

# **Pit and Impoundment Evaluation and Sampling Plan**

**For**

**Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations  
(ETD-10 Project)**

*Prepared for:*

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Divisions of Air Quality  
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## **1.0 Background**

Marcellus Shale is a rock formation located under parts of West Virginia, Pennsylvania, and New York. This rock formation contains large reserves of natural gas that are commonly being explored using recently developed horizontal drilling and hydraulic fracturing techniques. The West Virginia Legislature enacted the Natural Gas Horizontal Well Control Act §22-6A on December 14, 2011. As part of this Act, the West Virginia Department of Environmental Protection (WVDEP) is to perform studies concerning the practices involved with horizontal drilling, followed by a report of the findings and recommendations.

A research study is being performed, focusing on the potential health and safety concerns resulting from horizontal drilling techniques. Among the key areas of research are the surrounding air quality, the generated light and noise, and the structural integrity and safety of the pits and impoundments retaining fluids for the gas wells. The intent of the Pit and Impoundment Evaluation and Sampling Plan is to ascertain and document the suitability of the construction and use of these structures in minimizing the potential environmental effects related to horizontal drilling.

## 2.0 Roles and Responsibilities

A list of West Virginia University Department of Civil and Environmental Engineering (WVU CEE) personnel directly involved in this study is included in **Appendix A** along with contact information.

### **John Quaranta, Ph.D., P.E., Principal Investigator**

- Provide oversight and direction of project
- Provide technical oversight concerning soil property testing on pits and impoundments
- Serve as lead investigator for pits and impoundments
- Oversee field sampling efforts for soil property testing

### **Richard Wise, MSCE, EIT, Research Engineer**

- Select, schedule, and direct activities of field staff to complete the planned sampling activities
- Serve as primary point of contact for pits and impoundments team
- Assist with preparation of reports to WVDEP

### **Andrew Darnell, MSCE, EIT, Research Engineer**

- Assist with selecting and scheduling to complete the planned sampling activities
- Oversee and assist with preparation of reports to WVDEP

### **Michael Kulbacki, BSCE, Research Associate**

- Conduct field sampling activities
- Assist with compilation and reporting of field and laboratory data and results

### **Matt Idleman, BSCE, Research Associate**

- Conduct field sampling activities
- Assist with compilation and reporting of field and laboratory data and results

### **Justin Pentz, BSCE, Research Associate**

- Assist with compilation and reporting of field and laboratory data and results

### 3.0 Study Design

The intent of the field sampling and soil property testing in this plan is to ascertain and document the safety and structural integrity of the pits and impoundments used to retain fluids during the development of horizontal gas wells for Marcellus Shale. Cooperating with the WVDEP, WVU personnel will receive 18 candidate permit files for pits and impoundments with varying characteristics, from which 12 sites will be selected for field visit and evaluation, leading to a determination of six sites for in-depth soil property testing by a subcontractor.

The WVDEP will establish site access by contacting the natural gas developers. WVU will coordinate with the WVDEP to schedule and conduct soil property testing on the horizontal gas well sites. Furthermore, WVU personnel will make visual observations of the surrounding environment and take Global Positioning System (GPS) referenced pictures during sampling visits to assist with site evaluation.

Collection of site soil will be performed by WVU personnel at various locations on each site. These locations will be predetermined based on WVDEP permit reviews. The site soil will be tested in accordance with American Society for Testing and Materials (ASTM) Standards at the WVU Department of Civil and Environmental Engineering Soil Mechanics Laboratory. The specific soil property tests to be performed are field moisture content, grain-size distribution and hydrometer, Atterberg Limits, Specific Gravity, Standard Proctor, hydraulic conductivity (rigid wall) and shear strength.

