B.C. SOIL HEALTH ASSESSMENT FIELD SAMPLING PROTOCOL

December 2025

Sustainable Canadian Agricultural Partnership

British Columbia | cleanBC

Canada

Prepared by

B.C. Ministry of Agriculture and Food with support from the B.C. Provincial Soil Health Technical Working Group

Contact: dieter.geesing@gov.bc.ca and ahmed.lasisi@gov.bc.ca

We gratefully acknowledge the Delta Farmland and Wildlife Trust (April Stainsby and Patricia Kulikowski), ES Crop Consult (Marjolaine Dessureault), Kootenay and Boundary Farm Advisors (Rachael Roussin and Sarah Hirschfeld), and Catherine Tarasoff for their thoughtful and invaluable comments and suggestions.

Funding was provided in part by the governments of Canada and British Columbia under the Sustainable Canadian Agricultural Partnership, a federal-provincial-territorial initiative; additional funding provided by CleanBC.

Disclaimer

Contents

B.C. Soil Health Assessment Field Sampling Protocol

Version: 15 January 2026

Using a standardized field sampling protocol improves consistency when comparing and interpreting soil test results. The B.C. Soil Health Assessment Field Sampling Protocol was developed by the B.C. Ministry of Agriculture and Food, with support from the B.C. Provincial Soil Health Technical Working Group, to establish a consistent standard for collecting soil samples used in soil health and fertility assessments. The proposed procedures align with the B.C. SOIL HEALTH ASSESSMENT LABORATORY PROCEDURES.

While adherence to this protocol is recommended, adjustments may be necessary for specific research objectives or unique soil conditions, such as coarse-fragment or organic soils. In such cases, the following information should be clearly documented:

a. The method used
b. Sample IDs
c. Sampling location

Definitions/Acronyms

In this document:

A **Management Unit (MU)** is an area of land that is mostly the same in terms of soil type, slope, crop, and management history.

In many cases, an MU is the same as a field. However, if a field is larger than about 25 acres (10 hectares) or has areas that are very different, it is best to divide it into smaller MUs.

A **Sampling Point (SP)** is a specific location within an MU where a soil sample is taken. This can be a single sample or one of several subsamples that are mixed together to make a composite sample representing the whole MU.

The individual samples that make up a **composite soil sample** are called **subsamples**. Each subsample is a small amount of soil collected from one spot in the field; several subsamples are combined and mixed to form on composite sample.

Summary of Procedures

This protocol describes standard methods for collecting soil samples as part of a soil health assessment. A surveyor who follows all the steps outlined here will collect a total of 11 samples, which will then be sent to a laboratory to test selected chemical, physical, and biological properties[1].

Except for one of the two composite samples described in section (A), all samples are taken from the top 0–15 cm of soil.

(A) For each management unit (usually one field), collect two composite samples:

- one from the 0–15 cm layer, and
- one from the 15–30 cm layer (nitrate only).

To make each composite sample, take soil from **15–20 different spots** in the field (called "sampling points (SP)"). Break up the large soil clumps and mix the subsamples from each sampling depth in separate, clean buckets. From each mixed sample, take about two handfuls of soil and place them into separate, clearly labeled bags. Either air-dry the samples right away or store them in a cooler at about 4 °C. Send both bags to the laboratory for testing.

Laboratory analysis for the fertility and carbon composite samples includes:
a. Total Carbon (C) and Nitrogen (N)
b. Soil organic matter
c. Nitrate
d. Phosphorus (P) and Potassium (K)
e. pH and salinity
f. Carbon mineralization
g. Nitrogen mineralization

Sections (B) to (E) apply to **three (3) sampling points** within the management unit. At each of these points, the surveyor:

(B) Takes one composite sample for **bulk density** determination in the laboratory. This composite sample is made by combining three subsamples taken about 2–3 feet apart using a core sampling ring. The combined soil is placed in a bag and sent to the laboratory. Each field requires three composite bulk-density samples, each composed of 3 subsamples (= total of 9 subsamples per MU).

(C) Determines **soil texture** by the feel method. If the surveyor is not used to estimating texture by hand, they should instead use the bulk density samples from section (B) for a laboratory texture test.

In that case, the surveyor must make sure the lab report clearly shows which bulk density ring each texture result belongs to.

