ACTIVITY-BASED AIR SAMPLING FOR ASBESTOS

CONTENTS

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1.0 SCOPE AND APPLICATION

Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) Superfund Policy Directive 9345.4-05 - Clarifying Cleanup Goals and Identification of New Assessment Tools for Evaluating Asbestos at Superfund Cleanups - requires EPA Regions to develop risk-based, site-specific action levels to determine if response actions should be taken, when materials containing less than (<) 1 % (percent) asbestos are found at a site, and to outline some activities that will assist in evaluating such risk at Superfund sites. The Framework for Investigating Asbestos-Contaminated Superfund Sites - OSWER Directive 9200.0-68 addresses asbestos at Superfund sites by recommending a risk-based, site-specific approach for site evaluation based on current asbestos science. This guidance provides a recommended flexible framework for investigating and evaluating asbestos contamination at Superfund removal and remedial sites.

The relationship between the concentration of asbestos in a source material and the concentration of fibers in air that results when that source is disturbed is very complex and dependent on a wide range of variables. To date, no method has been found that reliably predicts the concentration of asbestos in air given the concentration of asbestos in the source. The framework emphasizes an empirical approach to site characterization because models to predict airborne asbestos concentrations from soil concentrations have not been validated. Specifically, a combination of soil, dust, and air samples are recommended to characterize exposure. Concentrations of asbestos in air at the location of a source disturbance are measured rather than predicted. Therefore, personal monitoring in the form of activity-based sampling (ABS) is the most appropriate technique to estimate exposure. Personal exposure is influenced by the activities performed, the duration of the activity, and the site-specific soils of interest.

At a number of diverse sites across the country, the U.S. EPA has demonstrated that disturbance of soil with low levels of asbestos (including soil concentrations less than 1.0% as measured by Polarized Light Microscopy (PLM) can potentially result in significant concentrations (greater than [>] 0.1 structures per cubic centimeter [S/cc]) of respirable asbestos fibers in the breathing zone of individuals engaged in various physical activities. This may result in a cancer risk in excess of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedial objectives.

Since personal monitoring is more representative of actual exposure than samples obtained from a fixed downwind location (McBride 1999, Rodes 1995, Hildemann 2005), personal monitoring results are generally most relevant for risk characterizations. Thus, the best measure of actual exposure to an individual would be through the collection of personal air samples over the exposure period of interest (National Institute for Occupational Safety and Health [NIOSH] 1977). However, at CERCLA sites, it is neither always possible nor practical to do so. EPA has thus developed a sampling procedure called ABS, designed to mimic the activities of a potential receptor.

As part of ABS, U.S. EPA or contracted personnel trained in hazard recognition and mitigation, serve as surrogates for the potentially exposed populace of interest. ABS simulates routine activities in order to mimic and evaluate personal exposures from disturbance of materials potentially contaminated with asbestos. Similar sampling approaches have been used to assess exposures to pesticides and lead (U.S. EPA 2000) and this technique has long been a cornerstone of industrial hygiene wherein workplace exposures are routinely assessed via personal exposure monitoring.

This document provides guidance for ABS activities or scenarios. Personal monitoring is conducted during various activities such as raking, All-Terrain Vehicle (ATV) riding, rototilling, digging, a child playing in the dirt, power weed cutting, lawn mowing, walking with a stroller, bicycling, playing basketball, or other relevant site activities.

A Quality Assurance Project Plan (QAPP) in Uniform Federal Policy (UFP) format describing the project objectives must be prepared prior to deploying for a sampling event. The sampler needs to ensure that the methods used are adequate to satisfy the data quality objectives listed in the UFP-QAPP for a particular site. This document is not intended to be used as a substitute for a site-specific UFP-QAPP but rather intended as a reference for developing site-specific UFP-QAPPs.

The procedures in this SOP may be modified, dependent on site conditions, equipment limitations or other procedural limitations. In all instances, the procedures employed must be documented on a Field Change Form and attached to the UFP-QAPP. These changes must be documented in the final deliverable.

2.0 METHOD SUMMARY

As personal exposure is influenced by the activities performed, the duration of the activities, and the site-specific conditions, it is recommended that a site-specific ABS scenario be chosen or developed. A site-specific ABS scenario will best characterize the potential asbestos human health exposure.

For ABS, a site-specific activity(ies) or scenario(s) is/are selected that represents an activity(ies) or scenario(s) that is/are occurring currently on site or around the site or an activity(ies) or scenario(s) is selected that is likely to occur on the site in the future. Activity(ies) or scenario(s) selected should be comprised of a worse case activity(ies) or scenario(s) to determine the full potential impact to human health.

Once the activity(ies) or scenario(s) is selected, soil samples are collected to determine/confirm concentrations of asbestos in the area for ABS. The area(s) is selected and the ABS is conducted with personnel in PPE while collecting samples from their breathing zone, the perimeter of the ABS area, and the reference/background location. Additional samples may be collected farther from the ABS perimeter to determine how far asbestos is being transported from the ABS area.

Special consideration should be given when characterizing exposure to children as it has been hypothesized that children are more prone to exposure than adults (U.S. EPA 2000) because they tend to be closer to the source. Sample flow rates, duration, and final volume will need to be weighed against the number of counted grid openings (cost factor) to obtain the needed sensitivity. Sampling periods should be of sufficient durations (averaging time) to facilitate collection of a representative sample to achieve the required level of sensitivity.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

3.1 Sample Preservation

No preservation is required for asbestos samples.

3.2 Sample Handling, Container, and Storage Procedures

1. Place a sample label on the cassette indicating a unique sampling number. Do not put sampling cassettes in shirt or coat pockets as the filter can pick up fibers or a static charge that could disturb the dust deposited on the filter media.

2. To the extent possible, samples should be handled gently with the filter inlet facing upward to avoid disturbing the particulate deposited on the filter and to minimize the potential of imparting a static charge to the cassette, which might alter the particulate deposition on the filter media.

3. Place the cassette individually in a manila-type envelope or other appropriate container that will not relay a static charge to the cassette. Under extremely low humidity conditions (less than 10% relative humidity), plastic bags such as Ziploc or Glad can develop a static charge that may affect the particle distribution of the filters. Each envelope should be marked with the sample identification number, total volume and date.

4. To the best extent possible, the sampling cassettes in the manila envelopes should be placed right side up so that the cassette inlet cap is on top and cassette base is on bottom (International Organization for Standardization [ISO] 10312). Place samples into a shipping container and use enough packing material (e.g., bubble wrap) to prevent jostling or damage. Samples must be handled gently so as not to disturb the dust deposited on the filter media. Do not use vermiculite or any other type of fibrous packing material for samples. If possible, carry the samples by hand to the laboratory.

5. Provide appropriate documentation with samples (i.e., chain of custody and requested analytical methodology).

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

4.1 Area Selection

When selecting areas for ABS, consideration should be given to the potential for off-site migration of contaminants and possible exposure to the public. Particulate migration off-site should be minimized, and constraints or mitigation protocols should be established to minimize public exposure. These constraints/mitigation protocols may include restricting public access to the area, conducting the ABS in remote areas of the site, dust suppression using water mist, building a containment structure, etc. Air sampling should be conducted to document the airborne concentration of asbestos at the site perimeter during activities.

4.2 Flow Rate Considerations

For activities that generate a large quantity of dust (i.e., particulates), sample flow rates may need to be reduced accordingly to avoid overloading the filters. For example, a sampling pump flow rate of approximately 1.0 liter per minute (L/min) for a 30-minute period was found most effective at one site for monitoring for asbestos while riding ATVs on dusty soils, while high soil moisture and reduced particulate generation at another site permitted a 5.0 L/min flow rate for up to 2-hours.

High flow rates may result in filter damage due to failure of its physical support associated with increased pressure drop, leakage of air around the filter mount so that the filter is bypassed, or damage to the asbestos structures (breakup of bundles and clusters) due to increased impact velocities (ISO 10312). High flow rates can also disrupt or tear the filters during initial pump startup due to the shock load placed on the filter when the pump is first started.

Sampling larger volumes of air and analyzing greater areas of the filter media can theoretically lower the limit of detection indefinitely. In practice, the total suspended particulate (TSP) concentration limits the volume of air that can be filtered, as TSP can obscure asbestos fibers. The ISO Method 10312 states that the direct analytical method cannot be used if the general particulate loading exceeds approximately 25% coverage of the collection filter. An airborne concentration of approximately 10 micrograms per cubic meter (μg/m^3), corresponding to clean rural air, results in approximately 10% coverage of the filter media based on a 4,000-liter (L) sample.

The following formula from ISO 10132 may be used to calculate the analytical sensitivity:

$$S = \frac{A_t}{K A_g V}$$

Where:
S = Analytical sensitivity expressed in structures per liter (S/L)
A_t = Active area in square millimeters (mm^2) of the collection media or filter
A_g = Mean area in mm^2 of the grid openings examined
K = Number of grid openings examined
V = Volume of air sampled, in liters (L)

NOTE: 25-millimeter (mm) cassettes have an effective filter area of 385 mm^2 and 37-mm cassettes have an effective filter area of 855 mm^2. The typical grid opening is 0.0057 mm^2. Note: Grid size will vary between laboratories; therefore, dimensions should be verified prior to calculating the number of grid openings that must be counted to achieve a particular level of sensitivity.

