Field Sampling Manual for Reactive Sulphide Tailings

MEND Project 4.1.1

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FIELD SAMPLING MANUAL FOR REACTIVE SULPHIDE TAILINGS

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Table of Contents

Table of Contents

Table of Contents

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

A fundamental requirement for the monitoring and study of natural environments is the ability to collect high-quality samples of solid, liquid, and gaseous phases. It is through the collection of such samples that analyses can be performed to define existing undisturbed conditions or to delineate impacts of human activity. The collection of high-quality samples is the first step in the overall process of environmental protection and, if an acceptable sample cannot be obtained, then the subsequent tasks of analysis, interpretation, and response may be of little benefit. In recognition of this importance, the Mine Environment Neutral Drainage (MEND) Program has commissioned Canect Environmental Control Technologies Ltd., a subsidiary of Norecol Environmental Consultants Ltd., to prepare this manual of sampling methodology.

A major environmental concern today is the disturbance of natural environments by human activities which result in the development of acidic conditions. This disturbance occurs during industrial activity where air emissions result in acidic rainfall and during mining and excavation where reactive sulfide minerals are exposed to the atmosphere. It is an objective of the MEND Program to examine the evolution of acidic conditions during mining activity. Acidic conditions at a minesites can develop in rock piles, on mine walls, and in tailings impoundments which hold the waste products from ore processing. This manual specifically addresses sampling methods for tailings impoundments and their surrounding basins.

A multidisciplinary environmental study in the vicinity of a tailings impoundment involves the collection of solid, liquid, and pore-gas samples. These samples may be used for physical, chemical, and microbiological analysis and must be of high quality with minimal disturbance. The optimum methods for collection of high-quality samples are dependent on such factors as site-specific conditions and equipment availability, which preclude the development of a rigid prescriptive guide for sampling methodology. The collection of high-quality samples may not even be feasible at some impoundments, requiring a compromise on quality. As a result, this manual is designed to offer guidance and recommendations on the selection of appropriate sampling methodology while recognizing the importance of site-specific conditions and the value of on-site decision making. Emphasis is placed on maximizing sample quality by minimizing both sample disturbance and artificial contamination during sampling. Because subsurface environments are often chemically reducing (anoxic), a significant source of sample disturbance and contamination is exposure to the atmosphere.

This manual contains several indexes in Chapter 2 to summarize the solid, liquid and pore gas phase methods according to such factors as the type of required equipment and the degree of isolation from the atmosphere. A flowchart is also presented in Chapter 2 to summarize the indexes and to guide the selection of potentially appropriate methodology.

The methods for collection of samples in this manual are divided into three primary chapters covering solid, liquid, and pore-gas phases. The concise presentation of each method explains the objectives, descriptions, advantages and disadvantages. Chapter 3 presents the methods for collecting solid-phase samples, divided into the general categories of (1) heavy-powered equipment including drill rigs, (2) light-powered equipment including samplers used in association with drill rigs, and (3) hand-operated equipment. Many of these methods for solid-phase sampling provide the necessary borehole or excavation needed for subsequent collection of subsurface groundwater and pore gas using piezometers, wells, and gas ports. Chapter 4 describes the methods for collecting liquid-phase samples, divided into categories on the basis of (1) collecting a sample during drilling, (2) physically separating water from a solid-phase sample, (3) sampling from a well installed after drilling (4) sampling from installations established independently of drilling and (5) retrieving a groundwater sample using a pump or bailer. In Chapter 5, methods for sampling pore gas are grouped on the basis of (1) collecting a sample during drilling, (2) establishing sampling ports after drilling, (3) installing sampling ports independently of drilling, and (4) employing a syringe sampler or on-site autoanalyzer.

Chapter 6 contains a summary of quality control recommendations for the collection of high - quality solid, liquid and pore-phase samples. The chapter is based on the individual recommendations in Chapters 3, 4 and 5.

CHAPTER 2
INDEXES AND FLOWCHART FOR METHOD SELECTION

The goal of this manual is to assist in the selection of potentially appropriate sampling methodology for solid, liquid, and pore-gas phases in the vicinity of a tailings impoundment. In order to meet this goal, Chapter 2 presents indexes and a flowchart summarizing relevant characteristics of the 22 solid sampling methods of Chapter 3, the 24 methods for liquid phases in Chapter 4, and the 8 methods for pore gas in Chapter 5. The indexes and flowchart are categorized on the basis of phase, location relative to land or water surface, available equipment, isolation from the atmosphere, and disturbance during sampling.

The following are three simplified case histories to familiarize the reader with the use of the flowcharts.

a) **High integrity solid and liquid samples are required for the edge of a tailings pond to determine the acid generation potential of the solids and the groundwater quality of immediately below the water table. The water table is approximately 4 m below the surface.**

Index 2-2 lists the available methods for both solid and liquid samples in the subsurface. For the liquid samples a high degree of isolation is desired from the atmosphere and other types of contamination and the appropriate methods are listed in Index 2-4. For the solid sample methods resulting in a low degree of sample disturbance during collection are required (Index 2-5). Both heavy and light powered equipment are available for the study (Index 2-3). The flowchart in Appendix 2-6 simplifies this selection process.

Therefore, a split-spoon sampler within a hollow stem auger is selected to obtain the solid samples at specific depth intervals. The liquid samples are obtained from an observation well installed after solid sampling. The groundwater is obtained using a piston pump sampler.

b) **Solid sampling at the surface of a tailings impoundment is required to determine the acid generation potential of the solids. The surface is not stable for heavy or light powered equipment. The degree of sample disturbance or degree of isolation from the environment is not important for this program, the budget is minimal and site access is limited.**

A shovel is selected for sampling at the surface of the tailings impoundment. (Index 2-6)

c) **A high quality liquid sample is required to determine the water chemistry in the vadose zone adjacent to a tailings impoundment.**

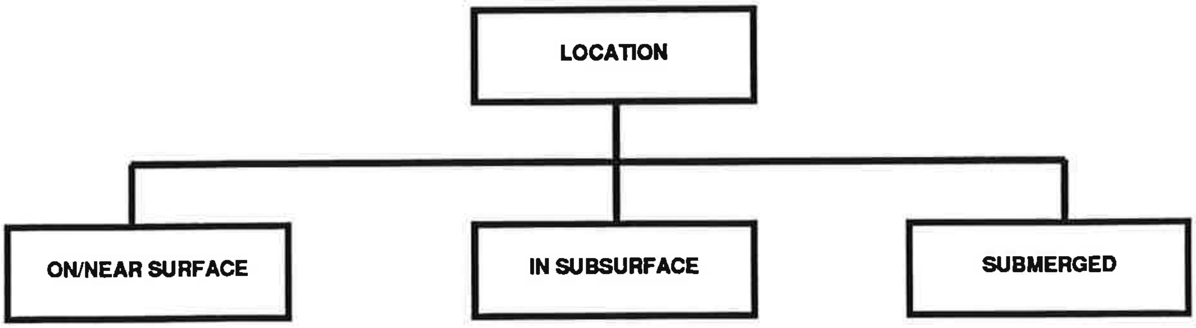
A high quality teflon suction lysimeter is selected to obtain a water sample from the vadose zone. (Index 2-4, 2-6).

INDEX 2-1
Phases To Be Sampled
(Solid, Liquid, Pore-Gas)

PHASE

SOLIDS	LIQUIDS	PORE-GAS
Auger	In-filling of drill stem	Sampling port extended beyond stem
Rotary Drill	Advance intake past drill stem	Single level port
Hammer Drive	Centrifugation of solids	Multiple level ports
Cable Tool	Pressurized consolidation of solids	Closed-circuit ports
Trenching	Porewater displacement from solids	Drive-point ports
Split spoon	Monitor well	Syringes
Shelby tube	Piezometer, single and multi-level	Autoanalyzer
Piston sampler	Suction lysimeter	
Vibrating core drill	Drive-point piezometer	
Gravity coring of submerged samples	Surface-water grab	
Grab sampling of submerged samples	Streambed seepage meter	
Shovel/Bucket	Wash boring/jetting	
Hand auger	Peristaltic pump	
Hand-driven corer	Centrifugal pump	
Gravity core, submerged samples	Gas-driven pump: single, double, triple tube	
University of Sherbrooke block sampler	Piston pump	
Core-freezer sampler	Bladder pump	
Sampling box for exposed samples	WaTerra pump	
	Syringe sampler	
	Bailer: single, double valve	

INDEX 2-2
Location of Desired Sample Relative to Land/Water Surface (Surface, Subsurface, Submerged)



ON/NEAR SURFACE

- Trenching
- Shovel/Bucket
- Hand auger
- Hand-driven corer
- Surface-water grab
- Sampling box for exposed samples

IN SUBSURFACE

- Auger
- Rotary Drill
- Hammer Drive
- Cable Tool
- Split spoon
- Shelby tube
- Piston sampler
- Vibrating core drill
- University of Sherbrooke block sampler
- Core-freezer sampler
- Using drill stem
- Separation from solid phase
- Following solid sampling
- Independent of solid sampling
- Pumps and Bailers
- Sample collection devices

SUBMERGED

- Gravity coring
- Grab sampling
- Seepage meters
- Surface-water grab
- Sampling box

INDEX 2-3
Exent of Available Powered Equipment
(Hand, Light-powered, Heavy-powered)

HEAVY-POWERED	LIGHT-POWERED	HAND OPERATED
Auger	Trenching	Shovel/bucket
Rotary Drill	Split spoon	Hand auger
Hammer Drill	Shelby tube	Hand-driven coring
Cable Tool	Piston sampler	Gravity core submerged
Water sampling using drill stem	Vibrating coring	Sampling box for submerged sampling
Pore gas sampling using drill stem	Gravity coring	Sampling box for exposed samples
	University of Sherbrooke block sampler	Surface water grab
	Core-freezer sampler	Streambed seepage meter
	Grab sample of submerged samples	Water sample by WaTerra pump
	Water sample by electrical or gas-driven pumps	Water sample by bailer
	Pore-gas sampling/analysis by autoanalyzer	Pore-gas sample by syringe

INDEX 2-4
Degree of Desired Isolation from the Atmosphere and Other Contamination[a]

LOW	HIGH
Solids	**Solids**
Auger flights	Split spoon (with inner liner)
Rotary drill	Shelby tube, sealed
Hammer drive	Piston sampler
Cable tool	Vibrating coring, with inner liner
Trenching	Gravity coring, submerged, with liner
Grab sampling	University of Sherbrooke block sampler
Sampling box for submerged sampling	Core-freezer sampler
	Sampling box for exposed samples
Liquids	**Liquids**
In-filling of drill stem	Advance intake beyond drill stem
Centrifugation	Piezometer
Pressurized consolidation	Seepage meter
Porewater displacement	Peristaltic pump
Monitor well	Piston pump
Suction lysimeter	Bladder pump
Surface-water grab	WaTerra pump
Wash-boring/jetting	Syringe sampler
Centrifugal pump	Bailer, double valve (with modifications)
Gas-driven pumps	
Bailer, single-valve	
Pore-Gas	**Pore-Gas**
Port extended beyond drill stem	Single port
	Multiple port
	Closed-circuit port
	Syringe sampler
	Autoanalyzer
	Auto analyzer

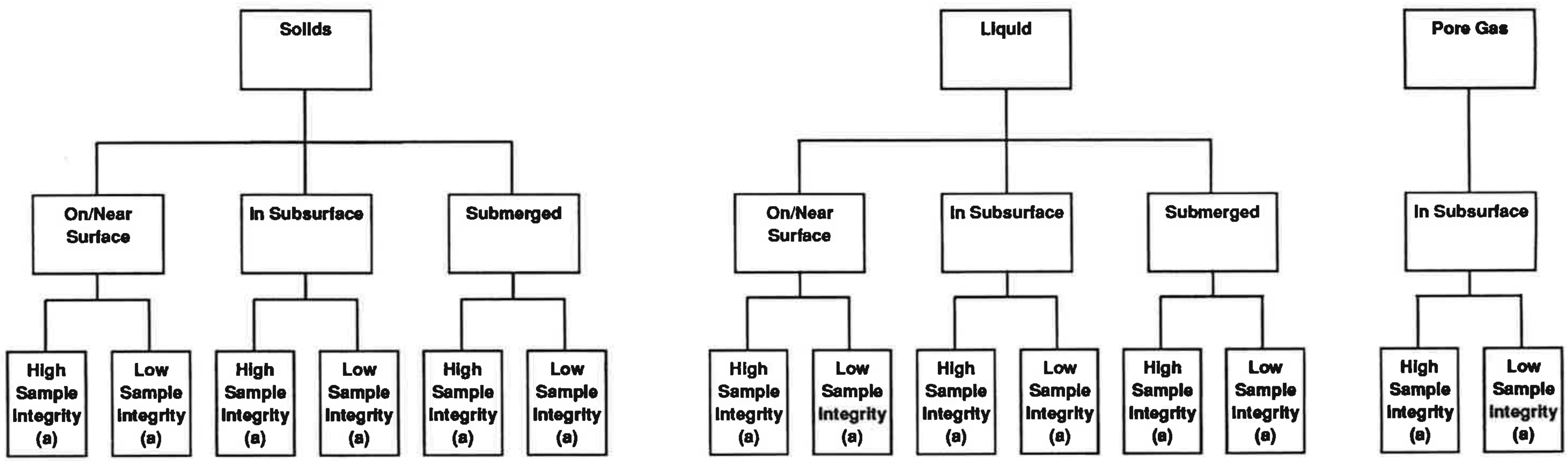
a This rating is a qualitative in nature and will vary with equipment, site conditions, and operator.

INDEX 2-5
Degree of Sample Disturbance during Collection[a]
(Low, Moderate, High)

LOW	MODERATE	HIGH
Solids	**Solids**	**Solids**
Split spoon	Rotary drill, core barrel	Auger
Shelby tube	Hammer drive	Rotary drill
Piston sampler	Trenching	Cable tool
University of Sherbrooke block sampler	Grab sampling, submerged	Hand auger
Vibratory coring	Shovel/bucket	
Hand-driven core	Core-freezer sampler	
Gravity coring, submerged		
Sampling box for submerged sampling		
Sampling box for exposed samples		
Liquids	**Liquids**	**Liquids**
Surface-water grab	Advance intake beyond stem	In-filling of stem
Streambed seepage meter	Pressurized consolidation	Centrifugation
Peristaltic pump	Porewater displacement	Wash-boring/jetting
Piston pump	Monitor well installation	Gas-driven pumps (single tube)
Bladder pump	Piezometer installation	
Syringe sampler	Suction lysimeter	
Bailer, double valve	Centrifugal pump	
	Gas-driven pumps (double tube, triple tube)	
	WaTerra pump	
	Bailer, single valve	
Pore-gas	**Pore-gas**	**Pore-gas**
Closed-circuit (with autoanalyzer)	Withdrawn from advanced intake beyond stem	
Closed-circuit (with syringe)	Single-level port (with autoanalyzer)	
Single-level port (with syringe)	Multiple-port (with autoanalyzer)	
Multiple port (with syringe)	Collector for migrating pore gas	

[a]This rating is qualitative in nature and will vary with equipment, site conditions, and operator

INDEX 2-6
Flowchart for Sampling Methods



a This rating is qualitative in nature and will vary with equipment, site conditions, and operator.
b H - handheld sampler
c L - lightpowered
d P - heavy powered

CHAPTER 3
SAMPLING OF SOLID PHASE

The collection of most solid-phase samples in the vicinity of tailings impoundments requires access to the subsurface. Subsurface rock and sediment consist of a porous solid matrix with pore space filled by gases, water, or a combination of both. Equipment for the collection of solid-phase samples varies from lightweight, hand-operated samplers to truck-mounted samplers. These criteria of weight and complexity represent the primary level of classification in this chapter.

3.1 Heavy Powered Equipment

3.1.1 Auger

3.1.1.1 Hollow stem

OBJECTIVES:

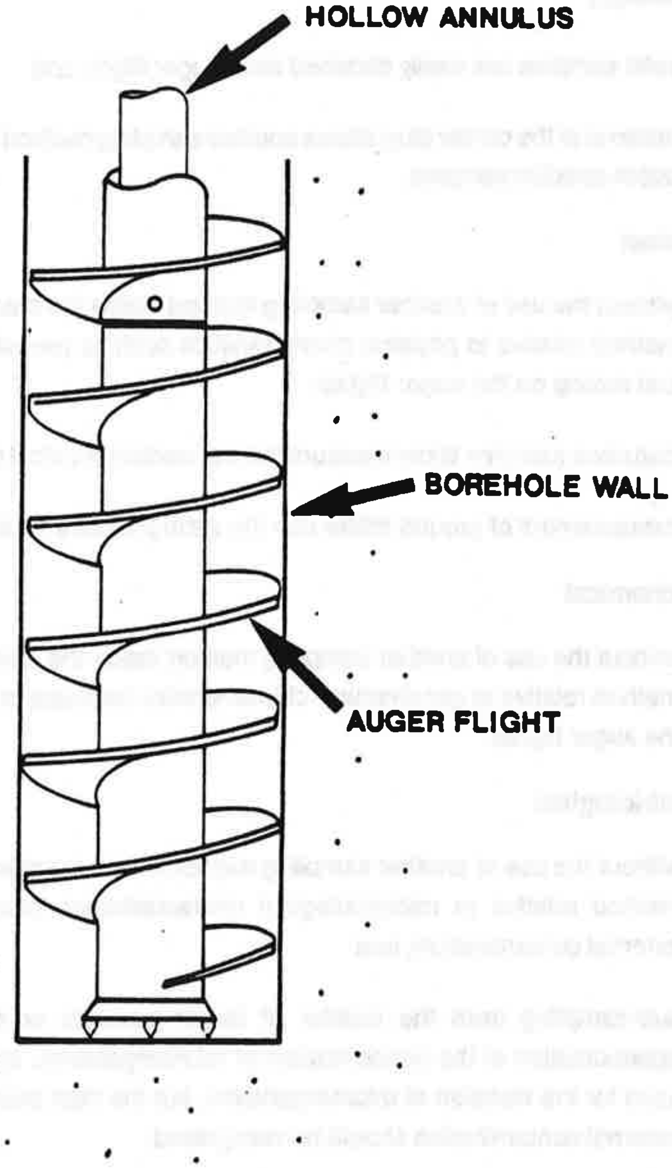
- to bring solid-phase samples to the surface on auger flights for solid-phase analysis;
- to allow depth-specific sampling of the solid phase using other methods inside the hollow stem (Section 3.2);
- to allow depth-specific sampling of the liquid phase inside or beyond the hollow stem (Section 4.1);
- to provide a solid sample for the extraction of porewater (Section 4.2);
- to permit installation of piezometers and wells (Section 4.3);
- to allow depth-specific sampling of the pore-gas phase inside or beyond the hollow stem (Section 5.1); and
- to permit installation of permanent gas-sampling installations (Section 5.2).

DESCRIPTION:

The auger stem (Figure 3.1.1-1) penetrates the subsurface sediments through a combination of stem rotation and downward force on the stem, provided by the auger rig. Occasionally, the auger stem is rotated without downward pressure or the stem is lifted then lowered a few feet to prevent entrapment of the stem by the sediment. As rotation occurs, cuttings are brought to the surface on the auger flights. These cuttings represent the solid-phase samples provided by this method. At any selected depth, the center plug can be removed from the auger stem and another sampling method, such as a split spoon or water pump, can be used inside the stem to obtain depth-specific samples of the solid, liquid, or pore-gas phases.

This method cannot be used in rock formations and has difficulty penetrating coarse-grained formations such as gravel and cobbles. If the auger rig is equipped with rotary-drill capability, the center plug can be removed from the stem and a rotary rock bit can be lowered inside the stem and rotated to shatter sporadic coarse material.

Hollow stem augers can be used with larger-diameter casing, but the hollow stem inherently provides many of the advantages of casing including depth-specific sampling and temporary borehole stabilization.



HOLLOW-STEM AUGER	
Figure no. **3.1.1-1**	**MEND TAILINGS SAMPLING MANUAL**
Date **Aug. 1989**	Drawn by **CANECT**

ADVANTAGES:

General

- there is relatively fast penetration of fine-grained sediments, particularly unconsolidated tailings;
- solid samples are easily obtained from auger flight; and
- removal of the center plug allows another sampling method to be used inside the stem to obtain depth-specific samples.

Physical

- without the use of another sampling method inside the stem, there are few advantages of this method relative to physical characteristics such as porosity because of sample disturbance and mixing on the auger flights;
- disturbed samples allow measurement of certain physical parameters such as grain size; and
- measurement of ground inflow into the stem provides an indication of hydraulic conductivity.

Geochemical

- without the use of another sampling method inside the stem, there are few advantages to this method relative to geochemical characteristics because of sample disturbance and mixing on the auger flights.

Microbiological

- without the use of another sampling method inside the stem, there are few advantages to this method relative to microbiological characterization because of cross-contamination and external contamination; and
- sub-sampling from the interior of larger particles or clumps of materials can give an approximation of the concentration of microorganisms, and this method of sampling can be used for the isolation of microorganisms, but the high probability of cross-contamination and external contamination should be recognized.

DISADVANTAGES:

General

- penetration of rock and coarse-grained sediments is not possible; and
- depth limitation is approximately 30 metres.

Physical

- samples brought to the surface on auger flights are altered from their in-situ physical condition and physical parameters such as porosity are changed; and
- samples brought to the surface on auger flights may be mixed with material at shallower depths.

Geochemical

- samples brought to the surface on auger flights are altered from their in-situ geochemical condition;
- samples brought to the surface on auger flights may be mixed with material at shallower depths; and
- at the surface, samples are exposed to the atmosphere and oxidizing conditions.

Microbiological

- samples brought to the surface on auger flights may be contaminated with microorganisms originating at shallower depths; and
- as the samples are unprotected from the atmosphere, samples containing low concentrations of microorganisms can be sufficiently contaminated to distort the true in-situ microbiological characteristics.

SELECTED REFERENCES

Keely, J.F., and K. Boateng. 1987. Monitoring well installation, purging, and sampling techniques - Part 1: Conceptualizations. Ground Water, 25, p. 300-313.

3.1.1.2 Solid stem

OBJECTIVES:

- to provide solid phase samples brought to the surface on auger flights for solid-phase analysis;
- to allow depth specific sampling of the solid phase using other methods in stable boreholes (Section 3.2);
- to provide solid phase samples for the extraction of porewater (Section 4.2);
- to permit installation of piezometers and wells (Section 4.3) if the borehole is stable; and
- to permit installation of permanent gas-sampling installations (Section 5.2) if the borehole is stable.

DESCRIPTION:

The solid stem is similar in design and operation to the hollow stem (Section 3.1.1.1), except that the stem is solid metal. As the stem is rotated, cuttings are brought to the surface on the auger flights. The cuttings represent the solid-phase samples provided by this method. At any selected depth, the auger stem can be removed and, if the borehole is stable, another sampling method (Section 3.2) can be used inside the borehole to obtain depth-specific solid-phase samples.

This method cannot be used in unconsolidated rock formations or in unconsolidated coarse grained sediments such as gravel and cobbles. In loose non-cohesive materials, casing is required to prevent collapse of the borehole during stem withdrawal, and to prevent contamination of deep samples by materials falling from shallow sections of the borehole.

ADVANTAGES:

General

- there is relatively fast penetration of fine grained sediments, particularly unconsolidated tailings; and
- solid samples are easily obtained from auger flights.

Physical

- without the use of another sampling method inside the borehole, there are few advantages to this method relative to physical characteristics such as porosity because of sample disturbance and mixing on the auger flights; and
- disturbed samples allow measurement of certain physical parameters such as grain-size and mineralogy.

Geochemical

- without the use of another sampling method in the borehole, there are few advantages of this method relative to geochemical characteristics because of sample disturbance and mixing on the auger flights.

Microbiological

- without the use of another sampling method inside the bore hole, there are few advantages to this method relative to microbiological characterization because of cross-contamination and external contamination; and
- sub-sampling from the interior of larger particles or clumps of materials can give an approximation of the concentrations of microorganisms and this method of sampling may be used for the isolation of microorganisms, but the high probability of cross-contamination and external contamination should be recognized.

DISADVANTAGES:

General

- penetration of rock and coarse-grained sediments is not possible;
- depth limitation is approximately 30 metres;
- borehole instability in non-cohesive material such as some types of tailings may require the use of casing; and
- use of other sampling methods (Section 3.2) requires the removal of the stem from the borehole.

Physical

- samples brought to the surface on auger flights are altered from their in-situ physical condition and physical parameters such as porosity are changed; and
- samples brought to the surface or auger flights may be contaminated with materials at shallower depths.

Geochemical

- samples brought to surface on auger flights are altered from their in-situ geochemical condition;
- samples brought to the surface on auger flights may be contaminated with material at shallower depths; and
- at the surface, samples are exposed to the atmosphere and oxidizing conditions.

Microbiological

- Samples brought to the surface on auger flights may be contaminated with microorganisms originating at shallower depths; and
- as the samples are unprotected from the atmosphere, samples containing low concentrations of microorganisms can be contaminated sufficiently to distort the true in-situ microbiological characteristics.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

3.1.2 Rotary Drill

3.1.2.1 Forward circulation

OBJECTIVES:

- to provide solid-phase samples brought to the surface by air, water or mud for solid phase analysis;
- to allow depth specific sampling of solid phase using other methods inside the borehole (Section 3.2);
- to permit installation of piezometers and wells (Section 4.3); and
- to permit permanent gas sampling installations (Section 5.2).