If the soil in the management unit (MU) has the same texture throughout, one texture test is enough.

[1] The standard laboratory methods are described in the document *Soil Health Laboratory Procedures for B.C*.

(D) Collects at least **nine soil aggregates** for aggregate-stability testing. The aggregates should be carefully extracted, placed in small vials, and submitted to the laboratory. For each MU, the surveyor submits three vials, each containing at least nine aggregates—for a total of at least 27 aggregates.

(E) Extracts soil using a **bulk-density ring** and submits the intact sample (left in the ring and sealed with lids at both ends) to the laboratory for **plant-available water** determination. Total: three (3) samples per management unit.

Note: It is often easier to collect samples for sections (B) to (E) by digging a small trench, as explained in section (D): **Sampling for Soil Aggregates.**

When is the Best Time to Sample?

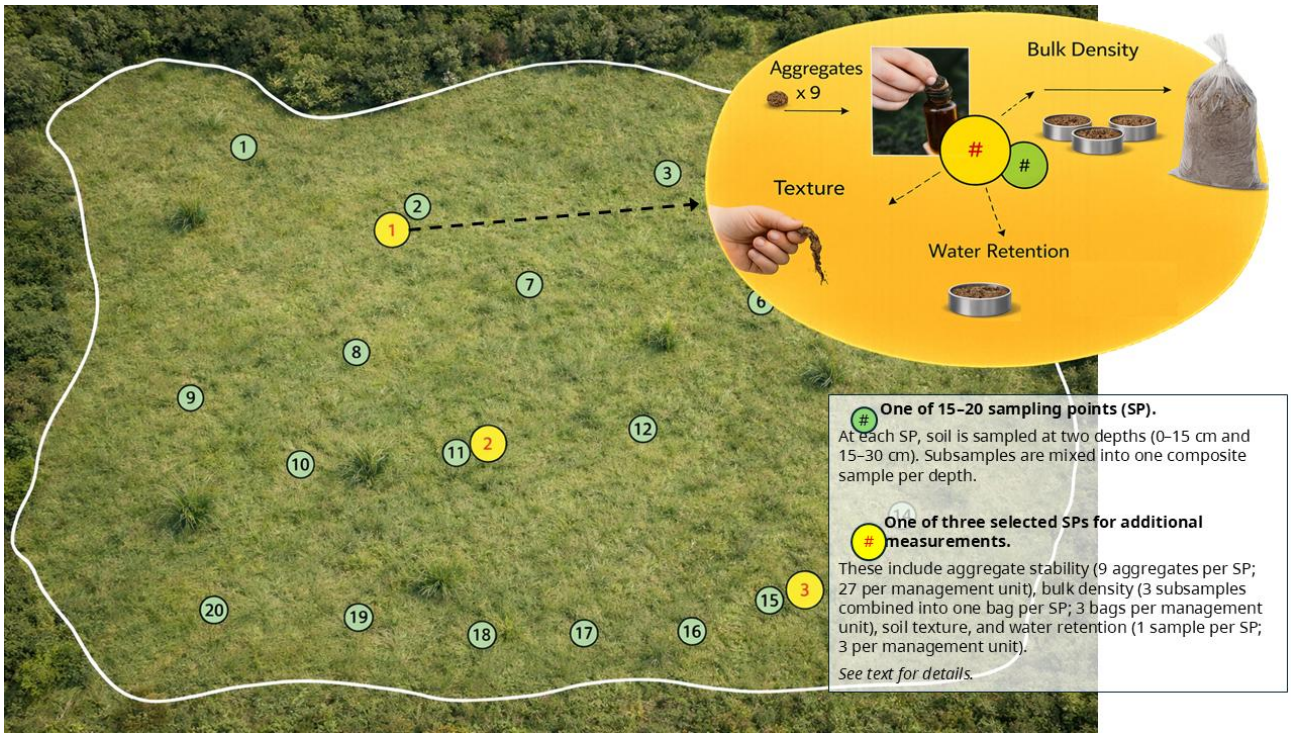
Many soil properties change over time and from year to year because of farming practices, plant growth, and weather. However, they also change with the same year. This seasonal change is especially strong for mineral nitrogen and biological soil properties, while it is less pronounced for most other (chemical and physical) soil properties.

