Resolution Copper Mining Monitoring Plan

PREPARED FOR:
RESOLUTION COPPER
A MEMBER OF RIO TINTO GROUP

PREPARED BY:
AIR SCIENCES INC.

PROJECT 262-1
NOVEMBER 2011

SECTION

A PROJECT MANAGEMENT ELEMENTS

Resolution Copper Mining Monitoring Plan (MP)

A.1 Title and Approval Sheet

Vicky Peacey	11/16/2011
Project Director	Date
Resolution Copper Company	

Kathy Steerman	11/1/2011
Project Manager	Date
Air Sciences Inc.	

Dave Randall	11/1/2011
Project Oversight	Date
Air Sciences Inc.	

(See PCAQCD approval letter in Appendix D)	11/15/2011
Michael Sundblom	Date
Environmental Programs Supervisor	
Pinal County Air Quality Control District	

A.2 Table of Contents

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A.3 Distribution List

The names and contact information for all personnel who will contribute to this monitoring plan can be found in Table 1. Each individual on the distribution list will receive a copy of the monitoring plan and will also receive any revisions made to the document.

Table 1: Program Principals

Key Project Individuals	Contact Information
Vicky Peacey Manager - Environmental Assessments Resolution Copper Company	102 Magma Heights Superior, AZ 85273 520-689-3313 Victoria.Peacey@riotinto.com
Kathy Steerman Monitoring and Project Manager Air Sciences Inc.	1301 Washington Ave., Suite 200 Golden, CO 80401 720-389-4201 Kathy@airsci.com
Dave Randall Principal Air Quality Scientist Air Sciences Inc.	1301 Washington Ave., Suite 200 Golden, CO 80401 720-389-4221 drandall@airsci.com
Aaron Schlabaugh Monitoring Engineer and Quality Control (QC) Manager Air Sciences Inc.	1301 Washington Ave., Suite 200 Golden, CO 80401 720-389-4225 aschlabaugh@airsci.com
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Michael Sundblom Environmental Programs Supervisor Pinal County Air Quality Control District	31 N. Pinal Street, Bldg F Florence, AZ 85132 520-866-6953 Michael.Sundblom@pinalcountyaz.gov

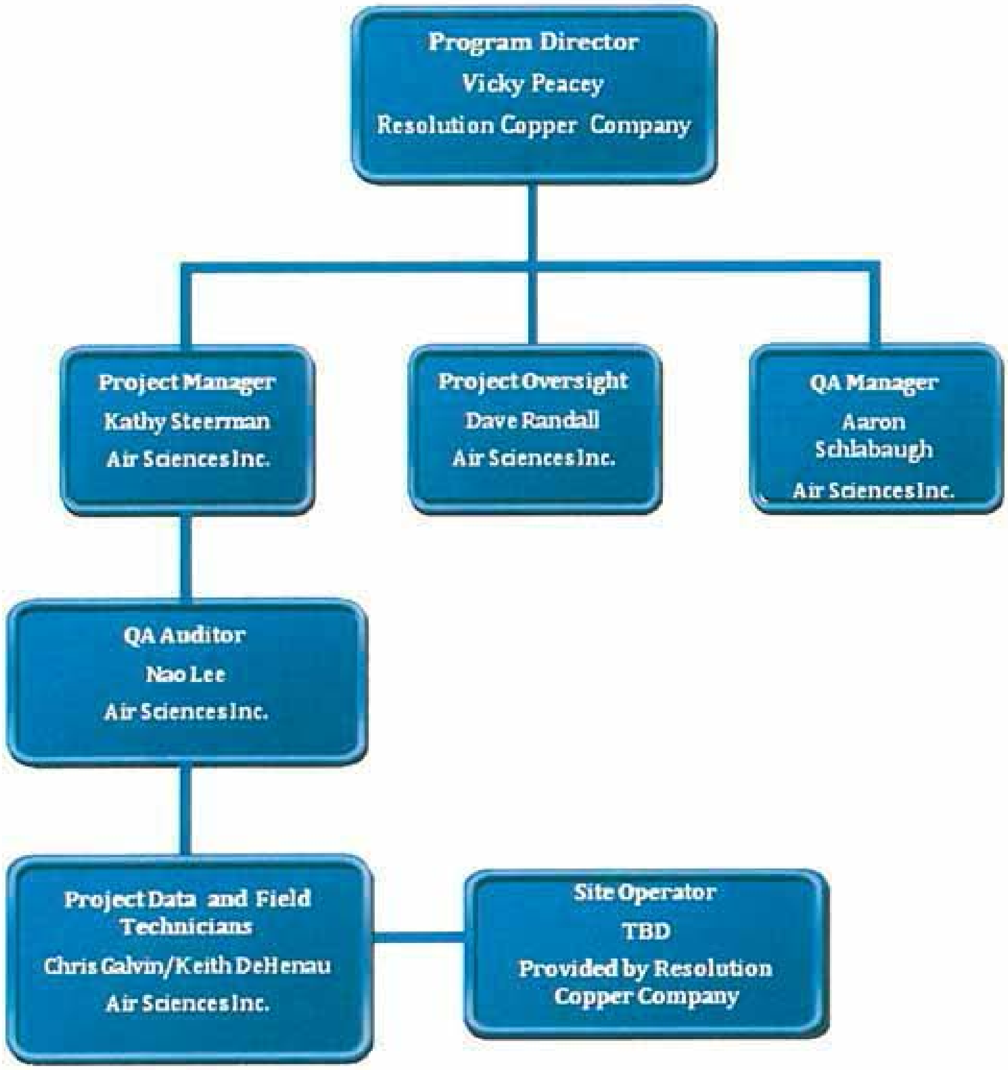
A.4 Project Task/Organization

Air Sciences Inc. (Air Sciences) will assist Resolution Copper Company (RCC) in the installation, operation, and maintenance of three ambient air and meteorological monitoring stations associated with the Resolution Copper Mine in Superior, Arizona. The monitoring program at each RCC site will include a high level of quality control as required by the Environmental Protection Agency (EPA) and State of Arizona guidelines. Data collection and processing will be performed by a team experienced in collecting and processing these types of data. The program principals are found in Table 2 and Figure 1.

Table 2: Project Task/Organization

Project Individual(s)	Roles and Responsibilities	Reports To:
Program Director Vicky Peacey	Performs supervisory role. Holds overall project responsibility and decision-making authority over project plan. Communicates with agencies.	
Project Manager Kathy Steerman	Provides draft and final copy of project plan. Provides administrative project control. Manages field engineers and technicians. Conducts final review and certification of data.	Program Director
Project Oversight Dave Randall	Provides project administrative support. Lends guidance on regulatory issues and provides input on monitoring data and how they apply to modeling, permitting, and compliance.	Program Director
Quality Assurance Manager Aaron Schlabaugh	Oversees operations and maintenance of stations. Assures QA/QC compliance. Ensures that project databases are current. Reviews calibrations and audits. Acts as principal contributor to quarterly and annual reports.	Project Manager
Quality Assurance Auditor Nao Lee	Performs second-party audits on all installed stations. Compiles and submits written audit and calibration findings. Assists with field maintenance and repair.	Program Director
Project Data and Field Technicians Chris Galvin, Keith DeHenau	Provide technical support to field crews and site operators. Act as liaisons between field personnel and technical support. Perform daily level-1 QA/QC on incoming data.	Project Manager
Site Operator To be provided by RCC	Performs weekly site checks. Notifies Air Sciences' Data Technicians when parameters are out of specification. Conducts scheduled maintenance. Provides local presence for quick response to problems.	Project Manager

Figure 1: Project Plan Organizational Chart



A.5 Problem Definition/Background

Resolution Copper Mining LLC (RCML) intends to implement a meteorological and air quality monitoring program to support several efforts during the pre-feasibility and other mine development phases: environmental assessments, impact analyses, and documents required by the National Environmental Policy Act (NEPA); meteorological and air quality data to be processed and used as input for AERMOD (American Meteorological Society / Environmental Protection Agency Regulatory Model) dispersion modeling; air quality baseline data and AERMOD analyses to be used to support RCML's application to the Pinal County Air Quality Control District (PCAQCD) for air permit(s).

This monitoring plan includes the details of the plan to install three monitoring sites in areas of potential emission sources for RCML facilities. The stations and the parameters to be monitored are listed in Table 3.

Table 3: Monitoring Stations

		Far West	West Plant	East Plant
AERMOD Meteorological Data	Horizontal wind speed (meters per second [m / s])	✓	✓	✓
	Horizontal wind direction (degrees[°])	✓	✓	✓
	Horizontal wind direction standard deviation (sigma theta)	✓	✓	✓
	Air temperature (degrees Celsius [°C])	✓	✓	✓
	Vertical temperature difference (ΔT, Delta T, [°C])	✓	✓	✓
	Relative Humidity (percent [%])	✓	✓	✓
	Solar Radiation (watts per square meter [W / m^2])	✓	✓	✓
	Barometric pressure (millimeters of mercury [mmHg])	✓	✓	✓
	Precipitation (inches [in])	✓	✓	✓
Ambient Air Data	FEM Particulate Matter less than 10 Microns (PM_{10})	✓	✓	✓
	FEM Particulate Matter less than 2.5 Microns ($PM_{2.5}$)	✓	✓	✓
	Sulfur Dioxide (SO_2)			✓
	Ozone (O_3)			✓
	Nitrogen Dioxide (NO_2)			✓

The locations of these monitoring stations are shown in Figure 3, Figure 4, and Figure 5.

The monitoring will be conducted in accordance with the following publications:

- EPA Guidance for Quality Assurance Project Plans (EPA QA/G5, December 2002)
- Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program (EPA-454/B-08-003, December 2008)
- Quality Assurance Handbook of Air Pollution Measurement Systems, Volume IV: Meteorological Measurements (EPA-454/B-08-002, March 2008)
- Transfer Standards for the Calibration of Ambient Air Monitoring Analyzers for Ozone (EPA-454/B-10-001)
- Code of Federal Regulations (40 CFR Parts 50 and 58)
- Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) (EPA-450/4-87-007, May 1987)
- Meteorological Monitoring Guidance for Regulatory Modeling Applications (EPA-454/R-99-005, February 2000)

A.6 Project Task/Description

A.6.1 Description

The primary tasks of this project are to:

1. Collect and monitor AERMOD-ready meteorological parameters at all three stations.

2. Collect and monitor accompanying air quality data, including:

    a. $PM_{2.5}$ and PM_{10} at all three stations.

    b. NO_x, O_3, and SO_2 data at the East Plant site.

The parameters measured, their sampling frequency, and sample averaging periods are listed in Table 4.

Table 4: Monitoring Parameters

Measured Parameter	Sampling Frequency	Measurement Averaging Period	Reporting Units
Nitrogen Oxides (NO_x)	Continuous	Hourly	parts per billion (ppb)
Ozone (O_3)	Continuous	Hourly	parts per billion (ppb)
Sulfur Dioxide (SO_2)	Continuous	Hourly	parts per billion (ppb)
Particulate Matter (PM_{10})	Continuous	Hourly	micrograms per cubic meter ($\mu g/m^3$) (STP)[1]
Particulate Matter ($PM_{2.5}$)	Continuous	Hourly	$\mu g/m^3$
Wind Speed	1-Second Scan	15-Minute	Meters/second (m/s)
Wind Direction	1-Second Scan	15-Minute	Degrees From (°)
Temperature (2 m and 10 m)	1-Second Scan	15-Minute	Degrees Celsius (°C)
Temperature Differential (10 m – 2 m) (DT)	1-Second Scan	15-Minute	Degrees Celsius (°C)
Solar Radiation (SR)	1-Second Scan	15-Minute	Watts per meter square (W/m^2)
Relative Humidity (RH)	1-Second Scan	15-Minute	Percent (%)
Barometric Pressure (BP)	1-Second Scan	15-Minute (sample)	Millimeters of mercury (mmHg)
Precipitation	1-Second Scan	15-Minute (totalization)	Inches (in)

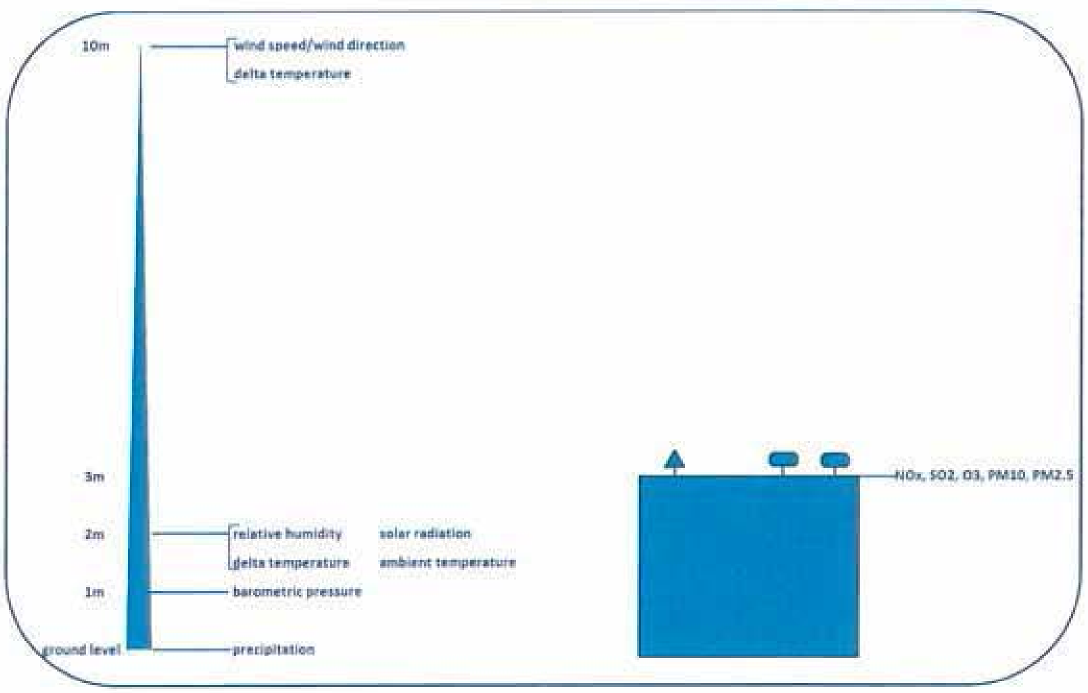
[1] Data converted to Standard Temperature and Pressure (STP)

These data may be used to support future air dispersion modeling work and to characterize ambient concentrations, existing conditions, and potential contributions from sources for any reportable event (as may be required in future air permit conditions).

The NO_x, SO_2, and O_3 concentrations measured at the east plant facility will be considered representative of the west plant facility, other potential tailing alternatives located in the globe Miami area location near pinto valley, and the general region surrounding the Superior area. According to EPA's Guideline on Air Quality Modeling (40 CFR 51, Appendix W), monitors used to determine ambient background concentrations should be located in the vicinity of the source and if they are not, a "regional site" may be used to determine background concentrations. A "regional site" is one that is located away from the area of interest, but is impacted by similar natural and distant man-made sources. The east plant meets both criteria since it is located in the vicinity all potential sites, is effected by similar small nearby emission sources, and is representative of rural conditions. Thus, the use of ambient data from the east plant facility to represent ambient conditions at all proposed facilities is appropriate.

Figure 2 is a schematic of sensor heights. All air monitoring equipment will be housed in a climate-controlled shelter that will be well equipped for internal temperature control and will provide easy roof access to inlets and manifolds. The tower will be mounted on a poured pad and will tip down for easy access for audits and calibrations. At each site, convective atmospheric stability will be measured primarily by solar radiation measurement during the daytime and delta temperature during the evening (SRDT). Missing SRDT data can be replaced with wind direction deviation (sigma theta).

Figure 2: Sensor Heights



A.6.2 Monitoring Location

The locations of the stations are shown with topography and in relation to nearby towns/areas of population in Figure 3, Figure 4, and Figure 5. GPS-derived coordinates for each station are listed in Table 5. Figure 10 through Figure 14 are panoramic (180-degree) photos that show the nearby obstructions, topography, and vegetation at the sites. The center points of the pairs of photos for each site are views to east and west.

Table 5: Station Locations

Station	Location	Latitude (Deg)	Longitude (Deg)	Elevation (f)	Method of Determination
West Plant	01S12E35NWSE	33.2994	-111.1021	2,949	GPS
East Plant	01S13E32SWNW	33.3030	-111.0676	4,199	GPS
Far West	02S10E30SWSE	33.2207	-111.3613	1,790	GPS

Figure 3: Project Location Map - Far West, West, and East Plant Station Locations

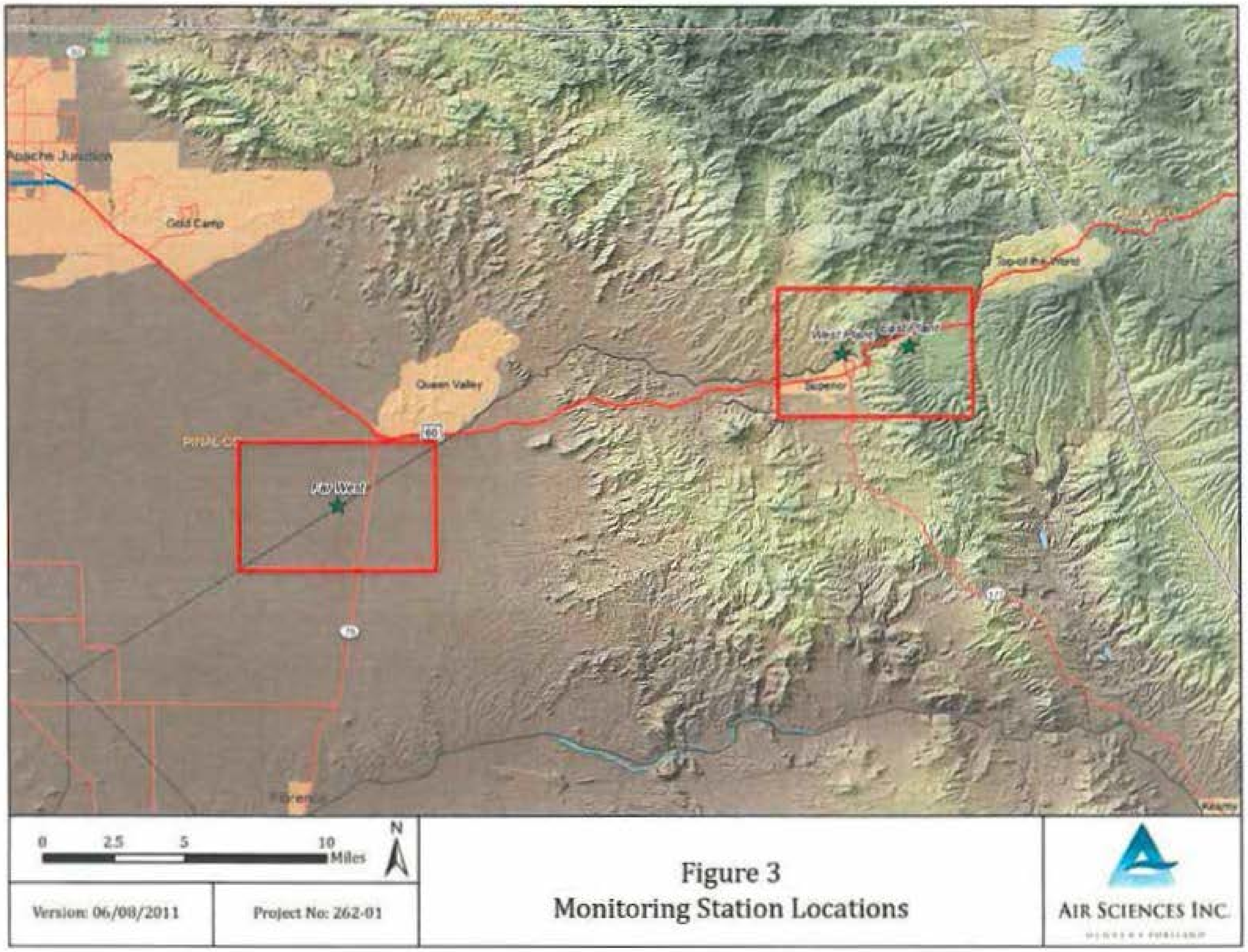


Figure 3
Monitoring Station Locations

Figure 4: Project Location Map – Zoom-In of East Plant and West Plant Station Locations

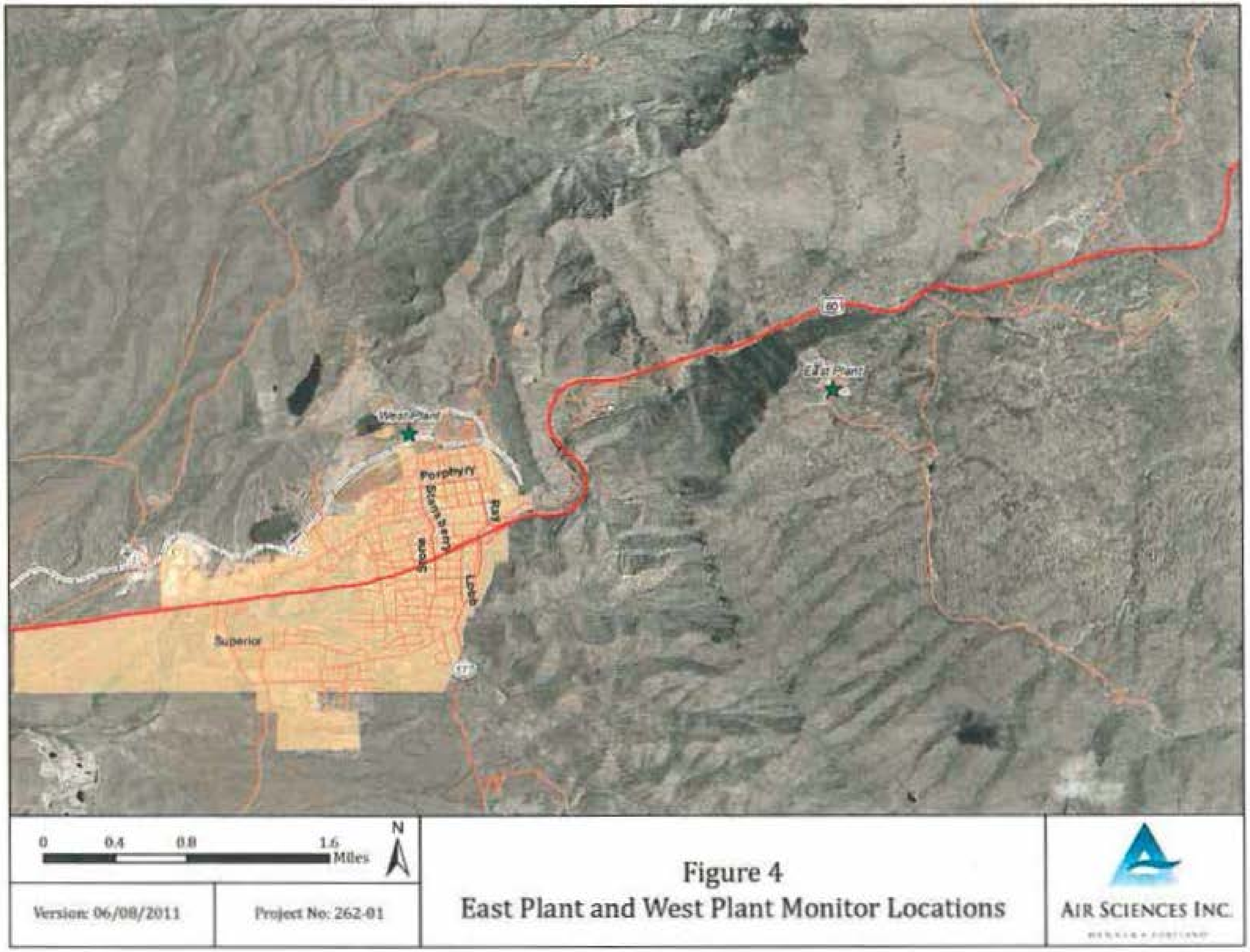
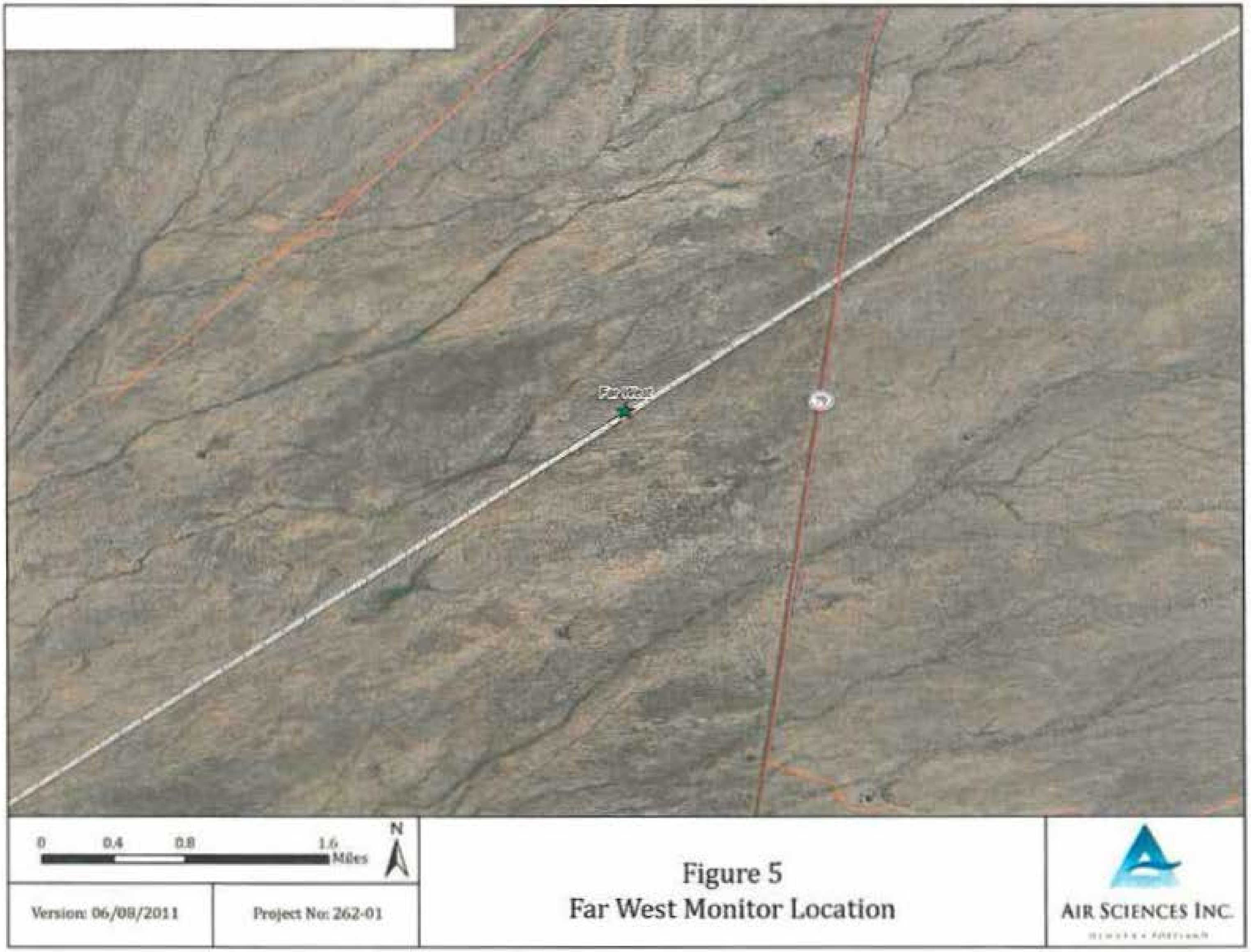


Figure 4
East Plant and West Plant Monitor Locations

Figure 5: Project Location Map - Zoom-In of Far West Station Location



A.6.3 Monitoring Locations with proposed mining overlays

The following figures show the mining layout plans in relation to each monitoring site. Final site selection for tailings and other activities are not finalized and the following figures are proposed altneratives. Monitoring at the three sites covers sites that may be selected for operations by RCML .

Figure 6: Project Location Map - Overview of monitoring sites in relation to proposed activities

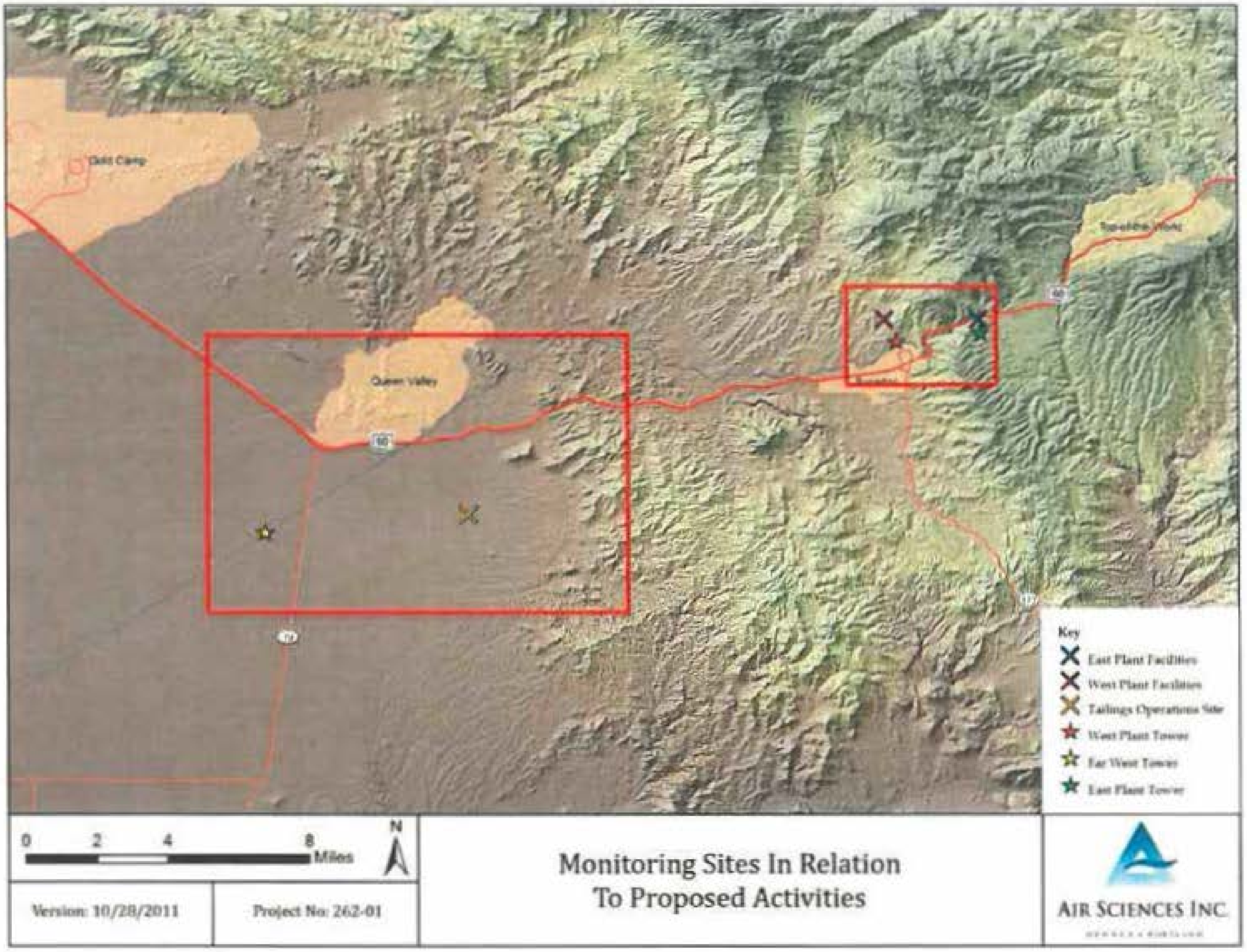


Figure 7: Project Location Map - Far West Tailings Scenario

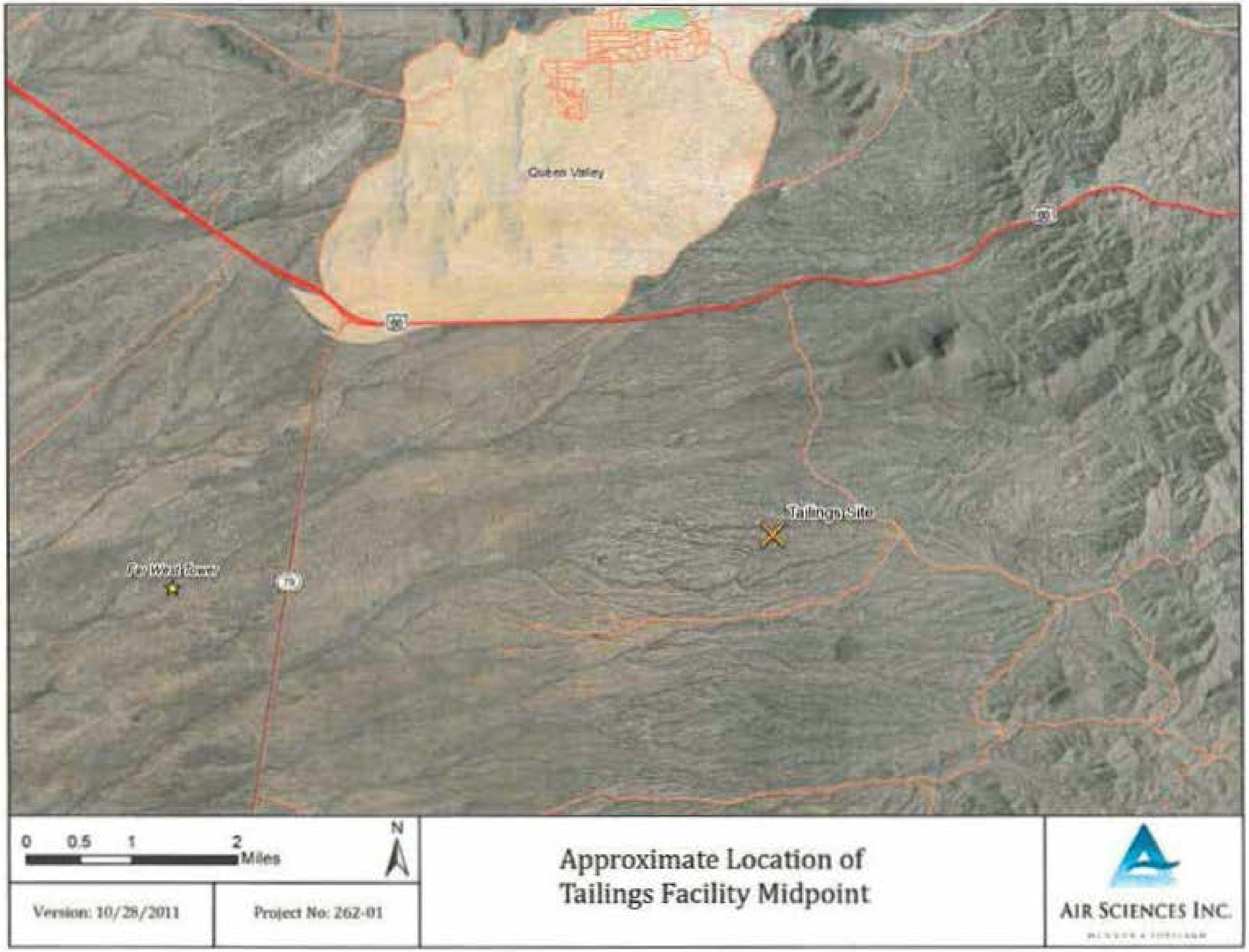


Figure 8: Project Location Map - Approximate location of proposed west plant facilities (ore stockpile / mill)

