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Technical Guidance for the Development of Tribal Air Monitoring Programs

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Technical Guidance for the Development of Tribal Air Monitoring Programs

Community and Tribal Programs Group
Ambient Air Monitoring Group
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
RTP, NC 27711

Foreword

This intent of this document is to help tribes gain a better understanding of the ambient air monitoring process and provide information on resources and tools that help to build and sustain an air quality monitoring program. This document includes the following information to help tribes plan, implement and assess their air quality program activities:

- steps for identifying goals and objectives for conducting air monitoring;
- information for planning and selecting the appropriate type of monitoring network including discussions of staffing, network design, monitor selection, quality system development and training;
- costs for operating a monitoring network, funding sources and resources for writing a grant proposal and work plan;
- implementation of monitoring networks;
- data acquisition, management and reporting, and
- data analysis and interpretation including information on modeling techniques.

The intended audience for this document is the tribal environmental professionals. The document has been assembled by a team represented by Tribes involved in monitoring, personnel from the Institute of Tribal Environmental Professionals (ITEP) and EPA Regional Office and Headquarters staff who are involved in resource allocations, tribal air grant award and management, program evaluation, strategic planning of monitoring networks, and technical support to monitoring programs. State monitoring officials may also benefit from reading this document as it may improve their understanding of tribal goals and how EPA strives to help tribes meet their goals.

The document might be considered the "yellow pages" of information on ambient air monitoring. It is not intended to provide the details of each specific monitoring program but it can provide the key attributes and web addresses that would lead one to those details.

This guidance should also be considered a "living" document. As new environmental problems arise, as regulations change or as improvements are made in monitoring technology, this document will be revised to reflect the changes. It is anticipated that the document will undergo a review and revision every 5 years. Therefore, comments and suggestions on this document are encouraged at any time and should be emailed to the current OAQPS Tribal Air Coordinator at the following website: http://www.epa.gov/air/tribal/coordinators.html.

This document is available at the following internet website: http://www.epa.gov/air/tribal/airprogs.html. The document can be read and printed using Adobe Acrobat Reader software, which is freeware that is available from many Internet sites (including the EPA web site).

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Acknowledgements

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Tribal Monitoring Organizations and Associations

Annabel Allison	Institute of Tribal Environmental Professional
Ryan Callison	Inter-Tribal Environmental Council
Ken Cronin	National Tribal Environmental Council
Farshid Farsi	Institute of Tribal Environmental Professional
Glenn Gehring	Institute of Tribal Environmental Professional
Bill Grantham	National Tribal Environmental Council
Stephen Hartsfield	National Tribal Air Association
Eric Nicolar	Penobscot Indian Nation
Lisa Reiner	Quinault Tribe
Melinda Ronca-Battista	Institute of Tribal Environmental Professional
Joy Wiecks	Fond du Lac Tribe

EPA

Norm Beloin	Region 1
Motria Caudill	Region 5
Mike Copeland	Region 8
George Dilbeck	Office of Indoor Air and Radiation
Tyler Fox	Office of Air Quality Standards and Planning
James Hemby	Office of Air Quality Standards and Planning
Phil Lorang	Office of Air Quality Standards and Planning
Tami Laplante	Office of Air Quality Standards and Planning
Julie McClintock	Office of Air Quality Standards and Planning
Laura McKelvey	Office of Air Quality Standards and Planning
Bill Nally	Region 6
Keith Rose	Region 10
Rich Scheffe	Office of Air Quality Standards and Planning
Joe Tikvart	Office of Air Quality Standards and Planning

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List of Abbreviations and Acronyms

AMDAS	Ambient Monitoring Data Analysis System
AQI	Air Quality Index
AQMG	Air Quality Monitoring Group
AQS	Air Quality System
BAM	beta-attenuation monitor
CAA	Clean Air Act
CAFO	confined animal feeding operation
CASTNET	Clean Air Status and Trends Network
CENRAP	Central Regional Air Planning Association
CFR	*Code of Federal Regulations*
CMAQ	Community Multi-scale Air Quality Model
CMB	chemical mass balance
CO	carbon dioxide
CV	coefficient of variation
DAS	data acquisition system
DQA	data quality assessment
DQOs	data quality objectives
EDO	environmental data operation
EPA	Environmental Protection Agency
EPM	Emissions Production Model
ESAT	Environmental Services Assistance Team
FCCS	Fuel Characteristic Classification System
FEM	Federal Equivalent Method
FRM	Federal Reference Method
GAP	General Assistance Program
GIS	graphical information systems
HAP	hazardous air pollutants
ICR	information collection request
IHS	Indian Health Service
IMPROVE	Interagency Monitoring of Protected Visual Environments
IT	information technology
ITEP	Institute for Tribal Environmental Professionals
LEADS	Leading Environmental Analysis Display System
MANE-VU	Mid-Atlantic/Northeast Visibility Union
MDN	Mercury Deposition Network
mg/m^3	milligrams per cubic meter
MQOs	measurement quality objectives
NAAMS	National Ambient Air Monitoring Strategy
NAAQS	National Ambient Air Quality Standards
NADG	National Air Data Group
NADP	National Atmospheric Deposition Program
NATA	National Air Toxics Assessment
NATTS	National Air Toxics Trend Stations
NCore	National Core Network
NERL	National Exposure Research Laboratory
NIST	National Institute of Standards and Technology

List of Abbreviations and Acornyms (continued)

NOAA	National Oceanic an Atmospheric Administration
NOy	reactive nitrogen compounds
NO_x	nitrogen oxides
NPS	National Park Service
O_3,	ozone
OAQPS	Office of Air Quality Planning and Standards
OAR	Office of Air and Radiation
OECA	Office of Enforcement and Compliance Assurance
OEI	Office of Environmental Information
OMB	Office of Management and Budget
ORD	Office of Research and Development
PBT	persistent bioaccumulative toxics
PE	performance evaluation
PEP	Performance Evaluation Program
PFIRS	Prescribed Fire Incident Reporting System
PM	particulate matter
$PM_{2.5}$	particulate matter $\leq$ 2.5 microns
PMF	positive matrix factorization
PPM	parts per million
PSD	Prevention of Significant Deterioration
PTFE	polytetrafluoroethylene
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QMP	quality management plan
READY	Real-time Environmental Applications and Display System
RPOs	Regional Planning Organizations
RSM	response surface model
SCRAM	Support Center for Regulatory Atmospheric Modeling
SIP	State Implementation Plan
SLAMS	State and Local Monitoring Stations
STAG	State and Tribal Assistance Grants
SO_2	sulfur dioxide
SOP	standard operating procedure
TAR	Tribal Authority Rule
TAMS	Tribal Air Monitoring Support Center
TEOM	tapered element oscillating microbalance
TEISS	Tribal Emissions Inventory Software Solution
TIP	Tribal Implementation Plan
TREX	Tribal Environmental Exchange
TRI	Toxic Release Inventory
TSA	technical systems audit
USDA	United States Department of Agriculture
$\mu g/m^3$	micrograms per cubic meter
VISTAS	Visibility Improvement State and Tribal Association of the Southeast
WRAP	Western Regional Air Partnership

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Section 1

Introduction and Purpose

Why Do Tribes Want to Conduct Air Monitoring?

One of the most important reasons that tribes are conducting air quality monitoring is to gather information on the long-term air quality effects on the health of the tribal community and their tribal lands. In many cases, tribes use their lands for subsistence hunting, fishing and harvesting native plants. These subsistence cultures are affected by increased exposure to pollutants. In addition, the environment is often integral to religious and traditional practices. Some tribes are concerned that long-term exposures to air pollutants, acid rain, and heavy metal deposition will adversely affect these resources as well as their physical and mental health. The following information provides some specific objectives for tribes to conduct ambient air monitoring and includes some examples of tribes performing monitoring for these objectives.

Air Monitoring for Compliance with Health-Based National Ambient Air Quality Standards (NAAQS)

Tribes are currently monitoring to demonstrate compliance with national standards, primarily for ozone and particulate matter, in areas of the country that are not in compliance with the NAAQS for these pollutants or have no existing monitoring. The data from these sites may be used to demonstrate the need to develop a tribal implementation plan, to show the inadequacies of state or federal implementation plans (or monitoring networks) or to warn tribal members of unhealthy air quality. Tribes may also be well located to perform air monitoring that broadens the coverage of state monitoring networks. Several tribes in the Northeast operate ozone and $PM_{2.5}$ air monitoring sites in areas that the states are less able to monitor. An example of this is the Wampanoag Tribe of Gay Head at Aquinnah, MA (Martha's Vineyard) who is currently operating an air monitoring program consisting of an ozone monitor, an IMPROVE sampler and a meteorological station. The station is located in the Massachusetts non-attainment area in a location where there is no state air monitoring. In 2005, the station recorded four days above the 8-hr. ozone NAAQS and provided the tribe with health-related air quality data to inform tribal members. Data from this station will also provide the tribe with the ability to ensure that ozone air quality standards will be met in the future.

PM_{10} monitoring has been on-going in non-attainment areas on tribal lands in Montana for many years. The Confederated Salish and Kootenai Tribes and the Northern Cheyenne Tribes were designated non-attainment for PM_{10} in 1989. Ongoing monitoring for PM_{10} will be required to satisfy compliance with their respective Tribal Implementation Plans. $PM_{2.5}$ monitoring was also initiated in these two areas as a screening tool to ensure compliance with the $PM_{2.5}$ standard.

Impairment of Visibility for Vistas Within or Near Reservations

Visibility is another important measurement objective for tribal reservations designated as Federal Mandatory Class 1 areas or in areas where regional haze is of concern. The CAA amendments of 1990 set a target of improving visibility in mandatory Class 1 areas to natural visibility conditions by 2064. Data from these sites will provide tribes important information on the impacts of regional haze on visibility on tribal lands. Examples of visibility measurements include the operation of IMPROVE monitors by a number of tribes and the operation of haze-cameras on tribal lands. The Aroostook Band of Micmac Indians operate both an IMPROVE monitor and a haze camera at their air monitoring site in Presque Isle Maine. Data from this site is included in the National IMPROVE web page and the haze camera is included as part of the NESCAUM haze-cam network. The Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation in northern Montana also operate an IMPROVE monitor which they use to monitor the status of their voluntary Class 1 air shed. They, the Confederated Salish and Kootenai Tribes, and the Northern Cheyenne Tribes operate IMPROVE samplers that supplement the core IMPROVE network and provide valuable information on areas that would otherwise lack monitoring resolution.

Toxic Air Pollutants for Health and Ecological Effects

Tribes are also monitoring for hazardous air pollutants and/or air toxics. Air monitoring for these pollutants can either be for short-term exposures when there is a chemical release, or for long-term community and ecological impacts. Sources of these pollutants include nearby stationary sources, area sources, mobile sources, and long distance transport from urban areas. Data from these sites provide the tribes critical information on hazardous pollutant exposures and impacts of air toxics on communities and tribal lands through risk analyses conducted using this monitoring data. Examples of this type of monitoring include mercury deposition monitoring or the impact of a nearby power plant or pulp mill. The Nez Perce Tribe of Idaho is currently conducting air toxics monitoring in the town of Lewiston and on their reservation for toxic emissions from the Potlatch pulp mill in Lewiston. Several tribes in Maine conduct monitoring for metals and mercury deposition for long-term trend data on their tribal lands. In addition, several New England tribes are collecting and analyzing fish tissue data both as a measure of fish contamination and as an indicator of mercury deposition.

Monitoring to Support AQI and AIRNow

Tribes are operating continuous monitoring for ozone and $PM_{2.5}$ and converting these data to the appropriate Air Quality Index (AQI). The AQI relates concentration of pollutants to potential health effects and can be used to alert a community to unhealthy air quality conditions. Another critical role for tribal monitoring is being part of the national AIRNOW mapping program. These sites provide near real-time data quality information and valuable information to better understand the fate and transport of air pollution. The data is also valuable for use in mapping programs in rural areas where there is little or no state data.

Significant Air Quality-Related Environmental and Cultural Resource Concerns

Tribes are conducting air quality monitoring to gather information on the long-term air quality effects on the tribal community and on tribal lands. In many cases, tribes use their ancestral lands for subsistence hunting and fishing, traditional rites and harvesting native plants. Tribes are concerned that long-term exposures to air pollutants, acid rain, and heavy metal deposition will adversely affect these resources. It should be noted that this type of air monitoring requires a long-term commitment of funding and resources (for operation of equipment and analyses/assessments of the data). Examples of this type of monitoring include operating trace level SO2, CO and NOy monitors, sulfate, nitrate, metals, and the operations of National Atmospheric Deposition Network (NADP), Mercury Deposition Network (MDN) and IMPROVE samplers. Data from this type of monitoring can also help to assess the short and long-term effects of long distance transport on tribal lands and the effects of atmospheric deposition on the ecology of their lands. The Nez Perce, Yakama Nation, Umatilla and Warm Springs Tribes are involved in a cooperative effort to look at air impacts in the Columbia River Gorge Scenic Area where all four tribes have treaty fishing rights. Part of this air quality assessment includes the impacts of air pollution on rock art.

Regional Monitoring

Another critical role for tribal monitoring is being part of a Regional/State monitoring network. Tribes may be well located to perform air monitoring that broadens the coverage of State Implementation Plan (SIP) monitoring networks and supports the national AIRNOW mapping program. Several tribes in the Northeast operate ozone and $PM_{2.5}$ air monitoring sites in areas that the states are unable to monitor, such as the island of Martha's Vineyard, MA or far eastern ME. Not only do these sites provide extended coverage for the regional air monitoring program, but also they provide improved coverage for EPA's AIRNOW real-time air quality mapping program. These sites provide valuable information to better understand the fate and transport of air pollution.

Determining Air Quality Background Levels and Establishing Air Quality Baselines for Prevention of Significant Deterioration (PSD)

In some cases, tribes will need to conduct air quality monitoring to determine air quality background levels or to establish a baseline. This information is important for the protection of areas with pristine air quality and to provide quantitative data before new stationary sources are located in or near Indian country. This monitoring can also help in identifying the role of off-reservation sources and /or to build a case for developing partnerships to control emissions from those sources.

Source Monitoring

Tribes may need to conduct emission monitoring on their major point sources for compliance purposes. This may be in the form of stack tests or by conducting continuous emission monitoring. Normally, source monitoring is conducted for particulate, sulfur dioxide, nitrogen oxides, volatile organic compounds and/or carbon monoxide.

Indoor Air Quality

The increase in asthma and respiratory disease, and the attempt to discover their causes, has led to an increased awareness that indoor environments play a large, if not the largest, role in causing these health problems. Molds, tobacco smoke, radon, improper ventilation, insect infestations, and cooking/heating fires all play a role in increasing the effects of respiratory distress on affected populations and, to a disproportionate extent, the tribal members. Funding for monitoring projects such as the Radon Monitoring Program, Tools for Schools, and others, can be used to assist in identifying problems and determining solutions. This monitoring information can be used to act or to influence mechanisms that will help in the remediation of health problems related to indoor air quality.

Tribal Authority

EPA's tribal air policy emphasizes that as sovereign governments, tribes set their own air program goals. Section 301 (d) of the 1990 Clean Air Act (CAA) Amendments provides federally recognized tribal governments the authority to implement CAA programs for lands for which they can demonstrate jurisdiction. The Tribal Authority Rule (TAR) promulgated on February 12, 1998, further delineates the authority of tribes to implement air quality programs under the Act.

EPA's goal for the tribal air program is to assist tribes in understanding air quality problems and to establish and meet air quality goals, rather than to set goals or timetables for the tribes. EPA's Strategic Plan for 2003-2008 states:

> "EPA is committed to working with tribes on a government-to-government basis to develop the infrastructure and skills tribes need to assess, understand, and control air quality on their lands. We will increase air monitoring in Indian country, and, in consultation with tribes, we will establish needed federal regulatory authorities and help tribes develop and manage their own air programs in a manner consistent with EPA Indian Policy and tribal traditions and culture. We plan to complete a policy determining when Federal Implementation Plans are appropriate for bringing Clean Air Act programs to Indian country. We will support tribal air programs by providing technical support, assistance with data development, and training and outreach, and we will help tribes participate in discussions of national policy and operations and in regional planning and coordination activities. Where tribes choose not to develop their own programs, we will implement air quality programs directly."

In developing its annual budget plans, EPA considers whether sufficient resources are available to support tribal air monitoring that is necessary and appropriate to protect air quality in Indian country and to provide important data that helps meet state, local, or national monitoring data needs. Each year, EPA's budget request to Congress includes a certain amount of funding for use in awarding grants to tribes to support air quality management.

Currently, there are five hundred and fifty six (556) federally recognized tribes in the United States. Of this number, approximately 125 tribes currently receive federal funding from the U.S. Environmental Protection Agency to address environmental issues that are pertinent to their lands and community members. As Figure 1.1 indicates, many tribes are using federal funds to monitor and report data to EPA national data bases.

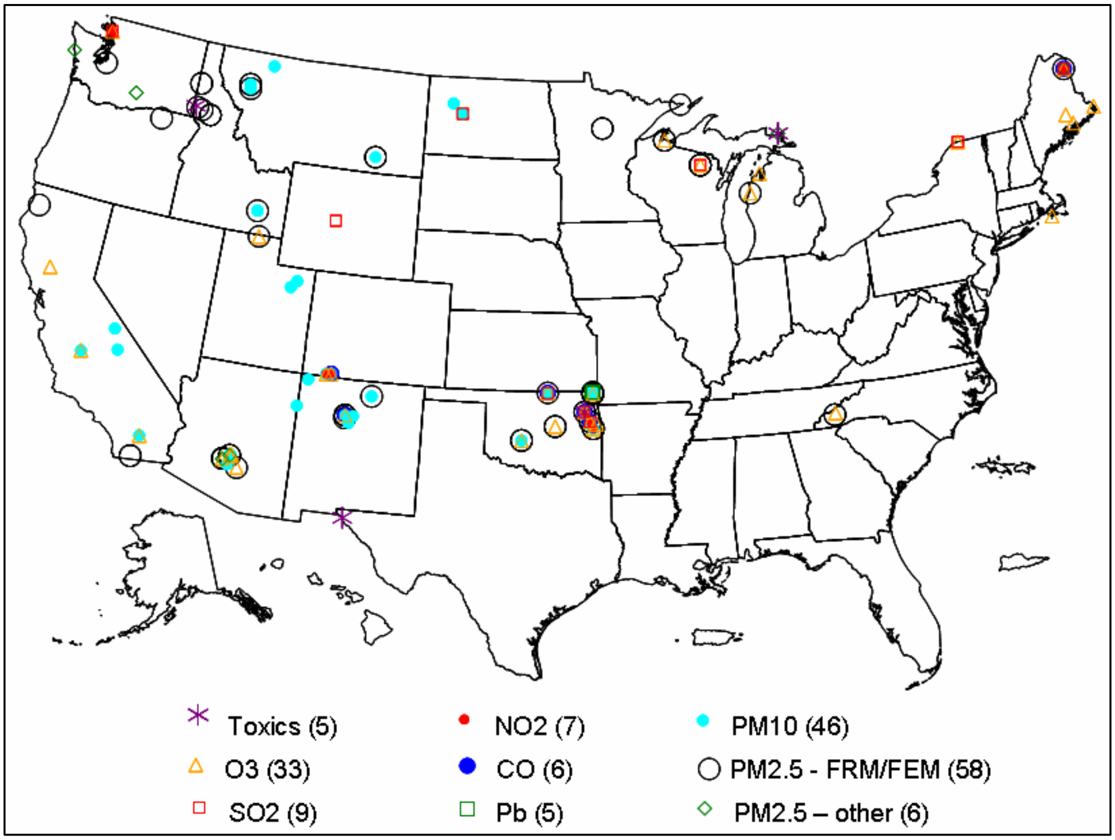

Figure1.1 Tribal Monitors – Toxic and criteria pollutant sites active in the Air Quality System (AQS)

What is EPA's National Ambient Air Monitoring Strategy (NAAMS), What is NCore, and Are There Opportunities for the Tribes?

Federal agencies, state, tribal and local air agencies operate and maintain a wide variety of ambient monitoring systems across the U.S. Many of these systems now serve multiple environmental objectives, even though they may have been sited originally for a more limited purpose. Over time, regardless of whether the original objective remains or diminishes in importance, air quality management developments may warrant rethinking how best to use the monitoring system for other environmental and air program objectives. Of importance is to recognize all of the different types of monitoring and the various environmental and other program purposes they serve, and then identify ways in which integration of these monitoring systems may aid in fulfilling those objectives, perhaps with increased efficiency. For example, national ambient air monitoring networks support the evaluation of trends in national air improvement; state, tribal and local air monitoring systems support local goals, and special purpose monitoring support individual studies.

Collectively, EPA refers to all of these various monitoring efforts as the National Ambient Air Monitoring Strategy (NAAMS). The Strategy is designed to outline EPA's current efforts and future plans to maintain and enhance the NAAMS to meet the nation's air quality goals and challenges. In addition, technology advances over time. This includes both the capabilities of the monitoring hardware and the ability to record, store, disseminate and analyze the monitoring data. A second key element of this Strategy is to ensure that the monitoring programs are flexible enough to provide incentives for improved monitoring and improved use of the monitoring data.

Finally, EPA has developed a systematic data quality approach over the past several years; the quality system requirements for most ambient monitoring pre-dates that development. As such, there is a strong need to ensure that quality assurance programs are appropriate for the type of monitoring. The NAAMS looks at each of these areas discussed above and provides EPA's overall approach for achieving these objectives through an integrated NAAMS. The NAAMS can be found at: http://www.epa.gov/ttn/amtic/monstratdoc.html. The NAAMS identifies and integrates tribal monitoring as part of the environmental/program objectives.

The NAAMS emphasizes multi-pollutant sites, continuous monitoring methods, and important pollutants previously not included in State and Local Air Monitoring Stations (SLAMS), such as ammonia and reactive nitrogen compounds (NO_y). When completed, this modified network will meet a number of important needs: improved data flow and timely reporting to the public; NAAQS compliance determinations; support for development of emissions strategies; improved accountability for control programs; and support for scientific and health-based studies.

Structurally, the central component of this Strategy will be the NCore multi-pollutant monitoring sites. Monitors at NCore multi-pollutant sites will measure particles ($PM_{2.5}$, speciated $PM_{2.5}$, $PM_{10-2.5}$), O_3, SO_2, CO, nitrogen oxides ($NO/NO_2/NO_y$), and basic meteorology. Monitors for all the gases except for O_3 would be more sensitive than standard Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitors, so they could accurately report concentrations that are well below the respective NAAQS but that can be important in the formation of O_3 and PM. The objective is to locate sites in broadly representative urban (about 55 sites) and rural (about 20 sites) locations throughout the country to help characterize regional and urban patterns of air pollution. By combining these monitoring programs at a single location, EPA and its partners can maximize the multi-pollutant information available. This greatly enhances the foundation for future health studies and NAAQS revisions.

The NAAMS highlights the fact that the NCore strategy could benefit from including tribes because the tribes can provide additional monitoring sites, fill data gaps, and measure background conditions.

What is the EPA Regions' Role in Managing Air Quality Monitoring Activities?

Because of the diversity in goals from tribe to tribe, EPA has taken the approach of delegating to the EPA Regional Office level the tasks of assisting tribes in identifying their goals and the task of managing the available resources to help meet those goals. Because EPA Regions understand individual tribal situations, effective decisions about funding and in-kind assistance are best made at the Regional Office level. Regional Offices have taken the initiative to help tribes set air quality goals and design ambient monitoring to support these goals. Regions have prioritized requests from tribes when they collectively exceed the tribal air management grant funds available to the Regional Office. Regional Offices also negotiate, award and manage grants to individual tribes. They provide in-person, telephone, and written guidance and assistance to the tribal governments at all these stages. To date, Regional Offices and individual tribes have entered into grants that have dedicated a portion of the available tribal air management resources to plan, establish and operate a diverse range of ambient air monitoring stations in Indian country.

On the technical side, the Regional Office provides a wealth of experience in ambient air quality monitoring. They are in constant communication with the Headquarters Office and the Office of Research and Development (ORD) and keep current on advancements in monitoring technologies and information management. Many have capabilities in helping to solve technical problems, provide audits of equipment and can assist in transferring data to national data bases.

In the course of this highly decentralized process, Headquarters and Regional Offices have prepared a limited body of technical guidance on tribal air monitoring to determine whether to monitor, what type of monitoring to do, and how EPA will prioritize requests for funding assistance. This guidance is rather general in nature, reflecting the need to accommodate the diversity of tribal situations.[1] In addition to this limited body of strategic guidance, tribes have access to the large body of EPA guidance on monitoring technologies, quality assurance, and data management. While originally prepared for use by state and local government agencies, this technical guidance is equally applicable to monitors in tribal settings.

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[1] The available strategic guidance (excluding technical guidance on monitor operations and maintenance) includes the following documents, and perhaps others at the individual Regional Office level:

1. 4-page section titled "Tribal Air Quality Management" in the *Final National Program and Grant Guidance for Fiscal Years 2006-2008*, April 27, 2005.
2. Memo from Jeffrey R. Holmstead, "Criteria for Providing Funds to Tribes from the State and Tribal Grant Assistance Appropriation for 103 and 105 Grants," January 27, 2005.
3. **"**MENU ITEM***:*** Air Quality Monitoring Activities**,"** in *The Tribal Air Grant Framework - A Menu of Options For Developing Tribal Air Grant Work Plans and Managing Grants for Environmental Results*, September 2004. http://yosemite.epa.gov/R10/AIRPAGE.NSF/283d45bd5bb068e68825650f0064cdc2/e34950b285534aa988256dfe0063be55/$FILE/The%20TRIBAL%20AIR%20GRANTS%20FRAMEWORK%20final.pdf
4. Guidance for Conducting: TRIBAL AIR QUALITY ASSESSMENTS, U.S. EPA Region 10, April 15 2005.

Resources Available for Monitoring

For the last several years, Congress has appropriated about $11 million for tribal air quality activities, which include air monitoring. This funding has not changed significantly over the past 12 years, yet the number of grant applications from individual tribes has increased. This has caused the funding to become competitive and many EPA Regional Offices report that they are not able to meet all requests to provide grant funds for tribal air monitoring. In addition, the tribes have opportunities to receive funds for monitoring from other sources. A good example of this is the community scale air toxics monitoring grants [2].

In addition to the competition for limited resources, recent Office of Management and Budget (OMB) regulations have required that federal agencies be more accountable for the programs they administer. The OMB, on a regular basis, assesses EPA's Air Program to determine how well it is managed in terms of having appropriate and well defined goals, applying resources towards those goals, providing guidance to partners who help meet the goals, having systems in place to observe how well the goals are met, and making adjustments in the program when necessary to reach those goals. In addition to meeting OMB expectations, this "goals and feedback" model ensures that limited resources are used in ways that best meet the right goals. Programs that are found by OMB to have serious weaknesses in management are asked to make corrections and face the possibility of funding reductions in future year budget proposals to Congress.

The most recent review of the NAAQS air quality program by OMB has made EPA managers and staff more conscious about the importance of being able to document that the tribal assistance portion of the Air Program meets OMB measures and goals, guides participants to meet those goals, tracks progress, and makes adjustments when needed. Part of the documentation process will include ensuring that tribal monitoring programs meet EPA requirements for appropriate documentation, have monitoring objectives that one can determine measurable progress towards improved air quality, and that data are submitted to appropriate databases that can help to quantify this progress. This technical guidance document has been developed to help those tribes interested in ambient air monitoring make the best steps forward in the development of their air monitoring programs.

Purpose of the Technical Guidance Document

This intent of this document is to help tribes gain a better idea of the ambient air monitoring process and provide information on resources and tools that help to build and sustain an environmental monitoring program. In order to help tribes plan, implement and assess their program activities this document includes:

- steps for identifying goals and objectives for conducting air monitoring,
- information for planning and selecting the appropriate type of monitoring network including discussions of staffing, network design, monitor selection, quality system development and training,
- costs for operating a monitoring network, funding sources and tips and resources for

[2] http://www.epa.gov/air/grants_funding.html#0516

writing a grant proposal and work plan,
- implementation of monitoring networks,
- data acquisition, management and reporting, and
- data analysis and interpretation including information on modeling techniques.

The intended audience for this document is the tribal environmental professional. The document has been assembled by a team represented by Tribes involved in monitoring, personnel from the Institute of Tribal Environmental Professionals (ITEP) and EPA Regional Office and Headquarters staff who are involved in resource allocations, tribal air grant award and management, program evaluation, strategic planning of monitoring networks, and technical support to monitoring programs. State monitoring officials may also benefit from reading this document, as it may improve their understanding of tribal goals and how EPA strives to help tribes meet their goals.

The technical guidance document attempts to provide a generic level of information on planning and implementing an air monitoring program and then describes the assessment of the monitoring data. Therefore, the sections have been developed in an order that one would plan and implement a monitoring program.

The document tries to provide information on all the major national monitoring programs although many examples are related to the criteria pollutant network. The first Appendix in the document provides factsheets on the major national monitoring programs like the Criteria Pollutant Network, NCORE, PAMS, National Air Toxics Trends Network, Chemical Speciation Network, IMPROVE, CASTNET, and the National Atmospheric Deposition Network which includes the National Trends Network, the Atmospheric Research Monitoring network and the Mercury Deposition Network. Each fact sheet contains internet links to subjects like:

Overall program objectives	Pollutants measured
References to the methods	Siting Criteria
Quality Assurance	Data Management

The document is not meant to replace any of this information so it does not try to provide all the details. It identifies and describes the important areas to think about during the development and implementation of air monitoring programs but then provides the important links to find the specific information a Tribe might need.

The document is written in a manner that tells the reader what to consider. It's not intended to dictate what must be done, so throughout the document the reader will find discussions of options for consideration. For example, there is a discussion of the pros and cons of automated versus manual instruments and what might be best for certain situations.

The document might be considered a "yellow pages" of information on ambient air monitoring. It is not intended to provide the details of each specific monitoring program but it can provide the key attributes and web addresses/links that would lead one to those important details.

Section 2

Developing the Monitoring Objectives

Before a tribe decides to monitor and go through the process of developing a network, or propose a monitoring project using federal funds, they should be able to describe why the monitoring is needed. In some cases, monitoring may be needed for the same objectives of some of the major EPA ambient air monitoring networks such as the State and Local Air Monitoring Stations (SLAMS) or Interagency Monitoring of Protected Visual Environments (IMPROVE). These networks have specific monitoring objectives and also have extensive technical documentation on how the networks are developed, implemented, quality assured and reported to specific data bases. Appendix A provides information on many of the important national monitoring programs and links to where additional monitoring implementation details can be found. The tribes may be asked to participate in these networks to fill data gaps or they may decide there is a need for a particular site. In addition, Section 1 described some other reasons why a tribe might need to develop an air monitoring program.

Four important questions should be considered by the tribe before monitoring begins:

1) Why are we monitoring?
2) What are we monitoring?
3) Who in the tribal organization will watch the results as they come in and how?
4) What will our response or plan be if our monitoring data indicates unhealthy conditions?

Tribes will have a good idea whether there is a health or an environmental problem that needs to be solved, but it's not always explained in a way that helps all those involved in addressing the problem make the best decisions. It is important that resources spent on monitoring (funds and people) are used wisely and that the data collected help the tribes make the right decisions. Therefore, making sure everyone involved in the monitoring activity knows what the problem is, what decisions will be made, and with how much certainty the decision can be made, will be important first steps in the development of an appropriate monitoring network.

The following steps can help ensure the monitoring program will be developed in a way that allows for the proper communication of environmental problems and will assist in securing the resources necessary to develop the monitoring network. These steps do not have to be formal and they don't have to be followed in the order they are listed, but they do help in the development of a monitoring program geared to meet specific objectives.

Step 1: Get the Right People Together

This first step is to get the key people together that need to develop the monitoring program. These key people can be identified as decision makers and technical personnel:

Decision makers- The term represents the individuals who are the ultimate data users. The decision makers, in many cases, are the individuals who must provide answers and make the "decisions" to take further actions based on "what the data says". The decision makers are usually the people that know what the problem(s) is/are, know what timeframe they need answers, and are usually the ones that make decisions on how to spend the money.

Technical personnel – This term represents people with expertise in various fields like network development, monitoring methods, quality assurance, information technology and statistics. These people implement the monitoring program and provide the decision makers with valuable information, **during the planning stages**, on what is possible. This group needs to understand from the decision maker(s) exactly what needs to be collected and why it needs to be collected in order to tailor the monitoring network to answer the decision maker's question within the budget provided.

These two groups need to work together and should be communicating frequently to ensure that few misunderstandings arise.

Step 2: Determine Reasonable Budget Constraints

The ambient air monitoring a tribe will be able to perform will depend on the resources available both in manpower and funds. Although a tribe may be at the early stages in planning the project, management may have already provided the program with a budget that will help set the bounds for what is possible. If not, some reasonable estimate should be made so that as one proceeds through the following steps, a monitoring project is not developed that can not be afforded. Over many years of monitoring, EPA has developed reasonable national estimates of the costs for ambient air monitoring for the SLAMS. Attachment B provides a listing of these costs for the 6 criteria pollutants.

The technical staff necessary to implement the program is an important budget consideration, especially if the personnel are not currently on staff. Staffing issues are discussed in Section 3.

Step 3: Determine What Is/Are the Problem(s) and the Pollutants of Interest

Data can be used to address more than one question (or objective), but many times it is important to prioritize these questions since the development of the monitoring network and the technology used might be better served for one particular monitoring objective than another. For example, monitoring for a hotspot (emission source affecting a community) versus monitoring to establish a good average background concentration level may require a different monitoring network and potentially different equipment (more sensitive monitors may be needed for background). In addition, there is a possibility that only one site might be necessary for hotspot monitoring, whereas a few sites might be required for the average background concentrations. By identifying the problem in as much detail as possible, the right monitoring solution can be developed. In the example above, the two problems might be written as:

1. *Tribal community X is suffering from increased pollutant concentration Y and we think it's because of the emissions of pollutant Z from industrial sources ABC.*

Or

2. *We think that the pollutant X coming from outside our community is significantly influencing our ambient air concentrations in community Y but we have no information on our background concentration levels to prove this.*

These problems are simplified, but very often decision makers and technical staff have different opinions on what the problem(s) is/are. Different problems could lead to different monitoring solutions and one solution is not necessarily the best solution for the most important problem. Only when the problem is defined in writing can people realize they have different definitions of the problem and by working together, come to clear agreement on the true (or agreed upon) and most important problem. This step helps put both the decision makers and the technical personnel on the same page.

Determine the Pollutant(s) of Interest

As a part of the step described above, the tribe will have identified a pollutant or pollutants of interest. A tribe can identify which pollutants are of the greatest concern through existing methods and tools such as:

- EPA Air Quality System (AQS): A national database that tracks air monitoring data from state, local, tribal, and other entities
- Air Quality Index (AQI) and AIRNow
- Toxic Release Inventory (TRI), National Emissions Inventory (NEI)
- Other tribes and tribal consortiums who have their own monitoring programs
- Data from existing programs such as IMPROVE, Clean Air Status and Trends Network (CASTNET), National Atmospheric Deposition Program (NADP), etc.
- State and tribal emission inventories (many tribes do their own inventory prior to deciding on the need for monitoring)
- Private industry monitoring data
- Climatology data
- Observations from other environmental programs within the same tribal agency (i.e. water quality, forestry, wildlife management)
- Federal Land Managers
- Regional Planning Organizations - Central Regional Air Planning Association (CENRAP), Western Regional Air Partnership (WRAP), Visibility Improvement State

and Tribal Association of the Southeast (VISTAS), Mid-Atlantic/Northeast Visibility Union (MANE-VU), Midwest RPO, etc.)

If monitoring is conducted to obtain information on specific sources, the monitoring should also focus on the category of source. The category of source will help determine what method of monitoring should be used and if it is worth pursuing. Categories can be broken down as follows:

- Stationary or Point (see SCC codes for full list http://www.epa.gov/ttn/chief/codes/index.html http://www.epa.gov/ttn/chief/codes/index.html#scc)
    - Factories
    - Power Plants
    - Chemical Process Industries
    - Petroleum Refineries
- Minor Area (please see AP-42, Chapter 13 http://www.epa.gov/ttnchie1/ap42/)
    - Dry Cleaners
    - Road Dust
    - Gas Stations, Auto Body Shops
    - Wood burning Stoves, Burn Barrels
    - Crop Burning/Prescribed Burning
- Mobile (please see AP-42, for full listing)
    - On-Road
        - Trucks (Semi tractors/trailers)
        - Buses
        - Cars
    - Off-Road
        - Farm vehicles
        - Construction Equipment
        - Trains
        - Recreational Vehicles (Boats, ATV's, Snowmobiles, etc.)

Tribes can assess the risks that different pollutants pose by studying unit risks and reference concentrations. This information is available on EPA's National Center for Environmental Assessment (NCEA), Integrated Risk Information System (IRIS) website: http://cfpub.epa.gov/ncea/ . The EPA has its own assessment group called the Risk Assessment Forum which was "established to promote Agency-wide consensus on difficult and controversial risk assessment issues and to ensure that this consensus is incorporated into appropriate Agency risk assessment guidance". The Risk Assessment Forum information can be found at the following website: http://cfpub.epa.gov/ncea/raf/index.cfm . Tribes should be aware that the scientific understanding of these pollutants may change over time as more data becomes available. Also, different organizations and experts can have different assessments of these substances.

Step 4: Turn the Problem into a Question

Once the problems are decided upon, they can be made into a question. If a tribe just focused on problem number 1 above (hotspot) the questions might be:

a. *What is the effect of pollutant Z from industrial source ABC on the ambient air concentration in tribal community X ?*

Or

b. *What is the fence-line ambient air emissions from pollutant Z from industrial source ABC?*

So even with problem 1, the question might be asked in a number of ways (such as a or b). The way the final question is phrased would then lead to additional questions. Let's say that question (a) is what the tribe wants to answer. Some additional questions might be:

- Do we need to know what the background concentrations would be without industrial source ABC? We might need background estimates.
- What constitutes tribal community X? This would determine the geographical boundary of the study and describes the area the monitoring data is trying to represent.
- Are we going to try and correlate pollution concentrations to a particular health problem(s) (maybe an incremental increase in hospital admissions or some other measurement of a health condition)?
- How much data is needed in order to say with confidence that industrial source ABC is a problem? Should we make sure source ABC agrees that this would be proof so we don't get into arguments later on?
- Is there a threshold value (action limit like the NAAQS) where a decision will be made to take some kind of action? If some type of action limit is developed then that is where we want to be sure our data is correct. For example a statement could be made like:

  " If we find that industrial source ABC contributes 50% of the pollutant Z concentration on community X and the ambient air concentration reaches 90% of the NAAQS (or the threshold value) we will require industrial source ABC to shut down until the air gets cleaner.

.

- Beside the pollutant measurements, what other measurements are needed (meteorology, hospital admissions, questionnaires, locational information etc.)?
- What are the time periods of interest? Do we care about hourly concentrations, 24 hour concentrations or work week? This would determine the sample frequency. Is it better to have more sites sampling less frequently or fewer sites sampling more frequently?
- What quality of measurements are needed (precision, bias, completeness, detection limit[1])? Is it better to have fewer measurements that are sampled more accurately with a

[1] Definitions for these terms can be found in Section 3 of the QA Handbook Volume II Part 1 http://www.epa.gov/ttn/amtic/qabook.html

more expensive device or more measurements (at maybe more sites) with equipment that is less expensive to operate but may not be as accurate?
- How much money do we have to do this?

These are some of the important questions that need to be asked. What is important to know is whether the initial question can be answered with an acceptable level of certainty with the funds that are available. There are tradeoffs with many of the questions, but the idea is to have the right people around who focus on the ultimate question that needs to be answered so that when the network is developed, it is optimized to provide the best information for the money available. It is also suggested that the answers to the above questions are documented because it will provide the rationale for the final decisions, can be used to develop program documentation (quality assurance project plans) and provides a historical record that can be used by those that may be responsible for future monitoring efforts. Going through this process is beneficial because the information can be used to improve the network if additional resources become available or the problem changes.

A Practical Example of Monitoring Tradeoffs That Affect a Decision

During the development of the $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS), EPA wanted to know how different sampling frequencies, data completeness and different levels of precision and bias would affect a decision maker's ability to make correct decisions. In order to give decision makers a tool that would allow them to play "what-if" scenarios, the EPA developed a software tool that allows certain variables to change, in order to see what effect the change had on the decision makers' ability to make a comparison to the NAAQS. The following provides an example of the $PM_{2.5}$ Data Quality Objective Tool. This tool is available on the AMTIC Website http://www.epa.gov/ttn/amtic/dqotool.html.

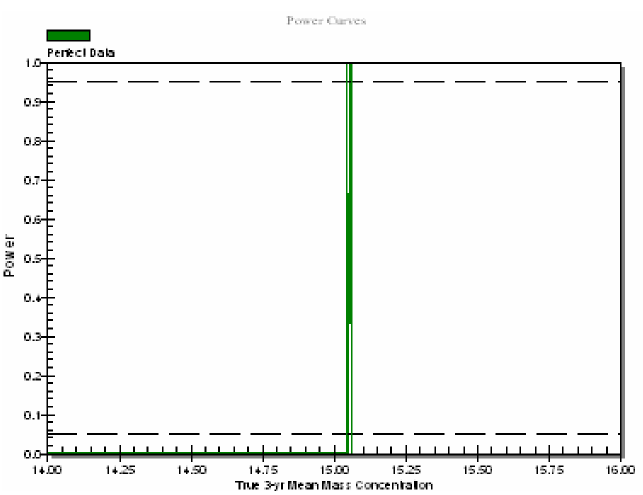

Figure 2.1. Decision curve representing "perfect" data

The software uses historical $PM_{2.5}$ data to generate data values for a "typical" $PM_{2.5}$ site. The action limit is the NAAQS value which is 15.05 ug/m^3. A curve on either side of the action limit represents the probability of making an incorrect attainment decision. The first graph (Fig. 2.1) represents a site that is monitoring every day, has a complete data set (100%) and has no bias or imprecision. Therefore it's considered "perfect" data and the green line represents that any 3-year $PM_{2.5}$ average above 15 would always be declared non-attainment and any 3-year $PM_{2.5}$ average less than 15 would be declared in attainment. In other words, the data are perfect representations of reality and allow the decision makers to always make the correct decision.

