SOP-1
CALIBRATION OF THE SCALER RATEMETER (Ludlum 2221)
And DETCTOR (2”x2” NaI Scintillator)

1. SCOPE

1.1 Purpose

To provide a standard procedure for the calibration of the Ludlum Ratemeter, model 2221 with a 2”x2” NaI Scintillation Detector (the Ludlum 44-10 or Eberline SPA-3).

The 2221 is a portable, battery operated, self-contained counting instrument designed for operation with scintillation, proportional or G-M detectors. When combined with scintillation detectors, the Ludlum 2221 is used for the detection and measurement of gamma radiation. This instrument configuration is used for detection of surface soil gamma radioactivity.

1.2 Applicability

This instrument will be calibrated every twelve months, after repairs, or when the instrument function check fails. This method can be used with any Scaler/Ratemeter with a 2”x2” NaI scintillation detector configuration.

2. REFERENCES

2.1 Technical Manual for Scaler Ratemeter, Model 2221

4. REQUIREMENTS

4.1 Tools, Material, Equipment

4.1.1 Small screwdriver.

4.1.2 Ludlum Model 500 Pulser or equivalent.

4.1.3 A source of sufficient gamma radiation activity to allow a response for high voltage plateau and function check. A 1% uranium ore in a sealed can is used.

4.2 Precautions, Limit

4.2.1 The detector to Scaler/Ratemeter connector cable could easily be damaged if the weight of the 2”x2” NaI detector is suspended with it.

4.2.2 The NaI scintillation crystal is fragile. Shock to the crystal could cause a fracture or a crack, which could impact operation.

4.2.3 Do not leave the reading lamp on for any length of time as it will rapidly drain the battery voltage.

4.3 Acceptance Criteria

The instrument response to the calibration source should be within ± 20%.

5. LUDLUM 2221 OPERATION CALIBRATION

Record Scaler/Ratemeter information (model and serial number) on the Scaler/Ratemeter Calibration Form. Record information about the calibration source (Pulser and/or source, 1% uranium ore standard).

5.1 Check the battery condition by pressing the “BAT” button with instrument switched on. If the meter does not indicate the battery charge above 5.3 volts, replace the four (4) D-cell batteries.

5.2 Set the threshold value as follows:

5.2.1 With the instrument turned on, press the threshold button. Read the displayed reading. If necessary adjust the **“**THR**”** adjustment screw until the threshold reads 100.

NOTE: The ‘THR” adjustment screw is located under the calibration cover

5.3 Set the WIN (window) IN/OUT to OUT.

5.4 Connect the Ludlum 500 Pulser to the 2221.

5.5 Switch SCALER/DIG RATEMETER switch to DIG RATEMETER.

5.6 Select 400 CPM on the Pulser (multiplier switch to 1 and count rate adjusted to 400 cpm).

5.7 Adjust Pulser amplitude above the set threshold (100 mV) until a steady count rate is observed.

5.8 Record the meter rate count response in AS FOUND column on the calibration form. If the meter response is not within 10% of the Pulser set count rate of 400 cpm, adjust the R40 Meter Cal (Labeled MCAL) on the processor board for 400 cpm on the meter.

5.9 Repeat steps 5.6 to 5.8 for 4000, 40,000 and 400,000 cpm pulses.

5.10 Switch SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

5.11 Select 400 counts on the pulser (multiplier switch to 1 and count rate adjusted to 400)

5.12 Count the pulses on the meter for one minute by pressing COUNT switch.

5.13 Record the meter response counts in AS FOUND column on the calibration form. If the meter count is not within 10% of the pulser set counts of 400 cpm, adjust the R40 Meter

Cal (Labeled MCAL) on the processor board and repeat step 5.12 until a count of 400 is observed on the meter.

5.14 Repeat steps 5.11 to 5.13 for 4000, 40,000 and 400,000 pulses.

If the meter reading could not be set within 10% of the pulses generated by the pulser, the meter requires repair and calibration prior to use.

The Ludlum 2221 is ready for detector calibration and operation.

6. DETECTOR HIGH VOLTAGE AND BACKGROUND CALIBRATION

Record Scaler/Ratemeter (Ludlum 2221) and 2”x2” NaI detector (Eberline SPA-3 or Ludlum 44-10) information (model and serial number) on the Scaler/Detector Calibration Form. Record information about the calibration source (1% uranium ore standard).

6.1 Connect the calibrated Ludlum 2221 to the 2”x2” NaI detector.

6.2 Turn the Ludlum 2221 ON. Set WIN ON/OFF to OFF.

6.3 Check Threshold setting. Should be at 100 mV.

6.4 Switch SCALER/DIG RATEMETER switch to SCALER. Select Count Time to 1 Minute.

6.5 Set HV to 500 VDC.

6.6 Expose the detector to the 1% uranium ore can by placing directly under the detector.

6.7 Obtain one-minute counts with the detector exposed to the source at every 50-volt increment until voltage plateau is passed and sudden increase in the counts is observed. (Usually the for the 2”x2” NaI detector, the high voltage plateau maximum voltage is about 1300 to 1400 VDC.). Record the counts under the READING CPM SOURCE in the calibration form.

6.8 Return HV setting back to 500 VDC.

6.9 Remove the source away from the detector. Obtain one-minute background counts with the detector shielded from the source at every 50-volt increment until similar voltage to the source high voltage plateau reading. Record the counts under the READING CPM BACKGROUND in the calibration form.

6.10 Plot voltage versus cpm reading for both the source and background high voltage data. From the plot, select the optimum operating high voltage, which is usually at least about 50 volts above the knee of the plateau curve for a greater counting stability. The optimum high voltage should be also within the background plateau curve for background counting stability.

6.11 Set the Ludlum HV at the optimum operating voltage determined above.

The Ludlum 2221 and the 2”x2” NaI detector configuration is ready for efficiency calibration and establishing the operating background and source function check.

7. OPERATING BACKGROUND SOURCE FUNCTION CHECK DETERMINATION

7.1 Set the Ludlum 2221 to Scaler mode, Count Time at 1 minute, with WIN OUT and THR at 100.

7.2 Remove any type of the sources away from the detector. Obtain five one-minute background counts. Record the background counts in the calibration form. Average the five one-minute background counts. Record the average background counts in the calibration form. The daily function check background counts should be within 20% of this average.

7.3 Expose the 1% uranium ore source (in the sealed can). Note the exact location of the source to the detector. Obtain five one-minute background counts with the detector exposed to the source. Record the source counts in the calibration form. Average the five one-minute source counts. Record the average source counts in the calibration form. The source position to the detector for the function check should be exactly the same as this calibration, and the source counts for the daily source function check counts should be within 20% of this average.

8. EFFICIENCY CALIBRATION

8.1 Using the Map in the DOE Field Calibration Report (DOE/ID/12584-179) go to the Grants calibration site. Locate GPL pad (87.78 pCi/gm Ra-226, 0.50 pCi/gm Th-232 and 15.58 pCi/gm K-40) as shown in the Grants Calibration Site layout in the DOE report.

8.2 Set the Ludlum 2221 to Scaler mode, Count Time at 1 minute, with WIN OUT and THR at 100.

8.3 Obtain five one-minute counts with detector at the center of the pad at about 18 inches from the pad surface. Record the counts on the Calibration Form. Also obtain five one-minute counts with detector collimated at same height and record the counts on the Form.

8.4 Average the five calibration counts (cpm) and record on the form and calculate efficiency for collimated and uncollimated (bare) detector.

Efficiency (cpm/pCi/gm) = Cal Pad average one-minute counts (cpm)/87.78 pCi/gm

This efficiency may be used for Minimum Detectable Concentration (MDC)

9. MDC CALCULATION

9.1 MDC for Static Gamma Radiation Measurement (for 0.05 probability for both false positive and false negative errors)

$$MDC = C \times [3 + 4.65 (B^{0.5})]$$

Where

C = Detector calibration factor, pCi/gm/cpm (for this survey as determined above).
B = Number of background counts that are expected to occur while performing a sample measurement.

Example: If the background count from the function check for the detector is 7862 cpm, and the slope value is 0.001418 pCi/gm/cpm (705 cpm/pCi/gm), then the MDC for a one minute static measurement would be:

MDC = 0.0014 pCi/gm/cpm x [3 + 4.65 (7862 cpm)$^{0.5}$] = 0.59 pCi/gm

9.2 MDC for Scan Gamma Radiation survey

The scan MDC is assumed for a scan rate of about 3 feet per second and a one second interval (based on a detector that is focused on about 36 – 42 inches diameter area at about 18 inches from ground surface). Also, a surveyor efficiency (p) of 0.5 is assumed. First calculate the Minimum Detectable Count Rate (MDCR) as follow:

$$MDCR = d' \times (bi^{0.5}) \times (60/i)$$

Where

d’ = value for true positive and false positive proportion. A value of 1.38 will be used for 95% true and 60% false positive proportion.
bi = number of background counts in the interval i (cpm/60 sec/min for one second interval).

For a detector background count of 7820 cpm, the MDCR for one second interval would be:

MDCR cpm = (1.38) x (7820 cpm x 1 sec x 1 min/60 sec)$^{0.5}$ x 60 sec/min = 945 cpm.

Then calculate the $MDCR_{surveyor}$ using surveyor efficiency (p) of 0.5 as follow:

$MDCR_{surveyor} = MDCR/p^{0.5}$ = 945 cpm/($0.5^{0.5}$) = 1,337 cpm.

From the $MDCR_{surveyor}$, calculate the scan MDC using the following:

Scan MDC = $MDCR_{surveyor}$, cpm x C, pCi/gm/cpm

Where C = Detector calibration factor, pCi/gm/cpm (for this survey as determined above).

For a C of 0.0014 pCi/gm/cpm (705 cpm/pCi/gm), the Scan MDC would be:

Scan MDC = 1,337 cpm x 0.0014 pCi/gm/cpm = 1.87 pCi/gm

The integration count time for static measurement may be increased, and the scan rate for radiation scan survey may be reduced to lower MDCs to desired levels.

The Ludlum 2221/2”x2” NaI detector configuration is ready for a site-specific soil Ra-226 to gamma radiation level calibration (SOP-2) and performing field gamma radiation survey (SOP-3). A daily function check must be performed prior to use.

Attachment A, SOP #RAD-01
AVM Environmental Services Inc.

Scaler/Ratemeter Calibration Form

Model___________________________ S/N __________________

Calibration Source____

Threshold (input sensitivity), Found at _______________ mV Left or Set at __________ mV

Window, In/Out__________ Window _______________ mV

Pulser Amplitude Set @___________________________mV

Range/Mode	Calibration Point (Pulser Setting) cpm x multiplier	As Found Reading	Left or Set Reading

HV Set @______________ VDC

____
____
____
____
____
____
____

Date ________________________ Calibrated By _____________________________________

Attachment B, SOP #RAD-01
AVM Environmental Services Inc.
Scaler/Ratemeter - Detector Calibration Form

Scaler/Ratemeter ____
Detector ____

Source: ______________________________ Strength: _________________

Scaler/Ratemeter Threshhold set @ _______mV, Window IN/OUT ________, Window _____ mV

HV	Reading, CPM (Source)	Reading, CPM (Background)
500		
550		
600		
650		
700		
750		
800		
850		
900		
950		
1000		
1050		
1100		
1150		
1200		
1250		
1300		
1350		
1400		

Background reading at designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

Count Readings with 1 percent U_3O_8 can directly under shielded probe on designated function check location in office.

Count #	Reading (CPM)
1	
2	
3	
4	
5	
Average	

HV Set @ ________________________ VDC (Instrument) ___________________VDC (DVM Fluke 8020I

Input Sensitivity (THR), mV _________________

Function Check with 1 percent U_3O_8 ore in can. Can Directly under the detector.
Acceptable Function check range is: ____________________ to _________________ CPM

Count Readings for Calibration Pad GPL (87.78 pCi/gm Ra-226)

	Bare (Uncollimated)		Collimated
#1	______ cpm	#1	______ cpm
#2	______ cpm	#2	______ cpm
#3	______ cpm	#3	______ cpm
#4	______ cpm	#4	______ cpm
#5	______ cpm	#5	______ cpm
Average	______ cpm	Average	______ cpm
Eff(avg cpm/87.78 pCi/gm	______ cpm/pCi/gm	Eff	______ cpm/pCi/gm

Date ______________________________ By ____

SOP -2
Gamma Ray Intensity to Ra-226 Soil Concentration Correlation
@ UNC's NECR Mine Site

1.0 Purpose

The purpose of this procedure is to develop a correlation between Ra-226 concentrations in surface soil and the field gamma radiation level measurement. The correlation is developed basically for a site-specific calibration of field instrumentation (2'x2' NaI scintillation detector), for determining Ra-226 concentration in surface soil by performing field gamma radiation level survey. The correlation will be used to determine Ra-226 concentrations in surface soils at the Northeast Church Rock Mine Site (NECR).

2.0 Scope

Ra-226 is primarily an alpha emitting radionuclide with a gamma radiation emission of 186 KeV at about 4% intensity. This low energy and intensity of the Ra-226 gamma radiation emission makes direct determination of Ra-226 in the field a difficult task. However Bi-214, a Ra-226 decay product, emits high energy (609-1764 KeV, see Table 1.) gamma radiation at a total of approximately 80% intensity. The gamma radiation of Bi-214 can be readily and accurately measured in the field utilizing a NaI scintillation detector having high sensitivity.

TABLE 1

NUCLIDE	ENERGY KEV	INTENSITY
Bi-214	609.3	46.3
	1120.3	15.1
	1764.5	15.8

Bi-214 is a decay product of Ra-226 through Rn-222, a gas, some of which emanates from the soil. This phenomenon results in activity disequilibrium between Ra-226 and Bi-214 in the soil. The fraction of emanation from Rn-222 varies with characteristics (geometrix) of particular soils. Previous studies have shown that up to 80% of the Rn-222 decayed from Ra-226 in soil is retained within the soil matrix.

If soil geometry and other parameters such as moisture, radon emanation fraction, vertical contamination profile, gamma ray shine from nearby sources, and land topography are consistent, the ratio of Bi-214 to Ra-226 would be consistent. This means there would be a direct relation (correlation) between Bi-214 gamma radiation levels and Ra-226 concentrations in the soil. The gamma radiation from other naturally occurring isotopes in soil, such as and Th-232 decay products and K^{40}, may contribute to gross gamma radiation intensity. In addition, background gamma radiation from cosmic rays also contributes to gross gamma radiation intensity. However, the gamma radiation level from such naturally occurring isotopes and sources are generally at a constant level. A linear regression would identify such a constant to correct for and minimize interference with the gamma radiation level and Ra-226 soil concentration correlation.

The correlation procedure is designed to calibrate a 2"x 2" NaI scintillation detector by determining a site-specific correlation between gamma radiation intensity and Ra-226 concentration in soil. The gross gamma radiation intensity (count rate) will be measured at 15 locations. Soil samples will be collected from these locations for Ra-226 analysis by an off site laboratory. The locations of the soil samples and gamma radiation level measurement will be selected from background range to about 25 pCi/gm Ra-226 concentration, and the majority of the measurements will be collected from background range to about 10 pCi/gm Ra-226 concentration. A linear regression will be performed between gamma radiation count rate and corresponding Ra-226 concentrations in soil to determine the correlation. The goal is to attain a correlation coefficient (r^2) of 0.8 or better.

