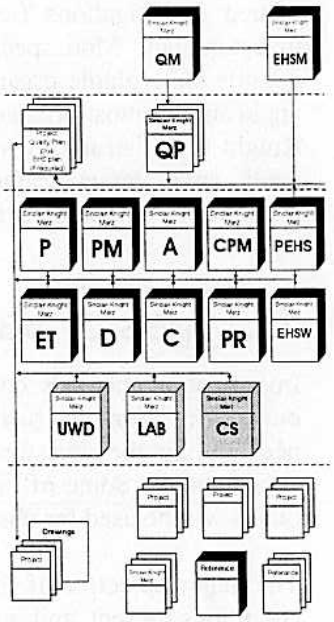
Contents - Contaminated Site (CS) Work Instructions



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1. Introduction

This environmental soil sampling standard operating procedure (SOP) was developed to orient and assist Sinclair Knight Merz employees in the collection and handling of soil samples for hazard waste-related investigations (referred to as environmental sampling herein) rather than geotechnical investigations. More specifically, the document outlines environmental sampling procedures for semi-volatile and volatile organic compounds in soil. In general, the practices described in this SOP are applicable to most organic and inorganic contaminants that are encountered during a typical Sinclair Knight Merz hazardous waste investigation. Although many of the geotechnical sampling principles apply, environmental sample stresses immediate containment and preservation of the soil to minimise the loss of contaminants through volatilisation as well as proper documentation and handling of the soil.

2. Types of Sampling Methods and Samples

Investigation methods commonly used during the completion of environmental investigations are outlined in Work Instruction No. 4. Once an investigation method has been selected, there will be need during the investigation to collect soil samples representative of the sub-surface conditions encountered. Some of the soil samples will be collected for subsequent laboratory analysis, while others will be used for observing and logging of the sub-surface conditions.

The major objective of soil sampling is to collect a sample that is representative of the sub-surface conditions present, and in particular, the chemical composition of the sample should be representative of the chemical composition of the sampling interval. Therefore, considerable care needs to be taken during the investigation and collection of the sample not to introduce chemical compounds to the sample. The field supervisor needs to closely monitor the investigation methods to ensure that the integrity of the samples and to ensure the potential of cross-contamination of samples is minimised.

For a detailed review of some of the sampling methods, the reader references are listed above, however, methods commonly used in environmental investigations are discussed below.

Soil sampling used routinely in environmental investigations can be broken into four main types:

1) Drive sampling methods where a sampler is hammered (drive) into the soils.
2) Push sampling methods where a sampler is pushed into the soils with the sample recovered when the sampler is recovered.
3) Continuous sampling methods where a sampler can be used to obtain a continuous core of soil.
4) Grab sampling where a sample is collected from soil brought to the surface during drilling, test pitting operations, directly from the face of a test pit or soil exposure or is collected from a soil stockpile.

From the various types of sampling methods, two main types of sample are collected.

i. *Disturbed samples* are samples where the soil has been disturbed loosing its natural soil structure, moisture and physical properties. Disturbed samples are collected from drive sampling, continuous samples can be collected by push sampling methods.
ii. *Undisturbed samples* are samples where the soil remains more-or-less in its undisturbed state, retaining its natural soil structure, moisture content and physical properties. Undisturbed samples can be collected by push sampling methods.

From a geotechnical view, where they are concerned with the physical properties (eg. strength, permeability, etc.) of soils, it is important to know whether a sample is disturbed or undisturbed as this can effect the types of physical testing that should be undertaken on soil samples.

Normally, from an environmental contamination view, whether a sample is disturbed or undisturbed is not that important, as we are normally mainly concerned about the chemical composition of the soil samples. Generally, the chemical composition of a soil sample would not be expected to change if it is undisturbed, apart from the possibility of significant disturbance may lead to loss of some volatile compounds. However, there may be situations when we are concerned with the physical properties of the soils and may wish to undertake physical testing of the soils (eg. permeability testing to assess the expected flow rates of contaminants through the soil) when it may be necessary to obtain undisturbed soils samples.

Therefore, it is necessary before commencing a field investigative program, to clearly understand the objectives of the study, and sampling and testing requirements in order to select the appropriate sampling methodologies.

Samples collected during investigations may be either *discrete samples* or *composite samples.* Discrete samples are samples collected over a discrete sampling interval that is representative of that interval, but based on observations and may also be assessed to be representative of the surrounding soils. Composite samples comprise a sample that is made up of a series of sub-samples from a range of locations, material types or depth intervals. Composite samples are representative of the composite sample, therefore, actual contaminant concentrations may be higher than laboratory results in some sub-samples and lower in other sub-samples.