To reduce the effect of seasonal changes, follow two simple rules:

- Do not sample right after tillage or adding amendments. Wait at least four weeks before taking samples.
- Sample at the same time each year. This makes it easier to compare results from year to year.

For most methods in this guide, the best time to sample is when the soil is moist but not wet (this is called field capacity). Sampling under these conditions is easier and gives more accurate results, especially when sampling for physical properties. In British Columbia, early spring is usually the best time to sample, after the soil has drained enough to enter the field but before preparing the seedbed. Sampling after harvest in late summer is also possible, especially when nitrogen and phosphorus data are needed to meet the B.C. Code of Practice for Agricultural Environmental Management. The main disadvantage of summer sampling is that soils can become hard and difficult to sample after prolonged dry periods, and surface residues may also interfere with sampling. These considerations are particularly important when collecting samples for physical soil properties. Consequently, there is no single best time for soil sampling, but following the two key principles above will help ensure consistent, representative, and reliable results.

How Many Samples?



Example of how soil sampling points are laid out within a MU. About 15–20 randomly selected locations (green points) are selected to collect subsamples that are combined into a composite sample for soil fertility, carbon, and selected biological tests. Three carefully chosen locations (yellow points) are used to assess soil physical condition in more detail.

Summary of Samples and Sampling Points (SP) per MU					
Soil Property	**Number of Subsamples *per SP***	**Number of Composite Samples *per SP***	**Number of SPs *per MU***	**Total number of Subsamples *per MU***	**Total number of Samples Submitted to Lab *per MU***
Fertility and Carbon	1 (0 – 15 cm) 1(15 – 30 cm)	n/a	15 – 20	15-20 (0 – 15 cm) 15-20 (15 – 30 cm)	2 bags
Bulk Density	3	1	3	9	3 bags
Aggregate Stability	≥ 9 aggregates	1 vial	3	≥ 27	3 vials
Water retention	One sample per sampling point		3	n/a	3 rings
Texture	By feel or analysis (0-15)		3	3 assessments per MU	*See text below*

Materials

This table is only for guidance. You might not need all the tools or consumables listed, and some can be replaced with similar ones.

X means required

(X) means optional or depending on conditions

Item / Description	Comment	General / Fertility & Carbon	Bulk Density	Aggregate Stability	Water Retention	Texture
Core soil sampling probe	36" is most often used	X				
Spade	Sharpshooter or flat spade (or equivalent)	X[1]	X	X	X	
Sampling bags	Freezer-type bags, ~25 × 25 cm (10″ × 10″)	X	X	X	X	X
Recording book	If applicable	X				
Data / site survey form	Contact Ministry staff for latest version					
Two plastic buckets	4–5 gal (15–20 L)	X				
Ruler / measuring tape	For consistent sampling depth		X	X		
Knife	Long-bladed (“chef’s knife”) preferred	X	X	X		
Sharpies / writing tools	Permanent marker for labels		X			
Writing materials	Pen/pencil, clipboard, etc.		X			
GPS or smartphone app	Ensure landowner/tenant consent	(X)	(X)	(X)	(X)	(X)
Unique sample ID	Use waterproof labels or write on bags	X	X	X	X	X
Sieve (≈8 mm opening)	Equivalent to Tyler 2.5 mesh	(X)				
Sieve (≈2 mm opening)	Equivalent to Tyler 10 mesh					(X)
Bulk density rings with lids	Known volume, Ø > 3″; preferred: D 4″ × H 1.94″ (≈400 ccm)		X		X	
Short plank of wood	Used with mallet for ring insertion			X		
Rubber mallet	For driving rings into soil			X		
Brush	Cleaning soil surfaces			X		
Towel	To wipe or protect samples			X		
Clippers / scissors	Cutting roots or vegetation			X		

Portable scale	≥ 2 kg, at least one decimal; kitchen scales may work		(X)			
30–50 ml screw-cap vials	For aggregates; e.g. Amazon sample link			X		
Bubble wrap	To prevent sample disturbance			X		
Box	Cardboard or similar for shipping			X		
Flat hard surface	E.g. plywood board or tote lid			X		
Plastic container	~15 × 15 × 15 cm			(X)		
Texture-by-feel guide	Printed and laminated reference					X
Water	For cleaning, feel method, and tests		(X)	(X)	(X)	X
Screwdriver	To remove soil from probe	(X)				
Tape	High-quality painter's tape recommended				(X)	
Vegetable oil	To lubricate rings or prevent sticking				(X)	
Packing peanuts	Cushioning for transport				(X)	
Food wrap	Sealing moisture-sensitive samples				(X)	

(1) The use of a dedicated soil sampling probe is encouraged but, if not available, a spade can be used.

