<u>Appendix A-1</u>

Field Collection Protocols for Mineral Soils

In the field, the final location of the sample site is based on the information obtained from office preparation and on the field conditions encountered by the sampling crew. The objective is to get within 500 m of the pre-selected site and for the final site to have the same soil landscape characteristics as the 1 km^2 target area. For example, a target site was identified in the office as being in an upland area associated with podzolic soils. Once in the field, however, its actual location was determined to be in a low-lying area with gleysol soils but surrounded by upland areas with podzolic soils. In this case, the site would be moved to a point within 500 m of the original site in one of the surrounding upland areas.

Other factors that affect final site selection include the avoidance of sample sites as follows:

1) Closer than 200 meters from major highways;

2) Closer than 100 meters from rural roads;

3) Closer than 100 meters from buildings;

4) Closer than 50 meters from end rows in agricultural fields or in areas where large quantities of fertilizer have been deposited; and

5) Closer than 5 km downwind from an active major industrial activity, such as a power plant or smelter.

All sampling equipment that comes into contact with the geochemical samples must be either polyethylene or simple steel in composition. Some steel implements, e.g., shovels, are coated with various types of paint which may peel off and get into the sample. Use of these is unacceptable unless all paint has been removed prior to sampling. An exception to this rule is the use of stainless steel equipment for the collection of samples for analysis of organic compounds.

Particular care must be taken to ensure that all devices used to collect samples for chemical analysis are cleaned prior to every use to avoid cross contamination. Once the pieces of equipment have been cleaned, they must be protected from possible contamination by placing them in plastic bags.

At an ideal mineral soil site the following will be collected: a sample, referred to as the “public health” layer (PH), collected from the top of the H horizon to 5 cm below the top; an A-horizon sample; a B-horizon sample; a C-horizon sample; and separate samples from each of the above horizons and the PH layer for later determinations of bulk density and moisture content.

Field Equipment Checklist

General

GPS unit set to decimal degrees and NAD83/WGS84 Datum
Maps
Clipboard
Field cards
Digital camera
Tape measure (metric) and 15 cm ruler
Munsell soil colour chart
Permanent black markers
Dry eraser board for sample labels for photos
Compass (with inclinometer)
Core box to lay out soil samples for photos and identification
Squeeze or medicine bottle with 10% HCL
Misting bottle
Plastic tarpaulin or sheet
Extra batteries for GPS and camera

Collection Tools

Steel heavy weight shovel (round point fire fighter)
Shovel (Montana sharpshooter)
Soil dutch auger, with one extension
Polyethylene garden trowel
Margin mason trowel (5” x 2”)
Pointing mason trowel (7” x 3”)
Folding pruning saw (7” blade) for cutting roots and into the A-horizon
Mallet and wood block
Acrylic/lexan coring tube and extruding foam plug/saran wrap
Cleaning brushes and cloths

Equipment for Sample Storage

Large Kraft paper bags (12’’ x 6” x 2”)
Plastic sleeves to protect samples during transport
Plastic pails (5 gallon) with lids for sample shipping
Centrifuge tubes (50 ml)
Metal tins for collection of samples for bulk density/moisture content analysis
Electrical tape for sealing plastic bags and metal tins
Plastic garbage bags to be used for lining 5 gallon plastic pails

At the Site – Step by Step Procedures for Soil Sampling

Preparations for sampling

1) Proceed to the pre-selected site noting vegetation cover, types of exposed bedrock and surficial deposits, and possible sources of contamination in the vicinity of the site. Ideally the collection of samples will take place at the designated site. However, if the site is unsuitable, e.g., backyard of home or grounds of a smelter, select an alternate site within 500 m of the pre-selected site following the guidelines outlined above.

2) Ensure that all tools used for sampling have been properly cleaned to avoid contaminating the samples.

3) At a potential site, core samples are collected with an auger to obtain information on the soil profile. To do this, bore into the ground to the depth of the top of the auger bit (about 25 cm). Remove the bit from the hole with the soil core in place and place this core segment into a core box. Re-insert the auger into the hole, bore down another 25 cm and remove the auger from the hole. Discard the top few centimetres of soil from the core and place the second segment in the core box in line with the previous core. Repeat this process, each time noting the auger depth just before removing it from the hole. This is accomplished by (1) placing a finger on the auger shaft level with the ground surface and (2) lining up the shaft with the top of the core box which corresponds to the ground surface. Next, carefully remove the soil from the auger bit. The goal is to examine the uppermost 75 to 100 cm of the soil profile in order to establish the soil type.