Table 1 provides an example of the minimum number of grid openings that must be counted to achieve various sensitivities and detection limits (DLs).

It is frequently more efficient to employ collocated samplers to collect a high and low volume of air. This increases the likelihood of at least one of the two samples being readable using the direct analytical method (ISO 10312) than to lose the sample due to overloading or having to analyze by the indirect method (ISO 13794).

4.3 Transmission Electron Microscopy Specimen Preparation Methods

It can be argued that direct methods yield an under-estimate of the asbestos structure concentration because other particulate material with which they are associated conceals many of the asbestos fibers present. Conversely, indirect methods can be considered to yield an over-estimate because some types of complex asbestos structures disintegrate during the preparation, resulting in an increase in the numbers of structures counted.

It is left to the end user to determine which Transmission Electron Microscopy (TEM) specimen preparation method should be utilized. It is recommended that all relevant site participants meet and consult with a risk assessor well in advance of any sample collection.

If direct transfer TEM sample preparation is preferred, it is suggested that a microscope be brought to the site with the sampling team. With rapid information on overloading, adjustments in sample flowrate can be made quickly, preventing unnecessarily overloaded samples.

4.3.1 ISO 10312 Direct-Transfer TEM Specimen Preparation Methods

Direct-transfer TEM specimen preparation methods have the following interferences:

- This method cannot discriminate between individual fibers of asbestos and elongate fragments (cleavage fragments and acicular particles) from non-asbestos analogues of the same amphibole mineral.

- Complete identification of every chrysotile and/or amphibole fiber is not possible due to instrumental limitations and the nature of some of the fibers. Additionally, complete identification of every amphibole fiber is not practical due to the limitations of both time and cost.

- On rare occasions, some amphibole fibers can visually be misidentified as chrysotile. Particles of other minerals having visual compositions similar to those of some amphiboles could be erroneously classified as amphibole. Use of energy dispersive X-ray analysis (from the method) can eliminate the misidentification.

- The achievable detection limit (DL) is restricted by the particulate density on the filter, which in turn is controlled by the sampled air volume and the total suspended particulate concentration in the atmosphere being sampled.

- The precision of the result is dependent on the uniformity of the deposit of asbestos structures on the sample collection filter.

- Air samples must be collected so that they have particulate and fiber loadings within narrow ranges. If too high of a particulate loading occurs on the filter, it may not be possible to prepare a satisfactory TEM specimen by the direct-transfer method and an accurate fiber count may not be possible.

4.3.2 ISO 13794 Indirect TEM Specimen Preparation Methods

For the indirect preparation method the membrane filter, or a portion of it, is placed on a microscope slide, sample face downward and ashed in a low temperature Plasma Asher until complete calcination of the filter is achieved. The ash is then recovered in distilled water and the solution is then filtered on a polycarbonate filter. The indirect transfer method re-distributes the particulate on a new membrane filter.

Indirect TEM specimen preparation methods have the following interferences:

- The size distribution of asbestos structures is modified (clusters, matrices bundles, etc. may be broken up during sample preparation).

- There is increased opportunity for fiber loss or introduction of extraneous contamination from laboratory glassware, process water, etc.

  When sample collection filters are ashed, any contamination in the filter medium is concentrated in the new TEM specimen

- There is a possibility of misidentification of fibers for which both the morphologies and the electron diffraction (ED) patterns are reported based on visual observation only. This can be rectified by the use of energy-dispersive x-ray analysis (EDXA) and the observation of the 0.73 nanometer (nm) reflection of chrysotile in the ED pattern.

- Particles of a number of other minerals may have compositions similar to amphiboles. These could be classified as amphibole when the classification criteria does not include zone-axis ED techniques

The direct analytical method (ISO 10312) is the preferred method and every reasonable effort should be made to prevent overloading of the filter. Samples that are overloaded may, at the discretion of the project management team, be analyzed by ISO Method 13794 "Ambient air – Determination of asbestos fibres – Indirect-transfer transmission electron microscopy method" (ISO 2019). Results of the ISO 13794 analysis should be reviewed separately from the ISO 10312 samples and a decision made regarding combining the two data sets should be discussed with the site toxicologist/risk assessor. The QAPP should contain information on when ISO 13794 is used and what decisions may be made with the data.

4.4 Analytical Sensitivity

Sample volumes and detection/quantification limits should be specified in the site-specific QAPP with flow rates and sampling periods adjusted accordingly. Typical sensitivity limits that have been employed for risk assessment have been approximately 0.001 S/cc for ABS samples and 0.0001 S/cc for background or reference sample locations. These limits can vary and should be determined in advance. Based on ISO 10312 (Table 1 of Section 11), a sensitivity limit of 0.001 S/cc would require a sample volume of greater than 500 L to keep the number of grid openings to be counted below 100 in order to keep analytical costs under control. In dusty environments overloading may occur. Therefore, lower sample volumes may need to be collected. Similarly, a sample volume greater than 5,000 L would be required to reach 0.0001 S/cc with fewer than 100 grid openings to count.

Sampling volumes will be determined, based on the analytical sensitivity required for a particular task. The sensitivity is defined as the structure concentration corresponding to the detection of one structure by ISO 10312. Sensitivities can vary from project to project and within tasks on a project. The desired sensitivity can be met through a combination of volume collected and number of filter grids counted by the microscopist for the TEM by the direct transfer method. Limit of detection is usually defined as 3 times the analytical sensitivity. Before collecting any samples, consult with the end line stakeholders, toxicologists and risk assessors in the early stages of project planning in order to determine the required analytical sensitivity.

The following example, of number of grids to be counted, is a condensed excerpt from the Code of Federal Regulations Chapter 40 Part 763, Subpart E, Appendix A. In this example, the number of grids to be counted will reflect an analytical sensitivity of 0.005 structures per cubic centimeter from a 25-millimeter (mm) filter with an effective area of 385 mm^2.

Volume in Liters	Grid Openings
600	23
1200	11
1800	8
2400	6
3000	5
3600	4

Once the desired analytical sensitivity is determined, an agreement between the risk assessor, project leader, and sampling personnel must be reached to determine how to reach that analytical goal. The question to be asked is "What is the preferred method to reach the sensitivity?" A higher sample volume or additional grid counting by the laboratory? Cost may be a factor. Increasing sample volumes could double the length of the sampling event, while counting additional grids will increase costs. It is imperative that these details are clarified well in advance of field work.

4.5 Sampling Cassette Orientation

Air sampling cassettes must be oriented with the open face pointing down to preclude large non-respirable particles from falling or settling onto the filter media.

5.0 EQUIPMENT/APPARATUS

- Battery powered personal sampling pumps capable of providing a constant flow-rate of 1.0 L/min up to 4.0 L/min for the time to achieve the desired volume of air sampled. Note that some, but not all personal sampling pumps are capable of 5 L/min.

- Battery or alternating current higher flow sampling pumps (i.e., QuickTake 30 or AirCon-2), capable of providing a constant flow-rate of 8.0 to 16 L/min for the time to achieve the desired volume of air sampled. Note that the AirCon-2 is capable of achieving flow rates as low as 2 L/min. If AC power is not available, a generator should be obtained. The generator should be positioned downwind from the sampling pumps.

- Mixed cellulose ester (MCE) filter cassettes with conductive extension cowls, typically 0.8 micrometer (µm), 25-mm diameter, purchased from a certified vendor with appropriate documentation of low filter background counts, consistent filter area and certified leak-free cassettes (SKC 225-321 or equivalent). MCE filter cassettes 0.45-µm, 25-mm diameter (SKC 225-327 or equivalent) may also be used. However, higher flow rates will not be able to be achieved due to backpressure issues with the sampling pumps. Filter selection should be discussed with the site toxicologist/risk assessor and documented in the QAPP.

Additional Equipment

- Sampling train setups (Sensidyne Gilian 800143, SKC 225-1 or equivalent)
- Tygon tubing, with Luer (Gilian 200156 or equivalent) type adaptor
- Backpacks
- Sampling stands (SKC Model Tripod Stand 228-506 or equivalent)
- Duct tape
- Tools, miscellaneous (e.g., screwdrivers, pliers, cutting tool, etc.)
- Envelopes, manila-type (coin size #6 preferred)
- Sample labels
- Logbook and/or sampling worksheets
- Scribe supplies
- Precision rotameter or primary flow standard appropriate for sampling flow rate
- Personal protective equipment (PPE), including but not limited to respirators, boots, gloves, eye protection, hard hat, to be determined based on type of activity and possible exposure

- Decontamination equipment (Plastic sheeting, Liquinox, buckets, brushes, water, Hudson sprayers, garbage bags, etc.)
- Power sources (line power, solar recharging batteries, power inverters, generators, etc.)

6.0 REAGENTS

None required.

7.0 PROCEDURES

7.1 Pre-Site Sampling Preparation

1. Have and comply with approved Health and Safety Plan (HASP) and UFP-QAPP.
2. Determine the extent of the sampling effort (number of locations, repetitions, number of samples, etc.), the sampling methods to be employed, and the types and amounts of equipment and supplies needed from the QAPP.
3. Obtain necessary sampling equipment, ensure it is in working order, and fully charged (if necessary).
4. Perform a general site survey prior to site entry in accordance with the site-specific HASP.
5. Once on site the instrument calibration is performed in the clean zone and the pumps are then deployed to their sampling locations. The calibration procedures are listed below.

