Safety Protocols for Soil Sampling

Summary

Many people believe that soil sampling contains little risk, but this is not true. Soil sampling techniques available involve shovels, hand augers, backhoe pits, hydraulic direct push probes, and drill rigs that advance hollow stem augers. Some of the potential risks include sampling in areas containing buried utilities, pit cave-in, equipment failure, dehydration, muscle skeletal injury, and allergic reactions to plants and insect stings. The purpose of this section is to discuss the applicability of soil sampling methods and key safety issues associated with these methods. Each of these methods can have significant safety hazards, some of which can result in long-term injury or death. The safety protocols presented should be a starting point for project planning.

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As we explore key safety issues, a set of recommended Safety Protocols (SP) is presented (Table 1). Some references on universal safety issues related to safe soil sampling are OSHA (1989), ASTM (1997), and "Drilling Safety Guide" (Diamond Core Drill Manufacturers Association, 2001).

Table 1. Recommended Safety Protocols. This list is not exhaustive.

SP1	An organization or work group should have a safety program. Safety should be the foundation of each work plan and activity. Our goal must be that each of us can return to our families at the end of each work day.
SP2	Locate the presence of all utilities in the work area before digging.
SP3	Know the address where you are working and make sure others know this address.
SP4	Use the buddy system.
SP5	Know the biological hazards in the work environment and make sure coworkers communicate about any known personal life-threatening allergies and where specialized first aid materials are located.
SP6	Only enter confined spaces in compliance with industry-established procedures and with proper air-sampling, ventilation, engineering controls, and emergency retrieval systems in place.
SP7	Plan for, have available, and use appropriate personal protective equipment.

Safety Protocol 1
An organization or work group should have a safety program.

Safety should be the foundation of each work plan and activity. Our ultimate goal must be that each of us can return to our families at the end of each work day.

- At a minimum, workers should have the equivalent of Red Cross First Aid Training. Training is available for a minimum charge from the local chapter of the American Red Cross or from other private vendors.
- Each work place, vehicle, and personal equipment pack should be equipped with an appropriate first aid kit that contains the materials likely to be needed for first aid in that work environment.

Soil Science: Step-by-Step Field Analysis
Sally Logsdon, Dave Clay, Demie Moore, and Teferi Tsegaye, editors

Safety Protocol 2
Locate the presence of all utilities in the work area before digging.

- Call 811 or your local utility hotline to have publicly owned utilities located and marked.
- Contact private vendors and others, such as property owners, to locate probable locations of private utilities.
- After utilities are marked, walk the site and make sure that what is marked makes sense. Are there gas meters, water meters, or transformers that do not have utilities marked between them and a structure?

Utilities may be publicly owned, crossing right-of-ways on public or private property, or may be privately owned. Privately owned utilities may include water lines, natural or liquefied petroleum gas lines, sewer lines, etc. between the point of public ownership and the point of use such as between a water or gas meter and a structure.

As prescribed by federal law managed by the U.S. Department of Transportation, every state has some form of state-mandated program for the pre-location of buried utilities. Typically, there is a requirement for the operator of the excavating equipment (the company, agency, or homeowner) to contact the published 800 number and request that utilities be located. Usually there is a notification requirement of 48 to72 hours before the scheduled work. There can be strict fines, as well as civil liability, for failure to comply. These fines are often levied if phone lines, gas lines, power lines, or other utilities are damaged and/or personal injury occurs. Compliance is important because right-of-ways for subsurface utilities can cross undeveloped tracts of land and may no longer be clearly marked. Examples of these are high-pressure natural gas lines, fiber optic lines, and water lines.

As of April 2007, the telephone number 811 can be dialed nationwide in the U.S. and the call will be forwarded to the local call center. Information is available on the Internet at http://www.call811.com, a webpage providing a consortium of utility industry stakeholders called Common Ground Alliance. This webpage has local contact numbers for each area of each state and additional information.

Safety Protocol 3
Know the address where you are working and make sure others know this address.