Procedures

A) Sampling for General Soil Fertility and Carbon

Soil Sampling for Soil Fertility (0–15 cm) and 15–30 cm (only nitrate-N)

1. Prepare your supplies

- Soil corer or sharp spade
- Two clean buckets (one for 0–15 cm, one for 15–30 cm)
- Ziploc or sample bags
- Permanent marker for labelling
- Optional: GPS or phone (recording coordinates may need the farmers' consent)

2. Label your sample bags

Write on each bag:

- Unique sample ID
- Field name or location
- Sampling date
- Depth (0–15 cm or 15–30 cm)

3. Take the soil samples

- Choose **15–20 spots** across the field in a **W or zigzag pattern**.
- At each spot, remove plants, residue, and litter from the surface.
- Use the corer or spade to take soil from **0–30 cm** deep.
- Cut the core into **two parts:**
    - Top part (0–15 cm) → put in **bucket 1**
    - Bottom part (15–30 cm) → put in **bucket 2**
- If a spade or shovel is used, correct for the wedge shape: cut off the edges on both sides of the wedge to get a column that has even thickness from top to bottom**.**

4. Mix and make composite samples

- Mix all soil from **bucket 1** together (this is your 0–15 cm composite sample).
- Mix all soil from **bucket 2** together (this is your 15–30 cm composite sample).
- Break up big clods gently by hand.

5. Fill sample bags

- Put about **600 g (about 2 cups)** of mixed soil from each bucket into the **labelled bags**.
- You should have **two bags total per field** (one for each depth).

6. Store and send

- Keep samples **cool** (in a cooler or fridge).
- **Send to the lab within 48 hours** for testing.
- If samples cannot be submitted within 48 hrs (or will arrive at the laboratory before the weekend), **air-dry** the samples:
    - Spread the soil: Place the soil on clean paper, plastic, or a tray in a thin layer (no more than 2–3 cm thick).
    - Break up clumps: Gently crush large lumps with your fingers or a clean tool, but do not grind the soil.
    - Let it dry naturally: Leave the soil at room temperature in a dry, shaded, well-ventilated area

B) Sampling for Bulk Density

For bulk density, take samples at three SPs per MU, which can be part of the Soil Fertility sampling spots. At each SP, take three subsamples, mix them, and make one composite sample per SP. After sampling, the surveyor should have three bulk density composite samples per MU

Soil should be moist but not wet (at field capacity) before sampling. This makes it easier to push the ring into the soil and avoids sampling when soil is shrinking or swelling. If the soil is too dry, add some water and let it soak in for 2–3 hours before sampling. A little vegetable oil around the ring edge can also help it slide into the soil.

How to Take Soil Samples for Bulk Density (0-15 cm)

1. Get your tools ready

- Bulk density metal rings
- Mallet
- Wooden block
- Knife
- Plastic bags or containers for samples
- Permanent marker for labelling
- Small brush
- (Optional) Vegetable oil to help insert the ring

2. Choose your sampling spots

- Select **three sampling points** in the field.
- These points can be a subset of those used for soil fertility sampling.

3. Prepare the spot

Remove any surface plants and plant litter. Then remove the **top 2 inches (about 5 cm)** of soil. (see footnote[2]). The described depth applies only when sampling with rings with a height of 2 inches (5 cm). For all other sizes, check box *Considerations when selecting bulk density ring dimensions*

- The soil should be **moist but not wet**.
    - If too dry, sprinkle some water and wait **2–3 hours**.

4. Insert the ring

- Lightly oil the ring edge to help it go in.

[2] The described depth applies only if surveyor is sampling with rings that are 2 inches (5 cm) high. For all other sizes, see the box *Considerations when selecting bulk density ring dimensions*

- Place the ring flat on the soil surface.
- Place the wood block across the ring and gently tap it in with a mallet until it is filled and level with the ground.
- Cut the soil carefully around the ring and underneath so the soil inside stays intact.