7.2 Calibration Procedures

To determine if a sampling pump is measuring the flow rate or volume of air correctly, it is necessary to calibrate the equipment. Sampling pumps should be calibrated on a routine basis and prior to use. Preliminary calibration should be conducted using a primary or secondary calibrator with a representative filter cassette installed between the pump and the calibrator. The representative sampling cassette can be reused for calibrating other pumps that will be used for asbestos sampling. The same cassette lot used for sampling should also be used for the calibration. A sticker should be affixed to the outside of the extension cowl marked "Calibration Cassette."

Constant flow calibration readings are obtained before and after sampling. If the flow rate changes by more than 5% during the sampling period, the average of the pre- and post-calibration rates will be used to calculate the total sample volume. The sampling pump used will provide a non-fluctuating air-flow through the filter, and the flow rate should be maintained within 10% of the initial volume flow rate throughout the sampling period. The value of these flow-rate measurements will be used to calculate the total air volume sampled. A constant flow or critical orifice controlled pump meets these requirements. If at any time the measurement indicates that the flow-rate has decreased by more than 30%, the sampling may be terminated. The end user of the data will determine if the sample should be analyzed. Flexible tubing is used to connect the filter cassette to the sampling pump. Sampling pumps can be calibrated prior to coming on-site to reduce the amount of time spent performing on-site calibration activities.

7.2.1 Calibrating a Personal Sampling Pump with a Rotameter

1. For U.S. EPA Environmental Response Team (ERT) rotameters perform calibrations following directions established in ERT SOP, *Rotameter Calibration.*

2. Set up the calibration train using a rotameter, sampling pump and the sampling cassette that will be used during the sampling event. The sampling trains may be set up prior to field mobilization and will be checked in the field prior to use.

3. To set up the calibration train, attach one end of the tubing (approximately 2 feet) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap or open-faced calibration adapter to the rotameter. Insure that the tubing and rotameter used to calibrate the pump do not restrict the airflow.

4. The flow meter should be as level as possible when recording flow rates.

5. Turn the sampling pump on.

6. Turn the flow adjust screw (or knob) on the sampling pump until the float ball on the rotameter is lined up with the pre-calibrated flow rate value on the rotameter. Note: rotameters should be marked with the previous calibration date and corresponding flow rates and scale. Confirm the flow rate after approximately 10 seconds. Adjust flow rate accordingly.

7. A verification of calibration is generally performed on site in the clean zone immediately prior to the sampling.

7.2.2 Calibrating a Personal Sampling Pump with an Electronic Calibrator

1. Refer to the manufacturer's manual for operational instructions. Ensure that the unit has been calibrated within the past year.

2. Set up the calibration train using a sampling pump, electronic calibrator, and the actual sampling cassette or a representative filter cassette. The same lot of cassettes used for sampling must also be used for calibration.

3. To set up the calibration train, attach one end of tubing (approximately 2 feet) to the cassette base; attach the other end of the tubing to the inlet plug on the pump. Another piece of tubing is attached from the cassette cap or open-faced calibration adapter to the electronic calibrator.

4. Turn the electronic calibrator and sampling pump on. Select a flow rate to calibrate.

5. Turn the flow-adjust screw or knob on the pump until the desired flow rate is attained on the rotameter. Confirm the flow rate after approximately 10 seconds. Adjust flow rate accordingly. Record the flow rate and calibrator information.

7.3. Meteorology

It is recommended that an on-site, portable, 3-meter meteorological station be established. If possible, sample after 36 hours of dry weather when wind conditions are representative for the climatology of the location based on month and time of day. Wind speed, wind direction, temperature and station pressure should be recorded on the meteorological station data logger and real-time data should be available for review. Suggested meteorological station specifications can be found in Table 2, Appendix A. Alternatively, a nearby representative meteorological station, may be used to acquire the necessary data.

7.4 Soil Moisture

As stated previously, sampling should be performed during periods of dry weather that are climatologically representative of the area being studied. Soil moisture plays a major role in determining potential exposure. If the objective of the ABS activity is to be conducted during the worst-case conditions, the sampling should be conducted under the driest conditions possible. It is up to the discretion of the EPA site manager to determine the objective of the site work.

General Historical Data

Soil moisture will vary by region and by time of year. Soil moisture and precipitation information is available through the Climate Prediction Center and the National Weather Service.

The simplest way to see when the driest time of year to conduct sampling, would be is to utilize a climatological average map. While not precise, this graphic approximates the depth of water in millimeters (mm) of the top meter of soil. Use the monthly tabs to view the data. The map can be accessed by the following link:

https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilwet_clim.shtml#

An example national map depicting a 30-year climatological average soil moisture can be found in Appendix B. These maps are available for each month.

Station Specific Precipitation Data

Throughout the country are meteorological observation stations. Many of these stations can provide details of their average monthly rainfall data. Appendix C provides a step-by-step procedure to determine average precipitation data for many areas throughout the country.

Soil Moisture Determination

For most ABS studies, soil moisture has been determined by one of two ways either in the field using a field screening instrument (non-destructive) giving a volumetric water content (VWC) or by drying a sample in the field or at a laboratory for a gravimetric determination (destructive).

Field screening instrumentation determines soil moisture by providing a percentage of VWC. This can happen quickly in the field. VWC is defined as the volume of water divided by volume of soil sample.

A gravimetric analysis (i.e., ASTM 2216) determines soil moisture by comparing the weight of a sample before and after drying. This method involves initially weighing the sample as collected and then drying in an oven at 110˚C (± 5˚C). After cooling to room temperature, the dry sample is weighed. The mass of water is calculated by subtracting the dry weight from the wet weight. The percentage of soil moisture is calculated by the dividing the mass of water by the mass of the dry sample and multiplying by 100.

Volumetric soil moisture is related to gravimetric soil moisture when the GWC is multiplied by the bulk soil density. Bulk soil density can be calculated by dividing the dry soil mass by the volume of soil.

Soil bulk density can be derived at the time of the gravimetric analysis and will vary based on the type of soil being measured. Soil bulk density is the ratio of the dry soil mass to the soil sample volume. If the soil bulk density is not readily available, some typical soil densities were found (Yu et al 1993) to range from 1.2 grams per cubic centimeter (g/cc) for clay to 1.52 g/cc for sand.

Soil type information is found through the US Department of Agriculture's, Natural Resource Conservation Service web site: https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Soil bulk density will vary with each sample collected. Most research papers base their soil moisture content on the gravimetric method.

As shown above, the volumetric water content of soil will be higher than the gravimetric water content.

For simplicity of field-based decisions, it is recommended to use field screening instruments (by VWC) to make the decision prior to performing ABS. It is highly recommended that these instruments have an annual calibration certificate and have the ability to be field checked or field calibrated prior to use. Multiple instruments should be available during the sampling event due to instrument variability and fragility. Instruments that have been utilized in the past include the Omega HSM50 Series and the Extech MO750.

<u>What is the acceptable amount of moisture in the soil?</u>

Some literature suggests that a contaminant release from a soil disturbance would be inhibited if the soil moisture exceeds 10% by gravimetric means (12% to 15% VWC). Based on these studies and in conjunction with EPA's goal of addressing potential risk to public health under reasonable maximum exposure situations, an average soil moisture level of 10% (12% to 15% VWC) or less should be considered the optimum level when conducting ABS. Given the fact there is a great amount of variability across the country in terms of average or typical soil moisture conditions based primarily on annual or seasonal precipitation variability, the risk manager must ask if 10% is a realistic expectation in the area of concern. It may be in the southwest, but in the northwest or the southeast, soil moisture may exceed 10% (GWC) as a normal condition.

Under abnormally wet conditions for any given region if ABS cannot be delayed, additional options can be employed with the consent of the EPA decision maker to obtain sample results without the bias of the abnormally wet soils. Refer to Section 7.6.12 Alternative ABS Methods for additional information.

Sampling should be delayed if rainfall has exceeded 1/4-inch in the past 36 hours, unless it can be demonstrated that the acceptable soil moisture content can be achieved. Activity-based samples should be collected under conditions when the soil is relatively dry and average moisture levels do not exceed 10% (12% to 15% VWC). As previously stated, when sampling in a region where typical soil moisture and/or average annual/seasonal precipitation levels make it highly unlikely that soil moisture levels will fall below 10%, even during abnormally dry periods, then ABS could proceed with approval of the EPA decision maker using an average soil moisture content of less than 25% VWC (17% to 21% GWC).

Soil moisture should be measured within each sampling area (grid) using a soil moisture meter prior to collection of ABS air samples. For each area, soil moisture will be collected from a minimum of 10 locations at a depth based on the scenario (see Appendix A, Table 3). The average of the 10 locations should equal 10% or less (or 25% or less depending on the location of the site as described above).

ABS activities should be considered above the 25% average only in rare situations. The organization responsible for the field activities needs to demonstrate that the observed soil moisture conditions are typical and/or reasonable for the area. The EPA official responsible for the site must be in agreement with the decision to continue with the ABS activity; and that these conditions have been discussed in the approved site specific QAPP. Any variation of these conditions must be documented on a field change form, providing the data quality objectives are not altered. The burden of proof lies with the organization responsible for performing the ABS activities. This organization may wish to consult with ERT and/or the Asbestos Technical Review Workgroup (TRW) prior to initiation of site activities.

