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ENVIRONMENT

Ms. Elizabeth B. Lukowski
Engineering Geologist
Division of Environmental Remediation
New York State Department of Environmental Conservation
625 Broadway
Albany, New York 12233-7014

Subject:
National Fuel
Dunkirk Former MGP Site
Work Plan for Off-Site Monitoring Wells

Date:
February 22, 2012

Contact:
Scott A. Powlin

Phone:
315 671 9456

Email:
Scott.Powlin@arcadis-us.com

Our ref:
B0023301 #10

ARCADIS of New York, Inc.
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Dear Ms. Lukowski:

On behalf of National Fuel (NFG), this letter presents a proposed work plan for installing two off-site monitoring wells at the former manufactured gas plant (MGP) site located at 31 West 2nd Street in Dunkirk, New York. The installation of these monitoring wells was initially discussed during the February 2, 2012 conference call between the New York State Department of Environmental Conservation (NYSDEC), NFG, and ARCADIS. The purpose of the call was to discuss the results of the second phase of Site Characterization (SC) fieldwork that was conducted in 2011 and a path forward for the project. The call was attended by Ms. Tanya Alexander and Mr. Lee Hartz of NFG, Ms. Elizabeth Lukowski and Mr. Gardiner Cross of the NYSDEC, and Mr. Terry Young and Mr. Scott Powlin of ARCADIS.

During the call, NFG and the NYSDEC discussed the need to install two off-site monitoring wells downgradient from the MW-1 area to define the downgradient extent of elevated benzene concentrations in groundwater in the MW-1 area. The new wells would be located on the City Rights of Way (ROWs) at the intersection of West 2nd Street and Eagle Street. The NYSDEC indicated that they would need to review the 2010 SC data summary in combination with the 2011 SC data summary to determine whether installation of the two monitoring wells would be the only requirement to finalize the SC. All individuals on the call agreed that the elevated benzene levels could be attributed to the presence of a historical oil tank located in the MW-1 area. The NYSDEC also suggested that an Interim Remedial Measure (IRM) of the oil tank could be considered to address the elevated benzene concentrations in both soil and groundwater in that area.

During the call, the NYSDEC indicated that they would discuss the proposed new wells with the NYS Department of Health (NYSDOH) and confirm that the NYSDOH was in agreement with the proposal. Following the call, ARCADIS sent the data summary for

the 2010 SC activities to the NYSDEC via electronic mail. On February 15, 2012, the NYSDEC sent an electronic mail to NFG requesting that NFG submit a letter work plan for installation of the two monitoring wells to evaluate the potential presence of dissolved-phase benzene downgradient from the MW-1 area. The proposed plan for installing and sampling of the new monitoring wells is discussed below.

Proposed Fieldwork

As discussed and agreed to during the abovementioned correspondence, NFG proposes to install two overburden monitoring wells at the intersection of West 2nd Street and Eagle Street. The proposed locations of the monitoring wells are shown on Figure 1. Data collected from the monitoring wells will be evaluated to assess the potential presence of dissolved-phase volatile organic compounds (VOCs) (primarily benzene) downgradient from the MW-1 area. A secondary objective of this new work will be to evaluate whether a dissolved-phase plume could be migrating off-site.

Monitoring wells will be installed and developed using the same methods previously employed at the site. Prior to monitoring well installation, a vacuum-excavation truck or hand-clearing will be used to clear each monitoring well location to approximately 5 feet below grade. NFG is planning that each location be cleared using this method as an added safety measure to avoid conflicts with below grade utilities during the drilling activities. The hand-clearing will be completed in addition to the DigSafely NY call-in.

Upon clearing each location, the monitoring well borings will be drilled using conventional 4.25-inch inner diameter hollowed-stem auger (HSA) drilling techniques and continuous split-spoon sampling. Soil samples will be collected continuously from the borings for visual characterization and headspace-screening with a photoionization detector (PID). Monitoring well screens will be installed at the approximate same depth as all other monitoring wells previously installed at the site - on the bedrock surface, which is typically encountered between 15 to 19 feet below grade. Screens will consist of 10-foot long, 10-slot, 2-inch diameter schedule 40 PVC. The filter pack material will consist of Grade #0 sand installed to approximately two feet above the well screen. An approximate two-foot thick hydrated bentonite seal will be placed on top of the filter pack, and the remaining annular space will be filled with cement/bentonite grout up to approximately 1-foot below grade. Each well will be secured at the surface with an 8-inch diameter, flush-mounted curb box.

A minimum of 24 hours after installation, the monitoring wells will be developed by surging/bailing. The wells will be developed until the water removed from the wells is reasonably free of visible sediment (50 nephelometric turbidity units [NTUs]), if possible, or until the turbidity levels stabilize, assuming a minimum of 10 well volumes of water have been removed from the monitoring well during development. Following

development, wells will be allowed to recover for at least one week before groundwater is purged and sampled.

Two rounds of groundwater sampling are proposed for the two new monitoring wells. The sampling rounds will be spaced approximately 2 months apart. During each sampling event, groundwater will be sampled from the two new monitoring wells using low-flow sampling techniques. Samples will be submitted for analysis of Target Compound List (TCL) VOCs, TCL semi-VOCs (SVOCs), and total cyanide. A comprehensive round of water-level measurements will be obtained from all site monitoring wells during each sampling event.

The location, ground surface elevation, and measuring point elevations of the monitoring wells will be surveyed after the wells are installed. Consistent with the previous survey work at the site, horizontal coordinates will be tied to New York State Plane Central (3102) coordinate system (NAD 83), and all elevations will be established with respect to NAVD 1988.

Investigation-derived waste (IDW) generated from the additional wells will be containerized for appropriate characterization and disposal. Wastes will be segregated by waste type and placed in Department of Transportation (DOT)-approved 55-gallon steel drums or polyethylene tanks. Field staff will maintain an inventory of all waste vessels and will appropriately label each container with the contents, generator, location and date. NFG will coordinate off-site disposal of waste materials upon completion of the field activities.

Field Methods and Analytical Protocol

Field activities will be conducted in accordance with the procedures detailed in the NYSDEC-approved Site Characterization Work Plan for the Dunkirk Former MGP Site (ARCADIS, 2009) and the following supporting appendices:

- Field Sampling Plan (FSP)
- Quality Assurance Sampling and Analysis Project Plan (QA/SAPP)
- Health and Safety Plan (HASP)
- DNAPL Contingency Plan (DCP)

As described in the QAPP, analytical samples will be submitted for laboratory analysis using United States Environmental Protection Agency (USEPA) SW-846 Methods as referenced in the most recent edition of the NYSDEC Analytical Services Protocol (ASP), with Category B analytical laboratory reports. Data Usability Summary Reports (DUSRs) of the laboratory data packages will be prepared and the results of the DUSR will be incorporated into data tables prepared for the project.

