM_{2.5}$ monitoring and are able to provide near real-time estimates of fine particle pollution via Ecology's WAQA and EPA's AirNOW web sites. Nephelometers are an excellent tool for reporting near real-time $PM_{2.5}$ concentrations at sites with pollution levels below the NAAQS. However, because nephelometers are not an FRM/FEM for $PM_{2.5}$ monitoring, the resulting $PM_{2.5}$ data cannot be used to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS). For this reason, when pollution levels routinely exceed 80 percent of the NAAQS, FRM/FEM monitoring is established.

Met One M903 (formerly manufactured by Radiance Research) and Ecotech nephelometers are the only nephelometers used for near real-time $PM_{2.5}$ data collection and reporting within the Washington Network.

10.1.4 Chemical speciation network $PM_{2.5}$ monitoring

Chemical Speciation Network $PM_{2.5}$ monitoring is conducted at fewer than 5 locations in the Washington Network. The instruments used for this purpose are as follows (neither instrument is approved as a Federal Reference or Equivalent Method for the purposes of $PM_{2.5}$ monitoring):

- Met One SASS or Super SASS
- URG 3000N

A full description of the operating principles and operational procedures can be found on EPA's AMTIC/Speciation web site.

10.2 PM_{10} monitoring

Federal equivalent method PM_{10} monitoring - Thermo Scientific TEOM 1400a continuous PM_{10} Monitors (Automated Equivalent Method: EQPM-1090-079) are used at a handful of locations within the Washington Network, all on the east side of the Cascade Mountains. Other than during high wind events (i.e., exceptional events), these monitors typically record concentrations well below the NAAQS and are in place primarily to satisfy SIP maintenance requirements for ongoing PM_{10} monitoring in former nonattainment areas.

Particle-laden air is drawn into the Thermo Scientific TEOM 1400a monitor through an air inlet followed by an exchangeable filter cartridge where the particulate mass collects. The inlet system may or may not be equipped with the optional sampling head which pre-separates particles at either a 2.5 µm or 10 µm diameter. The filtered air then proceeds through the sensor unit which consists of a patented microbalance system. As the sample stream moves into the microbalance system (filter cartridge and oscillating hollow tapered tube), it is heated to the temperature specified by the control unit. This is done to minimize the deposition of water due to changes in ambient humidity.

The unit consists of a TEOM Sensor Unit; TEOM Control Unit; Flow Splitter (3 liter/min. sample flow); Teflon-Coated Glass Fiber Filter Cartridges; PM_{10} inlet (16.7 liter/min.). Seasonal adjustments to sample inlet temperature are made to reduce volatilization of particles. Mass concentrations are reported under standard conditions for temperature and pressure.

10.3 $PM_{10\text{-}2.5}$ monitoring

Ecology conducts Federal Reference Method $PM_{10\text{-}2.5}$ (PM Coarse) monitoring (Manual Reference Method: RFPS-0509-176) at a single site in Seattle–Beacon Hill. This Federal Reference Method is known as a "subtraction method." Sampling consists of a pair of Thermo Scientific Partisol®-Plus 2025 sequential samplers with one configured as a $PM_{2.5}$ sampler (RFPS-0498-118) and the other configured as a PM_{10C} sampler with the $PM_{2.5}$ WINS Impactor replaced with a Thermo Scientific Partisol® 2025 downtube (RFPS-1298-127). The Partisol®-Plus 2025 samplers must be operated with any software version 1.003 through 1.5. Ecology operates the 2025 Sequential samplers in accordance with its 2025 Sequential Sampler SOP.

10.4 Lead monitoring

Ecology conducts Federal Equivalent Method (Manual Equivalent Method: EQL–0512–202) lead monitoring for NAAQS compliance purposes at a single site in Seattle-Beacon Hill. A low-vol Thermo Scientific Partisol®-Plus 2025 sequential sampler, configured for PM_{10}, is used for sample collection. This 2025 sampler, and all associated samples, is also used for the PM_{10} portion of $PM_{10-2.5}$ sampling (subtraction method) at Beacon Hill (see Section 10.3 above). Sample filters are first sent to Manchester Lab for determining $PM_{10-2.5}$ mass concentrations and are subsequently sent to Eastern Research Group (ERG) for Inductively Coupled Plasma- Mass Spectrometry (ICP-MS) analysis. Additional information on this method can be found on ERG's SOP, available through EPA's AMTIC web site.

10.5 Continuous monitors for gaseous pollutants

EPA reference or equivalent methods monitors are used for collection of gaseous pollutant data for comparison to the NAAQS. These analyzers are continuous monitors that have met EPA equivalency requirements for measuring specific pollutants. Each model analyzer will be installed with adherence to procedures, guidance, and requirements detailed in 40 CFR Parts 50, 53, and 58; EPA QA Handbook Volume II, Part 1, the analyzer manufacturer's operation manual, and the SOPs.

10.5.1 Carbon monoxide (CO) measurements

The Teledyne Advanced Pollution Instrumentation, Inc. Model 300EU (Automated Reference Method: RFCA-1093-093) is used for monitoring CO at the NCore and Seattle near-road locations.

The analytical principle is based on absorption of infrared (IR) light by the CO molecule. The analyzer operates on the principle that CO has a sufficiently IR absorption spectrum so that the absorption of IR by the CO molecule can be used as a measure of CO concentration in the presence of other gases. CO absorbs IR maximally at 2.3 and 4.6 *u*m. Since NDIR is a spectrophotometric method, it is based upon the Beer-Lambert law. The degree of infrared radiation reduction depends on the length of the sample cell, the absorption coefficient, and CO concentration introduced into the sample cell.

A Thermo Electron/Thermo Environmental Instruments Models 48C (Automated Reference Method: RFCA-0981-054) is used at a single location in Spokane (3rd and Washington).

10.5.2 Ozone (O_3) measurements

All ozone analyzers in the network use the Ultraviolet (UV) absorption method to measure for ozone. The analytical principle is based on absorption of UV light by the ozone molecule and subsequent use of photometry to measure reduction of the quanta of light reaching the detector at 254 nm. The degree of reduction depends on the path length of the UV sample cell, the ozone concentration introduced into the sample cell, and the wavelength of the UV light.

The Teledyne Advanced Pollution Instrumentation, Inc. Model 400E (Automated Equivalent Method: EQOA-0992-087) operates at all Air Quality Program ozone monitoring sites. The instrument operates on a full-scale range of 500 ppb, at any ambient temperature in the range of 5˚C to 40˚C, with a sample flow rate of 800 ± 80 cm3/min, and with a TFE filter.

10.5.3 Nitrogen dioxide (NO_2) measurements

The Teledyne Advanced Pollution Instrumentation Model 200EU (Automated Reference Method: RFNA-1194-099) is used to monitor NO_2 at the Seattle-Beacon Hill and near-road locations.

The analytical principle is based on the chemiluminescent reaction of NO with O_3. This reaction produces a characteristic near-infrared luminescence with an intensity that is linearly proportional to the concentration of NO present. The reaction results in electronically excited NO_2 molecules which revert to their ground state, resulting in an emission of light or chemiluminescence.

The Model 200EU is operated on any full-scale range between 0-0.05 ppm and 0-1.0 ppm, with a PTFE filter element or a Kynar® DFU installed in the internal filter assembly, with the settings as described in EPA's list of approved Federal and Equivalent Methods.

10.5.4 Sulfur dioxide (SO_2) measurements

The analytical principle used to measure SO_2 is based on measuring the emitted fluorescence of SO_2 produced by the absorption of ultraviolet (UV) light. The UV lamp emits ultraviolet radiation which passes through a 214 nm band pass filter, excites the SO_2 molecules producing fluorescence which is measured by a photomultiplier tube (PMT) with a second UV band pass filter. SO_2 absorbs in the 190-230 nm region free of quenching by air and relatively free of other interferences.

A Teledyne Advanced Pollution Instrumentation model T100U (Automated Equivalent Method: EQSA-0495-100) is used for SO_2 monitoring at the NCore stations (Cheeka Peak, Seattle-Beacon Hill) and Anacortes.

10.5.5 Total reactive oxides of nitrogen (NOy) measurements

NOy is measured at the Cheeka Peak and Seattle-Beacon Hill NCore stations.

At Seattle-Beacon Hill, a Thermo Environmental Instruments Model 42C nitrogen oxides analyzer (Automated Reference Method: RFNA-1289-074) with a converter is used.

The analytical principle is based on the chemiluminescent reaction of NO with an excess of O_3. This reaction produces a characteristic near infrared luminescence with an intensity that is linearly proportional to the concentration of NO present. The reaction results in electronically excited NO_2 molecules which revert to their ground state, resulting in an emission of light or chemiluminescence.

At Cheeka Peak, a Teledyne Advanced Pollution Instrumentation model T200U analyzer (Automated Reference Method, RFNA 1194-099) is used.

The analytical principle for both instruments is based on the chemiluminescent reaction of NO with an excess of O_3. This reaction produces a characteristic near infrared luminescence with an intensity that is linearly proportional to the concentration of NO present. The reaction results in electronically excited NO_2 molecules which revert to their ground state, resulting in an emission of light or chemiluminescence.

10.6 Air toxics monitoring

Air Toxics Monitoring is conducted at the NCore monitoring station in Seattle-Beacon Hill. A full description of analytical methods can be found in the Air Toxics Monitoring Quality Assurance Project Plan on Ecology's web site.

11. Sample Handling and Custody

For manual method sampling (i.e., samples collected on filters or in canisters, etc.), it is critical that air monitoring samples are handled appropriately in order to preserve the integrity of the sample and ensure proper chain of custody. Custody records provide a reviewable trail for quality assurance purposes and serve as evidence in legal proceedings.

The Air Quality Program contracts with FedEx to transport $PM_{2.5}$ pre- and post-sampled filters from the Manchester Laboratory to and from air monitoring operator offices around the state. Ecology uses United Parcel Service (UPS) for the shipment of CSN and NATTS samples.

Couriers provide tracking numbers for each shipment between labs and field offices. Information describing the enclosed filters/samples is placed on bills of lading, and copies of shipping receipts and tracking numbers are retained as part of the sample record. In the case of $PM_{2.5}$ filters, the shipping container (a small cooler filled with blue ice or Utek cooler packs) is secured with a wire custody lock and addressed to the specific individual authorized to receive the package.