Composite samples should be prepared in accordance with the details given later in this General Operating Procedure.

3. Equipment

This section lists various types of equipment that can be used to collect surface and sub-surface soil samples. In addition, several instruments used in the monitoring of contaminated soils for volatile organic compounds during soil sampling are mentioned.

3.1 Samplers

Commonly used surface and sub-surface samplers include:

Drive Samplers:
- Standard Penetration Test (SPT) sampler

Push Samplers
- Shelby tube

- U50 and U75 tubes

Continuous Samplers:
- Core barrels
- Drive and push samplers used continuously

Grab Samplers:
- Hand augers
- Shovel and towel

These various sampling methods and the associated procedures for use are discussed below.

3.2 Field Monitors

It is common in most environmental investigations to undertake field monitoring to provide information on contamination levels. Most of this field equipment is used for the detection and monitoring of volatile vapours and gases. Field equipment monitors include:

- Organic Vapour Analysers (OVA), which include photo ionisation detectors (PID) and flame ionisation detectors (FID)
- Combustible Gas Indicator (CGI)
- Toxic Gas Monitors

4. Sampling Methods

4.1 Drive Sampling Methods

Drive sampling methods can be used in conjunction with hollow-stem and solid stem auger and various rotary-drilling techniques. The drive sampler can be lowered down the centre of the hollow stem augers and rotary drill rods, but if using solid stem augers, the augers will need to be removed before the sampler can be inserted to the base of the borehole. Drive samplers include the Standard Penetration Test (SPT) split spoon samplers. The split spoon samplers are driven 450mm into the ground using a standard 760mm drop of a 63.5kg hammer.

Before attaching the sampler to the drill rods, the sampler splits and any other parts that are likely to come into contact with the soil should be checked to see that they are clean and free from contamination. If there is any doubt, it should be decontaminated before use.

When the borehole has been drilled to the required sampling depth, the drive sampler is attached to the drill rods and lowered to the base of the borehole. (Note that, if drilling with solid stem augers, a check should be made so that the drive sampler is at the base of the hole and that the hole has not caved in. If the sampler is not within 50mm of the base of the hole, the sampler should be withdrawn and augers placed down the hole to clean it out.) When the sampler is at the base of the borehole, mark the rods at the top of the borehole or drill rods, and mark off 3 x 150mm intervals above this. Count the blows for each of the 150mm intervals and record each separately, and add the number of blows for the last two intervals (300-400mm) to obtain the penetration resistance "N".

For example: 4, 6, 15 N = 19

The first 150mm interval is considered to be the seating drive. If the sampler is driven less than 450mm, this should be recorded on the log with the number of blows before penetration is achieved. The standard penetration resistance "N" provides information on the density of uncohesive soils (sand) and strength of cohesive soils (clays and silts). There are numerous reference charts, which provide this information for the SPT sampler.

As stated above, samples recovered from the standard split spoon, are altered by the driving action and are considered to be "disturbed" samples. Upon retrieval of the SPT sampler, the sampler can be broken open and the soils monitored with an Organic Vapour Analyser (OVA), logged and sub-samples transferred to appropriate sample jars for subsequent laboratory testing. The sampler is then decontaminated, and reassembled for the next sampling event. One disadvantage of the SPT sampler is that the soil comes into direct contact with the splits. Which are commonly rusty and have been used on numerous occasions for collection of contaminated soils samples, thus, even with good decontamination procedures there is still potential for cross-contamination of the soils samples. Therefore, it is necessary to ensure that the splits, and core catcher, are properly decontaminated (steam clean is the preferred method) before reuse.

As decontamination can take some time to properly complete, having a second sampler or even second set of splits present will keep the drilling moving along at a good rate. Once the first sampler is removed, the second one can be used, and drilling can commence straight away, while sampling from and decontamination of the second sampler is carried out.

Drive samplers can be used to obtain samples at selected intervals or for continuous sampling of unconsolidated soils. They cannot normally be used in rock. Sub-surface soil samples are generally retrieved at regular intervals (ie, every 0.5m or 1.5m) or at changes in strata. However, if during drilling, more data is needed to fully evaluated conditions, such as stratigraphy or the extent of a contaminated soil zone, then additional samples should be obtained or continuous sampling can be undertaken using the drive sampler. If continuous sampling is undertaken using the drive sampler, after the completion of each sampling event, the borehole should be advanced to the level of the base of the last sample, before proceeding to the collection of the next sample.

