Conservation Evaluation and Monitoring Activity

Soil Health Testing

CEMA 216

Definition

Quantitative testing for biological, chemical, and physical characteristics of soil and constraints using approved laboratory methods.

Applicable Land Uses

All Land Uses.

REQUIREMENTS

Qualified Individual Requirements

The Natural Resources Conservation Service (NRCS) strongly encourages Conservation Evaluation and Monitoring Activity (CEMA) participants to know Qualified Individual (QI) requirements to ensure the person they employ to provide the CEMA is fully qualified to meet the objectives of the activity.

A QI for Soil Health Testing CEMA 216 meets one of the following:

1) Certified Crop Advisor (CCA) or Certified Professional Agronomist (CPAg) through the American Society of Agronomy or a Certified Professional Soil Scientist (CPSS) or Associate Professional Soil Scientist (APSS) through the Soil Science Society of America.
    a) A producer could search for a QI by visiting the Science Societies' "Find Professional | Search" page.
2) Technical Service Provider (TSP) certified for Conservation Practice Activity Soil Health Management Plan (Code 116) or Design and Implementation Activity Soil Health Management System Design (Code 162).
    a) A producer could search for a QI by visiting the "Find a Technical Service Provider" for technical service providers certified for CPA 116 or DIA 162.
3) An associate degree or higher in soil science, agronomy, crop science, plant science, rangeland management, agricultural sciences with soils emphasis, environmental science, natural resources, or a closely related field, and at least 2 years of experience collecting soil for laboratory analysis.
4) Individuals working under the guidance or management of a QI are allowed to collect soil samples for this CEMA.

General Requirements

1) This CEMA includes the performance of work and documentation of the tasks, results, interpretations, and other activities described herein by a QI.

2) Prior to initiation of the CEMA, the QI must arrange a pre-work conference to ensure all parties understand the participant's objectives, required deliverables, and characteristics of the CEMA tasks.

   a) The parties in the pre-work conference must include the participant, the QI, and the NRCS field office staff. The parties should agree whether they will join in-person or join via phone, web-meeting, etc.

   b) If a TSP is needed to support a specific practice or intends to use the results in conservation planning, it is recommended that the TSP be invited to the pre-work conference.

3) A QI may use any reference information, resource concerns, conservation practice standards, and related documents in the NRCS Field Office Technical Guide (FOTG) for the state where this CEMA is performed. The FOTG home page hyperlink is: https://efotg.sc.egov.usda.gov/#/

Technical Requirements

This CEMA includes details to collect and analyze soil based on soil health principles, resource concerns, and planning objective(s). Soil samples are to be collected in the NRCS-identified planning land unit (PLU) and submitted to commercial laboratories for analysis using standardized methods.

Following are technical requirement sections on soil testing, determining soil sampling purpose, strategy, and locations, sample collection, handling, and shipping, and laboratory requirements.

Soil Testing

1) All soil health testing will assess the following five soil processes and indicators to evaluate the soil ecosystem: Soil Aggregation, Soil Carbon Cycling, Microbial Activity, Carbon Food Source, and Nitrogen Food Source. Participants must choose the preferred or alternate laboratory method for each process/characteristic below.

   a) References to methods can be found in TN 470-16 Soil Health Testing to Support Conservation Planning and the References section of this document.

Table 1. Each soil process should be measured to evaluate overall soil health. Choose a method to measure the soil indicator from each column.

Soil Process and Indicator	Soil Aggregation – Wet Aggregate Stability	Carbon Cycling – Soil Organic C (SOC)	Microbial Activity – Soil Respiration	Carbon Food Source for Microorganisms – Labile Carbon	Nitrogen Food Source for Organisms – Bioavailable Nitrogen
Reason for Measurement	Measure of the physical soil environment. Related to water infiltration, carbon and nutrient storage, biological activity, and reduced erosion	Related to soil structure, fertility, and provides microbes with food	Measure of how active the microbes are in the soil	Carbon food that is easily taken up by microbes	Related to protein that is readily available to microbes
Preferred Method	Wet sieving	Dry combustion	24-hour incubation/burst	Permanganate Oxidizable Carbon (POXC)	Autoclaved Citrate Extractable (ACE) protein content

