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Appendix B

Emission Measurements from Construction Activities

Quality Assurance Project Plan Revision 1

Prepared for
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711
Office of Research and Development
Air Pollution Prevention and Control Division
(MD-61)

Attn: Charles C. Masser,
Work Assignment Manager

Under Subcontract to
Pacific Environmental Services, Inc.

EPA Contract No. 68-D-70-002
Work Assignment 2-04
MRI Project No. 4813-02

October 6, 1999

Preface

This quality assurance project plan was prepared for the U.S. Environmental Protection Agency by Midwest Research Institute (MRI) under subcontract number 68D7002-MRI, Work Assignment No. 2, from Pacific Environmental Services, Inc. The prime contract for this effort is EPA Contract 68-D-70-002, Work Assignment 2-04. Under this work assignment, MRI is providing assistance in characterizing construction-related particulate matter emissions and controls in terms of mass and particle size distribution.

Questions concerning this plan should be addressed to Dr. Chatten Cowherd, Work Assignment Leader, at (816) 753-7600, Ext. 1586.

MIDWEST RESEARCH INSTITUTE

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October 6, 1999

UNCONTROLLED

EMISSION MEASUREMENTS FROM CONSTRUCTION ACTIVITIES

NORTH CENTRAL KANSAS TECHNICAL COLLEGE

QUALITY ASSURANCE PROJECT PLAN (QAPP)
REVISION 1

WORK ASSIGNMENT 2-04
EPA CONTRACT NO. 68-D-70-002
PES SUBCONTRACT NO. 68D70002
MRI WORK ASSIGNMENT NO. 2
MRI PROJECT NO. 4813-02

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Revision History:

Revision 0: This QAPP was prepared as a companion to the site-specific test plan (dated June 12, 1998) produced for the work assignment. The QAPP was designed to be in compliance with the guidance document "EPA Guidance for Quality Assurance Project Plans" (EPA QA/G-5). To aid in the review of this document versus applicable guidance, this document has been structured to mimic the required classes and elements of QA/G-5. Sections 1 to 4 cover the classes A to B given in the guidance document.

Revision 1: October 6, 1999—Revised to incorporate changes in text requested by EPA and PES.

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Section 1.
Project Management

1.1 Project/Task Organization (A4)

The key personnel participating in the project are listed in this section. For Midwest Research Institute (MRI), the Work Assignment Leader (WAL) is Dr. Chatten Cowherd and Dr. Greg Muleski is the Field Test Leader (FTL). The Quality Assurance Officer (QAO) for MRI is Mr. Mark Horrigan. Mr. Andrew Trenholm is the Program Manager (PgM) for the overall contract. All individuals except Mr. Trenholm are located at MRI's Kansas City office and any correspondence to them should be directed to

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A brief narrative of the project-specific roles and responsibilities is given below.

The program manager will assure corporate management that the work is conducted in accordance with the quality assurance (QA) requirements. As PgM, Mr. Trenholm:

- Evaluates staff credentials to ensure that they have the requisite training and experience necessary to complete the project.
- Ensures that the program is appropriately organized with effective lines of communication and that program responsibilities and authorities for making critical decisions are clearly understood.
- Ensures that the QAO is involved in the program from the planning stage through the issuance of the final report.

- Reviews QA Project Plans (QAPP) and project-specific Test Plan and Standard Operating Procedures (SOPs). Ensures that program QA requirements are addressed in the QAPP and SOPs. Ensures that the QAPP and SOPs are reviewed and approved as required.

- Ensures that the work is adequately and appropriately inspected by the WAL and that the results are reviewed.

- Reviews any audit reports from the QAO or the QA Unit and reviews and evaluates responses from the PL. Ensures that the actions taken are timely and appropriate.

- Reports project status, problems, and corrective actions as required by the contract, division Quality Management System (QMS), QA Program Plan, or QAPP. Reports program status to division and corporate management.

- Reports audits conducted or directed by the EPA to corporate management and the QA Unit. Prepares and routes responses to the audit reports through division management and the program QAO.

- Reviews work products and reports to ensure that QA goals were met. Approves technical reports.

Dr. Chatten Cowherd, the WAL, will have overall technical oversight of the project. Dr. Cowherd will have day-to-day responsibility for the project and will be responsible for conducting the work in accordance with the QA requirements. The WAL is responsible for assuring Department management that the work is conducted in accordance with the QA requirements, and he has the authority to override project staff on QA matters. As WAL, Dr. Cowherd:

- Evaluates staff credentials to ensure that they have the requisite training and experience necessary to complete the project.

- Ensures that the project is appropriately organized with effective lines of communication. Ensures that project responsibilities and authorities for making critical QA decisions are clearly understood.

- Ensures that the QAO is involved in the project from the planning stage through the issuance of the final report, is fully informed, and is kept apprised of program schedules.

- Coordinates the development of any required QAPPs and project specific SOPs. Anticipates problems and helps define prevention, detection, and remedial action systems. Ensures that program and work assignment QA requirements are addressed in the QAPP. Ensures that QAPPs, Test Plans, and SOPs are reviewed and approved as required.

- Approves, distributes, and enforces the QAPP and SOPs. Justifies and approves modifications to and deviations from the QAPP and SOPs.

- Justifies deviations from MRI's division QMS and SOPs. Obtains approval for deviations from division management.

- Routinely inspects the work and documents the results in the project records. Ensures that the work is adequately and appropriately inspected and that the results are reviewed. Reviews any audit/inspection reports from the QAO or the QA Unit. Ensures that any problems detected by inspection or audit are immediately communicated to the appropriate staff, that actions taken are timely and appropriate, and that the actions taken are documented in the project records.

- Reports problems and actions taken to the PgM and the QAO.

- Reports project status, problems, and corrective actions to appropriate management as required by the contract, division QMS, QA Program Plan, or QAPP. Reports project status to program management.

- Reviews work products and reports to ensure that QA objectives have been met. Ensures that critical data are adequately verified or validated. Approves all technical reports.

The WAL will be assisted by the Field Test Leader (FTL), Dr. Greg Muleski, who is responsible for providing oversight for the field testing program, coordination with the host facilities, and providing data interpretation and review. Dr. Muleski or his designee will have day-to-day responsibility for decisions made on-site during the field exercise.

The MRI program QAO will be Mr. Mark Horrigan who is independent of the technical management staff. He will conduct or direct audits as required, by corporate QA policy, the QAPP, or at the request of the EPA. The QAO:

- Assists in preparing all QAPPs.

- Reviews and approves the QAPP, and reviews project reports.

- Conducts or directs the conduct of systems, performance evaluation, and data audits as required and reviews reports as required by corporate policy, EPA, or the program management.

- Reports audit results along with any problems and corrective action requests to the WAL and PgM, and division management.

- Reports project QA status to division management, and the Manager of Quality Assurance.

The Manager of Quality Assurance reports to the Executive Vice President and Chief Operations Officer. The personnel of the QA Unit conduct general audits to assure corporate management and clients that work is conducted in accordance with the QAPP, MRI, and division QMS, and MRI corporate QA policy. The QA personnel have the authority to work directly with project management and staff on QA matters and to communicate directly with client's or subcontractor's QA staff.