## 4.0 Sampling Sites

Site selection will be conducted by analyzing a set of 18 candidate permits provided by the WVDEP based on a set of criteria set forth by WVU. These criteria will be used to choose 12 sites with a variety of pit characteristics for evaluation. The factors encompassed in the criteria include the following:

- Location within the State of West Virginia
- Company Size: small, medium, or large
- Pit Characteristics:
  - Permit Number/Site Name
  - Age
  - Size (area, depth)
  - Use (flowback water, freshwater, centralized, associated)
  - Construction Material (natural soil, HDPE lined)
  - Construction Method (incised, berm)
  - Placement (hill crest, cut into slope, valley)

Once the 12 sites for evaluation are selected, field visits to those sites will be conducted for verification, visual observations, and checklist data collection using the evaluation form shown in Figure 1. Six sites will be selected from the candidate list of 12 sites for further in-depth soil testing. These six sites will have field soil compaction density tests performed by a WVU subcontractor, Potesta and Associates, Inc.

**West Virginia University – Civil & Environmental Engineering ETD-10  
Marcellus Horizontal Gas Well Flowback Water and Centralized Pits Evaluation Form**

DATE & TIME		County		Company	
WEATHER		Latitude		Pit Name	
		Longitude		API No.	
<b>A. PERMIT INFORMATION</b>					
Pit Width (ft.)		Minimum Berm Crest Width (ft.)		Construction Type	
Pit Length (ft.)		Upstream Slope (H:V)		Liner Type	
Depth (ft.)		Downstream Slope (H:V)		Date Built	
Freeboard(ft.)				Date Reclaimed	
<b>B. FIELD AS-BUILT CONSTRUCTION AND SITE CONDITIONS</b>					
Pit Width (ft.)		Berm Crest Width (ft.)		Crest Height (ft.)	
Pit Length (ft.)		Upstream Slope (H:V)		Up Slope Length (ft.)	
Depth (ft.)		Downstream Slope (H:V)		Down Slope Length (ft.)	
Freeboard (ft.)		Water Elevation		Groundwater Elevation	
Is the pit/impoundment in the NFIP 100-yr floodplain?			Is the pit/impoundment within 1 000 feet of a public water source?		
Is the pit/impoundment within 500 feet of a dwelling, perennial stream, or private water source?			Is the pit/impoundment within 100 feet of a wetland?		
<b>C. PIT/IMPOUNDMENT</b>					
		<b>Existence</b>	<b>If YES then Evaluate Significance of Problem</b>		
		Yes/No/NA	Low < 33%	Moderate 33 - 66%	High > 66%
					Remarks
1	Are there any observed surface erosions, cracks, settlements, or scarps?				
2	Are there any slope movements or animal burrows?				
3	Are there any depressions, sinkholes, or slides into the pit present?				
4	Are there any signs of mine subsidence on or adjacent to the embankment?				
5	Are there any observed trees, tall weeds, or other vegetation?				
6	Are there any seeps, wet zones, or losses of soil?				
7	Are there any eddies/whirlpools or other signs of leakage or seeps present?				
8	Are there any liner tears, bulges, holes, wind uplifts, or seam separations?				
9	Are there any areas where the liner is strained?				
10	Are there any areas where the liner has rock or debris on top of it?				
11	Is there any tear potential for the liner?				
12	Are there any deformations, cracks, or settlements around the anchor trench?				
13	Are there any signs of pipe abnormalities (gouge marks, leaks, cracks)?				
14	Are there any areas where the pipe is not properly supported?				
15	Are there any signs of pipes having significant sagging in line?				
16	Are there any signs of obstructions (trees, garbage, etc.)?				
17	Are there any signs of water in ditch associated with pit?				
18	Are there any obstructions around the discharge outlet?				
19	Are there any signs of downstream slope movement into ditch?				
WVU (Name / Signature)					DATE
WVDEP (Name / Signature)					
Company Representative (Name / Signature)					