Soil Process and Indicator	Soil Aggregation – Wet Aggregate Stability	Carbon Cycling – Soil Organic C (SOC)	Microbial Activity – Soil Respiration	Carbon Food Source for Microorganisms – Labile Carbon	Nitrogen Food Source for Organisms – Bioavailable Nitrogen
Alternate Method(s)	Cornell Sprinkle infiltrometer or Image Analysis (e.g., SLAKES)	SOC calculated from Soil Organic Matter (SOM) measured by Loss on Ignition (LOI)	96-hour incubation	Water extractable organic carbon	Water extractable organic nitrogen

2) All soil health testing will measure soil pH and texture to interpret the soil health indicator results. Participants must choose the preferred or alternate laboratory method for both soil pH and texture below:

Table 2. Soil characteristics are used to interpret soil health indicators. Choose a method to measure the soil characteristic from each column.

Soil Characteristic	Soil Texture	Soil pH
Preferred Method	Kellogg Soil Survey Laboratory (KSSL) Particle Size Distribution Analysis by pipette	1:1 water
Alternate Methods	Hydrometer method or laser diffraction	0.01M CaCl2 or regional method referenced on the NAPT-PAP website

3) Participants who would like an advanced soil health test with additional microbial diversity/ functional diversity information should choose one of the methods below:

Table 3. If additional soil biological information is desired, choose a method to measure microbial/ functional diversity.

Soil Indicator	Microbial Diversity/Functional Diversity
Preferred Method	Phospholipid Fatty Acid (PLFA)
Alternative Method	Choice of three of the five following soil enzymes: • β-Glucosidase (Carbon Cycling) • N-acetyl-β-D-glucosaminidase (Carbon and Nitrogen Cycling) • Protease (Nitrogen Cycling) • Acid and/or Alkaline Phosphatase (Phosphorus Cycling) • Arylsulfatase (Sulfur Cycling)

Determining Soil Sampling Purpose, Strategy, and Locations

4) Record the purpose and strategy for soil health testing.

5) Design the soil sampling strategy based on goals, available tools, previous resource concern assessments (such as in-field soil health assessments), and other applicable guidance. Analyze the soil type, topography, and management information to determine appropriate sampling locations within a PLU.

6) Identify the 3 main locations for soil health testing. The Soil Sample Planning Optimizer Tool (SSPOT) or another geospatial sampling identification tool can be used.

7) Use the following sampling strategies (figure 1), or combination of strategies, when applicable:

   a) Stratified – Soil in the PLU is heterogenous and contains different soil types across different landscape positions. Sampling locations are chosen randomly within delineated

subareas (or strata) in proportion to the size of the subarea in relation to the PLU.

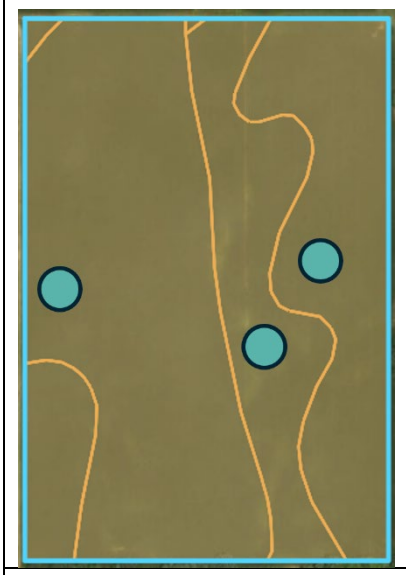
b) Random – Soil in the PLU is homogeneous and there are few problem areas. Sampling locations are chosen by assigning random numbers to areas on a grid overlay.

c) Problem – Distinct areas with uneven plant production or growth are strategically sampled.

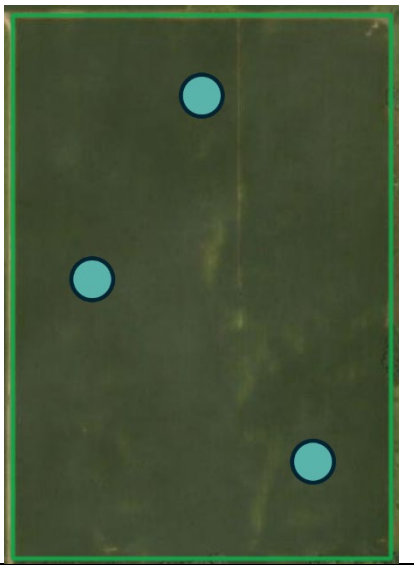
This strategy requires collecting three separate composite samples from within the PLU:

1. Problem Area: Collect a composite sample from an area that consistently shows poor performance (e.g., an area with low productivity, a sandy ridge, or a clay knob).
2. Representative Area: Collect a composite sample that represents the average condition of the rest of the field, avoiding the specific "good" and "problem" spots already sampled.
3. Another area: This could include another problem area, if there is more than one, or another representative area.