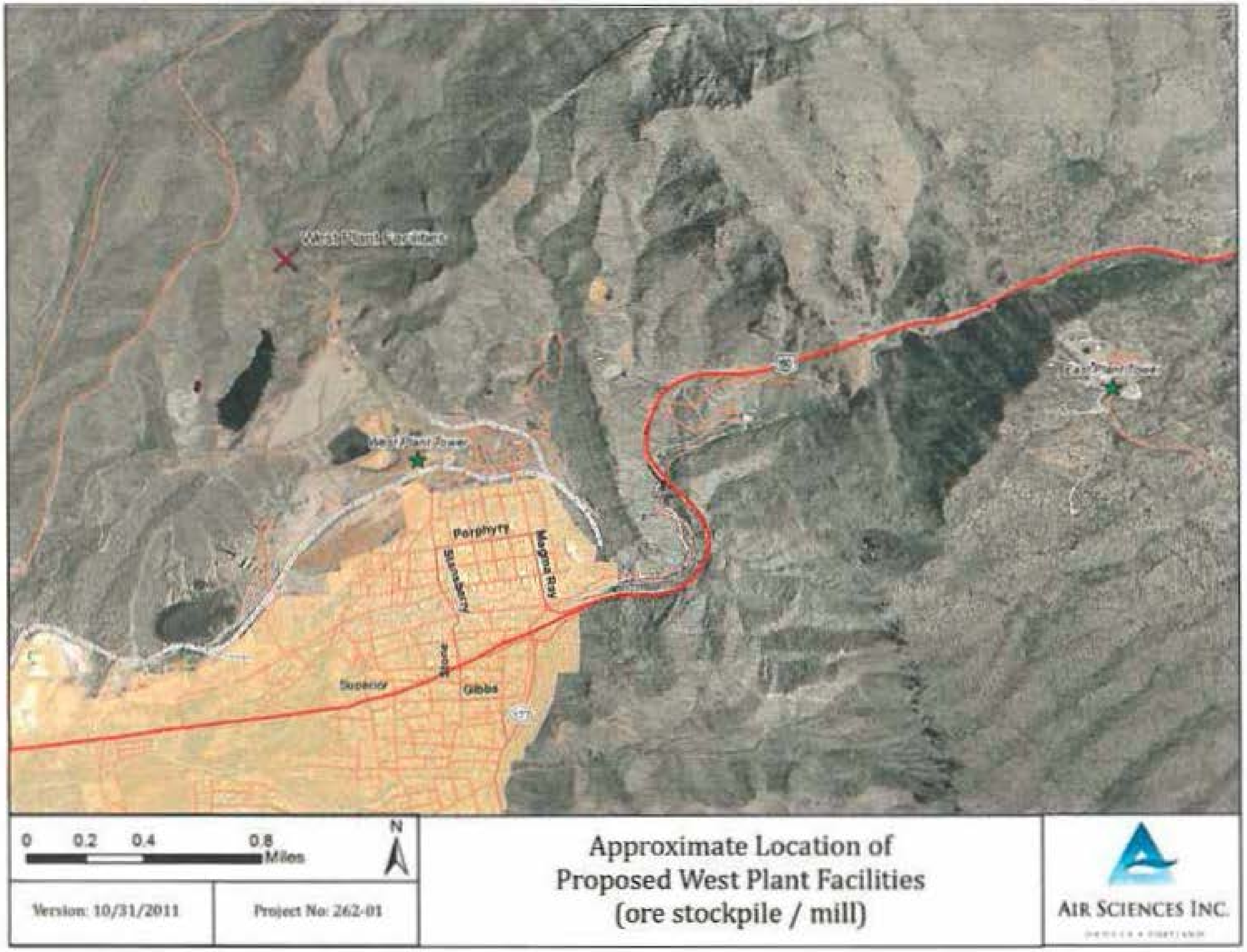
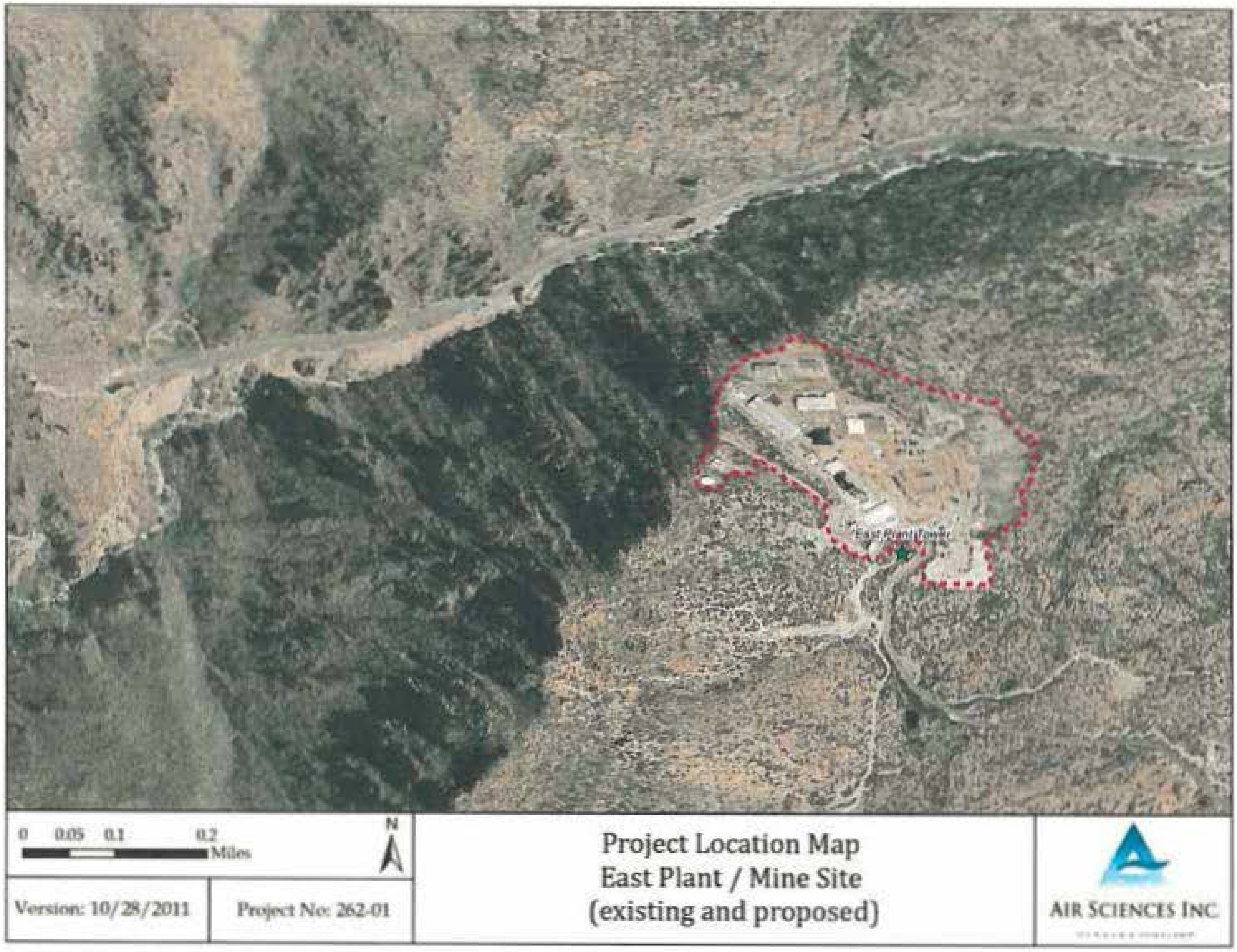


Figure 9: Project Location Map - East Plant / Mine Site (existing and proposed)



An approximate project schedule to support the RCC monitoring program is provided in Table 6.

Table 6: Project Schedule

ID	Task Name	Start	Finish
1	Quality Assurance Project Plan Development	7/1/2011	8/31/2011
2	Equipment Selection, Purchase, and Receipt	8/1/2011	10/31/2011
3	Site Installation	9/1/2011	11/30/2011
4	Local Personnel Training	9/1/2011	11/30/2011
5	Data Collection	12/1/2011	1/1/2013
6	Monitoring Quarter – 1Q 2012	1/1/2012	3/31/2012
7	Monitoring Quarter – 2Q 2012	4/1/2012	6/30/2012
8	Monitoring Quarter – 3Q 2012	7/1/2012	9/30/2012
9	Monitoring Quarter – 4Q 2012	10/1/2012	12/31/2012
10	Final Report and Data Package Submittal	1/1/2013	2/28/2013

Tasks included during each quarter of monitoring will include the following:

- Continuous data review
- Quarterly audits and calibrations of air quality instrumentation and associated reports
- Semi-annual audits and calibrations of meteorological instrumentation and associated reports
- Quarterly data reports

A.7 Quality Objectives and Criteria

The primary quality objectives are taken from EPA guidelines. The Data Quality Objectives (DQOs) include supporting compliance with air quality standards. The Measurement Quality Objectives (MQOs) for each measured parameter are listed in Table 7 through Table 12.

A.7.1 Ambient Air Monitoring – Oxides of Nitrogen

This project will include use of the Teledyne API model T200 with the following EPA designation: RFNA-1194-099. This instrument is designed to measure oxides of nitrogen (NO_x) (with nitrogen dioxide, NO_2, as an indicator) at trace levels in ambient air. The instrument will be operated continuously to collect hourly NO, NO_2, and NO_x concentrations on a continuous basis.

The precision of the analyzer will be assessed by challenging the instrument with a known concentration of standard gas at least once a day. This precision check will be automated, but the Site Operator or the QA Manager can also perform the span.

The QA Auditor will assess the accuracy of the monitor at least quarterly by performing multi-point calibrations and assessing the operation of the system. Data completeness (percent) will be assessed by dividing the number of valid run days by the amount of run days that exist for the quarter, and then multiplying that number by 100. The DQO for data completeness is 75 percent for the quarter.

by dividing the number of valid run days by the amount of run days that exist for the quarter, and then multiplying that number by 100. The DQO for data completeness is 75 percent for the quarter.

In the event of a sampler malfunction, steps taken to remedy the malfunction will be initiated immediately upon discovery of the malfunction. The Program Director will be notified within 24 hours of discovery of failure if immediate repair is unattainable. Information included in the notification to the Program Director will include the reason for the malfunction and the plan for replacement or repair.

The DQOs and MQOs for NO_2 are listed in Table 7.

A.7.2 Ambient Air Monitoring – Ozone

This project will include use of the Teledyne API model T400 with the following EPA designation: EQOA-0992-087. This instrument is designed to measure ozone (O_3) at trace levels in ambient air. The instrument will be operated to collect hourly O_3 concentrations on a continuous basis.

The precision of the analyzer will be assessed by challenging the instrument with an internal ozone generator nightly. This precision check will be automated, but the Site Operator or the QA Manager can also perform the span.

The QA Auditor will assess the accuracy of the monitor at least quarterly by performing multi-point calibrations and evaluating the operation of the system using a certified transfer standard. Data completeness (percent) will be assessed by dividing the number of valid run days by the amount of run days that exist for the quarter, and then multiplying that number by 100. The DQO for data completeness is 75 percent for the quarter.

In the event of a sampler malfunction, steps taken to remedy the malfunction will be initiated immediately upon discovery of the malfunction. The Program Director will be notified within 24 hours of discovery of failure if immediate repair is unattainable. Information included in the notification to the Program Director will include the reason for the malfunction and the plan for replacement or repair.

The DQOs and MQOs for O_3 are listed in Table 8.

A.7.3 Ambient Air Monitoring – Sulfur Dioxide

This project will include use of the Teledyne API model T100 with the following EPA designation: EQSA-0495-100. This instrument is designed to measure Sulfur Dioxide (SO_2) at trace levels in ambient air. The instrument will be operated to collect hourly SO_2 concentrations on a continuous basis.

The precision of the analyzer will be assessed by challenging the instrument with a known concentration of standard gas at least once a day. This precision check will be automated, but the Site Operator or the QA Manager can also perform the span.

The QA Auditor will assess the accuracy of the monitor at least quarterly by performing multi-point calibrations and assessing the operation of the system. Data completeness (percent) will be assessed by dividing the number of valid run days by the amount of run days that exist for the quarter, and then multiplying that number by 100. The DQO for data completeness is 75 percent for the quarter.

In the event of a sampler malfunction, steps taken to remedy the malfunction will be initiated immediately upon discovery of the malfunction. The Program Director will be notified within 24 hours of discovery of failure if immediate repair is unattainable. Information included in the notification to the Program Director will include the reason for the malfunction and the plan for replacement or repair.

The DQOs and MQOs for SO_2 are listed in Table 9.

A.7.4 Particulate Matter Monitoring

This project will use two Beta Attenuation Monitors (BAM-1020 monitors), the first of which is configured as a $PM_{2.5}$ Federal Equivalency Method (FEM) (EQPM-0308-170). The second BAM-1020 monitor is configurable as a $PM_{2.5}$ FEM (EQPM-0308-170), but it is set to monitor PM_{10}. The instruments will be operated continuously to collect hourly PM_{10} and $PM_{2.5}$ concentrations every day.

Data completeness (percent) will be assessed by dividing the number of valid run days by the amount of run days that exist for the quarter, and then multiplying that number by 100. The DQO for data completeness is 75 percent for the quarter.

The QA Auditor will assess the accuracy of the PM monitors by auditing the flow rate with a certified flow transfer standard at least quarterly, in addition to monthly checks performed by site operators.

In the event of a sampler malfunction, steps taken to remedy the malfunction will be initiated immediately upon discovery of the malfunction. The Program Director will be notified within 24 hours of discovery of failure if immediate repair is unattainable. Information included in the notification to the Program Director will include the reason for the malfunction and the plan for replacement or repair.

Comparability requirements for $PM_{10\text{-}2.5}$ are assured through the EPA designation EPA EQPM-0308-170. The accuracy of the monitor will be assessed through monthly audits of the flow rate by using a certified flow transfer standard.

The DQOs and MQOs for PM_{10} and $PM_{2.5}$ are listed in **Table 10**andTable 11, respectively.

A.7.5 Meteorological Monitoring

The MQOs are defined as described in the *EPA Meteorological Monitoring Guidance for Regulatory Modeling Applications*, Sections 3 and 5. Data completeness (percent) will be assessed by dividing the number of valid run days by the amount of run days that exist for the quarter, and then multiplying that number by 100. The DQO for data completeness is 90 percent for the quarter.

The system performance will be assessed by the QA Auditor semi-annually (twice a year) in the form of rotating audits and calibrations.

In the event of sensor or logger malfunction, steps taken to remedy the malfunction will be initiated immediately upon discovery of the malfunction. The Program Director will be notified within 24 hours of discovery of failure if immediate repair is unattainable. Information included in the notification to the Program Director will include the reason for the malfunction and the plan for replacement or repair.

Accuracy and precision of the parameters measured for this project are assured through proper calibration and maintenance procedures. The accuracy of the sensors will be challenged by comparison and collocation with certified transfer standards. The precision and bias of the sensors used are controlled by having selected sensors that meet the performance specifications in EPA-454/R-99-005.

The DQOs and MQOs for meteorological parameters are listed inTable 12.

Table 7: NO_x Collection Measurement and Data Quality Objectives

CRITICAL CRITERIA - NO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
One-Point QC Check Single Analyzer	1/2 weeks	≤ ±10% (percent difference)	0.01 - 0.10 ppm Relative to routine concentrations 40 CFR Part 58 App A Sec 3.2
Zero/Span Check	Nightly	Zero drift ≤ ±3% of full scale Span drift ≤ ±10% of 80% full scale setpoint.	

OPERATIONAL CRITERIA - NO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Shelter Temperature			
Temperature Range	Daily (hourly values)	5 to 40°C (Hourly avg.) (per manufacturer (MFGR) specifications)	Taken from T200 MFGR specifications
Temperature Control	Daily (hourly values)	≤ ±2°C Standard Deviation (SD) over 24 hours	
Temperature Device Check	2/year	±2°C of standard	
Precision (Using One-Point QC Checks)	Calculated annually and as appropriate for design value estimates	90% Confidence Limit (CL) Coefficient of Variation (CV) ≤ 10%	90% CL of CV 40 CFR Part 58 App A Sec 4.1.2
Bias (Using One-Point QC Checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ ±10%	95% CL of absolute (ABS) bias estimate 40 CFR Part 58 App A Sec 4.1.3

Table 7: NO_x Collection Measurement and Data Quality Objectives (Continued)

OPERATIONAL CRITERIA - NO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Verification/Calibration	Upon receipt/adjustment/ repair/installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	Instrument residence time ≤ 2 min dynam. parameter ≥ 2.75 ppm-min. All points within ±2% of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points) 40 CFR Part 50 App F
Converter Efficiency	During multi-point calibrations, span and audit 1/2 weeks	96%	
Gaseous Standards		NIST-Traceable (National Institute of Standards and Technology) (e.g., EPA Protocol Gas)	Vendor must participate in EPA Protocol Gas Verification Program 40 CFR Part 58 App A Sec 2.6.1
Zero Air/ Zero Air Check	1/year	Concentrations below lower detection limit (LDL)	
Gas Dilution Systems	1/3 months	Accuracy ±2%	
Detection			
Noise	NA	0.005 ppm	40 CFR Part 53.20
Lower Detectable Level	1/year	0.01 ppm	40 CFR Part 53.20

SYSTEMATIC CRITERIA - NO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Standard Reporting Units	All data	ppb	40 CFR Part 58 App S
Completeness (Seasonal)	Quarterly	75%	Annual standard (hourly data)
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling Train		Borosilicate glass (e.g., Pyrex®) or Teflon®	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E

Table 8: O_3 Collection Measurement and Data Quality Objectives

CRITICAL CRITERIA - Ozone			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
One-Point QC Check Single Analyzer - Onsite Photometer	1/2 weeks	≤ ±7% (percent difference)	0.01 - 0.10 ppm relative to routine concentrations 40 CFR Part 58 App A Sec 3.2
Zero/Span Check	Nightly	Zero drift ≤ ±2% of full scale Span drift ≤ ±7% of 80% full scale setpoint.	

OPERATIONAL CRITERIA - Ozone			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Shelter Temperature			
Temperature Range	Daily (hourly values)	5 to 40°C (Hourly avg.) (per MFGR specifications)	Taken from T400 MFGR specifications
Temperature Control	Daily (hourly values)	≤ ±2°C SD over 24 hours	
Temperature Device Check	2/year	±2°C of standard	
Precision (Using One-Point QC checks) Onsite Photometer	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 7%	90% CL of CV 40 CFR Part 58 App A Sec 4.1.2
Bias (Using One-Point QC Checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ ±7%	95% CL of ABS bias estimate 40 CFR Part 58 App A Sec 4.1.3

Table 8: O_3 Collection Measurement and Data Quality Objectives (Continued)

OPERATIONAL CRITERIA - Ozone			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Verification/Calibration	Upon receipt/adjustment/ repair/ installation/ moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2%of full scale of best-fit straight line Linearity error < 5%	Multi-point calibration (0 and 4 upscale points) 40 CFR Part 50 App D Sec 5.2.3
Zero Air		Concentration below LDL	
Gaseous Standards		NIST-Traceable (e.g., EPA Protocol Gas)	40 CFR Part 58 App A Sec 2.6.1
Zero Air Check	1/year	Concentrations below LDL	
Ozone Local Primary Standard - Certified to Region 8 EPA Standard Reference Photometer Serial No. 8 (SRP 8)			
Qualification	Upon receipt of transfer standard	±4% or ±4 ppb (whichever greater)	Transfer Standard Doc EPA 600/4-79-056 Section 6.4
Certification	After qualification and upon receipt/adjustment/repair	Relative Standard Deviation (RSD) of six slopes ≤ 3.7% SD of 6 intercepts 1.5	Transfer Standard Doc EPA 600/4-79-056 Section 6.6
Recertification to Local Primary Standard	Beginning and end of O_3 season or 1/6 months, whichever less	New slope = ±0.05 of previous and RSD of six slopes ≤ 3.7% SD of 6 intercepts 1.5	1 recertification test that is then added to most recent 5 tests If does not meet acceptability, certification fails
Lower Detectable Level	1/year	0.003 ppm	

Table 8: O_3 Collection Measurement and Data Quality Objectives (Continued)

SYSTEMATIC CRITERIA - Ozone			
Criteria	Frequency	Acceptable Range	Information/Action
Standard Reporting Units	All data	ppm	
Completeness (seasonal)	Daily	75% of hourly averages for the 8-hour period	8-Hour Average
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling Train		Borosilicate glass (e.g., Pyrex®) or Teflon®	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E
EPA Standard Ozone Reference Photometer (SRP) Recertification	1/year	Regression slope = 1.00 ±0.01 and intercept < 3 ppb	Certification to EPA Region 8 Standard Reference Photometer (SRP 8)

Table 9: SO_2 Collection Measurement and Data Quality Objectives

CRITICAL CRITERIA - SO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
One-Point QC Check Single Analyzer	1/2 weeks	≤ ±10% (percent difference)	0.01 - 0.10 ppm Relative to routine concentrations 40 CFR Part 58 App A Sec 3.2
Zero/Span Check	Nightly	Zero drift ≤ ±3% of full scale Span drift ≤ ±10% of 80% full scale setpoint.	

OPERATIONAL CRITERIA - SO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Shelter Temperature			
Temperature Range	Daily (hourly values)	5 to 40°C (Hourly avg.) (per manufacturer (MFGR) specifications)	Taken from T100 MFGR specifications
Temperature Control	Daily (hourly values)	≤ ±2°C Standard Deviation (SD) over 24 hours	
Temperature Device Check	2/year	±2°C of standard	
Precision (Using One-Point QC Checks)	Calculated annually and as appropriate for design value estimates	90% Confidence Limit (CL) Coefficient of Variation (CV) ≤ 10%	90% CL of CV 40 CFR Part 58 App A Sec 4.1.2
Bias (Using One-Point QC Checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ ±10%	95% CL of absolute (ABS) bias estimate 40 CFR Part 58 App A Sec 4.1.3

Table 9: SO_2 Collection Measurement and Data Quality Objectives (Continued)

OPERATIONAL CRITERIA - SO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Verification/Calibration	Upon receipt/adjustment/ repair/installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ±2% of full scale of best-fit straight line	Multi-point calibration (0 and 4 upscale points)
Gaseous Standards		NIST-Traceable (National Institute of Standards and Technology) (e.g., EPA Protocol Gas)	Vendor must participate in EPA Protocol Gas Verification Program 40 CFR Part 58 App A Sec 2.6.1
Zero Air/ Zero Air Check	1/year	Concentrations below lower detection limit (LDL)	
Gas Dilution Systems	1/3 months	Accuracy ±2%	
Detection			
Noise	NA	0.005 ppm	40 CFR Part 53.20
Lower Detectable Level	1/year	0.01 ppm	40 CFR Part 53.20
SYSTEMATIC CRITERIA - SO_2			
Criteria	**Frequency**	**Acceptable Range**	**Information/Action**
Standard Reporting Units	All data	ppb	40 CFR Part 58 App S
Completeness (Seasonal)	Quarterly	75%	Annual standard (hourly data)
	24 hours	75%	24-hour standard
	3 hours	75%	3-hour standard
Sample Residence Times		< 20 seconds	
Sample Probe, Inlet, Sampling Train		Borosilicate glass (e.g., Pyrex®) or Teflon®	40 CFR Part 58 App E
Siting		Un-obstructed probe inlet	40 CFR Part 58 App E

Table 10: Continuous PM_{10} Collection Measurement and Data Quality Objectives

CRITICAL CRITERIA - PM_{10} CONTINUOUS			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Sampling Period	Continuous	75% of hourly samples must be valid for valid 24-hour reading	
Sampling Instrument BAM 1020 Equipped with MEDO Pump			
Average FR	Every 24 hours of operation	Average within 5% of design	Recommendation
Verification/Calibration			
One-Point FR Verification	1/ month	Average within 5% of design	Part 58 App A Sec 3.2.3
Reference Membrane Verification (BAM)	Hourly	±4% of ABS Value	

OPERATIONAL EVALUATIONS TABLE - PM_{10} CONTINUOUS			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Verification/Calibration			
System Leak Check	Every 30 days	< 1.0 liters per minute (lpm)	Method 2.11 Sec 2.3.2, BAM 1020 Manual
FR Multi-Point Verification/Calibration	Quarterly	All 3 points within ±4% of design	Method 2.11 Sec 2.3.2, BAM 1020 Manual
Audits			
Semi-Annual FR Audit	Quarterly	10% of audit standard design	Part 58 App A Sec 3.2.4
Monitor Maintenance			
Inlet/Downtube Cleaning	Quarterly	Cleaned	Method 2.11 Sec 6, BAM 1020 Manual
Nozzle Cleaning	Monthly or as needed	Cleaned	BAM 2010 Manual
MFGR-Recommended Maintenance	Per MFGR manual	Per MFGR manual	

Table 10: Continuous PM_{10} Collection Measurement and Data Quality Objectives (Continued)

SYSTEMATIC CRITERIA - PM_{10} CONTINUOUS			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Data Completeness	Quarterly	≥ 75%	Part 50 App K Sec 2.3
Reporting Units	All values	$\mu g/m^3$ at standard temperature and pressure (STP)	Part 50 App K
Rounding Convention			
24-hour, Hourly	Quarterly	Nearest 10 $\mu g/m^3$ (≥ 5 round up)	Part 50 App K Sec 1
Verification/Calibration standards and re-certifications - All standards should have multi-point certifications against NIST-Traceable standards			
FR Transfer Standard	1/year	±2% of NIST-Traceable SD	Part 50 App J Sec 1
Field Thermometer	1/year	±0.5°C resolution, ±0.1°C accuracy	Recommendation
Field Barometer	1/year	±1 mmHg resolution, ±5 mmHg accuracy	Recommendation
Calibration and Check Standards			
FR Transfer Standard	1/year	±2% of NIST-Traceable SD	Method 2.10 Sec 9
Verification/Calibration			
Clock/Timer Verification	Quarterly	1 min/month	Recommendation

Table 11: Continuous $PM_{2.5}$ Collection Measurement and Data Quality Objectives

CRITICAL CRITERIA - $PM_{2.5}$ CONTINUOUS, Local Conditions			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Sampling Period 24-hour estimate	Continuous	75% of hourly samples must be valid for valid 24-hour reading	Part 50 App L Sec 3.3, Part 50 App L Sec 7.4.15
Hour Estimate	Every hour	Instrument-dependent	See operator's manual
Sampling Instrument BAM 1020 Equipped with MEDO Pump			
Average FR	Every 24 hours of op	Average within 5% of 16.67 liters/minute	Part 50 App L Sec 7.4
Variability in FR	Every 24 hours of op	CV ≤ 2%	Part 50 App L Sec 7.4.3.2
Verification/Calibration			
One-Point FR Verification	1/4 weeks	±4% of transfer standard	Part 50 App L Sec 9.2.5, Part 58 App A Sec 3.2.3 & 3.3.2
Reference Membrane Verification (BAM)	Hourly	±4% of ABS Value	

OPERATIONAL CRITERIA - $PM_{2.5}$ CONTINUOUS, Local Conditions			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Verification/Calibration			
Leak Check	Every 30 days	< 1.0 liters per minute (lpm)	Part 50 App L Sec 7.4
Temperature Calibration	Quarterly	±2°C	Part 50 App L Sec 9.3
Pressure Verification	Quarterly	±10 mm Hg	Part 50 App L Sec 9.3
Other Monitor Calibrations	Per MFGR operating manual	Per MFGR operating manual	
FR Calibration	If multi-point verification failure	±2%	Part 50 App L Sec 9.2

Table 11: Continuous $PM_{2.5}$ Collection Measurement and Data Quality Objectives (Continued)

OPERATIONAL CRITERIA - $PM_{2.5}$ CONTINUOUS, Local Conditions			
Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.11)
Calibration & Check Standards (working standards)			Part 58 App A Sec 3.3.3
Field Thermometer	1/yr	±0.1°C resolution, ±5 mm Hg accuracy	Method 2.12 Sec 4.2 & 6.4
Field Barometer	1/yr	±1 mm Hg resolution, ±5 mm Hg accuracy	Method 2.12 Sec 4.2 & 6.5
Shelter Temperature			
Temperature Range	Daily (hourly values)	20 to 30°C (Hourly avg.) or per MFGR specifications if designated to a wider temperature range	Generally the 20-30 °C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	±2°C SD over 24 hours	
Temperature Device Check	2/year	±2°C	

Table 11: Continuous $PM_{2.5}$ Collection Measurement and Data Quality Objectives (Continued)

OPERATIONAL CRITERIA - $PM_{2.5}$ CONTINUOUS, Local Conditions			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Monitor Maintenance			
Virtual Impactor Very Sharp Cut Cyclone	Every 30 days	Cleaned/Changed	Method 2.12 Sec 9.2
Inlet Cleaning	Quarterly	Cleaned	Method 2.12 Sec 9.3
Filter Chamber Cleaning	Quarterly	Cleaned	Method 2.12 Sec 9.3
Circulating Fan Filter Cleaning	Quarterly	Cleaned/Changed	Method 2.12 Sec 9.3
Nozzle Cleaning	Monthly or more frequently as needed	Cleaned	BAM 1020 Manual
MFGR-Recommended Maintenance	Per MFGR Manual	Per MFGR Manual	

SYSTEMATIC CRITERIA - $PM_{2.5}$ CONTINUOUS, Local Conditions			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Data Completeness	Quarterly	> 75%	Part 50 App N Sec 4.1 (b) 4.2 (a)
Reporting Units		$\mu g/m^3$ at ambient temp/pressure ($PM_{2.5}$)	Part 50.3
Rounding Convention			
Annual 3-yr average	Quarterly	Nearest 0.1 $\mu g/m^3$ (> 0.05 round up)	Part 50 App N Sec 2.3
24-hour, 3-year average	Quarterly	Nearest 1 $\mu g/m^3$ (> 0.5 round up)	Part 50 App N Sec 2.3
Detection Limit			
Lower DL	Hourly	$\leq 3.6\ \mu g/m^3$	BAM 1020 Spec sheet
Upper Conc. Limit	Hourly	10,000 mg/m^3 (milligrams per cubic meter)	BAM 1020 Spec sheet
FR Transfer Std.	1/yr	±2% of NIST-Traceable Std.	Part 50 App L Sec 9.1 & 9.2
Field Thermometer	1/yr	±0.1°C resolution, ±0.5°C accuracy	Method 2.12 Sec 4.2.2
Field Barometer	1/yr	±1 mm Hg resolution, ±5 mm Hg accuracy	Method 2.12 Sec 4.2.2

Table 11: Continuous $PM_{2.5}$ Collection Measurement and Data Quality Objectives (Continued)

SYSTEMATIC CRITERIA - $PM_{2.5}$ CONTINUOUS, Local Conditions			
Criteria	**Frequency**	**Acceptable Range**	**Information (CFR or Method 2.11)**
Calibration & Check Standards			
FR Transfer Std.	1/yr	±2% of NIST-Traceable Std.	Part 50 App L Sec 9.1 & 9.2
Verification/Calibration			
Clock/Timer Verification	Quarterly	1 min/mo**	Part 50 App L Sec 7.4

1/ value must be flagged due to current implementation of BAM (sampling 42 minute/hour) only 1,008 minutes of sampling in 24-hour period

* = not defined in CFR

SD = Standard Deviation

CV = Coefficient of Variation

@ = Scheduled to occur immediately after impactor cleaned/changed.

** = need to ensure data system stamps appropriate time period with reported sample value

Table 12: Meteorological Collection Measurement and Data Quality Objectives

CRITICAL CRITERIA - Meteorological Parameters							
Measurement	**Method**	**Reporting Units**	**Operating Range**	**Resolution**	**Minimum Sample Frequency**	**Raw Data Collection Frequency**	**Completeness**
Ambient Temperature	Thermistor	°C	-30 - 50	0.1	Hourly	15 minutes	90%
Vertical Temperature Difference (Delta T)	Thermistor	°C	-3 - 7	0.1	Hourly	15 minutes	90%
Relative Humidity (RH)	Psychtrometer/Hygrometer	%	0 - 100	0.5	Hourly	15 minutes	90%
Barometric Pressure (BP)	Aneroid Barometer	mmHg	600 - 1,100	0.5	Hourly	15 minutes	90%
Wind Speed	Cup or Sonic Anemometer	m/s	0.5 - 50	0.25	Hourly	15 minutes	90%
Wind Direction	Vane or Sonic Anemometer	Degrees	0 - 360	1	Hourly	15 minutes	90%
Solar Radiation	Pyranometer	Watts/m²	0 - 1,300	10	Hourly	15 minutes	90%
Precipitation	Tipping Bucket	Inches/hour	0 - 50	0.001 Inch/day	Hourly	15 minutes	90%

OPERATIONAL EVALUATION TABLE - Meteorological Parameters			
Visual QC Checks	**Acceptance Range**	**Frequency**	**Reference**
Site Checks	Verify local conditions as compared to sensor disposition	Weekly	QA Handbook Vol. IV
Audits All Met Parameters	Meet requirements in QA Handbook Vol. IV	Every 6 months	QA Handbook Vol. IV
Calibrations All Met Parameters	Meet requirements in QA Handbook Vol. IV	Every 6 months	QA Handbook Vol. IV

A.8 Special Training Needs/Certification

The NO_x, O_3, SO_2, particulate samplers, and meteorological instrumentation should be operated under the guidance of the Project Manager and Project Data and Field Technician who have extensive experience with this equipment. Any non-routine work on these stations must be conducted by a qualified technician who has more than two years of experience with these sampling systems.

Site Operators for this project will receive training on the operation and maintenance of the sampling systems and related equipment. Training will be conducted by the Project Manager or his/her designees. Site-specific training checklists will document the training sessions and will be filed and maintained in the Ambient Air and Meteorological Monitoring file records. A copy of this training record can also be found in Appendix C.

A.9 Documents and Records

Documentation and records for this project will typically include, but are not limited to:

- QA plan and revisions
- Certifications of calibration equipment and standards
- Standard Operating Procedures (SOPs)
- Logbook or journal entries
- Site check forms
- Copies of maintenance records and site log books
- Calibration and audit reports
- Quarterly reports
- Raw data files

Hard copies of all the forms that will be used to document the system performance and data custody can be found in Appendix A.