Site Operations & Infrastructure Evaluation	
Date:	Pit/Impoundment Name:
1	What is the type and frequency of company site inspections at the pit/impoundment? (routine or special inspection) (visual, walking)
2	What type of training or background does the inspector possess relative to pit/impoundment inspection?
3	How many years of training does the inspector have in evaluating pits/impoundments?
4	Is there a standardized form/procedure used to inspect and record observations of the pit/impoundment inspection?
5	Who developed the form and how is the information used to evaluate pit/impoundment safety?
6	Are there safety and emergency procedures for the pit/impoundment?
7	Is there an Emergency Action Plan (EAP) for the pit/impoundment? Is the EAP posted at the site with contact numbers?
8	Has the pit/impoundment inspector been trained on how to use the EAP?
9	Has the EAP been evaluated using a Table Top Review or other method? (If so, when?)
10	Does the company have a policy on pit/impoundment safety?
11	How frequently does a Professional Engineer inspect the site?
12	Other comments:

Figure 1: Evaluation Form



## **5.0 Field Sampling Methods**

For the field testing, several items will be purchased. These items are organized into two categories: personal protective equipment (PPE) and field tools. The following list contains the items that will be purchased.

### **Personal Protective Equipment (PPE)**

Hard hats  
Steel-toed shoes (metatarsal)  
Coveralls (flame retardant)  
Leather gloves

### **Field Tools**

Range Finder  
100-foot tape  
Jerricans  
Soil jars  
Latex gloves  
Small garden hand shovels  
Tape measures  
Ziploc bags (quart)  
Ziploc bags (gallon)  
5 gallon buckets with lids  
Duct Tape

During the site evaluations, WVU personnel will abide by all safety and PPE requirements mandated by the company on whose site the field sampling is being performed. The field sampling will consist of digging several test holes at key locations across each site, such as the toe, face, and crest of the pit or impoundment slope. The test hole locations will be planned prior to the site visit based on the information gathered from WVDEP permit files. The soil gathered from the test holes will be labeled with the site name, date, and location of the test hole. The sample locations will be restored to the original conditions to ensure that no damage will be done to the pit or impoundment. WVU personnel will also make visual observations of the surrounding environment and take GPS-referenced pictures during sampling visits. After the collection of soil samples, all tools will be cleaned and stored in containers to avoid cross-contamination between sites. In addition, the tools will be inspected for damage after each use. All PPE will be similarly decontaminated, and all disposable materials will be removed from the site in a garbage bag. Once collected, the soil will be taken to the WVU Department of Civil and Environmental Engineering Soil Mechanics Laboratory for soil property testing.

In addition to the field sampling performed by WVU, *in situ* field compaction and moisture content data from various locations on six sites will be collected by Potesta and Associates, Inc. This field testing will involve using a nuclear surface gauge such as a Troxler 3430 model. The gauge measures approximately 30 inches long by 14 inches wide by 17 inches tall, and will be placed on a flat base prepared with a shovel. The tests will be performed in accordance with ASTM D-6938-06. The planned locations will comprise the toe, mid-slope, and crest of the downstream slope. Approximately four to twelve data points will be taken at each site. These field soil results will be incorporated into the analysis along with the laboratory soil testing performed by WVU. The importance of this data is to correlate the *in situ* soil density with the engineering plans and specifications.

## 6.0 Laboratory Soil Testing Methods

Geotechnical soil property testing will consist of collecting soil samples for laboratory testing in order to obtain independent verification of properties and site conditions. This work will be specific to the soils used to construct the pits and impoundments. Specific soil testing will be performed at the WVU Department of Civil and Environmental Engineering Soil Mechanics Laboratory and will include the following: field moisture content, grain-size distribution and hydrometer, Atterberg Limits, Specific Gravity, Standard Proctor, hydraulic conductivity (rigid wall) and shear strength. The soil property tests and associated ASTM Standards are listed in Table 1. The necessary equipment and the procedure for each of these soil property tests are detailed in the following sections.

Soil Property Test	ASTM Standard
Field Moisture Content	D2216
Grain-Size Distribution and Hydrometer	D422
Atterberg Limits	D4318
Specific Gravity	D854
Standard Proctor	D698
Hydraulic Conductivity (Rigid)	D5856
Shear Strength	D3080/D3080M

Table 1: Soil Tests and Standards

### 6.1 Field Moisture Content (ASTM D2216)

#### Specified Equipment For This Soil Property Test:

1. Drying oven
2. Balances
3. Specimen containers (with lids)
4. Heat resistant tongs

#### Laboratory Soil Testing Procedure:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D2216 "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass".*

1. Determine the mass of a dry, clean moisture content container and record the number printed on the container and the mass of the container on a data sheet.
2. Place a representative sample of soil in the container. Weigh the container plus moist soil and record the mass on a data sheet.