More information on the shipment of samples can be found in the instrument-specific SOPs as well as the Air Toxics Monitoring QAPP.

12. Laboratory Methods

The Air Quality Program contracts with accredited laboratories for sample analyses. A list of these laboratories is presented below.

Table 9: Summary of Pollutants and Accepted Analytical Methods

Network/Laboratory	Pollutant	Acceptable Method	Reference
SLAMS Manchester	PM_{10} Hi-Vol	Gravimetric	40 CFR Part 50, Appendix B
	$PM_{2.5}$	Gravimetric	40 CFR Part 50, Appendix L
	$PM_{10-2.5}$	Gravimetric/Subtraction	40 CFR Part 50, Appendix O
NATTS Eastern Research Group	Lead PM_{10} Low-Vol	Energy-dispersive X-ray fluorescence spectrometry	40 CFR Part 50, Appendix Q
	Carbonyls	High Performance Liquid Chromatography	TO-11A
	PAHs	Gas Chromatography / Mass Spectrometry	TO-13A
	VOCs	Gas Chromatography	TO-15
CSN Research Triangle Institute	$PM_{2.5}$	Gravimetric	40 CFR Part 50, Appendix L
	Elements	EDXRF	CSN QAPP and SOPs
	Anions		CSN QAPP and SOPs
	Cations		CSN QAPP and SOPs
	Organic, Elemental, Carbonate, Total Carbon	Thermal Optical Carbon Analyzer	CSN QAPP and SOPs
	Semi-Volatile Organic Compounds	Gas Chromatography/ Mass Spectrometry (GC/MS)	CSN QAPP and SOPs

The SLAMs network provides rigorous quality control requirements for the analytical methods. These methods are found in 40 CFR Part 50 and described further in the associated references to the CFR.

Some of the NATTS methods are derived from the Toxics Organic Method Compendium 3. Others, like the Chemical Speciation Network (CSN), may be developed specifically for the program based on the national laboratory currently performing the analysis. The NATTS and CSN networks follow the performance-based measurement process paradigm. These networks' QAPPs and/or technical assistance documents suggest a method, but also allow some flexibility to use other methods that meet the given network's Measurement Quality

Objectives. Various independent proficiency test samples and technical systems audits are performed to ensure that the data quality within these networks remain acceptable.

For ambient air samples to provide useful information or evidence, laboratory analyses must meet the following four basic requirements:

- Equipment must be frequently and properly calibrated and maintained.
- Personnel must be qualified to perform the analysis.
- Analytical procedures must be in accordance with accepted practice.
- Complete and accurate records must be kept.

The Air Quality Program requires that each laboratory should define these critical activities and ensure there are consistent methods for their implementation before any data is collected.

13. Quality Control

13.1 Data quality assessments

Data Quality Assessments (DQAs) are statistical summaries that determine if the DQOs are met and describe data uncertainty. If the DQOs are not met, the DQAs are used to determine whether modifications to the DQOs are necessary and/or whether more stringent quality control is required.

13.2 Code of Federal Regulations-related quality control samples

40 CFR Part 58, Appendix A identifies a number of quality control samples that must be implemented for the SLAMS and SPMS. All SLAMS and SPMS sites within the Washington Network equipped with FRM/FEM instruments are operated according to these requirements. Current requirements for quality control samples for FRMs and FEMs can be found in 40 CFR Part 58, Appendix A.

13.3 Use of computers for quality control

Computer-based data loggers equipped with EnvidasFW or Envidas Ultimate software are used exclusively in the Washington Network. All loggers are TCP/IP addressable, allowing for remote access and extensive automation of quality control on several different types of monitors. These features facilitate quality control test replication, provide near real-time quality control results, and decrease the required number of required operator trips to monitoring stations. For these reasons, the use of computer-based data loggers can result in substantial cost savings and reduced loss of data. Among other activities, Washington Network data loggers are used by operational personnel to:

- Schedule recurring automated quality control checks at prescribed intervals
- Electronically record, store, and report quality control results (zero, precision, span)
- Electronically record all station activities (i.e., electronic logbook)

- Plot zero/precision/span results (i.e., control charts)
- Run reports on measures of linearity of calibrations (e.g., standard error or correlation coefficient)
- Automatically flag data associated with out-of-control results
- Set up email notifications for quality control failures and instrument problems
- Remotely interface with instruments in the field to diagnose operational problems

14. Procurement of Equipment

Monitoring instrumentation is vetted by staff in Ecology's Calibration and Repair Laboratory and by personnel at partner agencies before purchase or approval for use in the Washington Network. Ecology priorities looking for opportunities to field test equipment before making purchases, particularly when evaluating the most expensive instrumentation. Instruments are evaluated for:

- Bias/precision
- Comparability to Reference and Equivalent Method instruments/analyzers
- Reliability
- Ease of operation
- Availability of automated quality control
- Manufacturer support
- Price (including consumables and replacement parts)

In order to maximize the effectiveness of available funding and ensure that prospective equipment meets all performance criteria and certifications, detailed specifications must be clearly identified in requests for quotes before purchase. This is especially critical when expensive or large volume purchases are made. At a minimum, purchased equipment should be accompanied by a one year warranty. Vendors do not receive payment until acceptance testing has been completed and the subsequent results are satisfactory. Instruments used in the Washington Network must meet all Ecology performance specifications and requirements before any data will be submitted to AQS.

Less expensive items (tools, extension cords, fittings, etc.) may be purchased by station operators with approval from their supervisor.

14.1 Inspection/acceptance of supplies and consumables

Acceptance criteria must be consistent with overall project technical and quality criteria. Some of the acceptance criteria for FRMs and FEMs are specifically detailed in 40 CFR Part 50. Other evaluations of acceptance criteria, such as observing damage caused during shipping, can only occur after equipment has been delivered from the manufacturer.

Ecology Calibration and Repair staff will be contacted by agency shipping and receiving personnel located within headquarters or regional offices. The staff receiving the items will:

- Perform a rudimentary inspection of the package(s) as received.
- Note any obvious problems with the shipment such as a crushed box or wet cardboard.
- Open the package and inspect the contents.
- Compare contents with the packing slip to verify that the order is complete.
- Plug in and turn on the instrument or equipment (if applicable) to ensure it powers up correctly.

If problems with the order are discovered:

- Note problems/issues on the packing list.
- Notify shipping and receiving staff about missing or damaged items, and immediately call the vendor.

If the order is complete and in good condition:

- Sign and date the packing list, and send to the Air Quality Program Purchasing Coordinator so that payment can be made in a timely manner.
- Place Ecology tag on the item (if purchased with Ecology funds).
- Place ordered supplies in stock equipment/supplies in the appropriate pre-determined area.
- Enter equipment with an Ecology tag into the Site Information Management System (SIMS) Equipment Inventory database.

All O_3, CO, NO_2, and SO_2 analyzers used in the Washington Network have been designated as either Federal Reference or Equivalent Methods. Therefore, these analyzers are assumed to be of sufficient quality for the data collection operation. Testing of such equipment is done by EPA through the procedures described in 40 CFR Part 50.

Ecology Calibration and Repair staff will perform and document multi-point calibration verification checks before deploying any instrument to the field. If any of these checks are out of specification (the MQO is all points must be within ±2 percent of full scale of a best-fit straight line), corrective action will be taken. If the instrument meets the acceptance criteria, it will be assumed to be operating properly. Some equipment may be received by Ecology regional offices. In these cases, regional staff are responsible for conducting acceptance testing and ensuring equipment is properly calibrated and operational before installation.

14.2 Maintenance of equipment – roles and responsibilities

The Washington Network SOPs identify specific preventive maintenance designed to limit downtime, costly repairs, and data loss. Station operators are responsible for following SOPs, performing all routine preventive/corrective maintenance, and for recording all such activities in the station's electronic logbook. Operators are also responsible for reviewing the results of all automated and manual calibrations to ensure proper instrument operation.

In addition to routine maintenance and review of quality control, other activities must be performed bi-monthly, monthly, quarterly, semi-annually and annually, depending on the pollutant being measured and the type of monitor being used. Operators should refer to the instrument-specific SOP, manufacturers' manuals, and 40 CFR Part 58, Appendix A for the preventive maintenance and quality control requirements/schedules.

Supervisors are responsible for ensuring that station operators carry out required preventive maintenance and quality control activities in a timely manner. Preventive maintenance is not a static process. Periodic changes to preventive maintenance schedules and/or SOPs are necessary in order to reflect new instrument models, any changes to the measurement method, and, in the case of FRM/FEMs, changes to the CFR.

Required frequencies for preventive maintenance and quality control as defined in the CFR (FRM/FEM) and/or Washington Network QAPPs and SOPs must be followed, regardless whether a given task is completed earlier than scheduled. In other words, if a multi-point calibration is conducted in August, instead of September, the next multi-point calibration would be required 6 months after August. Supervisors should be aware of preventive maintenance requirements and periodically verify that station operators are meeting them.

Following all repairs, instrument verifications (e.g., single or multi-point) must be conducted. If the instrument is found to be outside acceptable limits, it must be recalibrated and a subsequent verification ("as-left") performed.

Lists can facilitate the organization and tracking of tasks and improve the efficiency of preventive maintenance operations. A checklist of regular maintenance activities (e.g., periodic zero-span checks, daily routine checks, data dump/collection, calibrations, etc.) is recommended. A spare parts list, including relevant catalog numbers, is also recommended, as it facilitates ordering replacement parts. Such lists should be readily accessible, and include the types and quantities of spare parts already on hand.

14.3 Ecology calibration and repair laboratory

Ecology's Calibration and Repair Laboratory provides technical assistance, calibration, and repair services for monitoring efforts associated with the Washington Network. Station operators should contact the Calibration and Repair Laboratory for assistance with non-routine maintenance, in the event of an instrument or equipment failure, and for general questions regarding field calibration and operations.

14.4 Station saintenance

Station maintenance is an important element of ensuring collection of acceptable quality data. At a minimum, station maintenance items should be checked monthly and more often as site conditions require. For example, sweeping and cleaning dust off surfaces/instruments may

need to be performed more often in desert environments. Examples of station maintenance activities include:

- Floor cleaning
- AC filter replacement
- Weed and litter removal
- Grass cutting
- Roof/leak repair
- Inlet and manifold cleaning/replacement
- Desiccant replacement
- Cleaning of shelter exterior and interior
- Ladder, safety rail inspection

All maintenance activities should be documented in the electronic logbook.