A.9.1 Data Reporting Package Format and Documentation Control

The QA Manager will submit quarterly summary data reports to the Program Director within 90 days of the conclusion of each quarter of the monitoring program. Each report will contain:

- The number of possible observations for the quarter, the number of actual valid observations for the quarter, and the data completeness (percent) for the quarter with an explanation of any instrument malfunction for each parameter
- All valid hourly meteorological data collected during the quarter laid out in a monthly matrix

- Joint frequency distributions of wind speed and direction and direction by stability class for the quarter
- Summary of maximum wind gusts for each 24-hour period for the quarter
- Graphical summaries of the monthly averages and the means and extremes for the meteorological parameters
- Listing of gravimetric data results accompanied by sampler-run information
- Summaries of the concentrations for hourly values and applicable averaging periods for NO_x, O_3, SO_2, PM_{10}, and $PM_{2.5}$ with discussions of maximum recorded values and supplemental information on any recorded valid concentrations that are worthy of further discussion
- Hourly NO_x, O_3, SO_2, PM_{10}, and $PM_{2.5}$ data presented in a monthly matrix
- Copies of any calibrations and audits performed during the quarter
- Copies of all verifications and site check forms performed during the quarter

A.9.2 Data Reporting Package Archiving and Retrieval

The data will be stored on Air Sciences' server until they have been processed into quarterly reports. At that time the data will be transferred, in triplicate, to optical discs. The optical discs will be stored in a climate-controlled environment at Air Sciences' offices and at a location off-site. Data-storage devices (fire-proof hard drives) are swapped out every other week to assure a secondary backup location. Data retrieval will be conducted at the request of the Program Director or PCAQCD. Air Sciences stores project data for a minimum of five years after collection.

A.9.3 Quality Assurance Project Plan Distribution

Within 30 days of approval and full signature completion of the monitoring plan, the document will be distributed by the Program Director to all signatories.

SECTION

B DATA GENERATION AND ACQUISITION

B.1 Sampling Process Design and Methods Requirements

B.1.1 Purpose

The system is designed to provide meteorological (wind speed, wind direction, sigma theta, air temperature, air temperature differential, solar radiation, relative humidity, barometric pressure, and precipitation), NO_x, O_3, SO_2, PM_{10}, and $PM_{2.5}$ concentration data in support of air permit applications and other environmental purposes. The system design includes three air quality and meteorological monitoring stations in the network. This document describes the plan for the three stations.

B.1.2 Monitoring Site Locations

At this pre-feasibility stage of mine development, there are multiple alternatives for operations that include several distinct locations. Historical air quality and meteorological monitoring associated with historic operations of the Resolution Project has included monitoring stations at several of the areas. The monitoring program identified in this document will continue (or resume) the monitoring at three of the historical monitoring locations, but with updated instrumentation, sensors, and strict adherence to current regulatory guidance. The monitoring stations and their distances to the town of Superior can be seen in Table 13.

The East Plant site is located approximately two miles east of the town of Superior, where future underground mining and ore processing and conveying will take place. This station will collect meteorological data, particulate data and air pollutants (PM_{10}, $PM_{2.5}$, and O_3, NO_x, and SO_2) representative of that area and suitable as input to the AERMOD modeling system. This site is representative of the Pinto Valley region, and has available power.

The West Plant site is located near the base of elevated terrain in the relatively flat region just north of Superior. This station will include monitoring of meteorological parameters and particulate data (PM_{10}, and $PM_{2.5}$). This station was selected due to its representativeness of a location that is central to the Resolution Project's operations and local population and its proximity to available power.

The Far West site will monitor meteorological parameters as well as particulate matter (PM_{10} and $PM_{2.5}$). This site is approximately 16 miles southwest of the town of Superior. One of the operational alternatives for the Resolution Project includes locating a tailings storage area just east of the proposed Far West monitoring station. Selection of this location is based on its representativeness of meteorological conditions that could influence dust emissions from the tailings disposal area. Another goal of the monitoring program at this site is to establish existing ("background") concentrations of particulate matter in the area proximate to the location of this potential emissions source for the Resolution Project.

Table 13: Monitoring Stations Summary

Station	Approximate Location	Type of Monitoring Station
East Plant	2 Miles East of Superior	Meteorological and Air Quality
West Plant	Northern Edge of Superior	Meteorological and Air Quality
Far West	16 Miles West of Superior	Meteorological and Air Quality

B.1.3 Monitoring Scales

Each monitoring site at RCC will be designed and used as special purpose monitors. Scale applicability as it relates to State and Local Air Monitoring Stations (SLAMS), Photochemical Assessment Monitoring Stations (PAMS), and other monitoring networks is not entirely relevant to this program. With input from PCAQCD, the language used in 40 CFR Part 58 Appendix D was fit to the RCML program to help identify the most suitable scaling definition for each monitoring station (listed in

Table 14).he site locations were selected, and then scales that applied to the locale and purpose were chosen as a best fit, as opposed to the intended order outlined in 40 CFR Appendix D, where scale drives monitor location selection.

The monitoring scales applied to all three sites relate to the monitoring site type of "background and regional transport", assigning the regional scale as the most applicable to these sites.[1] Regional scale is defined in 40 CFR Part 58, Appendix D, section 1.2, as "rural areas with reasonably homogenous geography without large sources, which extend from tens to hundreds of kilometers". This description aligns the spatial scale with the project goals, which focus on baseline monitoring. Baseline monitoing goals are associated with the appropriate "regional scale" again in table D-1 of 40 CFR.

Figure 10 through Figure 14 are panoramic (180-degree) photos that show the nearby obstructions, topography, and vegetation at the sites.

[1] Throughout the monitoring program, RCML will be conducting remediation, pre-development, and development activites proximate to the West Plant and East Plant stations. These activities will emit dust and combustion emissions. As a routine aspect of the monitoring data QA/QC review, Air Sciences and RCML will investigate elevated pollutant concentrations and assess (qualitatively and/or quantitatively) the likelihood that monitored concentrations were influence by local, RCML (or other unusual, intermittent) sources. Remediation, pre-development, and development activities will not occur during normal mining operations.

Table 14: Scale Applicability as Related to the Monitoring Stations

	Monitored Air Pollutants	Purpose	Scale(s)	Key Words
East Plant	PM_{10}, $PM_{2.5}$, O_3, NO_x, SO_2	Baseline	Regional	Rural areas of reasonably homogenous geography without large sources, extending from tens to hundreds of kilometers.
West Plant	PM_{10}, $PM_{2.5}$	Baseline	Regional	Rural areas of reasonably homogenous geography without large sources, extending from tens to hundreds of kilometers.
Far West	PM_{10}, $PM_{2.5}$	Baseline	Regional	Rural areas of reasonably homogenous geography without large sources, extending from tens to hundreds of kilometers.

Figure 10: East Plant Facing West

Figure 11: East Plant Facing East

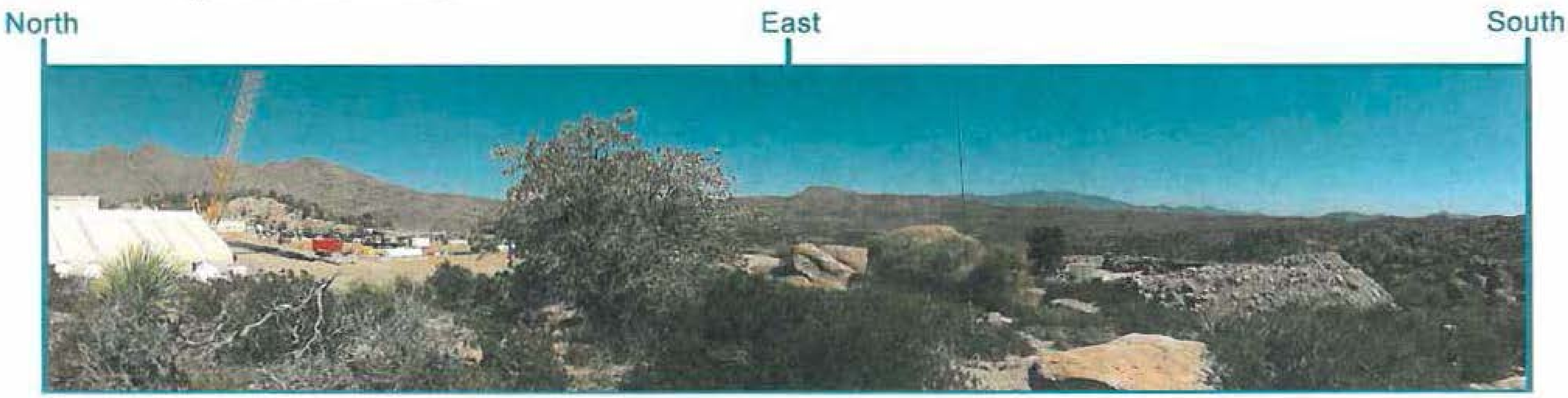


Figure 12: West Plant Facing East

Figure 13: West Plant Facing West

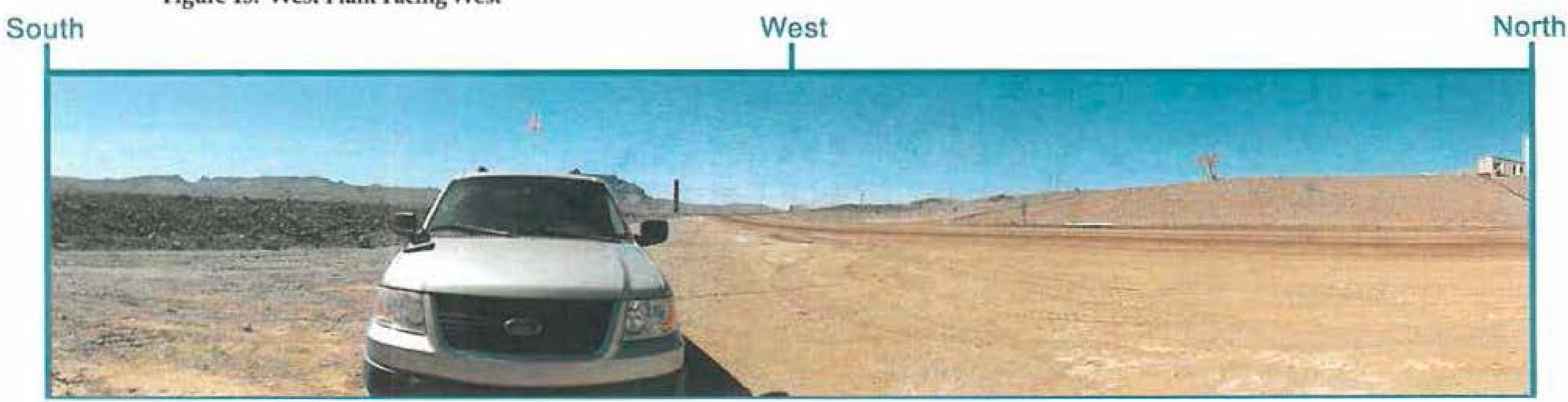


Figure 14: Far West

Facing North

Facing South

Facing West

Facing East

B.2 Sampling Methods

Sampling of meteorological and ambient air concentrations will be performed using appropriate monitoring methods to assure representative samples. The following sections cover the methods that will be used in this program, instrument installation, and the operational environment.

The monitoring methods employed for the Resolution Mine Ambient Air and Meteorological Monitoring Program are designated by the U.S. EPA as either Automated Reference Methods or Manual Reference Methods, consistent with the *Ambient Monitoring Guidelines for Prevention of Significant Deterioration* (EPA-450/4-87-007).

Continuous analyzers and samplers will be deplyed to measure NO_x, O_3, SO_2, PM_{10}, and $PM_{2.5}$. Sensors and data loggers purchased from Campbell Scientific will be used to measure, post-process, and store meteorological parameters.

The following are the descriptions of these instruments and monitoring methods.

B.2.1 NO_x Monitoring

NO_x will be measured using the Teledyne T200 Chemiluminescence NO_x Analyzer. These analyzers have an EPA equivalency designation as a Reference Method (RFNA-1194-099). Average hourly NO_x values will be measured over the duration of the one-year (minimum) sampling period. The instrument will be calibrated through the employment of the Teledyne API T700 Dynamic Dilution Calibrator. Zero Air will be provided using the Teledyne API model 702 Zero Air System.

The SOP for the T200 Analyzer is provided in Appendix B.

B.2.2 O_3 Monitoring

O_3 will be measured using the Teledyne T400 UV Absorption O_3 Analyzer. These analyzers have an EPA equivalency designation as a Reference Method (EQOA-0992-087). Average hourly O_3 values will be measured over the duration of the one-year (minimum) sampling period. The instrument will be checked by nightly spans through the employment of the "Level 3" Teledyne API T700 Dynamic Dilution Calibrator utilizing the additional photometer transfer standard add-on. Zero Air will be provided using the Teledyne API Model 702 Zero Air System.

Quarterly calibrations and verifications will be carried out by challenging the Teledyne T400 with a "Level 2" transfer standard which is certified annually to the EPA Region 8 Standard Reference Photometer , Serial No. 8 (SRP 8). All documentation will be submitted to support this traceability.

The SOP for the T400 Analyzer is provided in Appendix B.

B.2.3 SO_2 Monitoring

SO_2 will be measured using the Teledyne T100 UV Fluorescence SO_2 Analyzer. These analyzers have an EPA equivalency designation as a Reference Method (EQSA-0495-100). Average hourly SO_2 values will be measured over the duration of the one-year (minimum) sampling period. The instrument will be calibrated through the employment of the Teledyne API T700 Dynamic Dilution Calibrator. Zero Air will be provided using the Teledyne API model 702 Zero Air System.

The SOP for the T100 Analyzer is provided in Appendix B.

B.2.4 PM_{10} and $PM_{2.5}$ Monitoring

PM_{10} and $PM_{2.5}$ will be measured using Met One BAM 1020 Monitors. These monitors have an EPA equivalency designation as a reference method (EQPM-0308-170). Average hourly PM_{10} and $PM_{2.5}$ values will be measured over the duration of the sampling period. The BAM 1020 samplers will use the 2011 firmware of 3.6.3 and are capable of internally converting results to standard (temperature and pressure) conditions for PM_{10} output. All $PM_{2.5}$ data will be reported in actual (temperature and pressure) conditions.

The SOP for the BAM 1020 monitor is provided in Appendix B.

B.2.5 Meteorological Monitoring

The sensors to be used for the horizontal wind speed, horizontal wind direction, ambient temperature, delta temperature, barometric pressure, solar radiation, and precipitation will be acquired through Campbell Scientific and will meet the specifications stated in the *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (EPA-454/R-99-005). These sensors will be continuously operated throughout the program. Spare parts and supplies will be retained in case they are needed for maintenance or repair.

The sensors will be mounted on a 10-meter open lattice tower. The sensor heights are listed in Table 15 and are also described in Figure 2. The summary of meteorological sensors and performance specifications are listed in Table 16 and Table 17.

The SOPs for the meteorological sensors are provided in Appendix B.

The selection of delta temperature probe height was based on section 3.2.2.1 in EPA-454/R-99-005, which says the temperature difference should be measured at 20 and 100 times the estimated surface roughness length (SRL). The estimated SRL (for the purpose of temperature probe placement) for the three stations was based on visual inspection of the landscape of all three sites and then choosing an appropriate description of terrain classification using EPA-454/R-99-005,

Table 6-10. "Low crops, occasional large obstacles" was determined to be an appropriate description of the areas proximate to the three stations. Table 6-10 provides a SRL of 0.10 meters for this terrain classification. A SRL of 0.10 meters results in temperature probe placement heights of 2 meters (20 times SRL) and 10 meters (100 times SRL).

The monthly and directionally-specific SRLs for terrain surrounding the monitoring sites will be determined when the inputs and setup of the AERMOD and AERSURFACE analyses take place. The methodology for AERMOD and AERSURFACE will be submitted in the modeling protocol to be submitted and approved by PCAQCD.

Table 15: Sensor Heights

Parameter	Height (meters)
Wind speed	10
Wind direction	10
Ambient temperature	2
Relative humidity	2
Barometric pressure	1
Precipitation	Ground
Delta temperature	2, 10
Solar radiation	2

Table 16: Summary of Meteorological Accuracies and Resolution

Parameter	Sensor	Range	Accuracy	Standard	Measurement Resolution	Reference
Wind Direction	R.M. Young 05305	0 to 360 degrees	+3 degrees	Accuracy: +5 degrees	1.0 degree	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Wind Speed	R.M. Young 05305	0.4 to 45 m/s	+0.2 m/s	Accuracy: +0.2 m/s up to speeds of 5 m/s and +5% thereafter	0.1 m/s	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Amb. Temp.	Calibrated R.M. Young 41342 Platinum RTD	-50°C to +50°C	+0.1 degrees	+0.5 degrees	0.1°C	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Delta Temp.	Paired, Calibrated R.M. Young 41342 Platinum RTD	-50°C to +50°C	+0.05 degrees	+0.1 degrees	0.02°C	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Relative Humidity	Campbell Scientific Model HMP45C	0.8 to 100%	+2% (0 to 90% RH) and +3% (90 to 100% RH)	1.5°C dew point temperature error	1%	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Solar Radiation	CMP-3	310-2800 nanometers	+5%	+5%	10 W/m2	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Barometric Pressure	Vaisala PT110	500 to 1,100 millibars (mb)	+0.5 to 1.5 mb (temp. depend.)	+3 mb	+0.5 mb	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1
Precipitation	Met One Model 385 12-Inch Rain Gauge	n/a	0.5% when precip. <0.5 inch and 2% when precip. >3 inches	+10% of observed or +0.5 mm	0.01 inch	EPA-454/4-B08-002 Table 0-7, EPA-454/R-99-005, February 2000, Table 5-1

Table 17: Sensor Response Characteristics

Meteorological Variable	Sensor	Parameter	MFGR Specifications	Required Specifications	Reference
Wind Speed	R.M. Young 05305	Starting speed	0.4 m/s	<0.5 m/s	EPA-454/R-99-005, February 2000, Table 5-2
		Distance constant	2.1 m	<5 m	EPA-454/R-99-005, February 2000, Table 5-2
Wind Direction	R.M. Young 05305	Starting speed	0.5 m/s	<0.5 m/s @ 10 degrees	EPA-454/R-99-005, February 2000, Table 5-2
		Damping ratio	0.3	0.4 to 0.7	EPA-454/R-99-005, February 2000, Table 5-2
		Delay distance	1.3 m	<5 m/s	EPA-454/R-99-005, February 2000, Table 5-2
Temperature	R.M. Young 41342 Platinum RTD	Time constant	42 seconds	<1 minute	EPA-454/R-99-005, February 2000, Table 5-2
Delta Temperature	Paired, calibrated R.M. Young 43347 Platinum RTD	Time constant	42 seconds	<1 minute	EPA-454/R-99-005, February 2000, Table 5-2
Solar Radiation	Kipp & Zonen CMP3	Time constant	10 micro-seconds	5 seconds	EPA-454/R-99-005, February 2000, Table 5-2

B.2.6 Environmental Controls

Weatherproof enclosures will be installed at all three air monitoring sites to assure protection of sensitive components. Each enclosure will be equipped with Heating, Ventilating, and Air Conditioning (HVAC) units, which will keep all analyzers and monitors within the approved temperature range required by the instrument manufacturers (5° to 40°C). Relative humidity indicator cards are employed to track the level of moisture inside each enclosure. Desiccant packs are installed when necessary to assure a dry environment.

B.3 Sampling Handling and Custody

B.3.1 Data Custody

Data retrieval, quality control, and processing will be documented in the Air Sciences data acquisition storage system (DASS). Receipt and inspection of Site Check Forms and all other program documentation will be stored in two places. One copy will be scanned and saved to an electronic project file, and the originals will be filed at Air Sciences. All forms will be submitted with each quarterly report.

The data will be QA'd weekly and stored on Air Sciences' server and backed up on optical disk. Following data reduction, the data will remain in the DASS until they are analyzed and summarized for the quarterly reports. Upon submission of the quarterly reports, the data will be archived in triplicate to optical disk and stored in a climate-controlled environment both on- and off-site.

B.4 Analytical Methods

The monitoring will be conducted in accordance with the following publications:

- Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program (EPA-454/B-08-003, December 2008)
- Quality Assurance Handbook of Air Pollution Measurement Systems Volume IV: Meteorological Measurements (EPA-454/B-08-002, March 2008)
- Code of Federal Regulations (40 CFR Parts 50 and 58)
- Meteorological Monitoring Guidance for Regulatory Modeling Applications (EPA-454/R-99-005, February 2000)
- Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) (EPA 450/4-87-007, May 1987)

B.5 Quality Control

The quality control for the program will be conducted through use of site checks every week, along with quarterly sampler audits and calibrations. These guidelines are documented in Table 7 through Table 12.

Multi-point calibrations of the PM_{10}, $PM_{2.5}$, NO_x, SO_2 and O_3 analyzers will be conducted upon installation, quarterly thereafter, and in the event of malfunction, equipment relocation, or audit failures. Multi-point calibrations are used to assess the linearity of the analyzers.

Flow audits will be performed on the PM_{10} and $PM_{2.5}$ samplers on a monthly basis.

A summary of the QC checks performed can be found in Table 18.

Table 18: Summary of Ambient Air Monitoring QC Checks

Field Operation Activities	Schedule			
	Each Visit	Monthly	Quarterly	Semi-Annually
Visually inspect all monitoring instrumentation	X			
Record all observations in Onsite Operations Review form and Station Log	X			
Inspect sample line and manifold and replace inline filters if needed		X		
Inspect $PM_{2.5}$ cyclone and clean dust port		X		
Perform calibration checks			X	
Perform audits for air monitoring instrumentation			O	
Perform audits for meteorological instrumentation				O

Responsible party:

X - Project Data Technicians and Site Operators

O - QA Auditor

The critical validation criteria tables outline criteria deemed essential to maintaining the validity of the samples. Data not meeting the criteria will either be flagged with an explanation or invalidated. The cause for the deviation will be investigated and remedied. The critical criteria, operational evaluations, and systematic criteria are listed for each parameter in Section A.7. Air quality and meteorological data will be flagged or investigated based on the parameters listed in Table 19.

Table 19: Quality Control Screening Criteria

Parameter	Screening Criteria	Action
Gas Analyzers	Span value ±10% of set point	Investigate data
	Zero ±3% of full scale	Investigate data
PM_{10} and $PM_{2.5}$	Flow is not between 0.792 and 0.876 m^3	Investigate data
	Temperature is less than -50°C or greater than 50°C	Investigate data
	BP is not between 500 and 700 mb	Investigate data
Wind Speed	Is less than zero or greater than 50 m/s	Invalidate data
	Does not vary by more than 0.001 m/s	Investigate data
	Varies by more than 10 m/s within 1 hour	Investigate data
	Does not vary by more than 1.5 m/s within 8 hours	Investigate data
	Does not vary by more than 2 m/s within 24 hours	Investigate data
	Varies by more than 20 m/s within 24 hours	Investigate data
Wind Direction	Is less than zero or greater than 360 degrees	Invalidate data
	Does not vary by more than 1 degree within 1 hour	Investigate data
	Does not vary by more than 10 degrees within 8 hours	Investigate data
Temperature	Is less than -50°C or greater than 50°C	Invalidate data
	Is greater than the local record high	Investigate data
	Is less than the local record low	Investigate data
	Does not vary by more than 0.01°C within 1 hour	Investigate data
	Varies by more than 5°C within 1 hour	Investigate data
	Does not vary by more than 1°C within 8 hours	Investigate data
	Varies by more than 10°C within 8 hours	Investigate data
	Does not vary by more than 4°C within 24 hours	Investigate data
	Varies by more than 20°C within 24 hours	Investigate data
Delta Temperature	Is greater than 1.2°C during the daytime	Investigate data
	Is greater than 6°C or less than -3°C	Investigate data
	Does not vary by more than 0.01°C within 1 hour	Investigate data
	Varies by more than 4°C within 1 hour	Investigate data
	Does not vary by more than 0.01°C within 8 hours	Investigate data
	Varies by more than 4°C within 8 hours	Investigate data
Solar Radiation	Is greater than 1,500 W/m^2	Invalidate data
	Is greater than zero at night	Investigate data
	Does not vary by more than 1 W/m^2 within 1 hour	Investigate data
	Varies by more than 300 W/m^2 within 1 hour	Investigate data
	Does not vary by more than 1 W/m^2 within 8 hours	Investigate data
	Varies by more than 800 W/m^2 within 8 hours	Investigate data

Table 18: Quality Control Screening Criteria (Continued)

Parameter	Screening Criteria	Action
Barometric Pressure	Is greater than 700 mb	Investigate data
	Is less than 500 mb	Investigate data
Relative Humidity	Is greater than 105%	Investigate data
	Is less than 5%	Investigate data
	Varies by more than 30% within 1 hour	Investigate data
	Does not vary by more than 0.001% within 1 hour	Investigate data
Precipitation	Is greater than 0.5 inch of accumulation within 1 hour	Investigate data
	Is greater than 1 inch of accumulation within 8 hours	Investigate data

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

Before instrumentation is deployed, the equipment is visually inspected for damage. After installation and prior to data collection, all sensors and systems will be calibrated according to the listed procedures. Thereafter, site checks will be performed every week for the duration of the monitoring period. In addition, routine maintenance procedures will be performed according to manufacturer recommendations.

B.6.1 Site Visits

At a minimum frequency of weekly, the Site Operator will visit each site and complete the appropriate Site Check Forms. The purpose of this site check is to visually inspect the station, listen for anomalies in the pumps, and assure that all systems are operating as expected. In addition to the visual inspection, each QC activity will be performed according to the stipulated schedule.

B.6.2 Spare Parts

Spare parts will be stored on site. The spare parts will include spare pumps, o-rings, sensor replacements, and other consumables such as filter tape and tubing.

B.7 Instrument/Equipment Calibration and Frequency

The instrument calibration and check frequency is listed in the critical, operational, and systematic tables in Section A.7. A NIST-traceable flow meter will be used to measure and calibrate flows on the particulate monitors and will be certified annually. The gas analyzers will be calibrated and span checks will be performed using a Teledyne API T700 Dynamic Dilution Calibrator. The calibration equipment standards for meteorological parameters are listed in Table 20.

Table 20: Meteorological Calibration/Audit Standard Criteria

Equipment	Calibration Equipment	Calibration Frequency	Reference
Wind Speed	R.M. Young 18802 Anemometer Drive 200 to 15,000 RPM	1/year	EPA-454/B-08-002/Appx. C
	R.M. Young 18820A Controller Unit Motor Assembly	1/year	EPA-454/B-08-002/Appx. C
	R.M. Young 18310 Propeller Torque Disc	1/year	EPA-454/B-08-002/Appx. C
Wind Direction	R.M. Young 18212 Vane Angle Fixture - Tower Mount	N/A	EPA-454/B-08-002/Appx. C
	Brunton Transit for Solar Azimuth	N/A	EPA-454/B-08-002/Appx. C
Temperature	VWR Model 61161-382 ASTM -0/+50C NIST-Traceable Thermometers	1/year	EPA-454/B-08-002/Appx. C
Delta Temperature	VWR Model 61161-382 ASTM -0/+50C NIST-Traceable Thermometers	1/year	EPA-454/B-08-002/Appx. C
Solar Radiation	Collocated NIST-Traceable Pyranometer	1/year	EPA-454/B-08-002/Appx. C
Relative Humidity	VWR RH Thermo-Hygro Pen	1/year	EPA-454/B-08-002/Appx. C
Barometric Pressure	VWR Model 23609-208 NIST-Traceable BP sensor	1/year	EPA-454/B-08-002/Appx. C
Data Logger	Fluke 8060A DMM	1/year	N/A

B.8 Inspection/Acceptance of Supplies and Consumables

The only consumables in this program are the compressed calibration gases for SO_2 and NO_x and the filter tape rolls for the PM_{10} and $PM_{2.5}$ instrumentation.

B.8.1 Particulate Monitoring Filter Tape Inspection

BAM sampling tape should be visually inspected for defects prior to and after the two-month tape-roll life. Upon removal of the tape, the sampling areas will be visually inspected for holes or blurry sampling dots, which are all indicators of the need for maintenance.

B.9 Non-Direct Measurements

This project does not require data from non-direct measurement sources.

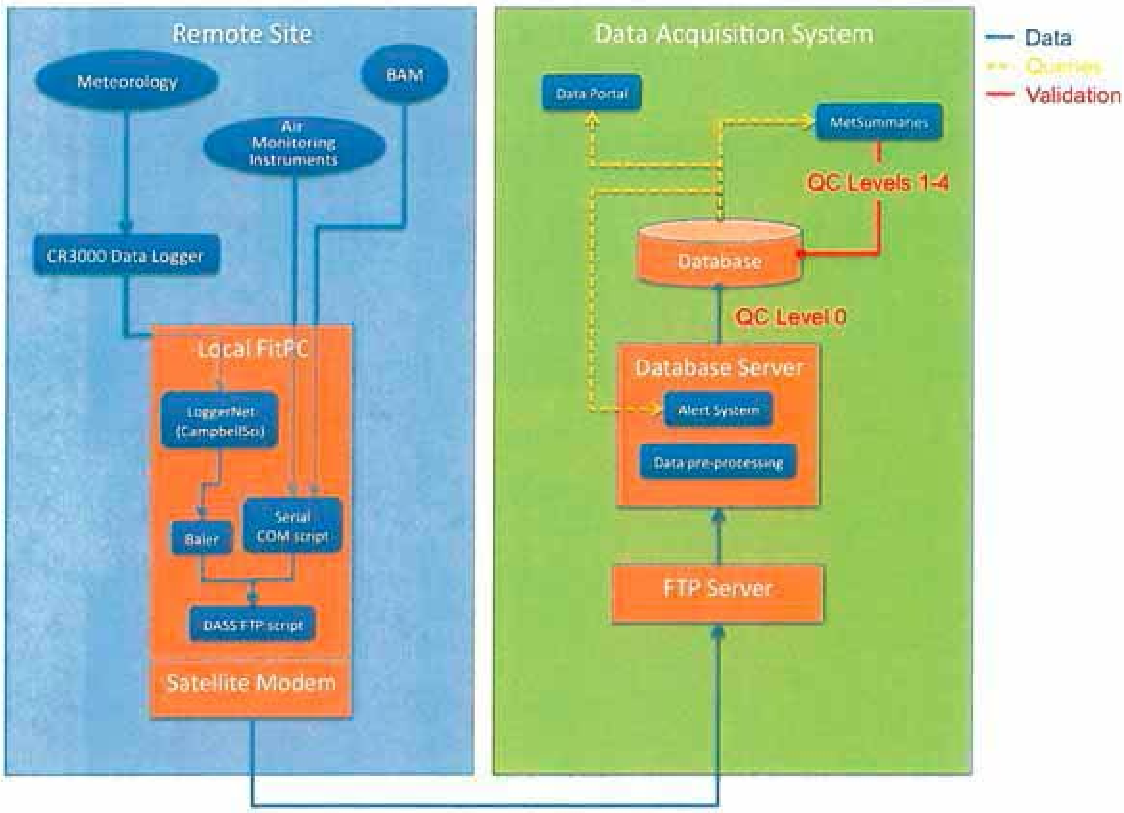
B.10 Data Management

The management of all data associated with this project is critical to assuring the quality of the program. Summaries of the procedures are found in the following sections.

B.10.1 Data Acquisition

The data will be automatically downloaded remotely via Verizon Wireless broadband Internet every hour (minimum). Data transfer to Air Sciences' server/database system (DASS) is set up using Campbell Scientific Loggernet (Version 3.4.1) software for the meteorological data, and site-specific file transfer protocol (FTP) data transfer scripts for the SO_2, NO_x, O_3, and particulate instrumentation. The overall data pathway is illustrated in Figure 16.

Figure 16: Data Transfer Flowchart



Data Validation

Raw data files are compared to the Site Check Forms that the Site Operator documents in the field. The instantaneous, two-second data logger readings recorded by the Site Operator are compared to the 15-minute averages that are logged in the DASS by the Project Data Technician. Each parameter recorded by the data logger should be within the tolerances outlined in Table 21 when compared to the reading documented by Site Operator. If these tolerances are not met, the data collected prior to and after the data period in question will be investigated. The Site Operator may be requested to visit the site and perform another site check. If a malfunction is found, the data will be invalidated back in time to the point where the last known valid data were recorded and up to the point where the sampler is determined to be operating properly.

Table 21: Site Check Tolerance Limits

Parameter	Tolerance
Wind Speed	±2.2 m/s
Wind Direction	±20 degrees
Ambient Temperature	±3°C
Delta Temperature	±0.5°C
Solar Radiation	±100 W/m^2
Barometric Pressure	±3 mb
Relative Humidity	±20%
PM_{10} and $PM_{2.5}$ Flow	±5%
NO_x	±10%
SO_2	±10%
O_3	±10%

After the raw data are checked against the Site Check Forms, and any calibration data have been invalidated, the hourly averages will be transferred into the project's database in the DASS.

The processing program used by Air Sciences will perform some automated QC. For example, all parameters will be checked for appropriate variance against manufacturer operating criteria. Data points found to be outside the performance standards of the sensor will be investigated. If the variance of the data is outside the criteria in Table 21, then such data will be flagged. If irregularities are found, they will be investigated in order to determine if the sensor or instrument may be malfunctioning. Corrective action will be taken, and data will be invalidated as necessary. In cases where the flagged data are actually found to be valid, the technical justification for this finding will be documented and the data will be included in the final data set.

B.10.2 Data Transmission

All data will be transmitted via Verizon Wireless broadband from the internal memory of the data logger or on-site PC. The downloaded data will be checked for missed readings as well as against previous downloads to ensure that the data set is complete. In the event that data are found to be missing, the data will be downloaded again to determine if the data are in fact not present or have been over-written. The data transmittal and completeness of the data set will be recorded in the DASS.

The NO_x, SO_2, O_3, and particulate data will be downloaded hourly via serial output to an on-site computer. There are no analog conversions performed on this method of data transfer (i.e., the data download is a direct download). These data are in turn transferred to the DASS using an FTP script via broadband Internet every hour and incorporated into the database system.

B.10.3 Data Reduction

Data to comprise meteorological hourly averages are collected on-site every two seconds and placed into temporary storage. The data logger computes these raw data into 15-minute averages. The 15-minute averages are processed into hourly averages and then placed into permanent storage on the DASS. All particulate data are recorded hourly in actual conditions. Each hourly PM_{10} value is converted to standard temperature and pressure (STP) values, and then those STP values are averaged to calculate the 24-hour average.

The wind speed, temperature, delta temperature, and solar radiation data are reduced as scalar averages using the equation below.

$$\overline{u} = \frac{1}{N}\sum_{1}^{N} u_i$$

The wind direction data are reduced as a unit vector according to the following equations.

$$V_S = \frac{1}{N}\sum_{1}^{N} Sin\theta_i$$

$$V_C = \frac{1}{N}\sum_{1}^{N} Cos\theta_i$$

$$\overline{\theta} = ArcTan\left(\frac{V_S}{V_C}\right) + X$$

If Vc < 0 then X = +180
If Vs < 0 then X = +360
If Vs > 0 then X = +0

The wind direction deviation is reduced using the Yamartino algorithm found below.

$$\sigma(\theta 1) = ArcSin(\varepsilon)\left[1 + 0.1547\varepsilon^3\right]$$

where $$\varepsilon = \left[1 - \left((V_S)^2 + (V_C)^2\right)\right]^{\frac{1}{2}}$$

and Vs and Vc are as defined above.