3. Place the container and soil in an oven and allow the soil to dry overnight (at least 15 to 16 hours).
4. Determine the mass of the container and contents after the soil is dry, and record the mass on a data sheet.

## **6.2 Grain-Size Distribution and Hydrometer (ASTM D422)**

### Specified Equipment For These Soil Property Tests:

1. Balances
2. Hard bristle brush
3. Various-sized round, stackable testing sieves (ASTM E 11 or AASHTO M 92)
4. Vibratory table
5. Two graduated cylinders (one liter)
6. Hydrometer
7. High-speed electric mixer with steel mixing cup
8. Deflocculating agent (sodium hexametaphosphate)
9. Thermometer
10. 600 mL glass beaker
11. Spatula
12. Squirt bottles
13. Distilled water supply
14. Chemical weighing spoon
15. Chemical weighing dish

### Laboratory Soil Testing Procedure for Grain-Size Distribution:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D422 "Standard Method for Particle-Size Analysis of Soils".*

1. Weigh out a 500 g soil sample, oven-dried according to ASTM recommendations.
2. Record the mass of each clean sieve and the pan on a data sheet.
3. Place the soil sample in the uppermost sieve and secure with a lid.
4. Put the stack of sieves in the mechanical sieve shaker and shake for 5 minutes.
5. Remove the sieves from the shaker and set aside to allow dust to settle.
6. Remove each sieve from the stack, starting at the top.

7. Shake the first sieve over a sheet of paper until no particles fall onto the paper. Empty any soil particles on the paper into the next sieve.
8. Weigh the first sieve and record the mass of the sieve and soil retained on the data sheet.
9. Repeat Steps 7 and 8 for each sieve.

Laboratory Soil Testing Procedure for Hydrometer Analysis:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D422 "Standard Method for Particle-Size Analysis of Soils".*

1. Weigh out exactly 50 g of oven-dried soil in a 600 mL glass beaker.
2. Fill one 1-liter graduated cylinder with distilled water and place the hydrometer slowly inside.
3. Place the filled graduated cylinder and one empty 1-liter graduated cylinder on a stable counter in an area where the cylinders will not be shaken or moved for at least two hours.
4. Weigh out 2.5 g of sodium hexametaphosphate into a small dish.
5. Mix the soil with 250 mL of distilled water in a 500 mL glass beaker. Stir the slurry with a spatula and break the clumps of clay down into individual particles as much as possible.
6. Pour the slurry into a steel mixing cup and wash the remaining soil into the mixing cup.
7. Add the deflocculating agent (sodium hexametaphosphate).
8. Use distilled water to fill the mixing cup to two-thirds full.
9. Turn on the high-speed mixer and mix the soil slurry for one minute. Wash the suspension into the empty 1-liter graduated cylinder.
10. Add distilled water to fill the cylinder to the 1-liter mark and place a rubber stopper on the open end of the cylinder.
11. Cover the stopper with a hand and repeatedly turn the cylinder upside-down and right-side-up again until the suspension is thoroughly mixed.

12. Take hydrometer readings at total elapsed times of 15, 30, 60, and 120 seconds without removing the hydrometer, and record the readings on a data sheet. Remix the suspension and repeat the four readings until a consistent pair of readings is obtained.
13. Remix the suspension and restart the test, taking no readings until two minutes have passed.
14. Take hydrometer readings at total elapsed times of 2, 4, 8, 15, 30, 60, and 90 minutes, and record the readings on a data sheet.
15. After each reading, remove the hydrometer from the cylinder and store in the graduated cylinder filled with clean water. Place a thermometer in the clean water to determine the temperature of the hydrometer.