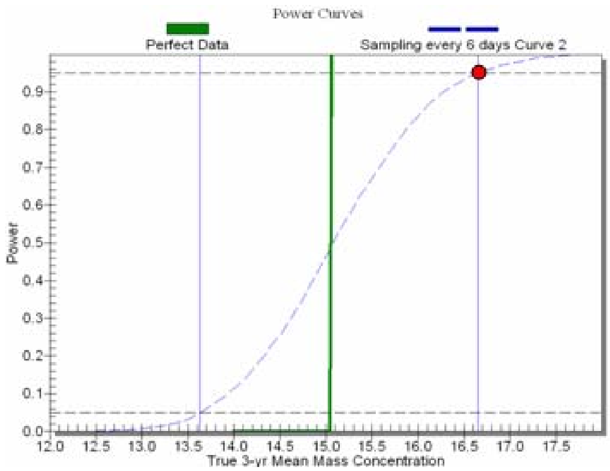

Figure 2.2 Decision curve with 1-in-6 day sampling

Figure 2.2 demonstrates what would happen if instead of sampling every day, the sampler was on a 1-in-6 day schedule (which is acceptable). The dashed blue line represents a true concentration. However, because the tribe is not sampling every day, even though the true 3-year concentration might be greater than 15.05 ug/m^3, a mistake can be made (there is a probability) that the site is declared in attainment (less than 15.05) when it is in truth non-attainment. The red dot represents a true concentration. Following the red dot over to the Y axis, it falls on the 95% probability (power) line. What this says is that 95% of the time one will declare that the 3-year average is greater than 15.05 ug/m^3 (action limit) when the true concentration is greater than or equal to 16.7 ug/m^3 when sampling at a 1-in-6 day interval. However, as one moves down the blue dashed line to a concentration that is closer to the action limit there is greater probability of making a mistake.

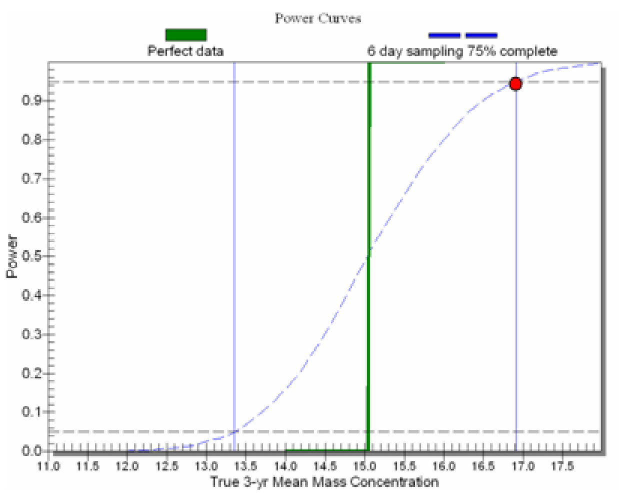

Figure 2.3 Decision curve with 1-in-6 day sampling and 75% complete

The last graph (Fig 2.3) demonstrates what would happen if a monitoring organization sampled on a 1-in-6 day schedule but collected only 75% of the data (which is acceptable). The blue vertical lines gets a little wider meaning that one would be 95% sure that the 3-year average is greater than 15.05 ug/m^3 if the true value was greater than or equal to 16.9 ug/m^3. These graphs do not include any measurement errors like imprecision and bias which would make the blue vertical lines wider. The tool allows this uncertainty to be incorporated into the decision making process.

The example demonstrates that when tribes are developing a monitoring program, there are tradeoffs that need to be discussed in order to produce the best quality information within the budgets available. In the above example, the final decision might be that instead of going to every day sampling, the monitoring agency decides to implement 1-in-3 day sampling and maintain a completeness objective of 85%. The tradeoff is spending less money by not sampling everyday (sacrificing some accuracy), but collecting enough data (increasing completeness) to make the decision maker comfortable that the data collected represents the air quality status.

Step 5: Optimize the Sampling Design and Start Planning the Network

By using the objective setting process, the tribe will have clearly defined monitoring objectives. Within the available resources (funds and technical personnel), it will also know where it needs to monitor, how often it needs to monitor, and the quality of the data it needs to collect. It is very important to document the decisions that have been made through these steps, since this information will be important in the development of sampling plans and quality assurance project plans.

Do You Want More Information About Setting Objectives?

The approach discussed in the material above follows the process described in the EPA guidance document: *Systematic Planning Using the Data Quality Objectives Process* (http://www.epa.gov/quality/qa_docs.html). In addition, there is a case study that has been developed for a PM_{10} monitoring project that provides a good example of the steps involved in this process http://www.epa.gov/quality/qs-docs/casestudy2-final.pdf . The case study demonstrates how the objective setting process can work to bring different concerns, people of various levels and kinds of expertise, and limited resources together to produce data that serves the most important decisions.

Section 3

Program Planning

Once it is decided what type of monitoring is needed, based on the development of the monitoring objectives, the next step is planning the network. This step will involve compromises that can affect whether or not the monitoring objective(s) are met. It is important to keep this in mind as the tribe plans, funds and implements the network. The important aspects of planning the network include the following topics:

- Staffing
- Network Design
- Monitor/Sampler Selection
- Quality System Development
- Information Technology
- Training

These are listed in the order that a tribe might use in planning a monitoring network. As mentioned in Section 2, one does need to have some rough estimate of the funds that either are available or could be available (if seeking federal funds) for the monitoring program. However, as a tribe steps through the aspects of planning, it will find that it is an iterative process where compromises between staffing, network design, monitor selection and QA will be made and all will have an affect on the monitoring program costs. Once all the technical decisions are made, a tribe will have a better idea of what the actual monitoring programs costs will be and this detail will help justify the costs to management and in any grant application.

3.1 Technical Staffing

Depending on whether a monitoring program is new or an addition to activities it routinely performs, the staffing issue may or may not be important. However, there are a number of functions, depending on the type of monitoring, which will require expertise within the tribe or funds available to secure that expertise. Table 3-1 identifies these functions and provides some of the key activities within the functional category. The monitoring organization can use this list as a starting point and add functions and activities as needed. Once the list is completed, it can be used in the development of position descriptions for recruitment and training programs.

Not all functions are needed for the entire duration of the project. Tribes may feel that it can contract some of the functions that are needed. For example, a tribe may wish to contract the information technology (IT) function to have the monitoring instruments connected to a data logging system that would transfer data to a local data base and eventually to an external data base like AQS. This part of the process might be considered a "one-time" event needing a particular expertise whose function might not require a full time person. However, it is critical that someone within the program understands this IT function to ensure data collection is operating properly on a day-to-day basis.

Table 3-1 Monitoring Functions that Need Some Level of Staffing or Expertise

Function	Activities
Procurement	- Purchasing capital equipment and consumables - Developing contracts and maintenance agreements - Applying for EPA grants
Technical	- Setting up a monitoring site, electricity, communications - Developing standard operating procedures - Selecting and installing monitoring equipment - Calibrating equipment, performing quality control - Shelter and equipment maintenance
Data Analysis (Statistical)	- Understanding population and measurement uncertainty - Developing sampling designs - Developing networks to achieve objectives - Assessing/interpreting data (data quality assessments)
Quality Assurance	- Developing quality systems, QMPs/QAPPs - Developing data quality objectives - Implementing technical systems audits, performance evaluations - Validating data - QA reporting
Information Technology	- Selecting information technology (data loggers and local data base) - Developing analyzer outputs to data loggers and data transfer to local data base - Transfering data from local data base to external data repositories (AQS, etc.)

3.2 Network Design

A monitoring site or a network of monitoring sites should be chosen based on the objectives described in Section 2. If monitoring will be implemented to support one or more of the nationally implemented networks, there will most likely be requirements or guidance available on the development of an appropriate network and the sites within the network. Appendix A provides information on the network/site requirements of the most common national air monitoring networks.

Some tribal boundaries are so large that monitors are needed in multiple locations or multiple monitors may be needed to study transport issues. Monitors for different pollutants may be placed at the same site, which can provide a more robust data set for understanding what is happening to air quality and why (one of the objectives of the NCore network[1]). In all cases, whether developing a network for a specific tribal issue or providing data vital to support national monitoring networks, the network should be designed with consideration for the following:

Representativeness – One of the most important attributes of any ambient air monitoring network is representativeness. This term refers to the degree in which data accurately and precisely represent the condition that is being measured in order to meet the objectives of the monitoring program. It does not matter how accurate or precise the data are if a site was placed for the intent to measure background conditions actually reported pollutant concentrations influenced by a source because conclusion drawn from the data has a high probability of being

[1]National Ambient Air Monitoring Strategy (http://www.epa.gov/ttn/amtic/monstratdoc.html)

incorrect. So, the first goal should be finding the most representative site(s) for the monitoring objective.

Monitor/Sampler Requirements and Siting- Some monitoring technology requires that analyzers be kept within a certain operating temperature range. Maintaining this temperature range will most likely require some type of shed or enclosure and require heating and cooling. Selecting monitors/samplers may require tradeoffs between data quality (higher sensitivity instruments that may need more care and maintenance) and those that may be more "hardy" under the conditions (remote site that receives less frequent site visits) that prevail at the site. Section 3.3 provides more detail on the decisions that need to be made to select an appropriate monitor, but it is obvious that the type of monitor selected can affect the network design and the siting requirements. Determine if meteorological measurements will be necessary and whether the closest source of this information is adequate.

Logistics- Because many reservations are located in rural areas, access to the site, as well as electrical or phone service, may be limited. Tribes are encouraged to look at alternative solutions, such as radio or satellite communications systems and generator, wind, or solar-derived power. Also, there will be some frequency at which operators will need to visit sites for maintenance, filter and/or data collections and quality assurance activities. There needs to be some thought given to ensuring that the operator will be able to get to the site **safely** to perform the required monitoring activities and for carrying equipment and gases needed for quality assurance audits. The site should be accessible year-round and should allow for the location of a shed or trailer, if needed. Adequate security (locked fences) is usually required.

Depending on the type of monitor chosen and the local climate, a monitoring shed or trailer that is weather-tight, temperature-controlled, and has adequate space may be needed. If a trailer is not available, shed kits can be purchased locally. There should be a consideration for future monitoring needs when arranging for a shelter so that extra space and adequate power sources are available. Depending on the monitoring objectives, the organization may be able to house the monitors/samplers in existing buildings and run monitor probes and inlets out of these buildings.

NOTE: It may sometimes be necessary to make compromises in the network design which may affect the representativeness of the site(s). Any compromises should be brought to the attention of the decision maker/data user before final network design decisions are made. In addition, the reasons for these compromises should be documented so that if data are found to be non-representative or additional resources are acquired, the monitoring program can justify making the necessary improvements.

3.3 Monitor Selection

Once the pollutant parameter has been identified, the sampling method/monitor can be selected. The final decision depends on many factors such as: cost, detection limit, precision and bias, level of tribal monitoring experience, seasonal conditions, expected program continuity, the need to monitor for one or multiple pollutants, monitor maintenance/service requirements, and conditions at the monitoring site (electricity and communications availability). In addition, some monitoring programs, such as the SLAMS network, require the use of monitors that have been designated and certified as FRM or FEM. Therefore, monitoring for SLAMS purposes restricts the type of monitors/samplers available for selection. Tribes that plan to participate in established national networks should consult with experts in the networks for advice and/or any restrictions on the monitors/samplers that can be used.

Ambient air monitors can be broken down into two general groups, manual and continuous:

- Manual Samplers
  - Produce time-averaged data
  - Use sampling media
    - filters, cartridges, canisters, precipitation samples
  - Samples are analyzed in a separate step in a qualified laboratory
  - Generally do not need a shed or trailer, may need shade

- Continuous Samplers
  - Analyze the air in the field providing a signal which is converted into a concentration
  - Can produce a continuous data stream that can be saved (data logger), aggregated over various time intervals (e.g.,1-minute, 5-minute, 1-hour) and transferred to other data bases
  - Most need to be housed in a shed or trailer

The selection of a particular monitor is very important. For example, many tribes conduct $PM_{2.5}$ monitoring. They will have to make a choice of deploying manual samplers or continuous monitors. The table below presents some decisions that will have to be weighed in selecting the optimal instrumentation.

Manual $PM_{2.5}$ Sampler	**Continuous $PM_{2.5}$ Monitor**
Pros	
Easy to use Do not need a shelter Does not need much information management technology	Produces daily or more frequent (event) results Better chance of complete data for better data certainty
Cons	
May not be able to afford every day sampling Must have filter analysis at a lab (added cost) Filters can get lost/damaged reducing data completeness	More sophisticated to operate and require data logger May not produce results similar to FRM Need a shelter, adding to expense Not FRM/FEM-can't use for comparison to NAAQS Costs almost twice as much as a manual instrument

In Section 2, three figures were used to provide examples of the added uncertainty when going from every day sampling to 1-in-6 day sampling. The use of a continuous vs. a manual instrument represents this case since many organizations can not afford to operate a manual sampler on an every day sampling frequency. However, the extra cost of a continuous sampler and the shelter may be about the same as the operation of 2 manual instruments at a 1-in-6 day sampling frequency which may provide less uncertainty than one continuous monitor operating every day (which may not produce FRM-like data). You can see how the planning activity and the tradeoffs need to be reviewed in order to make the best choice for the monitoring organization.

Tribes are encouraged to collect meteorological data at the monitoring site. Usually, a minimal meteorological station measures wind speed and direction, relative humidity, temperature, barometric pressure, and precipitation, and uses a data logger for gathering and storing data. This involves purchasing and operating additional pieces of equipment.

Each monitor has requirements for siting to ensure that it collects "real" ambient air. These criteria should be investigated for each monitor before a purchase or a site is decided upon. Most importantly, monitors need to be situated a certain distance away from trees or other tall obstructions, such as buildings, and the monitor probe needs to be situated a certain distance above the ground. See Appendix A for references and web addresses to the appropriate siting information for some of the national monitoring programs.

3.4 Quality System Development

During the objective setting process, the acceptable level of data quality for the monitoring program will be defined. Data is virtually useless unless its quality is known. As an example, can the following statement be accepted:

The average height of all men in Idaho is 5 ft. 8 in.:

if the measurements were done correctly but were based on measuring 3 men in Idaho?

Or

if they selected 2,000 men from Idaho at random but had someone estimate the height instead of using a reliable measuring device?

In both cases there is serious doubt about the quality (the amount or accuracy) of the data that was used to make the statement. If it is not known how the information was collected, it might be considered believable because the average height is somewhat close to the national average height for men. However, with more information, the validity of the statement would be questioned. In order to ensure that the statements that are made from the data collected from a monitoring program can be believed, a quality system needs to be developed and implemented.

A quality system is the "blueprint" or framework by which an organization applies sufficient quality control (QC) and quality assurance (QA) practices to ensure that the results of its environmental programs meet or exceed expectations[2]. It is based upon the model of planning the work, doing what was planned, assessing the results against the performance criteria, validating data, and making improvements if necessary.

[2] American National Standard: Quality systems for environmental data and technology programs-Requirements with guidance for use http://www.asq.org/quality-press/index.html

Although this guidance document has not been developed specifically for programs supported with EPA funds, it is believed that all data collection programs need some form of quality system. The system will provide the organization information about the quality of data collected and do it often enough so that measurements systems that are out of control can be corrected without significant data loss.

The EPA, as well as many federal, tribal, state, local and international organizations are developing and using consensus standards to implement vital aspects of environmental programs. These consensus standards help ensure consistency in products and information from various sources and entities. The foundation of the EPA quality assurance policy is derived from the *"American National Standard: Quality Systems for Environmental Data and Technology Programs-Requirements with Guidance for Use*[2]*(ANSI/ASQ E4)."* Tribes not utilizing EPA funds for the collection of environmental data may want to follow the suggested requirements in this document.

Quality System Requirements for EPA Funded Programs

EPA QA Policy 5360.1[3] requires that all organizations funded by EPA for environmental data collection develop quality management plans (QMPs) and quality assurance project plans (QAPPs) before collecting data.

- **QMP** - describes the quality system in terms of the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces for those planning, implementing, and assessing activities involving environmental data collection. The QMP is not specific to any particular project, but related to how the monitoring organization implements its quality system. It is possible to use General Assistance Program (GAP) grants to fund the development of QMPs (see section 4).

- **QAPP**- is a formal document describing, 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). The QAPP is specific to a particular monitoring project. Standard operating procedures (SOPs) are part of the QAPP development process and are vital to the quality of any monitoring program.

Guidance for the development of both these documents can be found on the EPA Quality Staff's website[3]. In addition, EPA has provided flexibility to EPA organizations on how they implement this policy, allowing for use of a graded approach. Since EPA funds the collection and use of data for a number of monitoring objectives and for organizations with a broad range of capabilities, flexibility in the QMP and QAPP requirements is necessary. For example, data collection for the purpose of comparison to the National Ambient Air Quality Standards (NAAQS) will require more stringent requirements, while monitoring programs for special purposes may not require the same level of quality assurance. The level of detail of QMP and QAPPs, as explained by the EPA Quality Staff in the EPA Quality Manual, "should be based on

[3] (http://www.epa.gov/quality1/)

a common sense, graded approach that establishes the QA and QC requirements commensurate with the importance of the work, available resources, and the unique needs of the organization." The ambient air program has developed a graded approach that will help the tribes develop both QMP and QAPPs. Appendix C provides information on this approach. If a tribe is using EPA funds for their project, they should consult with their EPA Regional Office on how to use the graded approach.

Quality Assurance Manager

One major component of the quality system is the quality assurance manager (QAM). The following description is derived from EPA Order 5360.1

> *A quality assurance manager (QAM), or person assigned to an equivalent position, who functions independently of direct environmental generation, model development, or technology development responsibility; who reports on quality issues to the senior manager having executive leadership authority for the organization; and who has sufficient technical and management expertise and authority to conduct independent oversight of and assure the implementation of the organization's quality system in the environmental programs of the organization.*

Any organization accepting EPA funds for environmental data operations (which includes air monitoring) is required to have a position that covers the functions listed above. It is realized that many tribes, due to the size of its monitoring organization, will have difficulty meeting this requirement. However, the QMP and QAPPs must address how the tribes will ensure that some level of independent oversight of its quality system is performed. This requirement can be covered by:

- establishing a QA management function within the monitoring organization
- different divisions/branches (air and water) within the monitoring organization providing this function
- different tribes providing this function for each other
- tribes combining funds to hire an organization to provide an independent QA function
- working with tribal consortia or organizations to provide this function

It is very important for tribes to work with the organization that will be approving the QMP and QAPP(s) to ensure that the QA management function is adequately addressed.

Quality Assurance Project Plans and Standard Operating Procedures

For most of the major national monitoring programs, QA requirements and/or guidance have been developed that must (if a regulatory requirement), or are strongly suggested, be followed. Many programs such as the $PM_{2.5}$ Chemical Speciation Network and the National Toxics Trends Network have developed program QAPPs that can be referenced and/or adopted by the monitoring organization by providing written confirmation to the EPA Regions.

QAPP/SOP development can be a lengthy process, depending on the complexity of the monitoring and the monitoring objective. Once a tribe has finished writing the QAPP, it is submitted to the Regional Office for approval. QAPPs should be written and approved before any "official" data is collected. The QAPP provides the funding organization some assurance that the monitoring organization has performed adequate planning to control and assess the quality of its data before funds are spent on data of questionable quality. In many cases, EPA provides funding for the tribal monitoring organization to purchase the necessary equipment and consumables to start a monitoring project, as well as time, to become familiar with the instruments in order to develop an adequate QAPP. However, once this initial funding is provided, the QAPP should be written before any funding for routine monitoring is spent. There are a number of ways QAPPs can be developed:

- Start from scratch and use the EPA guidance documents and technical assistance documents for developing a project specific QAPP. This may be necessary for very specific projects.
- Utilize various model or generic QAPPs that have been developed for some of the ambient air monitoring programs. An example of these include:
    - PM2.5 Model QAPP[4]
    - National Toxics Trends Site (NATTS) Model QAPP[5]
- Utilize generic QAPPs that are approved for implementing networks such as the $PM_{2.5}$ Chemical Speciation Network and the IMPROVE Networks.
- Utilize QAPPs developed from other monitoring organizations but modify it to the appropriate specific language for the monitoring activity.
- Utilize Turbo-QAPP software for the development of criteria pollutant QAPPs.

The EPA has worked with the Institute of Tribal Environmental Professionals (ITEP) to develop a generic ambient air monitoring QAPP software product called Turbo-QAPP. Turbo-QAPP mimics the functions of software like Turbo-Tax to lead tribal monitoring personnel through the development of their project specific ambient air monitoring QAPPs. Turbo-QAPP should help tribes by providing most of ambient air monitoring guidance for the criteria pollutants within a click of a mouse. The first working version will be available, free to the tribes, in 2007. For information on Turbo-QAPP, contact ITEP (http://www4.nau.edu/itep/).

Quality Control

Quality Control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer. The process establishes techniques to both prevent the generation of unacceptable data and take appropriate corrective action when data is determined to be unacceptable.

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[4] PM2.5 Model QA Project Plan (QAPP) http://www.epa.gov/ttn/amtic/pmqainf.html

[5] Quality Assurance Guidance Document -- Model Quality Assurance Project Plan for the National Air Toxics Trends Stations http://www.epa.gov/ttn/amtic/airtoxqa.html

There is a wide variety of techniques that fall under the category of QC. Figure 3.1 lists a number of these activities. However, it is the responsibility of the tribal monitoring organization, through the development of their QAPP and quality system to develop and document the:

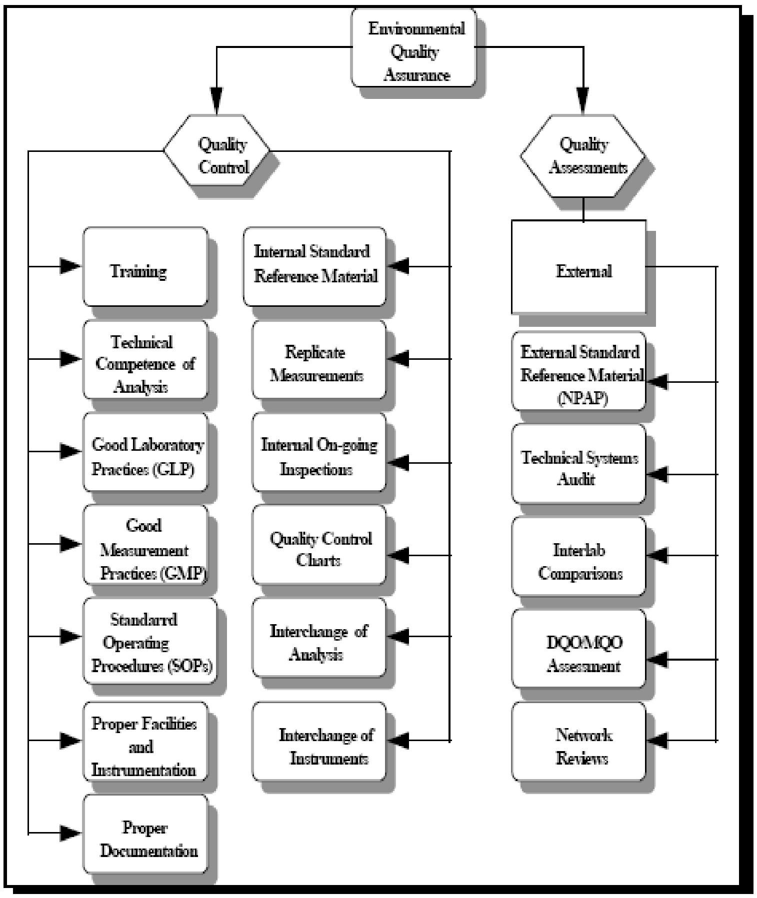


Figure 3.1 Types of quality control activities

- QC techniques
- frequency of the check and the point in the measurement process in which the check is introduced
- traceability of standards
- matrix of the check sample
- level of concentration of analyte of interest
- actions to be taken in the event that a QC check identifies a failed or changed measurement system
- formulae for estimating data quality indicators
- procedures for documenting QC results, including control charts
- description of how the data will be used to determine that measurement performance is acceptable

Many of the national monitoring programs implement many of the techniques discussed in Figure 3.1. Appendix A provides the references to the quality system material where these QC checks are discussed. Some programs, such as the ambient air monitoring program, develop measurement quality objectives tables for the criteria pollutants, which provide listings of the major quality control samples and the acceptance criteria.

3.5 Information Management

Information management covers many aspects of a monitoring program. It should not refer simply to the data that is produced by a monitor that gets uploaded to a data logger. It also needs to encompass the entire measurement system which includes:

- Personnel – training/certification records, who visited the site, performed checks, removed and shipped filters etc
- Logbooks- shelter logs, instrument logs, filter logs
- Control charts
- QMP/QAPPS/SOPs and date of approvals or changes
- Field data sheets and chain of custody forms
- Calibration and standards certifications, repair and maintenance records
- Important memos that reflect decisions made to the monitoring program
- Data certification letters
- Data collection

Part of information management involves site and instrument logbooks where information and results are recorded manually. A site logbook should be kept to detail maintenance activities, problems at the site and how these problems were corrected. For example, power outages and equipment failures need to be noted. In addition to a site logbook, a separate logbook should be kept for each individual monitor to record the results of calibrations and other procedures. Logbooks serve as the "institutional memory" of a site or monitor and can help staff members remember when a specific problem occurred and how it was addressed. Newer technologies that provide for the capture of data electronically are acceptable, as long as the information is easily accessible for review and it provides the same capabilities as the logbook. In addition, if this information is stored electronically, a second copy of these records should be stored in a safe place.

Tribes need to appropriately handle the information they produce because any of the information discussed above can affect the ultimate validity of the data. As a tribe starts planning the monitoring network, it should create a list of the vital information that will pertain to the program and develop a filing system to ensure this information is identified and stored appropriately. ITEP has an online data management course that covers, in detail, how to set up a data management system that can be taken at a student's own pace.

Data Collection Technology

Continuous monitors collect large volumes of data that need to be recorded as it is generated. Data from all types of monitors needs to be stored until it can be reviewed and quality assured. Once the data is quality assured, it needs to be corrected, flagged as necessary, and placed in a repository where other interested parties can view it. Section 6 is devoted to data acquisition and management.

3.6 Training

Adequate education and training are integral to any monitoring program that strives for reliable and comparable data. Training is aimed at increasing the effectiveness of employees and their organization. When thinking about what training an organization might need, Table 3-1 can be used as a guide and can be used to determine whether the person performing the function is trained in the activities assigned to that function. If not, then a training program can be worked out with an employee to get the necessary skills to be successful in that function. In order to keep track of the capabilities of the technical staff, some information that can be recorded in personnel files include:

- personnel qualifications- general and position specific
- training requirements - by position
- frequency of training

Cross-training should also be considered so that more than one individual can adequately perform some of the more important functions. Due to high rates of turnover in many monitoring programs, the development of detailed standard operating procedures (SOPs) is critical for ensuring a smooth transition from one person to the next. The importance of good SOPs can not be overemphasized.

Training Courses

Over the years, a number of courses have been developed for personnel involved with ambient air monitoring and quality assurance aspects. Such training may consist of classroom lectures, workshops, teleconferences, and on-the-job training. Formal and informal training is offered through the following organizations:

Institute for Tribal Environmental Professionals (ITEP) http://www4.nau.edu/itep/ - assists Indian Tribes in the management of their environmental resources through effective training and education programs. More information about the ITEP courses is discussed below.

EPA Air Pollution Training Institute (APTI) http://www.epa.gov/apti/ - provides technical air pollution training to state, tribal, and local air pollution professionals, although others may benefit from this training. The curriculum is available in classroom, telecourse, self-instruction, and web-based formats.

Air & Waste Management Association (AWMA)
http://www.awma.org/enviro_edu/index.html A&WMA- offers a variety of products and services to help meet the professional development and educational needs of environmental professionals, university students, grades K-12 students and teachers, and the general public.

American Society for Quality Control (ASQC) http://www.asq.org/training-and-certification.html - serves as an advocate for quality. It is a knowledge-based global community of quality control experts, with nearly 100,000 members dedicated to the promotion and advancement of quality tools, principles, and practices in their workplaces and in their communities.

EPA Quality Staff http://www.epa.gov/quality/train.html - develops generic training on quality-related issues and also organizes a national conference that includes training. Attendance to conferences and training is free.

EPA Regional Offices http://www.epa.gov/epahome/locate2.htm - provides a wealth of technical experience and often holds meetings, conferences and training activities. Most Tribes are in contact with one or more Regional Offices.

Regional Planning Organizations (RPOs)
http://www.epa.gov/air/visibility/regional.html#thefive#thefive **-** addresses visibility impairment from a regional perspective. Today, EPA provides funding to five RPOs to address regional haze and related issues. The RPOs hold various conference and training activities of interest to the tribes.

National Monitoring Programs - Many of the websites representing the national monitoring programs (see Appendix A) advertise training and should be reviewed at some regular frequency to take advantage of these opportunities.

Instrument Manufacturers – Some manufacturers offer regular training courses at their facilities or offer services to set up the monitor and train staff for a daily fee plus travel costs. As part of the purchase/review process, tribes should ask the manufacturers whether training is offered.

In addition, the EPA provides a tribal website that describes upcoming training and provides links to other training opportunities that might be of interest to tribes. http://www.epa.gov/air/tribal/training.html

ITEP Courses

ITEP and the Tribal Air Monitoring Support (TAMS) center offer courses including: air toxics monitoring, meteorological monitoring, writing a QAPP, dataloggers, air quality computations, data management, PM monitoring, ozone monitoring, Tribal Emission Inventory Software Solution (TEISS), and EPA's Air Quality System (AQS). ITEP offers data analysis courses where tribes can learn basic statistical techniques used for demonstrating compliance with the NAAQS. Certain data needs to be uploaded to the EPA's AQS or AIRNOW databases if funded with EPA grants. Tribes should consider which of these courses they want to attend and plan for travel costs.

ITEP courses are available for some types of monitors, but not all. Neighboring tribes, tribal consortiums, or state or local agencies, where appropriate, may also offer assistance. If a tribe is a member of an RPO, arrangements might be made for some training. Federal agencies such as the U.S. Forest Service and National Park Service sometimes operate monitors and may offer assistance.

Section 4

Funding

Tribes should seek monitoring funds once the pollutants of concern have been identified, the size of the monitoring network has been determined, the site(s) selected, and the specific monitor(s) chosen. It is likely that the source of these funds may be a federal grant. The following sections provide information on the major sources of ambient air monitoring grant funding available to the tribes, explain the process of seeking those funds through the development of a grant proposal and workplan, and provide some specific information on the costs of some of the ambient air monitoring activities.

4.1 Clean Air Act (CAA) Grants

The EPA Office of Air and Radiation (OAR) is committed to working with the tribes to develop and implement Clean Air Act (CAA) programs in Indian country and build capacity to address air quality issues. One of OAR's primary tools in this effort is to award CAA grants to the tribes.

The EPA offers ambient air funding under Sections 103 and 105 of the Clean Air Act. Section 103 grants are for air program planning and short-term projects, while Section 105 grants are for operating ongoing air programs and for long-term projects. Section 103 grants have the advantage of not requiring the tribe to match any of the federal funds, while Section 105 grants require a tribal match of between 5% and 40% of the total amount of the grant. Further information on tribal match requirements can be found in 40CFR § 35.575 or 40CFR § 49.4{q} http://www.gpoaccess.gov/cfr/index.html. A tribe may want to begin with a 103 grant and apply for 105 funding after the air program has been established.

4.2 General Assistance Program (GAP) Grants

Tribal requests for EPA assistance may involve more than one media program. In those instances, the statutes require the tribes to separately account for each programs' funds. This is a barrier for most tribes because it inhibits integrated environmental approaches, and tribes sometimes lack the basic infrastructure to comply with the accountability requirements of these diverse statutes and regulations.

In response to the Agency's request for more flexibility in assisting the tribes to build their overall environmental management capacity, Congress first authorized EPA to create the Multi-Media Assistance Program and subsequently enacted the "Indian Environmental General Assistance Program Act of 1992". This program provides general assistance grants to Indian tribal governments and intertribal consortia to build capacity to administer environmental regulatory programs on Indian lands; and provide technical assistance from EPA to Indian tribal governments and intertribal consortia in the development of multimedia programs to address environmental issues on Indian lands. Information on GAP can be found at the following website http://www.epa.gov/indian/laws3.htm. As mentioned in Section 3, some of the required quality system documentation like QMPs and QAPPs may be funded through the GAP grants, since these documents can cover more than one media.

The EPA OAR maintains a tribal website at: http://www.epa.gov/air/tribal/ . This site is designed to strengthen EPA and tribal air quality programs in Indian country by providing timely and user-friendly access to key information; promoting the exchange of ideas; and making available relevant documents to all environmental professionals who live and work in Indian country. This website provides a link http://www.epa.gov/air/tribal/grants.html to the following grants and funding that may be of interest to the tribes:

- Science to Achieve Results (STAR) Research Grants - EPA's National Center for Environmental Research, STAR Requests for Applications invite research proposals from U.S. academic and non-profit institutions and state and local governments.
- State and Tribal Grant Program (STAG) Funding Opportunities - EPA's Office of Enforcement and Compliance Assurance (OECA) offers grant funds to regulatory partners to strengthen their ability to address environmental and public health threats, while furthering the art and science of environmental compliance.
- Federal Grants - Allow organizations to electronically find and apply for competitive grant opportunities from all federal grant-making agencies.
- OAR Grants - This website includes the local community air toxics grant solicitations and includes Community Air Toxics Monitoring grants and grant information for the Community Action for a Renewed Environment (CARE) Program.
- EPA Environmental Justice Grants – Provides grants focused on environmental justice.
- Tribal Grants – Describes funding opportunities available from EPA's American Indian Environmental Office (AIEO).

4.3 Other Funding Options

As more tribes apply for EPA air grants, competition has become tighter. This means that tribes may have to find alternate funding sources. Creative opportunities can be found for tribes to link their interests to those of other organizations. For instance, the National Oceanic and Atmospheric Administration (NOAA) may award grants to tribes to obtain meteorological data that is of interest both to NOAA and the tribe. A United States Department of Agriculture (USDA) – Concentrated Animal Feeding Operations (CAFO) grant might be obtained to fund ammonia monitoring (of interest in regional haze considerations). Indian Health Services (IHS) may fund monitoring, if it is believed that air emissions are directly causing health problems on a Reservation.

The desire to keep data confidential may also lead tribes to pursue other alternatives. Some tribes pay for their monitoring using tribal funds. Other tribes have obtained monitoring funds through Regional Planning Organizations (RPOs) to collect monitoring data beneficial to both the tribe and the RPO. Some tribes work with state agencies to share monitoring costs and responsibilities and then share the data with the state agency. Some air-related activities can coincide with other federal grants. For example, a meteorological station could gather air quality data that includes data for alternative wind energy feasibility studies under a Federal Energy Resources Commission grant.

4.4 The Grant Workplan- For the Tribe Seeking Federal Funds

Developing a comprehensive workplan is one of the first efforts in seeking grant funds. Grants are competitive, so the EPA Regions select those monitoring programs that appear to be the best candidates to achieve success. The will judge this, in part, by the grant application and workplan. To assist tribes in writing effective grants, OAR developed a document entitled: *Tribal Air Grants Framework: A Menu of Options.* This document can be found on http://www.epa.gov/air/tribal/grants.html.

Approvable work plans need to have:

1. one or more **objectives** (that's why the objective setting can be so important),
2. **activities** that support the achievement of the **objectives**, and
3. **outcomes** or **deliverables** that will produce **environmental results** within the **objectives**. The tribe should also try to develop performance measures and milestones that help measure progress on achieving the environmental results.

For example, in Section 2, one possible objective was written:

> *What is the effect of pollutant Z from industrial source ABC on the ambient air concentration in tribal community X ?*

So from this example the words in bold would be solved as follows:

- The **objective** would be find out what the effect was;
- the **activities** would be the monitoring necessary to collect the data that proves or disproves an effect;
- the **outcomes/deliverables** would be a set of reports and various statistical analysis quantifying the effect that the pollution had, and;
- the **environmental results** would be the mitigation that would take place to reduce the harm from the pollutant on the community and performance measures may be the type of tracking or follow up that is done periodically to show measured progress in the mitigation (like an annual X% decrease in concentration over the next 5 years).

The EPA Office of Grants and Debarment at: http://www.epa.gov/ogd/ provides good information on the grants process. This website: http://www.epa.gov/ogd/recipient/tips.htm provides tips on applying for a grant and is included in its entirety in Appendix D. These tips will help in the development of the workplan, as well as how to build a good budget proposal for the monitoring effort. In addition, Appendix D also includes a summary of EPA Grants, and a listing of websites for more information on the Indian GAP.

4.5 Costs of Monitoring

Before any kind of funding request can be made, cost information must be collected for implementing the monitoring program. Costs vary widely with the type of monitor needed and where it will be located. These costs may cover:

- personnel and travel,
- construction of a monitoring shed or purchase of a monitoring trailer,
- installation of electricity and phone service (these costs may be considerable in rural areas),
- purchase of a data management system,
- lab costs,
- purchase of calibration devices and standards,
- spare parts for monitor,
- tools for working on the monitor,
- shipping costs to the lab, and
- lab services [1].

If a tribe is becoming part of a program, such as IMPROVE, many of these costs will be combined into an annual program fee. Some monitors and/or calibration equipment are very complex and must be shipped back to the vendor for servicing, so these costs should be considered. Vendors often offer services to visit the site and install more complex monitors and provide training sessions to tribal staff. Though this may be costly, tribes may want to consider this option.

Every three years, EPA is required to perform an Information Collection Request (ICR) for its major programs. The ICR provides national estimates on the costs to implement the ambient air monitoring program. EPA surveys a number of representative monitoring organizations, aggregates this information and provides an average cost for operating a monitoring site for an individual pollutant. Appendix B includes summary estimates of the costs for operating the criteria pollutants ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, PM_{10} and $PM_{2.5.}$ There is an additional table that provides general costs not covered in the pollutant specific costs. The values should be used as “ballpark” estimates and a starting point. Tribes should consult with vendors, other air monitoring programs and the appropriate EPA Regions for more specific values.

[1] For example, the cost of lab and shipping services for an IMPROVE protocol site is ~ $35,000 per year.

Section 5

Monitoring Implementation

Section 3 provided the reader with general information necessary to plan a monitoring activity in enough detail to determine the costs and resources necessary for monitoring and to develop a workplan to seek federal funds. This section provides additional details of monitoring implementation. The information is not specific to any one monitoring program and should be used as general guidance.

5.1 Participation in National Monitoring Programs

Tribes may be interested in participating in nationally established air monitoring programs. All of these programs provide **requirements** that must be met in order for the data to be used in a specific monitoring program, as well as **guidance** that provides additional detail of a requirement or suggestions for implementation that can be followed or modified as the tribe feels appropriate for its circumstance. An example of a requirement is the use of federal reference or equivalent methods (FRM/FEM) for monitoring for comparison to the NAAQS, whereas guidance is the suggested cleaning of the $PM_{2.5}$ very sharp cut cyclone every month.

National air monitoring programs of interest to the tribes include:

- State or Local Air Monitoring Stations (SLAMS)
- National Core (NCore)
- Photochemical Assessment Monitoring Stations (PAM)
- $PM_{2.5}$ Chemical Speciation Network
- National Air Toxics Trends Stations (NATTS)
- Interagency Monitoring of Protected Visual Environments (IMPROVE)
- Clean Air Status and Trends Network (CASTNET)
- National Atmospheric Deposition Program/ National Trend Network (NADP/NTN)

Each program mentioned has detailed information and guidance on the objectives of the network, the types of monitors/samplers used, siting the equipment and the data to be collected. Appendix A contains a fact sheet for each of the programs mentioned above that can be used as a navigational tool to find the information on particular monitoring implementation subjects.

5.2 How Long Might it Take to Start Monitoring

Tribes should consider the timing involved in installing a monitor. For example, a grant received in late summer may result in monitors being placed the following spring. Time is needed to receive the grant money, hire personnel, order the monitor, prepare the site, write the QAPP, contract laboratory analysis, and learn how to operate the monitor. These steps can take months and can be slowed by weather conditions. Depending on the conditions of the grant and timeline described in the workplan, one year may be a reasonable time period to anticipate when the first day of "real" data collection might start. In any case, both the tribe and the organization funding the monitoring should come to agreement on a realistic implementation date.

5.3 Monitor Placement

Proper siting of the sampling equipment and sampling probes is necessary to ensure that the monitors and samplers are obtaining representative samples of the ambient air.

Final placement of the monitor at a selected site depends on physical obstructions and activities in the immediate area, accessibility/availability of utilities and other support facilities in correlation with the defined purpose of the specific monitor and its design. Because obstructions such as trees and fences can significantly alter the air flow, monitors should be placed away from obstructions. It is important for air flow around the monitor to be representative of the general air flow in the area to prevent sampling bias. Detailed information on urban physiography (e.g., buildings, street dimensions) can be determined through visual observations, aerial photography and surveys. Such information can be important in determining the exact locations of pollutant sources in and around the prospective monitoring site areas.

Network designers should avoid sampling locations that are unduly influenced by down wash or ground dust (e.g., a rooftop air inlet near a stack or a ground- level inlet near an unpaved road); in these cases, the sample intake should either be elevated above the level of the maximum ground turbulence effect or placed at a reasonable distance from the source of ground dust.

Depending on the defined monitoring objective, the monitors are placed according to exposure to pollution. Due to the various physical and meteorological constraints discussed above, tradeoffs may occur to locate a site in order to optimize sample collection. Any decisions that lead to a non-optimal (but most feasible at the time) location should be documented.

The goal in siting stations is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring objective of the station. The representative measurement scales of greatest interest are shown below:

Micro	Concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters
Middle	Concentrations typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometer
Neighborhood	Concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range
Urban	Overall, citywide conditions with dimensions on the order of 4 to 50 kilometers. This scale would usually require more than one site for definition
Regional	Usually a rural area of reasonably homogeneous geography and extends from tens to hundreds of kilometers
National/Global	Concentrations characterizing the nation and the globe as a whole.

Table 5-1 illustrates the relationships among the basic monitoring objectives and the scales of representativeness that are generally most appropriate for that objective.

Table 5-1. Relationship Among Monitoring Objectives and Scales of Representativeness.