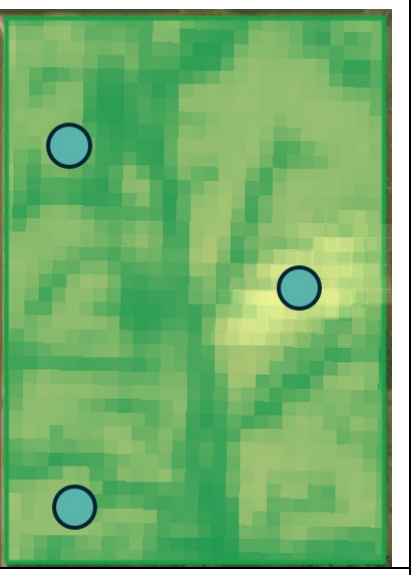
Figure 1. This shows the main sampling location of the three sampling strategies in the same field. Each circle represents a main location. The stratified example has a field divided into three subunits based on their soil type. The random example has soil collected from three random spots in the field. The problem area sampling has soil collected from a problem area and two representative areas.



Stratified Sampling



Random Sampling



Problem Area Sampling

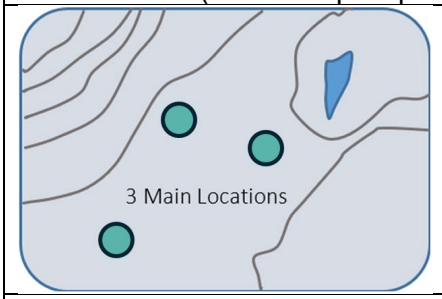
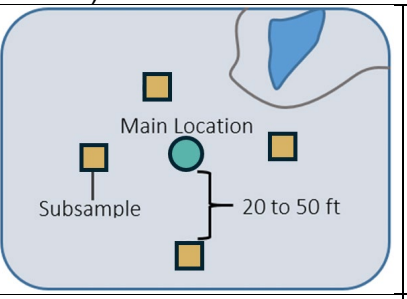
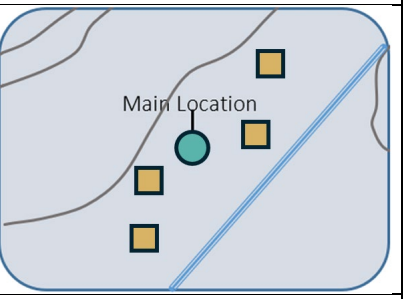
8) Plan subsampling around each main location. At each of the 3 main locations, soil must be collected from the main location plus 4 additional subsamples about 20 to 50 feet from the main location (5 subsamples, in total, per location). These five subsamples will be combined into a composite sample (the main location and four samples surrounding it). Each PLU must have three separate composite samples to send to the laboratory. See figure 2.

a) When there are spatial limitations, such as close proximity to a fence row, road, property line, or another soil type, select 4 sites in a more linear, W-shaped, or zig-zag pattern.

b) When there are spatial limitations, such as in small-scale situations, subsample sites may be located less than 20 feet from the main location, as long as supporting rationale is provided.

c) For forest systems, see Forest Soil Health Testing fact sheet regarding placement of sample locations and considerations for sampling (e.g., rock, organic mats, roots, etc.).

Figure 2. At each main location, collect soil from the main location and 4 subsamples around the main location (5 subsamples per/location).

		
Identify 3 main locations within a CMU that is of interest to the producer. Soil will be collected and sent to the lab from all 3 locations.	Select 4 sites surrounding each main location to subsample. Collect and mix soil from all 5 sites. Space 20-50 ft apart.	When there is a spatial limitation, like a road or property line, select 4 sites in a more linear, W-shaped, or zig-zag pattern.

Sample Collection, Handling, and Shipping

9) Before going to the field, it is essential to contact your chosen soil testing laboratory to confirm their specific sampling protocols. Laboratory requirements can vary significantly, and adhering to their guidance is critical for accurate results. Failure to follow the lab's specific instructions for collection, handling, and shipping could invalidate your samples.