After the 15-minute data have been downloaded, they are processed into one-hour averages using in-house software. The same equations listed above will be used for the second reduction. Additionally, the format of the 15-minute data is hour-ending. The modeling applications, which will utilize these data, require that the data are in hour-beginning format. Therefore, all data are converted to hour-beginning format after reduction.

The only additional calculation required from the 15-minute data is the hourly stability class. The Pasquill-Gifford (P-G) stability classes will be calculated using the Solar Radiation Delta Temperature (SRDT) method. This requires use of the wind speed, solar radiation, and delta temperature to determine the stability class of a given time period. Table 22 through

Table 24 are used to determine stability class.

Table 22: Key to SRDT Method for Estimating P-G Stability Categories

B.10.3.1.1 Daytime

	Solar Radiation (W/m²)			
Wind Speed (m/s)	≥ 925	925–675	675–175	< 175
< 2	A	A	B	D
2 - 3	A	B	C	D
3 - 5	B	B	C	D
5 - 6	C	C	D	D
≥ 6	C	D	D	D

B.10.3.1.2 Nighttime

	Vertical Temperature Gradient	
Wind Speed (m/s)	< 0	> 0
< 2	E	F
2.0 - 2.5	D	E
> 2.5	D	D

If any temperature or solar radiation data are invalidated, and only wind data are available, the stability class will be determined by the direction deviation (sigma theta) method. This method requires the use of the wind direction deviation, wind speed, and clock time of the 15-minute data period, an indicator of whether the 15-minute period is during the day or night. In

Table 24, the Standard Deviation of Wind Azimuth Angle is a function of both surface roughness and measurement height. The surface roughness lengths for the monitoring sites will be determined when the inputs and setup of the AERMOD and AERSURFACE analyses take place. Upon determination of the surface roughness lengths, the applicability of the adjustment of the angle groupings (an alternative method for determining stability class when temperature or solar radiation data are invalidated) will be assessed. The methodology for AERMOD and AERSURFACE will be submitted in the modeling protocol to be submitted and approved by PCAQCD.

The measurement height of the stations, however, requires that the angle groupings be adjusted in accordance with Section 6.4.4 of the EPA *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, which states: "If the measurement height is other than 10 meters, the category boundaries will need adjustment." As an initial adjustment, the lower-bound values will be multiplied by:

$$(Z/10)^{P_\theta}$$

Where P_θ is a function of the P-G stability category as provided in Table 23.

Table 23: P_θ as a Function of the P-G Stability Category

P-G Stability	P_θ
A	-0.06
B	-0.15
C	-0.17
D	-0.23
E	-0.38

Table 24: Lateral Turbulence Criteria for Initial Estimate of P-G Stability Category

Initial Estimate of P-G Category	Standard Deviation of Wind Azimuth Angle σ (10 m)	Standard Deviation of Wind Azimuth Angle σ (18.2 m)
A	$22.5 \leq \sigma$	$21.6 \leq \sigma$
B	$17.5 \leq \sigma < 22.5$	$15.8 \leq \sigma < 21.6$
C	$12.5 \leq \sigma < 17.5$	$11.1 \leq \sigma < 15.8$
D	$7.5 \leq \sigma < 12.5$	$6.4 \leq \sigma < 11.1$
E	$3.8 \leq \sigma < 7.5$	$2.9 \leq \sigma < 6.4$
F	$\sigma < 3.8$	$\sigma < 2.9$

Initial Estimate of P-G Category		Wind Speed (m/s)	Final Estimate of P-G Category
Daytime	A	$u < 3$	A
	A	$3 \leq u < 4$	B
	A	$4 \leq u < 6$	C
	A	$6 < u$	D
	B	$u < 4$	B
	B	$4 \leq u < 6$	C
	B	$6 \leq u$	D
	C	$u < 6$	C
	C	$6 \leq u$	D
	D, E, or F	Any	D
Nighttime	A	$u < 2.9$	F
	A	$2.9 \leq u < 3.6$	E
	A	$3.6 \leq u$	D
	B	$u < 2.4$	F
	B	$2.4 \leq u < 3.0$	E
	B	$3.0 \leq u$	D
	C	$u < 2.4$	E
	C	$2.4 \leq u$	D
	D	Any	D
	E	$u < 5$	E
	E	$5 \leq u$	D
	F	$u < 3$	F
	F	$3 \leq u < 5$	E
	F	$5 \leq u$	D

B.10.4 Data Storage and Retrieval

The data will be stored on the Air Sciences server until they have been processed and reported in quarterly reports. At that time, the data will be transferred, in triplicate, to optical disc. The optical discs will be stored in a climate-controlled environment both on- and off-site for a minimum of five years. Data retrieval will be conducted at the request of the Program Director or PCAQCD.

SECTION

C ASSESSMENTS AND OVERSIGHT

C.1 Assessment and Response Actions

Ongoing assessments will be conducted by the Project Manager and other staff. The results of these assessments will be documented in the DASS journal and on-site logbook. The Project Field Technician will be responsible for rapidly following up on all findings, including taking corrective actions for deficiencies and nonconforming conditions. Responses will be documented in writing and will be reported to the Project Manager.

C.1.1 Site Verification Checks

The NO_x, SO_2, O_3, and particulate instrumentation as well as the metorological sensors will be checked at least once a week by the Site Operator.

C.1.2 Performance Audits

Performance audits of the sampling systems and meteorological systems will be conducted by the QA Manager or the Project Field Technician upon startup of the project, quarterly, or whenever equipment is repaired, replaced, or moved. The meteorological stations will be audited or calibrated every six months using equipment and personnel that are rotated so that the same equipment and personnel are not used on consecutive 6-month audits/calibrations.

C.2 Reports to Management

C.2.1 Quarterly Reporting

Formal reports will be prepared quarterly and QA'd by the Project/QA Manager prior to being sent to the Program Director. These reports will be filed with the Program Director within 90 days of the completion of a monitoring quarter. These reports will include:

1. Project status
2. Monitoring data collected for that period (in desktop color separation (DCS) format)
3. Sample information:
    a. Sample date
    b. Site name, place, and time
    c. Individual sample data that include every sample scheduled to be collected during the reporting period or the reason why the sample is missing
    d. Number of possible observations for the quarter
    e. Number of actual valid observations for the quarter
    f. Percent data recovery

g. Analytical techniques or methods used for sampling

h. Data summaries based on EPA data rules

4. Copies of Site Check Forms
5. Anecdotally conveyed notes and anomalies
6. Corrective actions taken (if any)
7. Data CDs

SECTION

D DATA VALIDATION AND USABILITY

D.1 Data Review, Validation, and Verification Requirements

D.1.1 Data Review QA Levels

Generally, there are four "levels" of air quality and meteorological data validation. When a data set has undergone a level of review, it passes on to the next level. The process is used to determine the validity of the data.

- Level 0 validated data are essentially raw data obtained directly from the DASS in the field. Level 0 data have been reduced and possibly reformatted but are not edited or reviewed. These data have not been adjusted for known biases or issues that may have been identified during preventive maintenance checks or audits. These data may be used to monitor instrument operations on a frequent basis but should not be used to satisfy permit conditions, to compare against reporting thresholds and applicable air quality standards, or as input to dispersion models.

- Level 1 data validation involves quantitative and qualitative reviews for accuracy, completeness, and internal consistency. Quantitative checks are performed by DASS software screening programs, and qualitative checks are performed by meteorologists or field staff who manually review the data for outliers and other anomalies. Quality control flags are assigned, as necessary, to indicate the data quality. Data are only considered validated at Level 1 after final audit reports have been issued and any adjustments, changes, or modifications to the data have been made and documented.

- Level 2 data validation involves comparisons with independent data sets. This function includes, for example, making comparisons to other meteorological or ambient pollution data or upper-air measurement systems.

- Level 3 data validation involves a more detailed analysis and final screening of the data. The purpose of the final step is to verify that there are no inconsistencies among the related data (such as issues with scalar and vector data or inconsistencies with relative humidity during precipitation events, etc.). Graphics programs may be run to examine the overall consistency among related data (i.e., checking diurnal patterns against other parameters or reviewing strip charts for final analysis). Data sets that pass Level 3 QC review are appropriate for use to satisfy permit conditions, to compare against reporting thresholds and applicable air quality standards, and as input to dispersion models.

D.1.2 Data Calculations

D.1.3 Particulate Data

Particulate data are measured and initially stored in **Actual** conditions. All PM_{10} particulate data will be converted by the screening program to STP values using the following equation:

Equation 1: Correcting Actual Particulate Concentrations to Standard Conditions

$$Q_s = Q_a * \left(\frac{P_a}{T_a} \right) * \left(\frac{298}{760} \right)$$

T_a = Ambient Temperature (Kelvin) (Kelvin = Celsius + 273)
P_a = Ambient Barometric Pressure (mmHg)
Q_a = Actual Volumetric Flow from Reference Meter

D.2 Verification and Validation Methods

Data validation refers to the review process in which data are screened for errors and anomalies. All data validation will be done in accordance with EPA method-specific procedures. Data validation tables (Table 19) will be followed. Significant anomalies will be flagged or notated in the quarterly reports. All suspect data will be investigated further.

D.3 Reconciliation with User Requirements

Changes in the end-user requirements of the instrumentation may be necessary from time to time. Some changes may require altering costs, data, and/or reporting turnaround time, and/or modifying existing (or developing new) SOPs. Changes will be accommodated, when technically feasible, according to the following procedure:

- The Q/A Manager will notify the Project Manager of the changes.
- The impact of the requested changes (costs, turnaround times, SOPs) will be communicated in the notification.
- Any limitations on the use of the data will also be communicated.
- The Project Manager will provide written authorization to implement the changes.
- Documentation (as an addendum to this monitoring plan) of the changes will be provided.

Any changes involving the sampling methods, detection limits, or new parameters will be submitted to PCAQCD for review and approval prior to implementation.

SECTION E

ABBREVIATIONS AND ACRONYMS

ABS	absolute
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AERSURFACE	A tool to aid in obtaining realistic and reproducible surface characteristic values for input into AERMET
AERMET	The meteorological processor to process meteorological data for the AERMOD model
BAM	Beta Attenuation Monitor
BP	Barometric Pressure
CFR	Code of Federal Regulations
CL	Confidence Limit
CV	Coefficient of Variation
DASS	data acquisition storage system
DCS	desktop color separation
Delta T	temperature difference
DQO	Data Quality Objective
EPA	Environmental Protection Agency
FEM	Federal Equivalency Method
FR	flow rate
FTP	file transfer protocol
HVAC	Heating, Ventilating, and Air Conditioning
LDL	lower detection limit
lpm	liters per minute
mb	millibars
MFGR	manufacturer
mg	milligram
mmHg	millimeters of mercury
MQO	Measurement Quality Objective
m/s	meter per second

ABBREVIATIONS AND ACRONYMS – Continued

NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
O_3	Ozone
PAMS	Photochemical Assessment Monitoring Station
PCAQCD	Pinal County Air Quality Control District
PEP	Performance Evaluation Program
P-G	Pasquill-Gifford
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter with an Aerodynamic Diameter less than 2.5 Microns
PM_{10}	Particulate Matter with an Aerodynamic Diameter less than 10 Microns
ppb	parts per billion
ppm	parts per million
PQAO	Primary Quality Assurance Organization
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QC	Quality Control
RCC	Resolution Copper Company
RCML	Resolution Copper Mining LLC
RH	Relative Humidity
RSD	Relative Standard Deviation
SD	Standard Deviation
SOP	Standard Operation Procedures
SRDT	Solar Radiation Delta Temperature
SO_2	Sulfur Dioxide
SRL	Surface Roughness Length
STP	Standard Temperature and Pressure
$\mu g/m^3$	micrograms per cubic meter
W/m^2	watts per square meter

APPENDIX A
Site Check and Audit Forms

METEOROLOGICAL AND PARTICULATE CALIBRATION DATA

AIR SCIENCES INC.

DENVER • PORTLAND

Client :	
Job No. :	
Site :	
Date :	
Time:	
Auditors:	

Data Logger	
Model :	CR3000
Serial No :	

WIND SPEED, m

Model: 05305 Calibration Motor No.: ______

Serial No: ______ Calibration Disk No.: ______

System Linearity Check

	Input rpm	Target* m/s	Logger Reading m/s	Difference m/s	Acceptance Criteria
1.	0.0	0.00			0.0
2.	200.0	1.00			0.0
3.	400.0	2.10			0.0
4.	600.0	3.10			0.0
5.	800.0	4.10			0.0
6.	1000.0	5.10			0.0
7.	2000.0	10.20			0.0
8.	3000.0	15.40			0.0
9.	4000.0	20.50			0.0
10.	5000.0	25.60			0.0

Met One
*Target (m/s) = (((rpm x 2)/60) x 0.800) + 0.44
*Target (mph) = (((rpm x 2)/60) x 1.789) + 1.07

RM Young
*Target (m/s) = rpm x 0.00512

Bearing Torque Test (Passing 0.5 m/s = 0.4 g-cm)

Clockwise ______ g-cm

Counterclockwise ______ g-cm

WIND DIRECTION, m

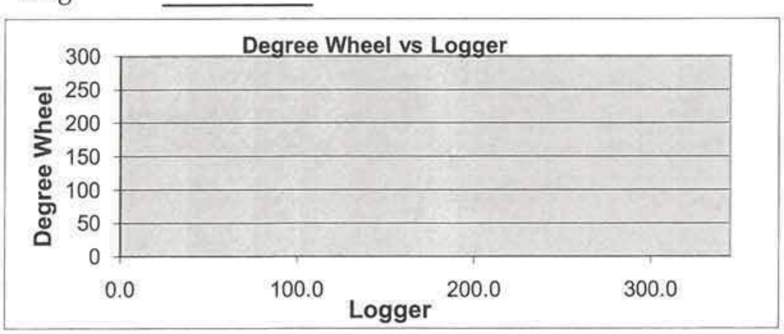
Model: ______ Serial No: ______ Compass No.: ______

System Linearity Check Declination = ______ East

Orientation	Compass (Degrees)	Target (Degrees)	Logger Reading (Degrees)	Difference (Degrees)	Acceptance Criteria
1. Vane	82.3			0.0	±5
Tail	260.9				±5

	Initial Logger (Degrees)	Difference (Degrees)	Corrected Logger (Degrees)	Difference (Degrees)	Acceptance Criteria
0					±3
45					±3
90					±3
135					±3
180					±3
225					±3
270					±3

Avg ______



Ambient Temperature, 2m

Model: ____________ Serial No: ______________

Standard Id: ____________

System Linearity Check

	Measured (°C)	Logger Reading (°C)	Difference (°C)	Acceptance Criteria (°C)
1.				±0.5
2.				±0.5
3.				±0.5
4.				±0.5
5.				±0.5
6.				±0.5
7.				±0.5
8.				±0.5
9.				±0.5
10.				±0.5

Delta Temperature, 2m, 10m

Model: ____________ Serial No (2m): ______________

Standard Id: ____________ Serial No (10m): ______________

System Linearity Check

	Standard (°C)	Lower T (°C)	Upper T (°C)	Difference Lower T [1] (°C)	Difference Upper T [1] (°C)	Difference Delta T [1] (°C)
Bath 1				0.00	0.00	0.00
Bath 2				0.00	0.00	0.00
Bath 3				0.00	0.00	0.00

1. The acceptance criteria for deviation from the standard for both upper and lower temperatures is ± 0.5
2. The acceptance criteria for deviation from the standard for delta temperatures is ± 0.1

Relative Humidity, 2m

Model: ____________ Serial No: ______________

Standard Id: ____________

System Linearity Check

	Measured (%)	Logger Reading (%)	Difference (%)	Acceptance Criteria (%)
1.				±5
2.				±5
3.				±5
4.				±5
5.				±5
6.				±5
7.				±5
8.				±5
9.				±5
10.				±5

Barometric Pressure, 2m

Model: ______ Serial No: ______

Standard Id: ______

System Linearity Check

	Measured (mmHg)	Logger Reading (mmHg)	Difference (mmHg)	Acceptance Criteria (mmHg)
1.				±2.3
2.				±2.3
3.				±2.3
4.				±2.3

PRECIPITATION, GROUND LEVEL

Model: ______ Serial No: ______

System Linearity Check

	Water (cc)	Calculated Target* (inches)	Logger Reading (inches)	Difference (inches)
1.			0.01	#VALUE!
2.			0.01	#VALUE!
3.			0.01	#VALUE!
4.			0.01	#VALUE!
5.			0.01	#VALUE!
6.			0.01	#VALUE!
7.			0.01	#VALUE!
8.			0.01	#VALUE!
9.			0.01	#VALUE!
10.			0.01	#VALUE!
Total	0.00	0.00	0.10	#VALUE!

Reading taken from final storage for period averaged data = ______ inches

*Target (Campbell Scientific gauge) = water (cc)/8.25 * 0.01 (inches)
*Target (Qualimetrics gauge) = water (cc)/8.68 * 0.01 (inches)
*Target (Met One gauge) = water (cc)/8.24 * 0.01 (inches)
*Target (Novalynx gauge) = water (cc)/18.53 * 0.01 (inches)

SOLAR RADIATION, 2m

Model: CMP3 Serial No: ____________ Standard Serial No: ____________

System Linearity Check

	Standard (w/m²)	Logger Reading (w/m²)	Difference (w/m²)	Acceptance Criteria
1.				± 25 W/m^2 or 10%
2.				± 25 W/m^2 or 10%
3.				± 25 W/m^2 or 10%
4.				± 25 W/m^2 or 10%
5.				± 25 W/m^2 or 10%
6.				± 25 W/m^2 or 10%
7.				± 25 W/m^2 or 10%
8.				± 25 W/m^2 or 10%
9.				± 25 W/m^2 or 10%
10.				± 25 W/m^2 or 10%
		Avg		

METEOROLOGICAL AND PARTICULATE AUDIT DATA

AIR SCIENCES INC.

DENVER • PORTLAND

Client : ________________
Job No. : ________________
Site : ________________
Date : ________________
Time: ________________
Auditors: ________________

Data Logger ________________
Model : CR3000
Serial No : ________________

WIND SPEED, m

Model:	05305	Calibration Motor No.:	
Serial No:		Calibration Disk No.:	

System Linearity Check

	Input rpm	Target* m/s	Logger Reading m/s	Difference m/s	Acceptance Criteria
1.	0.0	0.00			0.0
2.	200.0	1.00			0.0
3.	400.0	2.10			0.0
4.	600.0	3.10			0.0
5.	800.0	4.10			0.0
6.	1000.0	5.10			0.0
7.	2000.0	10.20			0.0
8.	3000.0	15.40			0.0
9.	4000.0	20.50			0.0
10.	5000.0	25.60			0.0

Met One
*Target (m/s) = (((rpm x 2)/60) x 0.800) + 0.44
*Target (mph) = (((rpm x 2)/60) x 1.789) + 1.07

RM Young
*Target (m/s) = rpm x 0.00512

Bearing Torque Test (Passing 0.5 m/s = 0.4 g-cm)

Clockwise ________ g-cm
Counterclockwise ________ g-cm

WIND DIRECTION, m

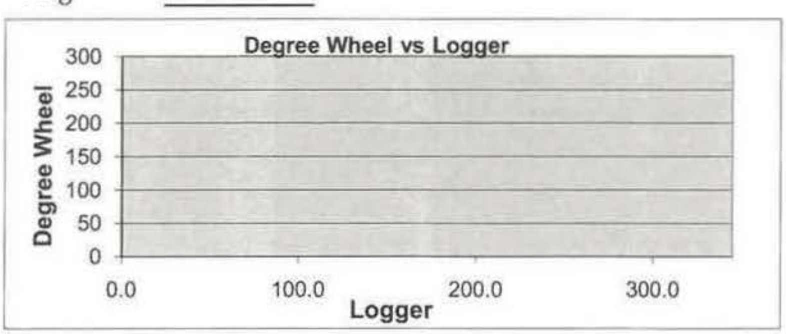
Model: ________ Serial No: ________ Compass No.: ________

System Linearity Check Declination = ________ East

Orientation	Compass (Degrees)	Target (Degrees)	Logger Reading (Degrees)	Difference (Degrees)	Acceptance Criteria
1. Vane	82.3			0.0	±5
Tail	260.9				±5

	Initial Logger (Degrees)	Difference (Degrees)	Corrected Logger (Degrees)	Difference (Degrees)	Acceptance Criteria
0					±3
45					±3
90					±3
135					±3
180					±3
225					±3
270					±3

Avg ________



Ambient Temperature, 2m

Model: ____________ Serial No: ____________

Standard Id: ____________

System Linearity Check

	Measured (°C)	Logger Reading (°C)	Difference (°C)	Acceptance Criteria (°C)
1.				±0.5
2.				±0.5
3.				±0.5
4.				±0.5
5.				±0.5
6.				±0.5
7.				±0.5
8.				±0.5
9.				±0.5
10.				±0.5

Delta Temperature, 2m, 10m

Model: ____________ Serial No (2m): ____________

Standard Id: ____________ Serial No (10m): ____________

System Linearity Check

	Standard (°C)	Lower T (°C)	Upper T (°C)	Difference Lower T [1] (°C)	Difference Upper T [1] (°C)	Difference Delta T [1] (°C)
Bath 1				0.00	0.00	0.00
Bath 2				0.00	0.00	0.00
Bath 3				0.00	0.00	0.00

1. The acceptance criteria for deviation from the standard for both upper and lower temperatures is ± 0.5
2. The acceptance criteria for deviation from the standard for delta temperatures is ± 0.1

Relative Humidity, 2m

Model: ____________ Serial No: ____________

Standard Id: ____________

System Linearity Check

	Measured (%)	Logger Reading (%)	Difference (%)	Acceptance Criteria (%)
1.				±5
2.				±5
3.				±5
4.				±5
5.				±5
6.				±5
7.				±5
8.				±5
9.				±5
10.				±5

Barometric Pressure, 2m

Model: ________ Serial No: ________

Standard Id: ________

System Linearity Check

	Measured (mmHg)	Logger Reading (mmHg)	Difference (mmHg)	Acceptance Criteria (mmHg)
1.				±2.3
2.				±2.3
3.				±2.3
4.				±2.3

PRECIPITATION, GROUND LEVEL

Model: ________ Serial No: ________

System Linearity Check

	Water (cc)	Calculated Target* (inches)	Logger Reading (inches)	Difference (inches)
1.			0.01	#VALUE!
2.			0.01	#VALUE!
3.			0.01	#VALUE!
4.			0.01	#VALUE!
5.			0.01	#VALUE!
6.			0.01	#VALUE!
7.			0.01	#VALUE!
8.			0.01	#VALUE!
9.			0.01	#VALUE!
10.			0.01	#VALUE!
Total	0.00	0.00	0.10	#VALUE!

Reading taken from final storage for period averaged data = ________ inches

*Target (Campbell Scientific gauge) = water (cc)/8.25 * 0.01 (inches)
*Target (Qualimetrics gauge) = water (cc)/8.68 * 0.01 (inches)
*Target (Met One gauge) = water (cc)/8.24 * 0.01 (inches)
*Target (Novalynx gauge) = water (cc)/18.53 * 0.01 (inches)

SOLAR RADIATION, 2m

Model: CMP3 Serial No: ____________ Standard Serial No: ____________

System Linearity Check

	Standard (w/m^2)	Logger Reading (w/m^2)	Difference (w/m^2)	Acceptance Criteria
1.				± 25 W/m^2 or 10%
2.				± 25 W/m^2 or 10%
3.				± 25 W/m^2 or 10%
4.				± 25 W/m^2 or 10%
5.				± 25 W/m^2 or 10%
6.				± 25 W/m^2 or 10%
7.				± 25 W/m^2 or 10%
8.				± 25 W/m^2 or 10%
9.				± 25 W/m^2 or 10%
10.				± 25 W/m^2 or 10%
		Avg		

AIR SCIENCES INC.

Monthly Flow Verification PM_{10} or $PM_{2.5}$

PARTICULATE MONITORING PROJECT
PROJECT NO. ________

Met One BAM 1020 PM_{10} $PM_{2.5}$ S/N:
Firmware:
Calibrator: ____________________ S/N: ____________________

Date of Flow Audit: ____
Time of Flow Audit: ____

	BAM	Audit STD
Ambient Temperature (AT) °c		
Berometric Pressure mmHg		

	Set Point (lpm)	BAM	% Diff (1)	STD Flow Meter	% Diff (2)
(1) Actual Flow	15.0				
Acceptable Differential		***14.700 - 15.300***	***+/- 2%***	***14.250 - 15.750***	***+/- 5%***
(2) Actual Flow	18.4				
Acceptable Differential		***18.032 - 18.768***	***+/- 2%***	***17.480 - 19.320***	***+/- 5%***
(3) Actual Flow	16.7				
Acceptable Differential		***16.336 - 17.034***	***+/- 2%***	***15.865 - 17.535***	***+/- 5%***

Calculations:
(1) % Diff = [(BAM - Set Point)/Set Point]*100 (+/- 2%)
(2) % Diff = [(BAM - Calibrator)/Calibrator]*100 (+/- 5%)

	BAM	
(2) Leak Test		**Should be < 1.0 LPM**

Comments/Abnormalities: ____

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Signature: ____

Upon completion of this form, fax to Air Sciences at 303-279-3796

BAM WEEKLY SITE CHECK FORM PM_{10} and $PM_{2.5}$
AIR MONITORING PROJECT
PROJECT NO. _______

AIR SCIENCES INC.

Date:______________________ Time:________________________ Operator:__________________________

I. BAM SAMPLER – Weekly Checks.

YES	NO	
		1. The sampler is intact and the inlet head is unobstructed.
		2. The vacuum pump is running and sounds normal.
		3. The temperature shield is intact, and the sensor is inside of it.
		4. The BAM is reading the correct time and day.
		5. The tape is in the proper position and does not need to be changed (tape should be changed every 2 months).
		6. Error log was checked (F3), and errors followed up on (see manual).
		7. Climate control appears operational (If it's cold out the shelter should feel warm, if it's hot out the shelter should feel cool)

II. BAM SAMPLER – Routine Maintenance (monthly). Check yes if maintenance was performed during this visit. *See page 95 of BAM manual.*

YES	NO	
		1. Inlet Flow check Performed
		2. Visual inspection and dust removal
		3. Leak check performed

II. BAM SAMPLER – Routine Maintenance (every 2 months). Check yes if maintenance was performed during this visit. *See page 95 of BAM manual.*

YES	NO	
		1. Filter tape replaced
		2. PM10 head cleaned
		3. Inlet nozzle and nozzle are cleaned

III. BAM SAMPLER – Routine Maintenance (semiannual). Check yes if maintenance was performed during this visit. *See page 31 of BAM manual.*

YES	NO	
		1. Replaced muffler on the pump (*Work performed by Air Sciences or HMH)
		2. Complete calibration of flow system (*Work performed by Air Sciences or HMH)

IV. BAM SAMPLER – Routine Maintenance (annual). Check yes if maintenance was performed during this visit. *See page 97 of BAM manual.*

YES	NO	
		1. Carbon vanes in pump checked/replaced (*Work performed by Air Sciences or HMH)
		2. Inlet system cleaned (*Work performed by Air Sciences or HMH)

**Comments/Unusual Occurrences: ____

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Signature: ______________________________

**Fax completed form to Air Sciences at 303-279-3796

SO_2 Monitoring Site Check Form

AIR SCIENCES INC.

DENVER • PORTLAND

Site:____

Site Operator: ____________________ **Date:** ______________

Sampler Make and Model	Teledyne API T100 SO_2 Monitor
Sampler SN	
Last Calibration Date	

Instrument Check Start Time	
Instrument Check Stop Time	
Filter Replacement Y/N	
Shelter Temp (5 to 40 °C)	

Level 1 Zero/Span (1/2 Weeks)

Check the 0 and 400 ppb with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	Initial SO_2 Value (ppb)	Final SO_2 Value (ppb)	Acceptance Criteria	Adjustment Required? Y/N
Zero Air			± 3% of full Scale (-6 to 6 PPB)	
400 PPB			≤ ± 10% (360 to 440 PPB)	

Level 2 Zero/Span (nightly or as needed)

Check the 0 and 400 ppb with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	SO_2 Value (ppb)	SO_2 Value (ppb)	Acceptance Criteria	Adjustment Required? Y/N
Zero Air			± 10% of full Scale (-40 to 40 PPB)	
400 PPB			≤ ± 10% (360 to 440 PPB)	

Multipoint Calibration (Quarterly, or as needed)

Check the 0, 100, 200, 300, 400 and 500 ppb ranges with the T700 Dilution Calibrator.

Target (ppb)	Calibration Value T700 (ppb)	Recorded SO_2 Value T100 (ppb)	Acceptance Criteria	Adjustment Required? Y/N
Zero Air			$R^2 < .995$	
100 PPB			"	
200 PPB			"	
300 PPB			"	
400 PPB			"	
500 PPB			"	

R^2 = ____________________

Site Operator comments/observations:

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Air Sciences Inc. Reviewed On (Date and Time): ________________________________

AIR SCIENCES INC.

Site:______________________________
Project ID:________________________
SO2 Analyzer Site check form T100

Date:_____________________________________
Operator:________________________________ **Date Audited:**________________
Instrument Serial Number:__________________ **Audited By:**__________________

Please complete the following table (weekly)

Parameter	Recorded Value	Acceptable Value
RANGE	PPB/PPM	50 PPB to 20 PPM
STAB	PPB/PPM	<= 1 PPB with Zero Air
SAMPLE FLOW	CM^3	500 ± 50
FLOW	CM^3	80 ± 15
PMT SIGNAL WITH ZERO AIR	mV	-20 to 150
PMT SIGNAL AT SPAN GAS CONC	mV/PPB	0-5,000 mV/0-20,000 PPB
NORM PMT SIGNAL AT SPAN GAS CONC	mV/PPB	0-5,000 mV/0-20,000 PPB
AZERO	mV	-20 to 150
HVPS	V	400 - 800
RCELL TEMP	°C	50 ± 1
BOX TEMP	°C	AMBIENT ± 5°C
PMT TEMP	°C	7 ± 2°C
IZS TEMP*	°C	50 ± 1°C
MOLY TEMP	°C	315 ± 5°C
RCEL PRESS	IN-HG-A	<10
SAMPLE PRESS	IN-HG-A	AMBIENT ± 1
SLOPE		1.0 ± 0.3
OFFSET		50 to 150
		1.0 ± 0.3
		50 to 150
ETEST	PMT mV	2000 ± 1000
OTEST	PMT mV	2000 ± 1000

Values are in the Signal I/O

REF_4096_mV	mV	4096mV ±2mV and Stable
REF_GND	mV	0 ± 0.5 and Stable

Comments or unusual occurances:____

Failure Messages:____

Air Sciences Inc, 1301 Washington Avenue Suite 200, Golden, CO 80401
303-988-2960 (P)
303-988-2968 (F)

AIR SCIENCES INC.

DENVER • PORTLAND

Site:____________________

Project ID:______________

Site Operator: ____________________ **Date: ______________**

Sampler Make and Model	Teledyne API T200 NOx Monitor
Sampler SN	
Last Calibration Date	

Instrument Check Start Time	
Instrument Check Stop Time	
Filter Replacement Y/N	
Shelter Temp (5 to 40 °C)	

Level 1 Zero/Span (1/2 Weeks)

Check the 0 and 400 ppb with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	Initial Value (ppb)	Final Value	Acceptance Criteria	Adjustment Required? Y/N
Zero Air			± 3% of full Scale (-6 to 6 PPB)	
400 PPB			≤ ± 10% (360 to 440 PPB)	

Level 2 Zero/Span (nightly or as needed)

Check the 0 and 400 ppb with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	NOx Value	Acceptance Criteria	Adjustment Required? Y/N
Zero Air		± 10% of full Scale (-40 to 40 PPB)	
400 PPB		≤ ± 10% (360 to 440 PPB)	

Multipoint Calibration (Quarterly, or as needed)

Check the 0, 100, 200, 300, 400 and 500 ppb ranges with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	Calibration Value (ppb)	Recorded NOx Value	Acceptance Criteria	Adjustment Required? Y/N
Zero Air	0		$R^2 < .995$	
100 PPB	100		"	
200 PPB	200		"	
300 PPB	300		"	
400 PPB	400		"	
500 PPB	500		"	

R^2 = ____________________

Site Operator comments/observations:

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Air Sciences Inc. Reviewed On (Date and Time): ______________________________

AIR SCIENCES INC.

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Site:_____________________________
Project ID:________________________
NOx Analyzer Site check form T200

Date:___________________________________
Operator:________________________________ Date Audited:______________
Instrument Serial Number:_________________ Audited By:________________

Please complete the following table (weekly)

Parameter	Recorded Value	Acceptable Value
RANGE	PPB/PPM	50 PPB to 20 PPM
Nox STAB	PPB/PPM	<= 1 PPB with Zero Air
SAMPLE FLOW	CM^3	500 ± 50
OZONE FLOW	CM^3	80 ± 15
PMT SIGNAL WITH ZERO AIR	mV	-20 to 150
PMT SIGNAL AT SPAN GAS CONC	mV/PPB	0-5,000 mV/0-20,000 PPB
NORM PMT SIGNAL AT SPAN GAS CONC	mV/PPB	0-5,000 mV/0-20,000 PPB
AZERO	mV	-20 to 150
HVPS	V	400 - 800
RCELL TEMP	°C	50 ± 1
BOX TEMP	°C	AMBIENT ± 5°C
PMT TEMP	°C	7 ± 2°C
IZS TEMP*	°C	50 ± 1°C
MOLY TEMP	°C	315 ± 5°C
RCEL PRESS	IN-HG-A	<10
SAMPLE PRESS	IN-HG-A	AMBIENT ± 1
Nox SLOPE		1.0 ± 0.3
Nox OFFSET		50 to 150
NO SLOPE		1.0 ± 0.3
NO OFFSET		50 to 150
ETEST	PMT mV	2000 ± 1000
OTEST	PMT mV	2000 ± 1000

Values are in the Signal I/O

REF_4096_mV	mV	4096mV ±2mV and Stable
REF_GND	mV	0 ± 0.5 and Stable

Comments or unusual occurances:____

Failure Messages:____

Air Sciences Inc, 1301 Washington Avenue Suite 200, Golden, CO 80401
303-988-2960 (P)
303-988-2968 (F)

AIR SCIENCES INC.