DESCRIPTION:

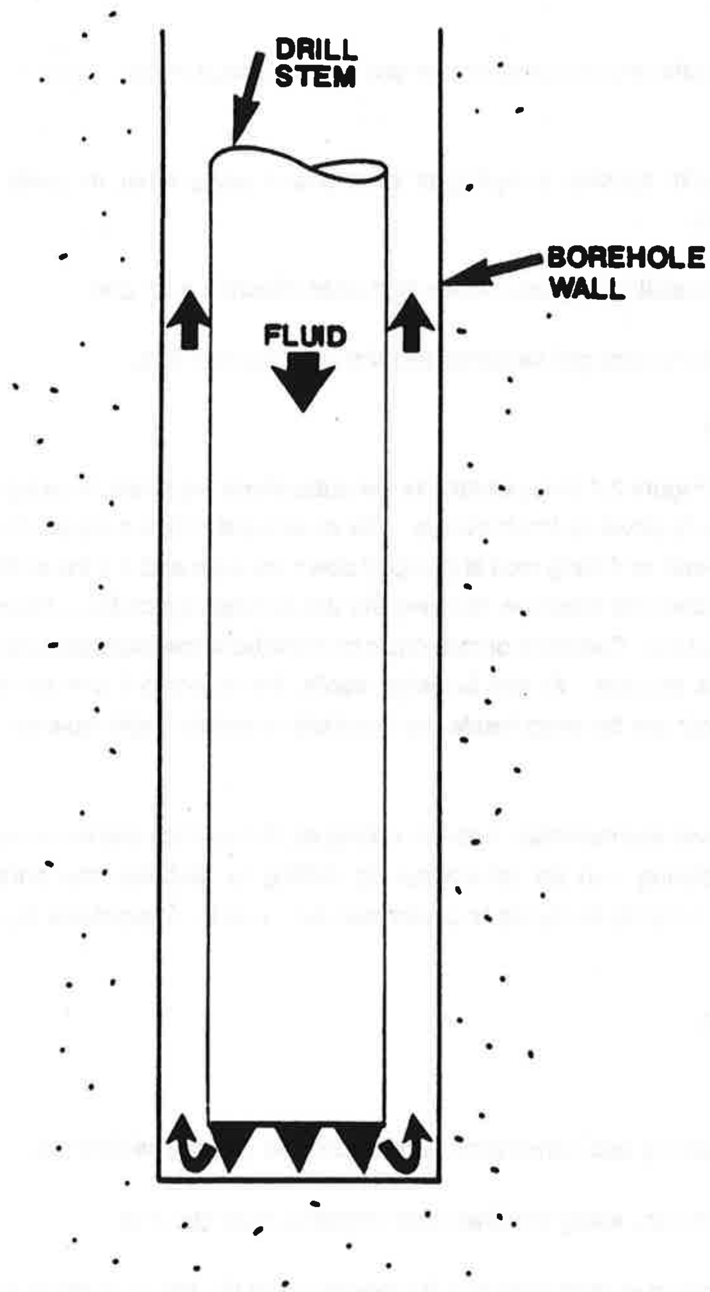
The rotary drill (Figure 3.1.2-1) penetrates the subsurface materials by using a rotating drill bit and circulating fluids to advance the borehole. The downward force on the stem is provided by the rig. Typically, air, water or drilling mud is pumped down the pipe and out the drilling bit. The fluid then flows upward within the borehole, flushing the drill cuttings which have been dislodged by the bit to the ground surface. Sediment or rock chips from the borehole represent the solid-phase samples provided by this method. At any selected depth, the rotary drill can be removed and another sampling method can be used inside the borehole to obtain depth-specific samples of the solid phases.

In loose, cohesiveness materials, water or drilling muds must be used to maintain a stable borehole. Alternatively, casing can be driven during drilling to stabilize the borehole. Air rotary is recommended in highly fractured or cavernous rock, due to unavoidable loss of drilling fluids and circulation.

ADVANTAGES:

General

- there is relatively fast penetration of rock and fine grained sediments;
- solid samples are easily obtained from borehole cuttings; and
- depth restriction is determined by the power of the rig and is normally greater than hundreds of metres.



FORWARD CIRCULATION ROTARY DRILL

Figure no. 3.1.2-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

Physical

- without the use of another sampling method inside the borehole, there are few advantages to this method relative to physical characteristics because of sample disturbance of sediment; for rock chips, some characteristics may be measurable.

Geochemical

- without the use of another sampling method inside the borehole, there are no advantages to this method relative to geochemical characteristics due to sample disturbance and addition of air, water or drilling mud.

Microbiological

- without the use of another sampling method inside the borehole, there are no advantages to this method relative to microbiological characteristics due to sample disturbance and contamination from the circulating fluids.

DISADVANTAGES:

General

- there are more variables to consider when using rotary drilling rather than auger such as type of drill bits and circulation of a drilling fluid such as air, water or mud;

- depth of geologic contact cannot be well defined because of the variable rate at which the cuttings travel to the ground surface;

- when using air rotary, the wet cuttings blown up the borehole from below the water table may stick to the sides of the hole and plug up the borehole;

- when drilling in saturated, non-cohesive sediments such as sand and gravel the borehole may collapse when air rotary is used without casting;

- water or mud will contaminate sediment beyond the borehole; and

- the use of another sampling method (Section 3.2) usually requires the removal of the stem from the borehole.

Physical

- samples brought to the surface are altered from their in-situ physical condition and physical parameters such as porosity may be altered;

- when using drilling mud, it is difficult to separate the fine textured materials within a sample from suspended solids in a drilling fluid; and

- samples brought to the surface may be mixed with material at shallower depths.

Geochemical

- samples brought to the surface are altered from their in-situ geochemical condition and the alteration may be greater with water and mud than with air;
- samples brought to the surface are mixed with materials at shallower depths unless casing is used; and
- at the surface, samples are exposed to air and oxidizing conditions.

Microbiological

- samples exposed to the atmosphere may become contaminated; and
- samples brought to the surface may be cross-contaminated with materials originating from shallower depths, and may be severely contaminated or diluted by the circulating fluids.

SELECTED REFERENCES

Barrett, J., P.C. Deutsch, F.G. Ethridge, W.T. Franklin, R.D. Heil, D.C. McWhorter, A.D. Youngberg. 1980. Procedures recommended for overburden and hydrologic studies of surface mines. USDA Forest Service General Technical Report 1NT-71 Intermountain Forest and Range Experiment Station Ogden, Utah.

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

3.1.2.2 Reverse circulation

OBJECTIVES:

- to provide solid-phase samples brought to the surface by air, water or mud for solid phase analysis;
- to allow depth specific sampling of solid phase using other methods inside the borehole (Section 3.2);
- to permit installation of piezometers and wells (Section 4.3); and
- to permit permanent gas sampling installations (see Section 5.2).

DESCRIPTION:

The rotary drill (Figure 3.1.2-2) penetrates the subsurface materials by using a rotating drill bit and circulating fluids to advance the borehole. The downward force on the stem is provided by the rig. Typically, air, water or drilling mud is pumped down the annulus between the inner and outer wall (dual wall pipe) and over the drill bit. The fluid then flows upward within the inner drill pipe, flushing the drill cuttings which have been dislodged by the bit to the ground surface. Sediment or rock chips from the borehole represent the solid-phase samples provided by this method. These samples are essentially depth specific unless material from the borehole walls is actively caving and dropping down to the bit. At any selected depth, the rotary drill can be removed and another sampling method can be used inside the borehole to obtain depth-specific samples of the solid phases.

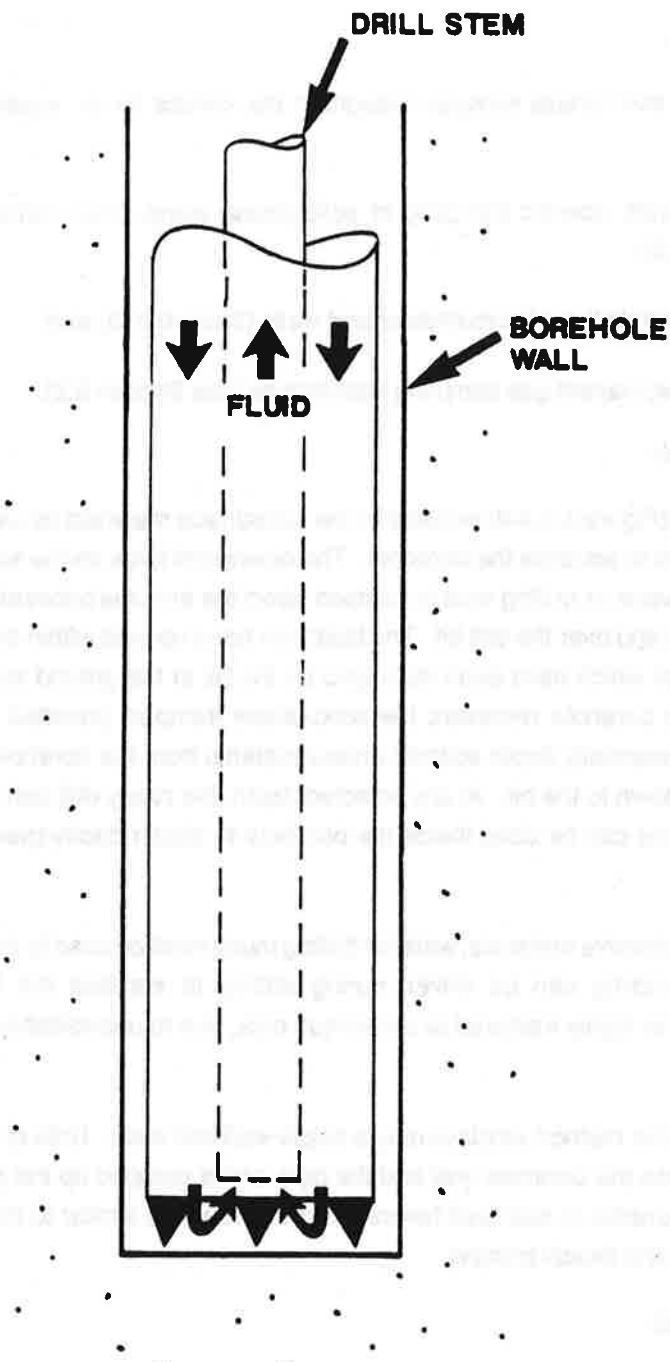
In loose, non-cohesive materials, water or drilling muds must be used to maintain a stable borehole. Alternatively, casing can be driven during drilling to stabilize the borehole. Air rotary is recommended in highly fractured or cavernous rock, due to unavoidable loss of drilling fluids and circulation.

A variation on this method employs only a single-wall drill stem. Drilling fluid is pumped down the annulus between the borehole wall and the pipe and is pumped up the pipe. This variation does not have the benefits of dual-wall reverse circulation and is similar to forward circulation rotation in advantages and disadvantages.

ADVANTAGES:

General

- there is relatively fast penetration of rock and fine grained sediments;
- solid samples as cuttings are easily obtained from the inner pipe; and
- depth restrictions is determined by the power of the rig and is normally greater than hundreds of metres.



REVERSE CIRCULATION ROTARY DRILL (DUAL WALL)	
Figure no. 3.1.2–2	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

Physical

- without the use of another sampling method inside the borehole, there are few advantages of this method relative to physical characteristics of sediment because of sample disturbance;
- for rock chips, some characteristics may be measurable; and
- sample contamination by mixing with shallower sediments is minimized.

Geochemical

- without the use of another sampling method inside the borehole, there are no advantages to this method relative to geochemical characteristics due to sample disturbance and addition of air, water or drilling mud.

Microbiological

- without the use of another sampling method inside the borehole, there are no advantages to this method relative to microbiological characteristics due to sample disturbance and contamination from circulating fluids.

DISADVANTAGES:

General

- there are more variables to consider when using rotary drilling rather than augering such as type of drill bits and circulation of a drilling fluid such as air, water or mud;
- the borehole may collapse when air rotary issued without casing in saturated, non-cohesive sediments;
- when using air rotary, the wet cuttings blown up the drill stem from below the water table may stick to the wall and plug up the drill core;
- water or mud will contaminate sediment beyond the borehole; and
- the use of another sampling method (Section 3.2) usually requires the removal of the stem from the borehole.

Physical

- samples brought to the surface are altered from their in-situ physical condition, and physical parameters such as porosity may be altered; and
- when using drilling mud, it is difficult to separate the fine textured materials within a sample from suspended solids in a drilling fluid.

Geochemical

- samples brought to the surface are altered from their in-situ geochemical condition and the alteration may be greater with water and mud than with air; and

- at the surface, samples are exposed to the atmosphere and oxidizing conditions.

Microbiological

- samples exposed to the atmosphere may become contaminated; and

- samples brought to the surface on auger flights will be severely cross-contaminated with materials originating from shallower depths, and will be severely contaminated or diluted by the circulating drilling fluids.

SELECTED REFERENCES:

Barrett, J., P.C. Deutsch, F.G. Ethridge, W.T. Franklin, R.D. Heil, D.C. McWhorter, A.D. Youngberg. 1980. Procedures recommended for overburden and hydrologic studies of surface mines. USDA Forest Service General Technical Report 1NT-71 Intermountain Forest and Range Experiment Station Ogden, Utah.

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

3.1.2.3 Core barrels

OBJECTIVES:

- to provide relatively undisturbed solid-phase samples for solid-phase analysis;
- to provide continuous sampling of the solid phase;
- to provide a solid sample for extraction of pore water (Section 4.2);
- to permit the installation of piezometers and wells (Section 4.3); and
- to permit the installation of permanent gas-sampling installations (Section 5.2).

DESCRIPTION:

Core barrels (Figure 3.1.2-3) require rotary drill capability. The core barrel consists of a hollow sample-collection barrel and a diamond- tooth coring bit. The core barrel is lowered to the bottom of the borehole with solid drill rods. The drilling rig then spins the rod and core barrel and the bit cuts a cylindrical core of rock which is held inside the core barrel. Core barrels require the use of drilling fluids. There are two common types of barrels, a single and a double tube. The single tube abrades and rotates the core sample during collection and the double tube has an extra barrel to minimize abrasion of the sample during drilling. The less common triple-tube core barrel provides the least disturbed core with the in-situ orientation of the rock intact after coring is completed. At any selected depth the barrel can be retrieved for recovery and analysis of core.

This method is most efficient in soft uniform sedimentary rock. The presence of major fractures may slow the operation due to loss of drilling fluids.

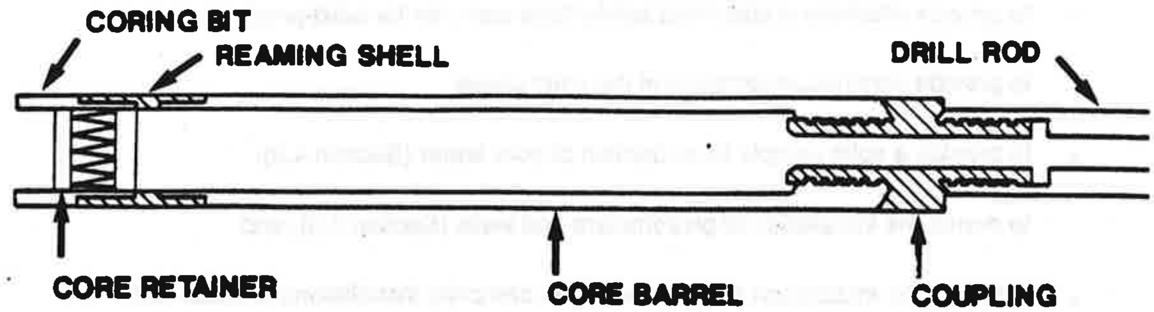
ADVANTAGES:

General

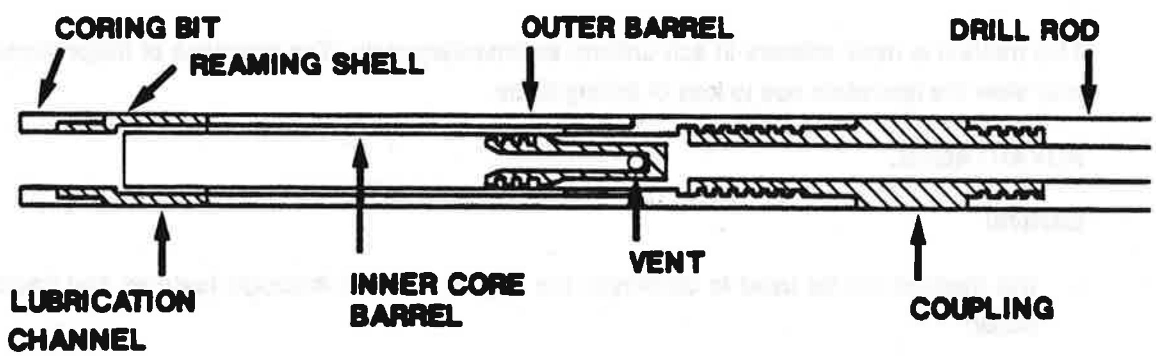
- this method can be used to determine the depths at which lithologic features and fractures occur;
- relatively intact in the samples can be obtained; and
- depth restriction is dependent on the power of the rig.

Physical

- core samples are relatively undisturbed and their in-situ physical condition and physical parameters may be only negligibly altered, allowing the analysis of physical characteristics.



SINGLE-TUBE CORE BARREL



DOUBLE-TUBE CORE BARREL

ROTARY DRILL CORE BARRELS	
Figure no. 3.1.2-3	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

Geochemical

- core samples are relatively undisturbed and their in-situ geochemical condition can be generally determined if there has been minimal contamination by drilling fluids; and
- exposure to air is minimized during sample collection.

Microbiological

- samples in the core are relatively undisturbed and their in-situ microbiological characteristics can be generally determined if there has been no contamination by the drilling fluids; and
- samples are protected from exposure to the atmosphere during collection.

DISADVANTAGES:

General

- this coring is costly and time-consuming, with high equipment costs; costs are also dependent on the number of tubes in the barrel; and
- coring in hard gravel or a soft matrix can result in loss or destruction of equipment.

Physical

- depending on the number of tubes in the barrel, sample abrasion and physical distortion may be significant.

Geochemical

- samples may be altered from their in-situ geochemical condition with the alterations possibly greater with water and mud than with air; and
- samples are exposed to the atmosphere and oxidizing conditions after retrieval.

Microbiological

- samples exposed to the atmosphere may become contaminated; and
- samples may be contaminated by contact with drilling fluids.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Gear, B.B., J.P. Connelly. 1985. Guidelines for monitoring well installation. In: 5th National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, National Water Well Association, Columbus, Ohio, p. 84-115.

3.1.3 Hammer drive (Becker Hammer)

OBJECTIVES:

- to provide disturbed solid-phase samples brought to the surface by air for solid-phase analysis;
- to allow depth-specific sampling as part of the drilling process;
- to allow relatively undisturbed depth-specific sampling of the solid phase using other methods inside the drill stem (Section 3.2);
- to obtain liquid-phase samples using the drill stem (Section 4.1);
- to permit the installation of piezometers and wells (Section 4.3);
- to obtain pore-gas samples using the drill stem (Section 5.1); and
- to permit the installations of permanent gas sampling installations (Section 5.2).

DESCRIPTION:

The stem consists of lengths of double-walled steel pipe that are driven into unconsolidated materials with a repetitive power-driven hammer. Air is forced down the annulus between the concentric pipes and returned upward through the center pipe carrying the cuttings. This is similar in concept to dual-wall reverse rotary drilling (Section 3.1.2.2), but does not involve stem rotation, so that the outer pipe acts as casing to stabilize the borehole. This approach provides continuous, depth-specific samples as hammering proceeds. At any selected depth, the hammer unit and air pump can be retracted so that another sampling method such as a split spoon (Section 3.2) can be used inside the stem-casing. After total depth is reached, the stem is pulled back to the surface by the hydraulic jacking unit built into the rig.

This method is most successful in loose unconsolidated materials. The optional use of rotary drilling with the rig will allow penetration of rock; however, this option is essentially equivalent to rotary drilling with casing (Section 3.1.2).

ADVANTAGES:

General

- there is relatively fast penetration of unconsolidated materials;
- solid samples are easily collected from the cyclone at the surface;
- this method inherently uses casing to stabilize borehole walls;
- rotary drilling inside the stem allows the penetration of rock and cobbles; and

- other sampling methods (Section 3.2) can be used without the need of removing the drill stem).

Physical

- there are few advantages due to the physical disturbance during air-lifting to the surface; and
- disturbed samples are obtained from depth-specific intervals.

Geochemical

- there are relatively few advantages due to the disturbance caused by air-lifting of the cuttings to the surface, and
- disturbed samples are obtained from depth-specific intervals.

Microbiological

- without the use of another sampling method, there are no advantages to this method due to sample disturbance and contamination from the pumped air.

DISADVANTAGES:

General

- depth restrictions depend on the degree of consolidation, friction within the borehole, and degree of saturation, sometimes limiting depth to less than a few tens of metres; and
- penetration of rock and coarse-grained materials requires rotary drilling inside the stem.

Physical

- samples brought to the surface are altered from their in-situ physical condition and physical parameters such as porosity are altered.

Geochemical

- samples brought to the surface are altered from their in-situ geochemical condition.

Microbiological

- samples may be contaminated due to the large flow rate of air.

SELECTED REFERENCE:

Anderson, L.G. 1968. New method of overburden drilling. Western Miner, November.

3.1.4 Cable tool

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to allow depth-specific sampling of the solid phase using other methods inside the borehole (Section 3.2);
- to permit installations of piezometers and wells (Section 4.3); and
- to permit installation of permanent gas-sampling installations (Section 5.2).

DESCRIPTION:

The cable tool method involves the repeated raising and dropping of a heavy bit attached to a cable or rope and a hoist (Figure 3.1.4-1). The cuttings are occasionally removed with a bailer. The use of the bailer may require the cuttings to be in suspension in water and thus water may be added to the borehole when drilling above the water table. Below the water table the in-situ water may provide adequate moisture. Casings can be driven as the borehole is advanced in order to stabilize the borehole and guide the bit.

The cable tool rig is generally not equipped to operate borehole sampling devices (Section 3.2). The cable tool method is applicable to most materials and is successful in fractured or broken formations.

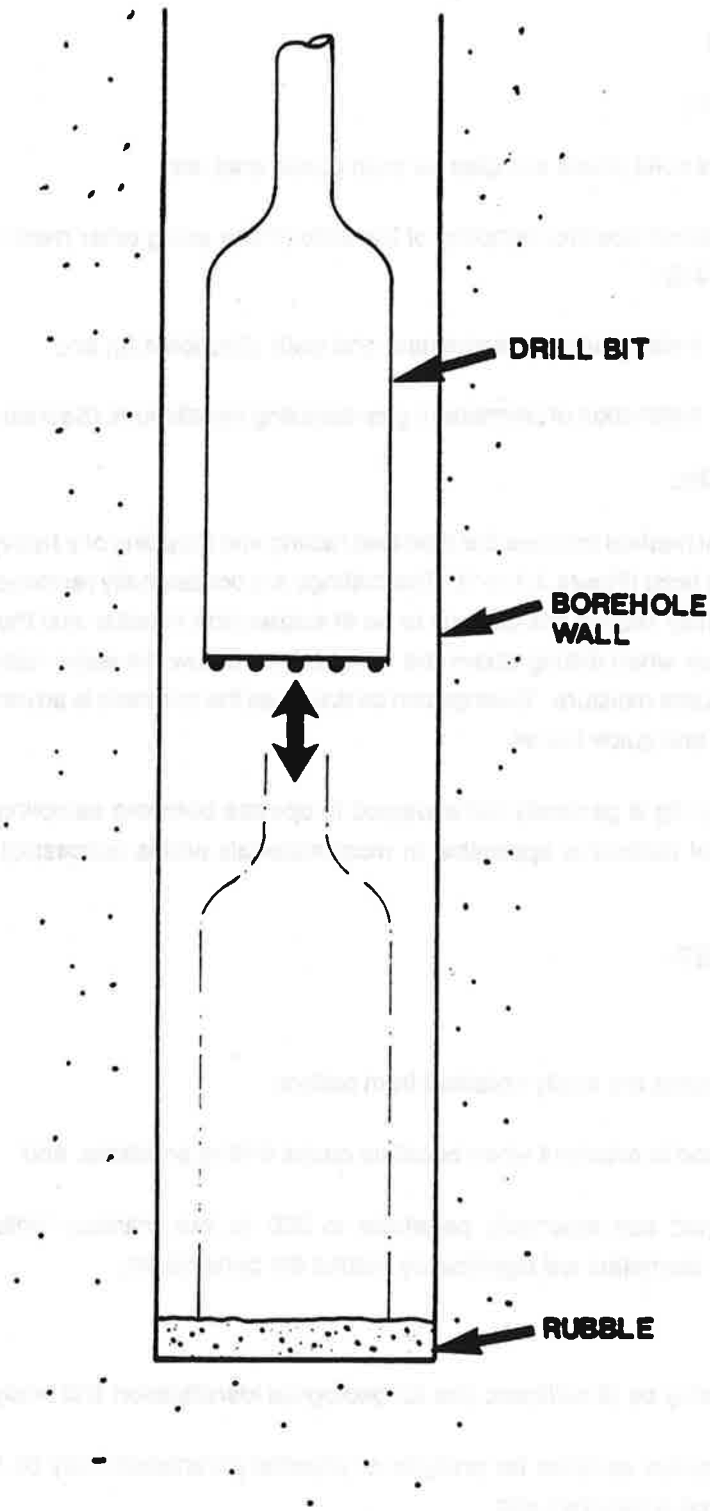
ADVANTAGES:

General

- solid samples are easily obtained from bailers;
- this method is excellent when boulders cause drilling problems; and
- this method can reportedly penetrate to 300 m, but practical limitations and reasonable borehole diameters will significantly restrict the penetration.

Physical

- cuttings may be of sufficient size for geological identification and analysis;
- representative samples for analysis of physical parameters may be obtained if disturbance from the bit is minimal; and
- if casing is used, the movement of water and materials from the shallower depths and the potential for cross-contamination are minimized.



CABLE TOOL DRILL	
Figure no. **3.1.4-1**	**MEND TAILINGS SAMPLING MANUAL**
Date **Aug. 1989**	Drawn by **CANECT**

Geochemical

- there are few advantages to this method due to the repeated breakage of the solid phase and the subsequent exposure to air or foreign water.

Microbiological

- there are few advantages to this method.