The QA Unit's personnel have the authority to request immediate corrective action for noncompliance to the MRI program (the MRI QA plan, division QMS, and program QA requirements). Dr. Gene Podrebarac, Manager of Quality Assurance, provides QA oversight for corporate management for all programs. As a member of the QA Unit, Mr. Mark Horrigan, QAO, provides QA oversight for this program.

Project staff report to the WAL. Project staff are responsible for conducting work in accordance with division, program, and project QA requirements. They have the authority to request information and help for problems from the PL, the QAO, department management, and the QA Unit. Project staff and supervisors:

- Follow division QMS, the QA Program Plan, and any QAPP and SOPs.

- Obtain approval from the WAL for any deviations in the QA Program Plan, QAPP, or SOP.

- Report work assignment status to the WAL.

- Immediately report problems to the WAL and the QAO and help resolve the problems.

Figure 1-1 presents an organizational chart showing the management structure.

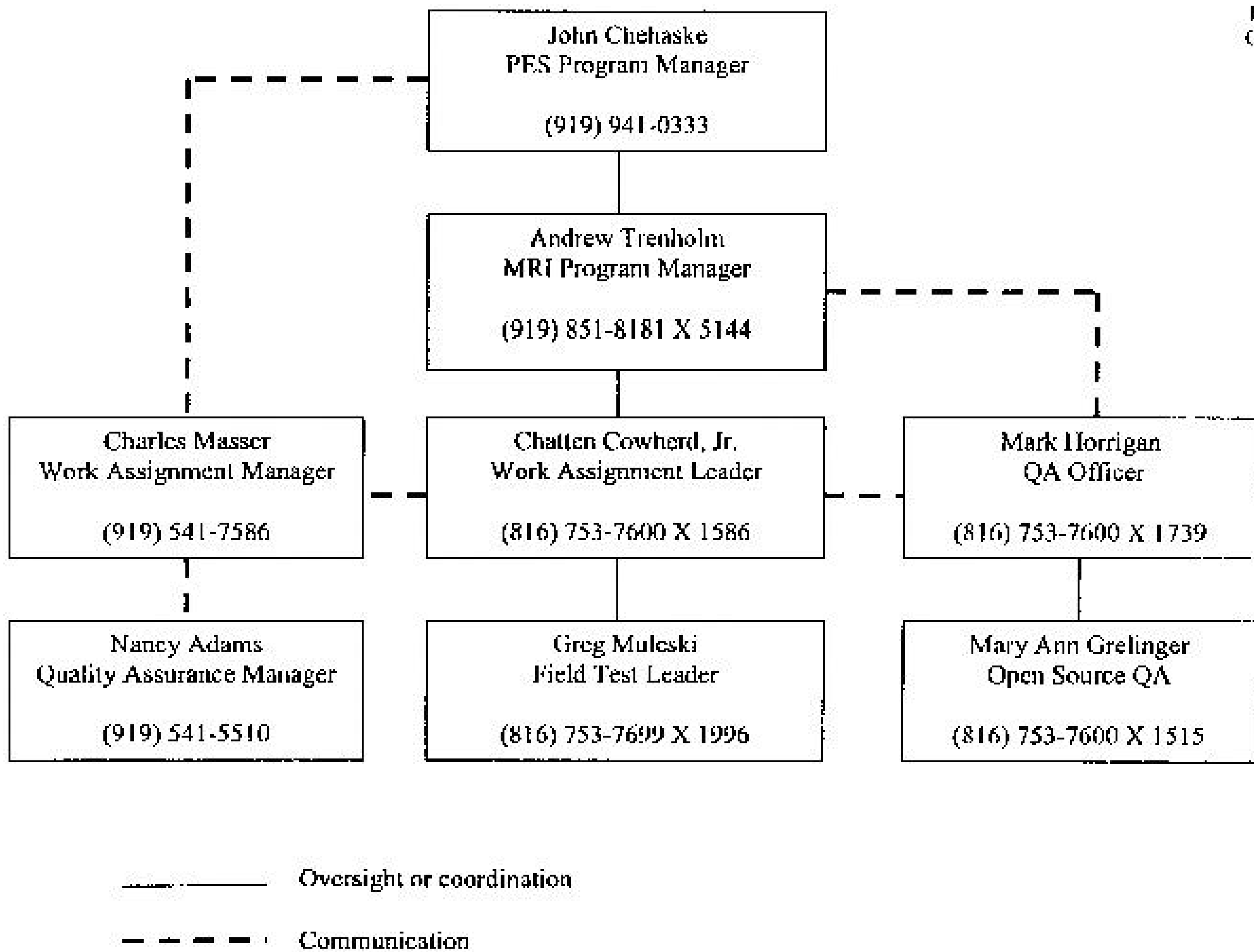

Figure 1-1. Project Organization Chart

1.2 Problem Definition/Background (A5)

An earlier scoping study [1] and AP-42 background document [2] identified several drawbacks in the limited information available for PM emissions from construction activities. In general, the PM information references total suspended particulate (TSP) and not the two size ranges of current regulatory interest—namely, PM-10 and PM-2.5.

A field program conducted during 1998 developed emission factor data for construction activities related to scraper operations. The current program will build upon the previous work. The present study will not only examine the effectiveness of watering in controlling on-site dust emissions but also implications of a watering program. Watering at construction sites can result in higher off-site PM emissions as material is tracked onto surrounding paved surfaces where it is available for resuspension by passing vehicles.

Because the emissions are not released through a stack, duct, or vent, standard EPA reference test methods do not apply. Furthermore, because source characterization requires (a) a shorter time duration for sampling and (b) encountering very high particulate concentrations, EPA reference methods for ambient monitoring as written in the CFR require modification when adapted for open source emission testing.

Note that, even though there are no directly applicable methods in the CFR, the test method to be used has undergone extensive evaluation and review. EPA/ORD since the 1970s has published approximately 10 test reports based on the exposure profiling method and performed a collaborative evaluation of the method during the 1980s. Furthermore, OAQPS recommends exposure profiling for the testing of open dust sources because the method isolates a single emission source while not artificially shielding the source from ambient conditions (e.g., wind). The EPA open source emission factors with the highest quality ratings are typically based on the exposure profiling method. In addition, the surface material sampling procedures to be followed are also based on the techniques included in AP-42 to characterize dust sources.

1.3 Project Task Description

The present study is directed toward the two major goals:

1. Characterize the PM-10 control efficiency of different amounts of water applied to scraper travel routes under various traffic (vehicle weight and traffic volume) and meteorological (temperature and evaporation rate) conditions.

2. Examine the amount of material tracked from areas treated with different amounts of water to paved surfaces.

Past studies have found that a substantial fraction of PM emissions from construction activities is related to transport of earth and other materials around the site. Because of the generally short-term nature of travel routes at construction sites, operators throughout the United States commonly employ water to control PM emissions rather than relying on more expensive chemical dust suppressants.