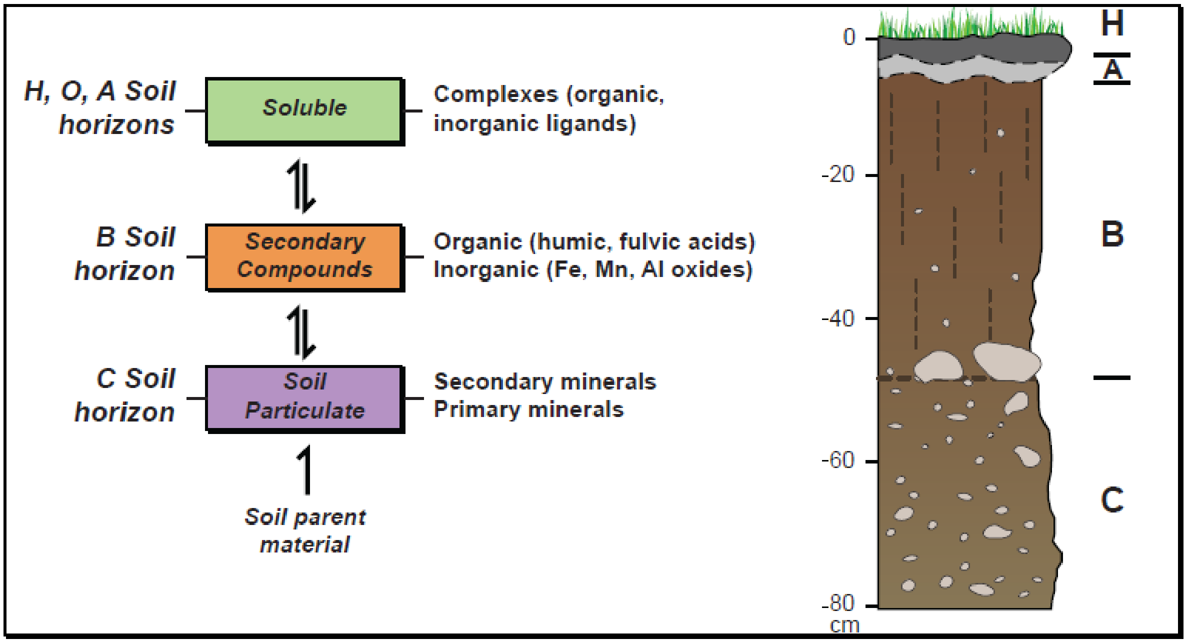

Diagram shows an idealized soil profile (right side) and descriptions of the soil materials and phases.

4) Take a photograph of the complete core and then squeeze a stream of 10% HCL along the length of the core to test for effervescence.

5) Once the soil type at the site is identified as being either a primary or secondary soil according to the Soil Landscapes of Canada (SLC) guidelines, begin digging the soil pit for sampling.

Digging the soil pit for sampling

6) A suitable sample pit is a rectangular hole, at least 60 cm wide and 70 cm long, that is free of roots and loose material. The depth of the pit depends on the distance to the top of the C-horizon layer, but should be at least be 60 cm. Where possible, align the long axis of the pit such that one face will be exposed to the direction of maximum light to enhance photography. One side of the long axis of the pit will be used for the collection of A-horizon and B-horizon samples, including those collected for bulk density. Avoid any disturbance or compaction of the area around the face used for sampling. Do not walk on it. Pile the spoil material well away from the pit to prevent it from being knocked back into the hole. Ensure that the pit

Step 6. Digging the sample pit.

faces are clean and the soil profile is easily observed. Trim the roots flush with the surfaces of the pit faces.

7. A good technique to expose the soil profile on the selected face is to gently flick small portions of the soil away from the pit face using a trowel (scraping tends to smear the horizons). Clean all loose materials from the pit. Take a photograph of the pit showing the exposed soil profile.

Collecting C-horizon samples

8) Collect a sample of C-horizon for bulk density and moisture content determinations from the bottom of the sample pit. To do this, push and/or tap the corer with a mallet and wooden block down from the bottom of the pit. Remove the corer, supporting its underside by a trowel if necessary. Trim the soil flush with the end of the core cylinder. If the top of the sample is not at right angles to the cylinder take at least two measurements of length and average the two.

9) The second sample collected from the C-horizon is for inorganic chemical element analysis. If possible, this sample is collected from a depth greater than 75 cm by boring into the bottom of the pit using a dutch auger. After each bore into the same hole, discard the top few centimetres of material from the augur bit before putting the remainder into sample bags. Two pre-labelled Kraft paper bags are filled about ¾ full. Fill to just below the set of four holes at the top of the bag (approximately (3-4 litres).