DISADVANTAGES:

General

- penetration rates are typically slow;
- marginal success should be anticipated in liquified tailings piles; and
- other sampling methods (Section 3.2) are not easily implemented.

Physical

- samples brought to the surface in the bailers are altered from their in-situ physical conditions and some physical parameters are changed; and
- cuttings may be repeatedly crushed by the bit before removal from the borehole.

Geochemical

- if water is added for removal of cuttings, geochemical conditions in a sample may be altered; and
- the slow rate of penetration and cuttings removal increases the degree of atmospheric contamination and oxidation.

Microbiological

- external contamination will be caused if water is used for removal of cuttings; and
- the slow rate of penetrating and cuttings removal increases the probability of external contamination.

SELECTED REFERENCES:

Barrett, J., P.C. Deutsch, F.G. Ethridge, W.T. Franklin, R.D. Heil, D.C. McWhorter, A.D. Youngberg. 1980. Procedures recommended for overburden and hydrologic studies of surface mines. USDA Forest Service General Technical Report 1NT-71, Intermountain Forest and Range Experiment Station Ogden, Utah.

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Keely, J.F. and K. Boateng. 1987. Monitoring Well Installation, Purching and Sampling Techniques - Part 2: Case Histories. Ground Water, 25, p. 300-313.

Richter, H.R. and M.G. Collentine. 1983. Will my monitoring wells survive down there? design and installation techniques for hazardous waste sites. In: Proceedings of the 3rd National Symposium on Aquifer Restoration and Ground Water Monitoring, National Water Well Association, Columbus, Ohio, p. 223-229.

3.2 Light Powered Equipment

3.2.1 Split spoon

OBJECTIVES:

- to provide solid-phase samples for solid-phase analysis;
- to provide depth specific sampling of the solid phase with heavy powered equipment (Section 3.1); and
- to provide a solid sample for the extraction of porewater (Section 4.2).

DESCRIPTION:

The split spoon is a thick-walled metal sampler (Figure 3.2.1-1) which is mounted on drill rods and extended down through a hollow stem auger or casing to the bottom of a borehole. The sampler is advanced by a hammer into the subsurface material to obtain the sample. The spoon is then hoisted to the surface and is split open, allowing sample removal.

The sampler is intended for unconsolidated material, and it is sometimes necessary to use a sample retainer in the shoe of the sampler to prevent loss of the sample. The sampler is not easily driven into dense or consolidated material, and attempts to do so may result in damage to the spoon. An optional inner liner within the spoon which is removed with the sample aids in sample removal and atmospheric isolation of the sample.

ADVANTAGES:

General

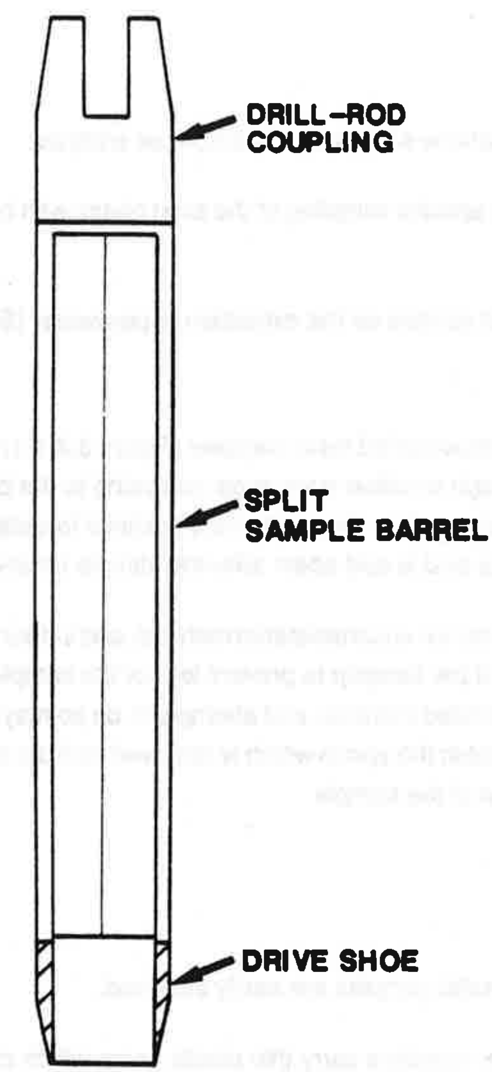
- unconsolidated solid samples are easily obtained;
- some split spoon samplers carry thin plastic liners which can be easily removed for transport and storage; and
- depth limitation is dependent on the length of drill rod.

Physical

- samples that are relatively undisturbed may be used for measurement of physical parameters such as grain size; and
- detailed stratigraphy can be defined.

Geochemical

- samples that are relatively undisturbed may be used to measure geochemical parameters; and



CROSS-SECTION OF A SPLIT SPOON SAMPLER

Figure no. 3.2.1-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

- with the optional liner, exposure to the atmosphere is limited and samples are easily preserved.

Microbiological

- samples that are relatively undisturbed may be used for microbiological characterization and isolation;
- cross-contamination and external contamination may be greatly decreased by washing the spoon with methanol;
- microbes may retain their in-situ conditions in the interior portions of the core samples, resulting in high quality sub-samples; and
- very high quality samples are possible by this method of sample recovery.

DISADVANTAGES:

General

- sample size is limited due to relatively short length of tube.

Physical

- hammering may result in stress causing some sample consolidation which may change physical characteristics;
- when samples are removed from the sampler without an inner liner, the transfer may disaggregate non-cohesive materials; and
- some pore water may be lost due to consolidation of samples during hammering.

Geochemical

- some porewater may be lost when consolidation occurs during sampling;
- chemically unstable samples are exposed to the atmosphere during sample removal if an inner liner is not used;
- samples may be altered from their in-situ geochemical condition due to pressure from consolidation; and
- cross-contamination between samples may occur unless the spoon is reliably washed between sampling events.

Microbiological

- consolidation of samples and separation of pore water results in some alteration of in-situ conditions; and

- exposure to the atmosphere occurs during transfer of samples from the split-spoon core barrels to sample receptacles which may result in slight alteration of the microbiological characteristics of the sample.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

3.2.2 Shelby tube

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to provide depth specific sampling of the solid phase with heavy powered equipment (Section 3.1); and
- to provide a solid sample for the extraction of porewater (Section 4.2).

DESCRIPTION:

- The Shelby tube is a short length of thin-walled metal pipe which is mounted on drill rods and extended down through a hollow stem auger or casing to the bottom of a borehole. The sampler is advanced manually or hydraulically by pushing the tube into the material which minimizes the disturbance of the sample. As the tube is retrieved, care must be taken not to jar the tube so that recovery is maximized.
- The sampler works best in relatively loose or soft deposits (sands, silts, clays) and is not suitable in dense or consolidated materials.

ADVANTAGES:

General

- unconsolidated solid samples are easily obtained;
- samples are retained in tube and can be readily preserved;
- depth limitation is dependent on the length of drill rod; and
- the relatively low cost of the tube allows each sample to be taken and preserved within a tube, eliminating cross-contamination among samples.

Physical

- samples are relatively undisturbed and can be used for measurement of physical parameters such as grain size; and
- detailed stratigraphy can be defined.

Geochemical

- samples are relatively undisturbed and can be used for detailed measurement of geochemical parameters;
- exposure to the atmosphere is minimized; and

- samples are readily preserved.

Microbiological

- samples that are relatively undisturbed may be used for microbiological characterization and isolation;
- cross-contamination and external contamination may be greatly decreased by washing the sampler with methanol;
- microbes may retain their in-situ conditions resulting in high quality sub-samples;
- very high quality samples are possible by this method of sample recovery; and
- external contamination due to atmospheric exposure can be avoided by retaining the recovered sample in the sampler.

DISADVANTAGES:

General

- non-cohesive granular soils can be difficult to sample because of sample loss during retrieval;
- sample size is limited due to relatively short length of tube (approximately 0.75 m); and
- only the end of the tube can be examined in the field if the sample is kept in the sampling tube.

Physical

- some consolidation may occur, changing some physical parameters.

Geochemical

- pore water may be lost or altered if some consolidation occurs during sampling.

Microbiological

- consolidation of samples and separation of pore water could result in some alteration of the in-situ conditions.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

3.2.3 Piston sampler

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to provide depth specific sampling of solid phase with heavy powered equipment (Section 3.1); and
- to provide a solid sample for extraction of porewater (Section 4.2).

DESCRIPTION:

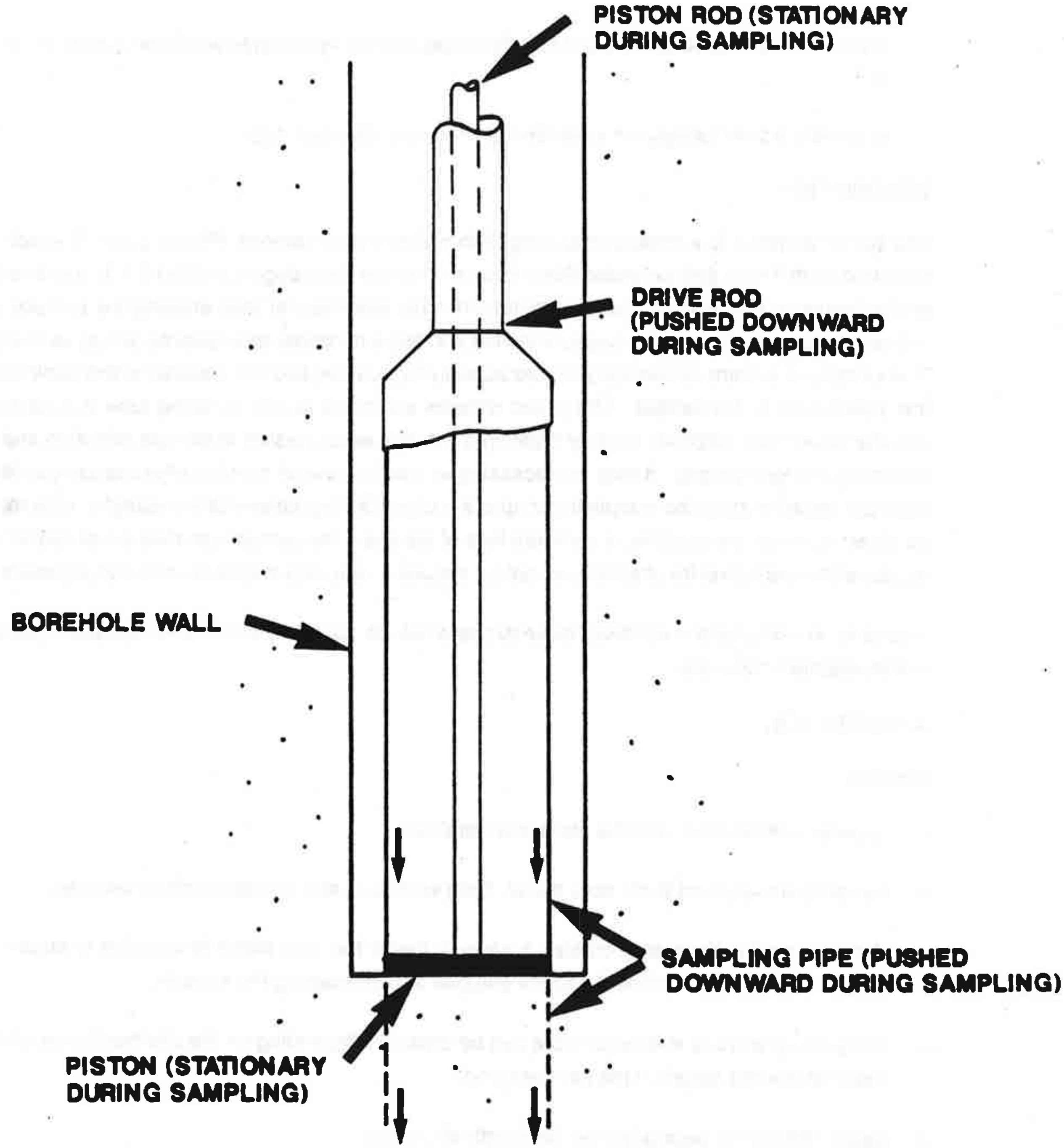
The piston sampler is a replaceable, long, thin-walled metal sampler (Figure 3.2.3-1) which is mounted on drill rods and extended down through a hollow stem auger (Section 3.1.1.1) or casing to the bottom of a borehole. The fixed piston prevents any material from entering the sampler as it is extended down through the auger or casing and helps minimize disturbances during sampling. The sampler is advanced manually or hydraulically by pushing into the material which minimizes the disturbance of the sample. The piston remains stationary as the sampling tube is advanced into the subsurface material, thereby creating a vacuum which assists in sample retention and in obtaining a longer sample. It may be necessary to wait for several minutes after the sampler has been advanced to allow the sample to set up in the tube. During retrieval of the sampler, care must be taken not to jar the sampler to minimize loss of sample. The sample can then be stored in the replaceable core barrel for shipment or can be extruded, resulting in disturbance and exposure.

The sampler works best in relatively loose deposits (sands, silts, clays) and is not suitable in dense or consolidated materials.

ADVANTAGES:

General

- unconsolidated solid samples are easily obtained;
- samples are retained in the core barrel, if not extruded, and can be readily preserved;
- during sampling the piston creates a vacuum inside the care barrel to assist in overcoming friction between the sediment and the sampler and in retaining the sample;
- samples up to three metres or more can be obtained depending on the characteristics of the material and the length of the sampler; and
- depth limitation is dependent on the length of drill rod.



CROSS-SECTION OF ONE TYPE OF PISTON SAMPLER

Figure no.	MEND TAILINGS SAMPLING MANUAL
3.2.3-1	
Date: Aug. 1989	Drawn by: CANECT

Physical

- samples are relatively undisturbed if not extruded from the sampler and can be used for measurement of physical parameters; and
- detailed stratigraphy can be defined if not extruded.

Geochemical

- samples are relatively undisturbed if not extruded and can be used for measurement of geochemical parameters;
- exposure to the atmosphere is minimized if samples are not extruded; and
- samples are readily preserved.

Microbiological

- samples that are relatively undisturbed may be used for microbiological characterization and isolation;
- cross-contamination and external contamination may be greatly decreased by washing the sampler with methanol;
- microbed may retain their in-situ conditions in the core samples, resulting in high quality sub-samples;
- very high quality samples are possible by this method of sample recovery; and
- external contamination due to atmospheric exposure can be avoided by retaining the recovered sample in the sampler.

DISADVANTAGES:

General

- non-cohesive granular materials may be difficult to sample using this method because of sample loss during retrieval and modifications to the method such as a sample retainer may have to be used; and
- only the ends of the core barrel can be examined in the field if sample is preserved in the barrel.

Physical

- some consolidation may occur, particularly in long samples, where friction with the sampler walls resist entry of the sample; and
- extrusion of the sample from the core barrel resulting in exposure to the atmosphere.

Geochemical

- porewater may be lost or altered if some consolidation occurs during sampling.

- Microbiological

- consolidation of samples and separation of pore water could result in some alteration of the in-situ conditions.

SELECTED REFERENCES:

Munch, J. and R.W.D. Killey. 1985. Equipment and methodology for sampling and testing non-cohesive sediments. Ground Water Monitoring Review, 5, No. 1., p. 38-42.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

3.2.4 University of Sherbrooke block sampler

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to allow depth-specific sampling of the solid phase with heavy powered equipment (Section 3.1); and
- to provide a solid sample for the extraction of porewater (Section 4.2).

DESCRIPTION:

The University of Sherbrooke block sampler is used to recover a relatively undisturbed cylindrical block sample of cohesive sediment and consists of a cutting head fitted with three diaphragm blades (Figure 3.2.4-1). The sampler requires a borehole of approximately 40 cm in diameter drilled with a flat bottom mechanical auger. Water or a bentonite mud slurry can be used to decrease bottom heaving. The sampler is then used to first excavate an annular slot around the sample, the base of the sample is then cut from the underlying sediment with the diaphragm blades, and the sample is lifted to the surface. The undisturbed sample can then be packaged for transport.

This method can be used in cohesive materials, and results in a block sample from which sub-samples comparable to those recovered by hand carving from a trench (Section 3.2.9). However, samples may be recovered safely from depths greater than those possible by trenching.

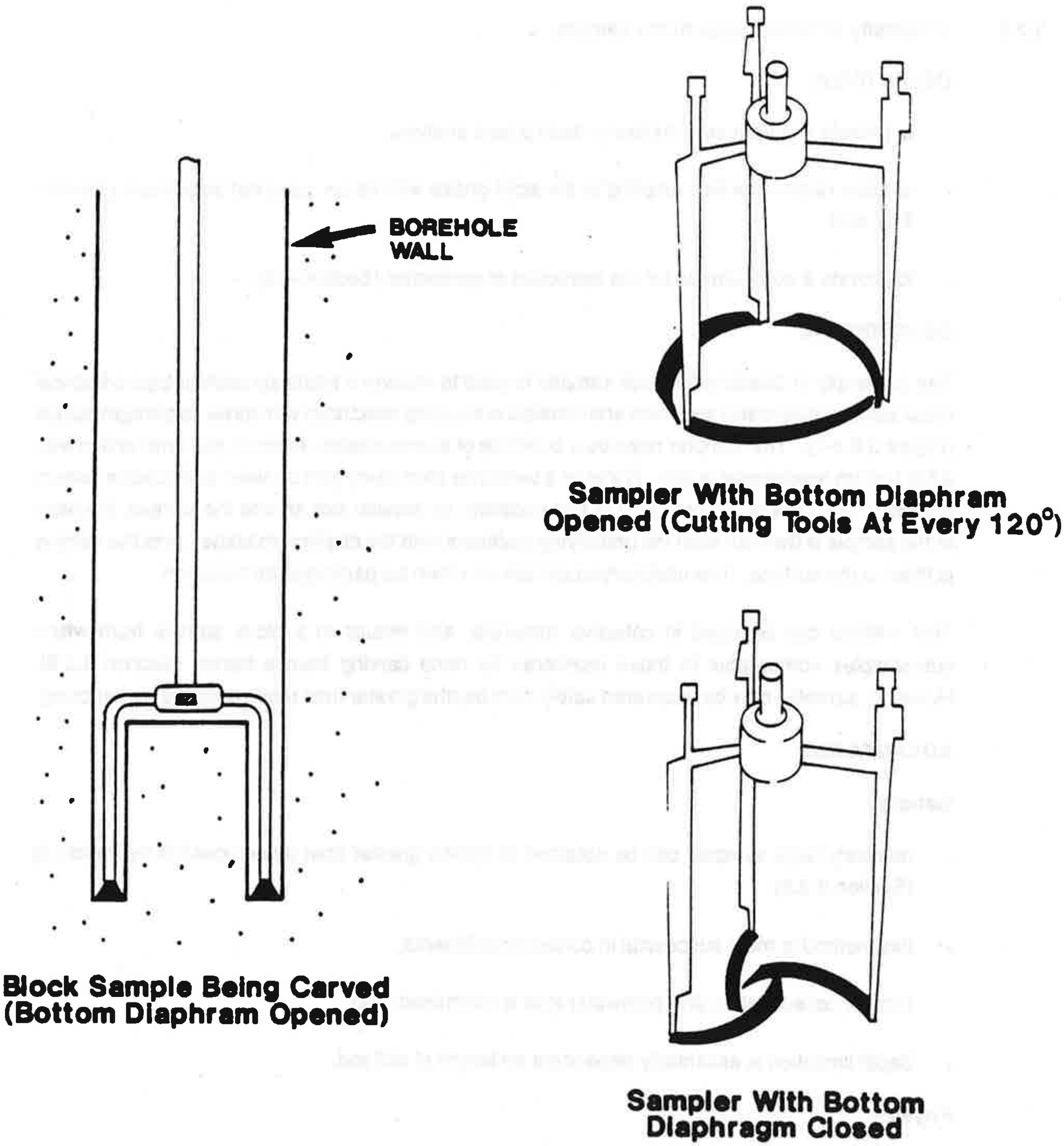
ADVANTAGES:

General

- relatively large samples can be obtained at depths greater than those possible by trenching (Section 3.2.9);
- this method is most successful in cohesive sediments;
- sample consolidation and porewater loss is minimized; and
- depth limitation is essentially dependent on length of drill rod.

Physical

- sample consolidation and porewater loss is minimized so that physical characteristics will be representative of in-situ conditions; and
- the stratification, continuity, structure and other physical parameters can be examined either on-site or after transport.



UNIVERSITY OF SHERBROOKE BLOCK SAMPLER	
Figure no. 3.2.4-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

Geochemical

- sub-samples can be used for the extraction and analysis of porewater.

- Microbiological

- high quality sub-samples from the interior of the block that are uncontaminated by drilling mud, water, or air can be used for microbiological analysis and isolation.

DISADVANTAGES

- the exterior of the sample block will be contaminated by drilling fluids and materials from shallower depths; and
- this method is limited to soft cohesive materials, and will be hindered by boulders and rock.

Physical

- the release of confining pressure around the sample may result in expansion and changes in some physical characteristics.

Geochemical

- exposure of the sample to air during sample retrieval will alter chemically reduced aqueous species and minerals; and

- exposure to drilling mud or foreign water will alter geochemical characteristics in the outer shell of the sample or throughout the entire sample.

Microbiological

- some portion of the sample may be contaminated by drilling fluids.

SELECTED REFERENCES:

Lefebvre, G. and C. Poulin. 1979. A new method of sampling in sensitive clay. Canada Geotech. J., 16, p. 226-223.

3.2.5 Core-freezer (Shapiro) sampler

OBJECTIVES:

- to provide solid-phase samples for solid-phase analysis; and
- to provide a solid sample for the extraction of porewater (Section 4.2).

DESCRIPTION:

A gravity core sampler, which is operated manually and incorporates a refrigeration jacket, is used to collect liquified tailings or soft submerged sediments. The apparatus consists of a jacketed coring device. During operation, the jacket is filled with crushed ice and alcohol, they allowed to sink under its own weight. After 5 to 10 minutes, the sampler is brought to the surface, the freezing mixture replaced with water, and the frozen core transferred to a receptacle.

ADVANTAGES:

General

- the sampler is most successful in liquified sediments; and
- samples are relatively undisturbed during sampling.

Physical

- measurement of some physical parameters such as grain size may be performed on the disturbed sample after removal from the sampler.

Geochemical

- measurement of geochemical characteristics not affected by exposure to the atmosphere may be measured after removal from the sampler.

Microbiological

- samples that are relatively undisturbed can be used for microbiological characterization and isolation; and
- cross-contamination and external contamination is minimized by washing the interior of the sampler with methanol.

DISADVANTAGES:

General

- small sample size;
- penetration of rock and coarse-grained sediments is not possible;

- disturbance and exposure of the sample occurs during removal of the sample from the core barrel;
- slight distortion occurs in the outer centimeter of the core; and
- depth restriction is dependent on the length of the core barrel.

Geochemical

- samples may be altered from their in-situ geochemical condition due to initial consolidation and later atmospheric exposure during sample transfer; and
- porewater may be lost due to consolidation of sample.

Microbiological

- consolidation of samples and separation of porewater results in some alteration of in-situ conditions; and
- exposure to the atmosphere occurs during transfer from the core-freezer to sample receptacles which may result in slight alteration of the microbiological characteristics of the sample.

SELECTED REFERENCES:

Shapiro, J. 1958. The core-freezer - A new sampler for lake sediments. Ecology, 39, 758.

3.2.6 Vibrating coring drill

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to permit the installation of piezometers and other permanent liquid sampling installations (Section 4.3); and
- to permit the installation of permanent gas sampling installations (Section 5.2).

DESCRIPTION:

The vibrating coring drill operates on the principle of drill string oscillation, and does not require water or air for operation. The drill head produces vibrations that are transmitted to the drill rods and overburden immediately adjacent to the machine. The material around the cutting head is liquified and the drill stem settles into the unconsolidated material. As the drill penetrates the soil layers, a sample flows into the hollow drill rod. The material outside is packed due to the motion and acts as natural casing which remains open, so that the drill rods can be removed and replaced without borehole collapse. The sample is then extruded from the rods. The drill cannot penetrate consolidated materials or large cobbles.

ADVANTAGES:

General

- portable, ideal for helicopter assisted programs;
- there is fast penetration of unconsolidated sediment; and
- solid samples are easily obtained.

Physical

- samples may be disturbed only to a minor extent and may be used for measurement of some physical parameters such as grain size.

Geochemical

- isolation from the atmosphere is accomplished during drilling.

Microbiological

- samples that are relatively undisturbed may be used for microbiological characterization and isolation;
- cross-contamination and external contamination may be greatly decreased by washing the sampler with methanol; and

- microbes may retain their in-situ conditions resulting in high quality sub-samples.

DISADVANTAGES:

General

- subtle geologic changes and small scale stratification can not be identified;
- when drilling in saturated, non-cohesive sediment such as sand, the borehole may collapse after stem withdrawal; and
- penetration of consolidated materials and coarse-grained sediments is limited.

Physical

- some consolidation may occur altering some physical parameters;
- vibration, liquification, and consolidation may result in a distortion of some physical characteristics; and
- extrusion of the sample results in physical disturbance.

Geochemical

- extrusion of sample results in exposure of sample to the atmosphere which leads to the oxidation of chemically reduced aqueous species and minerals; and
- porewater may be lost or altered due to some consolidation during of drilling.

Microbiological

- the process of vibration, liquification, and consolidation results in some alteration of in-situ conditions and microbial activity; and
- extrusion of the sample results in atmospheric contamination.

SELECTED REFERENCES:

Archibald, C.W., J.F. Archibald, A.D. Archibald and J.H. Nantel. 1983. Grant 020 - Application of vibra-corer drills for rapid overburden sampling. Ontario Geol. Survey Misc. Papers, No. 115.

3.2.7 Piston gravity coring of submerged sediments

OBJECTIVES:

- to obtain solid-phase samples for solid phase analysis; and
- to provide a solid-phase sample for the extraction of porewater.