Monitoring Objective	Appropriate Siting Scale
Highest Concentration	Micro, middle, neighborhood, sometimes urban
Population	Neighborhood, urban
Source impact	Micro, middle, neighborhood
General/background	Neighborhood, regional
Regional Transport	Urban/regional
Welfare-related	Urban/regional

5.4 Monitoring Station Design

Monitoring organizations should design their monitoring stations with the station operator in mind. Careful thought to safety, ease of access to instruments and optimal work space should be given every consideration. If the station operator has these issues addressed, he/she will be able to perform their duties more efficiently and diligently. Instruments placed in areas that are difficult to access can frustrate operators and prolong downtime. The goal is to optimize data collection and quality. This must start with designing the shelter and laboratory around staff needs and requirements.

EPA is aware that monitoring stations may be located in urban areas where space and land are at a premium, especially in large cities that are monitoring for NO_x and CO. In many cases, the monitoring station is located in a building or school that is gracious enough to allow an agency to locate its equipment there. Sometimes, a storage or janitorial closet is all that is available. This can pose serious problems. If the equipment is located in a closet, it can be difficult for the agency to control the temperature, humidity, light, vibration and chemicals that the instruments are subjected to. In addition, security can also be an issue if people other than agency staff have access to the equipment. Tribes should seriously consider locating its air monitoring equipment in stand-alone shelters with limited access, or modify existing rooms to the recommended station design, if funds and staff time are available.

In general, air monitoring stations should be designed for functionality and ease of access, i.e., instrumentation easily accessed for operation and repair. In addition, the shelter should be able to withstand any weather that the local area may generate. In the past, small utility trailers were the norm in monitoring shelters. However, in some areas, this will not suffice. Recently, steel and aluminum storage containers are gaining wide acceptance as monitoring shelters. It is recommended that monitoring stations be housed in shelters that are fairly secure from intrusion or vandalism. All sites should be located in fenced or secure areas with access only through locked gates or secure pathways. The shelter's design dictates that it be insulated (R-19 minimum) to prevent temperature extremes within the shelter. All foundations should be earthquake secured. All monitoring shelters should be designed to control excessive vibrations and external light falling on the instruments, and provide 110/220 VAC voltage throughout the year. When designing a monitoring shelter, make sure that enough electrical circuits are secured for the current load of equipment, plus other instruments that may be added later (e.g., audit equipment). Figure 5.1 represents one shelter design that has proven adequate.

This design is not a requirement, but should be thought of as an optimum condition, if funding for this type of shelter set-up is available.

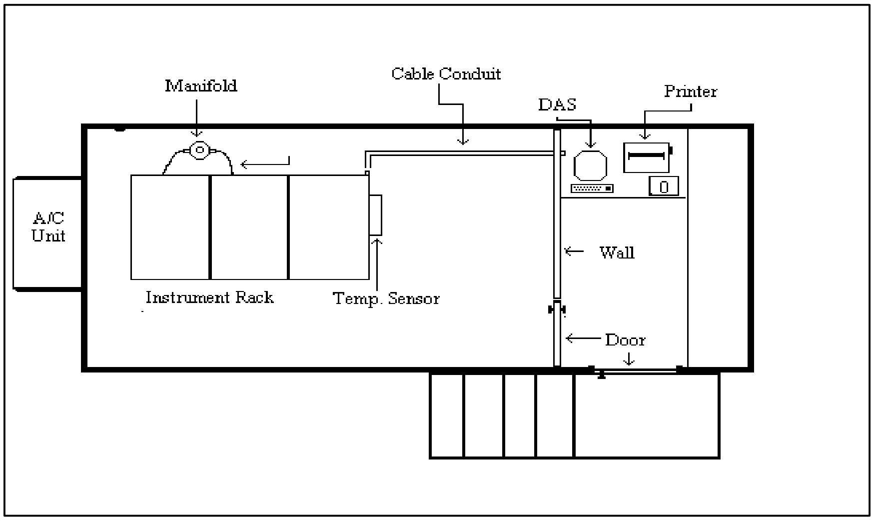


Figure 5.1 Example design for a monitor shelter.

In the shelter there are two rooms separated by a door. Having the entry into the computer/data review room allows access to the site without having to initially enter the room that houses the equipment. It also isolates the equipment from cold/hot air that can come into the shelter when someone enters. Also, the data acquisition system (DAS)/data review area is isolated from the noise and vibration of the equipment. This area can be a place where the operator can print data and prepare samples for the laboratory. This also gives the operator an area where cursory data review can take place. If something is observed during this initial review, then possible problems can be corrected or investigated at that time. The DAS can be linked through cables that travel through conduit into the equipment area. The conduit is attached to the ceiling or walls and then dropped down to the instrument rack.

The air conditioning/heating unit should be mounted to heat and cool the equipment room. When specifying the unit, make sure it will cool the room on the warmest and heat on the coldest days of the year. Also, make sure the electrical circuits are able to carry the load. If necessary, keep the door closed between the computer and equipment room to lessen the load on the heating or cooling equipment.

All air quality instrumentation should be located in an instrument rack or equivalent. The instruments and their support equipment are placed on sliding trays or rails. By placing the racks away from the wall, the rear of the instruments are accessible. The trays or rails allow the site operators access to the instruments without removing them from the racks. Most instrument vendors offer sliding rails as an optional purchase.

Sampling Environment -

A proper sampling environment demands control of all physical parameters external to the samples that might affect sample stability, chemical reactions within the sampler, or the function of sampler components. The important parameters to be controlled are summarized in Table 5-2.

NOTE: The following sampling environment information is specific to the requirements for the SLAMS monitoring network. Therefore, it may be acceptable to use different sampling environment conditions if the analyzers are used for other monitoring objectives and will not be used for comparison to the NAAQS.

With respect to environmental temperature for analyzers, most have been tested and qualified over a temperature range of 20°C to 30°C; few are qualified over a wider range. This temperature range specifies both the range of acceptable operating temperatures and the range of temperature change which the analyzer can accommodate without excessive drift. The range of temperature change that may occur between zero and span adjustments, is the most important. When one is outfitting a shelter with monitoring equipment, it is important to recognize and accommodate the instrument with the most sensitive temperature requirement.

Table 5-2 Environment Control Parameters

Parameter	Source of specification	Method of Control
Instrument vibration	Manufacturer's specifications	Design of instrument housings, benches, etc., per manufacturer's specifications.
Light	Method description or manufacturer's specifications	Shield chemicals or instruments that can be affected by natural or artificial light.
Electrical voltage	Method description or manufacturer's specifications	Constant voltage transformers or regulators; separate power lines; isolated high current drain equipment such as hi-vols, heating baths, pumps from regulated circuits.
Temperature	Method description or manufacturer's specifications	Regulated air conditioning system 24-hour temperature recorder; use electric heating and cooling only.
Humidity	Method description or manufacturer's specifications	Regulated air conditioning system; 24-hour temperature recorder.

To accommodate energy conservation regulations or guidelines specifying lower thermostat settings, designated analyzers located in facilities subject to these restrictions may be operated at temperatures down to 18°C, provided the analyzer temperature does not fluctuate by more than 10°C between zero and span adjustments. Operators should be alert to situations where environmental temperatures might fall below 18°C, such as during night hours or weekends. Temperatures below 18°C may necessitate additional temperature control equipment or rejection of the area as a sampling site.

Shelter temperatures above 30°C also occur, due to temperature control equipment that is malfunctioning, lack of adequate power capacity, or shelters of inadequate design for the environmental conditions. Occasional fluctuations above 30°C may require additional assurances that data quality is maintained. Sites that continually have problems maintaining adequate temperatures may necessitate additional temperature control equipment or rejection of the area as a sampling site. If this is not an option, a waiver to operate beyond the required temperature range should be sought with the EPA Regional Office, if it can be shown that the site can meet established data quality requirements.

In order to detect and correct temperature fluctuations, a 24-hour temperature recorder at the analyzer site is strongly suggested. These recorders can be connected to data loggers and should be considered official documentation that should be filed. Many vendors offer these type of devices. Usually they are thermocouple/thermistor devices of simple design and are generally very sturdy. Reasons for using electronic shelter temperature devices are two-fold: (1) through remote interrogation of the DAS, the agency can tell if values collected by air quality instruments are valid, and (2) that the shelter temperature is within a safe operating range if the air conditioning/heating system fails.

5.5 Design of Probes and Manifolds for Automated Methods

There are a number of designs for sampling probes and manifolds. OAQPS has developed monitoring guidance for the NCore precursor gas network that provides a good discussion of this subject http://www.epa.gov/ttn/amtic/precur.html. Since this information is appropriate to a number of monitoring networks, it is included in its entirety in Appendix E. Some important variables affecting the sampling manifold design are the diameter, length, flow rate, pressure drop, residence time and materials of construction. A few of these subjects will be described below.

Probe Material-

Depending on the monitoring program, the allowable material for sample probes, inlets and manifolds may be very specific. For example borosilicate glass and FEP Teflon or their equivalent are the only materials allowed for the gaseous pollutants in the SLAMS and NCore precursor gas networks. This information can be found in 40 CFR Part 58 Appendix E. Monitoring organizations should check whether various monitoring programs have specific guidance on probe/inlet/manifold material.

Residence Time-

The residence time of pollutants within the sampling manifold is critical. Residence time is defined as the amount of time that it takes for a sample of air to travel from the opening of the cane (inlet probe) to the inlet of the instrument and is required to be less than 20 seconds for reactive gas monitors. It is recommended that the residence time within the manifold and sample lines to the instruments be less than 10 seconds. If the volume of the manifold does not allow this to occur, then a blower motor or other device (vacuum pump) can be used to decrease the residence time. The residence time for a manifold system is determined in the following way. First the volume of the cane, manifold and sample lines must be determined using the following equation:

$$\textit{Total Volume} = Cv + Mv + Lv$$

where:

Cv = Volume of the sample cane and extensions
Mv = Volume of the sample manifold and trap
Lv = Volume of the instrument lines.

Each of the components of the sampling system must be measured individually. To measure the volume of the components, use the following calculation:

$$V = pi * (d/2)^2 * L$$

where:

V = volume of the component, cm^3
pi = 3.14
L = Length of the component, cm
d = inside diameter, cm

Once the total volume is determined, divide the volume by the flow rate of all instruments to calculate the residence time.

Probe Placement -

Probes and manifolds must be placed to avoid introducing bias to the sample. Important considerations are probe height above the ground, probe length (for horizontal probes), 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 near physical obstructions (e.g., chimneys and trees etc.) that can affect the air flow in the vicinity of the probe
- height of the probe above the ground depends on the pollutant being measured

Probe and Manifold Maintenance-

After an adequately designed sampling probe and/or manifold has been selected and installed, the following steps will help maintain constant sampling conditions:

1. **Conduct a leak test**. For the conventional manifold, seal all ports and pump down to approximately 1.25 cm water gauge vacuum, as indicated by a vacuum gauge or manometer connected to one port. Isolate the system. The vacuum measurement should show no change at the end of a 15-min period.
2. **Establish cleaning techniques and schedule.** A large diameter manifold may be cleaned by pulling a cloth on a string through it. Otherwise the manifold must be disassembled periodically and cleaned with distilled water. Soap, alcohol, or other products that may contain hydrocarbons should be avoided when cleaning the sampling train. These products may leave a residue that may affect volatile organic measurements. Visible dirt should not be allowed to accumulate.
3. **Plug the ports on the manifold when sampling lines are detached.**
4. **Maintain a flow rate in the manifold.** Flow rate should be either 3 to 5 times the total sampling requirements or at a rate equal the total sampling requirement plus 140 L/min. Either rate will help to reduce the sample residence time in the manifold and ensure adequate gas flow to the monitoring instruments.

5. **Maintain the vacuum in the manifold.** This should be less than 0.64 cm water gauge. Keeping the vacuum low will help to prevent the development of leaks.

Most of the support services necessary for the successful operation of ambient air monitoring networks can be provided by the laboratory. The major support services are the generation of reagent water and the preparation of standard atmospheres for calibration of equipment. Table 5-3 summarizes guidelines for quality control of these two support services.

Table 5-3 Techniques for Quality Control of Support Services

Support Service	Parameters affecting quality	Control techniques
Laboratory and calibration gases	Purity specifications vary among manufacturers	Develop purchasing guides
	Variation among lots	Overlap use of old and new cylinders
	Atmospheric interferences	Adopt filtering and drying procedures
	Composition	Ensure traceability to primary standard
Reagents and water	Commercial source variation	Develop purchasing guides. Batch test for conductivity
	Purity requirements	Redistillation, heating, deionization with ion exchange columns
	Atmospheric interferences	Filtration of exchange air
	Generation and storage equipment	Maintenance schedules from manufacturers

In addition to the information presented above, the following should be considered when designing a sampling manifold:

- suspending strips of paper in front of the blower's exhaust to permit a visual check of blower operation
- positioning air conditioning vents away from the manifold to reduce condensation of water vapor in the manifold
- positioning sample ports of the manifold toward the ceiling to reduce the potential for accumulation of moisture in analyzer sampling lines, and using borosilicate glass, stainless steel, or their equivalent for VOC sampling manifolds at PAMS sites is to avoid adsorption and desorption reactions of VOC's on FEP Teflon.

More detailed information on probe/manifold design can be found in Appendix A of the document titled: *Technical Assistance Document for Precursor Gas Measurements in the NCore Multi-pollutant Monitoring Network* http://www.epa.gov/ttn/amtic/pretecdoc.html.

5.6 Preventive Maintenance

Every tribal monitoring organization should develop a preventive maintenance program. Maintaining the network equipment helps prevent downtime and costly repairs. Preventive maintenance is an ongoing portion of quality control. Since this is an ongoing process, it normally is enveloped into the routines performed at some designated frequency such as weekly, monthly, quarterly, semi-annually, and annually.

Preventive maintenance is the responsibility of the station operators and the supervisory staff. It is important that the supervisor reviews the preventive maintenance work, and continually checks the schedule. The supervisor is responsible for making sure that the preventive maintenance is being accomplished in a timely manner. Preventive maintenance is not a static process. Procedures must be updated for many reasons, including but not limited to, new models or types of instruments and new or updated methods.

The preventive maintenance schedule is changed whenever an activity is moved or is completed. For instance, if a multipoint calibration is performed in February instead of the March date, then the six-month due date moves from September to August. The schedule is constantly in flux because repairs must be followed by calibrations or verifications.

Instrumentation Log-

Each instrument and support equipment (with the exception of the instrument racks) should have an instrumentation repair log. The log can be a folder or bound notebook that contains the repair and calibration history of that particular instrument. Whenever multipoint calibrations, instrument maintenance, repair, or relocation occur, detailed notes should be recorded in the instrumentation log. The log contains the most recent multipoint calibration report, a preventive maintenance sheet, and the acceptance testing information. If an instrument is malfunctioning and a decision is made to relocate that instrument, the log travels with that device. The log can be reviewed by staff for possible clues to the reasons behind the instrument malfunction. In addition, if the instrument is shipped to the manufacturer for repairs, the log always travels with the instrument. This helps non-agency repair personnel troubleshoot instrument problems.

Station Log-

The station log is a chronology of the events that occur at the monitoring station. The log is an important part of the equation because it contains the narrative of problems and solutions to problems. While the technical details are recorded in the instrumentation log, the station log notes should be written in a narrative style. Additional items that belong in the station log are:

- the date, time, and initials of the person(s) who arrived at the site,
- brief description of the weather (i.e., clear, breezy, sunny, raining),
- brief description of exterior of the site.
- any changes that might affect the data, for instance, if someone is parking a truck or tractor near the site, this may explain high NO_x values, etc.,
- any unusual noises, vibrations or anything out of the ordinary,
- description of the work accomplished at the site (i.e., calibrated instruments, repaired analyzer), and
- information about the instruments that may need repairs or troubleshooting.

Station Maintenance-

Station maintenance is a portion of preventive maintenance that does not have to occur on a routine basis. These tasks usually occur on an "as needed" basis. The station maintenance items are checked monthly or whenever an agency knows that the maintenance needs to be performed. Examples of some station maintenance items include:

- floor cleaning
- shelter inspection
- air conditioner repair
- AC filter replacement
- weed abatement
- roof repair
- general cleaning.

Routine Operations-

Routine operations are the checks that occur at specified periods of time during a monitoring station visit. The duties are the routine day-to-day operations that must be performed in order to operate a monitoring network at optimal levels. Some typical routine operations are detailed in Table 5-4.

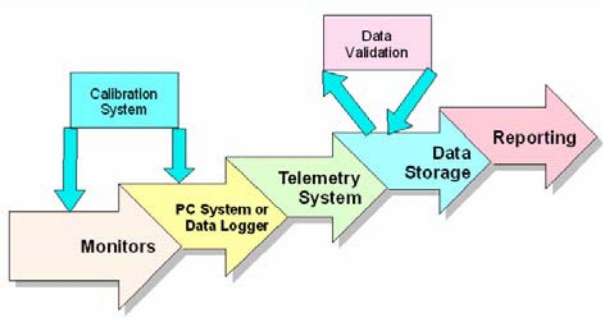
Table 5-4 Routine Operations

Item	Each Visit	Weekly	Monthly
Print Data	X		
Mark Charts	X		
Check Exterior		X	
Change Filters		X	
Drain Compressor		X	
Leak Test		X	
Check Desiccant			X
Inspect tubing			X
Inspect manifold and cane			X
Check electrical connections			X

In addition to these items, the exterior of the building, sample cane, meteorological instruments and tower, entry door, electrical cables, and any other items deemed necessary to check should be inspected for wear, corrosion, and weathering. Costly repairs can be avoided in this manner.

Section 6

Data Acquisition, Management and Transfer



The ambient pollutant data generated by gas analyzers or manual samplers must be captured, organized, and verified in order to be useful. The process of capturing the data is known as data acquisition. The organization of the data is known as data management. These data acquisition/management systems must be effectively managed using a set of guidelines and principles by which adherence will ensure data integrity. EPA has a document entitled *Good Automated Laboratory Practices* (GALP) http://www.epa.gov/irmpoli8/policies.htm. The GALP defines six data management principles:

1. ***DATA***: *The system must provide a method of assuring the integrity of all entered data. Communication, transfer, manipulation, and the storage/recall process all offer potential for data corruption. The demonstration of control necessitates the collection of evidence to prove that the system provides reasonable protection against data corruption.*

2. ***FORMULAE***: *The formulas and decision algorithms employed by the system must be accurate and appropriate. Users cannot assume that the test or decision criteria are correct; those formulas must be inspected and verified.*

3. ***AUDIT***: *An audit trail that tracks data entry and modification to the responsible individual is a critical element in the control process. The trail generally utilizes a password system or equivalent to identify the person or persons entering a data point, and generates a protected file logging all unusual events.*

4. ***CHANGE***: *A consistent and appropriate change control procedure capable of tracking the system operation and application software is a critical element in the control process. All software changes should follow carefully planned procedures, including a pre-install test protocol and appropriate documentation update.*

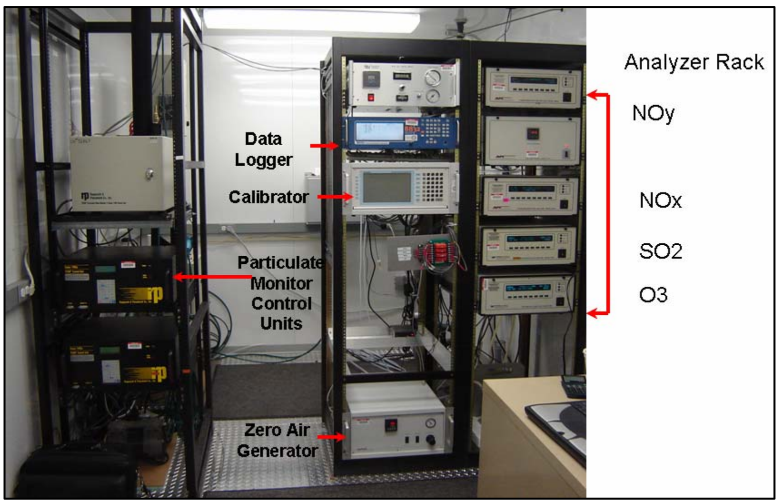
5. ***STANDARD OPERATING PROCEDURES (SOPs)***: *Control of even the most carefully designed and implemented systems will be thwarted if appropriate procedures are not followed. The principle implies the development of clear directions and standard operating procedures (SOPs); the training of all users; and the availability of appropriate user support documentation.*

6. ***DISASTER***: *Consistent control of a system requires the development of alternative plans for system failure, disaster recovery, and unauthorized access. The control principle must extend to planning for reasonable unusual events and system stresses.*

This section provides guidance in these areas, including identification of advanced equipment and procedures that are recommended for implementation. The recommended procedures rely on digital communication by the data acquisition system to collect a wider variety of information from the analyzers, to control instrument calibrations, and to allow for more routine, automated, and thorough data quality efforts. The section will discuss:

1. **Data acquisition-** collecting the raw data from the monitor/sampler, storing it for an appropriate interval, aggregating or reducing the data, and transferring this data to final storage in a local data base (tribal monitoring organizations database)
2. **Data management**- ensuring the integrity of the data collection systems
3. **Data transfer**- preparing and moving data to external data bases such as AIRNOW or the Air Quality System (AQS).

Some tribal organizations may have one or a few monitoring sites and may collect data by visiting the monitoring site at a prescribed frequency to download raw data from the analyzer(s) with the use of data acquisition systems as simple as a laptop computer. What is most important in any data acquisition process is that the raw data values that are stored in the analyzer are transferred to other media in a manner that does not affect data integrity. This means the value that the analyzer records is the value that should be in the final database. Although some of this information may not be applicable to all monitoring programs, it is included to provide information on the technologies available and the advantages that they offer.



Typical monitoring and data acquisition system

6.1 Data Acquisition

Data acquisition system (DAS) is a term that describes any system that collects, stores, summarizes, reports, prints, calculates, or transfers data. The transfer is usually from an analog or digital format to a digital medium. In addition, this section will discuss limitations with data collected with DAS. Uncertainty of data will be discussed and how to ascertain the quality of the data.

Air quality professionals have used DAS since the early 1980s. The first systems were single- and multi-channel systems that collected data on magnetic media. This media was usually hand transferred to a central location or laboratory and uploaded to a central computer. The need to hand transfer data has diminished with the advent of digital data transfer from the monitoring stations to a central location. However, errors in data reporting can occur with strip chart, as well as digital data.

DAS Layout and Collection -

Figure 6.1 shows the basic transfer of data from the instrument to the final product- a hard copy report, or transfer to a central computer. The instrument has a voltage potential that generally is a DC voltage. This voltage varies directly with the concentration collected. Most instruments' output is a DC voltage in the 0-1 or 0-5 volts range.

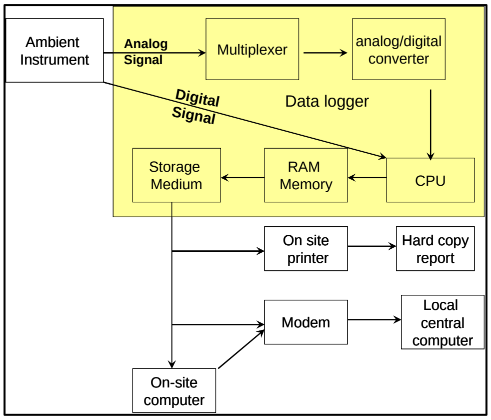


Figure 6.1 DAS data flow

- Voltage is measured by the multiplexer that allows voltages from one or many instruments to be read at the same time.
- Multiplexer sends a signal to the a/d converter that changes the analog voltage to a low amperage digital signal.
- A/d converter send signals to the central processing unit (cpu) that directs the digital electronic signals to a display or to the random access memory (ram), which stores the short-term data until the end of a pre-defined time period.
- Cpu then shunts the data from the ram to the storage medium which can be a data logger, computer hard-drive or computer diskette.
- Computer storage medium can be accessed remotely, or at the monitoring location.

The data transfer can occur via modem to a central computer storage area or printed out as hard copy. In some instances, the data can be transferred from one storage medium (i.e., hard drive to a diskette or tape) to another storage medium. Figure 6.1 also shows the different routes of the analog signal versus a digital signal.

Analog versus Digital DAS -

Most analyzers built within the last 15 years have the capability (RS232 ports) to transfer digital signals, yet many monitoring organizations currently perform data acquisition of automated monitors by recording an analog output from each gas analyzer using an electronic data logger. The analog readings are converted and stored in digital memory in the data logger for subsequent automatic retrieval by a remote data management system. This approach can reliably capture the monitoring data, but does not allow complete control of monitoring operations, and the recorded analog signals are subject to noise that limits the detection of low concentrations. Furthermore, with this analog data acquisition approach, the data review process is typically labor-intensive and not highly automated. For these reasons, EPA encourages the adoption of digital data acquisition methods. In that regard, the common analog data acquisition approach often does not fully utilize the capabilities of the electronic data logger. Many data loggers have the capability to acquire data in digital form and to control some aspects of calibrations and analyzer operation, but these capabilities are not utilized in typical analog data acquisition approaches.

Digital data acquisition reduces noise in the recording of gas monitoring data, thereby improving sensitivity. It also records and controls the instrument settings, internal diagnostics, and programmed activities of monitoring and calibration equipment. Such data acquisition systems also typically provide automated data quality assessment as part of the data acquisition process.

It may be cost-effective for tribal agencies to adopt digital data acquisition and calibration control simply by more fully exploiting the capabilities of their existing electronic data loggers. For example, many gas analyzers are capable of being calibrated under remote control. The opportunity to reduce travel and personnel costs through automated calibrations is a strong motivator for monitoring organizations to make greater use of the capabilities of their existing data acquisition systems. The NCore multi-pollutant sites are taking advantage of the newer DAS technologies. Details of these systems can be found in the technical assistance document for this program[1] http://www.epa.gov/ttn/amtic/pretecdoc.html.

Figure 6.2 illustrates the recommended digital data acquisition approach for the NCore sites. It presents the data flow from the gas monitors, through a local digital data acquisition system, to final reporting of the data in various public databases. This schematic shows several of the key capabilities of the recommended approach. A basic capability is the acquisition of digital data from multiple analyzers and other devices, thereby reducing noise and minimizing the effort needed in data processing. Another capability is two-way communication, so that the data acquisition system can interrogate and/or control the local analyzers, calibration systems, and even sample inlet systems, as well as receive data from the analyzers. Data transfer to a central location is also illustrated, with several possible means of that transfer shown. Monitoring organizations are urged to take advantage of the latest technology in this part of the data acquisition process, as even technologies such as satellite data communication are now well established, commercially available, and inexpensive to implement for monitoring operations.

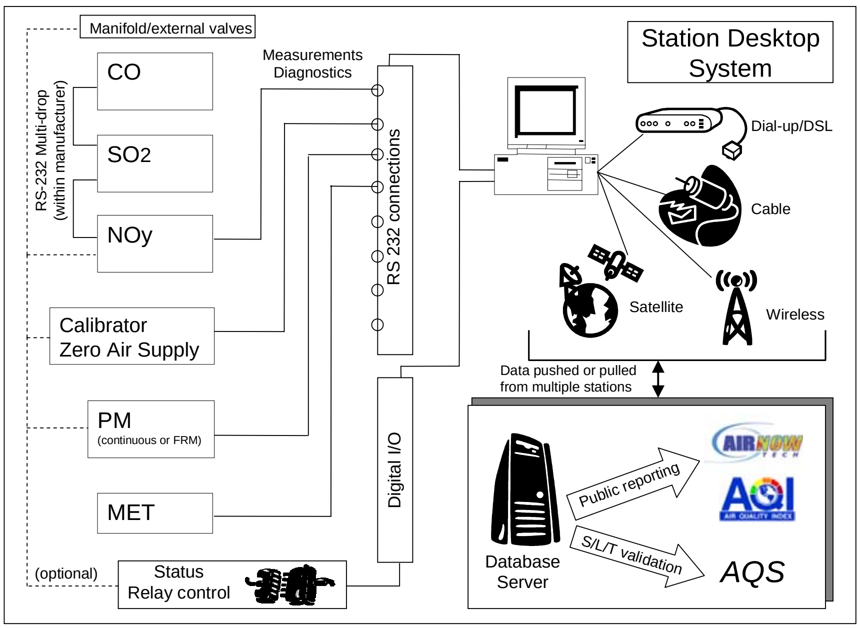


Figure 6.2 Flow of data from gas analyzers to final reporting

Depending on the monitoring objective, it may be important that data are reported in formats of immediate use in public data bases such as AQS, and Air Quality Index sites such as

[1] Version 4 of the Technical Assistance Document for Precursor Gas Measurements in the NCore Multi-pollutant Monitoring Network.

the multi-agency AIRNow sites. An advantage of DAS software is the ability to facilitate the assembly, formatting and reporting of monitoring data to these databases.

Digital data acquisition systems such as those in Figure 6.2 offer a great advantage over analog systems in the tracking of calibration data, because of the ability to control and record the internal readings of gas analyzers and calibration systems. That is, a digital data acquisition system not only can record the analyzer's output readings, but can schedule and direct the performance of analyzer calibrations, and record calibrator settings and status. Thus, flagging of calibration data to distinguish them from ambient monitoring data is conducted automatically during data acquisition with no additional effort or post-analysis. These capabilities greatly reduce the time and effort needed to organize and quantify calibration results.

Purchasing of DAS Systems-

There are a number of vendors supplying data logger technologies for ambient air monitoring. Some of these organizations have the expertise to set up the DAS systems to produce final concentration values in the formats necessary for data transfers to external data bases like AIRNow or AQS. As part of the acquisition process, tribal monitoring organizations may want to consider adding this feature to the bid since it could save in DAS set-up time down the road. In addition, ITEP offers a training course on data loggers that might be appropriate to take before making a purchase. ITEP's course list can be found at: http://www4.nau.edu/itep/trainings/aiaqtp.asp.

DAS Quality Assurance -

Quality assurance of the DAS is based on the system being operated within some range of performance; i.e., that the data collected on the DAS and reported to the central database is the same as that generated by the monitoring equipment. For DAS, there are two sources of error between the instrument (sensor) and the recording device: (1) the output signal from the sensor, and (2) the errors in recording by the data logger. This section will provide ways to ascertain quality data from DAS. Among the practices used to document DAS performance are routine calibration checks of the data acquisition system itself, data trail audits and performance audits.

DAS Calibration- In the case where analog signals from monitoring equipment are recorded by the DAS, the calibration of a DAS is similar to the approach used for calibration of a strip chart recorder. To calibrate the DAS, known voltages are supplied to each of the input channels and the corresponding measured response of the DAS is recorded. Specific calibration procedures in the DAS owner's manual should be followed when performing such DAS calibrations. The DAS should be calibrated at least once per year. Appendix F provides a simple approach for calibration of the DAS.

In addition, gas analyzers typically have an option to set output voltages to full scale, or to ramp the analog output voltages supplied by the analyzer over the full output range. Such a function can be used to check the analog recording process from the analyzer through the DAS.

Data Trail Audit - A data trail audit consists of following one or more data values from the analyzer through collection by the DAS, through data processing, to reporting to the central data repository. This audit should be conducted by those personnel assigned to manage the data acquisition hardware and software and should be conducted at least annually. The procedure to be followed is that one or more data points or data averages reported from the analyzer (e.g., hourly values) should be collected by the DAS and checked on the DAS storage medium, and, in the final format, reported to the data repository. The same values must be traceable through all steps of the data acquisition and reporting process.

Performance Audit - The performance audit consists of challenging the instrument and DAS to a known audit source gas and observing the final response. The response should correspond to the value of the audit source gas. Although the performance audit may indicate that the analyzer is malfunctioning, it could also indicate DAS malfunction.

Initialization Errors -All data acquisition systems must be initialized. The initialization consists of an operator "setting up" the parameters so that the voltages produced by the instruments can be read, scaled correctly and reported in the correct units. Errors in initializations can create problems when the data is collected and reported. Read the analyzer manufacturer's literature before parameters are collected. If the manufacturer does not state how these parameters are collected, request this information. The following should be performed when setting up the initializations:

- Check the full scale outputs of each parameter.
- Calibrations should be followed after each initialization (each channel of a DAS should be calibrated independently). Appendix F provides an example of a DAS calibration technique.
- Review the instantaneous data stream, if possible, to see if the DAS is collecting the data correctly.
- Save the initializations to a storage medium; if the DAS does not have this capability, print out the initialization and store it at the central computer location and at the monitoring location.
- Check to see if the flagging routines are performed correctly; data that are collected during calibrations and down time should be flagged correctly.
- Check the DAS for excessive noise (variability in signal). Noisy data that are outside of the normal background are a concern. Noisy data can be caused by improperly connected leads to the multiplexer, noisy AC power, or a bad multiplexer. Refer to the owner's manual for help on noisy data.
- Check to see that the average times are correct. Some DAS consider 45 minutes to be a valid hour, while others consider 48 minutes. Agency guidelines should be referred to before setting up averaging times.

6.2 Data Management

The following sections provide guidance when managing the data in a monitoring program.

Security-

Data management systems need to be safeguarded against accidental or deliberate:

1. **Modification or destruction of data** - This relates to maintaining the integrity of the data, which includes developing policy/procedures for computer use (password protection and authorization), data entry (i.e., double entry, verification checks, etc.), editing, and transfer.
2. **Unavailability of data or services** - Ensuring that data do not get lost (i.e., data backup policies and storage on more than one media or system) or that services are not interrupted (maintenance of hardware, surge protection, backup systems).
3. **Unwanted disclosure of data** - This relates to confidentiality and ensuring that secured or confidential data cannot accidentally or deliberately be disclosed.

Standard Operating Procedures -

Standard operating procedures (SOPs) are protocols for routine activities involved in a data collection activity that generally involve repetitious operations performed in a consistent manner. SOPs should be established for:

- maintaining system security
- defining raw data (distinction between raw and processed data)
- entry of data
- verification of manually or electronically input data
- interpretation of error codes/flags and corrective action
- changing data
- data analysis, processing, transfer, storage, and retrieval
- backup and recovery
- electronic reporting (if applicable).

Software -

Software, either developed internally or “off-the-shelf” must accurately perform its intended function. Tests of the software prior to implementation should occur and be documented. Algorithms should be checked and source code reviewed as part of the process. Source code, including processing comments, should be archived. Procedures for reporting software problems and corrective action should be in place.

Data Entry and Formatting -

Electronic DAS can record, average, and compile the monitoring data in a variety of reporting formats. If the tribal monitoring organization transfers data to an external database (i.e., AIRNOW, AQS etc.), the personnel responsible for the DAS should assure that the reported data are in the formats required for such reporting to databases. Information on the requirements of major databases such as AQS can be found in Appendix A.

In many cases, monitoring data are reported as hourly average values. However, it is suggested that the tribal monitoring organizations consider recording and archiving data with shorter time resolution (e.g., as five minute averages). Such data can be used to compute averages over longer time periods and are valuable for diverse data analyses. For example, short time period data can be used to assess the variability and uncertainty in hourly or longer time period data, to evaluate temporal trends or source impacts, and be used in special research projects. The availability of high time resolution data is valuable to the data-user community, and is likely to foster analyses of air quality that could not be attempted with hourly or longer data periods.

Data Review-

The review of collected data is the most important means to assure data quality in ambient monitoring. The review process has multiple stages, beginning with observations in the field, continuing through the analysis of electronic data, and ending with the reporting of final data. Data review should be the subject of a SOP that defines the criteria an agency will apply in processing and reporting the monitoring data.

Data review in the field should involve the observations and records of site operators on topics such as the operational status of analyzers, the need for maintenance or repair, the occurrence of unexpected or unexplained readings, the existence of difficult or unusual meteorological conditions, and the observation of ambient data outside the normal range for the site. At a minimum, such observations must be recorded in a station/instrument logbook or other document. Preferably, such observations should be recorded by electronic word processor. These records should be associated with the ambient data through the data acquisition system. Data review in the field is the first step in flagging suspect data for subsequent review.

Data review is a key component of the data analysis process. Electronic data acquisition systems allow automatic flagging of data based on the status (i.e., alarms, internal diagnostics, calibration results) of the analyzer, or based on other criteria such as expected data ranges. However, review of the data by experienced personnel is still necessary. This review should be carried out promptly after data collection and should take into account any field observations such as those noted above. The aim of this review is to identify and remove suspect data, and to identify and retain valid data based on the variety of information recorded. Software associated with an electronic data acquisition system can be used to automatically compare various types of data to flag or confirm the validity of the ambient measurements.

The final step of data review is conducted to ensure that data is appropriately reduced (aggregated, averaged etc.) and formatted for reporting. The usefulness of publicly accessible data repositories is dependent on the consistency and accuracy of the processed data submitted to the repositories. Careful review of the data should take place to assure complete and correct submission of formatted data sets.

6.3 Data Management Tools to Assist the Tribes

As is the case with most tribal monitoring organizations that are running a small number of monitors, personnel can not be devoted to single tasks like data management, and therefore, it is not always easy to keep up with the data management load. In addition, the data management function in small tribal organizations requires knowledge of the analyzers and samplers (raw data retrieval), data loggers, communication services (modems, satellite telemetry etc.) data storage, and transfer to external data bases. Realizing the burdens that are placed on the tribal monitoring organizations, tools have been developed that should make the data management job easier.

The Tribal Data Toolbox -

The Institute for Tribal Environmental Professionals (ITEP) developed the Tribal Data Toolbox. This data management tool offers tribes a comprehensive MS Access database that can house all operational data from air monitoring operations, including administration (site, sampler, QC equipment, and personnel data), operations (importing and flagging continuous met and pollutant data and PM filter data), analysis (QC reports, summary reports, charts, ozone NAAQS calculations), and reporting (AQS-format file generation for all pollutant and met data). The Toolbox is form-driven so users do not need to know Access programming to use it. Results of QC checks are entered into the database and used to validate data.

The Toolbox has been pilot tested at a number of tribal programs and against a wide variety of instruments, methods, and dataloggers. Three phases of data review and validation are incorporated into the Toolbox, so that data is sent through a “pipeline” of:

1. data review and flagging (qualification) at the time of initial import,
2. quarterly data flagging based on logbooks and audit reports, and
3. final data validation to determine data acceptability for AQS data entry, final report generation, and the assignment of AQS null value codes.

The database provides functions for backing up and archiving data. All data tables, charts, and reports can be exported to MS Word, Excel or Adobe.

The User Guides are hyperlinked from within the database, and provide over 100 pages of operation-specific help. The Toolbox is ideal as a stand-alone data management system or in conjunction with other software. An advantage of the Toolbox is that it can be a repository for all the tribe’s air data, enabling queries such as parameter-to-parameter comparisons by date, site, or other factors. Existing databases, text files, or excel files can be easily imported.

An on-line course on the Toolbox will be ready for students in 2007. This course will provide example data from met sensors, gas analyzers, PM continuous instruments, and PM filter data and provide specific exercises for each function. In addition to the Toolbox, ITEP staff can, as resources allow, come to tribal offices, import existing data and train new users. As ITEP continues to improve the Toolbox, new versions will be released and each version will include an import-previous-version function so that no data is lost.

Tribal Environmental Exchange (TREX) Network-

In Fiscal Year 2005, the Walker River Tribe took a lead role in establishing the **TR**ibal **E**nvironmental e**X**change (TREX) Network in partnership with federally recognized tribes, ITEP, and IPS MeteoStar, Inc. The TREX Network is designed to assist tribes, who are actively conducting ambient air monitoring activities using continuous samplers, by developing a streamlined approach to retrieve air data quickly, validate the data, and submit it to national databases such as EPA's Air Quality System (AQS), AIRNow, and the Air Quality Index (AQI). The TREX Network tribes are able to accomplish data collection, validation, and submission to EPA national databases by using software known as Leading Environmental Analysis Display System (LEADS).

The TREX Network serves as an additional form of technical support to tribes who are interested in submitting air quality data to AQS, AIRNow, and the AQI. The next step is to upgrade the TREX Network's capabilities to send data via a CDX node to the EPA databases. Tribes must pay an annual fee to IPS MeteoStar to use the LEADS Software. LEADS can prepare AQS-ready files, but the tribal-user needs to validate and submit the data to AQS.

VOCDat-

VOCDat is a Windows-based program that imports and displays air pollutant data collected as part of the air toxics, particulate matter, and ozone precursor monitoring networks. Users perform quality control tasks on the data (e.g., apply screening criteria, visually inspect data), perform exploratory data analysis, and prepare data sets ready to import to the AQS. This software enables monitoring organizations to rapidly validate and release data. VOCDat is a free program and is available at the following Website: http://vocdat.sonomatech.com/.

The Ambient Monitoring Data Analysis System (AMDAS)-

AMDAS is a PC-based, user-friendly, menu driven program that provides air quality analysts and managers with easy point-and-click access to air quality data for browsing, preparing tabular and graphical summaries, and performing statistical analyses. No knowledge of statistical data analysis software programs is required to use AMDAS. AMDAS currently includes features specifically designed for the analysis of meteorological and air quality data contained in EPA's Air Quality System (AQS). AMDAS can be used to analyze meteorological data, routine air quality data (i.e., hourly ozone, oxides of nitrogen, carbon monoxide, etc.), speciated VOC and carbonyl compound data (i.e., PAMS data), and atmospheric particulate matter data, including PM-10 and PM-2.5 total mass and speciated sample data.

AMDAS is primarily written in the S statistical computing language and makes use of the many enhancements and extensions to S contained in the S-PLUS data analysis package. To use AMDAS, the user must have the S-PLUS 6.2 statistical data analysis software package installed on a Windows PC. S-PLUS is available from Insightful Corp. (www.insightful.com). AMSDAS is free and can be obtained from the Enhanced Ozone & Precursor Monitoring website located at http://www.environ.org/amdas/.

Technical Assistance for Data Management -

ITEP Technical Specialists are available to assist tribes one-on-one with using the Tribal Data Toolbox, or, to a more limited extent, their own systems to prepare valid, AQS-submission ready files. Most assistance will be provided by phone or online. The American Indian Air Quality Training Program's (AIAQTP) Professional Assistance (PA) Program provides some funds to cover travel. Funds are allocated each year based on requests and specific needs but travel funds for this service can not be guaranteed. Tribes may want to consider securing travel funds for a one-on-one technical specialist visit, if needed.

6.4 Data Transfer to External Databases

Depending on the monitoring objectives, tribes may be participating/supporting national monitoring programs like IMPROVE, CASTNET, NCore or SLAMS. These programs have databases that accept data under particular formats and requirements. As mentioned earlier, developing DAS systems to capture the data in the specific formats is very advantageous and may alleviate many data processing steps. Since the AQS system is one of the major systems that the tribes will report data to, the next few sections will be devoted to a discussion of this system.