Collecting samples from the “public health” (PH) layer

10) Bulk density samples from the 0-5 cm depth interval or public health (PH) layer, and samples for inorganic analyses from the A- and B-horizons are collected from the undisturbed side of the pit. This is accomplished by systematically exposing layers and collecting samples from a cut made into the undisturbed wall of the pit.

11) The next part of the sampling procedure involves collection of samples from the 0-5 cm (PH) interval. Regardless of the mixture of horizons or soil materials, a composite of all soil materials present (mineral and/or organic) are collected between 0 and 5 cm, with 0 cm referring to the

upper soil surface. The upper soil surface is considered to be the top boundary of the first soil layer that can support plant/root growth. This equates to: (a) for bare mineral soils: the air/earth interface; (b) for vegetated mineral soils: the upper boundary of the first layer that supports root growth - the top of the H-horizon if it is present; and (c) for organic soils (not covered in this manual): the upper boundary of the first layer that supports root growth, excluding freshly fallen plant litter, but including litter that has compacted and begun to decompose. These samples may be in part duplicative of other samples such as the O or A horizons, but are valuable for providing information on that portion of the soil to which humans are most often exposed.

Collect the PH sample for bulk density analysis. At the undisturbed edge of the sample pit clear away the L- and F-horizon materials to expose the H-horizon material or upper mineral soil (usually the A-horizon). At a depth of 5 cm below the exposed surface (the 0 cm level), slide a flat trowel into the pit face. Push the coring device down until it meets the surface of the trowel. Lift out the core keeping the trowel on its underside for support. The sample should fill the coring device to a depth of 5 cm and be flush with the base of the coring device.

11A) Using foam plugs wrapped in Saran, extrude the material into a metal container labelled with the sample number and volume of sample (length of core tube x diameter). Use electrical tape to seal any gaps between the lid and the container. Insert the metal container into a Ziploc bag and seal.

12) Collect a PH sample for analysis of inorganic components. Use the pruning saw to cut out a block of soil materials adjacent to the core hole remaining from the bulk density sample. A block of about 25 x 25 x 5 cm is needed to fill two previously labelled Kraft paper bags. Slice the block down the middle and use a trowel to lift each section into the Kraft bag.

Collecting samples from the A-horizon

13) Collect a bulk density sample of the A-horizon from an undisturbed side of the pit. One potential spot to collect this sample is located adjacent to the gap in the surface where the PH sample was removed for inorganic analysis. Clear an area to expose the top of the A horizon.

Insert a flat trowel into A-horizon layer (above the Ae horizon, if present) and push the corer down from the surface to the trowel. Remove the coring device and continue as in Step 11A.

14) Collect a sample of A-horizon material for inorganic element analysis. Label two Kraft paper bags. Collect 3-4 litres of A-horizon material (excluding Ae material) near the area from which the A-horizon bulk density sample was collected. (Note: The coring device must be made of plastic.) After sufficient material is collected, continue clearing the cut downwards on the side of the pit until the top of the B-horizon is exposed.

Collecting B-horizon samples

15) Collect a sample for bulk density analysis from the B-horizon layer. Push and/or tap the corer with a mallet and wooden block down from the B-horizon surface until the bottom of the B-horizon is reached or as far as it is possible to go without compressing the sample. Remove the corer, supporting its underside by a trowel if necessary. Trim the soil flush with the end of the core cylinder. If the top of the sample is not at right angles to the cylinder take at least two measurements of length and average the two. Proceed as in Step 11A.

16) Collect a B-horizon sample for inorganic element analysis. Prior to sampling, label two Kraft paper bags. Collect approximately 3-4 litres of B-horizon material from the area near where the B-horizon bulk density sample was collected. Collect from the upper zone of enrichment (illuviated zone) on the pit face.

Completing the site

17) Complete the documentation of field observations on the field sheet. Take a series of photographs, at least one from each of the four points of the compass.

18) Begin filling in the pit. When the fill material is about 10 cm below the surface drop a sealed Ziploc bag containing a horseshoe and a Tyvex tag with the site ID into the hole. Continue filling in the pit.

19) Flag the site and note the end time. Go to the next site or finish for the day.