Although PM emissions from watered unpaved roads has attracted attention since at least the early 1980s, only two watering tests have been conducted at construction sites. In addition to the simple scarcity of data specifically referenced to construction sites, there are concerns about how well watering tests of unpaved roads in other settings can be applied to the construction sites. Because temporary routes are not nearly as well constructed as conventional unpaved roadways, available data may not accurately reflect the efficiency afforded by watering at construction sites.

Mud/dirt trackout from construction sites constitutes a large component of construction dust emissions in urban areas, where tracked mud/dirt substantially raise the silt loadings on adjacent paved roadways. Trackout is observed to increase as soil moisture increases, but this effect has not been quantified. There are a variety of candidate methods for decreasing the accumulation of mud/dirt on tires or removing accumulated mud/dirt as vehicles exit a construction site. However, the control efficiency test data for these measures are limited.

The first goal—namely, characterizing the effectiveness of water to control on-site dust emissions—requires that air emission sampling be conducted to compare the mass of PM emitted from controlled and uncontrolled travel routes. A scraper traveling over an unpaved route constitutes a "moving point" emission source that can be treated as a "line" source. That is to say, the source can be assumed to be uniformly emitting along the linear path of the scraper. Figure 1-2 shows not only a schematic of the operations but also the basis for the line source test methodology. As long as the distance traveled is substantially greater than the downwind distance from the path to the sampling array, then only a single vertical array of samplers ("tower") is necessary to characterize the PM plume. In other words, because the source is considered as uniformly emitting over the length of the operational pass, a vertical array is sufficient to characterize the vertical distribution of concentration and wind speed in the plume.

Because the test method relies on ambient winds to carry emissions to the sampling array, acceptance criteria for wind speed/direction are necessarily based on the results from antecedent monitoring. That is to say, the immediate past record is used to determine acceptability for the current or upcoming period of time. As a practical matter, this requires that wind monitoring must be conducted immediately before starting a test. Testing does not begin unless the mean conditions remain in the acceptable ranges of:

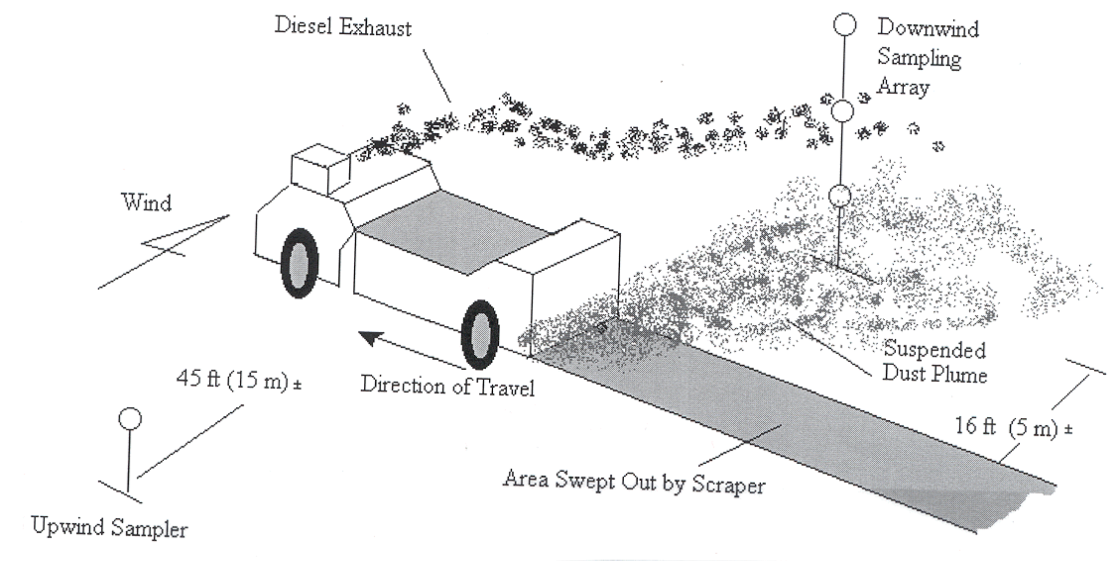

Figure 1-2. Schematic Illustration Test Procedure for Moving Point Source

1. Mean wind speed between 3 and 20 mph

2. Mean wind direction less than 45 degrees from the perpendicular to linear path of the moving point source

for at least two consecutive 5-minute averaging periods. Similarly, testing is suspended if the wind speed of direction move outside the acceptable ranges for two consecutive 5-minute averaging periods. Sampling may be restarted if acceptable conditions return. In that case, the same criterion of two consecutive acceptable 5-minute periods are followed to restart a test.

In a like manner, nozzles are added/removed or inlets reoriented if the mean wind speed of direction over two consecutive 5-minute averaging periods indicate the need for such action. These changes in sampler inlet conditions can be made at any time during a test. The actions are recorded on the run sheet. Nozzle placements are recorded on spaces in the middle of the example run sheet give in Appendix B of the site-specific test plan. Because reorientation applies equally to all samplers, that action is recorded in the general comment section at the bottom of the run sheet.

The second goal of characterizing off-site implications of watering requires comparison of the mass of mud/dirt carried onto paved surfaces. In this case, a surface sampling program will be used collect the mud/dirt samples for size analysis. The material is collected by vacuum cleaning predetermined areas of the roadway. A captive test site at MRI Deramus Field Station (Grandview, Missouri) will be used to test mud/dirt trackout controls, in order to control site conditions and vehicles during the study.

1.4 Quality Objectives (A7)

This test program will develop particulate control efficiency for (a) watering of scraper travel routes and (b) application of two to four controls for mud/dirt trackout. Specific objectives, in descending order of priority, are:

- Develop uncontrolled and controlled PM-10 emission factors for watering of unpaved scraper travel routes.

- Determine the PM-2.5 fraction of the PM-10 emissions from scraper travel routes, with and without watering.

- Determine mud/dirt trackout rates from uncontrolled, unpaved soil surfaces onto a paved roadway.

- Determine mud/dirt trackout rates after application of each control measure

There is no way to directly assess the accuracy of the emission factor or the mass tracked onto a paved surface. The approach adopted here is to set goals for component measurements that are combined. For example, particle concentration and wind speed are multiplied together to produce point values of exposure, which are then integrated over height to develop the emission factor. Thus, data quality objectives (DQOs) are established for the wind speed and concentration measurements. Similarly, sample weights and sieve results are combined to develop the "silt loading" value (which represents the mass of sub-200 mesh material present per unit area of road surface). In that case, DQOs are established for weighing and sieving the samples.

The measurement approaches employed here will undoubtedly reduce the uncertainty associated with current estimates used in construction emission inventories. This statement is based on the fact that currently available estimation tools are based on very limited data, most of which has been collected outside the construction industry.

Because of the unsteady nature of ambient conditions and because emission levels will increase as the watered surface dries out, multiple tests cannot necessarily be considered replicate measurements. For this reason, precision DQOs for emission factors and silt loadings apply only to uncontrolled conditions.

The data quality goals are presented in Table 1-1.