Depth of Soil Moisture Measurement

The depth at which the soil moisture measurements are collected should mimic the depth of the soil collection recommendations from Appendix A, Table 3. If the instrument requires the measuring probe to be deeper than the depth listed in Table 3, field personnel should collect soil from the anticipated ABS affected depth and place it into a sampling jar. Add the soil to the jar so that the soil moisture probe can be placed at the manufacturer's recommended depth for proper soil moisture measurements.

7.5 General Sampling Information

For all activity-based sampling events, except as noted otherwise, collect asbestos samples from the breathing zones of the event participants. Each activity or scenario participant will don appropriate PPE. The backpack utilized during the scenario generally contains high- and low-flow sampling pumps fitted with appropriate type of cassettes secured to the shoulder straps near the operator's lapels in the breathing zone. The breathing zone can be visualized as a hemisphere approximately 6 to 9 inches around an individual's face. Breathing zone samples provide the best approximation of the concentration of contaminants in the air that an individual is actually breathing. Specific breathing zone heights should be determined on a project-by-project basis based on the anthropometrics for the study population and the participants' positions during the performance of each task.

If it is necessary to relieve a participant from the activity, another sample collector should be suited and ready to participate in the ABS prior to the personnel exchange. The participant will stop the activity, remove the backpack or belt and pass it to the relief participant similar to the transfer of a baton in a relay race. The original participant will assist the relief participant with donning and adjusting the backpack or belt. The exchange is anticipated to take less than 60 seconds, therefore the sampling pumps and event time clock will not be halted during the exchange. If the exchange requires more than 60 seconds, the pump and event clock will be stopped until activity is re-initiated. Alternatively, extend the scenario for the "lost" time.

For all asbestos sampling, an asbestos sampling train consisting of 0.8-µm or a 0.45-µm, 25-mm MCE filter connected to a sampling pump is used. Specify the filter pore size in the UFP-QAPP. The top cover from the cowl extension on the sampling cassette will be removed ("open-face") and the cassette oriented face down for all asbestos filters. All samples should be collected open-faced unless a specific requirement for sampling closed-faced exists.

For activity-based sampling, calibrate sampling pumps to collect between 2 and 12 L/min of air through the filter depending on the pump capacity and analytical goals. Dusty conditions may dictate lower flow rates. The flow rate is based upon the duration of time required to collect the target volume that meets the site-specific analytical sensitivity limit as specified in the UFP-QAPP.

Generally, each activity based sampling event should be repeated a minimum of three times in the same area, or if not possible, in an area with similar asbestos soil concentrations, to determine trends, demonstrate data reproducibility, or assess variability. This can be accomplished by a single participant repeating the activity three or more times or by having a single simulation in three areas with similar asbestos soil concentrations. If soil moisture or seasonal variability is a concern, three events for each different season or meteorological condition may be appropriate. The decision to conduct multiple repetitions of an activity in a single area should be based on the data quality objectives of the project and specified in the UFP-QAPP.

During most ABS activities, participants may be fitted with two sampling pumps or samplers may be collocated to sample a high and low volume of air to increase the likelihood of at least one of the two samples being analyzed using the direct analytical method (ISO 10312) without overloading. Ideally, a volume of 560 L (based on 40 Code of Federal Regulations [CFR] 763) should be collected for the low-flow samples, and a volume up to 4,000 L should be collected for the high-flow samples. Volumes less than 560 L may be collected if the decision makers are in agreement and the sampling design is documented in a site specific QAPP. The targeted high volume is typically 1,200 L, which permits counting approximately 54 grid openings for a sensitivity level of 0.001 S/cc. Based on Table 1 of Appendix A, additional grid openings may be used if a lower sample volume must be collected (Refer to Section 4.4 for additional information).

7.6 Site-Specific Activity-Based Sampling Scenarios

If site-specific ABS is undertaken, the number and types of activities and the types of scenarios should be based on current and/or potential land use and potential impact to adjacent property. As potential hazardous dust is produced, every effort must be taken to minimize exposure on or off-site. The activity selected may also be used to assess the effectiveness of institutional or legal controls placed on the future use of the land. Land use assumptions should be based on a factual understanding of site-specific conditions and reasonably anticipated use. The land use evaluated for the assessment should be based on a residential exposure scenario (i.e., the default worst-case) unless residential land use is not plausible for the site. Future land use assumptions should be consistent with reasonably anticipated future land use based on input from planning boards, appropriate officials and the public. The site-specific scenario and the area selected to perform the scenario in should be identified and substantiated in the UFP-QAPP.

The following sections discuss a partial list of potential ABS scenarios that can be conducted on site. If implementation of other scenarios is necessary, use professional judgement to develop and execute the scenario and associated sampling activities.

7.6.1 Raking

The raking scenario is appropriate for all sites with soils potentially contaminated with asbestos. ABS should be performed in a grid pattern to evaluate the potential for fiber release from soil over a portion of the site. If the analytical results are above the criteria that were derived for the site, then remediation or institutional controls should be implemented, or additional site-specific ABS should be undertaken. If the analytical results are below the criteria that were derived, then no further action may be necessary.

In this activity or simulation, a participant will rake a lawn or garden area to remove debris such as rocks, leaves, thatch, and/or weeds using a leaf rake (or bow rake), with a rake width of approximately 20 to 28 inches. Participants should strive to disturb the top half-inch of soil with an aggressive raking motion. This depth will vary based on the objective of the scenario specified in the UFP-QAPP.

Each raking participant donning appropriate PPE will be fitted with a high and low flow sampling pump contained in a backpack with the cassette secured to the shoulder straps near the operator's lapels in the breathing zone. A typical low sampling pump flow rate can vary from 1 to 5 L/min. A high flow sampling pump rate can vary from 2 to 12 L/min

Personnel will rake a lawn or garden area to remove debris for a minimum of 1 to 2 hours (flow rate and sensitivity level dependent). Raking will occur in a measured area specified in the QAPP with vegetation, soil or rocks/gravel and will occur in an arched motion raking from one side of the participant to the other. As an example, the participants may rake the debris towards themselves facing one side of the square for 15 minutes then the participant will turn 90 degrees clockwise and begin a new side. Participants may continue to rake each side of the square and rotate 90 degrees. Unique shaped parcels can be addressed using logic and best professional judgement. Once several small piles of debris have been made, the participant may pick up the debris and place it in a trash can. The sequence of raking, rotating and picking up debris shall be repeated for the duration of the sampling period. The participant should stay in the same sampling area or grid for the entire sampling period.

7.6.2 ATV Riding

This scenario might be appropriate for recreational areas or other areas where ATVs are typically ridden where asbestos contamination is present. This activity is designed to be representative of one, two, or more ATV participants riding on a course or trail. Riders should maintain their relative position (lead, middle, and tail) throughout the activity.

Each ATV rider wearing appropriate PPE may be fitted with two personal sampling pumps set at two distinct flow rates, to collect high and low flow samples, due to filter overloading concerns. The cassettes for the personal sampling pumps should be attached to the shoulder straps of the backpack proximal to the riders' lapels in the breathing zone. It may be beneficial to attach a dust monitor (e.g., DustTrak or equivalent) to the tail ATV to record dust levels and gauge dust loading. The sampling pumps can be carried in a backpack while the dust monitor, if used, can be mounted to the ATV.

Personnel will ride the ATVs around a course at the same time until a sufficient volume of air has been collected to achieve the required sensitivity limit. The riders, one lead rider and one following rider, will vary the vehicle speed between 5 and 30 miles per hour (mph). Riders will strive for an average speed typical of riders in the area, but ideally 10 mph. The average speed is a target speed only; vehicle speeds will be adjusted to meet track conditions. Vehicles will be equipped with a speedometer and odometer to record speeds and distance traveled. ATV riding and sampling may be conducted for 30 to 120 minutes in duration, depending on dust loading and required detection limits. The ATVs may be equipped with a global positioning system (GPS) unit or utilize an appropriate phone application to estimate average speed and distance traveled.

ATVs and ATV tires are selected as appropriate for the area under investigation. Specifically, the size (i.e., weight, horsepower, etc.) of the ATV should be appropriate for the study area. The vehicle tires should have a tread pattern that is representative of those typically used in the area. Local ATV shops or ATV clubs can be consulted for guidance.

7.6.3 Child Playing in the Dirt

This scenario might be appropriate for sites where schools, playgrounds, parks, or residential areas, etc. are contaminated with asbestos with the overarching criteria being areas where a child might be expected to play or dig in the dirt. This scenario was designed to be representative of a child playing in the dirt with a shovel and pail.

The event participant wearing appropriate PPE may be fitted with high and low flow personal sampling pumps; the inlet to the filter will be at a height of approximately 1 to 3 feet above the ground to simulate a child’s breathing zone. The actual pump units should be secured in a backpack or on the belt of the participant.

A participant should sit on the ground while digging or scraping the top 2 to 6 inches of surface soil, placing it in a small bucket or pail and dumping it back on the ground. The activity should be paced such that soil will be placed in the bucket and dumped approximately every two to five minutes, regardless of the amount of material in the bucket. The bucket should be emptied rapidly from a height of approximately 12 inches, based on observations of two to four-year-olds playing in a sandbox.