3.0 Instrumentation

A 2”x2” NaI Scintillation detector (an Eberline SPA-3 or Ludlum 44-10 detector) and a Scaler/Ratemeter, (Eberline ESP-l/2 or Ludlum Model 2221) will be used for field gamma radiation level measurements and to select sampling locations. The Scaler/rate meter will be calibrated, using SOP -1 to assure that it counts the electronic pulse generated and sent by the detector. An optimum operating high voltage for the detector will be established by performing a high voltage plateau on the detector using SOP-1. The input sensitivity (threshold) of the Scaler/Ratemeter will be set @ 100 mV to avoid interference from low level background radiation. The pulses generated by the detector for gamma radiation (609 KeV) from Bi-214 are significantly higher than 100 mV, as verified by using 1% uranium ore standard.

It is likely that the Ra-226 concentration in soil is significantly elevated in some localized areas (hot spots) within the survey areas. Since NECR is a mine site, it is likely that small piles or ore rock may be scattered within the survey area. Shine from such nearby localized hot spots may interfere with gamma radiation level measurement at area of interest, as the high energy gamma radiation can travel long distance in air, up to 50 feet, before ionizing. If needed, shine interference will be reduced by placing the detector in a 0.5-inch thick collimated lead shield. In addition to obtaining a correlation for a bare (uncollimated) detector, a correlation will also be developed for a lead collimated detector by obtaining gamma radiation level measurements for both collimated and uncollimated detector at each location.

A radiation survey in the arroyo for bed sediment would require different geometry of the survey system detector compared to surface soils in a fairly plain geometry. During the radiation survey for arroyo bed sediments, gamma radiation shine from the arroyo banks would also interfere with the survey. Therefore, a separate correlation with soil samples and gamma radiation levels would be developed for survey in the arroyo.

4.0 Gamma Radiation Measurements and Soil Sample Collection for Correlation

Gamma radiation measurements for the correlation will be performed using static gamma radiation survey in the SOP-3. The gamma radiation survey and surface soil sample locations will be identified by gamma ray count rate to retrieve the desired range of concentrations from background to about 25 pCi/gm for the correlation regression. Using a vendor calibrated exposure rate meter, 15 locations ranging from background to 35 uR/hr exposure rate will be selected. Twelve locations will be selected at low range, background, 12, 15, 18, 20 and 22 uR/hr (about background to 10 pCi/gm), and three locations from 25 to 35 uR/hr exposure rate. The selected sampling location areas will be relatively flat terrains, and large enough so that moving around several steps in each direction should not affect readings significantly. For the selected sample location, three one-minute counts will be obtained at each location. The detector will be approximately 12 to18 inches from the ground surface.

Soil samples for the correlation will be collected using surface soil sampling SOP-15. A five-point composite sample at a depth of 0” to 6” will be collected from each of the gamma radiation level measurement location. One soil sample aliquot point will be from the center point directly under the detector, and the other four aliquots from four points that are 18 inches from the center points in four directions (90 degrees apart). Each soil sample aliquot will be approximately 200 grams, collected by using the hand scoop method if soil texture is loose, or a using a hand augur if soil texture is sufficiently compacted. The sampling locations will be marked with flags. The five 200-gram soil sample aliquots will be combined (total of 1000 gram) in a mixing bowl, homogenized and placed in a sample bag. Each sample bag will be marked and labeled with appropriate sample identification. Soil sampling equipment will be decontaminated between each sampling location using SOP-5. All soils samples will be shipped to Energy Laboratories, Inc. (ELI) for Ra-226 on a dry basis using EPA gamma spectroscopy method 901.1.

5.0 Linear Regression Analysis

To determine the correlation between gamma radiation level counts and corresponding Ra-226 concentration in soil content, i.e. to determine a calibration factor, a liner regression analysis will be performed on the sample Ra-226 concentration in pCi/gm, Y, and the associated gamma radiation count rate, cpm at X, from all the sample locations using a least-square liner regression and plotting the results.

Linear regression data will be summarized by the generalized equation:

$$Y = mX + b$$

where,

Y = soil concentration in pCi/gm,
m = slope, pCi/gm/cpm
X = count rate (the mean) in cpm
b = constant, y intercept

This correlation will provide a site specific calibration factor (m) in pCi/gm/cpm for the 2”x2” NaI detector, with a constant (b) to correct for any interference, specifically at lower range. Error in predicting concentrations and desired safety factors should be used for the correlation. Confidence limit line may be calculated and displayed with correlation using published probability and statistical methods.

SOP-3
AVM Environmental Services, Inc.
Field Gamma Radiation Survey for Ra-226 Concentration in Soil
@ UNC's NECR Mine Site

1.0 SCOPE

1.1 Purpose

This procedure will be used to determine the Ra-226 concentration in surface soil by gamma radiation survey for conducting a removal site evaluation at the Northeast Church Rock Site (NECR).

1.2 Applicability

AVM Environmental Services, Inc will be performing gamma radiation surveys to determine Ra-226 in surface soil for the removal site evaluation at the Northeast Church Rock Site, consistent with the Removal Site Evaluation Work Plan for the NECR.

2.0 EQUIPMENT AND MATERIALS

2.1 Ludlum 2221 or Eberline ESP Scaler/Ratemeter coupled with a Ludlum 44-10 or an Eberline SPA-3 2"x2" NaI crystal scintillation detector for gamma radiation detection. (SPA-3 and Ludlum 44-10 are both similar 2"x2" NaI crystal scintillation detectors).

2.2 A global positioning system (GPS) with differential correction and receiver/data logger.

2.3 Collimating lead shield for the 2"x2" NaI detectors, if needed to reduce gamma-ray shine interference and focus on area of interest. The 0.5-inch thick collimating lead shield, which surrounds the NaI crystal, is contained within a protective marlex housing.

2.4 A vendor calibrated exposure (uR/hr) meter.

2.5 Map of survey areas with marked grid nodes and transects. Ink pen and appropriate Field Survey Forms to record readings and notes.

2.6 Measuring tape

3.0 GAMMA RADIATION SURVEY PROTOCOL

The Ra-226 content determination in soil by gamma radiation surveys will be conducted as either scan survey (walkthrough) or static survey (stationary) measurements.

3.1 Static surveys will be performed at specified grid nodes within survey areas. Also, static survey measurement will be performed at each correlation sampling point. The detector will be held at about 12 to 18 inches from the ground surface. The scaler/rate meter will be set in the count SCALER MODE. A one- minute count (cpm) of gamma radiation level will be obtained at each location for static gamma radiation survey.

3.2 Scan surveys (walkthrough surveys) will be performed by walking with the detector at about

12 to 18 inches from the ground surface with the scaler/ratemeter in count RATE MODE. Scan surveys will be performed within each survey area by walking in serpentine shape along transects to locate any hot spots and at survey area boundaries to delineate lateral extent of Ra-226 contamination as specified in NECR RSE Work Plan. The scan rate will be approximately one to two feet per second based on an acceptable minimum detectable concentration (MDC).

3.3 Scan radiation surveys will also be performed in the unnamed arroyo to determine Ra-226 levels in the bed sediments.

4.0 INSTRUMENT CONFIGURATION & OPERATIONS

Prior to any instrument function check or the operation, the technician will read the Technical Manual for the instrument operations (Ludlum 2221 or ESP-2) and the correlation Method (SOP-2) for the rationale behind the gamma radiation surveys.

The field gamma radiation survey for Ra-226 content in soil will be performed using an Eberline ESP or Ludlum 2221 Ratemeter/Scaler. The Ratemeter/Scaler is connected to a 2”x2” NaI crystal scintillation detector (SPA-3 or Ludlum 44-10) which detects gamma radiation emitted from Bi-214, a decay product of Ra-226 in the soil. The uncollimated detector will be held at approximately 12 to 18 inches from the ground surface. For a survey of high energy gamma radiation of 609 KeV, the uncollimated detector should be sensitive to at least an area of about five to six feet radius area under the detector. The Model 2221 Scaler/Ratemeter with external RS232 connector can be coupled to a GPS receiver and data logger where the gamma radiation count rate in cpm would be logged with its corresponding coordinate in one or two second intervals.

For radiation surveys where significant shine interference is present from nearby areas, the 2”x2” NaI crystal scintillation detector will be installed in a collimating lead shield to reduce gamma shine interference. For the radiation survey in the unnamed arroyo, the detector will be collimated to avoid radiation shine interference from the arroyo banks. The detector shield is contained within a protective marlex housing. During the survey, the detector is held approximately 12 to 18 inches above ground level. The collimated detector will be most sensitive to the 36 to 48 inch diameter area under the detector.

4.1 Instrument Function Check

An operational function check will be performed on the Scaler/Ratemeter (ESP or Ludlum 2221) and the detector (SPA-3 or Ludlum 44-10) each day prior to any field surveys. Verify calibration validity for the Scaler/Ratementer and the detector. Calibration date for the instruments must be within one year. If not, the instrument must be calibrated with a certificate in file. The function check will be performed in field office. The following function check procedures will be used and the pertinent information recorded on the Scaler/Ratemeter – 2”x2” NaI Detector Function Check Form (**Attachment A**).

4.1.1 Scaler/Ratemeter General Setting

If an Eberline ESP Scaler/Ratemeter is used for the instrument configuration, the calibration constant must be set @ 1.0+00; and dead time must be set @ 1.4-05 sec.

If Ludlum 2221 Scaler/Ratemeter is used for instrument configuration, the WIN toggle switch must be in OUT position.

4.1.2 Visual inspection

Perform a visual inspection of the instrument, cables, detector and the shield, checking for signs of any damage. Test for possible electrical shorts in the cable (with the instrument in the audio mode, move the cable and note for any sudden increase in counts on the Scaler/Ratemeter).

4.1.3 Calibration Due

Verify calibration validity for the Scaler/Ratemeter and the detector. Calibration date for the instruments must be within one year.

4.1.4 Battery charge

Assure that the Scaler/Ratemeter battery is functional. For ESP Scaler/Ratemeter it should not be indicating a "Low BAT" signal. For Ludlum 2221, the battery voltage digital readout must be at least 5.3 volts.

4.1.5 High Voltage

The detector high voltage must match that determined during high voltage calibration (HV Plateau) for that detector.

4.1.6 Threshold (input sensitivity)

Check and make sure that the Scaler/Ratemeter threshold is set at 100 mv. If not, set the threshold at 100 mV. Ludlum 2221 Threshold can be set by the instrument digital read out display.

4.1.7 Window

If Ludlum 2221 Scaler/Ratemeter is used for instrument configuration, the WIN toggle switch must be in OUT position.

4.1.8 C.C. Calibration Constant

If an Eberline ESP Scaler/Ratemeter is used for the instrument configuration, the calibration constant must be set @ 1.0+00; and dead time must be set @ 1.4-05 sec.

4.1.9 Background Counts

The background counts will be determined for the same time interval as the field survey count time, generally one minute. The background counts will be performed at the designated location in the field office. A location will be designated in the field office for obtaining the required daily background counts. Keep all beta/gamma radiation sources away from the detector while performing the background check. The background function check counts must be within 20% of the background counts obtained during the detector high voltage calibration.

4.1.10 Source Function Counts

Obtain the gamma radiation source, (1% U_3O_8 ore standard sealed in a red can marked Function Check Source”). The 1% ore standard was used to determine the acceptable count range for the detector during calibration. Place the source at the same location on the detector used to obtain the source function check counts during calibration. Count the source for one minute and note the counts in cpm. The source function check counts must be within 20% of the source counts obtained during the detector and Scaler/Ratemeter calibration.

4.1.11 Instrument Tolerance

The Scaler/Ratemeter – detector detecting and counting tolerance is expressed as percent deviation from the mean of the acceptable count range. The background counts and the source function check counts must be within 20% of the mean established following instrument calibration. If the source count is outside this range, pull the instrument from service. The instrument will be repaired or re-calibrated prior to use.

4.1.12 Technician

After completing the function check, initial in the column marked TECH of the function check form.

4.2 Instrument Minimum Detectable Concentration Calculations

If required, calculate MDC for the instrumentation as described in SOP-1 (Instrument MDC Calculation). Calculate MDC for appropriate survey, i.e. Direct Measurement MDC for static (stationary) gamma radiation survey and scan MDC for scan or walkthrough gamma radiation survey. Record the MDC in the Function Check Form (Attachment A).

5.0 FIELD GAMMA RADIATION SURVEY PROCEDURE.

5.1 Static (stationary) Gamma Radiation Survey

Static surveys will be performed at specified grid nodes within survey areas or other locations, such as correlation sampling points as needed in the field. The technician will perform the static (stationary) gamma radiation survey as follows:

1. Perform the function check as indicated in Section 4.2 of this procedure.

2. Insure that the Scaler/Ratemeter (Ludlum 2221) is set in scaler (integration) mode and the integration time is set for one minute. Turn the Scaler/Ratemeter audio speaker to the ON position.

3. Locate the survey point (grid node or a correlation sampling point) in the field using appropriate map with sampling point.

4. Hold the detector at approximately 12 to 18 inches from the ground surface above the desired survey point. Obtain a one minute integrated count.

5. Record the counts in cpm and appropriate corresponding survey point information (location ID

and/or coordinates etc) on the Static Gamma Radiation Survey Field Form (Attachment C).

6. The Ra-226 content in the soil will be calculated form the gamma radiation survey counts (cpm) using the calibration equation established from the correlation for that detector.

7. Repeat step 3 to 5 for additional surveys.

5.2 Scan (walkthrough) Gamma Radiation Survey

Scan radiation surveys (walkthrough surveys) will be performed by walking at a rate of about one to two feet per second with the detector at about 12 to 18 inches from the ground surface with the scaler/ratemeter in count RATE MODE. The scan rate will be based on an acceptable MDC. Scan surveys will be performed at coverage rate of up to 20% within survey areas to identify any hot spots by walking in serpentine shape along transects. The scan percentage of an area will be determined based on the static survey of the grid nodes in that survey area as follow:

- If over 80% of the static survey within a survey area exceed the screening level (equal to DCGL plus background), there would be no scan survey in that area.
- If 60 to 80% of static survey exceeds the screening level, 5% of that area would be scanned.
- If 40 to 60% of static survey exceeds the screening level, 10% of that area would be scanned.
- If 20 to 40% of static survey exceeds the screening level, 15% of that area would be scanned.
- If less than 20 % of static survey exceeds the screening level, 20% of that area would be scanned.

Note: If the scan radiation surveys report areas that exceed the screening level and have not been delineated by the static and scan radiation surveys, then the percentage of area scanned will be reevaluated in the field.

The Scan radiation surveys will also be performed at survey area boundaries to delineate lateral extent of Ra-226 contamination. This scan survey will be performed by walking along the 80 foot spacing transects perpendicular to the initial perimeter of each survey area. These transects would run between the most outer 80 foot static grid node inside the initial boundary to the next 80 foot grid node outside the survey area boundary.

In addition, the scan survey will also be performed in the unnamed arroyo for surveying the bed sediments by walking in serpentine shape along the bed with collimated detector at about 12 to 18 inches above the sediment bed.

The technician will perform the scan radiation survey as follows:

For the scan survey within the survey areas and in the unnamed arroyo, the Ludlum 2221 with external RS232 output connector will be coupled to a GPS system (Trimble XRS Pro mapping grade GPS) with receiver/data logger to collect and store the survey data. The GPS receiver will store in the electronic data file the gamma radiation count rate to its corresponding location coordinates. This configuration can provide a gamma radiation intensity level in counts per minute (cpm) at approximately every one to two feet along the scan path based on a scan rate of one to two feet per second. The GPS receiver/antenna will be carried in a backpack. At the end of each survey day, the field data will be downloaded to a laptop computer for processing.