5. Remove and clean

- Lift the ring out carefully.
- Trim off any extra soil at the top and bottom so the soil is flush with the ring edges.
- Wipe off loose dirt outside the ring.
- Empty soil into sample bag or container

7. Repeat and combine

- Take two more rings at each sampling point (SP) about 1 foot separated (three in total per SP).
- Mix the three subsamples together to make **one composite sample per point**.
- Volume of one bulk density rings as described in this protocol is 400 cm^3. Since three subsamples are taken, the total extracted volume is 400 cm^3 x 3 = 1,200 cm^3 per SP.

6. Store and label

- **Labell bag or container** with:
    - Sample ID
    - Field name
    - Date
    - Depth (e.g., 5–10 cm)

7. Proceed to the next SP and repeat

You should have **three composite samples per field (MU)** to send to the lab.

Note:

(1) For sampling below 15 cm, see appendix for how to Take Soil Samples for Bulk Density (15-30 cm)

(2) Coarse fragments can make sampling more difficult. For guidance, see the appendix “What to Do with Coarse Mineral Fragments.”

C) Texture

Soil texture will be checked at the same three sampling points (SPs) that you use for bulk density, water retention, and aggregate stability.

How to Determine Texture

Perhaps the easiest method is the **"Feel Method**" described by Thien (1979). There are many good online videos and guides demonstrating this method (see the Resources section).

If you have not practiced hand-texturing before, you can ask the laboratory to do a texture analysis for you. In that case, it is often easiest to use soil from the bulk density samples for the lab test. For cost reasons: if the soil texture is fairly uniform in the management unit, one sample is enough. Consider comparing with the texture described for the MU in the Soil Information Finder Tool.

Comment: If you find large and consistent texture differences within a management unit (for example, sandy soil in one area and heavy clay in another), you should consider dividing the area into separate Management Units (MUs).

D) Sampling for Aggregate Stability

Soil should be **moist but not wet** before sampling. If the soil is too dry, gently add some water and let it soak in for **2–3 hours** before sampling.

It is very important that soil aggregates reach the laboratory **without being disturbed or broken**. To reduce the risk of damage:

- Place (don't push or shake) as many aggregates as possible into each vial to reduce empty space (more than the minimum 9).
- Wrap vials in **bubble wrap**.
- Place them on **foam** or in a **box with a rack** to keep them upright and cushioned.

At least **nine aggregates** are collected at **three sampling points per management unit (MU)** — a total of **at least 27 aggregates**.

Get Your Tools Ready

- **Spade or flat shovel** – for cutting and removing the soil plug (sharp edges make clean cuts).
- **Soil knife or trowel** – for trimming edges of the plug.

Plastic or glass vials with screw caps – each should hold at least nine aggregates (20–30 mL size, wide mouth preferred; centrifuge vials work well, too).

- **Bubble wrap or soft padding** – to protect vials during transport.

Examples of vials used for collecting soil aggregates.

- **Permanent marker and labels** – to mark each vial with site ID, date, and depth.
- **Hard surface** – such as a plank or tray for working on the plug.

Procedure

1. **Dig a small trench** about **15 cm deep, 15 cm wide, and 15 cm long.**
   Leave one side of the trench undisturbed.
2. **Cut** about **15 cm deep** into the soil on both sides of the undisturbed wall.
3. **Insert the spade** about 5 cm back from the wall and at a slight angle to remove a **soil plug**.
   If the plug doesn't come out cleanly, use a soil knife to carefully trim away extra soil on the sides and the bottom.
4. **Place the plug** on a flat, hard surface with the undisturbed side facing up.
5. **Gently break** the plug by hand into smaller pieces.

6. **Select aggregates** that are **3–12 mm** in size from the **top 6 cm** of the plug. Choose slightly larger ones when possible.
7. **Gently place** the aggregates into a vial until it is full (at least nine per sampling point). Fill the vial completely to prevent movement.
8. **Pack vials carefully** in a bubble-wrapped box, keeping them upright and secure.
9. **Repeat** at two other SPs.
10. After completing all sites, you should have **at least 27 aggregates per MU.**

Note: If you wish to use the trench to also sample for bulk density and water retention, see below section: *How to dig a trench for combined sampling of bulk density, water retention, and aggregate stability*

Tip: Do not walk on top of the soil that will be used for removing the plug.