1.5 Project Narrative (A8)

The overall objective for this work assignment is to provide improved information regarding the control of PM-10 and PM-2.5 emissions from construction activities. As discussed earlier and in the site-specific test plan (SSTP), previous studies have identified the limitations with available data and prioritized field testing needs. Because of logistical difficulties posed by the emission sources of interest in the work assignment, the field testing program relies on "captive" operations to control site conditions.

Unlike traditional emission sources, construction-related activities result in open dust sources. The exposure profiling method (as discussed in Section 2.2) is applicable to a wide class of anthropogenic emission sources. Because the method effectively isolates the dust contribution of a single emission source under investigation, exposure profiling is the EPA-preferred emission measurement technique for open sources. Furthermore, because mud/dirt trackout is a "precursor" to open dust emissions, neither traditional stack tests nor exposure profiling is directly applicable. For that reason, the second objective of the work assignment relies on measurement of the silt loading present on paved surfaces near trackout points.

Table 1-1. Data Quality Objectives

Measurement	Method	Accuracy (%)	Precision (%)	Completeness (%)
PM-10 emission factor	Mass flux profiling	– [a]	± 45[b]	– [c]
PM-10 concentration	High volume samplers	± 10[d]	± 40[e]	≥ 90
PM-2.5 concentration	High volume cascade impaction	± 15[f]	± 50[e]	≥ 90
Wind speed	Gill anemometer	± 10[g]	± 10[h]	≥ 90[i]
Wind direction	R. M. Young wind station	± 10[g]	-	≥ 90[i]
Filter weights	Analytical balance	± 10[j]	± 10[k]	100
Moisture content	Weight loss upon drying	± 10[j]	± 10[l]	– [m]
Silt Content	Dry sieving	± 10[j]	± 10[l]	–[m]
Silt Loading	Vacuum sampling of road surface	–[n]	± 50[o]	– [p]

[a] Because the emission factor is calculated from particle concentrations and wind speed, the approach taken here is to set goals for the component measurements.
[b] Refers to the range percent of replicate measurements made of uncontrolled conditions. See discussion in text.
[c] At least one set of replicate measurements will be conducted for scrapers traveling over uncontrolled surface.
[d] Based on audit of volumetric flow controller.
[e] Based on range percent of co-located samplers. At least one test with co-located samplers will be conducted for the uncontrolled transit tests.
[f] Based on pre- and post-test settings of flow rate.
[g] Based on calibration with manufacturer-recommended device.
[h] Based on pre- and post-test co-locations of both unit in a steady air flow.
i Refers to percentage of time during testing that wind lies within acceptable range of 3 to 30 mph and ±45° from perpendicular to linear path of moving point source.
[j] Based on Class S calibration weights.
[k] Based on independent audit weights.
[l] Based on independent analysis of a riffle-split sample.
[m] At least one sample from each test site will be riffle split for duplicate analysis. (This assumes that at least one paved road sample obtained has a mass ≥ 800 g).
[n] Because silt loading is calculated, the approach taken here is to set goals for the component measurements.
[o] Refers to percent range of embedded co-located paved road surface loading samples.
[p] At least one embedded co-locate sample will be collected.

1.6 Special Training Requirements/Certification (A9)

This testing program will be conducted by personnel who have been trained in performing air sampling for the determination of emission measurements.

1.7 Documentation and Records (A9)

1.7.1 General Discussion

All data collected in the study will be entered directly into bound laboratory notebooks and standard data forms using permanent black ink and will be signed/dated by sampling personnel. Notebooks and data forms are to be inspected for completeness and accuracy by the appropriate field supervisor at the end of each test. At that time, data forms are grouped by test number and bound into 3-ring binders. Appendix A in the test plan [4] presented examples of the data forms to be used.

The work plan provided the reporting requirements for the work assignment. MRI will combine the results obtained at the two host facilities in one test report. The report will include hard copies of all data records specified in Section 1.6.2. The following information will be included:

Sample Collection Records: These will include run sheets that record the date, time, and location of sampling; sampler flow rates; operator; and key observations (comments). In addition, filter log sheets will clearly identify which filter or other collection media were used in specific samplers. Data forms are also used to record the location; method of collection; and any field splits of bulk (earth) material samples taken in connection with the emission tests.

Calibration Records: All sampler flow calibration records will be documented as to operator: time/date of calibration; transfer standard identifier (serial number); date and resulting of calibration of the transfer standard to the primary standard; key observations; QC results; and any problems/corrective actions taken.

Corrective Action Reports: These reports will be summarized and discussed in the final report as needed. If a corrective action report is directly applicable, it will be included in the data package.

Laboratory Analysis Records: Laboratory analyses are primarily gravimetric. Bound filter laboratory books are used to record the tare, final and audit weights of all air sample collection media. Specially designed data forms are used to record the sieve and pan weights used in the moisture and silt (minus-200 mesh) analyses for the bulk samples.

Personnel Training Files: These records are maintained by MRI's QA Unit. They are available for inspection but will not be supplied as part of the raw data.

General Field Procedures: Test procedures will be described and discussed in the report.

Waste Disposal: No hazardous/special wastes will be generated. Disposal of general solid waste (e.g., unused splits of bulk material samples) will be negligible. Thus, no records will be made part of the data packet.

1.7.2 Data Reporting Package Format and Documentation Control

In recording raw data, MRI will follow documentation practices (SOPs MRI-0055 and MRI-0056) to assure data of known and defensible quality. These also will include:

- Information will be entered on standard data forms using permanent black ink. See the test plan for example forms.

- Manual corrections will be made by drawing a line through the incorrect information, leaving the original information intact and legible. Corrections will be initialed, dated, and explained by the person making the correction.

- Corrections to any existing computer spreadsheet will involve modifying the file; saving it under a new file name; and leaving the original intact.

- All recorded data will be traceable to a sampling location, sampling time, instrument, operator, measurement method, calibration records, and final sample results.

The test report will discuss data collection, QA/QC and sample results. It will be accompanied by a series of appendices that contain the raw data and supporting information. The FTC will assemble the raw data files (hard copies and, as necessary, electronic versions). The FTC and WAL will jointly prepare the report. The WAL will review the data package and attach it to the report as an appendix.

1.7.3 Data Reporting Package Archiving and Retrieval

MRI will archive the data for the period of time required by EPA's contract with PES. The following record will be available:

- Personnel credentials

- Project procedures, reports, and plans
- All project internal correspondence, meeting minutes, etc.
- Hard copy of all raw data and field records

Section 2.
Measurement/Data Acquisition (B)

Table 2-1 presents an overview of the testing program. In the table, "mass flux profiling" refers to the method for determination of an individual emission factor/rate. The exposure profiling test method is discussed in Section 2.2 of this QAPP and in even more detail in the site-specific test plan. The term "particle size profiling" is used to denote the test method designed to characterize the particulate size distribution at two heights. Because of the need to collect adequate mass of the smaller size fractions, a single particle size test spans several mass flux tests.

The third test method mentioned in Table 2-1—*manual cleaning*—refers to characterization of the loose surface material present on the paved road surface. The collection and analysis method are described in Appendices C.1 and C.2 of AP-42, respectively. Copies of those are included in the appendix to this QAPP.