<u>Appendix A-2</u>

Field Card for Collecting Mineral Soils

Tri-National Mineral Soil Sampling Field Data

Site Sample
- GRTS Site ☐
- NFI Site ☐

Cell ID | **Site ID** | **RepStat** | **Resampled Site**: No / Yes ➡ (Previous Site ID) | **NFI Network Label**

Samples Collected

- PH interval
  - *for inorg. analysis* ☐
  - *for org. analysis* ☐
- A - horizon ☐
- B - horizon ☐
- C - horizon ☐
- Anthrax ☐
- NFI (0-15cm) ☐
- Other: ______

	Moisture Only	Bulk Density	Sample depth interval Top	Bottom
PH	☐	☐ ➔	____cm	____cm
A-horizon (% of A and H material collected when A material is insufficient)	☐	☐ ➔	____cm / ➔ A____%	____cm / H____%
B-horizon	☐	☐ ➔	____cm	____cm
C-horizon	☐	☐ ➔	____cm	____cm

NTS

Latitude NAD83 (Decimal Degrees)

Longitude NAD83 (Decimal Degrees)

Elevation m

Weather
- Sunny/Clear ☐
- Partly cloudy ☐
- Overcast ☐
- Rain ☐
- Sleet ☐
- Snow ☐

Date D D M M Y Y

Time S T A : R T — F I N : S H

Air Temp. °C

Name of Samplers

Type of Surface Material
- Mineral Soil ☐
- Organic Soil ☐
- Non-Soil ☐
- Urban ☐

Mode of Deposition
- Anthropogenic ☐
- Colluvial ☐
- Eolian ☐
- Fluvial ☐
- Glaciofluvial ☐
- Glaciolacustrine ☐
- Glaciomarine ☐
- Lacustrine ☐
- Marine ☐
- Residual ☐
- Saprolite ☐
- Till (Morainal) ☐
- Undifferentiated Mineral ☐
- Volcanic ☐

Local Surface Expression

Mineral Surface Form
- Blanket ☐
- Dissected ☐
- Fan ☐
- Hummocky ☐
- Inclined ☐
- Pitted ☐
- Level ☐
- Rolling ☐
- Ridged ☐
- Steep ☐
- Terrace ☐
- Undulating ☐
- Veneer ☐

Vegetation Cover
- Agricultural Crops ☐
- Coniferous Forest ☐
- Deciduous Forest ☐
- Grassland ☐
- Arctic Desert ☐
- Lichen ☐
- Mixed Forest ☐
- Parkland ☐
- Shrubland ☐
- Tundra
  - *Alpine* ☐
  - *High Shrub* ☐
  - *Medium Shrub* ☐
  - *Low Shrub* ☐
  - *Broken Herb - Low Shrub* ☐
- Unvegetated Surface ☐
- Meadow, Wet ☐

Rockiness
- Nonrocky (<2%) ☐
- Slightly rocky (2-10%) ☐
- Moderately rocky (10-25%) ☐
- Very rocky (25-50%) ☐
- Exceedingly rocky (50-90%) ☐
- Excessively rocky (>90%) ☐

Stoniness
- Nonstony (<0.01%) ☐
- Slightly stony (0.01 - 0.1%) ☐
- Moderately stony (0.1 - 3%) ☐
- Very stony (3 -15%) ☐
- Exceedingly stony (15 - 50%) ☐
- Excessively stony (>50%) ☐

Bedrock Type
- Igneous, (Intrusive) ☐
- Igneous, (Extrusive) ☐
- Igneous, (Pyroclastic) ☐
- Metamorphic ☐
- Sedimentary ☐
- Evaporites, Organics, Precipitates... ☐
- Other ☐

Slope

Slope Type
- Simple ☐
- Complex ☐

Slope Gradient

% Slope	Class	
0 to 3	1	☐
4 to 9	2	☐
10 to 15	3	☐
16 to 30	4	☐
31 to 60	5	☐
>60	6	☐

Sample Site Position on Slope
- Crest ☐
- Upper Slope ☐
- Middle ☐
- Lower Slope ☐
- Toe ☐
- Depression ☐

Slope Aspect °

Drainage
- Very rapidly drained ☐
- Rapidly drained ☐
- Well drained ☐
- Moderately well drained ☐
- Imperfectly drained ☐
- Poorly drained ☐
- Very poorly drained ☐

Contamination
- None ☐
- Possible ☐
- Probable ☐
- Definite ☐
  - Farming ☐
  - Housing ☐
  - Industry ☐
  - Logging ☐
  - Mining ☐
  - Road ☐
  - Garbage ☐
  - Other ______

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Mineral Soil Field Card
Page 1 of 3

Soil Horizon Description

Site ID

#	1 Horizons				2 Depth		3 HB		4 Colour	5 Mottles				6 Roots			7 CF	8 Structure			9 MC	10 Texture	11 Eff
#	D	Ma	Suffix	M	Up	Low	D	F		A	S	C	Colour	S	Q	L	%	G	T	C			
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							

Soil Profile Diagram

Depth of thaw ☐ cm
Not Applicable ☐
Unknown ☐

Depth to watertable ☐ cm
Unknown ☐

Estimated max thaw depth ☐ cm
Not applicable ☐
Unknown ☐

Depth to impermeable layer ☐ cm
Unknown ☐

Depth to bedrock ☐ cm
Not applicable ☐
Unknown ☐

Soil Classification (Section 3)

Order	Great Group	Sub-Group

Comments:

SITE PHOTOS!