Air Quality System (AQS)-

AQS is the system administered by the EPA and is used by many different groups to assess the status of the Nation's air quality. The Office of Air Quality Planning and Standards (OAQPS) and other AQS users rely upon the system's data to assess air quality, assist in attainment/non-attainment designations, assess trends, evaluate state implementation plans (SIPs) for non-attainment areas, perform modeling for permit review analysis, and other air quality management functions. AQS information is also used to prepare reports for Congress as mandated by the Clean Air Act.

The AQS includes a repository of ambient concentrations of air pollution data collected by EPA, tribal, state, and local air pollution control agencies from thousands of monitoring stations. AQS also contains meteorological data, descriptive information about each monitoring station (including its geographic location and its operator), and quality assurance/quality control information.

Using AQS-

In order to use AQS, monitoring organization representatives must be registered AQS users. AQS registration forms and procedures are available on the AQS website http://www.epa.gov/ttn/airs/airsaqs/. Registration forms should be submitted to the appropriate EPA Regional Office (also listed on the website) for processing and approval. Once approved, an AQS user identification and password will be provided.

Agencies can either designate the agency representatives for data entry or data retrieval (or both). Only individuals designated for data entry can add or modify the agency's data within AQS. All registered users can retrieve any data (i.e., their agency's data or any other agency's data) in many different formats from AQS.

Getting Data into AQS-

In order to report data to or access data from AQS, you will need the following hardware/software:

Hardware:

PC:	IBM Compatible
Disk space:	180 MB , Additional space will be needed for data files
Processor:	Pentium 600 MHz or better (120 MHz minimum)
Memory:	64MB RAM or more (32MB minimum)
Video Card:	SVGA (800X600 resolution) or XGA (1024X768 resolution) or better
Display:	256 colors or better
Additional:	Mouse and CD-ROM (if not downloading software)

Software:

Platforms:	Windows 95, 98, ME, 2000, NT, XP
Connectivity:	Microsoft Internet Explorer 5.5 and Internet access TCP/IP or EPA WAN
Additional:	Adobe Acrobat Reader

The AQS User's Guide provides excellent details on how to submit data and/or retrieve data from AQS. This manual can be found at the following website http://www.epa.gov/ttn/airs/airsaqs/manuals/manuals.htm.

AQS Data Submission Requirements-

EPA regulations, for data used in comparison the NAAQS, require monitoring organizations to report air monitoring data at least quarterly. Data for one calendar quarter are due to EPA by the end of the following quarter. However, some values may be absent due to incomplete reporting, and some values subsequently may be changed due to quality assurance activities. Today, monitoring organizations can submit data directly to AQS via a web application. Users will need access to the internet in order to access AQS. Registered users may also retrieve data through the AQS application and through the use of third party software such as the Discoverer tool from Oracle Corporation. In addition, the data submitted to AQS is certified as valid on an annual basis. This normally occurs 6 months (by July 1) after the end of the calendar year (i.e., 2006 data is certified by July 1, 2007).

Who has Access to Data Once Submitted to AQS ?

Registered users have direct access to all data in AQS and they typically make over 60,000 data retrievals from AQS a year. AQS data can be retrieved in over 30 different fixed format reports and/or work files. Although the public has access to retrieve data, only tribal personnel with rights (through AQS passwords), and the EPA AQS administrator have the authority to change data in AQS for a particular tribes monitors.

AQS data are also available to non-registered users, including the general public through a number of web-based systems including:

AirData – The website provides access to air pollution data for the entire United States. AirData produces reports and maps of air pollution data based on specific criteria. The site provides access to yearly summaries of United States air pollution data, taken from AQS. AirData has annual summary data only and does not include detailed hourly or daily measurements of air pollution http://www.epa.gov/air/data/index.html.

AirNow- EPA, NOAA, NPS, tribal, state, and local agencies developed the AIRNow website to provide the public easy access to national air quality information for $PM_{2.5}$ and ozone. The website offers daily AQI forecasts, as well as real-time AQI conditions for over 300 cities across the U.S. and provides links to more detailed air quality websites http://airnow.gov/.

***AQS* DataMart-** Users of the AQS Data Mart are air quality data analysts in the regulatory, academic, and health research communities who need to download large volumes of detailed air quality data for analysis. The AQS Data Mart itself does not provide interactive analytical tools. Anyone can get access to the system, but a Central Data Exchange (CDX) node (EPA's link to the Exchange Network) user ID and password are required to execute the service. You can get a user ID and password by calling the CDX Node Helpdesk at 888-890-1995 or emailing at epacdx@csc.com and telling them you need a node account to access the AQS Data Mart http://www.epa.gov/ttn/airs/aqsdatamart/.

How AQS can be used to Retrieve Tribal Monitoring Data in Useful Forms?

OAQPS modified AQS to allow the use of tribal codes in the place of state/county codes for data loading and retrieval. This change allows tribal users to submit and retrieve tribal data without using a reference to geo-political FIPS State and County codes, and thus reinforces EPA's commitment to recognizing tribal sovereignty. In addition, AQS has created a Monitor Type Code "Tribal Monitor". It is suggested that the tribes use this code to identify the monitors under the tribe's responsibility.

AQS Technical Support

There are a number of ways that tribes can get assistance in using AQS. The following lists some sources of assistance.

AQS Application Online Help-

The AQS application features online help from the AQS Users Guide. This User Guide and other user manuals should be the first source for help. Appendix A of this User Guide includes screen prints of most menus, definitions of icons and a glossary of terms.

AQS Website-

The AQS website http://www.epa.gov/ttn/airs/airsaqs/ is an important resource for AQS users. The website contains a wide range of information for the AQS users including:

- AQS registration procedures
- All AQS related manuals and documents, including the AQS Data Dictionary, the AQS Coding Manual, the AQS User Guide and AQS Training materials
- Descriptions of codes used in AQS
- Lists of frequently asked questions (FQA's) with answers
- Copies of important memos related to AQS, including all those issued with the release of AQS enhancements (i.e., "release memos")
- List of AQS contacts in EPA and in monitoring agencies
- Access to hundreds of data files, primarily nationwide data files by pollutant, by year
- Information about the location and agenda for the annual AQS Conference

The AQS Helpdesk-

The EPA Call Center is available at 1-866-411-4EPA (4372) or via email at epacallcenter@epa.gov . Hours are Monday-Friday 6:00am – 6:30pm Eastern Time. The helpdesk should also be your initial contact for any user problems. There are basically two levels to the help desk. All calls initially go to the EPA Call Center in Washington which might be considered Level 1. The Level 1 personnel can handle most simple questions or issues related to passwords or problems associated with AQS access. If the problem is more complicated it will be forwarded to a staff in RTP, NC (Level 2) who are more knowledgeable about the AQS system. Call center personnel will log and track the problem and contact the user with a resolution or any other necessary follow-up. When calling the helpdesk, the user must identify his/herself as an "AQS user" because Level 1 personnel support multiple applications. This helpline covers all aspects of AQS, from simple questions such as changing passwords, modifying reports and retrieving specific data, to changing/correcting monitoring data. Also, EPA's ten regional offices each have an AQS representative that assist tribes in using AQS.

If the problem relates directly to CDX, such as problems using the CDX Customer Retrieval Key, a CDX mailbox issue, or invalid/expired CDX password, contact CDX Help Desk at 1-888-890-1995 or via email at epacdx@csc.com. Hours are Monday-Friday 8:00am – 6:00pm Eastern Time.

AQS User Support Network-

A user support network has been established for use by the AQS user community. Please feel free to use the user support network to make comments and suggestions. Questions, comments and suggestions may help someone else with a similar problem, as well as provide EPA with a better feel for problems in using the application. The user support network can be accessed at http://groups.yahoo.com/group/AQSUsers/. Instructions for use of the group are available from Yahoo. Please realize that the use of Yahoo for the group does not imply any endorsement of Yahoo by the US EPA. This group is un-moderated and EPA is not responsible and does not endorse information therein.

AQS User Notices from EPA-

E-mails containing AQS updates and information are periodically sent to all registered AQS users. For example, when AQS is enhanced or modified, a detailed notice is sent to all users explaining the changes. Also, AQS users are notified about planned (and unplanned) occasions when AQS will not be operational, such as for scheduled maintenance by the National Computer Center or when AQS must be taken off-line to install a new enhancement.

AQS users should remember to keep their e-mail address and other contact information current. If users need to make changes or updates to their contact information, they should log onto AQS and select "Admin", then "Security" from the toolbar, and update information.

Tribal Q&A Web Conferencing Sessions-

Another avenue to seek help is through the Tribal Q&A web conferencing session, which allows all participants to follow a briefing or demonstration on each user's desktop PC screen. These sessions include personnel from EPA, ITEP and any tribe that would like to participate and/or needs help solving an AQS problem. The goal of the Group is "to work together to solve each others problems". Tribes that have been successful in getting the data management systems to report into AQS are invited to participate in order to help others be successful in this process. Calls take place every two months and are advertised on the ITEP website.

AQS Orientation Training-

Each month, EPA invites new registered users to participate in an AQS orientation training session. The orientation session is presented by the AQS User Support Team members that AQS users work with if they have problems using the AQS system. This session uses a web conferencing system which allows all participants to follow a briefing or demonstration on each user's desktop PC screen. The orientation session provides a new user with :

- a brief demo of how to navigate through AQS screens,
- a walkthrough of available resources (manuals, training materials) on the AQS Website, and
- an introduction of the AQS Support Team and functions.

The overheads for this orientation session are on the AQS website at: http://www.epa.gov/ttn/airs/airsaqs/training/training.htm.

AQS Introductory Training Courses-

EPA offers AQS Introductory training a number of times a year, in addition to offering it at their annual meeting. The 2 ½ days hands-on computer training course teaches students how to navigate through the AQS software, including how to load and retrieve data. Topics include:

- Components of AQS
- AQS user registration
- Data management & formatting
- Hardware/software needs
- AQS data types
- Editing data for AQS
- Precision & Accuracy Reporting System (PARS)
- Standard reports

Visit the AQS website for information on the next training course http://www.epa.gov/ttn/airs/airsaqs/training/training.htm. This site also posts all the training materials.

ITEP, in cooperation with EPA, also offers AQS introductory training courses. The AQS course is designed to teach tribal air quality professionals to perform the data entry operations involved with data reporting to the AQS. Computer work involving hands-on data entry (upload), access, and retrieval is a major focus of the training. OAQPS and experienced tribal staff act as the instructors for these courses. Some participants may need a follow-up on-site visit to order to connect to the AQS system and prepare data for submission. Visit the ITEP website for information on the next training course http://www4.nau.edu/itep/trainings/aiaqtp.asp.

Section 7

Data Interpretation-Understanding Monitoring Data and Its Implications

There are many approaches to data interpretation ranging from a simple data summary to complex statistical procedures. The range of possibilities can be overwhelming, but is easily narrowed by asking a simple question: "Why was monitoring conducted in the first place?" The appropriate use of monitoring data is intimately linked with the monitoring objective. Assuming that the monitoring agency has followed the procedures outlined in previous sections of this document, the existing or proposed monitoring plan has a purpose in mind and steps have been taken to ensure that the final data product is adequate for its intended purpose.

For example, an agency located in a potential high ozone area may set up an ozone monitor to determine attainment of the National Ambient Air Quality Standard (NAAQS). Quality assurance measures must be put in place to collect reliable data for a 3-year period. If the dataset is found to meet data quality objectives, then it may be used as the basis for NAAQS attainment designation for the area. If the data are incomplete or otherwise compromised, then an attainment determination may not be possible.

Similarly, there are data quality requirements for hazardous air pollutant (HAP) monitoring which is intended for use in exposure assessment and health risk interpretation. It is not uncommon for an agency to collect ambient HAP data only to later discover that the wrong target compounds were reported or that detection limits were too high to allow comparing the data against cancer risk benchmarks. These problems can be minimized by effective planning which identifies the intended use of monitoring data and delineates specific monitoring quality objectives.

The main goal of this section is to help tribal staff achieve monitoring program objectives through an effective use of monitoring data. The section will provide an overview of data uses and links to relevant guidance documents and examples. Possible data uses include: determining attainment of NAAQS for criteria pollutants; characterizing population exposure to HAPs, also known as "air toxics"; assessing air pollutant trends over time; and attributing source contribution to air pollution.

Basic data summary and statistical techniques allow the monitoring agency to effectively communicate project results. These methods are important for a variety of purposes: to inform tribal members and other stakeholders about local air quality; to summarize monitoring results in final project report or grant related documents; and to describe prior air quality findings as part of the justification for new or continued funding in a grant application.

This section will be useful to an agency that has already collected a dataset and needs help understanding it. However it may be even more valuable to a program manager who is in the stages of planning an air quality study as it will provide a clear understanding of what an ambient monitoring program can do for them and what questions it can answer. Depending on the technical capabilities of tribal staff, some of the techniques described here may be performed in-house, while others may require partnering with another agency or hiring a contractor.

7.1 Specific Data Uses

Criteria pollutants -

Tribal agencies that conduct ambient air quality monitoring most frequently collect data for the six common pollutants (also referred to as "criteria" pollutants): carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM), and sulfur dioxide (SO_2). PM falls into two categories: particles that are10 micrometers in diameter and smaller (PM_{10}) and particles that are 2.5 micrometers in diameter and smaller ($PM_{2.5}$). This section will describe how criteria pollutant monitoring data may be interpreted and used as part of an air quality management program. For more information on sources of criteria pollutants, see: http://www.epa.gov/air/urbanair/6poll.html

NAAQS Attainment -

EPA has set NAAQS standards for the six criteria pollutants. The NAAQS include both primary and secondary standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. Table 7-1 below lists the current NAAQS for criteria pollutants. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$). Appendix G provides additional information about the NAAQS standards.

"Designation" is the term EPA uses to describe the air quality in a given area for any of the criteria pollutants. Geographic areas are designated as "attainment" or "nonattainment" based on ambient air monitoring data collected in that area and reported to the AQS national database. Tribes and states submit recommendations to EPA as to whether or not an area is attaining the NAAQS for a criteria pollutant. After working with the tribal and state agencies and considering the air quality data, EPA officially designates an area as attainment or nonattainment. If an area is designated as nonattainment, state, local and tribal governments must develop and implement control plans to reduce pollution. A Tribal Implementation Plan (TIP) is a set of regulatory programs that a tribe develops and adopts to help attain or maintain national air quality standards. EPA designates an area as a "maintenance area" once a nonattainment area meets the standards and additional redesignation requirements in the AA [Section 107(d)(3)(E)],

Table 7-1. National Ambient Air Quality Standards

Pollutant	Primary Stds.	Averaging Times	Secondary Stds.
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour[(1)]	None
	35 ppm (40 mg/m^3)	1-hour[(1)]	None
Lead	1.5 µg/m^3	Quarterly Average	Same as Primary
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	Revoked[(2)]	Annual[(2)] (Arith. Mean)	Revoked[(2)]
	150 µg/m^3	24-hour[(3)]	Same as Primary
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual[(4)] (Arith. Mean)	Same as Primary
	35 µg/m^3	24-hour[(5)]	Same as Primary
Ozone	0.08 ppm	8-hour[(6)]	Same as Primary
	0.12 ppm	1-hour[(7)] (Applies only in limited areas)	Same as Primary
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)	-------
	0.14 ppm	24-hour[(1)]	-------
	-------	3-hour[(1)]	0.5 ppm (1300 µg/m^3)

Source http://www.epa.gov/air/criteria.html

[(1)] Not to be exceeded more than once per year.

[(2)] Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the agency revoked the annual PM_{10} standard in 2006 (effective December 17, 2006).

[(3)] Not to be exceeded more than once per year on average over 3 years.

[(4)] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m^3.

[(5)] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m^3 (effective December 17, 2006).

[(6)] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

[(7)] (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is $\leq$ 1, as determined by appendix H.
(b) As of June 15, 2005 EPA revoked the 1-hour ozone standard in all areas except the fourteen 8-hour ozone nonattainment Early Action Compact (EAC) Areas.

The website listed below provides an unofficial list of tribes in 8-hour ozone nonattainment areas as of April 15, 2004. Official nonattainment boundaries are specified in 40 CFR Part 81. http://www.epa.gov/ozonedesignations/tribaldesig.htm.

Detailed instructions on how to determine attainment status based on ambient monitoring data may be found in the Code of Federal Regulations (CFR) Title 40 Part 50. The relevant passages for each criteria pollutant is included as Appendix G and may also be accessed on the web at: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e18bc4907fc6d399c035b0bd125e238b&tpl=/ecfrbrowse/Title40/40cfr50_main_02.tpl.

Understanding the Air Quality Index (AQI) and AIRNow-

The AQI is an index for reporting daily air quality. It tells how clean or polluted the air is and what associated health effects might be a concern for the public. The AQI focuses on health effects that may be experienced within a few hours or days after breathing polluted air. EPA calculates the AQI for five of the criteria pollutants: O_3, PM, CO, SO_2, and NO_x. The AQI scale runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of “50” represents good air quality with little potential to affect public health, while an AQI value over “300” represents hazardous air quality.

An AQI value of “100” generally corresponds to the national air quality standard (see Table 1) for the pollutant, which is the level EPA established set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above “100”, air quality is considered to be unhealthy – at first for certain sensitive groups of people, then for everyone as AQI values get higher.

Raw ambient air monitoring data is converted into AQI values using standard formulas developed by EPA. An AQI value is calculated for each pollutant in an area. The highest AQI value for the individual pollutants is the AQI value for that day. For example, if a certain date had AQI values of “90” for ozone and “88” for sulfur dioxide, the AQI value would be “90” for that area on that day.

The purpose of the AQI is to help the public understand what local air quality means to their health. To make it easier to understand, the AQI is divided into six categories, each of which corresponds to a different level of health concern. The six levels of health concern and what they mean are:

- **"Good" (green)-**The AQI value for your community is between 0 and 50. Air quality is considered satisfactory, and air pollution poses little or no risk.
- **"Moderate" (yellow)** -The AQI for your community is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **"Unhealthy for Sensitive Groups"(orange)-**When AQI values are between 101 and 150, members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.
- **"Unhealthy" (red)-** Everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects.
- **"Very Unhealthy"(purple)-** AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.
- **"Hazardous"(dark red)-** AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

The AIRNow website at: http://www.airnow.gov/ delivers daily AQI forecasts as well as real-time AQI conditions for over 300 cities across the United States. EPA developed the AIRNow program together with the National Oceanic and Atmospheric Administration (NOAA), National Park Service (NPS), and tribal, state, and local agencies to provide the public with easy access to national air quality information. AQI data are presented in maps which are generated based on "real-time" ambient monitoring data using either federal reference or equivalent monitoring techniques or techniques approved by the state, local or tribal monitoring agencies. Although some preliminary data quality assessments are performed, the data are not fully verified and validated through the quality assurance procedures that monitoring organizations use to officially submit and certify data in AQS. Therefore, data that are used on the AIRNow website are for the purpose of reporting the AQI. Information on the AIRNow website is not used to formulate or support regulation, guidance or any other Agency decision or position.

There are a number of tribal monitoring agencies participating in AIRNow. Tribes interested in joining the AIRNow network should visit the publications site at the AIRNow website. There is a guidance document entitled "*Guideline for Reporting of Daily Air Quality - Air Quality Index (AQI)*" which is designed to aid local agencies in reporting the air quality using the AQI as required in the Code of Federal Regulations (CFR).

> **NOTE:** In December 2006 EPA revised the PM2.5 daily standards (24-Hour) from 65 to 35 ug/m3. EPA is expected to modify the AQI to match this new standard in Spring, 2008. Although the basic concepts described above will remain the same, there may be some changes in AQI values.

Air quality characterization for ambient, deposition, and visibility data -

The previous section focused on criteria pollutants and interpreting data in terms of the NAAQS rules. Beyond the six criteria pollutants, however, there are hundreds of other pollutants and indices that a monitoring agency may wish to address. These non-criteria pollutants and measures include ambient air toxics, wet/dry deposition, visibility data, and even biomonitoring of ozone injury to sensitive plants. These types of data do not have corresponding national air quality standards that help guide data summary and interpretation. Instead, monitoring results should be described using basic summary statistics. The data may also be visualized using simple graphic techniques. The national monitoring network fact sheets in Appendix A provide additional details about these important national air programs and include weblinks to areas that describe the uses of the data.

7.2 Basic Data Interpretation Summary Statistics

The first step in summarizing air quality data is to take inventory of the number of samples collected, the range of measurements, and to provide related information about the monitoring schedule. It is important to specify the measurement units of the pollutant. If any of the samples are below detection limits (called "nondetects"), then it becomes necessary to state the method detection limit (MDL), as well as the number or percent of samples below the MDL. An example in table form is shown below.

Table 7-2. Example of Monitoring Data Summary

Pollutant	Sampling schedule	Sampling period	Total samples	Unit	MDL	Min. value	Max. value	Percent samples <MDL
Benzene	1-in-6 days	Jan. 2003 – Dec. 2004	107	ppbC	0.01	0.02	1.3	0
1,3-butadiene	1-in-6 days	Jan. 2003 – Dec. 2004	107	ppbC	0.01	Below MDL	0.8	78%
Arsenic (PM_{10})	Monthly	Jan. 2003 – June. 2004	18	ug/m^3	0.002	Below MDL	0.012	65%
Cadmium (PM_{10})	Monthly	Jan. 2003 – June. 2004	18	ug/m^3	0.01	Below MDL	0.02	21%
Lead (PM_{10})	Monthly	Jan. 2003 – June. 2004	18	ug/m^3	0.005	0.008	0.31	0

If any of the monitored pollutants has nondetect values, then this issue must be resolved before moving on to data analysis. There are a number of ways to handle data that is below some level of detection and guidance should be sought on the best way to handle this information. It is generally not recommended to delete nondetects from the dataset because this will cause an upward bias in the results; similarly nondetects should not be replaced by zeroes because this biases the results downward.

Note that a high percentage of nondetects results in less reliable data summary statistics. Although there is no definite cut-off, a pollutant with greater than 50% nondetects should be treated with care and one with more than 80% nondetects may be removed from further analysis or may need to be summarized in a different manner. Depending on the importance of a specific pollutant to the monitoring study, the data analyst has a few choices: state that the pollutant has a very high rate of nondetects and remove it from the data analysis; include the pollutant and point out potential problems related to nondetects; or include the pollutant and use advanced statistical techniques developed for datasets with a high rate of nondetects. Statistical techniques that may be useful in handling datasets with a high rate of nondetects are described in the following article: *Less than obvious – statistical treatment of data below the detection limit*, Dennis R. Helsel (USGS), Environmental Science and Technology, Vol. 24, No. 12, 1990.

The rest of this section describes ways to summarize basic characteristics of the dataset using common statistical measures. Some useful examples include: measures of central tendency, such as the mean or median; measures of relative standing, such as percentiles; measures of dispersion, such as range, variance, standard deviation, coefficient of variation, or interquartile range; measures of distribution symmetry or shape; and measures of association between two or more variables, such as correlation. These measures can be used for description and communication about the dataset.

The definitions and procedures outlined in the next sections are primarily taken from the EPA document "Guidance for Data Quality Assessment – Practical Methods for Data Analysis" (EPA/600/R-96/084) which is available at the website: http://www.epa.gov/quality/qs-docs/g9-final.pdf .

Mathematical formulas that allow the user to calculate descriptive statistics using a simple calculator or computer spreadsheet program are provided in this section. Data analysts that want to perform advanced statistical procedures may consider investing in a statistical software packages. Resources for those interested in learning more are provided at the end of this section.

Central tendency -

The most common estimates for central tendency in environmental data are the mean and median. The **mean** may be considered to be the "center of gravity" of the dataset. It is calculated as a basic arithmetic average. The **median** is the value which falls directly in the middle of the data when the measurements are ranked in order from smallest to largest. Thus ½ of the data are smaller than the sample median and ½ of the data are larger than the sample median. Unlike the mean, the median is not influenced by a small number of extreme values.

Formula 1. Measuring central tendency

Let $X_1, X_2, \ldots, X_n$ represent the n data points.

Sample Mean: The sample mean $\bar{x}$ is the sum of all the data points divided by the total number of data points (n):

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

Sample Median: The sample median ($\tilde{X}$) is the center of the data when the measurements are ranked in order from smallest to largest. To compute the sample median, list the data from smallest to largest and label these points $X_{(1)}, X_{(2)}, \ldots, X_{(n)}$ (so that $X_{(1)}$ is the smallest, $X_{(2)}$ is the second smallest, and $X_{(n)}$ is the largest).

If the number of data points is odd, then $\tilde{X} = X_{([n+1]/2)}$

If the number of data points is even, then $\tilde{X} = \dfrac{X_{(n/2)} + X_{([n/2]+1)}}{2}$

Relative Standing (Percentiles) -

It may be useful to know the relative position of one or several observations in relation to all of the observations. Percentiles are one such measure of relative standing that may also be useful for summarizing data. A percentile is the data value that is greater than or equal to a given percentage of the data values. For example the data point which is the 25^{th} percentile is greater than or equal to 25% of the data values and is less than or equal to 75%. Important percentiles usually reviewed are the quartiles of the data: the 25^{th}, 50th, and 75^{th} percentiles. The 50^{th} percentile is also called the sample median (previously described), and the 25^{th} and 75^{th} percentiles are used to estimate the dispersion of a data set (next section).

Formula 2. Calculating percentiles

Let $X_1, X_2, ..., X_n$ represent the n data points. To compute the p^{th} percentile, y(p), first list the data from smallest to largest and label these points $X_{(1)}, X_{(2)}, . . ., X_{(n)}$ (so that $X_{(1)}$ is the smallest, $X_{(2)}$ is the second smallest, and $X_{(n)}$ is the largest). Let t = p/100, and multiply the sample size n by t. Divide the result into the integer part and the fractional part, i.e., let nt = j + g where j is the integer part and g is the fraction part. Then the p^{th} percentile, y(p), is calculated by:

If g = 0, $y(p) = (X_{(j)} + X_{(j+1)})/2$

otherwise, $y(p) = X_{(j+1)}$

<u>Example</u>: The 90^{th} and 95^{th} percentile will be computed for the following 10 data points (ordered from smallest to largest) : 4, 4, 4, 5, 5, 6, 7, 7, 8, and 10 ppb.

For the 95th percentile, t = p/100 = 95/100= .95 and nt = (10)(.95) = 9.5 = 9 + .5. Therefore, j = 9 and g = .5. Because g = .5 $\neq$ 0, $y(95) = X_{(j+1)} = X_{(9+1)} = X_{(10)}$ = 10 ppm. Therefore, 10 ppm is the 95^{th} percentile of the above data.

Measures of Dispersion-

Measures of central tendency are more meaningful if accompanied by information on how the data spread out from the center. Measures of dispersion in a data set include the range, variance, sample standard deviation, coefficient of variation, and the interquartile range. These measures are all described below and formulas provided.

The easiest measure of dispersion to compute is the sample ***range***. For small samples, the range is easy to interpret and may adequately represent the dispersion of the data. For large samples, the range is not very informative because it only considers (and therefore is greatly influenced) by extreme values.

The sample ***variance*** measures the dispersion from the mean of a data set. A large sample variance implies that there is a large spread among the data so that the data are not clustered around the mean. A small sample variance implies that there is little spread among the data so that most of the data are near the mean. The sample variance is affected by extreme values and by a large number of nondetects. The sample standard deviation is the square root of the sample variance and has the same unit of measure as the data.

The ***coefficient of variation (CV)*** is a unitless measure that allows the comparison of dispersion across several sets of data. The CV is often used in environmental applications because variability (expressed as a standard deviation) is often proportional to the mean.

When extreme values are present, the ***interquartile range*** may be more representative of the dispersion of the data than the standard deviation. This statistical quantity does not depend on extreme values and is therefore useful when the data include a large number of nondetects.

Formula 3. Calculating measures of dispersion

Let $X_1, X_2, ..., X_n$ represent the n data points.

Sample Range: The sample range (R) is the difference between the largest value and the smallest value of the sample, i.e., R = maximum - minimum.

Sample Variance: To compute the sample variance (s^2), compute:

$$s^2 = \frac{\sum_{i=1}^{n} X_i^2 - \frac{1}{n}(\sum_{i=1}^{n} X_i)^2}{n-1}$$

Sample Standard Deviation: The sample standard deviation (s) is the square root of the sample variance, i.e.,

$$s = \sqrt{s^2}$$

Coefficient of Variation: The coefficient of variation (CV) is the standard deviation divided by the sample mean (Section 2.2.2), i.e., CV = s/ $\bar{X}$. The CV is often expressed as a percentage.

Interquartile Range: Use the directions in Section 2.2.1 to compute the 25th and 75th percentiles of the data (y(25) and y(75) respectively). The interquartile range (IQR) is the difference between these values, i.e.,
IQR = y(75) - y(25).

Trends analysis-

EPA uses trend analysis to assess year-to-year changes in ambient air quality and pollutant emissions. Annual Trends Reports are EPA's "report card" on the status of air quality and emission reductions. Annual trends reports and special studies dating back to 1994 are available at: http://www.epa.gov/airtrends/reports.html. Some methods used in these reports will be useful to tribal agencies.

The data analyst needs a reasonably long and complete dataset to distinguish a genuine trend from other kinds of data variability. A suspected trend in data may not be a "real" trend, but a function of data variation caused by weather conditions or other factors. For example, because higher temperatures cause more formation of some pollutants, like ozone and formaldehyde, a year with warmer temperatures may have higher concentrations of these pollutants, regardless of any possible changes in precursor emissions. Thus the measurements in one year may be higher than the previous year, but we cannot reliably say that there is an upward trend in ambient concentrations.

Although it is tempting to calculate trends based on two or three years of data, more years are needed to calculate a meaningful trend. For dispersion modeling, meteorologists recommend using between 3 and 5 years of data to assess the "baseline" condition. With this in mind, we suggest the following:

- 1 to 3 years of monitoring data – do not use for trend analysis
- 4 to 5 years of monitoring data – consider trend results to be "preliminary"
- 6 or more years of monitoring data – adequate dataset for trend analysis

If there are enough years of data available, then it is also important to confirm that each year has adequate data completeness. Multi-year trends can only be calculated if each year has a valid summary statistic (e.g. annual mean) based on sufficient data. The issue of data completeness was previously discussed in the section on data quality objectives and data validation.

Assuming that there are enough complete years of monitoring, then an annual air quality statistic can be determined for each individual year of air monitoring and then a trend may be evaluated for multiple years.

Percent change-

Actual ambient concentrations have little meaning to the general public and a change in concentration (for example a "0.04 ppb decline over 8 years") is even more abstract. For this reason EPA most often explains trends in terms of a percent change over time. The example below (Fig. 7.1) shows the trend calculation and graph format most widely used in trend reports. The main trend statistic is the combined annual average of multiple monitoring sites. The figure also shows the 90th and 10th percentiles of all site averages for each year.

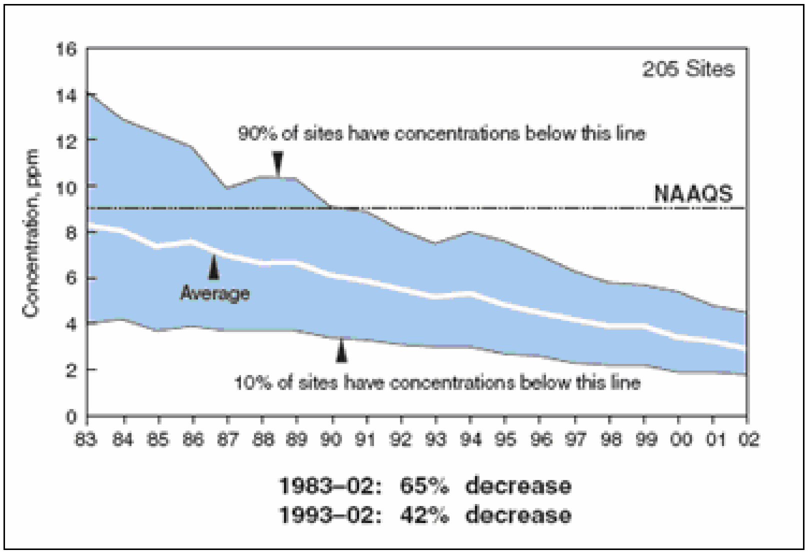


Figure 7.1 CO air quality, 1983-2002, based on annual second maximum 8-hr average

Formula 4. Percent change over multiple years of monitoring

$$P = \left[\frac{(c_F - c_S)}{c_s} \right] \times 100$$

Where C_S = concentration at the start; C_F = concentration at the finish of the time period. A positive P indicates an upward trend and a negative value indicates a downward trend.

In the carbon monoxide example above,

$$P = \left[\frac{(2.9\,ppm - 8.2\,ppm)}{8.2\,ppm} \right] \times 100 = -64.6\%$$

There are some important pitfalls to the percent change approach to trends. The main concern is that if the dataset has strong year-to-year variability, then the existence of a positive or negative trend is dependent on which years are chosen as the start and finish. Figure 7.2 below shows national annual total manganese emissions as reported to the Toxics Release Inventory (TRI). The percent change in emissions between 1988 and 2003 is –26%. However, the downward trend is magnified if we look only at 1989 through 1997 (–88%); the trend is relatively flat if the time period is 1993–1999 (–2%); the trend reversed if we look at 1991 to 1999 (+19%). For this reason it is preferable to use the percent change method for a dataset with smooth trends. Highly variable datasets should be evaluated by using a moving average (described below) or with a more rigorous statistical method, such as linear regression or using non-parametric methods.

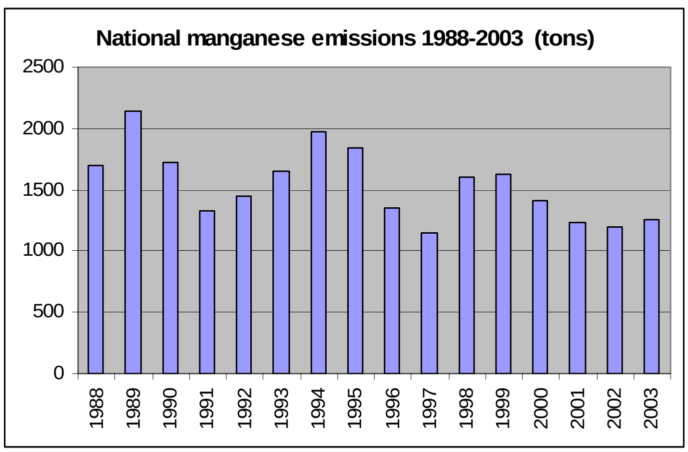


Figure 7.2. Example of dataset with variable year-to-year data

<u>National Air Toxics Trend Site (NATTS) method</u>

Trends within the new NATTS network are figured based on six (6) years of annual average concentrations for key HAPs, specifically benzene, 1,3-butadiene, arsenic, chromium, acrolein, and formaldehyde. The trend is calculated by finding the percent difference between the mean of the first three annual concentrations and the mean of the last three annual concentrations. This is a variation on the percent change method described above.

Formula 5. NATTS trend method

First the annual average concentration (Xi) is found for each year i = 1, 2, 3, 4, 5 & 6. Then the mean (X) for the first three years and the mean (Y) for years 4 through 6 is calculated:

$$X = \frac{X_1 + X_2 + X_3}{3} \text{ and } Y = \frac{X_4 + X_5 + X_6}{3}$$

The downward trend (T) is the percent decrease from the first 3-year period to the second.

$$T = \frac{X - Y}{X} \cdot 100$$

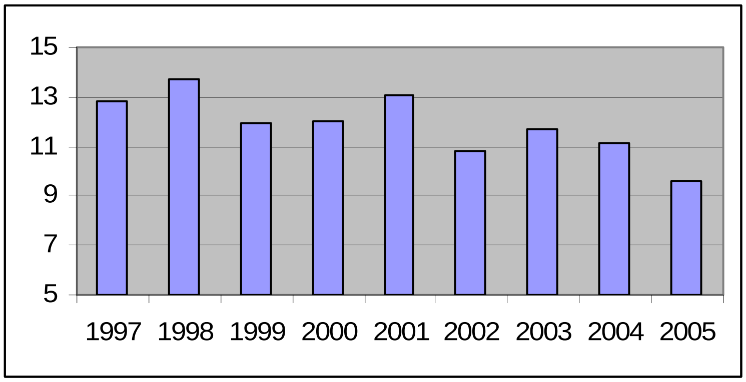
According to the data quality objectives (DQOs) for the NATTS program, a trend of at least 15 percent is considered a significant decrease. A tribal agency may wish to adopt this protocol for their own monitoring program or adapt it as needed through consultation with quality assurance experts. The Quality Assurance Guidance Document for the NATTS program is available at: http://www.epa.gov/ttn/amtic/files/ambient/airtox/nattsqapp.pdf.

Moving average-

A dataset with considerable year-to-year variability may be smoothed out by calculating a moving average. Instead at looking at annual averages that rise and fall with each year, we look at 3-year, 4-year, or 5-year averages which are less subject to variability swings.

The example graphs in Figure 7.3 below shows data graphed first as annual averages and then as a moving 3-year average. The first figure shows annual averages from 1997 to 2005; the second shows the combined average for 1997 through 1999, then 1998-2000, 1999-2001, and so forth. The downward trend in data is more evident in the second figure.

Year	Mercury wet deposition (µg/m^2)
1997	12.8
1998	13.7
1999	11.9
2000	12.0
2001	13.1
2002	10.8
2003	11.7
2004	11.1
2005	9.6



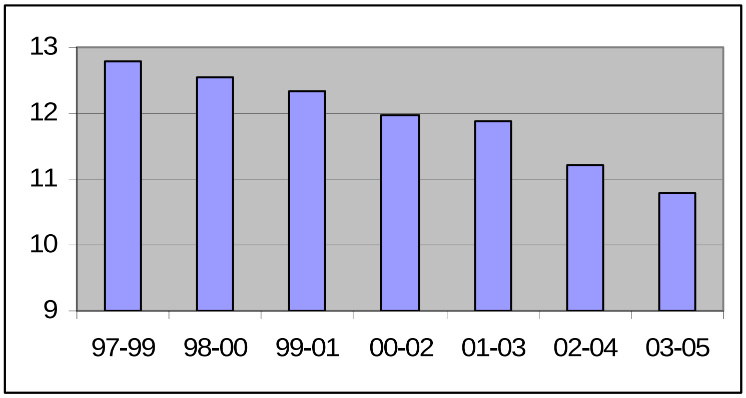


Figure 7.3 Data trend presented with annual average and moving average

7.3 Data visualization

Simple graphing techniques are useful to describe the dataset and communicate monitoring results. Graphs can be used to identify patterns and trends in the data. Graphical representations include displays of individual data points, statistical quantities, temporal data, spatial data, and two or more variables.

Detailed instructions on how to produce these graphics are provided in Section 2 of the previously mentioned "Guidance for Data Quality Assessment – Practical Methods for Data Analysis," available at: http://www.epa.gov/quality/qs-docs/g9-final.pdf.

Histogram/Frequency Plots -

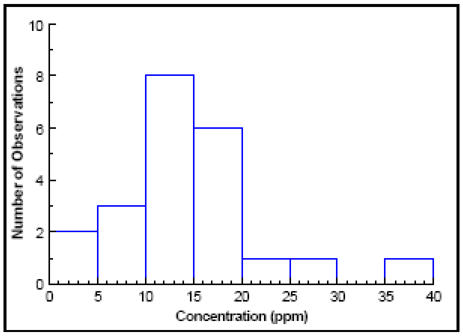


Figure 7.4. Example of a frequency plot

Two of the oldest methods for summarizing data distributions are the frequency plot (Fig. 7.4) and the histogram. Both the histogram and the frequency plot use the same basic principles to display the data: dividing the data range into units, counting the number of points within the units, and displaying the data as the height or area within a bar graph.

Box and Whisker Plot -

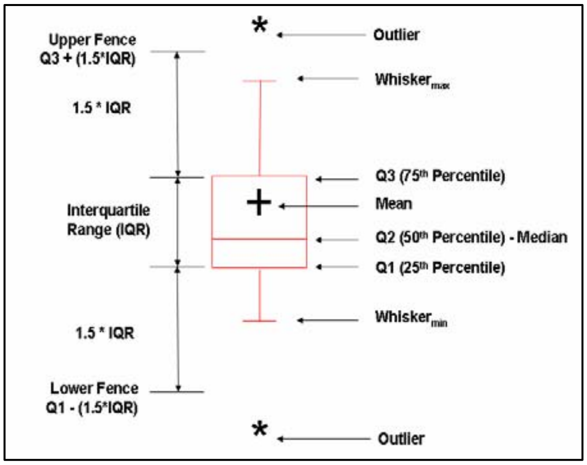


Figure 7.5. Box and whisker plot

A box and whisker plot or box plot (Fig. 7.5) is a schematic diagram useful for visualizing important statistical quantities of the data. A box and whiskers plot is composed of a central box divided by a line and two lines extending out from the box called whiskers. The length of the central box indicates the spread of the bulk of the data (the inter-quartile range, 25^{th} to 75^{th} percentile), while the length of the whiskers show how stretched the tails of the distribution are. The sample median is displayed as a line through the box and the sample mean is displayed using a '+' sign. Any unusually small or large data points are displayed by a '*' on the plot.

Scatter Plot -

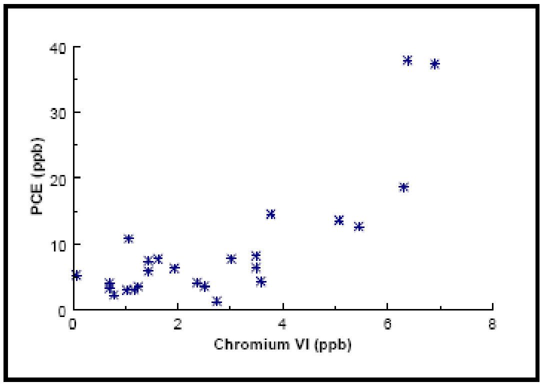


Figure 7.6. Example of a scatter plot

For data sets consisting of paired observations where two or more variables are measured for each sampling point, a scatter plot (Fig 7.6) is a powerful tool for analyzing the relationship between two or more variables. Both potential outliers from a single variable and potential outliers from the paired variables may be identified on this plot. A scatter plot also displays the correlation between the two variables. Scatter plots of highly linearly correlated variables cluster compactly around a straight line.