2.1 Sampling Process Design (Experimental Design) (B1)

As discussed in the SSTP, past studies have found that a substantial fraction of PM (particulate matter) emissions from construction activities is related to transport of earth and other materials around the site. Because of the generally short-term nature of travel routes at construction sites, operators throughout the United States commonly employ water to control PM emissions rather than relying on more expensive chemical dust suppressants.

Mud/dirt trackout from construction sites constitutes a large component of construction dust emissions in urban areas, where tracked mud/dirt substantially raise the silt loadings on adjacent paved roadways. Trackout is observed to increase as soil moisture increases, but this effect has not been quantified. There are a variety of candidate methods for decreasing the accumulation of mud/dirt on tires or removing accumulated mud/dirt as vehicles exit a construction site. However, the control efficiency test data for these measures are limited.

Emission tests at NCK Technical College will be conducted under a variety of meteorological conditions (e.g., temperature, wind speed, cloud cover) and operating conditions (e.g., weight and speed of vehicle equipment, number of vehicle passes per unit time, and time of day). Of particular interest is on-site collection of pan evaporation measurements so control efficiency decay rates for watering can be referenced to readily available meteorological data. Because control efficiency is greatest immediately after water is applied to the roadway and decays as the surface dries, testing will span a broad range of times after watering, so reliable average control efficiency data are obtained.

Table 2-1. Test Design

Operation	Travel surface	Pollutant	No. of tests	Test method	Approx. time (min) per test
NCK Tech. College					
Transit-Native Soil	Uncontrolled	PM-10	3	Mass flux profiling	15
		PM-2.5	1	Particle size profiling	75
	Watered:	PM-10	3	Mass flux profiling	30-60
	Appl. 1	PM-2.5	1	Particle size profiling	120
	Watered:	PM-10	3	Mass flux profiling	30-60
	Appl. 1a	PM-2.5	1	Particle size profiling	120
	Watered:	PM-10	3	Mass flux profiling	30-60
	Appl. 2	PM-2.5	1	Particle size profiling	120
	Watered:	PM-10	3	Mass flux profiling	30-60
	Appl. 2a	PM-2.5	1	Particle size profiling	120
Deramus Field Station					
Trackout-Native Soil	Uncontrolled	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
	Control 1	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
	Control 2	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
	Control 3	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
Trackout-Sandy Soil	Uncontrolled	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
	Control 1	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
	Control 2	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		
	Control 3	Surface loading		Manual cleaning	60 min
	Moisture 1		3		
	Moisture 2		3		

At the trackout test site at the Deramus Field Station, no emission testing will be performed, but the operational features of trackout vehicles will be documented. In addition, the aggregate material properties of the test soil surfaces, from which trackout originates, will be characterized.

Table 2-2 presents a projected schedule of activities during the test program.

Table 2-2. Testing Schedule

Date	Activity	Comments
7/26/99 - 7/30/99	Perform filter (tare) analysis	
	Prepare sampling equipment/supplies	
9/9/99 - 9/10/99	Load equipment and transport equipment to NCK Technical College	Schedule to coordinate with start of hands-on training fall semester
9/13/99	Establish on-site laboratory at NCK Technical College	
9/13/99 - 9/14/99	Conduct baseline uncontrolled tests at NCK Technical College	
9/14/99 - 9/24/99	Conduct controlled tests at NCK Technical College	
9/25/99	Return equipment and NCK Technical College samples to main MRI laboratories	
10/15/99	Establish test area at DFS	
10/18/99-10/25/99	Conduct baseline uncontrolled tests at DFS	
11/8/99 - 12/3/99	Conduct controlled tests at DFS	
12/13/99	Complete sample analyses	
12/23/99	Complete data reduction	

The general test methodology of mass flux profiling is described in the SSTP. Within this measurement framework, the critical and non-critical measurements described in Table 2-3 will be made. In this sense, “critical” denotes that these measurements are necessary to ensure that project objectives are met.

Table 2-3. Critical and Non-critical Measurements for Emission Factors

Measurement	Comments
Critical	
• Filter weights • Sampler flow rates • Wind speed	These three variables are used to calculate the mass flux over the plume area and the emission factor.
• Volume of earth moved • Number of scraper passes	These measurements are necessary to normalize the mass flux and obtain an emission factor. The scraper count will be tallied during the test by individual equipment ID. The total volume will be determined by multiplying the count for an individual unit by its manufacturer-rated capacity.
Non-critical	
• Elapsed time	Even though this quantity is needed to determine concentrations, its effect is multiplied out in determining the emission factor. Furthermore, in determining PM-2.5 to PM-10 ratios, only the relative filter catches are necessary.
• Pressure drop across filter • Barometric pressure • Ambient temperature	These three variables are used to determine the sampling rate for a high-volume sampler equipped with a volumetric flow controller (VFC). However, flow rate varies only slightly over the possibly encountered range of each variable.
• Wind direction • Horizontal wind speed	These variables are of interest primarily to ensure that conditions are suitable for testing. In this way, the measurements are useful for operational decisions but do not affect the calculated emission factor.
• Moisture content • Silt content	These measurements deal with the earthen material being handled. They do not affect the calculated emission factor.

2.2 Sample Handling and Custody Requirements (B3)

The majority of environmental samples collected during the test program consists of particulate matter captured on a filter medium. Analysis will be gravimetric, as described in Section 2.4. SOP MRI-8403 describes the procedure, which is summarized below.

To maintain sample integrity, the following procedure will be used. Each filter will be stamped with a unique 7-digit identification number. A file folder is also stamped with the identification number and the filter is placed in the corresponding folder.

Particulate samples are collected on glass fiber filters (8 in by 10 in) or on glass fiber impaction substrates (4 in by 5 in). Prior to the initial (tare) weighing, the filter media are equilibrated for 24 h at constant temperature and humidity in a special weighing room. Impactor substrates are greased by spraying the collection surface with a solution of 140 g of stopcock grease in 1 L of reagent grade toluene. Thereafter, they undergo the same tare weighing steps, as do the filters.

During weighing, the balance is checked at frequent intervals with standard (Class S) weights to ensure accuracy. The filters remain in the same controlled environment for at least 24 hr until a second analyst reweighs them as a precision check. A minimum of ten percent (10%) of the filters and collection media used in the field will serve as blanks to account for the effects of handling. The QA guidelines pertaining to preparation of sample collection media are presented in Section 2.5.

The filters are placed in their folders. Groups of approximately 50 are sealed in heavy-duty plastic bags and stored in a heavy corrugated cardboard box equipped with a tight-fitting lid. Unexposed filters are transported to the field in the same truck as the sampling equipment and are then kept in the field laboratory.

Because the glass fiber impactor substrates are greased, they are not placed in the file folders for transport. Instead, they are stored in specially designed frames that keep the greased surfaces separate from one another and "face up." Cases that securely hold stacks of the frames are used to transport the substrates to and from the field.