### **6.3 Atterberg Limits (ASTM D4318)**

#### Specified Equipment For These Soil Property Tests:

1. Liquid limit device
2. Grooving tool
3. Moisture content containers
4. Glass or plastic plate
5. Soil mixing equipment (dish, spatula, and water bottle)
6. Balance

#### Laboratory Soil Testing Procedure for Liquid Limit:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D4318 "Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils".*

1. Obtain a sample of air-dry, pulverized clay weighing 100 g.
2. Measure the height of the fall for the liquid limit device.
3. Place the air-dry soil in an evaporating dish and mix with 15 to 20 mL of distilled water, or until the soil is near the liquid limit.
4. Place the soil in the liquid limit device to a maximum thickness of 1 cm and smooth with a spatula.
5. Use a grooving tool to cut a groove into the soil.
6. Lift and drop the cup by turning the crank at a rate of about two drops per second until the groove closes along a distance of one-half inch.

7. Add soil and repeat process until the number of blows for closure is the same on two consecutive tests.
8. Record the number of blows on a data sheet.
9. Remove a slice of soil from the portion of soil that closed the groove together and place in a moisture content container to determine the water content.
10. Add more water to the soil as needed in order to perform the test three times with blow counts between five and 50.

Laboratory Soil Testing Procedure for Plastic Limit:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D4318 "Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils".*

1. Mix 15 g of air-dry soil with water so that the soil is slightly wet of the estimated plastic limit.
2. Roll the soil into a thread with a diameter of one-eighth inch on a glass or plastic plate.
3. Break the thread into six or eight pieces.
4. Squeeze the pieces together into a uniform mass and reroll to a thread with one-eighth inch diameter.
5. Repeat Steps 2-4 until the soil can no longer be rolled into a thread.
6. Gather the portions of crumbled soil together and place in a moisture content container to determine the water content.

#### **6.4 Specific Gravity (ASTM D854)**

Specified Equipment For This Soil Property Test:

1. 250 ml volumetric flask
2. 500 ml volumetric flask
3. Thermometer
4. Balance
5. Vacuum hoses with rubber stoppers to fit on volumetric flasks
6. Small vibratory table
7. Medicine dropper

### Laboratory Soil Testing Procedure:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D854 “Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer”.*

1. Obtain 150 g of soil, 50 g of which is used to measure specific gravity while the remaining soil is used to determine water content.
2. Weigh a clean, dry volumetric flask and record on a data sheet.
3. Pour 50 g of soil into the flask.
4. Fill the flask two-thirds full with distilled water.
5. Place the vacuum hose with rubber stopper on the neck of the flask and open the valve to apply a vacuum to the soil-water mixture.
6. Fill the flask to the etch mark with distilled water, using the medicine dropper near the end.
7. Use a paper towel to dry the outside of the flask and the inside of the neck above the water level.
8. Weigh the flask plus soil and water and record the mass on a data sheet.
9. Place a thermometer inside the flask to determine the temperature of the mixture and record on a data sheet.
10. Empty the soil from the flask, and repeat Steps 6-9 using only distilled water.

### **6.5 Standard Proctor (ASTM D698)**

#### Specified Equipment For This Soil Property Test:

1. Compaction mold
2. Compaction hammers
3. Soil mixer
4. Sharpened straight edge
5. Tools for breaking apart compacted samples (hammer, ice pick, etc.)
6. Extruder to remove samples from mold
7. Large scoop for handling soil
8. Balance
9. Oven
10. Moisture cans



### Laboratory Soil Testing Procedure:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D698 “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort”.*

1. Weigh out 3,000 g of air-dried soil.
2. Weigh the mold (not including the weight of the collar).
3. Determine the amount of water to add to the soil sample in order to obtain a specific, or known, water content.
4. Place the soil in the mixer and slowly add water to bring the water content of the soil to the desired value.
5. Remove the soil from the mixer and compact into the mold using three equal lifts and twenty-five blows for each lift with the compaction hammer.
6. Remove the collar and trim the soil flush with the top of the mold using a sharpened straight edge.
7. Weigh the mold plus the soil and record on a data sheet.
8. Extrude the soil from the mold using the extruder.
9. Cut the sample into three equal layers and place representative portions of soil from each layer into a moisture content container to determine water content.
10. Break the sample into reasonably fine pieces and place back into the mixer, adding water to achieve the next desired compaction water content. Repeat the process as necessary.