E) Sampling for Water Retention

You can collect water retention samples at the same sampling points (SPs) used for bulk density.

The procedure is almost the same, but there is one key difference:

At each SP, take only one intact soil core and leave the soil inside the metal ring.

- Do not empty the soil into a bag, instead:
  - Seal both ends of the ring tightly with lids.
  - Place the rings carefully in a container.
  - Use bubble wrap or other soft padding to protect them during transport to the lab.

You should have three rings with soil per Management Unit (MU) for water retention testing.

Label each ring with:

- a unique ID,
- the sampling date
- the sample location

If the rings do not have sharpened edges, mark which side is the top and which is the bottom, as this is important for the lab analysis.

How to Dig a Trench for Combined Sampling of Bulk Density, Water Retention, and Aggregate Stability

It is usually faster and easier to collect samples for bulk density, water retention, and aggregate stability at the same time by digging one trench at each sampling site.

1. Dig a trench about 1.5–2 feet (45–60 cm) long, 20 cm deep, and 15 cm wide.
2. Keep one short end of the rectangular trench undisturbed — do not dig or cut this side. You will use this undisturbed wall later for aggregate stability sampling (see section D, *SAMPLING FOR AGGREGATE STABILITY*).
3. On one of the long sides of the trench, use a sharp knife or spade to remove a thin layer of soil about 15 cm wide and 5 cm deep. This will create a clean, flat surface for inserting the bulk density and water retention rings.
    - The depth of soil you remove depends on the height of your sampling rings.
    - The example here uses 5 –cm high rings.
    - If your rings are a different height, adjust the depth accordingly (see Appendix *How to Find the Midway of a 15-cm Layer*).

After digging a small trench, a thin top layer is removed from one side to insert four rings: three bulk density rings (soil emptied and combined into one bag per sampling point) and one water retention ring (left intact and sealed with lids).

The right side of the trench remains undisturbed and is used for aggregate stability sampling.

Soil for the water retention test is submitted inside a bulk density ring, with both ends sealed with lids

Helpful Resources

Soil Sampling

Taking a soil sample https://www.youtube.com/watch?v=uq3ZPdYl5ng

Soil Health Institute 2023. Standard Operating Procedure Soil Health Sampling. https://soilhealthinstitute.org/app/uploads/2023/05/SOP_SoilSampling-v1.2.pdf

Ministry of Agriculture and Food Soil Sampling Guidelines:https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/soil-nutrients/nutrient-management/what-to-apply/soil-nutrient-testing/soil-sampling-guidelines

Hand Texturing:

https://www.nrcs.usda.gov/sites/default/files/2022-11/texture-by-feel.pdf

https://wiki.ubc.ca/Soil_Texture_-_Hand_Texturing_Method

Thien, S. 1979. A flow diagram for teaching texture-by-feel analysis (Journal of Agronomic Education) https://doi.org/10.2134/jae.1979.0054

Assessing soil texture by the feel method https://www.youtube.com/watch?v=GWZwbVJCNec

Contacts

agriservicBC@gov.bc.ca

BC Environmental Laboratory

Courier Address

Unit A, 2071 Malaview Ave West, Sidney, BC, V8L 5X6

Appendix

Things to Consider When Choosing Bulk Density Ring Size

There is no single "best" bulk density ring size for all situations. The most appropriate size depends on several factors, including:

- **Your sampling goal** (for example, measuring bulk density only, or bulk density plus water retention);
- **Sampling depth** (such as the full 0–15 cm layer or smaller depth increments); and
- **Practical considerations**, including ring availability, cost, weight, and ease of handling in the field.

Whenever possible, using the **same ring for more than one purpose** can save both time and equipment. In this protocol, the same rings are used to measure bulk density and to transport intact soil cores to the laboratory for water retention testing.

In general, **larger rings provide more stable and reliable measurements**. Regardless of ring size, it is best to keep the **length-to-diameter ratio below 0.75**. This reduces the relative importance of friction along the ring walls when inserting the ring and helps minimize disturbance of the soil core.

However, very long or large rings (for example, 15 cm tall) can be difficult to push into the soil, heavy to handle, and result in large amounts of soil that are cumbersome to manage in the field and lab.