Once they have been used, exposed filters are placed in individual glassine envelopes and then into numbered file folders. Groups of up to 50 file folders are sealed within heavy-duty plastic bags and then placed into a heavy-duty cardboard box fitted with a lid. Exposed and unexposed filters are always kept separate to avoid any cross-contamination. When exposed filters and the associated blanks are returned to the laboratory, they are equilibrated under the same conditions as the initial weighing. After reweighing, a minimum of 10% of each type are audited to check weighing accuracy.
In addition to filters and collection media described above, a second set of samples is collected to characterize the bulk material properties of the earth being moved. Of particular interest are the surface moisture and silt (mass fraction below 200 mesh upon dry sieving) contents. A composite sample consisting of a minimum of 3 increments will be collected from both the loaded and unloaded material for each test. Sample collection will follow procedures contained in Appendix C.1 in EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) [5].

In order to ensure traceability, all filter and material sample transfers will be recorded in a notebook or on forms. The following information will be recorded: the assigned sample codes, date of transfer, location of storage site, and the names of the persons initiating and accepting the transfer. Data forms were included as an appendix to the site-specific test plan.

2.3 Analytical Methods Requirements (B4)

All analytical methods required for this testing program are inherently gravimetric in nature. That is, the final and tare weights are used to determine the net mass of particulate captured on filters and other collection media. The tare and final weights of blank filters are used to account for the systematic effects of filter handling. Finally, the determination of surface moisture and silt contents are also gravimetric in nature and are described in Appendix C.2 of EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) [5]. The following procedures are followed whenever a sample-related weighing is performed:

- An accuracy check at the minimum of one level, equal to approximately the tare weight and actual weight of the sample or standard. Standard weights should be class S or better.

- The observed mass of the calibration weight (not including the tare weight) must be within 1.0% of the reference mass.

- If the balance calibration does not pass this test at the beginning of the weighing, the balance should be repaired or another balance should be used. If the balance calibration does not pass this test at the end of the weighing, the samples or standards should be reweighed using a balance that can meet these requirements.

2.4 Quality Control Requirements (B5)

Routine audits of sampling and analysis procedures are to be performed. The purpose of the audits is to demonstrate that measurements are made within acceptable control conditions for particulate source sampling and to assess the source testing data for precision and accuracy. Examples of items audited include gravimetric analysis, flow rate calibration, data processing, and emission factor calculation. The mandatory use of specially designed reporting forms for sampling and analysis data obtained in the field and laboratory aids in the auditing procedure.

To prepare hi-vol collection media (filters and impactor substrates) for use in the field, filters and substrates are weighed under stable temperature and humidity conditions. After they are weighed and have passed audit weighing, the filters are packaged for shipment to the field. Table 2-4 outlines the general requirements for conditioning and weighing sampling media. Note that the audits weights are performed by a second, independent analyst.

Table 2-4. Quality Control Procedures for Sampling Media

Activity	QC check/requirement
Preparation	Inspect and imprint glass fiber media with identification numbers.
Conditioning	Equilibrate media for 24 h in clean controlled room with relative humidity of 40% (variation of less than ±5% RH) and with temperature of 23 °C (variation of less than ±1 °C).
Weighing	Weigh hi-vol filters to nearest 0.05 mg.
Auditing of weights	Independently verify final weights of 10% of all filters and substrates used in the field either to collect samples or as blanks (at least four from each batch). Reweigh entire batch if weights of any hi-vol filters deviate by more than ±2.0 mg. For tare weights, conduct a 100% audit by a second analyst after an additional 24 h of equilibration. Reweigh any high-volume filter whose weight deviates by more than ±1.0 mg. Follow same procedures for impactor substrates used for sizing tests. Audit limits for impactor substrates are ±1.0 and ±0.5 mg for final and tare weights, respectively.
Correction for handling effects	Weigh and handle at least one blank for each 1 to 10 filters of each type used to test.
Calibration of balance	Balance to be calibrated once per year by certified manufacturer's representative. Check prior to each use with laboratory Class S weights.

As indicated in Table 2-4, a minimum of 10% field blanks will be collected for QC purposes. This involves handling at least 1 blank filter for every 10 exposed filters in an identical manner to determine systematic weight changes due to handling steps alone. These changes are used to mathematically correct the net weight gain for the effects of handling. A field blank filter is loaded into a sampler and then immediately recovered without any air being passed through the media. This technique has been successfully used in many MRI programs to account for systematic weight changes due to handling.

After the particulate matter samples and blank filters are collected and returned from the field, the collection media are placed in the gravimetric laboratory and allowed to come to equilibrium. Each filter or substrate is weighed, allowed to return to equilibrium for an additional 24 h, and then a minimum of 10% of the exposed filters are reweighed by a second analyst. If a filter or substrate fails the audit criterion, the entire lot will be allowed to condition in the gravimetric laboratory an additional 24 h and then reweighed. The tare and first weight criteria for filters (Table 2-2) are based on an internal MRI study conducted in the early 1980s to evaluate the stability of several hundred 8- x 10-in glass fiber filters used in exposure profiling studies.

Because the test method relies on ambient winds to carry emissions to the sampling array, acceptance criteria for wind speed/direction are necessarily based on the results from antecedent monitoring. That is to say, the immediate past record is used to determine acceptability for the current or upcoming period of time. As a practical matter, this requires that wind monitoring must be conducted immediately before starting a test. Testing does not begin unless the mean conditions remain in the acceptable ranges of:

1. Mean wind speed between 3 and 20 mph.

2. Mean wind direction less than 45 degrees from the perpendicular to linear path of the moving point source.

for at least two consecutive 5-minute averaging periods. Similarly, testing is suspended if the wind speed or direction move outside the acceptable ranges of two consecutive 5-minute averaging periods. Sampling may be restarted if acceptable conditions return. In that case, the same criterion of two consecutive acceptable 5-minute periods are followed to restart a test.

2.5 Instrument/Equipment Testing, Inspection and Maintenance Requirements (B6)

Inspection and maintenance requirements for sampling equipment are provided in Table 2-5. Note that because the cyclone preseparator is cleaned between individual tests, only limited maintenance is required.

2.6 Instrument Calibration and Frequency (B7)

Calibration and frequency requirements for the balances used in the gravimetric analyses are given in Table 2-4.

Requirements for high-volume (hi-vol) sampler flow rates rely on the use of secondary and primary flow standards. The Roots meter is the primary volumetric standard and the BGI orifice is the secondary standard for calibration of hi-vol sampler flow rates. The Roots meter is calibrated and traceable to a NIST standard by the manufacturer. The BGI orifice is calibrated against the primary standard on an annual basis. Before going to the field, the BGI orifice is first checked to assure that it has not been damaged. In the field, the orifice is used to calibrate the flow rate of each hi-vol sampler. (For samplers with preset volumetric flow controllers, no calibration is possible but the orifice is used to audit the nominal 40 acfm flow rate.) Table 2-5 specifies the frequency of calibration and other QC checks regarding air samplers.

Table 2-6 outlines the QC checks employed for miscellaneous instrumentation needed.