A sampling period and flow rate to collect a sufficient volume of air will be determined as to achieve the project-specific detection/quantification limit. The sampling period can be divided into equal sub-periods to facilitate having the participant face each compass direction for an equal amount of time during the activity. This approach is designed to mitigate the effect of wind direction on potential exposure. Random head and body movement during the activity should further mitigate the impact of wind direction on exposure. Ideally, the participants should face each compass direction at least twice during the sampling event. For example, during a two-hour or 120-minute event, the participant might face North for 15 minutes, rotate to the East for 15 minutes, then South for 15 minutes, then West for 15 minutes and return to the North to repeat the cycle. Participants should attempt to move to a fresh patch of soil after the completion of each cycle (360-degree rotation).

7.6.4 Gardening/Rototilling

This scenario might be appropriate for sites where gardening or surface disturbance to a depth of approximately one foot is anticipated. This activity is designed to be representative of individuals participating in gardening activities using a rototiller.

Each rototilling participant donning appropriate PPE will be fitted with high- and low-flow sampling pumps. The actual pump units may be contained in a backpack with the cassette secured to the shoulder straps near the operator's lapels in the breathing zone.

Personnel will operate a rototiller for one to two hours to loosen soil in the yard to a depth of approximately 12 inches. The depth chosen is area-specific and will need to be determined on a case-by-case basis. A rear-tine rototiller in the six to eight horsepower range should be selected. Other types or sizes of tillers may be appropriate based on the soil conditions and type of gardening being conducted.

A 100 to 720-square-foot (ft^2) plot of land should be selected to till. The average size of a community garden in New Jersey was 720 ft^2 based on a survey conducted by Rutgers University in 1991 (Patel 1991). The edges will be delineated. Square plots are preferred. The rototiller operator should conduct typical associated activities such as removing rocks and debris from the tilled area. To account for the effects of varying wind direction on potential exposure, the operator should till the soil back and forth towards each side of the square continuously for 10 minutes, shut down the machine or place it in neutral, and rake or sort through the material for five minutes. The operator should then turn 90 degrees in a clockwise direction and repeat the previous 15-minute procedure. The operator should continue to rotate 90 degrees clockwise every 15 minutes until the one to two-hour sampling period is complete. The participant should stay in the same plot for the entire sampling period.

7.6.5 Weed Cutting

This scenario might be appropriate for sites where lawn maintenance might be conducted such as in residential and commercial areas. This activity is designed to simulate a person trimming weeds and grasses with a gas or electric powered weed cutter.

Each weed-cutting participant may be fitted with high and low flow personal sampling pumps. The pump units can be contained in a backpack with the cassette secured to the shoulder straps near the operator's lapels in the breathing zone. Personnel wearing appropriate PPE will operate a gas or electric-powered string trimmer. Ideally, a 25 to 35-cubic centimeter (cc) gas or electric-powered trimmer with a 16 to 18-inch cutting swath is selected. Trimming and edging will occur in a measured area with thick vegetation (typically 100 to 720-ft^2, based on a typical residential garden) (Patel 1991). Trimming should be performed using a side to side sweeping motion with the operator moving in a series of straight lines back and forth towards one side of the selected area for 10 minutes, resting five minutes, and turning 90 degrees in a clockwise direction before repeating this 15-minute procedure for the duration of the sampling period. The participant should stay in the same plot for the entire sampling period.

7.6.6 Digging

Digging might be appropriate for sites where construction projects are likely to occur or where plants might be planted. Digging will occur in a measured area with vegetation, soil or rocks/gravel.

Each participant donning appropriate PPE may be fitted with high and low flow personal sampling pumps contained in a backpack with the cassette secured to the shoulder straps near the operator's lapels in the breathing zone. The participants should dig a hole to approximately two feet deep and two feet in diameter (representative of planting a small shrub or digging a fencepost; site-specific dimensions should be specified in the UFP-QAPP) (Vodak 2004), and place the soil next to the hole. The participants should then refill the hole with the soil that had been removed. Upon refilling a hole, participants should rotate 90 degrees in a clockwise direction and continue to dig and refill additional holes until the sampling period is complete. The sequence of digging, filling, and rotating should be repeated for the duration of the sampling period.

7.6.7 Lawn Mowing

Lawn mowing may be appropriate for sites where lawn maintenance may be conducted, such as residential and commercial areas.

Each lawn-mowing participant may be fitted with high and low flow personal sampling pumps contained in a backpack with the cassette secured to the shoulder straps near the operator's lapels in the breathing zone. Personnel wearing appropriate PPE will operate a gas or electrically powered lawn mower. Mowing should occur in a measured area with thick vegetation and should occur in a shrinking square pattern. Participants will divide the area into a number of squares that decrease in size towards the center of the square by the width of the mower swath. Mower blades should be set at approximately 2 to 2.5 inches, but the mower blade settings may vary based on the thickness of the vegetation to be cut. A bagless, side-discharge 3- to 5-horsepower lawn mower should be used for this exercise. The mowing operation should be repeated for the duration of the sampling period.

7.6.8 Walker with Stroller

This scenario might be appropriate for sites such as parks, paths, trails, or open-space. The high and low flow personal sampling pump units may be secured in a backpack. The cassette for the personal sampling pumps may be attached to the shoulder straps of the backpack proximal to the walker's lapel in the breathing zone. A second set of pumps should be placed in the stroller with the filter inlets in a child's potential breathing zone.

During these events, walkers wearing appropriate PPE pushing a stroller should walk back and forth along a portion of a path until a sufficient volume of air has been collected to achieve the required detection limit. The walkers should vary their speed between 1.5 and 4 mph. Walkers should strive for an average speed of 2 mph. The average speed is a target speed only; speeds will be adjusted to meet trail conditions. Walkers may be equipped with a GPS unit or utilize an appropriate phone application to estimate average speed and distance traveled.

7.6.9 Jogging

This scenario might be appropriate for sites such as parks, paths, trails, or open-space. The high and low flow pump units may be secured in a backpack. The cassette for the personal sampling pumps may be attached to the shoulder straps of the backpack proximal to the jogger's lapel in the breathing zone.

During these events, joggers wearing appropriate PPE will run/jog back and forth along a portion of a path until a sufficient volume of air has been collected to achieve the required detection limit. The joggers should vary their speed between 2.5 and 5 mph. Joggers should strive for an average speed of 4 mph. The average speed is a target speed only; speeds can be adjusted to meet trail conditions. Joggers may be equipped with a GPS unit or utilize an appropriate phone application to estimate average speed and distance traveled.

Two or more joggers can participate in this activity. When multiple joggers participate, they should maintain their relative position throughout the event (lead, middle, and tail). Joggers should be spaced five feet apart.

7.6.10 Two Bicycles

Bicycling might be appropriate for sites such as parks, paths, trails, or open-space. Two bicyclists wearing appropriate PPE should ride back and forth with one leading and one following along the length of the on-site portion of a path, or ride around a site (no trail) until a sufficient volume of air has been collected to achieve the required detection limit.

The bicycling participants may each be fitted with high and low flow personal sampling pumps. The actual pump units may be contained in backpacks with the cassettes secured to the shoulder straps near the cyclists' lapels in the breathing zone.

During these events, the bicycle riders may vary their speed between 3 and 15 mph. Riders should strive for an average speed of 8 mph. The average speed is a target speed only; adjust bicycle speeds to meet trail conditions. Bicycles may be equipped with a GPS or utilize an appropriate phone application to estimate average speed and distance traveled. Riders should maintain their relative position (lead and tail) throughout the activity.

7.6.11 Basketball Scenario

This scenario might be appropriate for sites where basketball courts are present. The basketball scenario was developed to simulate a group of recreational basketball players gathering to play a casual game of basketball for 60 to 120 minutes on an outdoor concrete or macadam court. Between four and 10 players wearing appropriate PPE can participate in this exercise. Personnel wearing appropriate PPE can be fitted with high and low flow personal sampling pumps contained in a backpack with the cassette secured to the shoulder straps near the operator's lapels in the breathing zone.

<u>Suggested Scenarios:</u>

- Two of the players may sweep the court with push brooms from the perimeter of the court to the center. While these two people are sweeping the court, the remaining personnel should mill about under the basket and take a few shots.

- Shot practice participants stand around the key as for a free throw, with the exception that one of the participants is positioned under the basket to retrieve the ball after each shot. The player closest to the basket on the left side (facing the basket) takes two shots and the ball/shooter rotates counter-clockwise after those two shots. Each person shoots consecutively until everyone has taken two shots. The entire group then rotates clockwise. This sequence should be repeated until time expires. Ideally, each player should shoot from each key position and take a turn retrieving the ball under the basket.

- Each player takes turns practicing lay-ups. All players line up on the left side of the basket (facing the basket) and shoot one after another. The first person shoots then retrieves the ball for next person in line and so on. Players can use two basketballs with the second person bouncing the ball outside of the key as the first person shoots. Players should run a full cycle from left then a full cycle from right; repeating the left, right cycles until the interval time is up.

- Shot practice as described above may be conducted.

- A half-court game may be played to the degree practical.

- A lay-up drill as described above may be conducted.