15. Equipment Certification and Calibration

Calibration establishes the quantitative relationship between the true value (in ppm, ppb, $\mu g/m^3$, L/min, etc.) and the instrument response. This relationship is used to convert subsequent instrument response values to corresponding known values. The response of most instruments has a tendency to change somewhat with time (drift), so the calibration must be updated (or the instrument's response adjusted) periodically to maintain an acceptable degree of accuracy. Each instrument is calibrated as directed by the manufacturer's manual. Detailed calibration procedures for the Federal Reference Methods for CO, NO_2, O_3, and SO_2, can be found in the appropriate appendices to 40 CFR Part 50.

Each instrument is calibrated in Ecology's Calibration and Repair Laboratory before it is deployed to the field to collect data. All data and calculations involved in these calibration activities are recorded in a calibration logbook.

15.1 Calibration standards

All ambient monitoring instruments used within the Washington Network are calibrated and verified using calibration standards. Cylinders of compressed gas, ozone standards, and flow standards are certified as traceable to a NIST primary standard. "Traceable" is defined in 40 CFR Parts 50[21] and 58[24] as meaning *" ... that a local standard has been compared and certified, either directly or via not more than one intermediate standard, to a primary standard such as a National Institute of Standards and Technology Standard Reference Material (NIST SRM) or a EPA/NIST-approved Certified Reference Material (CRM)".* The certification procedure includes:

- Establish the concentration of the working standard relative to the primary standard
- Certify that the primary standard (and hence the working standard) is traceable to an NIST primary standard

- Include a test of the stability of the working standard over several days
- Specify a recertification interval for the working standard

Certification of the working standard is established by the Calibration and Repair and Quality Assurance laboratories or by the standard manufacturer.

15.2 Certification of calibration/audit standards

Standards used for conducting quality control checks, calibrating air monitoring instruments, and conducting quality assurance performance audits within the Washington Network must be recertified as accurate on a frequency as defined in the CFRs (FRM/FEM) and Washington Network QAPPs and SOPs. Gaseous standards (cylinders) for use in routine quality control checks and analytical audits are obtained from vendors such as Scott Marrin, Inc. and are certified for NIST-traceability and accuracy for a defined duration. Flow, temperature, and pressure standards, as well as other equipment used for conducting flow and other quality control operations and audits, are certified by Ecology's Calibration and Repair staff or by standard manufacturers.

EPA protocol gases are purchased from commercial sources and are analyzed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards" document number EPA-600/R97/121, revised September 1997. All mixtures are traceable to the National Institute of Standards and Technology (NIST) gaseous Standard Reference Materials (SRM) using EPA procedures, and meet or exceed the appropriate EPA protocol specifications for accuracy. A Certificate of Analysis (COA) is provided with each mixture. The COA contains the replicate analysis data, the NIST traceable reference standard, and the analytical instrument used in the analysis. Gas that is beyond the labeled expiration date is not used for calibration or auditing.

Ecology maintains separate labs, equipment, and functionality between its Calibration and Repair and Quality Assurance laboratories in order to preserve the separation of operations and QA. Standards and equipment used for QA purposes are recertified by QA personnel in the Quality Assurance lab, while standards and equipment used for operational purposes are recertified by Calibration and Repair lab personnel in the Calibration and Repair lab.

Ecology's Calibration and Repair staff uses its primary and laboratory standards to recertify the majority of the flow, temperature, and pressure, standards used in the Washington Network. Certain flow standards (e.g., devices that measure flows below 3 L/min) cannot be recertified by the Calibration and Repair laboratory and should be sent back to the manufacturer for recertification at intervals specified by the manufacturer. Manufacturers often charge several hundred dollars or more for this service and turn-around times can vary, sometimes taking several weeks. Therefore, whenever possible, station operators should send their standards to the Calibration and Repair staff to reduce costs and minimize downtime.

The Calibration and Repair and Quality Assurance laboratories each maintain a set of NIST-traceable standards, some of which are primary standards. The recertification frequency for each of these standards, where applicable, is presented in **Table 10** below.

Table 10: Standards Maintained in the Calibration and Repair Laboratory

Calibration and Audit Standards		
Standard	**Laboratory**	**Frequency**
Carbon monoxide cylinders	• Calibration and Repair • Quality Assurance • NWRO	As defined by supplier for the given concentration
$PM_{2.5}$ Roots Meter	• Calibration and Repair • Quality Assurance	Every 10 years
Ozone Primary Standard	• Calibration and Repair • Quality Assurance	Every year
Multi-blend cylinder gas for trace gas and NO_2	• QA • NWRO	Every 2 years
NIST traceable thermometer (Agency primary)	• Quality Assurance	Never
Barometer (agency primary)	• Calibration and Repair • Quality Assurance	Never

15.3 Calibration standards for ozone

In ambient air monitoring applications, precise ozone concentrations called standards are required for the calibration of ozone analyzers. Ozone standards cannot be stored for any practical length of time due to the reactivity and instability of the gas. Therefore, ozone concentrations must be generated and measured on-site using a separate ozone generator, known as a transfer standard.

Qualification consists of demonstrating that the transfer standard is sufficiently stable (repeatable) to be useful as a transfer standard. Repeatability is necessary over a range of variables such as temperature, line voltage, barometric pressure, elapsed time, operator adjustments, or other conditions, any of which may be encountered during use. After a transfer standard has been shown to meet the qualification requirements, certification is required before it can be used.

EPA guidance states that “a verified transfer standard of Level 3 and greater must be reverified at the beginning and end of the ozone season or at least every six months whichever is less.” Therefore, Ecology’s Calibration and Repair staff recertifies transfer standards before each ozone season (May 1 – September 30) for sites that are operated seasonally, and every 6 months for year-round sites.

Test concentrations of ozone must be traceable to a Level 1 primary standard UV photometer as described in 40 CFR Part 50, Appendix D. Uncertainty increases with additional levels.