If a sample is lost during retrieval, then the sampler should be driven again before continuing ontot the next sampling interval. In uncohesive sediments, a core catcher will probably be required to prevent the sample from falling out of the sampler during its recovery. In some situations where the soils are loose and granular, it may not be possible to recover a sample. However, an idea of the composition of the soils can be obtained by close inspection of the inside of the splits (a small amount of soil tends to remain in the split).

Duplicate samples can be collected from the recovered soil sample by slicing segments of the recovered core into longitudinal sections over the one sampling interval and transferring soil from each side of the equivalent section intervals to separate containers. The duplicate sample can be saved for additional laboratory testing, if required, or for further inspection.

4.2 Push Sampling Methods

Push tube sampling involves the use of a thin walled, open ended, tube sampler, which has a bevelled cutting edge on the bottom of the tube. Push tube sampling methods can be used in conjunction with hollow stem auguring, solid stem auguring, the various rotary drilling techniques, hand augers, and with backhoes and excavators in test pits of trenches and hand operated systems can be used in soft soils and sediments.

A range of push tube samplers exist, including the Shelby tube, U50 (51mm ID tube) and U75 (76mm ID) tubes, Dimension sampler, and Pitch sampler.

4.2.1 Sampling with Drilling Rig

Thin walled sampling tubes can be connected to a sample boss or adaptor attached to drilling rods (generally A sized rods). Like drive sampling, the thin walled tube attached to the drill rods can be lowered down the centre of the hollow stem augers and rotary drill rods, but when using solid stem augers, these will need to be removed from the borehole.

The cutting edge of the thin walled sampling tube is normally recessed to give a slightly reduced internal diameter at the point of sample entry. This recessing allows the sample to slide more freely into the sample tube, but permits some swelling of the sample.

Before attaching the sampler to the drill rods, the sampling tube and any other equipment likely to come into contact with soil should be checked to see that it is clean and free of contamination. If there is any doubt, it should be decontaminated before use.

The sample boss or adaptor is normally fitted with ports to permit the escape of water or air as the sample is pushed in and also contains a non return valve to assist with sample retention during removal of the sample. If the samples are continually lost during retrieval, these should be checked to see that they are functioning correctly.

When the borehole has been drilled to the required sampling depth, the thin walled sampler is lowered on the drill rods to the base of the borehole. (Note that, if drilling with solid stem augers, a check should be made so that the drive sampler is at the base of the hole and that the hole has not caved in. If the sampler is not within 50mm of the base of the hole, the sampler should be withdrawn and augers placed down the hole to clean it out.) When the sampler is on the base of the borehole, mark the rods attached to the sampler at the top of the borehole or drill rods and measure off and mark the required distance to be pushed (this should be about 0.1-0.15m less than the length of the sampler). The rods attached to the sampler should be attached to the head of the drilling rig and using the weight of the drilling rig or the hydraulics, if necessary, the sampler should be pushed to the required distance into the soils at the base of the borehole.

If the sampler reaches refusal measure the achieved penetration and record on log sheet. Remove the sampler.

Upon retrieval of the thin walled sampler, clean any loose material off, measure the recovery and monitor the soils for organic vapours with an Organic Vapour Analyser (OVA) and log the soils. The sample should be trimmed, and sealed with teflon sheeting placed over each end and, if possible, plastic caps should then be fitted over the teflon sleeve ends. The plastic caps should then be sealed with teflon or electrical tape. The sample should then be place "deep" end down in a plastic sample container, sealed, and labelled.

Alternatively, the sample may be pushed out of the tube and transferred to appropriate sample containers.

Push sampling can be used to obtain samples at selected intervals or for continuous sampling of unconsolidated cohesive soils. They cannot normally be used in rock or in uncohesive soils. Sub-surface soil samples are generally retrieved at regular intervals (ie, every 0.5m or 1.5m) or at changes in strata. However, if during drilling, more data is needed to fully evaluate conditions such as

stratigraphy or the extent of a contaminated soil zone, then additional samples should be obtained or continuous sampling can be undertaken using the push sampler. If continuous sampling is undertaken using the push sampler, after the completion of each sampling event, the borehole should be advanced to the level of the base of the last sample before proceeding to the collection of the next sample.

If a sample is lost during retrieval, the hole should be cleaned out and then the sampler should be driven again before continuing onto the next sampling interval.