Codes for Horizon Description

#	1 Horizons				2 Depth		3 HB		4 Colour	5 Mottles				6 Roots			7 CF	8 Structure			9 MC	10 Texture	11 Eff
	D	Ma	Suffix	M	Up	Low	D	F		A	S	C	Colour	S	Q	L	%	G	T	C			
1	-	B	f	-	22	34	G	S	Reddish Brown	C	F	D	Red Brown	F	P	T	30	M	B	F	VF	Sandy Loam	S

1 Horizons
D: Lithological discontinuity
Ma: Master horizons (O, A, B, C)
Suffix: Suffixes
M: Modifier (B1, B2, B3)

3

Horizon Boundary	
Distinctness (Vertical Change)	**F**orm
A: Abrupt (<2cm)	**S:** Smooth
C: Clear (2-5 cm)	**W:** Wavy
G: Gradual (5-15cm)	**I:** Irregular
D: Diffuse (>15cm)	**B:** Broken

Table 1. Correlation of Munsell colours with descriptive colours (AG Boden, 1994)

4

Colour hue and value 5	Chroma /1	/2	/3	/4	/6	/8
7.5R 5/				Gray Red	Red	
10R 5/	Reddish Gray		Red Gray		Gray Red	
2.5YR 5/					Red Brown	
5YR 5/	Brownish Gray		Brown Gray		Reddish Brown	
7.5YR 5/		Brown Gray	Gray Brown		Brown	
10YR 5/	Gray				Yellowish Brown	
2.5Y 5/		Yellowish Gray	Yellow Gray		Yellow Brown	
5Y 5/	Greenish Gray		Green Gray	Gray Green	Olive Green	
5G 5/						
5B 5/	Blue Gray					
5BG 5/						

5

Mottles		
Abundance	**S**ize (mm)	**C**ontrast
F: Few (<2mm)	**F:** Fine (<5)	**F:** Faint
C: Common (2-20)	**M:** Medium (5-15)	**D:** Distinct
M: Many (>20)	**C:** Coarse (>15)	**P:** Prominent

6

Roots			
Quantity \ Size	**F:** Fine (<2mm)	**M:** Medium (2-5mm)	**C:** Coarse (>5mm)
F: Few	10	1	1
P: Plentiful	10-100	1-10	1-5
A: Abundant	>100	>10	>5

Location
T: Throughout
M: Matted on top of horizons
C: in cracks

7 Coarse Fragments (CF)
Estimated value in % (>0.2 cm)

8 Structure
Grade
W: Weak
M: Moderate
S: Strong
Type
S: Structureless
B: Blocklike
P: Platelike
R: Prismlike
Class
VF: Very fine
F: Fine
M: Medium
C: Coarse

9 Moist consistency
L: Loose
VF: Very friable
F: Friable
M: Firm
VM: Very firm

10 Field Texture
Clay, Sandy Clay, Sandy Clay Loam
Silt, Silty Sand, Silt Loam, Silty Clay Loam
Loam, Sandy Loam, Loamy Sand
Sand, Very Fine Sand, Fine Sand, Medium Sand, Coarse Sand, Very Coarse Sand

11 Effervescence
N: Noncalcareous
W: Weakly
S: Strongly
E: Extremely

Appendix B-1

Notes on Field Procedures for Soil Gas Radon and Gamma Ray Spectrometry Measurements

Field Equipment Checklist for Soil Gas Radon and Gamma Ray Spectrometry

Prior to commencing field measurements ensure that all equipment listed below is available and in good working order.

Basic equipment checklist:

30 - Hollow steel probes
5 - Punch Wires
2 - Simple Retractors
1 - Special Retractor
4 - Drive Heads
Short Lost Tips (used for soil gas radon only sampling)
Long Lost Tips (used for direct permeability measurements with Radon-JOK)

Specialized equipment for sampling and measuring soil gas radon:

10 - 150 ml Syringes
Rubber tubing (2 sizes) and tubing adapters
1 - Nylon hammer
1 - ERM-3 Soil Radon Meter
25 - IK-250 ml Ionization Chambers
1 - Modified foot pump
1 - Manual

RADON-JOK Soil permeability equipment:

For logistical reasons this unit may not be used for standard Tri-National Soil survey sites but will be used for detailed urban fill-in studies.