Time Plot -

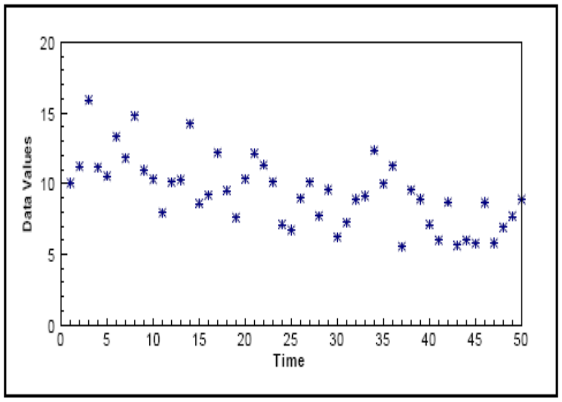


Figure 7.7. Example of a time plot

One of the simplest plots to illustrate a large amount of information is a time plot. A time plot (Fig 7.7) is a plot of the data over time. This plot makes it easy to identify large-scale and small-scale trends over time. Small-scale trends show up on a time plot as fluctuations in smaller time periods. For example, ozone levels over the course of one day typically rise until the afternoon, then decrease, and this process is repeated every day. An example of a large-scale trend is a multi-year decrease in air pollution resulting from effective air quality control programs. For example, the annual average concentration of NO_x at a particular monitoring site may decline over the course of several years as a result of emissions controls at local industries and the introduction of cleaner cars.

7.4 References, Tools, and Resources

EPA courses -

EPA's Air Pollution Training Institute (APTI) provides technical air pollution training to state, tribal, and local air pollution professionals, although others may benefit from this training. The curriculum is available in classroom, telecourse, self-instruction, and web-based formats. Examples of some courses are described below.

Introduction to Environmental Statistics

This series of online lectures was developed for EPA by the University of Illinois at Chicago School of Public Health, Environmental and Occupational Health Sciences Division. No registration is required to access the archived lectures. The lectures are available at this website: http://www.epa.gov/air/oaqps/eog/envirostats/index.html.

- Module 1: Interpreting Your Monitoring Data
- Module 2: Sampling and Analytical Limitations & Sample Detection Limits
- Module 3: Quality Assurance Quality Control
- Module 4: Analysis of Trends
- Module 5: Language of Data Graphing
- Module 6: Censored Values and Extreme Values
- Module 7: Fundamentals of Trajectory Analysis

Introduction to Environmental Statistics - SI:473B

This course introduces the student to the basic concepts of statistical analysis. The course was designed for students with little formal education in statistics who must apply statistical techniques to analyze environmental data. The package has seven modules, a workbook, and a VHS format video tape. The workbook and video tape are mailed to the student by EPA, but it is necessary to acquire one of the recommended companion texts. Course information is available at: http://www.epa.gov/air/oaqps/eog/catalog/si473b.html

Training Courses on Quality Assurance and Quality Control Activities-

EPA Quality Staff develops a variety of traditional training courses on quality assurance (QA) and quality control (QC) activities and the EPA quality system. Two subject area of particular interest are "Interpreting Monitoring Data" and "Introduction to Data Quality Assessment." Materials are available at: http://www.epa.gov/quality/trcourse.html.

Other tools and resources

Statistics books:

- **Basic Statistical Methods for Engineers and Scientists**, Adam Neville, John Kennedy, International Textbook Company (out of print)
- **Probability and Statistics for Engineers**, Irwin Miller, John Freund, Prentice Hall
- **Statistics Concepts and Applications**, David Anderson, Dennis J. Sweeney, Thomas A. Williams, West
- **Exploring Statistics – A Modern Introduction**, Larry J. Kitchens, West
- **Engineering Statistics**, Robert V. Hogg, Johannes Ledolter, Macmillan
- **Introduction to Statistical Thinking**, E.A. Maxwell, Prentice Hall
- **Statistical Analysis for Decision Making**, Morris Hamburg, Harcourt Brace Jovanovich

EPA has a website for Quality-Related Resources which contains links to other sources of information on quality systems available on the web: http://www.epa.gov/quality/qa_links.html.

Examples of tools and resources available through the EPA quality resources page:

- DataPlot (National Institutes of Science and Technology) is a free, public-domain, multi-platform software system for scientific visualization, statistical analysis, and non-linear modeling. http://www.itl.nist.gov/div898/software/dataplot.html/.
- StatPages.Net (by John C. Pezzullo) contains links to online calculators, free statistical software, online statistics books, tutorials, and related resources http://members.aol.com/johnp71/javastat.html.
- Statistics Calculators (UCLA Department of Statistics) includes calculators for statistical graphs, power calculations, sample size calculations, etc http://calculators.stat.ucla.edu/.
- Guide to Statistical Software (George Mason University) provides a comparison of commercially available statistical software http://www.galaxy.gmu.edu/papers/astr1.html.

Putting monitoring data into context

Criteria pollutants-

In addition to determining NAAQS attainment and AQI values, tribal monitoring agencies may benefit from putting monitoring data into a broader context. There are a few ways to do this. Tribes may look up data for the same pollutant at other monitoring sites located in the same state or region to see how the values compare. It may also be helpful to look at a nation-wide summary of data or a list of nonattainment areas. A broader context may also be obtained by learning about national trends in air quality data.

EPA's AirData website provides access to air pollution data for the entire U.S. as submitted to AQS. AirData produces reports and maps of air pollution data based on user-specified queries. For example, a tribal agency located in Arizona may wish to look up last year's ozone data for all monitoring sites in the state. The link below is the interface where the user selects the geographic area for the data search. Subsequent web pages narrow the search to the desired pollutant, year, and report format http://www.epa.gov/air/data/geosel.html.

EPA's Air Explorer is a collection of user-friendly visualization tools for air quality analysts. The tools generate maps, graphs, and data tables based on criteria pollutant data reported to AQS. This is a developmental site. Based on user feedback, EPA is continually improving the existing tools and developing new ones http://www.epa.gov/mxplorer/index.htm.

EPA's "Green Book" lists all nonattainment areas in the U.S. The user can access a variety of maps and reports for each criteria pollutant at this website: http://www.epa.gov/air/oaqps/greenbk/.

EPA tracks air pollution trends using two main indicators: ambient air monitoring data and pollutant emissions. EPA estimates national emissions of criteria pollutants and air toxics based on many factors, including actual measurements, levels of industrial activity, fuel consumption, vehicles miles traveled, and other estimates of activities that cause pollution. For EPA's most recent evaluation of air pollution trends, see: http://www.epa.gov/airtrends/.

The Visibility Information Exchange Web System (VIEWS) is an online exchange of air quality data, research, and ideas designed to understand the effects of air pollution on visibility in support of the Regional Haze Rule http://vista.cira.colostate.edu/views.

Air toxics, deposition, and other monitoring data-

Air toxics monitoring data from other sites in the U.S., as submitted to AQS, may be accessed through the AirData website. Additionally, some materials are available from nation-wide air toxics data analyses. The following links may be useful for putting toxics data into context:

- Geographic Variability in Air Toxics
  http://www.epa.gov/ttn/amtic/files/ambient/airtox/2005%20workshop/spatial.pdf
- Temporal Trends in Air Toxics
  http://www.epa.gov/ttn/amtic/files/ambient/airtox/2005%20workshop/temporal.pdf

The Clean Air Status and Trends Network (CASTNET) is the nation's primary source for data on dry acidic deposition and rural, ground-level ozone. CASTNET consists of over 80 sites across the eastern and western United States and is cooperatively operated and funded by the National Park Service. Data are available for download for ambient air pollutants and wet/dry deposition at this site: http://www.epa.gov/castnet/data.html.

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a national network of precipitation monitoring sites. The network includes over 200 monitoring sites, including those operated by nine tribal agencies. Data are available for download at: http://nadp.sws.uiuc.edu/sites/ntnmap.asp.

The Mercury Deposition Network (MDN) is a national database of weekly concentrations of total mercury in precipitation and the seasonal and annual flux of total mercury in wet deposition http://nadp.sws.uiuc.edu/sites/mdnmap.asp.

EPA established the National Dioxin Air Monitoring Network (NDAMN) to determine the temporal and geographical variability of atmospheric CDDs, CDFs and coplanar PCBs at rural and nonimpacted locations throughout the United States. Summary reports are available: http://www.epa.gov/glnpo/monitoring/air2/bio_toxics.html.

The Integrated Atmospheric Deposition Network (IADN) was established by the United States and Canada for conducting air and precipitation monitoring in the Great Lakes Basin. PAHs, PCBs, and organochlorine compounds are measured in air and precipitation samples in the U.S. and Canada http://www.msc.ec.gc.ca/iadn/index_e.html.

The USDA Forest Service's Forest Health Monitoring (FHM) is a national program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis. The FHM program uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources and develops analytical approaches to address forest health issues that affect the sustainability of forest ecosystems http://fhm.fs.fed.us/.

The USDA Forest Service's Forest Inventory and Analysis (FIA) uses biomonitoring to monitor the potential impact of tropospheric ozone (smog) on forests. This program uses bioindicator plants to detect and quantify ozone stress in the forest environment. A nationwide network of ozone biomonitoring sites has been established across the forested landscape. Each year, these sites are evaluated for the amount and severity of ozone injury on sensitive plants. The foliar injury data is used to monitor changes in relative air quality over time and to examine relationships between ozone stress and tree health http://www.fiaozone.net/.

Source apportionment -

In the absence of air monitoring, pollutant emissions data may be used to help characterize air quality. This Section focuses on evaluating air monitoring data in the context of emissions sources that may be impacting the monitor site. Different approaches are described to identify pollution sources and to estimate the potential to affect local air quality.

Using emissions inventories -

If monitoring data show that a specific pollutant is exceeding air quality standards, or is otherwise causing concern, then emission inventories can identify potential sources. Summary emission data are most easily accessed on EPA's website: http://www.epa.gov/air/data. By searching in the state or county of interest in AirData, the user can access the National Emission Inventory (NEI) for data on point, nonpoint, and mobile sources. NEI contains information about sources that emit criteria air pollutants and their precursors, and hazardous air pollutants. The AirData website generates reports based on facility-specific and county aggregate emissions data.

Tribal agencies can contact their respective state environmental agency to get more detailed information on sources (smaller sources) that might not be included in the NEI.

Meteorological Data-

Meteorological data collected at an air monitoring site can be used to further interpret pollutant measurements and potential impact from emissions sources. Wind data can be summarized over a year or multiple years to show prevailing wind direction at a given site. A diagram called a "wind rose" characterizes the wind conditions over time. The example below is a wind rose produced by the Texas Commission on Environmental Quality for Wichita Falls. The figure shows the frequency of winds coming from each direction, broken out by wind speed category.

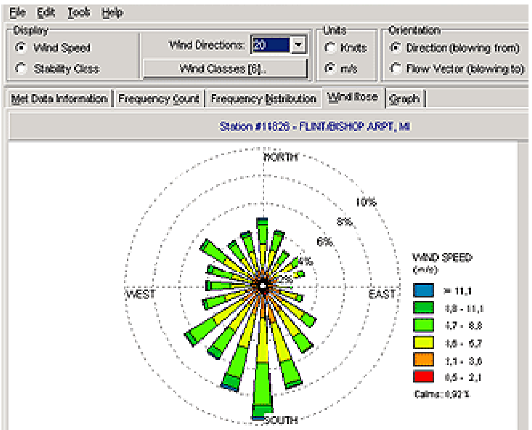


Figure 7.8. Wind rose

If a major pollution source is identified near tribal land, then a wind rose can show whether the air monitor site is likely to be downwind of the emission source on an occasional or frequent basis. An industrial facility that is predominantly upwind of tribal land is more likely to impact the air monitor than a facility that is generally downwind. A wind rose (Fig 7.8) program called WRPLOT View is available from Lakes Environmental Software for free download at this site: http://www.weblakes.com/lakewrpl.html.

To investigate further, the data analyst may conduct a wind-direction analysis. This approach requires finding daily wind data that is reported concurrently with air sampling events. Monitoring data may be divided into "high pollution days" and "low pollution days", and the meteorological data consulted to see whether higher concentrations occur on days when the winds come from a certain direction. Alternatively, each hourly or daily pollutant measurement can be divided into one of sixteen categories according to the predominant wind sector (north, north-northeast, northeast, east-northeast, etc.) and the average concentrations for all sectors compared with one another.

Tribal agencies may generate wind roses or conduct wind-direction data analysis using on-site meteorological data. If the tribe does not have a meteorological station, data may be obtained from other agencies that have a nearby meteorological station. In some cases, the data may be downloaded from AQS. Technical staff at the state agency may have insights on how to locate data from other sources. Historic wind data for many communities (useful for wind roses) is available for free download at this website: http://www.webmet.com. Recent meteorological data is considerably more difficult to find and often must be purchased from a private company.

If long-range transport of pollutants is a concern, then another approach to consider is the HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) model developed by NOAA. HYSPLIT (Fig 7.9) can map a back trajectory (a track showing where an air parcel passed before reaching the air monitor). The example below shows the back trajectory of different air parcels that may have reached a monitor in western Michigan over a 24-hour period. The air parcels originated in several different states (Iowa, Missouri, Illinois and Indiana); however they all passed through northern Illinois before reaching the monitor in Michigan. If this particular date had been a high ozone day, then the Hysplit results would suggest that precursor pollutants from the greater Chicago area contributed to ozone formation. Hysplit can be downloaded for free or used on-line on the National Oceanic and Atmospheric Administration's (NOAA) website: http://www.arl.noaa.gov/ready/hysplit4.htm.

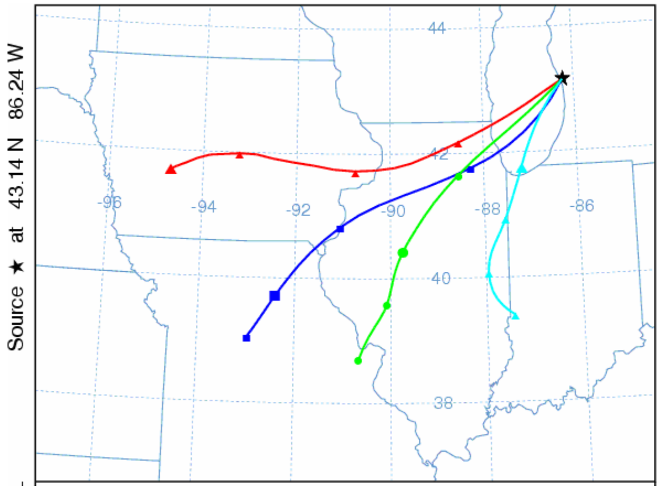


Figure 7.9 Example of Hysplit backward wind trajectory

NOAA's Real-time Environmental Applications and Display sYstem (READY) accesses and displays meteorological data and runs trajectory and dispersion model products http://www.arl.noaa.gov/ready.html.

Exposure assessment for hazardous air pollutants-

Air toxics, or HAPs, are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. Examples of toxic air pollutants include benzene, which is found in gasoline; perchlorethlyene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds.

Links to more information about air toxics are provided below.

- EPA's Health Effects Notebook provides fact sheets about the 188 HAPs: http://www.epa.gov/ttn/atw/hlthef/hapindex.html
- Air Pollution and Health Risk http://www.epa.gov/ttn/atw/3_90_022.html
- Evaluating Exposures to Toxic Air Pollutants: A Citizen's Guide http://www.epa.gov/ttn/atw/3_90_023.html
- Risk Assessment for Toxic Air Pollutants: A Citizen's Guide http://www.epa.gov/ttn/atw/3_90_024.html

Risk assessment is a tool used by environmental specialists to estimate the increased risk of health problems in people who are exposed to different amounts of toxic substances over a long period of time. The risk assessment process has four steps:

- Hazard assessment – what health problems are caused by the pollutant?
- Dose-response assessment – what are the health problems at different exposures?
- Exposure assessment – how much of the pollutant do exposed people inhale?
- Risk characterization – what is the extra risk of health problems in the exposed population?

Air toxics monitoring data may be used in the exposure assessment step of risk assessment. If sufficient data exist for the pollutants of concern, then monitoring data may be used instead of, or in addition to, dispersion modeling outputs.

Using monitoring data in a risk assessment can be a very complex process, requiring assistance from a statistician and toxicologist, among other specialists. To decide whether a full-blown risk assessment is warranted, EPA Region 4 scientists developed a screening procedure that can help monitoring staff do a preliminary evaluation of their air toxics data. The document, *A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Data Sets* is available at the website:http://www.epa.gov/region4/air/airtoxic/athera1.htm.

EPA has also developed a community air screening how-to manual for use by groups that includes non-technical community residents and leaders, as well as technical experts. The manual describes a process that uses input from a wide variety of community stakeholders http://www.epa.gov/oppt/cahp/howto.html.

If the tribal agency has determined that a complete technical risk assessment is needed, then EPA guidance documents are available for use by tribal staff or contractors. The Air Toxics Risk Assessment Reference Library is located at: http://www.epa.gov/ttn/fera/risk_atra_main.html. The library provides information on the fundamental principles of risk-based assessment for air toxics and how to apply those principles in different settings, as well as strategies for reducing risk at the local level.

EPA has compiled dose-response data for air toxics for use in risk assessments, including values for long-term (chronic) inhalation and short-term (acute) inhalation exposures. This information is regularly updated as new information becomes available about the toxicity of specific HAPs. The dose-response values provided at this site are recommended by EPA as the most appropriate for use in air toxics risk assessment http://www.epa.gov/ttn/atw/toxsource/summary.html.

Multi-media risk assessment using ambient and deposition monitoring data-

For a limited subset of HAPs, it is important to consider deposition from air to soil, vegetation, or water bodies. Many studies indicate that some pollutants emitted into the atmosphere (e.g., mercury) are passed to humans or wildlife through non-inhalation pathways (e.g., an air pollutant deposited from the air onto the soil, followed by ingestion of the soil by people or by other living things in an ecosystem). These air pollutants typically are persistent in the environment, have a strong tendency to bioaccumulate, and exhibit moderate to high toxicity.

A variety of computer models are available to describe the multimedia transport and fate of pollutants released to the atmosphere. EPA developed TRIM.FaTE, a model that can estimate pollutant concentrations in multiple environmental media and biota, for use in ecological risk assessment. The model is available at: http://www.epa.gov/ttn/fera/trim_fate.html. Other multi-media models are available here: http://www.epa.gov/ttn/fera/multi_related.html.

Section 8

Assessment of Ambient Air Quality in Indian Country in the Absence of Air Monitoring

In tribal lands where air monitoring has not been conducted, tribes may want to use non-monitoring methods to determine approximate concentrations of air pollutants in order to decide if air monitoring is necessary. Several methods, requiring various degrees of technical expertise and financial resources, are identified in this section. These methods include:

- internet-based tools for accessing and analyzing ambient data,
- air quality models, including near-field dispersion models, regional photochemical models, and receptor models,
- modeling frameworks and assessments, and
- spatial interpolation of modeling and ambient data.

Internet-based tools that access observed concentration data can be useful because some air pollutants concentrations typically do not vary sharply across fairly large distances. As a result, data collected at monitoring sites off the tribal land can be informative of what the situation is within the tribal boundary. This approach is best suited to ozone, $PM_{2.5}$, and a few air toxics that have such long residence times in the atmosphere and have relative constant concentrations over a large scale (e.g., carbon tetrachloride and choloroform). Relying on data from monitors in other areas is less reliable for other pollutants such as PM_{10}, CO, and most air toxics. The internet-based tools provide ways to see data from individual monitoring sites of interest. In addition to monitoring data available through the Internet, industrial sources sometimes monitor for certain pollutants to fulfill permit conditions or to meet prevention of significant deterioration (PSD) requirements. The purpose of this monitoring is for sources to verify modeling predictions that fenceline concentrations of these pollutants will not exceed a certain level. Sources may be willing to share this monitoring data with local tribes. These data could give tribes a rough idea of the pollutant concentrations that exist in the area. These data may also be available through the permitting agency to whom the data is reported.

Air quality models and tools are ways to estimate air pollutant concentrations if emissions are known or can at least be estimated. Dispersion models are appropriate when the emission sources are relatively close to the area where estimates of concentrations are needed, for example, when an industrial plant is on tribal land or near its border. Larger-scale photochemical models are used to estimate the combined effects of mobile, area, and stationary point sources over a large area, and are referred to as “regional scale” models. They are most useful for estimating reactive pollutants such as ozone and $PM_{2.5}$, as well as impacts of air pollutants on visibility. Using these models rather than monitoring data from sites off the tribal land allows users to make future predictions to see how future emissions controls may improve air quality compared to the current concentration.

In addition, there are national or regional assessments that provide estimated results based on air quality models and tools that can be used to characterize concentrations on tribal lands. These assessments rely upon modeling tools and techniques that are made available to tribes. In addition, there are statistical techniques that can combine model predicted and observed data to provide an improved and more complete characterization of concentrations on tribal lands when limited or no monitoring data exist.

8.1 Internet-Based Tools for Ambient Air Quality Assessment

There are internet-based tools that can be useful when conducting ambient air quality assessments in Indian country. These tools provide information on the locations and types of current and historical ambient air monitoring networks, monitoring data, emissions data from point and area sources, and meteorological data. In addition, internet tools are available that assist with interpreting data. Websites include a wide variety of interactive maps and graphs. These tools are accessible to the public and are fairly easy to use. Becoming familiar with these tools enables the tribal environmental professional to better understand the local and surrounding airsheds and helps to assess the potential for pollution transport into Indian country. Much of the data obtained from these tools have associated geospatial coordinates available on the websites. When data are downloaded with geospatial coordinates they can be integrated into a graphical information system (GIS) map. GIS integration allows for a more comprehensive and visual assessment. GIS integration is encouraged for ambient air quality assessments. GIS software is available to federally recognized tribes through the Bureau of Indian Affairs at: http://www.doi.gov/bureau-indian-affairs.html .

This section provides information to help tribal environmental professionals determine issues that may be of concern in the absence of monitoring data obtained directly from the jurisdictional area. The information in this section is not intended to be comprehensive. This section does not provide all the information available from a particular website, or list all websites that may be useful in assessing ambient air quality. Tribal professionals are encouraged to explore beyond what is listed in this document.

An initial air quality web-based assessment should include:

- Identifying existing and historical ambient air monitoring networks and their locations, as well as areas where data gaps exist
- Obtaining all available air monitoring data from the surrounding areas
- Identifying criteria and toxic emissions from area and point sources, and understanding the potential for transport of primary and secondary pollutants from those sources
- Characterizing prevailing and seasonal wind patterns for both local and surrounding areas
- Determining wind transport paths on days when high pollutant concentrations were observed at monitoring sites (backward trajectories as discussed in Section 7)
- Determining pollutant dispersion from sources in the transport path on days when high concentrations were observed at monitoring sites
- Identifying any health data that may indicate air quality problems
- Integrating data into a GIS program

Recommended Websites

For modeling, a key website to consider is the EPA's Support Center for Regulatory Atmospheric Modeling (SCRAM) http://www.epa.gov/ttn/scram/. This website is maintained by EPA's Air Quality Modeling Group (AQMG). The AQMG conducts modeling analyses to support policy and regulatory decisions in the Office of Air and Radiation (OAR) and provides leadership and direction on the full range of air quality models and other mathematical simulation techniques used in assessing control strategies and source impacts. Documentation and guidance for these air quality models can be found on this website, including downloadable computer code, input data, and model processors.

Another important website is the National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) web server. This site has a web-based system called the Real-time Environmental Applications and Display sYstem (READY) http://www.arl.noaa.gov/ready.html that has been developed for accessing and displaying meteorological data and running trajectory and dispersion model products.

Many of the regional planning offices provide more local information on modeling and reports associated with regional specific modeling activities.

8.2 Air Quality Modeling

Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. Based on inputs of meteorological data and source information like emission rates and stack height, these models are designed to characterize primary pollutants that are emitted directly into the atmosphere and, in some cases, secondary pollutants that are formed as a result of complex chemical reactions within the atmosphere. These models are important to our air quality management system because they are widely used by agencies tasked with controlling air pollution to both identify source contributions to air quality problems and assist in the design of effective strategies to reduce harmful air pollutants. For example, air quality models can be used during the permitting process to verify that a new source will not exceed ambient air quality standards or, if necessary, determine appropriate additional control requirements. In addition, air quality models can also be used to predict future pollutant concentrations from multiple sources after the implementation of a new regulatory program, in order to estimate the effectiveness of the program in reducing harmful exposures to humans and the environment.

The most commonly used air quality models include the following:

1) Dispersion Models—These models are typically used in the permitting process to estimate the concentration of pollutants at specified ground-level receptors surrounding an emissions source.

2) Photochemical Models—These models are typically used in regulatory or policy assessments to simulate the impacts from all sources by estimating pollutant concentrations and deposition of both inert and chemically reactive pollutants over large spatial scales.

3) Receptor Models—These models are observational techniques which use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations.

8.3 Dispersion Models: Local and Near-Field Applications

Dispersion modeling uses mathematical formulations to characterize the atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations. These air quality models are used to determine compliance with National Ambient Air Quality Standards (NAAQS), and other regulatory requirements such as New Source Review (NSR) and Prevention of Significant Deterioration (PSD) regulations. These models are addressed in Appendix A of EPA's Guideline on Air Quality Models (also published as Appendix W of 40 CFR Part 51), which was originally published in April 1978 to provide consistency and equity in the use of modeling within the U.S. air quality management system. These guidelines are periodically revised to ensure that new model developments or expanded regulatory requirements are incorporated.

These types of models can be useful to tribes in estimating the concentrations of inert pollutants impacting air quality on tribal lands from local sources such as nearby large stationary sources. In order to run these models, a tribe needs to know the emission rates of pollutants of concern (e.g., NOx, SO2, and PM) from each source and needs to have the appropriate meteorological data required by the model. These models can also be used to determine the improvements in air quality, which can be achieved by placing emission controls on inert pollutants at stationary sources.

AERMOD -

AERMOD http://www.epa.gov/scram001/dispersion_prefrec.htm#aermod is a steady state Gaussian plume dispersion model whose formulation is based on planetary boundary layer principles. The modeling system consists of three programs - a dispersion program (AERMOD), a terrain processor program (AERMAP), and a meteorology processor program (AERMET). AERMET reads in hourly surface meteorological data, upper air data and surface characteristics and generates a surface file and a profile file. AERMAP extracts terrain elevations from U.S. Geological Survey Digital Elevation Model (DEM) files (e.g., 10-meter and 7.5 minute) and calculates height scales based on user provided location coordinates (i.e., Universal Transverse Mercator [UTM], NAD27). Using the files generated from AERMAP, AERMET, source information, and specific model run options within the AERMOD dispersion program, inert air pollutant concentrations are estimated at designated locations and for specified averaging periods.

The AERMOD dispersion program simulates transport and dispersion for point, area and volume sources. Sources may be located in a rural or urban area. The dispersion model also accounts for wake effects using the PRIME building downwash algorithm. An estimate of concentration should only be made for a source-to-receptor distance of less than 50 kilometers. The AERMOD Modeling System is expected to be promulgated as an U.S. EPA recommended model and codified in the Guideline on Air Quality Models, Appendix W to 40 CFR Part 51 http://www.epa.gov/ttn/oarpg/t1/meta/m25875.html. With AERMOD promulgation, the Industrial Source Complex Short Term 3 (ISCST3) dispersion model will no longer be recognized as a preferred model.

A screening version of the AERMOD Modeling System is under development. Unlike AERMOD, AERSCREEN uses a screening meteorological data set with the dispersion program to estimate maximum hourly concentrations. The AERSCREEN predicted hourly concentrations are expected to be higher than the maximum 1-hour concentrations predicted by the AERMOD dispersion program. Scaling factors are applied to the AERSCREEN 1-hour concentration to obtain concentrations for other averaging periods. AERSCREEN will replace the SCREEN3 Model. AERSCREEN will be available on the following website: http://www.epa.gov/scram001/dispersion_screening.htm.

CALPUFF -

The CALPUFF Modeling System (CALPUFF) is a multi-layer, multi-species, non-steady-state puff dispersion modeling system that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. CALPUFF contains three primary programs - CALMET, CALPUFF and CALPOST. CALMET reads in mesoscale meteorology from observations and/or from predictions by prognostic meteorological models (e.g. MM5 and RUC) and develops hourly meteorological variables on a three-dimensional gridded modeling domain. With the output from CALMET, source information, and specific model run options, CALPUFF is used to generate hourly concentration or deposition flux files. CALPOST is employed to process the CALPUFF output files to estimate concentration impacts at Federal Class I areas and impacts to Air Quality Related Values (AQRV) such as visibility.

The U.S. EPA recommends the use of the CALPUFF Modeling System for source-to-receptor distances greater than 50-kilometers. CALPUFF is also recommended by the Inter Agency Workgroup on Air Quality Modeling (IWAQM) for use in evaluating impacts on visibility and deposition in Federal Class I areas. On a case-by-case basis, the CALPUFF Model can be used in a near field application, and during stagnant or complex wind conditions. The CALPUFF Modeling System has been promulgated for regulatory application in the Guideline on Air Quality Models, Appendix W to 40 CFR Part 51.

8.4 Photochemical Air Quality Models: National and Regional Applications

Photochemical air quality models have become widely recognized and routinely utilized tools for regulatory analysis and attainment demonstrations by assessing the effectiveness of control strategies. These photochemical models are large-scale air quality models that simulate the changes of pollutant concentrations in the atmosphere using a set of mathematical equations characterizing the chemical and physical processes in the atmosphere. These models are applied at multiple spatial scales from local, regional, national, and global.

There are two types of photochemical air quality models commonly used in air quality assessments: the Lagrangian trajectory model that employs a moving frame of reference, and the Eulerian grid model that uses a fixed coordinate system with respect to the ground. Earlier generation modeling efforts often adopted the Lagrangian approach to simulate the pollutants formation because of its computational simplicity. The disadvantage of Lagrangian approach, however, is that the physical processes it describes are somewhat incomplete. Most of the current operational photochemical air quality models have adopted three-dimensional Eulerian grid modeling mainly because of its ability to better and more fully characterize physical processes in the atmosphere and predict the species concentrations throughout the entire model domain.

These large-scale, multi-pollutant models are used to estimate the combined effects of many emission, mobile, area, and stationary point sources over a large area, and are referred to as "regional scale" models. They are most useful for estimating ozone, $PM_{2.5}$, and impacts of air pollutants on visibility. These types of models require large amounts of source emissions data and meteorological data, and require specialized technical expertise. More relevant to the tribes is that these models have been used by the Regional Planning Organizations, EPA, and some individual states. As an alternative to running these models, tribes should consider accessing the modeling results generated by other agencies that cover the reservations.

Community Multi-scale Air Quality (CMAQ) Model -

The CMAQ modeling system has been designed to approach air quality with a "one-atmosphere" manner by including state-of-the-science capabilities for modeling multiple air quality issues, including tropospheric ozone, fine particles, toxics, acid deposition, and visibility degradation. Hence, CMAQ combines the scientific expertise from each of these areas into one "community model". In addition to being a multi-pollutant model, CMAQ also was designed to have multi-scale capabilities so that separate models are not needed for urban and regional scale air quality modeling. The target grid resolutions and domain sizes for CMAQ range spatially and temporally over several orders of magnitude. With the temporal flexibility of the model, simulations can be performed to evaluate longer term pollutant transport, as well as short-term transport from localized sources. With the model's ability to handle a large range of spatial scales, CMAQ can be used for urban and regional scale model simulations.

The CMAQ modeling system simulates various chemical and physical processes that are thought to be important for understanding atmospheric trace gas transformations and distributions. The CMAQ modeling system utilizes three separate modeling components: a meteorological model (typically MM5) for the description of atmospheric states and air mass motions, an emissions model (typically SMOKE) for man-made and natural emissions that are injected into the atmosphere, and a chemistry-transport model for simulation of the chemical transformation and fate (the CCTM model). The meteorological and emissions model outputs are required inputs into the CMAQ chemistry-transport model, hence this is viewed as a modeling system.

CMAQ's current structure is based on a modularity level that distinguishes between its main driver, science modules, data estimation modules, and control/utility subroutines in the model. This enables the attainment of higher resolution than commonly seen in previous models.

The distinction remains at a division between the science models (including submodels for meteorology, emissions, chemistry-transport models), and analysis and visualization subsystems. Typically the CMAQ modeling system is run on a multi-processor Linux or UNIX computer cluster environment and usually requires, at minimum, over 1 terabyte of storage capacity.

Current CMAQ and SMOKE model codes and training are available from the CMAS Center at: http://www.cmascenter.org/. Current MM5 model code and training is available from UCAR at: http://www.mmm.ucar.edu/mm5/.

8.5 Receptor Models: Source Contributions

Receptor models are mathematical or statistical procedures for identifying and quantifying the sources of air pollutants at a receptor location. Unlike photochemical and dispersion air quality models, receptor models do not use pollutant emissions, meteorological data and chemical transformation mechanisms to estimate the contribution of sources to receptor concentrations. Instead, receptor models use the chemical and physical characteristics of gases and particles measured at source and receptor to both identify the presence of and to quantify source contributions to receptor concentrations. These models are therefore a natural complement to other air quality models and are used as part of State Implementation Plans (SIPs) for identifying sources contributing to air quality problems. EPA has developed the Chemical Mass Balance (CMB) and UNMIX models, as well as the Positive Matrix Factorization (PMF) method for use in air quality management. CMB fully apportions receptor concentrations to chemically distinct source-types depending upon the source profile database, while UNMIX and PMF internally generate source profiles from the ambient data.

Chemical Mass Balance (CMB)—The EPA-CMB Version 8.2 uses source profiles and speciated ambient data to quantify source contributions. Contributions are quantified from chemically distinct source-types rather than from individual emitters. Sources with similiar chemical and physical properties cannot be distinguished from each other by CMB.

UNMIX—The EPA UNMIX model "unmixes" the concentrations of chemical species measured in the ambient air to identify the contributing sources. Chemical profiles of the sources are not required, but instead are generated internally from the ambient data by UNMIX, using a mathematical formulation based on a form of factor analysis. For a given selection of species, UNMIX estimates the number of sources, the source compositions, and source contributions to each sample.

Positive Matrix Factorization (PMF)—The PMF technique is a form of factor analysis where the underlying co-variability of many variables (e.g., sample-to-sample variation in PM species) is described by a smaller set of factors (e.g., PM sources) to which the original variables are related. The structure of PMF permits maximum use of available data and better treatment of missing and below-detection-limit values. Also available is a document which discusses the PMF methodology: "A Guide to Positive Matrix Factorization" http://www.epa.gov/ttn/amtic/files/ambient/pm25/workshop/laymen.pdf.

8.6 Modeling Tools and Assessments

There are a number of modeling tools and assessments that are available and provide useful information on concentrations of air pollutants including air toxics and criteria pollutants. This section provides a selection of readily available tools and assessment results.

National Air Toxics Assessment (NATA): 1999-

The 1999 NATA http://www.epa.gov/ttn/atw/nata1999/ is a nationwide study of potential inhalation exposures and health risks associated with 133 air toxics and diesel particulate matter (diesel PM), based on emissions data for 1999. The initial national-scale assessment is comprised of four major technical components: 1) compiling a national emissions inventory of air toxics and diesel PM for the year 1999 from outdoor sources; 2) estimating 1999 air toxics and diesel PM ambient concentrations; 3) estimating 1996 population exposures; and 4) characterizing potential public health risks.

The purpose of the NATA is to gain a better understanding of the air toxics problem. Specifically, the goal of the assessment is to assist in: 1) identifying air toxics of greatest potential concern in terms of contribution to population risk; 2) characterizing the relative contributions of various types of emission sources to air toxics concentrations and population exposures; 3) setting priorities for collection of additional air toxics data and research to improve estimates of air toxics concentrations and their potential public health impacts; 4) tracking trends in modeled ambient air toxics concentrations over time; and 5) measuring progress toward meeting goals for inhalation risk reduction from ambient air toxics.

BlueSky Modeling Framework-

BlueSky http://www.airfire.org/bluesky/ is a modeling framework which brings together the latest state-of-the-science for modeling fuels, fire, smoke, and weather into one centralized processing system. It makes sophisticated emission, dispersion and weather prediction models and model output easily accessible to the operational fire and air quality management communities. The modeling framework is designed to predict cumulative impacts of smoke from forest, agricultural, and range fires, including both prescribed fire and wild fire.

The BlueSky system was designed as a tool to aid land managers using fire on the landscape in making go/no-go/go slow decisions with regard to smoke management. BlueSky provides hourly predictions of $PM_{2.5}$ concentrations based on information available from multi-agency tracking systems such as FASTRACS and RAZU, and from wildfire 209 reports. Trajectory predictions available in BlueSky RAINS indicate the direction and height of smoke plumes 12 hours out in time.

The BlueSky modeling framework has 5 components. Although the specific models used within each component may change over time as the modeling science advances, the basic structure will remain the same. As of June 2005, fire characteristics are processed through the Emissions Production Model (EPM) to give emission estimates of particulates ($PM_{2.5}$, PM_{10}, and total PM), carbon compounds (CO, CO_2, CH_4, non-methane hydrocarbons), and heat generated.

The emission estimates from EPM, along with meteorology from MM5, are input data to the CALPUFF dispersion model and the HYSPLIT trajectory model. The BlueSky system framework merges meteorology with emission estimates to yield an integrated regional-scale analysis of smoke dispersion and aerosol concentrations.

The BlueSky concentration fields and trajectories are displayed on the website in the Rapid Access INformation System (RAINS); a Geographic Information System (GIS) application developed by EPA Region 10. BlueSky/RAINS builds on the RAINS concept as an avenue for making BlueSky model output available to users in an interactive ***ArcIMS*** format. Integrating BlueSky with RAINS allows the user to zoom in on areas of interest, step through time, and overlay GIS data layers such as sensitive receptors, boundaries, roads, rivers and topography. Trajectories showing the direction, height, and timing of smoke movement can be shown. Meteorological output for a number of parameters is also available. Maps showing roads, rivers, boundaries, and a variety of smoke sensitive receptors can be selected. To access BlueSkyRAINS go to http://www.blueskyrains.org .

Primary inputs to BlueSky include weather, fire characteristics, and fuels. This section briefly describes the sources for each of these input parameters.

Weather **–** Predictions of wind speed and direction, as well as mixing height are required to determine smoke trajectories and $PM_{2.5}$ concentrations. Weather inputs come from the MM5 mesoscale meteorological model.

Fire Characteristics **–** In order to arrive at an accurate prediction of smoke emissions, it is necessary to get detailed information about the size, location and timing of a prescribed burn or wildfire. This information is retrieved from interagency reporting systems such as FASTRACS in the Pacific Northwest, RAZU in Montana and Idaho and will soon be available from the Prescribed Fire Incident Reporting System (PFIRS) in California. Alternative ways of providing input on prescribed burns for BlueSky are also being developed. Wildfire information is also accessed automatically each day from 209 reports available from the National Interagency Fire Center (NIFC). PFIRS can be found at: http://www.arb.ca.gov/smp/pfirs/pfirs.htm.

Fuels **–** Fuel model and fuel loading information is essential to emissions modeling. BlueSky uses fuel characteristics derived from the Fuel Characteristic Classification System (FCCS) to arrive at this information. FCCS can be found at: http://www.fs.fed.us/pnw/fera/fccs/.

BlueSky output products can be viewed as animations or as static hourly images using BlueSky RAINS. BlueSky output can be viewed as either a Java Script animation (recommended for high speed internet connections) or Gif animation (recommended for dial up internet connections). Users must select a resolution and the type of animation then click on the appropriate square.

The animations show model predicted $PM_{2.5}$ concentrations and wind flow patterns at the surface. Animations are useful for getting a big picture look at predicted $PM_{2.5}$ over time for all the fires and burns in the system for a given run. While it is possible to stop the loop and look at individual frames, it is not possible to zoom in or add information to the images. At the bottom of the animation page is a dropdown menu which allows the user to select animations from any BlueSky run going back to September of 2002.

HYSPLIT Trajectory Model-

The National Oceanic and Atmospheric Administration (NOAA), Air Resources Laboratory (ARL), Real-Time Applications and Display System (READY) website has a variety of tools available including backward trajectories modeling software (HYSPLIT), as well as tools that model meteorological conditions at a selected latitude and longitude at the ground surface and at elevations above the ground. The backward trajectories can be integrated into GIS by downloading the endpoints file, modifying the file slightly and using the right-click "Create Feature Class from XY Table" function in ArcCatalog. Specific instructions are available at the TAMS Center Website. Backward trajectories are useful in understanding transport issues by mapping the path air took prior to entering the monitor.

Response Surface Modeling-

EPA developed a Response Surface Model (RSM) based on the Community Multi-scale Air Quality (CMAQ) model to support the Regulatory Impact Assessment for the proposed PM2.5 National Ambient Air Quality Standards (NAAQS). RSM is based on a new approach known as air quality meta-modeling that aggregates numerous pre-specified air quality modeling simulations into a multi-dimensional air quality "response surface". Simply, this metamodeling technique is a "model of the model" and can be shown to reproduce the results from an individual modeling simulation with little bias or error. The RSM is based on statistical relationships between model inputs and outputs to provide real-time estimates of these air quality changes. The RSM provides a wide breadth of model outputs which can be used to develop emissions control scenarios. The RSM approach informs the selection and evaluation of various control scenarios. This approach allows for the rapid assessment of air quality impacts of different combinations of emissions reductions and was used to estimate air quality changes for various control scenarios for the proposed $PM_{2.5}$ NAAQS. The documentation provides information on: 1) the emissions inventories and development of projections; 2) the air quality modeling and development of model inputs; 3) development and experimental design of the RSM; and 4) the performance and validation of the RSM as compared to the air quality modeling. This documentation is available at: http://www.epa.gov/scram001/reports/pmnaaqs_tsd_rsm_all_021606.pdf.

8.7 Spatial Interpolation of Modeling and Ambient Data

The need for spatial (geostatistical) interpolation models in the regulatory environment has grown in the past few years. Spatial interpolation as applied to air monitoring data is loosely defined as the procedure for estimating ambient air concentrations at unmonitored locations in a certain area based on available observations within the proximity of the area. The justification underlying spatial interpolation is the assumption that points closer together in space are more likely to have similar values than points more distant. EPA uses spatial interpolation to review decisions on monitoring network design and to predict the efficacy of emission control programs.

Due to the limited number of monitoring sites across the country, especially for pollutants that cover a large area, such as ozone and fine particles, there is a need to use spatial interpolation to predict ambient concentrations in unmonitored locations.