DENVER • PORTLAND

Site:____________________

Project ID:________________

Site Operator: ____________________ **Date:** ____________

Sampler Make and Model	Teledyne API T400 Ozone Monitor
Sampler SN	
Last Calibration Date	

Instrument Check Start Time	
Instrument Check Stop Time	
Filter Replacement Y/N	
Shelter Temp (5 to 40 °C)	

Level 1 Zero/Span (1/2 Weeks)

Check the 0 and 400 ppb with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	Initial Value (ppb)	Final Value	Acceptance Criteria	Adjustment Required? Y/N
Zero Air			± 2% of full Scale (-8 to 8 PPB)	
400 PPB			≤ ± 7% (372 to 428 PPB)	

Level 2 Zero/Span (nightly or as needed)

Check the 0 and 400 ppb with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	O3 Value	Acceptance Criteria	Adjustment Required? Y/N
CalZ (Zero)		± 10% of full Scale (-40 to 40 PPB)	
CalS (400 PPB)		≤ ± 10% (360 to 440 PPB)	

** *When using the internal generator, if percent difference is greater than 10%, use the ozone transfer standard (700E) to perform the zero/span check. If percent the percent difference using the transfer standard is greater than 10%, recalibrate and invalidate back to the last acceptable span check. (% Diff= [(instrument response- known value)/known value] x 100%)*

Multipoint Calibration (Quarterly, or as needed)

Check the 0, 100, 200, 300, 400 and 500 ppb ranges with the T700 Dynamic Dilution Calibrator.

Reading (ppb)	Calibration Value (ppb)	Recorded O3 Value	Acceptance Criteria	Adjustment Required? Y/N
Zero Air	0		$R^2 < .995$	
100 PPB	100		"	
200 PPB	200		"	
300 PPB	300		"	
400 PPB	400		"	
500 PPB	500		"	

R^2 = ____________________

Site Operator comments/observations:

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Air Sciences Inc. Reviewed On (Date and Time): ______________________________

AIR SCIENCES INC.

Site:______________________
Project ID:__________________
O3 Analyzer Site check form T400

Date:______________________________
Operator:___________________________ Date Audited:____________
Instrument Serial Number:______________ Audited By:_____________

Please complete the following table (weekly)

Parameter	Recorded Value	Acceptable Value
RANGE	PPB/PPM	1-10,000 PPB
STABIL		<= 0.3 PPM with Zero Air
O3 MEAS	mV	2500-4800 mV
O3 REF	mV	2500-4800 mV
O3 GEN*	mV	80 mV - 5000 mV
O3 DRIVE	mV	0 - 5000 mV
PRES	IN-HG-A	-2" Ambient Absolute
SAMPLE FL	CM^3/Min	800 ±10%
SAMPLE TEMP	°C	10 - 50 °C
PHOTO LAMP	°C	50 °C ± 1°C
O3 GEN TMP*	°C	48 °C ± 3°C
BOX TEMP	°C	10 - 50 °C
SLOPE		1.0 ± .15
OFFSET	PPB	0.0 ± 5.0 PPB

Values are in the Signal I/O

REF_4096_mV	mV	4096mV ± 2mV and stable
REF_GND	mV	0 ± 0.5 and stable

Record the sample flow and sample pressure with the sample inlet on rear of instrument capped

Sample Flow __________(cm^3/Min)	Sample Pressure __________(IN-HG-A)

Comments or unusual occurances:____

____

____

____

Failure Messages:____

____

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Air Sciences Inc, 1301 Washington Avenue Suite 200, Golden, CO 80401
303-988-2960 (P)
303-988-2968 (F)

APPENDIX B

Standard Operating Procedures

AIR SCIENCES INC.

DENVER • PORTLAND

Standard Operating Procedure
Met One BAM-1020
Particulate Analyzer
Revision 4

Document Information:

Document Title	Air Sciences Standard Operating Procedure Met One BAM-1020 Particulate Analyzer
Document Number	SOP_1020-4
Date of Origination	December 1, 2009

Authorizations and Approvals:

Title	Name	Date	Signature
Originator Monitoring Manager	Kathy Steerman	01/15/2010	Kathy Steerman
QA Monitoring Systems Engineer	Aaron Schlabaugh	03/31/2011	[illegible]

Annual Review and Revision History:

Description of Changes	Revision Number	Date	Authorization and Approval
Responded to ADEQ comments in email dated 12/15/2009	SOP-1020-1	01/04/2010	Kathy Steerman
Changed SOP to reflect tri-level flow calibration	SOP-1020-2	02/16/2010	Kathy Steerman
Updated leak check information and BAM manual references	SOP-1020-3	03/31/2011	[illegible]
Jessica Crichfield and Phil Hoffmann reformatted and edited SOP.	SOP-1020-4	08/19/2011	

1.0 OPERATION, MAINTENANCE, AND AUDIT PROCEDURES

This document provides procedures for properly operating, maintaining, and auditing the Met One BAM-1020 Particulate (PM_{10} and $PM_{2.5}$) Analyzer. The BAM-1020 is a continuous particulate monitor and equivalent method (designation No. EQPM-0798-122 for PM_{10} and EQPM-0308-170 for $PM_{2.5}$). Much of the following content appears in the *BAM-1020 Continuous Particulate Monitor Operating Manual* (Operating Manual) (Met One Instruments, Inc.). Refer to the Operating Manual for more detailed instrument protocol.

1.1 Principles of Operation

The BAM-1020 measures and records hourly particulate mass concentrations in ambient air, using beta ray attenuation to calculate collected particle mass concentrations in units of $\mu g/m^3$. A ^{14}C element (<60μCi) is a constantly emitting source of high-energy electrons, also known as beta particles. The beta particles are counted by a scintillation detector. The clean tape and the particle-laden tape are compared, and any difference is counted to derive the hourly result.

1.2 Safety Precautions

Take normal precautions to avoid electrical shock.

Disconnect power before working with electrical components.

Use caution when working on elevated surfaces.

The ^{14}C radioactive source should not be dismantled or manipulated by anyone except the manufacturer.

1.3 Sampling Interferences/Precautions

- Proper grounding is essential for good performance.
- Keep all inlet lines free of moisture.
- Install an inlet heater when available.

1.4 Equipment and Supplies

- BAM-1020 sampler
- Filter paper rolls
- Cotton swabs
- Isopropyl alcohol
- Sharp tool
- Flashlight

- Screwdriver, pliers, adjustable wrenches
- Flow verification standard (DeltaCal or BIOS)
- Temperature and pressure verification standard
- Site and instrument log book

1.5 Sampler Installation

Site selection should be based on several factors, including prevailing wind direction, monitoring equipment configuration, site accessibility, infrastructure requirements, security of the site location, and proximity to significant particulate sources in the area. To operate within the EPA equivalent method requirements, the monitor should be installed in a self-contained enclosure with internal environmental controls that maintain a temperature between 20 and 30°C. Electrical service to the site must be made available, if possible. If possible, cellular service is desired, but not necessary.

The inlet should have a 1- meter radius free of any objects that may influence flow, and it should be a minimum of 2 meters high. The inlet should also be more than 20 meters from the dripline of any trees and must be at least 10 meters from the dripline if trees act as an obstruction. Collocated monitors must be within 4 meters of each other, but at least 1 meter apart.

The distance from the sampler, inlet, or 90% of monitoring path to an obstacle (such as a building) must be at least twice the height that the obstacle protrudes above the sampler, inlet, or monitoring path, respectively. The inlet must also have unrestricted airflow 270 degrees around the inlet or 180 degrees if the inlet is near the side of a building.

Finally, the probe, sampler, and monitoring path should be away from minor sources. The separation distance is dependent on the height of the minor source's emission point (such as a flue), the type of fuel or waste burned, and the quality of the fuel (sulfur, ash, or lead content). This criterion is designed to avoid undue influences from minor sources.

1.6 Operational Procedures

1.6.1 Start Sampling

To start sampling:

1. From the main menu, press the **OPERATE** soft-key.
2. Press the **NORMAL** soft-key. The BAM-1020 may take up to two minutes before sampling. Tape movement will occur approximately four minutes before the beginning of the next collection cycle.

   Note: If the sampler is not left in the **Normal Operate** mode, it may interfere with the remote communication process.

3. Download the system configuration.

a. Check and ensure that the date is correct.

b. Check and ensure that the time is correct (within ±5 sec of NIST).

c. Check and ensure that the ABS number is correct for the BAM being used.

Note: This information should be kept as part of the permanent record for the site.

1.6.2 Routine Service Checks (Weekly)

Perform routine service checks on the BAM-1020. The checks may be performed more frequently but should be performed at least weekly. Document all results and maintenance activities using the appropriate BAM-1020 forms.

1.6.3 Flow Checks (Monthly)

During the flow check, values are only recorded and compared to determine if they are within passing parameters. If any of the values are outside the passing parameters, the system must be calibrated (see section 1.6.4).

Figure 1. Actual Flow Calibration Screen

```
·MULTIPOINT·FLOW·CALIBRATION       ·
·           TARGET···BAM·····STD    ·
·         AT:·········23.8····23.8·C  ·
·         BP:··········760·····760·mmHg
·<CAL>  FLOW·1: ·15.0····15.0····15.0·LPM  ·
·       FLOW·2: ·18.3····18.3····18.3·LPM  ·
·       FLOW·3: ·16.7····16.7    · 16.7·LPM ·
·   CAL······NEXT······DEFAULT···EXIT    ·
```

Enter the **TEST > FLOW** menu as shown above. The nozzle will lower automatically when this screen is entered. The **BAM** column is what the BAM-1020 measures for each parameter, and the **STD** column is where operators will record the values from the reference standard.

Press **CAL** to scroll through each line item.

Record all the above values in the screen shown, and then measure each with the **STD** equipment (Delta Cal). Record values on the standardized form. Flows should be within the target range ±5%, the temperature should be within 3°C, and the BP should be within 10 mmHg.

1.6.4 Calibrations (Quarterly)

Actual (volumetric) flow calibration is very fast and easy. This type of calibration can only be performed on BAM units that have an automatic flow controller and a BX-592 or BX-596 ambient temperature sensor on channel 6. The unit must also have the Flow Type set to **ACTUAL** in the **SETUP > CALIBRATE** menu or the flow calibration screen will not be visible.

Figure 2. Actual Flow Calibration Screen

```
·MULTIPOINT·FLOW·CALIBRATION    ·
·               TARGET····BAM······STD   ·
·            AT:·········23.8····23.8·C    ·
·            BP:··········760·····760·mmHg
·<CAL>  FLOW·1: ·15.0····15.0····15.0·LPM   ·
·       FLOW·2: ·18.3····18.3····18.3·LPM   ·
·       FLOW·3: ·16.7····16.7    · 16.7·LPM ·
·   CAL······NEXT······DEFAULT····EXIT     ·
```

Enter the **TEST > FLOW** menu as shown above. The nozzle will lower automatically when this screen is entered. The **BAM** column is what the BAM-1020 measures for each parameter, and the **STD** column is where operators will record the values from the reference standard. The **<CAL>** symbol will appear next to the parameter selected for calibration. The ambient temperature (AT) and barometric pressure (BP) must be calibrated first, as the **BAM** uses these to calculate the air flow rate in actual mode.

Measure the ambient temperature with the reference standard positioned near the BX-592 or BX-596 ambient temperature probe. Enter the value from the reference standard into the **STD** field using the arrow keys. Press the **CAL** hot key to correct the **BAM** reading. The **BAM** and **STD** values should now be the same.

Press the **NEXT** hot key to move the **<CAL>** indicator to the **BP** field, and repeat the same steps for barometric pressure.

After the temperature and pressure readings are correct, remove the PM_{10} and $PM_{2.5}$ heads from the inlet tube and install your reference flow meter onto the inlet. Press the **NEXT** hot key to move the **<CAL>** indicator to the first flow point of 15.0 lpm (liters per minute). The pump will turn on automatically. Allow the unit to regulate the flow until the **BAM** reading stabilizes at the target flow rate. Enter the flow value from your standard into the **STD** field using the arrow keys. Press the **CAL** hot key to correct the **BAM** reading.

Note: The BAM reading will not change to match the STD until after you have entered all three calibration points.

Press the **NEXT** hot key to move the **<CAL>** indicator to the second flow point of 18.3 lpm and repeat the process.

Press the **NEXT** hot key to move the **<CAL>** indicator to the third flow point of 16.7 lpm and repeat the process. Enter the flow value and press **<CAL>**.

When all the calibrations are complete, the BAM-1020 flow readings should match the traceable flow standard reading at 16.7 lpm, +/- 0.1 lpm. Exit the calibration menu.

The **DEFAULT** hot key can be pressed to reset the user calibration from the selected parameter and replace it with a factory setting. If any of the **FLOW** parameters are selected, the **DEFAULT** key will reset the calibrations of all three flow points. This feature can be used to start over with a calibration if difficulty is encountered.

1.6.5 Leak Checks (Monthly)

Leak checks should be performed at least monthly and whenever the filter tape is changed. Almost all air leaks in the BAM system occur at the nozzle where it contacts the filter tape. The BAM-1020 has no way of automatically detecting a leak at this interface because the airflow sensor is located downstream of the filter tape. There will normally be a very small amount of leakage at the tape, but an excessive leak lets an unknown amount of air enter the system through the leak instead of the inlet. This will cause the total air volume calculation (and the concentration) to be incorrect. Allowing a leak to persist may cause an unknown amount of data to be invalidated. Perform the following steps to check for leaks.

1. Remove any sampling heads from the inlet tube. Install the leak test valve onto the inlet tube. Turn the valve to the **OFF** position to prevent any air from entering the inlet tube.
4. In the **TEST > TAPE** menu, advance the tape to a fresh, unused spot.
5. In the **TEST > PUMP** menu, turn on the pump. The flow rate should drop below 1.0 lpm. If the leak flow value is 1.0 lpm or greater, then the nozzle and vane need cleaning, or there may be another small leak in the system.
6. Resolve the leak and perform the check again. A properly functioning BAM with a clean nozzle and vane will usually have a leak value of about 0.5 lpm or less using this method, depending on the type of pump used.
7. Turn the pump off, remove the leak test valve, and re-install the inlet heads.
8. Record leak value on a standardized monthly flow check/calibration sheet.

Note: The reason for the 1.0 lpm leak flow allowance is due to the test conditions. With the inlet shut off, the vacuum in the system is very high—about 21 in Hg. This is many times greater than the BAM-1020 will encounter during normal sampling. If the leak reading during this test is less than 1.0 lpm, there should not be a significant leak during normal operation.

1.6.6 Performance Evaluation Audits (Semi-Annual)

Semi-annual performance evaluation audits are required to be performed by an independent third-party twice a year. This will include a semi-annual flow audit.

1.7 Maintenance, Diagnostics, and Troubleshooting

1.7.1 Error Checks

Make sure the BAM-1020 is in the top menu (Press the **EXIT** hot key until it is no longer available). Press the **F3** key. This will recall the last 10 errors recorded by the BAM-1020. Review the error and decide the appropriate corrective action.

1.7.2 Cleaning Sampling Head

The PM_{10} inlet requires removal from the inlet tube, disassembly, and cleaning. Disassemble the PM_{10} inlet and wipe it clean with a lint-free cloth. Ensure that all O-ring surfaces are in excellent shape and are re-installed correctly. If O-rings are damaged, see Section 10 of the BAM-1020 manual for replacement parts.

Clean the inlet nozzle and nozzle area. The inlet nozzle on the BAM-1020 can have a buildup of filter paper in one or more spots. This buildup may eventually cause holes to be punched in the filter tape. Symptoms of punched tape can cause the BAM-1020 to have erroneous negative concentration values and flow readings that are incorrect. The nozzle and vane should be cleaned each time the filter tape is replaced. Nozzle cleaning instructions are as follows.

1.7.3 Cleaning the Nozzle

Required tools include cotton swabs, a flashlight, isopropyl alcohol, and a sharp tool.

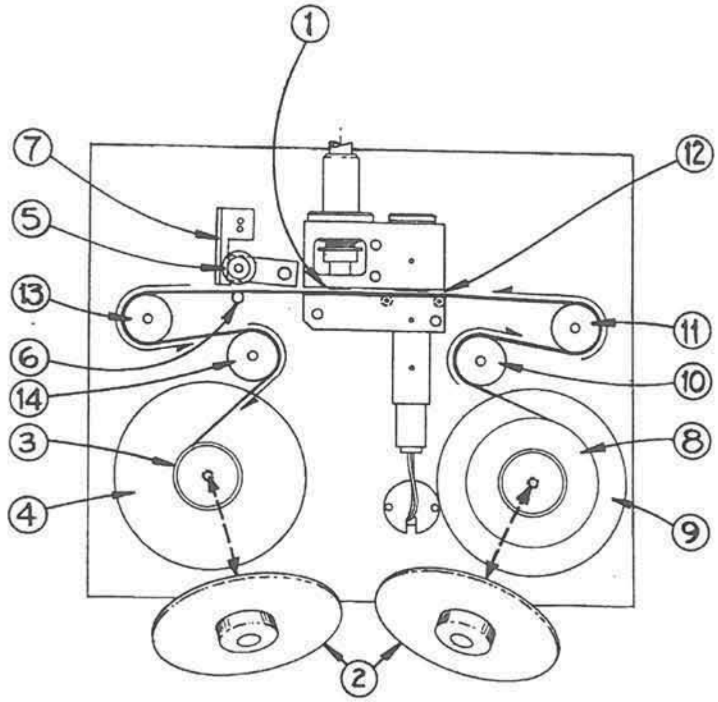
Remove the filter tape from the BAM-1020 (see page 33 of the Operating Manual). In the BAM-1020 main menu, press **TEST**. In the **TEST** menu, select **PUMP** and lower the nozzle. Lift the nozzle by pressing your thumb on the spring tensioner above the nozzle lip. Place a cotton swab with isopropyl alcohol under the nozzle and lower the nozzle onto the cotton swab. Slowly rotate the nozzle assembly. Eight to ten rotations will clean the nozzle. The vane (the cross-piece that sits under the filter paper where the nozzle contacts the filter paper) also needs to be cleaned. In the **TEST/PUMP** screen, lift the nozzle. The vane can be viewed by removing the inlet tube and looking down the inlet tube while shining a flashlight into the nozzle/vane area. Use a sharp tool (dental pick) to gently scrape the outside circumference of the vane to remove any filter paper build-up. Next scrape the cross-hair piece to remove any accumulation of paper. Finally, clean the entire area with a cotton swab and alcohol.

1.7.4 Changing the Tape

A roll of filter tape must be loaded into the BAM-1020 for sampling. One roll of tape should last approximately 60 days during normal operation. It is important to have several spare rolls of tape available to avoid data interruptions. Met One recommends wearing lint-free cotton gloves when handling the tape. Some agencies save the used rolls of tape for post-sampling analysis, although there is no guarantee that the sampled spots have not been contaminated. Discarding the used roll of filter tape is acceptable. Used filter tape should never be "flipped over" or re-used. This would result in measurement problems. Follow these steps to load a roll of filter tape:

1. Turn the BAM-1020 on and enter the **TAPE** menu (**Note:** This is not the same as the **TEST > TAPE** menu). If the nozzle is not in the **UP** position, press the **TENSION** soft-key to raise the nozzle.
2. Lift the rubber pinch roller assembly and latch it in the **UP** position. Unscrew and remove the clear plastic spool covers.
3. ***An empty core tube MUST be installed on the left (take-up) reel hub.*** This provides a surface on which the used tape can spool-up. Met One supplies a plastic core tube to use with the first roll of tape. After that, you can use the empty core tube left over from your last roll to spool-up the new roll. Never fasten the filter tape to the aluminum hub.
4. Load the new roll of filter tape onto the right (supply) reel, and route the tape through the transport assembly as shown in the drawing. Attach the loose end of the filter tape to the empty core tube with cellophane tape or equivalent.
5. Rotate the tape roll by hand to remove excess slack, and then install the clear plastic spool covers. The covers will clamp the rolls to the hubs to prevent slipping.
6. Align the filter tape so that it is centered on all the rollers. Newer units have score marks on the rollers to aid in visually centering the tape.
7. Unlatch and lower the pinch roller assembly onto the tape. The BAM will not function if the pinch rollers are latched up, as it has no way of automatically lowering the roller assembly.
8. Press the **TENSION** soft-key in the **TAPE** menu. The BAM-1020 will set the tape to the correct tension and alert you if there was an error with the process. Exit the menu.

Figure 3. Filter Tape Loading Diagram



1----NOZZLE IN "UP" POSITION
2----CLEAR SPOOL COVER WITH KNOB
3----EMPTY CORE TUBE
4----TAKE-UP SPOOL
5----PINCH ROLLERS
6----CAPSTAN SHAFT
7----LATCH
8----FILTER TAPE
9----SUPPLY SPOOL
10--SUPPLY TENSION ROLLER
11--RIGHT END ROLLER
12--SAMPLING/MEASURING AREA
13--LEFT END ROLLER
14--TAKE-UP TENSION ROLLER

The BAM-1020 has a built-in self-test function that automatically tests most of the tape control and flow systems of the unit. The self-test should be run right after each time the filter tape is changed and can also be used if the operator suspects a problem with the unit. More detailed diagnostic menus are also available for the BAM. They are described in the troubleshooting section of the Operating Manual.

The self-test feature is located in the **TAPE** menu. Press the **SELF TEST** soft-key to start the test. The tests will take a couple of minutes, and the BAM-1020 will display the results of each tested item with an **OK** or a **FAIL** tag. If all the test items are **OK**, the status will show **SELF TEST PASSED** as shown in the drawing below. If any item fails, the status will display an **ERROR OCCURRED** message.

Figure 4. Self-Test Status Screen

```
02/08/1999                15:29:30
LATCH: OFF                TAPE BREAK: OK
CAPSTAN: OK               TAPE TENSION: OK
NOZZLE DN: OK             SHUTTLE: OK
NOZZLE UP: OK             REF EXTEND: OK
FLOW: OK                  REF WITHDRAW: OK
Status:    SELF TEST PASSED
TENSION    SELF TEST              EXIT
```

1.7.5 Component Parts and Functions

LATCH:	This will display as **OFF** if the photo interrupter senses that the pinch rollers are unlatched as it is during normal operation. It will display as **ON** if the roller assembly is latched in the up position. The tape cannot move if the rollers are up.
CAPSTAN:	The capstan shaft is the component that moves the filter tape back and forth. The unit will rotate the capstan shaft forward and backward and will check if the photo interrupter sees the shaft rotating.
NOZZLE DN:	The unit will attempt to lower the nozzle and will check if the nozzle motor has moved to the down position with a photo interrupter. It is possible for the nozzle to become stuck in the **UP** position, even if the nozzle motor has successfully moved to the **DOWN** position. For this reason, proper inlet alignment and maintenance are necessary.
NOZZLE UP:	The unit will attempt to raise the nozzle and will check if the nozzle motor has moved to the **UP** position with a photo interrupter.
FLOW:	The unit will attempt to turn the pump on and will then look for output on the flow sensor. This test takes about one minute and will fail if the pump is not connected.
TAPE BREAK:	The unit will move the supply and take-up motors to create slack in the filter tape, and it will look for proper operation of the tensioner photo interrupters.
TAPE TENSION:	The unit will put tension on the filter tape and then check the condition of the tensioner photo interrupters.
SHUTTLE:	The unit will attempt to move the shuttle beam left and right and will check the motion with a photo interrupter.
REF EXTEND:	The unit will attempt to extend the reference membrane and will check the motion with a photo interrupter.
REF WITHDRAW:	The unit will attempt to withdraw the reference membrane, and will check the motion with a photo interrupter.

1.8 Data Records and Management

After completing the site check and filling out the site check form, sign and date the site check form, notate any conditions that were out of the ordinary (including weather, local conditions, etc.), and fax the form to Air Sciences Inc. (303-279-3796) within 24 hours of performing the site check.

Maintain a site log book in addition to the site check forms. Record the following during every site visit:

- Time of arrival on site
- Work performed on site/instrument
- Time of departure

Any other information useful to validating data, assuring that invalid data is removed, or maintenance notes should be included in the log book. The log book should be copied and submitted to Air Sciences within 7 days of the end of each quarter.

1.9 Troubleshooting

Refer to the Operating Manual for troubleshooting guidelines. If problems persist and a resolution cannot be determined by consulting the manual, notify one of the monitoring staff at Air Sciences Inc.

2.0 REFERENCES

Environmental Protection Agency. 2007. *Guidance for Preparing Standard Operating Procedures (SOPs)*. EPA/600/B-07/001. April 2007. http://www.epa.gov/QUALITY/qs-docs/g6-final.pdf. Accessed August 19, 2011.

Met One Instruments, Inc. *BAM-1020 Continuous Particulate Monitor Operating Manual, Revision G.*

AIR SCIENCES INC.

DENVER • PORTLAND

Standard Operating Procedure
Teledyne API Model T100 Sulfur Dioxide Monitoring Audit and Calibration Procedures
Revision 1

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CONTENTS PAGE

1.0 OPERATION, MAINTENANCE, AND AUDIT PROCEDURES

This document provides procedures for properly operating, maintaining, and auditing the Teledyne API Model T100 Sulfur Dioxide (SO_2) Analyzer. The T100 is a continuous SO_2 monitor and EPA equivalent method (EQSA-0495-100). Much of the following content is referenced from the *Model T100 UV Fluorescence SO_2 Analyzer Operational Manual* (Teledyne API 2010a) and the *Model T700 Dynamic Dilution Calibrator Operational Manual* (Teledyne API 2010b), herein referred to as the Operational Manuals. Refer to the Operational Manuals for more detailed instrument protocol.

1.1 Principles of Operation

The T100 SO_2 Analyzer is a microprocessor-controlled analyzer that determines the concentration of SO_2 by measuring the amount of UV fluorescence of gas sampled through the internal chamber.

1.2 Safety Precautions

Take normal precautions to avoid electrical shock.

Disconnect power before working with electrical components.

Use caution when working on elevated surfaces.

1.3 Sampling Interferences/Precautions

- Proper grounding is essential for good performance.
- Keep all inlet lines free of moisture.
- Keep exhaust and generators away from the manifold inlet.
- Other gases also react to UV light, such as NO and Poly-Nuclear Aromatics (PNA).
- See section 9.1.9 of the T100 Operation Manual.

1.4 Equipment and Supplies

- SO_2 Monitor (T100)
- Dynamic Dilution Calibrator (T700)
- Zero Air Gas Analyzer (T701)
- SO_2 gas supply (Table 3-12 of the T100 Operation Manual)
- Gloves
- Log books
- Site check forms and calibration/audit forms

1.5 Sampler Installation

Site selection should be based on several factors, including prevailing wind direction, monitoring equipment configuration, site accessibility, infrastructure requirements, security of the site location, and proximity to significant SO_2 sources in the area. To operate within the EPA equivalent method requirements, the monitor should be installed in a self-contained enclosure with internal environmental controls that maintain a constant temperature. The temperature of the shelter should be monitored hourly using an independent temperature logger or sensor. The instrument can operated in the 0 to 50 or 0 to 20,000 ppb range. Electrical service to the site must be made available. If possible, cellular service is desired, but not necessary.

1.6 Operational Procedures

1.6.1 Introduction

SO_2 instruments will be calibrated regularly as part of the QC program. A Teledyne T700 Dynamic Dilution Calibrator will be used for calibration of the SO_2 instruments. The T700 should be equipped with a NIST-traceable[1] SO_2 cylinder. The calibrated gas properties should be entered into the T700 gas properties appropriately.

There are a number of conditions that should be met prior to a calibration. First, the instrument should have at least three hours to warm up and stabilize, preferably overnight. Second, the range used during the calibration or zero/span check should be the same as that used during normal monitoring. Third, all operational adjustments to the instrument should be completed prior to calibration. Fourth, all parts of the gas flow system, such as sample lines, and particulate filters, which are used in normal monitoring, should also be used during calibration. Fifth, ensure that the pressure of the Zero Air Supply is approximately 30 psi, the Gas Pressure is approximately 30 psi, and the Regulator Pressure is approximately 20 psi. Finally, it is recommended that the recording devices and outputs used during normal monitoring be calibrated prior to the instrument calibration and that they be used during the calibration.

1.6.2 Calibration Equipment

1. Teledyne T700 Dynamic Dilution Calibrator with NIST-traceable SO_2 cylinder
2. Miscellaneous hand tools, calibration data sheets, site check form sheets, and station log book

1.6.3 Calibration Frequency

Site Check

Instrument site checks should be performed weekly. The site check form should be filled out and any parameters not within the listed operational range should be immediately investigated.

[1] National Institute of Standards and Technology

Level 1 Zero and Span Calibration

A zero and span calibration will be performed upon instrument startup, once every two weeks, after major repairs, and if the analyzer response is off by more than 3% of full scale for the zero, and 10% for full scale for the span.

Level 2 Zero-Span Checks

Automatic or manual Level 2 checks will be performed on the instrument as needed. Tolerance must be within 10%, or a Level 1 zero and span must be performed.

Multi Point Calibration

Multi point calibrations are performed on the instrument quarterly and are performed by an independent auditor.

1.6.3.1 Performing a Site Check (Weekly)

Every week, the "site check form" should be filled out by a site operator. All parameters should be within the acceptable value range listed on the site check form. If the parameter is outside the range, the error should be investigated immediately.

1.6.3.2 Performing a Level 1 Zero and Span (Every Two Weeks)

To set up the T700 to generate zero air:

1. Press **GEN**.
2. Press **AUTO**.
3. Toggle to **ZERO** using third key from the right.
4. Press **ENTER**.
5. Accept a flow of **5.000LPM** by pressing **ENTER**.
6. The upper-left-hand of the T700 should now say **GENERATE** instead of **STANDBY**.

To set up the T100 instrument:

1. Press **CALZ**.
2. Press **TST>** until you see **SO_2 STABIL = xxx**.
3. Let the T100 instrument reach a stability of <1.0 ppb.
4. Press **ZERO** on the T100.
5. Record the initial SO_2 value on the weekly sheet (displayed in the upper-right-hand corner).
6. Press **ENTER** to accept the value.
7. Record the final SO_2 value on the weekly sheet (displayed in the upper-right-hand corner).
8. Press **EXIT** on the T100 until the instrument is back to the main screen.

To set up the T700 to generate 400 ppb SO_2:

1. Press **STBY** on the T700 if it is still in **GENERATE**.
2. Press **GEN**.
3. Press **AUTO**.
4. Toggle to SO_2 using the third key from the right.
5. Make sure it is set to generate 400 ppb; change values if necessary.
6. Press **ENTER.**
7. Accept a flow of **5.000LPM** by pressing **ENTER**.
8. The T700 should now say **GENERATE** instead of **STANDBY**.
9. The SO_2 value should reach 400 ppb. (This may take awhile.)

To set up the T100 instrument:

1. Press **CALS**.
2. Press **TST>** until you see **SO_2 STABIL = xxx**.
3. Press **CONC**.
4. Press **SO2**.
5. Toggle and set the value to the actual concentration on the T700 display (approximately the target value).
6. Press **ENTER**.
7. Press **SO2**.
8. Toggle and set the value to the actual concentration on the T700 display and subtract 2 ppb.
9. Press **ENTER**.
10. Press **EXIT**.
11. Let the T100 instrument reach a stability of <1.0 ppb.
12. Press **SPAN**.
13. Record the initial SO_2 value on the weekly sheet (displayed in the upper-right-hand corner).
14. Press **ENTER** to accept the value.
15. Record the final value on the weekly sheet (displayed in upper-right-hand corner).
16. Press **EXIT** to return to **SAMPLE** main screen on the T100.
17. Put the T700 back into **STANDBY** mode by pressing **STBY**.

1.6.3.3 Performing a Level 2 Zero and Span (Nightly, or as Needed)

To set up the T700 to generate zero air:

1. Press **GEN**.
2. Press **AUTO.**
3. Toggle to **ZERO** using the third key from the right.
4. Press **ENTER**.
5. Accept a flow of **5.000LPM** by pressing **ENTER.**
6. The T700 should now say **GENERATE** instead of **STANDBY**.

To set up the T100 instrument:

1. Press **CALZ**.
2. Press **TST>** until you see **SO_2 STABIL = xxx**.
3. Let the T100 instrument reach a stability of <1.0 ppb.
4. Record the SO_2 value.

To set up the T700 to generate 400 ppb SO_2:

1. Press **STBY** on the T700 if it is still in **GENERATE**.
2. Press **GEN**.
3. Press **AUTO**.
4. Toggle to SO2 using the third key from the right.
5. Make sure it is set to generate 400 ppb; change values if necessary.
6. Press **ENTER**.
7. Accept a flow of **5.000LPM** by pressing **ENTER**.
8. The T700 should now say **GENERATE** instead of **STANDBY**.
9. The SO_2 value should reach 400 ppb. (This may take awhile.)

To set up the T100 instrument:

1. Press **CALS**.
2. Press **TST>** until you see **SO_2 STABIL = xxx**.
3. Let the T100 instrument reach a stability of <1.0 ppb.
4. Record the SO_2 value.
5. Press **EXIT** to return to **SAMPLE** main screen on the T100.

6. Put the T700 back into **STANDBY** mode by pressing **STBY.**

1.6.3.4 Performing a Multipoint Calibration (Quarterly, by Independent Auditor)

Perform Level 1 calibration as described in 1.6.3.2.

Set up the T700 to generate 300 ppb:

1. Press **STBY** on the T700 if it is still in **GENERATE**.
2. Press **GEN**.
3. Press **AUTO**.
4. Toggle to SO_2 using the third key from the right.
5. Make sure it is set to generate 300 ppb; change values if necessary.
6. Press **ENTER.**
7. Accept a flow of **5.000LPM** by pressing **ENTER**.
8. The T700 should now say **GENERATE** instead of **STANDBY**.

To set up the T100 instrument:

1. Press **CALS**.
2. Press **TST>** until you see **SO_2 STABIL = xxx**.
3. Let the T100 instrument reach a stability of <1.0 ppb.
4. Record the SO_2 value on the weekly sheet.
5. Put the T700 back into **STANDBY** mode by pressing **STBY**.
6. Repeat the steps above for generated values of 200, 100, 400, and 500 ppb.
7. Plot the values in Excel (ppb generated versus ppb measured).
8. Record the values on the weekly sheet. The regression line should be >.995 or above; otherwise, a Level 1 calibration should be performed.

1.7 Data Records and Management

Once the site check has been completed and the site check form filled out, the operator must sign and date the site check form, notate any conditions that were out of the ordinary (including weather, local conditions, etc.), and fax the form to Air Sciences Inc. (303-279-3796) within 24 hours of performing the site check.

1.8 Maintenance Schedule and Procedures

The particulate filter must be replaced weekly, or as needed, as part of the routine site check. See the Operations Manuals for instructions and part numbers. All other annual or semi-annual routine maintenance procedures are also listed in the Operations Manuals.

2.0 REFERENCES

Environmental Protection Agency. 2007. *Guidance for Preparing Standard Operating Procedures (SOPs)*. EPA/600/B-07/001. April 2007. http://www.epa.gov/QUALITY/qs-docs/g6-final.pdf. Accessed August 19, 2011.

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AIR SCIENCES INC.

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Standard Operating Procedure
SOP CS106
Campbell Scientific CS106
Audit and Calibration Procedures for the CS106 Barometric Pressure Sensor
Revision 1

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Title	Name	Signature/Date
Originator	Keith DeHenau	04/28/2011 Kathy Steerman
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Combined Audit & Calibration SOPs into one document	Revision No. 1	Kathy Steerman	8/9/11

CONTENTS PAGE

1.0 AUDIT: SCOPE AND APPLICABILITY

This document provides procedures for properly auditing the performance of the Campbell Scientific CS106 Barometric Pressure Sensor.