1. Perform the function check as indicated in Section 4.2 of this procedure.

2. Insure that the Scaler/Ratemeter (ESP or Ludlum 2221) is set in RATE mode. Turn the Ludlum 2221 audio speaker to the ON position. Set the RESP (response) toggle switch to F (fast) position. Connect the calibrated 2”x2” NaI detector.

   The Ludlum 2221 Scaler/Ratemeter is equipped with an external RS232 connector. Setup the GPS system with data receiver/logger as described in the Attachment D, GPS Setup, Operation and Data Management.

3. Field locate appropriate transects within the survey areas. Verify with the supervisor the approved scan rate.

4. Create appropriate file number and information for data logger and also record in the Scan/Walkthrough Gamma Radiation Survey Field Form (Attachment E).

5. Start Walking in a serpentine pattern along the transect in that survey area with the detector at approximately 12 to 18 inches from the ground surface. The GPS receiver will collect and store gamma radiation count rate (cpm) at every second with its corresponding coordinate while scanning through the walkthrough.

6. At the end of the day, download the survey data files into a laptop computer. The survey data will be processed as needed for presenting as the gamma radiation levels in counts per minute or converted into Ra-226 soil concentrations using equation developed through correlation, and plotting, if necessary through Arc View GIS computer application.

If the scan radiation survey is used for the investigation, such as delineation of survey area boundary, the scan survey will be performed without GPS configuration. The technician will perform the scan radiation survey control as follows:

1. Perform the function check as indicated in Section 5.2 of this procedure.

2. Insure that the Scaler/Ratemeter (ESP or Ludlum 2221) is set in RATE mode. Turn the Scaler/Ratemeter audio speaker to the ON position. For Ludlum 2221 Scaler/Ratemeter, set the RESP (response) toggle switch to F (fast) position.

3. Walk along a transect or within an area with the audio speaker ON and detector approximately 12 to 18 inches from the ground surface to investigate and determine any locations that exceed the site specific gamma radiation count rate screening level provided by your supervisor.

4. Investigate any high anomaly, as determined by audio response during the walkthrough survey, and by performing additional scan survey to identify the elevated area. Use the stationary surveys to determine the gamma radiation levels of the elevated area. Mark the area with pin flags, obtain the location coordinate with GPS system, and record the counts and record the information in the Scan/Walkthrough Gamma Radiation Survey Field Form (Attachment E).

6.0 ATTACHMENTS

Attachment	A	Scaler/Ratemeter – 2”x2” NaI Detector Function Check Form
Attachment	B	Removed (Instrument MDC Calculation) – See SOP-1
Attachment	C	Static Gamma Radiation Survey Field Form
Attachment	D	SOP #AVM-NECR-03A, GPS Setup, Operation and Data Management
Attachment	E	Scan/Walkthrough Gamma Radiation Survey Field Form

Attachment A, SOP #RAD-03
Scaler/Ratemeter - 2" x 2" NaI Detector Function Check
UNC's NECR Mine Site

Scaler/Ratemeter ID:___________________________________

Function Check Source ID: 1% U_3O_8 Ore in Sealed can

2" x 2" Detector ID:_____________________________________

Acceptable background Count (cpm) Range (20%) ______________________ to ____________________

Acceptable Source Count (cpm) Range (20%) ______________________ to _______________________

Date	Physical Check	Cal Due	Battery[1] Volts or OK	HV Volts	Threshhold mV [2]	Window In or OUT[3]	C.C.[4]	BKG Counts cpm	Source Counrts cpm	Within Acceptable Range Y or N	MDC pCi/gm

Note: (1) Battery Voltage for Ludlum 2221 must be >5.3 volts; (2) Threshhold must be at 100 mV; (3) Window Position must be OUT; (4) C.C. for Eberline ESP scaler must be 1.0±00

Attachment C, SOP #RAD-03
Gamma Radiation Survey @ UNC's NECR Mine Site

Static Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter___________________________, Detector ______________________________________

Instrument Calibration Date: ______________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Point ID/Description	Survey Point Coordinate		Gamma Radiation Reading, CPM	Comments/Notes
		Northing	Easting		

Technician Signature __________________________________, Reviewed by _____________________________________

Attachment D to SOP-03

GPS Setup, Operation, and Data Management

1. Purpose

The purpose of the procedure is to instruct the user on how to properly setup a Trimble Pro XRS GPS unit to perform real time GPS gamma surveys using a Trimble TSCe datalogger and Ludlum 2221 ratemeter/scaler with RS-232 data output.

2. Discussion

This SOP discusses the integration of a Trimble Pro XRS GPS unit, a Trimble TSCe datalogger, and a Ludlum 2221 ratemeter/scaler with RS-232 data output for use in conducting GPS radiological surveys. A data record is "logged" every time the 2221 outputs a data value to the TSCe through its RS-232 output. The GPS calculates its location every one second. The coordinate associated with each data value is interpolated between the locations calculated in the second before and after each data value is received. The TSCe records each data value as a "Not-In-Feature" record and associates the interpolated coordinate with the record.

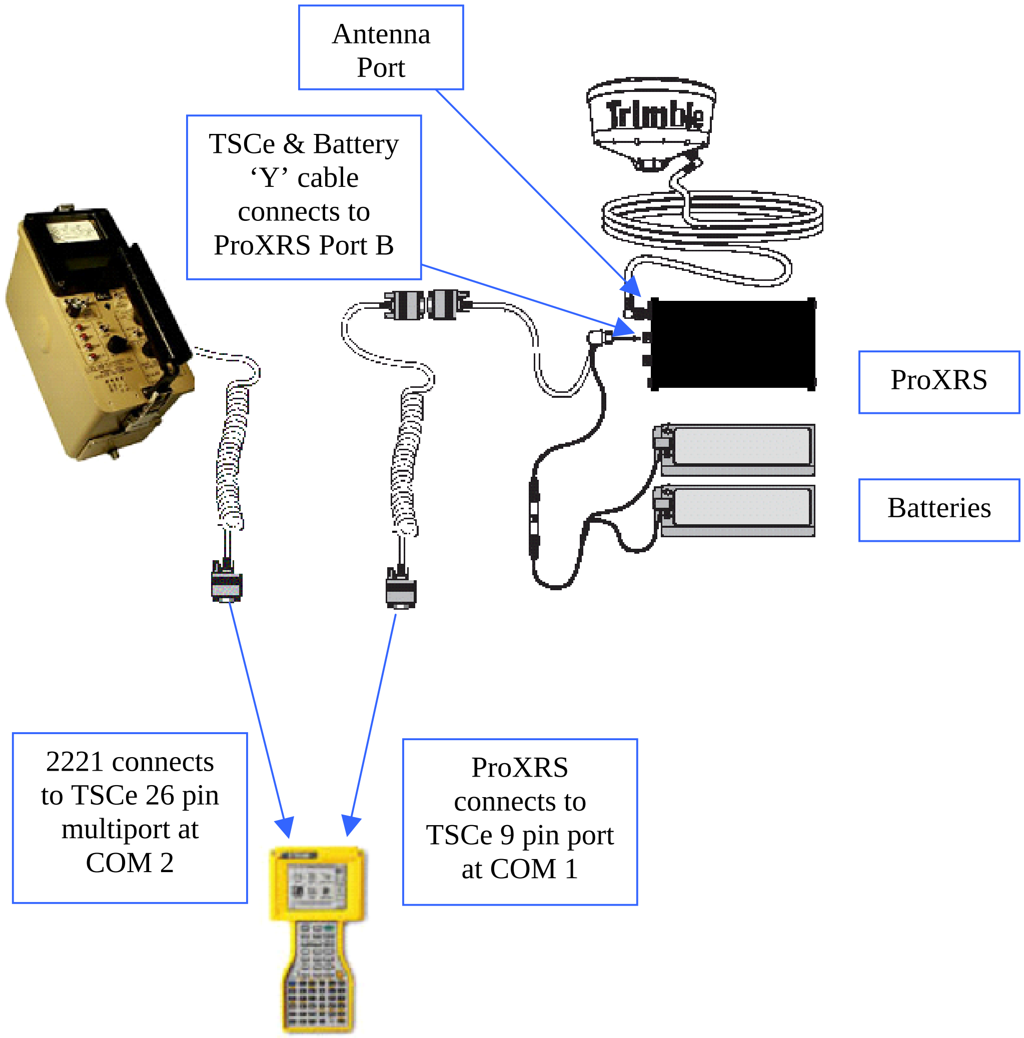
3. Setup Procedure

4.1 Equipment

4.1.1 Trimble Pro XRS GPS receiver
4.1.2 Trimble TSCe datalogger with stylus
4.1.3 Charged batteries
4.1.4 Ludlum 2221scaler/ratemeter with RS-232 output
4.1.5 Ludlum 44-10 probe (or some other detector)
4.1.6 All necessary cables

4.2 Cabling Setup

NOTE: Refer to Figure below for an example of proper cable configuration associated with the GPS receiver, datalogger, and 2221 integration.



4.2.1 Connect the GPS receiver data/power 'Y' cable to port B of the ProXRS receiver. Nothing connects to port A.

4.2.2 Connect the antenna cable to ANT port of the ProXRS receiver.

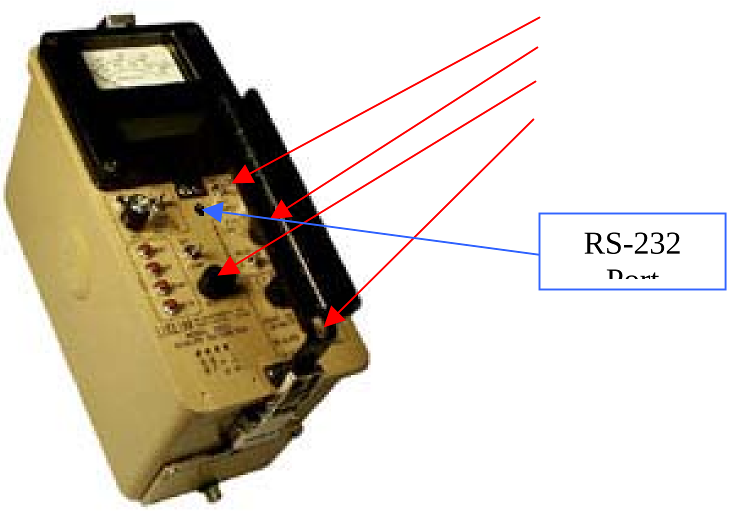
4.2.3 Connect the ProXRS receiver data output half of the data/power 'Y' cable to the TSCe COM1 port.

4.2.4 On the Ludlum 2221 connect the RS-232 data output cable to the TSCe COM2 port. You will have to use the DB9 to DB26 adaptor to connect to the TSCe COM2 port.

4.3 Ludlum 2221 Setup

4.3.1 Secure the RS-232 cable to 2221 handle. NOTE: The RS-232 cable is not very durable at the point where the wire housing and the metallic elbow meet. You need to tape/secure the cable to the handle to prevent premature cable shorting from causing problems with the survey data.

4.3.2 Set the following 2221 switches to the following positions:

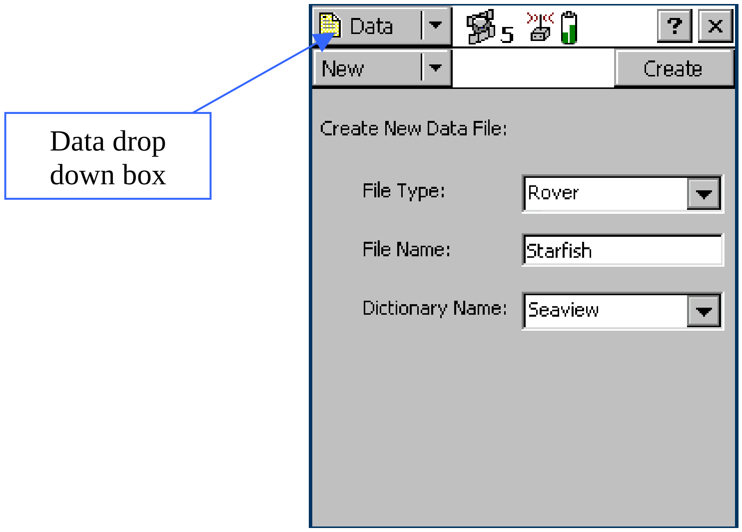


POWER:	ON
RESP:	F
WIN:	OUT
SCALER/DIG.RATE:	DIG. RATE

4 Operations Procedure

4.1 Opening a New File

4.1.1 From the opening window use the stylus and navigate to and tap the Data drop down box. Tap the Create button to create a new file.

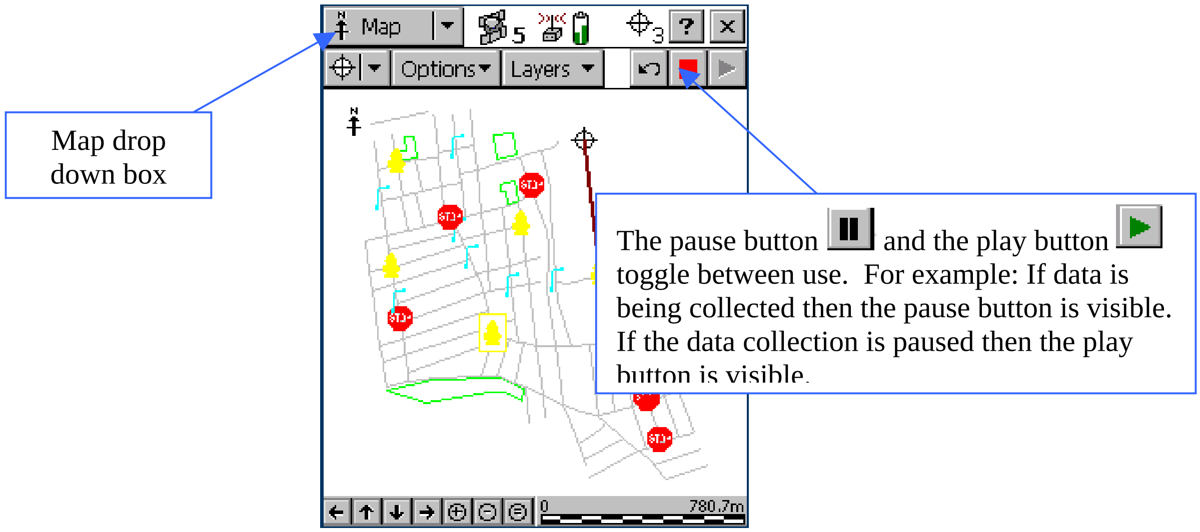


4.1.2 To open an existing file navigate to and tap the Existing File subsection list drop down box. Select the desired file and tap on the Open button in the upper right hand corner of the screen.

NOTE: Data collection will begin when a file is opened if TSCe and 2221 parameters are all set correctly and enough satellites are visible.