DESCRIPTION:

Piston gravity corers are used to collect sediment and tailings material submerged beneath surface water bodies. The corer is lowered slowly through the water column by winch and cable, and when the trigger mechanism encounters the top of the sediment, the core barrel is allowed to fall freely for up to several meters, penetrating the sediment (Figure 3.2.7-1). The piston within the core barrel remains in a fixed location as the core barrel advances into the submerged material, thereby creating a vacuum in the barrel which assists in sample retention and in obtaining a longer sample. The sample can then be stored in the replaceable inner sleeve or can be extruded, resulting in disturbance and exposure to the atmosphere.

The coring device works best in relatively unconsolidated deposits (sands, silts, clays) and is not suitable for dense or consolidated materials.

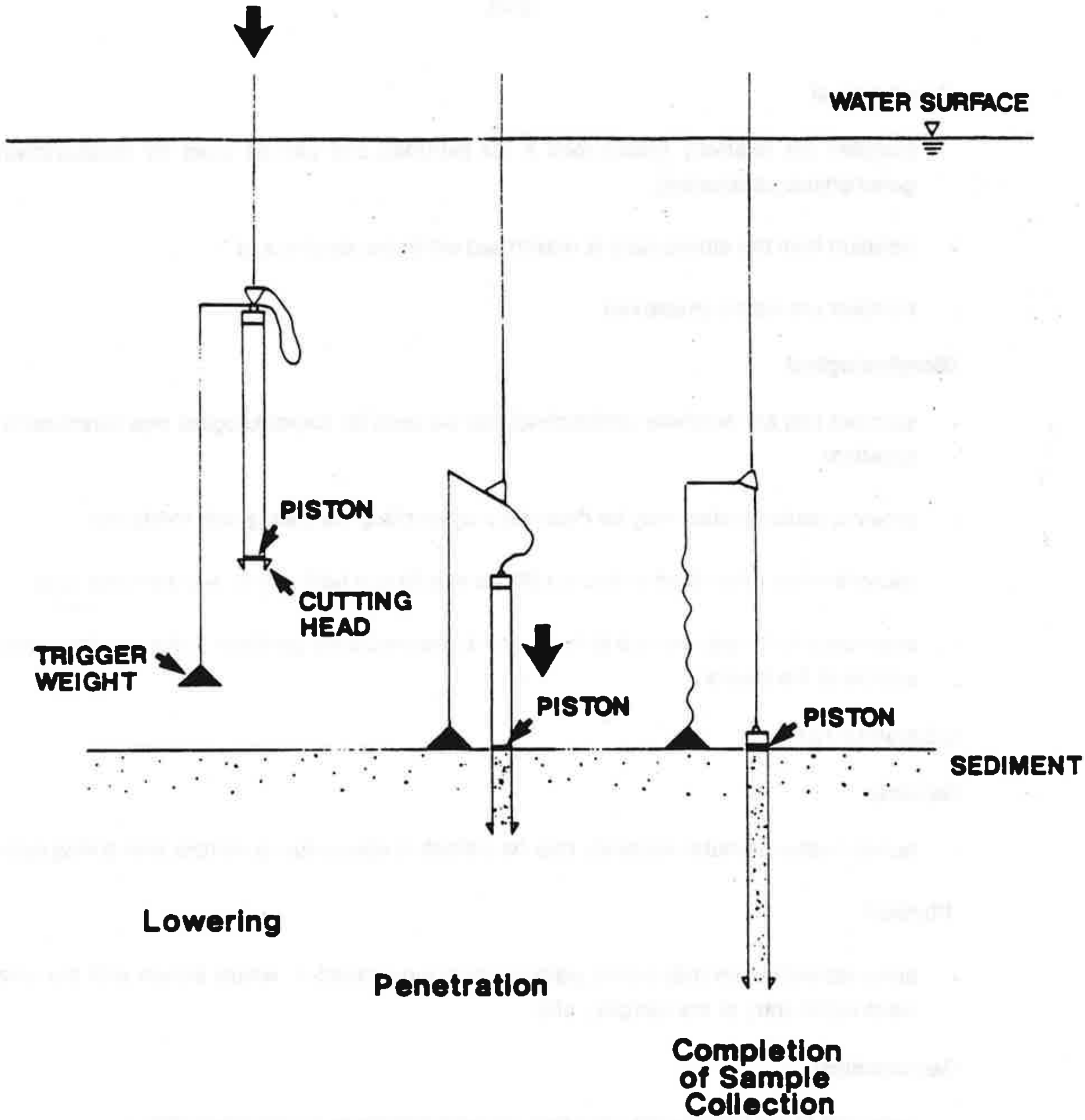
ADVANTAGES:

General

- unconsolidated, submerged solid samples are easily obtained;
- samples can be retained in the inner sleeve and can be readily preserved;
- during sampling the piston creates a vacuum inside the sampler to assist in overcoming friction between the sample and the sleeve and in retaining the sample; and
- samples up to three metres or more can be obtained depending on the characteristics of the material and the length of the sampler.

Physical

- samples are relatively undisturbed if not extruded from the corer and can be used for measurement of physical parameters;
- detailed stratigraphy can be defined; and
- transparent inner sleeves allow physical observation of the entire length of core.



PISTON GRAVITY CORING	
Figure no. 3.2.7-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

Geochemical

- samples are relatively undisturbed if not extruded and can be used for measurement of geochemical parameters;
- isolation from the atmosphere is maximized within the sleeve; and
- samples are readily preserved.

Microbiological

- samples that are relatively undisturbed may be used for microbiological characterization and isolation;
- external contamination may be decreased by washing the sleeve with methanol;
- microbes may retain their in-situ conditions resulting in high quality sub-samples; and
- external contamination due to atmospheric exposure can be avoided by retaining the recovered sample in the sleeve.

DISADVANTAGES:

General

- non-cohesive granular materials may be difficult to obtain due to sample loss during retrieval.

Physical

- some consolidation may occur, particularly in long samples, where friction with the sampler walls resist entry of the sample; and

Geochemical

- extrusion of the sample from sampler allows exposure to atmosphere; and
- porewater may be lost or altered if some consolidation occurs during sampling.

Microbiological

- consolidation of samples and separation of pore water results in some alteration of in-situ conditions; and
- external contamination from the overlying water is extremely probable.

SELECTED REFERENCES:

Shepard, Francis P. 1973. Submarine Geology 3rd Ed. Harper Row, New York.

3.2.8 Grab sampling of submerged sediments

OBJECTIVES:

- to obtain solid-phase samples for solid phase analysis.

DESCRIPTION:

A grab sampler consists of a set of metal jaws held open during descent through the water, and are forced closed upon contacting the sediment. The sampler is then hoisted to the surface. Some grab samplers have a canvas top to inhibit stirring of the sediment as it is returned to the surface.

ADVANTAGES:

General

- the sampler is easy to operate; and

- the size of the jaws determines the volume of sample.

Physical

- there are no major advantages to this method due to the degree of physical disturbance; and

- some samplers (for example, the Petersen Grab) may cause little disturbance and, by inserting a short tube into the retrieved sample, a short core may be able to provide details on small-scale stratigraphy.

Geochemical

- there are few advantages to this method relative to geochemical characteristics due to sample disturbance.

Microbiological

- the utility of this method is limited to sampling in which accurate quantitative analyses are not required and when the sampled material contains high concentrations of micro organisms which would minimize the apparent effects of external contamination; and

- sub-sampling from the interior of larger particles and clumps of materials can give an approximation of the concentration of microorganisms and this method of sampling may be used for the isolation of microorganisms, but the very high probability of cross-contamination and external contamination should be recognized.

DISADVANTAGES

General

- the size of the jaws determines the weight and size of supporting equipment, particularly the winch and cable.

Physical

- gravel or rocks may hold jaws sufficiently open for finer material to wash out during retrieval; and
- samples brought to surface are frequently altered from their in-situ physical condition and physical parameters are altered.

Geochemical

- samples brought to surface are altered from their in-situ geochemical condition.

Microbiological

- samples brought to the surface may be contaminated with microorganisms originating at shallower depths and in the overlying water; and
- because samples are unprotected from exposure to the atmosphere, samples containing low concentrations can be contaminated sufficiently to distort the true in-situ microbiological characteristics.

SELECTED REFERENCES:

Shepard, Francis P. 1973. Submarine Geology, 3rd Ed. Harper Row, New York.

3.2.9 Trenching

OBJECTIVES:

- to provide solid-phase samples for solid-phase analysis;
- to allow depth specific sampling of the solid-phase (Section 3.3); and
- to provide a solid sample for the extraction of porewater (Section 4.2).

DESCRIPTION:

A backhoe is used to excavate surficial material to depths of 3 to 6 m. This method is usually restricted to unconsolidated materials. Samples can be collected from the walls or floor of the trench as well as directly from the bucket. Additional solid-phase sampling can be performed using other sampling techniques such as a hand auger (Section 3.3).

ADVANTAGES:

General

- the trench provides human access and allows visual observation of trench walls and floor;
- samples can be obtained relatively quickly;
- large samples can be collected easily from the trench;
- other sampling techniques can be used to obtain samples at deeper depths, if required; and
- single layer samples or composites samples over specific depth intervals can be collected.

Physical

- samples are in their in-situ physical condition at some distance beyond the walls and the sides of the trench; and
- stratification, continuity, structure and other physical parameters can be examined after removal of disturbed material from the trench walls.

Geochemical

- samples are in their in-situ geochemical condition at some distance beyond the walls of the trench.

Microbiological

- samples are in their original in-situ condition just beyond the walls of the trench, allowing the collection of high quality samples for microbiological characterization and isolation; and

- this method provides optimum working conditions to recover high quality microbiological samples.

DISADVANTAGES:

General

- sample can only be obtained from relatively shallow depths;
- saturated, permeable materials can result in flooding of the trench or collapse of the walls; and
- penetration of rock or coarse grained sediments is not usually feasible.

Physical

- samples in backhoe buckets are usually altered from their in-situ physical condition; and
- visible material on trench walls is usually disturbed.

Geochemical

- samples in backhoe buckets are altered from their in-situ geochemical conditions; and
- visible material on trench walls is usually disturbed.

Microbiological

- depending upon the techniques used to recover sample material, this method has the fewest disadvantages of all of the other procedures described, and, if sampling directly from exposed surfaces is avoided, can provide extremely high quality microbiological samples.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Richter, H.R. and M.G. Collentine. 1983. Will my monitoring wells survive down there? design and installation techniques for hazardous waste sites. In: Proceedings of the 3rd Nat'l Symposium on Aquifer Restoration and Ground Water Monitoring, National Water Well Association, Columbus, Ohio, p. 223-229.

3.3 Hand-Operated Equipment

3.3.1 Shovel/bucket

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to allow depth specific sampling of the solid phase;
- to collect samples of the solid phase using other methods (for example, Section 3.3.2); and
- to provide a solid sample for extraction of porewater (Section 4.2).

DESCRIPTION:

A shovel is a hand implement consisting of a broad scoop or a hollowed out blade with a handle. The shovel is used to dig pits down to depths of around one metre. Disturbed solid-phase samples can be obtained while digging or from the walls and floor of the pit. Additional solid phase sampling can be performed using other sampling techniques, such as a hand auger. This technique is successful in unconsolidated materials and highly broken rock.

ADVANTAGES:

General

- the equipment is light weight and portable;
- shallow samples can be obtained relatively fast;
- large samples can be collected easily from shallow depths;
- other sampling techniques can be used for deeper samples, if required; and
- single layer samples or composites samples over specific depth intervals can be collected.

Physical

- samples are in their in-situ physical condition at some distance beyond the walls of the excavation;
- the stratification, continuity and structure can be examined after the removal of disturbed material from the pit walls; and
- disturbed samples still allow measurement of certain physical characteristics such as grain size.

Geochemical

- samples are in their in-situ geochemical condition at some distance beyond the walls of the pit; and
- disturbed samples are exposed to the atmosphere, but allow the measurement of geochemical characteristics which are not directly or indirectly altered by oxidation.

Microbiological

- samples are in their original in-situ condition just beyond the walls of the pit; and
- sub-sampling from the interior of larger particles or clumps of materials can give an approximation of the concentrations of microrganisms and this method of sampling may be used for the isolation of microorganisms, but the high probability of cross-contamination and external contamination should be recognized.

DISADVANTAGES:

General

- samples can only be obtained from relatively shallow depths;
- penetration of unbroken rock and coarse grained sediments is not feasible;
- collection of large quantities of samples is time-consuming; and
- excavated samples may be mixed with material from shallower depths.

Physical

- excavated samples are usually altered from their in-situ physical condition due to physical disturbance during excavation.

Geochemical

- excavated samples are altered from their in-situ geochemical condition due to disturbance and exposure to the atmosphere.

Microbiological

- excavated samples are altered from their in-situ conditions; and
- excavated samples are exposed to the atmosphere and are therefore susceptible to external contamination.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

3.3.2 Hand auger

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis;
- to permit installation of shallow piezometers and wells (Section 4.3.); and
- to permit installation of permanent gas-sampling installations (Section 5.2).

DESCRIPTION:

A hand auger (Figure 3.3.2-1) is a tool for boring holes consisting of a shank with a crosswise handle for turning a centre tapered feed screw with a cutting head which is essentially a small-scale, hand-operated version of the solid stem auger (Section 3.1.1.2).. The hand auger is screwed into the material until the auger flights are full. The auger is then withdrawn, cleaned, and reinserted into the original hole for further augering. There are various types of hand augers available depending on the type of cutting head and diameter of auger flights. Some types of hand augers include an interchangeable core barrel (Section 3.3.3).

ADVANTAGES:

General

- there is relatively fast penetration of fine-grained sediments;
- solid samples can be obtained relatively fast from auger flights; and
- the equipment is light weight and portable.

Physical

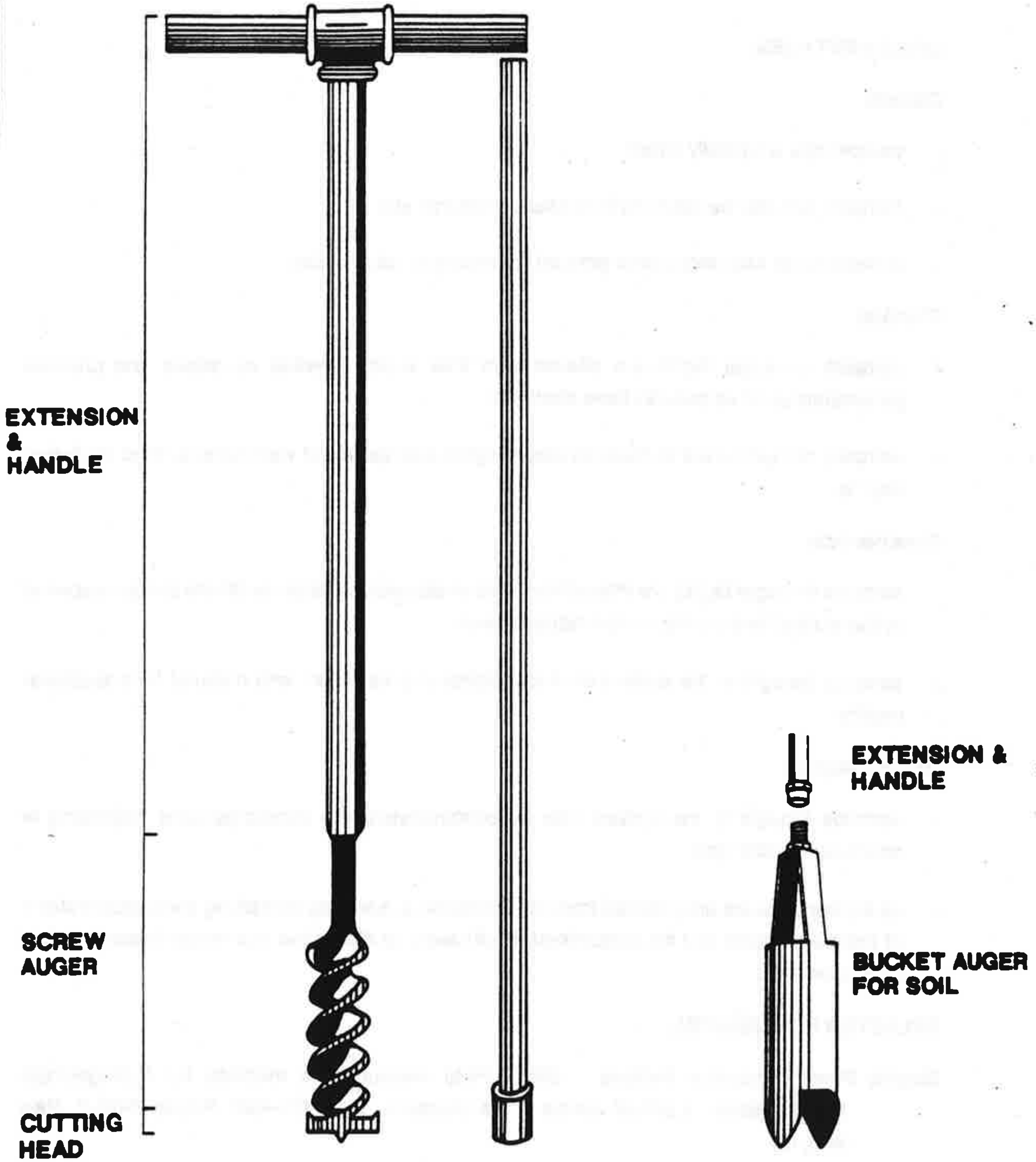
- there are no advantages to this method relative to physical characteristics because of sample disturbance and mixing on auger flights; and
- disturbed samples still allow measurement of certain physical characteristics such as grain size.

Geochemical

- there are no advantages to this method relative to geochemical characteristics because of sample disturbance and mixing on auger flights.

Microbiological

- without the use of another sampling method inside the bore hole, there are few advantages to this method relative to microbial characterization because of cross-contamination and external contamination.



HAND AUGERS	
Figure no. 3.3.2-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

DISADVANTAGES:

General

- sample size is typically small;
- samples can only be obtained from shallow depths; and
- penetration of rock and coarse grained sediments is not possible.

Physical

- samples on auger flights are altered from their in-situ physical conditions and physical parameters such as porosity have changed;
- samples brought to the surface on auger flights may be mixed with material from shallower depths.

Geochemical

- samples on auger flights are altered from their in-situ geochemical conditions and are exposed to the atmosphere during sample retrieval; and
- samples brought to the surface on auger flights may be mixed with material from shallower depths.

Microbiological

- samples brought to the surface may be contaminated with microorganisms originating at shallower depths; and
- as the samples are unprotected from the atmosphere, samples containing low concentrations of microorganisms can be contaminated sufficiently to distort the true in-situ microbiological characteristics.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

3.3.3 Hand-driven coring device

OBJECTIVES:

- to provide solid-phase samples for solid phase analysis; and
- to allow depth specific sampling of the solid phase.

DESCRIPTION:

A hand-driven coring device consists of a shank with a crosswise handle for turning or pushing, and a hollow tube at the bottom. The device is screwed or pushed into the sediment until the sampler is full. The device is then withdrawn, emptied into a container, cleaned, and reinserted into the original hole for the next sample. Some corers have a slot cut into the side of the probe to view the sample before it is extruded. This method is best-suited for unconsolidated materials.

A variation on this technique has a cutting edge along the side of the core barrel which shaves material from the sides of the hole during rotation. Counter rotation closes a gate to hold the sample within the barrel. This variation may be more successful than the standard method in non-cohesive sediment, but results in greater disturbance.

ADVANTAGES:

- solid samples can be obtained relatively fast; and
- the equipment is lightweight and portable.

Physical

- samples are relatively undisturbed prior to extrusion and may be used to measure some physical parameters; and
- small-scale stratigraphy may be examined prior to removal of sample from the core barrel.

Geochemical

- samples are relatively undisturbed prior to exposure to the atmosphere and may be used to measure some geochemical parameters.

Microbiological

- samples that are relatively undisturbed can be used for microbiological characterization and isolation; and
- cross-contamination and external contamination may be greatly decreased by washing the sampler and transfer utensils with methanol.

DISADVANTAGES:

General

- sample size is typically small;
- samples can only be obtained from relatively shallow depths;
- penetration of rock and coarse grained sediments is not possible; and
- disturbance and exposure of the sample occurs during removal of the sample from the core barrel.

Physical

- sampling may result in some consolidation of sample which may change some physical characteristics.

Geochemical

- samples may be altered from their in-situ geochemical condition due to initial consolidation and later disturbance during transfer;
- porewater may be lost due to consolidation of samples during coring; and
- exposure of the sample to the atmosphere will lead to oxidation.

Microbiological

- consolidation of samples and separation of pore water results in some alteration of in-situ conditions; and
- exposure to the atmosphere occurs during transfer from the hand-coring device to sample receptacles which may result in slight alteration of the microbiological characteristics of the sample.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

3.3.4 Gravity core sampler for submerged samples

OBJECTIVES:

- to obtain solid-phase samples for solid-phase analysis; and
- to provide a solid sample for the extraction of porewater (Section 4.2).

DESCRIPTION:

Gravity core samplers, such as the Phleger corer are manually operated and can be used to collect sediment and tailings material submerged beneath surface water bodies. The sampler, which is essentially a length of pipe with a cutting edge at the base, is lowered by a wire through the water and advance into the material by its own weight. The sampler generally consists of a water escape valve, a core retainer (inner sleeve), and a top check - valve. Gravity core samplers can be operated from a small boat. Variations on this technique include sections of commercially available pipe and a piston to assist in sample collection and retrieval.

ADVANTAGES:

General

- samples are obtained relatively fast; and
- the equipment is portable.

Physical

- undisturbed samples maintained by an inner liner may be used for measurement of physical parameters.

Geochemical

- undisturbed samples may be used for measurement of geochemical parameters.

Microbiological

- samples that are undisturbed and remain isolated by an inner liner may be used for microbiological characterization isolation.

DISADVANTAGES:

General

- sample size is typically small;
- non-cohesive granular materials may be difficult to sample because of sample loss during retrieval; and

- depth of penetration is relatively small.

Physical

- cc..solidation may occur during sampling, altering some physical characteristics.

Geochemical

- porewater may be lost or altered due to any consolidation during sampling; and
- the exposed portions of the sample will be exposed to the overlying water and the atmosphere, resulting in geochemical disturbance.

Microbiological

- consolidation of samples and separation of pore water results in some alteration of the in-situ conditions; and
- external contamination from the overlying water and exposure to the atmosphere may result in alteration of the microbiological characteristics.

SELECTED REFERENCES:

Shepard, Francis P. 1973. Submarine Geology, 3rd Ed. Harper Row, New York.

3.3.5 Sampling box for submerged samples

OBJECTIVES:

- to obtain solid-phase samples for solid phase analysis; and

- to provide a solid phase sample for the extraction of porewater.

DESCRIPTION:

The underwater box sampler consists of a removable sampling box, box holder, handgrip, and a closing arm with a bottom plate (Figure 3.3.5-1). For use, the removable box is attached to the box holder and the sample is recovered by inserting the box into the sediment and moving the bottom plate to the closed position with the closing arm. The assembly is then brought to the surface, where the sample box can either be detached for transport, or the sample can be transferred to a receptacle. The sampling box may be operated while wading in shallow water, with extension rods from a boat.

The sampling box operates best in soft relatively unconsolidated deposits, and results in a relatively disturbed sample. Relatively undisturbed samples are possible from soft cohesive consolidated sediments.

ADVANTAGES:

- solid samples are obtained relatively fast;

- equipment is portable; and

- retention of the sample in the detachable sample box decreases external contamination.

Physical

- undisturbed samples maintained by the box may be used for measurement of physical parameters.

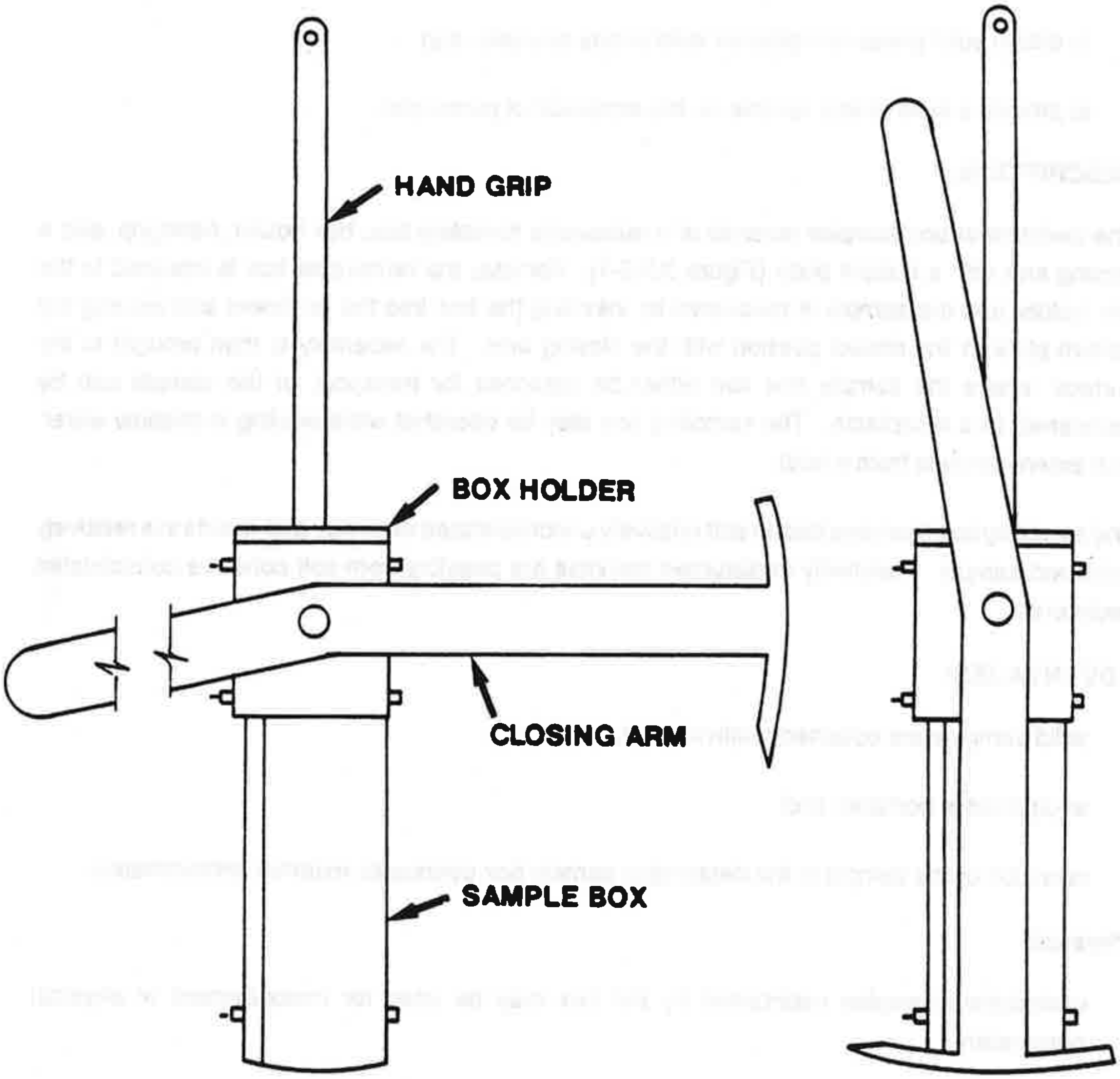
Geochemical

- undisturbed samples maintained by the box may be used for measurement of geochemical parameters.