1 - JOK Permeability Apparatus plus 1 special backpack for carrying apparatus
3 - Tripod legs
1 - Long Rubber tube
2 - Weights
2 - Spacer rings
2 - Distance screw heads
1 - Plum bob
1 - Manual and Nomogram Graph

RS-230 Gamma Ray Spectrometer:

1 - RS-230 gamma ray spectrometer
1 - data download cable (USB)
1 - charger and cable
2 - battery compartments (4 AA batteries)
4 - rechargeable AA batteries
1 - manual

GR-320 Gamma Ray Spectrometer:

May be supplied as backup for RS-230, can be used as primary field spectrometer.

1 - GR-320 Spectrometer console
1 - GPX-21 Detector
1 - Scintillometer
1 - Cs^{137} check source
2 - detector cables
1 - download (RS232) cable
1 - charger and cable
1 - GR-320 manual
1 - Explore software manual
1 - Pad Calibration printout

Laptop Computer:

1 - laptop computer with appropriate field data templates and spectrometer data downloading software (preferably with serial port for GR320 data downloading – if required)
1 - Backup and Recovery disk with manual
1 - Power cable and charger
1 - USB mouse
1 - Shoulder strap and carrying case
1 - USB memory stick

Extra Field Equipment and other useful tools/supplies to have:

1 - Geological Backpack for GR320 Spectrometer or to carry other equipment
1 - 7'x10' Orange Tarp
1 - Clipboard
1 - Field Vest
1 - Measuring Tape
2 - Forceps – for tubing
1 - Camera Tripod for spectrometer
1 - Multi-tool or pliers (to pull out punch wires)
Olfa Knife
Flagging tape (to tie around tops of probes and other small items)
Work gloves
AA batteries
Distilled water – for IC cleaning (purchase locally at any Drug store)

Night before the first site visit or between sites visited on the same day

The night before, if possible, verify that the background Rn concentrations for the ionization chambers (ICs) to be used the next day are at or below acceptable levels (approximately 0.7 kBq/m3). If the background concentration is significantly greater than 0.7 kBq/m3, the IC should be cleaned using a paper towel lightly dampened with distilled water. After cleaning allow IC to thoroughly dry then carefully reassemble the IC and repeat the measurement. Repeat these steps until background concentrations for those IC's to be used are acceptable. If the Rn concentration is close to an acceptable value, you may choose to repeat the measurement the following morning.

Note 1: Opening ICs immediately after taking a measurement at the sample site reduces the radon concentration and production of new radon progeny. If the same IC has to be used again the same day attempt to clean as described above, measure and record the background Rn concentration. Subtract this background value from the regular measurement.

Note 2: For proper IC maintenance, every 2 to 3 weeks check the integrity of the IC vacuum seal by evacuating all ICs and allowing them to sit for 8 to 12 hours. Afterwards, determine how easily a syringe full (150 cm) of air is pulled into the IC.

Before leaving the field vehicle at the sampling site

Prior to visiting the sample site, evacuate the ICs to be used either with the modified foot pump, usually 8 to 10 pulls, or with another suitable vacuum pump. The pump can then be left in the field vehicle. After the first 2 or 3 pulls and after the last pull, check the tightness of the large ring at top of the IC because it commonly becomes loose during evacuation.

If a GR320 gamma ray spectrometer is being used, it is necessary to conduct a system test on the instrument prior to visiting the sample site. The supplied Cs^{137} check source is used for the test. Record the GR320 serial numbers (console and detector) and the test results on a field data sheet. Leave the check source in the truck. Do not lose it. Turn off the GR320 to save battery power.

If a RS230 gamma ray spectrometer is being used, turn on the unit and allow it to stabilize before taking the first measurement. This ensures an accurate assay analysis. The RS230 will allow an assay even if the instrument is not stabilized, but the assay results may be incorrect. In very low count rate environments, stabilization may take several minutes.

Make sure that you have all the required field equipment before leaving the truck.

At a standard NASGLP site

Take out the field data sheet to record measurements. An example of the sheet is shown in Appendix B-2. Follow the step-by-step procedures listed below.

Step 1: Taking scintillometer measurements

While the soil team is searching for a suitable location for the sampling pit, survey a 10 x 10 m area in the vicinity of the pit to check for variations in total radioactivity. If the GR320 spectrometer is being used, use the total count scintillometer. If not, use the RS230 in 'SURVEY' mode. Record the range of values and estimated mean value on the field data sheet. Avoid measurements near any source of anomalous radioactivity, most commonly radioactive boulders.

Step 2: Hammering down the probes and setting up the spectrometer

Once a site for sampling is selected, it is necessary to hammer 5 steel probes fitted with lost tips into the ground. It is important to note that the target depth for each probe is 60 cm. If resistance is felt while hammering in the probes, do not force them. There may be a boulder in the soil. Extract the probe and try another location nearby. The hollow probes bend easily but they can be straightened out with a hammer or vice. Bring a large number of extra lost tips because relocations of probes may be required. Use punch wire to hammer down all lost tips. If short tips are being used, hammer them only to a depth where the punch wire can be easily grasped and removed. Use pliers if required.