Schedule and Reporting

Consistent with the approach for submitting the previous SC results to the NYSDEC, NFG proposes to submit a data summary report to the NYSDEC and follow up the submittal with a conference call to discuss the results and a path forward for the project. We anticipate the data summary will contain:

- Monitoring well completion logs for the new monitoring wells
- Analytical data summary table for monitoring well groundwater sample results
- A site plan including locations of the two additional monitoring wells
- A new water table elevation contour map including the hydraulic head information from the two new monitoring wells
- Updated cross-sections, as appropriate
- Updated figure depicting dissolved-phase constituents in groundwater, if any

NFG plans to conduct the additional fieldwork in spring 2012. We look forward to your approval of this work plan. In the meantime, if you have any questions, please feel free to contact me at 315.446.9120 or Tanya Alexander of NFG at 716.857.7410.

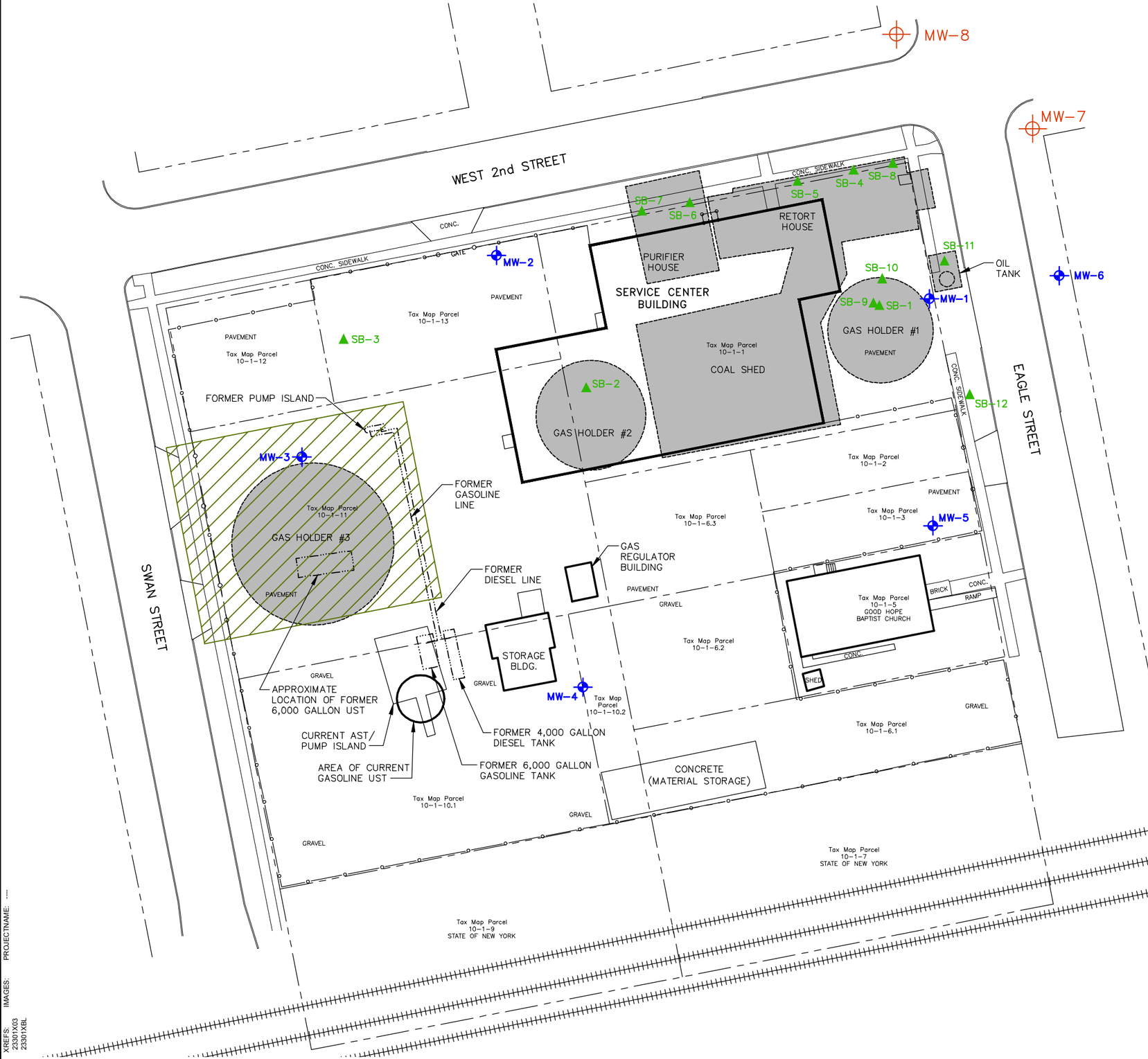
Sincerely,

ARCADIS of New York, Inc.

Scott A. Powlin
Sr. Geologist

Attachment

Copies:
Tanya Alexander, CHMM, REM, National Fuel
Lee Hartz, National Fuel
Gardiner Cross, NYSDEC
Anthony Lopes, NYSDEC – Region 9
Nathan Freeman, NYSDOH
Terry Young, ARCADIS



LEGEND:

- PROPOSED OFF-SITE MONITORING WELL LOCATION
- SOIL BORING
- MONITORING WELL
- FORMER MGP STRUCTURE
- FORMER PETROLEUM DISTRIBUTION STRUCTURES
- APPROXIMATE EXTENT OF PETROLEUM REMEDIATION AREA
- APPROXIMATE PROPERTY LINE
- RAILROAD
- EXISTING BUILDING
- CHAIN LINK FENCE

NOTES:

1. ALL LOCATIONS APPROXIMATE.
2. BASEMAP FORM NYS GIS CLEARINGHOUSE WEBPAGE FOR ORTHOIMAGERY AND CT MALE SURVEY OBTAINED ON SEPTEMBER 14, 2010.
3. APPROXIMATE EXTENT OF PETROLEUM REMEDIATION AREA BASED ON A HAND SKETCH MAP PROVIDED BY NATIONAL FUEL ON JANUARY 26, 2009. DATE OF REMEDIATION NOT DEFINED ON THAT MAP.
4. LOCATIONS OF GAS HOLDERS 2 AND 3 DIGITIZED FROM A MAY 10, 1956 DRAWING PROVIDED BY NATIONAL FUEL. ALL OTHER MGP STRUCTURES DIGITIZED FROM 1893 AND 1904 SANBORN FIRE INSURANCE MAPS.
5. LOCATIONS OF FORMER USTs, PUMP ISLAND, AND ASSOCIATED DISTRIBUTION LINES FROM MESCH ENGINEERING, P.C. DRAWING ENTITLED "SITE PLAN", ORIGINAL DRAWING DATED 9/17/87.
6. MONITORING WELLS MW-5 AND MW-6, AND SOIL BORINGS SB-9 THROUGH SB-12 FROM SURVEY FILE PROVIDED BY C.T. MALE ASSOCIATES, DATED 10/7/11.