4.2 Pausing Data Collection

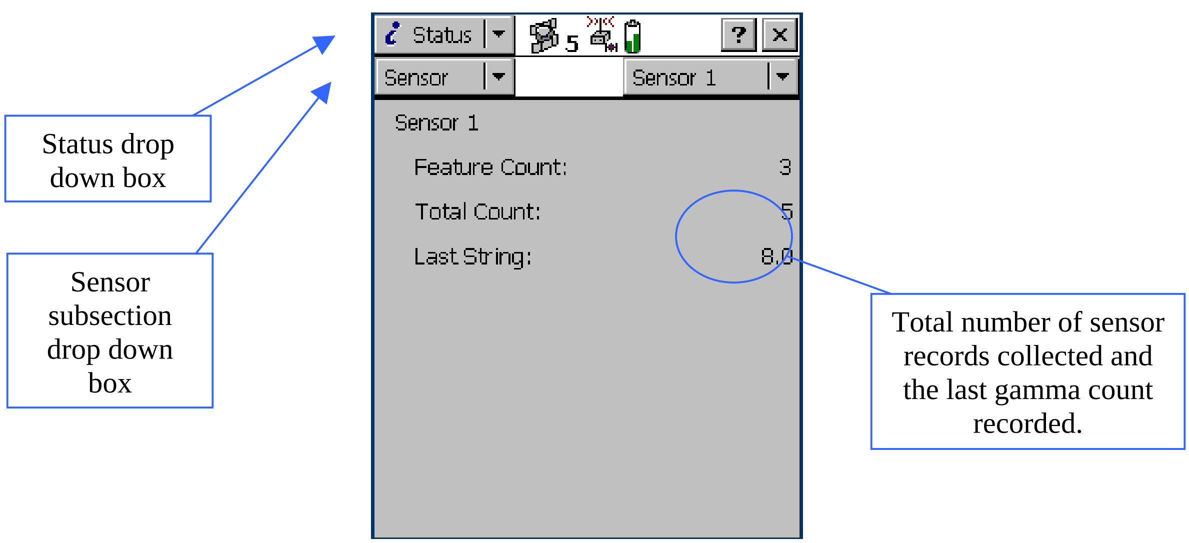
4.2.1 To pause data collection, navigate to the Map drop down box and tap on the pause button. To resume data collection, tap the play button.



4.3 Viewing Data Collection

NOTE: It is advised to view data collection at the beginning of each survey to ensure all setup parameters have been set correctly and system is correctly collecting data.

4.3.1 To view data collection, navigate to the Status drop down box and then the Sensor subsection drop down box. The Total Count line indicates the number of gamma counts collected. The Last String line indicates the last gamma count recorded.



4.4 Stopping Data Collection

4.4.1 There are two ways to stop and close a data file. You can close the TerraSync application completely, or you can close the individual survey file and leave the TerrSync application running.

4.4.2 To close the TerraSync application completely, tap the  in the upper right hand corner.

4.4.3 To close only the survey file, navigate to and tap the Data drop down box and then tap the Close button.

5 Creating a New Project or Opening and Existing Project

5.1 Create the Necessary Directories for a New Project

NOTE: When creating a new project, it is necessary to also create a new project folder with subfolders to keep all of the files properly organized. As projects get larger they become very complicated. It is recommended that the filing structure stick to the default Pathfinder Office setup.

5.2 Create a New Pathfinder Office Project

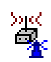
6 Download, Correction, and Exporting of Survey Data

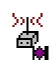
6.1 Download of Survey Data

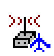
Note: Data is collected in the TSCe datalogger and must be connected to computer and data transferred for data to be corrected, exported and managed. Use he pathfinder Office Data Transfer Utility to transfer data to/from the computer and TSCe.

6.2 Differentially Correct Survey Data

NOTE: Most survey data collected will be collected in “real time”, meaning the data is differentially corrected as it is collected. It is still desirable to differentially correct the data “post process” to achieve highest accuracy for the data. The following figures are examples of images you will see on the TSCe screen indicating “real time” corrections are taking place:

DGPS Beacon Service: 

DGPS Subscription Service (OmniStar): 

WAAS Correction: 

6.3 Export Survey Data into ArcView Shapefile Format

Note: The data is collected in a Trimble file format. This file must be converted, or “exported”, into a ESRI ArcView GIS format known as a shape file. This is performed through the Pathfinder Office Export feature.

Attachment E, SOP #RAD-03
Gamma Radiation Survey @ UNC's NECR Mine Site

Scan/Walkthrough Gamma Radiation Survey Field Form

Instrumentation : Scaler/Ratemeter________________________________, Detector_______________________________________

Instrument Calibration Date: _____________________________, Instrument Daily Function Check Performed: __________

2"x2" NaI Detector Collimated ______ Yes or ______ No.

Survey Area/Unit Decsription ____

Survey Date/Time	Survey Area-Transect ID/Description	Gamma Radiation Reading Range CPM	Comments/Notes

Technician Signature _________________________________, Reviewed by ____________________________________

STANDARD OPERATING PROCEDURE 4

FIELD DOCUMENTATION

STANDARD OPERATING PROCEDURE 4

FIELD DOCUMENTATION

TABLE OF CONTENTS

PAGE

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is a general guidance document for the required documentation to be completed by field personnel during field investigations. Documentation in the form of field logbooks, reports, and forms shall be completed for every activity in the field. Records shall be maintained on a daily basis as the work progresses. All field documentation shall be accurate and legible because it is deliverable to the client as potentially a legal document. Sample field documentation forms are attached.

2.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often, additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects project-specific field documentation with input from other key project staff and UNC personnel.

Quality Control Manager: Performs field program audits. Ensures project data quality objectives are fulfilled.

Field Team Leader (FTL) and/or Field Geologist, Hydrogeologist, or Engineer: Responsible for completing the FTL logbook; documentation concerning supervision of team members; and, the duplication and distribution of applicable records.

Field Technician (or other designated personnel): Assists the FTL and/or field geologist, hydrogeologist, or engineer in the implementation of field tasks and field documentation.

3.0 FIELD DOCUMENTATION PROCEDURES

Field documentation serves as the primary foundation for all field data collected that will be used to evaluate the project site. All field documentation shall be accurate, legible and written in indelible black or blue ink. Absolutely no pencils or erasures shall be used. Incorrect entries in the field books, logs, or on forms that need to be deleted shall be crossed out with one line, initialed, and dated. Skipped pages or blank sections at the end of a page shall be crossed out with an "X" covering the entire page or blank section; "No Further Entries," initials, and date shall be written by the person crossing out the blank section or page. The responsible field team member shall write his/her signature, date, and time after the day's last entry.

To further assist in the organization of the field books, logs, or forms, the date shall be recorded on top of each page along with the significant activity description (e.g., surface sample or soil boring number). All original field documentation shall be retained in the project files. The descriptions of field data documentation given below serve as an outline; individual activities may vary in documentation requirements.

3.1 FIELD LOGBOOKS

The field logbook shall be a bound, weatherproof book with numbered pages, and shall serve primarily as a daily log of the activities carried out during the fieldwork. All entries shall be made in indelible black or blue ink. A field logbook shall be completed for each operation undertaken during the field tasks, such as field team leader notes, drilling, sampling, and site visitors. The logbook shall serve as a diary of the events of the day.

Field activities vary from project to project; however, the concept and general information that shall be recorded are similar. A detailed description of two basic example logbooks, suitable for documentation of field activities, is given below. These field logbooks include the FTL logbook and the field geologist/sampling team logbook.

FTL Logbook: The FTL's responsibilities include the general supervision, support, assistance, and coordination of the various field activities. As a result, a large portion of the FTL's day is spent rotating between operations in a supervisory mode. Records of the FTL's activities, as well as a summary of the field team's activities, shall be maintained in a logbook. The FTL's logbook shall be used to fill out daily/weekly reports. Items to be documented include:

- Record of tailgate meetings
- Personnel and subcontractors on job site and time spent on the site
- Field operations and personnel assigned to these activities
- Site visitors
- Log of FTL's activities: time spent supervising each operation and summary of daily operations as provided by field team members
- Problems encountered and related corrective actions
- Deviations from the sampling plan and reasons for the deviations
- Records of communications; discussions of job-related activities with the client, subcontractor, field team members, and project manager
- Information on addresses and contacts
- Record of invoices signed and other billing information
- Field observations

Field Geologist/Sampling Team Logbook: The field geologist or sampling team leader shall be responsible for recording the following information in a logbook:

- Health and Safety Activities
  - Calibration records for health and safety equipment (e.g., type of PID, calibration gas used, associated readings, noise dosimeters, etc.)
  - Personnel contamination prevention and decontamination procedures
  - Record of daily tailgate safety meetings
- Weather
- Calibration of field equipment
- Equipment decontamination procedures
- Personnel and subcontractors on job site and time spent on the site

- Site name and well or soil boring number
- Drilling activities
  - Sample location (sketch)
  - Drilling method and equipment used
  - Borehole diameter
  - Drill cuttings disposal/containerization (e.g., number of drums, roll-off bins, etc.)
  - Type and amount of drilling fluids used (e.g., mud, water, etc.)
  - Depth and time at which first groundwater was encountered The absence of water in the boring should also be noted.
  - Total drilling depth of well or soil boring
  - Type and amount of material used to abandon soil borings
  - Time and date of drilling, completion, and backfilling
  - Name of drilling company, driller, and helpers
- Sampling
  - Date and time of sample collection
  - Sample interval
  - Number of samples collected
  - Analyses to be performed on collected samples
- Disposal of contaminated wastes (e.g., PPE, paper towels, Visqueen, etc.)
- Field observations
- Problems encountered and corrective action taken
- Deviations from the sampling plan and reason for the deviations
- Site visitors

3.2 FIELD FORMS

Boring Logs: The preparation of boring logs shall be the responsibility of the field team members assigned to the drill rig. A detailed description of soil classification procedures is included in SOP-8. An example of the Soil Boring Log form is included in Appendix B. While a soil boring log will be completed for each soil boring drilled at the site some soil borings will not be continuously logged due to the proximity to other borings. After the geology and interface between native and fill material has been determined based on field observations, a determination will be made on the depth where other near-by soil borings will be logged. The specific format is dictated by project requirements; however, the following information shall be recorded on the soil boring log.

- Project name, project number, and site name
- Name of drilling company
- Soil boring ID and location (sketch)
- Drilling and backfilling dates and times
- Total depth of completed soil boring
- Name of the logger
- Description of unconsolidated materials
  - Lithologic description
  - Descriptive Unified Soil Classifications System (USCS) classification
  - USCS symbol
  - Descriptive observations including gradation, plasticity, moisture content, cementation, grain size, angularity of coarse particles, odor, fractures, visible contamination, specific mineralogy, bedding, PID readings, etc.)
- Color (use appropriate soil color chart [e.g., Munsel Color Chart])
- Description of consolidated materials
  - Geologic rock description
  - Rock type
  - Descriptive observations including relative hardness, density, texture, weathering, bedding, structures (e.g., fractures, joints, bedding, etc.), odor, visible contamination, PID readings and stratigraphic/lithologic changes
- Depth intervals of sample and the amount of sample recovered
- Blow counts
- Depth intervals from which samples are retained
- Analyses to be performed on collected samples

- Depth at which first groundwater was encountered, depth to water at completion of drilling, and the stabilized depth to water. The absence of water in the boring should also be noted
- Use of drilling fluids
- Evidence of contamination

3.3 PHOTOLOGS

Photologs are often used in the field to document site conditions (e.g., trenches and excavations, significant lithologic changes during soil logging and classification). While photographs may not always be required, they shall be used wherever applicable to show existing site conditions at a particular time and stage of the investigation or related site activity. Photolog information shall include:

- Photographer's names
- Date and time of photo
- Direction of the photo
- Prevailing weather conditions at the time the photo was taken
- Description of what the photo is intended to show
- Borehole identification number
- Interval

An engineer's scale or tape shall be included in any photographs taken of soil core. Any wasted frames or images in a roll of film or sequence of digital images shall be so noted in the field logbook.

3.4 LABELS AND CHAIN-OF-CUSTODY RECORDS

Documentation to be made during sampling activities includes sample labels, sample seals, Chain-of-Custody (COC) records, and sample register.

Sample Labels: A sample label shall be affixed to all sample containers. All samples will be labeled in a clear, precise way for proper identification in the field and for tracking in the laboratory. The samples will have identifiable and unique numbers. At a minimum, the sample labels will contain the following information:

- facility name
- sample number
- sample depth
- date of collection
- time of collection
- analytical parameter(s)
- method of sample preservation

The sample information (e.g., date, time, location ID, etc.) shall be written in indelible ink.

Custody Seals: Custody seals will be used to preserve the integrity of each sample container and cooler from the time the sample is collected until it is opened by the laboratory. Custody seals will be placed on each sample container after collection such that it must be broken to open the container. Two or more custody seals will be signed, dated, and placed on the front and back of the sample cooler prior to transport.

Chain-of-Custody Records: Chain-of-Custody (COC) procedures allow for the tracking of possession and handling of individual samples from the time of field collection through to laboratory analysis. Documentation of custody is accomplished through a COC record that lists each sample and the individuals responsible for sample collection, shipment, and receipt. A COC record is used to record the samples taken and the analyses requested. Each form will include the following information:

- sample number
- date of collection
- time of collection
- sample depth
- analytical parameter
- method of sample preservation
- number of sample containers
- shipping arrangements and airbill number, as applicable
- recipient laboratories
- signatures of parties relinquishing and receiving the sample at each transfer point

Whenever a change of custody takes place, both parties will sign and date the chain-of-custody form, with the relinquishing person retaining a copy of the form. The party that accepts custody will inspect the custody form and all accompanying documentation to ensure that the information is complete and accurate. Any discrepancies will be noted on the chain-of-custody form. Shipping receipts shall be signed and filed as evidence of custody transfer between field sampler(s), courier, and laboratory.

5.0 REFERENCES

RCRA Ground-Water Monitoring: Draft Technical Guidance, November 1992.

STANDARD OPERATING PROCEDURE 5

EQUIPMENT DECONTAMINATION

STANDARD OPERATING PROCEDURES 5

EQUIPMENT DECONTAMINATION

TABLE OF CONTENTS

1.0 INTRODUCTION

Decontamination of drilling, sampling equipment, monitoring equipment and support vehicles at the UNC site is a necessary and critical aspect of environmental field investigations. Proper decontamination is a key element in reducing the potential for cross-contamination between samples from different locations, ensuring that samples are representative of the sampled materials, as well as health and safety issues. Improper decontamination may result in costly re-collection and re-analysis of samples. All equipment used in the sampling process shall be properly decontaminated prior to the collection of each sample and after completion of sampling activities.

The procedures outlined in this standard operating procedure (SOP) shall be followed during decontamination of field equipment used in the sampling process, including drilling, soil/water sample collection, and monitoring activities. Any deviations from these procedures shall be noted in the field logbooks and approved by the MWH Project Manager, UNC Project Manager and the Quality Manager. Three major categories of field equipment, along with applicable decontamination methods for each, are discussed below.

2.0 DEFINITIONS

Brass Sleeve: Hollow, cylindrical sleeves made of brass and used as liners in split-spoon samplers for collection of undisturbed samples.

Auger Flight: An individual hollow-stem auger section, usually 5 feet in length.

Drill Pipe: Hollow metal pipe used for drilling, through which soil and groundwater sampling devices can be advanced for sample collection.

Potable Water: A drilling quality water source that can be used for steam cleaning and decontamination water. This source should be sampled at the beginning of each field program to set baseline concentrations.

Distilled Water: Commercially available or laboratory-grade water that has been distilled. Each batch of distilled water should be analyzed to set baseline concentrations. The distilled water will be used as rinse water during the decontamination of tools, sampling equipment and other small items.

Hand Auger: A sampling tool consisting of a metal tube with two sharpened spiral wings at the tip.

Split-Spoon Sampler: A sampling tool consisting of a thick-walled steel tube with a removable head and drive shoe. The steel tube splits open lengthwise when the head and drive shoe are removed.

Scoop: A sampling hand tool consisting of a small shovel- or trowel-shaped blade.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often, additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects project-specific drilling and sampling methods, and associated decontamination procedures with input from other key project staff and other personnel that are responsible for project quality control.

Quality Manager: Performs project audits. Ensures project-specific data quality objectives are fulfilled.

Field Team Leader (FTL) and/or Geologist, Hydrogeologist, or Engineer: Implements the field program and supervises other sampling personnel.