It is helpful to tie a short length of flagging tape around the top of each probe. This makes it easy to find the probes, especially in wooded areas with dense underbrush. Select probe locations that are distributed around, but not near or adjacent to, the soil pit. Avoid obviously wet or even damp ground. After the first probe is hammered in, set up the spectrometer using the camera tripod over or near the probe and start the first measurement. During the 5 minute count time for the first measurement, the remaining probes can be inserted. However, the crew member may wish to test the availability of soil gas at the first probe by attaching the 150 ml syringe and extracting the first 150 ml of soil gas. This should only be done on a probe inserted with a short "lost tip" and where only a radon sample will be collected.

If water is encountered at the 60 cm target depth, or no soil gas is available, as might be the case in very clay-rich soils, then the probe may be raised 5 or 10 cm and this test repeated. The remaining probes may then be inserted to this shallower depth. Record all depths and relevant comments on the field sheets.

If the permeability apparatus is not being used:

Short tips are needed. Attempt to carefully hammer down all lost tips to equal depths to ensure near constant volume at the bottom of each probe.

If the permeability apparatus is being used:

Long tips are required for those probes attached to the apparatus. Standard NASGLP protocols recommend direct permeability measurements on 2 of the 5 probes. These 2 probes, usually the first 2 must be inserted using the long lost tips.

Step 3: Taking spectrometer and permeability measurements

Taking 6 – 300 second spectrometer measurements is recommended, 1 at each of the 5 probes and the sixth in the sample pit. The pit measurement is made after the soil sampling is completed but before the hole is filled in. Every effort should be made to acquire this 6th soil pit measurement. If there is further time, additional spectrometer measurements can be taken either on the soil pile or at other undisturbed surface sites.

The following is a list of the necessary steps:

a) Start the first spectrometer measurement with the spectrometer attached to the camera tripod and suspended approximately 50 cm above the ground.

b) If required, set up the permeability apparatus. If the permeability apparatus is not being used, hammer in the remaining 4 soil gas probes using the short "lost tips" and hammer down the lost tips. Also, refer to Step 4, below, for details on how to estimate permeability when the apparatus is not being used.

c) Record the first spectrometer measurement. Move and start the second spectrometer measurement.

d) If required, conduct the first permeability measurement. If the measurement is zero or near-zero (i.e. little or no movement on the weights after approximately 5 minutes), record it on the field data sheet as “minimum permeability”. Stop and reconnect the long rubber hose to the second permeability probe. It is useful to separate the 2 permeability probes, inserted using long lost tips, by a distance of slightly less than two times the length of the long rubber hose. If this recommendation is followed, only one apparatus setup is required at a middle distance between the 2 probes. Be careful not to kink the hose or the apparatus will not function properly.

e) Record the second spectrometer measurement. Move and start the third measurement.

f) If required, conduct and record a second permeability measurement.

g) Record the third spectrometer measurement. Move and start the fourth measurement

h) Record the fourth spectrometer measurement. Move and start the fifth measurement

Step 4: Soil gas radon sampling

Remember that soil gas radon measurements are time-sensitive. Hence, as noted above, it is recommended that all surface spectrometer and direct permeability measurements be completed before the soil gas radon sampling is started.

In some field situations, it is not possible or practical to take soil permeability measurements using the apparatus because of field safety or logistical reasons, such as inaccessibility or rough terrain. When this is the case, estimates of soil permeability are made as follows: when collecting the soil gas sample with the syringe, evaluate the relative resistance encountered on the syringe pull and record the result on the field data sheet. For little or no resistance or an easy pull, record high permeability; for moderate resistance, record medium permeability; for high resistance or a hard pull, record low permeability.

Taking 5 soil gas radon measurements is recommended. Seek assistance if required, from the soil sampling crew for measuring the radon because these measurements are time-sensitive. If the permeability apparatus was used at the site, it is possible to use the same probes for the radon measurements. However in this case the permeability measurement must be conducted first. Avoid being too close to the soil pit. All hollow steel probes for collection of soil gas radon can be inserted at the most suitable time and the lost tips hammered down.

Hint for collecting in low permeability soils - If you encounter a probe with a hard to very hard syringe pull, i.e. 50 ml/5 ml or equivalent on the first pull, and it is difficult to get the required 150 ml for the first sample, use the extractors to raise the probe 5 cm and try again. Be careful to maintain the seal between the soil and the outside of the probe. If the syringe pull is still hard to very hard, raise the probe another 5 cm to the 50 cm depth and try again. Be sure to record any changes to the probe depths on the field data sheet. If, at 50 cm, gas collection is still hard or very hard, check the time and make the decision to stop and move to the next probe.