0 50' 100'

GRAPHIC SCALE

NATIONAL FUEL
DUNKIRK FORMER MGP SITE
DUNKIRK, NEW YORK
SITE CHARACTERIZATION

PROPOSED OFF-SITE MONITORING WELLS

ARCADIS

FIGURE
1

CITY: SYRACUSE, N.Y. DIV/GROUP: 141/ENVCAD DB: LPOSENAUER, RALLEN LD:(Opt) PIC:(Opt) PM: S.POWLIN TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\SYRACUSE\ACT\B0023001\0001\00002\DWG\SITE-CHAR23301P01.dwg LAYOUT: 1 SAVED: 2/21/2012 10:36 AM ACADVER: 18.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: PLTFULL.CTB PLOTTED: 2/21/2012 10:37 AM BY: ALLEN, ROYCE
XREFS: 23301X03 23301XBL IMAGES: PROJECTNAME: ---

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National Fuel Gas Distribution Corporation

Community Air Monitoring Plan

Dunkirk Former Manufactured Gas Plant Site
Dunkirk, New York

March 2012

Community Air Monitoring Plan

Dunkirk Former Manufactured
Gas Plant Site
Dunkirk, New York

Prepared for:
National Fuel Gas Distribution Corporation

Prepared by:
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Our Ref.:
B0023301.0001.00002

Date:
March 2012

1. Introduction

1.1 General

This *Community Air Monitoring Plan* (CAMP) has been prepared to support the implementation of investigation activities at the Dunkirk Former Manufactured Gas Plant (MGP) site (hereafter referred to as "site"), in Dunkirk, Chautauqua County, New York. The purpose of this CAMP is to describe the activities that will be conducted to monitor for potential airborne releases of constituents of concern during investigation activities. This CAMP fulfills the requirements set forth in the New York State Department of Environmental Conservation's (NYSDEC's) DER-10/Technical Guidance for Site Investigation and Remediation (May 2010) (DER-10). The DER-10 CAMP requirements are identified in DER-10 Appendix 1A, New York State Department of Health (NYSDOH) Generic Community Air Monitoring Plan, dated December 2009; and Appendix 1B, Fugitive Dust and Particulate Monitoring. DER-10 Appendices 1A and 1B are provided in Attachment A to this CAMP. The intent of this CAMP is to provide for a measure of protection of the downwind communities from potential airborne releases of constituents of concern during investigation activities. As such, this CAMP specifies the potential air emissions, air monitoring procedures, monitoring schedule and data collection and reporting for the investigation activities to be conducted, as described below.

1.2 Site Description

The approximately three-acre site is located at 31 West 2nd Street at the southeastern corner of the intersection of Swan Street and West 2nd Street in Dunkirk, Chautauqua County, New York. The site comprises a generally rectangular piece of land that is located in a mixed commercial and residential area. Lake Erie is located about 600 feet north of the site. The site is bordered by Swan Street to the west, West 2nd Street to the north, Eagle Street to the east, and an elevated railroad bed to the south. A Baptist Church is located near the southeastern corner of the site; however, a narrow strip of National Fuel property borders the church property to the south.

A National Fuel Service Center building sits on the northeastern quadrant of the site. The Service Center building consists of a high-bay garage located south of the attached office area. Two other buildings are present at the property – a small metal sided storage building and a brick gas regulator building, which are both located south-south west of the Service Center building. A fuel pump island is located west of the metal sided storage building and consists of a pump island supported by an above

ground storage tank (AST) containing diesel and an underground storage tank (UST) containing gasoline.

Refer to Figure 2 of the Site Characterization Work Plan (ARCADIS, 2009) for a visual depiction of site features.

1.3 Summary of Investigation Activities

As defined in the NYSDOH's Generic CAMP (included as Attachment A), investigation activities to be performed at the site have the potential to generate localized impacts to air quality. Activities covered by this CAMP may include:

- drilling soil borings
- excavating test pits or trenches
- sampling soil
- sampling groundwater from monitoring wells

1.4 Air/Odor Emissions and Control Measures

Air emissions control and fugitive dust suppression techniques will be used during the investigation activities identified above, as necessary, to limit the air/odor emissions from the site. Air monitoring for the specific purpose of protecting the community from site activity impacts (and verification thereof) will take place during both intrusive and non-intrusive investigation activities. Odor and dust control measures will be available at the site and used when necessary during these activities. The following vapor and dust control measures may be used during these activities, depending upon specific circumstances, visual observations, and air monitoring results:

- Polyethylene sheeting (for covering drill cuttings, etc.)
- Water/BioSolve® spray
- Minimizing excavation surface area to be exposed at any given time.
- Vapor suppression foam

Polyethylene sheeting/BioSolve®/foam would be used to control nuisance odors and volatile organic compound (VOC) emissions, as needed. Also, dust emissions at the site will be controlled by spraying water on exposed dry surface soil areas (e.g. stockpiled drill cuttings, etc., as appropriate), through the use of silt fences, and by covering soil stockpiles. Odor and dust control measures will be implemented based on visual or olfactory observations, and the results of airborne particulate and VOC monitoring.

2. Air Monitoring Procedures

2.1 General

Real-time air monitoring will be implemented at the site for VOCs, and particulate matter less than 10 microns in diameter (PM_{10}). A site boundary will be established for the purpose of air monitoring. Upwind and downwind monitoring locations will be determined through visual observation (wind vane, windsock, or similar technique). Monitoring will occur at each sample location and will include the use of hand-held direct-reading survey instruments.

2.2 Monitoring Location Selection

Monitoring activities will be determined daily based on visual observation of a wind direction. One upwind and one downwind monitoring location will be selected daily where both VOC and PM_{10} will be recorded. This upwind location will be established at the start of the workday, each day before the start of activities. Sampling activities will continue in the downwind direction throughout the day. If wind direction during the workday shifts greater than approximately +/-60 degrees from original upwind, then new upwind and downwind monitoring locations will be established. Any location changes will be documented in the field logbook.