   When you contact the lab, be sure to confirm the following:

   - Number & Amount of Samples: The exact number of samples and the volume of soil required for your desired analysis.
   - Handling & Storage: The proper protocol for the indicators being analyzed. This is especially critical for sensitive tests (e.g., PLFA), which may require specific soil temperatures, storing samples on ice in the field, or even freezing them immediately after collection.
   - Shipping: The required shipping methods and timelines to maintain sample integrity. For time-sensitive analyses, this could involve requirements like overnight shipping on dry ice.

10) Within the PLU, collect soil from at least 3 main locations in accordance with the identified sampling strategy.

   a) Reminder from above: At each of the 3 main locations, collect soil from the main location plus 4 additional subsamples (5 subsamples, in total, per location).

   b) Reminder from above: Subsamples must be taken about 20 to 50 feet from the main location. When there are spatial limitations, such as in small-scale situations, subsample sites may be located less than 20 feet from the main location, as long as supporting rationale is provided.

11) At each main location, combine all 5 subsamples to create one composite sample. Gently break up any large clods, and remove stones, roots, or debris from the soil. Gently mix the samples and place in sample bags marked (at a minimum) with name of main location and date collected (e.g., Fence Row, 05/03/2025).

12) Ensure all equipment is clean and free from residue prior to collection. Remove vegetation or

debris from the soil surface. If sampling for PLFA, sanitize sampling equipment in between collection of composite samples.

13) At each soil sampling site collect soil 2 inches thick by 2 inches wide by 6 to 8 inches deep. When practical, use a tile spade, sharpshooter, or straight shovel to collect soil. Dig a hole 8 inches deep and remove a 2-inch thick vertical, rectangular slice of soil between 0 to 6 and 0 to 8 inches in depth from the side of the hole. Sampling a soil slice in this way preserves the structure and aggregates better than sampling with a soil probe. If it is impractical to sample a slice of soil, then a soil probe that is 1-inch or more, inside diameter, will be used (Soil Health Technical No. 07, Guidance on Grab Sampling for Soil Health Testing).

14) Collect soil samples during the current growing season. Sample when soil moisture and temperature are not extreme and there have not been any recent physical disturbances, additions of soil amendments, or other chemical inputs.

15) All 5 subsamples collected at each main location should be representative of the same concept. Within each sample location avoid conflicting variables such as:

   a) Wheel tracks or drive lanes, field borders, depressions, or other odd areas within the field.

   b) Areas with historically lower or higher productivity.

   c) Different landscape positions.

   d) Fields with different plant species composition, or the same species with a different management.

   e) Eroded versus non-eroded areas.

   f) Saturated soil.

16) When using this activity to monitor practice effects over multiple years, it is recommended to remain consistent in the following ways: use the same georeferenced locations, employ the same sampling strategy, collect soil under similar soil conditions, collect soil at the same time of year, utilize the same lab tests and methods, and utilize the same laboratory.

17) Follow all USDA-APHIS regulations for prohibited, regulated, or quarantined soils.

Laboratory Requirements

18) Submit soil samples to laboratories with current certification or accreditation from one of the following:

   a) The Performance Assessment Program (PAP) from The North American Proficiency Testing Program (NAPT) under the auspices of the Soil Science Society of America,

      - A producer could search for a PAP-approved laboratory by visiting the NAPT-PAP program website at https://www.soils.org/napt-program/pap.

   b) The American National Standards Institute (ANSI) National Accreditation Board (ANAB),

   c) The International Organization for Standardization (ISO/IEC 17043:2010) for ISO 10694:1995,

   d) State-approved certification program that considers laboratory performance and proficiency to assure accuracy of soil test results.

DELIVERABLES

The QI must provide documentation showing that all tasks indicated in the **General Requirements** and **Technical Requirements** sections are complete, along with the following sections:

Cover Page

Cover page reporting the technical services provided by the QI. Cover page(s) must include the following:

1) CEMA name and number.
2) Participant information: Name, farm bill program name, contract number (QI obtains contract number from participant), land identification (e.g., state, county, farm, and tract number).
3) QI name, address, phone number, and email.
4) A statement by the QI explaining how they currently meet the Qualified Individual Requirements for this CEMA. Attaching or enclosing a copy of documentation on how the QI requirements are met is encouraged. Examples include:
    - Certification Name and Number,
    - License Name and Number,
    - Other brief written statement indicating how the requirements of a QI for this CEMA are met.
5) A statement by the QI that services provided meet NRCS requirements, such as:

    I certify the work completed and delivered for this CEMA:
    - *Complies with all applicable federal, state, tribal, and local laws and regulations.*
    - *Meets the general requirements, technical requirements, and deliverables for this CEMA.*
    - *Is consistent with and meets the conservation objectives for which the program contract was entered into by the participant.*
    - *Addresses the participant's conservation objectives for this CEMA.*

    QI Signature: _____ *Date:* _____
6) A Participant's acceptance statement, such as:

    I accept the completed CEMA deliverables as thorough and satisfying my objectives.