Ensures that proper decontamination procedures are followed. Prepares daily logs of field activities.

Field Sampling Technician (or other designated personnel): Assists the FTL, geologist, hydrogeologist, or engineer in the implementation of tasks and is responsible for the decontamination of sampling equipment.

4.0 DECONTAMINATION PROCEDURES

A decontamination pad designed to collect the rinsate and any associated soil or chemicals will be established in a location at the UNC site. The decontamination pad will be constructed in an area designated by UNC and will be used for the duration of the project. The decontamination pad will be large enough to accommodate the drill rig and support vehicles present at the site. The rinsate collected from the decontamination pad and from other onsite decontamination activities will be stored in labeled containers until the proper disposal protocol is established pending chemical characterization.

Soil boring drilling and soil sampling procedures require that decontaminated tools be employed in order to prevent cross-contamination. The decontamination procedures described below shall be followed to ensure that only uncontaminated materials will be introduced to the subsurface during drilling and sampling. The equipment decontamination process shall be undertaken before and after each use of the equipment and include either steam cleaning or washing. Steam cleaning of equipment shall be performed at a decontamination facility (e.g., dedicated steam-cleaning pad). The flooring of the decontamination pad shall be impermeable to water and have a sump or low area to collect the rinsate to be transferred into the storage containers.

The precise location of the decontamination facility shall be determined based on such factors as ease of access for personnel and proximity to work site and rinsate storage or staging areas.

4.1 DRILLING AND LARGE EQUIPMENT

The following procedures shall be used for decontamination of large pieces of equipment including drilling equipment and support vehicles. This will include percussion hammer drill pipe, hollow-stem auger flights, drill rods for sampling, the drill rig, support vehicles and other equipment and tools that may come in contact with sampling equipment or that may have possible contamination.

- Steam clean the external surfaces and internal surfaces, as applicable, on equipment using high-pressure hot water from an approved water source. If necessary, scrub using a phosphate-free detergent (e.g., Alconox™), or equivalent laboratory-grade detergent until all visible dirt, grime, grease, oil, loose paint, rust, etc., have been removed.
- Rinse with potable water.

4.2 SOIL SAMPLING EQUIPMENT

The following procedure will be used to decontaminate sampling equipment such as split-spoon samplers; brass sleeves; continuous core barrels; scoops; hand augers; metal sampling pans; and other sampling equipment and tools that may come into contact with samples.

- Wash and scrub equipment with phosphate-free, laboratory-grade detergent (e.g., Alconox™ or equivalent); steam cleaning may also be performed if possible.
- Rinse with dilute nitric acid
- Rinse with potable water.
- Rinse twice with deionized or distilled water.
- Air dry.
- Store in clean plastic bag or designated casing.

Personnel involved in decontamination activities shall wear appropriate protective clothing as defined in the project-specific health and safety plan.

5.0 PROCEDURE FOR OTHER WASTE DISPOSAL

Decontamination fluids (typically washwater) will be contained as generated. The washwater will be segregated from solids to the extent practicable (i.e., solids will be allowed to settle out of the washwater on the decontamination containment pad). Washwater will then be containerized to await waste determination. Solids will also be containerized in a separate container to await waste determination.

6.0 REFERENCES

Environmental protection Agency, RCRA Ground-Water Monitoring: Draft Technical Guidance, November 1992. Page 7-17.

STANDARD OPERATING PROCEDURE 8

SOIL CLASSIFICATION

STANDARD OPERATING PROCEDURE 8

SOIL CLASSIFICATION

TABLE OF CONTENTS

PAGE

1.0 INTRODUCTION

This standard operating procedure (SOP) is intended for use as a guide for soil logging procedures at sites requiring subsurface investigation. The SOP employs the Unified Soil Classification System (USCS) and the ASTM Standard D 2488 - 90 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure; ASTM, 1990). A thorough working knowledge of this SOP is critical for field personnel to standardize logging procedures and to enable subsequent correlation between borings at a site, allowing for accurate site characterization.

The information described in this SOP is summarized on the USCS chart in Attachment A. Laminated copies of this chart shall be available for all field personnel. Other field references may also be used according to personal preference. However, such references shall be based on the USCS.

2.0 DEFINITIONS

Use of the USCS requires familiarity with the grain size ranges that define a particular type of soil, as well as several other physical characteristics. The grain size definitions and physical characteristics upon which soil descriptions are based are presented below.

2.1 GRAIN SIZES

USCS grain sizes are based on U.S. standard sieve sizes, which are defined as follows:

- Standard sieves with larger openings are named according to the size of the openings in the sieve mesh. For example, a "No.3" sieve contains 3 openings per square inch.
- Standard sieves with smaller openings are given numbered designations that indicate the number of openings per square inch. For example, a "No. 4" sieve contains 4 openings per square inch.

The following grain size definitions are paraphrased from the ASTM Standard D 2488 - 90. Field personnel shall familiarize themselves with the grain size definitions and refer to the appropriate field guide for a visual reference.

Boulders: Particles of rock that will not pass a 12-in. (300-millimeter [mm]) square opening.

Cobbles: Particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. or 75 mm sieve.

Gravel: Particles of rock that will pass a 3-in (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

Coarse Gravel: Passes a 3-in. (75-mm) sieve and is retained on a 3/4-in. (19-mm) sieve

Fine Gravel: Passes a 3/4-in. (19-mm) sieve and is retained on a No. 4 (0.19 in. or 4.75-mm) sieve

Sand: Particles of rock that will pass a No. 4 (0.19 in. or 4.75-mm) sieve and be retained on a No. 200 (0.0029 in. or 75-micrometer [µm]) sieve with the following subdivisions:

Coarse Sand: Passes a No. 4 (0.19 in. or 4.75-mm) sieve and is retained on a No. 10 (0.079 in. or 2-mm) sieve

Medium Sand: Passes a No. 10 (0.079 in. or 2-mm) sieve and is retained on a No. 40 (0.017 in. or 425-µm) sieve

Fine Sand: Passes a No. 40 (0.017 in. or 425-µm) sieve and is retained on a No. 200 (0.0029 in. or 75-µm) sieve

Silt: Soil passing a No. 200 (0.0029 in. or 75-µm) sieve that is non-plastic or very slightly plastic, and that exhibits little or no strength when air-dried. Individual silt particles are not visible to the naked eye.

Clay: Soil passing a No. 200 (0.0029 in. or 75-µm) sieve that can be made to exhibit plasticity within a range of moisture contents, and that exhibits considerable strength when air-dried. Individual clay particles are not visible to the naked eye.

2.2 PHYSICAL CHARACTERISTICS

The physical characteristics described below are used in the USCS classification for fine-grained soils. Physical characteristics of coarse-grained soils and consolidated rock are presented in Section 4.2. A brief definition of each physical characteristic is presented including a description and criteria. However, with the exception of plasticity, the criteria for the field tests are generally too time-consuming to perform regularly in the field. A determination of the type of fine-grained soil present in the sample can generally be made on the basis of plasticity, as described in Section 4.1.2.

Dry Strength: The Dry Strength is described as the ease with which a dry lump of soil crushes between the fingers.

Description	Criteria
None:	The dry specimen crumbles into powder with mere pressure of handling.
Low:	The dry specimen crumbles into powder with some finger pressure.
Medium:	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High:	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.

Very High:	The dry specimen cannot be broken between the thumb and a hard surface.

Dilatancy Reaction: Dilatancy reaction is described at the speed with which water appears in a moist part of soil when shaken in the hand, and disappears while squeezing.

Description	Criteria
None:	No visible change in the specimen.
Slow:	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid:	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Toughness: Toughness is described as the strength of a soil, moistened near its plastic limit, when rolled into a 1/8-in. diameter thread.

Description	Criteria
Low:	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium:	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness.

High:	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Plasticity: Plasticity is described as the extent to which a soil may be rolled into a 1/8 in. thread, and re-rolled when drier than the plastic limit.

Description	**Criteria**
Nonplastic:	A 1/8-in. (3-mm) thread cannot be rolled at any water content.
Low:	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium:	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High:	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Defines objectives of fieldwork. Prepares drilling and sampling plans with input from the Project Hydrogeologist/Field Team Leader. Oversees and prepares subcontracts.

Field Team Leader (FTL) and/or Project Hydrogeologist, Geologist, or Engineer: Implements field program. Records and reviews boring logs. Supervises drilling subcontractor. Prepares daily logs of field activities.

4.0 SOIL LOGGING PROCEDURES

The following aspects of a project shall be considered before sampling and soil logging commences. This information is generally summarized in a project-specific work plan or field sampling plan, which shall be thoroughly reviewed by all field personnel prior to the initiation of work.

- Purpose of the soil logging (e.g., initial investigation, subsequent investigation, remediation, etc);
- Known or anticipated hydrogeologic setting including stratigraphy (i.e., consolidated/unconsolidated, depositional environment, presence of fill material, etc.), physical characteristics of the aquifer (porosity/permeability), type of aquifer (confined/unconfined), recharge/discharge conditions, aquifer thickness and groundwater/surface water interrelationships;
- Drilling conditions
- Previous soil boring or borehole geophysical logs (these should be carried to the field for reference)
- Soil sampling and geotechnical testing program
- Characteristics of potential chemical release(s) (i.e., chemistry, density, viscosity, reactivity, and concentration, etc.)
- Health and Safety requirements
- Regulatory requirements

The procedures used to determine the correct soil sample classification are described below.

4.1 FIELD CLASSIFICATION OF SOILS

The following soil classification procedures are based on the ASTM Standard D 2488 - 00 for visual-manual identification of soils (ASTM, 2000). When identifying soils, the proper USCS soil group name is given, followed by the group symbol. For clarity, the group symbol shall be placed in parentheses after the written soil group name. Alternatively, a separate column may be designated for the group symbol.

Soil identification using the visual-manual procedures is based on naming the portion of the soil sample that will pass a 3-in. (75-mm) sieve. Therefore, before classifying a soil, any particles larger than 3 inches (cobbles and boulders) shall be removed, if possible. The percentage of cobbles and boulders shall be estimated and recorded.

Using the remaining soil, the next step of the procedure is to estimate the percentages, by dry weight, of the gravel, sand, and fine fractions (particles passing a No. 200 sieve). The percentages shall be estimated to the closest 5 percent. In general, the soil is *fine-grained* (e.g., silt or clay) if it contains 50 percent or more fines, and *coarse-grained* (e.g., sand or gravel) if it contains less than 50 percent fines. If one of the components is present but estimated to be less than 5 percent, its presence is indicated by the term *trace*. For example, 'trace of fines' shall be added as additional information following the formal USCS soil description.

Procedure for Identifying Coarse-Grained Soils: If the sample has been determined to contain less than 50 percent fines, the soil may be classified as either *gravel* (if the percentage of gravel is estimated to be more than the percentage of sand), or *sand* (if the percentage of gravel is estimated to be equal to or less than the percentage of sand).

If the soil is predominantly sand or gravel but contains an estimated 15 percent or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "gravel with sand (GP)." If the sample contains any cobbles or boulders, the words "with cobbles” or "with cobbles and boulders" shall be added to group name. For example: "silty gravel with cobbles (GM)".

5 Percent or Less Fines: The soil is a 'clean gravel' or 'clean sand' if the percentage of fines is estimated to be 5 percent or less. 'Clean' is not a formal USCS name, but rather a general descriptor for implying little to no fines. Clean sands and gravels are given the USCS designation as either *well graded* or *poorly graded*, as described below.

The soil sample is *well-graded gravel* (GW), or *well-graded sand* (SW), if it has a wide distribution of particle sizes and substantial amounts of the intermediate particle sizes. On the other hand, the soil sample is a *poorly-graded gravel* (GP) or *poorly-graded sand* (SP) if it consists predominantly of one grain size (uniformly graded), or has a distribution of sizes with some intermediate sizes obviously missing (gap- or skip-graded).

<u>NOTE:</u> When using the USCS, keep in mind the differences between grading and sorting. The term grading is used to indicate the size class of particles contained in the sample, while sorting refers to the range of the particle sizes on either side of the average particle size. For example, poorly-graded sand containing predominantly one grain size would be considered well-sorted, and vice-versa. One notable exception to this general rule is a skip-graded (bi-modally distributed) sample: sand containing two distinct grain sizes would be considered both poorly-sorted and poorly-graded. The USCS uses only the *GRADING* descriptor in soil naming, not the sorting descriptor.

15 Percent Fines: If the percentage of fines is estimated to be 15 percent or more, the soil may be classified as *silty or clayey gravel* or *silty or clayey sand*. For example, a soil can be identified as *clayey gravel* (GC) or *clayey sand* (SC) if the fines are clayey, or as *silty gravel* (GM) or *silty sand* (SM) if the fines are silty. The coarse-grained descriptor "poorly-graded" or "well-graded" is not included in the soil name, but rather, shall be included as additional information following the formal USCS soil description.

>5 Percent but <15 Percent Fines: If the soil is estimated to contain greater than 5 percent and less than 15 percent fines, the soil sample shall be designated with a dual identification using two group symbols. The first group symbol shall correspond to the clean gravel or sand portion of the sample (i.e., GW, GP, SW, SP) and the second symbol shall correspond to the clayey/silty gravel or sand portion (i.e., GC, GM, SC, SM). The group name shall correspond to the first group symbol, and include the words "poorly-graded" or "well-graded", plus the words "with clay" or "with silt" to indicate the character of the fines. For example, "poorly-graded gravel with silt" would have the symbol GM, and "poorly graded gravels or gravel-sand mixtures" would have the symbol GP.

Procedure for Identifying Fine-Grained Soils: The USCS classifies inorganic, fine-grained soils according to their degree of plasticity and other physical characteristics defined in Section 2.2 and Tables 9-1 through 9-4 (i.e., soil sample with no or low plasticity is indicated with an "L"; and soil sample with high plasticity is indicated with an "H"). As indicated in Section 2.2, the field tests used to determine dry strength, dilatancy, and toughness are generally too time-consuming to be performed on a routine basis. However, the field test for plasticity can be easily performed. While field personnel shall be familiar with the definitions of the physical characteristics and concepts of the field tests, field classifications shall generally be based primarily on plasticity. NOTE: if precise engineering properties are necessary for the project (e.g., construction or modeling) geotechnical samples shall be collected for laboratory testing. The results of the laboratory tests shall be compared to the field logging results. Characteristic physical properties of fine-grained soils are listed below.

Silt (ML): the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic.

Lean clay (CL): inorganic clay soil with medium to high dry strength, no or slow dilatancy, medium toughness, and slightly plastic.

Organic soil (OL or OH): the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, from black to brown, when exposed to the air. Organic soils normally will not have a high toughness or plasticity.

Elastic silt (MH): the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity; will air dry more quickly than lean clay and have a smooth, silky feel when dry.

Fat clay (CH): soil has high to very high dry strength, no dilatancy, and high toughness and plasticity.

Other Modifiers for use with Fine-Grained Soils:

15 Percent to 25 Percent Coarse-Grained Material: If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words "with sand" or "with gravel" (whichever is predominant) shall be added to the group name. For example: "lean clay with sand (CL)" or "silt with gravel (ML)". If the percentage of sand is equal to the percentage of gravel, use "with sand".

30 Percent Coarse-Grained Material: If the soil is estimated to have 30 percent or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be the same or more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy silt (ML)", or "gravelly fat clay (CH)".

Procedure for Identifying Borderline Soils: To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example, a soil containing an estimated 50 percent silt and 50 percent fine-grained sand may be assigned a borderline symbol "SM/ML". Borderline symbols shall not be used indiscriminately. Every effort shall be made to first place the soil into a single group and then to estimate percentages following the USCS soil description.