### **6.6 Hydraulic Conductivity-Rigid Wall (ASTM D5856)**

#### Specified Equipment For This Soil Property Test:

1. Permeameter
2. Two porous stones
3. Two pieces of filter paper
4. Vacuum hoses
5. Membrane expander
6. O-rings
7. Compaction mold
8. Compaction hammers

9. Soil mixer
10. Sharpened straight edge
11. Tools for breaking apart compacted samples (hammer, ice pick, etc.)
12. Extruder to remove samples from mold
13. Large scoop for handling soil
14. Balance
15. Oven
16. Moisture cans

Laboratory Soil Testing Procedure:

*The following section is based on ASTM standard D5856 “Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter”.*

1. Compact moist soil into a Standard Proctor mold following procedure outlined previously.
2. Record all physical properties of the soil sample on a data sheet.
3. Soak two porous stones and two pieces of filter paper in the permeating fluid until saturated.
4. Place one porous stone over the bottom plate of the permeameter cell and cover with filter paper.
5. Extrude the soil sample and place on top of the filter paper.
6. Place the remaining filter paper, porous stone, and top plate on top of the soil sample.
7. Place hydraulic grease around the outside of both top and bottom.
8. Place the membrane inside the membrane expander with at least two inches of excess at both ends.
9. Use a vacuum to expand the membrane.
10. Use the membrane expander to lower the membrane until the soil sample, top plate and bottom plate are encompassed.
11. Unclasp the vacuum line and allow the membrane to collapse around the sample.
12. Remove the membrane from the expander.
13. Fold the top and bottom of the membrane to remove any wrinkles.

14. Place two O-rings on one end of the membrane expander and place the membrane expander over the soil sample with the O-rings on the bottom of the expander.
15. Remove the O-rings so that the membrane is held tight against the top and bottom plates.
16. Secure the tail-water lines to the top plate.
17. Place the acrylic cover over the sample and secure with top cap.
18. Open the top valve to allow air to escape and fill the cell with water through the bottom valve.
19. Close both valves when water comes out the top.
20. Secure all lines from the pressure board to the cell.
21. Fill all three reservoirs with water, leaving at least two inches of air at the top of the reservoirs.
22. Set the cell water pressure to 10 psi, the head-water pressure to 8 psi, and the tail-water pressure to 6 psi.
23. Open the head-water valve that is connected to the head-water reservoir.
24. Open the head-water valve beside the first and allow the water to flow until all air bubbles are removed. Close both valves and repeat with the tail-water lines.
25. Open both the head-water and tail-water valves to allow the sample to saturate. Close both valves when air bubbles stop.
26. Drain the tail-water reservoir until there is only 1 cm of water.
27. Fill the head-water reservoir to 30 cm of water.
28. Measure the height of water in the head-water, tail-water, and cell-water reservoirs and record on a data sheet.
29. Set a time to start the test and turn both valves on at that time.
30. Record the height of water in the head-water, tail-water, and cell-water reservoirs as well as time of the readings and record on a data sheet.
31. Turn off both the head-water and tail-water valves when the head-water reservoir is nearly empty.
32. Take the last reading of the heights and the final time and record on a data sheet.

