1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for solid stem auger drilling investigations. Solid stem auger drilling is a rotary drilling method which advances an auger assembly below the ground surface at a low velocity rotation. As drilling progresses additional auger flights can be added to form a continuous flight. Soil samples can be collected from the lead auger after it is brought to the surface. Monitoring wells can be installed in the borehole as long as sloughing is limited. This drilling method is well suited for relatively soft or loose, shallow unconsolidated soil deposits. Drilling and/or sampling difficulties may be encountered during drilling in dense soils or soils with cobbles and boulders, and in loose sandy deposits below the water table. The workable maximum drilling depth of the solid stem auger (SSA) method is dependent on soil type, depth of water table, characteristics of the drill rig, and the drillers' technique, but is commonly about 20 m to 30 m in good conditions and much less in some soil types. Deeper penetrations may be achieved with the combination of ideal drilling conditions, and drill rig. Disturbed samples are collected directly from the augers flights or, alternatively, less disturbed samples can be obtained from down-hole techniques provided the borehole does not collapse when the augers are removed.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on solid stem drilling investigations is provided in Part D1 – Soil Sampling, which must be used in conjunction with the information provided in this SOP. Guidance documents, the Environmental Management Act (EMA) and the Contaminated Sites Regulation (CSR), are available on the Contaminated Sites webpage at:

https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-remediation/contaminated-sites

The Water Sustainability Act (WSA) and the Groundwater Protection Regulation (GPR) are available at the following webpage:

https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/laws-rules/groundwater-protection-regulation

Solid stem drilling conducted within the provincial jurisdiction of BC for regulatory purposes must be carried out with consideration to the WSA, the GPR, the CSR, Part D1 and Part E2 of the BC Field Sampling Manual, and this document.

2. Quality Control

- Refer to individual SOPs for appropriate quality control requirements for soil sample collection and handling and/or monitoring well installation.
- Follow equipment decontamination procedures outlined below to minimize the potential for cross contamination between samples or boreholes.
- Ensure that field notes (including field logs) are legible (recorded in ink where possible) and complete.
- Retain all field notes to ensure information reported is accurate and defensible.
3. Recommended Equipment and Materials

Field Equipment provided by driller:
1. Drill rig with solid stem augers and associated equipment;
2. High pressure washing equipment;
3. Methanol and mild detergent solution;
4. Bentonite and/or grout; and
5. Monitoring well construction materials (PVC pipe, silica sand, bentonite/grout, well protection casing, cement).

Field Equipment provided by personnel:
6. Results of previous field investigations, including borehole logs;
7. Other sample tools as appropriate (refer to SOP’s as appropriate);
8. Suitable sample storage containers for the potential contaminants of concern (PCOC);
9. Digital camera/cell phone camera;
10. Site plan and underground utility location plan(s);
11. Field notebook;
12. Field log sheets;
13. Writing and marking utensils; and

Personal Protective Equipment (PPE) and Safety Equipment:
15. CSA approved steel toed work boots or steel toed rubber boots;
16. Hard hat;
17. High visibility safety vest (when working around heavy equipment and traffic areas);
18. Long sleeves and long pants;
19. Gloves (appropriate to potential contaminants of concern; typically new, clean nitrile);
20. Eye protection (must meet client or site specific requirements for potential hazards, i.e., goggles if splash hazard, etc.);
21. Hearing protection (if heavy equipment or other potential sources of noise will be present);
22. First aid kit applicable to size of project;
23. Eye wash station;
24. Respirator (if applicable); and,
25. Fire/chemical retardant coveralls (if applicable).

4. Procedures

1) Preparation: Obtain authorization to access the site if needed, and confirm that physical access to the site is possible (e.g., gates unlocked). Arrange subcontractors for traffic control, if required. Confirm the locations of underground and above ground services with all utility companies, BC OneCall, and underground utilities locates drawings. Confirm meeting time with the drilling subcontractor and review the list of required equipment. Assemble personal protective equipment, sampling tools, and data collected previously at or near the site. Review and understand the drilling objectives and scope of work. Ensure that arrangements have been made for the storage and or disposal of soil cuttings and fluids from decontamination/washing.

2) Arrival On Site: If this is the first site visit, complete a reconnaissance of the project area, noting safety hazards, overhead services, site layout, topography, adjacent property, and equipment on site. Confirm the accuracy of the existing site plan, or keep sufficient notes so that a site plan can be developed. Take photographs and observe unexpected conditions which may impact the planned investigation (e.g., access problems). Note the names of subcontractors and record the equipment used on site. Visually inspect subcontractor’s equipment for cleanliness and proper working order [e.g., frayed cables, leaking hydraulics, required safety equipment (power kill switch, fire extinguishers, etc.)]. Organize sample containers and prepare...
3) **Drilling Description:** A solid stem auger flight comprises a plugged or solid steel cylinder around which is welded a steel strip in the form of a helix. When connected, the flights form a continuous helix. The lead auger is equipped with a cutting head which typically is slightly larger in diameter than the auger column. The entire drilling assembly is connected to a drill head on the drill rig, and boreholes are advanced by a combination of rotation and downward pressure. Additional auger sections are added as required to form a continuous auger string. Auger flights are typically in 1.5 m (5 ft) sections, but drilling may be stopped at any depth for sampling. Solid stem auger sections are available in a range of diameters, and are specified by the nominal diameter of the drill head. Borehole advancement is usually in 1.5 m to 3.0 m (5 ft to 10 ft) increments depending on in-situ soil conditions. Between increments the entire auger string is withdrawn for sample collection and soil classification.