Table 2-5. Quality Control and Calibration Procedures for Sampling Equipment

Activity	QC check/requirement
Maintenance • All samplers	Check motors, brushes, gaskets, timers, and flow measuring devices at each plant prior to testing. Repair/replace as necessary.
Calibration • Volumetric flow controller	Prior to start of testing at each regional site, ensure that flow determined by orifice and the look-up table for each volumetric flow controller agrees within 7%. For 20 acfm devices (particle size profiling), calibrate each sampler against orifice prior to use at each regional site and every two weeks thereafter during test period. (Orifice calibrated against displaced volume test meter annually.)
Operation • Timing	Start and stop all downwind samplers during time span not exceeding 1 min.
• Isokinetic sampling (cyclones)	Adjust sampling intake orientation whenever mean wind direction changes by more than 30 degrees for 2 consecutive 5-min averaging periods. Suspend testing if mean wind direction (for two consecutive 5-min averaging periods) is more than 45 degrees from perpendicular to linear path of the moving point source. Change the cyclone intake nozzle whenever the mean wind speed approaching the sampler falls outside of the suggested bounds for that nozzle for two consecutive 5-min averaging periods. Suspend testing if wind speed falls outside the acceptable range of 3 to 20 mph for two consecutive 5-min averaging periods.
• Prevention of static deposition	Cover sampler inlets prior to and immediately after sampling.

Table 2-6. Quality Control and Calibration Procedures for Miscellaneous Instrumentation

Instrumentation	QC check/requirement[a]
Digital manometers	Compare reading against water-in-tube manometers over range of operating pressures using "Y" connectors and flexible tubing. Do not use units which differ by more than 7%.
Digital barometer	Compare against mercury-in-tube barometer. Do not use if more than 0.5 in Hg difference in reading.
Thermometer (mercury or digital)	Compare against NIST-traceable mercury-in-glass. Do not use if more than 3.0 C difference.
Gill anemometer	Conduct 4-point calibration of each unit over the range of 2 to 20 mph both before going to the field and upon return of the equipment to MRI's main laboratories. Use factory-specified anemometer drive device for calibration.
Watches/stopwatches	The field test leader will compare an elapsed time (> 1 hr) recorded by his watch against the US Naval Observatory master clock. Do not use if more than 3% difference. All crew members will synchronize watches (to the nearest minute) at the start of each test day.

[a] Activities performed prior to going to the field, except as noted.

2.7 Inspection/Acceptance Requirements for Supplies and Consumables (B8)

The primary supplies and consumables for this field exercise consist of the air and substrate sample collection media as well as vacuum cleaner bags. Prior to stamping and initial weighing (Table 2-4), each filter is visually inspected and is discarded for use if any pin-holes, tears, or other damage is found. Similarly, vacuum bags are examined for tears or other damage before tare weighing.

2.8 Data Acquisition Requirements (B9)

In addition to the field samples, MRI will also collect information on the physical size and operational parameters of equipment used in the field exercise. To the extent practical, physical characteristics will be obtained from the manufacturer or the manufacturer's literature. Physical dimensions will be measured and recorded.

2.9 Data Management (B10)

After return to MRI's main laboratories, raw data will be transferred from data sheets into computer spreadsheet programs to perform the calculations (described in Section 5.2 of the site-specific test plan) leading to net concentrations. In addition to raw data, the spreadsheet also contains cells for data derived from field measurements (such as flow rates determined from "look-up" tables using air temperatures and pressures). Cell formulas are included on the spreadsheet so that the reader can readily determine how a value is calculated. Validation activities are discussed in Section 4.0.

Section 3. Assessment/Oversight

The quality of the project and associated data are assessed within the project by the WAL, project personnel and peer reviewers. Oversight and assessment of the overall project quality are accomplished through the review of data, memos, audits, and reports by the program and division management and, independently, by the QAO.

3.1 Assessments and Response Actions (C1)

The effectiveness of implementing the QAPP and associated SOPs for a project are assessed through project reviews, field inspections, audits, and data quality assessment.

3.1.1 Project Reviews

The review of project data and the writing of project reports are the responsibility of the WAL who also is responsible for the conduct of the first complete assessment of the project. Although the project's data have been reviewed by the project personnel and assessed as to whether the data meet the measurement quality objectives, it is the WAL who must assure that overall the project activities meet the measurement and data quality objectives. The second review process is a technical peer review conducted by a technically qualified person who is familiar with the technical aspects of the project but not involved in the conduct of project activities. The peer reviewer is to present to the project leader an accurate and independent appraisal of the technical aspects of the project.

The division management will assure that the project management systems are established and functioning as required by division procedures and corporate policy. The division management is the final reviewer before the QAO and is responsible for assuring EPA that contractual requirements have been met. The QAO will conduct the final review of the report before submittal to EPA.

3.1.2 Field Inspections

Field inspections may be conducted by the WAL or QA field auditor. Inspections assess project activities that are considered important or critical to the requirements of the project. These critical activities may include, but are not limited to, sample collection and preservation, method development or validation, sample preparation, sample analysis, or data reduction. Field inspections are assessed with respect to the QAPP, SOPs, or other established methods, and are reported to the WAL and QAO. Any deficiencies or problems found during the in-phase inspections must be investigated with the results and responses or corrective actions reported in a Corrective Action Report (CAR), as discussed later in this section.

3.1.3 Audits

Independent systematic checks to determine the quality of the data will be performed during the conduct of this project. These checks will consist of a system and data audits as described below. In addition, the internal quality control measurements will be used to assess the performance of the analytical methodology. The combination of these audits and the internal quality control data allows the assessment of the overall data quality for this project.

The QAO is responsible for ensuring that audits are conducted as required by the QAPP. The WAL is responsible for evaluating corrective action reports, taking appropriate and timely corrective actions, and informing the QAO and PgM of the action taken. The QAO is then responsible for ensuring that the corrective action was taken.

The system audit will be conducted by the QAO prior to the start of the project activities. This audit will evaluate all components of the data gathering and management system to determine if these systems have been properly designed to meet the quality assurance objectives for this study. The system audit includes a careful review of the experimental design, the test plan, and the procedures. This review includes personnel qualifications, adequacy, and safety of the facilities and equipment, SOPs, and the data management system.

The system audit starts with the review of the QAPP, the SSTP, and the associated procedures and experimental design to ensure that they can meet the data quality objectives for the study. During the system audit, the QAO will inspect project activities and determine the laboratory's adherence to the SOPs and the QAPP. The QAO reports any area of nonconformance to the project leader and division management through an audit report. The audit report may contain corrective action recommendations. If so, follow-up inspections may be required and should be performed by the QAO to ensure corrective actions are taken. The system audit ends with a review of the report and an audit of the records at the completion of the study.

The data audit, an important component of a total system audit, is a critical evaluation of the measurement, processing, and evaluation steps to determine if systematic errors have been introduced. During the data audit, the QAO, or his designee, will randomly select data to be followed through the analysis and data processing. The scope of the data audit is to verify that the data handling system is correct and to assess the quality of the data generated.

The data audit, as part of the system audit, is not an evaluation of the reliability of the data presentation. The review of the data presentation is the responsibility of the WAL and the peer reviewer.