Geostatistical interpolation methods are stochastic methods, with kriging being the most well-known representative of this category. Conceptually, the goal of kriging is to find linear combinations of the data that are optimal and consistent with the observed data points. In particular, kriging is a statistical model that produces both a spatial surface of predictions for the process of interest as well as the uncertainty associated with those estimates. Kriging calculates weights for measured points in deriving predicted values for unmeasured locations. With kriging, however, those weights are based not only on distance between points, but also on the variation in measured concentrations as a function of distance. A major benefit of the various forms of kriging is that estimates of the model's prediction uncertainty can be calculated, considered in the analysis, and plotted along with the predicted values. Such uncertainty information is an important tool in the spatial decision making process.

There are three main kriging methods and each has unique assumptions that must be met. "Simple" kriging assumes that there is a known constant mean, that there is no underlying trend, and that all variation is statistical. "Ordinary" kriging is similar except it assumes that there is an unknown constant mean that must be estimated based on the data. "Universal" kriging differs from the other two methods in that it assumes that there is a trend in the surface that partly explains the data's variations. This should only be utilized when it is known that there is a trend in the data.

Ordinary kriging, which is addressed in this section, is a version of kriging that assumes the mean is constant, but unknown across the spatial domain of interest. Ordinary kriging defines the process as follows:

$$\mathbf{Z(x,y) = u + e(x,y)}$$

u = the overall, large-scale mean of the process across the spatial domain; and
e(x,y) = the small-scale random fluctuation of the process within the spatial domain.

In practice, ordinary kriging, for the purpose of spatial interpolation, is implemented via the following five steps:

Step 1: Build the Data Set

Often, an initial data set will require pre-processing to generate analysis data that better match the spatial process of interest with respect to temporal scale. This can be accomplished via some sort of temporal averaging of the initial data. For example, a data set of 1-hour ozone concentrations might be averaged in some manner to yield 8-hour concentrations for analysis. When pre-processing an initial data set via temporal averaging, some consideration must be given to the temporal completeness of the resulting average. If the initial data used to generate an endpoint, such as an annual average, are somehow temporally incomplete, the calculated endpoint may be biased in some manner. For example, many air pollutants exhibit significant seasonal fluctuations, so an annual average estimated from only a single quarter's worth of data (e.g., January through March) may not be representative of the true year-long average.

Step 2: Summarize and Understand the Data

Once the spatial analysis data set has been built, it is important to generate some initial summaries of the available data prior to analysis in order to obtain a better understanding of its empirical structure and behavior. Reasonable summaries include, but are not limited to, GIS maps of the spatial domain and available data locations, a histogram of the overall data distribution, and summary statistics, such as the data's mean, standard deviation, and various percentiles (e.g., minimum, median, maximum, etc.).

Step 3: Conduct a Variogram Analysis

Once the analysis data set has been built and explored to gain some basic understanding, the kriging modeling exercise can begin. The exercise begins by conducting a variogram analysis. This analysis typically consists of first generating an empirical variogram and then fitting a parametric model that adequately captures the structure of the empirical variogram. Ultimately, the estimated parameters of the variogram will be input for the kriging spatial prediction and uncertainty formulas from which a spatially interpolated surface is generated. In other words, once you have chosen a satisfactory variogram model, you then use that model as an input to the actual kriging process.

The most common models used in the variogram modeling process are: linear, spherical, exponential, rational quadratic, wave (or hole-effect), power, and Gaussian. Of these seven variogram models, three are used most commonly: spherical, exponential, and Gaussian. Exponential models fit best when the spatial autocorrelation decreases exponentially with increasing distance. Spherical models provide a better fit when spatial autocorrelation decreases to a point after which it becomes zero. Gaussian variograms tend to have an "S" shape, with a gradual upward slope at short distances, followed by a sharper upward slope at middle distances and, finally, by another gradual upward slope at long distances. To determine which of these models best fit the data, attempt to fit the data using all of these models. If the fitting procedure fails to converge for a given covariance function, remove it from consideration. By considering several variogram models, one can choose the model that best fits the data. Various software packages, including Surfer, GMS, SAS, S-Plus, and others will compute the empirical variogram and assist in the modeling process.

Step 4: Apply Spatial Prediction and Uncertainty Formulas

In the previous step, the spatial structure associated with the data was modeled using a variogram analysis. That variogram model is now applied to the task of spatial prediction. The current step of applying the variogram analysis results is relatively straightforward, if appropriate software is available for applying the equations. Surfer, GMS, S-Plus, SAS, and several other software packages have the capability to compute kriging estimates given data and a variogram function. Using these software packages, kriging predictions and standard errors can be generated everywhere in either a default or user-defined grid.

Step 5: Evaluate Model Performance

There are two primary ways to evaluate model performance. The first method is to map the interpolated concentrations and compare them to observed monitored values. Observed and estimated values at monitor sites should be close, but do not need to match exactly. Allowing some variation between observed and estimated values at monitoring locations may give better results for unmonitored areas. The second method is to review the uncertainty estimates generated by the model. The output from the kriging model consists of both estimated values, as well as uncertainty of the estimated values (e.g., standard errors). Locations within the vicinity of several monitors should have lower standard errors than areas with a sparse set of monitors. Also, there may be higher standard errors along the boundaries of the local domain. Including additional monitoring information outside the local domain should improve the standard errors along the boundaries of the domain.

A more detailed description of the kriging process can be found in the EPA report titled "Developing Spatially Interpolated Surfaces and Estimating Uncertainty", EPA-454/R-04-004, November 2004 or on the web at: http://www.epa.gov/oar/oaqps/pm25/docs/dsisurfaces.pdf.

Appendices A-H

Appendix **Page**

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Appendix A

National Air Quality Monitoring Program Fact Sheets

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National Air Monitoring Networks Fact Sheets

State or Local Air Monitoring Stations (SLAMS) Network

Background

The SLAMS make up the ambient air quality monitoring sites that are operated by State or local agencies for the primary purpose of comparison to the National Ambient Air Quality Standards (NAAQS), but may serve other purposes such as:

- provide air pollution data to the general public in a timely manner;
- support compliance with air quality standards and emissions strategy development; and
- support air pollution research studies.

The SLAMS network includes stations classified as NCore, PAMS, and Speciation, and formerly categorized as NAMS, and does not include Special Purpose Monitors (SPM) and other monitors used for non-regulatory or industrial monitoring purposes.

In order to support the objectives, the monitoring networks are designed with a variety of monitoring sites that generally fall into the following categories which are used to determine:

1. the highest concentrations expected to occur in the area covered by the network;
2. typical concentrations in areas of high population density;
3. the impact on ambient pollution levels of significant sources or source categories;
4. the general background concentration levels;
5. the extent of regional pollutant transport among populated areas, and in support of secondary standards; and
6. air pollution impacts on visibility, vegetation damage, or other welfare- based impacts.

The monitoring aspects of the SLAMS program are found in the Code of Federal Regulations, Title 40, Parts 50, 53 and 58.

SLAMS must use approved Federal reference method (FRM), Federal equivalent method (FEM), or Approved Regional Method (ARM) monitors for ambient pollutant levels being compared to the NAAQS.

Reference Category	**References**	**Comments**
Program References	40 CFR Part 50, 53 and 58 http://www.epa.gov/ttn/amtic/	
Pollutants Measured	O_3, CO, SO_2, NO_2 $PM_{2.5}$, PM_{10}, Pb	
Methods References	40 CFR Part 50 and 58 Appendix C http://www.epa.gov/ttn/amtic/criteria.html	Must be FRM, FEM, or ARM for NAAQS comparisons. Website lists designated methods
Network Design References	40 CFR Part 58 Appendix D, E	
Siting Criteria	40 CFR Part 58 Appendix E	
Quality System References	40 CFR Part 58 Appendix A http://www.epa.gov/ttn/amtic/quality.html http://www.epa.gov/ttn/amtic/met.html	 Website for QA Handbook Vol II Eebsite for QA Handbook Vol IV
Data Management References	http://www.epa.gov/ttn/airs/airsaqs/	Air Quality System

National Core (NCore) Network

Background

The NCore multi-pollutant stations are part of an overall strategy to integrate multiple monitoring networks and measurements. As required by the revised monitoring regulations promulgated in 2006, monitors at NCore multi-pollutant sites will measure particles ($PM_{2.5}$, speciated $PM_{2.5}$, $PM_{10-2.5,}$ speciated $PM_{10-2.5}$), O_3, SO_2, CO, nitrogen oxides ($NO/NO_2/NO_y$), and basic meteorology. Monitors for all the gases except for O_3 will be more sensitive than standard FRM/FEM monitors, so they could accurately report concentrations that are well below the respective NAAQS but that can be important in the formation of O_3 and PM.

The objective is to locate sites in broadly representative urban (about 55 sites) and rural (about 20 sites) locations throughout the country to help characterize regional and urban patterns of air pollution. The NCore network must be fully operational by 2011. Many stations will be operational before that deadline.

In many cases, states will collocate these new stations with STN sites measuring speciated $PM_{2.5}$ components, PAMS sites already measuring O_3 precursors, and/or NATTS sites measuring air toxics. By combining these monitoring programs at a single location, EPA and its partners will maximize the multi-pollutant information available. This greatly enhances the foundation for future health studies, NAAQS revisions, validation of air quality models, assessment of emission reduction programs, and studies of ecosystem impacts of air pollution.

Reference Category	**References**	**Comments**
Program References	http://www.epa.gov/ttn/amtic/monitor.html	
Pollutants Measured	SO_2, CO, NO and NO_y, and O_3, $PM_{2.5}$, $PM_{10-2.5}$, basic meteorological parameters	
Methods References	http://www.epa.gov/ttn/amtic/precursop.html http://www.epa.gov/ttn/amtic/pretecdoc.html	
Network Design References	http://www.epa.gov/ttn/amtic/monstratdoc.html	
Siting Criteria	http://www.epa.gov/ttn/amtic/pretecdoc.html	
Quality System References	http://www.epa.gov/ttn/amtic/qaqcrein.html	
Data Management References	http://www.epa.gov/ttn/amtic/pretecdoc.html	

Photochemical Assessment Monitoring Stations (PAMS)

Background

Section 182(c)(1) of the 1990 Clean Air Act Amendments (CAAA) require the Administrator to promulgate rules for the enhanced monitoring of ozone, oxides of nitrogen (NOx), and volatile organic compounds (VOC) to obtain more comprehensive and representative data on ozone air pollution. Immediately following the promulgation of such rules, the affected states were to commence such actions as were necessary to adopt and implement a program to improve ambient monitoring activities and the monitoring of emissions of NOx and VOC. Each State Implementation Plan (SIP) for the affected areas must contain measures to implement the ambient monitoring of such air pollutants. The subsequent revisions to Title 40, Code of Federal Regulations, Part 58 (40 CFR 58) required states to establish Photochemical Assessment Monitoring Stations (PAMS) as part of their SIP monitoring networks in ozone nonattainment areas classified as serious, severe, or extreme.

The chief objective of the enhanced ozone monitoring revisions is to provide an air quality database that will assist air pollution control agencies in evaluating, tracking the progress of, and, if necessary, refining control strategies for attaining the ozone NAAQS. Ambient concentrations of ozone and ozone precursors will be used to make attainment/nonattainment decisions, aid in tracking VOC and NOx emission inventory reductions, better characterize the nature and extent of the ozone problem, and prepare air quality trends. In addition, data from the PAMS will provide an improved database for evaluating photochemical model performance, especially for future control strategy mid-course corrections as part of the continuing air quality management process. The data will be particularly useful to states in ensuring the implementation of the most cost-effective regulatory controls.

Reference Category	References	Comments
Program References	http://www.epa.gov/ttn/amtic/pamsrein.html http://www.epa.gov/air/oaqps/pams/docs.html	
Pollutants Measured	Ozone, Nitrogen Oxides, VOCs, surface meteorological http://www.epa.gov/oar/oaqps/pams/general.html#parameters	
Methods References		
Network Design References	http://www.epa.gov/air/oaqps/pams/network.html	
Siting Criteria	http://www.epa.gov/oar/oaqps/pams/general.html#siting	
Quality System References		
Data Management References		

$PM_{2.5}$ Chemical Speciation Network

Background

As part of the effort to monitor particulate matter, EPA monitors and gathers data on the chemical makeup of these particles. EPA established a chemical speciation network consisting of approximately 300 monitoring sites. These sites are placed at various NAMS and SLAMS across the Nation. Fifty-four of these chemical speciation sites, the Speciation Trends Network (STN), will be used to determine, over a period of several years, trends in concentration levels of selected ions, metals, carbon species, and organic compounds in $PM_{2.5}$. Further breakdown on the location or placement of the trends sites requires that approximately 20 of the monitoring sites be placed at existing Photochemical Assessment Monitoring Stations (PAMS). The placement of the remaining trends sites will be coordinated by EPA, the Regional offices, and the monitoring agencies. Locations will be primarily in or near larger Metropolitan Statistical Areas (MSAs). The remaining chemical speciation sites will be used to enhance the required trends network and to provide information for developing effective State Implementation Plans (SIPs).

The STN is a component of the National $PM_{2.5}$ Monitoring Network. Although the STN is intended to complement the activities of the much larger gravimetric $PM_{2.5}$ measurements network component (whose goal is to establish if NAAQS are being attained), STN data will not be used for attainment or nonattainment decisions. The programmatic objectives of the STN network are:

- annual and seasonal spatial characterization of aerosols;
- air quality trends analysis and tracking the progress of control programs;
- compare the chemical speciation data set to the data collected from the IMPROVE network; and
- development of emission control strategies.

Stakeholders in the STN will be those at EPA seeking to determine concentration trends of $PM_{2.5}$ chemical species over a period of 3 or more years and decision-makers at tribal, state and local levels who will use the data as input to models and for development of emission control strategies and determination of their long-term effectiveness. Other users will be public health officials and epidemiological researchers. However, expectations for data sets from the STN must be put in context.

Reference Category	References	Comments
Program References	http://www.epa.gov/ttn/amtic/speciepg.html	
Pollutants Measured	ions, metals, carbon species, and organic compounds	
Methods References		
Network Design References		
Siting Criteria		
Quality System References	http://www.epa.gov/ttn/amtic/specqual.html	
Data Management References	http://www.epa.gov/ttn/amtic/specdat.html	

National Toxics Trends Network (NATTS)

Background

There are currently 188 hazardous air pollutants (HAPs), or Air Toxics (AT), regulated under the Clean Air Act (CAA) that have been associated with a wide variety of adverse health effects, including cancer, neurological, reproductive and developmental effects, as well as eco-system effects. In 1999. EPA finalized the Urban Air Toxics Strategy (UATS). The UATS states that emissions data are needed to quantify the sources of air toxics impacts and aid in the development of control strategies, while ambient monitoring data are needed to understand the behavior of air toxics in the atmosphere after they are emitted. Part of this strategy included the development of the National Air Toxics Trends Stations (NATTS). Specifically, it is anticipated that the NATTS data will be used for:

- tracking trends in ambient levels to facilitate tracking progress toward emission and risk reduction goals, which is the major objective of this program;
- directly evaluating public exposure & environmental impacts in the vicinity of monitors;
- providing quality assured data AT for risk characterization;
- assessing the effectiveness of specific emission reduction activities; and
- evaluating and subsequently improving air toxics emission inventories and model performance.

Currently the NATTS program is made up of 22 monitoring sites; 15 representing urban communities and 7 representing rural communities.

Reference Category	**References**	**Comments**
Program References	http://www.epa.gov/ttn/amtic/natts.html	
Pollutants Measured	33 HAPS which include metals, VOCs and carbonyls	
Methods References	http://www.epa.gov/ttn/amtic/airtox.html	
Network Design References	http://www.epa.gov/ttn/amtic/airtoxqa.html,	Reference : National Air Toxics Trends Stations – Quality Management Plan – final 09/09/05
Siting Criteria	http://www.epa.gov/oar/oaqps/pams/general.html#siting	Reference : 40 CFR part 58 Appendix E, PAMS Probe and Path Siting Criteria
Quality System References	http://www.epa.gov/ttn/amtic/airtoxqa.html	
Data Management References	http://www.epa.gov/ttn/amtic/toxdat.html	

Interagency Monitoring of Protected Visual Environments (IMPROVE)

Background

The Interagency Monitoring of Protected Visual Environments (IMPROVE) program is a cooperative measurement effort governed by a steering committee composed 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 for the protection of visibility in Class I areas (156 national parks and wilderness areas) as stipulated in the 1977 amendments to the Clean Air Act.

The objectives of IMPROVE are:

1. to establish current visibility and aerosol conditions in mandatory class I areas;
2. to identify chemical species and emission sources responsible for existing man-made visibility impairment;
3. to document long-term trends for assessing progress towards the national visibility goal;
4. and with the enactment of the Regional Haze Rule, to provided regional haze monitoring representing all visibility-protected federal class I areas where practical.

IMPROVE has also been a key participant in visibility-related research, including the advancement of monitoring instrumentation, analysis techniques, visibility modeling, policy formulation and source attribution field studies. In addition to 110 IMPROVE sites at visibility-protected areas, IMPROVE Protocol sites are operated identically at locations to serve the needs of state, tribes and federal agencies.

Reference Category	References	Comments
Program References	http://vista.cira.colostate.edu/improve/ http://vista.cira.colostate.edu/improve/Overview/IMPROVEProgram_files/frame.htm	
Pollutants Measured	PM_{10} & $PM_{2.5}$ mass concentration, and $PM_{2.5}$ elements heavier than sodium, anions, organic and elemental carbon concentrations. Optical & met. parameters at select sites	All sites have aerosol speciation monitoring by one day in three 24-hour duration sampling
Methods References	http://vista.cira.colostate.edu/improve/Publications/IMPROVE_SOPs.htm	
Network Design References	http://vista.cira.colostate.edu/improve/Publications/IMPROVE_SOPs.htm	
Siting Criteria	http://vista.cira.colostate.edu/improve/Publications/IMPROVE_SOPs.htm	
Quality System References	http://vista.cira.colostate.edu/improve/Data/QA_QC/qa_qc_Branch.htm http://www.epa.gov/ttn/amtic/visinfo.html	
Data Management References	http://vista.cira.colostate.edu/improve/Data/data.htm	

Clean Air Status and Trends Network (CASTNET)

Background

EPA, in coordination with the National Oceanic and Atmospheric Administration (NOAA), established CASTNET with the goal of assessing the impact and effectiveness of Title IV of the 1990 Clean Air Act Amendments (CAAA) through a large-scale monitoring network. CASTNET was designed to compile a sound scientific data base through routine environmental monitoring for the evaluation of air-quality management and control strategies. The network provides estimates of dry deposition using an inferential modeling method that relies on atmospheric concentrations, meteorological variables and other input as recorded at each site. The data record extends back to 1987, when routine field measurements first began under National Dry Deposition Network (NDDN). CASTNET currently consists of over 80 sites across the eastern and western United States and is cooperatively operated and funded with the National Park Service. CASTNET complements the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) which provides information on precipitation chemistry and wet deposition values.

The main objective of the network is to:

1) track the effectiveness of national and regional scale emission control programs;
2) report high quality, publicly available data on the temporal and geographic patterns of air quality and atmospheric deposition trends; and
3) provide the necessary information for understanding the environmental effects in sensitive terrestrial and aquatic receptor areas associated with atmospheric loadings of pollutants.

Reference Category	References	Comments
Program References	http://www.epa.gov/castnet/	
Pollutants Measured	-- weekly average atmospheric concentrations of sulfate, nitrate, ammonium, sulfur dioxide, nitric acid and base cations --hourly concentrations of ambient ozone levels --hourly averages of meteorological variables required for calculating dry deposition rates	
Methods References	CASTNET Quality Assurance Project Plan http://www.epa.gov/castnet/library.html	
Network Design References	CASTNET Quality Assurance Project Plan http://www.epa.gov/castnet/library.html	
Siting Criteria	CASTNET Quality Assurance Project Plan http://www.epa.gov/castnet/library.html	
Quality System References	CASTNET Quality Assurance Project Plan http://www.epa.gov/castnet/library.html	
Data Management References	http://www.epa.gov/castnet/library.html http://cfpub.epa.gov/gdm/index.cfm?fuseaction=aciddeposition.wizard	

National Atmospheric Deposition Network (NADP)

Background

The National Atmospheric Deposition Program (NADP) provides quality-assured data and information in support of research on the exposure of managed and natural ecosystems and cultural resources to acidic compounds, nutrients, base cations, and mercury in precipitation. NADP data serve science and education and support informed decisions on air quality issues related to precipitation chemistry.

The NADP operates three precipitation chemistry networks: the 250-station National Trends Network (NTN), 7-station Atmospheric Integrated Research Monitoring Network (AIRMoN), and 100-station Mercury Deposition Network (MDN). The NTN provides the only long-term nationwide record of the wet deposition of acids, nutrients, and base cations. NTN stations collect one-week precipitation samples in 48 states, Puerto Rico, the Virgin Islands, and Quebec Province, Canada. Complementing the NTN is the 7-station AIRMoN. The daily precipitation samples collected at AIRMoN stations support continued research of atmospheric transport and removal of air pollutants and the development of computer simulations of these processes. The 100-station MDN offers the only regional measurements of mercury in North American precipitation. MDN data are used to quantify mercury deposition to water bodies that have fish and wildlife consumption advisories due to this toxic chemical. Presently, 48 states and 10 Canadian provinces list advisories warning people to limit fish consumption due to high mercury levels. Advisories also were issued for Atlantic Coastal waters from Maine to Rhode Island and North Carolina to Florida, for the entire U.S. Gulf Coast, and for Hawaii.

In addition to these long-term monitoring networks, the NADP is responsive to emerging issues requiring new or expanded measurements. Its measurement system is efficient, its data meet pre-defined data quality objectives, and its reports and products are designed to meet user needs.

Reference Category	References	Comments
Program References	NADP http://nadp.sws.uiuc.edu/ AIRMoN http://nadp.sws.uiuc.edu/airmon/ MDN http://nadp.sws.uiuc.edu/mdn/	
Pollutants Measured	sulfate, nitrate, chloride, ammonium, calcium, magnesium, sodium, potassium, pH, mercury	
Methods References	http://nadp.sws.uiuc.edu/lib/manuals/opman.pdf http://nadp.sws.uiuc.edu/lib/manuals/mdnopman.pdf	
Network Design References	http://nadp.sws.uiuc.edu/lib/manuals/siteinst.pdf	
Siting Criteria	http://nadp.sws.uiuc.edu/lib/manuals/siteinst.pdf	
Quality System References	http://nadp.sws.uiuc.edu/QA/ http://nadp.sws.uiuc.edu/lib/qaplans/NADP-QMP-Dec2003.pdf http://nadp.sws.uiuc.edu/lib/qaplans/qapCal2006.pdf	
Data Management References	http://nadp.sws.uiuc.edu/airmon/getamdata.asp	

National Air Toxics Assessment (NATA)

Background

NATA is a national-scale assessment of 33 air pollutants (a subset of 32 air toxics on the Clean Air Act's list of 188, plus diesel particulate matter). The assessment considers the year 1996 (an update to 1999 is in preparation), including:

- compilation of a national emissions inventory of air toxics emissions from outdoor sources;
- estimates of ambient concentrations across the contiguous United States;
- estimates of population exposures; and
- characterizations of potential public health risks including both cancer and non-cancer effects.

NATA identifies those air toxics which are of greatest potential concern, in terms of contribution to population risk. This information is relevant and useful in assessing risk for tribal programs.

Reference Category	References	Comments
Program References	http://www.epa.gov/ttn/atw/nata/index.html	
Pollutants Measured	http://www.epa.gov/ttn/atw/nata/34poll.html	33 air pollutants (see link)
Methods References		
Network Design References		
Siting Criteria		
Quality System References		
Data Management References		

Appendix B

Monitoring Cost Sheets

Every 3 years, OAQPS develops a survey called an Information Collection Request (ICR) that is used to estimate the costs of implementing ambient air monitoring activities for the State and Local Monitoring Station (SLAMS) network. A number of monitoring organizations are contacted and requested to fill out the ICR. The values received from these organizations are then compiled and national cost estimates developed. The following site costs are based on the 2006 Information Collection Request (ICR) estimate for the ambient air quality network and are meant to provide general estimates of costs to implement the various types of monitors and samplers for the criteria pollutants implemented in the SLAMS.

NOTE: The following tables should be used to provide general categories of activities and "ballpark" estimates of hours and costs. They were developed using data from 2003-2005 so costs for products change. The tables can help a Tribe to estimate their own costs and should not be used as definitive costs and hours.

Additional information on the ICR can be found at the following site:
http://www.epa.gov/icr/icr.html

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Ozone Monitoring Costs (based on ICR)

Cost Element	Hours/ Site	Cost/ Site
1. Network Design		
Network design study (RO)	210	
Site selection (RO)	56	
Element #1 totals		
2. Site Installation		
Analyzer		$7,523
Spare analyzers		$7,523
Procurement	56	
Equipment installation	112	
Element #2 totals		
3. Supplies and Site Visits		
Supplies		
4 month season		$279
5 month season		$348
6 month season		$418
7 month season		$488
8 month season		$557
9 month season		$627
12 month season		$836
Routine site visits		
4 month season	40	
5 month season	50	
6 month season	60	
7 month season	70	
8 month season	80	
9 month season	90	
12 month season	120	
Element #3 totals		
4. Maintenance		
Spare parts/supplies		
4 month season		$348
5 month season		$435
6 month season		$522
7 month season		$609
8 month season		$697
9 month season		$784
12 month season		$1,045
Remedial repairs		
4 month season	4	
5 month season	5	
6 month season	6	
7 month season	7	
8 month season	8	
9 month season	9	
12 month season	12	
Routine maintenance		
4 month season	19	
5 month season	23	
6 month season	28	
7 month season	33	
8 month season	37	
9 month season	42	
12 month season	56	
Element #4 totals		
5. Data Management		
Data acquistion/processing		
4 month season	5	
5 month season	6	
6 month season	7	
7 month season	8	
8 month season	9	
9 month season	11	
12 month season	14	
Data reporting		
4 month season	3	
5 month season	4	
6 month season	5	
7 month season	5	
8 month season	6	
9 month season	7	
12 month season	9	
Data validation		
4 month season	4	
5 month season	5	
6 month season	6	
7 month season	7	
8 month season	8	
9 month season	9	
12 month season	12	
Data distribution		
4 month season	1	
5 month season	2	
6 month season	2	
7 month season	2	
8 month season	3	
9 month season	3	
12 month season	4	
Element # 5 totals		

Cost Element	Hours/ Site	Cost/ Site
6. Quality Assurance		
Audits		
4 month season	12	
5 month season	15	
6 month season	18	
7 month season	21	
8 month season	24	
9 month season	27	
12 month season	36	
Routine calibrations		
4 month season	9	
5 month season	11	
6 month season	13	
7 month season	15	
8 month season	17	
9 month season	20	
12 month season	26	
Coordination/implementation		
4 month season	1	
5 month season	2	
6 month season	2	
7 month season	2	
8 month season	3	
9 month season	3	
12 month season	4	
Training	5	
Reporting		
4 month season	2	
5 month season	2	
6 month season	3	
7 month season	3	
8 month season	3	
9 month season	4	
12 month season	5	
QA plan review (annual)	1	
QA plan preparation (RO)	75	
Element #6 totals		
7. Supervision		
Planning/coordination		
4 month season	4	
5 month season	5	
6 month season	6	
7 month season	7	
8 month season	8	
9 month season	9	
12 month season	12	
Supervision/review		
4 month season	10	
5 month season	13	
6 month season	15	
7 month season	18	
8 month season	20	
9 month season	23	
12 month season	30	
Element #7 totals		
Summary of Burdens and Costs	**NA**	**NA**
Summary Totals	**NA**	**NA**

NA- listed since tribes would have to select specific ozone seasons

Annual Monitoring Costs for PM2.5 (based on 2006 ICR)

Cost Element	Hours/ Site	Cost/ Site
1. Network Design		
Network design (RO)	210	$853
Site selection (RO)	56	$311
Element #1 totals		
2. Site Installation		
Analyzer		
PM-2.5 sampler (sequential)		$11,493
PM-2.5 sampler (sequential) spares		$11,493
PM-2.5 sampler (single channel)		$7,314
PM-2.5 sampler (single chan) spare		$7,314
PM-2.5 sampler (single channel) coll		$7,314
PM-2.5 sampler (seasonal)		$11,493
PM-2.5 sampler (continuous)		$19,120
PM-2.5 sampler (continuous) spares		$19,120
Speciation sampler (RTI, CA, OR)		$12,538
Data acquisition (laptop/PDA)		$418
Sampling platform		$2,090
Procurement	112	
Equipment installation		
Installation (single channel)	56	
Installation (sequential)	56	
PM-2.5 sampler (seasonal)	56	
Installation (continuous)	70	
Installation (speciation)	84	
Element #2 totals		
3. Sampling & analysis		
Filter (1/1) & acceptance testing		$940
Filter (1/3) & acceptance testing		$353
Filter (1/6) & acceptance testing		$176
Filter (seasonal) & acceptance testing		$411
Speciation sampling national contract		
Routine site visits (1/1)	180	
Routine site visits (1/3)	90	
Routine site visits (1/6)	90	
Routine site visits (seasonal)	31	
Routine site visits (continuous)	32	
Routine site visits (speciation)	180	
Laboratory service		
Microbalance		$448
Clean room for weighing		$11,194
Laboratory		
PM-2.5 sampler (sequential) 1/1	2	
PM-2.5 sampler (sequential) 1/3	0	
PM-2.5 sampler (single channel) & coll	0	
PM-2.5 sampler (seasonal)	8	
Element #3 totals		
4. Maintenance		
Spare parts/supplies		
PM-2.5 sampler (sequential)		$313
PM-2.5 sampler (single channel)		$261
PM-2.5 sampler (seasonal)		$287
PM-2.5 sampler (continuous)		$162
PM-2.5 sampler (speciation)		$522
Remedial repairs		
PM-2.5 sampler (sequential)	14	
PM-2.5 sampler (single channel)	8	
PM-2.5 sampler (seasonal)	14	
PM-2.5 sampler (continuous)	11	
PM-2.5 sampler (speciation)	14	
Routine maintenance		
PM-2.5 sampler (sequential)	14	
PM-2.5 sampler (single channel)	8	
PM-2.5 sampler (seasonal)	14	
PM-2.5 sampler (continuous)	14	
PM-2.5 sampler (speciation)	16	
Element #4 totals		

Cost Element	Hours/ Site	Cost/ Site
5. Data Management		
Data acquistion/processing		
PM-2.5 sampler (sequential)	90	
PM-2.5 sampler (single channel)	18	
PM-2.5 sampler (seasonal)	90	
PM-2.5 sampler (continuous)	16	
Data reporting		
PM-2.5 sampler (sequential)	23	
PM-2.5 sampler (single channel)	4	
PM-2.5 sampler (seasonal)	23	
PM-2.5 sampler (continuous)	12	
Data validation		
PM-2.5 sampler (sequential)	63	
PM-2.5 sampler (single channel)	12	
PM-2.5 sampler (seasonal)	63	
PM-2.5 sampler (continuous)	17	
Data distribution		
PM-2.5 sampler (sequential)	18	
PM-2.5 sampler (single channel)	2	
PM-2.5 sampler (seasonal)	18	
PM-2.5 sampler (continuous)	5	
Element #5 totals		
6. Quality Assurance		
Audit/calibration kit		
PM-2.5 Filter based sampler		$125
PM-2.5 sampler (continuous)		$75
QA plan preparation (RO)	75	
QA plan review (annual)	1	
Audits		
PM-2.5 sampler (sequential)	10	
PM-2.5 sampler (single channel)	10	
PM-2.5 sampler (seasonal)	5	
PM-2.5 sampler (continuous)	10	
Reporting		
PM-2.5 sampler (sequential)	4	
PM-2.5 sampler (single channel)	4	
PM-2.5 sampler (seasonal)	2	
PM-2.5 sampler (continuous)	4	
Implementation/coordination		
PM-2.5 sampler (sequential)	13	
PM-2.5 sampler (single channel)	13	
PM-2.5 sampler (seasonal)	7	
PM-2.5 sampler (continuous)	13	
Training		
PM-2.5 sampler (sequential)	6	
PM-2.5 sampler (single channel)	6	
PM-2.5 sampler (seasonal)	6	
PM-2.5 sampler (continuous)	6	
Element # 6 totals		
7. Supervision		
Planning/coordination		
PM-2.5 sampler (sequential)	12	
PM-2.5 sampler (single channel)	9	
PM-2.5 sampler (seasonal)	12	
PM-2.5 sampler (continuous)	9	
PM-2.5 sampler (speciation)	14	
Supervision/review		
PM-2.5 sampler (sequential)	32	
PM-2.5 sampler (single channel)	24	
PM-2.5 sampler (seasonal)	12	
PM-2.5 sampler (continuous)	24	
PM-2.5 sampler (speciation)	14	
Element #7 totals		
Summary of Burdens and Costs	**NA**	**NA**
Summary Totals	**NA**	**NA**

NA- listed since tribes would have to select specific PM2.5 samplers

Annual Monitoring Cost for Ambient Air Quality Program (Based on 2006 ICR Report)

	SO2		NO2		CO	
Cost Element	Hours/ Site	Cost/ Site	Hours/ Site	Cost/ Site	Hours/ Site	Cost/ Site
1. Network Design						
Network design study (RO)	210		210		210	
Site selection (RO)	56		56		56	
Element #1 totals						
2. Site Installation						
Analyzer*		$0		$12,224		$0
Spare analyzers*		$0		$12,224		$0
Procurement	56		56		56	
Equipment installation	112		112		112	
Element #2 totals						
3. Supplies and Site Visits						
Supplies		$836		$836		$836
Routine site visits	120				120	
Element #3 totals						
4. Maintenance						
Spare parts/supplies		$1,045		$1,045		$1,045
Remedial repairs	12		16		12	
Routine maintenance	56		70		56	
Element #4 totals						
5 Data Management						
Data acquistion/processing	14		20		14	
Data reporting	9		10		9	
Data validation	12		15		12	
Data distribution	4		5		4	
Element # 5 totals						
6. Quality Assurance						
Audits	36		72		36	
Routine calibrations	26		48		26	
Coordination/implementation	4		4		4	
Training	5		5		5	
Reporting	6		6		6	
QA plan review (annual) RO	1		1		1	
QA plan preparation (RO)	75		75		75	
Element #6 totals						
7. Supervision						
Planning/coordination	12		12		12	
Supervision/review	30		30		30	
Element #7 totals						
Summary of Burdens and Costs	**856**	**1,881**	**823**	**26,329**	**856**	**1,881**
Summary Totals						

	Pb	
Cost Element	Hours/ Site	Cost/ Site
1. Network Design		
Network design (reporting org)	210	
Site selection (reporting org)	56	
Element #1 totals		
2. Site Installation		
High volume sampler *		$2,090
Audit calibration kit*		$131
Procurement	56	
Equipment installation	56	
Element #2 totals		
3. Sampling and Analysis		
Supplies		$157
Filters		$157
Laboratory services (contract)		$1,682
Routine site visits	90	
Element #3 totals		
4. Maintenance		
Spare parts/supplies		$313
Remedial repairs	8	
Routine maintenance	8	
Element #4 totals		
5. Data Management		
Data acquistion/processing	8	
Data reporting	4	
Data validation	12	
Data distribution	1	
Element # 5 totals		
6. Quality Assurance		
Audits	12	
Coordination/implementation	4	
Training		
QA plan review (annual) RO		
QA plan preparation (RO)	60	
Element #6 totals		
7. Supervision		
Planning/coordination	4	
Supervision/review	6	
Element #7 totals		
Summary of Burdens and Costs	**595**	**4,529**
Summary Totals		

* Costs would not be incurred every year for these items.

PM10 Costs (based on 2006 ICR)

Cost Element	Hours/ Site	Cost/ Site
1. Network Design		
Network design (reporting org)	210	$1,707
Site selection (reporting org)	70	$451
Element #1 totals		
2. Site Installation		
Analyzer		
PM-10 sampler		$5,746
PM-10 sampler spares		$5,746
PM-10 sampler (continuous)		$18,388
PM-10 sampler (continuous) spares		$18,388
Sampling platform		$2,090
Procurement	28	
Equipment installation		
PM-10 sampler	28	
PM-10 sampler (continuous)	70	
Element #2 totals		
3. Sampling & analysis		
Filter cost		
Filter (1/1) & acceptance testing		$1,079
Filter (1/2) & acceptance testing		$540
Filter (1/3) & acceptance testing		$405
Filter (1/6) & acceptance testing		$202
Filter tape continuous		$522
Site visits		
Routine site visits (1/1)	120	
Routine site visits (1/2)	120	
Routine site visits (1/3)	180	
Routine site visits (1/6)	180	
Routine site visits (continuous)	32	
Laboratory service		
Microbalance		$90
Laboratory		
PM-10 sampler 1/1	48	
PM-10 sampler 1/2	24	
PM-10 sampler 1/3	16	
PM-10 sampler 1/6 & collocated	8	
Element #3 totals		
4. Maintenance		
Spare parts/supplies		
PM-10 sampler 1/1		$2,194
PM-10 sampler 1/2		$784
PM-10 sampler 1/3		$575
PM-10 sampler 1/6 & collocated		$162
PM-10 continuous		$580
Remedial repairs		
PM-10 sampler 1/1	36	
PM-10 sampler 1/2	18	
PM-10 sampler 1/3	12	
PM-10 sampler 1/6 & collocated	6	
PM-10 continuous	8	
Routine maintenance		
PM-10 sampler 1/1	36	
PM-10 sampler 1/2	18	
PM-10 sampler 1/3	12	
PM-10 sampler 1/6 & collocated	6	
PM-10 continuous	14	
Element #4 totals		

Cost Element	Hours/ Site	Cost/ Site
5. Data Management		
Data acquistion/processing		
PM-10 sampler 1/1	48	
PM-10 sampler 1/2	24	
PM-10 sampler 1/3	16	
PM-10 sampler 1/6 & collocated	8	
PM-10 continuous	12	
Data reporting		
PM-10 sampler 1/1	36	
PM-10 sampler 1/2	18	
PM-10 sampler 1/3	12	
PM-10 sampler 1/6 & collocated	6	
PM-10 continuous	20	
Data validation		
PM-10 sampler 1/1	60	
PM-10 sampler 1/2	30	
PM-10 sampler 1/3	20	
PM-10 sampler 1/6 & collocated	10	
PM-10 continuous	20	
Data distribution		
PM-10 sampler 1/1	12	
PM-10 sampler 1/2	6	
PM-10 sampler 1/3	4	
PM-10 sampler 1/6 & collocated	2	
PM-10 continuous	6	
Element #5 totals		
6. Quality Assurance		
Audit/calibration kit		
PM-10 sampler		$131
PM-10 sampler (continuous)		$376
QA plan preparation (RO)	80	
QA plan review (annual)		
Audits		
PM-10 sampler 1/1	72	
PM-10 sampler 1/2	36	
PM-10 sampler 1/3	12	
PM-10 sampler 1/6 & collocated	10	
PM-10 continuous	12	
Reporting		
PM-10 sampler 1/1	24	
PM-10 sampler 1/2	12	
PM-10 sampler 1/3	8	
PM-10 sampler 1/6 & collocated	4	
PM-10 continuous	4	
Training		
PM-10 sampler 1/1	4	
PM-10 sampler 1/2	4	
PM-10 sampler 1/3	4	
PM-10 sampler 1/6 & collocated	4	
PM-10 continuous	5	
Element # 6 totals		
7. Supervision		
Planning/coordination		
PM-10 sampler 1/1	4	
PM-10 sampler 1/2	4	
PM-10 sampler 1/3	4	
PM-10 sampler 1/6 & collocated	4	
PM-10 continuous	18	
Supervision/review		
PM-10 sampler 1/1	6	
PM-10 sampler 1/2	6	
PM-10 sampler 1/3	6	
PM-10 sampler 1/6 & collocated	6	
PM-10 continuous	6	
Element #7 totals		
Summary of Burdens and Costs	**NA**	**NA**
Summary Totals	**NA**	**NA**

NA- listed since tribes would have to select specific PM10 samplers

Ganeral Implementation Costs			
Cost Element		**Hours/ Site**	**Cost/ Site**
1. Network Design			
	Network design study (see pollutant)		
	Site selection (see pollutant)		
	Travel other than monitoring site	16	
	Saturation studies	12	
	Additional indirect cost adj ($2/hour)		
Element #1 totals			
2. Site Installation			
	Multigas calibrator		$14,627
	Zero air supply		$4,179
	Ambient air intake manifold assembly		$1,567
	Shelter (large, temp controlled)		$26,642
	Shelter (small, temp controlled)		$13,582
	Shelter delivery charges		$522
	Other shelter equipment/accessories		$4,179
	Site preparation		$4,702
	Power drop		$731
	Land/lease		
	Rent		
Element #2 totals			
3. Sampling and Analysis			
	Open path monitoring	?	
	Utilities		
	Vehicle		
	Travel time to sites		
Element #3 totals			
4. Maintenance			
Element #4 totals			
5. Data Management			
	Analysis and trends (rep org)	1040	$47,946
Element #5 totals			
6. Quality Assurance			
	Multigas calibrator		$14,627
	Zero air supply		$4,179
	Miscellaneous equipment		$2,090
Element #6 totals			
7. Supervision			
Element #7 totals			
Summary of Burdens and Costs			
Summary Totals		1068	139574.832

Appendix C

Using the Graded Approach for the Development of QMPs and QAPPs in Ambient Air Quality Monitoring Programs

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Using the Graded Approach for the Development of QMPs and QAPPs in Ambient Air Quality Monitoring Programs

EPA policy requires that all organizations funded by EPA for environmental data operations (EDOs) develop quality management plans (QMPs) and quality assurance project plans (QAPPs). In addition, EPA has provided flexibility to EPA organizations on how they implement this policy, allowing for use of a graded approach. The following proposal explains the graded approach for data collection activities related to ambient air monitoring. OAQPS proposes a graded approach for the development of QAPPs and QMPs.

The Graded Approach

The QMP describes the quality system in terms of the organizational structure, functional responsibilities of management and staff, lines of authority, and required interfaces for those planning, implementing, and assessing activities involving EDOs. Each program should provide appropriate documentation of their quality system. Here are a few ways that this could be handled.