7.6.12 Alternative ABS Methods

Alternative ABS methods may be considered in situations where traditional ABS activities cannot be performed. These conditions could be areas:

- Where soil moisture content may be above project-specific limits,
- Where the population may be considered to be too close to a study area, or
- When used for comparability between study areas.

7.6.12.1 Ex Situ Child's Play Scenario

The Ex Situ Child's Play Scenario (also known as the bucket of dirt scenario) utilizes a representative composite soil sample collected in a filled 5-gallon bucket. The composited soil can be placed in a secure dry location and allowed to dry naturally over time, or actively dried. Reassess the soil moisture periodically. Once soil moisture drops below 10%, the activity can proceed.

The Ex situ Child's Play scenario should be performed in an isolated location in an area prepared with visqueen sheeting surrounded by a berm of wood boards to create a barrier around the sampling area. This scenario is designed to be representative of a child playing in the dirt with a shovel and pail, similar to section 7.6.3.

The event participant wearing appropriate PPE may be fitted with high (4-6 L/min) and low (1-3 L/min) flow personal sampling pumps; the inlet to the filter will be at an eventual height of approximately 1 to 3 feet above the ground to simulate a child's breathing zone while seated. The actual pump units should be secured in a backpack or on the belt of the participant.

A participant should sit on the ground and empty the 5-gallon soil sample on the sheet. The scenario will consist of using a trowel to re-fill the bucket and dumping it back on the ground. The participant will continue to fill and empty the bucket for a sampling period and flow rate to collect a sufficient volume of air to achieve the project-specific detection/quantification limit. A typical timeframe is 45 to 60 minutes; visually inspect the filter during the scenario to prevent overloading.

For each soil sample, perimeter sample(s) (high flow) should be collected to ensure that asbestos is not getting outside the containment area. As this scenario is typically used with soil associated with low levels of contaminants, only a few samples maybe needed. The amount of these samples collected will depend on the number of iterations detailed in the site specific QAPP.

7.6.12.2 Fluidized Bed Asbestos Segregator (FBAS)

Another alternative method to help determine the risk associated with asbestos in soil, utilizes the fluidized bed asbestos segregator (FBAS). Soil, or other solid media, is collected from an area of interest. It is size-segregated by sieving and the fine fraction is then homogenized and fluidized in the FBAS. Small particles are elutriated from the bulk material and collected on a filter. The filter is then analyzed by TEM for identification and quantitation of fibers. The concentration of fibers in the soil can be expressed either as asbestos structures per gram (S/g) of soil or as mass percent (g of asbestos per 100 g of soil).

EPA has continued development and evaluation of the FBAS as it has become commercially available. For details on the use of FBAS, refer to Other Test Method 42: Sampling, Sample Preparation and Operation of the Fluidized Bed Asbestos Segregator here:
https://www.epa.gov/sites/production/files/2020-08/documents/otm_42_sampling_sample_preparation_and_operation_of_fluidized_bed_asbestos_segregator.pdf.

7.7 Cumulative Exposure Scenario

A cumulative exposure study may be appropriate for sites where individuals move about a site during the course of a day, with varying levels of exposure at multiple indoor and outdoor locations. The objective is to estimate aggregate and cumulative exposure to asbestos over the course of a day. Cumulative exposure studies should be conducted in order to increase understanding of linkages between sources of asbestos and subsequent exposure and dose to humans for use in mitigating risk and reducing exposure and disease.

Over periods of weeks, years or decades, exposures to environmental agents, such as asbestos, occur intermittently rather than continuously. The occurrence of long-term health effects, such as cancer, however, are routinely projected based on an average dose over the period of interest (typically years), rather than as a series of intermittent exposures. Consequently, long-term doses are usually estimated by summing doses across discrete exposure episodes and then calculating an average dose for the period of interest (e.g., year, lifetime, etc.).

For the cumulative exposure studies, times of up to 24-hours can be considered. Owners/residents should not be asked to wear personal air samplers to assess exposure. ABS actors should be instructed to mimic a particular routine of what may be considered a typical day. A log of activities should be maintained.

A minimal description of exposure for a particular route must include exposure concentration and the duration. This is the method of choice to describe and estimate short-term doses, where integration times are of the order of minutes, hours or days. When projecting long-term exposures, for years or a lifetime, since it is typically impractical to sample for the entire exposure period, short-term exposure estimates are assumed representative of long-term periods and are integrated to estimate long-term exposures, typically with a safety factor to account for variability. Observations of activities should be recorded throughout each cumulative exposure study, together with the other relevant factors including locations and activities during the study.

Samples are collected using a personal air pump with a flow rate of between 1 to 5 L/min. Samples shall be collected open-faced with the inlet facing downward at a personal breathing zone height of 4 to 6 feet for 24 hours. Because the battery life for a personal monitor is typically eight to 10 hours, the pump should be changed out at approximately 8-hour intervals (keeping the same filter cassette). Each pump is pre-calibrated prior to use. Wear each monitor at normal breathing height during all waking hours. During sleep, place the monitor in the same room as the sleeping individual. The sampling cassette will be placed proximal to the breathing zone of the reclined participant.

Should a study subject participate in a high dust generating activity such as riding an ATV, the 24 hour sampling cassette event should be paused and a short-term exposure sample should be collected on a separate cassette with an appropriately calibrated sampling pump. Once the high dust activity has been terminated, the original 24-hour cassette and pump should be resumed for the remainder of the sampling period. Results of the two or more samples, depending on the number of high dust generating events should be summed to derive the total 24-hour exposure data.

7.8 Background Sampling

Background (sometimes referred to as a reference sample location) samples should be considered for all sampling events and should be addressed in a site-specific UFP-QAPP. These samples are strongly recommended for all outdoor sampling events and encouraged for any indoor sampling. A background sample is defined as a sample collected upwind. while a reference sample location can be collected away from the immediate sampling area at a distance sufficient to prevent being influenced by the simulated activities and may be on or off the site. To the degree practical, the area selected for background sampling should be free of known asbestos contamination. For outdoor sampling, consider collecting samples outdoors in a manner consistent with Asbestos Hazard Emergency Response Act (AHERA) clearance sampling as per 40 CFR, Appendix A to Subpart E of Part 763. The background level should reflect the concentration of asbestos in air for the environmental setting on or near a site or activity location. The background level may not represent pre-release conditions or conditions in the absence of influence from sources at the site. A background level may or may not be less than the detection limit, but if it is greater than the detection limit, it should account for variability in local asbestos concentrations. Background samples may be collected concurrently with ABS using stationary sampling pumps. Background samples should not be impacted by the site ABS. Sampling and analytical parameters (sample volume grid opening count, etc.) should be prescribed to permit a detection limit approximately an order of magnitude below that of the ABS detection limit.

An Aircon-2 sampling pump (or equivalent) should be calibrated to collect 10 L/min for on-site and off-site air samples through the filter. The flow rate will allow a minimum target volume to meet the required sensitivity limit. Lower volume air samples may be collected concurrently at the ambient air sampling locations. If overloading of the filter is a concern, personal sampling pumps may also be utilized with the same media at a flow rate between 2 and 3 L/min in order to collect a lower sample volume. The ideal target sensitivity of these samples can be as low as the higher volume samples when additional grids are counted in accordance with the method. Collocated samples are collected to sample a high and low volume of air to increase the likelihood of at least one of the two samples being readable using the direct analytical method (ISO 10312).

7.9 Perimeter Sampling

Perimeter air sampling should be performed to determine the concentrations of asbestos at the activity perimeter or the site perimeter and to ensure that ABS activities do not result in excessive airborne asbestos emissions from the site.

Perimeter samples are defined as samples collected upwind, downwind, or crosswind of a specific activity. When selecting areas for ABS, consideration should be given to the potential for off-site migration of contaminants and to possible exposure to the public. Within the constraints of ABS, to the degree practical, particulate migration off site should be minimized, and constraints or mitigation protocols established to eliminate public exposure. These constraints/mitigation protocols may include conducting the ABS in remote areas of the site, dust suppression adjacent to the activity area using water mist, building a containment structure, etc. Air sampling should be conducted to document the airborne concentration of asbestos at the activity/site perimeter during activities. Perimeter air monitoring should be conducted to:

- Document air quality during ABS and establish perimeter levels of asbestos during site activities
- Monitor and document air quality during site activities near sensitive receptors
- Provide risk management information and address public concerns
- Reduce possible liabilities associated with ABS

An AirCon-2 sampling pump (or equivalent) can be calibrated to collect 10 L/min for on-site and off-site air samples through the filter. The flow rate will allow a target volume that will provide the required sensitivity limit. Lower volume air samples may be collected concurrently at the perimeter sampling locations using personal sampling pumps, if loading is an issue. These pumps will be utilized with the same media at a flow rate of between 2 and 3 L/min. The target sensitivity of these samples can be as low as the higher volume samples when additional grids are counted in accordance with the method.

7.10 Soil Sampling

The relationship between the concentration of asbestos in a source material (typically soil) and the concentration of fibers in air that results when the source is disturbed is very complex and depends on a wide range of variables. It is reasonable to say that besides the asbestos fiber concentration in soil, soil moisture, partial size distribution, and soil type generally have a significant impact on the concentration of asbestos released into the air during ABS.

A sufficient number of soil samples should be collected to characterize the study area. The sampling approach should be designed to collect information to support project decisions. In some cases, grab samples may be appropriate to inform nature and extent; however, incremental composite sampling is recommended to characterize exposure and support risk-based decisions. A sampling design program such as the Visual Sampling Plan is recommended for calculating the number and location of samples with the appropriate confidence intervals.