2.3 VOCs Monitoring

As required by the NYSDOH guidance for community air monitoring during intrusive activities, VOCs will be monitored continuously during ground intrusive activities (installation of soil borings and excavating test pits/trenches) with instrumentation that is equipped with electronic data-logging capabilities. A MiniRAE 2000 (or equivalent) will be used to conduct the real-time VOC monitoring. Attachment B provides detailed information on the MiniRAE 2000. All 15-minute readings will be recorded in the field logbook, as well as any instantaneous readings taken to facilitate activity decisions.

During non-intrusive site activities (collection of soil samples, well development, collection of groundwater samples), VOCs will be monitored periodically. Periodic monitoring may include monitoring upon arrival at the sample location, monitoring while opening a well cap, monitoring during well bailing and/or purging, and/or monitoring prior to leaving a sample location. However, if a sampling location is near

potentially exposed individuals, VOCs will be monitored continuously during sampling activities at that location.

2.4 Particulate Matter Monitoring

As required by the NYSDOH guidance (Attachment A), real-time particulate matter will be monitored continuously during intrusive site activities using instrumentation equipped with electronic data-logging capabilities. A MIE DataRAM (or equivalent) will be used to conduct the real-time PM_{10} monitoring. Attachment B provides detailed information on the MIE DataRAM. All 15-minute readings will be recorded in the field logbook, as well as any instantaneous readings taken to facilitate activity decisions.

Fugitive dust migration will be visually assessed during all work activities, and reasonable dust suppression techniques will be used during any site activities that may generate fugitive dust. These activities and their design controls were discussed previously in Section 1.4 of this plan.

2.5 Action Levels

The action levels provided below are to be used to initiate response actions, if necessary, based on real-time monitoring.

2.5.1 Action Levels for VOCs

As outlined in the NYSDOH guidance document (Attachment A), if the ambient air concentration of total VOCs exceeds 5 parts per million (ppm) above the background (upwind location) for the 15-minute average, intrusive site activities will be temporarily halted while monitoring continues. If the total VOC concentration readily decreases (through observation of instantaneous readings) below 5 ppm above background, then intrusive site activities can resume with continuous monitoring.

If the ambient air concentrations of total VOCs persist at levels in excess of 5 ppm above background but less than 25 ppm above background, intrusive site work activities will be halted, the source of the elevated VOC concentrations identified, corrective actions to reduce or abate the emissions undertaken, and air monitoring will be continued. Once these actions have been implemented, intrusive site work activities can resume provided the following two conditions are met:

- The 15-minute average VOC concentrations remain below 5 ppm above background.

- The VOC level 200 feet downwind of the sample location or half the distance to the nearest potential receptor or residential/commercial structure (whichever is less but in no case less than 20 feet) is below 5 ppm over background for the 15-minute average.

If the ambient air concentrations of total VOCs are above 25 ppm above background, the intrusive site activities must cease, and emissions control measures must be implemented.

Periodic monitoring for VOCs is required during non-intrusive activities such as collection of soil samples, well development, and the collection of groundwater samples from monitoring wells. If these activities are undertaken at the site, ambient direct-reading (instantaneous) VOC data will be periodically collected at the location of the non-intrusive activity and recorded in the field activity logbooks.

2.5.2 Action Level for PM_{10}

As required by the NYSDOH guidance (Attachment A), if the ambient air concentration of PM_{10} at any one (or more) of the sampling locations is noted at levels in excess of 100 micrograms per cubic meter ($\mu g/m^3$) above the background (upwind location), or if airborne dust is observed leaving the work area, intrusive site activities will be temporarily halted. The source of the elevated PM_{10} concentration is to be identified, corrective actions to reduce or abate the emissions will be undertaken, and air monitoring will continue. Work may continue following the implementation of dust suppression techniques provided the PM_{10} levels do not exceed 150 $\mu g/m^3$ above background.

If, after implementation of dust suppression techniques, PM_{10} levels are greater than 150 $\mu g/m^3$ above background, work must be stopped and site activities must be re-evaluated. Work may only resume provided that the dust suppression measures and other controls are successful in reducing PM_{10} levels less than 150 $\mu g/m^3$ above background and in preventing visible dust from leaving the site.

If the ambient air concentration of PM_{10} is above 150 $\mu g/m^3$ above background, the intrusive site activities must cease and emissions control measures must be implemented.

2.6 Meteorological Monitoring

Wind direction is the only meteorological information considered relevant for the investigation activities and CAMP. Meteorological monitoring will be conducted periodically at the site using a windsock, wind vane, or other appropriate equipment. Wind direction will be established at the start of each work day and may be re-established at any time during the work day if a significant shift in wind direction is noted.

2.7 Instrument Calibration

Calibration of the VOC and PM_{10} instrumentation will occur in accordance with each of the equipment manufacturer's calibration and quality assurance requirements. The VOC and PM_{10} monitors will be calibrated at least daily, and calibrations will be recorded in the field activity logbook.

3. Monitoring Schedule and Data Collection and Reporting

3.1 General

The proposed monitoring schedule and data collection and reporting requirements are discussed below.

3.2 Monitoring Schedule

Real-time VOC and PM_{10} monitoring will be performed continuously throughout the remedial action during intrusive site/materials handling activities. VOC monitoring will also be performed during non-intrusive sampling-type activities. Wind direction will be determined at the start of each day and at any other appropriate time during investigation activities.

3.3 Data Collection and Reporting

Air monitoring data will be collected continuously from VOC and PM_{10} monitors during intrusive site activities by an electronic data-logging system. The data management software will be set up so that instantaneous observed readings would be recorded by the electronic data acquisition system and averaged over 15-minute time periods. The 15-minute readings and instantaneous readings taken to facilitate activity decisions will be recorded and archived for review by NYSDOH and NYSDEC personnel.

Attachment A

NYSDOH Generic Community Air Monitoring Plan (from NYSDEC DER-10/Technical Guidance for Site Investigation and Remediation [May 2010])

APPENDIX 1A

New York State Department of Health
Generic Community Air Monitoring Plan

A Community Air Monitoring Plan (CAMP) requires real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at contaminated sites. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the CAMP helps to confirm that work activities did not spread contamination off-site through the air.

The generic CAMP presented below will be sufficient to cover many, if not most, sites. Specific requirements should be reviewed for each situation in consultation with NYSDOH to ensure proper applicability. In some cases, a separate site-specific CAMP or supplement may be required. Depending upon the nature of contamination, chemical- specific monitoring with appropriately-sensitive methods may be required. Depending upon the proximity of potentially exposed individuals, more stringent monitoring or response levels than those presented below may be required. Special requirements will be necessary for work within 20 feet of potentially exposed individuals or structures and for indoor work with co-located residences or facilities. These requirements should be determined in consultation with NYSDOH.