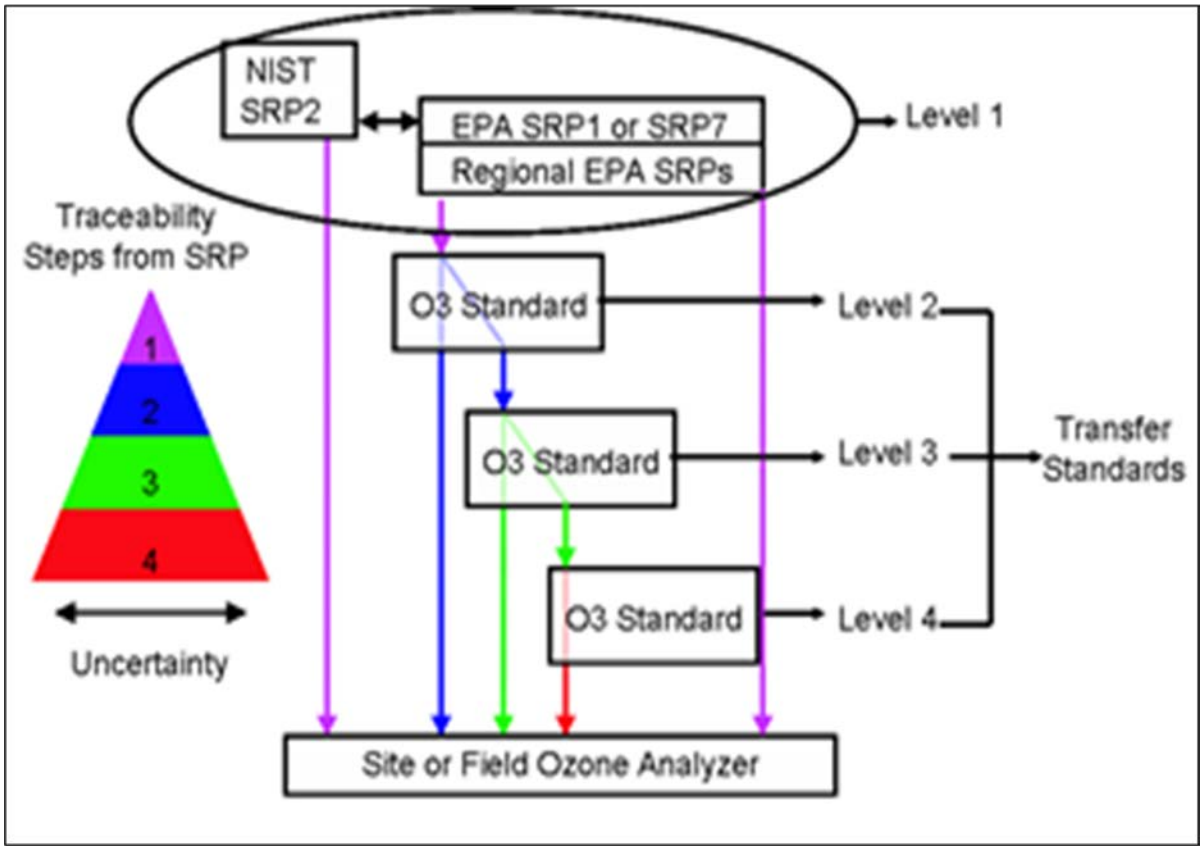

Figure 12: Ozone Transfer Standard Hierarchy

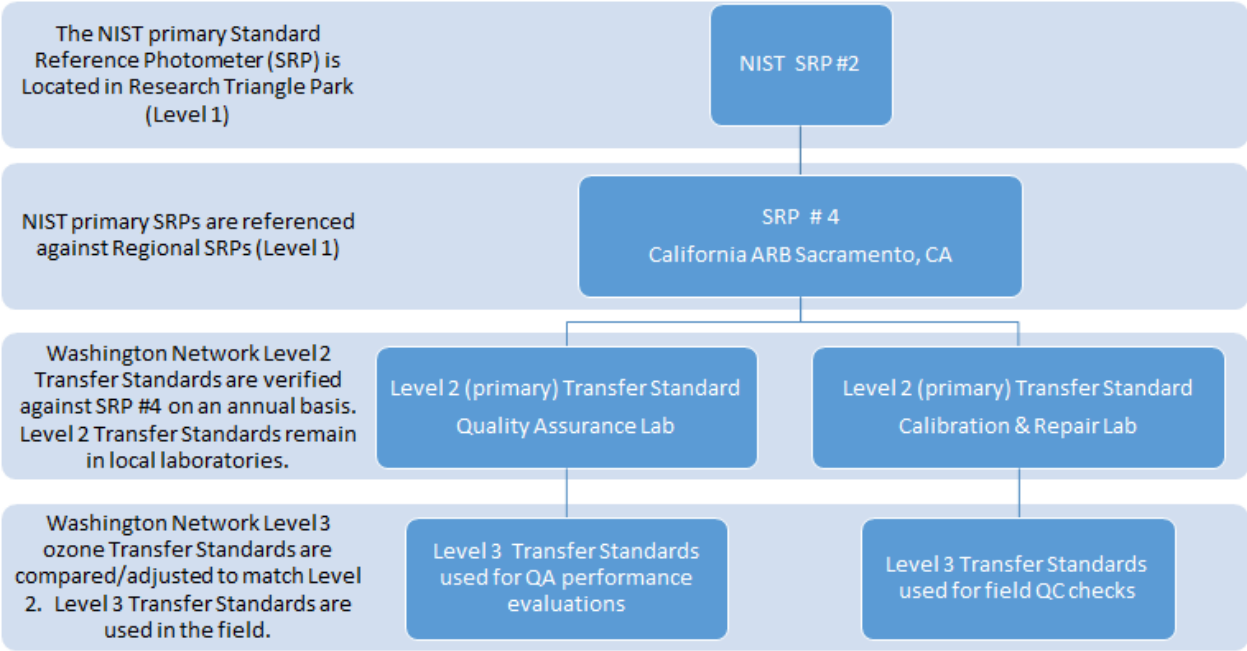

Figure 13: Washington Network Ozone Transfer Standards

15.4 Flow standards

The accuracy of flow measurements is critically important in air monitoring applications. Flow and volume measuring instruments are calibrated and certified against a primary flow meter on a yearly basis. Instruments that cannot be certified with a primary flow meter are sent to the manufacturer for recertification on a yearly basis.

15.5 Quality control checks

Automated and manual calibration verifications (quality control checks) are performed at specified intervals in the field by allowing the instrument to sample test atmospheres at known pollutant concentrations or flows (in the case of flow verifications). During quality control checks, the instrument is operated in its normal sampling mode, drawing the test atmosphere through all filters, scrubbers, conditioners, and other components used during normal air monitoring and through as much of the sampling train as practical. A quality control check is a verification of instrument calibration for past data collection ("as found"). For this reason, it is critical that instruments never be adjusted before or during a quality control check, and that any adjustments be made only after a verification is performed. Following any instrument adjustment(s), an additional quality control check ("as left") must be performed.

Automated calibration checks are typically scheduled for the early morning hours when pollution concentrations are often lowest and include a zero and precision test concentration.

An example of a quality control check (zero and precision points) on an ozone analyzer is presented in **Figure 14** below.

Figure 14: Graph of Automated Zero and Precision Check

15.5.1 Single- and multi-point quality control checks

Single-point quality control checks are conducted on Washington Network FRM/FEM gaseous analyzers are performed on a frequency defined by the current version of 40 CFR Part 58, Appendix A. Single-point quality control checks (also called precision checks) are used to determine gaseous analyzer precision and bias in relation to a known concentration. The CFR states that one-point quality control checks for gaseous analyzers *"should be related to the routine concentrations normally measured at sites within the monitoring network in order to appropriately reflect the precision and bias at these routine concentration ranges".* Single-point test levels for gaseous analyzers within the Washington Network are chosen in accordance with this guidance. Single-point quality control checks of gaseous analyzers are always accompanied by a zero test concentration. All single-point QCs must be performed via the Envidas data logger software which automatically records the results. The resultant Actual and Indicated (also called Assessment and Monitor, respectively) concentrations are submitted electronically to EPA's AQS.

Multi-point calibrations consist of three or more test concentrations, plus an added zero concentration. Multi-point calibrations are used to establish or verify the linearity of analyzers over the range of measured concentrations, upon initial installation, after major repairs, and at specified frequencies. Most modern analyzers have a linear or very nearly linear response. 40 CFR Part 58 states that the test concentrations chosen for multi-point quality control and performance audits "*should represent or bracket 80 percent of ambient concentrations measured by the analyzer being evaluated."* Gaseous monitors within the Washington Network are challenged at concentrations accordingly. All multi-point QCs must be performed via the Envidas data logger software to ensure that results are automatically recorded by the logger software. The electronic results are polled by the central data acquisition system and subsequently reported to EPA's AQS.

15.5.2 Monthly flow rate verifications

Monthly flow rate verifications are conducted on all Washington Network FRM/FEM particulate samplers as described in 40 CFR Part 58, Appendix A and in the Washington Network SOPs. The results of these verifications are recorded by station operators and the final results are submitted to EPA.

Monthly flow rate verifications are also conducted on all CSN, NATTS samplers as defined in the national program-specific and Washington Network QAPPs and SOPs.

15.5.3 Nephelometer quality control checks

Automated quality control checks are conducted on all Washington Network nephelometers at a minimum of 14 day intervals as defined in the Washington Network nephelometer SOPs. Nephelometer quality control checks consist of challenging the instrument with a test air sample (precision point) of known coefficient of light scattering (bscat) and a zero bscat sample generated by running sampled air through a particle filter. CO_2 is used exclusively in the

Washington Network for the purpose of nephelometer quality control checks due to its relatively low greenhouse-gas properties. All nephelometer quality control checks (including manual checks) must be conducted via the Envidas data logger software to ensure that results are automatically be recorded by the logger software. Manual checks are required every 90 days. Actual (Assessment) and Indicated (Monitor) precision results from nephelometer quality control checks are submitted electronically to EPA's AQS database.

15.6 Documentation

Documentation includes the date, time, station name, equipment verified and/or calibrated, type of calibration, and technician. A description of the results must be recorded in the electronic logbook. The electronic logbook is considered a legal record and, therefore, logbook entries must contain sufficient detail so that someone other than the station operator can get a clear picture of the activities performed. An example of a properly-documented logbook entry is shown in **Figure 15** below.

Additional information about documentation can be found in the Automated Method Data Documentation, Review and Validation Procedure on Ecology's web site.

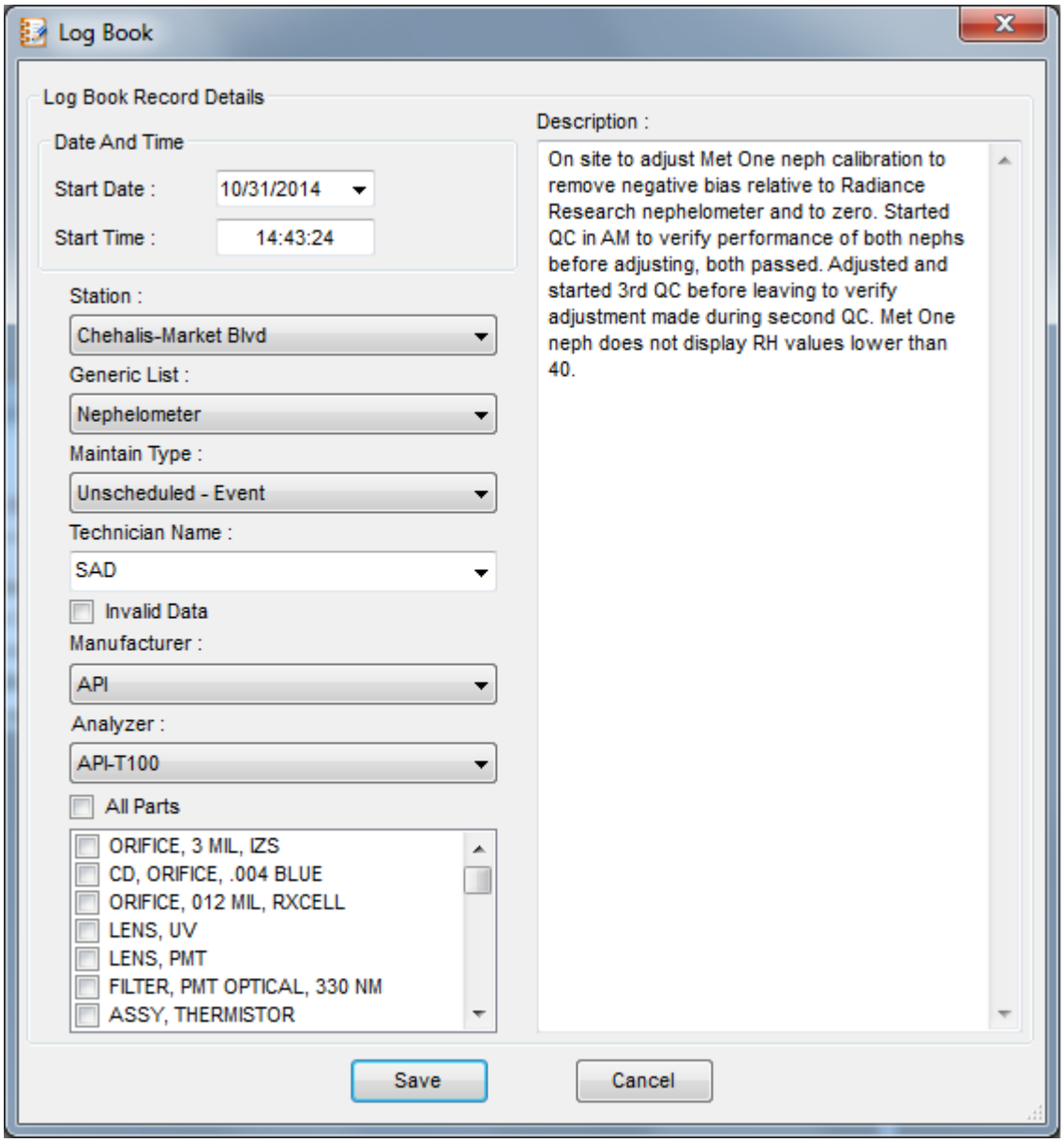

Figure 15: Example of a Properly-Documented Logbook Entry

15.7 Zero and span adjustments

Ambient monitoring instruments (analyzers and nephelometers) typically allow for zero and precision/span adjustments. These adjustments (recalibrations) are used to attenuate instrument response to correct for calibration drift.