1.1 Equipment and Supplies

- DeltaCal or a NIST traceable Barometric Pressure Sensor.
- Site log book/audit sheets.

1.2 Barometric Pressure Audit Procedures (Semi Annual)

A system response check is performed by the use of a DeltaCal or NIST traceable Barometric Pressure Sensor. The DeltaCal or NIST traceable Barometric Pressure Sensor is turned on and compared to the CS106 located on site. Since the sensor is semi-sealed, minimum maintenance is required:

- Visually inspect the cable connection to ensure it is clean and dry.
- Visually inspect the casing for damage.
- Ensure that the pneumatic connection and pipe are secure and undamaged.

The external case can be cleaned with a damp, lint-free cloth and a mild detergent solution.

Vaisala recommends recalibration every two years under normal use. In areas where a lot of contaminants are present, recalibration every year is recommended.

Conclusion

At the conclusion of the audit, complete all audit forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time at which the audit was conducted. Sign and date the audit form under any comments made.

1.3 Data Records and Management

Once the audit has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

1.4 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

2.0 CALIBRATION: SCOPE AND APPLICABILITY

This document provides procedures for properly calibrating, operating and maintaining the Campbell Scientific CS106 Barometric Pressure Sensor.

2.1 Principals of Operation

The CS106 analog barometer uses Vaisala's Barocap® silicon capacitive pressure sensor. The Barocap sensor has been designed for accurate and stable measurement of barometric pressure. The CS106 outputs a linear 0 to 2.5 VDC signal that corresponds to 500 to 1100 mb. It can be operated in a shutdown or normal mode. In the shutdown mode the datalogger switches 12 VDC power to the barometer during the measurement. The datalogger then powers down the barometer between measurements to conserve power.

2.2 Safety Precautions

Normal precautions should be taken to avoid electrical shock. Disconnect power before working with electrical components.

Use caution when working on elevated surfaces or towers.

2.3 Sampling Interferences/Precautions

- For the sensor to detect the external ambient pressure, the enclosure must vent to the atmosphere (i.e., not be 'hermetically sealed').
- It may be necessary to make a vent hole on the outer wall. In this situation, do not make the hole on one of the vertical side walls, as wind blowing around it can cause transient changes in pressure.

2.4 Equipment and Supplies

- Calibrated, certified, NIST traceable barometer or a collocated CS106.
- Site log book/calibration sheets.

2.5 Sensor Installation

To prevent condensation, install the sensor in an environmentally protected enclosure, complete with desiccant, which should be changed at regular intervals.

2.6 Operational Procedures

2.6.1 Assembly and Mounting

Tools Required:

- Adjustable wrench
- Small screw driver provided with datalogger
- Enclosure
- Philips Screw Driver

Remember that for the sensor to detect the external ambient pressure, the enclosure must vent to the atmosphere (i.e., not be 'hermetically sealed'). Enclosures purchased from Campbell Scientific properly vent to the atmosphere. The mounting holes for the sensor are one-inch-centered (three inches apart), and will mount directly onto the holes on the back plate of Campbell Scientific enclosures. Mount the sensor with the pneumatic connector pointing vertically downwards to prevent condensation collecting in the pressure cavity, and also to ensure that water cannot enter the sensor. To wire the data logger to the CS106, refer to the Instruction Manual for wiring schematics.

2.6.2 Barometric Pressure Calibration Procedures (Semi-annual)

A system response check is performed by the use of a collocated CS106 or NIST traceable Barometric Pressure Sensor. The CS106 or NIST traceable Barometric Pressure Sensor is turned on and compared to the CS106 located on site. Since the sensor is semi-sealed, minimum maintenance is required:

- Visually inspect the cable connection to ensure it is clean and dry.
- Visually inspect the casing for damage.
- Ensure that the pneumatic connection and pipe are secure and undamaged.

The external case can be cleaned with a damp, lint-free cloth and a mild detergent solution.

Vaisala recommends recalibration every two years under normal use. In areas where a lot of contaminants are present, recalibration every year is recommended.

Conclusion

At the conclusion of the audit, complete all audit forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time at which the audit was conducted. Sign and date the audit form under any comments made.

2.7 Data Records and Management

Once the calibration has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

2.8 Troubleshooting

Please refer to the manufacturer's manual for troubleshooting.

REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA/600/B-07-001 April 2007.

CS106 Barometric Pressure Sensor Instruction Manual, Revision 4/11.

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Standard Operating Procedure

SOP CS700

Campbell Scientific CS700

Audit and Calibration Procedures for the CS700 Tipping Bucket Rain Gage

Revision 1

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Authorizations and Approvals:

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Monitoring Engineer	Aaron Schlabaugh	04/20/2011

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Combined Audit & Calibration SOPs into one document	Revision No. 1		8/12/11

CONTENTS

1.0 AUDIT: SCOPE AND APPLICABILITY

This document provides procedures for properly auditing the performance of the CS700 Tipping Bucket Rain Gage.

1.1 Equipment and Supplies

- 20 mL syringe
- One gallon of water
- Site log book/audit sheets

1.2 Rain Gage Audit Procedures (Semi Annual)

The sensor is factory calibrated; recalibration is not required unless damage has occurred or the adjustment screws have loosened.

Nevertheless, the following calibration check is recommended once every 12 months:

- Remove the housing assembly from the base by removing the three screws and lifting upward on the housing.
- Check the bubble level to verify the rain gage is level.
- Pour water through the inner funnel to wet the two bucket surfaces. Using a graduated cylinder, slowly pour 314 cc (19.16 in3) of water, over a 15 minute period, into the collection funnel. This volume of water is equal to .39 in of rainfall (10 mm).
- After the water has passed through the rain gage, the tipping bucket should have tipped 39 times.
- If the rain gage fails to record the correct number of tips, return the unit to Campbell Scientific for recalibration.

If factory calibration is required, contact Campbell Scientific to obtain an RMA (see Warranty and Assistance in the front of the manual).

Conclusion

At the conclusion of the audit, complete all audit forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time which the audits for the rain gage sensor began and ended. Sign and date the audit form under any comments made.

1.3 Data Records and Management

Once the audit has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

1.4 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

2.0 CALIBRATION: SCOPE AND APPLICABILITY

This document provides procedures for properly calibrating, operating and maintaining the Campbell Scientific CS700 Tipping Bucket Rain Gage.

2.1 Principals of Operation

The CS700 tipping bucket rain gage is manufactured by Hydrological Services Pty. Ltd. (Model TB-3), and modified for use with Campbell Scientific dataloggers. It catches rainfall in the 7.87 in. (200 mm) collection funnel. When 0.01 in. of rainfall is collected, the tipping bucket assembly tips and activates a reed switch. The switch closure is recorded by the datalogger. After the bucket tips, the water drains out the screened base of the gage.

2.2 Safety Precautions

Normal precautions should be taken to avoid electrical shock. Disconnect power before working with electrical components.

Use caution when working on elevated surfaces or towers.

2.3 Sampling Interferences/Precautions

- For accurate measurements, the CS700 and CS700H must be placed away from objects that obstruct wind. The minimum distance should be at least 2 to 4 times the height of the obstruction.

2.4 Equipment and Supplies

- 20 mL syringe.
- One gallon of water
- Site log book/calibration sheets

2.5 Sensor Installation

The CS700 and CS700H should be mounted in a relatively level spot which is representative of the surrounding area. The ground surface around the rain gage should be natural vegetation or gravel. The gage should not be installed over a paved or concrete surface.

2.6 Operational Procedures

2.6.1 Assembly and Mounting

Tools Required:

- • Adjustable wrench
- • Small screw driver provided with datalogger
- • UV resistant cable ties

- • Small pair of diagonal-cutting pliers
- • 6 - 10″ torpedo level

The CS700 and CS700H are designed to mount on a flat surface. Three equally spaced mounting pads are provided. The mounting pads are pre-drilled for three 3/8″ (M8) bolts on a 9.21″ (234 mm) diameter bolt circle.

The CM240 mounting bracket is available from Campbell Scientific for installing the CS700 and CS700H. The CM240 base helps level the rain gage, ensuring a more accurate measurement. The base may be attached to a CM300-Series Mounting Pole or to a user-supplied 1.5 in. IPS (1.9 in. OD) unthreaded pipe. The pipe should be long enough to place the gage's orifice at a one-meter height. The rain gage should be high enough to be above the average snow depth. The pole or pipe can be placed directly into a concrete foundation, or attached to a concrete foundation using J-bolts or self-supporting with legs. A concrete pad is recommended, but it should not be installed over large paved or concrete surface.

Level the rain gage after mounting it. To level, remove the housing assembly from the base by loosening the three housing screws and lifting the housing upward. Adjust the three nuts on the CM240 bracket to level the gage. A bullseye level is mounted on the rain gage's base to facilitate leveling.

Remove the rubber shipping band and cardboard packing securing the tipping bucket assembly. Tip the bucket several times to insure the tipping mechanism is moving freely. Replace the housing assembly and tighten the three screws to secure the housing to the base.

2.6.2 Rain Gage Calibration Procedures (Semi-annual)

The sensor is factory calibrated; recalibration is not required unless damage has occurred or the adjustment screws have loosened.

Nevertheless, the following calibration check is recommended once every 12 months:

- Remove the housing assembly from the base by removing the three screws and lifting upward on the housing.
- Check the bubble level to verify the rain gage is level.
- Pour water through the inner funnel to wet the two bucket surfaces. Using a graduated cylinder, slowly pour 314 cc (19.16 in3) of water, over a 15 minute period, into the collection funnel. This volume of water is equal to .39 in of rainfall (10 mm).
- After the water has passed through the rain gage, the tipping bucket should have tipped 39 times.
- If the rain gage fails to record the correct number of tips, return the unit to Campbell Scientific for recalibration.

If factory calibration is required, contact Campbell Scientific to obtain an RMA (see Warranty and Assistance in the front of the manual).

2.7 Data Records and Management

Once the calibration has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

2.8 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA/600/B-07-001 April 2007.

CS700 Instruction Manual, Revision 04/11.

AIR SCIENCES INC.

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Standard Operating Procedure

SOP HMP45C

Campbell Scientific HMP45C

Audit and Calibration Procedures for the HMP45C Relative Humidity Sensor

Revision 1

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CONTENTS

1.0 AUDIT: SCOPE AND APPLICABILITY

This document provides procedures for properly auditing the performance of the Campbell Scientific HMP45C Relative Humidity Sensor.

1.1 Equipment and Supplies

- Calibrated, certified, NIST traceable relative humidity sensor.
- Site log book/calibration sheets

1.2 Relative Humidity Audit Procedures (Semi Annual)

1.2.1 Pre-adjustment System checks

The system response check is performed by comparing the sensor response with that of a calibrated NIST traceable relative humidity sensor. The two sensors should be collocated as closely as possible by taping the sensors together. After allowing time for the relative humidity readings to stabilize, the technician will record the calibration and datalogger values on the Relative Humidity Sensor Calibration Form. Check to see if the accuracy of the instrument is no more than ± 5%.

1.2.2 Maintenance and Adjustments

The HMP45C Probe requires minimal maintenance. Check monthly to make sure the radiation shield is free from debris. The black screen at the end of the sensor should also be checked for contaminants. The filter can be rinsed gently in distilled water. If necessary, the chip can be removed and rinsed as well. Do not scratch the chip while cleaning.

Conclusion

At the conclusion of the calibration, complete all calibration forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time at which the calibrations for the relative humidity sensors began and ended. Sign and date the calibration form under any comments made.

1.3 Data Records and Management

Once the audit has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

1.4 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

2.0 CALIBRATION: SCOPE AND APPLICABILITY

This document provides procedures for properly calibrating, operating and maintaining the Campbell Scientific HMP45C Relative Humidity Sensor.

1.1 Principals of Operation

The HMP45C Relative Humidity probe contains a Vaisala HUMICAP 180 capacitive relative humidity sensor . Approximately 0.15 seconds is required for the sensor to warm up after power is switched on.

1.2 Safety Precautions

Normal precautions should be taken to avoid electrical shock. Disconnect power before working with electrical components.

Use caution when working on elevated surfaces or towers.

1.3 Sampling Interferences/Precautions

- When installed in close proximity to the ocean or other bodies of salt water, a coating of salt may build up on the radiation shield, sensor, filter and even the chip.
- Long term exposure of the HUMICAP to certain chemicals and gases may affect the characteristics of the sensor and shorten its life.

1.4 Equipment and Supplies

- Calibrated, certified, NIST traceable relative humidity sensor.
- Site log book/calibration sheets

1.5 Sensor Installation

Sensors should be located over an open level area at least 9 m (EPA) in diameter. The surface should be covered by short grass, or where grass does not grow, the natural earth surface. Sensors should be located at a distance of at least four times the height of any nearby obstruction, and at least 30 m (EPA) from large paved areas. Sensors should be protected from thermal radiation, and adequately ventilated.

1.6 Operational Procedures

1.6.1 Assembly and Mounting

Tools Required:

- 1/2" open end wrench
- small screw driver provided with datalogger
- UV resistant cable ties
- Small pair of diagonal-cutting pliers

The HMP45C must be housed inside a radiation shield when used in the field. The 41003-5 Radiation shield has a U-bolt for attaching the shield to tripod mast/tower leg, or CM200 series crossarm. The radiation shield ships with the U-bolt configured for attaching the shield to a vertical pipe. Move the U-bolt to the other set of holes to attach the shield to a crossarm. Loosen the split-nut on the bottom plate of the 41003-5. Remove the yellow protective cap on the HMP45C, and insert the sensor into the shield. Tighten the split-nut to secure the sensor in the shield. Route the sensor cable to the instrument enclosure. Secure the cable to the tripod/tower using cable ties.

1.6.2 Relative Humidity Calibration Procedures (Semi-annual)

1.6.2.1 Pre-adjustment System checks

The system response check is performed by comparing the sensor response with that of a calibrated NIST traceable relative humidity sensor. The two sensors should be collocated as closely as possible by taping the sensors together. After allowing time for the relative humidity readings to stabilize, the technician will record the calibration and datalogger values on the Relative Humidity Sensor Calibration Form. Check to see if the accuracy of the instrument is no more than ± 5%

1.6.2.2 Maintenance and Adjustments

The HMP45C Probe requires minimal maintenance. Check monthly to make sure the radiation shield is free from debris. The black screen at the end of the sensor should also be checked for contaminants. The filter can be rinsed gently in distilled water. If necessary, the chip can be removed and rinsed as well. Do not scratch the chip while cleaning.

Conclusion

At the conclusion of the calibration, complete all calibration forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time at which the calibrations for the relative humidity sensors began and ended. Sign and date the calibration form under any comments made.

1.7 Maintenance, Diagnostics, and Troubleshooting

The HMP45C Probe requires minimal maintenance. Check monthly to make sure the radiation shield is free from debris. The black screen at the end of the sensor should also be checked for contaminants. The filter can be rinsed gently in distilled water. If necessary, the chip can be removed and rinsed as well. Do not scratch the chip while cleaning.

1.8 Data Records and Management

Once the calibration has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

1.9 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA/600/B-07-001 April 2007.

HMP45C Instruction Manual, Revision 03/09.

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Standard Operating Procedure
SOP 43347
Calibration and Audit Procedures for the Campbell Scientific RTD 43347 Temperature Sensors
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Jessica Crichfield edited and combined calibration and audit SOPs into one document.	1.0	8/19/2011	

CONTENTS PAGE

1.0 OPERATION AND CALIBRATION PROCEDURES

This section provides procedures for properly calibrating, operating, and maintaining the Campbell Scientific RTD 43347 Temperature Probe. Much of the following content appears in the *43347 RTD Temperature Probe and 43502 Aspirated Radiation Shield Instruction Manual* (Instruction Manual) (Campbell Scientific, Inc. 2010). Refer to the Instruction Manual for more detailed instrument protocol.

1.1 Principles of Operation

The 43347 is a 1000 ohm Resistance Temperature Device (RTD) used to measure ambient air temperature and delta or gradient air temperature. The standard 43347 probe has an uncertainty of ±0.3°C. For increased accuracy the 43347 probe should be ordered with a three point calibration with an uncertainty of ±0.1°C.

The 43347 should be housed in the 43502 motor aspirated radiation shield. The 43502 radiation shield employs concentric downward facing intake tubes and a small canopy shade to isolate the temperature probe from direct and indirect radiation. The 43347 probe mounts vertically in the center of the intake tubes. A brushless 12 VDC blower motor pulls ambient air into the shield and across the probe to reduce radiation errors. The blower operates off a 115 VAC/12 VDC transformer that is included with the shield.

1.2 Safety Precautions

Take normal precautions to avoid electrical shock.

Disconnect power before working with electrical components.

Use caution when working on elevated surfaces or towers.

1.3 Sampling Interferences/Precautions

The probes should be sited in a place where representative temperature may be obtained (outside of any known drafts or heat sources).

1.4 Equipment and Supplies

- Calibrated, certified, NIST-traceable[1] thermometer
- Water baths covering the temperature range of the sensor (about 0, about 15, and about 35°C)
- Site log book/calibration forms

[1] National Institute of Standards and Technology

1.5 Probe Installation

Sensors should be located over an open level area at least 9 m (EPA) in diameter. The surface should be covered by short grass, or where grass does not grow, the natural earth surface. Sensors should be located at a distance of at least four times the height of any nearby obstruction, and at least 30 m (EPA) from large paved areas. Sensors should be protected from thermal radiation and adequately ventilated.

1.6 Operational Procedures

1.6.1 Assembly and Mounting

Tools Required

- 1/2" open-end wrench
- Small screwdriver provided with datalogger
- Small Phillips screwdriver
- UV-resistant cable ties
- Small pair of diagonal-cutting pliers

Refer to the Instruction Manual (Campbell Scientific, Inc. 2010) for illustrative figures that represent the following operational procedures.

The 43502 mounting bracket has a U-bolt configured for attaching the shield to a vertical tripod mast or tower leg up to 2" in diameter. By moving the U-bolt to the other set of holes, the bracket can be attached to a CM200 series crossarm (e.g., the CM204). The CM204 crossarm includes the CM210 Mounting Kit for attaching the crossarm to a tripod mast or tower leg. For triangular towers (e.g., the UT30), an additional PN CM210 Crossarm Mounting Kit can be ordered for attaching the crossarm to two tower legs for additional stability. All parts listed can be purchased through Campbell Scientific.

Attach the 43502 to the tripod/tower or crossarm using the U-bolt. Tighten the U-bolt sufficiently for a secure hold without distorting the plastic v-block.

The blower cover is hinged to allow easy access for sensor installation and cable connections. Loosen the captive screw in the blower cover to open. The junction box provides terminals for cable connections and properly positions the sensor within the shield assembly.

With the blower cover open, connect blower power (12-14 VDC) to the terminals on the underside of the cover. Terminal designations positive (POS), negative (NEG), and optional tachometer (TACH), are marked on the printed circuit board. Blower power is normally provided by the plug-in power supply adapter included. BE SURE TO OBSERVE CORRECT POLARITY. Red is positive; black is negative. The blower motor draws approximately 420mA–480mA. Use sufficiently heavy gauge wire between the power supply adapter and the blower motor terminals to avoid significant voltage drop. Clamp the blower power cable with the cable clamp provided at the edge of the printed circuit card. When tying the cable to the mounting structure, provide a sufficient loop in the cable to allow the blower cover to be opened and closed easily.

Install the 43347 probe inside the 43502 shield using the sensor mounting bushing (supplied with the 43502). The sensor cable exits the side of the blower housing at the notches provided using the black grommet to provide a seal. Clamp the cable to the lower flange of the housing to keep it in proper position when the cover is closed. Route the sensor cable to the instrument enclosure. Secure the cable to the tripod/tower using cable ties.

1.6.2 Pre-adjustment Calibration Procedures

System Response Check

Perform the system response check by comparing the sensor response with that of a calibrated, NIST-traceable thermometer for at least three different temperatures. The ideal temperatures for sensor comparison are very cold, medium, and hot. The varying temperatures should be about -0°C, 15 to 25°C, and 30 to 40°C, respectively. Use three small insulated thermoses to reach these temperatures. Use an ice bath for the cold temperature range. Use warm and hot water for the warm and hot temperatures. Colocate the thermometer and temperature sensor as closely as possible by taping the sensors together. After allowing time for the temperature readings to stabilize, record the calibration and datalogger values on the Temperature Sensor Calibration Form. Check to see if the accuracy of the instrument is no more than ±0.5° (accuracy) and no more than ±0.1° for temperature difference between matched sensors in a delta temperature measurement system.

1.7 Maintenance, Diagnostics, and Troubleshooting

After performing all system inspections and calibration checks, review the results to determine what maintenance and adjustments are needed, if any. Follow the maintenance procedures in the Instruction Manual (Campbell Scientific, Inc. 2010). Since a true calibration of the sensor cannot be performed unless the sensor is checked across its full range, a sensor not conforming to the calibrated, NIST-traceable thermometer will most likely need to be replaced and sent back to the factory for a true calibration.

1.8 Data Records and Management

Once the calibration has been performed, record all values on a standardized form. The entire time period during which the sensors were compromised or removed from their aspirated shields should be invalidated.

1.9 Troubleshooting

Refer to the Instruction Manual (Campbell Scientific, Inc. 2010) for troubleshooting guidelines.

2.0 AUDIT PROCEDURES

This section provides procedures for properly auditing the RTD Temperature Probe.

2.1 Audit Procedures

Remove the temperature sensors from the aspirators and check them across three temperature points.

Perform the system response check by comparing the sensor response with that of a calibrated, NIST-traceable thermometer for at least three different temperatures. The ideal temperatures for sensor comparison are very cold, medium, and hot. The varying temperatures should be about -0°C, 15 to 25°C, and 30 to 40°C, respectively. Use three small insulated thermoses to reach these temperatures. Use an ice bath for the cold temperature range. Use warm and hot water for the warm and hot temperatures. Colocate the thermometer and temperature sensor as closely as possible by taping the sensors together. After allowing time for the temperature readings to stabilize, record the calibration and datalogger values on the Temperature Sensor Audit Form. Check to see if the accuracy of the instrument is no more than ±0.5° (accuracy) and no more than ±0.1° for temperature difference between matched sensors in a delta temperature measurement system.

2.2 Maintenance, Diagnostics, and Troubleshooting

After performing all system inspections and audit checks, review the results to determine what maintenance and adjustments are needed, if any. Follow the maintenance procedures in the Instruction Manual (Campbell Scientific, Inc. 2010). If the sensor fails the audit, it will need to be replaced or sent back to the manufacturer for repair.

2.3 Data Records and Management

After performing the audit, record all values on a standardized form. The entire time period during which the sensors were compromised or removed from their aspirated shields should be invalidated.

3.0 REFERENCES

Campbell Scientific, Inc. 2010. *43347 RTD Temperature Probe and 43502 Aspirated Radiation Shield Instruction Manual, Revision 12/10*. http://www.campbellsci.com/documents/manuals/rtd.pdf. Accessed August 18, 2011.

Environmental Protection Agency. 2007. *Guidance for Preparing Standard Operating Procedures (SOPs)*. EPA/600/B-07/001. April 2007. http://www.epa.gov/QUALITY/qs-docs/g6-final.pdf. Accessed August 18, 2011.

AIR SCIENCES INC.

Standard Operating Procedure

SOP 05305

R.M. Young 05305-AQ

Audit and Calibration Procedures for the RM Young 05305-AQ Wind Speed and Wind Direction Sensor

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CONTENTS

PAGE

1.0 AUDIT: SCOPE AND APPLICABILITY

This document provides procedures for properly auditing the performance of the RM Young 05305-AQ Wind Speed and Wind Direction Sensor.

1.1 Equipment and Supplies

- RM Young 18802 (or similar model) anemometer drive and motor
- RM Young linearity test fixture/degree wheel
- Torque wheel
- Tripod mounted survey-grade compass.
- Site log book/audit sheets

1.2 Wind Speed Audit Procedures (Semi Annual)

A system response check is performed by the use of an RM Young 18802 (or similar model) anemometer drive. The propeller is removed from the sensor shaft and the anemometer drive is attached. The sensor is then challenged at the speeds specified on the Wind Speed Audit Form (200 through 5000 rpm). The speeds measured by the datalogger for each specific revolution per minute (rpm) are compared to the calculated values. The equation for calculating wind speed as a function of anemometer drive rpm is given on the Wind Speed Audit Form.

The starting torque should be measured with a torque wheel and recorded on the wind speed audit form. If the starting torque of the sensor is greater than 0.004 g/cm clockwise or counterclockwise, the bearings may need to be refurbished.

1.3 Wind Direction Audit Procedures (Semi-annual)

1.3.1 Sensor Orientation

The process for auditing the wind direction sensor is below:

Compass

1. Determine declination for the area using a Geomag type program with the most recent models of the earth's magnetic field, or by performing a solar azimuth.
2. Use a clamp fashioned from a band clamp and rubber tubing to fix the wind vane in various directions.
3. Using a tripod mounted and leveled, survey grade compass align the compass so that it sights directly at the tail of the wind vane.
4. Obtain readings in each of the eight quadrants of the compass.
5. Record the readings from the datalogger and the compass on the Wind Direction audit form.

1.3.2 System Linearity Check

Using a RM Young linearity test fixture test the sensor at 45° intervals. Record the readings from the datalogger at each interval on the Wind Direction Audit Form and compare to the expected values. If possible, check the linearity of the instrument by fitting a curve and checking the slope, and intercept of the Y = X line. Check to see if the accuracy of the instrument is no more than ± 5° (accuracy) and ≤ 3° mean absolute error (linearity). Mean absolute error is calculated by the following equation:

$$\frac{\sum n}{X}$$

Where X is the precision of the instrument at any given degree, and n, is the number of measurements taken.

Conclusion

At the conclusion of the audit, complete all audit forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time which the audits for the wind speed and direction sensors began and ended. Sign and date the audit form under any comments made.

1.8 Data Records and Management

Once the audit has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

1.9 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

2.0 CALIBRATION: SCOPE AND APPLICABILITY

This document provides procedures for properly calibrating, operating and maintaining the RM Young 05305-AQ Wind Speed and Wind Direction Sensor

2.1 Principals of Operation

The 05305 is a high performance version of the 05103 designed to meet PSD specifications for air quality applications. Wind speed is measured with a helicoid-shaped, four-blade propeller. Rotation of the propeller produces an AC sine wave signal with frequency proportional to wind speed. Vane position is transmitted by a 10K ohm potentiometer. With a precision excitation voltage applied, the output voltage is proportional to wind direction.

2.2 Safety Precautions

Normal precautions should be taken to avoid electrical shock. Disconnect power before working with electrical components.

Use caution when working on elevated surfaces or towers.

Care should be taken to stop the propeller in high winds to avoid cuts and breakage.

2.3 Sampling Interferences/Precautions

- Proper grounding is essential for good performance.
- The propeller should be replaced if cracked or damaged.
- The body of the anemometer should be free of crack and chips.

2.4 Equipment and Supplies

- RM Young 18802 (or similar model) anemometer drive and motor
- RM Young linearity test fixture/degree wheel
- Tripod mounted survey-grade compass.
- Site log book/calibration sheets

2.5 Sensor Installation

Locate wind sensors away from obstructions (e.g. trees and building). As a general rule of thumb there should be a horizontal distance of at least ten times the height of the obstruction between the windset and the obstruction. If it is necessary to mount the sensors on the roof of a building, the height of the sensors above the roof, should be at least 1.5 times the height of the building.

2.6 Operational Procedures

2.6.1 Assembly and Mounting

Tools Required:

- 5/64" Allen wrench
- 1/2" open end wrench
- compass and declination angle for the site
- small screw driver provided with datalogger
- UV resistant cable ties
- small pair of diagonal-cutting pliers
- 6 - 10" torpedo level

Install the propeller to the propeller shaft using the nut provided with the sensor. The Wind Monitor mounts to a standard 1" IPS schedule 40 pipe (1.31" O.D.). A 12" long mounting pipe ships with the sensor for attaching the sensor to a 019ALU, or CM200 series crossarm with the CM220 or PN 1049 (All available through Campbell Scientific.) The 05103 can also be mounted to a CM110 series tripod mast with the CM216 Mast Mounting Kit. Mount the 019ALU or CM200 series crossarm to the tripod or tower. Orient the crossarm North-South, with the 1" Nu-Rail or CM220 on the North end. Secure the mounting pipe to the 019ALU or CM220. Place the orientation ring, followed by the Wind Monitor on the mounting pipe. Orient the junction box to the south, and tighten the band clamps on the orientation ring and mounting post. Final sensor orientation is done after the datalogger has been programmed to measure wind direction. Route the sensor cable along the underside of the crossarm to the tower/tripod mast, and to the instrument enclosure. Secure the sensor cable to the crossarm and mast using cable ties.

2.6.2 Wind Speed Calibration Procedures (Semi-annual)

2.6.2.1 Wind Speed Calibration Procedures

Pre-adjustment System Checks

A system response check is performed by the use of an RM Young 18802 (or similar model) anemometer drive. The propeller is removed from the sensor shaft and the anemometer drive is attached. The sensor is then challenged at the speeds specified on the Wind Speed Calibration Form (200 through 5000 rpm). The speeds measured by the datalogger for each specific revolution per minute (rpm) are compared to the calculated values. The equation for calculating wind speed as a function of anemometer drive rpm is given on the Wind Speed Calibration Form.

Maintenance and Adjustments

At this point the technician should review the performance of the sensor and determine what adjustments are required, if any. All basic maintenance should be performed before any serious adjustment of the sensor, or determination of a new multiplier and/or offset in the datalogger programming. All maintenance and adjustments should follow the guidelines presented by the manufacturer in the RM Young instrument manual.

Post-Adjustment Checks

If any maintenance or adjustments were performed, the steps listed in Section 2.1 of this procedure should be repeated and recorded on the Wind Speed Calibration Form. Results of the post adjustment checks should be closely evaluated. If the output values do not closely match the expected values, perform troubleshooting, maintenance, and adjustments as needed to correct the sensor response. If the sensor is deemed unrepairable by the technician, it should be replaced as soon as possible from the stock of back-up sensors for the monitoring project.

2.6.3 Wind Direction Calibration Procedures (Semi-annual)

2.6.3.1 Sensor Orientation

After the system is inspected, a check of the wind vane orientation is performed. The method for an orientation check of the wind vane are as follows:

Compass

1. Determine declination for the area using a Geomag type program with the most recent models of the earth's magnetic field, or by performing a solar azimuth.
2. Use a clamp fashioned from a band clamp and rubber tubing to fix the wind vane in various directions.
3. Using a tripod mounted and leveled, survey grade compass align the compass so that it sights directly at the tail of the wind vane.
4. Obtain readings in each of the eight quadrants of the compass.
5. Record the readings from the datalogger and the compass on the Wind Direction calibration form.

2.6.3.2 System Linearity Check

Using a RM Young linearity test fixture test the sensor at 45° intervals. Record the readings from the datalogger at each interval on the Wind Direction Calibration Form and compare to the expected values. If possible, check the linearity of the instrument by fitting a curve and checking the slope, and intercept of the Y = X line. Check to see if the accuracy of the instrument is no more than ± 5° (accuracy) and ≤ 3° mean absolute error (linearity). Mean absolute error is calculated by the following equation:

$$\frac{\sum n}{X}$$

Where X is the precision of the instrument at any given degree, and n, is the number of measurements taken.

2.6.3.3 Maintenance and Adjustment

At this point the technician should review the performance of the sensor and determine what adjustments are required, if any. All basic maintenance should be performed before any serious adjustment of the sensor, or determination of a new multiplier and/ or offset in the datalogger programming. All maintenance and adjustments should follow the guidelines presented by the manufacturer in the RM Young instrument manual. If the orientation was incorrect, the alignment of the cross arm will need to be adjusted following the linearity check.

2.6.3.4 Post Adjustment Checks

After all maintenance and adjustments have been made, the steps listed previously in this document should be repeated, respectively. All results should be recorded on the Wind Direction Calibration Form. Results of the post adjustment checks should be evaluated. If the output values do not closely match the expected values, perform troubleshooting, maintenance, and adjustments as needed to correct the sensor response. If the sensor is deemed un-repairable by the technician, it should be replaced as soon as possible from the stock of back-up sensors for the monitoring project.

Conclusion

At the conclusion of the calibration, complete all calibration forms noting any adjustments made, maintenance performed, and corrective actions taken, if any. Note the specific time which the calibrations for the wind speed and direction sensors began and ended. Sign and date the calibration form under any comments made.

2.7 Maintenance, Diagnostics, and Troubleshooting

When the linearity test is off by the approved 3%, the slope may need to be adjusted in the potentiometer. Set the slope in the datalogger to "1.0". Obtain the highest reading of the potentiometer. Divide that number into 360 to obtain the new slope (for example, 360/980 = 0.367). Enter the new slope (for example, 0.367) into the datalogger program and redo the linearity check.

Wind speed bearings and reed switches must be replaced or refurbished annually, and potentiometers must be replaced every two years. Follow manufacturer guidelines to perform this maintenance.

2.8 Data Records and Management

Once the calibration has been performed, all values must be recorded on a standardized form. The entire time period where the sensors were compromised or removed should be invalidated.

2.9 Troubleshooting

Please refer to the manufacturers manual for troubleshooting.

REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA/600/B-07-001 April 2007.

RM Young Instruction Manual, Revision 08/09.

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Standard Operating Procedure
DeltaCal Flowmeter
Revision 0

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Title	Name	Signature/Date
Originator	Chris Johnson	Kathy Steerman For Chris Johnson 6/28/11
Monitoring Manager	Kathy Steerman	Kathy Steerman 07/18/11

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Description of Changes	Rev. No	Authorization and Approval	Date

Contents

SECTION 1

SCOPE AND APPLICABILITY

1.1 Principals of Operation

The DeltaCal measures volumetric flow rate by utilizing a pressure transducer to assess the pressure drop caused by air being drawn through a venturi. As the flow rate through the venturi increases, the pressure drop also increases as the square root. A four times increase in pressure drop yields twice the flow rate. A desirable feature of the venturi is that most of the pressure drop created by the instrument is recovered in the expansion section of the venturi. Therefore, measurements are made at nearly the true operating conditions of the sampler.

The signal from the pressure transducer is sent to the microprocessor where it is combined via an algorithm with information from the barometric pressure sensor and the ambient temperature

sensor. To eliminate "fluttering" of the on screen display of volumetric flow rate, the first 20 readings are averaged and then carried on as a rolling average. Barometric pressure and temperature are monitored and displayed on a continuous basis, when the instrument is switched on. An additional temperature probe may be used for the purpose of auditing an FRM sampler's filter temperature. The temperature of the probe is displayed on the screen when it is plugged into the module. A cutaway diagram of the measuring head is shown in Appendix A.