Reliance on the CAMP should not preclude simple, common-sense measures to keep VOCs, dust, and odors at a minimum around the work areas.

Community Air Monitoring Plan

Depending upon the nature of known or potential contaminants at each site, real-time air monitoring for volatile organic compounds (VOCs) and/or particulate levels at the perimeter of the exclusion zone or work area will be necessary. Most sites will involve VOC and particulate monitoring; sites known to be contaminated with heavy metals alone may only require particulate monitoring. If radiological contamination is a concern, additional monitoring requirements may be necessary per consultation with appropriate NYSDEC/NYSDOH staff.

Continuous monitoring will be required for all ground intrusive activities and during the demolition of contaminated or potentially contaminated structures. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, test pitting or trenching, and the installation of soil borings or monitoring wells.

Periodic monitoring for VOCs will be required during non-intrusive activities such as the collection of soil and sediment samples or the collection of groundwater samples from existing monitoring wells. "Periodic" monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at wells on the curb of a busy urban street, in the midst of a public park, or adjacent to a school or residence.

VOC Monitoring, Response Levels, and Actions

Volatile organic compounds (VOCs) must be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone) on a continuous basis or as otherwise specified. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions. The monitoring work should be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. The equipment should be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment should be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

- If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.

- If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

- If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown.

All 15-minute readings must be recorded and be available for State (DEC and DOH) personnel to review. Instantaneous readings, if any, used for decision purposes should also be recorded.

Particulate Monitoring, Response Levels, and Actions

Particulate concentrations should be monitored continuously at the upwind and downwind perimeters of the exclusion zone at temporary particulate monitoring stations. The particulate monitoring should be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. The equipment must be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration should be visually assessed during all work activities.

- If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 150 mcg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.

- If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work must be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.

All readings must be recorded and be available for State (DEC and DOH) personnel to review.

NEW YORK STATE
DEPARTMENT OF
ENVIRONMENTAL CONSERVATION

Fugitive Dust Suppression and Particulate Monitoring Program (TAGM - 4031)

To:	Regional Hazardous Waste Remediation Engrs., Bur. Directors & Section Chiefs
From:	Michael J. O'Toole, Jr., Director, Division of Hazardous Waste Remediation (signed)
Subject:	Technical and Administrative Guidance Memorandum -- Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites
Date:	Oct 27, 1989

1. Introduction

Fugitive dust suppression, particulate monitoring, and subsequent action levels for such must be used and applied consistently during remedial activities at hazardous waste sites. This guidance provides a basis for developing and implementing a fugitive dust suppression and particulate monitoring program as an element of a hazardous waste site's health and safety program.

2. Background

Fugitive dust is particulate matter--a generic term for a broad class of chemically and physically diverse substances that exist as discrete particles, liquid droplets or solids, over a wide range of sizes--which becomes airborne and contributes to air quality as a nuisance and threat to human health and the environment.

On July 1, 1987, the United States Environmental Protection Agency (USEPA) revised the ambient air quality standard for particulates so as to reflect direct impact on human health by setting the standard for particulate matter less than ten microns in diameter (PM_{10}); this involves fugitive dust whether contaminated or not. Based upon an examination of air quality composition, respiratory tract deposition, and health effects, PM_{10} is considered conservative for the primary standard--that requisite to protect public health with an adequate margin of safety. The primary standards are 150 ug/m^3 over a 24-hour averaging time and 50 ug/m^3 over an annual averaging time. Both of these standards are to be averaged arithmetically.

There exists real-time monitoring equipment available to measure PM_{10} and capable of integrating over a period of six seconds to ten hours. Combined with an adequate fugitive dust suppression program, such equipment will aid in preventing the off-site migration of contaminated soil. It will also protect both on-site personnel from exposure to high levels of dust and the public around the site from any exposure to any dust. While specifically intended for the protection of on-site personnel as well as the public, this program is not meant to replace long-term monitoring which may be required given the contaminants inherent to the site and its air quality.

3. Guidance

A program for suppressing fugitive dust and monitoring particulate matter at hazardous waste sites can be developed without placing an undue burden on remedial activities while still being protective of health and environment. Since the responsibility for implementing this program ultimately will fall on the party performing the work, these procedures must be incorporated into appropriate work plans. The following fugitive dust suppression and particulate monitoring program will be employed at hazardous waste sites during construction and other activities which warrant its use:

1. Reasonable fugitive dust suppression techniques must be employed during all site activities which may generate fugitive dust.

2. Particulate monitoring must be employed during the handling of waste or contaminated soil or when activities on site may generate fugitive dust from exposed waste or contaminated soil. Such activities shall also include the excavation, grading, or placement of clean fill, and control measures therefore should be considered.

3. Particulate monitoring must be performed using real-time particulate monitors and shall monitor particulate matter less than ten microns (PM_{10}) with the following minimum performance standards:

   Object to be measured: Dust, Mists, Aerosols
   Size range: <0.1 to 10 microns
   Sensitivity: 0.001 mg/m^3
   Range: 0.001 to 10 mg/m^3
   Overall Accuracy: ±10% as compared to gravimetric analysis of stearic acid or reference dust

Operating Conditions:
Temperature: 0 to 40^{o}C
Humidity: 10 to 99% Relative Humidity

Power: Battery operated with a minimum capacity of eight hours continuous operation

Automatic alarms are suggested.

Particulate levels will be monitored immediately downwind at the working site and integrated over a period not to exceed 15 minutes. Consequently, instrumentation shall require necessary averaging hardware to accomplish this task; the P-5 Digital Dust Indicator as manufactured by MDA Scientific, Inc. or similar is appropriate.

4. In order to ensure the validity of the fugitive dust measurements performed, there must be appropriate Quality Assurance/Quality Control (QA/QC). It is the responsibility of the entity operating the equipment to adequately supplement QA/QC Plans to include the following critical features: periodic instrument calibration, operator training, daily instrument performance (span) checks, and a record keeping plan.

5. The action level will be established at 150 ug/m^3 over the integrated period not to exceed 15 minutes. While conservative, this short-term interval will provide a real-time assessment of on-site air quality to assure both health and safety. If particulate levels are detected in excess of 150 ug/m^3, the upwind background level must be measured immediately using the same portable monitor. If the working site particulate measurement is greater than 100 ug/m^3 above the background level, additional dust suppression techniques must be implemented to reduce the generation of fugitive dust and corrective action taken to protect site personnel and reduce the potential for contaminant migration. Corrective measures may include increasing the level of personal protection for on-site personnel and implementing additional dust suppression techniques (see Paragraph 7). Should the action level of 150 ug/m^3 be exceeded, the Division of Air Resources must be notified in writing within five working days; the notification shall include a description of the control measures implemented to prevent further exceedences.