Zero and span adjustments must always be followed by a calibration check ("as left"). Operators should allow sufficient time between any adjustment and the subsequent calibration check in order to ensure that the instrument readings are stable. This stabilization time may be substantial for some analyzers. Note that many modern instruments, such as the API 400

series ozone analyzers, actually provide a digital stability indicator as a diagnostic parameter that can be used to determine when instrument readings are stable.

Station operators should not make frequent small zero and span adjustments. Adjustments should be made only when the instrument drifts outside of the action limits defined in the instrument-specific SOP.

15.8 Frequency of calibration and analyzer adjustment

Quality control checks normally consist of a zero and precision point. However, a multi-point calibration check can substitute for a zero and precision quality control check, and will provide additional information as to instrument calibration and linearity of instrument response to test concentrations. In general, calibration checks must be conducted and instruments should be calibrated (or recalibrated):

- Before deployment;
- Upon initial installation;
- Following physical relocation;
- After any repairs or service that might affect its calibration;
- Following an interruption in operation of more than a few days;
- Upon any indication of analyzer malfunction or change in calibration;
- At a defined intervals (as dictated by manufacturer's recommendations, SOPs, and/or CFRs).

Instruments in routine operation are recalibrated periodically to maintain close agreement between instrument responses and test concentrations. The frequency of periodic recalibrations should be driven by action limits as defined in the instrument-specific SOPs. Calibrations may be conducted at levels below action limits, but thought should be given to several factors:

- The inherent stability of the instrument under the prevailing conditions of temperature, pressure, line voltage, etc. at the monitoring site
- The cost and inconvenience of carrying out the calibrations
- The quality of the ambient measurements needed
- The number of ambient measurements lost during calibration

15.9 Quality control failure data handling

Quality control check results that are outside the acceptance limits as defined in the instrument-specific SOPs will result in invalidation of the data collected during the period the instrument was operating outside acceptance limits. Ambient measurements are invalidated back to the most recent point in time where such measurements are known to be valid. This is typically the previous passing quality control check or performance audit, whichever is more recent. Data following a quality control check failure, instrument malfunction, or period of in-operation will be

considered invalid until a subsequent quality control check confirms that the instrument is again operating within acceptance limits.

In certain cases, it may be possible to identify a point in time where an instrument exceeded acceptance limits without invalidating data back to the last passing QC check or audit. A weight of evidence approach is used in such cases in order to determine data validity and identify likely causes of excessive drift, such as a power failure or other, fairly obvious malfunction.

16. Non-Network and Non-Direct Measurement Data

Non direct measurements are also called 'existing data'. It consists of data or information that may be used by Ecology, but is not generated by the Washington Network.

16.1 Non Washington network ambient air monitoring data

There are many entities that conduct ambient air monitoring within Washington that are not part of the Washington Network. Federal, state, and local clean air agencies and tribes conduct monitoring that is outside the scope, or is not funded, as part of the Washington Network. Nevertheless, Ecology recognizes the value and importance of these efforts and often displays such data via Ecology's WAQA web site. Other non-network air monitoring data can be found on other organizations' web sites. Non-network data is not subject to the requirements of the State's Quality System, is not reviewed or validated by Ecology Quality Assurance personnel, and is therefore not submitted to AQS. While non-network data is not reviewed or validated by Ecology, when it is of known and sufficient quality, it can augment knowledge of air quality issues around the state. Data of unknown quality, regardless of the collecting entity, should be used with caution.

Meteorological data gathered by other sources is a good example of non-network data that is nevertheless used as supplemental information for understanding, managing, and controlling air pollution in Washington. The U.S. Weather Service, National Climatic Data Center, and Regional Climate Centers collect data that can supplement information used to validate network meteorological site data, make decisions regarding where to locate monitoring sites, inform data analysis and modeling efforts, and make curtailment calls in airsheds without a Washington Network meteorological station.

16.2 Chemical and physical properties data

Chemical and physical properties data and conversion constants are often required in the processing of raw data into reporting units. This type of information that has not already been specified in the monitoring regulations will be obtained from nationally and internationally recognized sources. The following sources can be used without extensive review of their quality system requirements:

- National Institute of Standards and Technology (NIST)
- International Organization for Standardization (IOS), International Union of Pure and Applied Chemistry (IUPAC), American National Standards Institute (ANSI), and other widely recognized national and international standards organizations
- EPA
- The current edition of QA Handbooks

16.3 Geographic location and meta data

Specific geographical location of monitoring sites will be reported in latitude and longitude. The current coordinate system in use on most hand-held GPS devices is the World Geodetic System 1984 (WGS 84). Station operators are responsible for collecting this information whenever a new site is installed or a site is relocated. Operators must enter all required meta data into Ecology's SIMS before sampling. Operators also must record monitor changes (method changes, discontinuances, etc.) in the Site Information Management System (SIMS). Data from new sites and monitors will not be polled or reported to Ecology's WAQA web site until all required information has been entered into SIMS.

16.4 Historical monitoring information

Historical monitoring data and summary information may be used in conjunction with current monitoring results to calculate and report pollutant trends. When determining historical trends, past data must be reviewed to ensure comparability to current monitoring data. In cases where different sampling methods are combined to conduct trend analyses, known error, biases, and other potentially confounding factors must be identified and noted in all reports based upon such data.

17. Data Acquisition, Management, and Reporting

Successful strategies for air pollution prevention and reduction depend upon the correct interpretation of air monitoring data. Therefore, it is critical that ambient air monitoring data are:

- Easily accessible to a variety of users
- Of known and sufficient quality for intended use
- Aggregated in manners consistent for most common use

The Washington Network air monitoring data are collected, stored, and reported to meet these criteria. The various elements of Ecology's efforts in this regard are discussed below.

Envitech Ltd./DR DAS environmental data acquisition system - Envitech Ltd./DRDAS (Envidas) data acquisition and management software is used at all fixed monitoring locations throughout the Washington Network. Envidas data logger software is used to acquire ambient air data, trigger automated quality control, record quality control check results, determine validity of quality control check results, initiate alarms, send alerts, control automated data invalidation, and make electronic logbook entries.

Envidas data management software is used to archive data, produce various summary and air quality information reports, provide near real-time air pollution data and associated health information to the public, and submit data to AQS. The Envidas system software components are:

Data Logger

- Envidas Ultimate (and Ultimate Lite)
    - Envidas Ultimate Viewer
    - Envidas Ultimate Reporter
    - Envidas Ultimate Service Manager
    - Envidas Ultimate Setup
- Envidas For Windows (EnvidasFW)
    - Envidas For Windows Reporter
    - CommCenter

Central System (housed on servers at Ecology headquarters in Lacey)

- Microsoft SQL Server Database for all collected data (ambient and meta)
- Envista Setup (central polling and station configuration software)
- DR DAS XML Reporter (for submitting data to AQS)
- Envitech Web site Manager
- DR DAS FTP Import Export

Client Server/Desktop Software (located at Ecology and partner offices around the state)

- Envista Air Resources Manager (EnvistaARM) for producing various air quality summary reports, reviewing logbooks, and setting data validation
- UltraVNC (for accessing loggers remotely)
- Remote Desktop (for accessing loggers remotely)

Envidas Web site

- Available to the public
- Near real-time display of continuous monitoring data for the WAQA
- Meta site information and photos
- Downloadable data into excel and other formats
- Various summary and graphical pollution reports

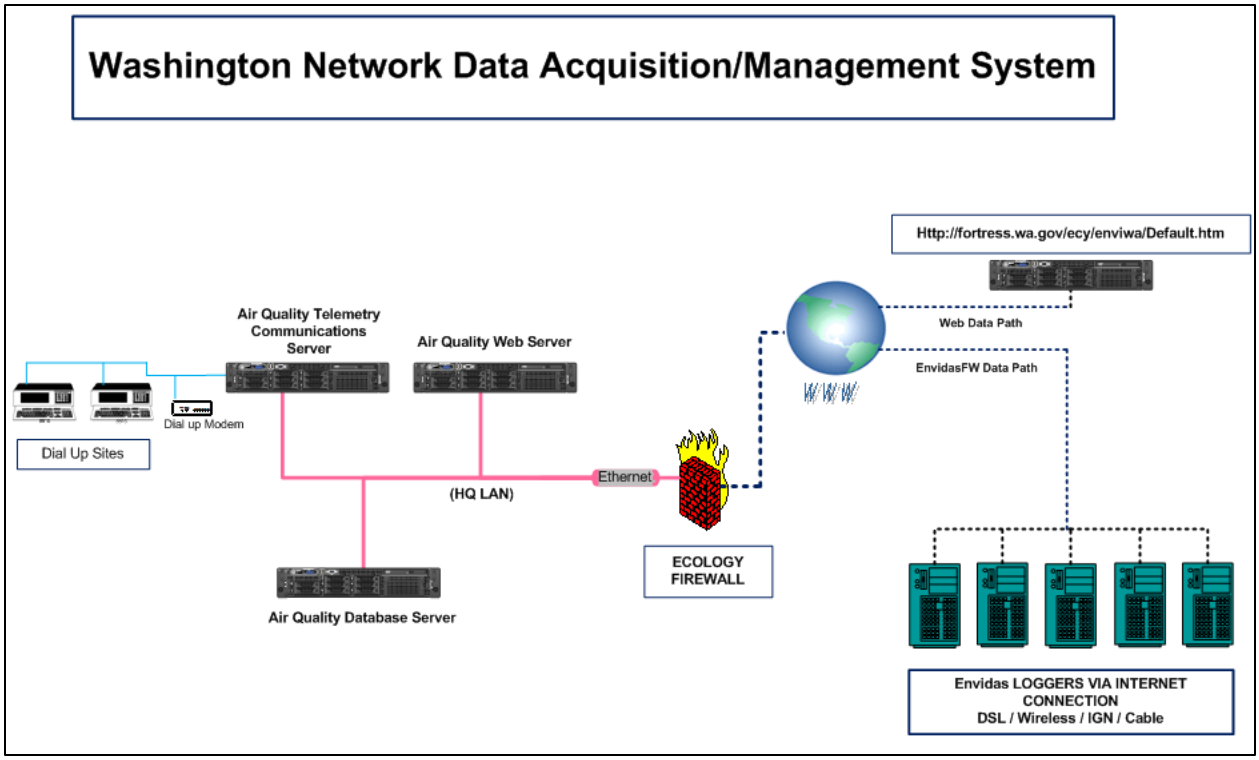

Figure 16: Basic Structure of WA Network Data Acquisition/Management System

18. Assessments and Response Actions

Performance evaluations and audits are conducted at regular intervals in order to assess the performance and quality of the Washington Network. These assessments are conducted by Ecology, EPA, and third party contractors with independence from normal station operations.