Therefore, for this protocol, we recommend rings that are **4 inches (10.16 cm) in diameter and 1.94 inches (4.93 cm) high**, giving a volume of approximately **400 cm^3**. This size strikes a good balance between measurement accuracy and field practicality. The 4-inch diameter is also large enough for laboratories to subsample cores for water retention analysis.

How to find the midway of a 15 cm layer

The bulk density ring used in this protocol is about **2 inches (5 cm)** tall, similar to many standard bulk density rings.

If you use a ring that is 5 cm tall, simply remove **5 cm of topsoil** before inserting the ring and the ring will sit in the **middle of the 15 cm topsoil layer**.

If your ring is a different height, you can calculate how much soil to remove with this simple formula:

$$\mathbf{(A - B) \div 2 = C}$$

Where:

- **A** = depth of the soil layer to be sampled (usually 0–15 cm)
- **B** = height of the ring
- **C** = depth of soil to remove before inserting the ring

Example:
If you want to sample the middle of a 15 cm layer and your ring is 7 cm high:

$$(15 - 7) \div 2 = \mathbf{4\ cm}$$

So, in this example, remove about 4 cm of soil before inserting the ring.

Reducing Sampling Size

Calculating Bulk Density Using a Reduced Soil Sample

Many laboratories can calculate bulk density for you if you provide the **volume of your sampling ring** (for example, 400 cm^3 in this protocol). However, when sampling many MUs, this can generate a lot of soil. Shipping all of that soil to the lab can quickly become expensive.

To reduce costs, you can **send only a small, representative portion** of each bulk density sample to the lab and do a few simple calculations yourself.

If you use this approach, it is best to **ask the lab to measure soil water (moisture) content only**. This avoids confusion and ensures the bulk density calculation is done consistently.

Part A — Preparing and Weighing the Soil (Field or Prep Area)

Step 1: Determine average bag weight

Weigh **five empty sample bags**, add the weights together, and divide by five.
→ This gives the **average bag weight**.
You only need to do this once if you always use the same type of bag.

Step 2: Weigh the empty bucket

Weigh an empty bucket and record its weight.

Step 3: Combine and mix the soil

Empty the soil from all (three) bulk density rings collected at one sampling point (SP) into the bucket and **mix thoroughly** to get a uniform sample.

Step 4: Weigh the bucket with soil

Weigh the bucket plus soil, then subtract the empty bucket weight (from Step 2).
→ This gives the **total soil weight** collected at that SP. Record this value.

Step 5: Take a representative subsample

From the mixed soil, take about **400 g (≈ 1½ cups)** and place it into a sample bag.

- If the soil contains many stones, take a bit more (up to **500 g or ~2 cups**)

Tip: Make sure the subsample represents the whole mix—don't avoid or selectively include stones.

Step 6: Weigh the subsample

Weigh the bag with soil, then subtract the **average bag weight** from Step 1.
→ This gives the **soil weight of the subsample** being sent to the lab. Record it.

Part B — Calculating Bulk Density

Step 7: Calculate the fraction of soil sent to the lab

Divide the wet soil weight of the subsample (Step 6) by the total wet soil weight (Step 4).
→ This gives the **fraction of soil** (from the total soil sampled at a SP) sent to the lab.

Step 8: Calculate the soil *volume* of the subsample

Multiply the fraction from Step 7 by the **total soil volume collected** (sum of ring volumes).
→ This gives the **soil volume represented by the lab sample**.

Step 9: Convert wet weight to dry weight

Soil laboratories usually report only the water content in percentage of a sample but not its dry weight. Using the **soil water content (%)** provided by the lab, calculate the dry weight of the sample:

$$\text{Dry weight} = \frac{\text{Wet weight}}{1 + (\text{reported water content } /100)}$$

Step 10: Calculate bulk density

$$\text{Bulk density} = \frac{\text{Dry soil weight}}{\text{Soil volume}}$$

Example — Reduced Sample Method

Step 1 — Average bag weight
Five empty sample bags weigh 30.4 g
→ 30.4 ÷ 5 = **6.1 g per bag**

Step 2 — Empty bucket weight
Empty bucket = **850 g**

Step 3 — Soil volume collected
Three rings × 400 cm^3 each = **1,200 cm^3**

Step 4 —Determine soil weight w/o bucket
Bucket + soil = 2,480 g
2,480 − 850 = **1,630 g of soil** without bucket