Concept - Small organizations may have limited ability to develop and implement a quality system. EPA should provide options for those who are capable of making progress towards developing a quality system. If it is clear that the EDO goals are understood and that progress in quality system development is being made, a non-optimal quality system structure, for the interim, is acceptable. The concept is to work with the small organization to view the QMP as a long-term strategic plan with an open ended approach to quality system development that will involve continuous improvement. The graded approach to QMP development is described below and is based on the size of the organization and experience in working with EPA and the associated QA requirements.

1. Small organization that just received its first EPA grant or using a grant for a discrete, small, project-level EDO. Such organizations could incorporate a description of its quality system into its QAPP.
2. Small organization implementing EDOs with EPA at more frequent intervals or implementing long-term monitoring programs with EPA funds. If such an organization demonstrates capability of developing and implementing a stand-alone quality system, it is suggested that an appropriate separate QMP be written.
3. Medium or large organization. Develop QMP to describe its quality system and QAPPs for specific EDOs. Approval of the recipient's QMP by the EPA Project Officer and the EPA Quality Assurance Manager <u>may</u> allow delegation of the authority to review and approve Quality Assurance Project Plans (QAPPs) to the grant recipient based on acceptable procedures documented in the QMP.

Quality Assurance Project Plans

The QAPP is a formal document describing, 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). The quality assurance policy of the EPA requires every EDO to have written and approved quality assurance project plans (QAPPs) prior to the start of the EDO. It is the responsibility of the EPA Project Officer (person responsible for the technical work on the project) to adhere to this policy. If the Project Officer gives permission to proceed without an approved QAPP, he/she assumes all responsibility. If a grantee's QMP is approved by EPA and provides for delegation of QAPP approval to the grantee, the grantee is responsible to ensuring approval of the QAPP prior to the start of the EDO.

The Ambient Air Monitoring Program recommends a four-tiered project category approach to the Ambient Air QA Program in order to effectively focus QA. Category I involves the most stringent QA approach, utilizing all QAPP elements as described in EPA R5[1] (see Table 2), whereas category IV is the least stringent, utilizing fewer elements. In addition, the amount of detail or specificity required for each element will be less as one moves from category I to IV. Table 1 provides information that helps to define the categories of QAPPs based upon the data collection objective. Each type of ambient air monitoring program EDO will be associated with one of these categories. The comment area of the table will identify whether QMPs and QAPPs can be combined and the type of data quality objectives (DQOs) required (see below). Table 2 identifies which of the 24 QAPP elements are required for each category of QAPP. Based upon a specific project, the QAPP approving authority may add/delete elements for a particular category as it relates to the project but in general, this table will be applicable based on the category of QAPP.

Flexibility on the systematic planning process and data quality objective (DQO) development

Table 1 describes 4 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 should be flexibility with the systematic planning process on how these DQOs are developed based on the particular category. For example, a category 1 project would have formal DQOs. Examples of category I projects, such as the State and Local Monitoring Stations (SLAMS), have DQOs developed by OAQPS. Category II QAPPS may have formal DQOs developed if there are national implications to the data (i.e., Speciation Trends Network) or less formal DQOs if developed by organizations implementing important projects that are more local in scope. Categories 3 and 4 would require less formal DQOs to a point that only project goals (category 4) may be necessary.

Standard Operating Procedures- (SOP)

SOPs are an integral part of the QAPP development and approval process and usually address key information required by the QAPP elements. Therefore, SOPs can be referenced in QAPP elements as long as the SOPs are available for review or are part of the QAPP.

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[1] EPA Requirements for QA Project Plans (QA/R-5) http://www.epa.gov/quality/qa_docs.html

Table 1. Ambient Air Monitoring Program QAPP/QMP categories

Categories	Programs	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 I projects require the most detailed and rigorous QA and QC for legal and scientific defensibility. Category I 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 QMP/QAPP combination 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 II projects may also include certain high visibility projects as defined by EPA management	Speciation Trends Toxics Mon.	Most agencies implementing Ambient Air Monitoring Networks will have separate QMPs and QAPPs. However, a Region has the discretion to approve QMP/QAPP combination for small monitoring organizations (i.e., Tribes)	Formal DQOs for national objective, Flexible DQOs for localized objectives
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 EDOs to study basic phenomena or issues, including proof of concepts, screening for particular analytical species, etc. Such projects generally do not require extensive detailed QA/QC activities and documentation	Education/Outreach		Project Objectives or Goals

Table 2 QAPP Elements

QAPP Element	Category Applicability
A1 Title and Approval Sheet	I, II, III, IV
A2 Table of Contents	I, II, III
A3 Distribution List	I,
A4 Project/Task Organization	I, II, III
A5 Problem Definition/Background	I, II, III
A6 Project/Task Description	I, II, III, IV
A7 Quality Objectives and Criteria for Measurement Data	I, II, III, IV
A8 Special Training Requirements/Certification	I
A9 Documentation and Records	I, II, III
B1 Sample Process (Network) Design	I, II, III, IV
B2 Sampling Methods Requirements	I, II, III,
B3 Sample Handling and Custody Requirements	I, II, III
B4 Analytical Methods Requirements	I, II, III, IV
B5 Quality Control Requirements	I, II, III, IV
B6 Instrument/Equipment Testing, Inspection & Maintenance	I, II, III
B7 Instrument Calibration and Frequency	I, II, III
B8 Inspection/Acceptance Requirements for Supplies and Con.	I,
B9 Data Acquisition Requirements for Non-direct Measurements	I, II, III
B10 Data Management	I, II
C1 Assessments and Response Actions	I, II,
C2 Reports to Management	I, II,
D1 Data Review, Validation, and Verification Requirements	I, II, III
D2 Validation and Verification Methods	I, II
D3 Reconciliation and User Requirements	I, II,

Appendix D

Grant Funding Information

The following information is provided in the Attachment:

1. **Tips on Writing a Grant Proposal** from the website**:**http://www.epa.gov/ogd/recipient/tips.htm

2. **A Summary of Some EPA Grants :** http://www.purdue.edu/envirosoft/grants/src/sumgrant.htm

3. **Indian General Assistance Program (GAP) FY 2007** list of some helpful websites related to the development of GAP applications and environmental programs.

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Tips On Writing a Grant Proposal

Grants are sums of money awarded to finance a particular activity or facility. Generally, these grant awards do not need to be paid back. Federal agencies and other organizations sponsor grant programs for various reasons. Before developing a grant proposal, it is vitally important to understand the goals of the particular Federal agency or private organization, and of the grant program itself. This can be accomplished through careful analysis of the Catalog of Federal Domestic Assistance (CFDA), Request for Initial Proposals (RFIP) or Request for Applications (RFA) and discussions with the information contact listed in each resource description. Through these discussions an applicant may find that, in order for a particular project to be eligible for funding, the original concept may need to be modified to meet the criteria of the grant program. In allocating funds, programs base their decisions on the applicant's ability to fit its proposed activities within the program's interest areas.

It is important for an applicant to become familiar with eligibility requirements and other criteria related to the organization and grant program from which assistance is sought. Applicants should remember that the basic requirements, application forms, information,
deadlines and procedures will vary for each grant maker.

Before You Begin Writing the Grant Proposal:

- Rule #1: Believe that someone wants to give you the money!
- Project your organization into the future.
- Start with the end in mind...look at your organization's big picture. Who are you? What are your strengths and priorities?
- Create a plan not just a proposal.
- Do your homework: Research prospective funders. Try and search locally first. Target funding source that has interest in your organization and program.

If you need the money now, you have started too late.

A successful grant proposal is one that is thoughtfully planned, well prepared, and concisely packaged. There are nine basic components in a solid proposal package:

<u>1. Proposal Summary</u>

The proposal summary appears at the beginning of the proposal and outlines the project. It can be a cover letter or a separate page. It should be brief: no longer than two or three paragraphs. It is often helpful to prepare the summary after the proposal has been developed. This makes it easier to include all the key points necessary to communicate the objectives of the project. The summary document becomes the foundation of the proposal. The first impression it gives will be critical to the success of the venture. It very possibly could be the only part of the package that is carefully reviewed before the decision is made to consider the project further.

2. Introduction of the Organization

Most proposals require a description of an applicant's organization and its past, present, and projected operations. Be concise, specific and compelling. Use the description to build credibility for your organization. (Start a "credibility" file.) Reinforce the connection between you and the grantor. Establish a context for your problem statement.

IN BRIEF: Who, what, when, why, and how much!

Some features to consider are:

- A brief biography of board members and key staff members,
- The organization's goals, philosophy, and record with other grantors,
- any success stories. The data should be relevant to the goals of the granting organization and its grant program, and should establish the applicant's credibility.

3. Problem Statement

The problem statement (or needs assessment) is a key element of a proposal. It should be a clear, concise, well-supported statement of the problem to be overcome using the grant funding. An applicant could include data collected during a needs assessment that would illustrate the problems to be addressed. The information provided should be both factual and directly related to the problem addressed by the proposal.

Zero in on a specific problem you want to solve or an issue you want to address;

Do not make assumptions of the reviewers,

Use statistics to support the existence of your problem or issue,

Make a connection between the issue and your organization,

Make a case for your project locally, not just nationally,

Demonstrate your knowledge of the issue or problem and,

Set-up the milestones of your goals and objectives, address the outcomes you wish to achieve.

4. Project Objectives

The project objectives should clearly describe the goals of the project. Applicants should explain the expected results and benefits of each objective. They should also list the specific criteria of the grant program. Then, describe how the proposal meets each criterion. Goals are general and offer the evaluator an understanding of the thrust of your program. Objectives are specific, measurable outcomes. They should be realistic and attainable. Objectives help solve the problem or address the issue. If your objectives make reference to a number -- make sure it is do-able. Do not confuse objectives with methods. Always be realistic.

5. Project Methods or Design

The project method outlines the tasks that will be accomplished with the available resources. It is helpful to structure the project method as a timeline. Early in the planning process, applicants should list the tasks that will have to be completed to meet the goals of the project. They can then break these into smaller tasks and lay them out in a schedule over the grant time period. This will provide a chance to consider what personnel, materials, and other resources will be needed to carry out the tasks.

Describe in detail the activities that will take place in order to achieve desired results. Make sure your methods are realistic. Describe WHY you have chosen these activities. Justify them over all other approaches your organization could have taken. Show your knowledge of the bigger picture. Include a timetable of major milestones.

6. Project Evaluation

Applicants should develop evaluation criteria to evaluate progress towards project goals. It is important to define carefully and exactly how success will be determined. Applicants should ask themselves what they expect to be different once the project is complete. If you are having a problem developing your evaluation process, you better take another look at your objectives. Be ready to begin evaluation as you begin your project.

Summative and Formative Evaluation:

Summative Evaluation is a plan to evaluate the project that measures how you will have met your objectives.

Formative Evaluation is a plan to evaluate the project during and after its execution. It can be used as a tool to make appropriate changes along the way.

7. Future Funding

Applicants may be asked to list expected sources of continuing funding after the conclusion of the grant. The applicant may also be required to list other sources and amounts of funding obtained for the project.

8. The Proposal Budget

Funding sources require different amounts of detail in the budget. Most Federal funding sources require a large amount of detail. Also, they usually provide budget forms with instructions. The budget format presented here is designed to match what most Federal agencies request. If the funding source requires a specific format, you must provide a budget in that format.

Your Budget is an Estimate

Your budget is an estimate. Still, you may not exceed the total amount for the grant. Do not feel you must spend the money to the penny. Your funding source will allow some freedom in spending the money. They might permit requests to change the budget. Such requests must be in writing. A written response becomes a formal "budget modification." The budget modification changes the conditions of the grant. Careful planning will decrease the number of changes that may be required. Also, careful planning shows honesty. This honesty will be necessary to get permission for future changes.

Be Specific

The numbers should be specific. Rounding an item to nearest thousand dollars does not inspire confidence. It also suggests you have not done much work preparing the budget. The reviewer will do a lot of work studying your budget. They expect you to you a lot of work planning the budget. If you round at all, round to dollars, or tens at most. Along the same lines, there is no place in the budget for miscellaneous or contingency items. Your planning should allow for contingencies. For example, a cost of living increase will happen before the grant begins. In this case, you should base salaries on the increased salaries. If you plan to buy equipment, contact the distributor to find out the cost of the equipment when you plan to purchase it. The amount of thought you give to preparing the budget will produce a better program. It will also increase your chances of receiving the grant.

This Format

This budget format is useful for planning both governmental and private grants. It has two basic parts: (I) Personnel costs, and (II) Non-Personnel costs. There is an optional third part called "Indirect Costs" that pertains to some grant applications. There is also a "Budget Summary." This is written after the budget is complete and is presented at the start of the budget.

The Proposal Budget Budget Summary

	Total	Total Requested	Total Match
Total this Grant	$100,671.12	$78,362.62	$22,308.50
Personnel			
Salaries and Wages	44,950.00	43,200.00	6,750.00
Fringe Benefits	12,148.62	10,479.12	1,669.50
Non-Personnel	$38,572.50	$24,683.50	$13889.00
Consultants and Contract Services	15,664.00	4,800.00	10,864.00
Equipment	7,710.00	7,085.00	625.00
Supplies	1,287.00	1,287.00	- 0 -
Travel	1,761.00	1,761.00	- 0 -
Other Costs	12200.00	9,800.00	2400.00

Costs are divided into two columns: "requested" and "match." The "requested" column is for items we are asking the funding source to pay for. The "match" column represents those items that are either to be paid for from some other source of funds, or which are actually donated or contributed to the project. In the case of a federal grant proposal, these two columns represent the "federal share" and the "non-federal share." Let's look at each of these budget components separately. To the funding source, this will be done in what is called the "budget detail." This is where each section of the budget is broken down. Budget calculations also appear here. If the funding source provides forms, much of the following information will fit into the appropriate space on the form.

Budget Detail - Personnel: Salaries and Wages

	Requested	Match
Personnel		
Salaries and Wages		
(1) Exec. Dir. @ $1,500/mo x 10% x 12 mos.		1,800.00
(1) Proj. Dir. @ $1,200/mo x 100% x 12 mos.	14,400.00	
(2) Counselors @ $900/mo x 100% x 11 mos.	19,800.00	
(1) Counselor* @ $900/mo x 50% x 11 mos.		4,950.00
(1) Secretary @ $750/mo x 100% x 12 mos.	9,000.00	
Total	$ 43,200.00	$ 6,750.00

*This half-time counselor position is contributed to this program by another social service agency.

First, enter the number of persons at the same salary and same job. Second, enter the title of the position. Third, enter the full monthly salary for that position. Do this whether the position is full-time or part-time. Pro-rating salaries for part-time positions can be very confusing. Clarify this by entering the percentage time that this person will be working on your project. Then, enter the number of months this person will be employed during the grant period. Next multiply the three numbers (number of people, salary, number of months working) to obtain totals. Enter these totals in one of two columns. Which column depending upon whether the funds are being requested of this funding source or coming from elsewhere.

Indicate personnel contributed by other agencies with an asterisk (*). Note the source of these additional personnel.

It is wise to have salary ranges for most, if not all, of the positions within your organization. If you do, then you may make an additional note to this section. For example: "All salaries within this budget item represent the middle step of the salary range for the position, except for those instances where a person is presently filling that position." You would then attach a copy of your salary schedule to the budget. This procedure can keep you from becoming locked into an exact salary. This also depends on your personnel policies. Your policies may allow the employment of a new person at any step within the salary range. By using the middle step for budget purposes, you allow for the averaging of the salary of a new employee. Some may come in at the first step, some at the top step. If the funding source advises another way of presenting salaries (for example, at the top step), then follow instructions.

When jobs are created that do not currently exist within your organization, conduct a survey to determine proper salaries. Find local agencies similar in size and mission. Try to identify positions in those agencies close to the new jobs in your agency. Salaries for these positions should be your guide. Save this survey information. The funding source might ask how you decided the salary of a new job.

In the salaries and wages section, enter only those positions where salaries are paid. These salaries can either be paid by the proposed grant, your regular budget, or by some other source of funding. Volunteers, who are not paid, will be entered in the "Consultants and Contract Services" item as other personnel.

Budget Detail - Personnel: Fringe Benefits

	Requested	Match
Personnel:		
Fringe Benefits		
SUI - 3.2% x $24,000 (California Rates)	768.00	
Workers Comp. Policy	350.00	
FICA - 6.13% x $43,200	2,648.16	
Health Insurance - 2 single employees @ $35/mo; 2 employees with dependents @ $98/mo; x12 mos. (employer pays 100%)	3,192.00	
Extended Disability Ins. -		
4 employees @ $4.02/mo x 12 mos.	192.96	
Vacation and Sick Leave - 16 wks.		
@ avg. salary of $208.00/wk.	3,328.00	
Fringe benefits for donated executive director, based on agency's total fringe benefit percentage (24%) of salary ($1,800)		432.00
Fringe benefits for donated counselor, based on donating agency's total fringe benefit percentage (25%) of salary ($4,950)		1,237.50
Total	$ 10,479.12	$1,669.50

Fringe benefits require a separate category in your budget. They should not be combined with staff salaries. Some funding sources will accept a fringe benefit as a percentage of payroll (for example, "22 percent of the above"). However, it is desirable to carefully explain all of the benefits covered by the grant. Do not do this if the funding source asks differently. Donated fringe benefits can be entered as payroll percentages. There are three kinds of fringe benefits that apply:

1.Mandated benefits - those required by the state in which you are located. Examples of required benefits are Workers Compensation Insurance and State Unemployment Insurance (SUI).

2.<u>Security (FICA)</u> - from which many public and private nonprofit agencies are exempt but in which most agencies voluntarily participate.

3.<u>Voluntary benefits</u> - vary from organization to organization. They include medical, dental, disability and life insurance, private retirement programs, reimbursement for work-related education expenses, reimbursement for parking, sabbatical leave, etc.

All organizations have some provisions for vacation and sick leave. Sometimes these are not written into the budget. Smaller organizations often omit this item from the fringe benefit description. If grant-supported staff does not take their vacations during the period of a grant, at the end of the grant, they may wind up with a financial burden for unused vacation time. Then they must find a source of funds to compensate staff for this earned vacation. Avoid this situation by including a figure for vacation and sick leave. Do this only if allowed for by the funding source.

Perform your actual calculations within the budget detail. For example, in California, the rate for State Unemployment Insurance during 1998 ranged from 0.4 percent to 4.9 percent (depending on the history of unemployment claims of the applicant) of the first $6,000 of each person's salary. The l999 Social Security rate was 6.43 percent of the first $22,900 of any salary.

Budget Detail - Consulting and Contract Services

	Requested	Match
1. Contractual Personnel		
C. Consulting and Contract Services		
Consulting Psychologist (Dr. Goodge, NY		
Physiological Assn.) 4 hrs/wk x $40 x 52 wks.		8,320.00
Evaluation Consultant (Dr. Fastback, Uni.		
Evaluation Center) 10 hrs/wk x $25/hr x 12 mos.	3,000.00	
Bookkeeping Services by Fold, Spindle, & Mutilate, Inc. $150/mo x 12 mos.	1,800.00	
(4) Volunteer tutors @ 5 hrs/wk each x 48 wks x $2.65/hr.		2,544.00
Total	$ 4,800.00	$10,864.00

Paid and unpaid (volunteer) consultants are listed in this section of your budget. Rather than employing a bookkeeper, you may use paid consultant time. If services are volunteered, that goes in here as well. Volunteer time may be allowed by some government funding sources. This occurs when they require some portion of the grant be matching funds, or in-kind contributions by the applicant. This raises the question of how to place a value on a volunteer's time. Gather written statements from the volunteers testifying to their commitment to volunteer services to your program. Remember, these must be like services. For an attorney to be valued at $40.00/hr. in your program, he/she must be providing legal services to you - not driving children to football games every Saturday. These statements establish the value of the volunteered time. They also are good credibility letters from persons sufficiently impressed with you to volunteer.

Volunteers who have not the needed skills to qualify for a specific role, and who have not been paid a salary in that role, must be rated at the current minimum wage. This happens no matter how well they perform.

Budget Detail - Non-Personnel: Rental, Lease, or Purchase of Equipment

	Requested	Match
Rental, Lease or Purchase of Equipment		
(1) Secretarial Desk @ $150	150.00	
(1) Secretarial Chair @ $65	65.00	
(2) Desks @ $100	200.00	
(2) Chairs @ $65	130.00	
(2) Desks donated by applicant @ rental value of $5/ea/mo x 12 mos.		120.00
(8) Chairs donated @ rental value of $5/ea/mo x 12 mos.		480.00
(1) File Server @ $5,220	5220.00	
(2) Spendthrift computers @ $30/mo leased x 12 mos.	720.00	
(1) Dynamite Copying machine leased @ $50/mo x 12 mos.	600.00	
Total	$ 7,085.00	$ 600.00

The second non-personnel item is for rental, lease or purchase of equipment. This will include computers, tables, chairs, desks, filing cabinets, copying equipment, etc. Unused equipment your agency now owns can be applied to this project. Attach an approximate rental value to the unused equipment. For example, rather than buying a new desk for a new person, use one you already have but are not now using. Find out what it would cost to rent the desk for a year, and put that value into your budget as a contribution from your agency.

Budget Detail - Non-Personnel: Supplies

	Requested	Match
Desktop supplies for 6.5 staff @ $125/ea/yr	812.50	
100 reams copy paper @ $2.75/ea and 5 toner refills @ $40/ea	475.00	
Total	$ 1,287.50	- 0 -

There are three separate kinds of consumables that might appear in your budget:

1. Desk top supplies. These include the normal pens, erasers, stationery, paper clips, etc. A reasonable cost for these items is $100 to $125 per year per person in your office unless these items are included in your indirect cost rate in which case you would not direct charge them. Experience should indicate whether this will be sufficient.

2. Copying supplies. Since copying has become universal, and since paper and toner are such expensive items, these should be separated from the above unless you are advised otherwise or these items are included in your indirect cost rate in which case you would not direct charge them.

3. Direct program-related consumables. These might be arts and crafts supplies provided to children in a child care program, etc.

Budget Detail - Non-Personnel: Travel

	Requested	Match
Local mileage for Project Director:		
100 mi/mo @ $0.17/mi x 12 mos.	204.00	
Local mileage for (2) Counselors:		
200 mi/mo @ $0.17/mi x 12 mos.	816.00	
Travel expenses for Project Director to attend Grantsmanship Center Training Program in Los Angeles, July 11-15, 19 - $325 tuition plus $218 round-trip air plus 6 days per diem @ $33/day	741.00	
Total	$ 1,761.00	- 0 -

Be specific. For local mileage, project the number of miles you expect each person to drive on the job each month. Multiply this by the accepted rate in your geographic area. Multiply again by the number of months in the grant period. For out-of-town travel, you must anticipate the travel that will be required during the grant. This may be easy for program-related travel (e.g., visiting remote program sites), but is more difficult in planning training and conference attendance. These items in your budget should be supported by a statement in your program narrative describing the need for and benefits of whatever travel is budgeted. You might include fees for training, as well as per diem and air travel expenses, in this category.

Budget Detail - Non-Personnel: Other Costs

This is the category for items that do not fit naturally into another category. Examples of items that might be:

1. Postage
2. Fire, theft, and liability insurance
3. Dues in professional associations paid for by the applicant
4. Subscriptions to periodicals
5. Publications costs

Other Costs

	Requested	Match
Telephone Installation @ $260	260.00	
(6) Instruments @ $45/ea/mo x 12 mos.	3,240.00	
Postage	600.00	
Insurance (Fire, Theft, Liability)	750.00	
Space Costs		
Office rent - 1,200 sq. ft. @ $6.00/ft/yr	7,200.00	
Tutoring space - contributed by local school: one classroom 20 hrs/wk x $50/wk x 48 wks.		2,400.00
Office janitorial @ $100/mo x 12 mos.	1,200.00	
Office Utilities @ $125/mo x 12 mos.	1,500.00	
Total	$ 11,200	$2,400

If you will be installing new telephones, get an estimate from the phone company (or other vendor) of the cost of installation. Then estimate the average monthly cost per instrument times the number of instruments times the number of months of the project. The first non-personnel item is space costs. That includes office rent, space used outside your office, utilities, maintenance, janitorial services, and essential renovations. As with all other budget items, you must be aware of "comparability" of costs. If you propose to pay much more for rent than the current rent in your community, be prepared to explain your choice.

Budget Detail - Indirect Cost

Organizations that operate several different funded projects face a problem. The cost to the organization of housing a project may drain the resources of the institution. Indirect costs are an attempt to compensate the organization for these costs. Indirect costs are also to provide a basis for sharing the costs of running a large institution among the various programs and projects within the institution.

Indirect costs are those costs of an institution which are not readily identifiable with a particular project or activity but nevertheless are necessary to the general operation of the institution and the conduct of its activities. The costs of operating and maintaining buildings, grounds and equipment, depreciation, general and departmental administrative salaries and expenses and library costs are types of expenses usually considered as indirect costs. In theory, all such costs might be charged directly; practical difficulties, however, preclude such an approach. Therefore, they arc usually grouped into common pool(s) and distributed to those institutional activities benefited through a cost allocation process. The end product of this allocation process is an indirect cost rate(s) which is then applied to individual grant and contract awards to determine the amount of indirect costs chargeable to the award.

Indirect costs may or may not be provided by a funding source. Generally, those sources that support higher educational institutions do provide them. Some funding sources place a ceiling upon indirect costs allowed in a given grant situation. Be sure to find out what percentage, if any, the funding source will allow for indirect costs, and determine which portion of your budget the percentage applies to. Sometimes indirect costs are a percentage of the total direct costs, or of the personnel costs, or of the salary and wages item alone.

Appendices

<u>Resumes</u>:

- Shows qualifications
- Shows work ethic and commitment
- Sometime can be a few paragraphs
- List other grants you have managed

<u>Letters of Support or Endorsement</u>:

- They are DIFFERENT
- Support implies partners
- Keep endorsement to a minimum
- Should be sent to you, the applicant. Do not send separately to the funder.

Other attachments: Do not include unless they are requested

A SUMMARY OF SOME EPA GRANTS

Please select among the following programs:

- Air Pollution Control Grants
- The Brownfield Economic Redevelopment Pilots
- The Climate Change Division's Environmental Justice Pilots
- Community-Based Lead Abatement Demonstration Projects
- Emergency Planning and Community Right-to-Know Technical Assistance Grants
- Environmental Education Grants Program
- EPA's Environmental Finance Program
- EPA Initiatives under the National Service Program
- Indian Environmental General Assistance Program
- Local Government Sustainable Buildings Project
- Minority Environmental Science. Engineering. and Technology Education initiative
- National Estuary Grant Program
- Environmental Finance Center (EFC) Pilots
- Environmental Justice Community University Partnership Grant Program
- Environmental Justice Small Grant Program
- Environmental Justice Through Pollution Grand Program
- Environmental Technology Initiative (ETI)
- Solid Waste Management Assistance
- Science to Achieve Result (STAR) Program
- Superfund Innovative Technology Evaluation Program (SITE)
- Superfund Technical Assistance Grants for Citizen Group at Priority Sites
- Training Grants for Lead-Based Paint Abatement Workers
- Wellhead Protection Demonstration Project
- Sustainable Development Challenge (SDC)
- Brownfields Grant Program
- Pollution Prevention Incentives for States (PPIS)

Indian General Assistance Program (GAP)
FY 2007

The following list provides some helpful websites related to the development of GAP applications and environmental programs.

Federal Application Forms and OMB Circulars
http://www.whitehouse.gov/omb/circulars/index.html

EPA Application Forms
http://www.epa.gov/ogd/AppKit/application.html

EPA GAP Guidance
http://www.epa.gov/indian/laws3.htm

EPA Region 10 Tribal Office
http://yosemite.epa.gov/r10/tribal.NSF

EPA Region 10 Grants
http://yosemite.epa.gov/r10/omp.nsf/webpage/Region+10+Grants+Administration+Unit

Government Performance and Results Act (GPRA) of 1993
www.epa.gov/budget/planning/gpra.htm

EPA Strategic Plan
www.epa.gov/ocfopage/plan/plan.htm

EPA Environmental Results Order (EPA Order 5700.7)
www.epa.gov/ogd/

EPA provided information and tutorials on Logic Model planning at:
http://yosemite.epa.gov/R10/ECOCOMM.NSF/webpage/measuring+environmental+results

Catalog of Federal Domestic Assistance
http://www.cfda.gov/

Applying for an Indirect Cost Rate
http://www.nbc.gov/icshome.html

Also available in hard copy are the ***"IGAP Supplemental Guide to the Application Kit for Financial Assistance", "Tools and Resources for EPA Assistance Applicants and Recipients"****, and* ***"Supplement to Tools and Resources".*** *If you would like a copy of any of these documents, please contact your EPA Tribal Coordinator, or Robert Woodman, Alaska Tribal Liaison, at 1-800-781-0983.*

Appendix E

Sample Manifold Design for Precursor Gas Monitoring

The following information is extracted from the document titled: *Version 4 of the Technical Assistance Document for Precursor Gas Measurements in the NCore Multi-pollutant Monitoring Network* which can be found on the AMTIC website at: http://www.epa.gov/ttn/amtic/pretecdoc.html

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Sample Manifold Design for Precursor Gas Monitoring

Many important variables affect sampling manifold design for ambient precursor gas monitoring: residence time of sample gases, materials of construction, diameter, length, flow rate, and pressure drop. Considerations for these parameters are discussed below.

Residence Time Determination: The residence time of air pollutants within the sampling system (defined as extending from the entrance of the sample inlet above the instrument shelter to the bulkhead of the precursor gas analyzer) is critical. Residence time is defined as the amount of time that it takes for a sample of air to travel through the sampling system. This issue is discussed in detail for NO_y monitoring in Section 4.2, and recommendations in Section 4 for the arrangement of the molybdenum converter and inlet system should be followed. However, residence time is also an issue for other precursor gases, and should be considered in designing sample manifolds for those species. For example, Code of Federal Regulations (CFR), Title 40 Part 58, Appendix E.9 states, "Ozone in the presence of NO will show significant losses even in the most inert probe material when the residence time exceeds 20 seconds. Other studies indicate that 10-second or less residence time is easily achievable."[1] Although 20-second residence time is the maximum allowed as specified in 40 CFR 58, Appendix E, it is recommended that the residence time within the sampling system be less than 10 seconds. If the volume of the sampling system does not allow this to occur, then a blower motor or other device (such as a vacuum pump) can be used to increase flow rate and decrease the residence time. The residence time for a sample manifold system is determined in the following way. First the total volume of the cane (inlet), manifold, and sample lines must be determined using the following equation:

$$\textit{Total Volume} = Cv + Mv + Lv \qquad \textit{Equation 1}$$

Where:

Cv = Volume of the sample cane or inlet and extensions
Mv = Volume of the sample manifold and moisture trap
Lv = Volume of the instrument lines from the manifold to the instrument bulkhead

The volume of each component of the sampling system must be measured individually. To measure the volume of the components (assuming they are cylindrical in shape), use the following equation:

$$V = \pi * (d/2)^2 * L \qquad \textit{Equation 2}$$

Where:
V = volume of the component, cm^3
π = 3.14
L = Length of the component, cm
d = inside diameter of the component, cm

Once the total volume is determined, divide the total volume by the total sample flow rate of all instruments to calculate the residence time in the inlet. If the residence time is greater than 20 seconds, attach a blower or vacuum pump to increase the flow rate and decrease the residence time.

Laminar Flow Manifolds: In the past, vertical laminar flow manifolds were a popular design. By the proper selection of a large diameter vertical inlet probe and by maintaining a laminar flow throughout, it was assumed that the sample air would not react with the walls of the probe. Numerous materials such as glass, plastic, galvanized steel, and stainless steel were used for constructing the probe. Removable sample lines constructed of FEP or PTFE were placed to protrude into the manifold to provide each instrument with sample air. A laminar flow manifold could have a flow rate as high as 150 L/min, in order to minimize any losses, and large diameter tubing was used to minimize pressure drops. However, vertical laminar flow manifolds have many disadvantages which are listed below:

- Since the flow rates are so high, it is difficult to supply enough audit gas to provide an adequate independent assessment for the entire sampling system;
- Long laminar flow manifolds may be difficult to clean due to size and length;
- Temperature differentials may exist that could change the characteristics of the gases, e.g., if a laminar manifold's inlet is on top of a building, the temperature at the bottom of the building may be much lower, thereby dropping the dew point and condensing water.

For these technical reasons, EPA strongly discourages the use of laminar flow manifolds in the national air monitoring network. It is recommended that agencies that utilize laminar manifolds migrate to conventional manifold designs that are described below.

Sampling Lines as Inlet and Manifold: Often air monitoring agencies will place individual sample lines outside of their shelter for each instrument. If the sample lines are manufactured out of Polytetrafluoroethylene (PTFE) or Fluoroethylpropylene (FEP) Teflon®, this is acceptable to the EPA. The advantages to using single sample lines are: no breakage and ease of external auditing. In addition, rather than cleaning glass manifolds, some agencies just replace the sampling lines. However, please note the following caveats:

1. PTFE and FEP lines can deteriorate when exposed to atmospheric conditions, particularly ultraviolet radiation from the sun. Therefore, it is recommended that sample lines be inspected and replaced regularly.
2. Small insects and particles can accumulate inside of the tubing. It has been reported that small spiders build their webs inside of tubing. This can cause blockage and affect the response of the instruments. In addition, particles can collect inside the tubing, especially at the entrance, thus affecting precursor gas concentrations. Check the sampling lines and replace or clean the tubing on a regular basis.
3. Since there is no central manifold, these configurations sometimes have a "three-way" tee, i.e., one flow path for supplying calibration mixtures and the other for the sampling of ambient air. If the three-way tee is not placed near the outermost limit of the sample inlet tubing, then the entire sampling system is not challenged by the provision of calibration gas. It is strongly recommended that at least on a periodic basis calibration gas be supplied so

that it floods the entire sample line. This is best done by placing the three-way tee just below the sample inlet, so that calibration gas supplied there is drawn through the entire sampling line.

4. The calibration gas must be delivered to the analyzers at near ambient pressure. Some instruments are very sensitive to pressure changes. If the calibration gas flow is excessive, the analyzer may sample the gas under pressure. If a pressure effect on calibration gas response is suspected, it is recommended that the gas be introduced at more than one place in the sampling line (by placement of the tee, as described in item #3 above). If the response to the calibration gas is the same regardless of delivery point, then there is likely no pressure effect.

Conventional Manifold Design - A number of "conventional" manifold systems exist today. However, one manifold feature must be consistent: the probe and manifold must be constructed of borosilicate glass or Teflon® (PFA or PTFE). These are the only materials proven to be inert to gases. EPA will accept manifolds or inlets that are made from other materials, such as steel or aluminum, that are lined or coated with borosilicate glass or the Teflon® materials named above. However, all of the linings, joints and connectors that could possibly come into contact with the sample gases must be of glass or Teflon®. It is recommended that probes and manifolds be constructed in modular sections to enable frequent cleaning. It has been demonstrated that there are no significant losses of reactive gas concentrations in conventional 13 mm inside diameter (ID) sampling lines of glass or Teflon® if the sample residence time is 10 seconds or less. This is true even in sample lines up to 38 m in length. However, when the sample residence time exceeds 20 seconds, loss is detectable, and at 60 seconds the loss can be nearly complete. Therefore, EPA requires that residence times must be 20 seconds or less (except for NOy). Please note that for particulate matter (PM) monitoring instruments, such as nephelometers, Tapered Element Oscillating Microbalance (TEOM) instruments, or Beta Gauges, the ambient precursor gas manifold is not recommended. Particle monitoring instruments should have separate intake probes that are as short and as straight as possible to avoid particulate losses due to impaction on the walls of the probe.

T-Type Design: The most popular gas sampling system in use today consists of a vertical "candy cane" protruding through the roof of the shelter with a horizontal sampling manifold connected by a tee fitting to the vertical section (Figure 1). This type of manifold is commercially available. At the bottom of the tee is a bottle for collecting particles and moisture that cannot make the bend; this is known as the "drop out" or moisture trap bottle. Please note that a small blower at the exhaust end of the system (optional) is used to provide flow through the sampling system. There are several issues that must be mitigated with this design:

- The probe and manifold may have a volume such that the total draw of the precursor gas analyzers cannot keep the residence time less than 20 seconds (except NOy), thereby requiring a blower motor. However, a blower motor may prevent calibration and audit gases from being supplied in sufficient quantity, because of the high flow rate in the manifold. To remedy this, the blower motor must be turned off for calibration. However, this may affect the response of the instruments since they are usually operated with the blower on.

- Horizontal manifolds have been known to collect water, especially in humid climates. Standing water in the manifold can be pulled into the instrument lines. Since most monitoring shelters are maintained at 20-30 ^{o}C, condensation can occur when warm humid outside air enters the manifold and is cooled. Station operators must be aware of this issue and mitigate this situation if it occurs. Tilting the horizontal manifold slightly and possibly heating the manifold have been used to mitigate the condensation problem. Water traps should be emptied whenever there is standing water.

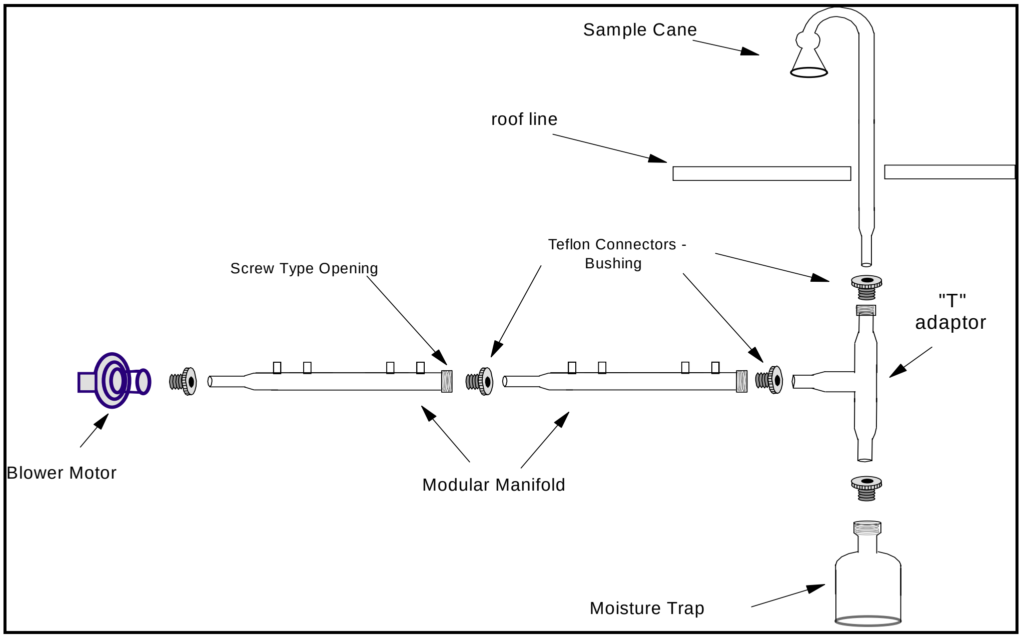

Figure 1. Conventional T-Type Glass Manifold System

California Air Resources Board "Octopus" Style: Another type of manifold that is being widely used is known as the California Air Resources Board (CARB) style or "Octopus" manifold, illustrated in Figure 2. This manifold has a reduced profile, i.e., there is less volume in the cane and manifold; therefore, there is less need for a blower motor. If the combined flow rates of the gas analyzers are high enough, then an additional blower is not required.

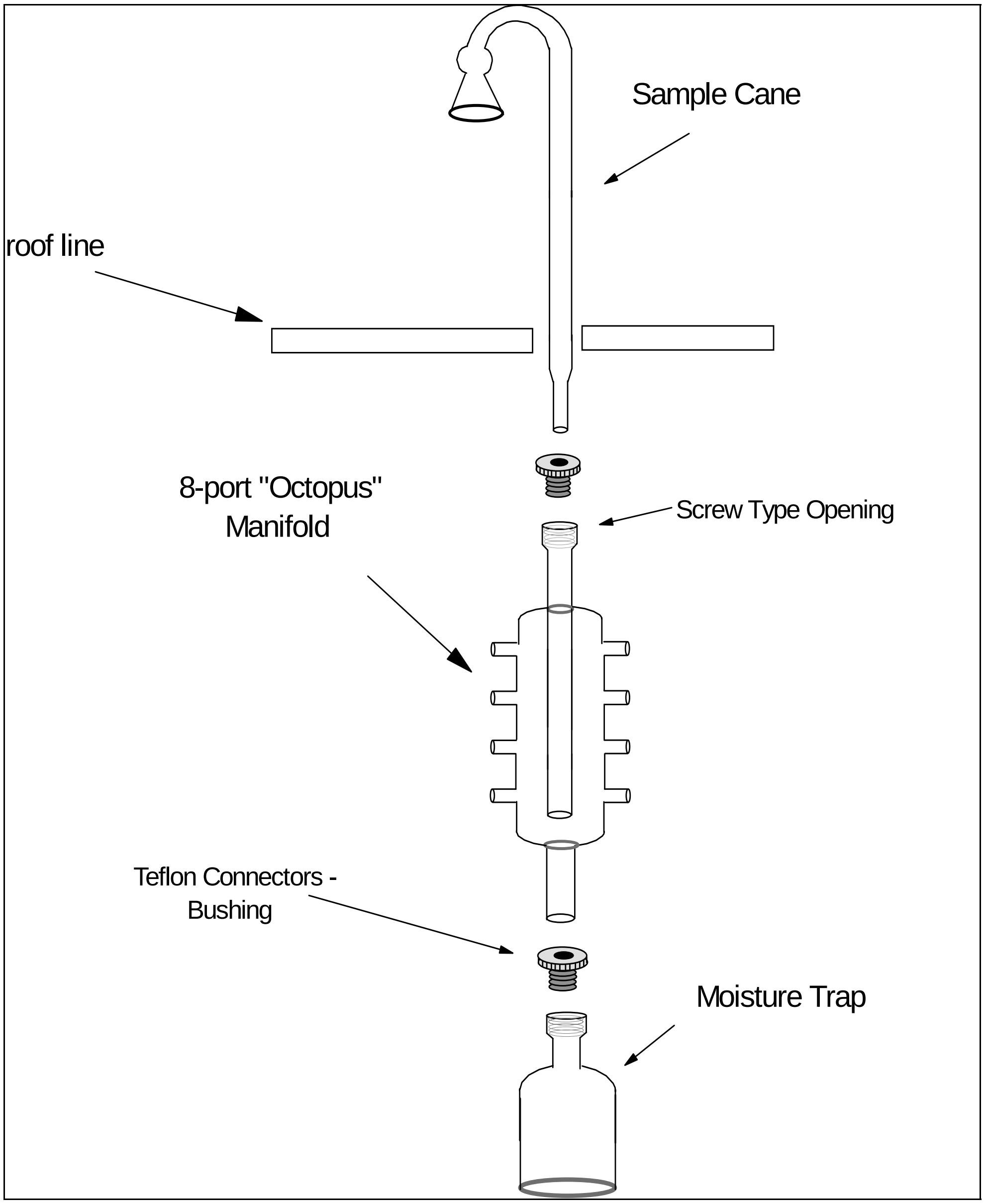

Figure 2. CARB or "Octopus" Style Manifold

Placement of Tubing on the Manifold: If the manifold employed at the station has multiple ports (as in Figure 2) then the position of the instrument lines relative to the calibration input line can be crucial. If a CARB "Octopus" or similar manifold is used, it is suggested that sample connections for analyzers requiring lower flows be placed towards the bottom of the manifold. Also, the general rule of thumb states that the calibration gas delivery line (if used) should be in a location so that the calibration gas flows past the analyzer inlet points before the gas is evacuated out of the manifold. Figure 3 illustrates two potential locations for introduction of the calibration gas. One is located at the ports on the "Octopus" manifold, and the other is upstream near the air inlet point, using an audit or probe inlet stub. This stub is a tee fitting placed so that "Through-the-Probe" audit line or sampling system tests and calibrations can be conducted.