33. Disassemble the cell and take final moisture contents for the top, middle, and bottom layers of the sample.

## **6.7 Shear Strength (ASTM D3080/D3080M)**

### Specified Equipment For This Soil Property Test:

1. Shear device
2. Shear box
3. Porous stones
4. Device for applying and measuring the normal force
5. Device for applying and measuring the horizontal force
6. Timer
7. Deformation devices

### Laboratory Soil Testing Procedure:

*The following section is referenced from the CE 351 Introductory Soil Mechanics Laboratory Manual, Department of Civil and Environmental Engineering, West Virginia University. This procedure is based on ASTM standard D3080/D3080M “Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions”.*

1. Assemble the shear box in the direct shear frame, placing porous stones on top and bottom.
2. Place the loading cap.
3. Attach and adjust the vertical displacement measurement device.
4. Obtain an initial reading for the vertical displacement device and a reading for the horizontal displacement device. Record the measurements on a data sheet.
5. Consolidate the soil sample under the appropriate force.
6. Measure the vertical deformation as a function of time and plot the time-settlement curve to determine the time to 50 percent consolidation.
7. Shear the soil sample and take readings of the horizontal displacement until the shear force peaks, remains constant, or results in a deformation of 10 percent of the original diameter of the sample.

## **7.0 Data Management**

Field evaluation data and observations will be recorded during each site visit. Data will be written in evaluation forms and field notebooks, and a review will be conducted on-site to ensure that all items have been evaluated. Field signatures will be obtained for all personnel involved with the evaluation. Once field personnel return to the office, the evaluation form will be transferred to project computers located in the WVU Department of Civil and Environmental Engineering Soil Mechanics Laboratory. Times, dates, and personnel involved in data collection will also be recorded in field notebooks and transferred to the electronic data file. The electronic copies will be saved on an external hard-drive, and one back-up will be created. As needed, once the data is transferred to the electronic data file, a review of the information will be conducted and reported to the WVDEP as part of the monthly progress updates. Photographs will be used to assist with documenting field activities and conditions. All hardcopy and electronic records will be delivered to the West Virginia Water Research Institute (WVWRI) Project Manager for retention and will be made available to the WVDEP upon request. All raw and processed data will be made available to the WVDEP as part of the monthly progress updates and final reporting activities.

## **8.0 Data Reduction**

Following laboratory soil testing, the results will be compiled into a tabular format to allow for comparisons to permit reviews and other published site data. Reference of field and laboratory testing results to other engineering infrastructure activities will be made as a basis for comparison and analysis of the safety of the pits and impoundments. This analysis will lead to a determination of the suitability and relative importance of the findings. Graphical outputs will also be generated to illustrate data trends and meaningful observations.

## **9.0 Health and Safety**

Prior to conducting field evaluations, WVU personnel will be completing the 40-hour HAZWOPER (Hazardous Waste Operations and Emergency Response) training. On each field evaluation, at least four WVU personnel will be present. WVU personnel will abide by all safety and PPE requirements mandated by the company on whose site the field evaluations and soil collection is being conducted.

In compliance with WVU Environmental Health & Safety policies and HAZWOPER training requirements, all WVU personnel will undergo a medical screening to determine a medical health baseline for each member prior to any field work. WVU personnel will also receive medical screenings within one year of the project's completion. Further medical monitoring will be conducted if recommended by WVU's Department of Occupational Medicine.

Before each field evaluation, WVU field personnel will attend site safety meetings to identify potential hazards and all procedures in place in the event an incident/accident occurs. If a hazard or danger is found at a sampling site, the field personnel will exit without delay, and the situation will be immediately reported to the WVDEP.

## 10.0 References

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## Appendix A: WVU CEE Project Personnel

<b>Name</b>	<b>Role</b>	<b>Email</b>	<b>Office Telephone</b>	<b>Address</b>
John Quaranta	Principal Investigator	<a href="mailto:jdquaranta@mail.wvu.edu">jdquaranta@mail.wvu.edu</a>	(304) 293-9942	West Virginia University PO Box 6103 Morgantown, WV 26506-6103
Richard Wise	Research Engineer	<a href="mailto:richard.wise@mail.wvu.edu">richard.wise@mail.wvu.edu</a>	(304) 293-9947	West Virginia University PO Box 6103 Morgantown, WV 26506-6103
Andrew Darnell	Research Engineer	<a href="mailto:andrew.darnell@mail.wvu.edu">andrew.darnell@mail.wvu.edu</a>	(304) 293-9947	West Virginia University PO Box 6103 Morgantown, WV 26506-6103
Michael Kulbacki	Research Associate	<a href="mailto:mkulback@mix.wvu.edu">mkulback@mix.wvu.edu</a>	(304) 293-9947	West Virginia University PO Box 6103 Morgantown, WV 26506-6103
Matt Idleman	Research Associate	<a href="mailto:midlema1@mix.wvu.edu">midlema1@mix.wvu.edu</a>	(304) 293-9947	West Virginia University PO Box 6103 Morgantown, WV 26506-6103
Justin Pentz	Research Associate	<a href="mailto:jpentz1@mix.wvu.edu">jpentz1@mix.wvu.edu</a>	(304) 293-9947	West Virginia University PO Box 6103 Morgantown, WV 26506-6103