Microbiological

- external contamination may be decreased by retaining the sample in the sample box for transport; and

- undisturbed samples may retain their in-situ microbiological conditions, and thus may be used for microbiological analysis and isolation.



Sampling Box in Open Position | **Sampling Box in Closed Position**

SAMPLING BOX FOR SUBMERGED SAMPLES	
Figure no. 3.3.5-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

DISADVANTAGES:

General

- sample size is typically small; and
- penetration of rock and coarse sediments is not possible.

Physical

- some consolidation and disturbance may occur during sampling and closure of the bottom plate, possibly altering some physical characteristics.

Geochemical

- pore water may be altered or lost if consolidation or disturbance occurs; and
- any exposure to the atmosphere or overlying water may alter geochemical characteristics.

Microbiological

- external contamination is possible from the overlying water and the atmosphere.

SELECTED REFERENCES:

Bouma, A.H. 1969. Methods for the study of sedimentary structures. Wiley-Interscience. New York.

3.3.6 Sampling box for exposed samples

OBJECTIVES:

- to obtain oriented and undisturbed samples of consolidated or unconsolidated solid materials; and
- to provide solid-phase samples for the extraction of porewater.

DESCRIPTION:

Box samplers (sometimes referred to as Senckenberg boxes) can be easily and economically constructed, and may range in size from pocket boxes (for samples as small as 5 x 2 x 2 cm) to boxes requiring the use of heavy recovery equipment with volumes up to one cubic metre. These samplers consist of several pieces of wood or metal forming a box and a removable cover. The box may be forced into the material to be sampled or may be placed over a block of material exposed by hand or equipment excavation, after which the sample and enclosing box are freed by severing the connection with underlying material using hand tools or the box cover. The covered sample is recovered in the box, or the sample may be retained in the box for transport, or the sample may be transferred to a receptacle in the field. Box samplers can be used in a wide variety of materials, such as consolidated, partially consolidated or unconsolidated soils, clays, muds and sands for the recovery of samples which are generally undisturbed and whose orientation is retained.

ADVANTAGES:

- undisturbed and orientated solid samples are easily and economically recovered;
- sample size is dependent on size of the sampler; and
- samples can be retained in the sampler box to minimize contact with the atmosphere.

Physical

- samples are generally undisturbed, except for the outer edges, when maintained in boxes and physical parameters can be measured.

Geochemical

- samples retained the boxes are relatively undisturbed and their geochemical conditions can be determined.

Microbiological

- high quality sub-samples from the interior of the box samples can be recovered which have not been contaminated by external contacts or exposures.

DISADVANTAGES:

General

- sample recovery is limited to the surface or very near the surface of the tailings area, or at the surface or near the surface of walls of trenches, pits or boreholes; and
- sample size is limited to the mass that can be recovered manually, or to ease of access of mechanical machines (i.e., front-end loaders).

Physical

- the process of excavation to expose a sample may cause some physical disturbance

Geochemical

- the exposure of the sides and/or top of a sample to the atmosphere will allow oxidation and other geochemical disturbance to begin.

Microbiological

- the exterior of the sample is contaminated by external physical contact and atmospheric exposure.

SELECTED REFERENCES:

Marcuson, W.F. and A.G. Franklin. 1979. State-of-the-art of undisturbed sampling of non-cohesive soils. Proceedings of the International Symposium of Soil Sampling, State-of-the-art on current practise of soil sampling, Singapore, pp. 57-71.

Reineck, H.E. 1961. Die Herstellung vov Meeresboden-Praparaten in Senchkenburg-Institut Wilhelmshaven. Museums Kunde, 2: 87-89.

CHAPTER 4
SAMPLING OF LIQUID PHASE

In the vicinity of a tailing impoundment, precipitation infiltrates into the subsurface or becomes surface flow. Additionally, regional groundwater and surface flow may move through the area. As a result, the constantly replenished liquid phase normally represents a large and mobile phase which can lead to water-quality degradation within, and to significant distances outside of, an impoundment. Because of the potential of water to migrate, many regulatory guidelines and objectives are directed to the liquid phase.

The sampling of the liquid phase in and around tailings impoundments, including both groundwater and surface water, can be performed during, after, and independent of solid sampling. Groundwater can be collected during solid sampling either by using the drill stem to provide access to the subsurface or by immediately separating the porewater from the solid sample with techniques such as centrifugation and consolidation. Groundwater can also be sampled from wells and piezometers installed in boreholes after solid sampling. Finally, water can be collected independently of solid sampling such as through surface water grab samples or drive-point piezometers. This chapter describes potentially successful methods on the basis of these categories. Furthermore, because groundwater in wells and piezometers is removed with pumps or bailers, a portion of Chapter 4 is dedicated to these devices.

Measurement of physical properties of water such as viscosity is not usually a requirement of environmental sampling and is thus not addressed under the Advantages and Disadvantages.

4.1 During Solid Sampling

4.1.1 In-filling of stem

OBJECTIVES:

- to sample liquid phase for liquid phase analysis;
- to provide depth specific sampling of liquid phase for liquid phase analysis; and
- to provide liquid-phase samples concurrent with solid phase sample collection (see Section 3.1).

DESCRIPTION:

At a selected depth, augering with a hollow-stem auger rig or dry drilling with a rotary rig ceases and groundwater is allowed to flow into the stem through the cutting head. This water is then raised to the surface with a pump or bailer (Section 4.5). A variation on this method uses a slotted section of stem to accelerate the rate of inflow and minimize stand-by time for the rig.

ADVANTAGES:

General

- samples can provide some immediate in-field determination of liquid phase characteristics; and
- relatively large sample volumes can be obtained from highly conductive materials.

Geochemical

- there are no major advantages due to contact with the stem and exposure to air.

Microbiological

- there are no major advantages due to potential cross-contamination from the stem and air.

DISADVANTAGES:

General

- silts and clay materials prevent rapid infilling of the stem.

Geochemical

- some geochemical parameters will be altered from contact with the stem and the air within the stem.

Microbiological

- external contamination from the sampling apparatus and the supporting liquid transferring equipment is probable; and
- exposure of the liquid sample to air within the stem may result in slight alteration of the microbiological characteristics.

SELECTED REFERENCES:

Taylor, T.W. and M.C. Serafini. 1988. Screened Auger Sampling: the technique and two case studies. Ground Water Monitoring Review, 8, No. 3, p. 145-152.

4.1.2 Advance intake past stem

OBJECTIVES:

- to sample liquid phase for liquid phase analysis;
- to provide depth specific sampling of liquid phase for liquid phase analysis; and
- to provide liquid phase samples concurrent with solid phase sample collection (Section 3.1).

DESCRIPTION:

An auger (Section 3.1.1) or rotary drill (Section 3.1.2) is used to excavate a borehole to a depth just above the desired interval. A rigid water sampling device (Figure 4.1.2-1) such as a steel screen with a tapered drive point is temporally driven to the desired interval and a water sample is removed. A specialized variation on this technique consists of a cone-shaped porous brass point fixed rigidly in the head of the lead auger. Flexible tubing extends from the porous tip to the ground surface. At a selected depth, a vacuum is applied to the tubing and a water sample is obtained.

ADVANTAGES:

General

- samples can provide some immediate in-field determination of liquid phase characteristics;
- large sample volumes can be obtained from highly conductive materials; and
- samples are taken below the zone disturbed by augers.

Geochemical

- samples may be representative of in-situ geochemical conditions of the liquid phase;

Microbiological

samples may be representative of in-situ microbiological conditions of the liquid phase.

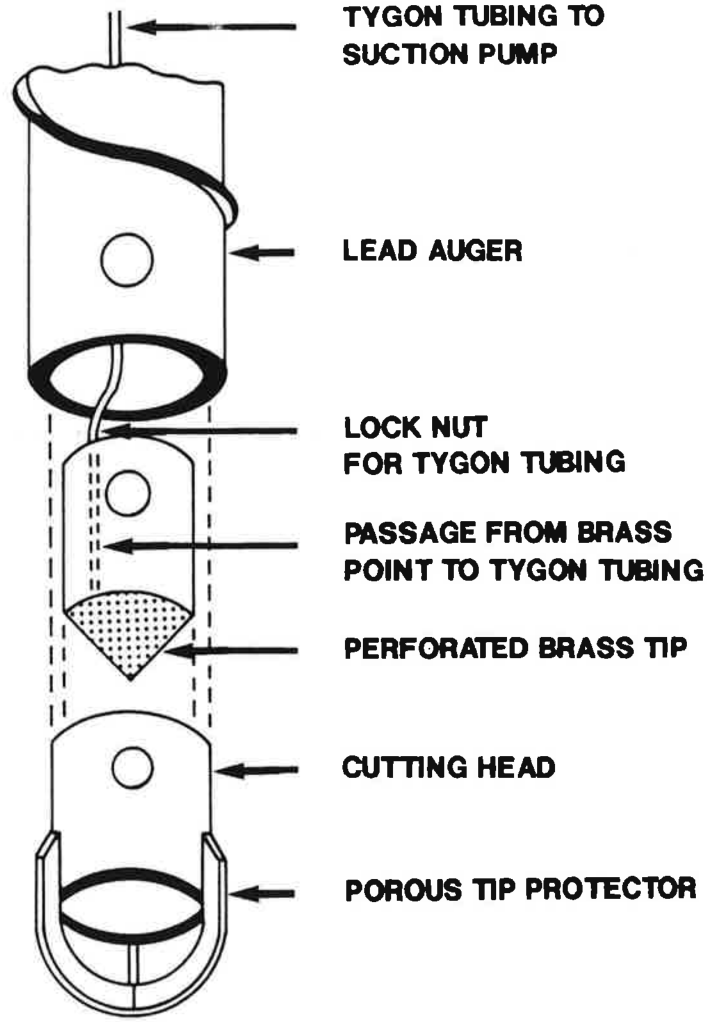
DISADVANTAGES:

General

- the sampler is not effective in silty or clay zones; and
- the vacuum-device variation is only suited for depth-to-water less than 7 m below ground.

Geochemical

- some geochemical parameters may be altered dependent on the flow rate and turbulence caused by sampler installation and groundwater removal; and



ADVANCE INTAKE PAST STEM SAMPLER	
Figure no. 4.1.2-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

- some geochemical parameters may be altered from contact with sampler materials such as steel.

Microbiological

- external contamination from the sampling apparatus and the supporting liquid transferring equipment is probable.

SELECTED REFERENCES:

Cherry, J.A., R.W. Gillham, E.G. Anderson and P.E. Johnson. 1983. Migration of contaminants in groundwater at a landfill: a case study, 2. Groundwater monitoring devices. J. Hydrology, 63, p. 31-49.

4.2 Separation From Solid Phase

4.2.1 Centrifugation

OBJECTIVES:

- to separate the liquid phase from the solid phase;
- to obtain liquid phase samples for liquid phase analysis; and
- to enable a depth-specific sample of liquid phase to be obtained for liquid phase analysis.

DESCRIPTION:

The method extracts porewater from sections of core by centrifigation. A section of core rests on a screen and perforated support disc and an optional filter disc. The porewater is then extracted by spinning the core-screen assembly in a swing-bucket centrifuge for several minutes. The yield is dependent on the volume of core and the retention capacity of the solids for water.

ADVANTAGES:

General

- pore water can be obtained relatively quickly from many types of materials.

Geochemical

- there are no major benefits.

Microbiological

- there are no major benefits.

DISADVANTAGES:

General

- the same location cannot be repeatedly monitored using this technique; and
- small sample volumes are normally obtained.

Geochemical

- exposure to the atmosphere during preparation and centrifugation will alter some geochemical characteristics including chemically reduced species.

Microbiological

- exposure to the atmosphere and unsterile equipment increase the probability of external contamination; and

- exposure to air may result in slight alteration of the microbiological characteristics of the sample.

SELECTED REFERENCES:

Munch, J. and R.W.D. Killey. 1985. Equipment and methodology for sampling and testing non-cohesive sediments. Ground Water Monitoring Review, 5, No. 1, p. 38-42.

4.2.2 Pressurized consolidation

OBJECTIVES:

- to separate the liquid phase from the solid phase;
- to obtain liquid phase samples for liquid phase analysis; and
- to enable a depth specific sample of liquid phase to be obtained for liquid phase analysis.

DESCRIPTION:

The method extracts porewater from sections of core by inducing consolidation. The samples are placed in a squeezing apparatus and the porewater is displaced from the sample during consolidation.

ADVANTAGES:

General

- porewater is relatively easily obtained from fine grained silty materials.

Geochemical

- there are no major benefits.

Microbiological

- there are no major benefits.

DISADVANTAGES:

General

- method is not advantageous for coarse grained sandy sediments and other relatively non-compressible materials;
- the same location cannot be repeatedly monitored using this technique; and
- small sample volumes are normally obtained.

Geochemical

- when the sample is removed from depth to the surface the fast-reacting geochemical characteristics of the liquid may be altered; and
- exposure to the atmosphere during preparation and consolidation will alter some geochemical characteristics including chemically reduced species.

Microbiological

- exposure to the atmosphere and unsterile equipment increase the probability of external contamination; and

- exposure to air may result in slight alteration of the microbiological characteristics of the sample.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical view of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.2.3 Porewater displacement

OBJECTIVES:

- to separate the liquid phase from the solid phase;
- to obtain liquid phase samples for liquid phase analysis; and
- to enable a depth specific sample of liquid phase to be obtained for liquid phase analysis.

DESCRIPTION:

The method extracts porewater from solid samples by displacement of the water with another fluid. Paraplex, an immiscible organic fluid, is one choice of fluid which is forced under pressure into one end of the sample.

ADVANTAGES:

General

- samples that are sandy and coarse grained, i.e., highly permeable, are best suited for this method; and
- displacement may provide a proportionally larger volume of porewater than through consolidation or centrifigation

Geochemical

- there are no major benefits.

Microbiological

- there are no major benefits

DISADVANTAGES:

General

- method is slow for fine grained silty or clay materials;
- the same location cannot be repeatedly monitored using this technique; and
- relatively small sample volume is normally obtained.

Geochemical

- some geochemical characteristics of the liquid phase may change due to the addition of displacing fluid; and

- exposure to the atmosphere during preparation and displacement will alter some geochemical characteristics including chemically reduced species.

Microbiological

- exposure to the atmosphere and unsterile equipment increase the probability of external contamination; and

- exposure to air may result in slight alteration of the microbiological characteristics of the sample.

SELECTED REFERENCES:

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.3 Following Solid Sampling

4.3.1 Monitor well

OBJECTIVE:

- to provide depth integrated liquid phase samples; and
- to provide liquid phase samples for liquid phase analysis.

DESCRIPTION:

A monitoring well is a pipe extending beneath the water table, installed in a borehole that has been drilled using either heavy equipment, such as a hollow stem auger (Section 3.1) or hand operated equipment (Section 3.3). The pipe has a slotted interval of generally greater than 1.5 m that allows the collection of groundwater from a relatively long interval of borehole. Monitoring wells can be of various diameters and various metallic and non-metallic materials, depending on the physical and chemical requirements.

ADVANTAGES:

General

- samples are relatively easy to obtain after well installation using pumps or bailers (Section 4.5);
- samples can be obtained repeatedly from a relatively long depth interval over an extended period of time; and
- the number of wells needed for monitoring a vertical interval is minimized by using longer screens for each well.

Geochemical

- after proper well installation and development, relatively undisturbed samples can be obtained and can be used for measurement of geochemical parameters; and
- repeated sampling and analysis will provide temporal trends.

Microbiological

- samples may be representative of in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- repeated sampling and analysis can provide temporal trends.

DISADVANTAGES:

General

- the maximum potential quality of samples collected through time is determined during the installation of a monitoring well; and

- where vertical hydraulic gradients are significant as found in many tailings impoundments, monitor wells provide an open passage for rapid vertical movement of water and contaminants.

Geochemical

- geochemical characteristics of the sample may be altered depending on pumps or bailers used to obtain sample (Section 4.5); and

- samples are representative of a relatively wide depth interval which may only provide a composite of geochemical characteristics from several distinct intervals of varying water quality.

Microbiological

- contamination from pumps and bailers is probable; and

- contamination resulting from microorganisms deposited or grown on the supporting liquid transfer system may distort temporal trends.

SELECTED REFERENCES:

Cherry, J.A., R.W. Gillham, E.G. Anderson and P.E. Johnson. 1983. Migration of contaminants in groundwater at a landfill: a case study, 2. Groundwater monitoring devices. J. Hydrology, 63, p. 31-49.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.3.2 Piezometer

4.3.2.1 Single piezometer

OBJECTIVES

- to provide depth specific liquid phase samples; and
- to provide liquid phase samples for liquid phase analysis.

DESCRIPTION:

A piezometer is a pipe extending beneath the watertable, installed in a borehole that has been drilled using either heavy equipment such as a hollow stem auger (Section 3.1) or hand operated equipment (Section 3.3). The pipe has a slotted interval of generally less than 1.5 m that enables the collection of groundwater from a specific depth interval. Piezometers can be of various diameters and various metallic and non-metallic materials, depending on the physical and chemical requirements.

ADVANTAGES:

General

- samples are relatively easy to obtain after piezometer installation using pumps or bailers (Section 4.5);
- samples can be obtained repeatedly from a relatively short depth interval over an extended period of time;
- samples are withdrawn from a relatively narrow depth interval allowing the detection of water-quality stratification; and
- the relatively short-screened interval precludes rapid vertical transport of water and contaminants between hydrogeologic units.

Geochemical

- after proper piezometer installation and development, relatively undisturbed samples can be obtained and can be used for measurement of geochemical parameters; and
- repeated sampling and analysis will provide temporal trends.

Microbiological

- samples may be representative of the in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- repeated sampling and analysis can provide temporal trends.

DISADVANTAGES:

General

- the maximum potential quality of samples collected through time is determined during the installation of a piezometer.

Geochemical

- geochemical characteristics of the sample may be altered depending on pump or bailer used to obtain sample (Section 4.5).

Microbiological

- contamination from the liquid transfer system is probable; and

- contamination resulting from microorganisms deposited or growing on the supporting liquid transfer system may distort temporal trends.

SELECTED REFERENCES:

Cherry, J.A., R.W. Gillham, E.G. Anderson and P.E. Johnson. 1983. Migration of contaminants in groundwater at a landfill: a case study, 2. Groundwater monitoring devices. J. Hydrology, 63 p. 31-49.

Gear, B.B., J.P. Connelly. 1985. Guidelines for monitoring well installation. In: 5th National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, National Water Well Association, Columbus, Ohio, p. 84-115.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.3.2.2 Multi-level piezometer

OBJECTIVES:

- to provide depth specific liquid phase samples; and
- to provide liquid phase samples for liquid phase analysis.

DESCRIPTION:

A multilevel piezometer is either a bundle of small diameter piezometers or a single pipe with several sampling ports stacked at various depths in a single borehole. A bundle piezometer (Figure 4.3.2-1) is constructed by fastening a selected number of pipes or lengths of tubing to a center piezometer. A multi-port piezometer (Figure 4.3.2-2) is a single pipe capped to prevent water from entering the bottom. Several small-diameter tubes extend down the center of the pipe and are individually attached to sampling ports.

The water samples can be obtained in several ways. One method is by suction applied at the top of each tube, which is only successful when water depths are less than 3-7 m. A second alternative involves the use of a narrow bailer. If the diameter of the tubing is sufficiently large, positive displacement pumps such as double-tube samplers can be used (Section 4.5). A fourth alternative for obtaining samples is by including a positive-displacement device such as a gas-driven piston (Section 4.5) in each tube during piezometer construction.

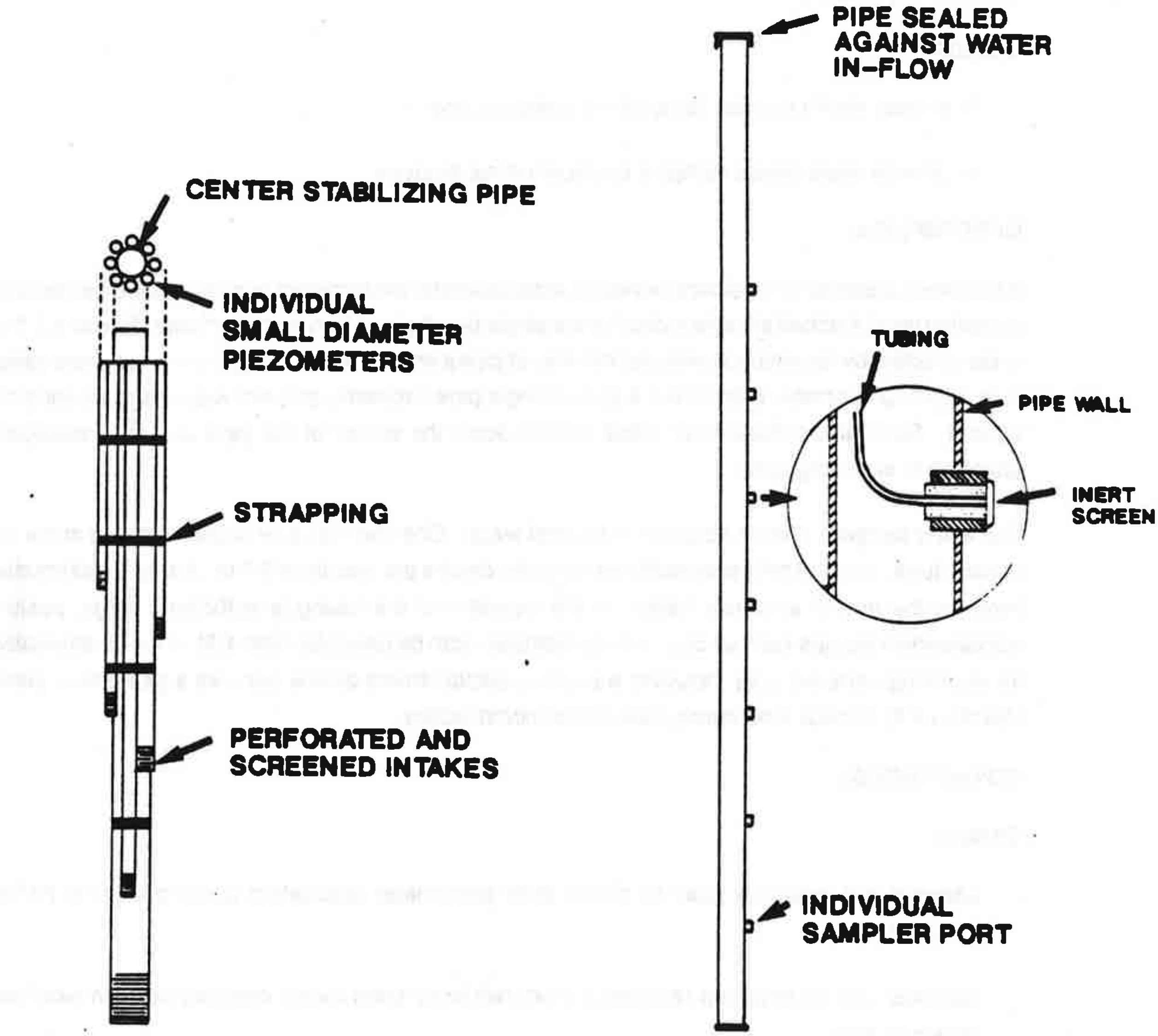
ADVANTAGES:

General

- samples are relatively easy to obtain after piezometer installation using pumps or bailers (Section 4.5);
- samples can be obtained repeatedly from relatively short depth intervals over an extended period of time;
- the relatively short-screened interval precludes rapid vertical transport of water and contaminants between hydrogeologic units; and
- the installation of several piezometers in one borehole can minimize costs, time, and materials, depending on the complexity of design.

Geochemical

- after proper well installation and development, relatively undisturbed samples can be obtained and can be used for measurement of geochemical parameters;
- repeated sampling and analysis will provide temporal trends; and



A) Bundle Type **B) Multi-Port Type**

MULTI-LEVEL PIEZOMETERS: BUNDLE / MULTI-PORT TYPE	
Figure no. **4.3.2-1**	**MEND TAILINGS SAMPLING MANUAL**
Date **Aug. 1989**	Drawn by **CANECT**

- samples are withdrawn directly from relatively short depth intervals allowing the detection of water-quality stratification.

Microbiological

- samples may be representative of in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- repeated sampling can provide temporal trends.