18.1 Independent assessment

Figure 17 below presents the minimum EPA requirement for QA independence within an organization. The Washington Network organizational structure displayed in **Figure 1** illustrates the relationship between the Ecology Quality Assurance group and monitoring operations.

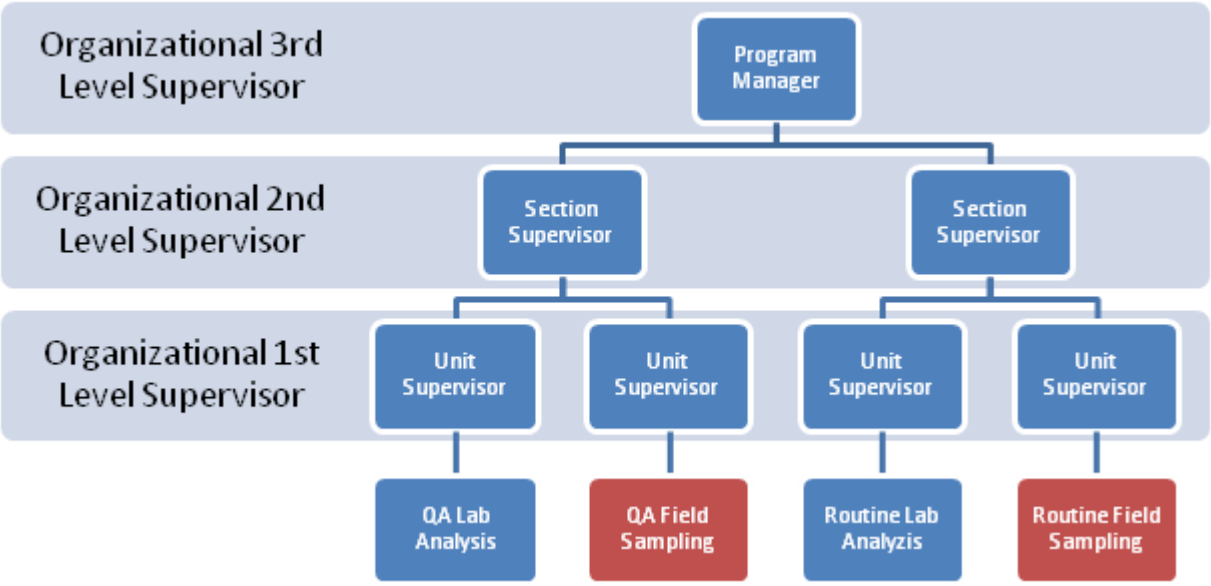

Figure 17: Minimum EPA Requirements for Quality Assurance Independence

Performance audits are conducted by Air Quality Program Quality Assurance personnel at routine intervals on all FRM/FEM, CSN, NATTS, and meteorological analyzers/monitors. EPA Region 10 and EPA's Office of Air Quality Planning and Standards contract with third parties to provide independent performance evaluations and audits as part of its National Performance Evaluation Program and Performance Audit Program (NPEP and NPAP).

EPA Region 10 staff conducts a technical systems audit (TSA) of the Washington Network at three year intervals.

These evaluations and audits and associated corrective actions are described in detail below.

18.2 Ecology quality assurance performance audits

Ecology Quality Assurance personnel conduct performance evaluations (audits) on all Washington Network SLAMS and SPMS FRM/FEM monitors at intervals dictated by federal requirements in the current version of 40 CFR 58, App. A. In addition, Ecology Quality Assurance personnel conduct performance audits on all CSN, NATTS, and meteorological monitors within the Washington Network as specified in the network-specific QAPP, SOPs, and/or EPA Quality Assurance Handbooks.

Ecology QA performance audits may be conducted with or without the station operator in attendance. During audits, QA personnel make observations, review documentation in the station's electronic logbook, review maintenance schedules, and inspect quality control results to determine how well the site, equipment, and documentation of such activities are being maintained and to evaluate whether CFR and SOP requirements are being met. Ecology Quality Assurance personnel maintain a separate lab and separate set of audit standards expressly for the purpose of conducting performance audits. In order to preserve the independence of the Quality Assurance audit and review process, all Quality Assurance audit

transfer standards, multi-gas calibrators, and associated audit gear are maintained and certified by Quality Assurance personnel and/or vendors who are separate from day-to-day monitoring site operations.

Ecology Quality Assurance personnel record observations, audit results, and findings in the electronic logbook. Audit results are recorded on Excel spreadsheets and emailed to the station operator, Quality Assurance and Air Monitoring Coordinators, Repair and Calibration staff, and grant/project managers. Performance audit results are entered into EPA's AQS.

18.2.1 Multi-point gaseous analyzer audits

Multi-point performance evaluations are conducted on all Washington Network gaseous analyzers at routine intervals. Ecology QA personnel select gaseous analyzer audit levels per the most recent direction and guidance found in the CFR, Quality Assurance Handbook, Vol II and EPA technical guidance. 40 CFR Part 58, Subpart G, states that audit levels should bracket 80 percent of ambient concentrations measured by the analyzer being evaluated. In order to facilitate this principle and allow for audits at the lower precursor (trace) concentrations typically seen at NCore sites, in 2010 EPA expanded the audit levels for gaseous analyzers from 5 to 10 levels. The levels and guidance for how to determine appropriate audit levels for each pollutant can be found in EPA Quality Assurance Handbook, Vol II.

For multi-point gaseous analyzer audits, Ecology Quality Assurance personnel transport QA standards and/or multi-gas calibrators to monitoring locations to generate known pollutant concentrations at appropriate audit levels. Test concentrations are simultaneously measured by both the QA standard and the monitoring station's analyzer. After stable readings are achieved at given test levels, the responses of the station analyzer are compared against the output of the QA standard. The audit ("actual" or "assessment") concentration and the corresponding analyzer ("indicated" or "monitor") response must be within acceptance limits as defined in the CFR (for FRM/FEMs) and Washington Network SOPs. Audit results outside of acceptable limits must be investigated to determine validity of results.

An example of a multi-point ozone performance audit is presented in **Figure 18**.

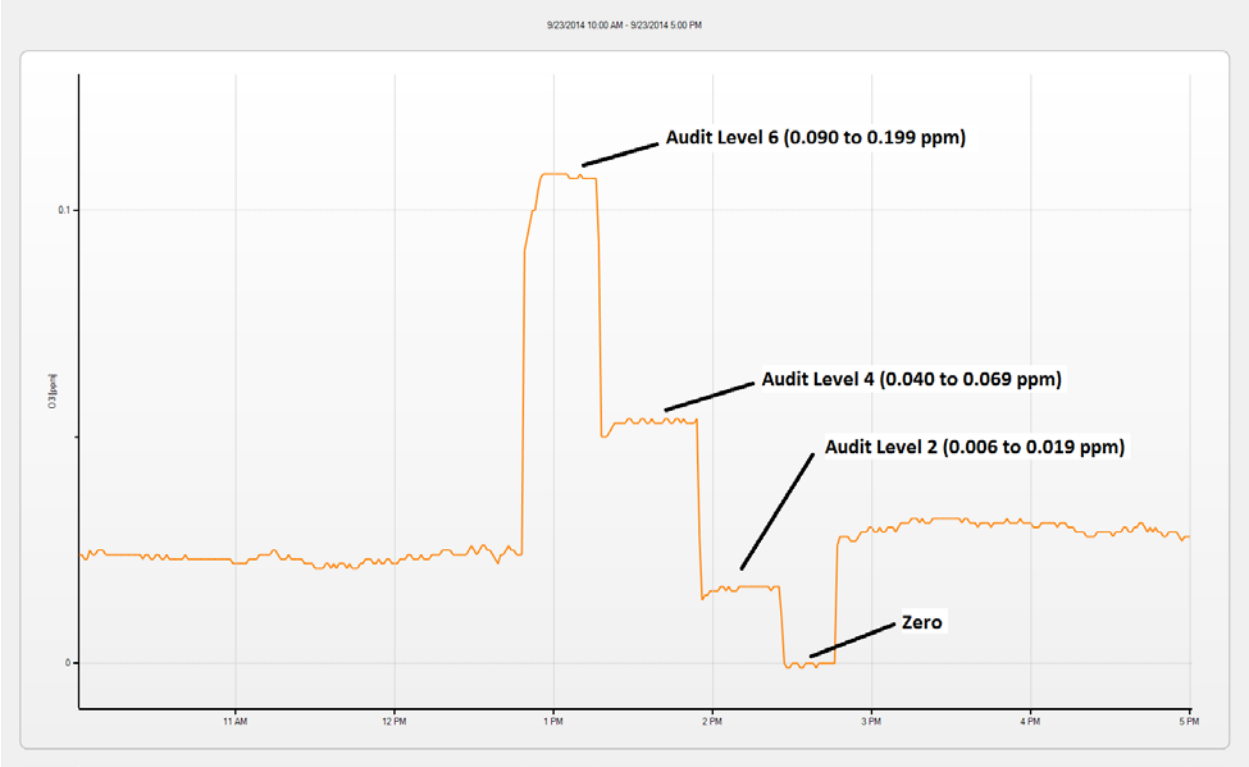

Figure 18: Example of an Ozone Performance Audit

18.2.2 Semi-annual flow audits

Ecology Quality Assurance personnel conduct semi-annual flow audits on all Washington Network FRM/FEM particulate instruments every 6 months as defined in 40 CFR 58, Appendix A. As mentioned previously, QA flow standards are recertified annually by QA personnel or vendors to ensure independence from station operations. In the event of a flow audit failure, QA personnel will use a secondary flow standard in an effort to confirm results. If passing results are achieved with a properly operating secondary flow standard, the secondary results will be used for the purposes of determining whether the station instrument is within acceptance limits.