Duplicate samples can be collected from the recovered soil sample and pushed out of the tube by slicing segments of the recovered core into longitudinal sections over the one sampling interval and transferring soil from each side of the equivalent section intervals to separate containers.

4.2.2 Sampling with Hand Auger and Backhoe

As stated above, push sampling using thin walled tube samples can be collected from shallow hand auger holes or from test pits excavated with a backhoe or excavator.

The sampling method is similar to that detailed above, except that it is usually necessary to drive the thin walled tubes with a sliding hammer or by blows from a sledge hammer. It is possible with a backhoe or excavator to hammer the tube slightly into the ground, then push the tube into the soils using the bottom of the bucket. When doing this, care need to be taken to push the tube straight into the soil (the operator will need guidance, as he will not be able to see the tube). Remember that you should not enter a trench or pit over 1.5m deep unless it is shored up.

Alternatively, it is sometimes possible, in cohesive soils, to obtain with the backhoe, a large bulk sample from the test pit of the trench. When this is brought to the surface, it may be possible to hammer a tube into this sample.

The sample handling, labelling, and preservation requirements are as discussed above.

4.2.3 Sediment Samplers

It is also possible to collect push tube samples from very soft soils and sediments, both above and below the water surface. Such samples are usually obtained using a piston sampler or sediment sampler, both of which operate on the same principle. This is to push the sampler into the ground, then create a vacuum to hold the sample in the sampler while withdrawing the sampler and sample form the soil.

A piston sampler may be one complete unit with a thin walled sampler permanently attached to the sampler, or alternatively a thin walled sampler may be able to be attached and removed.

The piston sampler and sampling tube are pushed through soft soils to an undisturbed layer with the piston positioned at the bottom of the sample tube. The sample tube is then pushed into the ground, at the same time the piston is pulled up, until it reaches the top of stroke. The piston is then kept at a constant level and the piston sampler is withdrawn. Contact of the sample with the piston helps keeps the sample in the tube. Piston samplers are normally used in soft deposits and are pushed into the ground rather than driven.

Once the sample has been recovered, the soil tube can be removed and the ends sealed, and the complete tube kept for future reference or forwarded to a laboratory for chemical analysis. Alternatively, the core can be extruded, logged, monitored with an OVA and sub-samples transferred

to appropriate sample jars for storage and/or laboratory analysis. Use of a clear thin walled tube allows the identification of any layering (which can be of particular importance for sediment samples) before extrusion of the sample.

With use casing, which can be advanced as sampling proceeds, it is possible to extend the sampling to depth.

4.3 Continuous Sampling Methods

As discussed above, continuous sampling can be undertaken using both driven and push sampling methods. However, a disadvantage of these systems is that they require the hole to be drilled out to the base of the last sample, before the next sample can be collected. This can result in very slow drilling, which means that it becomes fairly expensive.

However, the use of a continuous sampling system, utilising a small split tube core barrel with hollow stem auger drilling methods provides a much more effective method of continuous sampling. The core barrel, which comprises a barrel, drill bit, core catcher and split spoons, that is inserted inside of and at the base of the augers while drilling, recovers a soil core, which determines the length of the drilled interval. The bore barrel is recovered after each interval is drilled.

Representative sub-samples of the soil can be transformed to appropriate sample containers for future reference and/or laboratory analysis or the entire length of the soil cores shall be placed in core boxes, should it be necessary to retain them. If placing the core in core boxes, it is possible that samples may be collected at a future time for laboratory analysis, the core box should be lined with an inert material to prevent cross-contamination of the soil core.

Photographs can also be taken of the soil core for future reference.

After the soil core has been removed from the sampler, it should then be decontaminated, and reassembled for the next sampling event. One disadvantage of the continuous sampler is that the soils come into direct contact with the splits, which are commonly rusty and have been used on numerous occasions for collection of contaminated soil samples, thus even with good decontamination procedures, there is potential for cross-contamination of the soil samples. Therefore, it is necessary to ensure that the splits, bit and core catcher are properly decontaminated (steam cleaning is the preferred method) before reuse.

As decontamination can take some time to properly complete, having a second core barrel or even set of splits, drill bit and core catcher present, will keep the drilling moving along at a good rate. Once the first core barrel is removed, the second one can be used and drilling can commence straight away, while sampling from and decontamination of the second core barrel is carried out.

4.4 Grab Samples

Grab samples can be collected from distributed soils. Common situations of where grab samples can be collected include:

- drill cuttings
- surface sampling
- soil from test pit
- soil stockpile