3.1.4 Amendments and Revisions to the QAPP

This QAPP is designed to be a working tool for the staff conducting the study as well as the management of MRI and EPA. As a working document, it may become necessary to amend or revise the QAPP to reflect current activities. When there is a requirement to update the QAPP to correct minor discrepancies that have no effect on the overall conduct of the study or typing errors, an amendment (Figure 3-1) will be prepared and submitted to the EPA WAM, and the MRI WAL for approval. The format of the amendment record will be an assigned amendment number to the chapter/section where the statement will be changed, the original statement, the reason for the change, and the amended statement. The amended statement will use crossed-out text for deletions and red-lined text for additions. The effective date of the amendment will be the date of the submitted amendment unless otherwise noted.

When the changes involve major changes in the conduct of the study (i.e., changes in the design, collection, or processing of samples or data), a revision of the affected chapter in the QAPP will be required. When a chapter is revised, the entire chapter will be replaced.

3.2 Corrective Action

Corrective action is the process that occurs when the results of an audit or quality control measurement are shown to be unsatisfactory, as defined by the data quality objectives or by the measurement objectives for each task. The corrective action process involves the WAL and the QAO. In cases involving the analytical process, the corrective action also will involve the analyst. A written report (Figure 3-2) is required on all corrective actions.

The WAL will consult with appropriate staff having expertise in areas where difficulties are experienced and will propose solutions to situations requiring corrective action. Program management will be involved in the problem-solving discussions and may have input into final decisions.

QUALITY ASSURANCE PROJECT PLAN AMENDMENT RECORD

QAPP Title/Date: Quality Assurance Project Plan for ________________________

____

Origin Location: Midwest Research Institute

WAL: ____

PgM: ____

QAO: ____

EPA WAM: ____

No.	Section	Description
1		Statement: Reason: Amendment:
2		Statement: Reason: Amendment:
3		Statement: Reason: Amendment:
4		Statement: Reason: Amendment:

Figure 3-1. QAPP Modification Record

Project No.: __________

Date: __________

Corrective Action Report

Project Title/Description: ______________________________

Description of Problem:

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Originator: ______________ Date: __________

Investigation and Results:

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Investigator: ______________ Date: __________

Corrective Action Taken:

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Originator: ______________ Date: __________

Reviewer/Approval: ______________ Date: __________

Cc: Project leader, Program Manager, Division Manager, QA Unit

MRI-QA\CAR Form.DOC

Figure 3-2. Corrective Action Report

There are two types of corrective actions:

- **Immediate** corrective action is a quick response to improper procedures such as malfunctioning equipment. The need for such an action is usually identified by the analyst as a result of calibration checks and internal quality control sample analysis. The WAL, who will be notified of the problem immediately, will then take and document appropriate action. The WAL is responsible for and is authorized to halt the work if it is determined that a serious problem exists.

- **Long-term** corrective action is used to prevent the recurrence of unanticipated problems. The need for such action may be identified by audits. The long-term corrective action steps consist of:

  — Definition of the problem

  — Investigation to determine the cause

  — Determination of the appropriate corrective action

  — Implementation of the corrective action

  — Verification of the effectiveness of the corrective action by a follow-up inspection.

The WAL is responsible for and is authorized to implement any procedures to prevent the recurrence of problems.

3.3 Reports to Management (C2)

The status of the project will be reported to the WAL on a weekly basis by the project staff. Any problems found during the analytical process requiring corrective action will be reported immediately by the project staff to the WAL and the quality assurance officer through the investigation and corrective action documentation. The results of the in-phase inspection by the project or program management will be documented in the project files and reported to the QAO. In-phase inspections conducted by the QAO will be reported to management in the same manner as other audits.

Results of system audits, in-phase inspections, performance evaluations, and data audits conducted by the QAO will be routed to the WAL for review, comments, and corrective action, and forwarded to management. An assessment of the data will be sent for management review. The performance evaluations, control issues, and corrective action responses covered by the audit reports will be reviewed and approved by the program manager, section manager, and division management. The results of all assessments, audits, inspections, and corrective actions for the project will be summarized and included in a quality assurance/quality assessment section in the final report.

The reporting requirements are a draft final report and a final report submitted as part of the contractual obligation. Electronic deliverables in the form of data tables will also be submitted.

Section 4. Data Validation and Usability (D)

4.1 Data Review, Validation, and Verification Requirements (D1)

The data analysis procedures to be used for this project are procedures that have been passed through several layers of validation in substantiating the performance of the method. The procedure for calculation of a raw particulate concentration requires a sample mass and an associated sampler flow rate. It should be noted that blank-corrected sample mass is considered quantifiable (and usable for concentration calculation) only if it equals or exceeds three times the standard deviation for the net weight gain of the field blanks. The procedures for conversion of particulate concentrations to final end products are presented in Section 5.2 of the site-specific plan.

The FTL or his/her designee will conduct an on-site spot check to assure that data are being recorded accurately. After the field test, the QAO or his designee will check data input to assure accurate transfer of the raw data. The FTL or his designee will perform an independent check of any computer data reduction program through an independent hand-calculation of at least one test run. The FTL will report their findings to the WAL.

4.2 Validation and Verification Methods (D2)

For this project, all records will be evaluated for the adherence to all procedures and requirements. The items that will be reviewed include:

- Gravimetric audit weighing for the assessment of the particulate data
- Calibration and calibration criterion checks
- Results of all blanks
- Validation of data process systems or procedures
- Traceability and sample tracking

Selected data will be reconstructed, including tracing the calibration back to the primary standards. Any software (spreadsheets) used to determine numerical values will be checked by hand calculating all intermediate and final results for one run by referring to original sources of data (i.e., field filter logs, filter weight logs, run sheets, look-up tables for volumetric flow controllers).

4.3 Reconciliation with User Requirements (D3)

The data generated during the field exercise will be evaluated with respect to the user requirements to estimate PM-10 and PM-2.5 emissions from controlled and uncontrolled scraper travel and mud/dirt trackout. Recommendations for revisions to current AP-42 emission estimation methods will be presented in the test report.

Section 5. References

1. Midwest Research Institute. *Prototype Test and Quality Assurance Plan for Construction Activities*. EPA Contract 68-D7-0002, Work Assignment No. 1. February 1998.

2. Midwest Research Institute. *Background Documentation for AP-42 Section 11.2.4, Heavy Construction Operations*. EPA Contract No. 68-D0-0123, Work Assignment No. 44. April 1993.

3. Midwest Research Institute. *Emission Factor Documentation for AP-42 Section 13.2.2—Unpaved Roads*. Draft Report. EPA Contract No. 68-D2-0159, Work Assignment 4-02. September 1997.

4. Midwest Research Institute. *Emission Measurements of Particulate Mass and Size Emission Profiles from Construction Activities—Site-Specific Test Plan*. EPA Contract No. 68-D-98-027, Work Assignment 1-04. June 1998.

5. U.S. EPA. *Compilation of Air Pollutant Emission Factors*. AP-42, Fifth Edition. Research Triangle Park, NC. September 1995.

6. Baxter, T. E, D. D. Lane, C. Cowherd, Jr., and F. Pendleton. "Calibration of a Cyclone for Monitoring Inhalable Particulates." *Journal of Environmental Engineering*, 112(3), 468. 1986.