DISADVANTAGES:

General

- the maximum potential quality of samples is determined during installation and is dependent on reliable placement of sand filter packs and low permeability backfill seals for each piezometer or sampling port in the multilevel piezometer;
- to obtain appropriate vertical spacing of the monitoring sampling ports, the stratigraphy of the site must be known prior to piezometer construction; and
- up to several hours are required to construct the multi-level piezometer depending on the complexity.

Geochemical

- geochemical characteristics of the samples may be altered depending on pump or bailer used to obtain sample (Section 4.5).

Microbiological

- contamination from the supporting liquid transfer system is possible; and
- contamination resulting from microorganisms deposited or growing in the supporting liquid transfer system may distort temporal trends.

SELECTED REFERENCES:

Cherry, J.A., R.W. Gillham, E.G. Anderson and P.E. Johnson. 1983. Migration of contaminants in groundwater at a landfill: a case study, 2. Groundwater monitoring devices. J. Hydrology, 63, p. 31-49.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.3.3. Suction lysimeter

OBJECTIVES:

- to provide depth specific liquid phase samples; and
- to provide liquid-phase sample for liquid phase analysis from the vadose zone above the water table.

DESCRIPTION:

A suction lysimeter consists normally of a vacuum cylinder with a water saturated slightly permeable plastic or ceramic base cup. The water saturated cup must be in hydraulic contact with the tension-held water in pores so that, when the cylinder is placed under vacuum, water is drawn into the vacuum cylinder.

ADVANTAGES:

General

- samples are relatively easy to obtain after proper installation;
- samples can be obtained repeatedly from relatively short depth intervals over an extended period of time;
- suction lysimeters work best in moist, relatively coarse grained materials; and
- samples can be withdrawn from relatively short depth intervals allowing the detection of water-quality stratification.

Geochemical

- for samples with water chemistries not affected by vacuum removal of dissolved gases such as CO_2 and O_2 or the presence of foreign gases under partial vacuum, the samples can be used for measurement of geochemical parameters.

Microbiological

- samples may be representative of in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- repeated sampling and analysis can provide temporal trends.

DISADVANTAGES

General

- the time required to collect sufficient sample volume is dependent on physical characteristics of the sediment, and in low permeability soils may be required for sampling;

- hydraulic contact between the lysimeter and the sediment may be difficult to establish and maintain;
- suspended solids in water may plug the slightly permeable cup, preventing water collection;
- bacteria may plug the slightly permeable cup;
- the lysimeter may lose hydraulic contact in freezing/thawing soils;
- there is little agreement in the optimum amount of vacuum pressure to apply but both insufficient and excessive vacuum can result in no collection of water; and
- the installation of a lysimeter may cause varying degrees of disturbance of soil pore chemistry and flow patterns.

Geochemical

- soil porewater geochemistry may be altered during sampling due to leaching and adsorption of dissolved constituents onto the cup;
- vacuum de-gassing and long collection times may result in the alteration of sample chemistry over time; and
- the chemistry of water easily drained from large pores at low tensions may be different from that in associated smaller pores held under higher tension so that representative water chemistry is not easily determined.

Microbiological

- depending on the composition and pore size of the porous cup, some bacteria may not pass into the lysimeter;
- contamination from the supporting liquid transfer system is probable; and
- contamination resulting from microorgannisms that are deposited on and/or growing in the supporting liquid transfer system may distort temporal trends.

SELECTED REFERENCES

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Evertt, L.G., E.W. Hoylman, L.G. Wilson, L.G. McMillion. 1984. Constraints and categories of vadose zone monitoring devices. Ground Water Monitoring Review, 4, No. 1, p. 26-32.

Fishbaugh, T. 1984. Monitoring in the vadose and saturated zones utilizing fluoroplastic. Ground Water Monitoring Review, 4, No. 9, p. 183-187.

Hornby, W.J., J.D. Zabcik, and W. Crawley. 1986. Factors which affect soil-pore liquid: a comparison of currently available samplers with two new designs. Ground Water Monitoring Review, 6, No. 2, p. 61-66.

Peters, C.A. and R.W. Healy. 1988. The representativeness of porewater samples collected from the unsaturated zone. Ground Water Monitoring Review, 8, No. 2, p. 96-99.

4.4 Independent of Solid Sampling

4.4.1 Drive-point piezometer

OBJECTIVES:

- to provide depth specific liquid phase samples; and
- to provide liquid phase samples for liquid phase analysis.

DESCRIPTION:

A drive-point piezometer consists of a rigid casing enclosing a piezometer pipe with a drive point tip (Figure 4.4.1-1). The casing and piezometer are pushed or driven into the ground by hand or by hydraulic equipment to a selected depth beneath the water table. The casing is then recovered and the material surrounding the piezometer is allowed to collapse around it.

This method is best suited in unconsolidated materials such as tailings and clayey sediments. This method is usually not successful in rock formations and coarse grained formations such as gravel and cobbles.

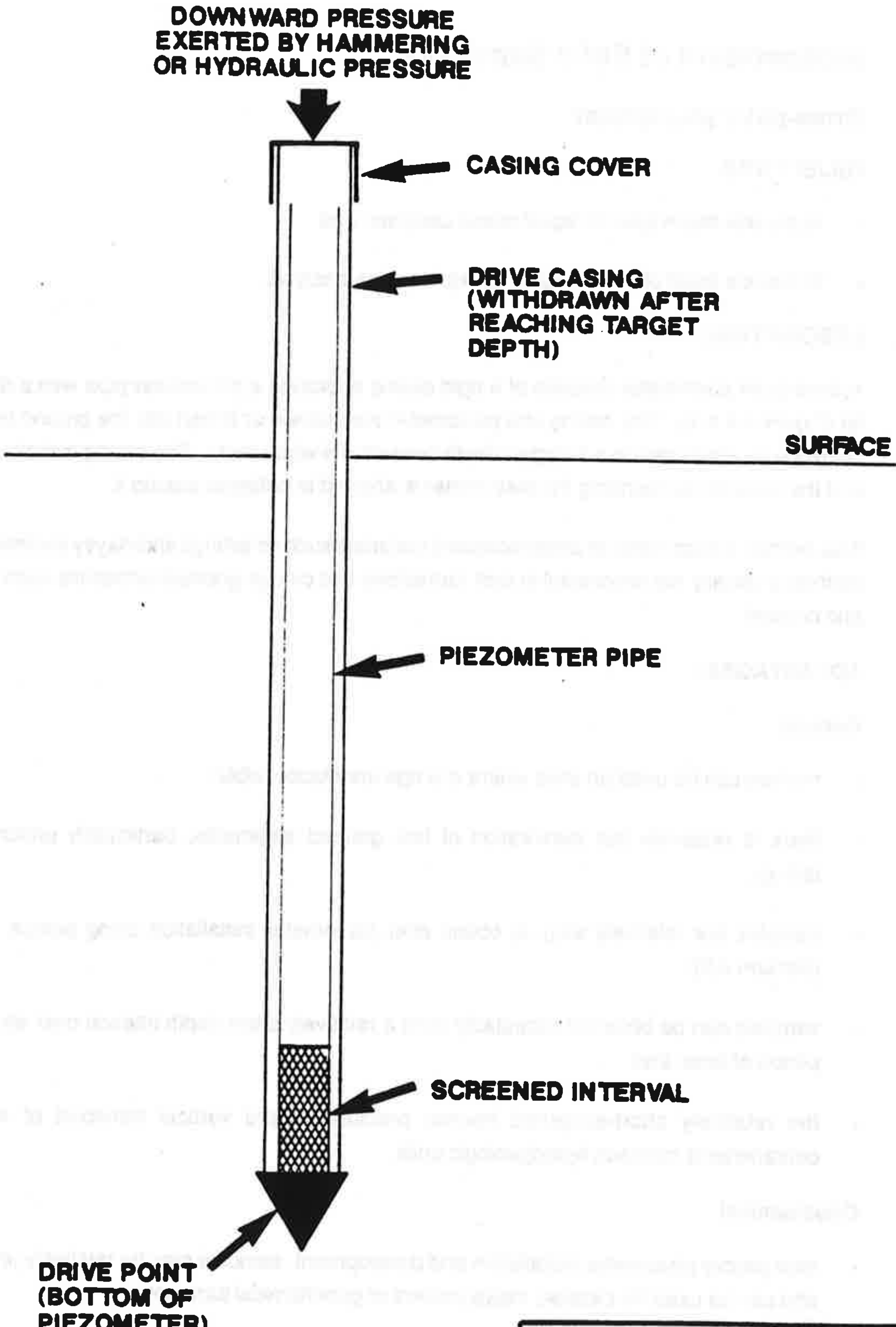
ADVANTAGES:

General

- method can be used on sites where drill rigs are inaccessible;
- there is relatively fast penetration of fine grained sediments, particularly unconsolidated tailings;
- samples are relatively easy to obtain after piezometer installation using pumps or bailers (Section 4.5);
- samples can be obtained repeatedly from a relatively short depth interval over an extended period of time; and
- the relatively short-screened interval precludes rapid vertical transport of water and contaminants between hydrogeologic units.

Geochemical

- after proper piezometer installation and development, samples may be relatively undisturbed and can be used for detailed measurement of geochemical parameters;
- samples are drawn from a relatively narrow depth interval; and



DRIVE-POINT PIEZOMETER

Figure no.	MEND TAILINGS SAMPLING MANUAL
4.4.1-1	
Date: Aug. 1989	Drawn by: CANECT

- samples are withdrawn from a relatively narrow depth interval, allowing the detection of water-quality stratificaton.

Microbiological

- samples may be representative of in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and

- repeated sampling and analysis can provide temporal trends.

DISADVANTAGES:

General

- sample collection must await collapse of the borehole around the piezometer;

- the maximum potential quality of samples collected through time is determined during installation;

- the maximum depth of a driven piezometer is dependent on the physical characteristics of sediment that it must be driven through; and

- solid phase samples cannot be collected using this method.

Geochemical

- geochemical characteristics of the sample may be altered depending on pump or bailer used to obtain sample (Section 4.5).

Microbiological

- contamination from pumps and bailers is probable; and

- contamination resulting from microorganisms deposited or growing in the supporting liquid transfer system may distort temporal trends.

SELECTED REFERENCES

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.4.2 Surface water grab sampler

OBJECTIVES:

- to provide depth-specific or depth-integrated liquid phase samples; and
- to provide liquid phase samples for liquid phase analysis.

DESCRIPTION:

Water samples are collected from streams, rivers, lakes, and tailings ponds to represent conditions that exist at the location at the time of sampling. The sampling container is usually totally immersed and filled with the water. Samples may be collected near the surface, at specific depths, or as depth integrated samples. One type of depth specific sampler is a Kemmerer sampler which is lowered to a specific depth in an open position. At the selected depth the sampler is closed via a messenger line and a depth specific sample is retained. Samples may be composited as single samples of equal or weighted volume. Samples may also be composited as time or flow proportional composites.

ADVANTAGES

General

- samples are relatively easy to obtain;
- samples can be obtained repeatedly from the same depth interval;
- equipment is lightweight and portable; and
- there is no theoretical depth limitation.

Geochemical

- as long as atmospheric isolation is maintained, samples are representative of the in-situ geochemical characteristics and can be used for measurement of geochemical parameters.

Microbiological

- provided that isolation from the atmosphere is maintained, samples may be representative of the in-situ microbiological conditions and can be used for microbiological characterization and isolation.

DISADVANTAGES:

General

- if the sample is not isolated by the device contamination with water from other depths will occur as the device is retrieved.

Geochemical

- water samples are usually exposed to the atmosphere for transfer to sample bottles so that some artificial oxidation should be anticipated (chemically reduced iron has been found in acidic surface waters).

Microbiological

- during travel through the water column, the sampler may become contaminated.

SELECTED REFERENCES

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

4.4.3 Streambed seepage meter

OBJECTIVES:

- to obtain liquid-phase sample for liquid phase analysis.

DESCRIPTION:

A seepage meter consists of a collection chamber, a stopper and a flexible plastic bag (Figure 4.4.3-1). The collection chamber is inserted into streambed and lakebed sediments, or tailings ponds and discharging groundwater is allowed to flow through the chamber. After the chamber has been flushed with groundwater, a collapsed plastic bag is attached and allowed to fill with a sample of the groundwater. A seepage meter is also used to measure the rate of groundwater discharge into, or recharge from, the surface water body.

ADVANTAGES

General

- samples are relatively easy to obtain;
- samples can be obtained repeatedly from the same location;
- equipment is relatively inexpensive; and
- the collection chamber may be left in place for later sampling.

Geochemical

- there are no major advantages to using this method for measuring geochemical parameters.

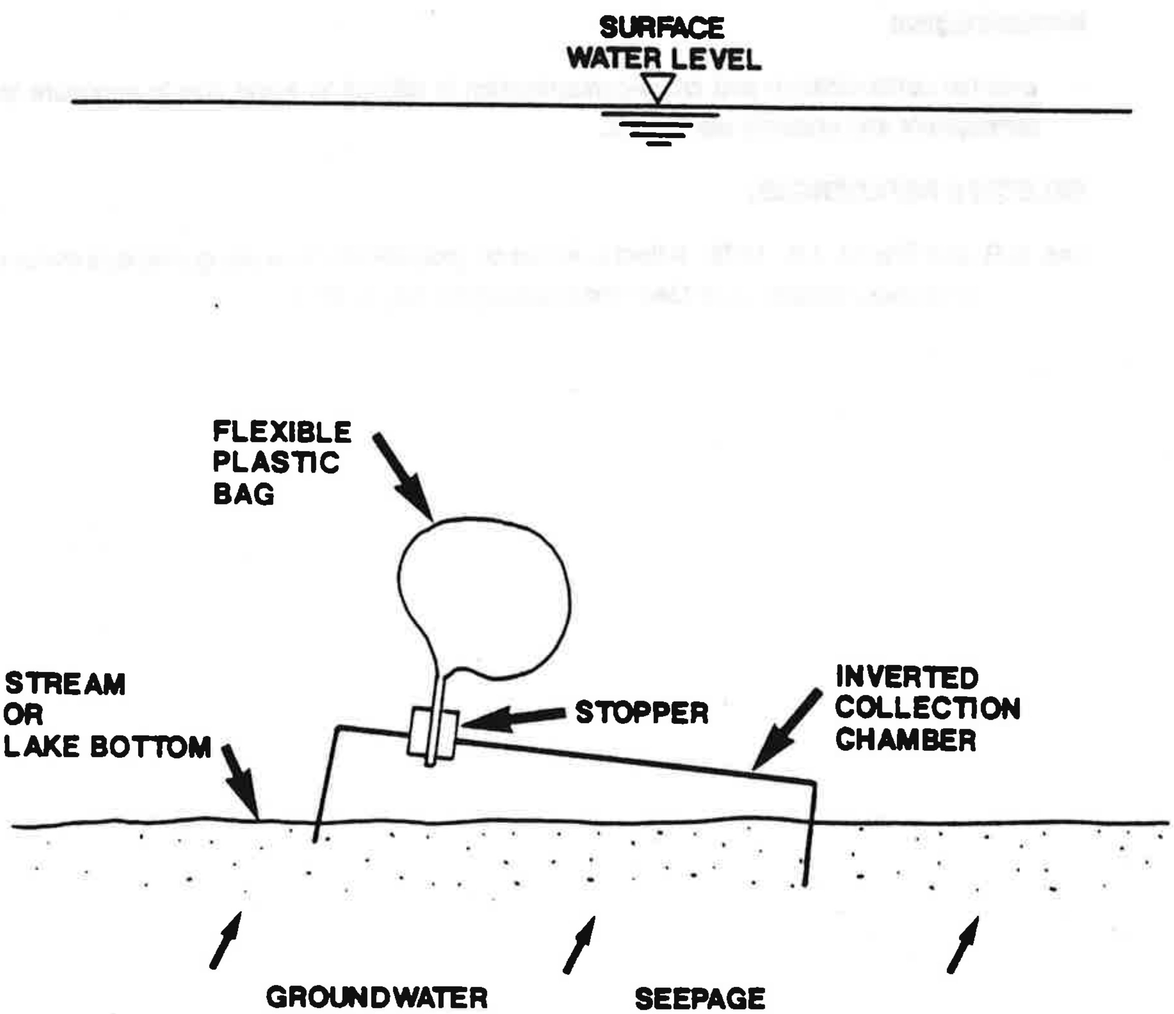
Microbiological

- the utility of this method is limited to sampling in which accurate quantitative analyses are not required and when the sampled material contains very high concentrations of microorganisms which would minimize the apparent effects of external contamination and cross-contamination..

DISADVANTAGES

General

- some sediment disturbance occurs during installation and sealing of the chamber in the sediment; and
- successful installation requires relatively soft sediments.



STREAMBED SEEPAGE METER	
Figure no. 4.4.3-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

Geochemical

- geochemical parameters may be altered due to contact with seepage meter materials and collapsible bag; and
- geochemical parameters may be altered due to atmospheric exposure during sample transfer for storage and shipping.

Microbiological

- external contamination and cross-contamination is difficult to avoid due to exposure to the atmosphere and unsterile equipment.

SELECTED REFERENCES:

Lee, D.R. and Cherry, J.A. 1978. A field exercise on groundwater flow using seepage meters and mini-piezometers. J. of Geological Education, 27, p. 6-10

4.4.4. Wash borings/jetting

OBJECTIVES:

- to provide liquid-phase samples for liquid phase analysis;
- to permit the installation of piezometers and other permanent liquid sampling installations (Section 4.3); and
- to permit the installation of permanent gas sampling installations (Section 5.2).

DESCRIPTION:

This method generally includes several variations whose objective is to loosen and wash away unconsolidated sediments with continuous streams of high-pressure water. Pipe or casing is driven into the sediment. The continuous loosening and removal of sediments allows pipe or casing to be gradually forced further into the sediment. The flow of water carries the cuttings to the top of the pipe or casing. Maximum achievable depth is dependent on maximum water pressure and physical characteristics of the sediment. This method is only successful in sediment that can be liquefied and mobilized by water jets.

ADVANTAGES:

- there is fast penetration of susceptible sediment.

Geochemical

- there are no major advantages to this method relative to geochemical characteristics because of subsurface disturbance and the use of foreign water.

Microbiological

- there are no major advantages due to contamination.

DISADVANTAGES:

General

- small-scale geologic changes or stratification cannot be identified;
- depth of geologic contacts cannot be well defined because of the variable rate at which the liquefied sediment may travel to the surface; and
- water jets may disturb sediment within a relatively large radius around the installation.

Geochemical

- sample quality is dependent on the degree of removal of jetted water from subsurface and the re-establishment of pre-existing conditions may require a relatively long period of time.

Microbiological

- **extreme probability of external contamination precludes the use of this method for microbiological examination.**

SELECTED REFERENCES

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

4.5 Pumps and Bailers

4.5.1 Peristaltic pump

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

A peristaltic pump is a self-priming, low volume vacuum pump that consists of a rotor and several ball bearing rollers within a pump head. Flexible tubing is inserted around the pump head and is squeezed by the rollers as they revolve around the rotor, thereby creating a suction. One end of the tube is placed into the piezometer or well and the other end is directed into a sample container. The sample is lifted through the tube by the vacuum applied at the surface.

ADVANTAGES

General

- wide variety of relatively inexpensive and portable pumps (relative to other types of pumps) are available;
- pumping rates can be regulated over a large range;
- suspended solids do not damage the pump; and
- piezometer diameter is not dependent on the diameter of the pumping mechanism.

Geochemical

- the sample has no direct contact with the pumping mechanism; and
- under a low vacuum, most geochemical characteristics are relatively unaltered and samples can be used for measurement of geochemical parameters.

Microbiological

- the probability of contamination may be greatly decreased by sterilizing the tubing before pumping; and
- exposure to the atmosphere can be minimized by collecting the samples in sterile receptacle under negative pressure.

DISADVANTAGES

General

- the pump can only be used to a depth of 5-8 meters;

- the unit may require an independent AC power source; and
- pumping rates are usually slow relative to other pumps.

Geochemical

- the pump subjects the water to negative pressure which may affect the concentrations of dissolved gases such as CO_2 as well as pH and concentrations of associated species.

Microbiological

- contamination is possible from microorganisms growing or deposited on the tubing wall.

SELECTED REFERENCES

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.2 Centrifugal pump

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

A centrifugal pump consists of an impeller attached directly to a rotating motor shaft. There are two varieties of centrifugal pumps, downhole and surface. Centrifugal pumps at the surface draw water through tubing lowered into a piezometer or well and share the same advantages and disadvantages as peristaltic pumps (Section 4.5.1) with the additional limitations that water comes into direct contact with the impeller and the pump must be primed with foreign water. The downhole centrifugal pumps do not require priming and drive water under positive pressure to the surface through tubing.

ADVANTAGES: (Downhole pumps)

General

- pumping rates may be controlled depending on size, number of stages and power;
- depth of operation is not significantly limited and is dependent on pump power and on tubing length and diameter; and
- suspended solids do not usually damage the pump.

Geochemical

- there are few major advantages relative to other types of pumps; and
- positive pressure during lifting does not draw dissolved gases from the water.

Microbiological

- the utility of this method is limited to sampling in which accurate quantitative analyses are not required and when the sampled material contains very high concentrations of microorganisms which would minimize the apparent effects of external contamination and cross-contamination.

DISADVANTAGES: (Downhole pumps)

General

- the unit requires a significant power source;
- pump units are relatively expensive; and
- minimum piezometer diameter for this device is dependent on pump diameter and is relatively large.

Geochemical

- pressure variations around the impeller may cause some disturbance of dissolved gases;
- the amount of chemical disturbance is generally dependent on flow rate and turbulence; and
- the water comes into contact with the pump body and impeller which are generally not inert, possibly resulting in the alteration of geochemical characteristics of the sample.

Microbiological

- external contamination and cross-contamination is difficult to avoid;
- exposure to the atmosphere and to unsterile equipment greatly increases the probability of contamination; and
- contamination is possible from microorganisms growing or deposited on the tubing walls.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.3 Gas driven (air lift) pump

4.5.3.1 Single-tube pump

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

This is a simplistic method whereby a flexible pipe is lowered into a piezometer or well. Pressurized air or gas is then forced down the tubing followed by water and gas spraying upward ("blowing out") out of the piezometer.

ADVANTAGES:

General

- samples can be collected relatively fast;
- equipment is relatively inexpensive;
- depth limitation is only dependent on length of tubing and gas pressure;
- minimum piezometer diameter for this pump is only limited by tubing diameter; and
- suspended solids do not damage the tubing.

Geochemical

- there are few advantages to this method due to the relatively high degree of sample oxidation, purging of dissolved gas, and contact with piezometer walls during blowout.

Microbiological

- there are few advantages to this method due to contamination from tubing, pressurized gas, and piezometer walls.

DISADVANTAGES:

General

- the pump requires compressed gas;
- compressed gas may be forced through a screen into the natural formation and/or any sand pack, altering the geochemical characteristics and the hydraulic connection;
- the random spray of water from a piezometer must be focussed or continued for a long period of time in order to obtain sufficient sample size; and

- the coating of the piezometer pipe with dissolved and suspended solids will chemically distort subsequent samples.

Geochemical

- the use of compressed gas and the turbulent movement of groundwater up the piezometer pipe will initiate sample oxidation and purging of dissolved gases, possibly resulting in changes in other parameters such as pH; and
- foreign gas may be forced through a screen resulting in gas pockets in the natural formation and sand pack and oxidation of adjacent solids and groundwater.

Microbiological

- contamination should be anticipated from microorganisms growing or deposited on tubing walls and piezometer pipe.

SELECTED REFERENCES

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.3.2 Double-tube pump

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analyses.

DESCRIPTION:

The double tube pump consists of two concentric lengths of tubing with an open annulus between the tubing (Figure 4.5.3-1). The tubing is lowered to below the water level and the inner tubing, which is slightly shorter than the outer tubing at the bottom, transmits pressurized gas downwards, resulting in the lifting of the water to ground level through the annulus. In effect, this design is a small-scale version of the single tube pump (Section 4.5.3.1) where the out tubing minimizes turbulence and oxidation during sampling, focuses the water into a sample bottle, and eliminates contact with piezometer walls during sampling.

A variation on this pump includes a one-way check valve at the bottom of the large tubing to allow entry of groundwater from the piezometer and to prevent compressed gas from entering the piezometer.