6. It must be recognized that the generation of dust from waste or contaminated soil that migrates off-site, has the potential for transporting contaminants off-site. There may be situations when dust is being generated and leaving the site and the monitoring equipment does not measure PM_{10} at or above the action level. Since this situation has the potential to migrate contaminants off-site, it is unacceptable. While it is not practical to quantify total suspended particulates on a real-time basis, it is appropriate to rely on visual observation. If dust is observed leaving the working site, additional dust suppression techniques must be employed. Activities that have a high dusting potential--such as solidification and treatment involving materials like kiln dust and lime--will require the need for special measures to be considered.

7. The following techniques have been shown to be effective for the controlling of the generation and migration of dust during construction activities:

    1. Applying water on haul roads.
    2. Wetting equipment and excavation faces.
    3. Spraying water on buckets during excavation and dumping.
    4. Hauling materials in properly tarped or watertight containers.
    5. Restricting vehicle speeds to 10 mph.
    6. Covering excavated areas and material after excavation activity ceases.
    7. Reducing the excavation size and/or number of excavations.

    Experience has shown that utilizing the above-mentioned dust suppression techniques, within reason as not to create excess water which would result in unacceptable wet conditions, the chance of exceeding the 150 ug/m^3 action level at hazardous waste site remediations is remote. Using atomizing sprays will prevent overly wet conditions, conserve water, and provide an effective means of suppressing the fugitive dust.

8. If the dust suppression techniques being utilized at the site do not lower particulates to an acceptable level (that is, below 150 ug/m^3 and no visible dust), work must be suspended until appropriate corrective measures are approved to remedy the situation. Also, the evaluation of weather conditions will be necessary for proper fugitive dust control--when extreme wind conditions make dust control ineffective, as a last resort remedial actions may need to be suspended.

There may be situations that require fugitive dust suppression and particulate monitoring requirements with action levels more stringent than those provided above. Under some circumstances, the contaminant concentration and/or toxicity may require appropriate toxics monitoring to protect site personnel and the public. Additional integrated sampling and chemical analysis of the dust may also be in order. This must be evaluated when a health and safety plan is developed and when appropriate suppression and monitoring requirements are established for protection of health and the environment.

Attachment B

Monitoring Equipment
Specifications

MiniRAE 2000

Portable Handheld VOC Monitor

The rugged MiniRAE 2000 is the smallest pumped handheld volatile organic compound (VOC) monitor on the market. Its Photoionization Detector's (PID) extended range of 0 to 10,000 ppm makes it an ideal instrument for applications from environmental site surveying to HazMat/ Homeland Security.

AutoRAE Compatible

Wireless

Key Features

- **Proven PID technology** The patented sensor provides a 3-second response up to 10,000 ppm and sets a new standard for resistance to moisture and dirt.
- **Wireless communication enabled and certified**
- **Self-cleaning lamp and sensor** The patented self-cleaning lamp and sensor minimize the need for maintenance and calibration.
- **The MiniRAE 2000 lamp and sensor can be taken apart in seconds for easy maintenance without tools!**
- **Measure more chemicals than with any other PID.** With over 100 Correction Factors built into the MiniRAE 2000 memory and the largest printed list of Correction Factors in the world (300+), RAE Systems offers the ability to accurately measure more ionizable chemicals than any other PID. When a gas is selected from the MiniRAE 2000's library, the alarm points are automatically loaded into the meter.
- **User friendly** screens make it easy to use for simple applications and flexible enough for sophisticated operations.
- **Drop-in battery** When work schedules require putting in more than the 10 hours supplied by the standard NiMH battery, the drop-in alkaline pack supplied with every MiniRAE 2000 lets you finish the job.
- **Rugged Rubber Boot** The standard rubber boot helps assure that the MiniRAE 2000 survives the bumps and knocks of tough field use.
- **Strong, built-in sample pump** draws up to 100 feet (30 m) horizontally or vertically.
- **Tough, flexible inlet probe**
- **Large keys** operable with 3 layers of gloves.
- **Easy-to-read display** with backlight.
- **Stores up to 267 hours of data** at one-minute intervals for downloading to PC.
- **3-year 10.6 eV lamp warranty**

Applications

HazMat/Homeland Security

- Initial PPE (personal protective equipment) assessment
- Leak detection
- Safety perimeter establishment and maintenance
- Spill delineation
- Decontamination
- Remediation

Industrial Hygiene/Safety

- Confined Space Entry (CSE)
- Indoor Air Quality (IAQ)
- Worker exposure studies

Environmental

- Soil and water headspace analysis
- Leaking underground storage tanks
- Perimeter fenceline monitoring
- Fugitive emissions (EPA Method 21)
- Vapor recovery breakthrough
- Landfill monitoring

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Specifications*

Detector Specifications

Size	8.2" L x 3.0" W x 2.0" H (21.8 x 7.62 x 5.0 cm)
Weight	20 oz with battery pack (553 g) w/o rubber boot
Sensor	Photoionization sensor with standard 10.6 eV or optional 9.8 eV or 11.7 eV UV lamp
Battery	• Rechargeable, external, field-replaceable Nickel-Metal-Hydride (NiMH) battery pack • Alkaline battery holder (for 4 AA batteries)
Operating Period	10 hours continuous operation
Display	Large LCD, backlight activated manually, by alarms or by darkness
Keypad	1 operation and 2 programming keys
Direct Readout	• VOCs as ppm by volume • High and low values • STEL and TWA (in hygiene mode) • Battery and shut down voltage
Alarms	90 dB buzzer and flashing red LED to indicate exceeded preset limits: • High: 3 beeps and flashes per second • Low: 2 beeps and flashes per second • STEL and TWA: 1 beep and flash per second • Alarms automatic reset or latching with manual override • Optional plug-in pen size vibration alarm • User adjustable alarm limits
Calibration	Two-point field calibration of zero and standard reference gas. Calibration memory of 8 calibration gases, alarm limits, span values and calibration date
Datalogging	267 hours (at one-minute intervals) with date/time. Header information includes monitor serial number, user ID, site ID, date and time
Sampling Pump	• Internal, integrated flow rate of 400 cc/min • Sample from 100' (30 m) horizontally or vertically
Low Flow Alarm	Auto shut-off pump at low flow condition
Communication	Download data and upload instrument set-up from PC through RS-232 link to serial port. Wireless communication enabled and certified (requires RAELink2 and ProRAE Remote to use)
Temperature	14° F to 104° F (-10° C to 40° C)
Humidity	0% to 95% relative humidity (non-condensing)
EM/RFI	Highly resistant to EMI /RFI. Compliant with EMC Directive 89/336/EEC
IP-rating	IP-55: protected against dust, protected against low-pressure jets of water from all directions
Hazardous Area Approval	• **US and Canada:** UL and cUL, Classified for use in Class I, Division 1, Groups A, B, C and D hazardous locations • **Europe:** ATEX II IG EEx ia IIC T4
Attachment	Durable bright yellow rubber boot w/belt clip & wrist strap
Warranty	Lifetime on non-consumable components (per RAE Systems Standard Warranty), 3 years for 10.6.V PID lamp, 1 year for pump and battery