    Participant Signature: _____ *Date:* _____
7) A space for an NRCS reviewer to certify the agency's acceptance of the completed CEMA such as:

    NRCS administrative review completion by:

    Signature: _____ *Title:* _____ *Date:* _____

Notes and Correspondence

1) Include documentation of each site visit, its participants, the activity completed in the field, and results of each site visit.
2) Copies of correspondence between the QI and the participant relating to goals for soil health

sampling, decision-making, and completion of this CEMA.

3) Copies of observations, data, or test results prepared during completion of this CEMA.

Maps, Diagrams, Plan Views

1) Maps to include, but not limited to:
   a) General location map to locate the sampling area, such as geographic coordinates, public land survey coordinates, roads to access the site, etc.
   b) Soil Sampling map showing the PLU polygon data and GPS point data (WGS84 latitude, longitude) for main sampling locations.
   c) Other maps as needed, with appropriate interpretations.
2) All maps developed for the CEMA will include:
   a) Map title.
   b) Client's name (individual or business).
   c) Assisted By [QI name].
   d) Date prepared.
   e) Map scale.
   f) North arrow.
   g) Appropriate map unit symbols and a map symbol legend on the map or as an attachment.

Evaluation or Monitoring Results

At a minimum, prepare a report including the following:

1) Purpose of soil health testing.
2) Report describing the sampling strategy used for the soil health test.
3) Location and sampling date.
4) Soil and weather conditions, to plan future sampling.
5) Sample identification code(s).
6) Laboratory test results.
7) Test result interpretations/observations describing the current status of soil health indicators, explanation of results from historic management history or current management, and potential management changes to maintain current soil health status or improve soil health status. This could include outputs from Soil Health models or tools used, if applicable.
8) Schedule of additional testing or monitoring at recommended frequency, as determined by the conservation plan.

Deliver Completed Work

The QI must:

1) Prepare and deliver two complete sets of all listed deliverables directly to the participant.
   a) Participant Copy: The Qualified Individual (QI) must provide the participant with one complete set of all required deliverables. This set must include the laboratory test results and will serve as the participant's permanent record.
   b) NRCS Field Office Copy: The QI must provide the participant with a second complete set of all required deliverables, **excluding the laboratory test results**. The participant is responsible for submitting this set to the local NRCS Field Office.
      - The QI must obtain the participant's prior approval before including laboratory test results in the NRCS Field Office Copy.
      - In accordance with the Privacy Act of 1974 (5 U.S.C. § 552a), the participant is not required to provide NRCS soil health test results to the NRCS Field Office.
      - The QI may submit deliverables directly to the local NRCS Field Office only if authorized by the participant using the CPA-1270 form.
   c) Ensure the local NRCS Field Office receives all CEMA deliverables early enough to thoroughly review the documentation before final acceptance is requested.

Post Testing Analysis

After laboratory results are supplied, participants are encouraged to submit the results and sampling location(s) coordinates to SoilHealthTest@usda.gov.

Laboratory test results will be used to improve and strengthen the Soil Health Assessment Protocol and Evaluation (SHAPE) process, procedures, and results (Nunes et al. 2024). No identifying information or results will be publicly available.

Appropriate CPA-1270 form to release participant information must be used to grant permission for the QI or NRCS field office to submit the test results.

Definitions

Subsample: A single sample of soil taken from one specific spot. Subsamples are combined into a larger composite sample.

Composite sample: A sample of soil made by mixing 5 soil subsamples together. A composite sample represents soil health for a specific area.

Image analysis: Method that uses digital photos or video to measure the physical breakdown of soil aggregates when exposed to water, providing a quantifiable indicator of their stability.

PLU (Planning Land Unit): A PLU is a unique geographic area, defined by a polygon, that has common land use and is owned, operated, or managed by the same client or clients. The PLU is the minimum unit for planning.

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