Soil analytical methods that may be considered include: US EPA 600/R/93/116, *Test Method: Method for the determination of asbestos in bulk building materials*, CARB 435, *Determination of asbestos content of serpentine aggregate*: Method 435 and ASTM Method 7521-16, *Standard test method for determination of asbestos in soil*. Soil sampling should be conducted in accordance with ERT SOP, *Soil Sampling.*

Additionally, soil characteristics should be documented in conjunction with the activity-based personal exposure monitoring using a portable soil moisture meter. Alternatively, soil characteristics can be documented in one of the following ways:

- Using American Society of Testing and Materials (ASTM), Method D2488 - 00: *Description and Identification of Soils (Visual-Manual Procedure)*,
- Soil moisture by ASTM Method D2216-05*: Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass* and grain size by ASTM Method D6913-04e1: *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis,* or
- Method D422-63 (2002): *Standard Test Method for Particle-Size Analysis of Soils.*

Soil samples should be representative of the soil being disturbed or used during ABS activities. Table 3 of Appendix A provides examples of soil sampling depths, which may be disturbed by the activity being performed.

8.0 CALCULATIONS

The sample volume is calculated from the average flow rate of the pump multiplied by the number of minutes the pump was running (volume = flow rate X time in minutes). The sample volume should be submitted to the laboratory and identified on the chain of custody for each sample (zero for lot, and field blanks).

The concentration result is calculated by dividing the number of asbestos structures reported after the application of the cluster and matrix counting criteria by the sample volume (concentration = number of asbestos structures/sample volume).

9.0 QUALITY ASSURANCE/QUALITY CONTROL

Specific Quality Assurance/Quality Control (QA/QC) activities that apply to the implementation of these procedures will be listed in the QAPP prepared for the applicable sampling event. The following general QA procedures also apply:

1. All sample collection data, including sample number, sample location, start and end times, start and end flow rates, pump number, media used and analysis/method must be documented on site logbooks or Field Sampling Worksheets.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer or instrument-specific SOPs, unless otherwise specified in the UFP-QAPP. Equipment checkout and calibration is necessary prior to sampling and must be done according to the instruction manuals supplied by the manufacturer.

3. Records must be maintained, documenting the training of the operators that use instrumentation and equipment for the collection of environmental information.

The following specific QC activities apply:

1. Provide one field blank per sampling event or per 20 samples, whichever is greater, unless otherwise specified in the analytical method or project-specific UFP-QAPP. The field blank should be

collected at the beginning of the sampling event and handled in the same manner as the sampling cassette except that no air is drawn through it.

2. Lot blanks should be collected at a rate of at least one per lot.

3. It is recommended to collect one collocated sample per sampling event or per 10 samples, whichever is greater. Collocated samples are two samples collected adjacent to each other at the same time at the same flow rates. See the project-specific UFP-QAPP for final determination.

For TEM analysis, the following QA/QC procedures apply:

1. Examine lot blanks to determine the background asbestos structure concentration.
2. Examine field blanks to determine whether there is contamination by extraneous asbestos structures during specimen preparation or handling.
3. Examine laboratory blanks to determine if contamination is being introduced during critical phases of the laboratory program.
4. To determine if the laboratory can satisfactorily analyze samples of known asbestos structure concentrations, reference filters can be examined. Reference filters should be maintained as part of the laboratory's QA program.
5. To minimize subjective effects, some specimens may be recounted by a different microscopist.
6. Asbestos laboratories must be accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).
7. At this time, performance evaluation samples for asbestos in air are not commonly available for Removal Program Activities; however, they should be considered on a case-by-case basis.

10.0 DATA VALIDATION

Data verification (completeness checks) must be conducted to ensure that all data inputs are present for ensuring the availability of sufficient information. This may include but is not limited to location information, start and end times, sampling method and total volume sampled. These data are essential to providing an accurate and complete final deliverable. The ERT contractor’s Task Leader (TL) is responsible for completing the UFP-QAPP verification checklist for each project.

Results of QC samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results accordingly with the project's data quality objectives.

11.0 HEALTH AND SAFETY

Based on Occupational Safety and Health Administration (OSHA) requirements, a site-specific HASP must be prepared for response operations under the Hazardous Waste Operations and Emergency Response (HAZWOPER) standard, 29 CFR 1910.120. Field personnel working for EPA’s ERT should consult the Emergency Responder Health and Safety Manual currently located at https://response.epa.gov/_HealthSafetyManual/manual-index.htm for the development of the HASP, required PPE and respiratory protection.

For all ABS, appropriate PPE, including protective coveralls, gloves and footwear, and a respirator with HEPA filter cartridges (P-100 or equivalent) should be worn to protect participants. Details regarding PPE and other protective measures should be specified in the site-specific HASP. Special consideration should be given to the physical safety of the event participants as well as heat stress associated with performing vigorous activities in impermeable clothing.

12.0 REFERENCES

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13.0 APPENDICES

A – Tables
B – Example 30-Year Climatological Average Soil Moisture Map
C – Procedure to Locate Local Average Precipitation Data

APPENDIX A
Tables
SOP: ERT-PROC-2084-21
March 2021

TABLE 1. Minimum Number of Grid Openings Required To Be Counted to Achieve a Given Analytical Sensitivity and Detection Limit (Adapted from ISO 10312)

Analytical Sensitivity Structures/cc	Limit of Detection Structures/cc	Volume of Air Sampled (Liters)					
		500	1,000	2,000	3,000	4,000	5,000
0.0001	0.0003	1,066	533	267	178	134	107
0.0002	0.0006	533	267	134	89	67	54
0.0003	0.0009	358	178	89	60	45	36
0.0004	0.0012	267	134	67	45	34	27
0.0005	0.0015	214	107	54	36	27	22
0.0007	0.0021	153	77	39	26	20	16
0.001	0.003	107	54	27	18	14	11
0.002	0.006	54	27	14	9	7	6
0.003	0.009	36	18	9	6	5	4
0.004	0.012	27	14	7	5	4	4
0.005	0.015	22	11	6	4	4	4
0.007	0.021	16	8	4	4	4	4
0.01	0.030	11	6	4	4	4	4

TABLE 2. Suggested Meteorological Station Specifications

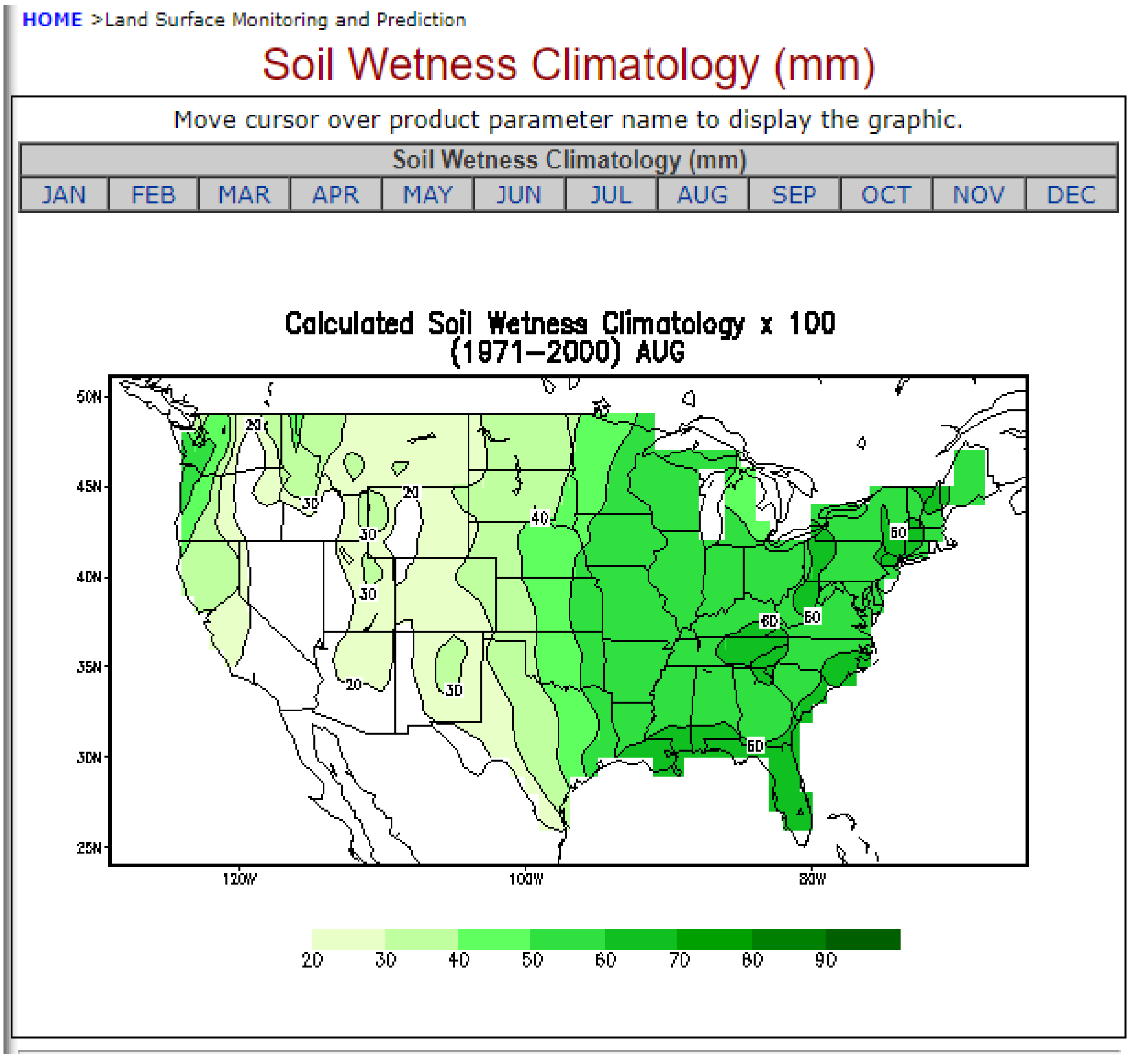
Variable	Accuracy	Resolution
Wind Speed (horizontal and vertical)	± (0.2 m/s + 5% of observed)	0.1 m/s
Wind Direction (azimuth and elevation)	± 5 degrees	1.0 degrees
Ambient Temperature	± 0.5" C	0.1" C
Precipitation	± 10% of observed or ± 0.5 mm	0.3 mm
Pressure	± 3 mb (0.3 kPa)	0.5 mb
Solar Radiation	± 5% of observed	10 W/m^2