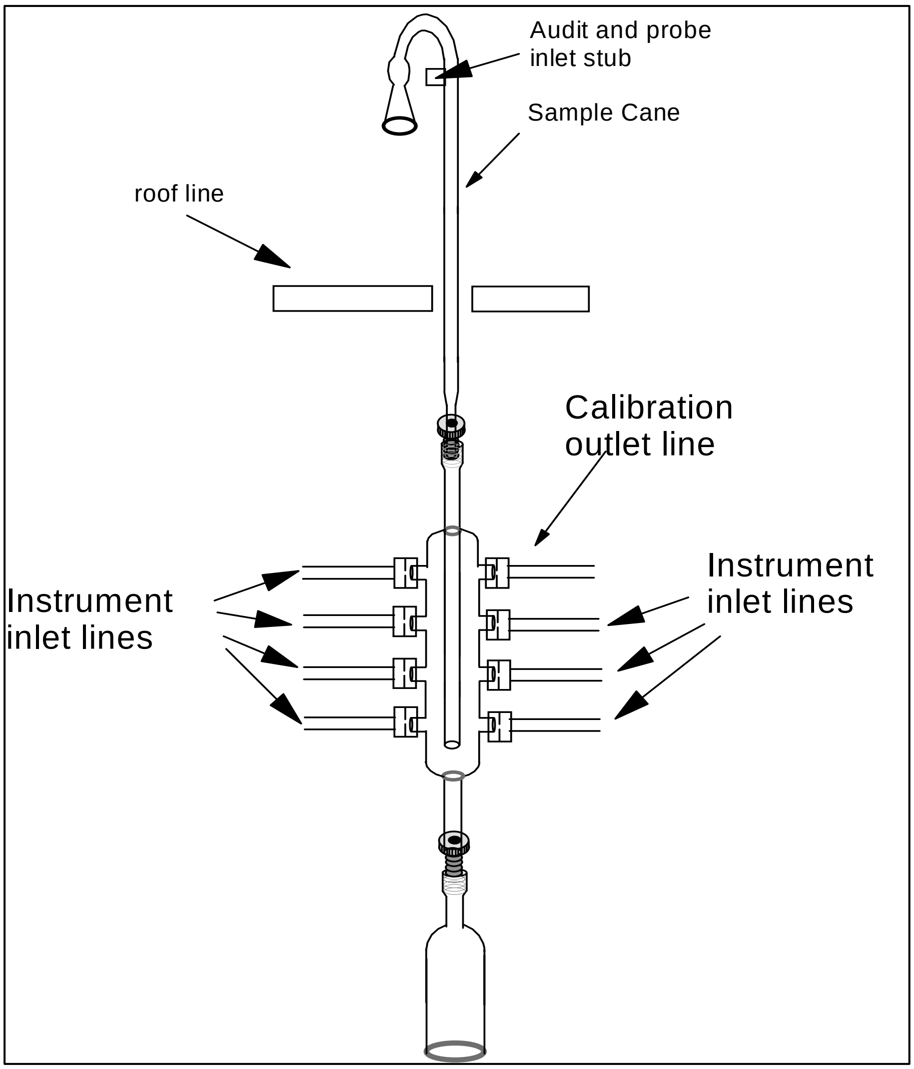

Figure 3. Placement of Lines on the Manifold

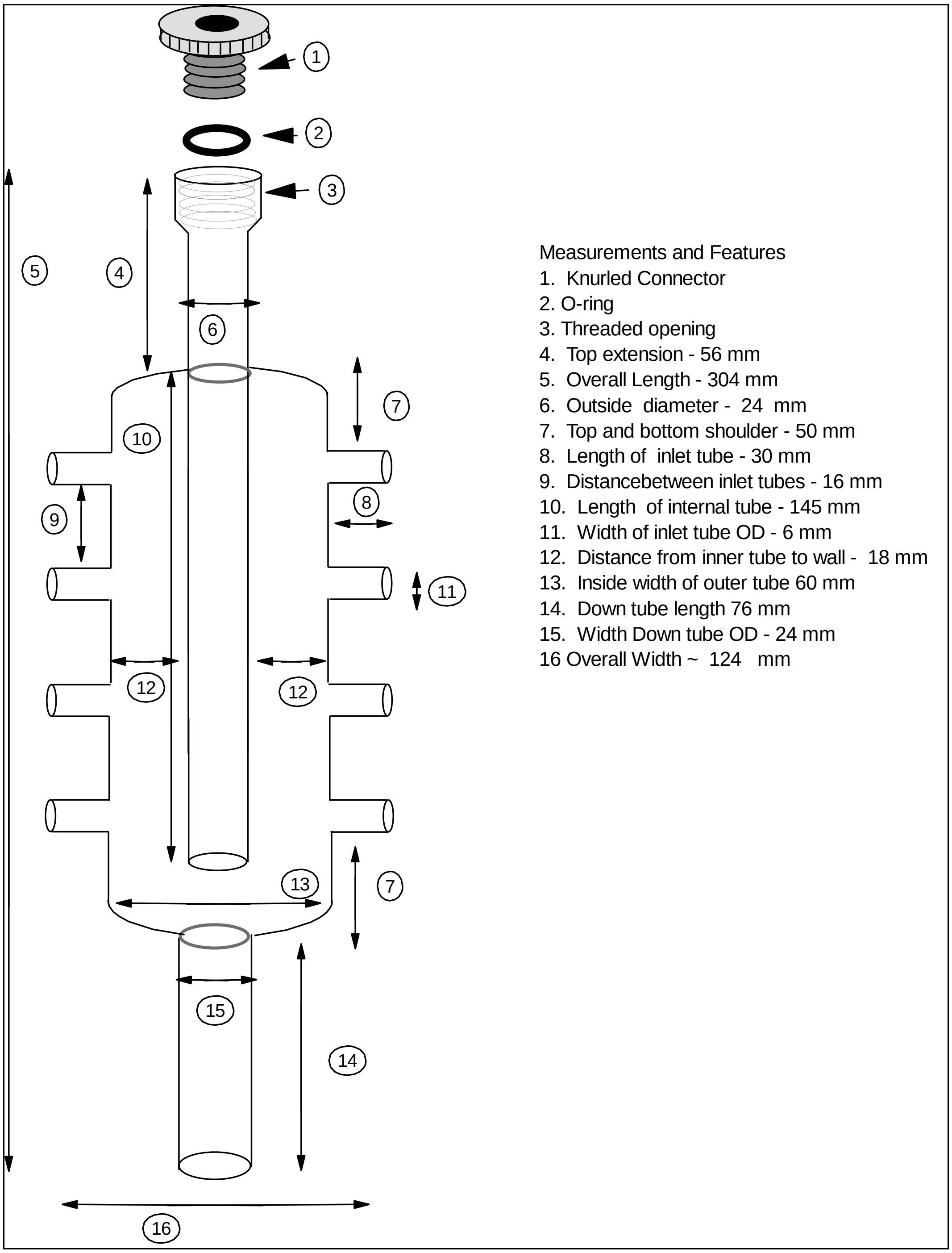

Figure 4. Specifications for an 'Octopus" Style Manifold

Figure 4 illustrates the specifications of an Octopus style manifold. Please note that EPA-OAQPS has used this style of manifold in its precursor gas analyzer testing program. This type of manifold is commercially available.

Vertical Manifold Design: Figure 5 shows a schematic of the vertical manifold design. Commercially available vertical manifolds have been on the market for some time. The issues with this type of manifold are the same with other conventional manifolds, i.e., when sample air moves from a warm humid atmosphere into an air-conditioned shelter, condensation of moisture can occur on the walls of the manifold. Commercially available vertical manifolds have the option for heated insulation to mitigate this problem. Whether the manifold tubing is made of glass or Teflon®, the heated insulation prevents viewing of the tubing, so the interior must be inspected often. The same issues apply to this manifold style as with horizontal or "Octopus" style manifolds: additional blower motors should not be used if the residence time is less than 20 seconds, and the calibration gas inlet should be placed upstream so that the calibration gas flows past the analyzer inlets before it exits the manifold.

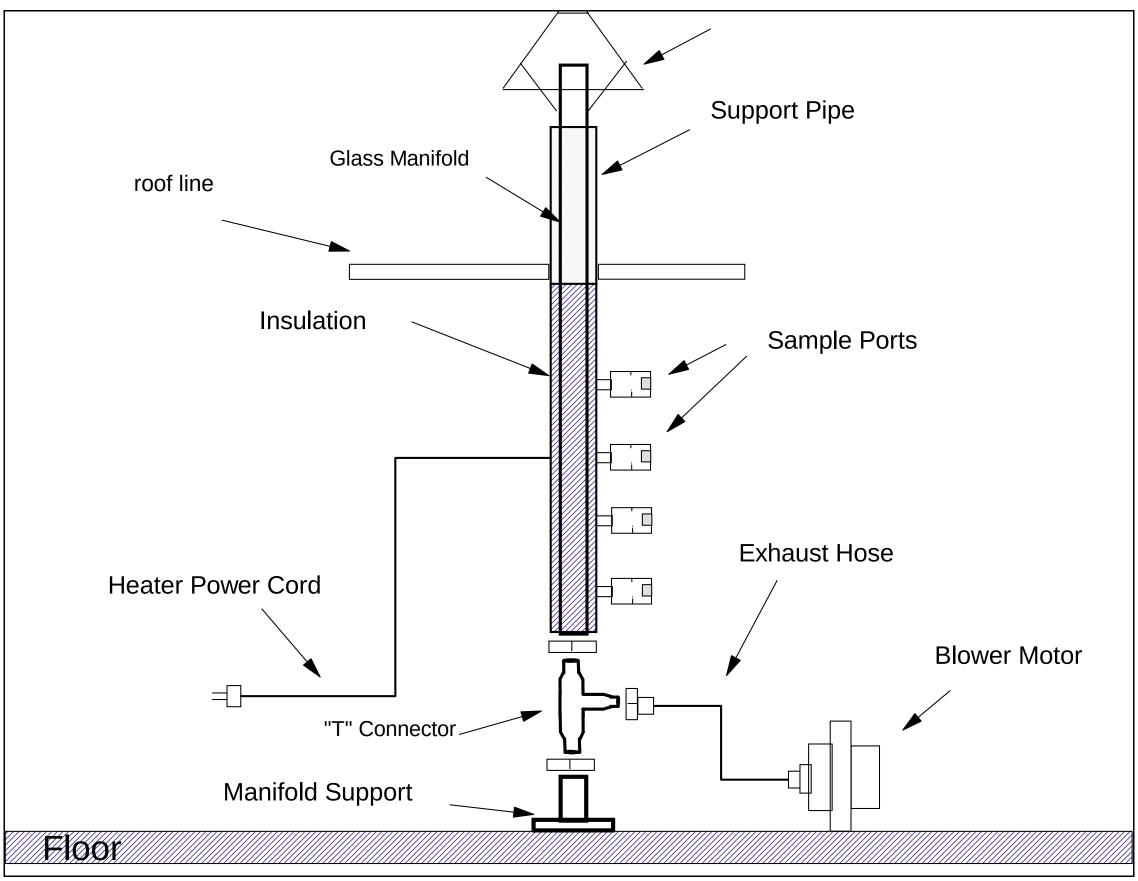

Figure 5. Example of Vertical Design Manifold

Manifold/Instrument Line Interface: A sampling system is an integral part of a monitoring station, however, it is only one part of the whole monitoring process. With the continuing integration of advanced electronics into monitoring stations, manifold design must be taken into consideration. Data Acquisition Systems (DASs) are able not only to collect serial and analog data from the analyzers, but also to control Mass Flow Calibration (MFC) equipment and solid state solenoid switches, communicate via modem or Ethernet, and monitor conditions such as shelter temperature and manifold pressure. As described in Chapter 6, commercially available DASs may implement these features in an electronic data logger, or via software installed on a personal computer. Utilization of these features allows the DAS and support equipment to perform automated calibrations (Autocals). In addition to performing these tasks, the DAS can flag data during calibration periods and allow the data to be stored in separate files that can be reviewed remotely.

Figure 6 shows a schematic of the integrated monitoring system at EPA's Burden Creek NCore monitoring station. Note that a series of solenoid switches are positioned between the ambient air inlet manifold and an additional "calibration" manifold. This configuration allows the DAS to control the route from which the analyzers draw their sample. At the beginning of an Autocal, the DAS signals the MFC unit to come out of standby mode and start producing zero or calibration gas. Once the MFC has stabilized, the DAS switches the analyzers' inlet flow (via solenoids) from the ambient air manifold to the calibration manifold. The calibration gas is routed to the instruments, and the DAS monitors and averages the response, flagging the data appropriately as calibration data. When the Autocal has terminated, the DAS switches the analyzers' inlet flow from the calibration manifold back to the ambient manifold, and the data system resets the data flag to the normal ambient mode.

The integration of DAS, solenoid switches, and MFC into an automated configuration can bring an additional level of complexity to the monitoring station. Operators must be aware that this additional complexity can create situations where leaks can occur. For instance, if a solenoid switch fails to open, then the inlet flow of an analyzer may not be switched back to the ambient manifold, but instead will be sampling interior room air. When the calibrations occur, the instrument will span correctly, but will not return to ambient air sampling. In this case, the data collected must be invalidated. These problems are usually not discovered until there is an external "Through-the Probe" audit, but by then extensive data could be lost. It is recommended that the operator remove the calibration line from the calibration manifold on a routine basis and challenge the sampling system from the inlet probe. This test will discover any leak or switching problems within the entire sampling system.

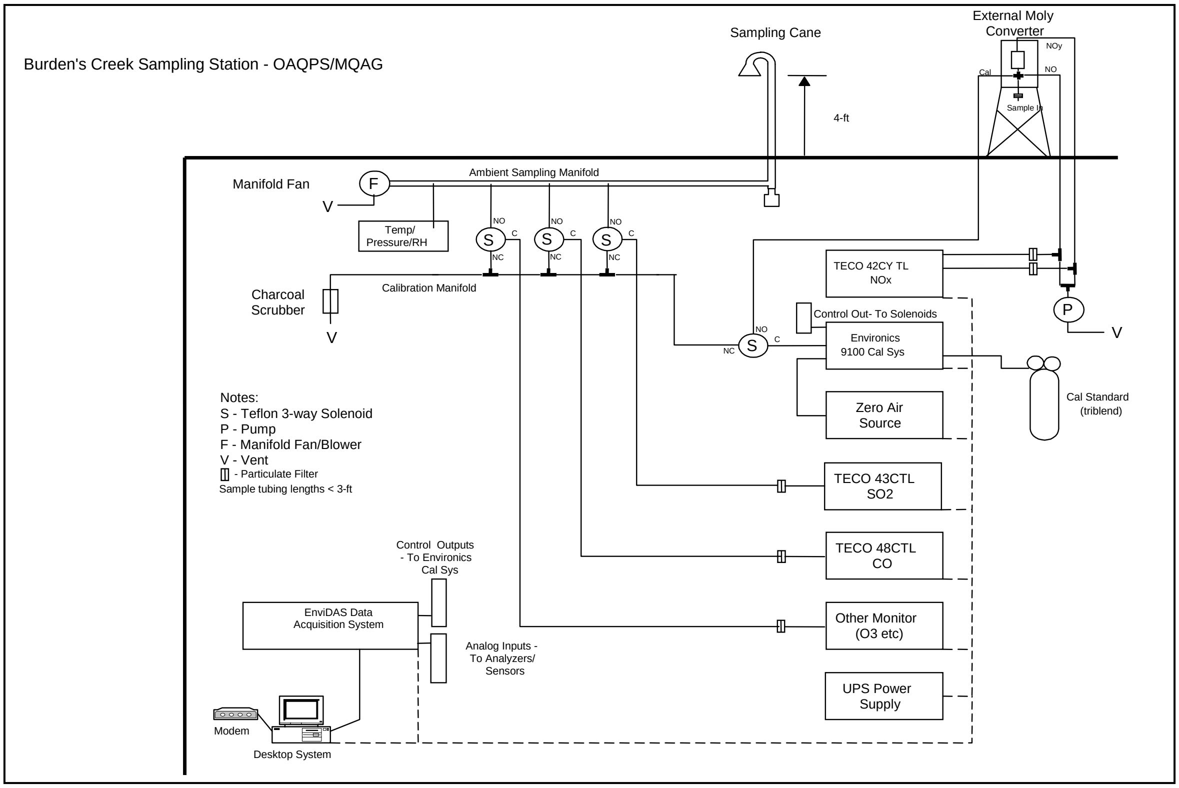

Figure 6. Example of a Manifold/Instrument Interface

Figure 7 shows a close up of an ambient/calibration manifold, illustrating the calibration manifold – ambient manifold interface. This is the same interface used at EPA's Burden's Creek monitoring station. The interface consists of three distinct portions: the ambient manifold, the solenoid switching system and the calibration manifold. In this instance, the ambient manifold is a T-type design that is being utilized with a blower fan at the terminal. Teflon® tubing connects the manifold to the solenoid switching system. Two-way solenoids have two configurations. Either the solenoid is in its passive state, at which time the ports that are connected are the normally open (NO) and the common (COM). In the other state, when it is energized, the ports that are connected are the normally closed (NC) and the COM ports. Depending on whether the solenoid is 'active' or not, the solenoid routes the air from the calibration or ambient manifold to the instrument inlets. There are two configurations that can be instituted with this system.

1. Ambient Mode: In this mode the solenoids are in "passive" state. The flow of air (under vacuum) is routed from the NO port through the solenoid to the COM port.
2. Calibration Mode: In this mode, the solenoids are in the "active" state. An external switching device, usually the DAS, must supply direct current to the solenoid. This causes the solenoid to be energized so that the NO port is shut and the NC port is now connected to the COM port. As in all cases, the COM port is always selected. The switching of the solenoid is done in conjunction with the MFC unit becoming active; generally, the MFC is controlled by the DAS. When the calibration sequences have

finished, the DAS stops the direct current from being sent to the solenoid and switches automatically back to the NO to COM (inactive) port configuration. This allows the air to flow through the NO to COM port and the instrument is now back on ambient mode.

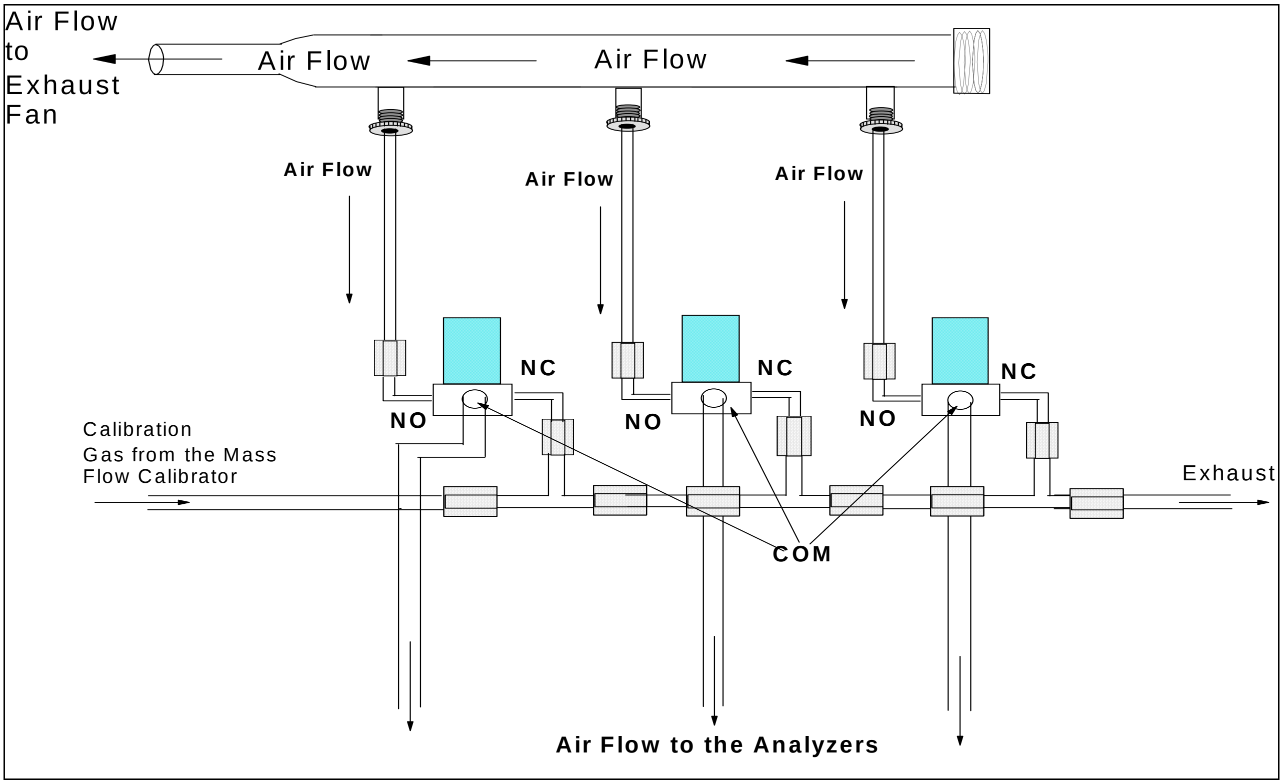

Figure 7. Ambient – Calibration Manifold Interface

Reference

1. Code of Federal Regulations, Title 40, Part 58, Appendix E.9

Appendix F

Example Procedure for Calibrating a Data Acquisition System

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DAS Calibration Technique

The following is an example of a DAS calibration. The DAS owner's manual should be followed. The calibration of a DAS is performed by inputting known voltages into the DAS and measuring the output of the DAS.

1. The calibration begins by obtaining a voltage source and an ohm/voltmeter.

2. Place a wire lead across the input of the DAS multiplexer. With this "shorted" out, the DAS should read zero.

3. If the output does not read zero, adjust the output according to the owners manual.

4. After the background zero has been determined, it is time to adjust the full scale of the system. Most DAS system work on a 1, 5 or 10 volt range, i.e., the full scale equals an output of voltage. In the case of a 0 - 1000 ppb range instrument, 1.00 volts equals 1000 ppb. Accordingly, 500 ppb equals 0.5 volts (500 milivolts). To get the DAS to be linear throughout the range of the instrument being measured, the DAS must be tested for linearity.

5. Attach the voltage source to a voltmeter. Adjust the voltage source to 1.000 volts (this is critical that the output be **1.000 volts**). Attach the output of the voltage source the DAS multiplexer. The DAS should read 1000 ppb. Adjust the DAS voltage A/D card accordingly. Adjust the output of the voltage source to 0.250 volts. The DAS output should read 250 ppb. Adjust the A/D card in the DAS accordingly. Once you have adjusted in the lower range of the DAS, check the full scale point. With the voltage source at 1.000 volts, the output should be 1000 ppb. If it isn't, then adjust the DAS to allow the high and low points to be as close to the source voltage as possible. In some cases, the linearity of the DAS may be in question. If this occurs, the data collected may need to be adjusted using a linear regression equation. See Section 2.0.9 for details on data adjustment. The critical range for many instruments is in the lower 10 % of the scale. It is critical that this be linear.

6. Every channel on a DAS should be calibrated. In some newer DAS systems, there is only one A/D card voltage adjustment which is carried throughout the multiplexer. This usually will adjust all channels. It is recommended that DAS be calibrated once per year.

Attachment G

Ambient Air Data Sources

The following information provides descriptions of various websites that help to display data in a number of ways and well as web addresses for a number of the major data bases.

Following these description are two information sheet that provide a description of the types of information that can be found in these data systems

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Air Pollution Data Sources -

This page provides access to data systems, maps, and information from the following website: **http://www.epa.gov/air/airpolldata.html**

Data Evaluation Tools

- **Air Data** -http://www.epa.gov/air/data The AirData site provides reports and maps of air pollution data for the entire United States based on criteria that you specify. *This area is primarily intended for the general public. It provides summary information from the Air Quality System.*

- **AirCompare** http://www.epa.gov/aircompare -This is a tool which provides local air quality information. AirCompare searches EPA air quality databases to pull information about pollutants reported under the Air Quality Index (AQI) – and to translate it into charts that show simply whether the previous year's air quality was healthy, unhealthy or unhealthy for specific groups more susceptible to pollution. The tool also can provide a multi-year snapshot of a county's air quality, based on a particular health issue.

- **Air Explorer** - http://www.epa.gov/airexplorer/ - Air Explorer is a collection of user-friendly visualization tools for air quality analysts. The tools generate maps, graphs, and data tables dynamically. *This area is primarily intended for air quality analysts and communications specialists. It provides summary information from the Air Quality System.*

- **AIRNow** – http://airnow.gov -The U.S. EPA, NOAA, NPS, tribal, state, and local agencies developed the AIRNow Web site to provide the public with easy access to national air quality information. AIRNow offers daily air quality forecasts as well as real-time air quality conditions for over 300 cities across the US, and provides links to more detailed State and local air quality information.

- **Air Trends** - http://www.epa.gov/air/airtrends/ Air Trends provides national and local air quality trends information. Data tables and reports document EPA's assessment of trends in terms of air quality, emissions, and meteorological changes over time. *This area is primarily intended for the general public. It provides summary information from the Air Quality System.*

- **Clean Air Markets Data and Maps** – http://cfpub.epa.gov/gdm. - Clean Air Markets Data and Maps provides a web-based interface to view unit, facility, emissions, and allowance data collected as part of EPA's emissions trading programs, as well as deposition data from the Clean Air Status and Trend Network (CASTNET).

- **Greenhouse Gas Emissions** http://www.epa.gov/climatechange/emissions/index.html-This section of the EPA Climate Change Site provides information and data on emissions of greenhouse gases to Earth's atmosphere, and also the removal of greenhouse gases from the atmosphere, including the official national inventory of U.S. greenhouse gas emissions. Governments at the federal, state and local levels prepare emissions inventories, which track emissions from various parts of the economy such as transportation, electricity production, industry, agriculture, forestry, and other sectors.

- **DATAFED** http://www.datafed.net/-.The goals of the DataFed site are to facilitate the access and flow of atmospheric data from providers to users, support the development of user-driven data processing value chains, and participate in specific application projects. Tools provided by DataFed include browsers and analysis tools for distributed monitoring data. DataFed also serves as data gateway for user programs (web pages, GIS, science tools). Currently DataFed is focused on the mediation of air quality data. Software provided for users include:

  1) Data Catalog for finding and browsing the metadata of registered datasets,
  2) Dataset Viewer/Editor for browsing specific datasets, linked to the Catalog,
  3) Data Views - geo-spatial, time, trajectory etc. views prepared by the user,
  4) Consoles, collections of views on a web page for monitoring multiple datasets, and
  5) Mini-Apps, small web-programs using chained web services (e.g. CATT, PLUME)

- **National-Scale Air Toxics Assessment (NATA)** http://www.epa.gov/ttn/atw/natamain - The National-Scale Air Toxics Assessment is EPA's ongoing comprehensive evaluation of air toxics in the U.S. These activities include expansion of air toxics monitoring, improving and periodically updating emission inventories, improving national- and local-scale modeling, continued research on health effects and exposures to both ambient and indoor air, and improvement of assessment tools.

- **Ambient Monitoring Data Analysis System (AMDAS)**–http://www.environ.org/amdas - AMDAS is a PC-based, user-friendly, menu driven program that provides air quality analysts and managers with easy "point and click" access to air quality data for browsing, preparing tabular and graphical summaries, and performing statistical analyses. AMDAS currently includes features specifically designed for the analysis of meteorological and air quality data contained in EPA's Aerometric Information Retrieval System (AIRS). AMDAS can be used to analyze meteorological data, routine air quality data (i.e., hourly ozone, oxides of nitrogen, carbon monoxide, etc.), speciated VOC and carbonyl compound data (i.e., PAMS data), and atmospheric particulate matter data, including PM10 and PM2.5 total mass and speciated sample data

Data Bases

- **Air Quality System (AQS)** - http://www.epa.gov/ttn/airs/airsaqs/ - The Air Quality System is EPA's repository of ambient air quality data. AQS stores data from over 10,000 monitors; 5000 of which are currently active. State, Local and Tribal agencies collect the data and submit it to AQS on a periodic basis. *This area is primarily intended for those in the state, local and tribal agencies and within EPA who load data into the AQS database or use data from this* database for analysis.

- **AQS Data Mart** - http://www.epa.gov/ttn/airs/aqsdatamart/ - The AQS Data Mart is a database containing all of the information from the AQS system. The AQS Data Mart was built as a storehouse of air quality information that allows users to make queries of unlimited quantities of data. The main AQS system must maintain constant readiness to accept data, and thus is limited in the number and size of queries it can respond to. The Data Mart has no such limitation, other than the "wall clock" time it takes for a query to run. The Data Mart also includes information from the EPA's substance and facility registry systems to allow for cross-media integration. Starting in the summer of 2007, it will also contain information from AirNow (the real time air quality reporting system) that participating agencies allow to be shared with the public.

- **CASTNET** - http://www.epa.gov/castnet/ -The Clean Air Status and Trends Network (CASTNET) is the nation's primary source for data on dry acidic deposition and rural, ground-level ozone. Operating since 1987, CASTNET is used in conjunction with other national monitoring networks to provide information for evaluating the effectiveness of national emission control strategies. CASTNET consists of over 80 sites across the eastern and western United States and is cooperatively operated and funded with the National Park Service.

- **IMPROVE Monitoring Data** - http://vista.cira.colostate.edu/improve/Data/IMPROVE/improve_data.htm - The IMPROVE monitoring network consists of aerosol, light scatter, light extinction and scene samplers in a number of National Parks and Wilderness areas. It also provides access to the raw data and data products. In addition to the data base, IMPROVE has a number of data related tools that can be found on there website at: http://vista.cira.colostate.edu/improve/Tools/tools.htm

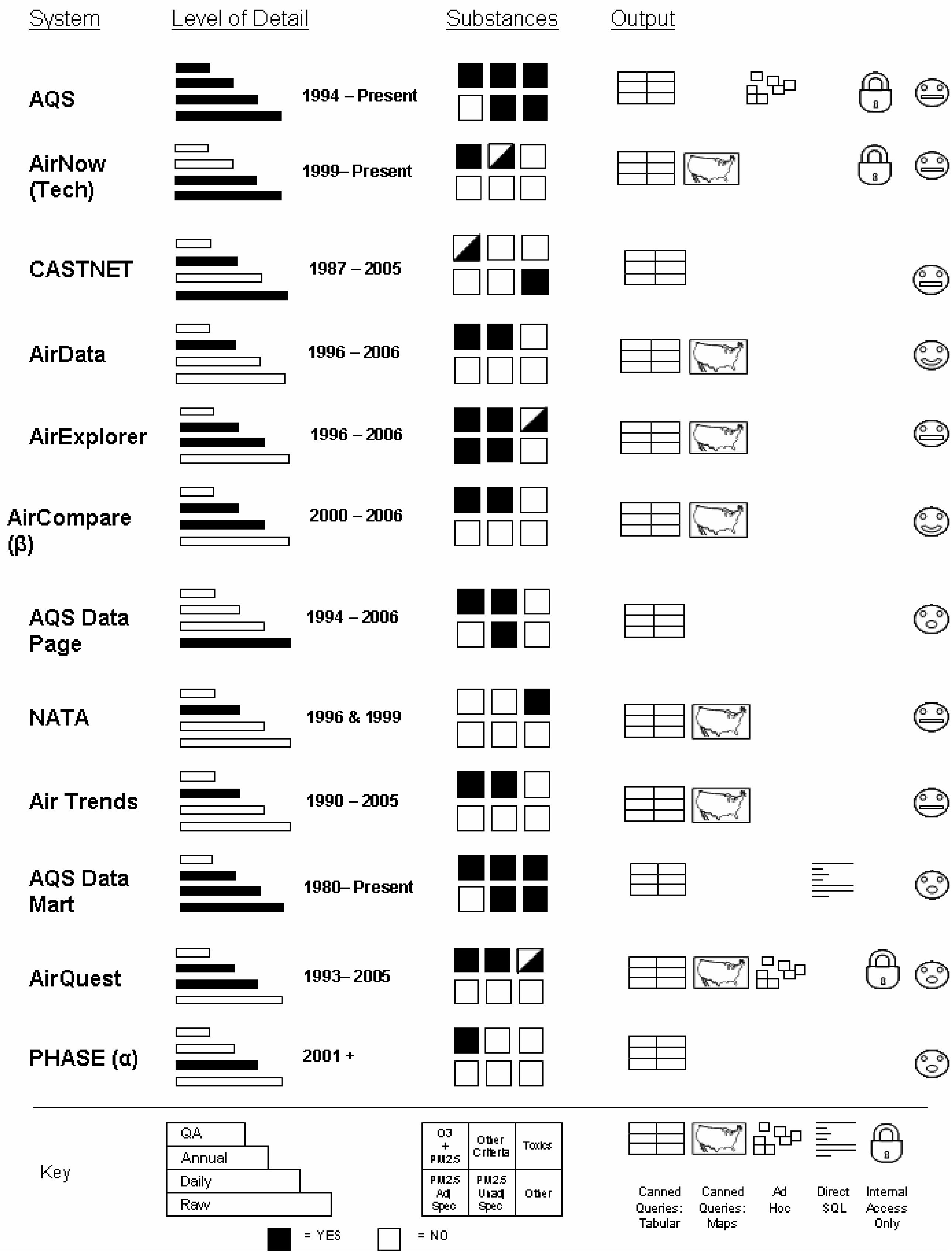
- **VIEWS** - http://vista.cira.colostate.edu/views/ -The Visibility Information Exchange Web System is an online exchange of air quality data, research, and ideas designed to understand the effects of air pollution on visibility and to support the Regional Haze Rule enacted by the U.S. Environmental Protection Agency (EPA) to reduce regional haze and improve visibility in national parks and wilderness areas

- **MADIS** - http://madis.noaa.gov/ - The Meteorological Assimilation Data Ingest System (MADIS) is dedicated toward making value-added data available from the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory (ESRL) Global Systems Division (GSD) (formerly the Forecast Systems Laboratory (FSL)) for the purpose of improving weather forecasting, by providing support for data assimilation, numerical weather prediction, and other hydrometeorological applications. MADIS subscribers have access to an integrated, reliable and easy-to-use database containing the real-time and archived observational datasets described on the website. Also available are real-time gridded surface analyses that assimilate all of the MADIS surface datasets (including the highly-dense integrated mesonet data). The grids are produced by the Rapid Update Cycle (RUC) Surface Assimilation System (RSAS) that runs at ESRL/GSD, which incorporates a 15-km grid stretching from Alaska in the north to Central America in the south, and also covers significant oceanic areas. The RSAS grids are valid at the top of each hour, and are updated every 15 minutes.

Air Quality Data Systems

System	Level of Detail				Time	Substances						Outputs				Audience		
	Raw	Daily	Annual	QA	Time range of most detailed data	Ozone + PM2.5	Other Criteria	Toxics	PM2.5 Adj. Spec	PM2.5 Unadj. Spec	Other	Canned queries: tabular	Canned queries: maps	Ad hoc	Direct SQL	Public	Sophisticated	Researchers
AQS	●	●	●	●	1994 – Present	●	●	●		●	●	●		●			●	
AirNow (Tech)	●	●			1999 – Present	●	○					●	●				●	
CASTNET	●		●		1987 - 2005	○					●	●					●	
IMPROVE	●	●	●	●	1988-2006				●	●	●	●	●	●	●	●		●
AIrData			●		1996 - 2006	●	●					●	●			●		
AirExplorer		●	●		1996 – 2006	●	●	○	●	●		●	●				●	
AirCompare (β)		●	●		2000 – 2006	●	●					●	●			●		
AQS Data Page	●				1994 – 2006	●	●			●		●						●
NATA			●		1996 & 1999			●				●	●				●	
Air Trends			●		1990 – 2005	●	●					●	●				●	
AQS Data Mart	●	●	●		1980 – Present	●	●	●		●	●	●			●			●
AirQuest		●	●		1993 – 2005	●	●	○				●	●	●				●
PHASE (α)		●			2001 +	●						●						●

Air Quality Data Systems



Appendix H

National Ambient Air Quality Standards Information

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Pollutant	Primary Standards	Averaging Times	Secondary Standards	CFR Supporting Information
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour[1]	None	**40 CFR § 50.8** (b) The levels of carbon monoxide in the ambient air shall be measured by: (1) A reference method based on appendix C and designated in accordance with part 53 of this chapter, or (2) An equivalent method designated in accordance with part 53 of this chapter. (c) An 8-hour average shall be considered valid if at least 75 percent of the hourly average for the 8-hour period are available. In the event that only six (or seven) hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using six (or seven) as the divisor. (d) When summarizing data for comparision with the standards, averages shall be stated to one decimal place. Comparison of the data with the levels of the standards in parts per million shall be made in terms of integers with fractional parts of 0.5 or greater rounding up.
	35 ppm (40 mg/m^3)	1-hour[1]	None	
Lead	1.5 µg/m^3	Quarterly Average	Same as Primary	**40 CFR § 50.12** National primary and secondary ambient air quality standards for lead and its compounds, measured as elemental lead by a reference method based on appendix G to this part, or by an equivalent method
Nitrogen Dioxide	0.053 ppm (100 µg/m^3)	Annual (Arith. Mean)	Same as Primary	**40 CFR § 50.11** (c) The levels of the standards shall be measured by: (1) A reference method based on appendix F and designated in accordance with part 53 of this chapter, or (2) An equivalent method designated in accordance with part 53 of this chapter. (d) The standards are attained when the annual arithmetic mean concentration in a calendar year is less than or equal to 0.053 ppm, rounded to three decimal places (fractional parts equal to or greater than 0.0005 ppm must be rounded up). To demonstrate attainment, an annual mean must be based upon hourly data that are at least 75 percent complete or upon data derived from manual methods that are at least 75 percent complete for the scheduled sampling days in each calendar quarter.

Pollutant	Primary Standards	Averaging Times	Secondary Standards	CFR Supporting Information
Particulate Matter (PM_{10})	150 ug/m^3	24-hour[1]	Same as Primary	**40 CFR § 50.6** (c) For the purpose of determining attainment of the primary and secondary standards, particulate matter shall be measured in the ambient air as PM10 (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers) by: (1) A reference method based on appendix J and designated in accordance with part 53 of this chapter, or (2) An equivalent method designated in accordance with part 53 of this chapter.
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual[3] (Arith. Mean)	Same as Primary	**40 CFR § 50.7** (1) A reference method based on appendix L of this part and designated in accordance with part 53 of this chapter; or (2) An equivalent method designated in accordance with part 53 of this chapter. (b) The annual primary and secondary PM2.5 standards are met when the annual arithmetic mean concentration, as determined in accordance with appendix N of this part, is less than or equal to 15.0 micrograms per cubic meter. (c) The 24-hour primary and secondary PM2.5 standards are met when the 98th percentile 24-hour concentration, as determined in accordance with appendix N of this part, is less than or equal to 65 micrograms per cubic meter.
	35 ug/m^3	24-hour[4]		
Ozone	0.08 ppm	8-hour[5]	Same as Primary	**40 CFR § 50. 10** (a) The level of the national 8-hour primary and secondary ambient air quality standards for ozone, measured by a reference method based on appendix D to this part and designated in accordance with part 53 of this chapter, is 0.08 parts per million (ppm), daily maximum 8-hour average. (b) The 8-hour primary and secondary ozone ambient air quality standards are met at an ambient air quality monitoring site when the average of the annual fourth-highest daily maximum 8-hour average ozone concentration is less than or equal to 0.08 ppm, as determined in accordance with appendix I to this part.

Pollutant	Primary Standards	Averaging Times	Secondary Standards	CFR Supporting Information
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)	-------	**40 CFR § 50.4** (c) Sulfur oxides shall be measured in the ambient air as sulfur dioxide by the reference method described in appendix A to this part or by an equivalent method designated in accordance with part 53 of this chapter. (d) To demonstrate attainment, the annual arithmetic mean and the second-highest 24-hour averages must be based upon hourly data that are at least 75 percent complete in each calendar quarter. A 24-hour block average shall be considered valid if at least 75 percent of the hourly averages for the 24-hour period are available. In the event that only 18, 19, 20, 21, 22, or 23 hourly averages are available, the 24-hour block average shall be computed as the sum of the available hourly averages using 18, 19, etc. as the divisor. If fewer than 18 hourly averages are available, but the 24-hour average would exceed the level of the standard when zeros are substituted for the missing values, subject to the rounding rule of paragraph (b) of this section, then this shall be considered a valid 24-hour average. In this case, the 24-hour block average shall be computed as the sum of the available hourly averages divided by 24.
	0.14 ppm	24-hour[1]	-------	
	-------	3-hour[1]	0.5 ppm (1,300 ug/m^3)	

[1] Not to be exceeded more than once per year.
[2] To attain this standard, the 3-year average of the weighted annual mean PM_{10} concentration at each monitor within an area must not exceed 50 ug/m^3.
[3] To attain this standard, the 3-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15.0 ug/m^3.
[4] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 65 ug/m^3.
[5] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

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Postal information in this section where appropriate.