4) **Core Logging and Sampling:** Begin drilling at the ‘clean background’ location if included in the drilling program. If a background location is not included in the drilling program drilling should begin at a location that theoretically is the site’s cleanest location proceeding to more contaminated locations. For a reasonable determination of sample depth, the augers must be advanced into the ground at a rate equal to the pitch of the helix (i.e., ensure that the augers are not over or under rotated). If the turning rate of the augers is too fast relative to the auger advancement, soil cuttings are "stretched" upwards from the drill bit, and accurate depth determination is not possible. Consideration should be given to collecting samples at changes in stratigraphy which can be inferred from changes in drilling action or cuttings, where visual or olfactory evidence of contamination is present, or at predetermined depths. Samples are obtained from the soil retained on the auger flight of the lead auger. To obtain representative sample material, scrape the face of the soil on the flight and collect samples from the freshly exposed material. Refer to soil collection SOP’s for specific sampling details.

If the borehole remains open and clean (i.e., minimal sloughing or caving) samples may be collected by pushing or driving a sampling device into the undisturbed formation in front of the auger head, using the drill rig hydraulics, or a drop hammer. Sampling devices which can be used include the split spoon sampler (split-barrel drive sampler), Shelby tubes, piston samplers, Geoprobe®, ring-lined barrel sampler, or modified versions of the above. Precaution should be taken to avoid drilling through low permeable soil horizons resulting in cross contamination of underlying soils and groundwater.

6) **Drill Cuttings:** Excess drill cuttings are typically produced during drilling, or upon auger removal. Drill cuttings should be stockpiled, covered with plastic, or placed in barrels for later characterization and/or disposal. If placed in barrels, the barrels should be clean, open top steel drums, suitable for storing and transporting the type and weight of material (typically 17H standard) produced on site. The barrels should be labeled with the consultants’ and clients’ names, the date, and a list of boreholes from which the cuttings originated. The location and number of barrels used should be recorded in field notes. In certain circumstances, cuttings may be returned to the borehole as backfill; however, this is only to occur with the client’s approval, and requires that the cuttings be uncontaminated and of a granular nature suitable for use as backfill.

6) **Borehole Completion:** If a monitoring well is to be installed, refer to SOP E2-2 for instruction. Otherwise, the borehole should be backfilled with bentonite/grout as site-specific conditions or client preferences warrant. In accordance with the Groundwater Protection Regulation a surface seal of bentonite or grout, at least 1 m thick if possible, should be placed at the ground surface of the drill hole to minimize infiltration of surface water to the drill hole. Backfilling with drill cuttings is to be avoided. Cuttings represent a preferential vertical pathway, and contaminated cuttings placed in a borehole could result in groundwater contamination. Cuttings used as backfill in drill holes often consolidate or settle with time. The settled subsurface can become a safety hazard to pedestrian traffic. As such, in areas of pedestrian traffic, the drill hole should be completed with a concrete plug at the ground surface if cuttings are used as backfill.

8) **Location Survey:** At a minimum the borehole/monitoring well location should be accurately located relative to permanent site features and recorded in field notes and site plans. Generally, the location’s northing, easting, ground elevation and top of casing elevation will also be surveyed or recorded with a GPS (including the level of
9) **Equipment Decontamination:** Between each use, sampling devices must either be manually cleaned or cleaned with a high pressure steam cleaner to remove visible contamination or residual soil attached to the core barrel. Sampling devices should be visually inspected for cleanliness after washing. If an oily or tar-like residual film or smearing remains scrub the equipment with methanol, followed by scrubbing/rinsing using a laboratory grade detergent solution, followed by a double rinse with water. At some sites, it may be required that wash liquids are collected for later disposal.

At the completion of each borehole, all down-hole equipment (augers) must be cleaned with a high pressure steam cleaner to remove visible contamination and residual soil stuck to the augers. The augers should be elevated off the ground (e.g., on lumber or work horses) during and after cleaning to prevent recontamination from the ground or spray-back during cleaning. If necessary, manual cleaning with stiff brushes, solvents and/or water may be required to remove stubborn soil and/or contamination. At some sites, it may be appropriate to collect wash liquids for later disposal.

10) **Store or dispose of all wastes** (liquids, cuttings, used gloves and materials) in an appropriate manner and leave the site in a tidy condition.

5. **References**


**Revision History:** 0.0 (New document)

**Approval**