***** Specifications are subject to change

****** Performance based on isobutylene calibration

Default Sensor Settings**

Gas Monitor (ppm)	Range (ppm)	Resolution Time (T90)	Response
VOCs	0 to 99.9 ppm	0.1 ppm	< 3 sec
	100 to 10,000 ppm	1 ppm	< 3 sec

MiniRAE 2000 and Accessories

Monitor only includes:

- RAE Systems UV lamp: 10.6 eV, 9.8 eV or 11.7 eV as specified
- ProRAE Suite software package for Windows® 98, NT, 2000 and XP
- Computer interface cable
- 5-inch Flex-I-Probe
- External filter
- Rubber boot with belt clip
- Alkaline battery adapter
- Tool kit
- Lamp cleaning kit
- Nickel-Metal-Hydride (NiMH) battery
- 120/230 V AC/DC wall adapter (if specified)
- Operation and maintenance manual

Monitor with accessories kit adds:

- Hard transport case with pre-cut foam padding
- 5 porous metal filters and O-rings
- Organic vapor zeroing adapter
- Gas outlet port and tubing

Optional calibration kit adds:

- 10 ppm isobutylene calibration gas, 34L
- Calibration regulator and flow controller

Optional Guaranteed Cost of Ownership Program:

- 4-year repair and replacement guarantee
- Annual maintenance service

DISTRIBUTED BY:

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Product Overview

All these applications in one small unit

- Indoor air quality monitoring
- Walk-through surveys
- Personal exposure monitoring
- Time & motion studies
- Workplace & plant monitoring
- Fixed-point continuous monitoring
- Remediation personal surveillance
- Remote alarming
- Mobile monitoring in vehicles & aircraft
- Toxicology & epidemiology studies
- Emergency response
- Testing air filtration efficiency

personalDataRAM™ Series

Measures airborne particulate concentration in real time

- pDR-1000AN
  For passive air sampling applications
- pDR-1200
  For active air sampling applications

personalDataRAM™ Series

Features and Technical Specifications

pDR-1000AN
Hand-held and fixed-point, real-time aerosol monitor/datalogger

Measure airborne particulate concentration in real-time

The *personal*DataRAM (*p*DR-1000AN) measures mass concentrations of dust, smoke, mists, and fumes in real time, and sounds an audible alarm whenever the user-defined level is exceeded. Conventional filter-based monitoring methods cannot indicate dangerous, real-time dust levels. In contrast, the *p*DR-1000AN alerts you to a problem within seconds, allowing you to take immediate action. With the datalogging enabled, the instrument automatically tags and time stamps the data collected, and stores it for subsequent retrieval, printing, or graphing through a computer.

Highest performance of any real-time personal particulate monitor

With a measurement range from 0.001 to 400 mg/m^3 (auto-ranging), and an optical feedback stabilized sensing system, the *p*DR-1000AN sets the standard for sensitivity, long-term stability and reliability.

The palm-sized *p*DR-1000AN weighs only 18 oz (0.5 kg) for easy portability and attachment to a belt or a shoulder strap. The absence of any moving parts, such as pumps, motors and valves, and the use of low-power semiconductors housed in a ruggedized case ensures long life and dependable operation.

High correlation with gravimetric measurement

The *p*DR-1000AN is a light-scattering photometer (i.e., nephelometer) incorporating a pulsed, high output, near-infrared light emitting diode source, a silicon detector/hybrid preamplifier, and collimating optics and a source reference feedback PIN silicon detector. The intensity of the light scattered over the forward angle of 50^o to 90^o by airborne particles passing through the sensing chamber is linearly proportional to their concentration. This optical configuration produces optimal response to particles in the size range of 0.1-10 µm, achieving high correlation with standard gravimetric measurements of the respirable and thoracic fractions.

Simple zeroing and calibration

The *p*DR-1000AN arrives practically ready to use after the easy zeroing step. The unit comes gravimetrically calibrated in mg/m^3 (NIST traceable) using standard SAE Fine test dust (ISO Fine). Zeroing with particle-free air is accomplished quickly and effectively under field conditions using the zeroing kit included with the instrument. Internal firmware controls an automatic calibration check. To maximize efficiency in the field, gravimetric calibration can be performed by comparison with a filter sampler and programming of the calibration constant.

Standard Accessories

- Universal voltage power supply
- PC communications software
- Zeroing kit
- Belt clip kit
- Instruction manual
- Carrying case
- Signal output cables

Optional Accessories

- Rechargeable battery pack (NiMH)
- Active sampling kit (converts *p*DR-1000AN to *p*DR-1200)
- Portable pump unit
- Shoulder strap
- Remote alarm interface
- Wall mounting bracket

pDR-1200
Active aerosol monitor/datalogger, plus aerodynamic sizing

Designed for active particulate monitoring applications

The *personal*DataRam™ (model *p*DR-1200) performs active sampling applications and aerosol sizing. The *p*DR-1200 requires a vacuum pump module to perform particle size selective measurements under field conditions. The separate pump (not included) is required for active sampling and aerosol sizing. With optional inlet accessories, the *p*DR-1200 is excellent for ambient air measurements under variable wind and high humidity conditions. It is ideal for respirable, thoracic, and PM2.5 monitoring, as well as continuous emission and test chamber monitoring. With an isokinetic sampling set, the *p*DR-1200 can be used for stack and duct extractive sampling monitoring. Membrane filters can be used to capture particles for particles for subsequent laboratory analysis.