It is common for soil investigators to work in remote areas without access to 911 coverage, either from land telephone lines or cell phones with global positioning system (GPS) coverage. The daily work plan should list a street address, GPS coordinates outlining a proposed work area, or other means of identifying the work location. This work plan should be left with someone at home or work who will know how to find us if we do not return at the appointed time. It is also important to know the address of where we are working as a team in the event someone is injured on-site. Driving directions should be in the job file at the office and on-site.

Safety Protocol 4
Use the buddy system.

Ideally we should work in teams so that if someone is injured or is ill, help can be obtained. If the buddy system is not possible, it is imperative that someone knows where we are working and when they should expect us to return. Development of this discipline can be life saving.

Safety Protocol 5
Know the biological hazards in the work environment and make sure coworkers communicate about any known personal life-threatening allergies and where specialized first aid materials are located.

A key component of work site safety is protection from organisms that cause allergic or other severe reaction, including plants, bees, snakes, and ticks. All of these organisms can be present at the work site and the work force should take adequate precautions and be prepared to respond to the unexpected. Some individuals are highly allergic to bee venom and require immediate administration of antihistamine drugs to prevent fatal reaction. If you have these allergies, it is imperative that you communicate this to your team members and friends. Carry the prescription drugs for self administration and make sure family and co-workers know where they are and how to use them. It is important to know that bee venom contains complex organic acids; therefore, application of a baking soda paste or mild bleach solution is a very important first aid step and often stops a reaction. These first aid steps should always be used as our bodies may develop allergic responses of increasing magnitude over time in response to each subsequent event.

Poison ivy, poison oak, poison sumac, and other plants have oils to which many are allergic. (See http://www.poison-ivy.org for pictures of some of these plants and the allergic reactions.) If the work area includes exposure to these plants, use protective clothing to minimize exposure. Wash exposed skin with soap and water as soon as possible. Inhaled smoke from campfires or burning brush piles (or wild fires) that contain these plants may cause severe, even fatal, damage to lung tissue.

Safety Protocol 6
Only enter confined spaces in compliance with industry-established procedures and with proper air-sampling, ventilation, engineering controls, and emergency retrieval systems in place.

Sampling at some sites can present exposure to soil gas or chemical contamination. Workers should be familiar with confined spaces, their properties, and the dangers they can present. Confined spaces and regulations are well defined by the U.S. Occupational Safety and Health Administration (OSHA). Training materials are available at http//www.OSHA.gov and from many private vendors. One very common property of confined spaces is the potential for the absence of adequate levels of oxygen to sustain human life and/or the presence of organic or other chemicals that are acutely toxic. A good example is a well vault. When a low pressure weather system passes through an area, the earth "exhales." A well containing hydrogen sulfide gas may "exhale" into the well vault, resulting in an at-

mosphere that may be immediately fatal if breathed. Well vault accidents are common in cold regions, where subterranean well houses are often used.

The atmosphere inside farm silos or manure pits can be anoxic. It is very common for three to five people to die in these accidents as family members and coworkers rush to assist someone they assume to have succumbed to heart failure.

Other examples of common confined spaces include a work trailer or lab where a volatile chemical is spilled, a septic tank, pump vault, sewer line, or storage tank.

Appropriate personal protective and air sampling equipment is imperative. This may include air-purifying respirators, chemical-resistant suits, or engineering controls such as a fan to move air away from a drill hole. While these techniques and equipment may be common to the environmental consulting community, the research community must be especially vigilant because of the typical inexperience of the student population and some technical staff.

Safety Protocol 7
Plan for, have available, and use appropriate personal protective equipment.

An important part of task planning is to verify that adequate personal protective equipment is in place. Selection of the personal protective equipment is based on the sampling equipment used, the terrain at the work site, weather, and other expected hazards. This may include adequate clothing for winter months, proper footwear, hard hats, eye and ear protection, communications equipment, and clothing that can be removed and disposed of if biological or chemical contamination is encountered. Soiled clothing can be a path for carrying contamination back to our homes and work places, impacting unsuspecting individuals.

Shovels and Hand Augers

Shovels and hand augers are the common tools of a scientist or soil evaluator who has limited capital resources or needs to access remote areas. These tools rely on the physical ability of the user to dig a hole. Holes are typically limited to a depth of about 4 feet, but hand augers may be extended to depths of 8 to 10 feet (~2.4–3 meters).