1.2 Sampling Interferences/Precautions

When turning the unit on the measuring head must have no air flowing through it and should be kept out of wind. Every time the instrument is switched on, it re-zeros itself. If air is flowing, that flow rate will be set as zero.

The control module must be in the position in which it is going to be used when switching on (horizontal or vertical). The case houses the pressure transducers, which are subject to the force of gravity. Positional changes can give rise to minor errors. This effect applies to all devices containing pressure transducers.

- In order to perform the most precise measurement audit, it is necessary for the DeltaCal to bein thermal equilibrium with the ambient environment in which the sampler to be audited islocated. The best procedure is to deploy the deltaCal, out of its carrying case, for ten minutesprior to the audit, in the vicinity of the sampler to be audited. Additionally, if the deltaCal issubject to a temperature change of more than five degrees during use, it should be rebooted.

Section 2

OPERATING PROCEDURES

2.1 Audit and Field Deployment Flow Verification

Remove the instrument from its carrying case and plug in the filter temperature probe to the labeled port provided in the end panel. (See Appendix B).

Turn off the sampler to be audited. Remove the "10 micron" louvered inlet. Leave the 12 inch down tube in place. Plunge the DeltaCal measuring head onto the 12-inch down tube. Turn on the DeltaCal, wait for the screen to finish the start up boot, and then turn on the air sampler.

Note: The flow resistance of the deltaCal head may cause momentary instability in the airsampler's flow control circuit. Once the air sampler's main screen flow rate indicator stabilizes, the reading may be taken.

Once the dynamic reading of flow rate is completed, the air sampler pump may be shut down per manufacturer's instructions and the filter temperature sensor may be audited. Open the filter cassette clamping mechanism and remove the cassette. You can now view the filter temperature sensor. Hold the probe of the DeltaCal filter temperature sensor within 1 cm. of the sampler's sensor without actually touching it. Shield both sensors from direct sunlight. Read both the sampler's indicated filter temperature and the DeltaCal's probe temperature and record them.

2.2 PM10 Instrument Calibration

The procedures and calculations for using the DeltaCal to calibrate a sampler are the same as an audit, except the flow rate tolerance is $\pm$2% rather than $\pm$4% as allowed for an audit. While full EPA procedures are carefully spelled out in the FRM, it is important to note that the flow rate should be calibrated at the operational point and at 10% above and below that point, as indicated below.

EPA FRM Calibration Points, and ± 2% allowable tolerance

- Standard Flow Rate - 16.67 lpm, 16.34 - 17.00
- 10% Below Standard - 15.00 lpm, 14.7 - 15.30
- 10% Above Standard - 18.30 lpm, 17.97 - 18.71

2.3 Data Records and Management

Each PM10 monitoring instrument has an associated set of audit and calibration forms. Volumetric flow measurements must be recorded on the appropriate form for each portable deployment/retrieval or routine audit and calibration event.

SECTION 3

MAINTENANCE PROCEDURES

Beyond battery replacement, the only part of the instrument requiring attention is the flow passage through the venturi. After long periods of use, some atmospheric dust can coat the interior flow surfaces. The presence of such a deposit may be determined by viewing the interior of the venturi under bright light, direct overhead sunlight being preferable. Holding the instrument in the inverted position, glance into the interior, seeking any discoloration of the white or silver surface. If it is determined that cleaning is required, refer to Appendix A.

3.1 Cleaning the Venturi

Remove the three knurled thumbscrews from the side of the measuring head and set aside. Grasp the body of the instrument, under the shoulder, in one hand and the venturi in the other. Gently pull the two sections apart. Avoid any pulling force to the Gill Screen. Set aside the upper section of the measuring head with the Gill screen attached and you are left with the venturi body shown in Appendix C. Rinse the entire venturi body in warm soapy water. Any deposits, which are not floated away, may be removed externally with a soft cloth. If internal deposits are not removed by soaking, the best procedure is to immerse the unit in an ultrasonic bath containing soapy water. If an ultrasonic bath is not available, judicious use of a pipe cleaner is recommended.

Following cleaning, the venturi may be dried using compressed air, or if not available, allowed to air dry. Be especially certain to blow all liquid out of the pressure taps and their attendant passages.

Inspect the silicone rubber "O" rings on each pressure tap. If any damage is observed, replace all four. Prior to reassembly, lubricate the "O" rings with a wipe of light grease. Prior to reinstalling the venturi into the body of the instrument, note that there is only one rotational position in which both the pressure taps and the three screw holes on the body can be aligned. Hence, incorrect assembly is impossible. Having determined the correct rotational position for reassembly, gently insert the venturi section into the recess, until the tips of the pressure taps bottom out. Rotate the venturi section gently back and forth (clockwise/counterclockwise) until the tips of the pressure taps go into the recesses provided. Slide the venturi longitudinally back and forth until the three screw holes line up and reinstall the three thumb screws, hand tight.

The two "O" rings in the socket of the instrument, which fits over the 12 inch down tube, during calibration procedures, should be frequently inspected for wear and tearing. They should be replaced at the first sign of wear and always kept lightly greased for ease of use.

SECTION 4

REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA/600/B-07-001 April 2007.

BGI USA DeltaCal Operator's Manual, V. 1.6.3.

APPENDIX A

Sectional View of Flow Measuring Head

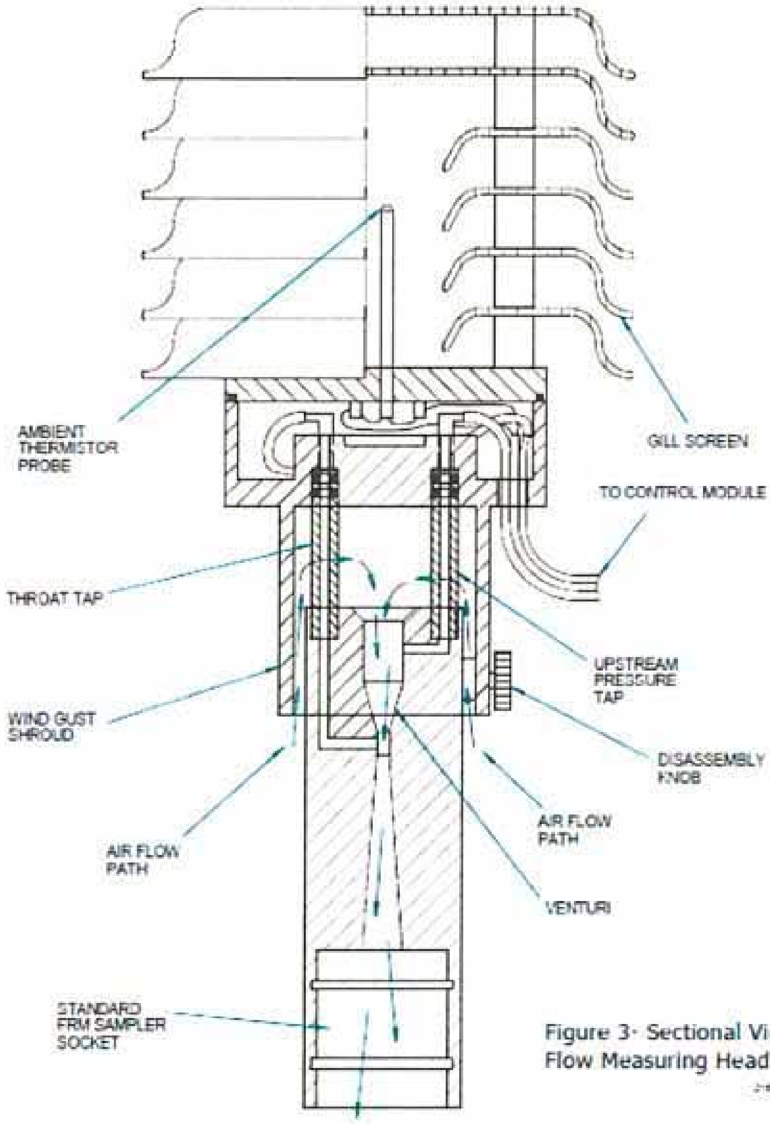
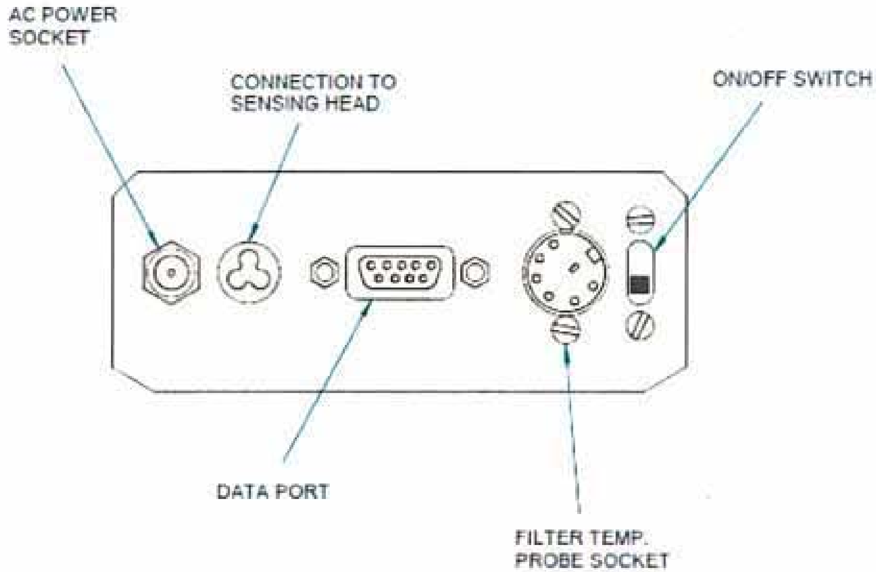


Figure 3- Sectional View of Flow Measuring Head

Sectional View of Flow Measuring Head

APPENDIX B

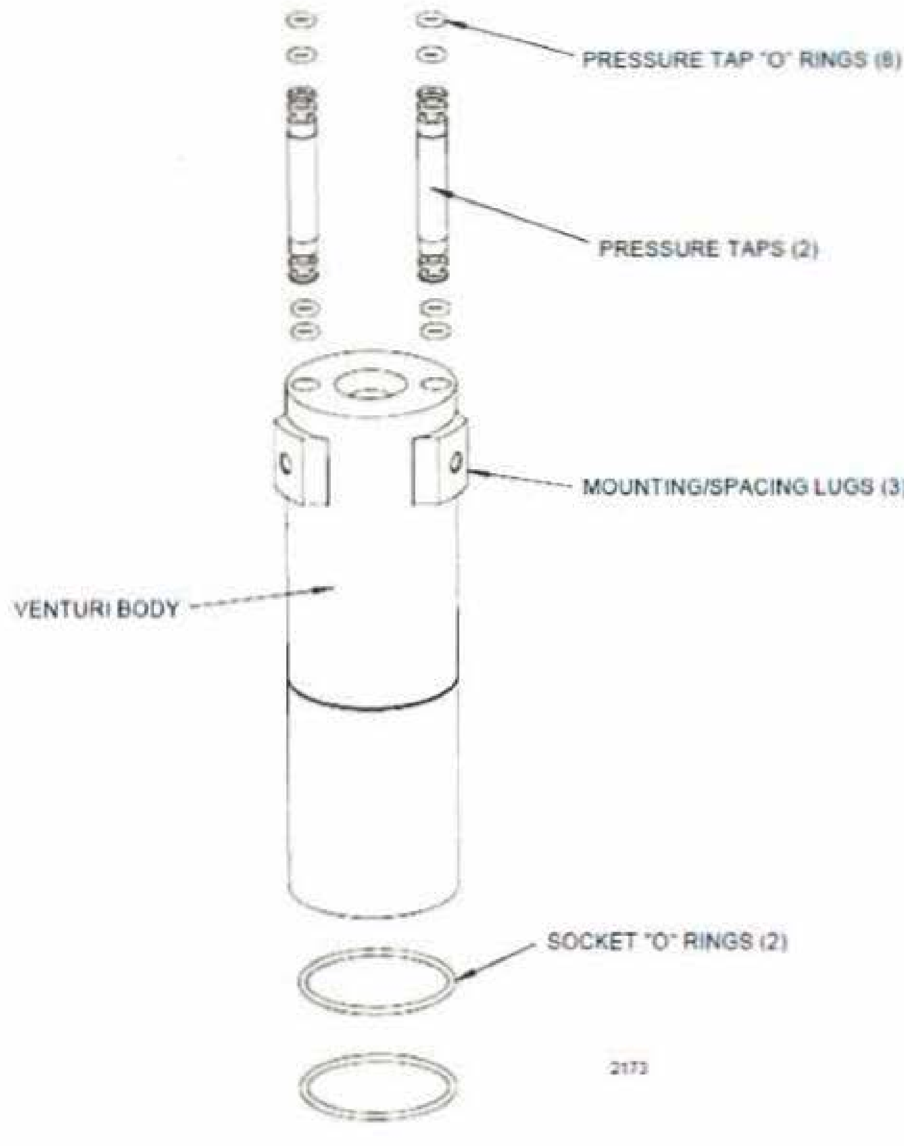
DeltaCal Control Panel



DeltaCal Control Panel

APPENDIX C

Details of Venturi Body



Details of Venturi Body

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Standard Operating Procedure

SOP QAQC-0001

Performing the 3 levels of QA/QC checks, Data Processing, and Met Summaries Software

Revision 0

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SECTION 1

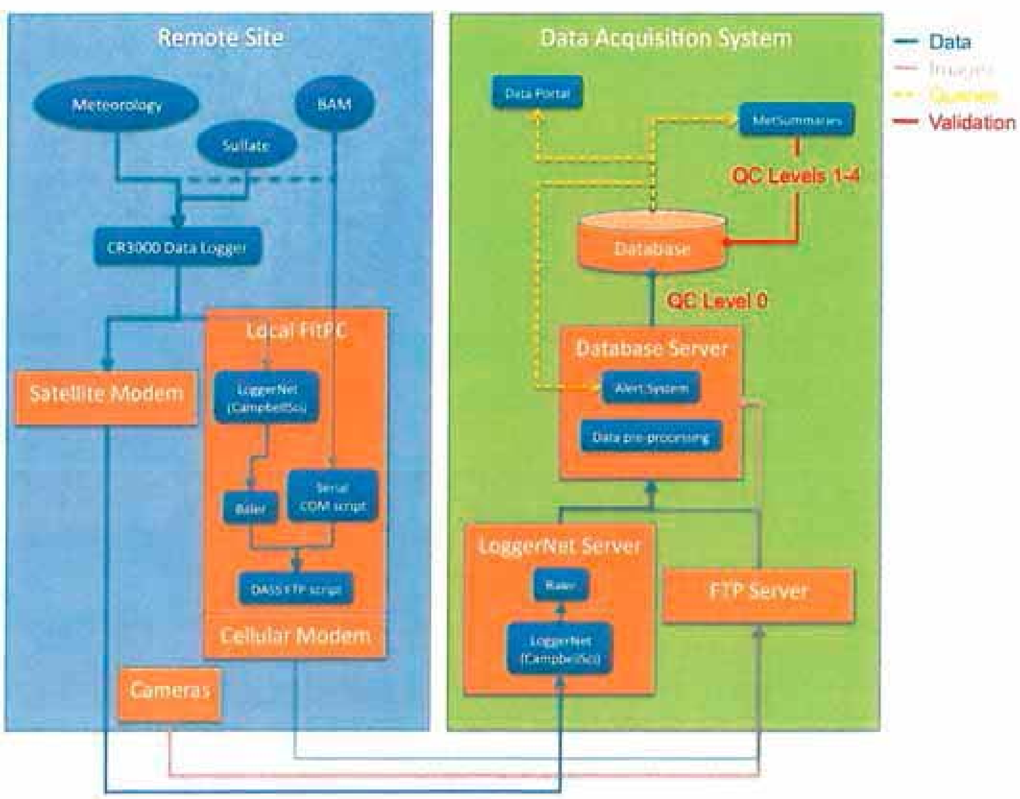
SCOPE AND APPLICABILITY

This document provides a description of the automatic transmittal of data into the Air Sciences server/database system (DASS), automatic alerts, and the processes and steps taken to perform Level 0 through Level 3 quality assurance, quality control, and data validation on all data prior to reporting or data submission.

1.1 Principals of Operation

Meteorological data is automatically downloaded remotely via cellular broadband modem every hour. Data transfer to the DASS is set up using Campbell Scientific Loggernet (V 3.4.1) software for the parameters collected using a Campbell Scientific CR3000 datalogger. Other particulate and air quality instrumentation are downloaded hourly using on-site remote computers, and that data is transferred to the DASS using site-specific FTP data transfer scripts for each parameter. This download method is via direct serial, so no analog conversions are necessary. An example of the overall data pathway is illustrated below.

Figure 1: Data Transfer Flowchart



1.2 Equipment and Supplies

- Laptop or Desktop Computer
- Capable internet connection

1.3 QA Operational Procedures

1.3.1 Level 0 QA/QC

Level 0 Quality control is performed using the DASS's automatic filters. These filters are defined primarily by the ranges of the sensors, although other flags and filters may be used specific to certain instrument parameters. A summary of Level 0 review is as follows:

- Data is received at FTP server
- Data is filtered before population into DASS
- Data outside manufacturer's recommended is invalidated.
- Data that is outside of usual limits is flagged.
- AQ Summary email is sent @ 0700
- ID Summary email is sent @ 0700

Based on the above parameters, each site will generate a summary email to responsible parties every morning at 6:00 a.m. These summary emails are a first alert to allow the analyst to identify deficiencies, or know immediately if the data did not populate into the database as expected. An example of a summary email is seen below in Figures 2 and 3.

The AQ/Met Master Daily Summary example email (Figure 2) will identify how much data for each parameter was populated in the last 24 hours. On the left side of each summary is the "Percent Recovery" section. Green boxes with 100 mean all data is present, and no data was outside the basic parameters set for each sensor. Yellow boxes show small amounts of data missing (possibly a flow audit), and the box will be red if the data present is less than 50 percent. On the right side of each summary is the "Count of Flagged Data" section. This alerts the analyst to parameters that were automatically invalidated by the DASS. For example, wind speed should not be less than 0 m/s, or greater than 65 m/s. Anything outside this range will be flagged as yellow in the "Count of Flagged Data" section. Air Quality instrumentation will be flagged every day for 1 or two hours for nightly zero and span checks.

The Invalid Data Detail Summary example email (Figure 3) will identify why each data was flagged in the "Count of Flagged Data" section. This allows the analyst a to see at a glance why data was invalidated or flagged by the DASS, and whether or not it warrants further investigation. The parameters set for each sensor can be found in Appendix A.

Figure 2: AQ/Met Master Daily Summary

05/10/10: SX-EW Met Summary, Last Seven Days

	Percent Recovery							Count of Flagged Data (Out of 96)						
	05/10	05/09	05/08	05/07	05/06	05/05	05/04	05/10	05/09	05/08	05/07	05/06	05/05	05/04
Wind Spd 10m	100	100	100	100	100	100	100	0	0	0	0	0	0	0
Wind Dir 10m	100	100	100	100	100	100	100	0	0	0	0	0	0	0
Ambient T	100	100	100	100	100	100	100	0	0	0	0	0	0	0
RH	100	100	100	100	100	100	100	0	0	0	0	0	0	0
BP	100	100	100	100	100	100	100	0	0	0	0	0	0	0
Voltage	100	100	100	100	100	100	100	0	0	0	0	0	0	0

05/10/10: SX-EW BAM Summary, Last Seven Days

	Percent Recovery							Count of Flagged Data (Out of 24)						
	05/10	05/09	05/08	05/07	05/06	05/05	05/04	05/10	05/09	05/08	05/07	05/06	05/05	05/04
Conc	95	100	100	100	100	100	100	0	0	0	0	0	0	0
Flow	95	100	100	100	100	100	100	0	0	0	0	0	0	0
*Expect occasional 1-2 invalid writes per day due to flow/span checks														

05/10/10: SX-EW SO4 Summary, Last Seven Days

	Percent Recovery							Count of Flagged Data (Out of 144)						
	05/10	05/09	05/08	05/07	05/06	05/05	05/04	05/10	05/09	05/08	05/07	05/06	05/05	05/04
SO4 Conc	100	100	100	100	100	100	100	2	2	2	2	2	2	2
SO2 Conc	100	100	100	100	100	100	100	3	3	3	3	3	3	3
Spl_Flow	100	100	100	100	100	100	100	3	3	3	3	3	3	3
*Expect regular 2-3 invalid writes per day due to flow/span checks.														

Figure 3: Invalid Data Detail Summary

SXEW, Table140, SO4_Cycle 05 10 2010

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
:00	-33.95	-0.094	0.671	-1.173	0.178	-0.079	0.453	0.656	1.312	-1.459	-1.153	-1.356	-0.465	-0.571	1.271	2.051	1.067	0.094	-1.43	0.17	1.29	-0.735	0.381	-0.05
:10	-7999.0	0.399	-0.519	0.389	0.425	-0.844	-0.064	0.738	2.099	-1.287	-1.184	-0.911	-0.915	0.094	-0.324	2.818	0.197	-1.282	-0.92	0.018	2.226	-0.905	-0.355	-0.668
:20	-7999.0	-0.06	-0.808	0.7	-0.498	-0.315	-0.711	0.298	1.984	-1.261	-0.932	-1.131	-0.577	-0.304	-0.788	1.35	-0.718	1.069	-0.648	-0.5	0.578	-0.658	-1.06	-0.078
:30	-0.779	-0.624	0.393	0.529	0.012	1.368	-1.055	-0.021	1.392	-1.187	-1.371	-0.581	-0.998	0.049	-1.329	0.187	-1.187	1.674	-1.034	-0.949	0.624	0.087	-0.094	0.888
:40	-0.347	-0.331	-0.761	-0.657	1.179	1.653	-0.658	0.213	0.439	-1.009	-0.368	-0.226	-0.94	2.133	-0.78	-1.179	1.652	-0.228	-0.392	-0.737	0.04	0.301	0.494	1.393
:50	-0.529	0.728	-0.335	-0.183	0.742	0.345	-0.202	0.534	-1.044	-0.78	-0.843	-0.553	-0.844	2.278	0.378	-0.089	0.981	-1.57	-0.202	0.44	-0.835	0.378	1.217	-0.199

SXEW, Table140, SO2_Direct 05 10 2010

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
:00	-27.33	5.832	5.889	5.873	6.067	6.277	6.347	6.413	6.277	6.248	6.334	6.227	6.313	6.164	5.865	5.604	5.319	5.8	5.143	5.497	5.77	5.837	5.83	5.834
:10	-7999.0	5.914	5.891	5.867	6.066	6.052	6.362	6.34	6.281	6.183	6.289	6.097	6.117	6.033	5.811	5.537	5.237	5.035	5.292	5.633	5.807	5.79	5.793	5.738
:20	-7999.0	5.799	5.868	6.094	6.089	5.993	6.373	6.38	6.233	6.388	6.189	6.197	6.384	6.068	5.619	5.33	5.213	5.157	5.228	5.82	5.736	5.788	5.703	5.677
:30	5.912	5.902	5.934	6.126	6.051	5.884	6.278	6.263	6.403	6.431	6.258	6.173	6.074	6.042	5.566	5.279	5.029	5.306	5.208	5.765	5.749	5.789	5.625	5.735
:40	5.96	5.866	5.9	5.958	6.173	5.917	6.23	6.434	6.484	6.302	6.133	6.395	6.255	5.929	5.498	5.082	5.045	5.315	5.372	5.824	5.81	5.743	5.735	5.785
:50	5.897	5.858	5.888	6.041	6.157	6.015	6.369	6.268	6.25	6.356	6.198	6.217	6.143	5.869	5.462	5.182	5.218	5.254	5.482	5.8	5.792	5.78	5.731	5.849

SXEW, Table140, Sample_Flow 05 10 2010

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
:00	-32.88	0.457	0.456	0.457	0.459	0.459	0.459	0.462	0.462	0.461	0.461	0.461	0.46	0.46	0.458	0.456	0.454	0.453	0.453	0.454	0.456	0.457	0.457	0.457
:10	-7999.0	0.457	0.457	0.458	0.459	0.459	0.46	0.462	0.462	0.461	0.461	0.46	0.46	0.459	0.458	0.456	0.454	0.452	0.453	0.454	0.456	0.457	0.457	0.457
:20	-7999.0	0.457	0.457	0.458	0.459	0.459	0.46	0.462	0.461	0.461	0.461	0.46	0.46	0.459	0.457	0.455	0.454	0.452	0.453	0.453	0.457	0.457	0.457	0.457
:30	0.457	0.457	0.457	0.458	0.459	0.459	0.461	0.462	0.461	0.461	0.461	0.46	0.46	0.459	0.457	0.455	0.454	0.452	0.453	0.453	0.456	0.457	0.457	0.457
:40	0.457	0.457	0.457	0.458	0.459	0.459	0.461	0.462	0.461	0.461	0.461	0.46	0.46	0.459	0.457	0.455	0.453	0.452	0.453	0.458	0.457	0.457	0.457	0.457

1.3.2 Level 1 QA/QC

Level 1 data validation involves quantitative and qualitative reviews for accuracy, completeness, and internal consistency. Quantitative checks are performed by DASS software screening programs, and qualitative checks are performed by meteorologists or field staff who manually review the data for outliers and issues. Quality control flags are assigned, as necessary, to indicate the data quality. Data are only considered validated at Level 1 after final audit reports have been issued and any adjustments, changes, or modifications to the data have been made.

Level 1 QC is performed daily. Each day, the following tasks should be completed for each site for each parameter.

- Follow up on any Level 0 email alerts.
- Log in to each site and review real-time data using the "Numeric" function on Loggernet. Assure each parameter is within normal ranges by looking at real-time 2-second scans of each sensor.
- Backfill any missing data as necessary and follow up on any missing data that can't be backfilled.
- Contact site operator with issues
- Review and complete 15 minute comparative data in Site Checks
- Journal all issues in DASS
- Certify data in database to Level 1.
- Review all data from all sites (last 24 hours worth of data). Check against other sites when possible (see below procedures).
- Notify Project Manager of any National Ambient Air Quality Standard (NAAQS) or project-specific exceedances immediately.

To certify data to Level 1 using MetSummaries, select the project (1), then the parameter you wish to review (2). Identify the date range (typically 24 to 48 hours for level 1) (3)and then press "Generate Plot" (4). Review the plot for outliers. If there are any outliers, the data must be investigated further, or invalidated. If no outliers are present, the data may be updated to QC Level 1 by selecting that level in the QC Level box and pressing the "Update QC Level and Commit" button (5). Once this is performed, you must Commit changes to DASS to save it in the database (6). An example of wind speed review can be seen in Figure 4 and 5.

Figure 4: Example of beginning a level 1 data QA in MetSummaries

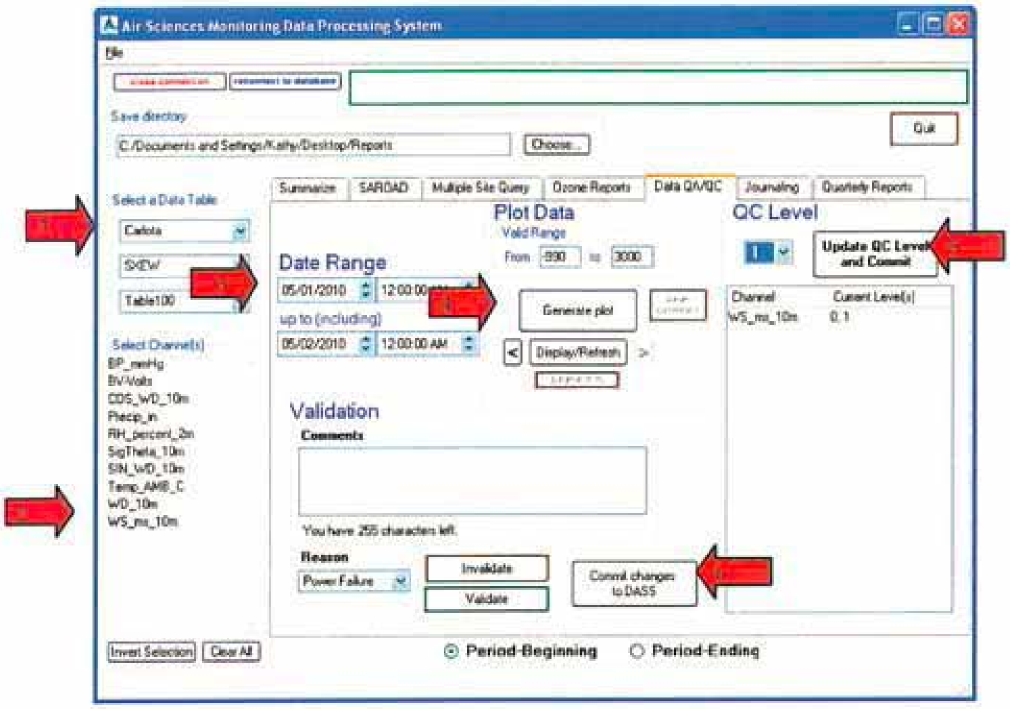
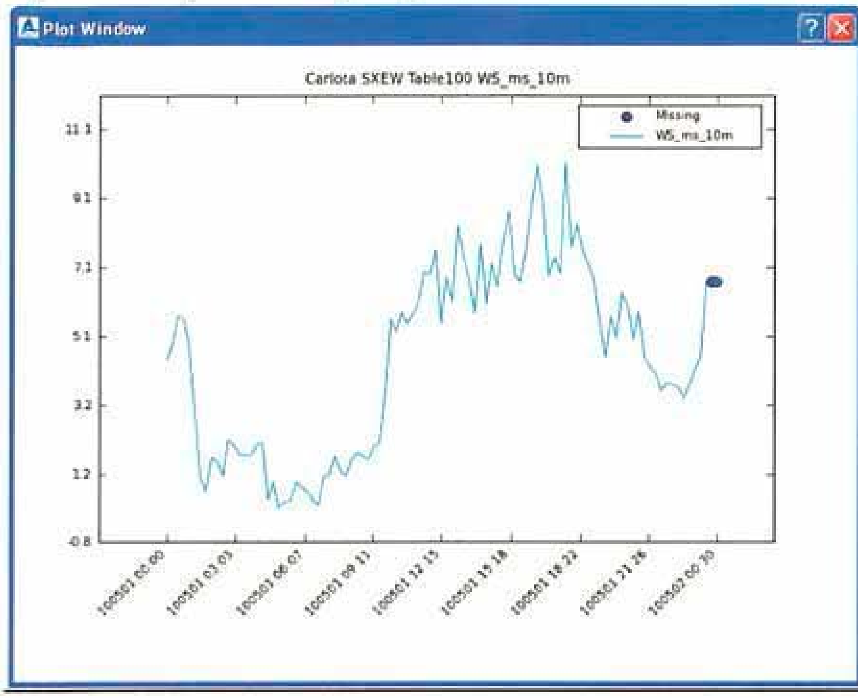


Figure 5: Example of Wind Speed plot for Level 1 review.



1.3.3 Level 2 QA/QC

Level 2 data validation involves comparisons with independent data sets, and reviewing larger sets of data. This function includes, for example, making comparisons to other meteorological or ambient pollution data or upper-air measurement systems. A different person will perform Level 2 data QC than the person who performed the week's Level 1 QC for each project. This is to assure a second set of eyes and a fresh look on the data.

Level 2 QC is performed weekly, preferably at the end of the week. Each week, the following tasks should be completed for each site for each parameter.

- Perform all bulleted tasks listed under Level 1, for the full week.
- Invalidate any data from site visits, audits, calibrations, or any other disruption of data.
- Journal any additional issues found.
- Communicate additional issues with original Level 1 reviewer.
- Perform a secondary review of all site checks for the week.
- Scan and file site check forms.
- Review all data from all sites (last week's worth of data). Check against other sites when possible (see below procedures). Be cognizant of trends, outliers, and sensor- or instrument-specific nuances.

To certify data to Level 2 using MetSummaries, select the project (1), then the parameter you wish to review (2). Identify the date range (a minimum of one week) (3)and then press "Generate Plot" (4). Review the plot for outliers. Compare sensors as well. In this example, precip and relative humidity are

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Standard Operating Procedure

SOP QAQC-0001

Performing the 3 levels of QA/QC checks, Data Processing, and Met Summaries Software

Revision 0

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SECTION 1

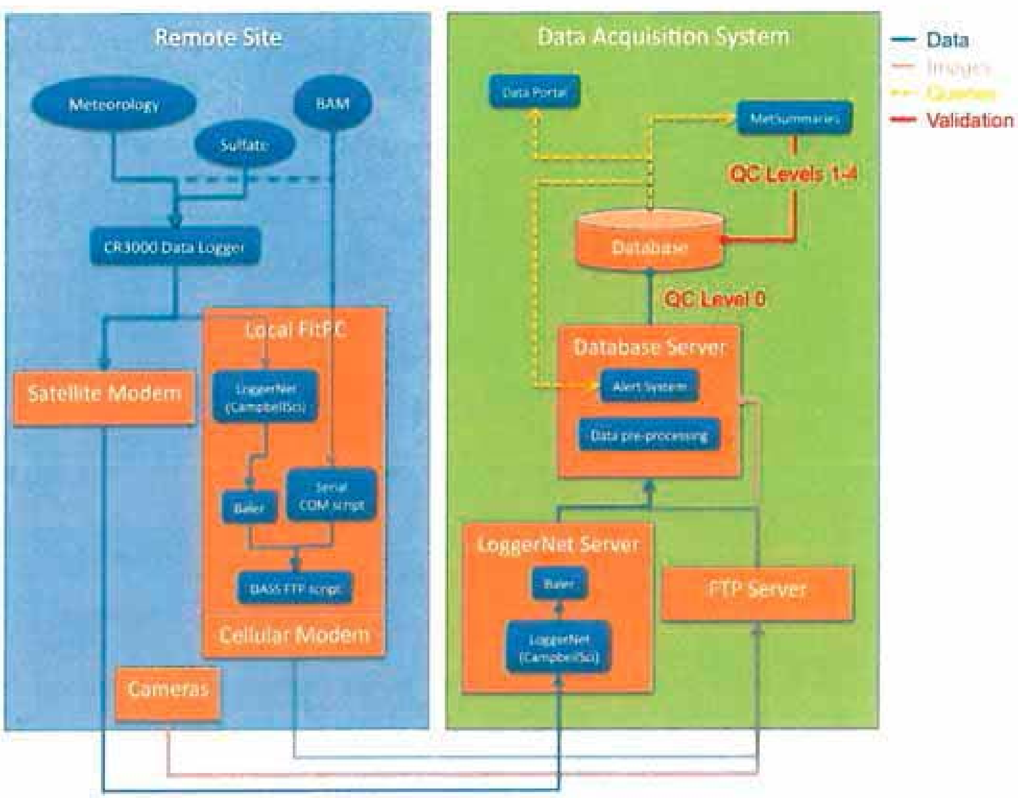
SCOPE AND APPLICABILITY

This document provides a description of the automatic transmittal of data into the Air Sciences server/database system (DASS), automatic alerts, and the processes and steps taken to perform Level 0 through Level 3 quality assurance, quality control, and data validation on all data prior to reporting or data submission.