The objective is to collect all or most of the soil gas samples from a consistent depth. If it is hard to collect a gas sample at the first probe, it is helpful to collect samples from the other probes at depths of 60 cm before returning to the first probe. If it is difficult to collect a sample at 60 cm at all probes, you may need to raise all to 55 cm or 50 cm. Pulling the probes to a shallower depth also applies if the top of the water table is high and water enters the syringe.

Step 5: Soil gas radon measurement

It is important to record the times that each IC is filled with soil gas from the syringe. Every effort must be made to start the measurement within the 13 to 17 minute window from the time the IC was filled. Remember to watch the time while collecting the soil gas samples.

1) Turn on the ERM monitor – make sure that the meter is set to “15”. To save time, the monitor can be turned on several minutes before the first IC reading is taken. Do not touch the IC and be careful to have no excessive movement while the measurement is in progress. Make sure that the cap is always on the monitor reader if no IC is being measured. Handle the ERM-3 meter with care, especially the reading connector. Avoid contaminating it with dust. Radon measurements should not be performed while it is raining.

2) Measure all ICs in the same sequence they were filled. Record the time the measurement started. It should be between 13 and 17 minutes from the time IC was filled. Record the IC # and the radon reading on the field sheet.

3) If several “0.0” values are encountered at any site, it is wise to “re-zero” the meter and repeat the measurement to confirm that the low value is correct. Remember to record the start times when each IC is measured.

4) Open the ICs immediately after the soil gas radon measurements have been finished and the detector has been removed from the reading connector. This reduces the build-up of longer-term progeny. See the note below on testing for radon progeny contamination. The note also provides information on maintaining the ICs and reusing them the same day.

5) After all ICs are measured, turn off the monitor. Place the ICs in the carrying case and extract all probes using either the simple or complex retractor. Disassemble the equipment and pack the permeability apparatus if it was used. Pay particular attention to collecting the smaller items and ensure that the field data sheet is properly completed.

Note on testing for radon progeny contamination:

As stated above, opening the IC immediately after a measurement reduces build-up of longer-term progeny and shortens the time required before the IC can be reused. The level of radon progeny contamination of the IC can be tested by taking a measurement on an atmospheric air sample (low radon) that has filled the IC, instead of a soil gas sample. The value should normally range from 0 to 0.7 kBq/m^3. The IC can be used the same day if the background value is acceptable or if a background measurement is performed immediately before that IC is to be used.

It is important to get into the habit of monitoring the IC background value routinely and making regular tests of the vacuum stability of each IC. It is helpful to cycle the use of all 25 ICs. The night before a site visit, determine which ICs may be used and measure their background radon concentrations. If they have levels below the normal maximum background of 0.7 kBq/m^3, no further action is needed. If the levels are higher, evacuate the IC, fill it with atmospheric air and remeasure. If the reading is still above 0.7, clean the IC with distilled water, dry it, and measure again. Repeat this procedure until the background level is 0.7 or less. If the IC is to be used again on the same day or even the next day, a cleaning and decontamination of the IC is recommended. Otherwise, take a “background” measurement with atmospheric air. Record the background radon value and subtract it from the measured soil gas value.

Appendix B-2

Field Card for Soil Radon-Gas and Natural Radioactivity Measurements

Tri-National Soil Sampling Field Data – Radioactivity and Radon

Date:	Cell I.D.		Site I.D.
RepStat :	Resampled Site : (Y)	(N)	NFI Plot:
NTS Sheet #:	Lat. (NAD83)		Long. (NAD83)
Weather:			Air Temp (C):
Time (In):	Time (Out):		
Name of Sampler(s):			

Radioactivity:

System Gain (if applicable)	Spectrometer	Serial	Peak		FWHM		Gain		
	GR320								
	GPX 21								
	RS 230								
Spec #	Total (ppm)	K (pct)	eU (ppm)	eTh (ppm)	Total (cpm)	K (cpm)	eU (cpm)	eTh (cpm)	Scint. Value

Radon

Radon Station #	Depth (m)	1^{st} Pull to / back to (ml)	Sample Vol. (ml)	Ion. Chamber #	Time IC Filled	Time of Meas.	Radon Bkgd (kBq/m^3)	Radon Conc. (kBq/m^3)	Comment

Permeability

Permeability Station #	Depth (m)	1 or 2 Weights	Time Started	Measured Time (s)	Permeability (k/m^2)	Comment

Additional Comments