4.2 DESCRIPTIVE INFORMATION FOR SOILS

After the soil name and symbol are assigned, the soil color, consistency/density, and moisture content shall be described in that order. Other information is presented later in the description, as applicable.

Color: Color is an important property in identifying both inorganic and organic soils, and may also be useful in identifying materials of similar geologic or depositional origin in a given location. Munsell Soil Color Charts or Rock Charts shall be used.

When using Munsell Soil Color Charts, use the appropriate color charts to assign the applicable color name and Munsell symbol to a wet soil sample (colors change as moisture content changes, and all color descriptions shall be made on wet soil for consistency). The ability to detect minor color differences varies among people, and the chance of finding a perfect color match in the charts is rare. Keeping this in mind shall help field personnel avoid spending unnecessary time and effort going through the chart pages. In addition, attempts to describe soils in detail beyond the reasonable accuracy of field observations may result in less accurate soil descriptions than would be achieved by simple expression of the dominant colors (Munsell Soil Color Chart, 1992). All soil color information shall be recorded in the field logbook or field forms.

It should be noted that soil color may also be impacted by contamination. To the extent possible, information pertaining to color impacted by such factors shall also be recorded on the boring logs.

Consistency/Density: Consistency is used to describe fine grained soils (silt and clay) and density is used to describe coarse grained (sand and gravel). Consistency and density can be described based on the blows per foot using a 140-pound hammer dropped

30" or by completing field tests. This and other pertinent information shall be clearly indicated in the field log book on the soil boring-log.

Criteria for Describing Consistency by field test

Consistency (Silt and Clay)	**Blows/ft***	**Thumb Penetration**
Term	2.0" ID	
Very soft:	0-2	Easily penetrated several inches by thumb.
Soft:	2-4	Easily penetrated 1in. (25 mm) by thumb. Molded with light finger pressure.
Medium stiff:	4-9	Can be penetrated ¼ in. (6 mm) by thumb with moderate effort. Molded with strong finger pressure.
Stiff:	9-17	Indented about penetrated ¼ in. (6 mm) by thumb but penetrated only with great effort.
Very stiff:	17-39	Readily indented by thumbnail.
Hard:	39-78	Indented with difficulty by thumbnail.
Very hard:	>78	Unable to indent with thumbnail.

Density (Sand and Gravel) Blows/ft*	**Blows/ft***	**Thumb Penetration**

Term	2.0" ID	
Very loose:	0-5	Easily penetrated with thumbnail
Loose:	5-12	Easily penetrated with finger pressure
Medium dense:	12-37	Penetrated by strong finger pressure.
Dense:	37-60	Penetrated only slightly by strong finger pressure.
Very dense:	>60	Penetrated only slightly by very strong finger pressure.

Moisture: Moisture condition of the soil shall be described as dry (absence of moisture, dusty, dry to the touch), moist (damp but no visible water), or wet (visible free water, saturated).

Angularity: Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, sub-angular, sub-rounded, or rounded in accordance with the following criteria:

Angular:	Particles have sharp edges and relatively planar sides with unpolished surfaces
Sub-angular:	Particles are similar to angular description but have rounded edges
Sub-rounded:	Particles have nearly planar sides but have well-rounded corners and edges
Rounded:	Particles have smoothly curved sides and no edges.

A range of angularity may be stated, such as "sub-rounded to rounded."

Grain Size: The maximum particle size found in the sample shall be described in accordance with the following information:

Sand Size:	If the maximum particle size is a sand size, describe as fine, medium, or coarse. (See Section 2 for sand size definitions.)
Gravel Size:	If the maximum particle size is a gravel size, describe the diameter of the maximum particle size in inches.
Cobble or Boulder Size:	If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle.

For gravel and sand components, describe the range of particle sizes within each component; for example, "about 20 percent fine to coarse gravel, about 40 percent fine to coarse sand".

Odor: Due to health and safety concerns, NEVER intentionally smell the soil. This could result in exposure to volatile contaminants that may be present in the soil. If, however, an odor is noticed, it shall be described accordingly. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation (sometimes a hydrogen sulfide or "rotten egg" smell). If the odor is determined to be due to the likely presence of petroleum-based products or other chemicals, it shall be described as such. Organic vapor readings from organic vapor monitoring equipment shall be noted on the field boring-log. The project-specific health and safety plan shall then be consulted for specific information and guidelines on the appropriate level of protection necessary for the continuation of field activities at the site.

Cementation: Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the following criteria:

Weak: Crumbles or breaks with handling or little finger pressure

Moderate: Crumbles or breaks with considerable finger pressure

Strong: Will not crumble or break with finger pressure.

The presence of calcium or magnesium carbonates may be confirmed on the basis of effervescence with dilute hydrochloric acid (HCl). Proper health and safety precautions shall be followed when mixing, handling, storing, or transporting HCl.

Structure: Structure of intact soils shall be described in accordance with the criteria in Table 9-7.

Lithology/Mineralogy: Describe the lithology (rock or mineral type) of the sand, gravel, cobbles, and boulders, if possible. It may be difficult to determine the lithology of fine and medium-grained sand or particles that have undergone alteration.

Additional Comments: Additional comments may include the presence of roots or other vegetation, fossils or organic debris, staining, mottling, iron and magnesium oxidation, difficult drilling, and caving or sloughing of the borehole walls. Also, when drilling in an area known or suspected to contain imported fill material, every effort shall be made to identify the contact between fill and native soils. If a soil is suspected to be fill, this shall be clearly indicated on the boring log following the soil description. Stratigraphic units and their contacts shall be noted wherever possible.

Bedrock Descriptions: If the soil boring penetrates bedrock, the boring log form shall indicate the rock type, color, weathering, fracturing, competency, mineralogy (including secondary mineral assemblages), structure, age (if known), and any other information available. If bedrock drilling is planned, the FTL, with the concurrence of the Project Manager, shall make arrangements to provide the field team with appropriate definitions and other pertinent information that shall be collected.

5.0 REFERENCES

ASTM, 2000, Standard D 2488 - 00 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Macbeth, 1992, Munsell Soil Color Charts.

STANDARD OPERATING PROCEDURE 11

TRENCHING AND TEST PITS

STANDARD OPERATING PROCEDURE 11

TRENCHING AND TEST PITS

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) describes methods and equipment commonly used for conducting trench and test pit excavations at hazardous waste sites. Shallow test pits and trench excavations are used to: 1) permit both lateral and vertical examination of subsurface conditions, 2) provide access for collecting shallow soil and groundwater samples, and 3) provide a means of determining the orientation of discontinuities in the subsurface.

2.0 DEFINITIONS

Angle of Repose: This is the steepest slope at which very loosely packed sand is stable. It represents the angle of internal friction of the granular material at its loosest state.

Trench or Test Pit: Linear excavation of varying width and depth, usually used for lateral and vertical examination of subsurface conditions, collection of soil and groundwater samples, and to provide a means of determining the orientation of discontinuities in the subsurface.

Ground Crew: Team consisting of excavating support crew and sampling crew.

Type A Soil: Cohesive soils with an unconfined compressive strength of 1.5 tons per square foot (tsf) or greater. Examples of this type of soil are clay, silty clay, sandy clay, and clay loam.

Type B Soil: Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (43 kPa), but less than 1.5 tsf (144 kPa); or

- Granular, cohesionless soils including angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam;
- Previously disturbed soils, except those which would otherwise be classified as Type C soil (see below);
- Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration;

- Dry rock that is not stable;
- Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less than 4:1, but only if the material would otherwise be classified as Type B.

Type C Soil: Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or

- Granular soils including gravel, sand, and loamy sand;
- Submerged soil or soil from which water is freely seeping;
- Submerged rock that is not stable;
- Material in a sloped, layered system where the layers dip into the excavation on a slope of 4:1 or steeper.

Unconfined Compressive Strength: The load per unit area at which a soil will fail in compression. It can be estimated in the field using a pocket penetrometer, or by testing in a materials testing laboratory.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often, additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects site-specific trenching/test pit program and sampling methods with input from other key project staff and UNC personnel. Oversees preparation of heavy equipment subcontract.

Field Team Leader (FTL) and/or Field Geologist, Hydrogeologist, or Engineer: Implements trenching/test pit program and supervises other sampling personnel. Prepares daily logs of field activities.

Field Technician (or other designated personnel): Assists the FTL and/or field geologist, hydrogeologist, or engineer in the implementation of field tasks.

4.0 TRENCH AND TEST PIT CONSTRUCTION

4.1 GENERAL

Trench and test pit excavations are typically carried out by motorized equipment such as rubber tires backhoes and track mounted excavators. Operators of excavating equipment shall be skilled and experienced in safe use of the equipment. A typical backhoe with an extending arm can excavate to a depth of approximately 15 feet. If investigations are required to penetrate beyond 15 feet, test pits may not be the most appropriate method of investigation and the use of other methods (e.g., soil borings) should be considered.

Safety Requirements and Procedures: Safety is perhaps the most critical consideration in any excavation project. This SOP does not address compliance with the regulations of the Occupational Safety and Health Administration (OSHA). Those issues shall be addressed in project-specific health and safety plans. Prior to all excavations, the FTL must confirm that any underground utilities (electric, gas, telephone, water, etc.) in the general vicinity have been clearly identified.

During excavation activities, standard hand signals shall be used for rapid and efficient communication between the backhoe operator and the ground crew. Before approaching the test pit or excavating machine, the ground crew must ascertain that the equipment operator has noted their presence and has stopped operation of the equipment.

Upon locating the area for excavation, the FTL shall determine wind direction and position the excavator upwind of the pending excavation. The backhoe operator shall outline the area of investigation by extending the bucket arm to its maximum length, and tracing a 180-degree outline around the area to be excavated to create the exclusion zone. The support crew shall cordon off the exclusion zone with barricades and brightly colored "caution" tape.

Once the equipment has been appropriately positioned, excavation can commence. If the area of investigation is beneath vegetative cover or surface debris, the backhoe operator shall scrape the initial 6 inches of topsoil to allow a clear and safe working area. In areas with no ground cover, any excavated fill material shall be stockpiled away from the immediate edge and away from the native soil to be excavated and sampled. The excavated native soil will be placed on clean plastic or native soil in 2-foot lifts. Both fill material and native soil shall be placed away from the trench to prevent excavated soil from re-entering the trench or pit, and to reduce pressure on the sidewalls. Sidewalls of the excavation may be sloped in loose soils to stabilize the sidewalls and prevent caving.

Excavated soil shall be stockpiled downwind of the ground crew and the equipment operator. Shifting winds may cause the equipment operator and ground crew to periodically move in order to remain upwind, or to curtail further activities. The support crew shall regularly monitor the equipment operator and ground crew’s airspace.

Material brought to the surface and handled shall be disposed of in accordance with procedures outlined in the Work Plan.

Entry of personnel into pits or trenches is strictly prohibited unless specifically approved by the site-specific health and safety plan, and special precautions and accommodations are provided. Strict adherence to state and federal Occupational Safety and Health Administration (OSHA) trenching guidelines (29CFR 1926.650) shall be observed. Under this standard, when personnel are required to enter an excavation 5 feet deep or more, adequate means of exit such as ladders, steps, ramps, and other full lateral support of the sidewalls must be provided and be within 25 feet of lateral travel. In addition, personnel entering the trench may be exposed to toxic, explosive, or oxygen-deficient atmospheres. Air monitoring can be performed before and during entry, and appropriate respiratory gear and protective clothing can be worn, if necessary. Caution must be exercised at all times and at least two people must be present at the immediate site (OSHA, 1990).

Care shall be taken to ensure that personnel do not stand too close to the edge of the trench, especially during sampling or depth measurements. The added weight of a person adjacent to the pit can increase the risk of sidewall failure.

Stability: Depending on the desired depth of excavation, the trench may require shoring (lateral support) to prevent the sides from collapsing. Lateral support may be provided by a portable aluminum frame system that uses a hydraulic pump to apply pressure to the sidewalls and that can be quickly inserted or extracted, or the sides benched to an appropriate angle. Only skilled personnel shall install timber supports or any other alternative support required in excavations.

Although personnel shall normally not be required to enter the excavation, it is important to know the possible behavior of the various soil types and conditions that may be encountered. Excavations in fill are generally much more unstable than those in native soil. The table below indicates maximum allowable slopes for different soil types (Federal register, Rules and Regulations, Vol. 84, October 1989).

MAXIMUM ALLOWABLE SLOPES

Soil or Rock Type	Maximum Allowable Slope (H:V) for Excavations Less Than 20 Feet
Stable Rock	Vertical (90 degrees)
Type A	3/4:1 (53 degrees)
Type B	1:1 (45 degrees)
Type C	11/2:1 (34 degrees)

The numbers shown above in parentheses, next to the maximum allowable slopes (MAS), are angles measured from the horizontal. In addition, a short-term MAS of ½:1 (63 degrees) is allowed in excavations in Type A soil that are 12 feet or less in depth. Short-term MAS for excavations in Type A soil greater than 12 feet in depth are ¾:1 (53 degrees). Sloping or benching for excavations greater than 20 feet in depth shall be designed by a registered professional engineer.

Excavations in very soft, normally consolidated clay should stand vertically, without support, to depths of approximately 12 feet in the short term only. This critical depth increases as the clays increase in consistency. Long-term stability is dependent on a combination of factors including the soil type, pore water pressures, and other forces acting within the soil. Fissured clays can fail along well-defined shear planes and, therefore, their long-term stability is not dependent on their shear strength and is difficult to predict.

Dry sands and gravels can stand at slopes equal to their natural angle of repose regardless of the depth of the excavation (angles can range from approximately 28 to 46 degrees depending on the angularity of grains and relative density).

Damp sands and gravel possess some cohesion and can stand vertically for a short period of time. However, the stability of water-bearing sands is very difficult to predict in open excavations. If they are cut steeply, as in trench excavation, seepage of water from the face will result in erosion at the toe followed by collapse of the upper part of the face until a stable angle of approximately 15 to 20 degrees is obtained.

Dry silts should stand unsupported vertically, especially if slightly cemented. Saturated silt is the most difficult material to excavate. Seepage of water into excavations in silt leads to slumping and undermining with subsequent collapse, eventually reaching a very shallow angle of repose.

It should not be assumed that excavations in rock will stand with vertical slopes unsupported. Their stability depends on the soundness, angle of bedding planes or joints, and the degree of fracturing. Unstable conditions can occur if bedding planes or joints slope steeply towards the excavation, especially in the presence of groundwater.

4.2 FIELD RECORDING AND SAMPLING TECHNIQUES

The field record shall include a field form giving the location, dimensions, and orientation of the pit or excavation, together with dimensioned sections of the sidewalls, description of the strata encountered, and details of any sampling or testing performed. Working from the ground surface, the technician or other designated personnel shall prepare a visual log of the strata/soil profile and decide the sampling interval. If possible, a photographic record of the excavation, with an appropriate scale, shall be obtained.

Soil samples from excavations can be either disturbed or undisturbed. Soil sample collection methods and procedures are described in SOP-14. Details of sample collection shall be provided in site-specific sampling plans.

4.3 BACKFILLING

Test pits or trenches shall be backfilled immediately upon completion of the excavation and soil sampling, or at a time determined by the Project Manager. Excavated material, including fill material will be placed back into the excavation in the order it was removed. During backfilling, the excavated material will be compacted in one or two foot lifts with the backhoe or excavator bucket. The backfilled material will be compacted to prevent settling of soil.

SECTION 5.0 REFERENCES

Excavations; U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), 1990 (Revised).