1.1 Principals of Operation

Meteorological data is automatically downloaded remotely via cellular broadband modem every hour. Data transfer to the DASS is set up using Campbell Scientific Loggernet (V 3.4.1) software for the parameters collected using a Campbell Scientific CR3000 datalogger. Other particulate and air quality instrumentation are downloaded hourly using on-site remote computers, and that data is transferred to the DASS using site-specific FTP data transfer scripts for each parameter. This download method is via direct serial, so no analog conversions are necessary. An example of the overall data pathway is illustrated below.

Figure 1: Data Transfer Flowchart



1.2 Equipment and Supplies

- Laptop or Desktop Computer
- Capable internet connection

1.3 QA Operational Procedures

1.3.1 Level 0 QA/QC

Level 0 Quality control is performed using the DASS's automatic filters. These filters are defined primarily by the ranges of the sensors, although other flags and filters may be used specific to certain instrument parameters. A summary of Level 0 review is as follows:

- Data is received at FTP server
- Data is filtered before population into DASS
- Data outside manufacturer's recommended is invalidated.
- Data that is outside of usual limits is flagged.
- AQ Summary email is sent @ 0700
- ID Summary email is sent @ 0700

Based on the above parameters, each site will generate a summary email to responsible parties every morning at 6:00 a.m. These summary emails are a first alert to allow the analyst to identify deficiencies, or know immediately if the data did not populate into the database as expected. An example of a summary email is seen below in Figures 2 and 3.

The AQ/Met Master Daily Summary example email (Figure 2) will identify how much data for each parameter was populated in the last 24 hours. On the left side of each summary is the "Percent Recovery" section. Green boxes with 100 mean all data is present, and no data was outside the basic parameters set for each sensor. Yellow boxes show small amounts of data missing (possibly a flow audit), and the box will be red if the data present is less than 50 percent. On the right side of each summary is the "Count of Flagged Data" section. This alerts the analyst to parameters that were automatically invalidated by the DASS. For example, wind speed should not be less than 0 m/s, or greater than 65 m/s. Anything outside this range will be flagged as yellow in the "Count of Flagged Data" section. Air Quality instrumentation will be flagged every day for 1 or two hours for nightly zero and span checks.

The Invalid Data Detail Summary example email (Figure 3) will identify why each data was flagged in the "Count of Flagged Data" section. This allows the analyst a to see at a glance why data was invalidated or flagged by the DASS, and whether or not it warrants further investigation. The parameters set for each sensor can be found in Appendix A.

Figure 2: AQ/Met Master Daily Summary

05/10/10: SX-EW Met Summary, Last Seven Days

	Percent Recovery							Count of Flagged Data (Out of 96)						
	05/10	05/09	05/08	05/07	05/06	05/05	05/04	05/10	05/09	05/08	05/07	05/06	05/05	05/04
Wind Spd 10m	100	100	100	100	100	100	100	0	0	0	0	0	0	0
Wind Dir 10m	100	100	100	100	100	100	100	0	0	0	0	0	0	0
Ambient T	100	100	100	100	100	100	100	0	0	0	0	0	0	0
RH	100	100	100	100	100	100	100	0	0	0	0	0	0	0
BP	100	100	100	100	100	100	100	0	0	0	0	0	0	0
Voltage	100	100	100	100	100	100	100	0	0	0	0	0	0	0

05/10/10: SX-EW BAM Summary, Last Seven Days

	Percent Recovery							Count of Flagged Data (Out of 24)						
	05/10	05/09	05/08	05/07	05/06	05/05	05/04	05/10	05/09	05/08	05/07	05/06	05/05	05/04
Conc	95	100	100	100	100	100	100	0	0	0	0	0	0	0
Flow	95	100	100	100	100	100	100	0	0	0	0	0	0	0

*Expect occasional 1-2 invalid writes per day due to flow/span checks.

05/10/10: SX-EW SO4 Summary, Last Seven Days

	Percent Recovery							Count of Flagged Data (Out of 144)						
	05/10	05/09	05/08	05/07	05/06	05/05	05/04	05/10	05/09	05/08	05/07	05/06	05/05	05/04
SO4 Conc.	100	100	100	100	100	100	100	2	2	2	2	2	2	2
SO2 Conc.	100	100	100	100	100	100	100	3	3	3	3	3	3	3
Spl_Flow	100	100	100	100	100	100	100	3	3	3	3	3	3	3

*Expect regular 2-3 invalid writes per day due to flow/span checks.

Figure 3: Invalid Data Detail Summary

SXEW, Table140, SO4_Cycle 05 10 2010

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
:00	-33.95	-0.094	0.671	-1.175	0.175	-0.079	0.453	0.636	1.312	-1.459	-1.133	-1.388	-0.463	-0.571	1.271	2.031	1.067	0.094	-1.43	0.17	1.29	-0.735	0.181	-0.05
:10	-7999.0	0.399	-0.519	0.389	0.425	-0.844	-0.084	0.758	2.099	-1.287	-1.184	-0.911	-0.915	0.094	-0.324	2.818	0.197	-1.282	-0.92	0.018	2.228	-0.905	-0.335	-0.868
:20	-7999.0	-0.06	-0.808	0.7	-0.493	-0.115	-0.711	0.298	1.884	-1.261	-0.832	-1.131	-0.577	-0.304	-0.788	1.35	-0.718	1.069	-0.646	-0.5	0.878	-0.658	-1.06	-0.078
:30	-0.779	-0.624	0.393	0.529	0.012	1.268	-1.055	-0.021	1.592	-1.187	-1.371	-0.381	-0.998	0.049	-1.329	0.187	-1.187	1.674	-1.034	-0.949	0.624	0.087	-0.094	0.833
:40	-0.147	-0.331	0.761	-0.687	1.179	1.683	-0.658	0.215	0.419	-1.059	-0.568	-0.238	-0.94	2.133	-0.75	-1.179	1.652	-0.228	-0.592	-0.757	0.04	0.301	0.494	1.393
:50	-0.329	0.728	-0.333	-0.188	0.742	0.345	-0.202	0.334	-1.044	-0.78	-0.845	-0.551	-0.644	2.278	0.378	-0.069	0.981	-1.37	-0.202	0.44	-0.835	0.378	1.227	-0.199

SXEW, Table140, SO2_Direct 05 10 2010

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
:00	-27.33	5.832	5.889	5.873	6.087	6.277	6.347	6.413	6.277	6.248	6.334	6.227	6.313	6.164	5.863	5.604	5.319	5.0	5.243	5.497	5.77	5.837	5.83	5.524
:10	-7999.0	5.934	5.891	5.887	6.066	6.082	6.362	6.34	6.231	6.185	6.239	6.097	6.117	6.033	5.811	5.537	5.237	5.033	5.292	5.633	5.807	5.79	5.783	5.728
:20	-7999.0	5.799	5.868	6.094	6.089	5.993	6.375	6.38	6.231	6.388	6.339	6.197	6.184	6.068	5.629	5.33	5.218	5.137	5.238	5.52	5.756	5.788	5.703	5.677
:30	5.912	5.902	5.914	6.128	6.031	5.884	6.278	6.265	6.403	6.431	6.238	6.373	6.074	6.042	5.366	5.179	5.059	5.306	5.208	5.785	5.749	5.769	5.823	5.723
:40	5.98	5.886	5.9	5.988	6.173	5.927	6.23	6.434	6.484	6.302	6.133	6.193	6.235	5.919	5.495	5.082	5.045	5.315	5.372	5.524	5.81	5.743	5.733	5.793
:50	5.897	5.838	5.888	6.041	6.137	6.023	6.369	6.288	6.23	6.356	6.198	6.217	6.243	5.869	5.462	5.182	5.218	5.234	5.482	5.5	5.792	5.78	5.751	5.849

SXEW, Table140, Sample_Flow 05 10 2010

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
:00	-32.88	0.437	0.436	0.437	0.439	0.459	0.459	0.462	0.462	0.461	0.461	0.461	0.46	0.46	0.458	0.456	0.454	0.453	0.453	0.454	0.456	0.457	0.457	0.457
:10	-7999.0	0.437	0.437	0.438	0.439	0.459	0.46	0.462	0.462	0.461	0.461	0.46	0.46	0.459	0.458	0.456	0.454	0.452	0.453	0.454	0.456	0.457	0.457	0.457
:20	-7999.0	0.437	0.437	0.438	0.439	0.459	0.46	0.462	0.461	0.461	0.461	0.46	0.46	0.459	0.457	0.455	0.454	0.452	0.453	0.455	0.457	0.457	0.457	0.457
:30	0.437	0.437	0.437	0.438	0.439	0.459	0.461	0.462	0.461	0.461	0.461	0.46	0.46	0.459	0.457	0.455	0.454	0.452	0.453	0.455	0.456	0.457	0.457	0.457
:40	0.437	0.437	0.437	0.438	0.439	0.459	0.461	0.462	0.461	0.461	0.461	0.46	0.46	0.459	0.457	0.455	0.453	0.452	0.453	0.456	0.457	0.457	0.457	0.457

1.3.2 Level 1 QA/QC

Level 1 data validation involves quantitative and qualitative reviews for accuracy, completeness, and internal consistency. Quantitative checks are performed by DASS software screening programs, and qualitative checks are performed by meteorologists or field staff who manually review the data for outliers and issues. Quality control flags are assigned, as necessary, to indicate the data quality. Data are only considered validated at Level 1 after final audit reports have been issued and any adjustments, changes, or modifications to the data have been made.

Level 1 QC is performed daily. Each day, the following tasks should be completed for each site for each parameter.

- Follow up on any Level 0 email alerts.
- Log in to each site and review real-time data using the "Numeric" function on Loggernet. Assure each parameter is within normal ranges by looking at real-time 2-second scans of each sensor.
- Backfill any missing data as necessary and follow up on any missing data that can't be backfilled.
- Contact site operator with issues
- Review and complete 15 minute comparative data in Site Checks
- Journal all issues in DASS
- Certify data in database to Level 1.
- Review all data from all sites (last 24 hours worth of data). Check against other sites when possible (see below procedures).
- Notify Project Manager of any National Ambient Air Quality Standard (NAAQS) or project-specific exceedances immediately.

To certify data to Level 1 using MetSummaries, select the project (1), then the parameter you wish to review (2). Identify the date range (typically 24 to 48 hours for level 1) (3)and then press "Generate Plot" (4). Review the plot for outliers. If there are any outliers, the data must be investigated further, or invalidated. If no outliers are present, the data may be updated to QC Level 1 by selecting that level in the QC Level box and pressing the "Update QC Level and Commit" button (5). Once this is performed, you must Commit changes to DASS to save it in the database (6). An example of wind speed review can be seen in Figure 4 and 5.

Figure 4: Example of beginning a level 1 data QA in MetSummaries

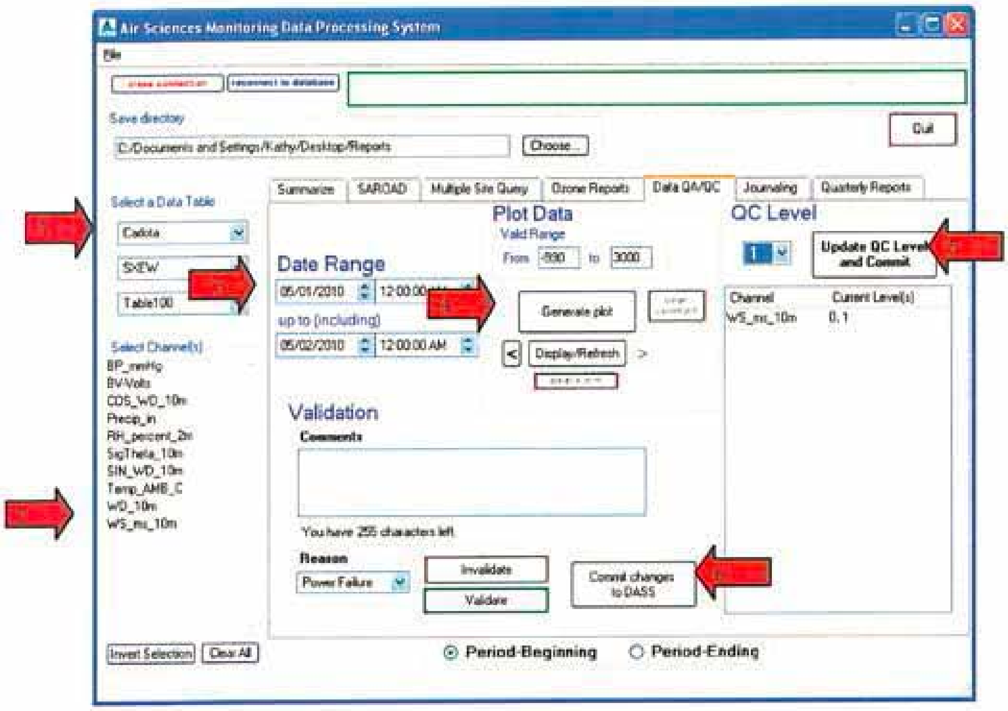
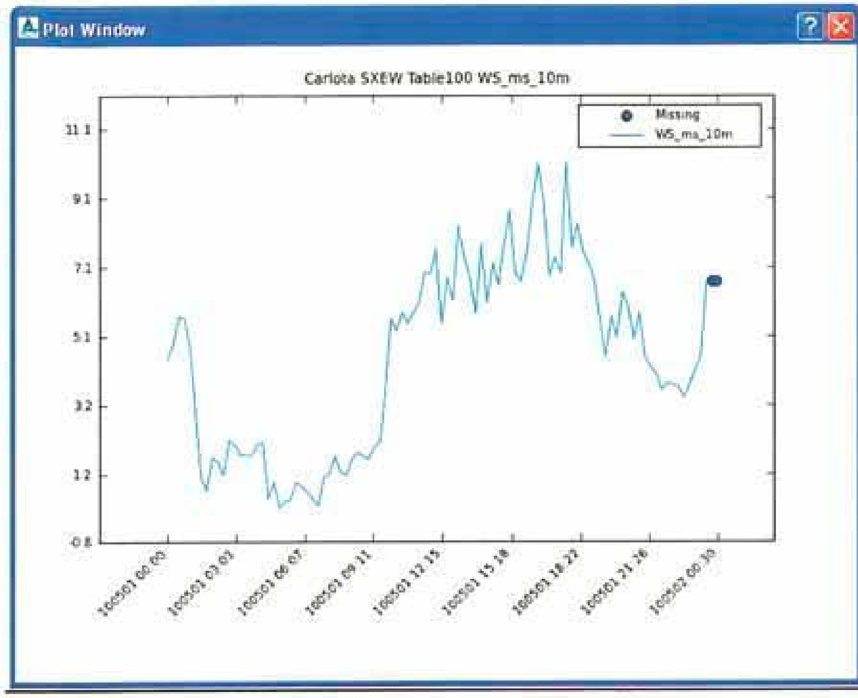


Figure 5: Example of Wind Speed plot for Level 1 review.



1.3.3 Level 2 QA/QC

Level 2 data validation involves comparisons with independent data sets, and reviewing larger sets of data. This function includes, for example, making comparisons to other meteorological or ambient pollution data or upper-air measurement systems. A different person will perform Level 2 data QC than the person who performed the week's Level 1 QC for each project. This is to assure a second set of eyes and a fresh look on the data.

Level 2 QC is performed weekly, preferably at the end of the week. Each week, the following tasks should be completed for each site for each parameter.

- Perform all bulleted tasks listed under Level 1, for the full week.
- Invalidate any data from site visits, audits, calibrations, or any other disruption of data.
- Journal any additional issues found.
- Communicate additional issues with original Level 1 reviewer.
- Perform a secondary review of all site checks for the week.
- Scan and file site check forms.
- Review all data from all sites (last week's worth of data). Check against other sites when possible (see below procedures). Be cognizant of trends, outliers, and sensor- or instrument-specific nuances.

To certify data to Level 2 using MetSummaries, select the project (1), then the parameter you wish to review (2). Identify the date range (a minimum of one week) (3)and then press "Generate Plot" (4). Review the plot for outliers. Compare sensors as well. In this example, precip and relative humidity are plotted together to see if RH climbs during precip events. Compare wind speed and wind direction sensors at separate heights to make sure they track, etc. If there are any outliers, the data must be investigated further, or invalidated. If no outliers are present, the data may be updated to QC Level 2 by selecting that level in the QC Level box and pressing the "Update QC Level and Commit" button (5). Once this is performed, you must Commit changes to DASS to save it in the database (6). An example of precipitation and relative humidity review can be seen in Figure 6 and 7.

Figure 6: Example of beginning a level 2 data QA in MetSummaries

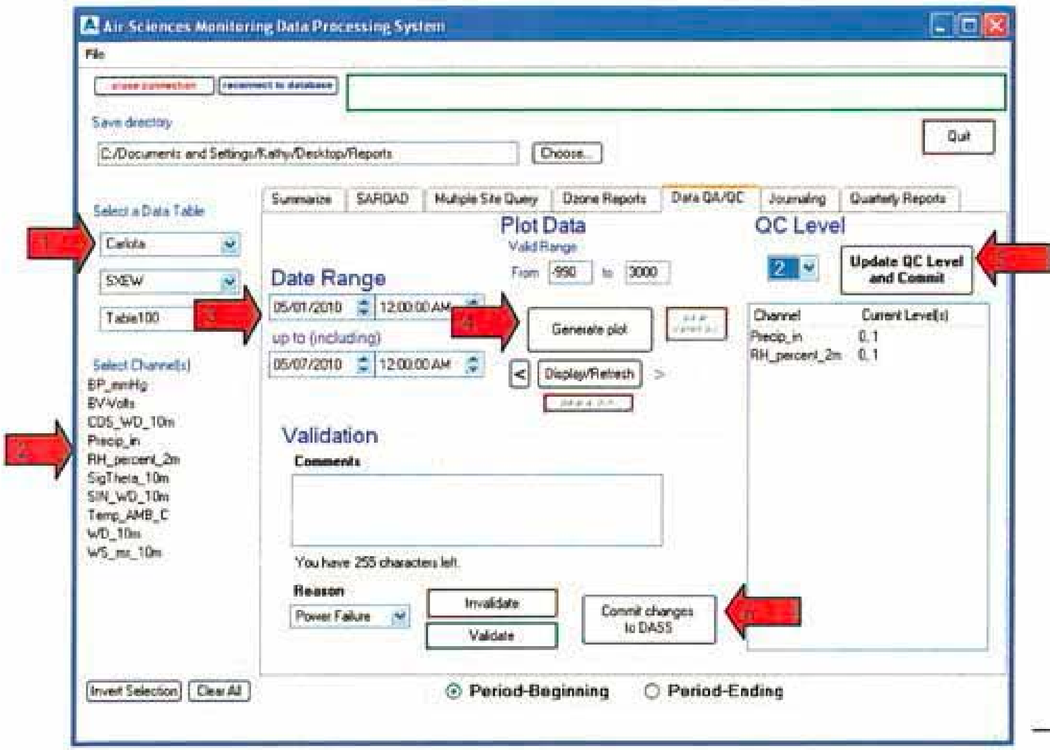
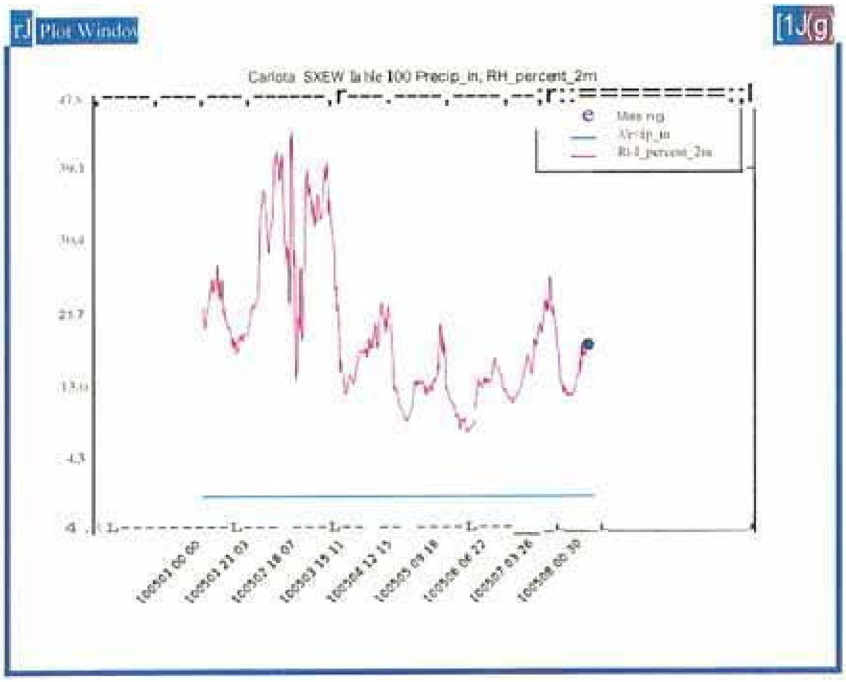


Figure 7:Example of Relative Humidity and Precipitation plot for Level 2 review



1.3.4 Level 3 QA/QC

Level 3 data validation involves a more detailed analysis and final screening of the data. The purpose of the final step is to verify that there are no inconsistencies among the related data (such as issues with scalar and vector data or inconsistencies with relative humidity during precipitation events, etc.). Graphics programs may be run to examine the overall consistency among related data (i.e., checking diurnal patterns against other parameters or reviewing strip charts for final analysis). Level 3 involves generating report appendixes and assuring all data is complete, and all data that are missing are easily explained through journal entries. This is the final validation stage, and data should be looked at through a data QA person's eyes. Level 3 data validation is typically performed by the QA/Program Manger, or personnel appointed to perform Level 3 by the QA/Program Manager.

Level 3 QC is performed weekly or at a minimum, monthly. Each week, the following tasks should be completed for each site for each parameter.

- Look at data in graphical form as defined in Level 2, for the full data set.
- Look up site audits and calibrations and assure any data from site visits, audits, calibrations, or any other disruption of data were invalidated and documented.
- Journal any additional issues found.
- Communicate additional issues with original Level 1 and Level 2 reviewers.
- Generate report documents and review for deficiencies.

1.4 Review tactics and

Listed below in Table 1 are a few guidelines on what to look for when reviewing data for typical site parameters.

Table 1: Data Review Guidelines

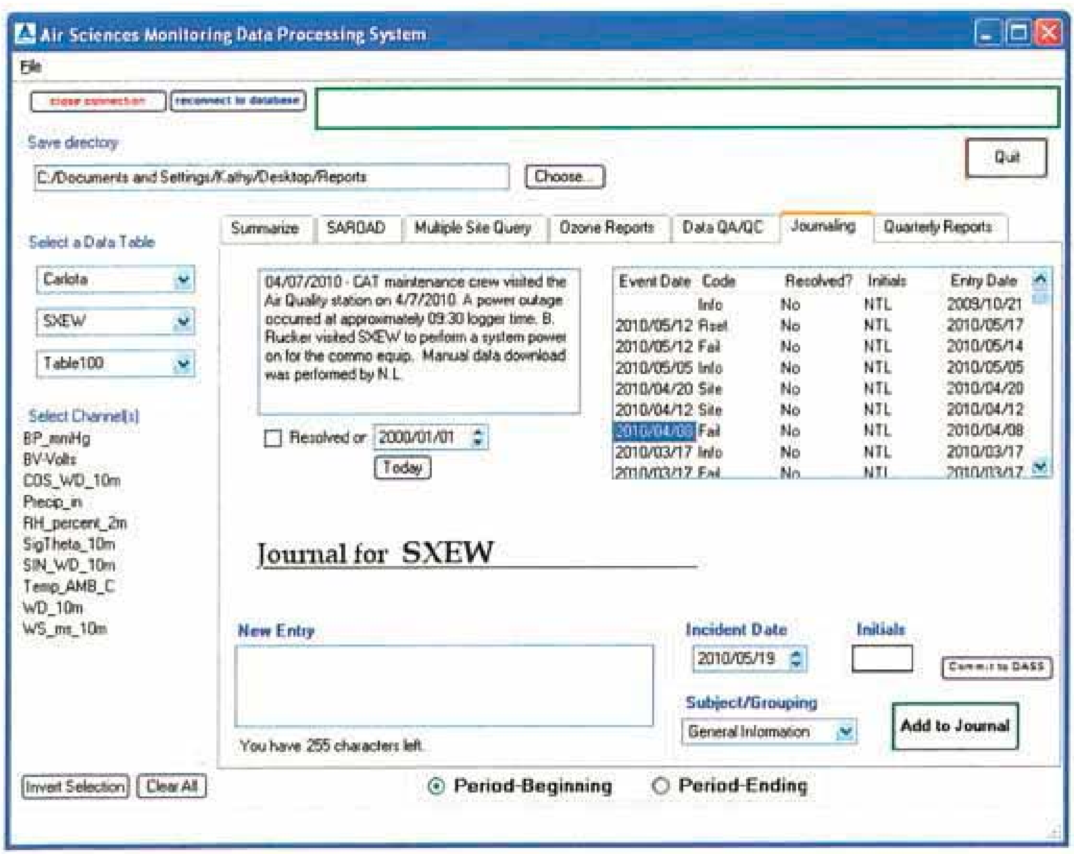
		If no:	
Parameter	**Situation**	**Investigate**	**Notify QA Manager Immedately**
Wind Speed	Are the values between 0 and 65 m/s?	X	
	Are there periods of zero winds greater than an hour?	X	X
	Are there periods where wind speed seems to be stuck for greater than an hour?	X	X
Wind Direction	Are the values between 0 and 360?	X	X
	Are there periods where the wind direction remains the same for greater than an hour?	X	X
Sine- Wind Direction	Are all readings between -1.0 and 1.0?	X	
Cosine- Wind Direction	Are all readings between -1.0 and 1.0?	X	
Sigma Theta	Are all readginst between 0 and 80?	X	
Temperature	Are the values between -50 and 50 °C?	X	
	Are there periods where the temperature doesn't change for greater than an hour?	X	X
	Does temperature climb during the day and fall at night?	X	
	If more than one temp sensor, do the temperatures track each other?	X	
Relative Humidity	Are the values between 0 and 100%?	X	
	Does the humidity go up during precipitation events?	X	
Barometric Pressure	Are the values between 500 and 760 mmHg?	X	
	Are there any sharp increases or decreases in the data?	X	X
Solar Radiation	Are the values between 0 and 1200 w/m^2?	X	
	Are the values 0 during the night?	X	
	Do the graphs increase with sunrise and decrease with nightfall?	X	
Battery Voltage	Are the values at least 11.0 mv?	X	X
	Do the graphs increase with sunrise and decrease with nightfall?	X	
PM10 Concentration	Do all data vary?	X	
	Are any readings greater than 200 ug/m3 (or 0.2 mg/m3)	X	X
	Are there any repeating values for more than 2 hours?	X	
PM10 Flow	Are values within 0.799 to 0.866 m3?	X	X
Ozone	Are values between 15 and 70 ppb	X	X
	Do nightly spans and zero values pass?	X	

1.5 Journaling and Documentation

Any data that was in need of investigation, was invalidated, or is missing should be identified in the journal. Journal entries in Metsummaries are specific to the project site. The journal entries should identify the date the situation occurred, the measures taken to resolve the situation, and a resolved date, if possible, along with technician's initials recording the event. An example of a journal entry can be found in Figure 8. Things that should always be journaled are:

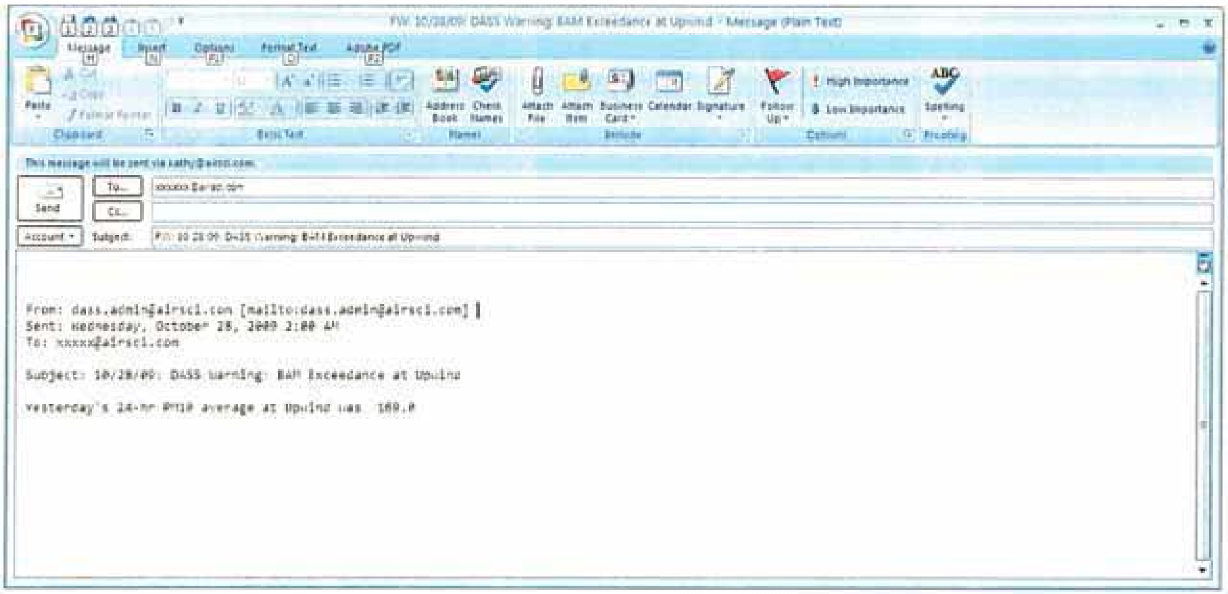
- Site visits, calibrations, or audits.
- Power disruptions.
- Maintenance performed on a sensor or instrument.
- Exceedances of the NAAQS or project-specific limits.
- Relevant correspondence with site operators.
- Missing data unable to be recovered, and a reason why.
- Site conditions worthy of mention (heavy snowfall, extreme winds, etc.)

Figure 8: Journal Entry Example



1.6 Exceedance Alerts

Sites who monitor particulate, ozone, or other air quality parameters that measure concentrations that may trigger NAAQS alerts have systems built into the DASS which will trigger email alerts to all relevant personnel when those limits are reached. This allows for timely notification to clients and state agencies that are required to be notified, sometimes as soon as within 24 hours of the event. Figure 9 is an example of a PM10 exceedance. This alert should be investigated immediately, and then reported to the proper agencies if the data is valid. See project specific responses in each project's quality assurance project plan for guidelines.



SECTION 2

REFERENCES

Guidance for Preparing Standard Operating Procedures (SOPs), EPA/600/B-07-001 April2007

APPENDIX C

Training Records

Resolution Mine
Training Records
Project Number 262-1

AIR SCIENCES INC.

Name (Print)	Date	Site training - Date TBD	AQ_BAM_1020_SOP_Rev 4	AQ_NOx Monitor_T200_SOP_Rev.1	AQ_O3 Monitor_T400_SOP	AQ_SO2 Monitor_T100_SOP	MET_Barometric Pressure Sensor_CS106_SOP_Rev.1	MET_Precipitation_CS700_SOP_Rev.1	MET_Relative Humidity Sensor_HMP45C_SOP_Rev.1	MET_Solar Radiation_CMP3_SOP_Rev.1	MET_Temp. Sensor_43347_SOP_Rev.1	MET_WS WD Sensor_05305_SOP_Rev.1	PROC_Data_QAQC_05102010	PROC_DeltaCal Flowmeter_SOP			Project Monitoring Plan Rev. 1 (TBD)
Kathy Steerman	8/10/2011		X	X	X	X	X	X	X	X	X	X	X	X			
Rory Attridge	8/10/2011		X	X	X	X	X	X	X	X	X	X	X	X			
Nao Lee	8/10/2011		X	X	X	X	X	X	X	X	X	X	X	X			
Aaron Schlabaugh	8/10/2011		X	X	X	X	X	X	X	X	X	X	X	X			
Chris Galvin	8/10/2011		X	X	X	X	X	X	X	X	X	X	X	X			
Keith DeHenau	8/10/2011		X	X	X	X	X	X	X	X	X	X	X	X			
Resolution:																	
Resolution:																	
Resolution:																	

APPENDIX D

PCAQCD Monitoring Plan Approval Letter

November 15, 2011

Sent via e-mail to drandall@airsci.com

Dave Randall
Principal/Vice President, Air Sciences Inc.
1301 Washington Avenue suite 200
Golden, CO 80401

Re: Resolution Copper Mining Monitoring Protocol

Dear Mr. Randall,

Resolution Copper Mining ("Resolution") has asked Pinal County Air Quality to concur in a "Mining Monitoring Plan" ("Plan") identified as Project 262-1 and presented to Pinal County in November, 2011.

Resolution is assessing the possible development of a copper mine in Pinal County, near the Town of Superior. Actual mining operations would be underground, but milling operations and tailings disposal would be above-ground.

The project constitutes a significant and complex undertaking that will trigger the preparation of an Environmental Impact Statement ("EIS) under the National Environmental Policy Act, or NEPA. The EIS will examine anticipated environmental impacts and alternatives, including air quality impacts.

The project would ultimately require revision of an existing air quality permit, which would also involve examination of incremental air quality impacts.

Assessing air quality changes requires a baseline characterization of existing air quality, and projecting future impacts requires a characterization of prevailing local meteorological conditions.

The overall project is still in an initial phase. Although extraction operations will obviously focus on the target ore body, Resolution is currently considering alternatives for the siting and configuration of beneficiation and tailings disposal operations.

To provide a foundation for development of an EIS, as well as for subsequent permit-related modeling, Resolution contacted Pinal County Air Quality to discuss the configuration and operation of a monitoring system to assess local air quality and meteorology. Those discussions have culminated the Plan, identified above.

For the project options that could play out in Pinal County, Figure 6 of the Plan shows the location of primary operations, and the corresponding monitoring locations. Resolution proposes to monitor ambient air quality and meteorological conditions near the existing shaft works east of Superior; near a proposed mill site lying just north of Superior; and approximately 5 miles west of a proposed tailings site, which would be located approximately 4 miles east-southeast of the intersection of U.S. 60 and State Route 79. The actual configuration of both mill and the tailings impoundment have not yet been defined. In addition, available information has not defined the configuration of the conveyance systems that would be required to transport ore from the mine, or to transport tailings to alternatives sites in either Pinal or adjoining Gila County.

Table 6 of the Plan proposes to collect air quality and meteorological data for 13 months.

Pinal County Air Quality has reviewed the system design and proposed operational protocols. Based on our current, limited understanding of the actual configuration of the project, Pinal Air quality agrees that the system and operational protocols described in the Plan will provide relevant ambient data for both background pollutant concentrations and prevailing meteorological conditions.

Please contact me at (520)866-6953 if you have questions or need additional information.

Sincerely yours,

/ms/

Mike Sundblom
Environmental Program Supervisor
Pinal County Air Quality

cc via e-mail: Don Gabrielson, PCAQCD
Kathy Steerman, Air Sciences, Inc.