18.2.3 Corrective action

In the event of an Ecology audit failure, the QA auditor will ensure that the audit standard is calibrated and operating correctly. If the standard is calibrated and operating correctly, Quality Assurance personnel will alert the station operator and may request additional information on data validity. The site operator must investigate the cause for the questionable data, document any problems found, perform necessary corrective actions, and respond in writing to Quality Assurance staff. Quality Assurance personnel and/or the AQP Quality Assurance Coordinator will make the final decision as to whether data will be invalidated. In the absence of a response from the operator, the questionable data will be invalidated back to the last valid quality control check. Data will continue to be considered invalid until it can be shown to meet the Air Quality Program MQO's.

18.2.4 Percent valid data

Percent valid data (also known as data completeness) is a metric reflecting the amount of certified valid data obtained from a monitor as compared to the amount expected under ideal conditions. The metric for percent valid data is typically expressed quarterly and annually in the Data Quality Assessment Reports (discussed below in section 19.1).

Data completeness (explained in section 8.19) is determined for each monitor. When calculating the metric, the sampling period and frequency (for manual methods) is taken into account and the result for a given monitor is expressed as a percentage. Monitors not meeting Ecology's 80 percent certified valid data goal are noted, along with an explanation, in the associated Data Quality Assessment Report (see 19.1 below) for the quarter/year in question. Data users should exercise caution when using incomplete data as incomplete datasets are associated with greater uncertainty.

18.3 EPA performance evaluations

Monitoring organization networks receiving funds from EPA are required to be assessed by independent parties. Federally-implemented programs using State and Tribal Assistance Grant (STAG) funds are provided to those organizations unable to support such programs due to financial or organizational constraints. The Washington Network participates in The National Performance Audit and National Performance Evaluation Programs (NPAP and NPEP) which are administered by EPA and supplement Ecology Quality Assurance activities designed to:

- Determine data comparability and usability across sites, monitoring networks, (Tribes, States, and geographic regions), instruments and laboratories
- Provide a level of confidence that monitoring systems are operating within data quality limits so data users can make decisions with acceptable levels of certainty
- Help verify the precision and bias estimates performed by monitoring organizations
- Identify where improvements (technology/training) are needed
- Assure the public of non-biased assessments of data quality
- Provide a quantitative mechanism to defend the quality of data
- Provide information to monitoring organizations on how they compare with the rest of the nation, in relation to the acceptance limits and to assist in corrective actions and/or data improvements

Figure 19: EPA Audit Trailer at Former Beacon Hill Location in Seattle

18.4 Technical systems audits

A Technical Systems Audit (TSA) is a thorough systematic, on-site, qualitative audit of facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of the Washington Network monitoring system. TSAs are conducted by EPA Region 10 at three year intervals.

19. Reports to Management

The Air Quality Program Quality Assurance Coordinator is responsible for ensuring a thorough, ongoing review of Washington Network data. Thorough review of collected data begins with station operators in the field. Operators are responsible for routinely reviewing collected data and automated quality control check results in order to catch errors in data collection early and prevent data loss.

Quality Assurance staff conduct a thorough review of all Washington Network data as part of the final data validation process. All documentation associated with sample collection and instrument operation, quality control check results, logbook entries, and collected data are examined in order to determine whether collections errors have occurred. Any data that are found to contain errors are described in the Ambient Air Monitoring Data Quality Assessment reports.

19.1 Data quality assessment reports

Data quality assessments are statistical and scientific evaluations of monitored data. Ecology Quality Assurance staff produce quarterly and annual Ambient Air Monitoring Data Quality Assessment reports. These reports provide summary statistical information on the effectiveness of data collection as well data quality indicators that serve as a metric for the adequacy of data for intended use. The Air Quality Program Quality Assurance Coordinator and

Quality Assurance personnel use this report to alert Washington Network managers to operational and/or systematic problems and identify options for improvements. The reports are emailed to EPA, Ecology management, and Washington Network partners.

The Air Quality Program Quality Assurance Coordinator is responsible for communicating the Washington Network measurement goals to partner agencies.

19.2 Air Quality System Reports

EPA's Air Quality System (AQS) contains many stock reports that are used by Ecology Quality Assurance personnel to assess data quality, certify data, and analyze how the Washington Network is faring in terms of the NAAQS. These reports can be generated within the AQS application. More details on these and other reports can be accessed at http://www.epa.gov/ttn/amtic/files/ambient/qaqc/boxplots.pdf. The most commonly used reports are described briefly below.

19.2.1 AMP251 QA raw assessment report

The AMP251 QA Raw Assessment Report is raw data from the following the following QC/QA activities:

- 1-Point Quality Control
- Annual Performance Evaluation
- Flow Rate Verification
- Semi-Annual Flow Rate Audit
- PMc Flow Rate Verification
- PMc Semi-Annual Flow Rate Audit
- Speciation Flow Rate Verification
- Speciation Semi-Annual Flow Rate Audit
- Performance Evaluation Program
- National Performance Audit Program
- Pb Analysis Audit
- Collocated Assessments

19.2.2 AMP256 QA data quality indicator report

The AMP256 QA Data Quality Indicator Report summarizes the precision, bias, and completeness results for the QC/QA the activities listed under the AMP251 report above. The completeness results for this report relate to whether quality control and quality assurance activities were conducted at required intervals. This report is used as a primary source for the information contained in the Ambient Air Monitoring Data Quality Assessment Reports.

19.2.3 AMP430 data completeness report

The AMP430 Data Completeness Report presents percent data completeness results for each monitor. This report is used in conjunction with the AMP256 QA Data Quality Indicator Report as a primary source for the Ambient Air Monitoring Data Quality Assessment Reports.

19.2.4 AMP480 design value report

The AMP480 Design Value Report is a helpful tool for quick snapshots of how the Washington Network criteria pollutant FRM/FEM monitors are faring in terms of the NAAQS. Users of this report should view the results as estimates. In order to determine exact design values, the methods in 40 CFR Part 50 should be used.

19.2.5 AMP600 certification evaluation and concurrence report

The AMP600 Certification Evaluation and Concurrence Report is used primarily by Ecology Quality Assurance personnel and the Ecology's AQS Coordinator to certify data in AQS on an annual basis.

20. Data Review, 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 provision of objective evidence that the particular requirements for a specific *intended use* are fulfilled. So, for example one could verify that for a monitor all Single-point QC were performed every two weeks as described in the SOP (*specified requirement*). However, if the checks were outside acceptance limits, the validation process might determine that the data could not be used for NAAQS determinations (*intended use*). It is important to describe the criteria for deciding the degree to which each data item has met its quality specifications. This section describes the techniques used to make these assessments. The information provided here is intended as a general overview. Additional information regarding the Washington Network data validation process can be found in Ecology's Automated Method Data Documentation, Review and Validation Procedure on Ecology public web site.

Review, verification, and preliminary data validation are performed by the station operator. A separate review, verification, and final data validation are performed by Ecology Quality Assurance personnel independent of station operations. These activities are done on an ongoing, routine basis. Station operators are responsible for reviewing collected data and quality control check results as often as possible to ensure errors in data collection are caught early and prevent excessive data loss.

20.1 Data review methods

Thorough review must be conducted on all manual and continuous method data. The primary purpose of this review is to identify and remove data that does not meet Measurement Quality Objectives. Individuals (station operators and Quality Assurance personnel) conducting data review must have sufficient knowledge of the major pollutants and air quality conditions prevalent at the monitoring station in question.

Graphical review of data facilitates the detection of outliers and other errors in measurements. The EnvistaARM software contains several graphical report options for this purpose. 1-minute Station Reports often reveal errors that are “smoothed out” by longer averaging periods. Group and Multi-station Reports are extremely helpful for comparing pollutant data in a given airshed/region and can be used to quickly spot data collection errors. An example of a readily-identifiable instrument problem as revealed by a Multi-station Report is presented in **Figure 20** below. It is clear that the nephelometer [NEPH(Bscat)] represented by the yellow line radically departs from the neighboring site nephelometers after a period of reasonable agreement. This nephelometer is almost certainly malfunctioning and the site operator should investigate.

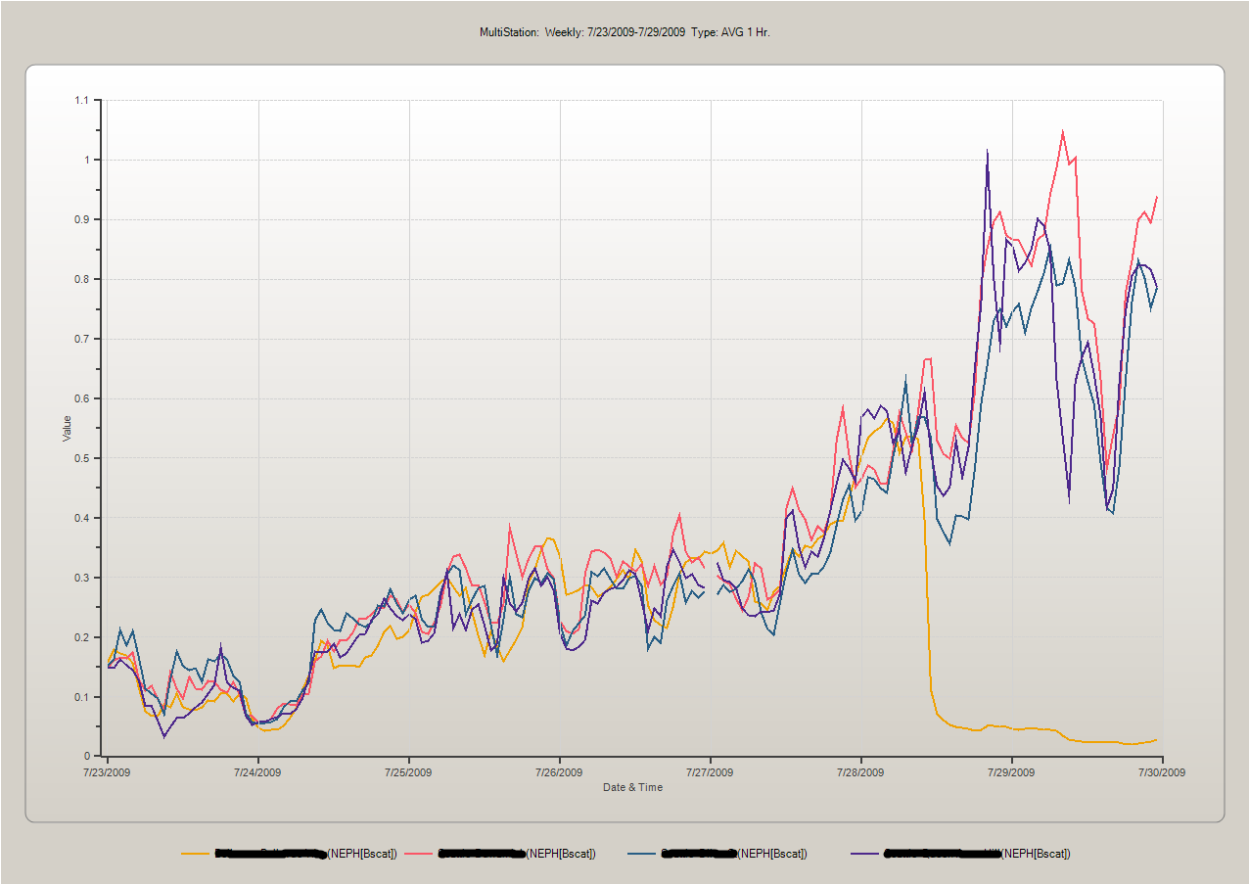

Figure 20: Example of Multi-Station Report

20.2 Data verification methods

Verification can be defined as confirmation through provision of objective evidence that *specified requirements* have been fulfilled. The data verification process involves the inspection, analysis, and acceptance of the field data or samples. These inspections can take the form of technical systems audits (internal or external) or frequent inspections by field operators and lab technicians. Questions that should be asked during the verification process include:

- Were data collection operations performed according to approved SOPs?
- Were data collection operations performed on the correct time and date? Many environmental operations must be performed within a specific time frame. For example, the NAAQS samples for filter-based particulate are collected from midnight to midnight on a pre-defined frequency and schedule set by EPA.
- Did the sampler or monitor perform correctly? Individual checks such as leak checks, flow checks, meteorological influences, and all other assessments, audits, and performance checks must have been acceptably performed and documented.
- Did the environmental sample pass an initial visual inspection? Many environmental samples can be flagged (qualified) during the initial visual inspection.
- Have manual calculations, manual data entry, or human adjustments to software settings been checked? Automated calculations should be verified and accepted before use, but at some frequencies these calculations should be reviewed to ensure that they have not changed.

20.3 Data validation methods

Data validation is an ongoing process designed to ensure that collected data meet the quality system goals of the Washington Network. Data validation is further defined as an examination and provision of objective evidence that the requirements for a specific *intended use* are fulfilled. The purpose of data validation is to detect and verify any data values that may not represent actual ambient air quality conditions at the sampling station. Effective data validation procedures usually are handled completely independently from the procedures of initial data collection.

Certain criteria, based upon the CFR as well as field operator and laboratory technician judgment, may be used to invalidate a sample or measurement. Washington Network acceptance limit criteria are identified in Ecology's instrument-specific SOPs.

Flags or result qualifiers are applied to data in order to identify potential problems with data within the Washington Network. Flags are applied automatically by the instrument and logger and after the fact by personnel responsible for data review and validation. Flags are used to indicate the reason that a data value:

- Did not produce a numeric result (null data code)
- Is not an ambient concentration (zero, precision, span data)
- Is questionable due to instrument status (automatically flagged by the logger or monitor)
- Has been invalidated due to not meeting the requirements in the QAP/SOPs

Flags can be used both in the field and in the laboratory to signify data that may be suspect due to contamination, special events or failure of QC limits. Flags can be used to determine if individual samples (data), or samples from a particular instrument will be invalidated. In all cases, data is thoroughly reviewed before any invalidation.

20.4 Automated methods

When zero, span, or one-point QC checks exceed acceptance limits, ambient measurements are invalidated back to the most recent point in time where such measurements are known to be valid. Usually this point is the previous passing quality control check, unless some other point in time can be identified and related to the probable cause of the excessive drift (such as a power failure or instrument/equipment malfunction). Data following a quality control check failure, instrument/equipment malfunction, or period of non-operation is considered invalid until verification can demonstrate that the instrument in question is operating within acceptance limits. Typically, this coincides with the next passing QC check.

Data may be invalidated when room or shelter temperatures exceed acceptable operating limits for a given instrument. Acceptable shelter temperature ranges are defined in the manufacturers' manuals and/or the Washington Network's instrument-specific SOPs.

20.5 Manual methods

The first level of data validation for manual methods is to accept or reject the sample(s) based upon results from operational checks of critical parameters in all three major and distinct phases of manual methods: Sampling, analysis, and data reduction. In addition to using operational checks for data validation, the user must observe all limitations, acceptance limits, and warnings described in the reference and equivalent methods that warrant data invalidation. Results from performance audits/evaluations as required by 40 CFR 58, Appendix A are not necessarily used as the sole criteria for data invalidation because they are intended to assess the quality of the data.

20.6 Validation templates

In June 1998, EPA established a national workgroup consisting of EPA staff and personnel from state, local, and other monitoring entities to develop a procedure for monitoring organizations to follow that would provide for consistent validation of criteria pollutant monitoring data across the United States. The Workgroup developed three tables of criteria where each table has a different degree of implication about the quality of the data. These tables can be found in the current version of EPA's Quality Assurance Handbook, Volume II, Appendix D.

Ecology Quality Assurance staff use the validation templates of FRM/FEM instruments during the validation process which include requirements found in 40 CFR Part 50 Appendices L and N, 40 CFR Part 58, Appendix A, Method 2.12, and any additional criteria as found in the Washington Network SOPs.

20.7 Verification and validation methods

Ecology Quality Assurance staff verifies and reviews all station operations, documentation, quality control activities and results, and maintenance activities in determining validity of data collected in the Washington Network. Verification is confirmed by examination and provision of objective evidence that specified requirements have been fulfilled. Ecology Quality Assurance staff perform Final Validation on all Washington Network data, locking the data from further editing and preparing it for submittal to AQS.

Earlier elements of this Quality Assurance Plan describe in detail how the activities in these data collection phases are implemented in order to meet the data quality objectives of the program. Review and approval of this QAP by the personnel listed on the approval page serves as an agreement for all involved that the processes described in the QAP will provide data of adequate quality. In order to verify and validate the phases of the data collection operation, Ecology QA staff uses qualitative assessments (e.g., technical systems audits, network reviews) to verify that the QAP is being followed and relies on the various quality control results, performed at specified intervals of the data collection operation, to validate that the data will meet the DQOs.

20.8 Data collection procedures

The use of quality control checks throughout the measurement process helps validate the activities occurring at each phase. The review of QC data such as precision data, performance evaluation results, and the equipment verification checks that are described in Sections 14 and 15 of this document are used to validate these activities.

21. Quality Improvement

The goal of reconciling collected data with user requirements is to determine whether the Washington Network is adequate to achieve the monitoring goals of the Air Quality Program, its data quality objectives (DQOs), and Measurement Quality Objectives (MQOs).

Ambient air monitoring data collected by the Washington Network is subsequently used to evaluate the adequacy of the sampling design. By continuously reviewing the data and assessing whether it is consistent with the objectives of the network, Ecology and its partners in the Washington Network can evaluate the adequacy of the network in terms of meeting its goals.

The data used in decisions about determinations of attainment of the NAAQS are never error-free and will always contain some level of uncertainty. Because of these uncertainties, there is

a possibility that an area may be determined to be nonattainment when it is actually in attainment or vice versa, resulting in potentially serious health, economic, and political consequences. This plan and Ecology's SOPs, if closely adhered to, will help ensure that Ecology and its partners understand the uncertainty inherent in the Washington Network ambient air monitoring data and limit the likelihood of these adverse consequences.

Acronyms and Abbreviations

AAMG	Ambient Air Monitoring Group
AMTIC	Ambient Monitoring Technology Information Center
APTI	Air Pollution Training Institute
AQI	Air Quality Index
AQP	Air Quality Program
AQPLT	Air Quality Program Leadership Team
AQS	Air Quality System
ANSI	American National Standards Institute
ARM	Approved Regional Method
AWMA	Air and Waste Management Association
CAA	Clean Air Act
CBSA	Core-Based Statistical Area
CFR	Code of Federal Regulations
CO	carbon monoxide
CSN	$PM_{2.5}$ Chemical Speciation Network
CRM	Certified Reference Material
CRO	Central Regional Office (Ecology)
DDR	Data Disposition Request
DQI	Data Quality Indicator
DQO	Data Quality Objective
EAP	Washington State Department of Ecology Environmental Assessment Program
Ecology	Washington State Department of Ecology
EDO	environmental data operation
EPA	Environmental Protection Agency
ERO	Eastern Regional Office (Ecology)
FARR	Federal Air Rules for Indian Reservations
FEM	Federal Equivalent Method
FEP	fluorinated ethylene propylene
FRM	Federal Reference Method
HAP	hazardous air pollutants
HQ	Ecology Headquarters
IOS	International Organization for Standardization
IR	infrared
IUPAC	International Union of Pure and Applied Chemistry
IMPROVE	Interagency Monitoring of Protected Visual Environments
µg/m3	micrograms per cubic meter
MAC	Monitoring Action Committee
MQO	Measurement Quality Objective
MSA	Metropolitan Statistical Area
NAAQS	National Ambient Air Quality Standards
NACAA	National Association of Clean Air Agencies
NATTS	National Air Toxic Trends Sites

NCore	National Core Network
NERL	EPA National Exposure Research Laboratory
NIST	National Institute of Standards and Technology
NO2	nitrogen dioxide
NPAP	National Performance Audit Program
NPEP	National Performance Evaluation Program
NWRO	Northwest Regional Office (Ecology)
O3	Ozone
OAQPS	Office of Air Quality Planning and Standards
PE	performance evaluation
PM	particulate matter
ppb	parts per billion
ppm	parts per million
PQAO	Primary Quality Assurance Organization
PSD	Prevention of Significant Deterioration
QA	quality assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
SIMS	Site Information Management System
SLAMS	State and Local Air Monitoring Stations
SLT	state, local, and tribal
SOP	standard operating procedures
SPMS	Special Purpose Monitoring Stations
SRM	Standard Reference Material
SRP	standard reference photometer
SO2	sulfur dioxide
SWRO	Southwest Regional Office (Ecology)
TEOM	Tapered Element Oscillating Microbalance
TSA	Technical Systems Audit
TSS	Technical Services Section (Ecology)
UV	ultraviolet
VOC	volatile organic compounds
WAQA	Washington Air Quality Advisory
WGS	World Geodetic System