m/s = meters per second
"C = degrees Centigrade
mm = millimeters
mb = millibar
W/m^2 = watts per square meter
kPa = kilopascal

TABLE 3. Recommended Soil Sampling Depth Based on Activities Performed

Activity Based Sampling Scenario	Soil Sampling and Soil Moisture Depth
Raking (metal garden or bow rake)	Surface to 3 inches
Raking (leaf rake)	Surface to 2 inch
ATV riding	Surface to 2 inch
Rototilling	Surface to 12 inches
Digging	Surface to depth of excavation
Child Playing in the dirt	Surface to 3 inches
Weed Whacking	Surface to 2 inches
Lawn Mowing	Surface to 2 inch
Walking with Stroller	Surface to 2 inch
Two Bicycles	Surface to 2 inch
Activities on solid surfaces such as asphalt or concrete	Microvacuum ASTM D 5755

APPENDIX B
Example 30-Year Climatological Average Soil Moisture Map
SOP: ERT-PROC-2084-21
March 2021

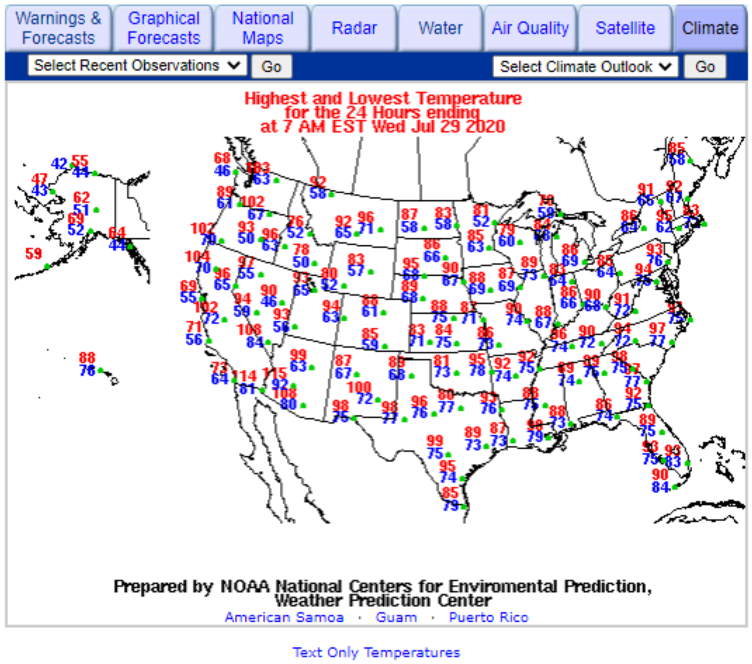


HOME >Land Surface Monitoring and Prediction
Soil Wetness Climatology (mm)
Move cursor over product parameter name to display the graphic.
Soil Wetness Climatology (mm)
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Calculated Soil Wetness Climatology x 100
(1971–2000) AUG
50N
45N
40N
35N
30N
25N
120W
100W
80W
20 30 40 50 60 70 80 90

APPENDIX C
Procedure to Locate Local Average Precipitation Data
SOP: ERT-PROC-2084-21
March 2021

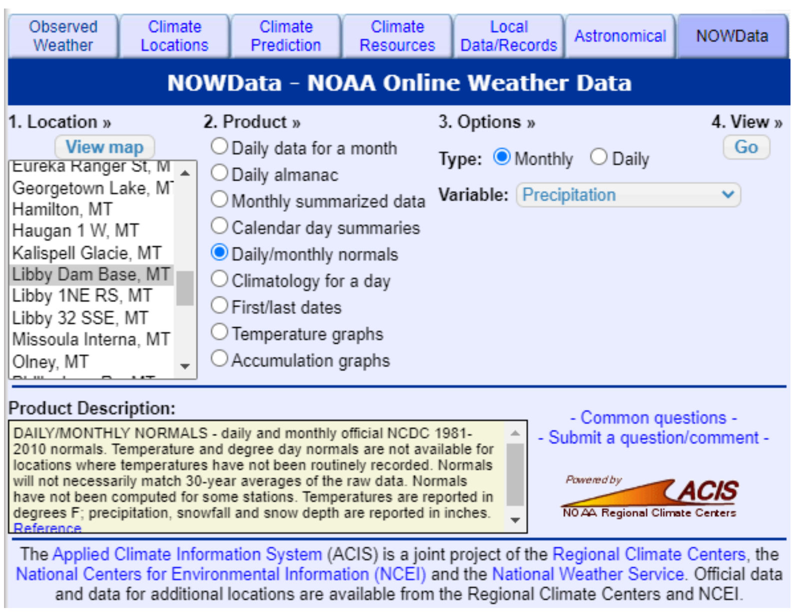
Locating Climatological Precipitation Norms by National Weather Service Observation Station

1. Go to www.weather.gov.
2. Click the **Past Weather** tab. A map similar to below will appear. Click on the area of interest on the map.

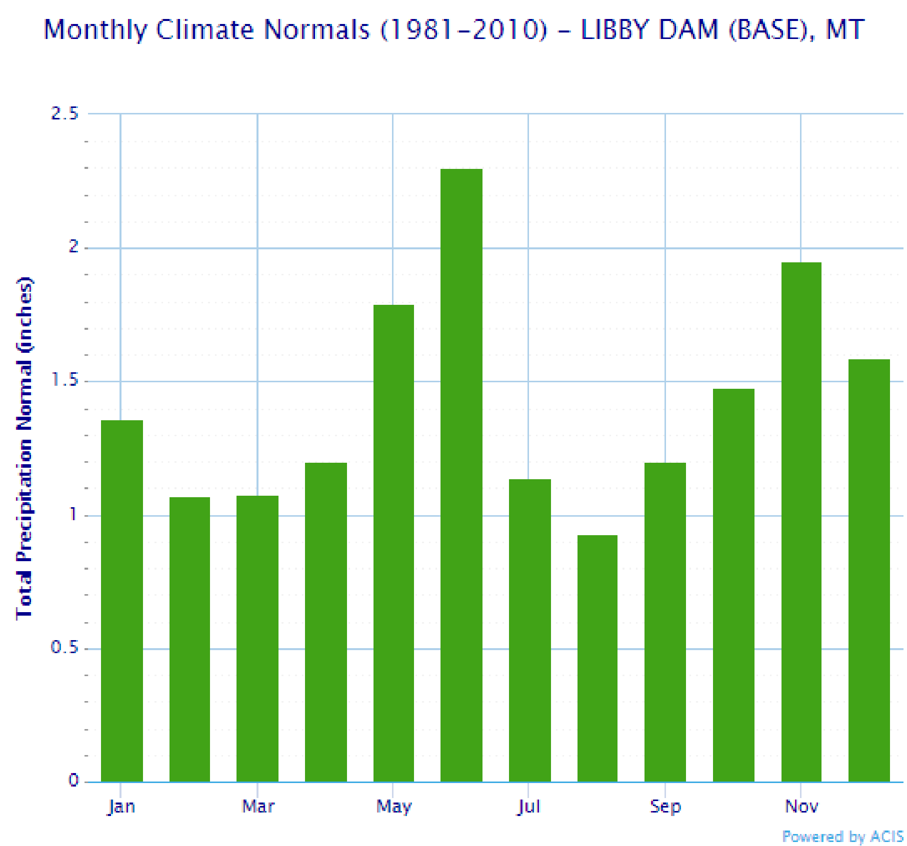


Click on the NOWData tab.

1. Location: Choose site closest to area of interest.
2. Product: Select **Daily/Monthly Normals.**
3. Type: **Monthly.** Variable: **Precipitation**
4. Click **Go**.



A graphic similar to below should appear.



Month	Total Precipitation Normal (inches)
January	1.36
February	1.07
March	1.08
April	1.20
May	1.79
June	2.30
July	1.14
August	0.93
September	1.20
October	1.48
November	1.95
December	1.59
Annual	17.09