Federal Register, Rules and Regulations, Vol. 84, No. 209, October 1989.

STANDARD OPERATING PROCEDURE 12

SAMPLE HANDLING AND SHIPPING

STANDARD OPERATING PROCEDURE 12

SAMPLE HANDLING AND SHIPPING

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) describes the requirements for sample identification, chain-of-custody (COC) documentation, and sample handling, storage and shipping. The purpose of this SOP is to define sample management activities as performed from the time of sample collection to the time they are received by the laboratory.

2.0 DEFINITIONS

Chain-of-Custody: An accurate written record of the possession of each sample from the time of collection in the field to the time the sample is received by the designated analytical laboratory.

Sample: Physical evidence collected for environmental measuring and monitoring. For the purposes of this SOP, sample is restricted to solid, aqueous, air, or waste matrices. This SOP does not cover samples collected for lithologic description nor does it include remote sensing imagery or photographs (refer to SOP-4 for field documentation procedures).

Sampler: The individual who collects environmental samples during fieldwork.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: The Project Manager is responsible for ensuring that the requirements for sample management are included in the appropriate project plans. The

Project Manager is responsible for coordinating sample management efforts with input from other key project staff and MWH personnel.

Quality Manager: Performs project audits. Ensures project-specific data quality objectives are fulfilled.

Field Team Leader and/or Field Hydrogeologist, Geologist or Engineer: Conducts the procedures described herein and, if applicable, the requirements of the project plan. Responsible for reviewing documentation developed from sample management to determine compliance with this SOP and project quality control (QC) requirements. Prepares daily logs of field activities.

Field Technician: Responsible for sample collection, documentation, packaging, and shipping. Assists the FTL and/or geologist, hydrogeologist, or engineer in the implementation of tasks.

4.0 PROCEDURES

4.1 APPLICABILITY

The sample handling and shipping procedures described in this SOP apply to all work conducted at the UNC site. The information in this SOP may be used by direct reference or incorporated into project-specific plans. Deviations or modifications to procedures addressed herein must be brought to the attention of, and approved by, the UNC Project Manager, MWH Project Manager and the Quality Manager.

4.2 SAMPLE MANAGEMENT

Sample Containers: The sample containers to be used shall be dependent on the sample matrix and analyses desired. Once opened, the containers shall be used immediately. If the container is used for any reason in the field (e.g., screening) and not sent to the laboratory for analysis, it shall be discarded. Prior to discarding the contents of the used container and the container, disposal requirements shall be evaluated. When storing before and after sampling, the containers shall remain separate from solvents and other volatile organic materials. Sample containers with preservatives added by the laboratory shall not be used if held for an extended period on the job site or exposed to extreme heat conditions. Containers shall be kept in a cool, dry place.

Sample Label. A sample label shall be affixed to all sample containers. Labels provided by the laboratory or another supplier may be used, and at a minimum shall include the following information:

- Client name, project title, or project location (sufficiently specific for data management)
- Sample location
- Sample identification number
- Date and time of sample collection
- Type of sample (grab or composite)
- Initials of sampler
- Preservative used
- Analyte(s) of interest.

After labeling, each sample shall be refrigerated or placed in a cooler containing wet ice to reduce sample temperature to approximately 4 degrees Celsius (°C).

Custody Seals. Custody seals will be used to preserve the integrity of each sample container and cooler from the time the sample is collected until it is opened by the laboratory. Custody seals will be placed on each sample container after collection such that it must be broken to open the container. Two or more custody seals will be signed, dated, and placed on the front and back of the sample cooler prior to transport.

Chain-of-Custody: Chain-of-custody (COC) procedures require a written record of the possession of individual samples from the time of collection through laboratory analyses. A sample is considered to be in custody if it is:

- In a person's possession
- In view after being in physical possession

- In a secured condition after having been in physical custody
- In a designated secure area, restricted to authorized personnel

The COC record shall be used to document the samples taken and the analyses requested. Information recorded by field personnel on the COC record shall include the following:

- Client name
- Project name
- Project location
- Sampling location
- Signature of sampler(s)
- Sample identification number
- Date and time of collection
- Sample designation (grab or composite)
- Sample matrix
- Signature of individuals involved in custody transfer (including date and time of transfer)
- Airbill number (if appropriate)
- Type of analysis and laboratory method number
- Any comments regarding individual samples (e.g., organic vapor meter readings, special instructions).

COC records shall be placed in a waterproof plastic bag (e.g., Ziploc®), taped to the inside lid of the cooler or placed at the top of the cooler, and transported with the samples. When the sample(s) are transferred, both the receiving and relinquishing individuals shall sign the record. Fedex hand carry shall serve as custody transfer between the field sampler and courier, as well as courier and laboratory. If a carrier service is used to ship the samples (e.g., Federal Express, etc.), custody records shall remain with the sampler until it is relinquished to the laboratory. The sampler shall retain copies of the COC record and airbill.

Sample Register/Sample Tracking: The sample register is a logbook field form or electronic database used to document which samples were collected on a particular day.

The sample register is also used as the key to correlate field samples with duplicate samples. Information recorded in the sample register shall include the following:

- Client name
- Project name and location
- Job number
- Date and time of collection
- Sample identification number
- Sample designation (e.g., grab or composite, etc.)
- Sample matrix (e.g., soil, groundwater, etc.)
- Number and type of bottles
- Type of analysis
- Sample destination
- Sampler's initials.

A sample tracking database, which includes the above information, may be substituted for a handwritten sample register. However, a hard copy of each day's sampling activities shall be maintained in the field files or field logbook as discussed in SOP-4 (Field Documentation).

Sample Preservation/Storage: The requirements for sample preservation are dependent on the desired analyses and the sample matrix. Unless otherwise specified by the project plan, sample preservation requirements shall be observed.

4.3 SAMPLE SHIPPING

Procedures for packaging and transporting samples to the laboratory are based on the actual chemical, physical, and hazard properties of the material. The procedures may also be based on an estimation of contaminant concentrations/properties in the samples to be shipped. Samples shall be identified as either environmental samples, excepted quantities samples, limited quantities samples, or standard hazardous materials. Environmental samples are defined as solid or liquid samples collected for chemical or geotechnical analysis. These samples are used to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, waste characterization, etc. Excepted quantities involve the shipment of a few milliliters of either an acid or base preservative in an otherwise empty sample container. Limited quantities are restricted amounts of hazardous materials that may be shipped in generic, sturdy containers. Standard hazardous material shipments require the use of stamped/certified containers. All samples shall be packaged and shipped or hand delivered to the laboratories the same day of sample collection, unless otherwise specified in the project-specific work plans.

The following paragraphs describe standard shipping procedures for different types of samples. Any exceptions to these procedures shall be defined in the project-specific work plan. It is the responsibility of the sampler to understand U.S. Department of Transportation (DOT) requirements and limitations associated with the shipment of all types of samples.

Sample Shipping via Commercial Carrier:

Aqueous or Solid Samples: Samples shall be packaged and shipped to the laboratories the same day of sample collection, unless otherwise specified in the project work plans and depending on holding time requirements for individual samples. For aqueous or solid samples that are shipped to the Contract Laboratory via a commercial carrier the following procedures apply:

- Sample labels shall be completed and attached to sample.
- The samples shall be placed upright in a waterproof metal (or equivalent strength plastic) ice chest or cooler.
- Ice in double Ziploc® bags (to prevent leakage) shall be placed around, among, and on top of the sample bottles. Enough ice shall be used so that the samples shall be chilled and maintained at 4°C ± 2°C during transport to the laboratory. Dry ice shall not be used. In addition, experience has shown that blue ice is inadequate.

- To prevent the sample containers from shifting inside the cooler, the remaining space in the cooler shall be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC form shall be placed in a waterproof plastic bag and taped to the inside of the cooler lid or placed at the top of the cooler.
- The lid shall be secured by wrapping strapping tape completely around the cooler in two locations.
- Custody seals shall be used on each shipping container to ensure custody. Custody seals used during the course of the project shall consist of security tape with the date and initials of the sampler.
- A copy of the COC record and the signed air bill shall be retained for the project files.

4.4 HOLDING TIMES

The holding times for samples will depend on the analysis and the sample matrix.

4.5 TRAINING

The U.S. DOT requires that all employees involved in any aspect of hazardous materials transport (e.g. shipping, transport, receipt, preparing documents, and etc.) receive training every three years. Contractors working on UNC Plant OU shall be responsible for providing training for their own employees.

4.6 ADDITIONAL INFORMATION

General questions regarding this SOP or inquiries on the safe transport of other specific chemicals or by other carriers should be referred to the MWH Project Manager.

5.0 REFERENCES

Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Disposal Sites by Contractors, Draft, Appendix D, April 1980.

STANDARD OPERATING PROCEDURES 13

SOIL SAMPLING PROCEDURES
FOR VOLATILE ORGANIC COMPOUND ANALYSIS

STANDARD OPERATING PROCEDURES 13

SOIL SAMPLING PROCEDURES

FOR VOLATILE ORGANIC COMPOUND ANALYSIS

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) describes methods and equipment that shall be used for collecting environmental surface soil, subsurface soil, and sediment samples for volatile organic compound (VOC) analysis. This SOP, prepared in accordance with SW-846 (December 1996), defines sample collection procedures for screening and definitive sampling levels, using a soil sampler, methanol, and sodium bisulfate preservation methods according to Method 5035A. The standard procedures for collecting VOC samples, subsurface soil samples, and surface soil samples are described in SOPs-13, 14, and 15, respectively. This document focuses on methods and equipment that are specific to sampling surface soil and subsurface soil analysis. It is not intended to provide an all-inclusive discussion of soil sample collection methods. Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Such innovations shall be clearly described in the project-specific sampling plan and approved by the SRI Project Manager, FMC Project Manager, and the Quality Manager.

2.0 DEFINITIONS

Environmental Sample: A solid sample collected for VOC analysis. These samples are used to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, waste characterization, etc.

TerraCore™ Soil Sampler: A disposable, volumetric sampling device. The TerraCore™ sampler collects soil samples for transfer in to vials.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and associated responsibilities. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects site-specific sampling methods, sample locations, and constituents to be analyzed with input from other key project staff.

Quality Manager: Overall management responsibility for the sampling methods, sample locations, and constituents to be analyzed with input from other key project staff and FMC personnel.

Field Team Leader (FTL) and/or Field Geologist, Hydrogeologist, or Engineer: Implements the sampling program and supervises other sampling personnel. Prepares daily logs of field activities.

Sampling Technician (or other designated personnel): Assists the FTL and/or geologist, hydrogeologist, or engineer in the implementation of tasks. Performs the actual sample collection, packaging, and documentation (e.g., sample label and log sheet, chain-of-custody record, etc).

4.0 SURFACE SOIL, SUBSURFACE SOIL, AND SEDIMENT SAMPLING PROCEDURES

4.1 BACKGROUND

Surface soil samples are typically collected from the ground surface to 6 inches below ground surface. Samples collected from greater than 6 inches below ground surface are considered subsurface soil samples. For standard subsurface soil collection techniques refer to SOP-14, then follow this SOP. For surface soil collection techniques refer to SOP-15, then follow this SOP.

4.2 SAMPLING PROGRAM OBJECTIVES

The objective of surface soil and subsurface soil is to characterize the VOC analytes and possibly identify potential sources of contaminants. Sampling objectives are typically diverse and dependent on the nature of the project-specific data quality objectives. Details pertaining to sample locations, number of samples, and type of analyses required, shall be presented in the Work Plan.

4.3 SAMPLING EQUIPMENT AND TECHNIQUES

Surface soil samples shall be collected as described in SOP-15 then transferred to a wide-mouth 4-ounce jar, or a vial with a chemical preservative using a syringe or Terra Core sampler. Subsurface soil samples will be brought to the surface following one of the procedures in SOP-14 and then transferred to a wide-mouth 4-ounce jar using a syringe or the TerraCore™ sampler, or a vial with a chemical preservative using a syringe or Terra Core™ sampler.

Terra Core™ Sampler: The Terra Core is a one time use transfer tool, designed to easily take samples from hard packed soils and transfer them to the appropriate containers for in-field chemical preservation. The Terra Core transfers soil samples as described in USEPA SW-846 Method 5035. The steps for use are as follows:

1. Have ready a tared 40ml glass VOA vial containing the appropriate preservative. With the plunger seated in the handle, push the Terra Core into freshly exposed soil until the sample chamber is filled. A filled chamber will deliver approximately 5 grams of soil.

2. Wipe all soil or debris from the outside of the Terra Core™ sampler. The soil plug should be flush with the mouth of the sampler. Remove any excess soil that extends beyond the mouth of the sampler.

3. Rotate the plunger that was seated in the handle top 90° until it is aligned with the slots in the body. Place the mouth of the sampler into the tared 40ml VOA vial containing the appropriate preservative, and extrude the sample by pushing the plunger down. Quickly place the lid back on the tared 40ml VOA vial.

Note: When capping the 40ml VOA vial, be sure to remove any soil or debris from the threads of the vial.

Methanol or Sodium Bisulfate Preservation: Methanol or Sodium Bisulfate Preservation is used with the Terra Core^{TM} sampler. Refer to SW-846 Method 5035A (U.S. EPA, 1996) for full details on sample preservation. A sodium bisulfate preservative solution is used for the collection of soil samples in which the suspected VOC concentration is in the range of 0.5 to 200 micrograms per kilogram (µg/kg). For soil samples in which the VOC concentration is suspected to be greater than 200 µg/kg, either a bulk sample may be collected (the laboratory will add a water miscible solvent) or the sample is collected in a vial that contains a water-miscible organic solvent (methanol). Soil or sediment samples are collected following the standard procedures in SOPs 14 or 15, and following the procedures described below.

1. For low VOC concentration samples (0.5 – 200 µg/kg): Collect the soil or sediment sample according to the procedures defined in the project specific Field Sampling Plan (FSP). Collect approximately a 5.0 gram sample (weighed in the field) and place it in a pre-weighed vial that already contains a stirring bar and a sodium bisulfate preservative solution and that has a septum-sealed screw cap. The sample vial with solution may be available from the laboratory. After sampling, the vial shall be immediately sealed and shipped (on ice) to the laboratory for analysis.

   Soil samples that contain carbonate minerals may effervesce when in contact with the sodium bisulfate. If this occurs, the sample shall be collected in an un-preserved vial or other sampling container.

2. For high VOC concentration samples (greater than 200 µg/kg): Collect the soil sample according to the procedures defined in the project specific FSP, then follow one of the two options below:

   Option 1: Collect a bulk sample in a vial or other suitable container without preservative. Seal the container and ship it (on ice) to the laboratory for analysis. The laboratory will take a sample from the container and add the appropriate amount of preservative prior to analysis.

Option 2: Collect approximately a 5 gram sample (weighed in the field) and place the sample in a pre-weighed vial with a septum-sealed screw-cap that contains 5 milliliters (mL) of water-miscible organic solvent, (methanol). The vial can either be prepared by the laboratory or prepared in the field at the time of sampling. Immediately prior to use, the vial shall be weighed and the weight (in grams [g]) of the methanol and vial recorded. If there is a reduction in weight of greater than 0.01 g then the vial shall not be used for sample collection. After weighing, the scale shall be tarred. Five (5) grams ± 0.5g of sample shall be transferred to the vial immediately after sample collection and in a manner that minimizes loss of VOCs using the procedures described in the project specific FSP. Quickly brush any soil off the vial threads and immediately seal the vial with the septum and screw-cap. Store samples on ice at 4°C.