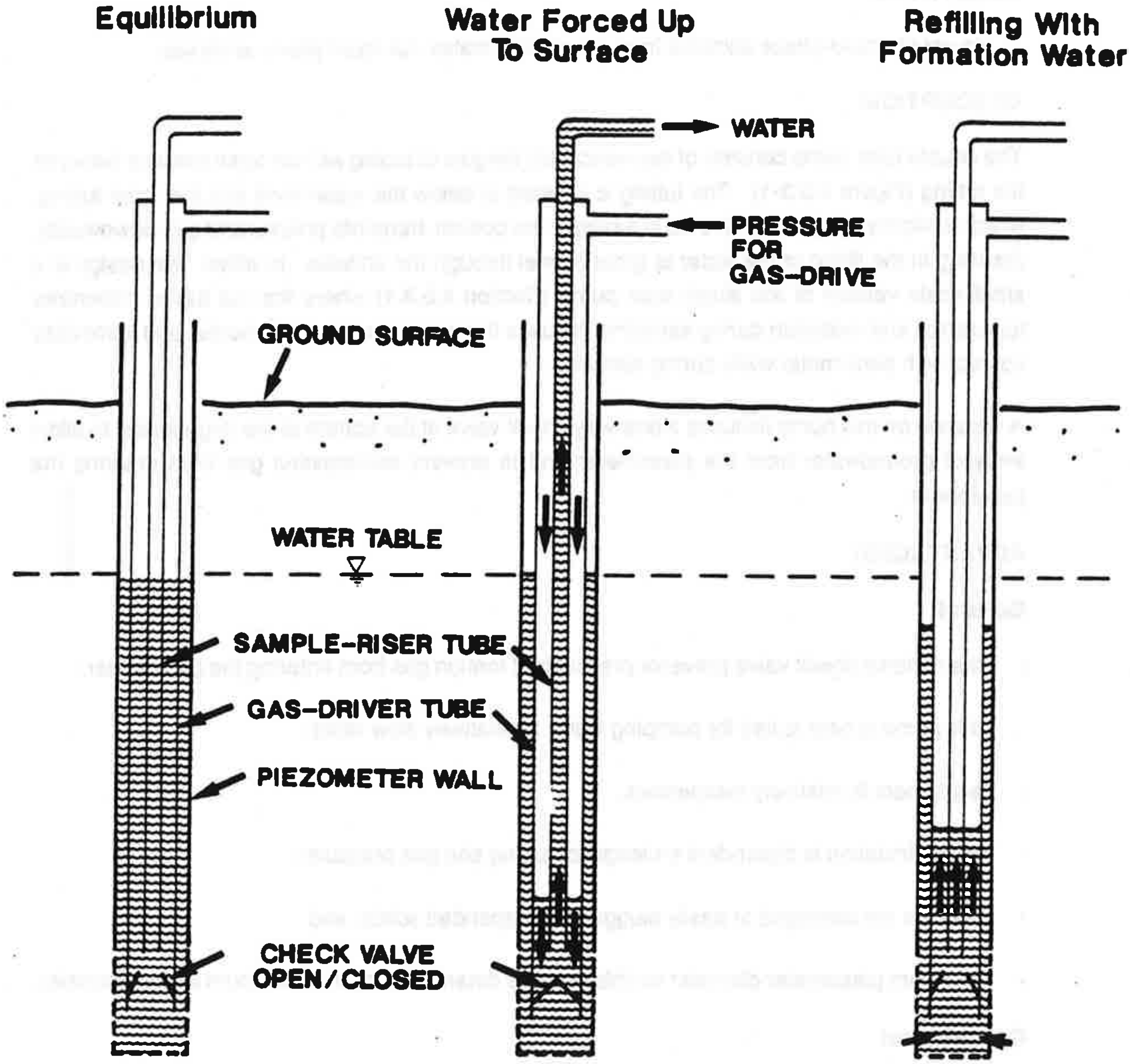
ADVANTAGES:

General

- the optional check valve prevents pressurized foreign gas from entering the piezometer;
- this pump is best suited for pumping water at relatively slow rates;
- equipment is relatively inexpensive;
- depth limitation is dependent on length of tubing and gas pressure;
- pump is not damaged or easily plugged by suspended solids; and
- minimum piezometer diameter for this pump is determined by the maximum tubing diameter.

Geochemical

- sample oxidation is minimized by using an inert gas and regulating the pressure;
- the sample remains isolated from the atmosphere during pumping;
- some geochemical characteristics may be relatively unaltered; and
- the tubing may be left in the piezometer for dedicated sampling to minimize cross-contamination.



This version of the pump was designed by the Institute for Groundwater Research, University of Waterloo, Ontario

DOUBLE-TUBE PUMP	
Figure no. **4.5.3-1**	**MEND TAILINGS SAMPLING MANUAL**
Date **Aug. 1989**	Drawn by **CANECT**

Microbiological

- samples may be representative of the in-situ microbiological conditions if sterile gas is used and therefore can be used for the characterization and isolation of microorganisms from the liquid phase;

- the probability of contamination can be decreased by sterilization of the tubing before pumping; and

- exposure to the atmosphere can be minimized during pumping.

DISADVANTAGES:

General

- The pump requires compressed gas;

- The tubing may be difficult to clean due to the random movement of gas and liquid through the annulus; and

- without a basal cneck valve, foreign gas may enter the piezometer, sand pack, or natural formation.

Geochemical

- the pump subjects the water to pressurized foreign gas which may affect the concentrations of dissolved gases and associated parameters such as pH; and

- if compressed air is used, pumping may cause oxidation of the water.

Microbiological

- contamination is possible from microorganisms growing or deposited on the walls of the tubing.

SELECTED REFERENCES:

Robin, M.J., D.J. Dytynyshyn, S.J. Sweeney. 1982. Two gas-drive sampling devices. Ground Water Monitoring Review, 2, No. 1, p. 63-68.

4.5.3.3 Triple-tube pump

OBJECTIVES:

- to obtain liquid phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

The triple tube pump consists of three concentric tubes: inner packer gas line, riser tube and outer gas drive tube. The primary difference from the double-tube pump (Figure 4.5.3-1) is the presence of the inner line which allows the basal packer to be inflated to seal off the lower portion of the well. The two outer lines are then used as a double-tube pump. The packer assembly essentially functions as a check valve to isolate compressed gas and disturbed water from the lower portion of the well. However, the triple-tube pump is reportedly more difficult to operate than the double-tube pump and is less efficient for small samples.

ADVANTAGES:

General

- the packer assembly isolates compressed gas and disturbed water from the lower portions of the piezometer;
- the pump best suited for pumping water at relatively slow rates;
- the pump is not damaged or easily plugged by suspended solids;
- equipment is relatively inexpensive;
- depth limitation is dependent on length of tubing and gas pressure; and
- the minimum well diameter for this pump is dependent on the maximum tubing diameter.

Geochemical

- sample oxidation is minimized by using an inert gas and regulating the pressure;
- the sample remains isolated from the atmosphere during pumping; and
- some geochemical characteristics may be unaltered and samples can be used for measurement of geochemical parameters.

Microbiological

- samples may be representative of the in-situ microbiological conditions if a sterile gas is used and therefore can be used for the characterization and isolation of microorganisms from the liquid phase;

- the probability of contamination can be decreased by sterilization of the tubing before pumping; and
- exposure to the atmosphere can be minimized during pumping.

DISADVANTAGES:

General

- the pump requires compressed gas;
- the operation is more complex than the double-tube pump; and
- the pump is reportedly less efficient than the double-tube pump for small samples.

Geochemical

- the pump subjects the water to pressurized foreign gas which may affect the concentrations of dissolved gases and associated parameters such as pH; and
- if compressed air is used, pumping may cause oxidation of the water.

Microbiological

- contamination is possible from microorganisms growing or deposited on the walls of the tubing.

SELECTED REFERENCES:

Robin, M.J., D.J. Dytynyshyn, S.J. Sweeney. 1982. Two gas-drive sampling devices. Ground Water Monitoring Review, 2, No. 1, p. 63-68.

4.5.4 Piston pump

OBJECTIVES:

- to obtain liquid phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

The piston pump is submersible with a automatic reciprocating piston-type action driven by compressed gas. The pump unit basically consists a cylinder and a switching unit. There are check valves so that groundwater can only be drawn into the cylinder from the piezometer. When the piston is retracted, groundwater is drawn in to the cylinder, and when advanced, groundwater is forced upwards through tubing to the surface. Variations on this design include dual, alternating cylinders and a stationary piston with a moving cylinder.

The pump is self priming and the pressurized gas driving the pump does not contact the water sample.

ADVANTAGES

General

- samples can be pumped at a relatively fast rate;
- pumping rates can be easily regulated; and
- depth limitation is dependent on length of tubing and gas pressure.

Geochemical

- geochemical characteristics of samples may be relatively unaltered and samples can be used for measurement of geochemical parameters; and
- the sample is isolated from the atmosphere and foreign gas during pumping.

Microbiological

- samples may be representative of the in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- exposure to the atmosphere can be avoided.

DISADVANTAGES:

General

- the pump requires compressed gas or a power source;

- unless the pump intake is filtered, particulate matter may damage the pump valves and piston mechanism;

- the pump is heavy;

- the pump may be relatively expensive; and

- minimum piezometer diameter for this pump is determined by the diameter of the pump mechanism.

Geochemical

- there is a possibility of contamination due to the sample being in contact with the pumping mechanism if the piston is not inert;

- there is a possibility of some distortions in dissolved gases and pH caused by a series of pressure changes in the piston; and

- pump and tubing may be difficult to clean thoroughly, resulting in cross contamination.

Microbiological

- contamination is possible from microorganisms growing or deposited on the walls of the tubing and in the pump

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.5 Bladder pump

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

A bladder pump consists of a flexible membrane (the bladder) enclosed in a rigid housing with an intake check valve, discharge check valve, and two tubes for application of pressurized gas to the rigid housing and for the lifting of water to the surface from the bladder. Prior to use, the pump is pressurized at the surface, causing the bladder to collapse, and is lowered to the desired sampling depth. The pressure is then relaxed between the bladder and housing and water enters the bladder. After filling, water in the bladder is squeezed through tubing upward towards the surface by re-pressurizing the housing. After the water is squeezed out, the pressure is again removed and fresh water again enters the bladder.

ADVANTAGES:

General

- samples can be pumped at a relatively fast rate depending on bladder size and rate of inflow;
- pumping rates can be easily regulated; and
- depth limitation is dependent on length of tubing and gas pressure.

Geochemical

- geochemical characteristics of samples may be relatively unaltered and samples can be used for measurement of geochemical parameters; and
- the sample is isolated from the atmosphere and foreign gas during pumping.

Microbiological

- samples may be representative of the in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- exposure to the atmosphere can be avoided.

DISADVANTAGES:

General

- the pump requires compressed gas or a power source;
- minimum piezometer diameter for this pump is dependent on pump diameter; and

- unless the pump intake is filtered, particulate matter may damage the valves in the pump.

Geochemical

- there is a possibility of contamination due to contact with the bladder if the bladder material is not inert;
- there is a possibility of distortion of dissolved gases and pH due to pressure changes within the bladder; and
- the pump and tubing may be difficult to clean thoroughly, resulting in cross contamination.

Microbiological

- contamination is possible from microorganisms deposited and growing in the tubing and bladder.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.6 WaTerra pump

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid-phase analysis.

DESCRIPTION:

This is a pump designed by WaTerra Pumps Ltd. of Toronto which basically consists of a one-way check valve at the bottom of a length of tubing which extends into a well from the surface. The tubing is moved in a rapid up-down motion (more than one stroke per second) by a hand lever or a gas-powered lever, allowing inertia to move water up the tubing as the tubing is raised and allowing groundwater to enter the bottom of the tubing as it is lowered. As pumping continues, water is decanted from the top of the tubing. This is basically a refinement of hand pumps that have been available for decades, but is designed to provide high-quality samples.

ADVANTAGES:

General

- depth limitation is dependent on the length of tubing and the ability to quickly raise-lower the weight of the tubing;
- the tubing and hand level are lightweight and portable depending on tubing length;
- minimum piezometer diameter for this pump is dependent on tubing diameter; and
- hand-driven equipment is inexpensive relative to other pumps.

Geochemical

- geochemical characteristics may be relatively unaltered;
- water remains isolated from the atmosphere during pumping; and
- water does not contact a metallic pump mechanism.

Microbiological

- samples may be representative of in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase; and
- exposure to the atmosphere can be avoided.

DISADVANTAGES:

General

- this technique is labour intensive relative to sample delivery rate;

- a high stroke rate must be maintained; and
- the check valve may be plugged by suspended solids.

Geochemical

- the extent of pressure variation and potential sample degassing has not been reported, but may not be significant based on analyses of volatile organic compounds.

Microbiological

- contamination is possible from microorganisms growing or deposited on the walls of the tubing.

SELECTED REFERENCES:

Barker, J.F., and R. Dickhout. 1988. An evaluation of some systems for sampling gas-charged groundwater for volatile organic analysis. Ground Water Monitoring Review, 8, No. 4, p. 112-120.

Rannie, E.H. and R.L. Nadon. 1988. An inexpensive, multi-use, dedicated pump for groundwater monitoring wells. Ground Water Monitoring Review, 8, No. 4, p. 100-106.

4.5.7 Syringe sampler

OBJECTIVE:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

A syringe sampler (Figure 4.5.7-1) may be considered a small-scale version of an air-tight bailer (Section 4.5.8) rather than a pump. A non-commercial version of this sampler consists of a standard 50 mL plastic or glass syringe in which the plunger handle has been removed, leaving the rubber piston inside the syringe barrel. The piston is placed in its most forward position and a vacuum line is attached to the back of the syringe. The sampler is then lowered into a well or piezometer. An in-line filter may be attached to the intake of the syringe so that groundwater is filtered as it flows into the syringe as the piston is retracted by vacuum. As soon as the syringe is filled, it is returned to the surface, the intake is sealed, and the vacuum hose is removed. If a gas-permeable plastic syringe is used, the syringe should be encapsulated in a sealant and submerged for maximum isolation.

ADVANTAGES:

General

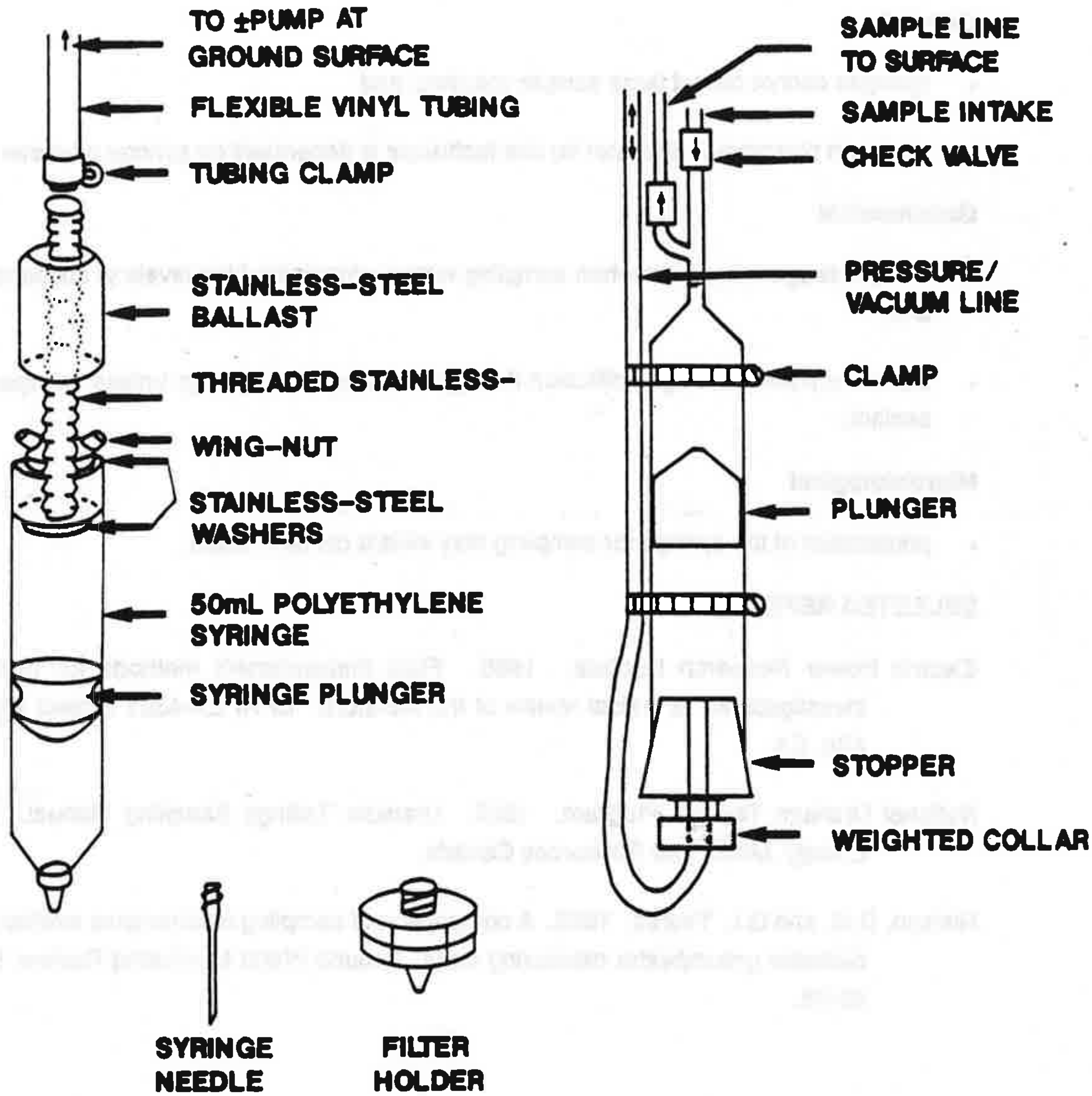
- samples can be taken at discrete intervals from any depth in a well;
- samples can be taken from slowly recharging wells and shallow wells due to the small sample volume;
- sampler equipment is lightweight and portable; and
- depth limitation is dependent on length of tubing; however, pressure may have to be initially applied to the sampler to keep the piston in place during lowering to greater depths.

Geochemical

- geochemical characteristics of samples may be relatively unaltered and samples can be used for detailed measurement of geochemical parameters;
- the sample does not come in contact with foreign gases and is subjected to very low negative pressure, thereby avoiding significant alteration of dissolved gases; and
- the syringe can be used as a sample container, thus removing the potential for cross contamination.

Microbiological

- samples may be representative of in-situ microbiological conditions and therefore can be used for the characterization and isolation of microorganisms from the liquid phase.



TWO EXAMPLES OF SYRINGE SAMPLERS

Figure no. 4.5.7-1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

DISADVANTAGES:

General

- syringes cannot collect large sample volumes; and
- minimum piezometer diameter for this technique is dependent on syringe diameter.

Geochemical

- some leakage may occur when sampling waters containing high levels of suspended solids; and
- there is a potential for gas diffusion through some types of syringe unless encapsulated in a sealant.

Microbiological

- preparation of the syringe for sampling may initiate contamination.

SELECTED REFERENCES:

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

National Uranium Tailings Program. 1985. Uranium Tailings Sampling Manual. NUTP-1E. Energy, Mines and Resources Canada.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.8 Bailers

4.5.8.1 Single valve

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

Bailers can be constructed of any rigid tubular material that can be easily machined. The bailer is lowered into and withdrawn from the well or piezometer using a cable or rope. A single valve bailer has a check valve on the bottom. As the bailer is lowered into the well, the check valve remains open allowing water to pass through the bailer. At a selected depth, the bailer is stopped, the valve closes and then the bailer is withdrawn from the well. The sample is then poured from the top of the bailer into appropriate sample containers.

ADVANTAGES:

General

- samples can be taken at discrete intervals from any depth in a well;
- depth limitation is dependent on length of cable or line;
- bailers are lightweight and portable;
- equipment is inexpensive; and
- minimum piezometer diameter for this device is dependent on bailer diameter.

Geochemical

- there are no significant advantages due to the lack of isolation during bailer retrieval and sample transfer.

Microbiological

- there are no significant advantages.

DISADVANTAGES:

General

- bailing is labour intensive relative to the sample delivery rate;
- sample volume is dependent on length and diameter of bailer;
- bailing does not supply a continuous flow of water to the surface; and

- the valve may not seal properly in water containing suspended solids.

Geochemical

- some aeration, degassing and turbulence can occur while lowering or raising the bailer and when pouring the sample from the bailer;
- some mixing of bailer water and shallow well water may occur during bailer retrieval;
- cross-contamination between wells can occur if the line and bailer are not dedicated to a single well; and
- the bailer and line may cause contamination if they are not made of inert materials.

Microbiological

- the lack of isolation during lowering of the bailer, bailer retrieval, and sample transfer may result in contamination.

SELECTED REFERENCES

Electric Power Research Institute. 1985. Field measurement methods for hydrogeologic investigations: a critical review of the literature. EPRI EA-4301 Project 2485-7, Palo Alto, CA.

Nielson, D.M. and G.L. Yeates. 1985. A comparison of sampling mechanisms available for small diameter groundwater monitoring wells. Ground Water Monitoring Review, 5, No. 2, p. 83-98.

4.5.8.2 Double valve

OBJECTIVES:

- to obtain liquid-phase samples from a sampling station for liquid phase analysis.

DESCRIPTION:

Bailers can be constructed of any rigid tubular material that can be easily machined. The bailer is lowered into and withdrawn from the well or piezometer using a cable or rope. A double valve bailer has a check valve at the bottom and top. As the bailer is lowered through the water column, water flows through the bailer. When the desired depth is reached, the bailer is stopped and both check valves close simultaneously and the bailer is then withdrawn from the well. The sample is poured from the bailer into appropriate sample containers. Variations on this design include the option of introducing high-purity inert gas during controlled draining of the bailer to minimize atmospheric contamination and the inclusion of a piston within the bailer to isolate the water sample from any overlying gas phase.

ADVANTAGES:

General

- samples can be taken at discrete intervals from any depth in a well;
- depth limitation is dependent on length of cable or line;
- bailers are generally lightweight and portable depending on the variation in design;
- equipment is relatively inexpensive depending on the variation in design; and
- minimum piezometer diameter for this device is dependent on bailer diameter.

Geochemical

- the enclosed nature of the bailer minimizes turbulence, aeration, and de-gassing during retrieval and sample transfer; and
- geochemical characteristics may be relatively unaltered.

Microbiological

- samples may be generally representative of in-situ microbiological conditions, although the initial lowering of the bailer through the water column may result in contamination.

DISADVANTAGES:

General

- bailing is labour intensive relative to the sample delivery rate;

CHAPTER 5
SAMPLING OF THE PORE-GAS PHASE

At the top of a tailings pile, there is frequently a zone where the porespace is not completely saturated with water. The composition of the pore gas in this unsaturated zone may be critical in determining the geochemistry of the solid and liquid phases, particularly when the pore-gas carries oxygen to acid-generating materials. As a result, high-quality samples of pore-gas may be an integral part of a sampling program.

Chapter 5 describes the methods for pore-gas sampling which can be employed during solid-phase sampling inside of a drill stem, after solid-phase sampling in permanently installed gas-sampling ports, and independent of solid sampling. Pore gas is usually withdrawn into a syringe for later analysis or directly circulated through an on-site autoanalyzer for immediate analysis. Both alternatives are described at the end of this chapter. Pore-gas samples are not analyzed for microbiological activity so that this category does not appear under Advantages and Disadvantages.

5.1 Sampling Port Extended Beyond a Drill Stem

OBJECTIVES:

- to provide pore gas samples for gas analysis;
- to provide depth-specific samples of pore-gas phase for gas phase analysis; and
- to provide pore-gas phase samples concurrent with solid phase sample collection (Section 3.1).

DESCRIPTION:

A conventional hollow stem auger method (Section 3.1.1.1) is used to auger the borehole to a depth just above the desired interval. A rigid sampling device such as a hollow steel pipe with a basal plug such as a large-head nail is driven into the underlying sediment to the desired depth. The sampler is then pulled up a few centimeters, which leaves the nail at the bottom of the hole and forms a small cavity for collection of pore gas. The gas is then removed from the pipe by an autoanalyzer for immediate analysis (Section 5.4.2) or by a gas-impermeable syringe for later analysis (Section 5.4.1).

ADVANTAGES:

General

- samples can provide some immediate in field determination of gas phase characteristics during augering; and
- samples are taken below the zone disturbed by augers.

Geochemical

- samples are representative of the in-situ geochemical conditions of the gas phase providing pore-gas sampling does not draw gas (air) from the overlying hollow stem.

DISADVANTAGES:

General

- the device is only suited for shallow depths because long lengths of pipe may bent when driven;
- only one sample from a specific depth interval can be obtained using this method; and
- the basal plug may not stay in place when lowering the pipe through the stem, resulting in a sediment-plugged pipe.

Geochemical

- if there is a poor seal along the sides of the pipe geochemical characteristics of the pore gas may be altered due to contamination by atmospheric gases within the stem; and

- sample integrity is partially dependent on the method used to obtain a sample (Section 5.4).

SELECTED REFERENCES:

Evaluation of this technique is based on the judgement of the study team.

5.2 Following Solid Sampling

5.2.1 Single level port

OBJECTIVES:

- to provide pore-gas samples for chemical analysis; and
- to provide depth-specific samples of pore gas.

DESCRIPTION

A single level port (Figure 5.2.1-1) consists of tubing or pipe, relatively impermeable to gases, cut to a specific length. The top end of the tubing is covered with removeable, gas-impermeable material to isolate the interior from the atmosphere. The tubing is lowered into a borehole (Chapter 3) and the bottom end is packed with filter material such as silica sand or glass wool to minimize movement of fine-grained particles during sample withdrawal. The borehole is then backfilled with low-permeability material to minimize gas movement vertically through the borehole. After installation, atmosphere- contaminated gas should be pumped from the tubing.

ADVANTAGES:

General

- the equipment is relatively easy to assemble and install; and
- samples can be obtained repeatedly from the same depth interval.

Geochemical

- after proper installation and development, samples are representative of the in-situ geochemical condition of the gas phase.