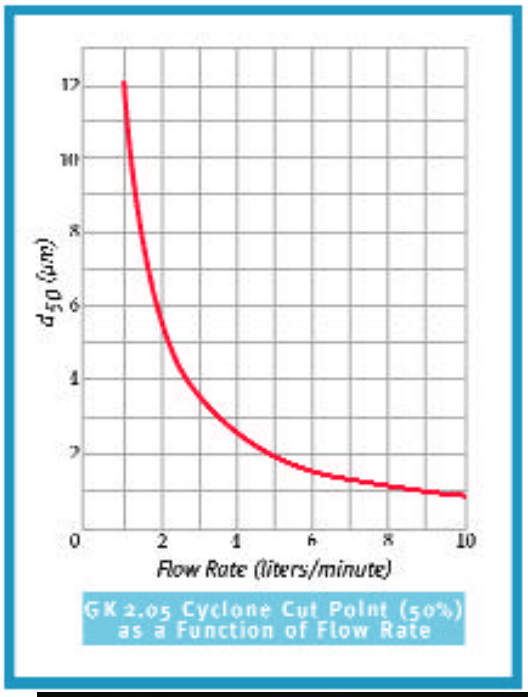
Aerodynamic particle sizing

The *p*DR-1200 incorporates an optimally designed metal cyclone (BGI Model GK 2.05) or the optional low flow cyclone (BGI Model Triplex SCC1.062-CUST) especially selected for PM2.5 collection at 1.5 LPM.

By operating the pump at specific sampling flow rates, the *p*DR-1200 cyclone preseparator provides precisely defined particle size cuts.

Primary calibration and particle samples by filter collection

An integral filter holder directly downstream of the photometric sensing stage accepts 37 mm filters. The calibration constant of the *p*DR-1200 is simply adjusted to coincide with the filter-determined concentration. Primary gravimetric calibration of the instrument concentration readout is easily accomplished under actual field conditions by means of this integral filter. Use membrane filters for chemical analysis or concurrent gravimetric measurements.



pDR-PU Attachable Pump Module

This optional accessory is designed for use with the *personal*DataRAM Model *p*DR-1200. It incorporates a dual-chamber diaphragm pump, a volumetric flow sensing, and control unit. The pump module operates from either an optional, rechargeable NiMH battery pack or from AC line current using the power supply/charger supplied with the *personal*DataRAM. The *p*DR-PU is designed as a modular unit that can be used in various combinations.

- Flow rate (user adjustable): 1 to 4 liters/minute
- Typical Conditions: 2 LPM @ 10 in H_2O (25 mbar) for up to 4 hours
- Maximum Conditions: 2 LPM @ 30 in H_2O
- Precision of constant flow rate control: ±2%
- Power: 9 VDC, 200 mA at 4 liters/minute (approximate)
- Dimensions: 4 in (100 mm) H x 3.6 in (90 mm) W x 1.8 in (45 mm) D
- Weight: 1 lb (0.45 kg)

personalDataRAM™ Series

At last,
a compact,
versatile,
real-time
aerosol monitor

Specifications

Concentration Measurement Range (auto-ranging)

Referred to gravimetric calibration with SAE Fine test dust (mmd = 2 to 3 mm sg = 2.5, as aerosolized)

0.001 to 400 mg/m^3

Scattering Coefficient Range

1.5 x 10^{-6} to 0.6 m^{-1}(approx) @ lambda = 880 nm

Precision/Repeatability Over 30 Days (2-sigma at constant temperature and full battery voltage)

- ±2% of reading or ±0.005 mg/m3, whichever is larger, for 1 second averaging time
- ±0.5 of reading or ±0.0015 mg/m^3, whichever is larger, for 10 second averaging time
- ±0.2% of reading or ±0.0005 mg/m^3, whichever is larger, for 60 second averaging time

Accuracy

Referred to gravimetric calibration with SAE Fine test dust (mmd = 2 to 3 mm, sg = 2.5, as aerosolized)

±5% of reading ±precision

Resolution

0.1% of reading or 0.001 mg/m^3, whichever is larger

Particle Size Range of Maximum Response

0.1 to 10 µm

Flow Rate Range (model pDR-1200)

1-10 liters/min (external pump required)

Aerodynamic Particle Sizing Range

1.0 to 10 µm (*p*DR-1200 only)

Concentration Display Updating Interval

1 second

Concentration Display Averaging Time (user selectable)

1 to 60 seconds

Alarm Level Adjustment Range (user selectable)

Selectable over entire measurement range

Alarm Averaging Time (user selectable)

Real-time (1 to 60 seconds) or STEL (15 minutes)

Datalogging Averaging Periods (user selectable)

1 second to 4 hours

Total Number of Data Points That Can Be Logged in Memory

More than 13,300

Number of Data Tags (data sets)

99 (maximum)

Logged Data

- Each data point: average concentration, time/date, and data point number
- Run summary: overall average and maximum concentrations, time/data of maximum, total number of logged points, start time/date, total elapsed time (run duration), STEL concentration, and time/date of occurrence, averaging (logging) period, calibration factor, and tag number

Analog Signal Output

0 to 5 V and 4 to 20 mA, with selectable full scale ranges between 0.1 and 400 mg/m^3

Power

- Internal battery 9 V alkaline, 20 hour run time (typical)
- Internal battery 9 V lithium, 40 hour run time (typical)
- AC source universal voltage adapter (included) 100-250 volts, 50-60 Hz (CE marked)
- Optional battery pack rechargeable NiMH, 72 hour run time typical (*p*DR-BP)

Readout Display

LCD 16 characters (4 mm height) x 2 lines

Serial Interface

RS232, 4800 baud

Computer Requirements

PC compatible, 486 or higher, Windows 95® or higher

Storage Environment

-20°C to 70°C (-4°F to 158°F)

Operating Environment

-10°C to 50°C (14°F to 122°F), 10 to 95% RH, non-condensing

Dimensions (max external)

153 mm (6.0 in) H x 92 mm (3.6 in) W x 63 mm (2.5 in) D (*p*DR-1000AN)
160 mm (6.3 in) H x 205 mm (8.1 in) W x 60 mm (2.4in) D (*p*DR-1200 including cyclone and filter holder)

Weight

0.5 kg (18 oz) (*p*DR-1000AN)
0.68 kg (24 oz) (*p*DR-1200)

Approvals

- Intrinsic safety approval by US Mine Safety & Health Administration (MSHA) coal-mining environments containing methane gas (the *p*DR-PU pump is not approved by MSHA)
- US FCC Rules (Part 15)
- CE certified

About Thermo

Thermo Electron Corporation, the world's leading maker of high-tech instruments, provides instruments, equipment, software, and solutions that help laboratory and industrial customers advance scientific knowledge, enable drug discovery, improve manufacturing processes, and protect people and the environment. With annual revenue exceeding $2 billion, Thermo is a global leader employing 11,000 people in 30 countries worldwide. The company is based in Waltham, Massachusetts.

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