Weigh the sealed vial containing the sample to ensure that 5.0 ± 0.5 g of sample was added. The balance should be calibrated in the field using class S weights at a weight appropriate for the sample containers. Record the weight of the sealed vial containing the sample to the nearest 0.01 g. It may be necessary to conduct several trial runs to determine the amount of soil required to meet the 5.0 ± 0.5 g criteria.

3. If the FSP calls for replicate samples, collect at least two replicate samples, one for replicate analysis, the other for percent moisture determination. The replicate samples should be collected from the same location or within close proximity to the location from which the original sample was collected.
4. Because the soil vial cannot be opened without compromising the integrity of the sample, at least one additional vial of sample may be collected for dry weight determination. This additional replicate must not contain methanol, since an aliquot will be used for dry weight determination.
5. All samples for VOC analysis shall be cooled to approximately 4°C, packed in appropriate containers, and shipped to the laboratory on ice. For further details on shipping and handling refer to SOP-12.

Oily Waste Samples: If oily waste samples are known to be soluble in methanol then sample vials may be used as described above. However, if oily waste samples are not known to be or are not soluble in methanol then the sample should be collected in an un-preserved vial.

5.0 DECONTAMINATION

All non-disposable equipment used in the sampling process shall be decontaminated prior to field use and between sample locations. Decontamination procedures are presented in SOP-5. Personnel shall don appropriate personal protective equipment as specified in the project-specific health and safety plan. Note that when handling the vials that contain methanol, methanol resistant gloves shall be worn. Investigation-derived waste generated in the sampling process shall be managed in accordance with the Work Plan.

6.0 REFERENCES

U.S. Environmental Protection Agency. 1996. SW-846 Method 5035A Revision 0, Closed System Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste Samples.

STANDARD OPERATING PROCEDURE 14

SUBSURFACE SOIL SAMPLING

STANDARD OPERATING PROCEDURE 14

SUBSURFACE SOIL SAMPLING

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) is a general reference for the proper equipment and techniques for the collection of subsurface soil samples. The purpose of these procedures is to enable the user to collect representative and defensible subsurface soil samples for chemical analyses, and to facilitate planning of the field sampling effort. These techniques will be followed whenever applicable, although site-specific conditions or project-specific data quality objectives may require adjustments in methodology.

This SOP focuses on methods and equipment that are readily available and typically used for subsurface soil sample collection. It is not intended to provide an all-inclusive discussion of subsurface soil sampling methods. Surface soil sampling techniques are discussed in SOP-15.

2.0 DEFINITIONS

Split-Spoon Sampler: A sampling tool consisting of a thick-walled steel tube with a removable head and drive shoe. The steel tube splits open lengthwise when the head and drive shoe are removed.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information will be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel will always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects site-specific sampling methods, sample locations, and constituents to be analyzed with input from other key project staff.

Quality Manager: Responsible for project quality control and field audits. Ensures project-specific data quality objectives are fulfilled.

Field Team Leader (FTL) and/or Geologist, Hydrogeologist, or Engineer: Implements the sampling program and supervises other sampling personnel. Ensures that proper chain-of-custody procedures are observed and that samples are collected, transported, packaged, and shipped in an appropriate and timely manner. Prepares daily logs of field activities.

Field Sampling Technician (or other designated personnel): Assists the FTL, geologist, hydrogeologist, or engineer in the implementation of tasks and is responsible for the proper use, decontamination, and maintenance of sampling equipment.

4.0 INTRODUCTION

The purpose of this SOP is to present methods for the collection of subsurface soil samples that will be used for environmental site characterization. Generally, subsurface soil samples are collected for chemical and/or geotechnical analysis.

4.1 CHEMICAL ANALYSIS

Chemical analysis of subsurface soil is conducted to assess the chemical properties of the subsurface materials. This information is used for site characterization and defining remedial design parameters. The samples are typically collected in relatively small quantities, often in several containers. Because the samples will be subjected to chemical analyses, prevention of cross contamination during the sampling effort is critical.

4.2 HEALTH AND SAFETY CONSIDERATIONS

All sampling operations will be conducted in a manner that complies with the project-specific health and safety plan. Thus, during the collection of samples, health and safety information will be collected as required to ensure the safety of the sampling personnel.

Sampling personnel will wear personal protective equipment that is appropriate for the sampling location, media, and contaminants of concern, as determined in the site-specific health and safety plan. At a minimum, this will include clean, disposable, waterproof gloves to prevent cross contamination between samples or skin contact with possible contaminants. Additional safety equipment, including waterproof boots, coveralls, splash shields, respirators, etc., will be worn based on existing conditions and requirements of the project-specific health and safety plan.

4.3 OTHER CONSIDERATIONS

During sampling, care will be taken to ensure that the resulting data are representative of site conditions. If conditions exist prior to the collection of a sample which suggest that materials from different stratigraphic units may have mixed (e.g., fill from a shallower depth that has sloughed into a hole and contacted soil at a greater depth), the hole or area will be thoroughly cleaned before sampling. It is critical that samples be representative of the materials scheduled to be sampled.

In addition, some individual sampling plans may require the collection of samples from a particular stratigraphic unit or layer rather than a particular depth. If, in these cases, a visual examination indicates that material from another layer has mixed with the sample, the non-desirable material will be separated from the sample or the sample will be discarded and re-collected.

4.4 SAMPLING EQUIPMENT AND METHODOLOGY

Sampling equipment typically used to collect subsurface soil samples for chemical and geotechnical analyses are listed below. Soil sample collection procedures using the listed types of equipment are outlined in the subsequent sections.

Chemical Analyses

- Split-spoon
- Trenching and test pits

Soil Sampling Methods for Chemical Analyses: Soil samples will be collected in sufficient volume to satisfy analytical laboratory requirements. If the sample volume is insufficient, another sample will be collected from a location immediately adjacent to the first sample.

Split-Spoon Samplers: A split-spoon sampler consists of a thick steel tube with a ball check valve in a removable head and a removable hardened steel shoe. The barrel splits lengthwise to expose the sample when the head and shoe are removed. Split-spoon samplers are used to collect undisturbed samples for chemical, as well as geotechnical/engineering analyses.

Split-spoon samplers are typically 1.5 to 3 inches in outside diameter (OD), 18 or 24 inches in length and, if desired, may be lined on the interior with brass or acetate liners, depending on the size of the liners. Split-spoon samplers and brass liners will be decontaminated prior to use and stored in clean plastic bags until use. Decontamination procedures are described in SOP-3. Both lined and unlined samplers are discussed below.

Split-Spoon Samplers with Liners: Brass or acetate liners may be placed inside the sampler in stacks. For sample collection, liners will be of a sufficient diameter to be retained within the sampler without obstructing the entry of a sample. The length of the sleeves will be specified in project-specific work plans.

To obtain a sample, the split-spoon will be lowered through the auger string or drill pipe to the underlying material and driven to the specified depth using a 140-pound (lb.) hammer falling 30 inches. The number of hammer blows required for every 6 inches of penetration will be recorded on the soil boring log during advancement of the sampler.

Once the sample is obtained, the split-spoon will be removed from the hole and handled according to the type of sampling or compositing method. Samples for the parameters may be submitted to the laboratory with the sample intact, or the sample can be extruded and transferred to appropriate sample containers. If a sample is submitted in the liner, the liner will then be capped on both ends.

Once the ends of the liner have been capped and sealed, the outside of the liner will be cleaned and the liner will be labeled appropriately. The label will be attached to the liner in such a manner to ensure that the label is not lost. Self-adhesive tape may be used for this purpose. Once a sufficient number of liners have been collected for laboratory analyses, the remaining liners may be used for head-space analyses and sample logging, as necessary. Samples collected with a split-spoon sampler will be handled as outlined in SOP-12.

Split-Spoon Samplers without Liners: The procedure for the collection of soil samples from split-spoon samplers without liners is similar to that outlined for samplers with liners. The spoon is lowered through the auger string or drill pipe to the underlying material and driven to the specified depth using a 140-lb hammer falling 30 inches. The number of hammer blows required for every 6 inches of penetration will be recorded on the soil boring log during advancement of the sampler.

Once the sample is obtained, the split-spoon will be removed from the hole and handled according to the type of sampling or compositing method. Samples for the parameters may be submitted to the laboratory with the sample intact, or the sample can be extruded and transferred to appropriate sample containers.

Trenching and Test Pits: Backhoes or excavators may be used to excavate trenches and test pits from which samples may be collected. The project-specific sampling plans will identify the method of sample collection. Backhoes or excavators are generally used where a visual examination of the materials is necessary prior to sampling (detailed in SOP-11). Either rubber-tired or track-mounted equipment may be used, depending on the anticipated depth of the required excavation. The equipment bucket will be decontaminated following the procedures in SOP-3.

Special care will be taken to ensure that individual samples are representative of the target subsurface media and not contaminated by materials from adjacent layers. This may require frequent cleaning of the excavation sidewalls or bottom to remove materials that have sloughed into the excavation prior to sampling.

5.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), 1986. Test Methods for Evaluating Solid Waste. SW-846 (Third Edition). Office of Solid Waste and Emergency Response. Washington, D.C.

STANDARD OPERATING PROCEDURE 15

SURFACE SOIL SAMPLING

STANDARD OPERATING PROCEDURE 15

SURFACE SOIL SAMPLING

TABLE OF CONTENTS

1.0 INTRODUCTION

This standard operating procedure (SOP) describes methods and equipment commonly used for collecting environmental surface soil samples for chemical and geotechnical analyses. The information presented in this SOP is generally applicable to the collection of all surface soil samples, except where the analyte(s) may interact with the sampling equipment. This SOP defines sample collection procedures using hand augers, shovels/trowels, and soil core samplers. Procedures for collecting subsurface soil samples are outlined in SOP-14.

This document focuses on methods and equipment that are readily available and typically applied in collecting surface soil samples. It is not intended to provide an all-inclusive discussion of sample collection methods. Specific sampling problems may require the adaptation of existing equipment or design of new equipment. Such innovations shall be clearly described in the project-specific sampling plan and approved by the UNC Project Manager, MWH Project Manager, and the Quality Manager.

2.0 DEFINITIONS

Environmental Sample: A solid sample collected for chemical or geotechnical analysis. These samples are used to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, waste characterization, etc.

Hand Auger: A sampling tool consisting of a stainless steel tube with two sharpened spiral wings at the tip.

Shovel/Trowel: A sampling device consisting of a stainless steel spade attached to a handle.

Soil Core Sampler: A variable diameter stainless steel tube that can be attached to a hammer for driving into surface soil. The tube can also be fitted with retaining liners.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

MWH Project Manager: Selects site-specific sampling methods, sample locations, and constituents to be analyzed with input from other key project staff.

Quality Manager: Overall management and responsibility for the sampling methods, sample locations, and constituents to be analyzed with input from other key project staff and UNC personnel.

Field Team Leader (FTL) and/or Field Geologist, Hydrogeologist, or Engineer: Implements the sampling program and supervises other sampling personnel. Prepares daily logs of field activities.

Sampling Technician (or other designated personnel): Assists the FTL, geologist, hydrogeologist, or engineer in the implementation of tasks. Performs the actual sample collection, packaging, and documentation (e.g., sample label and log sheet, chain-of-custody record, etc).

4.0 SURFACE SOIL SAMPLING

4.1 BACKGROUND

Surface soil samples are typically collected from the ground surface to 6 inches below ground surface. Samples collected from greater than 6 inches below ground surface are referred to as subsurface soil samples. Surface soil samples may be collected as grab samples or as composite samples. The sample method is determined based on the physical characteristics of the site and matrix.

- Grab sample: A sample taken from a particular location. Grab samples are useful in determining discrete concentrations, but also provide spatial variability when multiple samples are collected.
- Composite sample: A number of samples that are individually collected then combined (homogenized) into a single sample for subsequent analysis. Composite samples are useful when averaged or normalized concentration estimates of a waste stream or an area are desired.

4.2 SAMPLING PROGRAM OBJECTIVES

The objective of surface soil sampling is to characterize chemical properties of the soil, and possibly identify potential sources of contaminants. Sampling objectives are typically diverse and dependent on the nature of the project data quality objectives. Details pertaining to sample locations, number of samples, and type of analyses required, shall be presented in project-specific work plans.

4.3 SAMPLING EQUIPMENT AND TECHNIQUES

A surface soil sample may consist of a single scoop or core, or the sample may be a composite of several individual samples. Surface soil samples shall be obtained using hand augers, shovels/trowels, or soil core samplers.

Hand Auger: A hand auger consists of a stainless steel tube with two sharpened spiral wings at the tip. The auger typically cuts a 2-inch to 3-inch diameter boring. Because the auger is hand-driven, penetration in dense or gravelly soil may be difficult. For surface soil sample collection, the procedures outlined below shall be followed. Procedures for sample handling and shipping are presented in SOP-12.

1. Advance the auger by hand into the soil, to the desired depth (6 inches or less for surface soil samples), by turning in a clockwise direction with downforce applied.
2. Retrieve the auger to the surface, preferably without rotation.
3. Fill sample jars using decontaminated stainless steel spatulas or spoons.
4. Place samples for other analyses into a stainless steel bowl for homogenization. Prior to homogenization, remove twigs, rocks, leaves and other undesirable debris if they are not considered part of the sample.

Shovel/Trowel: Various shovel/trowel designs and sizes are commercially available for a variety of sampling applications. These devices are hand-driven and are typically used for sampling relatively soft, unconsolidated soil deposits. Some designs (e.g., the sharpshooter™) can be driven into hard, rocky soil by opening a deep, narrow hole. Shovels or trowels used for surface soil sampling shall be made of stainless steel. The procedures outlined below shall be followed while collecting samples with shovels or trowels. Procedures for sample handling and shipping are presented in SOP-12.

1. Drive the shovel/trowel into the soil. If the soil is dense, use your own weight to drive the shovel by stepping on the rear edge of the shovel.
2. Retrieve the shovel/trowel to the surface.
3. Fill sample jars using decontaminated stainless steel spatulas or spoons.
4. Place sample for remaining analyses into a stainless steel bowl for homogenization. Prior to homogenization, remove twigs, rocks, leaves and other undesirable debris if they are not considered part of the sample.

Soil Core Sampler: Soil core samplers consist of variable diameter (commonly 1-2 inches), stainless-steel tubes that can be attached to a hammer using a cap to allow for driving into surface soil. The steel tubes can also be fitted with aluminum or stainless steel liners for the collection of undisturbed samples. Polyethylene liner caps are used to seal the ends of the tube after sample collection. Soil core samplers can be used to obtain soil samples for chemical or geotechnical analysis. The use of liners allows for the collection of undisturbed samples, minimal loss of volatiles, and easy shipping to the analytical laboratory. The procedures outlined below shall be followed when collecting surface soil samples using this method.

1. Attach a stainless steel cap to the soil core sampler.
2. Attach the sampler and cap assembly to the hammer.
3. For the collection of undisturbed soil samples, install stainless-steel liners in the sampler.
4. Push the hammer and sampler into the surface soil. For dense soil, turn hammer slightly clockwise to enhance penetration.
5. Once the desired sample depth is reached, retrieve sampler to the surface and detach the sampler from the hammer.
6. To collect samples for chemical analysis, empty contents of the sampler into a stainless steel bowl for homogenization. Prior to homogenization, remove twigs, rocks, leaves and other undesirable debris if they are not considered part of the sample.

5.0 DECONTAMINATION

All equipment used in the sampling process shall be decontaminated prior to field use and between sample locations. Decontamination procedures are presented in SOP-3. Personnel shall don appropriate personal protective equipment as specified in the project-specific work plan. Any investigation-derived waste generated in the sampling process shall be managed in accordance with the procedures outlined in the Work Plan.