Use of a shovel or auger can cause acute damage to the user's back or other muscles, especially if the operator is not used to using the equipment and/or is not in good physical condition. Care should be taken if the user has any history of disk damage or other back problems. In this case the user should consult a physician prior to engaging in digging work.

Stretching before and after use can be helpful. If sharp pain or other evidence of back problems occurs, the augering or shoveling should be stopped immediately and medical treatment should be sought.

Technique is important. The legs should be used to pull an auger from the ground. Only a limited amount of turning should be done with each lowering of the auger to limit the amount of friction that must be overcome to remove the bucket from the hole. Chronic health problems associated with personnel using augers (i.e., a soil mapper, environmental health officer, or consultant) include

damaged rotator cuff injuries, disk damage, and chronic tendonitis. Investing in mechanically powered equipment or adoption of policies requiring the client to pay for or provide use of a backhoe are important options for protecting the long-term well-being of the soil investigator.

Soil sampling using a shovel or auger is a physically demanding activity. Adequate hydration is important, especially in summer months. Care must be taken by the investigator and any team members present to avoid succumbing to heat stress or heat stroke, a life-threatening situation.

Soil Pits

Mechanical excavation of soil pits is an extremely effective technique to overcome the concerns listed above and to increase productivity, but soil pits do involve their own safety issues:

- Potential to encounter buried utilities or structures
- Danger of collapse and potential burial of an investigator in a pit
- Danger to someone standing too close to the backhoe
- Danger to the backhoe operator
- Danger when operating on steep slopes, slippery slopes, or in the woods

Collapse

OSHA and related state agencies regulate the construction industry and limit the depth of excavations that can be entered depending on several conditions. Generally, an excavation that is not shored and is not sloped cannot be entered if the trench or pit is more than 4 feet deep (~1.2 meters). This depth can be shallower in fill material, wet soils, or sandy and stony soils. Pit collapse is especially of concern because it is common for a soil investigator to bend over in the pit and sample the lower parts of the pit. If the soil caves in, a ton or more of soil may bury a person, resulting in asphyxiation. Pits should be sloped back or shored appropriately (per OSHA 29 CFR 1926; OSHA, 1989). If at all possible, pits should not be deeper than 4 feet (~1.2 meters).

Inadvertent Burial

A soil consultant was buried alive and died in a pit in Virginia. The consultant was describing a pit on a lot adjacent to one that a backhoe operator was tasked to close pits on. The backhoe operator apparently was not aware that the pits were present on two separate lots and pushed the pit full of soil, with the consultant at the bottom. A safety

Word from the Field

After being in the consulting business for about two years, I decided to offer a summer job to my neighbor, a college senior. On the afternoon I called to offer him a job, he had started working for a local developer who had their own excavating crew. At almost the same time I was calling his home to offer him the job, the work crew sent "the new guy" back into a 15-foot-deep utility trench to retrieve a forgotten shovel. The trench caved in and he never received my call. Not only were many laws violated, but common sense was violated, resulting in a tragic loss. This tragedy became the heartfelt driving force for the commitment to safety in our company these last 20 years.

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flag or other system of communication should be used. If a machine arrives or starts working on or near the site that he or she is investigating, the soil investigator should immediately get out of a pit and make contact with the operator. Backhoe operators should be trained never to close a pit without checking to make sure there is no one in it.

Safe Observation of Backhoe Operations

No one should stand within the reach of the swing of the backhoe boom when the boom is fully extended. This is typically an arc that has a radius of 12 to 20 feet (~3.6–6 meters), depending on the machine. It is common for a bystander to be lulled into complacency by an experienced operator running a piece of machinery. However, backhoe booms, which move much faster than the reaction time of a bystander, have the potential for a deadly amount of momentum.

If a backhoe is moving through an area with standing or fallen trees, or is pushing over trees, observers should stay at a substantial distance because a tall tree can knock down another tree, potentially injuring someone 50 feet (~15 meters) or more from the machine. Observers are best to be well upslope or across the slope from a moving or operating machine. If a machine moving down or across a slope overturns, it may strike an observer standing 15 or 20 feet (~4.5–6 meters) downhill of the machine.