## **Appendix B: WVU Personnel Biographies**

### **John Quaranta, Principal Investigator**

John D. Quaranta, Ph.D., P.E. is an Assistant Professor with the Department of Civil and Environmental Engineering at West Virginia University. He has been involved with High Hazard dam safety projects in West Virginia since 2003. His research spanning 2003 to 2009 focused on improving dam structural safety and emergency action planning. His current research involves identifying risk reduction options based on consequences of failure scenarios in downstream communities for dams located in mountainous terrain.

Dr. Quaranta has developed and implemented dam safety training manuals and exercise programs; exercise reports on emergency action plan training; technical publications related to high hazard dam safety; and has attended or participated in dam safety workshops/seminars, all related to the steep mountainous terrain of West Virginia.

### **Richard Wise, Research Engineer**

Richard Wise is from Morgantown, West Virginia, and graduated from West Virginia University in December with a Master's Degree in Geotechnical Engineering. While attending graduate school, he worked on a project with the United States Army Corps of Engineers where he created inundation maps and served as an evaluator for an emergency exercise. In addition to a Master's Degree, he also received a Bachelor's Degree with a minor in mathematics from West Virginia University in 2010. Throughout his undergraduate education, he was member of the engineering honor society, Tau Beta Pi, and interned with the Natural Resources Conservation Service and the West Virginia Department of Transportation.

### **Andrew Darnell, Research Engineer**

Andrew Darnell is a West Virginia native, originally from Morgantown and currently living in Bruceton Mills. He graduated from West Virginia University with a Bachelor's Degree in Civil Engineering in 2010 and a Master's Degree in Civil Engineering in 2011. His thesis was based on a project with the United States Army Corps of Engineers, in which he created time-stepped inundation maps for a potential dam failure. Before attending graduate school, he completed two summer internships with the Pennsylvania Department of Transportation, where he served as a construction inspector and as an intern in the environmental design unit. He also interned with the Natural Resources Conservation Service, assisting with earthen dam modeling and rehabilitation studies.

**Michael Kulbacki, Research Associate**

Michael Kulbacki received a Bachelor of Science degree in Civil and Environmental Engineering from West Virginia University in 2012. He was a member of the West Virginia University Rifle team from 2008-2012; achievements during this duration include a National Championship (2008) and a three time All-American. Michael will attend West Virginia University's Graduate Program to seek a Master's Degree in Geotechnical Engineering.

**Matt Idleman, Research Associate**

Matt Idleman, from Keyser, West Virginia, received a Bachelor of Science degree in Civil and Environmental Engineering from West Virginia University in 2012. He is Treasurer of Chi Epsilon (Civil Engineering Honors Society), as well as an active member of the American Society of Civil Engineers, and a leader in the Mountaineer Maniacs organization, which is the largest student club on campus. Matt is currently planning to continue his schooling in pursuit of his Master's Degree.

**Justin Pentz, Research Associate**

Justin Pentz received a Bachelor of Science degree in Civil and Environmental Engineering from West Virginia University in 2012. He was a member of the West Virginia Rifle Team from 2008-2012; achievements during his duration include a Team National Championship in 2009 and a four-time individual All-American. Justin will attend West Virginia University's Graduate Program to seek a Master's Degree in Geotechnical Engineering.