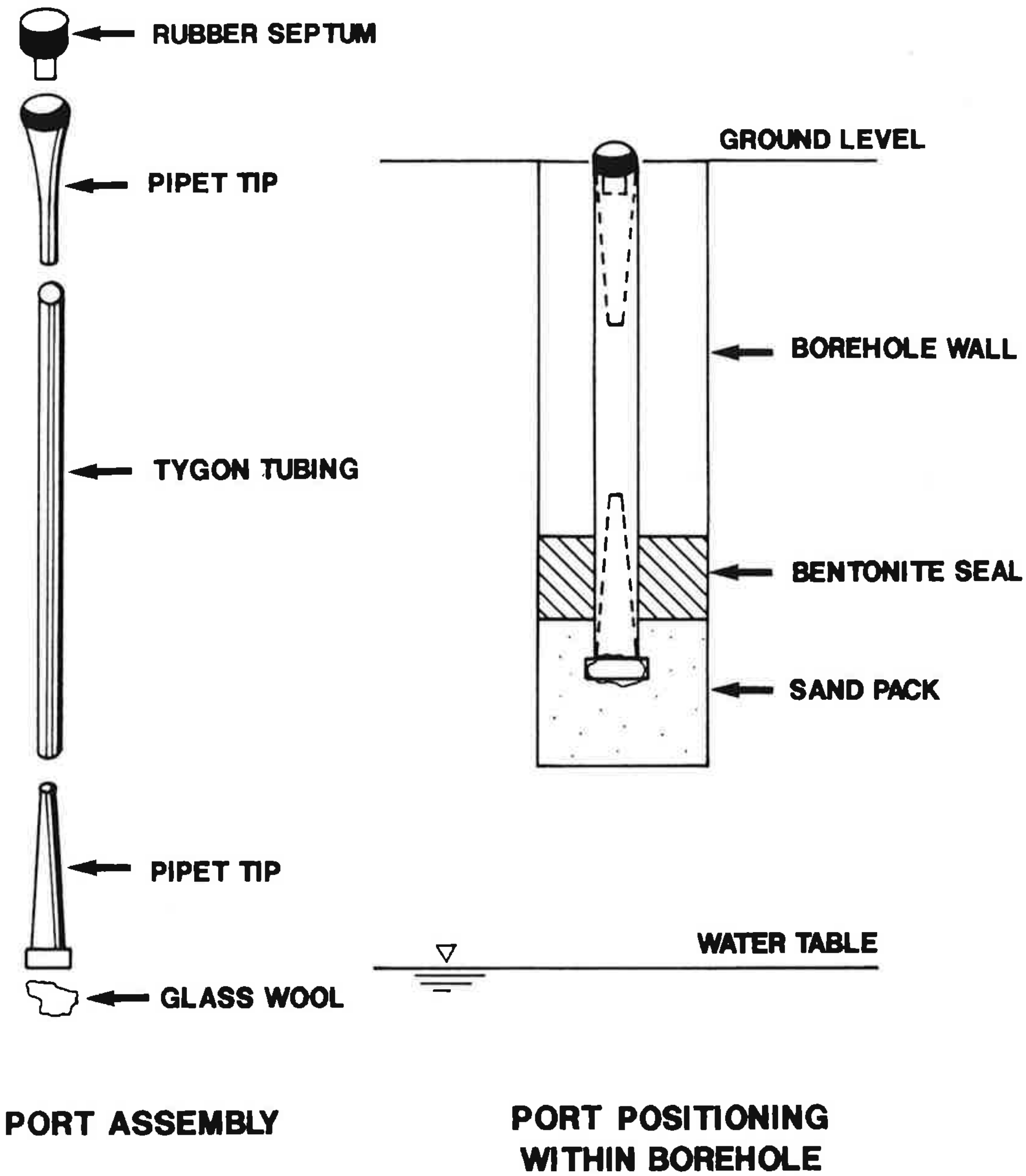
DISADVANTAGES

General

- improper backfilling may cause the tube to bend or collapse, making sampling difficult; and
- fine particles in the soil may clog the filter, making sampling difficult and slow.

Geochemical

- if there is a poor seal in the borehole or at the impermeable cover at the top of the tube, the geochemical characteristics of the pore gas may be altered due to contamination by atmospheric gases or pore gas from other depths.



SINGLE LEVEL PORT	
Figure no. 5.2.1–1	MEND TAILINGS SAMPLING MANUAL
Date Aug. 1989	Drawn by CANECT

SELECTED REFERENCES:

E.J. Reardon, G.B. Allison, and P. Fritz. 1979. Seasonal chemical and isotopic variations of soil CO_2 at Trout Creek, Ontario. Journal of Hydrology, 43, p. 335-371.

5.2.2 Multiple level ports

OBJECTIVES:

- to provide pore-gas samples for gas analysis; and
- to provide depth-specific samples of pore gas.

DESCRIPTION:

Multiple level ports consist of tubing cut in varying lengths. The design of each tube is similar to a single-level tube (Section 5.2.1). Each tube is labelled and then the tubes are assembled into a bundle and installed into a borehole (Chapter 3) with appropriate backfilling materials including impermeable seals between each sampling port. After installation, atmosphere-contaminated gas should be removed from each tube.

ADVANTAGES:

General

- easy to assemble;
- samples can be obtained repeatedly from the same depth interval; and
- multi-level samplers minimize installation costs and supplies.

Geochemical

- after proper installation and development, samples are representative of the in-situ geochemical condition of the gas phase.

DISADVANTAGES:

General

- improper backfilling may cause the tubes to bend or collapse making sampling difficult;
- fine particles in the soil may clog the filters, making sampling difficult and slow; and
- sample integrity is dependent on reliable placement of sand filter packs and low permeability backfill seals between each sampling port.

Geochemical

- if there is a poor seal in the borehole vertical migration of gas will occur which will alter the geochemical characteristics of the gas; and

- **If there is a poor seal in the borehole or at the impermeable cover at the top of the tube, the geochemical characteristics of the pore gas may be altered due to contamination by atmospheric gas or pore gas from other depths.**

SELECTED REFERENCES:

E.J. Reardon, G.B. Allison, and P. Fritz. 1979. Seasonal chemical and isotopic variations of soil CO_2 at Trout Creek, Ontario. Journal of Hydrology, 43, p. 335-371.

5.2.3 Closed circuit sampler

OBJECTIVES:

- to provide pore-gas samples for gas analysis; and
- to provide depth-specific samples of pore gas.

DESCRIPTION:

The sampler, currently under development, consists of an inverted cup with a porous membrane across the basal opening of the cup. This assembly is lowered into a borehole (Chapter 3) with two sampling tubes or pipes extending from the inner chamber of the cup to the surface where the tubes are capped by removable gas-impermeable seals. The borehole is then filled with an impermeable seal. The cup assembly provides a cavity for the open accumulation of pore gas and the two tubes form a closed-curcuit gas loop with the cup. This device thus allows the recirculation of pore gas through a non-destructive autoanalyzer (Section 5.4.2) or, alternatively, permits withdrawal of pore gas from one tube with the simultaneous replacement with an inert gas through the second tube. Both sampling techniques eliminate pressure gradients in the natural formation which could draw gas from the surface or another depth.

ADVANTAGES

General

- the equipment is relatively easy to assemble and install; and
- samples can be obtained repeatedly from the same depth interval.

Geochemical

- after proper installation and development, samples are representative of the in-situ geochemical condition of the gas phase; and
- there is no vacuum created during sampling which may draw down foreign gases into the device.

DISADVANTAGES:

General

- this is a new technique which is at the research and development stage.

Geochemical

- if there is a poor seal in the borehole or at the removable tubing caps, the geochemical characteristics of the sample may be altered by contamination from the atmosphere or other pore gas.

SELECTED REFERENCES:

Under development by T.P. Lim and N.K. Davé of the Elliot Lake Laboratory of CANMET (Ontario) and by K.A. Morin of Morwijk Enterprises (British Columbia).

5.3 Independent of Solid Sampling

5.3.1 Drive-point ports

OBJECTIVES:

- to provide pore-gas samples for gas analysis; and
- to provide depth-specific samples of pore gas.

DESCRIPTION:

A drive-point port (Figure 5.3.1-1) consists of a pre-cut hollow steel pipe with basal slots or a removable basal drive-point. The steel tube is driven into the material to the desired depth. If a removable drive-point is used, the pipe is pulled up several centimeters away from the drive-point forming an open cavity for pore-gas collection. A gas-impermeable cover is placed over the top end of the pipe.

ADVANTAGES:

General

- samples can provide some immediate in-field determination of gas phase characteristics if an autoanalyzer is used; and
- if the pipe is left in place, samples can be obtained repeatedly from the same depth interval.

Geochemical

- after proper installation and development, samples are representative of the in-situ geochemical characteristics of the gas phase.

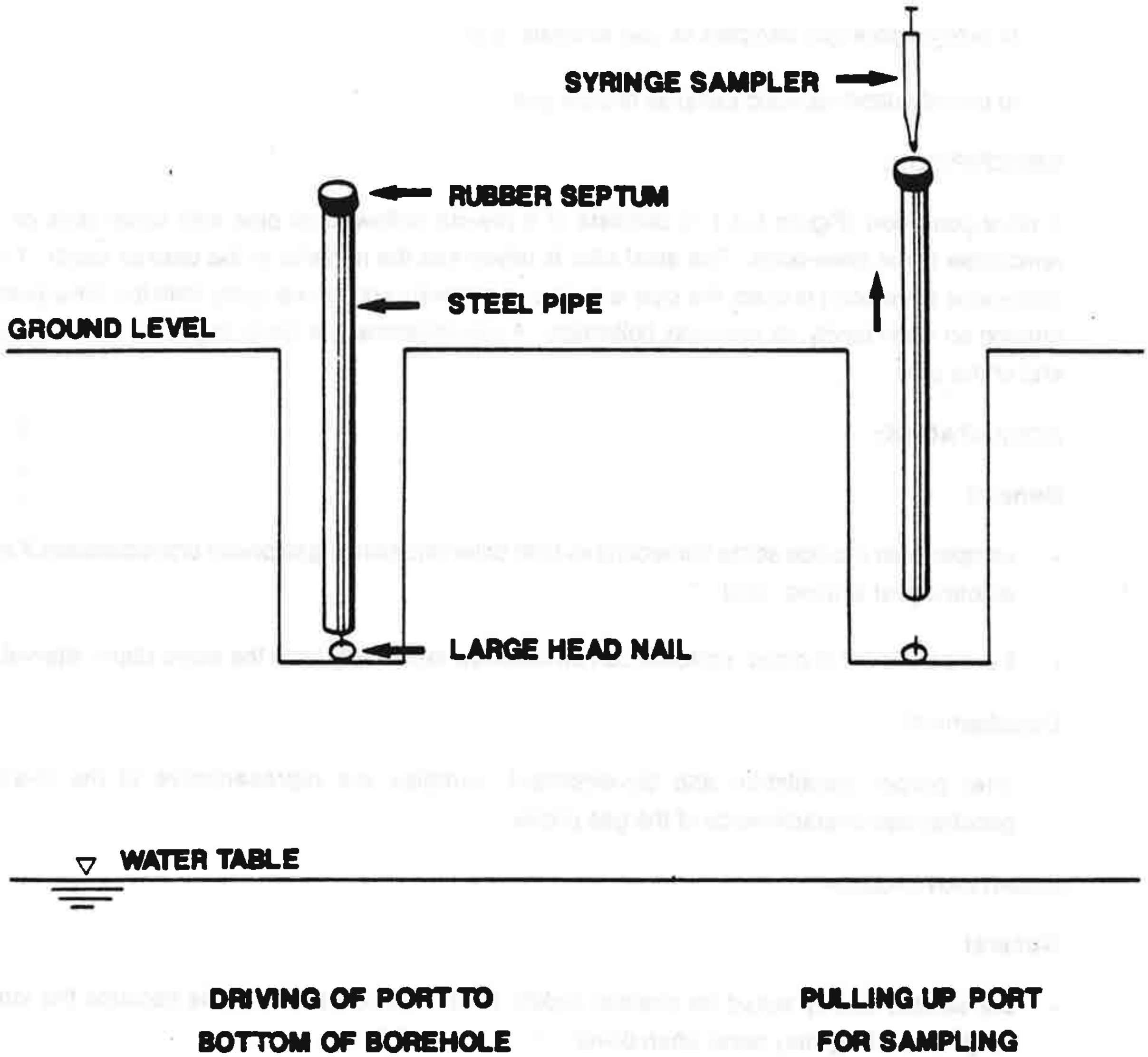
DISADVANTAGES:

General

- the sample is only suited for shallow depths in unconsolidated materials because the long lengths of tubing may bend when driven;
- there is no filter to prevent material from entering and clogging the tube during sampling; and
- collapse of the sediment around the tubing may not occur, allowing an open connection to the atmosphere.

Geochemical

- if there is a poor seal along the sides of the tube or at the impermeable cover at the top of the tube geochemical characteristics of the pore gas may be altered due to contamination by atmospheric gases or pore gas from other depths; and



DRIVE POINT PORT	
Figure no. **5.3.1-1**	**MEND TAILINGS SAMPLING MANUAL**
Date **Aug. 1989**	Drawn by **CANECT**

- if the pipe is withdrawn from the subsurface and the hole is not properly sealed, an open pathway for atmospheric contamination exists.

SELECTED REFERENCES:

E.J. Reardon, G.B. Allison, and P. Fritz, 1979. Seasonal chemical and isotopic variations of soil CO_2 at Trout Creek, Ontario. Journal of Hydrology, 43, p. 355-371.

5.3.2 Collector for migrating pore gas

OBJECTIVES:

- to provide gases migrating from/to soil and tailings piles.

DESCRIPTION:

This sampling chamber is similar in concept and purposes to the streambed seepage meter (Section 4.4.3), but is intended to collect pore gas which is "exhaled" from tailings impoundments during events such as barometric pumping and water-table fluctuations. The collection chamber can be inexpensively obtained by using part of a steel drum or bucket. The edges of the chamber are forced into and secured within the tailings or sediment mass. A small-diameter hole or valve in the top of the chamber allows movement of gas to/from the atmosphere and prevents the creation of a vacuum or an over pressure within the chamber. If pore gas is being forced out of the unsaturated zone, the chamber will contain a sample of the gas. If atmospheric gases are being drawn into the unsaturated zone, the chamber will contain a sample of the atmosphere. If there is no pore-gas movement, the small-diameter valve will minimize atmospheric diffusion into the chamber. Gas samples can be collected by syringe (Section 5.4.1) for later analysis or by on-site autoanalyzer (Section 5.4.2) for immediate analysis.

ADVANTAGES:

General

- samples are relatively easy to obtain;
- the sampler is easily and cheaply constructed;
- the sampler can be used for repeated consecutive collection of emanated gasses, or may be moved from one location to another; and
- the sampler can be used on the soil surface, in a borehole or excavated pit, and either in a horizontal or vertical position.

Geochemical

- samples are representative of the geochemical characteristics of migrating gases.

DISADVANTAGES:

General

- gas samples are only obtainable from relatively even surfaces which are sufficiently soft to allow insertion of the chamber.

Geochemical

- long-term residence of gas in the chamber may result in significant changes in chemical composition; and

- improper sealing of the chamber to the sediment may provide an open pathway for air to enter the chamber.

SELECTED REFERENCES:

This concept has been developed by the study team based on the streambed seepage meter of Section 4.4.3 and has apparently never been implemented or tested.

5.4 Sample Collection Devices

5.4.1 Syringe

OBJECTIVES:

- to obtain a pore-gas phase sample for gas analysis.

DESCRIPTION:

Syringes made of thick-walled glass are used to collect and store gas samples. Plastic syringes have been found to exchange gas and thus are not suitable without additional precautions. If the top portion of a sampling tube is flexible, the syringe and impermeable tubing cap should be placed in a tray of water during sample collection to maximize isolation from the atmosphere. The syringe is then connected to the tubing either by removing the impermeable cap and inserting the syringe tip into the tubing or by inserting a needle attached to the syringe through the cap. The tube should be purged for several volumes before a sample is retrieved After the gas sample is retrieved, an impermeable cap is placed on the syringe and the syringe is stored underwater.

ADVANTAGES:

General

- the sampler is lightweight and portable.

Geochemical

- geochemical characteristics of samples may be relatively unaltered and samples can be used for detailed measurement of geochemical parameters; and

- the syringe is used as a sample container, thus removing the possibility of cross contamination.

DISADVANTAGES:

General

- glass syringes are fragile; and

- the sample volume is small.

Geochemical

- sufficient leakage can occur with syringes with loosely sealed barrels; and

- gas diffusion through seals and syringe components is inevitable with time.

SELECTED REFERENCES:

The description is based on known procedures currently in use in Canada.

5.4.2 Autoanalyzer

OBJECTIVES:

- to obtain and immediately analyze pore-gas samples.

DESCRIPTION:

There are two different types of autoanalyzers that can be used for on-site pore-gas analysis. One type is non-circulating which withdraws a relatively small volume of gas from the sampling tube and is immediately analyzed for its chemical composition. The gas targeted for analysis may be absorbed onto a column or altered in its chemical composition before exiting the autoanalyzer. For use with the closed circuit port (Section 5.2.3), the autoanalyzer is connected to one sampling tube and the second tube is closed off or connected to a supply of inert gas.

The second type of autoanalyzer continuously withdraws gas from the port. This type may be used with the closed circuit sampler (Section 5.2.1) to recirculate the gas through the second tube of the sampler if gas analysis is non-destructive. In that case, the inflow and outflow are both connected to the sampling tube and there is no significant change in pressure within the device that may draw air or gases from other depths.

ADVANTAGES:

General

- rapid on-site analysis of pore-gas quality.

Geochemical

- there is no change in pressure that would draw foreign gases into the sampling device if the recirculating type of autoanalyzer is used; and
- geochemical composition of the gas phase will be relatively unaltered if quality control is maintained through installation and sampling.

DISADVANTAGES:

General

- an autoanalyzer may require an external power source; and
- depending on the type of autoanalyzer, only one parameter may be analyzed at a time.

Geochemical

- a destructive gas analyzer will alter the geochemical composition of the gases and should not be used for recirculating back into the pore-gas sampler.

SELECTED REFERENCES:

The description is based on procedures currently in use in Canada.

CHAPTER 6
QUALITY CONTROL RECOMMENDATIONS

This chapter is a summary of Quality Control Recommendations for individual methods in Chapters 3, 4, and 5. The most critical general and method-specific recommendations are presented.

6.1 Solid Phase Quality Control Recommendations

6.1.1 General Quality Control Recommendations

Equipment used in solid phase sampling should be cleaned between sampling locations to minimize cross contamination. Samples that are taken should be handled with clean inert tools, and should be placed in clean, gas-impermeable, tight fitting containers.

The solid phase, on various scales, is frequently heterogeneous, therefore, the sampling program objectives should be used to define the required sample size before employing a sampling method.

When taking the solid sample, care should be taken to minimized the evaporative loss of moisture from the solids to avoid precipitation of minerals which may change the geochemical composition of the solids and pore water. Also, exposure to oxygen should be minimized because ferrous iron, sulphide and other chemically reduced species may undergo oxidation resulting in geochemical changes as well as changes in alkalinity/carbonate and acidity.

6.1.2 Heavy Powered Equipment

When using an auger drilling method in cohesive sediment, the sediment may form thick "ribbons" which can be peeled from the auger, allowing a representative sample to be collected from the center of the ribbon.

In unconsolidated, non-cohesive materials, casing can be used to prevent the collapse of the borehole, thereby eliminating the contamination of deep samples by materials falling from shallower depths and to minimize the use of drilling mud. If casing is not used in unconsolidated, non-cohesive materials, drilling water or mud may be used to maintain a stable borehole. If drilling mud is used, the solid samples should be washed before analysis although some degree of sample disturbance and contamination will remain. A sample of the drilling mud should also be submitted for analysis.

When using a core barrel drilling method, external microbiological contamination may be minimized by washing the core barrel with methanol before and between coring operations.

When using a cable tool drilling method, frequent removal and storage of the cuttings will minimize the degree of oxidation.

6.1.3 Light Powered Equipment

Before using a downhole sampler, the bottom of the borehole should be cleared of cuttings to minimize contamination from material from shallower depths.

Samples collected using a core barrel or a downhole sampler with an inner liner should be sealed as quickly as possible; if an inner liner is not used, samples should be handled with clean inert tools and should be placed in clean gas-impermeable, tight fitting containers.

When using a downhole sampler, the cutting edge of the tube may be sharpened so that sample disturbance is minimized. After the tube has been advanced into the material, it may be necessary to wait up to 15 minutes so that the sample firmly remains in the tube. When pulling the sampler back through the drill stem or casing, care must be taken not to jar the sampler which may result in the loss of all or part of the sample.

Grab sampling in submerged cohesive sediment may retrieve thick clumps of material, a representative sample may be collected from the centre of the clump.

When using the trench method, a fresh surface at the bottom and sides of the trench should be exposed before using additional solid sampling equipment to minimize contamination from other materials.

6.1.4 Hand-Operated Equipment

When using the shovel/bucket method to obtain solid phase samples, a fresh surface should be exposed before using additional solid sampling equipment to minimize contamination from other materials.

Samples collected using gravity core sampler or sampling box for submerged samples with an inner liner should be sealed as quickly as possible; if an inner liner is not used, samples should be handled with clean inert tools and should be placed in clean gas-impermeable, tight fitting containers.

When using a gravity core sampler or sampling box for submerged samples, the cutting edge of the sampler may be sharpened so that sample disturbance is minimized. After the sampler has been advanced into the material, it may be necessary to wait up to 15 minutes so that the sample firmly remains in the sampler. When pulling the sampler back through the water column, care must be taken not to jar the sampler which may result in the loss of all or part of the sample.

When using a sampling box for exposed samples, the boxes should be cleaned prior to use. The boxes should be designed and built to maximize sample isolation and the samples collected should be retained in the boxes.

6.2 Liquid Phase Quality Control Recommendations

6.2.1 General quality control recommendations

Equipment used to obtain liquid phase samples should be cleaned between samples to minimize cross contamination. Equipment should not come in contact with surface sediments in order to minimize contamination of sample and, in some cases, piezometer.

Liquid samples should be filtered as quickly as possible, preferably immediately upon sampling. Field measurements of pH, Eh, temperature, specific conductance, alkalinity, and/or acidity should be performed immediately upon collection of the sample. Samples collected should be placed in clean, gas-impermeable bottles with no headspace and properly preserved.

6.2.2 Through a Drill Stem

When using the method of in-filling of stem to obtain a liquid sample, the depth and volume of sample should be carefully chosen due to possible water-quality stratification.

6.2.3 Separation from Solid Phase

When using pressurized consolidation to separate the liquid from the solid phase, the pressure should be minimized to lessen physical and chemical distortion of solids and porewater.

When using the porewater displacement method, physical and chemical distortions caused by the addition of displacing fluid should be accounted for.

6.2.4 Following Solid-Phase Sampling

When installing a monitoring well or piezometer, the screen length should be carefully chosen on the basis of project objective, site conditions, and the advantages and disadvantages of the method chosen. A reliable hydraulic connection between the hydrostratigraphic unit and the screen is required, and is usually accomplished through the installation of a sand pack or collapse of unconsolidated sediments around the screen. As well, hydraulic isolation of untargeted hydrostratigraphic units from the well is required and is usually accomplished using swelling bentonite above and, if necessary, below the screen.

All the materials should be cleaned before installation into the borehole to avoid contamination. Surficial materials should not come in contact with the equipment and lines during well development, which could introduce contaminants to the well.

After installation, wells should be pumped to remove cuttings and foreign water and to stabilize the installation. Water levels in the well during pumping should not fall below the top of the screen to prevent air entrapment and oxidation of surrounding sediment and groundwater.

When using a suction lysimeter, the vacuum should be minimized to limit sample degassing and alteration of geochemical parameters and to avoid drawing pore gas rather than pore water into the sampler. The problem of adsorption of ions onto the porous cup can be minimized by using teflon, resulting in more representative (higher) concentrations of parameters in the water sample.

6.2.5 Independent of Solid-Phase Excavation

When using a surface water grab sampler, sample agitation and contact with the atmosphere should be minimized during sample transfer. Boats are useful in sampling in areas of non-moving or slow moving water because wading for samples generally disturbs slow settling sediment.

When using a streambed seepage meter, a tight seal with the sediments must be obtained with minimum disturbance to the sediments.

When using a wash borings/jetting method, the amount of foreign water used in jetting should be minimized.

6.2.6 Pumps and Bailers

Before collecting a liquid phase sample, standing groundwater in a piezometer should be purged to remove stagnant water and bring in water which is representative of in-situ conditions.

When using the peristaltic, centrifugal, piston, bladder pumps, and single valve bailer, the avoidance of pressure variations and agitation will minimize the degassing of water during sampling and filtration.

When using the peristaltic, gas driven, and WaTerra pumps, the tubing may be left in the well for dedicated sampling to minimize cross-contamination. When using bailers, both the bailer and line may be left in the piezometer, if they are inert, for dedicated sampling to minimize cross-contamination.

When using a centrifugal, double and triple tube pumps, the pump should be operated in a continuous manner so that it does not produce pulsating samples that are aerated in the return tube or upon discharge.

The single-tube gas-driven pump method should be avoided.

When using a syringe sampler, gas-impermeable syringes should be used or gas-permeable syringes should be rendered impermeable after sample collection. If the sample obtained using a syringe sampler is decanted for on-site geochemical measurements, pH, Eh, temperature, specific conductance alkalinity, and/or acidity should be measured immediately upon sampling.

When using a double valve bailer, atmospheric isolation can be enhanced by using a variation in design such as a piston or displacement of water by low-oxygen gas during emptying of the bailer.

6.3 Pore-gas Phase Quality Control Recommendations

6.3.1 General Quality Control Recommendations

Generally, the pipe or tubing, and sample container should be relatively impermeable to gas. During installation, the pipe or tube should be inserted carefully so that it is not bent or cracked.

When using a sampling system, the system should be checked to ensure there are no gas leaks before installing the sampler and before taking a sample. Before a representative sample is taken, the gases in the pipe or tubing should be purged.

6.3.2 Sampling Port Extended Beyond a Drill Stem

When using this method, the sample volume should be minimized to limit the movement of air from the stem into the pores surrounding the pipe opening.

6.3.3 Following Solid Sampling

When installing the sampler, a reliable connection between the stratigraphic unit and the sampler is required, and is usually accomplished through the installation of a sand pack or collapse of unconsolidated sediments around the end of the tube or pipe, followed by the isolation of untargeted stratigraphic units by sealing the borehole above the basal end of the tube or pipe.

6.3.4 Independent of Solid Sampling

When using the drive-point ports, the amount of vacuum should be minimized when withdrawing samples to avoid clogging of the pipe.

When using the collector for migrating pore gas, the gases in the chamber should be purged before sampling and the residence time of a sample within the collection chamber should be minimized. The edges of the chamber must be sealed to the tailings or sediment to avoid contamination from atmospheric gases. When withdrawing samples from the collector the vacuum should be minimized to limit pressure gradients.

6.3.5 Sample Collection Devices

When using the syringe, gas should be withdrawn from the sampler at a slow rate. As well, isolation from the atmosphere should be maximized during sample collection and storage.

When using the autoanalyzer, the connections to the autoanalyzer should be checked to ensure there are no gas leaks before taking a sample. As well, the autoanalyzer should be calibrated, if necessary, with the appropriate gases before operation.

When using a circulating non-destructive autoanalyzer, the gas should be circulated through the autoanalyzer at a minimal rate.