Step 5 — Take subsample
About **2 cups** of soil placed in a bag (slightly stony soil)

Step 6 — Determine weight of subsample without bag
Bag + soil = 456 g
456 − 6.1 = **449.9 g ≈ 450 g of soil** (without bag)

Step 7 — Determine soil sent to lab as fraction of the total soil sampled
450 ÷ 1,630 = **0.276 (27.6%)** (means: 27.6% of the soil sampled at the SP was submitted to the lab)

Step 8 — Determine soil volume of subsample
Fraction from step 7 × total volume sampled at the SP from step 3 =
27.6% × 1,200 = **331 cm^3**

Step 9 — Convert wet soil weight to dry soil weight
Lab usually reports only the water content in percentage and not the dry weight of the sample. Assume they report **18% water content**
450÷ (1+(18/100)) = 450 ÷ 1.18 = **381 g dry soil**

Step 10 — Bulk density
381 g ÷ 331 cm^3 = **1.15 g/cm^3**

Final Result:

Bulk density = 1.15 g/cm^3

(a reduced sample bulk density calculator excel sheet is available upon request at agriserviceBC@gov.bc.ca)

When Bulk Density and Water Retention Sampling No Longer Makes Sense

If a soil contains a large amount of coarse fragments (stones or gravel larger than 2 mm), it becomes increasingly difficult to collect intact and representative samples for bulk density or water retention. More importantly, the **interpretation of the results becomes problematic**.

Bulk density and water retention measurements are meant to describe the behaviour of the **fine soil fraction**—the part of the soil that holds water, stores nutrients, supports microbial activity, and allows roots to grow. When stones make up a large share of the soil volume, this fine fraction no longer controls how the soil behaves.

- **Less than 30% stones by volume**
  Sampling with a bulk density ring generally works well, and results are usually reliable.
  → Record the estimated stone content, as it may later be used to adjust water retention values.
- **30–50% stones by volume**
  Sampling is still possible, but results become more variable and less reliable.
  → Carefully estimate and record stone content so water retention values can be corrected.
- **More than 50% stones by volume**
  Sampling for bulk density or water retention is **no longer meaningful**, because:
    - **Changes due to soil management are very difficult to detect**: the coarse fraction dominates the measurement—and stones are not affected by management practices such as tillage, cover crops, or organic amendments.
    - Water retention results become dominated by voids around stones rather than by soil texture and structure.
    - Small differences in stone size or placement can greatly affect measurements, leading to high variability and poor repeatability.

In very stony soils, bulk density and water retention measurements are therefore of limited value for tracking management effects over time. In these cases, **field observations** (rooting depth, crop performance, infiltration behaviour) or alternative indicators may provide more meaningful information for decision-making.

How to Sample Soils with Coarse Fragments

When sampling soils that contain larger stones or gravel, you may notice that some stones stick out of the bulk density ring or leave small voids when the sample is lifted from the ground. This is common in stony soils and can affect how representative the sample is if not handled carefully.

To reduce bias and improve consistency:

- Alternate between leaving and removing stones of similar size when they interfere with sampling, rather than always removing or always keeping them. This helps maintain a representative mix of fine soil and coarse fragments, and
- Increase the number of subsamples to five (5) per sampling point (SP) when preparing the composite sample. More subsamples help average out the natural variability caused by stones.

Because this approach increases the total amount of soil collected, you may need to reduce the overall sampling volume, as described earlier in this protocol, to keep handling and shipping practical.

Sampling for Bulk Density at Layers deeper than 15 cm

In some cases—such as when estimating **soil carbon stocks below 15 cm**—bulk density needs to be measured at greater depths.

The sampling method is the same as for the 0–15 cm layer, but an additional step is required: you must **create a new, flat soil surface** at the target depth before inserting the bulk density ring.

When using **5 cm-high rings**, this means preparing the insertion surface at **20 cm depth**. This places the ring in the middle of the 15–30 cm layer (15 cm plus 5 cm as explained under “How to Find the Midway of a 15 cm Layer”), ensuring the sample represents that layer accurately.

Because inserting and removing rings becomes more difficult below 15 cm, it is usually easiest to **dig a small trench** first and sample from the exposed soil face, following the approach described in section (D): *Soil Aggregate Sampling*.