Hard hats should be worn by all observers and equipment operators. Seat belts should be worn by equipment operators to ensure that they remain within the roll-over protection system of their machine in the event of an upset. Nothing should be pitched into the cab of a running backhoe. In one documented incident, someone threw a piece of pipe into a running backhoe. The pipe landed on a control lever and the resulting movement of the machine fatally injured the operator.

Fig. 1. A skid-mounted direct push probe using a hydraulic percussive hammer and a split spoon.

Hydraulic Push Probes

Hydraulic push probes have been common soil sampling tools for more than 50 years. Modern designs (Fig. 1) now include units that advance the sampling tube with hydraulic percussive force. These tools have

become mainstays of both the scientific and environmental sampling communities, especially in soils that are not excessively stony. Typically the sample tube is called a split spoon (Fig. 2).

Push probes typically load the steel push rods with tremendous force. Care must be taken to use protective shields and to maintain a safe operating distance. Hard hats, safety glasses, steel-toed boots, and ear protection should be worn when percussive units are used.

A concern often overlooked with units powered by hydraulic oil is the potential for rupture of a hydraulic hose or fitting. Safety glasses should always be worn when operating this equipment for this reason. Exposure of body parts to a pressurized oil, air, or water stream can result in severe injury or death.

Fig. 2. An opened split spoon with the soil core that has been collected.

Hollow Stem Auger Units (Drill Rig)

These units tend to be powered by either direct drive or hydraulic drive (Fig. 3) and have the capability of delivering both high levels of rotational force and vertical force. They should only be operated by trained staff. Hard hats, eye protection, ear protection, and steel-toed boots are required for safe operation. This safety equipment is also required for any observers, such as soil scientists, geologists, or property owners.

Fig. 3. A drill rig capable of drilling to 100 feet or more with hollow stem augers, rock coring equipment or air rotary equipment for collection of soil, rock, and water samples.

The units typically are operated by advancing a hollow stem auger (a pipe with auger flights wrapped around it) into the soil. A center stem is retracted, a sampling device (usually a split spoon) is attached to the end of the stem and the stem is then driven with a drop hammer. The drop hammer may either be attached to a rope wrapped around a spinning cathe-

ad on the rig or preferably a more modern safety (hydraulic) hammer.

Drill rigs pose danger from many sources. These dangers include, but are not limited to, frayed cables, cathead ropes, hydraulics, rig upset, and objects falling from the mast. As the hollow stem augers often weigh 100 to 150 pounds, augers should be lifted with winch cables when loading and unloading the auger string to and from the hole. When they must be manually handled, two people should handle them to minimize the risk of back injury. As with use of hand augers, many back injuries can be prevented with good physical conditioning programs and stretching programs. Loose clothing or unrestrained hair, which has the potential for getting caught in the rotating auger and to draw the person into the equipment, must be avoided. Gloves should always be worn to protect the hands from cuts and abrasions from sharp metal and frayed cable.

Summary

Sampling of soil and sediments is accomplished by a variety of methods. Each of these methods poses safety hazards that must be mitigated by good management and worker practice.

Obviously, as the level of mechanization increases, the potential for more catastrophic injury occurs. Safe work practice starts with safety education and awareness. Commitment by management and workers to safe work practices results in higher productivity and long-term worker ability both on and off of the job.

References

ASTM. 1997. ASTM Standards on Environmental Sampling. ASTM ENVSAMP-97. ASTM, West Conshohocken, PA.

Diamond Core Drill Manufacturers Association, National Drilling Association, National Ground Water Association-Drill Rig/Heavy Equipment Product Group and Safety Subcommittee. 2001. Drilling safety guide. International Drilling Association, Brunswick, OH.

Occupational Safety and Health Administration. 1989. 29 CFR Part 1926 Occupational Safety and Health Standards—Excavations: Final Rule: Part II. October 31, 1989. U.S. Dep. of Labor, Washington, DC.

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